# NON-TIME CRITICAL REMOVAL ACTION
# BASIS OF DESIGN
# CAUSEWAY DESIGN

## 100% CAUSEWAY DESIGN
## PHASES I and II

## STRATFORD ARMY ENGINE PLANT
## STRATFORD, CONNECTICUT

CONTRACT DAAAM-02-97-D-0005
DELIVERY ORDER NO. 0003

AUGUST 2001

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*Prepared for:*

U.S. Army Tank-automotive and Armaments Command
Stratford, Connecticut

*Prepared by:*

Harding ESE, Inc.
A MACTEC Company
Portland, Maine

Project No. 50796
Task No. 1042

AUGUST 2001

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**VOLUME III**

# 1.0 INTRODUCTION

Harding ESE, Inc., a MACTEC Company (Harding ESE) (formerly Harding Lawson Associates [HLA]) has been contracted to provide engineering services related to the Non-time Critical Removal Action (NCRA) design for the Causeway at the Stratford Army Engine Plant (SAEP) in the Town of Stratford, Fairfield County, Connecticut. The removal action is being conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (U.S. Environmental Protection Agency [USEPA], 1990), and the Base Closure and Realignment (BRAC) Cleanup Plan Guidebook (Department of Defense, 1993).

## 1.1 PURPOSE

This Basis of Design Document presents assumptions, references, and design criteria used in the development of the Causeway NCRA 100% design for both Phases I and II. Technical specifications, design drawings and supporting calculations and information are included as appendices. This document is consistent with the Final Causeway NCRA Decision Document (Harding ESE, 2001) and has been prepared in accordance with the Proposal for the Causeway NCRA Design for the SAEP facility, submitted by HLA in July 2000 (HLA, 2000), as modified for Phases I and II in March 2001.

The scope of Phase I includes the following work elements:

- Abandonment of designated existing monitoring wells.
- Installation and maintenance of erosion and sediment control measures.
- Installation and initial monitoring of five heave platforms and five stationary heave poles.
- Clearing of trees and brush from the Causeway.
- Removal of the containment berm around the Building 34 former aboveground storage tank (AST) farm and removal of associated protective posts and tank supports to existing ground surface, followed by paving of the former AST area, to improve access to the Causeway.
- Demolition to existing grade and off-site disposal of Building 5, including existing utility disconnection, to improve access to the Causeway.
- Excavation and off-site disposal of soil in ten locations (excavation areas) which contain contaminant concentrations in exceedance of specific Connecticut Department of Environmental Protection (CTDEP) Remediation Standard Regulation (RSR) criteria, or the federal Ambient Water Quality Criteria (AWQC), or soils identified as containing greater than 1 part per million (ppm) of polychlorinated biphenyls (PCBs).
- Demolition and off-site disposal of Building 59 and the Causeway weather station, including existing utility removal.
- Removal and off-site disposal of oversized surface debris measuring greater than two feet in any dimension, including the deteriorated concrete ramp at the end of the Causeway.
- Topographic survey of the Causeway.

The scope of Phase II includes the following work elements:

- Maintenance and modifications, as progress of the work dictates, of erosion and sediment control measures installed during Phase I of work on the Causeway.
- Monitoring of previously installed heave platforms and stationary heave poles, and installation and monitoring of temporary heave poles.
- Excavation of soil located on the Causeway sideslopes.
- Placement of satisfactory excavated material on the top of the Causeway and grading of the Causeway to the subgrade elevations indicated on the drawings.
- Removal and off-site disposal of additional oversized debris identified during Phase I and encountered during sideslope excavation.
- Placement of Rock Fill for toe scour protection and a reinforcing geogrid composite to provide additional toe support around the end of the Causeway.
- Placement of the Lower Cover System, consisting of gravel fill (as necessary), a woven geotextile, and polymeric marine mattresses (a graded rock fill wrapped in a specialty geogrid), on the excavated sideslopes of the Causeway.
- Placement of Rock Fill and Rip Rap between the lower and upper covers to facilitate drainage.
- Placement of the Upper Cover System, consisting, from bottom to top, of a sand bedding layer, a non-woven geotextile, interlocking concrete blocks, and interstitial gravel.
- Placement of a Vegetative Support Layer, consisting of vegetative support soils, erosion control material, and appropriate grass cover.
- Implementation of Environmental Land Use Restrictions (ELURs) preventing penetration of the cover system and dredging of the tidal flats, and limiting future construction on top of the cover system.

This document is organized to present both the Phase I and Phase II design rational and basis for design of the proposed cover system. Appendices A and B contain the 100% technical specifications and 100% design drawings for Phases I and II, respectively. Appendix C contains information regarding selection of the cover system option, including regulatory agency and public comments on the Engineering Evaluation/Cost Analysis (EE/CA), a cost evaluation of several cover system options, a letter to CTDEP requesting approval of the cover system as "another existing permanent structure" under the RSRs, cover system component information, and a filter analysis for the cover system gravel fill. The geotechnical evaluations and a wave analysis are contained in Appendices D and E, respectively and Appendix F contains calculations of the volume of soil to be removed from the Causeway as a result of contaminant concentrations in excess of specific CTDEP RSR criteria, AWQC, or 1 ppm for PCBs. Appendix G contains the 100% design engineering cost estimate for each phase of the work. Appendix H contains supplemental information providing details of existing conditions at Building 5, Building 34, and Building 59. Information from a manufacturer of ocean sediment control systems, describing issues related to the partially penetrating floating silt curtain (N.I.T.C.), is attached as Appendix I, and Appendix J contains a removal action construction schedule for the project duration.

## 1.2 SITE DESCRIPTION AND HISTORY

SAEP consists of approximately 124 acres, of which an estimated 76 acres are improved land consisting of 49 buildings, paved roadways and grounds, and five paved parking lots. Included in the improved land are an estimated 10 acres along the Housatonic River where fill was placed over tidal sediments during the development of SAEP facility, including the Causeway. Riparian rights are associated with the remainder of the SAEP facility. A riparian right is a right of access to, or use of, the shore, bed, or water of land on the bank of a natural watercourse. The riparian rights property consists of intertidal flats of the Housatonic River. An estimated two acres of property compose the Causeway, constructed to provide access to the river channel.

The Causeway was initially constructed and used as a means of launching seaplanes in the 1930s. Additional materials, of unknown origin, were deposited along the northern edge of the Causeway during the 1950s and 1960s. The source of the fill used to construct the Causeway is unknown, but it has been found to contain soil, cobbles, and construction debris (e.g., concrete, brick, and asphalt). Smaller amounts of other material (e.g., wood, glass, cinders, ash, and rebar) were also observed during field investigation activities. It was also reported that paint solvents and wastes were burned on the Causeway as part of fire-training operations.

Building 59, a concrete building with concrete blast walls, located near the origin of the Causeway from the facility, was constructed to house the nose cones of missiles, including the explosive charges used to open the nose cones. There is currently no unexploded ordnance present at the SAEP facility.

Investigation History and Remediation Approach. Chemical sampling and analysis of soil collected from the Causeway identified concentrations of chlorinated and fuel-related volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), polychlorinated biphenyls, and inorganics that exceeded specific CTDEP RSR criteria or AWQC. Low-level radiological contamination was also identified during sampling, and the affected areas were excavated in March 2000. This material was containerized and transported to an appropriate off-site, licensed, disposal facility. Evaluation of chemical analytical data is discussed in the Final Causeway Pre-design Investigation Report (Foster Wheeler Environmental Corporation [FW]/HLA, 2000a).

Based on the results of chemical sampling and the Final EE/CA report (FW/HLA, 2000b), it was recommended that an erosion control cover system be placed over the Causeway to prevent possible receptor contact with contaminated soil. The Final EE/CA also recommended that geotechnical investigations be conducted to assess subsurface conditions in the proximity of the Causeway.

Prior to initiation of geotechnical investigations, a preliminary global stability analysis was conducted to assist in location of geotechnical field borings, and to evaluate the feasibility of the cover system proposed in the EE/CA. Soil properties and subsurface geometry were assigned in the preliminary model, based on observations from previous investigations. The results of the preliminary analysis indicated the proposed 4-foot cover system would not result in an acceptable factor of safety (FS) (i.e., FS < 1.3, immediately following construction) for global stability of the Causeway. Subsequently, recommendations regarding potential modifications to the proposed design were made, including:

- Construction of a thinner cover system;
- Removal of construction debris prior to cover placement;
- Transfer of fill material from the toe of the Causeway slope to the top of the Causeway; and
- Use of an engineered cover material rather than traditional rip rap.

Discussions between the U.S. Army and Harding ESE personnel in October 2000 and consideration of agency and public comments on the Final EE/CA (Appendix C) led to a cost evaluation of four possible cover system options:

- 1.5-foot composite cover system – non-encroaching below 4.1 National Geodetic Vertical Datum, 1929 (NGVD) feet mean sea level (msl)
- 1.5-foot composite cover system – encroaching below 4.1 feet msl
- 2-foot rip rap cover system – non-encroaching below 4.1 feet msl
- 2-foot rip rap cover system – encroaching below 4.1 feet msl

The results of this evaluation indicated construction of a cover system, approximately 1.5 feet thick, would provide protection to potential human receptors and address public concerns regarding usability, at a cost similar to that for a rip rap cover system (Appendix C, Attachment B). The non-encroaching system was selected to address comments received from the CTDEP Office of Long Island Sound Programs. The comment was regarding maintaining the existing land area, "... to the extent practicable, the horizontal location of mean high water (4.1 feet NGVD), which is the landward extent of the public trust area" (see Appendix C, Attachment A).

Concurrent with the cover system cost evaluation, data collected during the geotechnical investigations was being used to evaluate physical properties for the underlying soil, and update the preliminary global stability analysis. Data collected during the geotechnical investigation is presented in the Geotechnical Investigation Summary Report (Harding ESE, 2000) and includes:

- visual identification of subsurface soil
- measurement of in-situ shear strength of organic sediment
- laboratory determination of physical properties and index parameters
- visual identification of the limit of Causeway fill material
- horizontal and vertical location of geotechnical borings
- completion of a topographic survey of the Causeway
- installation and sampling of a groundwater monitoring well

The final stability evaluation considered the four cover system options presented above and evaluated changes in various input assumptions. The results of the final geotechnical evaluations are presented in Appendix D and indicate the four proposed cover systems are feasible from a geotechnical perspective. These results were presented to the U.S. Army, the CTDEP, and the USEPA in a January 2001 meeting. The U.S. Army and the regulatory agencies provided preliminary agreement to the proposed non-encroaching 1.5-foot composite cover system and design activities were initiated.

## 1.3 GENERAL ELEMENTS OF DESIGN

Major scope items within the Causeway cover system design include the following:

1. Prepare a geotechnical evaluation of cover system stability and settlement based on cover design.

2. Provide information supporting the sediment containment systems; included in this Basis of Design document for completeness, although the sediment containment system is not included as part of the design.

3. Prepare designs for: the demolition of Building 59, Building 5, and the Causeway weather station; and the removal and off-site disposal of debris and some contaminated soil.

4. Prepare a design for the construction of the Causeway cover system, including a wave analysis, an ice abrasion evaluation, and vegetative cover material selection.

5. Split the design into two separate phases to allow early initiation of preliminary construction activities.

6. Prepare documentation necessary for application for a site-specific ELUR.

# 2.0 DESIGN ANALYSIS

## 2.1 EVALUATION OF DECISION DOCUMENT REQUIREMENTS AND PERFORMANCE STANDARDS

This removal action design is responsive to the requirements and performance standards identified in the Causeway NCRA Decision Document. This section presents the removal action objective for the Causeway NCRA established in the EE/CA (FW/HLA, 2000b) and describes how the design meets the objective:

- Prevent exposure to contaminated soils and prevent leaching of contaminants from soils in accordance with the CTDEP RSRs. The cover system and proposed long-term monitoring will meet the intent of the CTDEP RSRs, regarding isolation of soil contamination exceeding specific CTDEP RSR criteria or AWQC. Under the cover system option, precipitation may infiltrate the soils overlying the wastes; therefore, the removal action includes removal of soil containing contamination exceeding the CTDEP RSR criteria or the federal AWQC for VOCs, SVOCs, vanadium, or zinc. Soil removal and off-site disposal will eliminate the potential for these contaminants to leach to underlying groundwater.

### 2.1.1 Regulatory and Code Requirements

The removal action design is being prepared in conformance with the substantive requirements of the applicable relevant and appropriate requirements (ARARs) referenced in the Decision Document (Harding ESE, 2001). The action-specific ARARs and other criteria to be considered that are most applicable to the design are listed in Table 2-1.

The lower reaches of the Housatonic River, where construction work is to be conducted, includes areas of shellfish and finfish resources. According to CTDEP information, the Causeway is in close proximity to oyster seedbeds. The CTDEP does not allow what it considers to be unconfined excavation or filling work in the lower reaches of the Housatonic during certain times in order to protect shellfish and finfish resources. The relevant "closed" period for unconfined dredging is from April 1 through September 30. (April 1 to June 30 for finfish and June 1 to September 30 for shellfish). Phase I and II activities below the primary erosion control silt fence may not be performed during this “closed” period. Work above the primary erosion control silt fence is acceptable at any time under the CTDEP requirements, and requires best management practices that are to be followed during all site work. The location of the primary erosion control silt fence will be modified, or additional silt fencing will be installed, to accommodate work outside of the primary erosion control silt fence (i.e., excavation of soil in Excavation Area 5).

### 2.1.2 Recommended Materials, and Methods

Construction materials and general methods are provided in technical specifications and construction drawings.

### 2.1.3 Construction Schedule

A construction schedule providing a recommended sequence of activities and anticipated time frames has been prepared, and is included as Appendix J. The following assumptions were made during development of the engineering design construction schedule:

- Review periods for the cover system design are scheduled for 10 working days.
- Contractor procurement will be completed 30 working days after issuance of bid documents.
- Phase I activities, above the primary erosion control silt fence can be conducted during the "closed" period.
- Phase II activities and Phase I activities below the primary erosion control silt fence, including weather station demolition and oversized debris removal on the sideslopes of the Causeway, can not be completed during the "closed" period.
- Two crews will be used to complete sideslope soil excavation and lower cover system installation.
- Phase II excavation activities will be completed for a maximum of 5 hours each day, due to tidal conditions.

The presented schedule is an estimate only, and may be revised by the Contractor prior to and during construction; however, the Contractor must consider the following constraints during development of the construction schedule:

- Phase I activities below the primary erosion control silt fence and Phase II work may not be completed during the "closed" period.
- The site is located in a tidal area and excavation activities near the toe of the Causeway shall not be completed under water.
- On the sideslopes of the Causeway, the area to be excavated in any given day, or tide cycle, shall be no larger than that which can be covered with the lower cover system on the same day, or tide cycle.
- Placement of the vegetative support layer, including vegetative support soil, seed, and erosion control materials, may not be completed until after April 1.

## 2.2 STABILITY EVALUATIONS

An evaluation of the overall stability of the Causeway cover system has been completed, and includes a global stability analysis and an infinite slope (i.e., surficial) stability analysis under static loading conditions. The analyses are somewhat related with duplication and cross-referencing, due to similarities.

The primary means of assessing the ability of the Causeway to withstand different loading conditions is the determination of a FS. The FS is the ratio of the ability of the Causeway to resist an imposed load divided by the imposed load. Consequently, a FS greater than 1.0 indicates that the Causeway should be "stable" (stable = not experience unacceptable consequences due to the imposed loading condition) and a FS less than 1.0 indicates that the Causeway would be expected to "fail" (fail = unacceptable movement would occur, requiring repairs to the impacted portion of the cover system). Acceptable FS's are applied to different loading conditions based on the consequences/probability of such a failure; as well as the accuracy with which the situation can be modeled. Guidance is provided by regulatory authorities on acceptable minimum FS's for different loading/failure modes. Appendix D presents a technical memorandum summarizing the results of the geotechnical evaluations, including the stability evaluations.

In general, the analyses performed evaluated the following potential scenarios:

- Global Stability: The potential for a catastrophic failure through the Causeway fill materials, where fill material could be exposed to the environment after the cover system is installed.

- Cover Soil (Surficial) Stability: The potential for soils above the cover to slide or slough off, resulting in maintenance issues requiring minor re-grading and re-establishment of turf.

### 2.2.1 Global Stability

Evaluations of the global stability of the Causeway following construction of the cover system have been completed. The analyses performed are outlined below, and are included in Appendix D, Attachment A.

- Visual inspection of the preliminary final grading plan cross sections was completed to determine the most critical cross section. This cross section was identified as station 4+50, the section which would receive the largest amount of added fill material during cover system construction.

- Representative profiles were generated for two configurations, and drawn at true scale (i.e., no vertical exaggeration). The first configuration included matching the cover system to the existing Causeway toe and re-grading the entire Causeway (i.e., encroaching). The second configuration included maintaining existing grades below the 4.1 feet msl elevation and re-grading only above this elevation (i.e., non-encroaching).

- Soil properties and subsurface geometry were assigned based on the results of geotechnical investigations and literature information regarding the proposed cover materials. Two types of cover systems were evaluated for each configuration, a 1.5-foot thick cover system and a 2-foot thick rip rap cover system.

- Harding ESE used a computer program, SLOPE/W, to identify critical failure surfaces for global stability analyses. The representative geometry was input into the program and checked manually for accuracy. The model was run using limit equilibrium analysis with Bishop's Method of Slices. Static analyses only were conducted.

- Following analysis of the base conditions, variations in the input assumptions were evaluated, including failure along the top of the sand layer, the presence of tension cracks, reduced soil shear strengths, variations in fill properties, and low-tide conditions.

- The results indicate that the configuration with the lowest FS was the non-encroaching rip rap cover system with tension cracks. The associated FS was 1.48, above the necessary 1.3, immediately following construction; however, long-term stability typically is required to achieve a minimum factor of safety greater than 1.5. Because the lowest calculated FS for the Causeway scenarios is 1.48, a minor gain in strength would result in the required FS. A strength gain evaluation was not performed for the Causeway, because only a minor increase is required to achieve a FS of 1.5. In addition, the combination of high quality extensive field investigation and conservative assumptions incorporated in the evaluations, support use of a lower than typical minimum required FS.

- A seismic stability evaluation was not completed for the Causeway. A seismic event could result in damage to the proposed cover system and possible exposure of Causeway fill. Such an event would require repair/maintenance of any resulting damage; however, it is believed a seismic evaluation is not necessary. Flooding has occurred frequently over the life of the Causeway and expected to continue. The Causeway currently experiences sporadic flooding/inundation periods, when fill materials are exposed to water and there is a potential for contaminant leaching. As a result, soil from six excavations areas (where chemical sampling has shown unacceptable leaching potential) is being removed prior to cover system construction. The Causeway is not considered to be a critical structure, is not a landfill, and is proposed to have a permeable cover system. Damage to the Causeway cover system from a seismic event would not result in chemical exposures that would be uncontrolled until repair of the cover system.

- The structural stability of the Causeway under the 100-year flood event was not considered as part of the global stability evaluations performed. During the 100-year flood (El. 10.11), the Causeway will be nearly completely submerged. A more common occurrence at the Causeway, would be a hurricane when the water elevation would possibly reach El. 13.28. During these conditions, currents would be in the range of 1.5 knots, considering the width of the waterway at these flood elevations. The most structurally demanding situation would potentially occur when the tide is approaching high and large waves were pounding the cover system of the Causeway. Stability of the cover system under this extreme scenario is addressed in the revetment design (Section 2.5.6).

- The results of the analysis performed using the SLOPE/W model were checked using a manual method for a specified slip surface. Results of the manual check were within 8% of the SLOPE/W results.

Recommendations for cover system construction, based on the results of the global stability analysis, are included in Appendix D. Global stability calculations are included in Attachment A to Appendix D.

### 2.2.2 Cover Soil Stability

An infinite slope analysis of the top soil layer of the cover system was performed. Calculations are presented in Appendix D, Attachment A. The analysis included manual calculation of the maximum allowable slope given the estimated internal friction angle of the cover soil. The results of the analysis are as follows:

- The maximum side slopes of 3 horizontal to 1 vertical (3H:1V) were found to have an adequate FS of 1.8 under the conditions evaluated.

- The maximum allowable slope, given the estimated internal friction angle of the cover soil and the required end of construction FS of 1.3 is approximately 2H:1V and the long-term FS of 1.5 is approximately 2.3H:1V. The maximum slope used in this design is 3H:1V, which is flatter than that which would provide a FS of 1.5.

## 2.3 SETTLEMENT EVALUATION

A settlement analysis was performed to estimate the magnitude of settlement that may be expected to occur due to construction of the proposed cover system on the Causeway. Three types of settlement were calculated, including elastic deformation (not significant and therefore not included in the final results), primary consolidation settlement, and secondary consolidation settlement. The estimates for each were based on the results of laboratory testing on undisturbed samples of organic sediment collected during the geotechnical investigations. Testing results were used to estimate consolidation characteristics for the organic soils underlying the Causeway.

Results of the analysis performed (refer to Appendix D) are as follows:

- The Causeway should be expected to settle approximately 7 inches within the first year, following construction.
- The Causeway should be expected to continue to settle at a decreasing rate and may settle an additional 1 to 5 inches over the ensuing 50 years.

Recommendations for cover system construction, based on the results of the settlement analysis, are included in Appendix D. Settlement calculations are included as Attachment B to Appendix D.

## 2.4 GEOTECHNICAL EVALUATION CONSIDERATIONS

Based on the geotechnical analyses performed and the date gathered, the proposed final grades of the Causeway cover system provide for a condition following construction with an acceptable FS, with respect to movement. Long-term stability is expected to increase over time, as the underlying soils are consolidated and gain strength. The grades are expected to be adequate to maintain positive drainage after Causeway fill materials settle due to increased loading from the cover system. The provided design drawings, identify subgrade elevations and the thicknesses of the cover system.

## 2.5 GENERAL DESIGN CONSIDERATIONS

Causeway cover system construction will be divided into two phases, Phase I and Phase II. The elements of each phase are discussed in Subsections 2.6 and 2.7, respectively. This subsection presents general considerations regarding design of the cover system, and presents detailed information regarding two components of the design critical to both phases, heave monitoring, and erosion and sediment control measures.

During construction activities, personnel and construction equipment leaving the Causeway will be require decontamination to prevent the spread of contamination onto other portions of the SAEP facility and public areas. Equipment decontamination will be conducted in a designated decontamination area determined by the Contractor and accepted by the Contracting Officer. Vehicles and personnel leaving the Causeway, and other on-facility work areas (i.e., Building 5) will be decontaminated, as necessary, to reduce the potential for contaminating other portions of the facility or public areas. Water used during decontamination procedures that contains surfactants will be segregated from surfactant-free water, so that the surfactant-free water may be discharged to the Chemical Waste Treatment Plant (CWTP) sump at Building 63. No water containing surfactants shall be discharged to the Building 63 sump, unless directly authorized by the Contracting Officer.

Equipment operation and activities or processes performed by the Contractor in accomplishing the specified construction will be conducted in accordance with Federal and State emission and performance laws and standards. The Contractor will include an evaluation of the potential for impact to off-site receptors in the Environment Protection Plan.

The following site constraints will apply during removal action activities:

- Phase I work below the primary erosion control silt curtain and all Phase II work on the Causeway may not be completed during the "closed" period (see Subsection 2.1.1).
- Portions of the SAEP facility are off-limits to Contractor access, as indicated on the Drawings.
- Access to the Causeway is limited to a gate, approximately 20 feet wide at the origination of the Causeway from the main portion of the facility.
- The average length of the Causeway is 800 feet, the average width is approximately 200 feet at low tide and 80 feet at high tide.
- The site is located in a tidal area and excavation activities near the toe of the Causeway can not be completed under water. As a result, excavation activities in the tidal zone can only be completed for 4 to 5 hours each day.
- The area to be excavated on the Causeway sideslopes in any given day, or tide cycle, will be no larger than that which can be covered with the lower cover system on the same day, or tide cycle.
- Removal of oversized debris must be completed prior to installation of any cover system materials.

### 2.5.1 Heave Monitoring

Heave platforms and poles will be used as part of construction activities to monitor for movement of the Causeway during construction activities. Five platforms and five stationary poles will be installed as part of the Phase I work, to measure baseline conditions and to allow settlement of the platforms and poles into the surface of the mudflats (expected to be a few inches) prior to commencement of Phase II activities. In addition, temporary heave poles will be used to intensively monitor tidal sediment elevations in areas near where work is being completed.

The primary purpose of heave monitoring is to provide a means of monitoring the effect fill and cover system placement have on the underlying soft organic sediments. Two factors could result in unacceptable heave (defined later), 1) fill material being added too quickly and 2) the weight of the fill and equipment is too great to be supported by the soft organic sediments. Rapid fill placement could result in heaves due to buildup of excess porewater pressures resulting in either a mud wave or a bearing capacity type failure. Should underlying sediments become over-loaded due to the added weight of fill or cover materials, equipment, or stockpiled materials, a rotational failure could occur (but is considered unlikely). The Causeway will move during construction and the mud flats will heave; however, excessive movement should be taken as an indication that procedures need to be modified. Heave of any of the platforms or poles in the 3- to 6-inch range, or horizontal movement in a similar range should be cause for concern. The Contractor should stop work and the Engineer should be notified. All site personnel should be highly aware of this concern and make conscious efforts to keep an eye on the perimeter for both signs of heave and cracking within the fill; a monitoring and reporting program is outlined later in this section.

The pre-design geotechnical investigation was performed using widely spaced borings, which demonstrated some of the variability of both the Causeway fills and native sediments. The evaluations performed, indicate that the Causeway is expected to be stable following construction. However, during construction, loading conditions will vary. Limits for this project should be set for height of fill and locations where materials may be stockpiled on the Causeway, as follows: materials (relocated fill and cover materials) should not be stockpiled on the Causeway for over a period of one days' work, should not be stockpiled greater than four to six feet tall, should not be placed all in one area, and should not be placed on the sideslopes (i.e., outside the limits of the primary silt fence, as indicated on the Drawings).

The heave platforms and poles are required to provide a means to monitor the movement of the Causeway as cover materials are placed. Typically, settlement platforms are installed in the area of construction to monitor the downward movement associated with fill placement; however due to the cramped construction site and the increased potential for damage to such devices, heave platforms are more desirable. Five heave platforms and five stationary poles will be installed around the perimeter of the Causeway in the mud flats, at the approximate locations shown on the Drawings in Appendix B. The platforms will be situated at a distance of approximately 40 feet outward from the contact between fill/riverine sediments on the north side of the Causeway and 30 outward feet from the contact between fill/riverine sediments on the south side of the Causeway. These offsets are based on the results of the stability evaluations performed for the Causeway, and represent regions where a potential for heave exists. The five stationary heave poles will be placed inside the five heave platforms, at an approximate distance of 15 feet outward from the contact between fill/riverine sediments on the north side of the Causeway, and 10 feet outward from the contact between fill/riverine sediments on the south side of the Causeway.

The temporary heave poles will be placed during Phase II work, at the same distance from the Causeway as the stationary heave poles. Temporary poles will be placed at 50-foot intervals parallel to the contact between the fill/riverine sediments. They shall be placed up to 100 feet from the edge of an active excavation area, a minimum of 24 hours prior to work being conducted in that area. The temporary poles will be intensively monitored for a minimum of 24 hours before the initiation of work until 24 hours after completion of work in a particular area. A temporary heave pole may not be removed until 24 hours following the completion of work in any area within 100 feet of the pole.

The platforms are to be constructed using 2-layers of pressure-treated plywood, with a 2-inch galvanized steel pipe. The plywood should be placed on the surface of the mud with the pipe oriented vertically. Ballast (i.e., concrete blocks) will be required to keep the platform in place during high tide events. A detail of the platforms is provided on Drawing C-301 in Appendix B, Attachment A. The heave poles will consist of a 2-inch by 4-inch piece of pressure-treated lumber.

During Phase I: The platforms and stationary poles will be fitted with a target (as required by the surveyor to monitor their movement) at the top of the pipe. At installation, the pipe will be installed in a vertical orientation. Each pole/target will be surveyed for its northing and easting (N and E) to a minimum accuracy of +/- 0.1 foot. Each platform and pole will be monitored for elevation to a minimum accuracy of +/- 0.01 foot on a weekly basis during Phase I activities. This monitoring will be used to establish a baseline for more intensive monitoring that will be performed as part of Phase II. The platforms and poles will be removed following the completion of construction of the cover system, following Phase II. Phase I data will be reported by the Contractor, consisting of both hard copy report and an electronic file, distributed via e-mail, containing the date and reduced survey results along with a plot of movement over time.

During Phase II: Within one to two weeks prior to the initiation of earth moving activities on the Causeway, the Phase II monitoring will begin. Initial monitoring for Phase II will consist of re-surveying the northing and easting of the heave platforms and stationary heave poles to a minimum accuracy of +/- 0.1 foot. Elevation will be surveyed to a minimum accuracy of +/-0.01 foot. Regular monitoring during Phase II will be performed to a minimum accuracy of +/- 0.01 foot for elevation and +/- 0.1 foot for northing and easting. All platforms and stationary poles will be monitored at least twice a week during Phase II activities, except within 100 feet of an active work area, when intensive monitoring will be required.

Intensive monitoring of individual platforms, stationary poles, and temporary poles will be performed where active work (excavation, filling and stockpiling) is being performed between the centerline of the Causeway and the platform/pole at a 100-foot distance parallel to the centerline. Intensive monitoring will be performed three times a day (prior to the start of work, at mid-day, and at the end of the work day). The intensive monitoring will be reviewed continuously by the Contractor to assess both trends and any large changes in the locations of the platforms or poles. This intensive monitoring will be made available to the Contracting Officer's representative on a continuous basis. Reporting will be on a weekly basis, and will continue for the duration of Phase II and for two additional weeks following the completion of work. Reporting will consist of Phase I and II data, and be provided in both hard and electronic file, distributed via e-mail containing the date and reduced survey results along with a plot of movement over time.

### 2.5.2 Sediment and Erosion Control

#### 2.5.2.1 Permits

In accordance with the requirements of the State of Connecticut, ***Stormwater and Dewatering Wastewaters from Construction Activities:*** A general permit applies to all discharges of stormwater and de-watering wastewaters from construction activities which include, but are not limited to, clearing, grading, and excavation and which result in the disturbance of *five or more acres* of total land area on a site. The area of the Causeway, as defined by the floating silt curtain shown on the drawings, but not included in the design (not just the limit of work), measures approximately 3.9 acres, therefore no permit is required. The sediment and erosion control for the work will incorporate best management practices.

2.5.2.2 Housatonic River Sediment Control

The lower reaches of the Housatonic River, where construction work is to be conducted, includes areas of shellfish and finfish resources. According to CTDEP information, the Causeway is in close proximity to oyster seedbeds. The CTDEP does not allow what it considers to be unconfined excavation or filling work in the lower reaches of the Housatonic during certain times in order to protect shellfish and finfish resources. The relevant "closed" period for unconfined dredging is from April 1 through September 30. (April 1 to June 30 for finfish and June 1 to September 30 for shellfish). Phase I and II activities below the elevation of the primary erosion control fence may not be performed during this “closed” period. Work above the primary erosion control fence is believed to be acceptable at any time under the CTDEP requirements, and requires that best management practices be followed during all site work.

The options available for sediment control within the river are a partially penetrating curtain, fully penetrating permeable curtain, or an impermeable structure. The following provides an evaluation of the pros and cons of each alternative. Based upon comments from the CTDEP Office of Long Island Sound Programs (OLISP), sediment control within the river is not necessary if activities below the primary erosion control fence are conducted outside of the “closed” period. Therefore, sediment control measures within the river will not be implemented during this work. **The following four paragraphs no longer apply to this design, but have been retained for completeness.**

> Partially Penetrating Siltation Curtain: A partially penetrating siltation curtain floats on the surface and extends into the water a finite distance. The theory for operation, as demonstrated through performance, is that sediments tend to float near the surface until encountering the curtain at which time they stop migrating and settle out. In highly tidal areas, such as the Causeway, water needs to be allowed to flow in and out from behind the sediment curtain. This is particularly true where the area to be protected is a mud flat, where water is not present at low tide and a flow path needs to be maintained (unless a water tight structure is used). The effectiveness of the partially penetrating siltation curtain is considered the best available method for limiting the spread of sediments potentially resulting from Causeway construction activities.
>
> Fully Penetrating Siltation Curtain: Fully penetrating siltation curtains are made with an open structured geotextile, typically similar to a silt fence. Fully penetrating curtains work by filtering sediments that are suspended in the water as a result of disturbance. For this particular project, the turbidity of the river is considered to be great enough to clog these materials even without additional sediment load resulting from site excavation work. These types of materials will also, according to manufacturers, experience clogging due to marine organisms when exposed for more than a week or two. As they clog, removal and replacement of these silt curtains would be expected to generate additional suspended sediments. Also, as the tide drops, sediment-loaded water would likely overtop such a curtain and migrate a greater distance from the site. Housatonic River currents could destroy a fully penetrating barrier. Due to the size of the Causeway project, work cells would be required. The materials would require periodic cleaning, with limited life cycles due to damage incurred from washing of the materials to remove growth and sediment. In

addition to the technical reasons why this approach is not feasible, these types of materials are considerably more expensive.

Impermeable Structure: Impermeable structures include sheet piles, water bladders, temporary dams and earthen berms. Each of these types of structures would result in sediment release either during installation (i.e., earthen berm) or upon removal (i.e., pulling of sheet pile, lifting of water bladder shell that has sunk into the mud, or removal of settled supports and liners for temporary dams). These structures do, however provide true containment for sediment control. The costs for such structures would be considered prohibitive and inflate the cost of the remediation significantly with little overall benefit.

The floating siltation curtain does not provide sufficient confinement. Thus, the choice is either to use 28-inch tall floating siltation curtain with upland erosion controls and not initiate work until after September 30, or develop a method to separate the area being worked from direct, open hydrologic connection with the river. The concept of using a top-to-bottom silt curtain to create a work cell installed prior to initiation of work on a segment of the polymeric marine mattresses and moved after completion of each segment may satisfy concerns. However, it is uncertain if the manufacturer will endorse such use and if there is reasonable expectation that the silt curtain will withstand the anticipated site conditions.

#### 2.5.2.3 Phase I Activities

Phase I activities will produce a potential for sediment release to the environment and consequently require sediment and erosion control measures be included as part of the design. The Causeway site will be divided into two sections, as follows: 1) areas above approximate elevation 6 and 2) areas between elevation 6 and the limit of work (the toe of the Causeway). These sections have been established, because the site is dominated by tidal fluctuations that typically range up to elevation 4.1, resulting in two greatly differing environments.

In areas above elevation 6, as indicated on the Drawings, the area will be surrounded by a primary silt fence and jute matting will be applied as necessary. The silt fence will be installed at the beginning of the Phase I work and maintained throughout the duration of the work (and any interim period until the commencement of Phase II work). The silt fence will only be temporarily removed to allow access to lower areas of the site, with replacement/re-establishment to be performed as necessary (approved daily). The silt fence may require periodic replacement due to exposure to the saltwater.

In areas below silt fencing placement, in the inter-tidal zone, work activities will not be conducted within the "closed" period. This includes Causeway weather station removal and removal of oversized debris below the primary silt fence. Work will not be performed under standing water.

#### 2.5.2.4 Phase II Activities

Phase II activities will incorporate the same best management practice sediment and erosion control measures applied during Phase I. Work activities to be performed during Phase II will include the excavation of fill materials from the side slopes of the Causeway below elevation 4.1, to meet CTDEP requirements that the Causeway not encroach below this level. This excavation activity, and subsequent lower cover system construction, will pose a potential for sediment release; consequently, these activities will be performed outside of the "closed" period. Work activities will not be performed under water. Excavation for the toe of the lower cover system will create an excavation that is below existing grade, resulting in a bathtub effect. Excavation in this area may still be conducted, despite the area being below water, since the sidewalls will provide containment during active excavation.

## 2.6 PHASE I DESIGN ELEMENTS

Phase I will consist of mobilization and site preparation activities, installation of erosion and sediment control measures, building demolition, oversized debris removal, contaminated soil excavation, off-site transportation and disposal of waste materials, and topographic survey completion. This subsection details the Phase I design elements.

Prior to initiation of Phase I field activities, the Contractor will be required to prepare pre-construction documents, including, but not limited to, Work Plans, a Site Safety and Health Plan (SSHP), and an Environment Protection Plan. A Pre-construction Meeting will be conducted to review the plans and the construction schedule.

### 2.6.1 Mobilization and Site Preparation

Mobilization of Contractor personnel and equipment will be completed during Phase I work. Site preparation activities for Causeway cover system construction will include the following:

- Contractor site office establishment
- Decontamination and stockpile area construction
- Placement and initial monitoring of heave platforms and stationary heave poles (see Subsection 2.5.1)
- Monitoring well abandonment
- Clearing and grubbing

### 2.6.2 Erosion and Sediment Control

Temporary erosion and sediment control measures will be installed during Phase I construction activities to reduce the amount of sediment leaving the site. These measures will include installation of primary silt fencing, jute matting, and staked hay bales, as necessary. Following completion of Phase II construction activities, all disturbed areas, as appropriate, will be re-vegetated with a suitable grass cover and erosion control materials.

### 2.6.3 Building Demolition

Demolition of Building 5, Building 59, the Causeway weather station, and surface features near Building 34 will be completed as part of Phase I work. Activities will include:

- Building 5 demolition to existing grade, including existing utility disconnection and asbestos removal, to improve access to the Causeway.
- Building 59 demolition, including existing utility disconnection and foundation removal within 2 feet of existing grade.
- Weather station demolition, including existing utility removal and foundation removal within 2 feet of existing grade.
- Removal of the containment berm around the Building 34 former aboveground storage tank (AST) farm and removal of associated protective posts and tank supports to existing ground surface, followed by paving of the former AST area to improve access to the Causeway.
- Cleaning demolition debris, as necessary, to remove Causeway soil prior to transport to on-site stockpile areas. Cleaning will be conducted above the primary erosion control silt fence.
- Re-sizing of demolition material, as necessary, for ease in off-site transport.
- Characterization sampling and analysis for off-site disposal at the approved disposal facility.
- Removal, characterization, and off-site disposal of soil containing visual or olfactory contamination identified during building demolition, as directed by the Contracting Officer.

### 2.6.4 Removal of Oversized Debris

Surface debris larger than 2 feet in any dimension will be removed from the Causeway as Part of Phase I work to facilitate future grading of the Causeway surface (in Phase II). Phase I activities will include removal of materials from the surface of the Causeway, and documentation of additional subsurface debris encountered during surface debris removal. Removal of identified subsurface debris will occur as part of Phase II work.

Debris volume estimates, based on visual observation of the amount of debris on the Causeway surface, were made as part of Phase I design efforts. An estimated quantity of 3,800 cubic yards of in-place materials was identified for removal during Phase I. As for demolition debris, cleaning of the oversized debris will be conducted to remove Causeway soil prior to transport to on-site stockpile areas. Cleaning will be conducted above the primary erosion control silt fence. Re-sizing of the debris will be conducted, as necessary, for ease in off-site transport. Characterization sampling will be conducted as required by the accepting disposal facility.

### 2.6.5 Excavation of Contaminated Soil

As part of Phase I activities, soil containing VOCs, SVOCs, vanadium, or zinc in excess of the CTDEP RSRs Pollutant Mobility Criteria, ten times the Groundwater Protection Criteria, ten times the federal AWQC, or containing more than 1 part per million (ppm) of PCBs, will be excavated and transported to on-site storage areas for characterization.

An estimated 82 cubic yards of soil are to be excavated from ten distinct areas, identified as Excavation Areas 1 through 10 (i.e., EA-1 through EA-10) on the Existing Conditions Drawing. Appendix F presents the calculations of soil volumes requiring removal from the Causeway, based on the results of previous Synthetic Precipitate Leaching Procedure (SPLP) sampling and analysis.

Confirmation sampling will be conducted following removal of soil to confirm soil containing contamination above action levels has been removed. Samples will be collected from the sidewalls and base of the excavations, as required by CTDEP RSRs, and analyzed for the target compounds by the Contracting Officer's Representative. The limits of excavation will be established by the Contracting Officer's Representative.

### 2.6.6 Off-site Transportation and Disposal

Demolition debris, oversized debris, and excavated soil will be transported to an appropriately licensed, government approved, off-site disposal facility. For purposes of design cost estimation, it has been assumed that 10% of debris, soil contaminated with VOCs in exceedance of the RSRs, and soil contaminated with PCBs in exceedance of 1 ppm, will require disposal as hazardous waste. The remaining materials will be disposed of as non-hazardous waste. Treatment of the materials, prior to disposal, will be at the discretion of the receiving facility. Necessary transportation documents, including manifests and bills of lading, will be signed by the BRAC Coordinator, or Representative.

## 2.7 PHASE II DESIGN ELEMENTS

Phase II includes heave monitoring (see Subsection 2.5.1), sideslope excavation, oversized debris removal, Causeway grading, lower and upper cover system placement, rip rap transition placement between the two cover systems, vegetative support layer placement, topographic survey completion, demobilization, Environmental Land Use Restriction (ELUR) implementation, and long-term monitoring. This subsection details the tasks to be completed as part of Phase II work.

Prior to initiation of Phase II field activities, the Contractor will be required to modify pre-construction documents, as necessary, including the Work Plan, the SSHP, and the Environment Protection Plan. In addition, a Contractor Quality Control Plan will be required. A second Pre-construction Meeting will be conducted to review the plans and the construction schedule, as necessary.

### 2.7.1 Sideslope Excavation

An approximate one-foot thick layer of soil will be removed from the limit of Causeway fill material (at the toe of the slope) up to the 4.1-foot msl elevation. This soil will be re-located to the area of the Causeway above 4.1 feet msl, to allow for the placement of the lower cover system without modification of the existing elevations below 4.1 feet msl. Satisfactory excavated material will be used as fill material for future grading of the upper Causeway prior to cover construction.

The Contractor should be aware of the following conditions during excavation:

- Be aware of digging through the fill material into the underlying tidal sediments at the toe – may require modifications in design.
- Be aware of digging into weak mud material where there should be fill material – may indicate the presence of significant tension cracks.

Sideslope soil containing gross visual or olfactory contamination will be excavated and transported to on-site stockpile areas for further characterization and off-site disposal. Volume estimates for contaminated soil are based on a percentage of the total material to be removed from the Causeway sideslopes. It is estimated that 2% of the sideslope soil will contain gross contamination and require transport off the Causeway. In addition, oversized debris (greater than 2 feet in any dimension), uncovered during excavation, will be cleaned and transported to on-site stockpile areas (see Subsection 2.7.2).

### 2.7.2 Removal of Oversized Debris

Subsurface oversized debris, identified during removal of surface debris in Phase I, and debris encountered during sideslope excavation will be removed from the Causeway in Phase II to facilitate future grading of the Causeway surface.

For purposes of cost estimating, it has been estimated that 100 cubic yards of debris will be removed from the Causeway sideslopes and an estimated 200 cubic yards of debris will be removed from the upper portions of the Causeway during this construction phase. However, the actual volumes could vary significantly from these estimates, because the debris to be removed in Phase II is currently buried; therefore, visual identification cannot be completed. As for debris removed during Phase I, cleaning of the debris will be conducted to remove Causeway soil prior to transport to on-site stockpile areas. Cleaning will be conducted above the primary erosion control silt fence. Re-sizing of the debris will be conducted, as necessary, for ease in off-site transport. Characterization sampling will be conducted, as required by the accepting disposal facility.

### 2.7.3 Causeway Grading

Following material excavation, the Causeway will be graded into two distinct slope categories. Above elevation 4.1 feet, the Causeway subgrade will be graded at a maximum 3H:1V slope up to elevation 7 feet msl. Above 7 feet msl, the Causeway subgrade will be graded at a minimum 2% and maximum 5% slope to elevation 9.5 feet msl. Elevation 9.5 feet msl will be the top of the Causeway subgrade, no subgrade filling above elevation 9.5 will be allowed. Only subgrade fill elevations have been provided on the design drawings, since settlement will likely occur during cover placement. The subgrade will be rough graded to be as smooth and to grade as practicable. The presence of debris within the fill will result in an uneven surface that will be limited to a tolerance of +/-2-inches from the subgrade elevations shown on the drawings.

### 2.7.4 Off-site Transportation and Disposal

Oversized material, visually or olfactory contaminated material, and, as necessary, excess material excavated from the Causeway and not used during the grading process, will be transported off-site for disposal at an appropriately licensed, Government approved, disposal facility. During cover system design, an effort was made to balance cut and fill quantities and limit the volume of material requiring off-site disposal. In a similar manner, the design has been developed and the Contractor will be required to perform such that the minimum volume of excess material or fill material from off-site borrow sources is required.

### 2.7.5 Causeway Cover System

The cover system components selected during the design process were based on the following general requirements:

- Material durability under site conditions (i.e., salt water, wave conditions, periodic submersion, ice attack, and differential movement).
- Provide an acceptable FS with respect to structural stability.
- Provide an inaccessible structure to reduce the risk of direct contact with site fill materials.

The construction of the cover system is to be at the specified thicknesses. The project Drawings provide the subgrade development elevations; no final grades are provided. This is due to the fact that the cover systems will cause in an increase in loading on the Causeway which will likely result in settlement and movement of the Causeway. Since more weight added to the Causeway will result in more settlement and decreasing FSs with respect to stability, only the required thickness of cover soils will be placed and used in verifying quantities for pay items. A final site survey should be performed to document the surface elevation of the final cover.

The following subsections discuss the engineering evaluations conducted as part of the cover system design, and present the proposed lower and upper cover system components.

#### 2.7.5.1 Engineering Evaluations

**Durability of Cover Systems.** The materials used in the cover system have been selected and engineered to withstand the conditions that they are to be exposed to. The following provides a brief description of the durability issues addressed.

Salt Water. The materials used in the cover systems will be exposed to salt water. The Causeway is in a tidal flat area. The lower cover system extends approximately throughout the intertidal zone (mean low low water (MLLW) at elevation –2.72 ft msl to mean high high water (MHHW) at elevation 4.29 ft msl). The lower cover system is exposed to daily tidal cycles and the upper cover system (above MHHW) is subjected to periodic exposure to salt water due to wave run-up and overtopping, spray, and periodic flooding of the river. The lower cover system consists of geosynthetics and natural rock (non-carbonate), which are considered to be relatively non-susceptible to degradation when exposed to salt water in a marine environment. The upper portion of the Causeway contains two elements whose selection/design were based on their inherent susceptibility to salt water induced degradation, concrete and grass. The concrete to be used has been specifically developed by a manufacturer of concrete masonry units, that uses different casting methods and materials than those used for ready-mix concrete, so minimal research in the area of salt resistance is available. The selected mix has high strength, demonstrated frost resistance, and is expected to have a high resistance to salt water. Refer to Attachment D of Appendix C for information supplied by a manufacturer. The grass to be used has been selected for use at the site, based on a site visit, and is believed to represent the species best suited for the site conditions. Refer to Attachment E of Appendix C.

Waves. A wave analysis has been performed and is attached as Appendix E. The revetment design wave height is $1.27H_s$=3.87' (1.27 x significant wave height). This is the U.S. Army Corps of Engineers' recommendation for irregular wave conditions on revetments of dumped rip rap. The range of water depths used in the wave analysis corresponds to the intertidal zone ( MLLW to MHHW). The lower cover system has been designed by a manufacturer (Tensar, Corp.) to withstand this wave height. An interlocking block (Tri-Lock ®) is generally considered appropriate for use where up to 4 foot waves are expected, based on information provided by the manufacturer, refer to Attachment D of Appendix C. However, the interlocking blocks are not required for wave resistance, since they are located on the upper flat portion of the Causeway and beyond direct pounding of waves (although they are considered suitable for the design wave). The rip rap transition is the interface between the upper and lower cover systems. In order to prevent buoyant uplift of the upper cover system, it has been designed and detailed to efficiently shed water caused by wave run-up overtopping. The rip rap apron's underlying materials have been graded to allow any water under the interlocking concrete blocks to backflow unimpeded towards the revetment. The toe of the mattress, when placed directly on the mudline is considered by Tensar Corp. to be 'self-seating'. In other words, the wave action will gradually seat the mattress toe into the mudline, thereby eliminating significant excavation and rock-filling normally associated with rip rap revetments.

Submersion. The '100-year Frequency Tidal Flood' is at elevation 10.11 ft msl (reference 13, Appendix E). The top of the Causeway cover system is not expected to exceed elevation 11.5, making the Causeway not completely submerged during the 100-year event. In fact, it is more likely that the Causeway would be exposed to a Hurricane tidal flood, at elevation 13.28. ft msl The tidal flood will generate buoyant and current induced forces on the cover system. The buoyant force will have little or no effect on the highly permeable, polymeric marine mattresses. Local and global stability of the polymeric marine mattress is governed by the wave-action induced forces generated through the different intertidal water levels. The upper cover system will be underlain by a permeable system of sand and gravel, lessening the possibility of trapped air causing buoyant uplift. The flows in the river under flood conditions is expected to be approximately 2.0 ft/sec and has been considered in erosion control mat selection.

Ice Attack. The ability of the polymeric marine mattresses to withstand ice forces is necessary due to ice flows in the Housatonic River. Two major exposure conditions are considered to likely exist at the Causeway: 1) abrasion and 2) shear of the polymeric shell. A manufacturer has performed modified abrasion testing (modified L. A. Abrasion Test) to assess reductions in tensile strength of the polymeric shell. Refer to Attachment F of Appendix C. The testing indicated when exposed to 50 cycles of abrasion of the materials by ice, no significant reduction in ultimate strength was observed. To address the condition of ice against the mattress, a manufacturer performed an evaluation of the materials with a specific grid and stone size. Refer to Attachment F of Appendix C. The assessment assumed 6-inch-thick and a 3.7-foot wave height, and evaluated shearing of the grid, pressure against the grid, and the previously discussed abrasion. Based on these evaluations and assumptions, the materials specified are expected to be suitable for the intended use. These evaluations and testing were performed on one manufacturer's material and would need to be performed on another manufacturer's materials prior to approval for use on the project, and subject to acceptance.

Differential Settlement. Due to the varied nature of the Causeway fill and likely variations in the underlying organic sediments, added loading due to cover construction is expected to result in some differential settlement. Quantification of this is impractical; however, the magnitudes are not expected to be excessive. For this reason, a flexible cover system is required. The upper cover system of interlocking blocks is capable of distorting to a radius of 3 feet and can be exposed to moderate strains due to the gravel-filled voids between the blocks. The polymeric marine mattresses are a very flexible structure and is specifically designed to accommodate differential settlement.

**Structural Stability.** The stability of the cover system consists of several potential failure modes, including: global and cover stability described in Subsection 2.2; toe stability; sliding; and anchor requirements. The polymeric marine mattress, applied in similar situations, is typically installed by directly placing the mattress on the soils at the toe. The mattress settles into the soils and has what is considered to be a "self-sealing" toe. Toe stability for the polymeric marine mattress is typically provided by laying the mattress directly on grade and allowing the toe to settle, hence "self-sealing". At this site, the requirement of the cover system to not encroach below elevation 4.1 feet msl is considered critical. The mattresses will be buried, such that there surface approximates the existing grade below elevation 4.1. To enhance toe stability around the end of the Causeway, near the channel and in the area where waves are most likely, additional rock fill will be placed beneath the mattress. Refer to Attachment F of Appendix C for supporting information and calculations.

**Inaccessible Structure.**

Per Section 22a-133k-2 (b)(3) of the CTDEP RSRs:

> "The direct exposure criteria for substances other than PCB do not apply to inaccessible soil at a release area provided that if such inaccessible soil is less than 15 feet below ground surface an environmental land use restriction is in effect with respect to subject parcel or to the portion of such parcel containing such release area, which environmental land use restriction ensures that such soils will not be exposed as a result of excavation, demolition or other activities and that any pavement which is necessary to render such soil inaccessible is maintained in good condition unless and until such restriction is released in accordance with section 22a-133q-1…"

Per Section 22a-133k-1 (a)(28) of the CTDEP RSRs:

> "'Inaccessible soil' means polluted soil which is: (A) more than four feet below the ground surface; (B) more than two feet below a paved surface comprised of a minimum of three inches of bituminous concrete or concrete, which two feet may include the depth of any material used as sub-base for the pavement; or (C)(i) beneath an existing building or (ii) beneath another existing permanent structure provided written notice that such structure will be used to prevent human contact with such soil has been provided to the Commissioner."

The proposed cover for the Causeway consists of a lower cover system and an upper cover system, as previously described. The upper cover system will be placed over the portion of the Causeway that contains CTDEP RSR DEC exceedances.

In addition, approximately 6 inches of topsoil, seeded with suitable grass cover material will be placed on top of the upper cover system.

The cover thickness has been minimized due to geotechnical constraints associated with the stability and compressibility of the tidal sediments beneath the Causeway fill material. Should additional thickness be added to the Causeway, calculations indicate that a failure would be more likely to occur. Due to the expected differential movement expected, the cover system needs to be flexible, while still rendering the underlying soils inaccessible. The lower cover system will consist of roughly 10-15 tons of rock in each mattress, encased in a high-strength plastic webbing type material. The interlocking concrete blocks in the upper cover system are slightly wider at the top, with the gravel between the blocks acting to lock the blocks in place, making removal extremely difficult. These two types of covers will allow movement as the Causeway settles and are not expected to develop cracks, such as those that would develop if a more rigid type cover system like concrete of asphalt were used.

Therefore, in conjunction with an ELUR, the proposed cover system meets the intent of the CTDEP RSRs as an equivalent "existing permanent structure" to make the Causeway soils inaccessible.

2.7.5.2 Lower Cover System Components

The following provides a description of the materials to be used in the lower cover system and their design requirements, starting with the base of each cover system.

Gravel Bedding: Gravel bedding may be required to provide a uniform and stable base for the placement of the polymeric marine mattresses. The following are some conditions where this material would be required: 1) voids are created due to the removal of oversized materials from the sides of the Causeway, 2) soft pockets of fill material containing high water content would not provide adequate support, and 3) uneven excavation surface in excess of allowable tolerance. This material would be consistent with Connecticut Department of Transportation (CTDOT) No. 8 graded aggregate (Section M.01.01 – Graded Aggregate, page 545), basically a 3/8- to 1/2-inch crushed stone. No laboratory compaction testing or in-place testing will be required due to the uncompactible nature of this crushed stone.

Geogrid Composite: Around the perimeter of the Causeway, the thickness and nature of the fill material is expected to very greatly. Due to this expected variation, the ability of these materials to support the polymeric marine mattresses and Rock Fill Toe, additional support may be required. For the purpose of this design, it is assumed that the geogrid composite will be required to provide support of the Rock Fill and the mattresses over a 10-foot-wide weak zone. It has further been assumed that the soils beneath provide no support, a very conservative assumption. Using basic statics, the grid was assumed to strain 5% and the maximum tensile strength was determined in need to be greater than 1,600 pounds per foot. The grid will be placed in one roll-width (typically 12-feet) around the toe of the Causeway, so only the machine direction is required to provide support. Further the grid should provide an allowable tensile resistance (as defined by GRI GG4) of greater than 1,600 pounds per foot, which accounts for reductions due to installation damage (1.2), durability (1.5) and creep (2.5). The material should be a composite with a woven geotextile to provide additional support on soft sediments. Materials will be suitable for use in a saltwater environment (assumed to be part of the durability reduction factor required previously). Overlap lengths will be in accordance with manufacturers recommendations. Ties (suitable for salt water) will be placed at 1-foot centers at the ends of both the top and bottom of each seam, unless closer spacing is recommended by the manufacturer. Grids will be lain flat and maintained as taught as possible during placement of the rock fill/mattresses, as shown on the Drawings.

Rock Fill Toe. A graded rock fill will be installed at the toe of the Causeway slope, as shown on the drawings, to prevent scour of Causeway fill material from wave action on the marine mattresses. Rock fill material will be similar to the material used to fill the polymeric marine mattresses.

Woven Geotextile. A woven geotextile will be placed between the Rock Fill Toe and the polymeric marine mattresses. The material needs to resist clogging from marine organisms, which has been a problem at other sites with similar conditions. To alleviate the potential for clogging, typical filter criteria are not applied; instead, performance-based design is the approach recommend by mattress manufacturers. Based the recommendation of a manufacturer and engineering judgement, a woven monofilament with an apparent opening size of between a 30 and 50 US standard sieve and a 10 to 12 percent open area has been selected. This geotextile is expected to limit migration of Causeway fill material (i.e., silt and fine sand) from beneath the marine mattresses during wave events. If necessary for stability reasons, the geosynthetic material can be fastened to the underside of the marine mattresses prior to installation, or preferably staked to the surface of the prepared subgrade. Staking the geotextile to the subgrade may allow for tidal waters to contact the subgrade prior to placement of the polymeric marine mattresses in limited areas and increase daily work time.

Rock Fill Transition. A graded rock fill will be installed directly above the 3H:IV slope of the Causeway, as shown on the drawings, to provide drainage for the cover system. Rock fill material will be similar to the material used to fill the polymeric marine mattresses.

Polymeric Marine Mattresses. A one-foot-thick polymeric marine mattresses, constructed of a graded rock fill enclosed in a specialty geogrid, will be used to stabilize the sides of the Causeway. These mattresses will be placed in the excavated areas below the 4.1-foot msl elevation and will continue up at a maximum slope of 3H:1V slope and extend 3 feet up onto the upper portion of the Causeway. The mattresses are not typically tied together, since such ties could damage the geogrid even if minor differential movement occurs.

The structural geogrid used to manufacture the mattresses will be an integrally formed grid structure of a stress resistant copolymer polypropylene material with molecular weight and molecular characteristics which impart: 1) high resistance to loss of load capacity or structural integrity when the geogrid is subjected to mechanical stress in installation; 2) high resistance to deformation when the geogrid is subjected to applied force in use; and, 3) high resistance to loss of load capacity or structural integrity when the geogrid is subjected to long-term environmental stresses.

The approximate dimensions of the baskets are 4.5 feet wide, 30 feet long, and 1 foot deep. Where the length of Causeway slope is greater than 30 feet, the baskets may be tied together to increase the effective length. The rock fill selected for use in the baskets, due to ice and wave loading has been selected to be a well graded stone with a maximum $D_{50}$ of 3 inches with stone size ranging from 2- to 6-inches.

### 2.7.5.3 Upper Cover System Components

The following provides a description of the materials to be used in the upper cover system and the design requirements, starting with the base of the cover system.

Bedding Sand. Directly above the prepared subgrade will be a layer of bedding sand to form a smooth dense layer to support the interlocking concrete blocks. This sand bedding layer will consist of a well-graded sand to minimize the compactive effort required to provide a dense layer that will not move excessively when saturated. The material will be placed in one layer with a minimum thickness of 4 inches and a nominal thickness of 6 inches. Thickness may very based on the roughness of the prepared subgrade. The material will meet all the requirements of CTDOT for fine aggregate (Section M.03.01 2 – FINE AGGREGATE, pp. 552-553). The surface will be prepared by proof rolling with a static roller; no vibratory rollers will be permitted on the site. Due to the thin layer to be installed, density testing will be required using nuclear testing equipment with backscatter methods. Based on moisture-density testing results, materials will be placed at a minimum of 92% of Standard Proctor (ASTM D-698) and be within +/-3% of optimum moisture content at the time of placement. Following receipt of borrow source test results, these density and moisture content requirements may be modified based on the shape of the moisture-density test results. Periodic quality assurance/quality control (QA/QC) testing of the material will be required to assure consistency of materials to be used and the placement methods. In addition, analytical testing of the material for volatile organic compounds and semi-volatile organic compounds will be conducted on the bedding sand, at the rate specified by the Contracting Officer.

Non-Woven Geotextile. A non-woven geotextile will be placed directly above the sand bedding prior to placement of the interlocking concrete blocks. The geotextile is provided to limit damage to the sand bedding during installation of the blocks, provide additional support in the event of differential settlement, and to act as additional protection against contact with the underlying fill materials. The non-woven geotextile should have a minimum weight of 6 ounces per square yard, be spun-bonded, and have an apparent opening size equal to a 70 sieve. The geotextile is overlain by the gravel material, so minimal fines are expected to be available to clog/bind the geotextile, negating direct filter criteria evaluation techniques. However, the overlying vegetative support soils are expected to lose some fines into the gravel, which may migrate to the geotextile over time. With basically two AOS sizes to choose from, 70 and 100, the larger openings were selected because that would allow fines to pass into the underlying sand and reduce the potential for localized clogging of the geotextile below the blocks.

Interlocking Concrete Blocks. Four-inch-thick, interlocking concrete blocks will be placed on the upper portion of the Causeway above the 3H:1V slope. The interlocking blocks will be laid by hand and configured/trimmed to incorporate any surface features required on the Causeway. The concrete to be used in the manufacture of the blocks will be suitable for the intended use and environment (periodic exposure to salt water, frost, differential settlement of the underlying fill, and the presence of root systems). The manufacturer will certify and warrant the materials, for a minimum of 20 years, as well as provide manufacturing quality control test reports and results to document material characteristics. A manufacturer's representative will be required to be on-site to assure that the Contractor is installing the materials in accordance with manufacturer's recommendations and to accept subgrade prior to material placement. Materials delivered to the site will be subjected to both non-destructive and destructive testing as part of QA/QC testing to assure consistency of materials to be used.

Interstitial Gravel. Gravel will be used to lock the interlocking blocks together, preventing access to the underlying fill materials. The gravel used will be a CTDOT Class 114 Bituminous Concrete Mixture (Section M.04.03 – Bituminous Concrete Mixtures AC-20); a graded gravel ranging in size from the No. 200 Sieve to 1-inch. The material has been selected based on the results of a filter analysis conducted for the specified vegetative support soil (see Attachment G of Appendix C). The gravel will be spread over the entire surface of the upper cover system. A maximum 2-inch-thick layer of gravel will be placed over the interlocking blocks, and will be worked into the space between the blocks. The gravel will be compacted to a uniform thickness. Borrow source testing as well as testing of materials delivered to the site will be performed as part of QA/QC testing to assure consistency of materials to be used. No in-place testing of the materials is required.

### 2.7.6 Rip Rap Transition

Between the upper and lower cover system (near the crest of the sideslopes), a rip-rap transition zone will be installed to provide a consistent transition between the upper cover system and the lower cover system. Installation of a two- to three-foot wide band of rip-rap will also limit access to the lower cover system from the upper cover system, and will facilitate drainage from the upper cover system. Rock fill material, the same as used to fill the polymeric marine mattresses will extend beneath the upper and lower cover system to enhance drainage, as shown on the Drawings. The rock fill will be wrapped in the non-woven geotextile used beneath the interlocking blocks, the surface beneath the rip rap will not be wrapped. The rock fill transition will extend beneath the upper cover a distance of two to three feet. The base of the rock fill will be sloped at between 2 and 5% toward the outside of the Causeway to facilitate drainage. Borrow source testing will be required for gradation, but no field testing is warranted.

### 2.7.7 Vegetative Support Layer

The vegetative support layer will consist of vegetative support soil, grass seed, and an erosion control mat. The vegetative support layer is not considered a part of the cover system, for the purpose of limiting exposure to contaminated Causeway fill. The vegetative support soil will consist of a 6- to 8-inch-thick layer of sandy loam with sufficient moisture retention and nutrient characteristics to support vegetative growth of the selected grass. The vegetation to be established on the upper cover system will be a species of grass which is capable of growth under the periodic saltwater inundation which occurs at the Causeway. The grass species selected for use is a mix of Creeping Red Fescue (Festuca rubra), Annual Rye-grass (Lolium multiflorum), Timothy (Phleum pratense), White Clover (Trifolium repens), and Little Bluestem (Schizachyrium scoparius). These grasses were identified as native species during a site visit by New England Environmental, Inc. (see Attachment E of Appendix C), and will provide habitat for wildlife, and moderate pedestrian use.

An erosion control mat will be used to retain the vegetative support soil during precipitation and extreme high tidal events. Borrow source testing as well as testing of materials delivered to the site will be performed as part of QA/QC testing to assure consistency of materials to be used and placement methods. In addition, analytical testing of the material for volatile organic compounds and semi-volatile organic compounds will be conducted on the vegetative support soil, at the rate specified by the Contracting Officer. The grass seed should be provided with a certification of purity and guaranteed germination rate.

A specialist will be required to be on site during initial seed application and soil preparation to monitor the methods used.

### 2.7.8 Topographic Survey and Contractor Demobilization

A topographic survey will be completed following the placement of the vegetative support layer to document the final construction elevation of the Causeway. Demobilization of Contractor personnel and equipment will be completed following the completion of Phase II site work.

### 2.7.9 Implementation of Environmental Land Use Restrictions

Implementation of ELURs will be essential to the long-term permanence of the Causeway cover system. ELURs are not part of the design process, but are considered part of the remedy. ELUR would relate to the following issues:

- Prevention of the penetration of the cover system for any purpose
- Prevention of dredging of the adjacent tidal flats
- Prevention of placement of structures on top of the Causeway, with loads in excess of 1000 pounds per square foot (see Appendix D, Attachment A)
- Long-term monitoring of the cover system

# LIST OF ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| ARARs | Applicable Relevant and Appropriate Requirements |
| AWQC | Ambient Water Quality Criteria |
| BRAC | Base Closure and Realignment |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CTDEP | Connecticut Department of Environmental Protection |
| cy | cubic yard |
| DEC | Direct Exposure Criteria |
| E | easting |
| EE/CA | Engineering Evaluation/Cost Analysis |
| ELUR | Environmental Land Use Restriction |
| FS | factor of safety |
| FW | Foster Wheeler Environmental Corporation |
| Harding ESE | Harding ESE, A MACTEC Company |
| HLA | Harding Lawson Associates (formerly ABB-ES) |
| $H_s$ | significant wave height |
| msl | mean sea level |
| N | northing |
| NCP | National Contingency Plan |
| NCRA | Non-time Critical Removal Action |
| QA/QC | quality assurance/quality control |
| RSRs | Remediation Standard Regulations |
| SAEP | Stratford Army Engine Plant |
| SSHP | Site Safety and Health Plan |
| SPLP | Synthetic Precipitate Leaching Procedure |
| SVOCs | semi-volatile organic compounds |
| USEPA | United States Environmental Protection Agency |
| VOCs | volatile organic compounds |

Foster Wheeler/Harding Lawson Associates (FW/HLA), 2000a. Pre-design Investigation Report Causeway and Dike NCRA, prepared for the U.S. Army Corps of Engineers – New England District. April 14, 2000.

Foster Wheeler/Harding Lawson Associates (FW/HLA), 2000b. Final Engineering Evaluation/Cost Analysis for the Causeway and Dike, Stratford Army Engine Plant. Prepared for the U.S. Army Corps of Engineers – New England District. September 22, 2000.

Harding Lawson Associates (HLA), 2000. Proposal for Technical Support for Design Engineering Activities Stratford, Connecticut. Prepared in Response to Request for Proposal Dated July 13, 2000. July 19, 2000.

Harding ESE, Inc., A MACTEC Company (Harding ESE), 2000. Geotechnical Investigation Summary Causeway Non-time Critical Removal Action Design Stratford Army Engine Plant. Prepared for the U.S. Army Tank-automotive and Armaments Command (TACOM). December 2000.

Harding ESE, Inc., A MACTEC Company (Harding ESE), 2001. Final Causeway Non-time Critical Removal Action Decision Document Stratford Army Engine Plant. Prepared for the U.S. Army Tank-automotive and Armaments Command (TACOM). January 2001.

Stability calculations performed using SLOPE/W software, Version 4.20, developed by GEO-SLOPE International Ltd., Calgary, Alberta, Canada.

# TABLES

# TABLE 2-1
# ACTION-SPECIFIC ARARS, CRITERIA, ADVISORIES, AND GUIDANCE

## CAUSEWAY NON-TIME-CRITICAL REMOVAL ACTION
## DESIGN

## STRATFORD ARMY ENGINE PLANT
## STRATFORD, CONNECTICUT

| MEDIA | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN ARAR |
|---|---|---|---|---|
| <u>AIR</u> | | | | |
| <u>Federal</u> | CAA National Emission Standards for Hazardous Air Pollutants (NESHAP) (40 CFR Part 61, Subpart M) | Relevant and Appropriate | This requirement provides emission standards for specific pollutants for which no ambient air quality standard exists. NESHAPs have been promulgated for specific source types emitting certain pollutants, including asbestos. Subpart M establishes standards for inactive waste disposal sites and disposal of asbestos-containing material from demolition and renovation operations. | Although these standards do not directly apply to the asbestos-containing material in subsurface soil on the Causeway, these standards will be considered during design and implementation of remedial activities. |
| <u>State</u> | Connecticut Department of Environmental Protection (CTDEP) Abatement of Air Pollution (CGS Title 22a, Chapter 446c; RCSA §§ 22a-174-1, <u>et seq.</u>) | Applicable | These regulations require permits to construct and to operate specified types of emission sources and contain emission standards that must be met prior to issuance of a permit. Pollutant abatement controls may be required. Specific standards pertain to fugitive dust (RCSA § 22a-174-18(b)) and control of odors (RCSA § 22a-174-23) | Emission standards for fugitive dust will be met with dust control measures during excavation and transportation of contaminated Causeway fill material to comply with substantive requirements. |
| | Noise Pollution Control Act (CGS § 22a-69; RCSA §§ 22a-69-1 through 69-7.4) | Applicable | These regulations establish allowable noise levels. | Remedial activities will be conducted to comply with these regulations. |

# TABLE 2-1
# ACTION-SPECIFIC ARARS, CRITERIA, ADVISORIES, AND GUIDANCE

## CAUSEWAY NON-TIME-CRITICAL REMOVAL ACTION DESIGN

## STRATFORD ARMY ENGINE PLANT
## STRATFORD, CONNECTICUT

| MEDIA | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN ARAR |
|---|---|---|---|---|
| SURFACE WATER | | | | |
| Federal | Clean Water Act (CWA) National Pollutant Discharge Elimination System (NPDES) (40 CFR Parts 122, 125, 131, and 136) | Applicable | This rule requires permits for the discharge of pollutants from any point source into U.S. waters. | Excavation dewatering fluids will be routed through the on-site Oil Abatement Treatment Plant (OATP) prior to discharge to surface water. Effluent will meet the OATP discharge limitations, monitoring requirements, and best management practices. |
| State | Water Pollution Control Act (CGS §§ 22a-416 through 22a-438; RCSA §§ 22a-430-1 through 22a-430-7) | Applicable | This act requires permits for any discharge of water, substance, or material into the waters of the state. | Excavation dewatering fluids will be routed through the on-site OATP prior to discharge to surface water. This activity will be conducted in accordance with the requirements of this act (e.g., monitoring requirements and discharge limitations). |
| SOIL/WASTE MATERIAL | | | | |
| Federal | RCRA Identification and Listing of Hazardous Waste; Toxicity Characteristic (40 CFR 261.24) | Applicable | This requirement defines those wastes that are subject to regulation as hazardous waste under 40 CFR Parts 124 and 264. | Analytical results will be evaluated against the criteria and definitions of hazardous waste. The criteria and definition of hazardous waste will be referred to and utilized in development of alternatives and during remedial actions. |
| | RCRA Standards Applicable to Generators of Hazardous Waste (40 CFR Part 262) | Applicable | These standards govern storage, labeling, accumulation times, and disposal of hazardous waste. | Any hazardous waste generated during remedial activities will be managed in accordance with these standards. |

# TABLE 2-1
# ACTION-SPECIFIC ARARS, CRITERIA, ADVISORIES, AND GUIDANCE

## CAUSEWAY NON-TIME-CRITICAL REMOVAL ACTION DESIGN

## STRATFORD ARMY ENGINE PLANT
## STRATFORD, CONNECTICUT

| MEDIA | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN ARAR |
|---|---|---|---|---|
| | RCRA Container Storage Requirements (40 CFR Part 264, Subpart I) | Applicable | These requirements apply to owners and operators of facilities that use container storage to store hazardous waste. | If containers are used to store materials that are hazardous wastes, the containers will be managed according to these rules. |
| | RCRA Subtitle C, Subpart G – Closure and Post-Closure (40 CFR 264.110 – 264.120) | Relevant and Appropriate | This regulation details general requirements for closure and post-closure of hazardous waste facilities, including installation of a groundwater monitoring program. | Design and construction of the Causeway cover system will be conducted to minimize the need for further maintenance of the cover system. A monitoring and maintenance program will be implemented to ensure that the cover system remains protective of human health and the environment. |
| <u>State</u> | CTDEP Hazardous Waste Management (CGS §§ 22a-454 and 22a-449(c); RCSA §§ 22a-449(c)-100 through 110 and 22a-449(c)-11) | Relevant and Appropriate | This regulation specifies requirements for the design, operation, and closure of hazardous waste disposal facilities. This regulation incorporates by reference the RCRA requirements for hazardous waste facilities. | Management of any hazardous wastes generated during remedial activities will meet the minimum standards of this regulation. |
| | Guidelines for Soil Erosion and Sediment Control; The Connecticut Council on Soil and Water Conservation | To Be Considered | These guidelines provide technical and administrative guidance for the development, adoption, and implementation of erosion and sediment control program. | These guidelines will be incorporated into the remedial design for the Causeway. Erosion and sediment control measures will be implemented during excavation and cover system construction activities. |

# TABLE 2-1
# ACTION-SPECIFIC ARARS, CRITERIA, ADVISORIES, AND GUIDANCE

## CAUSEWAY NON-TIME-CRITICAL REMOVAL ACTION
## DESIGN

## STRATFORD ARMY ENGINE PLANT
## STRATFORD, CONNECTICUT

| MEDIA | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN ARAR |
|---|---|---|---|---|

Notes:

1. This table may not contain a complete listing of applicable federal and state requirements. The Contractor shall be responsible for identifying all potential Federal and State regulations pertaining to the work conducted under this contract.

ARAR = Applicable or Relevant and Appropriate Requirement
CAA = Clean Air Act
CFR = Code of Federal Regulations
CGS = Connecticut General Statutes
CTDEP = Connecticut Department of Environmental Protection
CWA = Clean Water Act
NESHAP = National Emission Standards for Hazardous Air Pollutants
NPDES = National Pollutant Discharge Elimination System
OATP = Oil Abatement Treatment Plant
RCRA = Resource Conservation and Recovery Act
RCSA = Regulations of Connecticut State Agencies
TSDF = treatment, storage, and disposal facility

# APPENDIX A

## TECHNICAL SPECIFICATIONS

ATTACHMENT A - PHASE I TECHNICAL SPECIFICATIONS
ATTACHMENT B – PHASE II TECHNICAL SPECIFICATIONS

# ATTACHMENT A

# PHASE I TECHNICAL SPECIFICATIONS

# NON-TIME CRITICAL REMOVAL ACTION
# TECHNICAL SPECIFICATIONS
# CAUSEWAY DESIGN

## 100% CAUSEWAY DESIGN
## PHASE I

## STRATFORD ARMY ENGINE PLANT
## STRATFORD, CONNECTICUT

CONTRACT DAAAM-02-97-D-0005
DELIVERY ORDER NO. 0003

*Prepared for:*

U.S. Army Tank-automotive and Armaments Command
Stratford, Connecticut

*Prepared by:*

Harding ESE, Inc.
A MACTEC Company
Portland, Maine

Project No. 50796
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STRATFORD ARMY ENGINE PLANT CAUSEWAY NCRA
PHASE I
STRATFORD, CONNECTICUT

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## DIVISION 1

## DIVISION 2

## DIVISION 13

# STRATFORD ARMY ENGINE PLANT CAUSEWAY NCRA - PHASE I

## BIDDING SCHEDULE

BASE BID ITEMS

| Item No. | Description | Estimated Quantity | Unit | Unit Price | Subtotal |
|---|---|---|---|---|---|
| 0001 | Mobilization | ----- | JOB | LS | $______ |
| 0002 | Site Preparation | ----- | JOB | LS | $______ |
| 0003 | Erosion and Sedimentation Controls | ----- | JOB | LS | $______ |
| 0004 | Clearing and Grubbing | ----- | JOB | LS | $______ |
| 0005 | Building 5 Asbestos-containing Material Removal and Disposal | ----- | JOB | LS | $______ |
| 0006 | Building 5 Demolition | 380 | Tons | $______ | $______ |
| 0007 | Building 59 Demolition | 525 | Tons | $______ | $______ |
| 0008 | Off-site Transport and Disposal (Hazardous Demolition Material) | 100 | Tons | $______ | $______ |
| 0009 | Off-site Transport and Disposal (Non-hazardous Demolition Material) | 900 | Tons | $______ | $______ |
| 0010 | Oversized Debris Removal and Disposal (Hazardous Material) | 800 | Tons | $______ | $______ |
| 0011 | Oversized Debris Removal and Disposal (Non-hazardous Material) | 6,900 | Tons | $______ | $______ |
| 0012 | Contaminated Soil Removal and Disposal (Hazardous Material) | 120 | Tons | $______ | $______ |
| 0013 | Contaminated Soil Removal and Disposal (Non-hazardous Material) | 45 | Tons | $______ | $______ |
| 0014 | Topographic Survey | ----- | JOB | LS | $______ |

# DIVISION 1

# GENERAL REQUIREMENTS

# SECTION 01010

## SUMMARY OF WORK
**12/94**

## PART 1 GENERAL

### 1.1 DESCRIPTION

The general description below is given to indicate the approximate scope of this project only. It does not limit the work required under the project drawings and specifications.

The work in this contract consists of preliminary activities conducted to clear the Stratford Army Engine Plant (SAEP) Causeway and nearby portions of the facility of structures and materials that would impede the construction of an erosion control cover system, consistent with the Non-time Critical Removal Action (NCRA) Decision Document (Harding ESE, 2001). Activities to be conducted as part of this work include, but are not limited to:

A. Abandonment of designated existing monitoring well.

B. Installation and maintenance of erosion and sedimentation control measures.

C. Clearing of trees and brush from the Causeway.

D. Installation and baseline monitoring of five heave platforms and five stationary heave poles.

E. Removal of the containment berm around the Building 34 former aboveground storage tank (AST) farm and removal of associated protective posts and tank supports to existing ground surface, followed by paving of the former AST area to improve access to the Causeway.

F. Demolition and off-site disposal of Building 5, including existing utility disconnection, to improve access to the Causeway.

G. Excavation and off-site disposal of soil in ten locations that contains contamination in exceedance of specific Connecticut Department of Environmental Protection (CTDEP) Remediation Standard Regulation (RSR) criteria, ten times the Groundwater Protection Criteria, soils identified as containing greater than 1 part per million (ppm) of polychlorinated biphenyls (PCBs), or the federal Acute Water Quality Criteria.

H. Demolition and off-site disposal of Building 59 and the Causeway weather station, including existing utility removal.

I. Removal and off-site disposal of oversized surface debris measuring greater than two feet in any dimension, including the deteriorated concrete ramp at the end of the Causeway.

J. Topographic survey of the Causeway at the completion of the work.

Incidental work, related to the activities listed above, shall also be included in the contract, and may include, personnel and equipment decontamination, on-site treatment and disposal of decontamination fluids, personnel health and safety, contract meetings, and project documentation.

### 1.1.1 Project Location

Work shall be conducted on the Causeway and within the Stratford Army Engine Plant facility in Stratford, Connecticut, as indicated on the drawings. The exact location will be indicated by the Contracting Officer.

### 1.1.2 Previous Findings and Investigations

#### 1.1.2.1 Causeway

Chemical sampling and analysis of soil collected from the Causeway identified areas where concentrations of chlorinated and fuel-related volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), PCBs, and inorganics exceed the CTDEP RSRs Direct Exposure Criteria (DEC) and Pollutant Mobility Criteria (PMC). Low-level radiological contamination was also identified during sampling, and the affected areas were excavated in March 2000. This material was containerized and transported to an appropriate off-site, licensed, disposal facility.

Based on the results of chemical sampling and an engineering evaluation, it was recommended that soil containing contaminants in excess of CTDEP RSRs PMC be removed from the Causeway and an erosion control cover system be placed over the Causeway to prevent possible receptor contact with remaining contaminated soil (exceeding CTDEP RSRs DEC). In addition, it was recommended that geotechnical investigations be conducted to assess subsurface conditions in the proximity of the Causeway, and that additional chemical sampling and analysis be completed to delineate the areas of soil exceeding CTDEP RSRs PMC.

Data collected during the geotechnical investigations was used to estimate physical properties for the underlying soil, and perform global stability and settlement analyses for the proposed cover system configuration. The results of the geotechnical investigations and analyses indicated the proposed cover system is viable from a geotechnical perspective. The additional chemical sampling and analysis, using Synthetic Precipitate Leaching Procedure (SPLP), delineated ten distinct areas of soil contamination exceeding CTDEP RSRs PMC, and/or containing PCBs greater than 1 ppm.

Photographs of portions of the surface of the Causeway were obtained on February 14, 2001. Copies of these photographs are attached to these specifications, for information only. Photograph locations and orientations are as indicated on the drawings.

#### 1.1.2.2 Building 59

Drawings representing the Building 59 structure are attached to these specifications, for Contractor use. Sampling results from the building are also attached.

### 1.1.2.3 Building 5

Drawings representing the Building 5 structure are attached to these specifications, for Contractor use. An asbestos survey has been completed along with a building inventory. Sampling results from the building are also attached.

### 1.1.2.4 Building 34 Former Aboveground Storage Tank Farm

A drawing for this area is attached to these specifications, for Contractor use.

## 1.2 REFERENCES

The following documents contain additional information regarding the SAEP Causeway:

A. Foster Wheeler/Harding Lawson Associates, April 2000. Final Pre-design Investigation Report for the Causeway and Dike NCRA.

B. Foster Wheeler/Harding Lawson Associates, September 2000. Final Engineering Evaluation/Cost Analysis for the Causeway and Dike, Stratford Army Engine Plant.

C. Harding ESE, Inc., January 2001. Final Causeway Non-time Critical Removal Action Decision Document, Stratford Army Engine Plant.

## 1.3 SUBMITTALS (NOT USED)

## 1.4 CONTRACTOR ACCESS AND USE OF PREMISES

### 1.4.1 Access to Work Site

The Contractor shall coordinate access to the site with SAEP security personnel, including obtaining contractor access badges. Security personnel shall be notified of arrival at the site and departure from the site on a daily basis. Access to the Causeway site is currently available through the security gate on Sniffens Lane. Notification of security personnel is necessary for access through this gate.

Work within the Housatonic River shall be initiated following a courtesy notification of the Town of Stratford Harbor Master, the Town of Milford Harbor Master, and the U.S. Coast Guard. The Contractor shall be responsible for contacting these agencies.

### 1.4.2 Work Limits

Work shall be restricted to the areas shown on the contract drawings in addition to storage areas assigned to this Contractor.

### 1.4.3 Radio Communications

Use SAEP-approved radios for communications with SAEP security personnel when on the work site. Obtain a communication radio from security personnel as required by SAEP security. Return the communication radio to security personnel as required.

Contractor-provided radios shall be approved by SAEP security personnel prior to use on the facility.

### 1.4.4 Work and Storage Areas

Areas within the project limits are available for use by the Contractor, for work, storage of equipment and materials, and field office use during the life of this contract, as indicated on the Drawings. The Contractor shall confine these activities to the limits as designated or approved by the Contracting Officer and shall be responsible for the security of the areas. Upon completion of the contract, the Contractor shall remove all equipment and materials, except as otherwise specified, and restore the site to its original condition as approved by the Contracting Officer at no additional cost to the Government.

### 1.4.5 Delivery of Materials

Notify the Contracting Officer at least 7 calendar days in advance of the date on which the materials and equipment shall be delivered to the site. Delivery and storage of materials shall be accepted only in the approved storage area. Currently, the areas designated for storage are as indicated on the Drawings.

### 1.4.6 Hours of Operations

Normal work hours are from 7:00 a.m. through 6:00 p.m., Monday through Friday. The Contractor will not be permitted to work on Saturdays, Sundays, or legal holidays unless otherwise authorized by the Contracting Officer. The exclusion of work on Saturdays, Sundays, and legal holidays has been considered in computing the performance time of this contract. The following legal holidays are observed:

January 1st
Third Monday in January
Third Monday in February
Last Monday of May
July 4th
1st Monday of September
2nd Monday of October
11th of November
Fourth Thursday of November
25th of December

When one of the above designated legal holidays falls on a Sunday, the following Monday will be observed as a legal holiday. When a legal holiday falls on a Saturday, the preceding Friday is observed as a holiday. Requests to perform work at other times shall be made in writing to the

Contracting Officer. Every effort will be made to accommodate such requests.

The CTDEP does not allow what it considers to be unconfined excavation or filling work in the lower reaches of the Housatonic during certain times of the year in order to protect shellfish and finfish resources. The relevant "closed" period for unconfined dredging is from April 1 through September 30. Phase I activities below the elevation of the primary erosion control fence may not be performed during this "closed" period.

### 1.4.7 Coordination With Other Work

It is anticipated that additional contractors may be working at other areas at SAEP during completion of this work. The Contractor shall be responsible for coordinating construction activities with other contractors working concurrently at the site in the same area.

## 1.5 WORK SEQUENCE AND SCHEDULING

The Contractor shall follow a specified task sequence when completing work activities at the site, and shall maintain a schedule approved by the Contracting Officer prior to initiation of work.

### 1.5.1 Work Sequence

The work shall be conducted using a phased approach, consisting of Phase I and Phase II. This Summary of Work details the activities to be conducted under Phase I; specifications associated with Phase II of this work will be provided in a separate package. The Contractor shall complete the following tasks as part of Phase I, prior to initiation of other tasks at the site:

a. Mobilization

b. Site Preparation

c. Erosion and Sedimentation Control

d. Demolition

e. Contaminated Soil Removal

f. Debris Removal

g. Topographic Survey

Following the completion of Phase I tasks, Phase II tasks are expected to commence. Erosion and sedimentation control measures shall be maintained in the interim between the two tasks under this Contract.

The purpose of the phased approach is to limit the number of activities being conducted on the Causeway at one particular time, due to space constraints; however, the Contractor may present approach modifications that result in a reduction in overall project duration and cost.

### 1.5.2 Pre-construction Submittals

The Contractor shall submit the following to the Contracting Officer for approval prior to the start of work on the site; Work Plan, Site Safety and Health Plan, Environment Protection Plan, Preliminary and Initial Project Schedules, and Contractor's Laboratory. The documents shall be submitted as required in Section 01330 SUBMITTAL PROCEDURES.

### 1.5.3 Phased Construction Schedule

Within the overall project schedule, commence and complete the work in phases. Each phase of the work shall be completed within the number of calendar days stated in the schedule.

a. Scheduled Start Day: The day designated as the beginning of a particular phase; the number listed is the number of calendar days from the commencement of work.

b. Completion Day: The day designated as the end of a given phase and the day the work in that phase must be completed; the number listed is the number of calendar days from the commencement of work.

c. If the work of a particular phase is complete before the scheduled completion day, immediately begin work on the subsequent phase unless otherwise restricted.

### 1.5.4 Organization at the Site

The Contractor shall employ ample personnel and sufficient equipment to accomplish the work of this contract in the least amount of time, within the execution period. Should the Contractor fail to maintain a satisfactory rate of progress, the Contracting Officer may require that additional personnel and equipment be placed on the work and weekend and overtime work be performed, in order that the work be brought up to schedule and maintained, at no additional cost to the Government.

## 1.6 PROJECT CONSTRAINTS

The Contractor shall make note of following constraints relating to this work on the SAEP Causeway:

A. No work on the Causeway may begin prior to the installation and acceptance of erosion and sedimentation control measures.

B. Activities below elevation 6 feet mean sea level and outside the primary erosion control fence may not be conducted between April 1 and September 30.

C.. Portions of the SAEP facility are off-limits to Contractor access, as indicated on the Drawings.

D. Access to the Causeway is limited to a gate, approximately 20 feet wide at the origination of the Causeway from the main portion of the facility.

E. The average length of the Causeway is 800 feet, the average width is approximately 200 feet at low tide and 80 feet at high tide.

F. The average width of the existing top (gently sloped) portion of the Causeway is 100 feet.

G. The site is located in a tidal area and demolition/excavation activities near the toe of the Causeway shall not be completed under water.

H. Removal of demolition and oversized debris must be completed prior to installation of any cover system materials.

## PART 2 PRODUCTS (NOT APPLICABLE)

## PART 3 EXECUTION (NOT APPLICABLE)

--End of Section--

## SECTION 01270

## MEASUREMENT AND PAYMENT
**02/94**

## PART 1 GENERAL

### 1.1 DESCRIPTION

This section covers measurement and payment for work items included in Phase I construction at the Stratford Army Engine Plant Causeway.

### 1.2 REFERENCES (NOT USED)

### 1.3 LUMP SUM PAYMENT ITEMS

Payment items for the work of this contract for which contract lump sum payments will be made are listed in the BIDDING SCHEDULE and described below. The lump sum price and payment made for each item listed shall constitute full compensation for furnishing all planning, submittals, labor, materials, and equipment, and performing any associated Contractor quality control, environmental protection, meeting safety requirements, tests and reports, and for performing all work required for which separate payment is not otherwise provided.

### 1.4 UNIT PRICE PAYMENT ITEMS

Payment items for the work of this contract on which the contract unit price payments will be made are listed in the BIDDING SCHEDULE and described below. The unit price and payment made for each item listed shall constitute full compensation for furnishing all planning, submittals, labor, materials, and equipment, and performing any associated Contractor quality control, environmental protection, meeting safety requirements, tests and reports, and for performing all work required for which separate payment is not otherwise provided.

When quantities increase by greater than 25% of the original quantity estimated, the contract unit price as established in the original contract will be paid for the quantity up to 25% beyond the original estimated quantity. Work beyond 25% of the estimated quantity will be paid for as follows:

a. By actual itemized cost and fixed fees as set forth by unit prices stated in the Contract Documents or subsequently agreed upon. In the event of an addition to the Contract, a fee of 10% shall be added for overhead and a fee of 10% shall be added for profit if the Work is done by his/her own forces, and 7-1/2% shall be added for administration and profit if the Work is done by a Subcontractor.

b. Cost shall be limited to the following: Cost of materials, cost of labor, and cost of overhead.

When quantities decrease by greater than 25% of the original quantity estimated, payment shall be made in accordance with a. and b. above.

## 1.5 BIDDING SCHEDULE - PAYMENT ITEMS

Payment items for the work of this contract on which the contract progress payments will be based are listed in the BIDDING SCHEDULE and are as briefly described below and as specified in these specifications. All costs for incidental items of work, not specifically mentioned as included in a particular Bid Schedule payment item, shall be included in the listed item most closely associated with the work involved.

### 1.5.1 Item No. 0001 "Mobilization"

a. Payment will be made for costs associated with mobilization, as defined in Special Clause PAYMENT FOR MOBILIZATION AND DEMOBILIZATION. This item includes furnishing labor, equipment, tools, materials, and supplies necessary to mobilize all personnel, equipment, and supplies to the site. This payment item also includes provision of temporary facilities, utility connections, signs, etc., associated with mobilization, as necessary. Preparation and submittal of pre-construction plans, including a Work Plan, a Site Safety and Health Plan (SSHP) and an Environment Protection Plan, along with obtaining personnel approvals for work at the facility, are also included in this item. Costs associated with demobilization will be covered under a separate item in Phase II of this contract (N.I.T.C.).

b. Unit of measure: job lump sum.

### 1.5.2 Item No. 0002 "Site Preparation"

a. Payment will be made for costs associated with site preparation activities, including: abandonment of monitoring well MWCD-00-01; stockpile area construction, monitoring, and maintenance; decontamination area construction; and heave platform and pole installation and initial monitoring. Payment for this item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work.

b. Unit of measure: job lump sum.

### 1.5.3 Item No. 0003 "Erosion and Sedimentation Controls"

a. Payment will be made for costs associated with installation, and maintenance of erosion and sediment control measures, including a floating silt curtain (N.I.T.C.), silt fencing, staked haybales, matting, and mulch cover. This payment item also includes maintenance of erosion control measures following the completion of Phase I and prior to implementation of Phase II for a one month period, as necessary.

b. Unit of measure: job lump sum.

1.5.4 Item No. 0004 "Clearing and Grubbing"

a. Payment will be made for costs associated with clearing brush and felling trees present on the Causeway. An estimated 12 to 18 small trees (approximately 4 inches in diameter) shall be cut off at ground surface, and minimal amounts of brush shall require clearing from the site. Felled trees and brush shall be chipped and spread out on the ground surface and worked into the soil, as directed by the Contracting Officer. Stumps shall be removed to a depth of 2 feet below the existing ground surface if greater than 4 inches in diameter. Payment for the item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work.

b. Unit of measure: job lump sum.

1.5.5 Item No. 0005 "Building 5 Asbestos-containing Material Removal and Disposal"

a. Payment shall be made for costs associated with removal and disposal of asbestos-containing material from Building 5. This payment item includes the costs associated with asbestos abatement activities, including personnel health and safety requirements, and off-site transport to the treatment/disposal facility. Payment for the item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work. For bidding purposes, the Contractor shall assume 10 cubic yards of asbestos-containing material shall require removal and disposal.

b. Unit of measure: job lump sum.

1.5.6 Item No. 0006 "Building 5 Demolition"

a. Payment shall be made for costs associated with demolition of Building 5 and appurtenances. This payment item includes the costs associated with existing utilities disconnection, demolition activities, and on-site debris transport to the stockpile area. Payment for the item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work.

b. Unit of measure: job lump sum.

1.5.7 Item No. 0007 "Building 59 Demolition"

a. Payment shall be made for costs associated with demolition of Building 59, the Causeway weather station, and the containment berm surrounding the Building 34 former aboveground storage tank (AST) farm. Removal of existing utilities associated with these structures, protective posts surrounding the berm, and tank supports within the berm are also included in this item. In addition, cleaning of demolition debris on the Causeway and on-site transport to the stockpile areas will be included in this item. Payment for the item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work.

b. Unit of measure: job lump sum.

1.5.8 Item No. 0008 "Off-site Transport and Disposal (Hazardous Demolition Material)

a. Payment will be made for costs associated with off-site transport and disposal of hazardous demolition debris. This payment item includes the costs associated with characterization sample collection and analysis, on-site material measurement (at on-site scales), and off-site transportation and disposal. Payment for the item will be full compensation for furnishing all materials, labor, equipment, health and safety, and all other incidentals necessary to complete the work.

b. The total quantity of material for which payment will be made will be the tonnage of hazardous debris transported off-site, as measured at on-site scales, immediately prior to transport off-site for disposal. Demolition debris shall be sorted, such that similar types of debris are measured separately from other types of debris (e.g., concrete, metal, etc.).

c. Unit of measure: tonnage hazardous.

1.5.9 Item No. 0009 "Off-site Transport and Disposal (Non-hazardous Demolition Material)

a. Payment will be made for costs associated with off-site transport and disposal of non-hazardous demolition debris. This payment item includes the costs associated with characterization sample collection and analysis, on-site material measurement (at on-site scales), and off-site transportation and disposal. Payment for the item will be full compensation for furnishing all materials, labor, equipment, health and safety, and all other incidentals necessary to complete the work.

b. The total quantity of material for which payment will be made will be the tonnage of non-hazardous debris transported off-site, as measured at on-site scales, immediately prior to transport off-site for disposal. Demolition debris shall be sorted, such that similar types of debris are measured separately from other types of debris (e.g., concrete, metal, etc.).

c. Unit of measure: tonnage non-hazardous.

1.5.10 Item No. 0010 "Oversized Debris Removal and Disposal (Hazardous Material)"

a. Payment will be made for costs associated with removal and off-site disposal of hazardous debris on the Causeway, greater than 2 feet in any dimension, including the deteriorated concrete ramp at the end of the Causeway. This payment item includes the costs associated with removal activities, debris washing on the Causeway, on-site transportation to stockpile areas, characterization sample collection and analysis, on-site material measurement (at on-site scales), and off-site transportation and disposal. Payment for the item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work.

b. The total quantity of hazardous oversized debris removal for which payment will be made will be the tonnage of debris removed from the Causeway, as measured at on-site scales, immediately prior to transport off-site for disposal. Oversized debris shall be sorted, such that similar types of debris are measured separately from other types of debris (e.g., concrete, metal, etc.). For Contractor bidding purposes, it is estimated that 800 tons of debris will require removal from the Causeway.

c. Unit of measure: tonnage hazardous.

1.5.11 Item No. 0011 "Oversized Debris Removal and Disposal (Non-hazardous Material)"

a. Payment will be made for costs associated with removal and off-site disposal of non-hazardous debris on the Causeway, greater than 2 feet in any dimension, including the deteriorated concrete ramp at the end of the Causeway. This payment item includes the costs associated with removal activities, debris washing on the Causeway, on-site transportation to stockpile areas, characterization sample collection and analysis, on-site material measurement (at on-site scales), and off-site transportation and disposal. Payment for the item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work.

b. The total quantity of non-hazardous oversized debris removal for which payment will be made will be the tonnage of debris removed from the Causeway, as measured at on-site scales, immediately prior to transport off-site for disposal. Oversized debris shall be sorted, such that similar types of debris are measured separately from other types of debris (e.g., concrete, metal, etc.). For Contractor bidding purposes, it is estimated that 6,900 tons of debris will require removal from the Causeway.

c. Unit of measure: tonnage non-hazardous.

1.5.12 Item No. 0012 "Contaminated Soil Removal and Disposal (Hazardous Material)"

a. Payment will be made for costs associated with excavation and off-site disposal of contaminated soil, determined to be hazardous by chemical analyses. Soil removed from Excavation Areas 7, 8, 9 and 10 shall be considered hazardous waste for purposes of disposal. This payment item includes the costs associated with excavation activities, air monitoring during excavation, on-site materials handling, characterization sample collection and analysis, and off-site transport and disposal. Payment for the item will be full compensation for furnishing all materials, labor, equipment, health and safety, and all other incidentals necessary to complete the work.

b. The total quantity of hazardous contaminated soil for which payment will be made will be the tonnage of soil removed from the Causeway, as measured at on-site scales, immediately prior to transport off-site for disposal. Measurement will be made following receipt of confirmation sampling results which document that all material above action levels has been removed. Approval for over-depth excavation or for the removal of any material outside the required areas shall be obtained in advance.

c. Unit of measure: tonnage Hazardous.

1.5.13 Item No. 0013 "Contaminated Soil Removal and Disposal (Non-hazardous Material)"

a. Payment will be made for costs associated with excavation and off-site disposal of contaminated soil, determined to be non-hazardous by chemical analyses. This payment item includes the costs associated with excavation activities, air monitoring during excavation, on-site materials handling, characterization sample collection and analysis, and off-site transport and disposal. Payment for the item will be full compensation for furnishing all materials, labor, equipment, health and safety, and all other incidentals necessary to complete the work.

b. The total quantity of non-hazardous contaminated soil for which payment will be made will be the tonnage of soil removed from the Causeway, as measured at on-site scales, immediately prior to transport off-site for disposal. Measurement will be made following receipt of confirmation sampling results which document that all material above action levels has been removed. Approval for over-depth excavation or for the removal of any material outside the required areas shall be obtained in advance.

c. Unit of measure: tonnage non-hazardous.

1.5.14 Item No. 0014 "Topographic Survey"

a. Payment will be made for costs associated with completion of a topographic survey on the Causeway, following completion of the Phase I tasks. The purpose of the topographic survey is to provide elevations of the Causeway following the completion of Phase I activities, such that measurement of Phase II soil excavation can be completed. The topographic survey shall be completed using previously identified benchmark locations and shall comply with the requirements of a Class A-1 survey in the State of Connecticut. Payment for this item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work.

b. Unit of measure: job lump sum.

## PART 2 PRODUCTS (NOT APPLICABLE)

## PART 3 EXECUTION (NOT APPLICABLE)

--End of Section--

# SECTION 01300

# PROJECT COORDINATION

## PART 1 GENERAL

### 1.1 DESCRIPTION

This section covers the procedures to be followed during project completion to ensure coordination between the Contractor, the Contracting Officer, Statford Army Engine Plant personnel, and other potential Contractor's is maintained.

### 1.2 REFERENCES (NOT USED)

### 1.3 SUBMITTALS (NOT USED)

### 1.4 CONTRACTOR RESPONSIBILITY

The Contractor shall be responsible for the following items:

a. Coordinate all work under this Contract with related work under other contracts, SAEP facility, and with facility and public utilities.

b. Obtain all permits necessary for completion of the Work, including, but not limited to, building demolition permits and excavation permits.

c. Make arrangements for temporary storage of materials and supplies and for timely delivery to the job site.

d. Assist the Contracting Officer as required in the review of construction, demolition, and the testing of materials.

e. Maintain up-to-date progress records and record drawings.

f. Maintain the project site in a neat condition.

g. Contact the State of Connecticut "call-before-you-dig" program, at 1-800-922-4455, prior to initiation of excavation and demolition activities.

h. Coordinate with all utilities, and notify the appropriate IPM personnel when demolition is scheduled in areas that may affect existing utilities. The IPM contact is Rich Meier (203) 385-6649.

i. Coordinate the work of subcontractors, equipment, and material suppliers.

j. Coordinate work within the Housatonic River with both the U.S. Coast Guard, the Town of Stratford Harbor Master, and the Town of Milford Harbor Master.

## PART 2 PRODUCTS (NOT APPLICABLE)

## PART 3 EXECUTION (NOT APPLICABLE)

--End of Section--

# SECTION 01320

# PROJECT SCHEDULE
06/97

## PART 1 GENERAL

### 1.1 DESCRIPTION

This section covers the procedures and format to be followed during development of the project schedule and the requirements associated with scheduling of the Phase I work.

### 1.2 REFERENCES

The publications listed below form a part of the specification to the extent referenced. The publications are referenced in the text by basic designation only.

ENGINEERING REGULATIONS (ER)

| | |
|---|---|
| ER 1-1-11 | (1995) Progress, Schedules, and Network Analysis Systems |

### 1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals not having a "GA" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-01 Pre-construction Submittals

Preliminary Project Schedule; GA

Shall define the Contractor's planned operations for the first 60 calendar days.

Initial Project Schedule; GA

Shall provide a reasonable sequence of activities which represent work through the entire project and shall be at a reasonable level of detail.

SD-06 Test Reports

Periodic Schedule Updates; GA

Shall enable the Contracting Officer to assess the Contractor's progress, and shall be based on the result of progress meetings.

### 1.4 QUALIFICATIONS

The Contractor shall designate an authorized representative who shall be responsible for the preparation of all required project schedule reports.

## PART 2 PRODUCTS (NOT APPLICABLE)

## PART 3 EXECUTION

### 3.1 GENERAL REQUIREMENTS

Pursuant to the Contract Clause, SCHEDULE FOR CONSTRUCTION CONTRACTS, a Project Schedule as described below shall be prepared. The scheduling of construction shall be the responsibility of the Contractor. Contractor management personnel shall actively participate in its development. Subcontractors and suppliers working on the project shall also contribute in developing and maintaining an accurate Project Schedule. The approved Project Schedule shall be used to measure the progress of the work, to aid in evaluating time extensions, and to provide the basis of all progress payments.

### 3.2 BASIS FOR PAYMENT

The schedule shall be the basis for measuring Contractor progress. Lack of an approved schedule or scheduling personnel will result in an inability of the Contracting Officer to evaluate Contractor's progress for the purposes of payment. Failure of the Contractor to provide all information, as specified below, shall result in the disapproval of the entire Project Schedule submission and the inability of the Contracting Officer to evaluate Contractor progress for payment purposes. In the case where Project Schedule revisions have been directed by the Contracting Officer and those revisions have not been included in the Project Schedule, the Contracting Officer may hold retainage up to the maximum allowed by contract, each payment period, until revisions to the Project Schedule have been made.

### 3.3 PROJECT SCHEDULE

The computer software system utilized by the Contractor to produce the Project Schedule shall be capable of providing all requirements of this specification. Failure of the Contractor to meet the requirements of this specification shall result in the disapproval of the schedule. Manual methods used to produce any required information shall require approval by the Contracting Officer.

### 3.3.1 Use of the Critical Path Method

The Critical Path Method (CPM) of network calculation shall be used to generate the Project Schedule. The Contractor shall provide the Project Schedule in the Precedence Diagram Method (PDM).

### 3.3.2 Level of Detail Required

The Project Schedule shall include an appropriate level of detail. Failure to develop or update the Project Schedule or provide data to the Contracting Officer at the appropriate level of detail, as specified by the Contracting Officer, shall result in the disapproval of the schedule. The Contracting

Officer will use, but is not limited to, the following conditions to determine the appropriate level of detail to be used in the Project Schedule.

### 3.3.2.1 Activity Duration

Contractor submissions shall follow the direction of the Contracting Officer regarding reasonable activity duration. A reasonable duration is one that allows the progress of activities to be accurately determined between payment periods (usually less than 2 percent of all non-procurement activities' Original Durations are greater than 20 days).

### 3.3.2.2 Procurement Activities

Tasks related to the procurement of long lead materials or equipment shall be included as separate activities in the project schedule. Long lead materials and equipment are those materials that have a procurement cycle of over 90 days. Examples of procurement process activities include, but are not limited to: submittals, approvals, procurement, fabrication, and delivery.

### 3.3.2.3 Government Activities

Government and other agency activities that could impact progress shall be shown. These activities include, but are not limited to: approvals, inspections, utility tie-in, Government Furnished Equipment (GFE) and Notice to Proceed (NTP) for phasing requirements.

### 3.3.2.4 Responsibility

All activities shall be identified in the project schedule by the party responsible to perform the work. Responsibility includes, but is not limited to, the subcontracting firm, contractor work force, or government agency performing a given task. Activities shall not belong to more than one responsible party. The responsible party for each activity shall be identified by the Responsibility Code.

### 3.3.2.5 Work Areas

All activities shall be identified in the project schedule by the work area in which the activity occurs. Activities shall not be allowed to cover more than one work area. The work area of each activity shall be identified by the Work Area Code.

### 3.3.2.6 Modification or Claim Number

Any activity that is added or changed by contract modification or used to justify claimed time shall be identified by a mod or claim code that changed the activity. Activities shall not belong to more than one modification or claim item. The modification or claim number of each activity shall be identified by the Mod or Claim Number. Whenever possible, changes shall be added to the schedule by adding new activities. Existing activities shall not normally be changed to reflect modifications.

### 3.3.2.7 Bid Item

All activities shall be identified in the project schedule by the Bid Item to which the activity belongs. An activity shall not contain work in more than one bid item. The bid item for each appropriate activity shall be identified by the Bid Item Code.

### 3.3.2.8 Phase of Work

All activities shall be identified in the project schedule by the phase of work in which the activity occurs. Activities shall not contain work in more than one phase of work. The project phase of each activity shall be by the unique Phase of Work Code.

### 3.3.2.9 Category of Work

All Activities shall be identified in the project schedule according to the category of work which best describes the activity. Category of work refers, but is not limited, to the procurement chain of activities including such items as submittals, approvals, procurement, fabrication, delivery, installation, start-up, and testing. The category of work for each activity shall be identified by the Category of Work Code.

### 3.3.2.10 Feature of Work

All activities shall be identified in the project schedule according to the feature of work to which the activity belongs. Feature of work refers, but is not limited to, a work breakdown structure for the project. The feature of work for each activity shall be identified by the Feature of Work Code.

### 3.3.3 Scheduled Project Completion

The schedule interval shall extend from NTP to the contract completion date.

### 3.3.3.1 Project Start Date

The schedule shall start no earlier than the date on which the NTP was acknowledged. The Contractor shall include as the first activity in the project schedule an activity called "Start Project". The "Start Project" activity shall have an "ES" constraint date equal to the date that the NTP was acknowledged, and a zero day duration.

### 3.3.3.2 Constraint of Last Activity

Completion of the last activity in the schedule shall be constrained by the contract completion date. Calculation on project updates shall be such that if the early finish of the last activity falls after the contract completion date, then the float calculation shall reflect a negative float on the critical path. The Contractor shall include as the last activity in the project schedule an activity called "End Project". The "End Project" activity shall have an "LF" constraint date equal to the completion date for the project, and a zero day duration.

#### 3.3.3.3 Early Project Completion

In the event the project schedule shows completion of the project prior to the contract completion date, the Contractor shall identify those activities that have been accelerated and/or those activities that are scheduled in parallel to support the Contractor's "early" completion. Contractor shall specifically address each of the activities noted in the narrative report at every project schedule update period to assist the Contracting Officer in evaluating the Contractor's ability to actually complete prior to the contract period.

### 3.3.4 Interim Completion Dates

Contractually specified interim completion dates shall also be constrained to show negative float if the early finish date of the last activity in that phase falls after the interim completion date.

#### 3.3.4.1 Start Phase

The Contractor shall include as the first activity for a project phase an activity called "Start Phase X" where "X" refers to the phase of work. The "Start Phase X" activity shall have an "ES" constraint date equal to the date on which the NTP was acknowledged, and a zero day duration.

#### 3.3.4.2 End Phase

The Contractor shall include as the last activity in a project phase an activity called "End Phase X" where "X" refers to the phase of work. The "End Phase X" activity shall have an "LF" constraint date equal to the completion date for the project, and a zero day duration.

#### 3.3.4.3 Phase X

The Contractor shall include a hammock type activity for each project phase called "Phase X" where "X" refers to the phase of work. The "Phase X" activity shall be logically tied to the earliest and latest activities in the phase.

### 3.3.5 Default Progress Data Disallowed

Actual Start and Finish dates shall not be automatically updated by default mechanisms that may be included in CPM scheduling software systems. Actual Start and Finish dates on the CPM schedule shall match those dates provided from Contractor Quality Control Reports. Failure of the Contractor to document the Actual Start and Finish dates on the Daily Quality Control report for every in-progress or completed activity, and failure to ensure that the data contained on the Daily Quality Control reports is the sole basis for schedule updating shall result in the disapproval of the Contractor's schedule and the inability of the Contracting Officer to evaluate Contractor progress for payment purposes. Updating of the percent complete and the remaining duration of any activity shall be independent functions. Program features which calculate one of these parameters from the other shall be disabled.

### 3.3.6 Out-of-Sequence Progress

Activities that have posted progress without all preceding logic being satisfied (Out-of-Sequence Progress) will be allowed only on a case-by-case approval of the Contracting Officer. The Contractor shall propose logic corrections to eliminate all out of sequence progress or justify not changing the sequencing for approval prior to submitting an updated project schedule.

### 3.3.7 Negative Lags

Lag durations contained in the project schedule shall not have a negative value.

## 3.4 PROJECT SCHEDULE SUBMISSIONS

The Contractor shall provide the submissions as described below. The data disk, reports, and network diagrams required for each submission are contained in paragraph SUBMISSION REQUIREMENTS.

### 3.4.1 Preliminary Project Schedule Submission

The Preliminary Project Schedule, defining the Contractor's planned operations for the first 60 calendar days shall be submitted for approval within 20 calendar days after the NTP is acknowledged. The approved preliminary schedule shall be used for payment purposes not to exceed 60 calendar days after NTP.

### 3.4.2 Initial Project Schedule Submission

The Initial Project Schedule shall be submitted for approval within 40 calendar days after NTP. The schedule shall provide a reasonable sequence of activities which represent work through the entire project and shall be at a reasonable level of detail.

### 3.4.3 Monthly Schedule Updates

Based on the result of progress meetings, specified in "Periodic Progress Meetings," the Contractor shall submit monthly schedule updates. These submissions shall enable the Contracting Officer to assess Contractor's progress. If the Contractor fails or refuses to furnish the information and project schedule data, which in the judgement of the Contracting Officer or authorized representative is necessary for verifying the Contractor's progress, the Contractor shall be deemed not to have provided an estimate upon which progress payment may be made.

### 3.4.4 Standard Activity Coding Dictionary

The Contractor shall use the activity coding structure defined in the Standard Data Exchange Format (SDEF) in ER 1-1-11, Appendix A. This exact structure is mandatory, even if some fields are not used.

### 3.5 SUBMISSION REQUIREMENTS

The following items shall be submitted by the Contractor for the preliminary submission, initial submission, and every periodic project schedule update throughout the life of the project:

#### 3.5.1 Data Disks

Two data disks containing the project schedule shall be provided. Data on the disks shall adhere to the SDEF format specified in ER 1-1-11, Appendix A.

#### 3.5.1.1 File Medium

Required data shall be submitted on 3.5 disks, formatted to hold 1.44 MB of data, under the MS-DOS Version 5. or 6.x, unless otherwise approved by the Contracting Officer.

#### 3.5.1.2 Disk Label

A permanent exterior label shall be affixed to each disk submitted. The label shall indicate the type of schedule (Preliminary, Initial, Update, or Change), full contract number, project name, project location, data date, name and telephone number or person responsible for the schedule, and the MS-DOS version used to format the disk.

#### 3.5.1.3 File Name

Each file submitted shall have a name related to either the schedule data date, project name, or contract number. The Contractor shall develop a naming convention that will ensure that the names of the files submitted are unique. The Contractor shall submit the file naming convention to the Contracting Officer for approval.

#### 3.5.2 Narrative Report

A Narrative Report shall be provided with the preliminary, initial, and each update of the project schedule. This report shall be provided as the basis of the Contractor's progress payment request. The Narrative Report shall include: a description of activities along the 2 most critical paths, a description of current and anticipated problem areas or delaying factors and their impact, and an explanation of corrective actions taken or required to be taken. The narrative report is expected to relay to the Government, the Contractor's thorough analysis of the schedule output and its plans to compensate for any problems, either current or potential, which are revealed through that analysis.

#### 3.5.3 Approved Changes Verification

Only project schedule changes that have been previously approved by the Contracting Officer shall be included in the schedule submission. The Narrative Report shall specifically reference, on an activity by activity basis, all changes made since the previous period and relate each change to documented, approved schedule changes.

### 3.5.4 Schedule Reports

The format for each activity for the schedule reports listed below shall contain: Activity Numbers, Activity Description, Original Duration, Remaining Duration, Early Start Date, Early Finish Date, Late Start Date, Late Finish Date, Total Float. Actual Start and Actual Finish Dates shall be printed for those activities in progress or completed.

#### 3.5.4.1 Activity Report

A list of all activities sorted according to activity number.

#### 3.5.4.2 Logic Report

A list of Preceding and Succeeding activities for every activity in ascending order by activity number. Preceding and succeeding activities shall include all information listed above in paragraph Schedule Reports. A blank line shall be left between each activity grouping.

#### 3.5.4.3 Total Float Report

A list of all incomplete activities sorted in ascending order of total float. Activities which have the same amount of total float shall be listed in ascending order of Early Start Dates. Completed activities shall not be shown on this report.

#### 3.5.4.4 Earnings Report

A compilation of the Contractor's Total Earnings on the project from the NTP until the most recent Monthly Progress Meeting. This report shall reflect the Earnings of specific activities based on the agreements made in the field and approved between the Contractor and Contracting Officer at the most recent Monthly Progress Meeting. Provided that the Contractor has provided a complete schedule update, this report shall serve as the basis of determining Contractor Payment. Activities shall be grouped by bid item and sorted by activity numbers. This report shall: sum all activities in a bid item and provide a bid item percent; and complete and sum all bid items to provide a total project percent complete. The printed report shall contain, for each activity: the Activity Number, Activity Description, Original Budgeted Amount, Total Quantity, Quantity to Date, Percent Complete (based on cost), and Earnings to Date.

### 3.5.5 Network Diagram

The network diagram shall be required on the initial schedule submission and on monthly schedule update submissions. The network diagram shall depict and display the order and interdependence of activities and the sequence in which the work is to be accomplished. The Contracting Officer will use, but is not limited to, the following conditions to review compliance with this paragraph:

#### 3.5.5.1 Continuous Flow

Diagrams shall show a continuous flow from left to right with no arrows from right to left. The activity number, description, duration, and estimated earned value shall be shown on the diagram.

#### 3.5.5.2 Project Milestone Dates

Dates shall be shown on the diagram for start of project, any contract required interim completion dates, and contract completion dates.

#### 3.5.5.3 Critical Path

The critical path shall be clearly shown.

#### 3.5.5.4 Banding

Activities shall be grouped to assist in the understanding of the activity sequence. Typically, this flow will group activities by category of work, work area and/or responsibility.

#### 3.5.5.5 S-Curves

Earnings curves showing projected early and late earnings and earnings to date.

## 3.6 PERIODIC PROGRESS MEETINGS

Progress meetings to discuss payment shall include a monthly onsite meeting or other regular intervals mutually agreed to at the pre-construction conference. During this meeting the Contractor shall describe, on an activity by activity basis, all proposed revisions and adjustments to the project schedule required to reflect the current status of the project. The Contracting Officer will approve activity progress, proposed revisions, and adjustments as appropriate.

### 3.6.1 Meeting Attendance

The Contractor's Project Manager and Scheduler shall attend the regular progress meeting.

### 3.6.2 Update Submission Following Progress Meeting

A complete update of the project schedule containing all approved progress, revisions, and adjustments, based on the regular progress meeting, shall be submitted not later than 4 working days after the monthly progress meeting.

### 3.6.3 Progress Meeting Contents

Update information, including Actual Start Dates, Actual Finish Dates, Remaining Durations, and Cost-to-Date shall be subject to the approval of the Contracting Officer. As a minimum, the Contractor shall address the following items on an activity by activity basis during each progress meeting.

#### 3.6.3.1 Start and Finish Dates

The Actual Start and Actual Finish dates for each activity currently in-progress or completed.

#### 3.6.3.2 Time Completion

The estimated Remaining Duration for each activity in-progress. Time-based progress calculations shall be based on Remaining Duration for each activity.

#### 3.6.3.3 Cost Completion

The earnings for each activity started. Payment will be based on earnings for each in-progress or completed activity. Payment for individual activities containing quality defects will not be made. A portion of the overall project amount may be retained based on delays of activities.

#### 3.6.3.4 Logic Changes

All logic changes pertaining to NTP on change orders, change orders to be incorporated into the schedule, contractor proposed changes in work sequence, corrections to schedule logic for out-of-sequence progress, lag durations, and other changes that have been made pursuant to contract provisions shall be specifically identified and discussed.

#### 3.6.3.5 Other Changes

Other changes required due to delays in completion of any activity or group of activities include: 1) delays beyond the Contractor's control, such as strikes and unusual weather. 2) delays encountered due to submittals, Government Activities, deliveries or work stoppages which make re-planning the work necessary. 3) Changes required to correct a schedule which does not represent the actual or planned prosecution and progress of the work.

## 3.7 REQUESTS FOR TIME EXTENSIONS

In the event the Contractor requests an extension of the contract completion date, or any interim milestone date, the Contractor shall furnish the following for a determination as to whether or not the Contractor is entitled to an extension of time under the provisions of the contract: justification, project schedule data, and supporting evidence as the Contracting Officer may deem necessary. Submission of proof of delay, based on revised activity logic, duration, and costs (updated to the specific date that the delay occurred) is obligatory to any approvals.

### 3.7.1 Justification of Delay

The project schedule shall clearly display that the Contractor has used, in full, all the float time available for the work involved with this request. The Contracting Officer's determination as to the number of allowable days of contract extension shall be based upon the project schedule updates in effect for the time period in question, and other factual information. Actual delays that are found to be caused by the Contractor's own actions, which result in the extension of the schedule, will not be a cause for a time extension to the contract completion date.

### 3.7.2 Submission Requirements

The Contractor shall submit a justification for each request for a change in the contract completion date of under 2 weeks based upon the most recent schedule update at the time of the NTP or constructive direction issued for the change. Such a request shall be in accordance with the requirements of other appropriate Contract Clauses and shall include, as a minimum:

a. A list of affected activities, with their associated project schedule activity number.

b. A brief explanation of the causes of the change.

c. An analysis of the overall impact of the changes proposed.

d. A sub-network of the affected area.

Activities impacted in each justification for change shall be identified by a unique activity code contained in the required data file.

### 3.7.3 Additional Submission Requirements

For any requested time extension of over 2 weeks, the Contracting Officer may request an interim update with revised activities for a specific change request. The Contractor shall provide this disk within 4 days of the Contracting Officer's request.

## 3.8 DIRECTED CHANGES

If the NTP is issued for changes prior to settlement of price and/or time, the Contractor shall submit proposed schedule revisions to the Contracting Officer within 2 weeks of the NTP being issued. The proposed revisions to the schedule will be approved by the Contracting Officer prior to inclusion of those changes within the project schedule. If the Contractor fails to submit the proposed revisions, the Contracting Officer may furnish the Contractor with suggested revisions to the project schedule. The Contractor shall include these revisions in the project schedule until revisions are submitted, and final changes and impacts have been negotiated. If the Contractor has any objections to the revisions furnished by the Contracting Officer, the Contractor shall advise the Contracting Officer within 2 weeks of receipt of the revisions. Regardless of the objections, the Contractor shall continue to update the schedule with the Contracting Officer's revisions until a mutual agreement in the revisions is reached. If the Contractor fails to submit alternative revisions within 2 weeks of receipt of the Contracting Officer's proposed revisions, the Contractor will be deemed to have concurred with the Contracting Officer's proposed revisions. The proposed revisions will then be the basis for an equitable adjustment for performance of the work.

## 3.9 OWNERSHIP OF FLOAT

Float available in the schedule, at any time, shall not be considered for the exclusive use of either the Government or the Contractor.

--End of Section--

# SECTION 01330

# SUBMITTAL PROCEDURES
09/00

## PART 1 GENERAL

### 1.1 DESCRIPTION

This section covers the procedures to be followed for submission of documents required under this contract. It also contains a copy of the anticipated submittal register for Phase I work.

### 1.2 REFERENCES (NOT USED)

### 1.3 SUBMITTALS

Submittals required are identified by SD numbers and titles as follows:

SD-01 Pre-construction Submittals

SD-02 Shop Drawings

SD-03 Product Data

SD-04 Samples

SD-05 Design Data

SD-06 Test Reports

SD-07 Certificates

SD-08 Manufacturer's Instructions

SD-09 Manufacturer's Field Reports

SD-10 Operation and Maintenance Data

SD-11 Closeout Submittals

Submittals are classified as follows:

#### 1.3.1 Government Approved

Government approval is required for extensions of design, critical materials, deviations, equipment whose compatibility with the entire system must be checked, and other items as designated by the Contracting Officer. Within the terms of the Contract Clause entitled "SPECIFICATIONS AND DRAWINGS FOR CONSTRUCTION," they are considered to be "shop drawings."

### 1.3.2 Information Only

All submittals not requiring Government approval will be for information only. They are not considered to be "shop drawings" within the terms of the Contract Clause referred to above.

## 1.4 APPROVED SUBMITTALS

The Contracting Officer's approval of submittals shall not be construed as a complete check, but will indicate only that the general method of construction, materials, detailing and other information are satisfactory. Approval will not relieve the Contractor of the responsibility for any error which may exist, as the Contractor under the Contractor Quality Control (CQC) requirements of this contract is responsible for dimensions, the design of adequate connections and details, and the satisfactory construction of all work. After submittals have been approved by the Contracting Officer, no re-submittal for the purpose of substituting materials or equipment will be considered unless accompanied by an explanation of why a substitution is necessary.

## 1.5 DISAPPROVED SUBMITTALS

The Contractor shall make all corrections required by the Contracting Officer and promptly furnish a corrected submittal in the form and number of copies specified for the initial submittal. If the Contractor considers any correction indicated on the submittals to constitute a change to the contract, a notice in accordance with the Contract Clause "CHANGES" shall be given promptly to the Contracting Officer.

## 1.6 WITHHOLDING OF PAYMENT

Payment for materials incorporated in the work will not be made if required approvals have not been obtained.

# PART 2 PRODUCTS (NOT APPLICABLE)

# PART 3 EXECUTION

## 3.1 GENERAL

The Contractor shall make submittals as required by the specifications. The Contracting Officer may request submittals in addition to those specified when deemed necessary to adequately describe the work covered in the respective sections. Units of weights and measures used on all submittals shall be the same as those used in the contract drawings. Each submittal shall be complete and in sufficient detail to allow ready determination of compliance with contract requirements. Prior to submittal, all items shall be checked and approved by the Contractor's Quality Control (CQC) System Manager and each item shall be stamped, signed, and dated by the CQC System Manager indicating action taken. Proposed deviations from the contract requirements shall be clearly identified. Submittals shall include items such as: Contractor's, manufacturer's, or fabricator's drawings; descriptive literature including (but not limited to) catalog cuts, diagrams, operating charts or curves; test reports; test cylinders; samples; O&M manuals (including parts list); certifications; warranties; and other such required submittals. Submittals requiring Government approval shall be scheduled and made prior to the acquisition of the material or equipment covered thereby. Samples remaining upon completion of the work shall be picked up and disposed of in accordance with manufacturer's Material Safety Data Sheets (MSDS) and in compliance with existing laws and regulations.

## 3.2 SUBMITTAL REGISTER

At the end of this section is a submittal register (ENG Form 4288) showing items of equipment and materials for which submittals are required by the specifications; this list may not be all inclusive and additional submittals may be required. The Contractor will also be given the submittal register files, containing the electronic ENG Form 4288 and instructions on the use of the files. These submittal register files will be furnished on a separate diskette. The Contractor shall submit the forms to the Contracting Officer for approval within 21 calendar days after NTP. The Contractor shall keep this diskette up-to-date and shall submit it to the Government together with the monthly payment request. The approved submittal register will support the scheduling document and will be used to control submittals throughout the life of the contract. The submittal register and the progress schedules shall be coordinated.

## 3.3 SCHEDULING

Submittals covering component items forming a system or items that are interrelated shall be scheduled to be coordinated and submitted concurrently. Certifications to be submitted with the pertinent drawings shall be so scheduled. Adequate time (a minimum of 14 calendar days exclusive of mailing time) shall be allowed and shown on the register for review and approval. No delay damages or time extensions will be allowed for time lost in late submittals.

## 3.4 TRANSMITTAL FORM (ENG FORM 4025)

The sample transmittal form (ENG Form 4025) attached to this section shall be used for submitting both Government approved and information only submittals in accordance with the instructions on the reverse side of the form. These forms will be furnished electronically to the Contractor on a separate diskette. This form shall be properly completed by filling out all the heading blank spaces and identifying each item submitted. Special care shall be exercised to ensure proper listing of the specification paragraph and/or sheet number of the contract drawings pertinent to the data submitted for each item.

## 3.5 SUBMITTAL PROCEDURE

Submittals shall be made as follows:

### 3.5.1 Procedures

Ten copies of the transmittal form and submittals shall be delivered to the Contracting Officer. Additional copies shall be maintained by the Contractor on site.

### 3.5.2 Deviations

For submittals which include proposed deviations requested by the Contractor, the column "variation" of ENG Form 4025 shall be checked. The Contractor shall set forth in writing the reason for any deviations and annotate such deviations on the submittal. The Government reserves the right to rescind inadvertent approval of submittals containing unnoted deviations.

## 3.6 CONTROL OF SUBMITTALS

The Contractor shall carefully control his procurement operations to ensure that each individual submittal is made on or before the Contractor scheduled submittal date shown on the approved "Submittal Register."

## 3.7 GOVERNMENT APPROVED SUBMITTALS

Upon completion of review of submittals requiring Government approval, the submittals will be identified as having received approval by being so stamped and dated. Seven copies of the submittal will be retained by the Contracting Officer and three copies of the submittal will be returned to the Contractor.

## 3.8 INFORMATION ONLY SUBMITTALS

Normally submittals for information only will not be returned. Approval of the Contracting Officer is not required on information only submittals. The Government reserves the right to require the Contractor to resubmit any item found not to comply with the contract. This does not relieve the Contractor from the obligation to furnish material conforming to the plans and specifications; will not prevent the Contracting Officer from requiring removal and replacement of nonconforming material incorporated in the work; and does not relieve the Contractor of the requirement to furnish samples for testing by the Government laboratory or for check testing by the Government in those instances where the technical specifications so prescribe.

## 3.9 STAMPS

Stamps used by the Contractor on the submittal data to certify that the submittal meets contract requirements shall be similar to the following:

CONTRACTOR

(Firm Name)

_____ Approved

_____ Approved with corrections as noted on submittal data and/or attached sheets(s).

SIGNATURE: ______________________________

TITLE: ______________________________

DATE: ______________________________

--End of Section--

# SUBMITTAL REGISTER
(ER 415-1-10)

CONTRACT NO.

TITLE AND LOCATION: Stratford Army Engine Plant Causeway NCRA, Stratford, Connecticut

PHASE I

CONTRACTOR

SPECIFICATION SECTION

|  |  |  |  | TYPE OF SUBMITTAL |  |  |  |  |  |  |  |  |  |  | CLASSIFICATION |  |  | CONTRACTOR SCHEDULE DATES |  |  | CONTRACTOR ACTION |  |  | GOVERNMENT ACTION |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TRANS-MITTAL NO. a. | ITEM NO. b. | SPECIFICATION PARAGRAPH NO. c. | DESCRIPTION OF ITEM SUBMITTED d. | PRE-CONSTRUCTION e. | SHOP DRAWINGS f. | PRODUCT DATA g. | SAMPLES h. | DESIGN DATA i. | TEST REPORTS j. | CERTIFICATES k. | MANF INSTRUCTIONS l. | MANF FIELD REPORTS m. | O & M n. | CLOSEOUT SUBMITTALS o. | INFO ONLY p. | GOV. APPROVED q. | REVIEWER r. | SUBMIT s. | APPROVAL NEEDED BY t. | MATERIAL NEEDED BY u. | CODE v. | DATE w. | SUBMIT TO GOVERN-MENT x. | CODE y. | DATE z. | REMARKS aa. |
|  |  | 01320, 1.3 | Preliminary Project Schedule | X |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |
|  |  | 01320, 1.3 | Initial Project Schedule | X |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |
|  |  | 01320, 1.3 | Periodic Schedule Updates |  |  |  |  |  | X |  |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |
|  |  | 01351,1.3 | Site Safety and Health Plan | X |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |
|  |  | 01410, 1.3 | Environment Protection Plan | X |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |
|  |  | 01411, 1.3 | Contractor's Laboratory | X |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |
|  |  | 01780, 1.3 | Phase I Completion Report |  |  |  |  |  |  |  |  |  |  | X |  | X |  |  |  |  |  |  |  |  |  |  |
|  |  | 02110, 1.3 | Heave Monitoring Reports |  |  |  |  |  | X |  |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |
|  |  | 02111, 1.3 | Work Plan | X |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |
|  |  | 02120, 1.3 | Recordkeeping |  |  |  |  |  | X |  |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |
|  |  | 02120, 1.3 | Exception Reports |  |  |  |  |  | X |  |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |
|  |  | 02120, 1.3 | EPA Off-site Plicy |  |  |  |  |  |  | X |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |
|  |  | 02120, 1.3 | Disposal Certificates |  |  |  |  |  |  | X |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |
|  |  | 02120, 1.3 | Shipping Documents and Packagings Certification |  |  |  |  |  |  | X |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |
|  |  | 02120, 1.3 | Notices of Non-compliance and Notices of Violation |  |  |  |  |  |  | X |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |
|  |  | 02576, 1.3 | Bituminous Pavement Mix |  |  | X |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |
|  |  | 01328, 1-3 | Asbestos Abatement Licemse | x |  |  |  |  |  |  |  |  |  |  |  | X |  |  |  |  |  |  |  |  |  |  |

## SUBMITTAL REGISTER
(ER 415-1-10)

CONTRACT NO.

TITLE AND LOCATION: Stratford Army Engine Plant Causeway NCRA, Stratford, Connecticut
PHASE I

CONTRACTOR

SPECIFICATION SECTION

| | | | | TYPE OF SUBMITTAL | | | | | | | | | | | CLASSIFICATION | | | CONTRACTOR SCHEDULE DATES | | | CONTRACTOR ACTION | | | GOVERNMENT ACTION | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TRANSMITTAL NO. | ITEM NO. | SPECIFICATION PARAGRAPH NO. | DESCRIPTION OF ITEM SUBMITTED | PRE-CONSTRUCTION | SHOP DRAWINGS | PRODUCT DATA | SAMPLES | DESIGN DATA | TEST REPORTS | CERTIFICATES | MANF INSTRUCTIONS | MANF FIELD REPORTS | O & M | CLOSEOUT SUBMITTALS | INFO ONLY | GOV. APPROVED | REVIEWER | SUBMIT | APPROVAL NEEDED BY | MATERIAL NEEDED BY | CODE | DATE | SUBMIT TO GOVERNMENT | CODE | DATE | REMARKS |
| a. | b. | c. | d. | e. | f. | g. | h. | i. | j. | k. | l. | m. | n. | o. | p. | q. | r. | s. | t. | u. | v. | w. | x. | y. | z. | aa. |
| | | 01328, 1-3 | ACM Certification | | | | | | | X | | | | | | X | | | | | | | | | | |

# TRANSMITTAL OF SHOP DRAWINGS, EQUIPMENT DATA, MATERIAL SAMPLES, OR MANUFACTURER'S CERTIFICATES OF COMPLIANCE

*(Read instructions on the reverse side prior to initiating this form)*

DATE

TRANSMITTAL NO.

## SECTION I - REQUEST FOR APPROVAL OF THE FOLLOWING ITEMS *(This section will be initiated by the contractor)*

TO:

FROM:

CONTRACT NO.

CHECK ONE:

☐ THIS IS A NEW TRANSMITTAL

☐ THIS IS A RESUBMITTAL OF TRANSMITTAL ______

SPECIFICATION SEC. NO. (Cover only one section with each transmittal)

PROJECT TITLE AND LOCATION

| ITEM NO. | DESCRIPTION OF ITEM SUBMITTED *(Type size, model number/etc.)* | MFG OR CONTR. CAT., CURVE DRAWING OR BROCHURE NO. *(See instruction no. 8)* | NO. OF COPIES | CONTRACT REFERENCE DOCUMENT | | FOR CONTRACTOR USE CODE | VARIATION *(See instruction No. 6)* | FOR CE USE CODE |
|---|---|---|---|---|---|---|---|---|
| | | | | SPEC. PARA. NO. | DRAWING SHEET NO. | | | |
| *a.* | *b.* | *c.* | *d.* | *e.* | *f.* | *g.* | *h.* | *i.* |
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REMARKS

I certify that the above submitted items have been reviewed in detail and are correct and in strict conformance with the contract drawings and specifications except as other wise stated.

______________________________

NAME AND SIGNATURE OF CONTRACTOR

## SECTION II - APPROVAL ACTION

ENCLOSURES RETURNED (List by Item No.)

NAME, TITLE AND SIGNATURE OF APPROVING AUTHORITY

DATE

## SECTION 01351

## SAFETY, HEALTH, AND EMERGENCY RESPONSE
02/99

## PART 1 GENERAL

### 1.1 DESCRIPTION

This section covers the health and safety requirements to be followed for completion of this work. The section provides additional requirements for implementing the accident prevention provisions of EM 385-1-1, and specifies a Site Safety and Health Plan (SSHP) which shall satisfy the requirements for submission of a separate Accident Prevention Plan (APP) as required by EM 385-1-1. The requirements shall apply to work performed in both "contaminated" and "clean" areas.

### 1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS (ACGIH)

| | |
|---|---|
| ACGIH Threshold Limits | (1998) Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices |

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

| | |
|---|---|
| ANSI Z358.1 | (1990) Emergency Eyewash and Shower Equipment |

CODE OF FEDERAL REGULATIONS (CFR)

| | |
|---|---|
| 10 CFR 20 | Standards for Protection Against Radiation |
| 29 CFR 1904 | Recording and Reporting Occupational Injuries and Illnesses |
| 29 CFR 1910 | Occupational Safety and Health Standards |
| 29 CFR 1926 | Safety and Health Regulations for Construction |
| 49 CFR 171 | General Information, Regulations, and Definitions |
| 49 CFR 172 | Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements |

ENGINEERING MANUALS (EM)

| | |
|---|---|
| EM 385-1-1 | (1996) U.S. Army Corps of Engineers Safety and Health Requirements Manual |

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH)

| | |
|---|---|
| NIOSH Pub No. 85-115 | (1985) Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities |

## 1.3 SUBMITTALS

Drawings and sample forms listed below shall be submitted as part of the SSHP, which will require government approval. Sampling results shall be submitted under separate cover. Government approval is required for submittals with a "GA" designation; submittals not having a "GA" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-01 Pre-construction Submittals

Site Safety and Health Plan; GA

The SSHP shall detail the health and safety procedures to be followed during completion of the work. The SSHP shall be developed in accordance with this specification. The plan shall be periodically reviewed by the Contractor and the Contracting Officer during work operations to keep it current and technically correct. The SSHP shall include, but not be limited to, the following:

a. Drawings including the initial work zone boundaries: Exclusion Zone (EZ), including restricted and regulated areas; Contamination Reduction Zone (CRZ); and Support Zone (SZ).

b. A decontamination plan detailing the procedures to be followed for equipment and personnel decontamination. In addition, drawings shall show the layout of the personnel and equipment decontamination areas.

c. A sample log form to be used to record each entry and exit into the site.

d. An air monitoring plan detailing the procedures to be followed for personnel exposure monitoring and field air sampling. The air monitoring program shall be developed in accordance with applicable Federal and State regulations. A sample reporting form also shall be submitted as part of the SSHP.

e. Federal and State spill response requirements and contact information.

## 1.4 REGULATORY REQUIREMENTS

Work performed under this contract shall comply with EM 385-1-1, applicable Federal, state, and local safety and occupational health laws and regulations. This includes, but is not limited to, Occupational Safety and Health Administration (OSHA) standards, 29 CFR 1910, especially Section .120, "Hazardous Waste Site Operations and Emergency Response" and 29 CFR 1926, especially Section .65, "Hazardous Waste Site Operations and Emergency Response". Matters of interpretation of standards shall be submitted to the appropriate administrative agency for resolution before starting work. Where the requirements of this specification, applicable laws, criteria, ordinances, regulations, and referenced documents vary, the most stringent requirements shall apply.

## 1.5 PRE-CONSTRUCTION MEETING

The pre-construction meeting shall be attended by the Contractor or his/her representative and the on-site construction manager. The meeting shall be held prior to the commencement of work on-site. The purpose of the meeting is to define the Contractor's Quality Control System, to thoroughly review the Contractor's schedule, submittals list, and Work Plan, SSHP, and other project documents required in these specifications, and to develop a mutual understanding of the specific requirements established by the contract.

### 1.5.1 Pre-Construction Safety Conference

The pre-construction safety conference shall be conducted as part of the pre-construction meeting, and shall be attended by the Contractor, or his/her representative, and the on-site construction manager prior to the commencement of work. Recommended discussion topics include:

a. Discussion of the purpose and benefits of Corps construction safety and health program and Contractor's accident prevention plan.

b. Review of the accident prevention clause of the contract and any other contractual safety and health clauses, EM 385-1-1, and other applicable safety and health codes and standards.

c. Review of any local health and safety requirements.

d. Review of any other special requirements particular to the contract at hand.

e. Review of the Contractor's Accident Prevention Plan, its deficiencies, and the corrections needed to bring it to an acceptable level.

f. Review of the Contractor's list of anticipated phases of work requiring an activity hazard analysis.

g. Review of accident investigation and report requirements, including the submission of worker exposure reports.

h. Discussion of the Contractor's proposals for controlling and coordinating the work of subcontractors.

(i) As noted above, the conference will be used to discuss and resolve deficiencies in the Contractor's Accident Prevention Plan. The agreements reached at the pre-construction safety conference shall become a matter of record and shall be included as amendments to the Contractor's accident prevention plan.

(ii) Minutes of the conference, including agreements reached and a record of attendance, shall be maintained. Copies of the minutes shall be forwarded to the safety and occupational health office for review and then forwarded to the official contract file. A copy of the minutes will also be provided to the Contractor.

## 1.6 SAFETY AND HEALTH PROGRAM

OSHA Standards 29 CFR 1910, Section .120 (b) and 29 CFR 1926, Section .65 (b) require employers to develop and implement a written Safety and Health Program for employees involved in hazardous waste operations. The site-specific program requirements of the OSHA Standards shall be integrated into one site-specific document, the SSHP. The SSHP shall interface with the employer's overall Safety and Health Program. Any portions of the overall Safety and Health Program that are referenced in the SSHP shall be included as appendices to the SSHP.

## 1.7 SITE SAFETY AND HEALTH PLAN

### 1.7.1 Preparation and Implementation

A SSHP shall be prepared covering onsite work to be performed by the Contractor and all subcontractors. The Safety and Health Manager shall be responsible for the development, implementation and oversight of the SSHP. The SSHP shall establish, in detail, the protocols necessary for the anticipation, recognition, evaluation, and control of hazards associated with each task performed. The SSHP shall address site-specific safety and health requirements and procedures based upon site-specific conditions. The level of detail provided in the SSHP shall be tailored to the type of work, complexity of operations to be performed, and hazards anticipated. Details about some activities may not be available when the initial SSHP is prepared and submitted. Therefore, the SSHP shall address, in as much detail as possible, anticipated tasks, their related hazards and anticipated control measures. Additional details shall be included in the activity hazard analyses as described in paragraph ACTIVITY HAZARD ANALYSES.

### 1.7.2 Acceptance and Modifications

Prior to submittal, the SSHP shall be signed and dated by the Safety and Health Manager and the Site Superintendent. The SSHP shall be submitted for review 21 calendar days prior to the Pre-construction Safety Conference. Deficiencies in the SSHP will be discussed at the pre-construction safety conference, and the SSHP shall be revised to correct the deficiencies and resubmitted for acceptance. Onsite work shall not begin until the plan has been accepted. A copy of the written SSHP shall be maintained onsite. As work proceeds, the SSHP shall be adapted to new situations and new conditions. Changes and modifications to the accepted SSHP shall be made with the knowledge and concurrence of the Safety and Health Manager, the Site Superintendent, and the Contracting Officer. Should any unforeseen hazard become evident during the performance of the work, the Site Safety and Health Officer (SSHO) shall bring such hazard to the attention of the Safety and Health Manager, the Site Superintendent, and the Contracting Officer, both verbally and in writing, for resolution as soon as possible. In the interim, necessary action shall be taken to re-establish and maintain safe working conditions in order to safeguard onsite personnel, visitors, the public, and the environment. Disregard for the provisions of this specification or the accepted SSHP shall be cause for stopping of work until the matter has been rectified.

### 1.7.3 Availability

The SSHP shall be made available in accordance with 29 CFR 1910, Section .120 (b)(1)(v) and 29 CFR 1926, Section .65 (b)(1)(v).

### 1.7.4 Elements

Topics required by 29 CFR 1910, Section .120 (b)(4) 29 CFR 1926, Section .65 (b)(4) and the Accident Prevention Plan as described in Appendix A of EM 385-1-1 and those described in this section shall be addressed in the SSHP. Where the use of a specific topic is not applicable to the project, the SSHP shall include a statement to justify its omission or reduced level of detail and establish that adequate consideration was given the topic.

## 1.8 SITE DESCRIPTION AND CONTAMINATION CHARACTERIZATION

### 1.8.1 Project/Site Conditions

The following information is a record of site contaminants and a description of the site. This information is provided to assist in preparing the SSHP. Additional sources of information are available as listed below.

#### 1.8.1.1 Site Information

The SAEP Causeway was initially constructed and used as a means of launching seaplanes in the 1930s. Additional materials, of unknown origin, were deposited along the northern edge of the Causeway during the 1950s and 1960s. Causeway fill material consists of soil, cobbles, and construction debris.

Soil contamination exceeding the Connecticut Department of Environmental Protection (CTDEP) Remediation Standard Regulation (RSR) Direct Exposure Criteria (DEC), the Pollutant Mobility Criteria (PMC), and/or the federal Freshwater Acute Aquatic Water Quality Criteria (AWQC) include chlorinated and fuel-related volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), polychlorinated biphenyles (PCBs), and inorganics. Low-level radiological contamination was also identified at three isolated locations in the Causeway fill material. Radiologically-contaminated soil was excavated, containerized, and transported to an appropriate off-site licensed treatment/disposal facility. A final radiological survey of the Causeway was conducted to verify complete removal of radiological material, and the facility has been released from the NRC license.

Building 5, the former Fuel Test Cell Facility, is scheduled for demolition during Phase I activities. The building roof and water pipe insulation were found to contain friable asbestos during a site-wide asbestos survey. Paint on the east wall of the building contains marginally high lead concentrations, and the sprinkler pipes also contain lead-based paint. The potential also exists for low levels of PCBs to be present in the paint.

Table 01351-1 lists the contaminants present in Causeway fill material above CTDEP RSRs, the maximum detected concentration, and the location of the maximum concentration. The sample locations are shown on Drawing No. C-104. A figure identifying the locations of chemical exceedances are included as attachments to these specifications.

**TABLE 01351-1**
**CONTAMINANTS OF CONCERN ON THE CAUSEWAY**

| **Contaminant of Concern** | **Maximum Concentration (mg/kg)** | **Sample Location** |
|---|---|---|
| **VOCs** | | |
| Cis-1,2-Dichloroethene | 120 | CB-99-04 |
| Methylene Chloride | 3.3 J | CB-99-03 |
| Tetrachloroethene | 81 | CB-99-02 |
| Trichloroethene | 8.8 | TP-DEP-11 |
| Vinyl Chloride | 24 | CB-99-04 |
| **SVOCs** | | |
| 2-Methylnaphhalene | 45 | CB-99-03 |
| Acenaphthene | 190 | CB-99-15 |
| Anthracene | 520 J | CB-99-15 |
| Benzo(a)Anthracene | 1200 J | CB-99-15 |
| Benzo(a)Pyrene | 880 J | CB-99-15 |
| Benzo(b)Fluoranthene | 940 J | CB-99-15 |
| Benzo(k)Fluoranthene | 880 J | CB-99-15 |
| Carbazole | 310 | CB-99-15 |
| Chrysene | 1200 | CB-99-15 |
| Dibenz(a,h)Anthracene | 8.1 | CB-99-12 |
| Dibenzofuran | 130 | CB-99-15 |
| Fluoranthene | 2700 | CB-99-15 |
| Fluorene | 250 J | CB-99-15 |
| Hexachlorobenzene | 1.4 | TP-DEP-11 |
| Indeno(1,2,3-CD)Pyrene | 350 | CB-99-15 |
| Naphthalene | 97 J | CB-99-15 |
| Phenanthrene | 2400 | CB-99-15 |
| Pyrene | 1800 J | CB-99-15 |
| **PCBs** | | |
| Aroclor - 1016 | 1.2 J | TP-99-22 |
| Aroclor - 1260 | 11 | TP-99-23 |
| **Inorganics** | | |
| Arsenic | 34.5 | CB-99-08 |
| Beryllium | 13.1 | TP-DEP-11 |
| Cadmium | 94.7 | TP-DEP-11 |
| Lead | 1510 J | TP-DEP-11 |
| Thallium | 8.3 | CB-99-08 |
| Vanadium | 2640 | TP-DEP-11 |
| Zinc | 41.4 J | CB-99-01 |

Note: J = estimated value

### 1.8.1.2 List of Available Documents

Further information regarding site conditions is available in the Causeway Pre-design Investigation Report (Foster Wheeler/HLA, April 2000), the Final Causeway Engineering Evaluation/Cost Analysis (Foster Wheeler/HLA, September 2000), and the Causeway Decision Document (Harding ESE, 2001). These documents are a part of the public record for this site, and are available for review in Room 15 of Building 1 at the Stratford Army Engine Plant, 550 Main Street, Stratford, Connecticut.

### 1.8.2 Plan Requirements

The SSHP shall include a site description and contamination characterization section that addresses the following elements:

a. Description of site location, topography, size and past uses of the site.

b. A list of contaminants which may present occupational health and safety hazards. This list shall be created by evaluating the analytical results in this section and by researching sources of information from past site investigation activities. Chemical names, concentration ranges, media in which found, locations onsite, and estimated quantities/volumes to be impacted by site work shall be included if known. The contamination characterization shall be reviewed and revised if new chemicals are identified as work progresses.

## 1.9 HAZARD/RISK ANALYSIS

The SSHP shall include a safety and health hazard/risk analysis for each site task and operation to be performed. The hazard/risk analysis shall provide information necessary for determining safety and health procedures, equipment, and training to protect onsite personnel, the environment, and the public. Available site information shall be reviewed when preparing the "Hazard/Risk Analysis" section of the SSHP. The following elements, at a minimum, shall be addressed.

### 1.9.1 Site Tasks and Operations

The SSHP shall include a comprehensive section that addresses the tasks and objectives of the site operations for Phase I of this project, and the logistics and resources required to reach those tasks and objectives. Tthe following is a list of anticipated Phase I site tasks and operations to be performed: site preparation; erosion control system installation; clearing; demolition; and excavation. This is not a complete list of site tasks and operations; therefore, it shall be expanded and/or revised, during preparation of the SSHP as necessary. It is anticipated that the SSHP for Phase I of this project can be completed as an addendum to the Phase I SSHP.

### 1.9.2 Hazards

The following potential hazards may be encountered during site work. These are not complete lists; therefore, they shall be expanded and/or revised as necessary during preparation of the SSHP.

#### 1.9.2.1 Safety Hazards

Potential safety hazards associated with the work on the Causeway could be related to, operation of demolition equipment and heavy construction equipment, electrical hazards associated with removal of existing utilities, safety hazards associated with working near the water, and safety hazards from scattered debris present on the site.

#### 1.9.2.2 Chemical Hazards

Potential chemical hazards that may be encountered during site work are discussed in paragraph SITE DESCRIPTION AND CONTAMINATION CHARACTERIZATION. The Hazard/Risk Analysis section of the SSHP shall describe the chemical, physical, and toxicological properties of contaminants, sources and pathways of employee exposures, anticipated onsite and offsite exposure level potentials, and regulatory (including Federal, state, and local) or recommended protective exposure standards. The SSHP shall also address employee exposure to hazardous substances brought onsite, and shall comply with the requirements of 29 CFR 1910, Section .1200 and 29 CFR 1926, Section .59, Hazard Communication.

#### 1.9.2.3 Physical Agents

Potential physical hazards during work on the Causeway could include, heat stress and cold stress, noise related hazards, physical strain from heavy lifting, and slips, trips, and falls from scattered debris on the surface of the Causeway.

#### 1.9.2.4 Radiological Hazards

A radiological survey identified radiological soil contamination on the Causeway in excess of federal guidelines. This contaminated soil was removed from the Causeway and sent off-site for disposal. A final survey of the Causeway did not identified any additional areas of radiological contamination, and the facility has been released from the NRC license. Radiological hazards are not anticipated to be encountered on the Causeway during this work; however, the Contractor shall notify the Contracting Officer if a whitish clay-like material, historically associated with radiological contamination on the Causeway is encountered during excavation activities.

#### 1.9.2.5 Biological Hazards

Potential biological hazards associated with the work on the Causeway could primarily include insect and animal bites; however, additional hazards may be associated with working near the water.

### 1.9.3 Action Levels

#### 1.9.3.1 General Requirements

Action levels shall be established for the situations listed below, at a minimum. The action levels and required actions (engineering controls, changes in PPE, etc.) shall be presented in the SSHP in both text and tabular form.

a. Implementation of engineering controls and work practices.

b. Upgrade or downgrade in level of personal protective equipment.

c. Work stoppage and/or emergency evacuation of onsite personnel.

d. Prevention and/or minimization of public exposures to hazards created by site activities.

## 1.10 ACTIVITY HAZARD ANALYSES

Prior to beginning each major phase of work, an Activity Hazard Analysis shall be prepared by the Contractor performing that work and submitted for review and acceptance. The format shall be in accordance with EM 385-1-1, figure 1-1. A major phase of work is defined as an operation involving a type of work presenting hazards not experienced in previous operations or where a new subcontractor or work crew is to perform. The analysis shall define the activities to be performed and identify the sequence of work, the specific hazards anticipated, and the control measures to be implemented to eliminate or reduce each hazard to an acceptable level. Work shall not proceed on that phase until the activity hazard analysis has been accepted and a preparatory meeting has been conducted by the Contractor to discuss its contents with everyone engaged in the activities, including the government onsite representatives. The activity hazard analyses shall be continuously reviewed and when appropriate modified to address changing site conditions or operations, with the concurrence of the Safety and Health Manager, the Site Superintendent, and the Contracting Officer. Activity hazard analyses shall be attached to and become a part of the SSHP.

## 1.11 STAFF ORGANIZATION, QUALIFICATIONS, AND RESPONSIBILITIES

An organizational structure shall be developed that sets forth lines of authority (chain of command), responsibilities, and communication procedures concerning site safety, health, and emergency response. This organizational structure shall cover management, supervisors and employees of the Contractor and subcontractors. The structure shall include the means for coordinating and controlling work activities of subcontractors and suppliers. The SSHP shall include a description of this organizational structure as well as qualifications and responsibilities of each of the following individuals. The Contractor shall obtain Contracting Officer's acceptance before replacing any member of the Safety and Health Staff. Requests shall include the names, qualifications, duties, and responsibilities of each proposed replacement.

### 1.11.1 Site Superintendent

A Site Superintendent, who has responsibility to implement the SSHP, the authority to direct work performed under this contract and verify compliance, shall be designated.

### 1.11.2 Safety and Health Manager

#### 1.11.2.1 Qualifications

The services of an Industrial Hygienist certified by the American Board of Industrial Hygiene shall be utilized. The name, qualifications (education summary and documentation, ABIH certificate), and work experience summary shall be included in the SSHP. The Safety and Health Manager shall have the following additional qualifications:

a. A minimum of 3 years experience in developing and implementing safety and health programs at hazardous waste sites and thorough familiarity with the requirements of 29 CFR 1910.120 and 29 CFR 1926.65.

b. Documented experience in supervising professional and technician level personnel.

c. Documented experience in developing worker exposure assessment programs and air monitoring programs and techniques.

d. Documented experience in the development of personal protective equipment programs, including programs for working in and around potentially toxic, flammable and combustible atmospheres and confined spaces.

e. Working knowledge of state and Federal occupational safety and health regulations.

#### 1.11.2.2 Responsibilities

The Safety and Health Manager shall:

a. Be responsible for the development, implementation, oversight, and enforcement of the SSHP.

b. Sign and date the SSHP prior to submittal.

c. Conduct initial site-specific training.

d. Be present onsite during the first 3 days of remedial activities and at the startup of each new major phase.

e. Visit the site as needed and at least twice per month for the duration of activities, to audit the effectiveness of the SSHP.

f. Be available for emergencies.

g. Provide onsite consultation as needed to ensure the SSHP is fully implemented.

h. Coordinate any modifications to the SSHP with the Site Superintendent, the SSHO, and the Contracting Officer.

i. Provide continued support for upgrading/downgrading of the level of personal protection.

j. Be responsible for evaluating air monitoring data and recommending changes to engineering controls, work practices, and PPE.

k. Review accident reports and results of daily inspections.

l. Serve as a member of the Contractor's quality control staff.

### 1.11.3 Site Safety and Health Officer (SSHO)

#### 1.11.3.1 Qualifications of SSHO

An individual and one alternate shall be designated the Site Safety and Health Officer (SSHO). The name, qualifications (education and training summary and documentation), and work experience of the Site Safety and Health Officer and alternate shall be included in the SSHP. The SSHO shall have the following qualifications:

a. A minimum of 1 year experience in implementing safety and health programs at hazardous waste sites where Level C personal protective equipment was required.

b. Documented experience in construction techniques and construction safety procedures.

c. Working knowledge of Federal and state occupational safety and health regulations.

d. Specific training in personal and respiratory protective equipment program implementation, confined space program oversight, and in the proper use of air monitoring instruments, and air sampling methods including monitoring for ionizing radiation.

#### 1.11.3.2 Responsibilities of SSHO

The Site Safety and Health Officer shall:

a. Assist and represent the Safety and Health Manager in onsite training and the day to day onsite implementation and enforcement of the accepted SSHP.

b. Be assigned to the site on a full time basis for the duration of field activities. The SSHO shall have no duties other than Safety and Health related duties. If operations are performed during more than 1 work shift per day, a site Safety and Health Officer shall be present for each shift.

c. Have authority to ensure site compliance with specified safety and health requirements, Federal, state and OSHA regulations and all aspects of the SSHP including, but not limited to, activity hazard analyses, air monitoring, monitoring for ionizing radiation, use of PPE, decontamination, site control, standard operating procedures used to minimize hazards, safe use of engineering controls, the emergency response plan, confined space entry procedures, spill containment program, and preparation of records by performing a daily safety and health inspection and documenting results on the Daily Safety Inspection Log.

d. Have authority to stop work if unacceptable health or safety conditions exist, and take necessary action to re-establish and maintain safe working conditions.

e. Consult with and coordinate any modifications to the SSHP with the Safety and Health Manager, the Site Superintendent, and the Contracting Officer.

f. Serve as a member of the Contractor's quality control staff on matters relating to safety and health.

g. Conduct accident investigations and prepare accident reports.

h. Review results of daily quality control inspections and document safety and health findings into the Daily Safety Inspection Log.

i. In coordination with site management and the Safety and Health Manager, recommend corrective actions for identified deficiencies and oversee the corrective actions.

### 1.11.4 Occupational Physician (OP)

### 1.11.4.1 Qualifications of OP

The services of a licensed physician, who is certified in occupational medicine by the American Board of Preventative Medicine, or who, by necessary training and experience is Board eligible, shall be utilized. The physician shall be familiar with this site's hazards and the scope of this project. The medical consultant's name, qualifications, and knowledge of the site's conditions and proposed activities shall be included in the SSHP.

### 1.11.4.2 Responsibilities of OP

The physician shall be responsible for the determination of medical surveillance protocols and for review of examination/test results performed in compliance with 29 CFR 1910, Section .120 (f) and 29 CFR 1926, Section .65 (f) and paragraph MEDICAL SURVEILLANCE.

### 1.11.5 Persons Certified in First Aid and CPR

At least two persons who are currently certified in first aid and CPR by the American Red Cross or other approved agency shall be onsite at all times during site operations. They shall be trained in universal precautions and the use of PPE as described in the Bloodborne Pathogens Standard of 29 CFR

1910, Section .1030. These persons may perform other duties but shall be immediately available to render first aid when needed.

### 1.11.6 Safety and Health Technicians

For each work crew in the exclusion zone, one person, designated as a Safety and Health technician, shall perform activities such as air monitoring, decontamination, and safety oversight on behalf of the SSHO. They shall have appropriate training equivalent to the SSHO in each specific area for which they have responsibility and shall report to and be under the supervision of the SSHO.

### 1.11.7 Certified Safety Professional (CSP)

The Safety and Health Manager may act as the CSP.

## 1.12 TRAINING

Personnel shall receive training in accordance with the Contractor's written safety and health training program and 29 CFR 1910 Section .120, 29 CFR 1926 Section .65, and 29 CFR 1926 Section .21. The SSHP shall include a section describing training requirements.

### 1.12.1 General Hazardous Waste Operations Training

Personnel entering the exclusion or contamination reduction zones shall have successfully completed 40 hours of hazardous waste instruction off the site; 3 days actual field experience under the direct supervision of a trained, experienced supervisor; and 8 hours refresher training annually. Onsite supervisors shall have completed the above training and 8 hours of additional, specialized training covering at least the following topics: the employer's safety and health program, personal protective equipment program, spill containment program, and health hazard monitoring procedures and techniques. Copies of current training certification statements shall be submitted prior to initial entry onto the work site.

### 1.12.2 Site-specific Training

Site-specific training sessions shall be documented in accordance with Section 01.B.03.b of EM 385-1-1.

#### 1.12.2.1 Initial Session (Pre-entry Briefing)

Prior to commencement of onsite field activities, all site employees, including those assigned only to the Support Zone, shall attend a site-specific safety and health training session of at least 4 hours duration. This session shall be conducted by the Safety and Health Manager and the Site Safety and Health Officer to ensure that all personnel are familiar with requirements and responsibilities for maintaining a safe and healthful work environment. Procedures and contents of the accepted SSHP and Sections 01.B.02 and 28.D.03 of EM 385-1-1 shall be thoroughly discussed. The Contracting Officer shall be notified at least 5 days prior to the initial site-specific training session so government personnel involved in the project may attend.

#### 1.12.2.2 Periodic Sessions

Periodic onsite training shall be conducted by the SSHO at least weekly for personnel assigned to work at the site during the following week. The training shall address safety and health procedures, work practices, any changes in the SSHP, activity hazard analyses, work tasks, or schedule; results of previous week's air monitoring, review of safety discrepancies and accidents. Should an operational change affecting onsite field work be made, a meeting prior to implementation of the change shall be convened to explain safety and health procedures. Site-specific training sessions for new personnel, visitors, and suppliers shall be conducted by the SSHO using the training curriculum outlines developed by the Safety and Health Manager.

## 1.13 PERSONAL PROTECTIVE EQUIPMENT

### 1.13.1 PPE Program

In accordance with 29 CFR 1910 Section .120 (g)(5) and 29 CFR 1926 Section .65 (g)(5), a written Personal Protective Equipment (PPE) program which addresses the elements listed in that regulation, and which complies with respiratory protection program requirements of 29 CFR 1910 Section .134, is to be included in the employer's Safety and Health Program. The Site Safety and Health Plan shall detail the minimum PPE ensembles (including respirators) and specific materials from which the PPE components are constructed for each site-specific task and operation to be performed, based upon the hazard/risk analysis. Components of levels of protection (B, C, D and modifications) must be relevant to site-specific conditions, including heat and cold stress potential and safety hazards. Only respirators approved by NIOSH shall be used. Onsite personnel shall be provided with appropriate personal protective equipment. Protective equipment and clothing shall be kept clean and well maintained. The PPE section of the SSHP shall include site-specific procedures to determine PPE program effectiveness and for onsite fit-testing of respirators, cleaning, maintenance, inspection, and storage of PPE.

### 1.13.2 Levels of Protection

The Safety and Health Manager shall establish appropriate levels of protection for each work activity based on review of historical site information, existing data, an evaluation of the potential for exposure (inhalation, dermal, ingestion, and injection) during each task, past air monitoring results, and a continuing safety and health monitoring program. The Safety and Health Manager shall also establish action levels for upgrade or downgrade in levels of PPE from the following specified minimum levels of protection. Protocols and the communication network for changing the level of protection shall be described in the SSHP. The PPE reassessment protocol shall address air monitoring results, potential for exposure, changes in site conditions, work phases, job tasks, weather, temperature extremes, individual medical considerations, etc.

#### 1.13.2.1 Components of Levels of Protection

The following items constitute minimum protective clothing and equipment ensembles to be utilized during this project:

Level D. Appropriate work attire, hard hat, protective eyeglasses, ANSI-approved steel toe work boots, and ear protection, as necessary.

Modified Level D. As for Level D. In addition, tyvek, nitrile gloves, protective over-boots

Level C. As for Modified Level D. In addition, full face respirator with chemical-appropriate cartridges.

Level B. As for Modified Level D. In addition, supplied air breathing system.

### 1.13.2.2 Initial Minimum Levels of PPE by Task

Based on available information, the initial minimum protective equipment requirements for each major task and operation are listed below. Available site information shall be reviewed and the list of tasks and operations and these levels of protection shall be expanded and/or revised during preparation of the SSHP.

MINIMUM PROTECTIVE EQUIPMENT REQUIREMENTS

| TASK/OPERATION | INITIAL LEVEL OF PROTECTION |
|---|---|
| Mobilization | Level D |
| Site Preparation | Level D |
| Erosion Control System Installation | Level D |
| Clearing | Level D |
| Demolition (except asbestos abatement) | Level D |
| Oversized Debris Removal | Modified Level D |
| Excavation | Modified Level D |
| Topographic Survey | Level D |

### 1.13.3 PPE for Government Personnel

Three clean sets of personal protective equipment and personal dosimeters for work on radioactive waste cleanup sites and clothing (excluding air-purifying negative-pressure respirators and safety shoes, which will be provided by individual visitors), as required for entry into the Exclusion Zone and/or Contamination Reduction Zone, shall be available for use by the Contracting Officer or official visitors. The items shall be cleaned and maintained by the Contractor and stored in the Contractor field office and clearly marked: "FOR USE BY GOVERNMENT ONLY." The Contractor shall provide basic training in the use and limitations of the PPE provided, and institute administrative controls to check prerequisites prior to issuance. Such prerequisites include meeting minimum training requirements for the work tasks to be performed and medical clearance for site hazards and respirator use.

## 1.14 MEDICAL SURVEILLANCE

The Safety and Health Manager, in conjunction with the Occupational Physician, shall detail, in the employer's Safety and Health Program and the SSHP, the medical surveillance program that includes scheduling of examinations, certification of fitness for duty, compliance with OSHA requirements, and information provided to the physician. Examinations shall be performed by or under the supervision of a licensed physician, preferably one knowledgeable in occupational medicine, and shall be provided without cost to the employee, without loss of pay and at a reasonable time and place. Medical surveillance protocols and examination and test results shall be reviewed by the Occupational Physician. The medical surveillance program shall contain the requirements specified below. Personnel working in contaminated areas of the site shall have been examined as prescribed in 29 CFR 1910 Section .120, and 29 CFR 1926 Section .65, and determined medically fit to perform their duties.

### 1.14.1 Frequency of Examinations

Employees shall have been provided with medical examinations as specified, within the past 12 months and shall receive exams annually thereafter (if contract duration exceeds 1 year); on termination of employment; reassignment in accordance with 29 CFR 1910 Section .120 (f)(3)(i), and 29 CFR 1926 Section .65 (f)(3)(i)(C); if the employee develops signs or symptoms of illness related to workplace exposures; if the physician determines examinations need to be conducted more often than once a year; and when an employee develops a lost time injury or illness during the period of this contract. The supervisor shall be provided with a written statement signed by the physician prior to allowing the employee to return to the work site after injury or illness resulting in a lost workday, as defined in 29 CFR 1904 Section .12 (f).

### 1.14.2 Content of Examinations

The following elements shall be included in the medical surveillance program. Additional elements may be included at the discretion of the occupational physician responsible for reviewing the medical surveillance protocols.

a. Complete medical and occupational history (initial exam only).

b. General physical examination of major organ systems.

c. Pulmonary function testing including FVC and FEV1.0.

d. CBC with differential.

e. Blood chemistry screening profile (e.g. SMAC 20/25).

f. Urinalysis with microscopic examination.

g. Audiometric testing (as required by Hearing Conservation Program).

h. Visual acuity.

i. Chest x-ray. (This test shall be performed no more frequently than every 4 years, unless directed by Occupational Physician.)

j. Electrocardiogram (as directed by Occupational Physician).

### 1.14.3 Information Provided to the Occupational Physician

The physician shall be furnished with the following:

a. Site information from paragraph, SITE DESCRIPTION AND CONTAMINATION CHARACTERIZATION.

b. Information on the employee's anticipated or measured exposure.

c. A description of any PPE used or to be used.

d. A description of the employee's duties as they relate to the employee's exposures (including physical demands on the employee and heat/cold stress).

e. A copy of 29 CFR 1910 Section .120, or 29 CFR 1926 Section .65.

f. Information from previous examinations not readily available to the examining physician.

g. A copy of Section 5.0 of NIOSH Pub No. 85-115.

h. Information required by 29 CFR 1910 Section .134.

### 1.14.4 Physician's Written Opinion

Before work begins a copy of the physician's written opinion for each employee shall be obtained and furnished to the Safety and Health Manager; and the employee. The opinion shall address the employee's ability to perform hazardous remediation work and shall contain the following:

a. The physician's recommended limitations upon the employee's assigned work and/or PPE usage.

b. The physician's opinion about increased risk to the employee's health resulting from work; and

c. A statement that the employee has been informed and advised about the results of the examination.

### 1.14.5 Medical Records

Documentation of medical exams shall be provided as part of the Certificate of Worker or Visitor Acknowledgment. Medical records shall be maintained in accordance with 29 CFR 1910 Section .120, and 29 CFR 1926 Section .65.

## 1.15 RADIATION DOSIMETRY

A radiation protection and dosimetry program shall be described in the SSHP and implemented in accordance with 10 CFR 20. Causeway soil containing radiological contamination above federal guidelines has been removed from the site. A final radiation survey has been completed on the Causeway and the facility has been released from the NRC license.

### 1.15.1 Evaluation

Radiation dosimetry shall be evaluated by an individual or company holding current personnel dosimetry accreditation from the National Voluntary Laboratory Accreditation Program (NVLAP). Electronic dosimetry may be used to assign external dose if approved by the Contracting Officer.

### 1.15.2 Documentation

Employee exposure to external radiation shall be documented. This shall include reviewing each employee's radiation exposure history in accordance with 10 CFR 20 Section .2104, for compliance with exposure standards prior to allowing the employee access to a restricted area. If the employee has no exposure history, the employee shall provide a signed written statement to that effect.

## 1.16 EXPOSURE MONITORING/AIR SAMPLING PROGRAM

The Safety and Health Manager shall prepare and implement an exposure monitoring/air sampling program in accordance with the air monitoring plan identified in the SSHP, to identify and quantify safety and health hazards and airborne levels of hazardous substances. The air sampling program shall be used to assure proper selection of engineering controls, work practices and personal protective equipment for affected site personnel and shall evaluate the potential impacts to off-site receptors. Available site information shall be reviewed and the exposure monitoring/air sampling program shall be expanded and/or revised for submittal as part of the SSHP.

At a minimum, air monitoring shall be conducted during excavation of soil contaminated with VOCs and SVOCs in exceedance of CTDEP RSRs PMC criteria. Monitoring activities should include the use of real-time monitoring equipment, including a photoionization detector or a flame ionization detector, to monitor concentrations of volatiles in the breathing zone. Additional monitoring devices should be available to identify the type of volatile contaminant present if levels in the breathing zone persist above action levels.

Dust monitoring should be conducted during demolition/excavation activities to ensure off-site migration of dust is not creating a potentially hazardous situation. At a minimum, real-time monitoring equipment shall be used to monitor the levels of airborne dust.

## 1.17 HEAT AND COLD STRESS MONITORING

The Safety and Health Manager shall develop a heat stress and cold stress monitoring program for onsite activities. Details of the monitoring program, including schedules for work and rest, and physiological monitoring requirements, shall be described in the SSHP. Personnel shall be trained to recognize the symptoms of heat and cold stress. The SSHO and an alternate person shall be designated, in writing, to be responsible for the heat and cold stress monitoring program.

### 1.17.1 Heat Stress

Physiological monitoring shall commence when the ambient temperature is above 70 degrees F. Monitoring frequency shall increase as the ambient temperature increases or as slow recovery rates are observed. An adequate supply of cool drinking water shall be provided for the workers. NIOSH Pub No. 85-115 may be consulted for guidance in determining protocols for prevention of heat stress.

### 1.17.2 Cold Stress

To guard against cold injury, appropriate clothing and warm shelter for rest periods shall be provided. Procedures to monitor and avoid cold stress shall be followed in accordance with the current TLVs for Cold Stress as recommended in ACGIH Threshold Limits.

## 1.18 SAFETY PROCEDURES, ENGINEERING CONTROLS AND WORK PRACTICES

The SSHP shall describe the standard operating safety procedures, engineering controls and safe work practices to be implemented for the work covered. These shall include, but not be limited to, the following:

### 1.18.1 General Site Rules/Prohibitions

General site rules/prohibitions (e.g., buddy system, eating, drinking, and smoking restrictions, etc.) will be applicable in the Exclusion Zone.

### 1.18.2 Work Permit Requirements

Work permits shall not be required for completion of this work.

### 1.18.3 Material Handling Procedures

Excavated soil containing concentrations of site contaminants in excess of CTDEP RSRs shall be transported off-site to an appropriate treatment/disposal facility. The material shall be excavated, placed into dump trucks, and transported directly to the treatment/disposal facility. No additional handling of the material shall be conducted, unless otherwise directed by the Contracting Officer. Contaminated material handling shall comply with the requirements in Section 02111 EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL.

#### 1.18.3.1 Spill and Discharge Control

Written spill and discharge containment/control procedures shall be developed in the SSHP and implemented during construction. These procedures shall describe prevention measures, such as building berms or dikes; spill control measures and material to be used (e.g. booms, vermiculite); location of the spill control material; personal protective equipment required to cleanup spills; disposal of contaminated material; and who is responsible to report the spill. If the spill or discharge is reportable, and/or human health or the environment are threatened, the National Response Center, the state, and the Contracting Officer shall be notified as soon as possible.

## 1.19 SITE CONTROL MEASURES

In order to prevent the spread of contamination and control the flow of personnel, vehicles, and materials into and out of work areas, site control measures shall be established and described in the SSHP. The SSHP shall describe the methodology to be used by the Safety and Health Manager and SSHO in determining work zone designations and their modifications, and procedures to limit the spread of contamination. The SSHP shall include procedures for the implementation and enforcement of safety and health rules for all persons on the site, including employers, employees, outside Contractors, government representatives, and visitors.

### 1.19.1 Work Zones

Initial anticipated Contractor accessible areas are shown on the drawings. Utilizing this guidance, work zone boundaries (exclusion zone, including restricted and regulated areas; contamination reduction zone; and support zone) and access points shall be established and the boundary delineations shall be included on the drawings and in the SSHP. Delineation of work zone boundaries shall be based on the contamination characterization data and the hazard/risk analysis to be performed as described in paragraph: HAZARD/RISK ANALYSIS. As work progresses and field conditions are monitored, work zone boundaries may be modified with approval of the Contracting Officer. Work zones shall be clearly identified and marked in the field (using fences, tape, signs, etc.). A site map, showing work zone boundaries and locations of decontamination facilities, shall be posted in the onsite office. Work zones shall consist of the following:

a. Exclusion Zone (EZ): The exclusion zone is the area where hazardous contamination is either known or expected to occur and the greatest potential for exposure exists. Entry into this area shall be controlled and exit may only be made through the CRZ.

b. Contamination Reduction Zone (CRZ): The CRZ is the transition area between the Exclusion Zone and the Support Zone. The personnel and equipment decontamination areas shall be separate and unique areas located in the CRZ.

c. Support Zone (SZ): The Support Zone is defined as areas of the site, other than exclusion zones and contamination reduction zones, where workers do not have the potential to be exposed to hazardous substances or dangerous conditions resulting from hazardous waste operations. The Support Zone shall be secured against active or passive contamination. Site offices, parking areas, and other support facilities shall be located in the Support Zone.

### 1.19.2 Site Control Log

A log of personnel visiting, entering, or working on the site shall be maintained. The log shall include the following: date, name, agency or company, time entering and exiting site, time entering and exiting the exclusion zone (if applicable), and personal protective equipment utilized. Before visitors are allowed to enter the Contamination Reduction Zone or Exclusion Zone, they shall show proof of current training, medical surveillance and respirator fit testing (if respirators are required for the tasks to be performed) and shall fill out the Certificate of Worker or Visitor Acknowledgment. This visitor information, including date, shall be recorded in the log.

### 1.19.3 Communication

An employee alarm system that has adequate means of on and off site communication shall be provided and installed in accordance with 29 CFR 1910 Section .165. The means of communication shall be able to be perceived above ambient noise or light levels by employees in the affected portions of the workplace. The signals shall be distinctive and recognizable as messages to evacuate or to perform critical operations. This includes: air horns for emergency situations, two-way radio communications for on-site Contractor personnel, and telephone for off-site communications.

In addition, the Contractor shall obtain a SAEP approved two-way radio for communication with SAEP personnel on a daily basis. This radio must be returned to SAEP upon departure from the site, daily.

### 1.19.4 Site Security

The SAEP site has 24-hour security personnel on-site, in addition to monitored perimeter fencing. The Contractor shall supply warning signs printed in bold large letters on contrasting backgrounds in English and/or where appropriate, in the predominant language of workers unable to read English. Signs shall be visible from all points where entry might occur and at such distances from the restricted area that employees may read the signs and take necessary protective steps before entering.

## 1.20 PERSONAL HYGIENE AND DECONTAMINATION

Personnel entering the Exclusion or Contamination Reduction Zones or otherwise exposed or subject to exposure to hazardous chemical vapors, liquids, or contaminated solids shall adhere to the following personal hygiene and decontamination provisions. Decontamination shall be performed in the CRZ prior to entering the Support Zone from the Exclusion Zone. Chapter 10.0 of NIOSH Pub No. 85-115 shall be consulted when preparing decontamination procedures. A detailed discussion of personal hygiene and decontamination facilities and procedures to be followed by site workers shall be submitted as part of the SSHP. Employees shall be trained in the procedures and the procedures shall be enforced throughout site operations. Persons disregarding these provisions of the SSHP shall be barred from the site.

### 1.20.1 Personnel Decontamination Facilities

A personnel decontamination facility shall be provided in the CRZ. This facility shall be used by both Contractor personnel and government representatives. The decontamination facility shall provide for separation of street clothing and contaminated PPE and shall be equipped with heating, lighting, ventilation, a change room and lockers, hot and cold water, towels, and soap in sufficient quantities for all anticipated personnel. Decontamination water containing surfactants shall be segregated from surfactant-free decontamination water for disposal.

### 1.20.2 Procedures

Minimum decontamination procedures are listed below. Available site information shall be reviewed and these procedures shall be expanded and/or revised for submittal as part of the SSHP.

Decontamination of on-site personnel shall include removal of gross contamination from PPE, removal of PPE (except gloves), removal of gloves, and washing and drying of exposed skin surfaces (e.g., hands, arms, face, etc.). Decontamination procedures should be completed in the above-listed order.

## 1.21 EQUIPMENT DECONTAMINATION

Vehicles and equipment used in the EZ shall be decontaminated in the CRZ prior to leaving the site. The procedures for decontamination of vehicles and equipment shall be addressed in the SSHP.

### 1.21.1 Equipment Decontamination Facilities

An equipment decontamination station shall be provided within the CRZ (on facility property) for decontaminating vehicles and equipment leaving the EZ. At a minimum, the decontamination station shall include the following: A traffic surface consisting of a minimum of 12 inches of crushed rock. The crushed rock shall be underlayed by a chemically resistant impermeable flexible membrane, such as HDPE, PVC or VLDPE with a minimum thickness of 40 mils. The liner shall be protected from damage on top with a geotextile. The base layer on which the membrane is placed shall be free of objects greater than 0.375 inches in diameter and any other materials which could puncture or damage the membrane. The pad shall be constructed to capture decontamination water, including overspray, and shall allow for collection and removal of the decontamination water using sumps, dikes and ditches as required. A steam cleaning system shall be used to remove site material from the equipment. The use of surfactants shall not be allowed, due to discharge requirements to the facility Chemical Waste Treatment Plant, unless approved by the Contracting Officer.

There shall be a designated "clean area" in the CRZ for performing equipment maintenance. This area shall be used when personnel are required by normal practices to come in contact with the ground, i.e., crawling under a vehicle to change engine oil. Equipment within the EZ or CRZ shall be decontaminated before maintenance is performed.

### 1.21.2 Procedures

Procedures for equipment decontamination shall be developed and utilized to prevent the spread of contamination into the SZ and offsite areas. These procedures shall address disposal of contaminated products and spent materials used on the site, including containers, fluids, oils, etc. Any item taken into the EZ shall be assumed to be contaminated and shall be inspected and/or decontaminated before the item leaves the area. Vehicles, equipment, and materials shall be cleaned and decontaminated prior to leaving the site. Construction material shall be handled in such a way as to minimize the potential for contaminants being spread and/or carried offsite. Prior to exiting the site, vehicles and equipment shall be inspected to ensure the adequacy of decontamination.

## 1.22 DEBRIS DECONTAMINATION

Demolition debris and oversized debris to be removed from the Causeway shall be cleaned of Causeway soil as detailed in Section 02220 DEMOLITION. The procedures for decontamination of debris shall be addressed in the SSHP.

## 1.23 EMERGENCY EQUIPMENT AND FIRST AID REQUIREMENTS

The SSHP shall describe the emergency and first aid equipment to be available onsite. The following items, as a minimum, shall be maintained onsite and available for immediate use:

a. First aid equipment and supplies approved by the consulting physician.

b. Emergency eyewashes and showers which comply with ANSI Z358.1.

c. Emergency-use respirators. For escape purposes, two 5- to 15-minute emergency escape masks shall be supplied. For rescue purposes, two positive pressure self-contained breathing apparatus (SCBA) shall be supplied. These shall be dedicated for emergency use only and maintained onsite in the Contamination Reduction Zone.

d. Fire extinguishers with a minimum rating of 20-A:120-B:C shall be provided at site facilities and in all vehicles and at any other site locations where flammable or combustible materials present a fire risk.

## 1.24 EMERGENCY RESPONSE AND CONTINGENCY PROCEDURES

An Emergency Response Plan, that meets the requirements of 29 CFR 1910Section .120 (l) and 29 CFR 1926 Section .65 (l), shall be developed and implemented as a section of the SSHP. In the event of any emergency associated with remedial action, the Contractor shall, without delay, alert all onsite employees that there is an emergency situation; take action to remove or otherwise minimize the cause of the emergency; alert the Contracting Officer; and institute measures necessary to prevent repetition of the conditions or actions leading to, or resulting in, the emergency. Employees that are required to respond to hazardous emergency situations shall be trained in how to respond to such expected emergencies. The plan shall be rehearsed regularly as part of the overall training program for site operations. The plan shall be reviewed periodically and revised as necessary to reflect new or changing site conditions or information. Copies of the accepted SSHP and revisions shall be provided to the affected local emergency response agencies. The following elements, as a minimum, shall be addressed in the plan:

a. Pre-emergency planning. The local emergency response agencies shall be contacted and met with during preparation of the Emergency Response Plan. Agencies to be contacted include local fire, police, and rescue authorities with jurisdiction and nearby medical facilities that may be utilized for emergency treatment of injured personnel. At these meetings, the agencies shall be notified of upcoming site activities and potential emergency situations. The response agencies' capabilities shall be ascertained and written response commitments obtained. The Contractor shall ensure the Emergency Response Plan for the site is compatible and integrated with the disaster, fire and/or emergency response plans of local, state, and Federal agencies.

b. Personnel roles, lines of authority, communications for emergencies.

c. Emergency recognition and prevention.

d. Site topography, layout, and prevailing weather conditions.

e. Criteria and procedures for site evacuation (emergency alerting procedures, employee alarm system, emergency PPE and equipment, safe distances, places of refuge, evacuation routes, site security and control).

f. Specific procedures for decontamination and medical treatment of injured personnel.

g. Route maps to nearest pre-notified medical facility. Site-support vehicles shall be equipped with maps. At the beginning of project operations, drivers of the support vehicles shall become familiar with the emergency route and the travel time required.

h. Emergency alerting and response procedures including posted instructions and a list of names and telephone numbers of emergency contacts (physician, nearby medical facility, fire and police departments, ambulance service, Federal, state, and local environmental agencies; as well as Safety and Health Manager, the Site Superintendent, the Contracting Officer and/or their alternates).

i. Criteria for initiating community alert program, contacts, and responsibilities.

j. Procedures for reporting incidents to appropriate government agencies. In the event that an incident such as an explosion or fire, or a spill or release of toxic materials occurs during the course of the project, the appropriate government agencies shall be immediately notified. In addition, the Contracting Officer shall be verbally notified immediately and receive a written notification within 24 hours. The report shall include the following items:

    (1) Name, organization, telephone number, and location of the Contractor.

    (2) Name and title of the person(s) reporting.

    (3) Date and time of the incident.

    (4) Location of the incident, i.e., site location, facility name.

(5) Brief summary of the incident giving pertinent details including type of operation ongoing at the time of the incident.

(6) Cause of the incident, if known.

(7) Casualties (fatalities, disabling injuries).

(8) Details of any existing chemical hazard or contamination.

(9) Estimated property damage, if applicable.

(10) Nature of damage, effect on contract schedule.

(11) Action taken to ensure safety and security.

(12) Other damage or injuries sustained, public or private.

k. Procedures for critique of emergency responses and follow-up.

## 1.25 CERTIFICATE OF WORKER/VISITOR ACKNOWLEDGEMENT

A copy of a Contractor-generated certificate of worker/visitor acknowledgement shall be completed and submitted for each visitor allowed to enter contamination reduction or exclusion zones, and for each employee, following the example certificate at the end of this section.

## 1.26 INSPECTIONS

The SSHO shall perform daily inspections of the jobsite and the work in progress to ensure compliance with EM 385-1-1, the Safety and Health Program, the SSHP and other occupational health and safety requirements of the contract, and to determine the effectiveness of the SSHP. Procedures for correcting deficiencies (including actions, timetable and responsibilities) shall be described in the SSHP. Follow-up inspections to ensure correction of deficiencies shall be conducted and documented. Daily safety inspection logs shall be used to document the inspections, noting safety and health deficiencies, deficiencies in the effectiveness of the SSHP, and corrective actions taken. The SSHO's Daily Inspection Logs shall be attached to and submitted with the Daily Quality Control reports. Each entry shall include the following: date, work area checked, employees present in work area, PPE and work equipment being used in each area, special safety and health issues and notes, and signature of preparer. In the event of an accident, the Contracting Officer shall be notified according to EM 385-1-1. Within 2 working days of any reportable accident, an Accident Report shall be completed on ENG Form 3394 and submitted.

## 1.27 SAFETY AND HEALTH PHASE-OUT REPORT

A Safety and Health Phase-Out Report shall be submitted within 10 working days following completion of the work, prior to final acceptance of the work. The following minimum information shall be included:

a. Summary of the overall performance of safety and health (accidents or incidents including near misses, unusual events, lessons learned, etc.).

b. Final decontamination documentation including procedures and techniques used to decontaminate equipment, vehicles, and on site facilities.

c. Summary of exposure monitoring and air sampling accomplished during the project.

d. Signatures of Safety and Health Manager and SSHO.

## EXAMPLE CERTIFICATE OF WORKER/VISITOR ACKNOWLEDGMENT

PROJECT NAME CONTRACT NO.
PROJECT ADDRESS
CONTRACTOR'S NAME
[EMPLOYEE'S][VISITOR'S] NAME

The contract for the above project requires the following: that you be provided with and complete formal and site-specific training; that you be supplied with proper personal protective equipment including respirators; that you be trained in its use; and that you receive a medical examination to evaluate your physical capacity to perform your assigned work tasks, under the environmental conditions expected, while wearing the required personal protective equipment. These things are to be done at no cost to you. By signing this certification, you are acknowledging that your employer has met these obligations to you.

I HAVE READ, UNDERSTAND AND AGREE TO FOLLOW THE SITE SAFETY AND HEALTH PLAN FOR THIS SITE.

| Name | Date |
|---|---|
| ------------------------------ | ------------------------------ |

FORMAL TRAINING: I have completed the following formal training courses that meet OSHA's requirements:

| | Date Completed |
|---|---|
| 40 hour: ............................ | ________________ |
| 8 hour supervisory:.................. | ________________ |
| 8 hour refresher:.................... | ________________ |

SITE-SPECIFIC TRAINING: I have been provided and have completed the site-specific training required by this Contract. The Site Safety and Health Officer conducted the training. ______________

RESPIRATORY PROTECTION: I have been trained in accordance with the criteria in [the Contractor's] [my Employer's] Respiratory Protection program. I have been trained in the proper work procedures and use and limitations of the respirator(s) I will wear. I have been trained in and will abide by the facial hair policy. ______________________

RESPIRATOR FIT-TEST TRAINING: I have been trained in the proper selection, fit, use, care, cleaning, and maintenance, and storage of the respirator(s) that I will wear. I have been fit-tested in accordance with the criteria in [the Contractor's] [my employer's] Respiratory Program and have received a satisfactory fit. [I have been assigned my individual respirator.] I have been taught how to properly perform positive and negative pressure fit-check upon donning negative pressure respirators each time.________________

MEDICAL EXAMINATION: I have had a medical examination within the last twelve months which was paid for by my employer. The examination included: health history, pulmonary function tests and may have included an evaluation of a chest ax-ray. A physician made determination regarding my physical capacity to perform work tasks on the project while wearing protective equipment including a respirator. I was personally provided a copy and informed of the results of that examination. My employer's industrial hygienist evaluated the medical certification provided by the physician and checked the appropriate blank below. The physician determined that there:

were no limitations to performing the required work tasks;

were identified physical limitations to performing the required work tasks.

Date medical exam completed

[Employee's] [Visitor's] Signature ______________________________
Date ____________________

Printed Name ______________________

Social Security Number _________________

Contractor's Site Safety and Health Officer Signature _______________

Date ____________________

Printed Name ______________________

Social Security Number _________________

## PART 2 PRODUCTS (NOT APPLICABLE)

## PART 3 EXECUTION (NOT APPLICABLE)

--End of Section--

## SECTION 01410

## ENVIRONMENT PROTECTION
**02/97**

## PART 1 GENERAL

### 1.1 DESCRIPTION

The Contractor shall perform the work minimizing environmental pollution and damage as the result of construction operations. Environmental pollution and damage is the presence of chemical, physical, or biological elements or agents which adversely affect human health or welfare; unfavorably alter ecological balances of importance to human life; affect other species of importance to humankind; or degrade the utility of the environment for aesthetic, cultural and/or historical purposes. The control of environmental pollution and damage requires consideration of land, water, and air, and includes management of visual aesthetics, noise, solid waste, and dust, as well as other pollutants. The environmental resources within the project boundaries and those affected outside the limits of permanent work shall be protected during the entire duration of this contract.

### 1.2 REFERENCES (NOT USED)

### 1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals not having a "GA" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-01 Pre-construction Submittals

Environment Protection Plan; GA

The Contractor shall submit, an Environment Protection Plan. Approval of the Contractor's plan will not relieve the Contractor of responsibility for adequate and continuing control of pollutants and other environmental protection measures. The environmental protection plan shall include, but shall not be limited to, the following:

a. Pre-construction Site Inventory Report indicating the site conditions prior to initiating work, including the conditions on property adjacent to the site.

b. Erosion and Sediment Control Plan detailing the procedures to be followed to limit erosion from the Causeway surface during site work.

c. A list of Federal, State, and local laws, regulations, and permits concerning environmental protection, pollution control and abatement that are applicable to the Contractor's proposed operations and the requirements imposed by those laws, regulations, and permits.

d. Methods for protection of features to be preserved within authorized work areas like air and water quality, fish and wildlife, tidal flat sediment, historical, archaeological, and cultural resources.

e. Procedures to be implemented to provide the required environmental protection, to comply with the applicable laws and regulations, and to correct pollution due to accident, natural causes, or failure to follow the procedures of the environmental protection plan.

f. Drawings showing locations of any proposed material storage areas, and stockpiles of excess or spoil materials.

g. Environmental monitoring plans for the job site, including land, water, air, and noise monitoring.

h. Traffic control plan including measures to reduce the amount of mud transported onto paved public roads by vehicles or runoff.

i. Methods of protecting surface and ground water during construction activities.

j. Plan showing the proposed activity in each portion of the work area and identifying the areas of limited use or nonuse. Plan should include measures for marking the limits of use areas.

k. A recycling and waste prevention plan with a list of measures to reduce consumption of energy and natural resources; for example: the possibility to shred fallen trees and use them as mulch shall be considered as an alternative to burning or burial.

l. Training for Contractor's personnel during the construction period.

## 1.4 CONTRACTOR REQUIREMENTS

### 1.4.1 Subcontractors

The Contractor shall ensure compliance with this section by subcontractors.

### 1.4.2 Permits

The Contractor shall obtain all needed permits or licenses. The Government will not obtain any permits for this project; see Contract Clause PERMITS AND RESPONSIBILITIES. The Contractor shall be responsible for implementing the terms and requirements of the appropriate permits as needed and for payment of all fees.

### 1.4.3 Pre-construction Site Inventory

Prior to starting any onsite construction activities, the Contractor and the Contracting Officer shall make a joint condition survey after which the Contractor shall prepare a brief report indicating on a layout plan the condition of trees, shrubs and grassed areas immediately adjacent to work sites and adjacent to the assigned storage area and access routes as applicable. This report will be signed by both the Contracting Officer and the Contractor upon mutual agreement as to its accuracy and completeness.

### 1.4.4 Meetings

The Contractor shall meet with representatives of the Contracting Officer to alter the environmental protection plan as needed for compliance with the environmental pollution control program.

### 1.4.5 Notification

The Contracting Officer will notify the Contractor in writing of any observed noncompliance with the previously mentioned Federal, State or local laws or regulations, permits, and other elements of the Contractor's Environment Protection Plan. The Contractor shall, after receipt of such notice, inform the Contracting Officer of proposed corrective action and take such action when approved. If the Contractor fails to comply promptly, the Contracting Officer may issue an order stopping all or part of the work until satisfactory corrective action has been taken. No time extensions shall be granted or costs or damages allowed to the Contractor for any such suspensions.

### 1.4.6 Litigation

If work is suspended, delayed, or interrupted due to a court order of competent jurisdiction, the Contracting Officer will determine whether the order is due in any part to the acts or omissions of the Contractor, or subcontractors at any tier, not required by the terms of the contract. If it is determined that the order is not due to Contractor's failing, such suspension, delay, or interruption shall be considered as ordered by the Contracting Officer in the administration of the contract under the contract clause SUSPENSION OF WORK.

### 1.4.7 Previously Used Equipment

The Contractor shall thoroughly clean all construction equipment previously used at other sites before it is brought into the work areas, ensuring that soil residuals are removed and that egg deposits from plant pests are not present.

### 1.4.8 Payment

No separate payment will be made for work covered under this section; all costs associated with this section shall be included in the contract unit and/or lump sum prices in the Bidding Schedule.

## 1.5 LAND RESOURCES

The Contractor shall confine all activities to areas defined by the drawings and specifications. Prior to the beginning of any construction, the Contractor shall identify the land resources to be preserved within the work area. Except in areas indicated on the drawings or specified to be cleared, the Contractor shall not remove, cut, deface, injure, or destroy land resources including trees, shrubs, vines, grasses, topsoil, and land forms without permission. No ropes, cables, or guys shall be fastened to or attached to any trees for anchorage unless specifically authorized. Where such emergency use is permitted, the Contractor shall provide effective protection for land and vegetation resources at all times as defined in the following subparagraphs. Stone, earth or other material displaced into uncleared areas shall be removed.

### 1.5.1 Work Area Limits

Prior to any construction, the Contractor shall mark the areas that need not be disturbed under this contract. Isolated areas within the general work area which are to be saved and protected shall also be marked or fenced. Monuments and markers shall be protected before construction operations commence. Where construction operations are to be conducted during darkness, the markers shall be visible. The Contractor's personnel shall be knowledgeable of the purpose for marking and/or protecting particular objects.

### 1.5.2 Landscape

Trees, shrubs, vines, grasses, land forms and other landscape features indicated and defined on the drawings to be preserved shall be clearly identified by marking, fencing, or wrapping with boards, or any other approved techniques.

### 1.5.3 Unprotected Erodible Soils

Earthwork brought to final grade shall be finished as indicated. Side slopes and back slopes shall be protected as soon as practicable upon completion of rough grading. All earthwork shall be planned and conducted to minimize the duration of exposure of unprotected soils. Except in cases where the constructed feature obscures borrow areas, quarries, and waste material areas, these areas shall not initially be totally cleared. Clearing of such areas shall progress in reasonably sized increments as needed to use the developed areas as approved by the Contracting Officer.

### 1.5.4 Disturbed Areas

The Contractor shall effectively prevent erosion and control sedimentation through approved methods including, but not limited to, the following:

a. Erosion and sedimentation control devices. The Contractor shall construct or install temporary and permanent erosion and sedimentation control features as indicated on the drawings. Berms, dikes, drains, sedimentation basins, grassing, and mulching shall be maintained until permanent drainage and erosion control facilities are completed and operative.

### 1.5.5 Contractor Facilities and Work Areas

The Contractor's field offices, staging areas, and stockpile storage shall be placed in areas designated on the drawings or as directed by the Contracting Officer. Temporary movement or relocation of Contractor facilities shall be made only when approved. Spoil areas shall be managed and controlled to limit spoil intrusion into areas designated on the drawings and to prevent erosion of soil or sediment from entering nearby waters. Spoil areas shall be developed in accordance with the grading plan indicated on the drawings. Temporary excavation and embankments for plant and/or work areas shall be controlled to protect adjacent areas from despoilment.

## 1.6 WATER RESOURCES

The Contractor shall keep construction activities under surveillance, management, and control to avoid pollution of surface and ground waters. Toxic or hazardous chemicals shall not be applied to soil or vegetation when such application may cause contamination of the fresh water reserve. Monitoring of water areas affected by construction shall be the Contractor's responsibility. All water areas affected by construction activities shall be monitored by the Contractor.

### 1.6.1 Erosion and Sedimentation Control

Erosion and sedimentation control measures shall be implemented during construction activities, as required in Section 02271 EROSION AND SEDIMENT CONTROL, to limit the runoff of sediment into the tidal flats and the Housatonic River.

### 1.6.2 Decontamination Water

Waste waters directly derived from decontamination activities shall not be allowed to enter water areas. Waste waters shall be collected and placed in storage tanks where suspended material can be settled out. Analysis for volatile organic compounds (VOCs) shall be performed, and results reviewed and approved, before water in storage tanks is discharged to the Building 63 Chemical Waste Treatment Plant (CWTP) sump, in accordance with the requirements specified in the Emergency Discharge Authorization Permit (Permit No. EA0100149). No surfactants shall be discharged to the CWTP without prior approval by the Contracting Officer.

### 1.6.3 Fish and Wildlife

The Contractor shall minimize interference with, disturbance to, and damage of fish and wildlife. Species that require specific attention along with measures for their protection shall be listed by the Contractor prior to beginning of construction operations.

## 1.7 AIR RESOURCES

Equipment operation and activities or processes performed by the Contractor in accomplishing the specified construction shall be in accordance with Federal and State emission and performance laws and standards. Ambient Air Quality Standards set by the Environmental Protection Agency shall be maintained. Monitoring of air quality shall be the Contractor's responsibility. All air areas affected by the construction activities shall be monitored by the Contractor in accordance with the air monitoring plan outlined in the SSHP.

### 1.7.1 Particulates

Dust particles; aerosols and gaseous by-products from construction activities; and processing and preparation of materials shall be controlled at all times, including weekends, holidays and hours when work is not in progress. The Contractor shall maintain excavations, stockpiles, haul roads, spoil areas, and other work areas within or outside the project boundaries free from particulates which would cause the air pollution standards to be exceeded or which would cause a hazard or a nuisance. Sprinkling or chemical treatment of an approved type will be permitted to control particulates in the work area. Sprinkling, to be efficient, must be repeated to keep the disturbed area damp at all times. The Contractor must have sufficient, competent equipment available to accomplish these tasks. Particulate control shall be performed as the work proceeds and whenever a particulate nuisance or hazard occurs.

### 1.7.2 Hydrocarbons and Carbon Monoxide

Hydrocarbons and carbon monoxide emissions from equipment shall be controlled to Federal and State allowable limits at all times.

### 1.7.3 Odors

Odors shall be controlled at all times for all construction activities, processing and preparation of materials.

### 1.7.4 Sound Intrusions

The Contractor shall keep construction activities under surveillance and control to minimize environment damage by noise. The Contractor shall comply with the provisions of the State of Connecticut rules.

## 1.8 WASTE DISPOSAL

Disposal of wastes shall be as specified in Sections 02120 TRANSPORTATION AND DISPOSAL OF HAZARDOUS MATERIALS and 02220 DEMOLITION and as specified below.

### 1.8.1 Solid Wastes

Solid wastes (excluding clearing debris) shall be placed in containers which are emptied on a regular schedule. Handling and disposal shall be conducted to prevent contamination. Segregation measures shall be employed so that no hazardous or toxic waste will become co-mingled with solid waste. The Contractor shall transport solid waste off Government property and dispose of it in compliance with Federal, State, and local requirements for solid waste disposal.

### 1.8.2 Hazardous Wastes

The Contractor shall collect hazardous materials in suitable containers observing compatibility. The Contractor shall transport hazardous waste off Government property and dispose of it in compliance with Federal and local laws and regulations. Spills of hazardous or toxic materials shall be immediately reported to the Contracting Officer. Cleanup and cleanup costs due to spills shall be the Contractor's responsibility.

## 1.9 HISTORICAL, ARCHAEOLOGICAL, AND CULTURAL RESOURCES

Existing historical, archaeological, and cultural resources within the Contractor's work area will be so designated by the Contracting Officer if any has been identified. The Contractor shall take precautions to preserve all such resources as they existed at the time they were first pointed out. The Contractor shall provide and install protection for these resources and be responsible for their preservation during the life of the contract. If during excavation or other construction activities any previously unidentified or unanticipated resources are discovered or found, all activities that may damage or alter such resources shall be temporarily suspended. Resources covered by this paragraph include but are not limited to: any human skeletal remains or burials; artifacts; shell, midden, bone, charcoal, or other deposits; rocks or coral alignments, pavings, wall, or other constructed features; and any indication of agricultural or other human activities. Upon such discovery or find, the Contractor shall immediately notify the Contracting Officer.

## 1.10 POST CONSTRUCTION CLEANUP

The Contractor shall clean up all areas used for construction.

## 1.11 RESTORATION OF LANDSCAPE DAMAGE

The Contractor shall restore landscape features damaged or destroyed during construction operations outside the limits of the approved work areas.

## 1.12 MAINTENANCE OF POLLUTION FACILITIES

The Contractor shall maintain permanent and temporary pollution control facilities and devices for the duration of the contract or for that length of time construction activities create the particular pollutant.

## 1.13 TRAINING OF CONTRACTOR PERSONNEL

The Contractor's personnel shall be trained in all phases of environmental protection. The training shall include methods of detecting and avoiding pollution, familiarization with pollution standards, both statutory and contractual, and installation and care of devices, vegetative covers, and instruments required for monitoring purposes to ensure adequate and continuous environmental pollution control.

## PART 2 PRODUCTS (NOT APPLICABLE)

## PART 3 EXECUTION (NOT APPLICABLE)

--End of Section--

# SECTION 01411

# SAMPLING PROCEDURES AND LABORATORY SERVICES

**01/94**

## PART 1 GENERAL

### 1.1 DESCRIPTION

This section covers the sampling and analysis of excavated soil and demolition/oversized debris, to determine the presence or absence of contamination for confirmation and characterization purposes. Collection and analysis of decontamination wastewater samples is also covered in this section.

### 1.2 REFERENCES

The references listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ENVIRONMENTAL PROTECTION AGENCY (EPA)

| | |
|---|---|
| SW-846 | Test Methods for Evaluating Solid Waste Physical/Chemical Methods, 3rd edition, latest revision. |
| EPA-600/4-79-20 | Methods for Chemical Analysis of Water and Wastes, Revised March 1983. |
| EPA-600/4-84-076 | Characterization of Hazardous Waste Sites - A Method Manual: Volume II. Available Sampling Methods, Second Edition, December 1984, NTIS No. PB85-168771 |
| EPA/540/G-87/003 | Data Quality Objectives for Remedial Response Activities - Development Process, March 1987. |

CORPS OF ENGINEERS (COE)

| | |
|---|---|
| ER 1110-1-263 | Chemical Quality Management for Hazardous Waste Remedial Activities, 1 October 1990 |

### 1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals not having a "GA" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-01 Pre-construction Submittals

Contractor's Laboratory; GA

The Contractor shall submit the name, address, telephone number and point of contact for the proposed laboratory as soon as possible, but no later than 7 days, after notice to proceed. This will expedite the laboratory validation/approval process.

As part of the Work Plan, specified in Section 02111 EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL, the Contractor shall submit a Sampling and Analysis Plan that provides the details of the field and laboratory sampling and testing requirements for this project. It shall include specific information (including reporting limits, methods, and/or standard operating procedures) for field screening and laboratory methods, as necessary.

As part of the Phase I Completion Report, specified in Section 01780 CLOSEOUT SUBMITTALS, the Contractor shall submit characterization sampling analytical results. Data submittals shall include the results of all analyses, including quality control (QC) sample analyses (e.g. duplicates and matrix spikes). Results should also include any unusual observations such as the presence of interferences, etc. Data reporting requirements for test results will be consistent with EPA's Level III Analytical Support Requirements as given in EPA/540/G-87/003. The test results report shall include information relating the identity of split QA samples (split QA samples sent to NED laboratory) to QC samples (duplicate samples sent to the Contractor's Laboratory). This information must be provided in order for the COE NED Laboratory to perform a data comparison between split sample results. Test reports should also include all applicable method references and dates for extraction and analysis of field samples. Information copies of the test reports shall be sent to the following address:

U.S. Army Corps of Engineers
Environmental Laboratory
476 Cold Brook Road
Hubbardston, MA 01452
ATTN: Mr. David Lubianez

U.S. Army Corps of Engineers
Engineering Management Division
424 Trapelo Road
Waltham, MA 02254-9149
ATTN: [Engineering Manager]

## 1.4 CONTRACTOR REQUIREMENTS

### 1.4.1 Laboratory Services

The Contractor shall provide and coordinate the services of an environmental chemical laboratory to take samples and perform analyses. Laboratory capabilities must be provided for the duration of the work. The facilities must meet the requirements of this specification and are subject to inspection and prior approval by the Contracting Officer.

### 1.4.1.1 Qualification of Laboratory

The Contractor's laboratory must be a successful participant in the Corps of Engineers (COE) laboratory validation program. If the laboratory does not currently possess COE validation for all parameters of interest, the validation procedures must be successfully completed prior to collection of project samples. The COE validation procedure consists of the following steps:

1. Upon receipt of the proposed Contractor's laboratory name, address and point of contact (POC), the COE will initiate the laboratory validation process by submitting a "Request for Evaluation of Commercial Laboratory". The request will be completed by the COE.

If the laboratory does not possess current validation for all parameters of interest, steps 2 through 4 will be followed. Steps 2 through 4 typically take 8 to 12 weeks to complete, but the actual time frame is highly dependent on the laboratory's response time and performance.

2. The laboratory will be contacted to submit its qualifications for review. This submittal may be in the form of an off-the-shelf Laboratory Quality Management Manual (LQMM) or in some other format. The submittal shall provide appropriate information for COE to evaluate and assess the laboratory's technical capabilities on the project required chemical analyses.

3. COE will provide the commercial laboratory with Proficiency Audit (PA) samples. Arrangements will be made with the laboratory for the analysis of these samples. Ordinarily, the commercial laboratory is not reimbursed for costs involved with the analysis of PA samples. PA samples are method and matrix specific, depending on the specific project requirements. PA sample results are returned to the designated COE office for evaluation. Successful analysis of PA samples are required prior to validation of a commercial laboratory.

4. A COE inspector may inspect a commercial laboratory only after steps 2 and 3 have been successfully completed. Prior to the inspection, the commercial laboratory will be asked to complete a preliminary questionnaire, which will be used as a checklist during the laboratory audit. The laboratory inspection is performed at the discretion of the COE, based on the project type and size, and past performance of the subject laboratory. The inspection requirement may be waived by the COE.

## PART 2 PRODUCTS (NOT APPLICABLE)

## PART 3 EXECUTION

### 3.1 SAMPLING AND TESTING - OVERALL TASKS

Sampling and testing will be used in the following tasks:

a. Characterization of excavated soil, demolition debris, and oversized debris for disposal.

b. Decontamination wastewater sampling for disposal.

The test parameters for each remediation action (e.g., disposal or characterization) shall be selected to comply with all applicable Federal, State, and local laws and regulations, and shall be defined in accordance with the accepting disposal facilities requirements.

## 3.2 SAMPLING PERSONNEL & DATA LOGGING

Samples of soils are to be taken by qualified personnel only. Personnel shall have documentable experience collecting hazardous waste samples and shall meet all health requirements for this type of work. Field sampling data shall be recorded in a bound log book consisting of the following:

(a) Date and time of sampling.

(b) Date and time of removal action.

(c) Sample identification: alphanumeric field sample number.

(d) Sample location: A hand-drawn sketch of the area showing landmarks and sample locations shall be provided. Soil sample locations will be defined by distance measurements to at least two separate, permanent landmarks. Measurements shall be accurate to within a foot.

(e) Depth of sample.

(f) Observations, including descriptions of material sampled, staining (if any), presence of odors, groundwater, etc.

(g) Weather conditions (e.g., temperature, wind, clouds, precipitation).

(h) Printed name of sampling personnel.

## 3.3 QUALITY ASSURANCE AND QUALITY CONTROL SAMPLES

For every ten samples or portion thereof, one shall be taken in triplicate with two of the samples being sent to the Contractor's laboratory (QC Field Duplicate) for analysis, and the remaining sample sent to the U.S. Army Corps of Engineers, Environmental Laboratory, 476 Cold Brook Road, Hubbardston, MA 01452. The samples shall be transported to the laboratory within two days of collection. The samples shall be clearly identified by the applicable project name, SAEP Causeway Phase 1. For samples submitted to the QA Laboratory, all project-related documentation (including chain of custody forms) shall contain the QA Laboratory identification number. Sample handling shall be according to Appendix F of ER 1110-1-263.

In addition, QC samples such as rinsate blanks and trip blanks (Volatiles only) should be collected and analyzed at the laboratory. Laboratory quality control samples, including matrix spike/matrix spike duplicate (MS/MSD) and laboratory method blanks, shall be analyzed according to the method requirements (at the stated frequencies) and reported with field sample results. The collection of additional sample volume may be necessary to provide sufficient sample volume for aqueous MS/MSD analysis. Other QC information such as surrogate spike recoveries should also be reported for organic analyses. All QA/QC information shall be reported to the Contracting Officer.

## 3.4 LABELING

Each sample container shall be clearly identified with the name of the project, the field sample number, date and time of sampling, and the name(s) of the sampling personnel. Field information shall be written in indelible ink and the label shall be affixed in such a manner to ensure that it does not become separated from its respective container.

## 3.5 PRESERVATION AND STORAGE

Properly labeled sample containers shall be placed in zip-lock bags and stored in an iced durable cooler during sampling operations. Following the conclusion of sampling operations on any given day, samples will either be shipped directly to the appropriate laboratories, or be transferred to refrigerated storage space maintained at 4°C (39°F). In every instance, samples must be received at the appropriate laboratories within two days of sample collection. Samples will be maintained in a refrigerated condition at all times, including during transportation.

Saturday and Sunday delivery of QA samples to the NED Environmental Laboratory (Quality Assurance) should be avoided. The normal hours of operation of the laboratory are 0700 to 1530, Monday through Friday.

The Contractor must notify the Quality Assurance Laboratory at least 48 hours in advance of sample receipt at the QA Laboratory (telephone number is (508) 928-4238). Sample shipments should be planned in advance, and not be delivered on Saturday and Sunday, or legal holidays.

## 3.6 SAMPLING AND ANALYSIS PLAN

The Contractor shall submit, as part of the Work Plan, a Sampling and Analysis Plan that provides the details of the field and laboratory sampling and testing requirements for this project. It shall include specific information (including reporting limits, methods, and/or standard operating procedures) for field screening and laboratory methods, as necessary. The guidelines for the plan may be taken directly from this specification.

### 3.6.1 Sample Types

The following is a list of sample types that will be collected for this project:

a. Excavated soil and removed demolition and oversized debris (characterization samples)

b. Wastewater generated during decontamination of equipment (decontamination samples).

### 3.6.2 Sampling

#### 3.6.2.1 Characterization Samples

Samples of excavated soil, demolition debris, and removed oversized debris, shall be collected and analyzed to determine the off-site disposition of the material. Soil samples shall be collected as composite samples from each identified excavation area. Several waste types (e.g., concrete, asphalt, metal, etc.) are anticipated to be generated from demolition activities and oversized debris removal. Each waste type should be sampled separately from the other waste types, at a frequency determined by the Contracting Officer, in accordance with the requirements of the accepting disposal facility.

#### 3.6.2.2 Decontamination Samples

Decontamination water samples shall be collected from 500-gallon tanks used to store wastewater generated during decontamination of equipment in the specified decontamination area. Decontamination water samples shall be collected prior to discharge of the water to the Building 63 Chemical Waste Treatment Plant (CWTP) sump, to confirm the absence of volatile contamination. Decontamination wastewater shall be discharged to the Building 63 CWTP sump in accordance with the requirements specified in the Emergency Discharge Authorization Permit (Permit No. EA0100149). The use of surfactants for decontamination shall not be allowed, due to discharge requirements to the facility CWTP, unless approved by the Contracting Officer.

### 3.6.4 Sample Collection Procedures

#### 3.6.4.1 Characterization Samples

Soil samples shall be taken as a composite sample from the excavated soil of each identified excavation area. The samples shall be collected as directed by the Contracting Officer, in accordance with the requirements of the accepting disposal facility. Soil collection equipment decontamination shall be conducted as directed for confirmation sampling.

It is anticipated that several different debris types will be generated from building demolition and oversized debris removal activities, including concrete, metal, plastics, asphalt, etc. The debris types shall be sampled separately from one another, as directed by the Contracting Officer, in accordance with the requirements of the accepting disposal facility.

#### 3.6.4.2 Decontamination Samples

Decontamination water shall be collected using a bailer or other transfer device according to Methods III-1 or III-2 specified in EPA-600/4-84-076. When sampling in this manner, capture any observed floating or sinking product, so as to collect a "worst case" sample.

### 3.6.5 Sample Parameters, Containers, and Preservatives

Sample containers shall be pre-cleaned according to SW-846, and may be purchased commercially from I-Chem, Eagle Picher, or other equivalent source. The Contractor shall be responsible for defining sample requirements in the Sampling and Analysis Plan, in accordance with the requirements of the Contractor's laboratory, the accepting disposal facility, and the Stratford Army Engine Plant NPDES Permit.

## 3.7 QUANTITIES OF SAMPLES

The Contractor shall be responsible for defining sample requirements, in accordance with the requirements of the accepting disposal facility, as part of the Contractor's Sampling and Analysis Plan.

## 3.8 ANALYTICAL METHODS AND PROCEDURES

The Contractor shall be responsible for defining sample requirements, in accordance with the requirements of the accepting disposal facility, as part of the Contractor's Sampling and Analysis Plan.

--End of Section--

# SECTION 01460

# SURVEY CONTROL

## PART 1 GENERAL

### 1.1 DESCRIPTION

The Contractor shall be responsible for completion of a topographic survey on the Causeway following completion of all Phase I activities. The survey shall be conducted by a Land Surveyor licensed in the State of Connecticut and shall comply with the requirements of a Class A-1 survey.

### 1.2 REFERENCES (NOT USED)

### 1.3 SUBMITTALS

A drawing shall be generated from the final topographic survey completed following Phase I activities. The drawing shall be included as part of the Phase I Completion Report (Section 01780 CLOSEOUT SUBMITTALS) and shall show final, Phase I as-built conditions of the project. The final computer-aided design and drafting (CADD) as-built drawings shall consist of electronic CADD drawing files in the format specified in Section 01780 CLOSEOUT SUBMITTALS.

### 1.4 CONTRACTOR REQUIREMENTS

The Contractor shall complete a topographic survey of the Causeway area following the completion of Phase I activities. The survey shall be conducted in compliance with the requirements of Section 01351 SAFETY HEALTH AND EMERGENCY RESPONSE and Section 01410 ENVIRONMENT PROTECTION. Surveying techniques employed in the field shall follow commonly accepted professional survey practices, which are appropriate for the task at hand. The Contractor must also adhere to the following requirements:

a. The Contractor shall utilize permanent control information provided by the Contracting Officer. Any additional control required to complete the survey shall be the responsibility of the Contractor.

b. Vertical and horizontal control shall be established with equipment capable of producing the accuracy specified herein. All surveying work shall be referenced to Connecticut State Plane NAD 83 (horizontal control) and NGVD 29 (vertical control). Calibration of leveling equipment (peg test) shall be performed each morning before initiation of activities when establishing temporary bench marks. All other operations shall require a weekly calibration.

c. The Subcontractor shall meet or exceed the horizontal and vertical accuracy criteria as defined by the Standards of Accuracy and General Specifications of the Geodetic Control Surveys established by the U.S. Department of Commerce. All horizontal and vertical angles should be doubled for accuracy.

d. The Contractor shall provide a survey base line and bench marks for construction purposes. Should any of these points be destroyed, the replacement cost will be borne by the Contractor. The Contractor shall assume the entire expense of rectifying work improperly constructed due to failure to maintain and protect such established survey points and bench marks.

e. The Contractor shall provide all surveys necessary for contractual payment quantities. The Contractor will coordinate surveying of payment quantities with the Contracting Officer or his/her representative. He or she shall give the Contracting Officer three days notice of a payment survey so that the Contracting Officer may be present at the agreed upon time.

f. The Contractor shall be responsible for the layout of all grid coordinate locations, lines, grades, and levels necessary for the proper construction of the work called for on the Drawings and in the Specifications, at no additional cost to the Government. The surveyor shall also be responsible for preparation of the final Phase I topographic survey.

g. The Contractor shall employ, at his own expense, a licensed Land Surveyor in the State of Connecticut to provide surveys necessary for final contractual payment quantities and for record drawing submission.

## PART 2 PRODUCTS (NOT APPLICABLE)

## PART 3 EXECUTION (NOT APPLICABLE)

### 3.1 SURVEY

The Contractor shall provide horizontal and vertical control points based upon the benchmark information provided by the Contracting Officer. The Contracting Officer will furnish site base mapping and construction drawings to be used for surveying efforts.

The Contractor shall perform a topographic survey of approximately seven acres of area near the Causeway. The drawings show the area of the Causeway for which surveying services will be required. The topographic survey shall include elevations of 100 linear feet of the SAEP Dike on either side of the Causeway extending 50 feet toward the facility, and elevations of river sediments (i.e., tidal flats) within 75 feet of the Causeway, including the five heave platforms and five stationary poles (Section 02110 HEAVE MONITORING). The survey shall be used to generate detailed elevation information for the Causeway and the surrounding area using 1-foot contours.

If required by the Contracting Officer, the location and elevations of designated landmarks shall be obtained. The horizontal locations shall be recorded to the closest 0.1 foot and the vertical elevations shall be recorded to the closest 0.01 foot.

## 3.2 SUBMITTAL

As part of the Phase I Completion Report (Section 01780 CLOSEOUT SUBMITTALS) the Contractor shall submit the following:

a. A copy of the original field survey book and sketches pertaining to the work, including benchmark information, traverse station ties (when available), and calibration information.

b. A hard copy of the site plan identifying 1-foot contour intervals of the Causeway and surrounding area as described above, and the horizontal locations of any designated landmarks.

c. Electronic files of the site plan on CD-ROM in the format specified in Section 01780 CLOSEOUT SUBMITTALS.

--End of Section--

# SECTION 01500

# CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS
**02/97**

## PART 1 GENERAL

### 1.1 DESCRIPTION

The Contractor shall be responsible for providing temporary construction facilities and controls necessary for this work, and removal of the facilities and controls, as necessary, following completion of the work.

### 1.2 REFERENCES (NOT USED)

### 1.3 SUBMITTALS

As part of the Work Plan, specified in Section 02111 EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL, the Contractor shall prepare a site plan indicating the proposed location and dimensions of any area to be used by the Contractor, the avenues of ingress/egress to the work areas, and details of fence installation or modification, as necessary. Any areas which may have to be graveled to prevent the tracking of mud shall be identified. The Contractor shall also indicate if the use of a supplemental or other staging area is desired.

### 1.4 CONTRACTOR REQUIRMENTS

### 1.4.1 Identification of Employees

The Contractor shall be responsible for furnishing to each employee, and for requiring each employee engaged on the work to display, identification as approved and directed by the Contracting Officer. Prescribed identification shall immediately be delivered to the Contracting Officer for cancellation upon release of any employee. When required, the Contractor shall obtain and provide fingerprints of persons employed on the project. Contractor and subcontractor personnel shall wear identifying markings on hard hats clearly identifying the company for whom the employee works.

### 1.4.2 Employee Parking

Contractor employees shall park privately owned vehicles in an area designated by the Contracting Officer. This area will be within reasonable walking distance of the construction site. Contractor employee parking shall not interfere with existing and established parking requirements of the facility.

### 1.4.3 Employee Sign-in

Contractor employees shall be responsible for registering with SAEP security personnel on a daily basis, prior to arriving at the Causeway. In addition, contractor employees must also sign out from the facility on a daily basis before leaving for the day. Employee sign-in will be conducted at SAEP security headquarters in Building 1, unless otherwise directed by the Contracting Officer.

## 1.5 AVAILABILITY AND USE OF UTILITY SERVICES

### 1.5.1 Payment for Utility Services

The Government will make all reasonably required utilities available to the Contractor from existing outlets and supplies, as specified in the contract. Unless otherwise provided in the contract, the amount of each utility service consumed shall be charged to or paid for by the Contractor at prevailing rates charged to the Government. The Contractor shall carefully conserve any utilities furnished without charge.

### 1.5.2 Meters and Temporary Connections

If necessary, the Contractor, at its expense and in a manner satisfactory to the Contracting Officer, shall provide and maintain necessary temporary connections, distribution lines, and meter bases (Government will provide meters) required to measure the amount of each utility used for the purpose of determining charges. The Contractor shall notify the Contracting Officer, in writing, 5 working days before final electrical connection is desired so that a utilities contract can be established. The Government will provide a meter and make the final hot connection after inspection and approval of the Contractor's temporary wiring installation.

### 1.5.3 Advance Deposit

An advance deposit for utilities consisting of an estimated month's usage or a minimum of $50.00 will be required. The last monthly bills for the fiscal year will normally be offset by the deposit and adjustments will be billed or returned as appropriate. Services to be rendered for the next fiscal year will require a new deposit. Notification of the due date for this deposit will be mailed to the Contractor prior to the end of the current fiscal year.

### 1.5.4 Final Meter Reading

Before completion of the work and final acceptance of the work by the Government, the Contractor shall notify the Contracting Officer, in writing, 5 working days before termination is desired. The Government will take a final meter reading, disconnect service, and remove the meters. The Contractor shall then remove all the temporary distribution lines, meter bases, and associated paraphernalia. The Contractor shall pay all outstanding utility bills before final acceptance of the work by the Government.

### 1.5.5 Sanitation

The Contractor shall provide and maintain, within the construction area, minimum field-type sanitary facilities approved by the Contracting Officer. In addition, toilet facilities will be available to Contractor's personnel near the location of the Contractor’s field office, currently designated as Building 4.

### 1.5.6 Telephone

The Contractor shall make arrangements and pay all costs for necessary telephone facilities.

## 1.6 BULLETIN BOARD, PROJECT SIGN, AND PROJECT SAFETY SIGN

### 1.6.1 Bulletin Board

Immediately upon beginning of work, the Contractor shall provide a weatherproof glass-covered bulletin board not less than 36 by 48 inches in size for displaying the Equal Employment Opportunity poster, a copy of the wage decision contained in the contract, Wage Rate Information poster, and other information approved by the Contracting Officer. The bulletin board shall be located at the project site in a conspicuous place easily accessible to all employees, as approved by the Contracting Officer. Legible copies of the aforementioned data shall be displayed until work is completed. Upon completion of work the bulletin board shall be removed by and remain the property of the Contractor.

### 1.6.2 Project and Safety Signs

The requirements for the signs, their content, and location shall be as directed by the Contracting Officer. The signs shall be erected within 15 days after receipt of the notice to proceed. The data required by the safety sign shall be corrected daily, with light colored metallic or non-metallic numerals. Upon completion of the project, the signs shall be removed from the site.

## 1.7 PROTECTION AND MAINTENANCE OF TRAFFIC

During construction the Contractor shall provide access and temporary relocated roads as necessary to maintain traffic. The Contractor shall maintain and protect traffic on all affected roads during the construction period except as otherwise specifically directed by the Contracting Officer. Measures for the protection and diversion of traffic, including the provision of watchmen and flagmen, erection of barricades, placing of lights around and in front of equipment and the work, and the erection and maintenance of adequate warning, danger, and direction signs, shall be as required by the State and local authorities having jurisdiction. The traveling public shall be protected from damage to person and property. The Contractor's traffic on roads selected for hauling material to and from the site shall interfere as little as possible with public traffic. The Contractor shall investigate the adequacy of existing roads and the allowable load limit on these roads. The Contractor shall be responsible for the repair of any damage to roads caused by construction operations.

### 1.7.1 Haul Roads

The Contractor shall construct access and haul roads necessary for proper execution of the work under this contract. Haul roads shall be constructed with suitable grades and widths; sharp curves, blind corners, and dangerous cross traffic shall be avoided. The Contractor shall provide necessary lighting, signs, barricades, and distinctive markings for the safe movement of traffic. The method of dust control, shall be adequate to ensure safe operation at all times (Section 01562 DUST CONTROL). Location, grade, width, and alignment of construction and hauling roads shall be subject to approval by the Contracting Officer. Lighting shall be adequate to assure full and clear visibility for full width of haul road and work areas during any night work operations. Upon completion of the work, haul roads designated by the Contracting Officer shall be removed.

### 1.7.2 Barricades

The Contractor shall erect and maintain temporary barricades to limit public access to hazardous areas. Barricades shall be securely placed, clearly visible with adequate illumination to provide sufficient visual warning of the hazard during both day and night.

## 1.8 CONTRACTOR'S TEMPORARY FACILITIES

### 1.8.1 Administrative Field Offices

The Contractor shall provide and maintain administrative field office facilities within the construction area at the designated site (Building 4). Government office and warehouse facilities will not be available to the Contractor's personnel.

### 1.8.2 Storage Area

Trailers, materials, or equipment shall not be placed or stored outside the fenced area unless such trailers, materials, or equipment are assigned a separate and distinct storage area by the Contracting Officer away from the vicinity of the construction site but within the facility boundaries. Trailers, equipment, or materials shall not be open to public view with the exception of those items which are in support of ongoing work on any given day. Materials shall not be stockpiled outside the fence in preparation for the next day's work. Mobile equipment, such as tractors, wheeled lifting equipment, cranes, trucks, and like equipment, shall be parked within the fenced area at the end of each work day.

### 1.8.3 Supplemental Storage Area

Upon Contractor's request, the Contracting Officer will designate another or supplemental area for the Contractor's use and storage of trailers, equipment, and materials. This area may not be in close proximity of the construction site but shall be within the facility boundary. Fencing of materials or equipment will not be required at this site; however, the Contractor shall be responsible for cleanliness and orderliness of the area used and for the security of any material or equipment stored in this area. Utilities will not be provided to this area by the Government.

### 1.8.4 Appearance of Trailers

Trailers utilized by the Contractor for administrative or material storage purposes shall present a clean and neat exterior appearance and shall be in a state of good repair. Trailers which, in the opinion of the Contracting Officer, require exterior painting or maintenance will not be allowed on the facility property.

### 1.8.5 Maintenance of Storage Area

Fencing shall be kept in a state of good repair and proper alignment. Should the Contractor elect to traverse, with construction equipment or other vehicles, grassed or unpaved areas which are not established roadways, such areas shall be covered with a layer of gravel as necessary to prevent rutting and the tracking of mud onto paved or established roadways; gravel gradation shall be at the Contractor's discretion.

### 1.8.6 Security Provisions

Adequate outside security lighting shall be provided at the Contractor's temporary facilities. The Contractor shall be responsible for the security of its own equipment; in addition, the Contractor shall notify SAEP security personnel requesting periodic security checks of the temporary project field office.

## 1.9 GOVERNMENT FIELD OFFICE

The government has an existing office on the facility grounds.

## 1.10 FACILITY COMMUNICATION AND TELEPHONE SERVICE

Whenever the Contractor has the individual elements of its plant so located that operation by normal voice between these elements is not satisfactory, the Contractor shall install a satisfactory means of communication, such as two-way radios, telephone, or other suitable devices. The devices shall be made available for use by Government personnel.

The Contractor shall obtain a SAEP-approved two-way radio for communication with SAEP personnel on a daily basis. This radio must be returned to SAEP upon departure from the site, daily.

The Contractor shall provide telephone service to the field offices and shall provide and maintain a telephone or equal means of communication in an easily accessible location at each of the significant construction areas on the project. Such means of communication shall be accessible during all work hours.

## 1.11 TEMPORARY PROJECT SAFETY FENCING

As soon as practicable, but not later than 15 days after the date established for commencement of work, the Contractor shall furnish and erect temporary project safety fencing surrounding the origination of the Causeway and the support zones. The safety fencing shall be a high visibility orange colored, high density polyethylene grid or approved equal, a minimum of 42 inches high, supported and tightly secured to steel posts located on maximum 10 foot centers, constructed at the approved location. The safety fencing shall be maintained by the Contractor during the life of the contract and, upon completion and acceptance of the work, shall become the property of the Contractor and shall be removed from the work site.

## 1.12 CLEANUP

Construction debris, waste materials, packaging material and the like shall be removed from the work site daily. Any dirt or mud which is tracked onto paved or surfaced roadways shall be cleaned away. Materials resulting from demolition activities which are salvageable shall be stored within the fenced area described above or at the supplemental storage area. Stored material not in trailers, whether new or salvaged, shall be neatly stacked when stored.

## 1.13 RESTORATION OF STORAGE AREA

Upon completion of the project and after removal of trailers, materials, and equipment from within the fenced area, the fence shall be removed and will become the property of the Contractor. Areas used by the Contractor for the storage of equipment or material, or other use, shall be restored to the original or better condition. Gravel used to traverse grassed areas shall be removed and the area restored to its original condition, including top soil and seeding as necessary.

## PART 2 PRODUCTS (NOT APPLICABLE)

## PART 3 EXECUTION (NOT APPLICABLE)

--End of Section--

# SECTION 01562

# DUST CONTROL

## PART 1 GENERAL

### 1.1 DESCRIPTION

The Contractor shall furnish and apply water or calcium chloride to the Causeway or haul roads for dust control as necessary or as directed by the Contracting Officer. When no items for dust control are included in the Contract, such work shall be considered incidental.

The Contractor shall assume responsibility for any Contract delays or work stoppages due to inappropriate or ineffective dust control measures.

### 1.2 REFERENCES

The general provisions of the Contract including General and Supplementary Conditions, and General Requirements, apply to the work specified in this Section.

### 1.3 SUBMITTALS

As part of the Work Plan, specified in Section 02111 EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL, the Contractor shall submit the proposed method for dust control, including dust control material(s), application method, and monitoring.

## PART 2 PRODUCTS

### 2.1 MATERIALS

Water used for dust control shall be free from oil, acid, and injurious alkali or vegetable matter. Housatonic River water is acceptable for use as dust control water.

Calcium chloride used for dust control must conform to the requirements of AASHTO M144, except that the requirements for "total alkali chloride" and "impurities" do not apply.

## PART 3 EXECUTION

### 3.1 WATER APPLICATION - SPRINKLING

Apply dust control agents by approved methods and with equipment that includes a tank with gauge-equipped pressure pump and a nozzle-equipped spray bar. Disperse through the nozzle under a minimum pressure of 20 pounds per square inch, gauge pressure. Use when authorized by the Contracting Officer for controlling dust on the Causeway work activities, and on approved haul roads between storage areas and the Causeway, as necessary.

## 3.2 CALCIUM CHLORIDE APPLICATION - SPREADING

Apply by mechanical spreaders or by hand at the rate designated by the manufacturer. Use when authorized by the Contracting Officer for controlling dust on the Causeway during work activities, and on approved haul roads between storage areas and the Causeway, as necessary.

--End of Section--

# SECTION 01780

# CLOSEOUT SUBMITTALS
**11/99**

## PART 1 GENERAL

### 1.1 DESCRIPTION

The Contractor shall be responsible for development of a Phase I Completion Report detailing the results of demolition and excavation activities and presenting the final topographic survey. The Contractor shall also perform necessary site cleaning activities and maintenance activities in preparation for Phase II of this work.

### 1.2 REFERENCES (NOT USED)

### 1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals not having a "GA" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-11 Closeout Submittals

Phase I Completion Report; GA

Document the results of demolition and excavation activities completed during Phase I of the work, including, but not limited to: field notes, excavation logs, photos, and analytical results. Present a drawing generated from the final topographic survey, completed following Phase I activities. The drawing shall also show final Phase I site conditions.

### 1.4 PROJECT RECORD DOCUMENTS

This paragraph covers drawings completed as a requirement of the contract. The terms "drawings", "contract drawings", and "drawing files" refer to drawings which are revised to be used for final drawings.

#### 1.4.1.1 Government-Furnished Materials

One set of electronic CADD files in the specified software and format, revised to reflect all bid amendments, will be provided by the Government at the Pre-construction Meeting (Section 01351 SAFETY, HEALTH, AND EMERGENCY RESPONSE).

#### 1.4.1.2 Working and Final Drawings

The Contractor shall revise 2 sets of paper drawings by red-line process to show the conditions during the execution of the project. These working, marked drawings shall be kept current on a weekly basis and at least one set shall be available on the job site at all times. Changes from the contract plans which are made in the work or additional information which might be uncovered in the course of construction shall be accurately and neatly recorded as they occur by means of details and notes.

The working, marked prints and final drawings will be jointly reviewed for accuracy and completeness by the Contracting Officer and the Contractor prior to submission of each monthly pay estimate. If the Contractor fails to maintain the working and final drawings as specified herein, the Contracting Officer will deduct from the monthly progress payment an amount representing the estimated cost of maintaining the drawings. This monthly deduction will continue until an agreement can be reached between the Contracting Officer and the Contractor regarding the accuracy and completeness of updated drawings. The working and final drawings shall show, but shall not be limited to, the following information:

a. The actual location, kinds, and sizes of all overhead, surface, and subsurface utility lines. In order that the location of these lines and appurtenances may be determined in the event the surface openings or indicators become covered over or obscured, the drawings shall show, by offset dimensions to two permanently fixed surface features, the end of each run including each change in direction. Valves, splice boxes and similar appurtenances shall be located by dimensioning along the utility run from a reference point. The average depth below the surface of each run shall also be recorded.

b. Correct grade, elevations, cross section, or alignment of earthwork or utilities if any changes were made from contract plans.

c. The topography, invert elevations and grades of drainage installed or affected as part of the project construction.

d. Changes or modifications from these specifications.

e. Where contract drawings or specifications present options, only the option selected for construction shall be shown on the final as-built prints.

f. Modifications (change order price shall include the Contractor's cost to change working and final as-built drawings to reflect modifications) and compliance with the following procedures.

    (1) Directions in the modification for posting descriptive changes shall be followed.

    (2) A Modification Circle shall be placed at the location of each deletion.

    (3) For new details or sections which are added to a drawing, a Modification Circle shall be placed by the detail or section title.

    (4) For minor changes, a Modification Circle shall be placed by the area changed on the drawing (each location).

(5) For major changes to a drawing, a Modification Circle shall be placed by the title of the affected plan, section, or detail at each location.

(6) For changes to schedules or drawings, a Modification Circle shall be placed either by the schedule heading or by the change in the schedule.

(7) The Modification Circle size shall be 1/2 inch diameter unless the area where the circle is to be placed is crowded. Smaller size circle shall be used for crowded areas.

### 1.4.1.3 Drawing Preparation

The drawings shall be modified as may be necessary to correctly show the features of the project as it has been constructed by bringing the contract set into agreement with approved working prints, and adding such additional drawings as may be necessary. These working, marked prints shall be neat, legible and accurate. These drawings are part of the permanent records of this project and shall be returned to the Contracting Officer after approval by the Government. Any drawings damaged or lost by the Contractor shall be satisfactorily replaced by the Contractor at no expense to the Government.

### 1.4.1.4 Computer Aided Design and Drafting (CADD) Drawings

Only personnel proficient in the preparation of CADD drawings shall be employed to modify the contract drawings or prepare additional new drawings. Additions and corrections to the contract drawings shall be equal in quality and detail to that of the originals. Line colors, line weights, lettering, layering conventions, and symbols shall be the same as the original line colors, line weights, lettering, layering conventions, and symbols. If additional drawings are required, they shall be prepared using the specified electronic file format applying the same graphic standards specified for original drawings. The title block and drawing border to be used for any new final drawings shall be identical to that used on the contract drawings. Additions and corrections to the contract drawings shall be accomplished using CADD files.

The Contractor will be furnished Microstation 95 software and a Windows NT operating system, as necessary. The electronic files will be supplied on compact disc, read-only memory (CD-ROM). The Contractor shall be responsible for providing all program files and hardware necessary to prepare final drawings. The Contracting Officer will review final drawings for accuracy and the Contractor shall make required corrections, changes, additions, and deletions.

a. CADD colors shall be the "base" colors of red, green, and blue. Color code for changes shall be as follows:

(1) Deletions (red) - Deleted graphic items (lines) shall be colored red with red lettering in notes and leaders.

(2) Additions (Green) - Added items shall be drawn in green with green lettering in notes and leaders.

(3) Special (Blue) - Items requiring special information, coordination, or special detailing or detailing notes shall be in blue.

b. The Contract Drawing files shall be renamed in a manner related to the contract number (i.e., 98-C-10.DGN) as instructed in the Pre-Construction Meeting. Marked-up changes shall be made only to those renamed files. All changes shall be made on the layer/level as the original item. There shall be no deletions of existing lines; existing lines shall be over struck in red. Additions shall be in green with line weights the same as the drawing. Special notes shall be in blue on layer #63.

c. When final revisions have been completed, the cover sheet drawing shall show the wording "RECORD DRAWING " followed by the name of the Contractor in letters at least 3/16 inch high. Original contract drawings shall be dated in the revision block.

d. Within 10 days (for contracts less than $5 million) after Government approval of all of the working drawings for Phase I, the Contractor shall prepare the final CADD drawings for that phase of work and submit two sets of blue-lined prints of these drawings for Government review and approval. The Government will promptly return one set of prints annotated with any necessary corrections. Within 7 days the Contractor shall revise the CADD files accordingly at no additional cost and submit one set of final prints for Phase 1 to the Government. The submittal shall consist of one set of electronic files on compact disc, read-only memory (CD-ROM) and one set of the approved working drawings. They shall be complete in all details and identical in form and function to the contract drawing files supplied by the Government. Any transactions or adjustments necessary to accomplish this is the responsibility of the Contractor. The Government reserves the right to reject any drawing files it deems incompatible with the customer's CADD system. Paper prints, drawing files and storage media submitted will become the property of the Government upon final approval. Failure to submit final drawing files and marked prints as specified shall be cause for withholding any payment due the Contractor under this contract. Approval and acceptance of final drawings shall be accomplished before final payment is made to the Contractor.

#### 1.4.1.5 Payment

No separate payment will be made for drawings required under this contract, and all costs accrued in connection with such drawings shall be considered a subsidiary obligation of the Contractor.

### 1.5 FINAL CLEANING

The premises shall be left clean following completion of Phase I. The site shall have waste, surplus materials, and rubbish removed. Temporary barricades, project signs, erosion control measures, and fencing shall be maintained until the initiation of Phase II, in accordance with the requirements of Section 01500 CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS. A list of completed clean-up items shall be submitted on the day of final inspection, unless otherwise directed by the Contracting Officer. Final cleaning shall comply with the requirements of Section 01410 ENVIRONMENT PROTECTION.

## PART 2 PRODUCTS (NOT APPLICABLE)

## PART 3 EXECUTION (NOT APPLICABLE)

--End of Section--

# DIVISION 2

# SITEWORK

# SECTION 02016

# EXISTING UTILITIES AND UNDERGROUND STRUCTURES

## PART 1 GENERAL

### 1.1 DESCRIPTION

The Contractor shall abandon and/or remove existing utilities, as specified in this Section, for Building 5, Building 59, and the Causeway weather station.

The approximate location of the existing overhead and surface electrical line near the Causeway is shown on the Drawings. The locations of existing underground utilities for Building 5 are shown on drawings attached to these specifications. The Contractor shall verify exact locations of all utilities and coordinate with all applicable utility owners prior to any site work, where it is reasonable to expect the presence of existing utilities, whether shown on the drawings or not.

### 1.2 REFERENCES (NOT USED)

### 1.3 SUBMITTALS

As part of the Work Plan (Section 02111 EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL), the Contractor shall submit a Demolition Plan for Building 5 and Building 59. As part of the Demolition Plan, the Contractor shall detail the process to be followed for utility abandonment and/or removal.

### 1.4 CONTRACTOR RESPONSIBILITY

The Contractor shall be responsible for any damage to existing utilities caused by the Contractor's efforts. If the Contractor does cause damage to the existing utility, he shall contact the affected utility owner as soon as the damage is discovered. The utility owner shall make the determination as to who makes the necessary repairs.

## PART 2 PRODUCTS (NOT APPLICABLE)

## PART 3 EXECUTION

### 3.1 UTILITY DISCONNECTION

Existing overhead, surface, and subsurface utilities shall be disconnected prior to demolition in accordance with the utility owner's requirements.

--End of Section--

# SECTION 02110

# HEAVE PLATFORMS

## PART 1 GENERAL

### 1.1 DESCRIPTION

The Contractor shall be responsible for equipment, supplies, and personnel necessary to install and monitor five (5) heave platforms and five (5) stationary heave poles, as indicated on the drawings and in these specifications. The heave platforms and stationary poles shall be installed prior to the initiation of Phase I work, such that monitoring of the heave platforms and poles may be conducted to collect background information on movement in the tidal flats.

Monitoring shall be conducted during the completion of Phase I work to assess background information and the impact of Phase I activities on tidal flat elevations. Monitoring of the heave platforms and stationary poles shall also be required during Phase II of this work (N.I.T.C.).

### 1.2 REFERENCES (NOT USED)

### 1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals not having a "GA" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Heave Monitoring Reports; GA

The Surveyor field records and computed measurements shall be submitted to the Engineer, at the end of each day the measurements are taken. Changes in the thickness and extent of fill between each surveyed reading of elevation shall also be reported.

On a weekly basis, the Contractor shall submit a summary of the results of heave monitoring, as indicated in this section, to the Contracting Officer. Reporting shall be provided in both hard and electronic file, and shall contain the date of monitoring and reduced survey results, along with a plot of movement versus time. Data reports shall contain data no older than 7 days, and intermediate reporting may be required due to unacceptable movements.

As part of the Work Plan (Section 02111 EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL), the Contractor shall submit a plan for installation and monitoring of the heave platforms and stationary poles. At a minimum, the plan shall detail the processes and materials to be used during installation of the heave platforms and poles, and the frequency of monitoring, as directed in the specifications and the drawings.

## PART 2 PRODUCTS

### 2.1 Heave Platforms

Heave platforms shall be constructed as indicated on the Drawings, and in accordance the Contractors approved Work Plan.

### 2.2 Heave Poles

Heave poles shall consist of pressure-treated 2 by 4 lumber, a minimum of 12 feet in length. Poles shall be provided with targets to facilitate the required survey accuracy and repeatability.

## PART 3 EXECUTION

### 3.1 Heave Platform Installation

Prior to initiation of Phase I work on the Causeway, the Contractor shall construct and install five (5) heave platforms at approximate locations as shown on the Drawings. The heave platforms shall be installed 30 feet from the approximate contact of the fill and riverine sediment on the South side of the Causeway, and 40 feet from the approximate contact on the North side of the Causeway.

### 3.2 Stationary Heave Pole Installation

Prior to initiation of Phase I work on the Causeway, the Contractor shall install five (5) stationary heave poles at approximate locations as shown on the Drawings. The stationary heave poles shall be installed 10 feet from the approximate contact of the fill and riverine sediment on the South side of the Causeway, and 15 feet from the approximate contact on the North side of the Causeway.

Stationary poles shall be installed such that the top provided for attachment of a suitable target between elevation 7 and 8`. Poles shall be advanced to a minimum depth of 5 feet below ground surface.

### 3.3 Monitoring Frequency

During Phase I activities, the location and elevation of heave platforms and stationary poles shall be surveyed at the following frequency:

a. Initial survey prior to initiation of Phase I work

b. Twice per week during the first month of Phase I activities

c. Once per week for the remainder of Phase I activities

Regular monitoring during Phase II shall be performed to a minimum accuracy of +/- 0.01 foot for elevation and +/- 0.1 foot for northing and easting.

The Contractor shall submit the results of general monitoring to the Engineer at the end of each day the measurements are taken. Changes in the thickness and extent of fill between each surveyed reading of elevation shall also be reported. On a weekly basis, the Contractor shall submit a summary of the results of heave monitoring to the Contracting Officer.

Intensive monitoring results shall be available to the Engineer on a continuous basis. If any movement (horizontal or vertical) greater than 0.5 foot is recorded within a 24 hour period, the Contractor shall STOP WORK and notify the Contracting Officer, representative, or Engineer immediately, so that the Engineer may evaluate the site conditions.

--End of Section--

# SECTION 02111

# EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL

## PART 1 GENERAL

### 1.1 DESCRIPTION

The work covered in this section includes excavation and temporary storage of approximately 82 cubic yards of contaminated soil and approximately 1,200 cubic yards of oversized debris, including the deteriorated concrete ramp located at the end of the Causeway. Approximate locations of excavation areas are shown on the drawings.

### 1.2 REFERENCES

More information regarding the results of sampling conducted on the Causeway can be found in the following:

a. Foster Wheeler/Harding Lawson Associates, April 2000. Final Pre-design Investigation Report for the Causeway and Dike NCRA.

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

| | |
|---|---|
| ASTM D 2487 | (1993) Classification of Soils for Engineering Purposes (Unified Soil Classification System) |
| ASTM D 5434 | (1993) Guide for Field Logging of Subsurface Explorations of Soil and Rock |

CODE OF FEDERAL REGULATIONS (CFR)

| | |
|---|---|
| 40 CFR 302 | Designation, Reportable Quantities, and Notification |

CONNECTICUT DEPARTMENT OF ENVIRONMENTAL PROTECTION (CTDEP)

Remediation Standard Regulations (RSRs)

### 1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals not having a "GA" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-01 Pre-construction Submittals

Work Plan; GA

Work Plan within 14 calendar days after notice to proceed. No work at the site, with the exception of site inspections and pre-construction surveys, shall be performed until the Work Plan is approved. The Contractor shall allow 14 calendar days in the schedule for the Government's review. No adjustment for time or money will be made if re-submittals of the Work Plan are required due to deficiencies in the plan. At a minimum, the Work Plan shall include:

a. Schedule of activities.

b. Site Layout.

b. Method of excavation/demolition and equipment to be used.

c. Shoring or side-wall slopes proposed, if necessary.

d. Dewatering plan, if necessary.

e. Storage methods and locations for liquid and solid contaminated material.

f. Dust control plan.

g. Heave platform installation and monitoring plan.

h. Waste management plan.

i. Demolition Plan (Section 02220 DEMOLITION).

j. Asbestos Abatement Plan (Section 13281 ASBESTOS ABATEMENT).

k. Contingency plan for securing the site prior to a major storm event, such as a hurricane or winter storm including removal of equipment and loose materials and adequate storage of these items.

The Contractor shall submit, as part of the Phase I Completion Report (Section 01780 CLOSEOUT SUBMITTALS), the results of laboratory testing for characterization sampling, copies of field log entries completed during excavation, and final drawings showing site conditions following the completion of Phase I work.

## 1.4 SURVEYS

A topographic survey shall be performed following excavation of contaminated soil and demolition/removal of material from the Causeway, in accordance with Section 01460 SURVEY CONTROL.

## 1.5 REGULATORY REQUIREMENTS

### 1.5.1 Permits and Licenses

The Contractor shall obtain required federal, state, and local permits for excavation and storage of contaminated material. Permits shall be obtained at no additional cost to the Government.

### 1.5.2 Air Emissions

Air emissions shall be monitored and controlled in accordance with Section 01410 ENVIRONMENT PROTECTION.

## 1.6 CHEMICAL TESTING

Required sampling and chemical analysis for off-site disposal shall be conducted as required by the accepting disposal facility, and in accordance with Section 01411 SAMPLING PROCEDURES AND LABORATORY SERVICES.

## 1.7 SCHEDULING

The Contractor shall notify the Contracting Officer seven calendar days prior to the start of excavation of contaminated material. The Contracting Officer shall be responsible for contacting regulatory agencies in accordance with the applicable reporting requirements.

## 1.8 ADDITIONAL GROSS POLLUTION

The potential exists for identification of additional gross contamination during excavation, building demolition, and site preparation activities. The Contractor shall make a conscious effort to identify such gross contamination, based on visual and olfactory evidence, and notify the Contracting Officer during site activities. The Contractor shall notify the Contracting Officer immediately if a whitish clay-like material historically associated with radiological contamination on the Causeway is encountered during excavation activities. Should contamination be identified, all work shall be performed as described in this section.

# PART 2 PRODUCTS

## 2.1 BACKFILL MATERIAL

Excavation areas shall not be backfilled during Phase I activities. During Phase II, excavated material from the sides of the Causeway shall be used to backfill the excavation areas (N.I.T.C.).

## 2.2 SPILL RESPONSE MATERIALS

The Contractor shall provide spill response materials including, but not limited to the following: containers, adsorbents, shovels, and personal protective equipment. Spill response materials shall be available at all times in which hazardous materials/wastes are being handled or transported. Spill response materials shall be compatible with the type of materials and contaminants being handled.

## PART 3 EXECUTION

### 3.1 EXISTING STRUCTURES AND UTILITIES

The Contractor shall take the necessary precautions to ensure no damage occurs to existing structures and utilities. Damage to existing structures and utilities resulting from the Contractor's operations shall be repaired at no additional cost to the Government.

Existing utilities scheduled for abandonment or removal, shall be addressed in accordance with Section 02016 EXISTING UTILITIES AND UNDERGROUND STRUCTURES.

### 3.2 CLEARING AND GRUBBING

Clearing and grubbing shall be performed to the limits shown on the drawings in accordance with Section 02230 CLEARING AND GRUBBING.

### 3.3 MATERIAL REMOVAL AND HANDLING

The work covered in this section includes excavation and temporary storage of approximately 82 cubic yards of contaminated soil and approximately 1,200 cubic yards of oversized debris, including the deteriorated concrete ramp present at the end of the Causeway. Approximate locations of excavation areas are shown on the drawings.

### 3.3.1 Contaminated Soil Removal

Chemical analysis of contaminated soil has previously been performed and results are presented in Appendix F. Subsurface conditions are presented in the Final Pre-design Investigation Report (Foster Wheeler/HLA, April 2000). The Contracting Officer shall be notified within 48 hours if contaminated material is discovered which has not been previously identified or if other discrepancies between data provided and actual field conditions are discovered.

### 3.3.1.1 Excavation

Areas of contamination shall be excavated to within 1 foot of the depth and extent shown on the drawings or as directed by the Contracting Officer. Excavation shall be performed in a manner that will limit the potential for contaminated material to be mixed with uncontaminated material. The Contractor shall maintain an excavation of sufficient size to allow workers ample room to complete the work. A log of the materials and any visible signs of contamination encountered during excavation shall be maintained for each area of excavation. Excavation logs shall be prepared in accordance with ASTM D 5434. Excavations should be marked and secured in accordance with the requirements specified in Section 01351 SAFETY, HEALTH, AND EMERGENCY RESPONSE(HTRW/UST).

#### 3.3.1.2 Shoring

Sheeting, bracing, or shoring shall be installed in the absence of adequate side slopes if there is a need for workers to enter the excavated area.

#### 3.3.1.3 Dewatering

Surface water shall be diverted to prevent entry into the excavation. It is not anticipated that dewatering activities will be necessary during Phase I excavation activities. Ground water is generally located 4 to 6 feet below pre-excavation ground surface and is not expected to be encountered during excavation activities.

### 3.3.2 Oversized Debris Removal

Visible surface debris greater than 2 feet in any dimension (i.e., oversized) shall be removed from the surface of the Causeway. It is estimated that approximately 3,800 cubic yards of solid debris will require removal from the Causeway, as indicated on the Drawings. The location and approximate volume of additional debris, discovered during the removal process, should be noted for future removal under Phase II of this work.

The concrete ramp and residual steel reinforcing at the end of the Causeway shall be removed as part of this work. The ramp shall be removed to a minimum of 2 feet below the existing grade, as necessary. Due to the location of the concrete ramp, removal must be conducted during low-tide conditions.

Asphaltic concrete road surfaces are evident on the surface of the Causeway. The Contractor shall leave this asphalt in place to provide a durable surface for Phase II work.

### 3.3.3 Handling Of Oversized Debris

Oversized debris shall be cleaned of excess soil first by using mechanical methods followed by use of high-pressure washing equipment, prior to removal from the Causeway. Washing shall be performed in close proximity to the removal area, with water allowed to infiltrate the ground surface. No surfactants shall be used. The Contractor shall perform washing in such a manner to minimize the volume of water used and the potential for migration of sediments, and shall perform washing only in areas above elevation 6, and above at least one active siltation barrier.

Rubbish and debris shall be removed from the Causeway daily, unless otherwise directed. Materials that cannot be removed daily shall be stored in areas specified by the Contracting Officer.

## 3.5 CONFIRMATION SAMPLING AND ANALYSIS

The Contracting Officer, or a representative, shall be present to inspect the removal of contaminated soil from each excavation area. After all material suspected of being contaminated has been removed, the excavation shall be examined for evidence of contamination and, if appropriate, field analysis used to determine the presence of volatile contamination using a real-time vapor monitoring instrument. Excavation of additional soil shall be as directed by the Contracting Officer, or the representative.

After all suspected contaminated material is removed, confirmation samples shall be collected by the Contracting Officer, or representative. The Contractor shall assist the Contracting Officer, or the representative, as requested. Based on test results, the Contracting Officer shall propose any additional excavation that may be required to remove material contaminated above action levels. Additional excavation shall be subject to approval by the Contracting Officer.

Confirmation sampling will not be conducted for demolition or oversized debris removal; however, the location and approximate volume of additional debris, discovered during the debris removal process, should be noted by the Contractor for future removal under Phase II of this work.

## 3.6 CONTAMINATED MATERIAL STORAGE

Material shall be placed in temporary storage immediately after excavation or removal from the Causeway. The following paragraphs describe acceptable methods of material storage. Storage units shall be in good condition and constructed of materials that are compatible with the material to be stored. If multiple storage units are required, each unit shall be clearly labeled with an identification number and a written log shall be kept to track the source of contaminated material in each temporary storage unit.

### 3.6.1 Stockpiles

Stockpiles shall be constructed to isolate stored contaminated material from the environment. The maximum stockpile size shall be 500 cubic yards. Stockpiles shall be constructed to include:

a. A chemically resistant geomembrane liner. Non-reinforced geomembrane liners shall have a minimum thickness of 20 mils. Scrim reinforced geomembrane liners shall have a minimum weight of 40 lbs. per 1000 square feet. The ground surface on which the geomembrane is to be placed shall be free of rocks greater than 0.5 inches in diameter and any other object which could damage the membrane.

b. Geomembrane cover to prevent precipitation from entering the stockpile. Non-reinforced geomembrane covers shall have a minimum thickness of 10 mils. Scrim reinforced geomembrane covers shall have a minimum weight of 26 lbs. per 1000 square feet. The cover material shall be anchored to prevent it from being removed by wind.

c. Berms surrounding the stockpile, a minimum of 12 inches in height. Vehicle access points shall also be bermed.

d. Storage and removal of liquid which collects in the stockpile, in accordance with paragraph Liquid Storage.

e. Inspection of the stockpile areas will be conducted on a weekly basis, or following a significant precipitation event, as necessary to assure continued compliance with contract requirements.

### 3.6.2 Roll-Off Units

Water-tight roll-off units shall be used to temporarily store contaminated material. An impermeable cover shall be placed over the units to prevent precipitation from contacting the stored material. The units shall be located in the Contractor storage area, as directed by the Contracting Officer. Liquid which collects inside the units shall be removed and stored in accordance with paragraph Liquid Storage.

### 3.6.3 Liquid Storage

Liquid collected from excavations and stockpiles shall be temporarily stored in 55-gallon barrels. Liquid storage containers shall be water-tight and shall be located in the Contractor storage area, as directed by the Contracting Officer.

## 3.7 SAMPLING

### 3.7.1 Sampling of Stored Material

Samples of excavated soil, demolition debris, and oversized debris shall be collected for characterization purposes of each debris type. Sample collection rates and analytical parameters shall be determined by the Contracting Officer in conjunction with the requirements of the accepting treatment, storage, and disposal (TSD) facility.

Stored material shall be treated/disposed offsite. Analyses for contaminated material to be taken to an offsite TSD facility shall conform to local, state, and federal criteria as well as to the requirements of the TSD facility. Documentation of all analyses performed shall be furnished to the Contracting Officer. Additional sampling and analyses, to the extent required by the accepting offsite TSD facility, shall be the responsibility of the Contractor and shall be performed at no additional cost to the Government.

### 3.7.2 Sampling Liquid

Liquid collected from storage areas and decontamination facilities shall be sampled at a frequency of once for every 500 gallons of liquid collected. Samples shall be tested for the following:

| Chemical Parameter | Action Level |
|---|---|
| Volatile Organics | 100 parts per billion |

Liquid with contaminant levels that exceed action levels shall be treated on-site using activated carbon until subsequent sampling results are below the action level. When the liquid is below the action level, it shall be discharged to the Building 63 Chemical Waste Treatment Plant sump. Documentation of all analyses performed shall be furnished to the Contracting Officer in the Phase I Completion Report (Section 01780 CLOSEOUT SUBMITTALS).

## 3.8 SPILLS

In the event of a spill or release of a hazardous substance (as designated in 40 CFR 302), pollutant, contaminant, or oil (as governed by the Oil Pollution Act (OPA), 33 U.S.C. 2701 et seq.), the Contractor shall notify the Contracting Officer immediately. If the spill exceeds the reporting threshold, the Contractor shall follow the pre-established procedures as described in the SSHP for immediate reporting and containment, as described in Section 01351 SAFETY, HEALTH, AND EMERGENCY RESPONSE (HTRW/UST).

## 3.9 BACKFILL

### 3.9.1 Confirmation Test Results

Excavations will not be backfilled during this phase of the work. Safety fencing shall be placed around any excavation greater than 2 feet deep and a layer of erosion control mulch shall be placed in accordance with Section 02271 EROSION AND SEDIMENT CONTROL. The excavations will be backfilled with material excavated from the sides of the Causeway during Phase II of this work (N.I.T.C.).

## 3.10 DISPOSAL REQUIREMENTS

Offsite disposal of contaminated material shall be in accordance with Section 02120 TRANSPORTATION AND OFF-SITE DISPOSAL.

## 3.11 PHASE I COMPLETION REPORT

Six copies of a Phase I Completion Report shall be prepared and submitted within 21 calendar days of completing work at the site. The report shall be labeled with the contract number, project name, location, date, name of general contractor, and the Corps of Engineers District contracting for the work. The Closure Report shall include the following information as a minimum:

a. A cover letter signed by a responsible company official certifying that all services involved have been performed in accordance with the terms and conditions of the contract documents.

b. A narrative report including, but not limited to, the following:

   (1) site conditions, groundwater elevation, and cleanup criteria;

   (2) excavation logs;

   (3) field screening readings;

   (4) quantity of materials removed from each area of contamination; and

   (5) quantities of water/product removed during dewatering.

c. Copies of all chemical and physical test results.

d. Copies of all manifests and land disposal restriction notifications.

e. Copies of all certifications of final disposal signed by the responsible disposal facility official.

f. Waste profile sheets.

g. Scaled drawings showing limits of each excavation, limits of contamination, and known underground utilities within 50 feet of excavation.

h. Progress Photographs. Color photographs shall be used to document progress of the work. A minimum of four views of the site showing the location of the area of contamination, entrance/exit road, and any other notable site conditions shall be taken before work begins. After work has been started, activities at each work location shall be photographically recorded weekly. Photographs shall be a minimum of 4 x 6 inches and shall include:

   (1) Soil removal, handling, and sampling.

   (2) Unanticipated events such as discovery of additional contaminated material.

   (3) Contaminated material storage.

   (4) Site or task-specific employee respiratory and personal protection.

   (5) Post-construction photographs. After completion of work at each site, the Contractor shall take a minimum of four views of each excavation site.

Photographs shall be mounted back-to-back in double face plastic sleeves punched to fit standard three ring binders. Each print shall have an information box attached. The box shall be typewritten and arranged as follows:

| | |
|---|---|
| Project Name: | Direction of View: |
| Location: | Date/Time: |
| Photograph No.: | Description of View: |

--End of Section--

## SECTION 02120

## TRANSPORTATION AND OFF-SITE DISPOSAL

**10/96**

## PART 1 GENERAL

### 1.1 DESCRIPTION

This section covers the transportation and off-site disposal of materials generated during the completion of Phase I work at the site. Material anticipated to require disposal includes excavated soil, oversized debris, and demolition debris.

### 1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

CODE OF FEDERAL REGULATIONS (CFR)

| | |
|---|---|
| 40 CFR 61 | National Emission Standards for Hazardous Air Pollutants |
| 40 CFR 261 | Identification and Listing of Hazardous Waste |
| 40 CFR 262 | Standards Applicable to Generators of Hazardous Waste |
| 40 CFR 263 | Standards Applicable to Transporters of Hazardous Waste |
| 40 CFR 264 | Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities |
| 40 CFR 265 | Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities |
| 40 CFR 266 | Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities |
| 40 CFR 268 | Land Disposal Restrictions |
| 40 CFR 270 | EPA Administered Permit Programs: The Hazardous Waste Permit Program |
| 40 CFR 300 | National Oil and Hazardous Substances Pollution Contingency Plan |

| | |
|---|---|
| 40 CFR 302 | Designation, Reportable Quantities, and Notification |
| 49 CFR 107 | Hazardous Materials Program Procedures |
| 49 CFR 172 | Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements |
| 49 CFR 173 | Shippers - General Requirements for Shipments and Packagings |
| 49 CFR 178 | Specifications for Packagings |

## 1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals not having a "GA" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Recordkeeping; GA

Information necessary to file state annual or EPA biennial reports for all hazardous waste transported, treated, stored, or disposed of under this contract. The Contractor shall not forward these data directly to the regulatory agency but to the Contracting Officer at the specified time. The submittal shall contain all the information necessary for filing of the formal reports in the form and format required by the governing Federal or state regulatory agency. A cover letter shall accompany the data to include the contract number, Contractor name, and project location.

Exception Reports; GA

In the event that a manifest copy documenting receipt of hazardous waste at the treatment, storage, and disposal (TSD) facility is not received within 35 days of shipment initiation, the Contractor shall prepare and submit an exception report to the Contracting Officer within 37 days of shipment initiation.

SD-07 Certificates

EPA Off-Site Policy; GA

A letter certifying that EPA considers the facilities to be used for all off-site disposal to be acceptable in accordance with the Off-Site policy in 40 CFR 300, Section .440. This certification shall be provided for wastes from Resource Conservation and Recovery Act (RCRA), 42 U.S.C. 6901 et seq., sites as well as from Comprehensive Environmental Response Compensation and Liability Act

(CERCLA), 42 U.S.C. 9601 et seq., responses. See Attachment A, sample certification, at the end of this section.

Disposal Certificates; GA

Certificates documenting the ultimate disposal of hazardous wastes and/or asbestos within 180 days of initial shipment. Receipt of these certificates will be required for final payment.

Shipping Documents and Packagings Certification; GA

All transportation related shipping documents to the Contracting Officer, including draft hazardous waste manifests, draft land disposal restriction notifications, draft asbestos waste shipment records, draft bill of ladings for hazardous materials, lists of corresponding proposed labels, packages, marks, and placards to be used for shipment, waste profiles, and supporting waste analysis documents, for review a minimum of 14 days prior to anticipated pickup. Packaging assurances shall be furnished prior to transporting hazardous material; "generator copies" of hazardous waste manifests, land disposal restriction notifications, asbestos waste shipment records, bill of ladings, and supporting waste analysis documents shall be furnished when shipments are originated; and "receipt copies" of asbestos waste shipment records at the designated disposal facility shall be furnished not later than 35 days after acceptance of the shipment.

Notices of Non-Compliance and Notices of Violation; GA

Notices of non-compliance or notices of violation by a Federal, state, or local regulatory agency issued to the Contractor in relation to any work performed under this contract. The Contractor shall immediately provide copies of such notices to the Contracting Officer. The Contractor shall also furnish all relevant documents regarding the incident and any information requested by the Contracting Officer, and shall coordinate its response to the notice with the Contracting Officer or his designated representative prior to submission to the notifying authority. The Contractor shall also furnish a copy to the Contracting Officer of all documents submitted to the regulatory authority, including the final reply to the notice, and all other materials, until the matter is resolved.

In the event of a spill or release of a hazardous substance (as designated in 40 CFR 302), or pollutant or contaminant, or oil (as governed by the Oil Pollution Act (OPA), 33 U.S.C. 2701 et seq.), the Contractor shall notify the Contracting Officer immediately. The Site Safety and Health Plan shall detail reporting requirements, as specified in Section 01351 SAFETY, HEALTH, AND EMERGENCY RESPONSE (HTRW/UST).

As part of the Work Plan, specified in Section 02111 EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL, the Contractor shall submit a plan detailing the manner in which wastes generated during the work shall be managed. The plan shall, at a minimum, describe the types and volumes of wastes anticipated to be managed as well as the management practices to be utilized. The plan shall also identify the method to be used to ensure accurate piece counts and/or weights of shipments; shall identify waste minimization methods; shall propose facilities to be utilized for treatment, storage, and/or disposal; shall identify areas on-site where hazardous wastes are to be handled; shall identify whether transfer facilities are to be utilized; and if so, how the wastes will be tracked to ultimate disposal; shall contain the name and address of the proposed disposal facility and proposed haul routes; shall indicate that all material leaving the site for disposal shall be adequately characterized in accordance with the accepting facility requirements; and shall contain copies of the current certificates of registration issued to the Contractor.

## 1.4 QUALIFICATIONS

### 1.4.1 Transportation and Disposal Coordinator

The Contractor shall designate, by position and title, one person to act as the Transportation and Disposal Coordinator (TDC) for this contract. The TDC shall serve as the single point of contact for all environmental regulatory matters and shall have overall responsibility for total environmental compliance at the site including, but not limited to, accurate identification and classification of hazardous waste and hazardous materials; determination of proper shipping names; identification of marking, labeling, packaging and placarding requirements; completion of waste profiles, hazardous waste manifests, asbestos waste shipment records, PCB manifests, bill of ladings, exception and discrepancy reports; and all other environmental documentation. The TDC shall have, at a minimum, one year of specialized experience in the management and transportation of hazardous waste.

### 1.4.2 Training

The Contractor's hazardous materials employees shall be trained, tested, and certified to safely and effectively carry out their assigned duties in accordance with Section 01351 SAFETY, HEALTH, AND EMERGENCY RESPONSE (HTRW/UST). The Contractor's employees transporting hazardous materials or preparing hazardous materials for transportation shall be trained, tested, and certified in accordance with 49 CFR 172.

### 1.4.3 Certification

The Contractor and/or subcontractors transporting hazardous materials shall possess a current certificate of registration issued by the Research and Special Programs Administration (RSPA), U.S. Department of Transportation, when required by 49 CFR 107, Subpart G.

## 1.5 LAWS AND REGULATIONS REQUIREMENTS

Work shall meet or exceed the minimum requirements established by Federal, state, and local laws and regulations that are applicable. These requirements are amended frequently and the Contractor shall be responsible for complying with amendments as they become effective. In the event that compliance exceeds the scope of work or conflicts with specific requirements of the contract, the Contractor shall notify the Contracting Officer immediately.

## 1.6 DEFINITIONS

a. Natural Soil/Material. A soil/material in which all substances naturally occurring therein are present in concentrations not exceeding the concentrations of such substance occurring naturally in the environment and in which no other substance is analytically detectable.

b. Polluted Soil/Material. A soil waste that has been determined to have been affected by a release of a substance at a concentration above the analytical detection limit for such substance, but at levels below that which would qualify it as a hazardous waste..

c. Hazardous Material. A substance or material which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and which has been so designated pursuant to the Hazardous Materials Transportation Act, 49 U.S.C. Appendix Section 1801 et seq. The term includes materials designated as hazardous materials under the provisions of 49 CFR 172, Sections .101 and .102 and materials which meet the defining criteria for hazard classes and divisions in 49 CFR 173. EPA designated hazardous wastes are also hazardous materials.

d. Hazardous Waste. A waste which meets criteria established in RCRA or specified by the EPA in 40 CFR 261 or which has been designated as hazardous by a RCRA authorized state program.

e. Special Waste. As defined in the CTDEP RSRs, is: "special wastes" mean the following wastes, so long as they are not hazardous waste pursuant to section 22a-115 of the General Statutes or radioactive material subject to section 22a-148 of the General Statutes: (1) water treatment, sewage treatment or industrial sludges, liquids, solids and contained gases; fly-ash and casting sands or slag; and contaminated dredge spoils; (2) scrap tires; (3) bulky waste, as defined in 22a-209-1; (4) asbestos; (5) residue; and (6) biomedical waste.

## PART 2 PRODUCTS

## 2.1 MATERIALS

The Contractor shall provide all of the materials required for the packaging, labeling, marking, placarding and transportation of non-hazardous and hazardous wastes and hazardous materials in conformance with Department of Transportation standards. Details in this specification shall not be construed as establishing the limits of the Contractor's responsibility.

### 2.1.1 Packagings

The Contractor shall provide bulk and non-bulk containers for packaging hazardous materials/wastes consistent with the authorizations referenced in the Hazardous Materials Table in 49 CFR 172, Section .101, Column 8. Bulk and non-bulk packaging shall meet the corresponding specifications in 49 CFR 173 referenced in the Hazardous Materials Table, 49 CFR 172, Section .101. Each packaging shall conform to the general packaging requirements of Subpart B of 49 CFR 173, to the requirements of 49 CFR 178 at the specified packing group performance level, to the requirements of special provisions of column 7 of the Hazardous Materials Table in 49 CFR 172, Section .101, and shall be compatible with the material to be packaged as required by 40 CFR 262. The Contractor shall also provide other packaging related materials such as materials used to cushion or fill voids in overpacked containers, etc. Sorbent materials shall not be capable of reacting dangerously with, being decomposed by, or being ignited by the hazardous materials being packaged. Additionally, sorbents used to treat free liquids to be disposed of in landfills shall be non-biodegradable as specified in 40 CFR 264, Section .314.

### 2.1.2 Markings

The Contractor shall provide markings for each hazardous material/waste package, freight container, and transport vehicle consistent with the requirements of 49 CFR 172, Subpart D, 40 CFR 262, Section .32 (for hazardous waste), and 40 CFR 61, Section .149(d) (for asbestos). Markings shall be capable of withstanding, without deterioration or substantial color change, a 180 day exposure to conditions reasonably expected to be encountered during container storage and transportation.

### 2.1.3 Labeling

The Contractor shall provide primary and subsidiary labels for hazardous materials/wastes consistent with the requirements in the Hazardous Materials Table in 49 CFR 172, Section .101, Column 6. Labels shall meet design specifications required by 49 CFR 172, Subpart E including size, shape, color, printing, and symbol requirements. Labels shall be durable and weather resistant and capable of withstanding, without deterioration or substantial color change, a 180 day exposure to conditions reasonably expected to be encountered during container storage and transportation.

### 2.1.4 Placards

For each off-site shipment of hazardous material/waste, the Contractor shall provide primary and subsidiary placards consistent with the requirements of 49 CFR 172, Subpart F. Placards shall be provided for each side and each end of bulk packaging, freight containers, transport vehicles, and rail cars requiring such placarding. Placards may be plastic, metal, or other material capable of withstanding, without deterioration, a 30 day exposure to open weather conditions and shall meet design requirements specified in 49 CFR 172, Subpart F.

### 2.1.5 Spill Response Materials

The Contractor shall provide spill response materials including, but not limited to, containers, adsorbent, shovels, and personal protective equipment. Spill response materials shall be available at all times in which hazardous materials/wastes are being handled or transported. Spill response materials shall be compatible with the type of material being handled.

## 2.2 EQUIPMENT AND TOOLS

The Contractor shall provide miscellaneous equipment and tools necessary to handle hazardous materials and hazardous wastes in a safe and environmentally sound manner.

# PART 3 EXECUTION

## 3.1 ON-SITE WASTE MANAGEMENT

These paragraphs apply to Government-owned waste only. Contractors are prohibited by 10 U.S.C. 2692 from storing contractor-owned waste on site for any length of time. The Contractor shall be responsible for ensuring compliance with all Federal, state, and local hazardous waste laws and regulations and shall verify those requirements when preparing reports, waste shipment records, hazardous waste manifests, or other documents. The Contractor shall identify hazardous wastes using criteria set forth in 40 CFR 261 or all applicable state and local laws, regulations, and ordinances. When accumulating hazardous waste on-site, the Contractor shall comply with generator requirements in 40 CFR 262 and any applicable state or local law or regulations. On-site accumulation times shall be restricted to applicable time frames referenced in 40 CFR 262, Section .34 and any applicable state or local law or regulation. Accumulation start dates shall commence when waste is first generated (i.e. containerized or otherwise collected for discard).

The Contractor shall only use containers in good condition and compatible with the waste to be stored. The Contractor shall be responsible for ensuring containers are closed except when adding or removing waste. The Contractor shall be responsible for immediately marking all hazardous waste containers with the words "hazardous waste" and other information required by 40 CFR 262, Section .32 and any applicable state or local law or regulation as soon as the waste is containerized. An additional marking shall be placed on containers of "unknowns" designating the date sampled, and the suspected hazard. The Contractor shall be responsible for inspecting containers for signs of deterioration and shall be responsible for responding to any spills or leaks. The Contractor shall inspect all hazardous waste areas weekly and shall provide written documentation of the inspection. Inspection logs shall contain date and time of inspection, name of individual conducting the inspection, problems noted, and corrective actions taken.

### 3.1.1 On-site Waste Classification

The Contractor, in consultation with the Contracting Officer and the waste transporter, shall identify all waste codes applicable to each hazardous and non-hazardous waste stream, as applicable, based on requirements in 40 CFR 261 or any applicable state or local law or regulation. The Contractor shall also identify all applicable treatment standards in 40 CFR 268 and state land disposal restrictions and shall make a determination as to whether or not the waste meets or exceeds the standards. Waste profiles, analyses, classification and treatment standards information shall be submitted to Contracting Officer for review and approval.

### 3.1.2 Waste Management Plan

As part of the Work Plan, specified in Section 02111 EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL, the Contractor shall submit a plan detailing the manner in which wastes generated during the work shall be managed. The plan shall, at a minimum, describe the types and volumes of wastes anticipated to be managed as well as the management practices to be utilized. The plan shall also identify the method to be used to ensure accurate piece counts and/or weights of shipments; shall identify waste minimization methods; shall propose facilities to be utilized for treatment, storage, and/or disposal; shall identify areas on-site where hazardous wastes are to be handled; shall identify whether transfer facilities are to be utilized; and if so, how the wastes will be tracked to ultimate disposal; shall contain the name and address of the proposed disposal facility and proposed haul routes; and shall contain copies of the current certificates of registration issued to the Contractor.

## 3.2 OFF-SITE WASTE MANAGEMENT

The Contractor shall use licensed solid waste landfills and RCRA Subtitle C permitted facilities which meet the requirements of 40 CFR 264. The Contractor may also use facilities operating under interim status which meet the requirements of 40 CFR 265. Off-site TSD facilities with significant RCRA violations or compliance problems (such as facilities known to be releasing hazardous constituents into ground water, surface water, soil, or air) shall not be used.

### 3.2.1 Description of Treatment, Storage, and Disposal Facility and Transporter

The Contractor shall provide the Contracting Officer with EPA ID numbers, names, locations, and telephone numbers of TSD facilities and transporters. This information shall be contained in the Waste Management Plan for approval prior to waste disposal.

### 3.2.2 Status of the Facility

Facilities receiving hazardous waste must be permitted in accordance with 40 CFR 270 or operating under interim status in accordance with 40 CFR 265 requirements, or must be permitted by an authorized state program. Additionally, prior to using a TSD Facility, the Contractor shall contact the EPA Regional Off-site Coordinator specified in 40 CFR 300, Section .440, to determine the facility's status, and document all information necessary to satisfy the requirements of the EPA Off-Site policy and furnish this information to the Contracting Officer.

### 3.2.3 Shipping Documents and Packaging Certification

Prior to shipment of any hazardous material off-site, the Contractor's Transportation and Disposal Coordinator (TDC) shall provide written certification to the Contracting Officer that hazardous materials have been properly packaged, labeled, and marked in accordance with Department of Transportation and EPA requirements.

### 3.2.4 Transportation

The Contractor shall use manifests for transporting hazardous wastes as required by 40 CFR 263 or any applicable state or local law or regulation. Special wastes shall be transported in accordance with applicable State regulations. Transportation shall comply with all requirements in the Department of Transportation referenced regulations in the 49 CFR series. The Contractor shall acquire manifests in accordance with the hierarchy established in 40 CFR 262, Section .21. The Contractor shall prepare hazardous waste manifests for each shipment of hazardous waste shipped off-site. Manifests shall be completed using instructions in 40 CFR 262, Subpart B and any applicable state or local law or regulation. Manifests and waste profiles shall be submitted to Contracting Officer for review and approval.

The Contractor shall prepare land disposal restriction notifications as required by 40 CFR 268 or any applicable state or local law or regulation for each shipment of hazardous waste. Notifications shall be submitted with the manifest to the Contracting Officer for review and approval. When the additional cost of sending a qualified USACE representative to a remote location for a small clean up project is unwarranted, the option of requiring the on-site Contractor to sign the manifests on behalf of the generator is permitted and should be considered. This option shall only be exercised on a project specific basis, if prior to the solicitation process, written authorization of the customer and approval of the Chief, Construction Division at the executing district has been obtained, and the technical provisions of the contract solicitation provide competing contractors notice of the requirement.

### 3.2.5 Treatment and Disposal of Hazardous Wastes

The hazardous waste shall be transported to an approved hazardous waste TSD facility within 90 days of the accumulation start date on each container. The Contractor shall ship hazardous wastes only to facilities which are properly permitted to accept the hazardous waste or operating under interim status. The Contractor shall ensure wastes are treated to meet land disposal treatment standards in 40 CFR 268 prior to land disposal. The Contractor shall propose TSD facilities via submission of the Waste Management Plan, as included in the Work Plan, subject to the approval of the Contracting Officer.

## 3.3 HAZARDOUS MATERIALS MANAGEMENT

The Contractor, in consultation with the Contracting Officer, shall evaluate, prior to shipment of any material off-site, whether the material is regulated as a hazardous waste in addition to being regulated as a hazardous material; this shall be done for the purpose of determining proper shipping descriptions, marking requirements, etc., as described below.

### 3.3.1 Identification of Proper Shipping Names

The Contractor shall use 49 CFR 172, Section .101 to identify proper shipping names for each hazardous material (including hazardous wastes) to be shipped off-site. Proper shipping names shall be submitted to the

Contracting Officer in the form of draft shipping documents for review and approval.

### 3.3.2 Packaging, Labeling, and Marking

The Contractor shall package, label, and mark non-hazardous and hazardous materials/wastes using the specified materials and in accordance with the referenced authorizations. The Contractor shall mark each container of hazardous waste of 104 gallons or less with the following:

"HAZARDOUS WASTE - Federal Law Prohibits Improper Disposal.
If found, contact the nearest police or public safety authority or the U.S. Environmental Protection Agency.
Generator's name ____________________________________
Manifest Document Number ___________________________".

### 3.3.3 Shipping Documents

The Contractor shall ensure that each shipment of non-hazardous and hazardous material sent off-site is accompanied by properly completed shipping documents.

### 3.3.3.1 Asbestos Waste Shipment Documents

The Contractor shall prepare waste shipment records as required by 40 CFR 61 for shipments of asbestos. Waste shipment records shall be submitted to the Contracting Officer for review and approval. Waste shipment records shall be signed by the Contractor.

### 3.3.3.3 Other Hazardous Material Shipment Documents

The Contractor shall prepare a bill of lading for each shipment of hazardous material which is not accompanied by a hazardous waste manifest or asbestos waste shipment record which fulfills the shipping paper requirements. The bill of lading shall satisfy the requirements of 49 CFR 172, Subpart C, and any applicable state or local law or regulation, and shall be submitted to the Contracting Officer for review and approval. For laboratory samples, the Contractor shall prepare bills of lading and other documentation as necessary to satisfy conditions of the sample exclusions in 40 CFR 261, Section .4(d) and (e) and any applicable state or local law or regulation. Bill of ladings requiring shipper's certifications will be signed by the Government.

## 3.4 OBTAINING EPA ID NUMBERS

The Contractor shall complete EPA Form 8700-12, Notification of Hazardous Waste Activity, and submit to the Contracting Officer for review and approval. The Contractor shall allow a minimum of 30 days for processing the application and assigning the EPA ID number. Shipment shall be made not earlier than one week after receipt of the EPA ID number.

## 3.5 SPECIAL REQUIREMENTS FOR ASBESTOS WASTES

When work involves asbestos-containing wastes, the Contractor shall manage these wastes in accordance with Section 13280 ASBESTOS ABATEMENT.

## 3.6 WASTE MINIMIZATION

The Contractor shall minimize the generation of hazardous waste to the maximum extent practicable. The Contractor shall take all necessary precautions to avoid mixing clean and contaminated wastes. The Contractor shall identify and evaluate recycling and reclamation options as alternatives to land disposal. Requirements of 40 CFR 266 shall apply to: hazardous wastes recycled in a manner constituting disposal; hazardous waste burned for energy recovery; lead-acid battery recycling; and hazardous wastes with economically recoverable precious metals.

## 3.7 RECORDKEEPING

The Contractor shall be responsible for maintaining adequate records to support information provided to the Contracting Officer regarding exception reports, annual reports, and biennial reports. The Contractor shall be responsible for maintaining asbestos waste shipment records for a minimum of 3 years from the date of shipment or any longer period required by any applicable law or regulation or any other provision of this contract.

## 3.8 SPILL RESPONSE

The Contractor shall respond to any spill of hazardous material or hazardous waste which are in the custody or care of the Contractor, pursuant to this contract. Any direction from the Contracting Officer concerning a spill or release shall not be considered a change under the contract. The Contractor shall comply with all applicable requirements of Federal, state, or local laws or regulations regarding any spill incident.

## 3.9 EMERGENCY CONTACTS

The Contractor shall be responsible for complying with the emergency contact provisions in 49 CFR 172, Section .604. Whenever the Contractor ships hazardous materials, the Contractor shall provide a 24-hour emergency response contact and phone number of a person knowledgeable about the hazardous materials being shipped and who has comprehensive emergency response and incident mitigation information for that material, or has immediate access to a person who possesses such knowledge and information. The phone must be monitored on a 24-hour basis at all times when the hazardous materials are in transportation, including during storage incidental to transportation. The Contractor shall ensure that information regarding this emergency contact and phone number are placed on all hazardous material shipping documents. The Contractor shall designate an emergency coordinator and post the following information at areas in which hazardous wastes are managed:

a. The name of the emergency coordinator.

b. Phone number through which the emergency coordinator can be contacted on a 24-hour basis.

c. The telephone number of the local fire department.

d. The location of fire extinguishers and spill control materials.

## Attachment A
## SAMPLE OFF-SITE POLICY CERTIFICATION MEMO

Project/Contract #: ____________________________________________________
Waste Stream: ____________________________________________________________
Primary TSD Facility, EPA ID # and Location: _____________________________
Alter. TSD Facility, EPA ID # and Location: ______________________________

| EPA Region | Primary Contact | Secondary Contact |
|---|---|---|
| I | (617) 565-9446 | (617) 573-1754 |
| II | (212) 637-4139 | (212) 264-2638 |
| III | (814) 566-3450 | (215) 597-8338 |
| IV | (404) 562-8589 | (404) 347-7603 |
| V | (312) 886-3587 | (312) 886-4445 |
| VI | (214) 665-2282 | (214) 655-2281 |
| VII | (913) 551-7883 | (913) 551-7667 |
| VIII | (303) 312-6419 | (303) 293-1506 |
| IX | (415) 744-2091 | (415) 744-2114 |
| X | (206) 553-1061 | (206) 553-1061 |

EPA representative contacted: ____________________________________________
EPA representative phone number: _________________________________________
Date contacted: _________________________________________________________

Comment: _______________________________________________________________
The above EPA representative was contacted on ___________. As of that date the above sites were considered acceptable in accordance with the Off-Site Policy in 40 CFR 300.440.

Signature: ___________________________________ Date: ___________________
Phone number: ___________________________________________________________

--End of Section--

## SECTION 02220

## DEMOLITION
**12/97**

## PART 1 GENERAL

### 1.1 DESCRIPTION

The work covered in this section includes demolition of Building 59, Building 5, the Causeway weather station, and the containment berm, protective posts, and tank supports around the Building 34 former above-ground storage tank (AST) farm. The work also includes disconnection of utilities, salvage of identified items and materials, and removal of resulting rubbish and demolition debris. In the interest of occupational safety and health, the work shall be performed in accordance with EM 385-1-1, Section 23, Demolition, and other applicable Sections. In the interest of conservation, salvage shall be pursued to the maximum extent possible; salvaged items and materials shall be disposed of as specified.

### 1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ENGINEERING MANUALS (EM)

| | |
|---|---|
| EM 385-1-1 | (1996) U.S. Army Corps of Engineers Safety and Health Requirements Manual |

### 1.3 SUBMITTALS

As part of the Work Plan, specified in Section 02111 EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL, a Demolition Plan shall be submitted that details the procedures proposed for the accomplishment of the work. The procedures shall provide for safe conduct of the work, including procedures and methods to provide necessary supports, lateral bracing and shoring when required, careful removal and disposition of materials specified to be salvaged, protection of property which is to remain undisturbed, coordination with other work in progress, and timely disconnection of utility services. The procedures shall include a detailed description of the methods and equipment to be used for each operation, and the sequence of operations in accordance with EM 385-1-1.

### 1.4 DUST CONTROL

The amount of dust resulting from demolition shall be controlled to prevent the spread of dust to occupied portions of the facility and to avoid creation of a nuisance in the surrounding area. Dust control shall comply with the requirements of Section 01562 DUST CONTROL.

## 1.5 PROTECTION

### 1.5.1 Protection of Personnel

During the demolition work the Contractor shall continuously evaluate the condition of the structures being demolished and take immediate action to protect all personnel working in and around the demolition site. No area, section, or component of floors, roofs, walls, columns, pilasters, or other structural element will be allowed to be left standing without sufficient bracing, shoring, or lateral support to prevent collapse or failure while workmen remove debris or perform other work in the immediate area. Excavations required for limited foundation removal shall be barricaded and labeled in accordance with applicable standards.

### 1.5.2 Protection of Structures

Floors, roofs, walls, columns, pilasters, and other structural components that are designed and constructed to stand without lateral support or shoring, and are determined to be in stable condition, shall remain standing without additional bracing, shoring, of lateral support until demolished, unless directed otherwise by the Contracting Officer. The Contractor shall ensure that no elements determined to be unstable are left unsupported and shall be responsible for placing and securing bracing, shoring, or lateral supports as may be required as a result of any cutting, removal, or demolition work performed under this contract.

### 1.5.3 Protection of Existing Property

Before beginning any demolition work, the Contractor shall examine the drawings and specifications to determine the extent of the work. The Contractor shall take necessary precautions to avoid damage to existing items to remain in place, to be reused, or to remain the property of the Government; any damaged items shall be repaired or replaced as approved by the Contracting Officer. The Contractor shall coordinate the work of this section with all other work and shall construct and maintain shoring, bracing, and supports as required. The Contractor shall ensure that structural elements are not overloaded and shall be responsible for increasing structural supports or adding new supports as may be required as a result of any cutting, removal, or demolition work performed under this contract.

### 1.5.4 Protection From the Weather

The interior of buildings to remain; salvageable materials and equipment shall be protected from the weather at all times. Due to the tidal nature and potential for severe weather conditions, work on the causeway shall be protected from possible submergence during high water events.

### 1.5.5 Environmental Protection

The work shall comply with the requirements of Section 01410 ENVIRONMENT PROTECTION. The Contractor shall not perform any demolition or debris removal until erosion and sedimentation controls have been installed, and approved by the Contracting Officer.

The Contractor shall wash demolition debris free of residual soils using high pressure water. Do not perform washing within 50 feet of soil excavation areas.

### 1.6 BURNING

The use of burning at the project site for the disposal of refuse and debris will not be permitted.

### 1.7 USE OF EXPLOSIVES

Use of explosives will not be permitted.

### 1.8 AVAILABILITY OF WORK AREAS

Areas in which the work is to be accomplished will be available during the hours of operation listed in Section 01010 SUMMARY OF WORK. Designated areas for Contractor use, as well as areas off-limits to Contractor use, are indicated on the Drawings.

## PART 2 PRODUCTS (NOT APPLICABLE)

## PART 3 EXECUTION

### 3.1 DEMOLITION EQUIPMENT

Due to the nature of subsurface materials, the Contractor shall use demolition equipment that will minimize the amount of dynamic energy imparted to the ground during demolition activities on the Causeway.

### 3.2 DEMOLITION

The following structures shall be removed from the site:

#### 3.2.1 Building 59

Overhead and surface utilities shall be disconnected as identified on the Drawings, prior to demolition activities at Building 59. Any underground structures associated with utilities shall be removed, as necessary. Utility removal shall be conducted in accordance with Section 02016 EXISTING UTILITIES AND UNDERGROUND STRUCTURES.

Building 59 is a former storage facility with one main storage room (Cell 1) measuring approximately 21 feet by 22 feet. Three smaller rooms (Cells 2, 3, and 4) are approximately 8 feet by 10 feet each. An 11-foot by 23-foot loading comprises the rest of the building. The roof is flat, approximately 1-foot thick, and covered with tar and gravel. Approximately 10 feet from the outer walls of Building 59 are 1-foot to 1-1/2-foot thick heavily reinforced buttressed concrete blast walls. Available drawings detailing the construction of Building 59 are attached to these specifications as Appendix H.

The existing exterior walls of Building 59 and all interior walls of the building shall be removed to a depth of 2 feet below existing grade. Building foundations should also be removed to a depth of 2 feet below existing grade. Basement slabs, if present, shall be broken up to permit drainage. The concrete ramp, located on the north side of Building 59, shall also be removed to a depth of 2 feet below existing grade, as part of Building 59 demolition. Concrete and debris that is in contact with site soils shall be washed on the Causeway using high-pressure water, in accordance with Paragraph 3.3.

The Contractor shall grade the surrounding area, to provide a maximum 4H:1V slope, to eliminate abrupt grade changes resulting from foundation removal.

### 3.2.2 Building 5

Building 5 is the former fuel system testing building. It is a one-story concrete block construction with a flat roof. The roof of the facility and water pipe insulation have been determined to contain asbestos (an estimated 10 cubic yards). Drawings detailing the construction of Building 5 and the location of underground utilities, are attached to these specifications as Appendix H, along with excerpts from an asbestos survey report.

Existing underground utilities shall be disconnected as identified in Section 02016 EXISTING UTILITIES AND UNDERGROUND STRUCTURES. Subsurface penetration should be limited during utility disconnection.

The existing exterior walls of Building 5 and all interior walls of the building shall be removed to existing grade. The surface slab of the building shall remain in place to prevent infiltration into the subsurface. Subsurface penetration should be limited during demolition activities. Structural elements, which are in contact with site soils and require removal, shall be washed at the building location using high-pressure water, in accordance with Paragraph 3.3. Salvaging shall be conducted to the extent practicable, and asbestos removal shall comply with the requirements of Section 13281 ASBESTOS ABATEMENT.

### 3.2.3 Causeway Weather Station

The Causeway weather station consists of a concrete slab, frost wall, chain-link fence, and a small amount of weather monitoring equipment. The fence and weather equipment shall be removed and salvaged as appropriate. The concrete slab shall be removed to a depth of 2 feet below existing grade. Due to the location of the weather station, demolition work must be conducted during low tide conditions. Concrete that is in contact with site soils shall be washed on the Causeway using high-pressure water, in accordance with Paragraph 3.3. An electrical conduit connecting the weather station to the facility shall be removed within the limits work, and salvaged, if possible.

### 3.2.4 Building 34 Containment Berm

The concrete berm surrounding the Building 34 former AST farm, the protective posts, and the tank supports, shall be removed to existing ground surface. The concrete berm is approximately one foot high and nine inches thick, with a total length of 250 feet. An estimated 60 protective posts surround the berm, and approximately five tank supports are located within the berm. Subsurface penetration in the area of the berm should be limited during removal activities.

Following removal of these structures, the area shall be prepared and paved in accordance with the requirements of Section 02576 BITUMINOUS CONCRETE PAVEMENT, to allow increased access to the Causeway area.

## 3.3 HANDLING OF DEMOLITION DEBRIS

### 3.3.1 Removal of Excess Soil

Demolition debris shall be cleaned of excess soil first by using mechanical methods followed by use of high-pressure cleaning equipment, prior to removal from the Causeway. Washing shall be performed in close proximity to the removal area, with water allowed to infiltrate the ground surface. No surfactants shall be used. The Contractor shall perform cleaning in such a manner to minimize the volume of water used and the potential for migration of sediments. Perform washing only in areas above elevation 6, and above at least one active siltation barrier.

### 3.3.2 Debris Removal

Rubbish and debris shall be removed from the Causeway daily, unless otherwise directed. Materials that cannot be removed daily shall be stored in areas specified by the Contracting Officer.

## 3.4 UTILITIES

Disconnection of utility services, with related meters and equipment, are specified in Section 02016 EXISTING UTILITIES AND UNDERGROUND STRUCTURES. When utility lines are encountered that are not indicated on the drawings, the Contracting Officer shall be notified prior to further work in that area.

## 3.5 DISPOSITION OF MATERIAL

Title to material and equipment to be demolished, except Government salvage and historical items, is vested in the Contractor upon receipt of notice to proceed. The Government will not be responsible for the condition, loss or damage to such property after notice to proceed.

### 3.5.1 Salvageable Items and Material

Contractor shall salvage items and material to the maximum extent possible.

#### 3.5.1.1 Material Salvaged for the Contractor

Material salvaged for the Contractor shall be stored as approved by the Contracting Officer and shall be removed from Government property before completion of the contract. Material salvaged for the Contractor shall not be sold on the site.

#### 3.5.1.2 Items Salvaged for the Government

Salvaged items to remain the property of the Government, if identified during work, shall be removed in a manner to prevent damage, and packed or crated to protect the items from damage while in storage or during shipment.

#### 3.5.1.3 Historical Items

Historical items, if identified during work, shall be removed in a manner to prevent damage. The following historical items shall be delivered to the Government for disposition: Corner stones, contents of corner stones, and document boxes wherever located on the site.

### 3.5.2 Unsalvageable Material

All unsalvageable material shall be disposed of off the site.

## 3.6 CLEAN UP

Debris and rubbish shall be removed from basement and similar excavations. Debris shall be removed and transported in a manner that prevents spillage. Local and state regulations regarding hauling and disposal shall apply.

## 3.7 PAVEMENTS

Existing pavements designated for removal shall be saw cut and removed in their entirety. Pavement subgrade material may remain in place.

## 3.8 DEMOLITION DEBRIS DISPOSAL

Non-contaminated, contaminated, special waste, and hazardous demolition debris shall be disposed off-site as directed in Section 02120 TRANSPORTATION AND OFF-SITE DISPOSAL.

--End of Section--

# SECTION 02230

# CLEARING AND GRUBBING
**06/97**

## PART 1 GENERAL

### 1.1 DESCRIPTION

The work covered in this section shall consist of clearing and grubbing on the Causeway. The following definitions relate to this work:

a. Clearing shall consist of the felling, trimming, and cutting of trees and shrubs into sections, chipping of the sections, and placement of the chipped material on the Causeway.

b. Grubbing shall consist of the removal and disposal of stumps, roots larger than 3 inches in diameter, and matted roots from the designated grubbing areas.

### 1.2 REFERENCES (NOT USED)

### 1.3 SUBMITTALS (NOT USED)

## PART 2 PRODUCTS (NOT APPLICABLE)

## PART 3 EXECUTION

### 3.1 CLEARING

Trees, stumps, roots, brush, and other vegetation in areas to be cleared shall be cut off flush with or below the original ground surface, except such trees and vegetation as may be indicated or directed to be left standing.

### 3.2 GRUBBING

Material to be grubbed, shall be removed to a depth of not less than 2 feet below the original surface level of the ground, if necessary. Depressions made by grubbing shall be filled with Causeway fill material during Phase II of this work (NITC). Safety fencing shall be placed around any excavation greater than 2 feet deep and a layer of erosion control mulch shall be placed in accordance with Section 02271 EROSION AND SEDIMENT CONTROL.

### 3.3 DISPOSAL OF MATERIALS

Logs, stumps, roots, brush, rotten wood, and other refuse from the clearing and grubbing operations shall be chipped and disposed on the Causeway ground surface, except when otherwise directed in writing. Surface spreading of chipper debris shall be performed using heavy equipment and worked into causeway fill materials, such that the thickness of chipped materials is less than 6 inches. The Contracting Officer will state the areas in which chipper debris may be placed.

--End of Section--

## SECTION 02271

## EROSION AND SEDIMENT CONTROL

## PART 1 GENERAL

### 1.1 DESCRIPTION

The Contractor shall provide the materials, equipment, and labor necessary for the installation, inspection, and maintenance of sediment and erosion control structures as specified herein or as required to protect surface waters. At the completion of the remedial construction, provide materials, equipment, and labor necessary for the removal, transport and disposal of silt and erosion control structures not specified to remain. Floating silt curtains (N.I.T.C.) are to remain in place after completion of Phase I, and through completion of Phase II Causeway cover construction (N.I.T.C.). Remove, transport, and dispose of sediment resulting from erosion control measures collected from disturbed areas in a manner consistent with overall intent of this specification and which does not result in additional erosion or sediment release.

### 1.2 REFERENCES

A. U.S. Environmental Protection Agency Publication 430/9-73-007 Processes, Procedures and Methods to Control Pollution Resulting from All Construction Activity.

B. U.S. Department of Agriculture Soil Conservation Service Publication dated July 1975, Standards and Specifications for Soil Erosion and Sediment Control in Developing Areas.

C. Connecticut Department of Environmental Protection, 1988. Erosion and Sediment Control Guidelines in combination with the text from the Stormwater General Permit.

### 1.3 SUBMITTALS

As part of the Environment Protection Plan, specified in Section 01410 ENVIRONMENT PROTECTION, the Contractor shall submit a plan for controlling erosion and siltation before beginning the construction work. Said plan shall also include the methods to be utilized for protecting and stabilizing excavations, slopes and stockpiles which will be the result of the construction work. Acceptance of this plan will not relieve the Contractor of responsibility for completing the work as specified. The plan shall include, but not be limited to, the following items regarding erosion control:

a. Shop drawings for the fabrication of the floating silt curtains (N.I.T.C.);

b. product data sheets from the manufacturer for the products to be supplied, for which no project specific requirements are provided herein;

c. product data sheets and certifications from the manufacturer of the silt curtain, indicating that the products supplied meet the project specific requirements, as specified herein;

d. product data sheets and certifications from the manufacturer of the helical anchors, indicating that the products supplied meet the project specific requirements, as specified herein and are appropriate for the intended use;

e. manufacturer's fabrication instructions, installation instructions and maintenance instructions for the sediment control devices to be used; and

f. manufacturer's qualifications for the manufacture of the floating silt curtain. Qualifications shall include materials fabrication and deployment experience. An approved manufacturer is Kepner Plastics Fabricators, Inc of Torrance, California. (N.I.T.C.)

### 1.4 REVIEW AND INSPECTION OF SEDIMENTATION CONTROL MEASURES

All construction under this project shall be subject to review and inspection by the appropriate State and Federal agencies responsible for ensuring the adequacy of sedimentation control measures.

### 1.5 QUALITY ASSURANCE

Prior to the installation of the floating silt curtain (N.I.T.C), the Contractor shall arrange a meeting at the site with the system supplier and, if applicable, the system installer to review manufacturer's recommended installation, and maintenance instructions. Materials shall be on-site and the Contractor shall be prepared to install a portion of the floating silt curtain (N.I.T.C.). The Contracting Officer shall be notified at least 5 days in advance of the time of the meeting.

## PART 2 PRODUCTS

### 2.1 MATERIALS

#### 2.1.1 Mulch

a. Late cut, matured, and cured hay.

b. When air-dried in the loose state, the contents of a representative bale shall lose not more than 15 percent of the resulting air-dry weight of the bale.

c. Free from primary noxious weed seeds and rough or woody materials.

#### 2.1.2 Matting for Erosion Control

a. Jute Mat:
   1. Open weave, single jute yarn averaging 130 pounds per spindle of 14,400 yards.

2. Yarn: Loosely twisted construction, not varying in thickness by more than 1/2 its normal diameter.
3. Woven Material: 48 inches wide, plus or minus 1 inch, with approximately 78 warp ends per width of cloth and 41 weft ends per linear yard, weighing 1.22 pounds per linear yard with a tolerance of plus or minus 5 percent.

b. Excelsior Mat:
1. Wood excelsior, at least 35 inches in width, weighing 0.8 pounds per square yard plus or minus 5 percent.
2. Covered with a netting on one side to facilitate handling and to increase strength.

c. Other Types of Matting: Those accepted by the Contracting Officer as equal in effectiveness to one of those specified above.

2.1.3 Staples

No. 11 (or heavier) plain iron wire, made from lengths of at least 12 inches.

2.1.4 Hay Bales

a. Consist of rectangular-shaped bales of hay or straw weighing at least 40 pounds per bale.

b. Free from primary noxious weed seeds and rough or woody materials.

2.1.5 Siltation Fence

Envirofence as manufactured by Mirafi Inc. or approved equal with an equivalent opening size of 30, or approved equal.

2.1.6 Floating Silt Curtain (N.I.T.C.)

a. Unless otherwise specified on the contract drawings, shop drawings, or directed by the Contracting Officer, the Floating Silt Curtain shall consist of the following materials. Those products followed by an "S", indicate that project specific product requirements are provided, "N" indicates that general requirements are provided herein.
(1) Float (N)
(2) Skirt (S)
(3) Nylon Lacing (N)
(4) Hi-Tension Webbing (S)
(5) Galvanized Ballast Chain (N)
(6) Aluminum End Connection (N)
(7) Brass Grommets (N)
(8) Stainless Steel Bolts (N)
(9) Anchors (S)

b. Skirt:

The skirt material, used to wrap the float for the silt curtain and to encase the ballast chain, shall be a coated fabric having the following characteristics:

| Property | Units | Type I | Type II |
|---|---|---|---|
| Base Fabric | | | |
| Weight | oz./sq. yd. | 6 | 5.5 |
| Fiber | | Polyester | Polyester |
| Coated Fabric | | | |
| Total Weight | oz./sq. yd. | 22 | 23 |
| Type of Coating | Both Sides | PVC | Urethane |
| Coating Distribution | Face | 60% | 60% |
| (by weight) | Back | 40% | 40% |
| Color | | High Vis. Yellow | High Vis. Yellow |
| Mechanical Properties | | | |
| Tensile Strength | Warp | 500 | 440 |
| Grab, lbs. | Fill | 450 | 440 |
| Tensile Strength | Warp | 400 | 275 |
| 1" strip, lbs. | Fill | 300 | 225 |
| Adhesion of Coating (film break) | lbs. / 2" | 25 | 25 |
| Hydrostatic | p.s.i. | 600 | 400 |
| Tear Resistance (tongue) | lbs. | 110 | 160 |
| Abrasion Resistance (taber) | cycles | 300 | 7,500 |
| To Exposure of Fabric | Wheel | H-22 | H18 |
| | Grab Load, lbs. | 1000 | 1000 |

2.1.7 Anchor (N.I.T.C.)

a. Two types of helical anchors shall be used to anchor the floating silt curtain and have the following properties.

b. Type 1 Anchor shall have a minimum pull out and lateral load capacity of 4,000 pounds each.

c. Type 2 Anchors shall have a minimum pull out and lateral load capacity of 3,000 pounds each.

d. The materials shall be suitable for use in an inter-tidal saltwater environment and shall include appropriate corrosion resistance.

e. Each anchor shall be supplied with an eye-hook to allow for connection to the floating silt curtain.

f. Provide a suitable length of 5/16-inch galvanized carbon steel chain to connect the anchor to the floating silt curtain, as shown on the drawings.

### 2.1.8 Hi-Tension Webbing (N.I.T.C.)

Hi-Tension Webbing to be used in Type 2 Floating Silt Curtains shall be 2-inch-wide polyester with a 10,000-pound per inch tensile capacity.

## PART 3 EXECUTION

## 3.1 PERFORMANCE

### 3.1.1 General

a. The CONTRACTOR shall implement and maintain erosion and sedimentation control measures, which effectively prevent accelerated erosion and sedimentation.

b. Earthmoving activities shall be conducted in such a manner as to prevent accelerated erosion and sedimentation.

c. Land disturbance shall be kept to a minimum.

d. The erosion and sediment control measures shall be conducted in accordance with the erosion and sediment control measures contained in the approved Work Plan.

e. Temporary erosion and sediment control measures shall be installed as the first step in construction, shall be continuously maintained, and shall not be removed until permanent cover is completely established and stabilized, with the Contracting Officer approval.

f. Furnish and place silt fence, check dams, and hay bales as temporary erosion and pollution control devices at locations in accordance with the approved Work Plan.

g. Erosion control devices shall delineate the work exclusion zones for the site tidal mud flats.

h. Temporary control shall be maintained both during Phase I work, as well as during the interim period leading up to Phase II work activities. Disturbed areas shall be covered with matting for erosion control above elevation 6 in areas where work is not to be performed for two weeks or longer.

i. Excavation shall not be conducted in areas outside the siltation fence unless additional siltation fence installed between the excavation area and the tidal flats.

### 3.1.2 Diverting Surface Water

a. Build, maintain, and operate all cofferdams, channels, flumes, sumps, and other temporary diversion and protection works needed to divert surface water through or around the construction site and away from the construction work while construction is in progress.

b. Storm runoff from disturbed areas must be discharged through temporary erosion control measures, in accordance with the approved Erosion and Sediment Control Plan prior to discharge into a natural water bodies.

3.1.3 Erosion Control Provisions

a. Construct all haul roads of a durable coarse granular surface material sufficiently protected from erosion through water and wind action by channeling water flow around the structure, protecting side slopes in accordance with the approved Work Plan.

b. Protect tidal areas, below elevation 6 by constructing silt fence at the top of slope to intercept storm runoff from the area.

c. The toe of slope shall be protected with floating silt curtains to be temporarily placed within the mud flats and channel. (N.I.T.C.)

d. Contain discharge from pumping operations during dewatering operations and washing of oversized materials by a dike constructed to prevent silt from entering the River, as necessary. Protect the area of the outlet pipe against erosion by flowing water by the construction of a rock or timber apron.

e. Prior to removal of all sediment control dikes, remove all retained silt or other materials at no additional cost to the Government.

f. Temporarily remove silt fence to allow access to work areas, replace in a timely fashion, as approved by the Contracting Officer.

3.1.4 Mulch

a. Undertake immediately after each area has been properly prepared. Wood chips from chipped trees may be substituted where approved by the Contracting Officer.

b. Apply hay that has been thoroughly fluffed at approximately, but not to exceed, 3 tons per acre unless ordered otherwise.

c. Blowing chopped mulch will be permitted when authorized.

d. Hay mulch should cover the ground enough to shade it, but the mulch should not be so thick that a person cannot see ground through the mulch.

e. Dispose of all baling wire or rope outside the limits of the project in approved areas.

3.1.5 Matting

a. Preparation:
  1. Surfaces of Ditches and Slopes:
    (a) Conform to grades and cross sections shown in the approved Work Plan.

(b) Finish to a smooth and even condition with all debris, roots, stones, and lumps raked out and removed.
(c) Loosen soil surface to permit bedding of the matting.
(d) Unless otherwise directed, apply seed prior to placement.

b. Jute:
1. Place strips lengthwise in the direction of the flow of water.
2. Where strips are laid parallel or meet as in a tee, overlap at least 4 inches.
3. Ends: Overlap at least 6 inches, shingle fashion.
4. The up-slope end of each strip of the matting shall be turned down and buried to a depth of not less than 6 inches with the soil firmly tamped against it.
5. The Contracting Officer may require that any other edge exposed to more than normal flow of water be buried in a similar manner.
6. Check Slots:
   (a) Build at right angles to the direction of the flow of water.
   (b) Space so that one check slot or one end occurs within each 50 foot length of slope.
   (c) Construct by placing a tight fold of the matting at least 6 inches vertically into the ground, and tamp the same as up-slope ends.
7. Edges of Matting: Bury around the edges of catch basins and other structures.

c. Excelsior:
1. Unroll in the direction of the flow of water.
2. Where strips are laid end to end, butt adjoining ends.
3. When adjoining rolls are laid parallel to one another, butt matting snugly.

d. Laying and Joining:
1. Except where jute matting is turned down, spread evenly and smoothly in close contact with the ground.
2. Cutout bulging seams and make joints as described above.
3. When ordered, additional seed shall be spread over jute matting, particularly at those locations disturbed by building the slots. Jute matting shall then be pressed onto the ground with a light lawn roller or by other satisfactory means.
4. Drive staples vertically into the ground flush with the surface.
5. On slopes flatter than 4:1, space staples not more than 3 feet apart in three rows for each strip, with one row along each edge and one row, alternately spaced, down the center, or as recommended by manufacturer.
6. On grades 4:1 or steeper, place staples in the same three rows, but spaced 2 feet apart, or as recommended by manufacturer.
7. On all overlapping or butting edges, double the number of staples, with the spacing halved; all ends of the matting and all required check slots shall likewise have staples spaced every foot.
8. Matting Placed Adjacent to Boulders or Other Obstructions: Staple with no space between the staples, to eliminate any loose edges of matting.

9. The above specified spacing of staples may be changed as ordered, depending upon varying factors such as the season of the year or the amount of water encountered or anticipated.
10. In driving the staples, take care so as not to form depressions or bulges in the surface of the matting.
11. Other Matting: Approved, alternate matting shall be applied in accordance with the recommendations of the manufacturer and as directed.

e. Floating Silt Curtain (N.I.T.C.):
   1. Install anchors in accordance with manufacturers recommendations.
   2. Install anchors and anchor connectors, such that when silt curtain is attached it can fall no closer than 5 feet from the limits of work, as shown on the Drawings.
   3. Install silt curtain in accordance with manufacturers recommendations.

f. Siltation Fence:
   1. Install per manufacturer's requirements and in locations shown on the Drawings and as directed by the Contracting Officer.

## 3.2 MAINTENANCE

3.2.1 Erosion and sediment control activities shall be conducted in accordance with the erosion and sediment control measures contained in the approved Work Plan.

3.2.2 Erosion and sediment control measures shall be inspected by the Contractor at least once a week and at least daily during prolonged rainfall events. Repair and/or maintenance of sedimentation and erosion control measures shall be made as soon as needed.

3.2.3 Sediments removed from sediment control devices prior to final cover installation shall be placed within the limits of the cover area, above elevation 6. Sediments shall be placed so as not to interfere with surface water drainage or pose a potential erosion problem in the future.

3.2.4 Maintain the integrity of sediment and erosion control measures throughout construction period.

3.2.5 Maintain floating silt curtain to account for settlement/movement of anchors. (N.I.T.C.)

3.2.6 Maintain all sediment and erosion control measures during the interim period between this work phase and initiation of final cover installation.

## 3.3 HAY BALES FOR EROSION CONTROL

3.3.1 Place as ordered to provide for temporary control of erosion or pollution or both.

3.3.2 Stake with the required stakes.

3.3.3 Upon acceptance of the Contract, the bales shall be left in place unless released to the Contractor.

## 3.4 REMOVAL OF TEMPORARY WORKS

3.4.1 Remove or level and grade to the extent required to present a sightly appearance and to prevent any obstruction of the flow of water or any other interference with the operation of or access to the permanent works.

-- End of Section--

# SECTION 02522

## MONITORING WELLS
05/98

## PART 1 GENERAL

### 1.1 DESCRIPTION

There are five existing groundwater monitoring wells on the Causeway, including MWCD-99-01A and -01B, MWCD-99-02A and -02B, and MWCD-00-01. The work covered in this section includes the abandonment of monitoring well MWCD-00-01 and the protection of the four remaining monitoring wells during construction activities.

### 1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

| | |
|---|---|
| ASTM D 1785 | (1996b) Polyvinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80, and 120 |

NSF INTERNATIONAL (NSF)

| | |
|---|---|
| NSF ANSI/NSF 14 | (1996) Plastics Piping Components and Related Materials |

### 1.3 SUBMITTALS

As part of the Phase I Completion Report, specified in Section 01780 CLOSEOUT SUBMITTALS, the Contractor shall submit the manufacturer's data and recommended installation instructions for the used well sealant material. A monitoring well abandonment record, for each monitoring well abandoned, shall also be submitted to the Contracting Officer as part of the Phase I Completion Report.

### 1.4 LICENSE REQUIREMENTS

All work related to monitoring wells is to be performed by a contractor licensed by the State of Connecticut to perform the work required under this contract.

## PART 2 PRODUCTS

### 2.1 WELL FILL SEALANT MATERIAL

Well fill sealant material shall be Floseal or approved equal.

## PART 3 EXECUTION

### 3.1 GENERAL

The Contractor shall protect or abandon existing monitoring wells as indicated in this section. The Contractor shall perform only the work required based on actual site conditions experienced.

### 3.2 PROTECTION OF EXISTING MONITORING WELLS

The Contractor shall maintain existing monitoring wells marked to remain and protect them from damage from equipment and vehicular traffic. Any items damaged by the Contractor shall be repaired by the Contractor. Protection of existing monitoring wells shall be incidental to the Work.

### 3.3 MONITORING WELL ABANDONMENT

#### 3.3.1 General

The existing groundwater monitoring well, MWCD-00-01, is scheduled to be abandoned. Monitoring well abandonment shall consist of filling the well with sealing material, removal of the protective casing, and removal of a portion of the solid riser pipe to a point 1 foot below the existing grade at the well. All filling of the well shall be continuous and conducted to manufacturer's specifications using the tremmie method.

#### 3.3.2 Well Decommissioning/Abandonment Records

Decommissioning/abandonment records shall include, as a minimum, the following:

a. Project name.

b. Well number.

c. Well location, depth and diameter.

d. Date of decommissioning/abandonment.

e. Method of decommissioning/abandonment.

f. Description and total quantity of well filler sealant material.

--End of Section--

# SECTION 02576

# BITUMINOUS CONCRETE PAVEMENT

## PART 1 GENERAL

### 1.1 DESCRIPTION

The work covered by this section consists of furnishing all labor, equipment and materials necessary to perform all operations in connection with application of a tack coat and construction of bituminous concrete pavement. All work shall be performed in accordance with this section of the specification and as shown on the contract drawings.

### 1.2 REFERENCES

The following publications of the issues listed below, but referred to hereafter by basic designation only, form a part of this section to the extent indicated by the references thereto.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

| | |
|---|---|
| ASTM D 977 | (1998) Emulsified Asphalt |
| ASTM D 2027 | (1997) Cutback Asphalt (Medium-Curing Type) |

CONNECTICUT DEPARTMENT OF TRANSPORTATION

Standard Specifications for Roads, Bridges, and Incidental Construction (State Standards)

### 1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES.

SD-03, Product Data

Bituminous Pavement Mix; GA

The Contractor shall submit for approval copies of the supplier's current job mix formulas at least ten working days prior to commencing any paving work.

### 1.4 CRITERIA FOR BIDDING

Base bids on the following criteria.

#### 1.4.1 Surface Pavement of Former AST Area

a. The price shall be full compensation for the required grade of asphalt tack coat placement, bituminous concrete placement, and all work incidental to the construction of a temporary pavement surface. This item will be incidental to the Building 59 Demolition bid item (Item No. 0006).

## PART 2 PRODUCTS

### 2.1 MATERIALS

### 2.1.1 Bituminous Concrete

Bituminous concrete for surface and binder courses shall conform to the applicable requirements of the State Standards.

### 2.1.2 Bituminous Concrete Mixture

The bituminous concrete binder course shall conform to the requirements listed in the State Standards. The mixture shall be obtained from a supplier regularly producing bituminous concrete under the State Standards. Approval shall be contingent on conformance of the completed pavement to the specification requirements including adherence to the suppliers current job mix formulas within specific toluene limits.

### 2.1.3 Tack Coat

Bituminous material used for the tack coat shall be emulsified asphalt conforming to ASTM D 977, grade RS-1.

## PART 3 EXECUTION

### 3.1 PREPARATION OF EXISTING SURFACES

The surface to receive new bituminous concrete surface course shall be cleared of existing gravel and soil and swept prior to placement of the tack coat.

### 3.2 TACK COAT

A tack coat shall be applied to the surface of the existing pavement and new binder courses prior to construction of the new bituminous concrete surface course. Bituminous material for the tack coat shall be RS-1 emulsified asphalt conforming to ASTM D 977. The emulsion shall be applied at a rate of approximately 0.05 gallons per square yard. The temperature of the emulsion shall range between 75 and 130°F at the time of application. The application shall be made just prior to placement of the bituminous concrete surface course and shall progress sufficiently ahead of the paving so that the surface to be paved will be "tacky".

### 3.3 BITUMINOUS CONCRETE PAVEMENT

Bituminous concrete pavement shall be placed and compacted in accordance with the State Standards. Compaction and density requirements for this work shall be as required in the State Standards.

### 3.3.1 Course Thickness

The bituminous concrete binder course shall be placed in one layer, approximately 1-1/2 inch thick. The bituminous concrete surface course shall be placed in one layer, which is sufficiently thick to provide a level surface along the ground.

--End of Section--

# DIVISION 13

# SPECIAL CONSTRUCTION

## SECTION 13281

## ASBESTOS ABATEMENT

## PART 1 GENERAL

### 1.1 DESCRIPTION

Work includes removal of all asbestos containing materials (ACM) from Building 5 and off-site disposal at a licensed disposal facility. A previous building survey has indicated ACM in the roof and in water pipe insulation in Building 5. Excerpts for the Building 5 asbestos survey report are included in Appendix H of the Basis of Design.

### 1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

CODE OF FEDERAL REGULATIONS (CFR) PUBLICATIONS

| | |
|---|---|
| 29 CFR 1926.58 | Asbestos (latest version) |
| 29 CFR 1910.134 | Respiratory Protection |
| 29 CFR 1910.145 | Specifications for Accident Prevention Signs and Tags |
| 40 CFR 61 | General Provisions, Subpart A |
| 40 CFR 61 | National Emission Standard for Asbestos, Subpart M |
| 40 CFR 763 | Asbestos Abatement Projects, Subpart G |
| 49 CFR 171 | General Information |
| 49 CFR 172 | Hazardous Materials |
| 49 CFR 173 | General Shipping Requirements |
| 49 CFR 177 | Transporter Requirements |
| 49 CFR 178-79 | Container Specifications |

American National Standard Institute (ANSI) Publication

| | |
|---|---|
| 29.2-79 | Fundamentals Governing the Design and Operation of Local Exhaust Systems |

U.S. Environmental Protection Agency (USEPA) Publication

| | |
|---|---|
| EPA 560/5-85-024 | Guidance for Controlling Asbestos Containing Materials in Buildings |

State of Connecticut

### 1.3 SUBMITTALS

As part of the Work Plan, specified in Section 02111 EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL, an Asbestos Abatement Plan shall be submitted that details the proposed procedures to be used in the removal and disposal of ACM. Such plan shall conform to this section and the USEPA requirements of 40 CFR 61.22. Refer to Part 3 of this specification section.

SD-01 Pre-construction Submittals

Submit a copy of a valid/current license for the asbestos abatement activities as required by the State of Connecticut.

SD-07 Certificates

A. Submit manufacturers' certification that vacuum pumps, ventilation equipment, and other equipment required to handle airborne asbestos fibers conform to ANSI 29.2.

B. The Contractor shall submit a list of ACM disposal facilities proposed for the disposal of all ACMs associated with this Contract. The list shall contain the address, telephone number and contact name for each facility. The Contractor shall provide written approval from each disposal facility of its acceptance of ACMs from this Contract and written notice from each asbestos disposal facility that it is in conformance with its operating permit.

C. Testing Laboratory: Submit the name, address, and telephone number of the testing laboratory selected for the monitoring of airborne concentrations of asbestos fibers along with certification that persons counting the samples have been judged proficient. Sampling is required under 29 CFR 1926.58. Monitoring shall be conducted daily to establish the exposure of each employee who is exposed inside the work area. The laboratory reading the tests shall be a participant of an approved and recognized Performance and Testing (PAT) program.

D. Monitoring Results: Submit all monitoring results to the Contractor Officer or a representative within 14 working days of such monitoring.

## 1.4 QUALITY CONTROL

### 1.4.1 Medical Requirements

The Contractor shall meet all medical requirements contained in 29 CFR 1926.58 including but not limited to medical exams and medical records.

A. Training

1. Ensure that all personnel exposed to airborne asbestos are familiar with the hazards of asbestos, safety and health precautions, and the use and requirements for protective clothing and equipment.
2. A "competent person" shall directly supervise all asbestos removal activities including but not limited to establishment of enclosures, ensuring enclosure integrity, controlling entry and exit from the enclosure, exposure monitoring, use of protective clothing and equipment, use of hygiene facilities, and use of engineering emission controls. The "competent person" shall

meet all the requirements identified in 29 CFR 1926.58(b) and 29 CFR 1926.58(e)(6)(iii).

B. Permits and Notification

1. Secure necessary permits in conjunction with ACM removal, hauling, and disposition and provide timely notification of such actions as may be required by federal, state, regional, and local authorities.
2. Notify the Regional Office of the USEPA in accordance with 40 CFR 61.22(d)(1), 10 days prior to commencement of the work.
3. Notify the Contracting Officer or a representative 2 weeks prior to the start of asbestos work.
3. Notify the Connecticut Department of Public Health at least 10 days prior to commencement of work.

C. Safety Compliance

1. Comply with laws, ordinances, rules, and regulations of Federal, state, regional, and local authorities regarding handling, storing, transporting, and disposing of asbestos waste materials.
2. Comply with the applicable requirements of the current issue of 29 CFR 1926.58 and 40 CFR 61, Subparts A and M.
3. Submit matters of interpretation of standards to the appropriate administrative agency for resolution before starting the work.
4. Where the requirements of this specification and reference documents vary, the most stringent requirements shall apply.

D. Respirator Program: Establish a respirator program as required by 29 CFR 1910.134.

## PART 2 PRODUCTS (NOT APPLICABLE)

## PART 3 EXECUTION

### 3.1 ASBESTOS ABATEMENT PLAN

As part of the Work Plan, the Contractor shall submit an Asbestos Abatement Plan and required project notification to the Contracting Officer and state and federal agencies, as required, for review. No work on-site will be permitted until the comments received from the regulatory agencies are adequately addressed by the Contractor. The Asbestos Abatement Plan shall outline work procedures that are in compliance with these specifications and cited regulations.

The approved plans and variances, completed with all comments addressed, shall be made a part of the Contract Documents by reference. The Contractor shall implement and maintain these procedures at the appropriate time prior to and during performance of the work. Failure to adhere to these plans will give Contracting Officer the right to issue a stop work order. The Contractor shall not be entitled to a time extension for such an action.

## 3.2 ASBESTOS ABATEMENT EQUIPMENT

The Contractor shall provide protective equipment as required by 29 CFR 1926.58.

## 3.3 ASBESTOS ABATEMENT PROCEDURES

### A. General Procedures

1. The Contractor is responsible for complying with all laws, ordinances, rules and regulations of Federal, state, and local authorities regarding handling, storing, transporting, and disposing of asbestos waste materials.
2. Provide asbestos control areas with caution signs and local exhaust as may be directed by the Contracting Officer or a representative in accordance with these specifications and 29 CFR 1926.58, 40 CFR 61, Subparts A and B. Use wet removal procedures. Personnel shall wear and use protective clothing and equipment as required by 29 CFR 1926.58. Eating, smoking, or drinking shall not be permitted in the asbestos control area. Personnel of other trades not engaged in the removal and demolition of asbestos shall not be exposed at any time to airborne concentrations of asbestos unless all the personnel protection provisions of this specification are complied with by the trade personnel.
3. Sufficiently wet asbestos material during removal, cutting, or other handling so as to reduce the emission of airborne fibers. Asbestos-containing debris shall be kept wet at all times. Method and techniques for removal are outlined in the appendices to 29 CFR 1926.58.
4. Remove materials and immediately place in plastic disposal bags. Where unusual circumstances prohibit the use of plastic bags, submit an alternate proposal for containment of asbestos fibers to the Contracting Officer for approval.
5. The Contractor may use the abatement procedures outlined in this specification, depending on the type of ACM and the Contractor's standard procedures. Alternate abatement procedures shall be detailed in the Contractor's Work Plan.

### B. Full Containment

1. Where deemed appropriate for friable ACM removal, full containment shall be used. The Contractor shall isolate the work area for the duration of the abatement, completely sealing all openings. Any fixed objects will be covered with 6-mil polyethylene sheets taped securely in place. All polyethylene used for establishing containment areas shall be a fire retarding type.
2. The entire floor within the immediate, contained, work area will be covered with two layers of 6-mil polyethylene extended up the vertical surfaces. On a daily basis, an additional 6-mil polyethylene liner will be placed below the planned work area.
3. Emergency exits shall be clearly marked by the Contractor's personnel and access will be maintained throughout the

abatement activities. Fire extinguishers will be located in each work area.

4. The Contractor shall install and maintain negative pressure equipment during the abatement and decontamination process. A sufficient number of negative air machines will be installed to ensure a complete air change within the containment every 15 minutes.
5. Attached to each full containment will be a three-chambered decontamination facility. The Contractor's three-chambered decontamination will consist of:

   a. An equipment room with an air lock to the work area and curtained doorway to the shower room.
   b. A shower room with two curtained doorways, one to the equipment room and one to the clean room. The shower room will contain sufficient showers with hot and cold water to support the planned crew during each work shift. The Contractor will contain and filter all shower wastewater. Wastewater will be filtered through a 5.0 micron filter, and drained into a sanitary sewer upon approval of the Contracting Officer or a representative.
   c. A clean room with one curtained doorway/entrance and one curtained doorway into the shower room.

C. Glovebag Method

1. Where feasible, the Contractor shall isolate working areas by constructing a single layer of 6-mil polyethylene to act as an isolation barrier (mini-containment).
2. The Contractor shall isolate the work area for the duration of the abatement, completely sealing all openings. The entire floor within the immediate work area will be covered with two layers of 6-mil polyethylene. Any fixed objects will be covered with 6-mil polyethylene taped securely in place.
3. Emergency exits will be clearly marked by The Contractor personnel and access will be maintained throughout the abatement activities. Fire extinguisher will be located at each work area.
4. The Contractor will install and maintain negative pressure equipment during the abatement and decontamination process. A sufficient number of negative air machines will be installed to ensure a complete air change within the containment four (4) times per hour.
6. Attached to each mini-containment will be a two-chambered decontamination facility. The Contractor's two-chambered decontamination will consist of:

   a. An equipment room with a curtained doorway to the isolated work area and curtained doorway to the shower room.
   b. A shower room with two curtained doorways, one to the equipment room and one to the clean room. The shower room will contain at least one shower with hot and cold water. The Contractor will contain and filter all shower waste water. Waste water will be filtered through a 5.0 micron

filter, and drained into a sanitary sewer upon approval of the Contracting Officer or a representative.

6. The Contractor may elect to use a three-stage decontamination facility as described earlier in place of the two-stage facility as a remote decontamination facility. If a remote decontamination facility is used, all personnel will be required to double-suit.
7. All abatement utilizing the glovebag method will be conducted so that the glovebag completely surrounds the object to be abated and contains all asbestos fibers released during the removal process. The glovebags will have tools and equipment to allow the Contractor to wet-down the ACM, and to maintain filtered negative-pressure on the glovebag internals. Following cutting of the insulation inside the bag, excess air will be removed by filtered vacuum, the glovebag will be removed and sealed and placed in secondary containment for disposal.
8. All of The Contractor's workers who utilize this method of removal must be highly trained, experienced and skilled in this method.

D. Wrap and Cut Method

1. This method of removal may be utilized when removing asbestos pipe insulation that is not damaged. Workers donning protective coveralls and 1/2 faced respirators will cordon off the work area and post proper signs at the perimeter. The asbestos insulation will then be wrapped-in-place with two layers of 6-mil polyethylene. All seals will be spray glued and duct taped.
2. Once the insulation is wrapped, glovebags shall be attached to the pipe. The glovebag abatement shall be done every ten to twenty (10-20) feet to allow the cutting of the pipes into manageable sections. Pipe and equipment prepared in this manner shall be transported to a decontamination area for gross removal and salvage. Alternately, wrapped equipment and piping may be sent directly to disposal if removal is not economical.
3. If pipe cut locations are not insulated, the use of glove bags will not be required at those locations.
4. A remote two-stage (or three-stage, if desired) decontamination facility shall be used for personnel decontamination.

E. Roofing Material

When removing roofing materials which contain ACM as described in 29 CFR 1926, Section .1101(g)(8)(ii), the Contractor shall use the following practices.

1. Roofing material shall be removed in an intact state. Wet methods shall be used to remove roofing materials that are not intact, or that will be rendered not intact during removal,

unless such wet methods are not feasible or will create safety hazards.

2. When removing built-up roofs, with asbestos-containing roofing felts and an aggregate surface, using a power roof cutter, all dust resulting from the cutting operations shall be collected by a HEPA dust collector, or shall be HEPA vacuumed by vacuuming along the cut line.
3. Asbestos-containing roofing material shall not be dropped or thrown to the ground, but shall be lowered to the ground via covered, dust-tight chute, crane, hoist or other method approved by the Contracting Officer.
4. Any ACM shall be lowered to the ground as soon as practicable, but not later than the end of the work shift. While the material remains on the roof it shall be kept wet or placed in an impermeable waste bag or wrapped in plastic sheeting.
5. Unwrapped material shall be transferred to a closed receptacle precluding the dispersion of dust.
6. Critical barriers shall be placed over roof level heating and ventilation air intakes.

## 3.4 MONITORING

A. Monitoring of airborne concentrations of asbestos fibers shall be in accordance with 29 CFR 1926.

B. Pre-removal Monitoring: The Contractor shall provide area monitoring inside prior to beginning work to establish ambient air quality.

C. Monitoring After Final Cleanup: The Contractor shall provide asbestos control area monitoring of asbestos fibers and establish the Time Weighted Average (TWA) of less than 0.01 fibers/cc after final clean-up but before removal of the enclosure of the asbestos control area. Monitoring shall use aggressive sampling techniques as described in the "Guidance for Controlling Asbestos-Containing Materials in Buildings" EPA 560/5- 85-024, Appendix M. Sampling shall be by the phase contrast microscopy (PCM) method. A minimum of five samples shall be taken for each asbestos control area. The sampling volume for each sample is to be approximately 3000 liters. Provide area monitoring and establish the TWA 5 days after the enclosure of the asbestos control area is removed or after final clean-up when an enclosure is not required. The fiber counts from these samples shall be less than 0.01 fibers/cc. Should any of the final samples indicate a higher value, take appropriate actions to re-clean the area and repeat the monitoring.

## 3.5 CLEANUP

A. General

1. The Contractor shall remove all asbestos debris.
2. The Contractor shall take any steps necessary to ensure that less than 0.01 fibers/cc airborne asbestos remains in the work area.

B. Housekeeping

1. Essential parts of asbestos dust control are housekeeping and clean-up procedures. The Contractor shall maintain surfaces of the asbestos work area free of accumulations of asbestos fibers, give meticulous attention to restricting the spread of dust and debris, and keep waste from being distributed over the general area. Do not blow down the space with compressed air.
2. When asbestos removal is complete, all asbestos debris is removed from the site, and final clean-up is completed, certify the area as safe before the signs are removed. Certification shall be a written statement by the Contractor that airborne concentrations of asbestos are less than 0.01 fibers/cc and all asbestos material has been removed from the area. Dispose of filters as asbestos contaminated materials.

## 3.6 DISPOSAL

A. The Contractor shall be responsible for ensuring:

1. Selection and acceptance of the ACM at an approved treatment or disposal facility.
2. That the facility is properly permitted to accept the ACM.
3. That the facility provides the stated disposal services.
4. That the disposal facility is in compliance with its permit(s) at the time of ACM disposal.

B. The Contractor shall collect asbestos waste, scrap, debris, bags, containers, equipment, and asbestos-contaminated clothing which may produce airborne concentrations of asbestos fibers and place in sealed impermeable bags. Affix caution label to each bag.

C. Procedure for hauling shall comply with 40 CFR 61 (Subpart B), state, regional, and local standards. ACM shall be transported in lined trucks.

D. Dispose of asbestos materials and asbestos contaminated materials at a licensed disposal facility.

## 3.7 MANIFEST RECORDS

A. Originate, maintain, and provide Transporter with copies of waste shipment manifests and/or bills of lading records for all ACM; verify wastes and quantities of each load shipped.

B. The manifest forms and records shall be consistent with the State of Connecticut, USEPA, and U.S. Department of Transportation requirements.

C. The Contracting Officer or a representative will sign the manifest, and will review the manifest for completeness and accuracy prior to final release.

--End of Section--

# ATTACHMENT B

# PHASE II TECHNICAL SPECIFICATIONS

# NON-TIME CRITICAL REMOVAL ACTION
# TECHNICAL SPECIFICATIONS
# CAUSEWAY DESIGN

## 100% CAUSEWAY DESIGN
## PHASE II

## STRATFORD ARMY ENGINE PLANT
## STRATFORD, CONNECTICUT

CONTRACT DAAAM-02-97-D-0005
DELIVERY ORDER NO. 0003

*Prepared for:*

U.S. Army Tank-automotive and Armaments Command
Stratford, Connecticut

*Prepared by:*

Harding ESE, Inc.
A MACTEC Company
Portland, Maine

Project No. 50796
Task No. 1042

AUGUST 2001

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STRATFORD ARMY ENGINE PLANT CAUSEWAY NCRA
PHASE II
STRATFORD, CONNECTICUT

# TABLE OF CONTENTS

# STRATFORD ARMY ENGINE PLANT CAUSEWAY NCRA - PHASE II

## BIDDING SCHEDULE

BASE BID ITEMS

| Item No. | Description | Estimated Quantity | Unit | Unit Price | Subtotal |
|---|---|---|---|---|---|
| 0001 | Phase II Site Preparation | ----- | JOB | LS | $_______ |
| 0002 | Erosion and Sediment Control | ----- | JOB | LS | $_______ |
| 0003 | Heave Platform Monitoring | ----- | JOB | LS | $_______ |
| 0004 | Final Survey Plan | ----- | JOB | LS | $_______ |
| 0005 | Excavation of Satisfactory Fill Material and Causeway Grading | 2,600 | CY | $_______ | $_______ |
| 0006 | Excavation, Handling, and Disposal of Excess Satisfactory Material | 10 | Tons | $_______ | $_______ |
| 0007 | Excavation, Handling, and Disposal of Unsatisfactory, Uncontaminated Material | 10 | Tons | $_______ | $_______ |
| 0008 | Hazardous Material Excavation, Handling, and Disposal | 70 | Tons | $_______ | $_______ |
| 0009 | Non-hazardous Material Excavation, Handling, and Disposal | 630 | Tons | $_______ | $_______ |
| 0010 | Geogrid Composite | 20,000 | SF | $_______ | $_______ |
| 0011 | Rock Fill (Toe) | 400 | Tons | $_______ | $_______ |
| 0012 | Rock Fill(Transition) | 2,000 | Tons | $_______ | $_______ |
| 0013 | Rip Rap (Transition) | 300 | Tons | $_______ | $_______ |
| 0014 | Woven Geotextile | 94,000 | SF | $_______ | $_______ |
| 0015 | Polymeric Marine Mattresses | 94,000 | SF | $_______ | $_______ |

## BIDDING SCHEDULE

BASE BID ITEMS

| Item No. | Description | Estimated Quantity | Unit | Unit Price | Subtotal |
|---|---|---|---|---|---|
| 0016 | Sand Bedding | 2,000 | Tons | $______ | $______ |
| 0017 | Non-woven Geotextile | 67,000 | SF | $______ | $______ |
| 0018 | Interlocking Concrete Block | 56,000 | SF | $______ | $______ |
| 0019 | Gravel | 350 | Tons | $______ | $______ |
| 0020 | Vegetative Support Layer | 2,625 | Tons | $______ | $______ |
| 0021 | Grass Seed | 56,000 | SF | $______ | $______ |
| 0022 | Monitoring Well Grade Adjustment | ----- | JOB | LS | $______ |
| 0023 | Demobilization | ----- | JOB | LS | $______ |

# DIVISION 1

# GENERAL REQUIREMENTS

## SECTION 01010

## SUMMARY OF WORK
**12/94**

## PART 1 GENERAL

### 1.1 DESCRIPTION

The general description below is given to indicate the approximate scope of this project only. It does not limit the work required under the project drawings and specifications.

The work in this contract consists of activities conducted to construct an erosion control cover system on the Stratford Army Engine Plant (SAEP) Causeway, consistent with the Non-time Critical Removal Action (NCRA) Decision Document (Harding ESE, January 2001). Activities to be conducted as part of this work include, but are not limited to:

a. Maintenance of erosion and sediment control measures placed during Phase I of work on the Causeway.

b. Excavation of soil located on the Causeway sideslopes, placement of satisfactory excavated material on the top of the Causeway, and grading of the Causeway to the elevations indicated on the drawings.

c. Off-site transport and disposal of unsatisfactory excavated material.

d. Removal and off-site disposal of oversized debris identified during Phase I activities and encountered during sideslope excavation.

e. Placement of the lower cover system, consisting of geogrid composite and a rock-filled toe (at the end of the Causeway), a woven geotextile, a rock-filled transition drainage layer, and polymeric marine mattress baskets, on the excavated sideslopes of the Causeway.

f. Placement of the upper cover system, consisting, from bottom to top, of Sand Bedding, a non-woven geotextile, interlocking concrete blocks, interstitial gravel, and gravel over the concrete blocks.

g. Placement of a Rip Rap transition connecting the lower cover system to the upper cover system and the Causeway cover to the existing rip rap at the origination of the Causeway from the flood control dike.

h. Placement of a vegetative support layer, including vegetative support soil, suitable grass cover, and an erosion control mat.

i. Monitoring well grade adjustments on four existing monitoring wells.

j. Completion of site surveys during and following the completion of Phase II construction activities.

k. Monitoring of heave platforms and stationary heave poles, installed during Phase I work, and installation and monitoring of temporary heave poles.

l. Demobilization activities, including removal of temporary facilities, removal of erosion control measures, and final site cleanup.

Incidental work, related to the activities listed above, shall also be included in the contract. Incidentals may include personnel and equipment decontamination, on-site treatment and disposal of decontamination fluids, personnel health and safety, contract meetings, quality control testing, and project documentation.

### 1.1.1 Project Location

Work shall be conducted on the Causeway and within the Stratford Army Engine Plant facility in Stratford, Connecticut, as indicated on the drawings. The exact location will be indicated by the Contracting Officer.

### 1.1.2 Previous Findings and Investigations

Chemical sampling and analysis of soil collected from the Causeway identified areas where concentrations of chlorinated and fuel-related volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and inorganics exceed the CTDEP RSRs Direct Exposure Criteria (DEC) and Pollutant Mobility Criteria (PMC). Low-level radiological contamination was also identified during sampling, and the affected areas were excavated in March 2000, containerized and transported to an appropriate off-site, licensed, disposal facility.

Based on the results of chemical sampling and an engineering evaluation, it was recommended that soil containing contaminants in excess of CTDEP RSRs PMC be removed from the Causeway and an erosion control cover system be placed over the Causeway to prevent possible receptor contact with remaining contaminated soil (exceeding CTDEP RSRs DEC). In addition, it was recommended that geotechnical investigations be conducted to assess subsurface conditions in the proximity of the Causeway, and that additional chemical sampling and analysis be completed to delineate the areas of soil exceeding CTDEP RSRs PMC. The additional chemical sampling and analysis, using Synthetic Precipitate Leaching Procedure (SPLP), delineated six distinct areas of soil contamination exceeding CTDEP RSRs PMC. During Phase I activities, these areas, and four additional areas where PCB concentrations exceed 1 part per million, shall be excavated, confirmatory samples shall be collected, and the materials shall be transported to an off-site disposal facility.

Data collected during the geotechnical investigations was used to estimate physical properties for the underlying soil, and perform global stability and settlement analyses for the proposed cover system configuration. The results of the geotechnical investigations and analyses indicated the proposed cover system is viable from a geotechnical perspective.

## 1.2 REFERENCES

The following documents contain additional information regarding the SAEP Causeway:

A. Foster Wheeler/Harding Lawson Associates, April 2000. Final Predesign Investigation Report for the Causeway and Dike NCRA.

B. Foster Wheeler/Harding Lawson Associates, September 2000. Final Engineering Evaluation/Cost Analysis for the Causeway and Dike, Stratford Army Engine Plant.

C. Harding ESE, Inc., January 2001. Final Causeway Non-time Critical Removal Action Decision Document, Stratford Army Engine Plant.

## 1.3 SUBMITTALS (NOT USED)

## 1.4 CONTRACTOR ACCESS AND USE OF PREMISES

### 1.4.1 Access to Work Site

The Contractor shall coordinate access to the site with SAEP security personnel, including obtaining contractor access badges. Security personnel shall be notified of arrival at the site and departure from the site on a daily basis. Access to the Causeway site is currently available through the security gate on Sniffens Lane. Notification of security personnel is necessary for access through this gate.

Work within the Housatonic River shall be initiated following a courtesy notification of the Town of Stratford Harbor Master, the Town of Milford Harbor Master, and the U.S. Coast Guard. The Contractor shall be responsible for contacting these agencies.

### 1.4.2 Work Limits

Work shall be restricted to the areas shown on the contract drawings in addition to storage areas assigned to this Contractor.

### 1.4.3 Radio Communications

Use SAEP-provided radios for communications with SAEP security personnel when on the work site. Return the communication radio to security personnel as required.

Contractor-provided radios shall be approved by SAEP security personnel prior to use on the facility.

### 1.4.4 Work and Storage Areas

Areas within the project limits are available for use by the Contractor, for work, storage of equipment and materials, and field office use during the life of this contract, as indicated on the Drawings. The Contractor shall confine these activities to the limits as designated or approved by the Contracting Officer and shall be responsible for the security of the areas. Upon completion of the contract, the Contractor shall remove all equipment and materials, except as otherwise specified, and restore the site to its original condition as approved by the Contracting Officer at no additional cost to the Government.

### 1.4.5 Delivery of Materials

Notify the Contracting Officer at least 7 calendar days in advance of the date on which the materials and equipment shall be delivered to the site. Delivery and storage of materials shall be accepted only in the approved storage area. Currently, the areas designated for storage are as indicated on the Drawings.

### 1.4.6 Hours of Operations

Normal work hours are from 7:00 a.m. through 6:00 p.m., Monday through Friday. The Contractor will not be permitted to work on Saturdays, Sundays, or legal holidays unless otherwise authorized by the Contracting Officer. The exclusion of work on Saturdays, Sundays, and legal holidays has been considered in computing the performance time of this contract. The following legal holidays are observed:

January 1st
Third Monday in January
Third Monday in February
Last Monday of May
July 4th
1st Monday of September
2nd Monday of October
11th of November
Fourth Thursday of November
25th of December

When one of the above designated legal holidays falls on a Sunday, the following Monday will be observed as a legal holiday. When a legal holiday falls on a Saturday, the preceding Friday is observed as a holiday. Requests to perform work at other times shall be made in writing to the Contracting Officer. Every effort will be made to accommodate such requests.

The CTDEP does not allow what it considers to be unconfined excavation or filling work in the lower reaches of the Housatonic during certain times of the year in order to protect shellfish and finfish resources. The relevant "closed" period for unconfined dredging is from April 1 through September 30. Phase II activities may not be performed during this "closed" period.

### 1.4.7 Coordination With Other Work

It is anticipated that additional contractors may be working at other areas at SAEP during completion of this work. The Contractor shall be responsible for coordinating construction activities with other contractors working concurrently at the site in the same area.

## 1.5 WORK SEQUENCE AND SCHEDULING

The Contractor shall follow a specified task sequence when completing work activities at the site, and shall maintain a schedule approved by the Contracting Officer prior to initiation of work.

### 1.5.1 Work Sequence

The work shall be conducted using a phased approach, consisting of Phase I and Phase II. This Summary of Work details the activities to be conducted under Phase II; specifications associated with Phase I of this work have been provided in a separate package. Erosion and sediment control measures installed during Phase I, shall be maintained during the completion of Phase II work. The Contractor shall complete the following tasks as part of Phase II, following completion of all Phase I tasks at the site:

a. Sideslope excavation and removal of unsatisfactory materials

b. Removal of oversized debris identified during Phase I and encountered during sideslope excavation

c. Causeway grading

d. Lower cover system placement

e. Upper cover system placement

f. Rip Rap transition placement

g. Vegetative support layer placement

h. Monitoring well grade adjustment

i. Site survey

j. Demobilization

The purpose of the phased approach is to limit the number of activities being conducted on the Causeway at one particular time, due to space constraints; however, the Contractor may present approach modifications that result in a reduction in overall project duration and cost.

### 1.5.2 Pre-construction Submittals

The Contractor shall submit the following to the Contracting Officer for approval prior to the start of work on the site; Work Plan, Site Safety and Health Plan Addendum, Environment Protection Plan Addendum, Contractor Quality Control Plan, Preliminary and Initial Project Schedules, and Contractor's Laboratory. The documents shall be submitted as required in Section 01330 SUBMITTAL PROCEDURES.

### 1.5.3 Phased Construction Schedule

Within the overall project schedule, commence and complete the work in phases. Each phase of the work shall be completed within the number of calendar days stated in the schedule.

a. Scheduled Start Day: The day designated as the beginning of a particular phase; the number listed is the number of calendar days from the commencement of work.

b. Completion Day: The day designated as the end of a given phase and the day the work in that phase must be completed; the number listed is the number of calendar days from the commencement of work.

c. If the work of a particular phase is complete before the scheduled completion day, immediately begin work on the subsequent phase unless otherwise restricted.

### 1.5.4 Organization at the Site

The Contractor shall employ ample personnel and sufficient equipment to accomplish the work of this contract in the least amount of time, within the execution period. Should the Contractor fail to maintain a satisfactory rate of progress, the Contracting Officer may require that additional personnel and equipment be placed on the work and weekend and overtime work be performed, in order that the work be brought up to schedule and maintained, at no additional cost to the Government.

## 1.6 PROJECT CONSTRAINTS

The Contractor shall make note of following constraints relating to this work on the SAEP Causeway:

A. Phase II work below the primary erosion control fence may not be completed during the "closed" period from April 1 to September 31.

B. Portions of the SAEP facility are off-limits to Contractor access, as indicated on the Drawings.

C. Access to the Causeway is limited to a gate, approximately 20 feet wide at the origination of the Causeway from the main portion of the facility.

D. The average length of the Causeway is 800 feet, the average width is approximately 200 feet at low tide and 80 feet at high tide.

E. The average width of the existing top (gently sloped) portion of the Causeway is 100 feet.

F. The site is located in a tidal area and excavation activities near the toe of the Causeway shall not be completed under water.

G. Removal of oversized debris must be completed prior to installation of any cover system materials.

H. On the sideslopes of the Causeway, the area to be excavated in any given day, or tide cycle, shall be no larger than that which can be covered with the lower cover system on the same day, or tide cycle.

## PART 2 PRODUCTS (NOT APPLICABLE)

## PART 3 EXECUTION (NOT APPLICABLE)

--End of Section--

## SECTION 01270

## MEASUREMENT AND PAYMENT
02/94

## PART 1 GENERAL

### 1.1 DESCRIPTION

This section covers measurement and payment for work items included in Phase II construction at the Statford Army Engine Plant Causeway.

### 1.2 REFERENCES (NOT USED)

### 1.3 SUBMITTALS (NOT USED)

### 1.4 LUMP SUM PAYMENT ITEMS

Payment items for the work of this contract for which contract lump sum payments will be made are listed in the BIDDING SCHEDULE and described below. The lump sum price and payment made for each item listed shall constitute full compensation for furnishing all plant, labor, materials, and equipment, and performing any associated Contractor quality control, environmental protection, meeting safety requirements, tests and reports, and for performing all work required for which separate payment is not otherwise provided.

### 1.5 UNIT PRICE PAYMENT ITEMS

Payment items for the work of this contract on which the contract unit price payments will be made are listed in the BIDDING SCHEDULE and described below. The unit price and payment made for each item listed shall constitute full compensation for furnishing all plant, labor, materials, and equipment, and performing any associated Contractor quality control, environmental protection, meeting safety requirements, tests and reports, and for performing all work required for each of the unit price items.

When quantities increase by greater than 25% of the original quantity estimated, the contract unit price as established in the original contract will be paid for the quantity up to 25% beyond the original estimated quantity. Work beyond 25% of the estimated quantity will be paid for as follows:

a. By actual itemized cost and fixed fees as set forth by unit prices stated in the Contract Documents or subsequently agreed upon. In the event of an addition to the Contract, a fee of 10% shall be added for overhead and a fee of 10% shall be added for profit if the Work is done by his/her own forces, and 7-1/2% shall be added for administration and profit if the Work is done by a Subcontractor.

b. Cost shall be limited to the following: Cost of materials, cost of labor, and cost of overhead.

When quantities decrease by greater than 25% of the original quantity estimated, payment shall be made in accordance with a. and b. above.

## 1.6 BIDDING SCHEDULE - PAYMENT ITEMS

Payment items for the work of this contract on which the contract progress payments will be based are listed in the BID SCHEDULE and are as briefly described below and as specified in these specifications. All costs for items of work, which are not specifically mentioned to be included in a particular Bid Schedule payment item, shall be included in the listed item most closely associated with the work involved.

### 1.6.1 Item No. 0001 "Phase II Site Preparation"

a. Payment will be made for costs associated with preparation activities to be completed for Phase II. This payment item includes furnishing labor, equipment, tools, materials, and supplies necessary to prepare the site for activities to be completed under Phase II, that have not been previously completed under Phase I. It includes mobilization of equipment that is necessary for Phase II activities, that was not mobilized during Phase I. This payment item also includes preparation and submittal of pre-construction plans, including, but not limited to, a Work Plan, a Site Safety and Health Plan (SSHP) Addendum, an Environment Protection Plan Addendum, a Contractor Quality Control (CQC) Plan, and project schedules. Application and approval of necessary permits shall also be completed under this item.

b. Unit of measure: job lump sum.

### 1.6.2 Item No. 0002 "Erosion and Sediment Control"

a. Payment will be made for costs associated with maintenance and removal of erosion and sediment control measures, including a floating silt curtain (N.I.T.C), silt fencing, and staked haybales. This payment item includes maintenance of erosion control measures starting one month after the completion of Phase I tasks or upon the initiation of Phase II tasks, and ending upon the removal of the control measures, following the completion of Phase II tasks. Payment for this item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work.

b. Unit of measure: job lump sum.

### 1.6.3 Item No. 0003 "Heave Platform and Pole Monitoring"

a. Payment will be made for costs associated with monitoring of the five heave platforms and five stationary heave poles installed during Phase I activities, and the installation and monitoring of temporary heave poles during the completion of Phase II work. Surveying of heave platforms and poles shall be conducted as specified in Section 02110 HEAVE MONITORING. Surveying shall be completed using previously identified benchmark locations and shall comply with the requirements of a Class A-1 survey in the State of Connecticut. Payment for this item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work. Payment for surveying completed to determine excavation and grading quantities is covered under Item No. 0005.

b. Unit of measure: job lump sum.

1.6.4 Item No. 0004 "Final Survey Plan"

a. Payment will be made for costs associated completion of a final topographic survey of the Causeway following the completion of Phase II work, and development of necessary as-built drawings. The final survey shall be completed as specified in Section 01460 SURVEY CONTROL. Surveying shall be completed using previously identified benchmark locations and shall comply with the requirements of a Class A-1 survey in the State of Connecticut. Payment for this item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work.

b. Unit of measure: job lump sum.

1.6.5 Item No. 0005 "Excavation of Satisfactory Fill Material and Causeway Grading"

a. Payment will be made for costs associated with excavation of satisfactory Causeway fill material from below the 4.1-foot msl contour and placement and grading of such material above elevation 4.1 feet msl. This item includes performing required excavation, handling, and grading activities, as shown on the contract drawings, and other operations incidental thereto, as necessary. Also included in this item are costs associated with marking of the limits of Causeway fill, as indicated on the drawings, prior to commencement of excavation activities. Payment for the item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work. Compensation for removal of excess satisfactory, unsatisfactory, and contaminated materials encountered during sideslope excavation is covered under Item Nos. 0006 through 0009.

b. The total quantity of excavated satisfactory material for which payment will be made will be the actual in-place quantity of material placed above the 4.1-foot msl contour. This quantity shall be measured by surveying the initial ground surface above the 4.1-foot msl contour prior to placement of sideslope material, surveying the final re-graded and compacted subgrade, and calculating the volume of material between the two. No allowance will be made for over-depth excavation of the sideslopes or for the removal of any material outside the required areas unless authorized. For purposes of bidding, it shall be assumed that 2,600 cubic yards of satisfactory material shall be excavated from the Causeway sideslopes and placed on the Causeway for grading.

c. Unit of measure: cubic yard.

1.6.6 Item No. 0006 "Excavation, Handling, and Disposal of Excess Satisfactory Material"

a. Payment will be made for costs associated with excavation of excess satisfactory material from below the 4.1-foot msl contour on the Causeway sideslopes, transport of such material to on-site stockpile areas, and eventual off-site transport and disposal. Characterization sampling of excess material shall also be covered by this payment item. Payment for the item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work.

b. The total quantity of excavated excess satisfactory material for which payment will be made, will be the tonnage of satisfactory material removed from the Causeway, as measured at on-site scales, immediately prior to transport off-site for disposal. For Contractor bidding purposes, it is estimated that 10 tons of excess satisfactory material will require removal from the Causeway.

c. Unit of measure: tons.

1.6.7 Item No. 0007 "Excavation, Handling, and Disposal of Unsatisfactory Uncontaminated Material"

a. Payment will be made for costs associated with excavation of unsatisfactory, uncontaminated material from below the 4.1-foot msl contour on the Causeway sideslopes, transport of such material to on-site stockpile areas, and eventual off-site transport and disposal. Characterization sampling of unsatisfactory, uncontaminated material shall also be covered by this payment item. Payment for the item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work.

b. The total quantity of excavated unsatisfactory, uncontaminated material for which payment will be made will be the tonnage of material removed from the Causeway, as measured at on-site scales, immediately prior to transport off-site for disposal. For Contractor bidding purposes, it is estimated that 10 tons of unsatisfactory, uncontaminated material will require removal from the Causeway.

c. Unit of measure: tons.

1.6.8 Item No. 0008 "Hazardous Material Excavation, Handling, and Disposal"

a. Payment will be made for costs associated with excavation, handling, and off-site disposal of hazardous material from the Causeway, including: 1) debris greater than 2 feet in any dimension, identified during Phase I activities or encountered during Phase II excavation, and determined, by sampling, to be hazardous and 2) grossly contaminated soil encountered during sideslope excavation, determined, by sampling, to be hazardous.

This payment item includes the costs associated with removal activities, debris cleaning on the Causeway, on-site transportation to stockpile areas, characterization sample collection and analysis, material measurement at on-site scales, and off-site transportation and disposal. Payment for the item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work.

b. The total quantity of hazardous material excavation, handling, and disposal for which payment will be made, will be the tonnage of hazardous material removed from the Causeway, as measured at on-site scales, immediately prior to transport off-site for disposal. Hazardous material shall be sorted, such that similar types of material are measured separately from other types of material (e.g., soil, concrete, metal, etc.). For Contractor bidding purposes, it is estimated that 70 tons of hazardous material will require removal from the Causeway.

c. Unit of measure: tonnage hazardous.

1.6.9 Item No. 0009 "Non-hazardous Material Excavation, Handling, and Disposal"

a. Payment will be made for costs associated with excavation, handling, and off-site disposal of non-hazardous material from the Causeway, including: 1) debris greater than 2 feet in any dimension, identified during Phase I activities or encountered during Phase II excavation, and determined, by sampling, to be non-hazardous and 2) grossly contaminated soil encountered during sideslope excavation, determined, by sampling, to be non-hazardous. This payment item includes the costs associated with removal activities, debris washing on the Causeway, on-site transportation to stockpile areas, characterization sample collection and analysis, material measurement at on-site scales, and off-site transportation and disposal. Payment for the item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work.

b. The total quantity of non-hazardous material excavation, handling, and disposal for which payment will be made, will be the tonnage of non-hazardous material removed from the Causeway, as measured at on-site scales, immediately prior to transport off-site for disposal. Non-hazardous material shall be sorted, such that similar types of material are measured separately from other types of material (e.g., soil, concrete, metal, etc.). For Contractor bidding purposes, it is estimated that 630 tons of non-hazardous material will require removal from the Causeway.

c. Unit of measure: tonnage non-hazardous.

1.6.10 Item No. 0010 "Geogrid Composite"

a. Payment will be made for costs associated with furnishing, transporting, storing (if applicable), and placing a geogrid composite around the perimeter of the Causeway, as shown on the contract drawings. The geogrid will consist of a woven geotextile and a geogrid, as specified in Section 02380 POLYMERIC MARINE MATTRESSES.

b. The total quantity of the geogrid composite for which payment will be made, will be the installed surface area of the geogrid, measured along the surface of the slope and as shown on the drawings, or by authorized modification. Measurements will not be made for overlaps, patches, or repairs of damaged materials, unless the Engineer specifies additional overlap width. Payment for this item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work. For Contractor bidding purposes, it is estimated that 20,000 square feet of geogrid shall be required for toe construction.

c. Unit of measure: installed square foot.

### 1.6.11 Lower Cover System

The lower cover system shall consist of, from bottom to top; Rock Fill (Toe), Rock Fill (Transition), Rip Rap (Transition), woven geotextile, and polymeric marine mattresses. The components of the lower cover system shall be bid as separate item numbers.

### 1.6.11.1 Item No. 0011 "Rock Fill (Toe)"

a. Payment will be made for costs associated with furnishing, transporting, stockpiling (if applicable), and placing the Rock Fill (Toe) layer, as identified on the contract drawings and as specified. This layer shall be used to prevent toe scour at the base of the Causeway slope in the areas identified on the drawings.

b. The total quantity of Rock Fill (Toe) for which payment will be made will be the tonnage of Rock Fill placed on the Causeway, measured immediately prior to placement, at on-site scales. For purposes of bidding, it shall be assumed that 400 tons of Rock Fill shall be placed in the toe area. Payment for this item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work.

c. Unit of measure: tons.

### 1.6.11.2 Item No. 0012 "Rock Fill (Transition)"

a. Payment will be made for costs associated with furnishing, transporting, stockpiling (if applicable), and placing the Rock Fill (Transition) layer, as identified on the contract drawings and as specified. This layer shall be used to provide drainage for the cover system.

b. The total quantity of Rock Fill (Transition) for which payment will be made will be the tonnage of Rock Fill placed on the Causeway, measured immediately prior to placement, at on-site scales. For purposes of bidding, it shall be assumed that 2,000 tons of Rock Fill shall be placed in the transition area. Payment for this item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work.

c. Unit of measure: tons.

1.6.11.3 Item No. 0013 "Rip Rap (Transition)"

a. Payment will be made for costs associated with furnishing, transporting, stockpiling (if applicable), and placing Rip Rap in the area between the lower cover system and the upper cover system, identified on the drawings as the Transition. Placement of Rip Rap for modification of the existing Rip Rap is also included in this payment item. The location and procedures for Rip Rap installation shall be as identified on the contract drawings, and as specified.

b. The total quantity of Rip Rap (Transition) for which payment will be made will be the tonnage of Rip Rap placed on the Causeway, measured immediately prior to placement, at on-site scales. For purposes of bidding, it should be assumed that 300 tons of Rip Rap shall be required for filling of the transition area and modifying existing Rip Rap on the Causeway. Payment for this item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work.

c. Unit of measure: tons.

1.6.11.4 Item No. 0014 "Woven Geotextile"

a. Payment will be made for costs associated with furnishing, transporting, storing (if applicable), and placing a woven geotextile, as identified on the contract drawings and as specified.

b. The total quantity of the woven geotextile for which payment will be made will be the installed surface area of the geotextile, measured along the surface of the slope and as shown on the drawings, or by authorized modification. Measurements will not be made for overlaps, patches, or repairs of damaged materials, unless the Engineer specifies additional overlap width. For purposes of bidding, it shall be assumed that 94,000 square feet are required for lower cover system construction. Payment for this item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work.

c. Unit of measure: installed square foot.

1.6.11.5 Item No. 0015 "Polymeric Marine Mattresses"

a. Payment will be made for costs associated with furnishing, transporting, storing (if applicable), fabricating, filling, and placing the polymeric marine mattresses, including the appropriate volume of Rock Fill, as identified on the contract drawings and as specified.

b. The total quantity of the mattresses for which payment will be made will be the installed surface area of the fabricated mattresses, measured along the surface of the slope and as shown on the plans, or by authorized modification. Measurements will not be made for overlaps, patches, or repairs of damaged materials, unless the Engineer specifies additional overlap width. For purposes of bidding, it shall be assumed that 94,000 square feet of mattress is required for lower cover system construction. Payment for this item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to fabricate the mattresses and complete the work.

c. Unit of measure: installed square foot.

### 1.6.12 Upper Cover System

The upper cover system shall consist of, from bottom to top; Sand Bedding, non-woven geotextile, interlocking concrete block, and Gravel. The components of the upper cover system shall be bid as separate item numbers.

### 1.6.12.1 Item No. 0016 "Sand Bedding"

a. Payment will be made for costs associated with furnishing, transporting, stockpiling (if applicable), and placing the Sand Bedding, as identified on the contract drawings and as specified.

b. The total quantity of Sand Bedding for which payment will be made will be the tonnage of Sand Bedding placed on the Causeway, measured immediately prior to placement, at on-site scales. The depth of the Sand Bedding shall be as shown on the drawings, or directed by the Contracting Officer, or representative. For purposes of bidding, it shall be assumed that 2,000 tons of Sand Bedding is required for upper cover system construction. Payment for this item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work.

c. Unit of measure: tons.

### 1.6.12.2 Item No. 0017 "Non-Woven Geotextile"

a. Payment will be made for costs associated with furnishing, transporting, storing (if applicable), and placing a non-woven geotextile, as identified on the contract drawings and as specified.

b. The total quantity of the non-woven geotextile for which payment will be made will be the installed surface area of the fabric, measured along the ground surface and as shown on the plans or by authorized modification. Measurements will not be made for overlaps, patches, or repairs of damaged materials, unless the Engineer specifies additional overlap width. For purposes of bidding, it shall be assumed that 67,000 square feet of non-woven geotextile is required for upper cover system construction. Payment for this item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work.

a. Unit of measure: installed square foot.

1.6.12.3 Item No. 0018 "Interlocking Concrete Block"

a. Payment will be made for costs associated with furnishing, transporting, storing (if applicable), and placing the interlocking concrete blocks, as identified on the contract drawings and as specified.

b. The total quantity of the concrete blocks for which payment will be made will be the installed surface area of the blocks, measured along the ground surface and as shown on the plans, or by authorized modification. Measurements will not be made for overlaps, patches, or repairs of damaged materials, unless the Engineer specifies additional overlap width. Placement of Gravel in the interstitial spaces between the blocks is included in payment Item No. 0019. For purposes of bidding, it shall be assumed that 56,000 square feet of interlocking concrete block is required for upper cover system construction. Payment for this item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work.

c. Unit of measure: installed square foot.

1.6.12.4 Item No. 0019 "Gravel"

a. Payment will be made for costs associated with furnishing, transporting, stockpiling (if applicable), and placing gravel in the interstitial spaces between the concrete blocks and as leveling material on the Causeway sideslopes. The location and procedures for gravel installation shall be as identified on the contract drawings and as specified.

b. The total quantity of the gravel for which payment will be made will be the tonnage of Gravel placed on the Causeway, measured immediately prior to placement, at on-site scales. For purposes of bidding, it should be assumed that 25 percent of the total area of the interlocking concrete blocks is open space and will require filling with Gravel. In addition, a maximum 2-inch layer of Gravel shall be placed over the concrete blocks and an estimated 200 cubic yards of gravel shall be required for leveling the Causeway sideslopes following excavation. A total estimate of 350 tons shall be used for bidding purposes. Payment for this item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work.

c. Unit of measure: tons.

1.6.13 Item No. 0020 "Vegetative Support Layer"

a. Payment will be made for costs associated with furnishing, transporting, stockpiling (if applicable), and placing the vegetative support layer, as identified on the contract drawings and as specified. The support layer shall consist of appropriate soil and erosion control materials.

b. The total quantity of vegetative support for which payment will be made will be the tonnage of soil placed on the Causeway, measured immediately prior to placement, at on-site scales. Costs for erosion control materials shall be considered incidental to this item. For purposes of bidding, it shall be assumed that 2,625 tons of soil will be required to provide adequate support for the grass. Payment for this item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work.

c. Unit of measure: tons.

1.6.14 Item No. 0021 "Grass Seed"

a. Payment will be made for costs associated with furnishing, transporting, stockpiling (if applicable), and placing the grass seed, as identified on the contract drawings and as specified.

b. The total quantity of grass seed for which payment will be made will be the actual area covered with seed, measured following placement of the seed. Measurements will be made along the slope of the ground, using methods generally recognized as conforming to good engineering practice. Payment for this item will be full compensation for furnishing all materials, labor, equipment, and all other incidentals necessary to complete the work.

c. Unit of measure: square foot.

1.6.15 Item No. 0022 "Monitoring Well Grade Adjustment"

a. Payment will be made for costs associated with grade adjustment of four existing monitoring wells. This item includes furnishing labor, equipment, tools, materials, and supplies necessary complete monitoring well grade adjustment, as shown on the drawings, and as specified in Section 02522 MONITORING WELLS.

b. Unit of measure: job lump sum.

1.6.16 Item No. 0023 "Demobilization"

a. Payment will be made for costs associated with demobilization, as defined in Special Clause PAYMENT FOR MOBILIZATION AND DEMOBILIZATION. This item includes furnishing labor, equipment, tools, materials, and supplies necessary to demobilize all personnel, equipment, and supplies to the site. This payment item also includes removal of temporary facilities, disconnection of temporary utility connections, removal of signs, final site cleanup, and preparation and submittal of final record documents. This item includes all other work and expenses incidental thereto for which payment is not provided under other items.

b. Unit of measure: job lump sum.

## PART 2 PRODUCTS (NOT APPLICABLE)

## PART 3 EXECUTION (NOT APPLICABLE)

--End of Section--

# SECTION 01300

# PROJECT COORDINATION

## PART 1 GENERAL

### 1.1 DESCRIPTION

This section covers the procedures to be followed during project execution to ensure coordination between the Contractor, the Contracting Officer, Statford Army Engine Plant personnel, and other potential Contractors is maintained.

### 1.2 REFERENCES (NOT USED)

### 1.3 SUBMITTALS (NOT USED)

### 1.4 CONTRACTOR RESPONSIBILITY

The Contractor shall be responsible for the following items:

a. Coordinate all work under this Contract with related work under other contracts, SAEP facility, and with facility and public utilities.

b. Obtain all permits necessary for completion of the Work, including, but not limited to excavation and construction permits.

c. Make arrangements for temporary storage of materials and supplies and for timely delivery to the job site.

d. Assist the Contracting Officer as required in the review of excavation, construction, and the testing of materials.

e. Maintain up-to-date progress records and record drawings.

f. Maintain the project site in a neat condition.

g. Contact the State of Connecticut "call-before-you-dig" program, at 1-800-922-4455, prior to initiation of excavation activities.

h. Coordinate with all utilities, and notify the appropriate IPM personnel when excavation is scheduled in areas that may affect existing utilities. The IPM contact is Rich Meier (203) 385-6649.

i. Coordinate the work of subcontractors, equipment, and material suppliers.

j. Coordinate work within the Housatonic River with the U.S. Coast Guard, the Town of Stratford Harbor Master, and the Town of Milford Harbor Master.

## PART 2 PRODUCTS (NOT APPLICABLE)

## PART 3 EXECUTION (NOT APPLICABLE)

--End of Section--

# SECTION 01320

# PROJECT SCHEDULE
06/97

## PART 1 GENERAL

### 1.1 DESCRIPTION

This section covers the procedures and format to be followed during development of the project schedule and the requirements associated with scheduling of the Phase II work.

### 1.2 REFERENCES

The publications listed below form a part of the specification to the extent referenced. The publications are referenced in the text by basic designation only.

ENGINEERING REGULATIONS (ER)

| | |
|---|---|
| ER 1-1-11 | (1995) Progress, Schedules, and Network Analysis Systems |

### 1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals not having a "GA" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-01 Pre-construction Submittals

Preliminary Project Schedule; GA

Shall define the Contractor's planned operations for the first 60 calendar days of Phase II activities.

Initial Project Schedule; GA

Shall provide a reasonable sequence of Phase II activities, which represent work through the entire project and shall be at a reasonable level of detail.

SD-06 Test Reports

Periodic Schedule Updates; GA

Shall enable the Contracting Officer to assess the Contractor's progress, and shall be based on the result of progress meetings.

### 1.4 QUALIFICATIONS

The Contractor shall designate an authorized representative who shall be responsible for the preparation of all required project schedule reports.

## PART 2 PRODUCTS (NOT APPLICABLE)

## PART 3 EXECUTION

### 3.1 GENERAL REQUIREMENTS

Pursuant to the Contract Clause, SCHEDULE FOR CONSTRUCTION CONTRACTS, a Project Schedule as described below shall be prepared. The scheduling of construction shall be the responsibility of the Contractor. Contractor management personnel shall actively participate in its development. Subcontractors and suppliers working on the project shall also contribute in developing and maintaining an accurate Project Schedule. The approved Project Schedule shall be used to measure the progress of the work, to aid in evaluating time extensions, and to provide the basis of all progress payments.

The Contractor shall develop the schedule considering the constraint that Phase II work may only be conducted on the Causeway between October 1 and April 30.

### 3.2 BASIS FOR PAYMENT

The schedule shall be the basis for measuring Contractor progress. Lack of an approved schedule or scheduling personnel will result in an inability of the Contracting Officer to evaluate Contractor's progress for the purposes of payment. Failure of the Contractor to provide all information, as specified below, shall result in the disapproval of the entire Project Schedule submission and the inability of the Contracting Officer to evaluate Contractor progress for payment purposes. In the case where Project Schedule revisions have been directed by the Contracting Officer and those revisions have not been included in the Project Schedule, the Contracting Officer may hold retainage up to the maximum allowed by contract, each payment period, until revisions to the Project Schedule have been made.

### 3.3 PROJECT SCHEDULE

The computer software system utilized by the Contractor to produce the Project Schedule shall be capable of providing all requirements of this specification. Failure of the Contractor to meet the requirements of this specification shall result in the disapproval of the schedule. Manual methods used to produce any required information shall require approval by the Contracting Officer.

#### 3.3.1 Use of the Critical Path Method

The Critical Path Method (CPM) of network calculation shall be used to generate the Project Schedule. The Contractor shall provide the Project Schedule in the Precedence Diagram Method (PDM).

### 3.3.2 Level of Detail Required

The Project Schedule shall include an appropriate level of detail. Failure to develop or update the Project Schedule or provide data to the Contracting Officer at the appropriate level of detail, as specified by the Contracting Officer, shall result in the disapproval of the schedule. The Contracting Officer will use, but is not limited to, the following conditions to determine the appropriate level of detail to be used in the Project Schedule.

#### 3.3.2.1 Activity Duration

Contractor submissions shall follow the direction of the Contracting Officer regarding reasonable activity duration. A reasonable duration is one that allows the progress of activities to be accurately determined between payment periods (usually less than 2 percent of all non-procurement activities' Original Durations are greater than 20 days).

#### 3.3.2.2 Procurement Activities

Tasks related to the procurement of long lead materials or equipment shall be included as separate activities in the project schedule. Long lead materials and equipment are those materials that have a procurement cycle of over 90 days. Examples of procurement process activities include, but are not limited to: submittals, approvals, procurement, fabrication, and delivery.

#### 3.3.2.3 Government Activities

Government and other agency activities that could impact progress shall be shown. These activities include, but are not limited to: approvals, inspections, utility tie-in, Government Furnished Equipment (GFE) and Notice to Proceed (NTP) for phasing requirements.

#### 3.3.2.4 Responsibility

All activities shall be identified in the project schedule by the party responsible to perform the work. Responsibility includes, but is not limited to, the subcontracting firm, contractor work force, or government agency performing a given task. Activities shall not belong to more than one responsible party. The responsible party for each activity shall be identified by the Responsibility Code.

#### 3.3.2.5 Work Areas

All activities shall be identified in the project schedule by the work area in which the activity occurs. Activities shall not be allowed to cover more than one work area. The work area of each activity shall be identified by the Work Area Code.

#### 3.3.2.6 Modification or Claim Number

Any activity that is added or changed by contract modification or used to justify claimed time shall be identified by a mod or claim code that changed the activity. Activities shall not belong to more than one modification or claim item. The modification or claim number of each activity shall be identified by the Mod or Claim Number. Whenever possible, changes shall be added to the schedule by adding new activities. Existing activities shall not normally be changed to reflect modifications.

### 3.3.2.7 Bid Item

All activities shall be identified in the project schedule by the Bid Item to which the activity belongs. An activity shall not contain work in more than one bid item. The bid item for each appropriate activity shall be identified by the Bid Item Code.

### 3.3.2.8 Phase of Work

All activities shall be identified in the project schedule by the phase of work in which the activity occurs. Activities shall not contain work in more than one phase of work. The project phase of each activity shall be by the unique Phase of Work Code.

### 3.3.2.9 Category of Work

All Activities shall be identified in the project schedule according to the category of work which best describes the activity. Category of work refers, but is not limited, to the procurement chain of activities including such items as submittals, approvals, procurement, fabrication, delivery, installation, start-up, and testing. The category of work for each activity shall be identified by the Category of Work Code.

### 3.3.2.10 Feature of Work

All activities shall be identified in the project schedule according to the feature of work to which the activity belongs. Feature of work refers, but is not limited to, a work breakdown structure for the project. The feature of work for each activity shall be identified by the Feature of Work Code.

### 3.3.3 Scheduled Project Completion

The schedule interval shall extend from NTP to the contract completion date.

### 3.3.3.1 Project Start Date

The schedule shall start no earlier than the date on which the NTP was acknowledged. The Contractor shall include as the first activity in the project schedule an activity called "Start Project". The "Start Project" activity shall have an "ES" constraint date equal to the date that the NTP was acknowledged, and a zero day duration.

### 3.3.3.2 Constraint of Last Activity

Completion of the last activity in the schedule shall be constrained by the contract completion date. Calculation on project updates shall be such that if the early finish of the last activity falls after the contract completion date, then the float calculation shall reflect a negative float on the critical path. The Contractor shall include as the last activity in the project schedule an activity called "End Project". The "End Project" activity shall have an "LF" constraint date equal to the completion date for the project, and a zero day duration.

#### 3.3.3.3 Early Project Completion

In the event the project schedule shows completion of the project prior to the contract completion date, the Contractor shall identify those activities that have been accelerated and/or those activities that are scheduled in parallel to support the Contractor's "early" completion. Contractor shall specifically address each of the activities noted in the narrative report at every project schedule update period to assist the Contracting Officer in evaluating the Contractor's ability to actually complete prior to the contract period.

### 3.3.4 Interim Completion Dates

Contractually specified interim completion dates shall also be constrained to show negative float if the early finish date of the last activity in that phase falls after the interim completion date.

#### 3.3.4.1 Start Phase

The Contractor shall include as the first activity for a project phase an activity called "Start Phase X" where "X" refers to the phase of work. The "Start Phase X" activity shall have an "ES" constraint date equal to the date on which the NTP was acknowledged, and a zero day duration.

#### 3.3.4.2 End Phase

The Contractor shall include as the last activity in a project phase an activity called "End Phase X" where "X" refers to the phase of work. The "End Phase X" activity shall have an "LF" constraint date equal to the completion date for the project, and a zero day duration.

#### 3.3.4.3 Phase X

The Contractor shall include a hammock type activity for each project phase called "Phase X" where "X" refers to the phase of work. The "Phase X" activity shall be logically tied to the earliest and latest activities in the phase.

### 3.3.5 Default Progress Data Disallowed

Actual Start and Finish dates shall not be automatically updated by default mechanisms that may be included in CPM scheduling software systems. Actual Start and Finish dates on the CPM schedule shall match those dates provided from Contractor Quality Control Reports. Failure of the Contractor to document the Actual Start and Finish dates on the Daily Quality Control report for every in-progress or completed activity, and failure to ensure that the data contained on the Daily Quality Control reports is the sole basis for schedule updating shall result in the disapproval of the Contractor's schedule and the inability of the Contracting Officer to evaluate Contractor progress for payment purposes. Updating of the percent complete and the remaining duration of any activity shall be independent functions. Program features which calculate one of these parameters from the other shall be disabled.

### 3.3.6 Out-of-Sequence Progress

Activities that have posted progress without all preceding logic being satisfied (Out-of-Sequence Progress) will be allowed only on a case-by-case approval of the Contracting Officer. The Contractor shall propose logic corrections to eliminate all out of sequence progress or justify not changing the sequencing for approval prior to submitting an updated project schedule.

### 3.3.7 Negative Lags

Lag durations contained in the project schedule shall not have a negative value.

## 3.4 PROJECT SCHEDULE SUBMISSIONS

The Contractor shall provide the submissions as described below. The data disk, reports, and network diagrams required for each submission are contained in paragraph SUBMISSION REQUIREMENTS.

### 3.4.1 Preliminary Project Schedule Submission

The Preliminary Project Schedule, defining the Contractor's planned operations for the first 60 calendar days shall be submitted for approval within 20 calendar days after the NTP is acknowledged. The approved preliminary schedule shall be used for payment purposes not to exceed 60 calendar days after NTP.

### 3.4.2 Initial Project Schedule Submission

The Initial Project Schedule shall be submitted for approval within 40 calendar days after NTP. The schedule shall provide a reasonable sequence of activities which represent work through the entire project and shall be at a reasonable level of detail.

### 3.4.3 Monthly Schedule Updates

Based on the result of progress meetings, specified in "Periodic Progress Meetings," the Contractor shall submit monthly schedule updates. These submissions shall enable the Contracting Officer to assess Contractor's progress. If the Contractor fails or refuses to furnish the information and project schedule data, which in the judgement of the Contracting Officer or authorized representative is necessary for verifying the Contractor's progress, the Contractor shall be deemed not to have provided an estimate upon which progress payment may be made.

### 3.4.4 Standard Activity Coding Dictionary

The Contractor shall use the activity coding structure defined in the Standard Data Exchange Format (SDEF) in ER 1-1-11, Appendix A. This exact structure is mandatory, even if some fields are not used.

## 3.5 SUBMISSION REQUIREMENTS

The following items shall be submitted by the Contractor for the preliminary submission, initial submission, and every periodic project schedule update throughout the life of the project:

### 3.5.1 Data Disks

Two data disks containing the project schedule shall be provided. Data on the disks shall adhere to the SDEF format specified in ER 1-1-11, Appendix A.

#### 3.5.1.1 File Medium

Required data shall be submitted on 3.5 disks, formatted to hold 1.44 MB of data, under the MS-DOS Version 5. or 6.x, unless otherwise approved by the Contracting Officer.

#### 3.5.1.2 Disk Label

A permanent exterior label shall be affixed to each disk submitted. The label shall indicate the type of schedule (Preliminary, Initial, Update, or Change), full contract number, project name, project location, data date, name and telephone number or person responsible for the schedule, and the MS-DOS version used to format the disk.

#### 3.5.1.3 File Name

Each file submitted shall have a name related to either the schedule data date, project name, or contract number. The Contractor shall develop a naming convention that will ensure that the names of the files submitted are unique. The Contractor shall submit the file naming convention to the Contracting Officer for approval.

### 3.5.2 Narrative Report

A Narrative Report shall be provided with the preliminary, initial, and each update of the project schedule. This report shall be provided as the basis of the Contractor's progress payment request. The Narrative Report shall include: a description of activities along the two most critical paths, a description of current and anticipated problem areas or delaying factors and their impact, and an explanation of corrective actions taken or required to be taken. The narrative report is expected to relay to the Government, the Contractor's thorough analysis of the schedule output and its plans to compensate for any problems, either current or potential, which are revealed through that analysis.

### 3.5.3 Approved Changes Verification

Only project schedule changes that have been previously approved by the Contracting Officer shall be included in the schedule submission. The Narrative Report shall specifically reference, on an activity by activity basis, all changes made since the previous period and relate each change to documented, approved schedule changes.

### 3.5.4 Schedule Reports

The format for each activity for the schedule reports listed below shall contain: Activity Numbers, Activity Description, Original Duration, Remaining Duration, Early Start Date, Early Finish Date, Late Start Date, Late Finish Date, Total Float. Actual Start and Actual Finish Dates shall be printed for those activities in progress or completed.

#### 3.5.4.1 Activity Report

A list of all activities sorted according to activity number.

#### 3.5.4.2 Logic Report

A list of Preceding and Succeeding activities for every activity in ascending order by activity number. Preceding and succeeding activities shall include all information listed above in paragraph Schedule Reports. A blank line shall be left between each activity grouping.

#### 3.5.4.3 Total Float Report

A list of all incomplete activities sorted in ascending order of total float. Activities which have the same amount of total float shall be listed in ascending order of Early Start Dates. Completed activities shall not be shown on this report.

#### 3.5.4.4 Earnings Report

A compilation of the Contractor's Total Earnings on the project from the NTP until the most recent Monthly Progress Meeting. This report shall reflect the Earnings of specific activities based on the agreements made in the field and approved between the Contractor and Contracting Officer at the most recent Monthly Progress Meeting. Provided that the Contractor has provided a complete schedule update, this report shall serve as the basis of determining Contractor Payment. Activities shall be grouped by bid item and sorted by activity numbers. This report shall: sum all activities in a bid item and provide a bid item percent; and complete and sum all bid items to provide a total project percent complete. The printed report shall contain, for each activity: the Activity Number, Activity Description, Original Budgeted Amount, Total Quantity, Quantity to Date, Percent Complete (based on cost), and Earnings to Date.

### 3.5.5 Network Diagram

The network diagram shall be required on the initial schedule submission and on monthly schedule update submissions. The network diagram shall depict and display the order and interdependence of activities and the sequence in which the work is to be accomplished. The Contracting Officer will use, but is not limited to, the following conditions to review compliance with this paragraph:

#### 3.5.5.1 Continuous Flow

Diagrams shall show a continuous flow from left to right with no arrows from right to left. The activity number, description, duration, and estimated earned value shall be shown on the diagram.

#### 3.5.5.2 Project Milestone Dates

Dates shall be shown on the diagram for start of project, any contract required interim completion dates, and contract completion dates.

#### 3.5.5.3 Critical Path

The critical path shall be clearly shown.

#### 3.5.5.4 Banding

Activities shall be grouped to assist in the understanding of the activity sequence. Typically, this flow will group activities by category of work, work area and/or responsibility.

#### 3.5.5.5 S-Curves

Earnings curves showing projected early and late earnings and earnings to date.

## 3.6 PERIODIC PROGRESS MEETINGS

Progress meetings to discuss payment shall include a monthly onsite meeting or other regular intervals mutually agreed to at the pre-construction conference. During this meeting the Contractor shall describe, on an activity by activity basis, all proposed revisions and adjustments to the project schedule required to reflect the current status of the project. The Contracting Officer will approve activity progress, proposed revisions, and adjustments as appropriate.

### 3.6.1 Meeting Attendance

The Contractor's Project Manager and Scheduler shall attend the regular progress meeting.

### 3.6.2 Update Submission Following Progress Meeting

A complete update of the project schedule containing all approved progress, revisions, and adjustments, based on the regular progress meeting, shall be submitted not later than four (4) working days after the monthly progress meeting.

### 3.6.3 Progress Meeting Contents

Update information, including Actual Start Dates, Actual Finish Dates, Remaining Durations, and Cost-to-Date shall be subject to the approval of the Contracting Officer. As a minimum, the Contractor shall address the following items on an activity by activity basis during each progress meeting.

#### 3.6.3.1 Start and Finish Dates

The Actual Start and Actual Finish dates for each activity currently in-progress or completed.

#### 3.6.3.2 Time Completion

The estimated Remaining Duration for each activity in-progress. Time-based progress calculations shall be based on Remaining Duration for each activity.

#### 3.6.3.3 Cost Completion

The earnings for each activity started. Payment will be based on earnings for each in-progress or completed activity. Payment for individual activities containing quality defects will not be made. A portion of the overall project amount may be retained based on delays of activities.

#### 3.6.3.4 Logic Changes

All logic changes pertaining to NTP on change orders, change orders to be incorporated into the schedule, contractor proposed changes in work sequence, corrections to schedule logic for out-of-sequence progress, lag durations, and other changes that have been made pursuant to contract provisions shall be specifically identified and discussed.

#### 3.6.3.5 Other Changes

Other changes required due to delays in completion of any activity or group of activities include: 1) delays beyond the Contractor's control, such as strikes and unusual weather. 2) delays encountered due to submittals, Government Activities, deliveries or work stoppages which make re-planning the work necessary. 3) Changes required to correct a schedule which does not represent the actual or planned prosecution and progress of the work.

### 3.7 REQUESTS FOR TIME EXTENSIONS

In the event the Contractor requests an extension of the contract completion date, or any interim milestone date, the Contractor shall furnish the following for a determination as to whether or not the Contractor is entitled to an extension of time under the provisions of the contract: justification, project schedule data, and supporting evidence as the Contracting Officer may deem necessary. Submission of proof of delay, based on revised activity logic, duration, and costs (updated to the specific date that the delay occurred) is obligatory to any approvals.

#### 3.7.1 Justification of Delay

The project schedule shall clearly display that the Contractor has used, in full, all the float time available for the work involved with this request. The Contracting Officer's determination as to the number of allowable days of contract extension shall be based upon the project schedule updates in effect for the time period in question, and other factual information. Actual delays that are found to be caused by the Contractor's own actions, which result in the extension of the schedule, will not be a cause for a time extension to the contract completion date.

### 3.7.2 Submission Requirements

The Contractor shall submit a justification for each request for a change in the contract completion date of under two (2) weeks based upon the most recent schedule update at the time of the NTP or constructive direction issued for the change. Such a request shall be in accordance with the requirements of other appropriate Contract Clauses and shall include, as a minimum:

a. A list of affected activities, with their associated project schedule activity number.

b. A brief explanation of the causes of the change.

c. An analysis of the overall impact of the changes proposed.

d. A sub-network of the affected area.

Activities impacted in each justification for change shall be identified by a unique activity code contained in the required data file.

### 3.7.3 Additional Submission Requirements

For any requested time extension of over two (2) weeks, the Contracting Officer may request an interim update with revised activities for a specific change request. The Contractor shall provide this disk within four (4) days of the Contracting Officer's request.

## 3.8 DIRECTED CHANGES

If the NTP is issued for changes prior to settlement of price and/or time, the Contractor shall submit proposed schedule revisions to the Contracting Officer within two (2) weeks of the NTP being issued. The proposed revisions to the schedule will be approved by the Contracting Officer prior to inclusion of those changes within the project schedule. If the Contractor fails to submit the proposed revisions, the Contracting Officer may furnish the Contractor with suggested revisions to the project schedule. The Contractor shall include these revisions in the project schedule until revisions are submitted, and final changes and impacts have been negotiated. If the Contractor has any objections to the revisions furnished by the Contracting Officer, the Contractor shall advise the Contracting Officer within two (2) weeks of receipt of the revisions. Regardless of the objections, the Contractor shall continue to update the schedule with the Contracting Officer's revisions until a mutual agreement in the revisions is reached. If the Contractor fails to submit alternative revisions within two (2) weeks of receipt of the Contracting Officer's proposed revisions, the Contractor will be deemed to have concurred with the Contracting Officer's proposed revisions. The proposed revisions will then be the basis for an equitable adjustment for performance of the work.

## 3.9 OWNERSHIP OF FLOAT

Float available in the schedule, at any time, shall not be considered for the exclusive use of either the Government or the Contractor.

--End of Section--

# SECTION 01330

# SUBMITTAL PROCEDURES
**09/00**

## PART 1 GENERAL

### 1.1 DESCRIPTION

This section covers the procedures to be followed for submission of documents required under this contract. It also contains a copy of the anticipated submittal register for Phase II work.

### 1.2 REFERENCES (NOT USED)

### 1.3 SUBMITTALS

Submittals required are identified by SD numbers and titles as follows:

SD-01 Pre-construction Submittals

SD-02 Shop Drawings

SD-03 Product Data

SD-04 Samples

SD-05 Design Data

SD-06 Test Reports

SD-07 Certificates

SD-08 Manufacturer's Instructions

SD-09 Manufacturer's Field Reports

SD-10 Operation and Maintenance Data

SD-11 Closeout Submittals

Submittals are classified as follows:

#### 1.3.1 Government Approved

Government approval is required for extensions of design, critical materials, deviations, equipment whose compatibility with the entire system must be checked, and other items as designated by the Contracting Officer. Within the terms of the Contract Clause entitled "SPECIFICATIONS AND DRAWINGS FOR CONSTRUCTION," they are considered to be "shop drawings."

### 1.3.2 Information Only

All submittals not requiring Government approval will be for information only. They are not considered to be "shop drawings" within the terms of the Contract Clause referred to above.

## 1.4 APPROVED SUBMITTALS

The Contracting Officer's approval of submittals shall not be construed as a complete check, but will indicate only that the general method of construction, materials, detailing and other information are satisfactory. Approval will not relieve the Contractor of the responsibility for any error which may exist, as the Contractor under the Contractor Quality Control (CQC) requirements of this contract is responsible for dimensions, the design of adequate connections and details, and the satisfactory construction of all work. After submittals have been approved by the Contracting Officer, no re-submittal for the purpose of substituting materials or equipment will be considered unless accompanied by an explanation of why a substitution is necessary.

## 1.5 DISAPPROVED SUBMITTALS

The Contractor shall make all corrections required by the Contracting Officer and promptly furnish a corrected submittal in the form and number of copies specified for the initial submittal. If the Contractor considers any correction indicated on the submittals to constitute a change to the contract, a notice in accordance with the Contract Clause "CHANGES" shall be given promptly to the Contracting Officer.

## 1.6 WITHHOLDING OF PAYMENT

Payment for materials incorporated in the work will not be made if required approvals have not been obtained.

# PART 2 PRODUCTS (NOT APPLICABLE)

# PART 3 EXECUTION

## 3.1 GENERAL

The Contractor shall make submittals as required by the specifications. The Contracting Officer may request submittals in addition to those specified when deemed necessary to adequately describe the work covered in the respective sections. Units of weights and measures used on all submittals shall be the same as those used in the contract drawings. Each submittal shall be complete and in sufficient detail to allow ready determination of compliance with contract requirements. Prior to submittal, all items shall be checked and approved by the Contractor's Quality Control (CQC) System Manager and each item shall be stamped, signed, and dated by the CQC System Manager indicating action taken. Proposed deviations from the contract requirements shall be clearly identified. Submittals shall include items such as: Contractor's, manufacturer's, or fabricator's drawings; descriptive literature including (but not limited to) catalog cuts, diagrams, operating charts or curves; test reports; test cylinders; samples; O&M manuals (including parts list); certifications; warranties; and other such required submittals. Submittals requiring Government approval shall be scheduled and made prior to the acquisition of the material or equipment covered thereby. Samples remaining upon completion of the work shall be picked up and disposed of in accordance with manufacturer's Material Safety Data Sheets (MSDS) and in compliance with existing laws and regulations.

## 3.2 SUBMITTAL REGISTER

At the end of this section is a submittal register (ENG Form 4288) showing items of equipment and materials for which submittals are required by the specifications; this list may not be all inclusive and additional submittals may be required. The Contractor will also be given the submittal register files, containing the electronic ENG Form 4288 and instructions on the use of the files. These submittal register files will be furnished on a separate diskette. The Contractor shall submit the forms to the Contracting Officer for approval within 21 calendar days after NTP. The Contractor shall keep this diskette up-to-date and shall submit it to the Government together with the monthly payment request. The approved submittal register will support the scheduling document and will be used to control submittals throughout the life of the contract. The submittal register and the progress schedules shall be coordinated.

## 3.3 SCHEDULING

Submittals covering component items forming a system or items that are interrelated shall be scheduled to be coordinated and submitted concurrently. Certifications to be submitted with the pertinent drawings shall be so scheduled. Adequate time (a minimum of 14 calendar days exclusive of mailing time) shall be allowed and shown on the register for review and approval. No delay damages or time extensions will be allowed for time lost in late submittals.

## 3.4 TRANSMITTAL FORM (ENG FORM 4025)

The sample transmittal form (ENG Form 4025) attached to this section shall be used for submitting both Government approved and information only submittals in accordance with the instructions on the reverse side of the form. These forms will be furnished electronically to the Contractor on a separate diskette. This form shall be properly completed by filling out all the heading blank spaces and identifying each item submitted. Special care shall be exercised to ensure proper listing of the specification paragraph and/or sheet number of the contract drawings pertinent to the data submitted for each item.

## 3.5 SUBMITTAL PROCEDURE

Submittals shall be made as follows:

### 3.5.1 Procedures

Ten copies of the transmittal form and submittals shall be delivered to the Contracting Officer. Additional copies shall be maintained by the Contractor on site.

### 3.5.2 Deviations

For submittals which include proposed deviations requested by the Contractor, the column "variation" of ENG Form 4025 shall be checked. The Contractor shall set forth in writing the reason for any deviations and annotate such deviations on the submittal. The Government reserves the right to rescind inadvertent approval of submittals containing unnoted deviations.

## 3.6 CONTROL OF SUBMITTALS

The Contractor shall carefully control his procurement operations to ensure that each individual submittal is made on or before the Contractor scheduled submittal date shown on the approved "Submittal Register."

## 3.7 GOVERNMENT APPROVED SUBMITTALS

Upon completion of review of submittals requiring Government approval, the submittals will be identified as having received approval by being so stamped and dated. Seven copies of the submittal will be retained by the Contracting Officer and three copies of the submittal will be returned to the Contractor.

## 3.8 INFORMATION ONLY SUBMITTALS

Normally submittals for information only will not be returned. Approval of the Contracting Officer is not required on information only submittals. The Government reserves the right to require the Contractor to resubmit any item found not to comply with the contract. This does not relieve the Contractor from the obligation to furnish material conforming to the plans and specifications; will not prevent the Contracting Officer from requiring removal and replacement of nonconforming material incorporated in the work; and does not relieve the Contractor of the requirement to furnish samples for testing by the Government laboratory or for check testing by the Government in those instances where the technical specifications so prescribe.

## 3.9 STAMPS

Stamps used by the Contractor on the submittal data to certify that the submittal meets contract requirements shall be similar to the following:

CONTRACTOR

(Firm Name)

_____ Approved

_____ Approved with corrections as noted on submittal data and/or attached sheets(s).

SIGNATURE: ______________________

TITLE: ______________________

DATE: ______________________

--End of Section--

# SUBMITTAL REGISTER
(ER 415-1-10)

CONTRACT NO.

TITLE AND LOCATION: Stratford Army Engine Plant Causeway NCRA, Phase II, Stratford, Connecticut

CONTRACTOR

SPECIFICATION SECTION

| | | | | TYPE OF SUBMITTAL | | | | | | | | | | | CLASSIFICATION | | | CONTRACTOR SCHEDULE DATES | | | CONTRACTOR ACTION | | | GOVERNMENT ACTION | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TRANSMITTAL NO. a. | ITEM NO. b. | SPECIFICATION PARAGRAPH NO. c. | DESCRIPTION OF ITEM SUBMITTED d. | PRE-CONSTRUCTION e. | SHOP DRAWINGS f. | PRODUCT DATA g. | SAMPLES h. | DESIGN DATA i. | TEST REPORTS j. | CERTIFICATES k. | MANF INSTRUCTIONS l. | MANF FIELD REPORTS m. | O & M n. | CLOSEOUT SUBMITTALS o. | INFO ONLY p. | GOV. APPROVED q. | REVIEWER r. | SUBMIT s. | APPROVAL NEEDED BY t. | MATERIAL NEEDED BY u. | CODE v. | DATE w. | SUBMIT TO GOVERNMENT x. | CODE y. | DATE z. | REMARKS aa. |
| | | 01320, 1.3 | Preliminary Project Schedule | X | | | | | | | | | | | | X | | | | | | | | | | |
| | | 01320, 1.3 | Initial Project Schedule | X | | | | | | | | | | | | X | | | | | | | | | | |
| | | 01320, 1.3 | Periodic Schedule Updates | | | | | | X | | | | | | | X | | | | | | | | | | |
| | | 01351,1.3 | Site Safety and Health Plan Addendum | X | | | | | | | | | | | | X | | | | | | | | | | |
| | | 01410, 1.3 | Environment Protection Plan Addendum | X | | | | | | | | | | | | X | | | | | | | | | | |
| | | 01411, 1.3 | Contractor's Laboratory | X | | | | | | | | | | | | X | | | | | | | | | | |
| | | 01780, 1.3 | Phase II Completion Report | | | | | | | | | | | X | | X | | | | | | | | | | |
| | | 02110, 1.3 | Heave Monitoring Reports | | | | | | X | | | | | | | X | | | | | | | | | | |
| | | 02111, 1.3 | Work Plan | X | | | | | | | | | | | | X | | | | | | | | | | |
| | | 02111, 1.3 | Weekly Progress Reports | | | | | | X | | | | | | | X | | | | | | | | | | |
| | | 02120, 1.3 | Recordkeeping | | | | | | X | | | | | | | X | | | | | | | | | | |
| | | 02120, 1.3 | Exception Reports | | | | | | X | | | | | | | X | | | | | | | | | | |
| | | 02120, 1.3 | EPA Off-site Policy | | | | | | | X | | | | | | X | | | | | | | | | | |
| | | 02120, 1.3 | Disposal Certificates | | | | | | | X | | | | | | X | | | | | | | | | | |
| | | 02120, 1.3 | Shipping Documents and Packagings Certification | | | | | | | X | | | | | | X | | | | | | | | | | |
| | | 02120, 1.3 | Notices of Non-compliance and Notices of Violations | | | | | | | X | | | | | | X | | | | | | | | | | |
| | | 02300, 1.3 | Earthwork | | | X | | | | | | | | | X | | | | | | | | | | | |

## SUBMITTAL REGISTER
(ER 415-1-10)

CONTRACT NO.

TITLE AND LOCATION: Stratford Army Engine Plant Causeway NCRA, Phase II, Stratford, Connecticut

CONTRACTOR

SPECIFICATION SECTION

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| TRANSMITTAL NO. a. | ITEM NO. b. | SPECIFICATION PARAGRAPH NO. c. | DESCRIPTION OF ITEM SUBMITTED d. | PRE-CONSTRUCTION e. | SHOP DRAWINGS f. | PRODUCT DATA g. | SAMPLES h. | DESIGN DATA i. | TEST REPORTS j. | CERTIFICATES k. | MANF INSTRUCTIONS l. | MANF FIELD REPORTS m. | O & M n. | CLOSEOUT SUBMITTALS o. | INFO ONLY p. | GOV. APPROVED q. | REVIEWER r. | SUBMIT s. | APPROVAL NEEDED BY t. | MATERIAL NEEDED BY u. | CODE v. | DATE w. | SUBMIT TO GOVERNMENT x. | CODE y. | DATE z. | REMARKS aa. |
| | | 02300, 1.3 | Contractor's Quality Control Testing Laboratory | | | | | | | X | | | | | | X | | | | | | | | | | |
| | | 02378, 1.3 | Geosynthetic Samples | | | | X | | | | | | | | | X | | | | | | | | | | |
| | | 02378, 1.3 | Geosynthetic Certificates | | | | | | | X | | | | | | X | | | | | | | | | | |
| | | 02380, 1.3 | Structural Geogrid | | | | X | | | | | | | | | X | | | | | | | | | | |
| | | 02380, 1.3 | Braid | | | | X | | | | | | | | | X | | | | | | | | | | |
| | | 02380, 1.3 | Mechanical Connection Elements | | | | X | | | | | | | | | X | | | | | | | | | | |
| | | 02380, 1.3 | Composite Geogrid | | | | X | | | | | | | | | X | | | | | | | | | | |
| | | 02380, 1.3 | Geogrid | | | | | | | X | | | | | X | | | | | | | | | | | |
| | | 02380, 1.3 | Manufacturer's Instructions | | | | | | | | X | | | | X | | | | | | | | | | | |
| | | 02380, 1.3 | Maintenance Plan | | | | | | | | | | X | | | X | | | | | | | | | | |
| | | 02440, 1.3 | Articulating Cellular Concrete Block | | | X | | | | | | | | | | X | | | | | | | | | | |
| | | 02440, 1.3 | Alternative Materials | | | X | | | | | | | | | | X | | | | | | | | | | |
| | | 02440, 1.3 | Articulating Cellular Concrete Block | | | | X | | | | | | | | | X | | | | | | | | | | |
| | | 02522, 1.3 | Well Casing Fill Material | | | X | | | | | | | | | X | | | | | | | | | | | |
| | | 02522, 1.3 | Well Adjustment Records | | | | | | X | | | | | | | | | | | | | | | | | |
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# TRANSMITTAL OF SHOP DRAWINGS, EQUIPMENT DATA, MATERIAL SAMPLES, OR MANUFACTURER'S CERTIFICATES OF COMPLIANCE

*(Read instructions on the reverse side prior to initiating this form)*

DATE

TRANSMITTAL NO.

## SECTION I - REQUEST FOR APPROVAL OF THE FOLLOWING ITEMS *(This section will be initiated by the contractor)*

TO:

FROM:

CONTRACT NO.

CHECK ONE:
☐ THIS IS A NEW TRANSMITTAL
☐ THIS IS A RESUBMITTAL OF TRANSMITTAL ______

SPECIFICATION SEC. NO. (Cover only one section with each transmittal)

PROJECT TITLE AND LOCATION

| ITEM NO. | DESCRIPTION OF ITEM SUBMITTED *(Type size, model number/etc.)* | MFG OR CONTR. CAT., CURVE DRAWING OR BROCHURE NO. *(See instruction no. 8)* | NO. OF COPIES | CONTRACT REFERENCE DOCUMENT | | FOR CONTRACTOR USE CODE | VARIATION *(See instruction No. 6)* | FOR CE USE CODE |
|---|---|---|---|---|---|---|---|---|
| | | | | SPEC. PARA. NO. | DRAWING SHEET NO. | | | |
| a. | b. | c. | d. | e. | f. | g. | h. | i. |
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REMARKS

I certify that the above submitted items have been reviewed in detail and are correct and in strict conformance with the contract drawings and specifications except as other wise stated.

NAME AND SIGNATURE OF CONTRACTOR

## SECTION II - APPROVAL ACTION

ENCLOSURES RETURNED (List by Item No.)

NAME, TITLE AND SIGNATURE OF APPROVING AUTHORITY

DATE

# SECTION 01351

# SAFETY, HEALTH, AND EMERGENCY RESPONSE
**02/99**

## PART 1 GENERAL

### 1.1 DESCRIPTION

This section covers the health and safety requirements to be followed for completion of Phase II work. The section provides additional requirements for implementing the accident prevention provisions of EM 385-1-1, and specifies a Site Safety and Health Plan (SSHP) Addendum which shall satisfy the requirements for submission of a separate Accident Prevention Plan (APP) as required by EM 385-1-1. The requirements shall apply to work performed in both "contaminated" and "clean" areas.

### 1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS (ACGIH)

| | |
|---|---|
| ACGIH Threshold Limits | (1998) Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices |

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

| | |
|---|---|
| ANSI Z358.1 | (1990) Emergency Eyewash and Shower Equipment |

CODE OF FEDERAL REGULATIONS (CFR)

| | |
|---|---|
| 29 CFR 1904 | Recording and Reporting Occupational Injuries and Illnesses |
| 29 CFR 1910 | Occupational Safety and Health Standards |
| 29 CFR 1926 | Safety and Health Regulations for Construction |
| 49 CFR 171 | General Information, Regulations, and Definitions |
| 49 CFR 172 | Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements |

ENGINEERING MANUALS (EM)

| | |
|---|---|
| EM 385-1-1 | (1996) U.S. Army Corps of Engineers Safety and Health Requirements Manual |

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH)

| | |
|---|---|
| NIOSH Pub No. 85-115 | (1985) Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities |

## 1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals not having a "GA" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-01 Pre-construction Submittals

Site Safety and Health Plan Addendum; GA

The SSHP Addendum shall detail the health and safety procedures to be followed during completion of Phase II work and shall be developed in accordance with this specification. The SSHP Addendum shall supplement the general procedures outlined in the SSHP (developed for Phase I work), but shall not duplicate information contained in the SSHP. The Contractor and the Contracting Officer shall periodically review the plan during work operations to keep it current and technically correct. The SSHP Addendum shall include, but not be limited to, the following:

a. Drawings including the initial work zone boundaries: Exclusion Zone (EZ), including restricted and regulated areas; Contamination Reduction Zone (CRZ); and Support Zone (SZ).

b. Activity Hazard Analyses for each task scheduled to be completed as part of Phase II work.

c. An air monitoring plan detailing the procedures to be followed for personnel exposure monitoring and field air sampling. The air monitoring program shall be developed in accordance with applicable Federal and State regulations. A sample reporting form also shall be submitted as part of the SSHP Addendum.

## 1.4 REGULATORY REQUIREMENTS

Work performed under this contract shall comply with EM 385-1-1, applicable Federal, state, and local safety and occupational health laws and regulations. This includes, but is not limited to, Occupational Safety and Health Administration (OSHA) standards, 29 CFR 1910, especially Section .120, "Hazardous Waste Site Operations and Emergency Response" and 29 CFR 1926, especially Section .65, "Hazardous Waste Site Operations and Emergency Response". Matters of interpretation of standards shall be submitted to the appropriate administrative agency for resolution before starting work.

Where the requirements of this specification, applicable laws, criteria, ordinances, regulations, and referenced documents vary, the most stringent requirements shall apply.

## 1.5 PRE-CONSTRUCTION MEETING

The Pre-construction Meeting shall be attended by the Contractor or his/her representative and the on-site construction manager. The meeting shall be held prior to the commencement of work on-site. The purpose of the meeting is to define the Contractor's Quality Control (CQC) System, to thoroughly review the Contractor's schedule, submittals list, and Work Plan, SSHP Addendum, and other project documents required in these specifications, and to develop a mutual understanding of the specific requirements established by the contract.

### 1.5.1 Pre-Construction Safety Conference

The Pre-construction Safety Conference shall be conducted as part of the Pre-construction Meeting, and shall be attended by the Contractor, or his/her representative, and the on-site construction manager prior to the commencement of work. Recommended discussion topics include:

a. Discussion of the purpose and benefits of Corps construction safety and health program and Contractor's accident prevention plan.

b. Review of the accident prevention clause of the contract and any other contractual safety and health clauses, EM 385-1-1, and other applicable safety and health codes and standards.

c. Review of any local health and safety requirements.

d. Review of any other special requirements particular to the contract at hand.

e. Review of the Contractor's Accident Prevention Plan, its deficiencies, and the corrections needed to bring it to an acceptable level.

f. Review of the Contractor's list of anticipated phases of work requiring an activity hazard analysis.

g. Review of accident investigation and report requirements, including the submission of worker exposure reports.

h. Discussion of the Contractor's proposals for controlling and coordinating the work of subcontractors.

    (i) As noted above, the conference will be used to discuss and resolve deficiencies in the Contractor's Accident Prevention Plan. The agreements reached at the pre-construction safety conference shall become a matter of record and shall be included as amendments to the Contractor's accident prevention plan.

(ii) Minutes of the conference, including agreements reached and a record of attendance shall be maintained. Copies of the minutes shall be forwarded to the safety and occupational health office for review and then forwarded to the official contract file. A copy of the minutes will also be provided to the Contractor.

## 1.6 SAFETY AND HEALTH PROGRAM

OSHA Standards 29 CFR 1910, Section .120 (b) and 29 CFR 1926, Section .65 (b) require employers to develop and implement a written Safety and Health Program for employees involved in hazardous waste operations. The site-specific program requirements of the OSHA Standards shall be integrated into one site-specific document, the SSHP Addendum. The SSHP Addendum shall interface with the employer's overall Safety and Health Program. Any portions of the overall Safety and Health Program that are referenced in the SSHP Addendum shall be included as appendices to the SSHP Addendum.

## 1.7 SITE SAFETY AND HEALTH PLAN

### 1.7.1 Preparation and Implementation

A SSHP Addendum shall be prepared covering onsite work to be performed by the Contractor and all subcontractors. The Safety and Health Manager shall be responsible for the development, implementation and oversight of the SSHP Addendum. The SSHP Addendum shall establish, in detail, the protocols necessary for the anticipation, recognition, evaluation, and control of hazards associated with each Phase II task performed. The SSHP Addendum shall address site-specific safety and health requirements and procedures based upon site-specific conditions. The level of detail provided in the SSHP Addendum shall be tailored to the type of work, complexity of operations to be performed, and hazards anticipated. Details about some activities may not be available when the initial SSHP is prepared and submitted. Therefore, the SSHP Addendum shall address, in as much detail as possible, anticipated tasks, their related hazards and anticipated control measures. Additional details shall be included in the activity hazard analyses as described in paragraph ACTIVITY HAZARD ANALYSES.

### 1.7.2 Acceptance and Modifications

Prior to submittal, the SSHP Addendum shall be signed and dated by the Safety and Health Manager and the Site Superintendent. The SSHP Addendum shall be submitted for review 21 calendar days prior to the Pre-construction Safety Conference. Deficiencies in the SSHP Addendum will be discussed at the pre-construction safety conference, and the SSHP Addendum shall be revised to correct the deficiencies and resubmitted for acceptance. Onsite work shall not begin until the plan has been accepted. A copy of the written SSHP Addendum shall be maintained onsite. As work proceeds, the SSHP Addendum shall be adapted to new situations and new conditions. Changes and modifications to the accepted SSHP Addendum shall be made with the knowledge and concurrence of the Safety and Health Manager, the Site Superintendent, and the Contracting Officer. Should any unforeseen hazard become evident during the performance of the work, the Site Safety and Health Officer (SSHO) shall bring such hazard to the attention of the Safety and Health Manager, the Site Superintendent, and the Contracting Officer, both verbally and in writing, for resolution as soon as possible. In the interim, necessary action shall be taken to re-establish and maintain safe working conditions in order to safeguard onsite personnel, visitors, the public, and the environment. Disregard for the provisions of this specification or the accepted SSHP Addendum shall be cause for stopping of work until the matter has been rectified.

### 1.7.3 Availability

The SSHP Addendum shall be made available in accordance with 29 CFR 1910, Section .120 (b)(1)(v) and 29 CFR 1926, Section .65 (b)(1)(v).

### 1.7.4 Elements

Topics required by 29 CFR 1910, Section .120 (b)(4) 29 CFR 1926, Section .65 (b)(4) and the Accident Prevention Plan as described in Appendix A of EM 385-1-1 and those described in this section shall be addressed in the SSHP Addendum. Where the use of a specific topic is not applicable to the project, the SSHP Addendum shall include a statement to justify its omission or reduced level of detail and establish that adequate consideration was given the topic.

## 1.8 SITE DESCRIPTION AND CONTAMINATION CHARACTERIZATION

### 1.8.1 Project/Site Conditions

The following information is a record of site contaminants and a description of the site. This information is provided to assist in preparing the SSHP Addendum. Additional sources of information are available as listed below.

#### 1.8.1.1 Site Information

The SAEP Causeway was initially constructed and used as a means of launching seaplanes in the 1930s. Additional materials, of unknown origin, were deposited along the northern edge of the Causeway during the 1950s and 1960s. Causeway fill material consists of soil, cobbles, and construction debris.

Soil contamination exceeding the Connecticut Department of Environmental Protection (CTDEP) Remediation Standard Regulation (RSR) Direct Exposure Criteria (DEC), the Pollutant Mobility Criteria (PMC), and/or the federal Freshwater Acute Aquatic Water Quality Criteria (AWQC) include chlorinated and fuel-related volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and inorganics. Low-level radiological contamination was also identified at three isolated locations in the Causeway fill material. Radiologically-contaminated soil was excavated, containerized, and transported to an appropriate off-site licensed treatment/disposal facility. A final radiological survey of the Causeway was conducted to verify complete removal of radiological material, and the facility has been released from the NRC license.

Table 01351-1 lists the contaminants present in Causeway fill material above CTDEP RSRs, the maximum detected concentration, and the location of the maximum concentration. The sample locations are shown on Drawing No. C-104

(Phase I Drawings). A figure identifying the locations of chemical exceedances are included as attachments to these specifications.

**TABLE 01351-1**
**CONTAMINANTS OF CONCERN ON THE CAUSEWAY**

| **Contaminant of Concern** | **Maximum Concentration (mg/kg)** | **Sample Location** |
|---|---|---|
| **VOCs** | | |
| Cis-1,2-Dichloroethene | 120 | CB-99-04 |
| Methylene Chloride | 3.3 J | CB-99-03 |
| Tetrachloroethene | 81 | CB-99-02 |
| Trichloroethene | 8.8 | TP-DEP-11 |
| Vinyl Chloride | 24 | CB-99-04 |
| **SVOCs** | | |
| 2-Methylnaphhalene | 45 | CB-99-03 |
| Acenaphthene | 190 | CB-99-15 |
| Anthracene | 520 J | CB-99-15 |
| Benzo(a)Anthracene | 1200 J | CB-99-15 |
| Benzo(a)Pyrene | 880 J | CB-99-15 |
| Benzo(b)Fluoranthene | 940 J | CB-99-15 |
| Benzo(k)Fluoranthene | 880 J | CB-99-15 |
| Carbazole | 310 | CB-99-15 |
| Chrysene | 1200 | CB-99-15 |
| Dibenz(a,h)Anthracene | 8.1 | CB-99-12 |
| Dibenzofuran | 130 | CB-99-15 |
| Fluoranthene | 2700 | CB-99-15 |
| Fluorene | 250 J | CB-99-15 |
| Hexachlorobenzene | 1.4 | TP-DEP-11 |
| Indeno(1,2,3-CD)Pyrene | 350 | CB-99-15 |
| Naphthalene | 97 J | CB-99-15 |
| Phenanthrene | 2400 | CB-99-15 |
| Pyrene | 1800 J | CB-99-15 |
| **PCBs** | | |
| Aroclor - 1016 | 1.2 J | TP-99-22 |
| Aroclor - 1260 | 11 | TP-99-23 |
| **Inorganics** | | |
| Arsenic | 34.5 | CB-99-08 |
| Beryllium | 13.1 | TP-DEP-11 |
| Cadmium | 94.7 | TP-DEP-11 |
| Lead | 1510 J | TP-DEP-11 |
| Thallium | 8.3 | CB-99-08 |
| Vanadium | 2640 | TP-DEP-11 |
| Zinc | 41.4 J | CB-99-01 |

Note: J = estimated value

1.8.1.2 List of Available Documents

Further information regarding site conditions is available in the Causeway Pre-design Investigation Report (Foster Wheeler/HLA, April 2000), the Final Causeway Engineering Evaluation/Cost Analysis (Foster Wheeler/HLA, September 2000), and the Causeway Decision Document (Harding ESE, 2001). These documents are a part of the public record for this site, and are available for review in Room 15 of Building 1 at the Stratford Army Engine Plant, 550 Main Street, Stratford, Connecticut.

### 1.8.2 Plan Requirements

The SSHP Addendum shall supplement the SSHP, prepared for Phase I work on the Causeway. The Addendum shall not duplicate information contained in the SSHP.

## 1.9 HAZARD/RISK ANALYSIS

The SSHP Addendum shall include a safety and health hazard/risk analysis for each site task and operation to be performed as part of Phase II. The hazard/risk analysis shall provide information necessary for determining safety and health procedures, equipment, and training to protect onsite personnel, the environment, and the public. Available site information shall be reviewed when preparing the "Hazard/Risk Analysis" section of the SSHP Addendum. The following elements, at a minimum, shall be addressed.

### 1.9.1 Site Tasks and Operations (Workplan)

The SSHP Addendum shall include a comprehensive section that addresses the tasks and objectives of the site operations for Phase II of this project, and the logistics and resources required to reach those tasks and objectives. The following is a list of anticipated Phase II site tasks and operations to be performed; site preparation, erosion control system maintenance and removal, excavation and Causeway grading, oversized debris removal, cover system placement, and seeding and finishing. This is not a complete list of site tasks and operations; therefore, it shall be expanded and/or revised, during preparation of the SSHP Addendum as necessary.

### 1.9.2 Hazards

The following potential hazards may be encountered during site work. These are not complete lists; therefore, they shall be expanded and/or revised as necessary during preparation of the SSHP Addendum.

#### 1.9.2.1 Safety Hazards

Potential safety hazards associated with the work on the Causeway could be related to, operation of heavy construction equipment, safety hazards associated with working near the water, and safety hazards from scattered debris and previous excavations present on the site.

#### 1.9.2.2 Chemical Hazards

Potential chemical hazards that may be encountered during site work are discussed in paragraph SITE DESCRIPTION AND CONTAMINATION CHARACTERIZATION. The Hazard/Risk Analysis section of the SSHP Addendum shall describe the chemical, physical, and toxicological properties of contaminants, sources and pathways of employee exposures, anticipated onsite and offsite exposure level potentials, and regulatory (including Federal, state, and local) or recommended protective exposure standards. The SSHP Addendum shall also address employee exposure to hazardous substances brought onsite, and shall comply with the requirements of 29 CFR 1910, Section .1200 and 29 CFR 1926, Section .59, Hazard Communication.

#### 1.9.2.3 Physical Agents

Potential physical hazards during work on the Causeway could include, heat stress and cold stress, noise related hazards, physical strain from heavy lifting, and slips, trips, and falls from scattered debris on the surface of the Causeway.

#### 1.9.2.4 Radiological Hazards

A radiological survey identified radiological soil contamination on the Causeway in excess of federal guidelines. This contaminated soil was removed from the Causeway and sent off-site for disposal. A final survey of the Causeway did not identified any additional areas of radiological contamination, and the facility has been released from the NRC license. Radiological hazards are not anticipated to be encountered on the Causeway during this work; however, the Contractor shall notify the Contracting Officer if a whitish clay-like material, historically associated with radiological contamination on the Causeway, is encountered during excavation activities.

#### 1.9.2.5 Biological Hazards

Potential biological hazards associated with the work on the Causeway could primarily include insect and animal bites; however, additional hazards may be associated with working near the water.

### 1.9.3 Action Levels

#### 1.9.3.1 General Requirements

Action levels shall be established in the SSHP Addendum for situations not identified in the SSHP.

## 1.10 ACTIVITY HAZARD ANALYSES

Prior to beginning Phase II work, Activity Hazard Analyses shall be prepared for each anticipated activity, by the Contractor performing that work and submitted for review and acceptance. The format shall be in accordance with EM 385-1-1, Figure 1-1. The analyses shall define the activities to be performed and identify the sequence of work, the specific hazards anticipated, and the control measures to be implemented to eliminate or reduce each hazard to an acceptable level. Work shall not proceed until the activity hazard analyses have been accepted and a preparatory meeting has been conducted by the Contractor to discuss its contents with everyone engaged in the activities, including the government on-site representatives. The activity hazard analyses shall be continuously reviewed and when appropriate modified to address changing site conditions or operations, with the concurrence of the Safety and Health Manager, the Site Superintendent, and the Contracting Officer. Activity hazard analyses shall be attached to, and become a part of, the SSHP Addendum.

## 1.11 STAFF ORGANIZATION, QUALIFICATIONS, AND RESPONSIBILITIES

An organizational structure shall be developed that sets forth lines of authority (chain of command), responsibilities, and communication procedures concerning site safety, health, and emergency response. This organizational structure shall be as specified in the Phase I Section 01351 SAFETY, HEALTH, AND EMERGENCY RESPONSE. The SSHP Addendum shall contain information on the organizational structure only if changes from the SSHP are anticipated.

## 1.12 TRAINING

Personnel shall receive training in accordance with the Contractor's written safety and health training program and 29 CFR 1910 Section .120, 29 CFR 1926 Section .65, and 29 CFR 1926 Section .21. The SSHP Addendum shall include a section describing training requirements, only if changes to the training program from those described in the SSHP are anticipated.

### 1.12.1 Site-specific Training

Site-specific training sessions shall be documented in accordance with Section 01.B.03.b of EM 385-1-1.

### 1.12.1.1 Initial Session (Pre-entry Briefing)

Prior to commencement of onsite field activities, all site employees, including those assigned only to the Support Zone, shall attend a site-specific safety and health training session of at least 4 hours duration. This session shall be conducted by the Safety and Health Manager and the Site Safety and Health Officer to ensure that all personnel are familiar with requirements and responsibilities for maintaining a safe and healthful work environment. Procedures and contents of the accepted SSHP Addendum and Sections 01.B.02 and 28.D.03 of EM 385-1-1 shall be thoroughly discussed. The Contracting Officer shall be notified at least 5 days prior to the initial site-specific training session so government personnel involved in the project may attend.

### 1.12.1.2 Periodic Sessions

Periodic onsite training shall be conducted by the SSHO at least weekly for personnel assigned to work at the site during the following week. The training shall address safety and health procedures, work practices, any changes in the SSHP or the Addendum, activity hazard analyses, work tasks, or schedule; results of previous week's air monitoring, review of safety discrepancies and accidents. Should an operational change affecting onsite field work be made, a meeting prior to implementation of the change shall be convened to explain safety and health procedures. Site-specific training sessions for new personnel, visitors, and suppliers shall be conducted by the SSHO using the training curriculum outlines developed by the Safety and Health Manager.

## 1.13 PERSONAL PROTECTIVE EQUIPMENT

### 1.13.1 PPE Program

In accordance with 29 CFR 1910 Section .120 (g)(5) and 29 CFR 1926 Section .65 (g)(5), a written Personal Protective Equipment (PPE) program which addresses the elements listed in that regulation, and which complies with respiratory protection program requirements of 29 CFR 1910 Section .134, is to be included in the employer's Safety and Health Program. The SSHP Addendum shall detail the minimum PPE ensembles (including respirators) and specific materials from which the PPE components are constructed for each site-specific task and operation to be performed as part of Phase II, based upon the hazard/risk analysis. Components of levels of protection (B, C, D and modifications) must be relevant to site-specific conditions, including heat and cold stress potential and safety hazards. Only respirators approved by NIOSH shall be used. Onsite personnel shall be provided with appropriate personal protective equipment. Protective equipment and clothing shall be kept clean and well maintained. The PPE section of the SSHP Addendum shall include site-specific procedures to determine PPE program effectiveness and for onsite fit-testing of respirators, cleaning, maintenance, inspection, and storage of PPE.

### 1.13.2 Levels of Protection

The Safety and Health Manager shall establish appropriate levels of protection for each work activity based on review of historical site information, existing data, an evaluation of the potential for exposure (inhalation, dermal, ingestion, and injection) during each Phase II task, past air monitoring results, and a continuing safety and health monitoring program. The Safety and Health Manager shall also establish action levels for upgrade or downgrade in levels of PPE from the following specified minimum levels of protection. Protocols and the communication network for changing the level of protection shall be described in the SSHP Addendum, only if changes from the SSHP are anticipated.

#### 1.13.2.1 Components of Levels of Protection

The components of the levels of PPE protection shall be a specified in the Phase I Section 01351 SAFETY, HEALTH, AND EMERGENCY RESPONSE.

#### 1.13.2.2 Initial Minimum Levels of PPE by Task

Based on available information, the initial minimum protective equipment requirements for each major task and operation are listed below. Available site information shall be reviewed and the list of tasks and operations and these levels of protection shall be expanded and/or revised during preparation of the SSHP Addendum.

MINIMUM PROTECTIVE EQUIPMENT REQUIREMENTS

| TASK/OPERATION | INITIAL LEVEL OF PROTECTION |
|---|---|
| Site Preparation | Level D |
| Sideslope Excavation | Level D |
| Causeway Grading | Level D |

| | |
|---|---|
| Oversized Debris Removal | Level D |
| Cover System Construction | Level D |
| Survey | Level D |
| Erosion Control System Removal | Level D |

### 1.13.3 PPE for Government Personnel

Three clean sets of personal protective equipment and personal dosimeters for work on radioactive waste cleanup sites and clothing (excluding air-purifying negative-pressure respirators and safety shoes, which will be provided by individual visitors), as required for entry into the Exclusion Zone and/or Contamination Reduction Zone, shall be available for use by the Contracting Officer or official visitors. The items shall be cleaned and maintained by the Contractor and stored in the Contractor field office and clearly marked: "FOR USE BY GOVERNMENT ONLY." The Contractor shall provide basic training in the use and limitations of the PPE provided, and institute administrative controls to check prerequisites prior to issuance. Such prerequisites include meeting minimum training requirements for the work tasks to be performed and medical clearance for site hazards and respirator use.

## 1.14 MEDICAL SURVEILLANCE

The medical surveillance program shall be detailed in the SSHP. Details regarding the program shall be included in the SSHP Addendum only if there are anticipated changes from the SSHP.

## 1.15 RADIATION DOSIMETRY

A radiation protection and dosimetry program shall be as described in the SSHP. Details regarding the program shall be included in the SSHP Addendum only if there are anticipated changes from the SSHP. Causeway soil containing radiological contamination above federal guidelines has been removed from the site. A final radiation survey has been completed on the Causeway and the facility has been released from the NRC license.

## 1.16 EXPOSURE MONITORING/AIR SAMPLING PROGRAM

The Safety and Health Manager shall prepare and implement an exposure monitoring/air sampling program in accordance with the air monitoring plan identified in the SSHP, to identify and quantify safety and health hazards and airborne levels of hazardous substances. The air sampling program shall be used to assure proper selection of engineering controls, work practices and personal protective equipment for affected site personnel and shall evaluate the potential impacts to off-site receptors. Available site information shall be reviewed and the exposure monitoring/air sampling program shall be expanded and/or revised for submittal as part of the SSHP Addendum.

At a minimum, air monitoring shall be conducted during sideslope excavation. Monitoring activities should include the use of real-time monitoring equipment, including a photoionization detector or a flame ionization detector, to monitor concentrations of volatiles in the breathing zone. Additional monitoring devices should be available to identify the type of volatile contaminant present if levels in the breathing zone persist above action levels.

Dust monitoring should be conducted during excavation/construction activities to ensure off-site migration of dust is not creating a potentially hazardous situation. At a minimum, real-time monitoring equipment shall be used to monitor the levels of airborne dust.

## 1.17 HEAT AND COLD STRESS MONITORING

The Safety and Health Manager shall develop a heat stress and cold stress monitoring program for onsite activities. Schedules for work and rest, and physiological monitoring requirements, shall be described as in the SSHP. Details regarding the monitoring program shall be included in the SSHP Addendum only is changes to the program are anticipated. Personnel shall be trained to recognize the symptoms of heat and cold stress. The SSHO and an alternate person shall be designated, in writing, to be responsible for the heat and cold stress monitoring program.

## 1.18 SAFETY PROCEDURES, ENGINEERING CONTROLS AND WORK PRACTICES

The SSHP Addendum shall describe the standard operating safety procedures, engineering controls and safe work practices to be implemented for Phase II work. Information contained in the SSHP regarding safety procedures shall not be duplicated in the Addendum. Possible procedures may include, but shall not be limited to, the following:

A. General Site Rules/Prohibitions

B. Material Handling Procedures

C. Spill and Discharge Control

## 1.19 SITE CONTROL MEASURES

In order to prevent the spread of contamination and control the flow of personnel, vehicles, and materials into and out of work areas, site control measures shall be as established and described in the SSHP. The SSHP Addendum shall not duplicate information contained in the SSHP, unless changes to the protocol are anticipated.

## 1.20 DECONTAMINATION

Personnel, equipment, and material entering the Exclusion or Contamination Reduction Zones or otherwise exposed or subject to exposure to hazardous chemical vapors, liquids, or contaminated solids shall adhere to the personal hygiene and decontamination provisions identified in the SSHP. A detailed discussion of personal hygiene and decontamination facilities and procedures to be followed by site workers shall be submitted as part of the SSHP. Information regarding decontamination shall not be duplicated in the SSHP Addendum, unless changes to the protocol are anticipated.

Employees shall be trained in the procedures and the procedures shall be enforced throughout site operations. Persons disregarding these provisions shall be barred from the site.

## 1.23 EMERGENCY EQUIPMENT AND FIRST AID REQUIREMENTS

The SSHP shall describe the emergency and first aid equipment to be available onsite. Information regarding emergency equipment and first aid requirements shall not be duplicated in the SSHP Addendum, unless changes to the information are required.

## 1.24 EMERGENCY RESPONSE AND CONTINGENCY PROCEDURES

An Emergency Response Plan, that meets the requirements of 29 CFR 1910Section .120 (l) and 29 CFR 1926 Section .65 (l), shall be developed and implemented as a section of the SSHP. Information regarding the Emergency Response Plan shall not be duplicated in the SSHP Addendum, unless changes to the information are required.

In the event of any emergency associated with remedial action, the Contractor shall, without delay, alert all onsite employees that there is an emergency situation; take action to remove or otherwise minimize the cause of the emergency; alert the Contracting Officer; and institute measures necessary to prevent repetition of the conditions or actions leading to, or resulting in, the emergency. Employees that are required to respond to hazardous emergency situations shall be trained in how to respond to such expected emergencies. The plan shall be rehearsed regularly as part of the overall training program for site operations. The plan shall be reviewed periodically and revised as necessary to reflect new or changing site conditions or information.

## 1.25 CERTIFICATE OF WORKER/VISITOR ACKNOWLEDGEMENT

A copy of a Contractor-generated certificate of worker/visitor acknowledgement shall be completed and submitted for each visitor allowed to enter contamination reduction or exclusion zones, and for each employee, following the example certificate at the end of this section.

## 1.26 INSPECTIONS

The SSHO shall perform daily inspections of the jobsite and the work in progress to ensure compliance with EM 385-1-1, the Safety and Health Program, the SSHP, the SSHP Addendum, and other occupational health and safety requirements of the contract, and to determine the effectiveness of the SSHP (and Addendum). Procedures for correcting deficiencies (including actions, timetable and responsibilities) shall be described in the SSHP.

Follow-up inspections to ensure correction of deficiencies shall be conducted and documented. Daily safety inspection logs shall be used to document the inspections, noting safety and health deficiencies, deficiencies in the effectiveness of the SSHP, and corrective actions taken. The SSHO's Daily Inspection Logs shall be attached to and submitted with the Daily Quality Control reports. Each entry shall include the following: date, work area checked, employees present in work area, PPE and work equipment being used in each area, special safety and health issues and notes, and signature of preparer. In the event of an accident, the Contracting Officer shall be notified according to EM 385-1-1. Within 2 working days of any reportable accident, an Accident Report shall be completed on ENG Form 3394 and submitted.

### 1.27 SAFETY AND HEALTH PHASE-OUT REPORT

A Safety and Health Phase-Out Report shall be submitted within 10 working days following completion of the work, prior to final acceptance of the work. The following minimum information shall be included:

a. Summary of the overall performance of safety and health (accidents or incidents including near misses, unusual events, lessons learned, etc.).

b. Final decontamination documentation including procedures and techniques used to decontaminate equipment, vehicles, and on site facilities.

c. Summary of exposure monitoring and air sampling accomplished during the project.

d. Signatures of Safety and Health Manager and SSHO.

## PART 2 PRODUCTS (NOT APPLICABLE)

## PART 3 EXECUTION (NOT APPLICABLE)

## EXAMPLE CERTIFICATE OF WORKER/VISITOR ACKNOWLEDGMENT

PROJECT NAME CONTRACT NO.
PROJECT ADDRESS
CONTRACTOR'S NAME
[EMPLOYEE'S][VISITOR'S] NAME

The contract for the above project requires the following: that you be provided with and complete formal and site-specific training; that you be supplied with proper personal protective equipment including respirators; that you be trained in its use; and that you receive a medical examination to evaluate your physical capacity to perform your assigned work tasks, under the environmental conditions expected, while wearing the required personal protective equipment. These things are to be done at no cost to you. By signing this certification, you are acknowledging that your employer has met these obligations to you.

I HAVE READ, UNDERSTAND AND AGREE TO FOLLOW THE SITE SAFETY AND HEALTH PLAN FOR THIS SITE.

Name Date

------------------------------ ------------------------------

FORMAL TRAINING: I have completed the following formal training courses that meet OSHA's requirements:

| | Date Completed |
|---|---|
| 40 hour: ............................ | ________________ |
| 8 hour supervisory:.................. | ________________ |
| 8 hour refresher:.................... | ________________ |

SITE-SPECIFIC TRAINING: I have been provided and have completed the site-specific training required by this Contract. The Site Safety and Health Officer conducted the training. ______________

RESPIRATORY PROTECTION: I have been trained in accordance with the criteria in [the Contractor's] [my Employer's] Respiratory Protection program. I have been trained in the proper work procedures and use and limitations of the respirator(s) I will wear. I have been trained in and will abide by the facial hair policy. ______________________

RESPIRATOR FIT-TEST TRAINING: I have been trained in the proper selection, fit, use, care, cleaning, and maintenance, and storage of the respirator(s) that I will wear. I have been fit-tested in accordance with the criteria in [the Contractor's] [my employer's] Respiratory Program and have received a satisfactory fit. [I have been assigned my individual respirator.] I have been taught how to properly perform positive and negative pressure fit-check upon donning negative pressure respirators each time.________________

MEDICAL EXAMINATION: I have had a medical examination within the last twelve months which was paid for by my employer. The examination included: health history, pulmonary function tests and may have included an evaluation of a chest ax-ray. A physician made determination regarding my physical capacity to perform work tasks on the project while wearing protective equipment including a respirator. I was personally provided a copy and informed of the results of that examination. My employer's industrial hygienist evaluated the medical certification provided by the physician and checked the appropriate blank below. The physician determined that there:

were no limitations to performing the required work tasks;

were identified physical limitations to performing the required work tasks.

Date medical exam completed

[Employee's][Visitor's] Signature ______________________________
Date ____________________

Printed Name ______________________

Social Security Number _________________

Contractor's Site Safety and Health Officer Signature _______________

Date ____________________

Printed Name ______________________

Social Security Number _________________

--End of Section--

# SECTION 01410

# ENVIRONMENT PROTECTION
02/97

## PART 1 GENERAL

### 1.1 DESCRIPTION

The Contractor shall perform the work minimizing environmental pollution and damage as the result of construction operations. Environmental pollution and damage is the presence of chemical, physical, or biological elements or agents which adversely affect human health or welfare; unfavorably alter ecological balances of importance to human life; affect other species of importance to humankind; or degrade the utility of the environment for aesthetic, cultural and/or historical purposes. The control of environmental pollution and damage requires consideration of land, water, and air, and includes management of visual aesthetics, noise, solid waste, and dust, as well as other pollutants. The environmental resources within the project boundaries and those affected outside the limits of permanent work shall be protected during the entire duration of this contract.

### 1.2 REFERENCES (NOT USED)

### 1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals not having a "GA" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-01 Pre-construction Submittals

Environment Protection Plan Addendum; GA

The Contractor shall submit, as necessary, an Environment Protection Plan Addendum that shall include revisions to the Environment Protection Plan submitted as part of Phase I work. Approval of the Contractor's plan will not relieve the Contractor of responsibility for adequate and continuing control of pollutants and other environmental protection measures. Work conducted as part of Phase II shall comply with the requirements identified in the Environment Protection Plan unless modified in the Addendum.

### 1.4 CONTRACTOR REQUIREMENTS

#### 1.4.1 Subcontractors

The Contractor shall ensure compliance with this section by Subcontractors.

#### 1.4.2 Permits

The Contractor shall obtain all needed permits or licenses necessary for Phase II work. The Government will not obtain any permits for this project;

see Contract Clause PERMITS AND RESPONSIBILITIES. The Contractor shall be responsible for implementing the terms and requirements of the appropriate permits as needed and for payment of all fees.

### 1.4.3 Pre-construction Site Inventory

Prior to starting any onsite construction activities, the Contractor and the Contracting Officer shall make a joint condition survey after which the Contractor shall prepare a brief report indicating on a layout plan the condition of trees, shrubs and grassed areas immediately adjacent to work sites and adjacent to the assigned storage area and access routes as applicable. This report will be signed by both the Contracting Officer and the Contractor upon mutual agreement as to its accuracy and completeness.

### 1.4.4 Meetings

The Contractor shall meet with representatives of the Contracting Officer to alter the Environmental Protection Plan as needed for compliance with the environmental pollution control program.

### 1.4.5 Notification

The Contracting Officer will notify the Contractor in writing of any observed noncompliance with the previously mentioned Federal, State or local laws or regulations, permits, and other elements of the Contractor's environmental protection plan. The Contractor shall, after receipt of such notice, inform the Contracting Officer of proposed corrective action and take such action when approved. If the Contractor fails to comply promptly, the Contracting Officer may issue an order stopping all or part of the work until satisfactory corrective action has been taken. No time extensions shall be granted or costs or damages allowed to the Contractor for any such suspensions.

### 1.4.6 Litigation

If work is suspended, delayed, or interrupted due to a court order of competent jurisdiction, the Contracting Officer will determine whether the order is due in any part to the acts or omissions of the Contractor, or subcontractors at any tier, not required by the terms of the contract. If it is determined that the order is not due to Contractor's failing, such suspension, delay, or interruption shall be considered as ordered by the Contracting Officer in the administration of the contract under the contract clause SUSPENSION OF WORK.

### 1.4.7 Previously Used Equipment

The Contractor shall thoroughly clean all construction equipment previously used at other sites before it is brought into the work areas, ensuring that soil residuals are removed and that egg deposits from plant pests are not present.

### 1.4.8 Payment

No separate payment will be made for work covered under this section; all costs associated with this section shall be included in the contract unit and/or lump sum prices in the Bidding Schedule.

## 1.5 LAND RESOURCES

The Contractor shall confine all activities to areas defined by the drawings and specifications. Prior to the beginning of any construction, the Contractor shall identify the land resources to be preserved within the work area. Except in areas indicated on the drawings or specified to be cleared, the Contractor shall not remove, cut, deface, injure, or destroy land resources including trees, shrubs, vines, grasses, topsoil, and land forms without permission. No ropes, cables, or guys shall be fastened to or attached to any trees for anchorage unless specifically authorized. Where such emergency use is permitted, the Contractor shall provide effective protection for land and vegetation resources at all times as defined in the following subparagraphs. Stone, earth or other material displaced into uncleared areas shall be removed.

### 1.5.1 Work Area Limits

Prior to any construction, the Contractor shall mark the areas that need not be disturbed under this contract. Isolated areas within the general work area which are to be saved and protected shall also be marked or fenced. Monuments and markers shall be protected before construction operations commence. Where construction operations are to be conducted during darkness, the markers shall be visible. The Contractor's personnel shall be knowledgeable of the purpose for marking and/or protecting particular objects.

### 1.5.2 Landscape

Trees, shrubs, vines, grasses, land forms and other landscape features indicated and defined on the drawings to be preserved shall be clearly identified by marking, fencing, or wrapping with boards, or any other approved techniques.

### 1.5.3 Unprotected Erodible Soils

Earthwork brought to final grade shall be finished as indicated. Side slopes and back slopes shall be protected as soon as practicable upon completion of rough grading. All earthwork shall be planned and conducted to minimize the duration of exposure of unprotected soils. Except in cases where the constructed feature obscures borrow areas, quarries, and waste material areas, these areas shall not initially be totally cleared. Clearing of such areas shall progress in reasonably sized increments as needed to use the developed areas as approved by the Contracting Officer.

### 1.5.4 Disturbed Areas

The Contractor shall effectively prevent erosion and control sedimentation through approved methods including, but not limited to, the following:

a. Erosion and sedimentation control devices. The Contractor shall construct or install temporary and permanent erosion and sedimentation control features as indicated on the drawings and as specified in Section 02271 EROSION AND SEDIMENT CONTROL. Berms, dikes, drains, sedimentation basins, grassing, and mulching shall be maintained until permanent drainage and erosion control facilities are completed and operative.

### 1.5.5 Contractor Facilities and Work Areas

The Contractor's field offices, staging areas, and stockpile storage shall be placed in areas designated on the drawings or as directed by the Contracting Officer. Temporary movement or relocation of Contractor facilities shall be made only when approved. Spoil areas shall be managed and controlled to limit spoil intrusion into areas designated on the drawings and to prevent erosion of soil or sediment from entering nearby waters. Spoil areas shall be developed in accordance with the grading plan indicated on the drawings. Temporary excavation and embankments for plant and/or work areas shall be controlled to protect adjacent areas from despoilment.

## 1.6 WATER RESOURCES

The Contractor shall keep construction activities under surveillance, management, and control to avoid pollution of surface and ground waters. Toxic or hazardous chemicals shall not be applied to soil or vegetation when such application may cause contamination of the fresh water reserve. Monitoring of water areas affected by construction shall be the Contractor's responsibility. All water areas affected by construction activities shall be monitored by the Contractor.

### 1.6.1 Erosion and Sediment Control

Erosion and sediment control measures, installed as part of Phase I, shall be inspected and maintained during Phase II construction activities, as required in the Section 02271 EROSION AND SEDIMENT CONTROL, to limit the runoff of sediment into the tidal flats and the Housatonic River.

### 1.6.2 Decontamination Water

Waste waters directly derived from decontamination activities shall not be allowed to enter water areas. Waste waters shall be collected and placed in storage tanks where suspended material can be settled out. Analysis for volatile organic compounds (VOCs) shall be performed, and results reviewed and approved, before water in storage tanks is discharged to the Building 63 Chemical Waste Treatment Plant (CWTP) sump, in accordance with the requirements specified in the Emergency Discharge Authorization Permit (Permit No. EA0100149). No surfactants shall be discharged to the CWTP without prior approval by the Contracting Officer.

### 1.6.3 Fish and Wildlife

The Contractor shall minimize interference with, disturbance to, and damage of fish and wildlife. Species that require specific attention along with measures for their protection shall be listed by the Contractor prior to beginning of construction operations.

## 1.7 AIR RESOURCES

Equipment operation and activities or processes performed by the Contractor in accomplishing the specified construction shall be in accordance with Federal and State emission and performance laws and standards. Ambient Air Quality Standards set by the Environmental Protection Agency shall be maintained. Monitoring of air quality shall be the Contractor's responsibility. All air areas affected by the construction activities shall be monitored by the Contractor.

### 1.7.1 Particulates

Dust particles; aerosols and gaseous by-products from construction activities; and processing and preparation of materials shall be controlled at all times, including weekends, holidays and hours when work is not in progress. The Contractor shall maintain excavations, stockpiles, haul roads, spoil areas, and other work areas within or outside the project boundaries free from particulates which would cause the air pollution standards to be exceeded or which would cause a hazard or a nuisance. Sprinkling or chemical treatment of an approved type will be permitted to control particulates in the work area. Sprinkling, to be efficient, must be repeated to keep the disturbed area damp at all times. The Contractor must have sufficient, competent equipment available to accomplish these tasks. Particulate control shall be performed as the work proceeds and whenever a particulate nuisance or hazard occurs.

### 1.7.2 Hydrocarbons and Carbon Monoxide

Hydrocarbons and carbon monoxide emissions from equipment shall be controlled to Federal and State allowable limits at all times.

### 1.7.3 Odors

Odors shall be controlled at all times for all construction activities, processing and preparation of materials.

### 1.7.4 Sound Intrusions

The Contractor shall keep construction activities under surveillance and control to minimize environment damage by noise. The Contractor shall comply with the provisions of the State of Connecticut rules.

## 1.8 WASTE DISPOSAL

Disposal of wastes shall be as specified in Section 02120 TRANSPORTATION AND DISPOSAL OF HAZARDOUS MATERIALS and as specified in the Phase I Section 01410 ENVIRONMENT PROTECTION.

## 1.9 HISTORICAL, ARCHAEOLOGICAL, AND CULTURAL RESOURCES

Existing historical, archaeological, and cultural resources within the Contractor's work area will be so designated by the Contracting Officer if any has been identified. The Contractor shall take precautions to preserve all such resources as they existed at the time they were first pointed out. The Contractor shall provide and install protection for these resources and be responsible for their preservation during the life of the contract. If during excavation or other construction activities any previously unidentified or unanticipated resources are discovered or found, all activities that may damage or alter such resources shall be temporarily suspended. Resources covered by this paragraph include but are not limited to: any human skeletal remains or burials; artifacts; shell, midden, bone, charcoal, or other deposits; rocks or coral alignments, pavings, wall, or other constructed features; and any indication of agricultural or other human activities. Upon such discovery or find, the Contractor shall immediately notify the Contracting Officer.

### 1.10 POST CONSTRUCTION CLEANUP

The Contractor shall clean up all areas used for construction to the satisfaction of the Contracting Officer.

### 1.11 RESTORATION OF LANDSCAPE DAMAGE

The Contractor shall restore landscape features damaged or destroyed during construction operations outside the limits of the approved work areas.

### 1.12 MAINTENANCE OF POLLUTION FACILITIES

The Contractor shall maintain permanent and temporary pollution control facilities and devices for the duration of the contract or for that length of time construction activities create the particular pollutant.

### 1.13 TRAINING OF CONTRACTOR PERSONNEL

The Contractor's personnel shall be trained in all phases of environmental protection. The training shall include methods of detecting and avoiding pollution, familiarization with pollution standards, both statutory and contractual, and installation and care of devices, vegetative covers, and instruments required for monitoring purposes to ensure adequate and continuous environmental pollution control.

## PART 2 PRODUCTS (NOT APPLICABLE)

## PART 3 EXECUTION (NOT APPLICABLE)

--End of Section--

# SECTION 01411

# SAMPLING PROCEDURES AND LABORATORY SERVICES

**01/94**

## PART 1 GENERAL

### 1.1 DESCRIPTION

This section covers the sampling and analysis of excavated soil containing gross visual or olfactory contamination and oversized debris, to determine the presence or absence of contamination for characterization purposes. Collection and analysis of decontamination wastewater samples is also covered in this section. Necessary confirmation sampling shall be completed by the Contracting Officer, or representative, and is not covered in this section.

### 1.2 REFERENCES

The references listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ENVIRONMENTAL PROTECTION AGENCY (EPA)

| | |
|---|---|
| SW-846 | Test Methods for Evaluating Solid Waste Physical/Chemical Methods, 3rd edition, latest revision. |
| EPA-600/4-79-20 | Methods for Chemical Analysis of Water and Wastes, Revised March 1983. |
| EPA-600/4-84-076 | Characterization of Hazardous Waste Sites - A Method Manual: Volume II. Available Sampling Methods, Second Edition, December 1984, NTIS No. PB85-168771 |
| EPA/540/G-87/003 | Data Quality Objectives for Remedial Response Activities - Development Process, March 1987. |

CORPS OF ENGINEERS (COE)

| | |
|---|---|
| ER 1110-1-263 | Chemical Quality Management for Hazardous Waste Remedial Activities, 1 October 1990 |

### 1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals not having a "GA" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-01 Pre-construction Submittals

Contractor's Laboratory; GA

The Contractor shall submit the name, address, telephone number and point of contact for the proposed laboratory as soon as possible, but no later than 7 days, after notice to proceed. This will expedite the laboratory validation/approval process.

As part of the Work Plan, specified in Section 02111 EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL, the Contractor shall submit a Sampling and Analysis Plan that provides the details of the field and laboratory sampling and testing requirements for this phase of work on the Causeway. It shall include specific information (including reporting limits, methods, and/or standard operating procedures) for field screening and laboratory methods, as necessary.

As part of the Phase II Completion Report, specified in Section 01780 CLOSEOUT SUBMITTALS, the Contractor shall submit characterization sampling analytical results. Data submittals shall include the results of all analyses, including quality control (QC) sample analyses (e.g. duplicates and matrix spikes). Results should also include any unusual observations such as the presence of interferences, etc. Data reporting requirements for test results will be consistent with EPA's Level III Analytical Support Requirements as given in EPA/540/G-87/003. The test results report shall include information relating the identity of split QA samples (split QA samples sent to NED laboratory) to QC samples (duplicate samples sent to the Contractor's Laboratory). This information must be provided in order for the COE NED Laboratory to perform a data comparison between split sample results. Test reports should also include all applicable method references and dates for extraction and analysis of field samples. Information copies of the test reports shall be sent to the following address:

U.S. Army Corps of Engineers
Environmental Laboratory
476 Cold Brook Road
Hubbardston, MA 01452
ATTN: Mr. David Lubianez

U.S. Army Corps of Engineers
Engineering Management Division
424 Trapelo Road
Waltham, MA 02254-9149
ATTN: Ms. Michelle Brock

## 1.4 CONTRACTOR REQUIREMENTS

### 1.4.1 Laboratory Services

The Contractor shall provide and coordinate the services of an environmental chemical laboratory to take samples and perform analyses. Laboratory capabilities must be provided for the duration of the work. The facilities must meet the requirements of this specification and are subject to inspection and prior approval by the Contracting Officer.

### 1.4.1.1 Qualification of Laboratory

The Contractor's laboratory must be a successful participant in the Corps of Engineers (COE) laboratory validation program. If the laboratory does not currently possess COE validation for all parameters of interest, the validation procedures must be successfully completed prior to collection of project samples. The COE validation procedure consists of the following steps:

1. Upon receipt of the proposed Contractor's laboratory name, address and point of contact (POC), the COE will initiate the laboratory validation process by submitting a "Request for Evaluation of Commercial Laboratory". The request will be completed by the COE.

If the laboratory does not possess current validation for all parameters of interest, steps 2 through 4 will be followed. Steps 2 through 4 typically take 8 to 12 weeks to complete, but the actual time frame is highly dependent on the laboratory's response time and performance.

2. The laboratory will be contacted to submit its qualifications for review. This submittal may be in the form of an off-the-shelf Laboratory Quality Management Manual (LQMM) or in some other format. The submittal shall provide appropriate information for COE to evaluate and assess the laboratory's technical capabilities on the project required chemical analyses.

3. COE will provide the commercial laboratory with Proficiency Audit (PA) samples. Arrangements will be made with the laboratory for the analysis of these samples. Ordinarily, the commercial laboratory is not reimbursed for costs involved with the analysis of PA samples. PA samples are method and matrix specific, depending on the specific project requirements. PA sample results are returned to the designated COE office for evaluation. Successful analysis of PA samples are required prior to validation of a commercial laboratory.

4. A COE inspector may inspect a commercial laboratory only after steps 2 and 3 have been successfully completed. Prior to the inspection, the commercial laboratory will be asked to complete a preliminary questionnaire, which will be used as a checklist during the laboratory audit. The laboratory inspection is performed at the discretion of the COE, based on the project type and size, and past performance of the subject laboratory. The inspection requirement may be waived by the COE.

## PART 2 PRODUCTS (NOT APPLICABLE)

## PART 3 EXECUTION

### 3.1 SAMPLING AND TESTING - OVERALL TASKS

Sampling and testing shall be performed for the following tasks:

a. Characterization of excavated soil and oversized debris for disposal.

b. Decontamination wastewater sampling for disposal.

c. Sand Bedding and Vegetative Support Soil for characterization, prior to placement on-site.

The test parameters for each remediation action (i.e., disposal or characterization) shall be selected to comply with all applicable Federal, State, and local laws and regulations, and shall be defined in accordance with the accepting disposal facilities requirements.

## 3.2 SAMPLING PERSONNEL & DATA LOGGING

Environmental samples are to be taken by qualified personnel only. Personnel shall have documentable experience collecting hazardous waste samples and shall meet all health requirements for this type of work. Field sampling data shall be recorded in a bound log book consisting of the following:

(a) Date and time of sampling.

(b) Date and time of removal action.

(c) Sample identification: alphanumeric field sample number.

(d) Sample location: A hand-drawn sketch of the area showing landmarks and sample locations shall be provided. Soil sample locations will be defined by distance measurements to at least two separate, permanent landmarks. Measurements shall be accurate to within a foot.

(e) Depth of sample.

(f) Observations, including descriptions of material sampled, staining (if any), presence of odors, groundwater, etc.

(g) Weather conditions (e.g., temperature, wind, clouds, precipitation).

(h) Printed name of sampling personnel.

## 3.3 QUALITY ASSURANCE AND QUALITY CONTROL SAMPLES

For every ten samples or portion thereof, one shall be taken in triplicate with two of the samples being sent to the Contractor's laboratory (QC Field Duplicate) for analysis, and the remaining sample sent to the U.S. Army Corps of Engineers, Environmental Laboratory, 476 Cold Brook Road, Hubbardston, MA 01452. The samples shall be transported to the laboratory within two days of collection. The samples shall be clearly identified by the applicable project name, SAEP Causeway Phase 1. For samples submitted to the QA Laboratory, all project-related documentation (including chain of custody forms) shall contain the QA Laboratory identification number. Sample handling shall be according to Appendix F of ER 1110-1-263.

In addition, QC samples such as rinsate blanks and trip blanks (Volatiles only) should be collected and analyzed at the laboratory. Laboratory quality control samples, including matrix spike/matrix spike duplicate (MS/MSD) and laboratory method blanks, shall be analyzed according to the method requirements (at the stated frequencies) and reported with field sample results. The collection of additional sample volume may be necessary to provide sufficient sample volume for aqueous MS/MSD analysis. Other QC information such as surrogate spike recoveries should also be reported for organic analyses. All QA/QC information shall be reported to the Contracting Officer.

## 3.4 LABELING

Each sample container shall be clearly identified with the name of the project, the field sample number, date and time of sampling, and the name(s) of the sampling personnel. Field information shall be written in indelible ink and the label shall be affixed in such a manner to ensure that it does not become separated from its respective container.

## 3.5 PRESERVATION AND STORAGE

Properly labeled sample containers shall be placed in zip-lock bags and stored in an iced durable cooler during sampling operations. Following the conclusion of sampling operations on any given day, samples will either be shipped directly to the appropriate laboratories, or be transferred to refrigerated storage space maintained at 4°C (39°F). In every instance, samples must be received at the appropriate laboratories within two days of sample collection. Samples will be maintained in a refrigerated condition at all times, including during transportation.

Saturday and Sunday delivery of QA samples to the NED Environmental Laboratory (Quality Assurance) should be avoided. The normal hours of operation of the laboratory are 0700 to 1530, Monday through Friday.

The Contractor must notify the Quality Assurance Laboratory at least 48 hours in advance of sample receipt at the QA Laboratory (telephone number is (508) 928-4238). Sample shipments should be planned in advance, and not be delivered on Saturday and Sunday, or legal holidays.

## 3.6 SAMPLING PLAN

The Contractor shall submit, as part of the Work Plan, a Sampling and Analysis Plan that provides the details of the field and laboratory sampling and testing requirements for this project. It shall include specific information (including reporting limits, methods, and/or standard operating procedures) for field screening and laboratory methods, as necessary. The guidelines for the plan may be taken directly from this specification.

### 3.6.1 Sample Types

The following is a list of sample types that will be collected for this project:

a. Excavated soil and removed oversized debris (characterization samples).

b. Wastewater generated during decontamination of equipment (decontamination samples).

c. Sand Bedding and Vegetative Support Soil to be brought on site and used as fill (fill samples).

### 3.6.2 Sampling

### 3.6.2.1 Characterization Samples

Samples of excavated soil and removed oversized debris, shall be collected and analyzed to determine the off-site disposition of the material. Soil samples shall be collected as composite samples from each identified excavation area. Several waste types (e.g., concrete, asphalt, metal, etc.) are anticipated to be generated from demolition activities and oversized debris removal. Each waste type should be sampled separately from the other waste types, at a frequency determined by the Contracting Officer, in accordance with the requirements of the accepting disposal facility.

### 3.6.2.2 Decontamination Samples

Decontamination water samples shall be collected from 500-gallon tanks used to store wastewater generated during decontamination of equipment in the specified decontamination area. Decontamination water samples shall be collected prior to discharge of the water to the Building 63 Chemical Waste Treatment Plant (CWTP) sump, to confirm the absence of volatile contamination. Decontamination wastewater shall be discharged to the Building 63 CWTP sump in accordance with the requirements specified in the Emergency Discharge Authorization Permit (Permit No. EA0100149). The use of surfactants for decontamination shall not be allowed, due to discharge requirements to the facility CWTP, unless approved by the Contracting Officer.

### 3.6.2.3 Fill Samples

Samples of Sand Bedding and Vegetative Support Soil, shall be collected and analyzed to verify the materials are natural soil, in accordance with CTDEP RSRs. Soil samples shall be collected as composite samples from the material borrow sources, at a frequency determined by the Contracting Officer, in accordance with the requirements of the CTDEP.

### 3.6.4 Sample Collection Procedures

### 3.6.4.1 Characterization Samples

Soil samples shall be taken as a composite sample from the excavated soil. The samples shall be collected as directed by the Contracting Officer, in accordance with the requirements of the accepting disposal facility.

It is anticipated that several different debris types may be generated from oversized debris removal activities, including concrete, metal, plastics, asphalt, etc. The debris types shall be sampled separately from one another, as directed by the Contracting Officer, in accordance with the requirements of the accepting disposal facility.

### 3.6.4.2 Decontamination Samples

Decontamination water shall be collected using a bailer or other transfer device according to Methods III-1 or III-2 specified in EPA-600/4-84-076. When sampling in this manner, capture any observed floating or sinking product, so as to collect a "worst case" sample.

### 3.6.4.3 Fill Samples

Fill samples shall be taken as a composite sample from the material borrow source area. The samples shall be collected as directed by the Contracting Officer, in accordance with the requirements of the CTDEP.

### 3.6.5 Sample Parameters, Containers, and Preservatives

Sample containers shall be pre-cleaned according to SW-846, and may be purchased commercially from I-Chem, Eagle Picher, or other equivalent source. The Contractor shall be responsible for defining sample requirements in the Sampling and Analysis Plan, in accordance with the requirements of the Contractor's laboratory, the accepting disposal facility, and the Stratford Army Engine Plant NPDES Permit.

## 3.7 QUANTITIES OF SAMPLES

The Contractor shall be responsible for defining sample requirements, in accordance with the requirements of the accepting disposal facility, as part of the Contractor's Sampling and Analysis Plan.

## 3.8 ANALYTICAL METHODS AND PROCEDURES

The Contractor shall be responsible for defining sample requirements, in accordance with the requirements of the accepting disposal facility, as part of the Contractor's Sampling and Analysis Plan.

--End of Section--

# SECTION 01451

# CONTRACTOR QUALITY CONTROL
**04/97**

## PART 1 GENERAL

### 1.1 DESCRIPTION

This section covers quality control procedures and testing to be completed during cover system installation on the Causeway. Prior to commencement of Phase II work, the Contractor shall prepare a Contractor Quality Control (CQC) Plan detailing the procedures to be followed and testing to be completed. Quality control testing shall be executed as required in this specification.

### 1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

| | |
|---|---|
| ASTM D 3740 | (1999b) Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction |
| ASTM E 329 | (1998a) Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction |

### 1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals not having a "GA" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-01 Pre-construction Submittals

Contractor Quality Control (CQC) Plan; GA

The Contractor Quality Control (CQC) Plan shall identify personnel, procedures, control, instructions, tests, records, and forms to be used during quality control testing. Construction will be permitted to begin only after acceptance of the CQC Plan or acceptance of an interim plan applicable to the particular feature of work to be started. Work outside of the features of work included in an accepted interim plan will not be permitted to begin until acceptance of a CQC Plan or another interim plan containing the additional features of work to be started.

### 1.4 MEASUREMENT AND PAYMENT

Separate payment will not be made for providing and maintaining an effective Quality Control program. Costs associated therewith shall be considered incidental and included in the applicable unit prices or lump-sum prices contained in the Bidding Schedule, as specified in Section 01270 MEASUREMENT AND PAYMENT.

## PART 2 PRODUCTS (NOT APPLICABLE)

## PART 3 EXECUTION

### 3.1 GENERAL REQUIREMENTS

The Contractor is responsible for quality control and shall establish and maintain an effective quality control system in compliance with the Contract Clause titled "Inspection of Construction". The quality control system shall consist of plans, procedures, and organization necessary to produce an end product which complies with the contract requirements. The system shall cover all construction operations, both onsite and offsite, and shall be keyed to the proposed construction sequence. The site project superintendent will be held responsible for the quality of work on the job and is subject to removal by the Contracting Officer for non-compliance with the quality requirements specified in the contract.

The site project superintendent in this context shall be the highest level manager responsible for the overall construction activities at the site, including quality and production. The site project superintendent shall maintain a physical presence at the site at all times, except as otherwise acceptable to the Contracting Officer, and shall be responsible for all construction and construction related activities at the site.

### 3.2 QUALITY CONTROL PLAN

The Contractor shall furnish for review by the Government, not later than 14 days after receipt of notice to proceed, the Contractor Quality Control (CQC) Plan. The plan shall identify personnel, procedures, control, instructions, tests, records, and forms to be used. Construction will be permitted to begin only after acceptance of the CQC Plan or acceptance of an interim plan applicable to the particular feature of work to be started. Work outside of the features of work included in an accepted interim plan will not be permitted to begin until acceptance of a CQC Plan or another interim plan containing the additional features of work to be started.

### 3.2.1 Content of the CQC Plan

The CQC Plan shall include, as a minimum, the following to cover all construction operations, both onsite and offsite, including work by subcontractors, fabricators, suppliers, and purchasing agents:

a. A description of the quality control organization, including a chart showing lines of authority and acknowledgment that the CQC staff shall implement the three phase control system for all aspects of the work specified. The staff shall include a CQC System Manager who shall report to the project superintendent.

b. The name, qualifications (in resume format), duties, responsibilities, and authorities of each person assigned a CQC function.

c. A copy of the letter to the CQC System Manager signed by an authorized official of the firm which describes the responsibilities and delegates sufficient authorities to adequately perform the functions of the CQC System Manager, including authority to stop work which is not in compliance with the contract. The CQC System Manager shall issue letters of direction to all other various quality control representatives outlining duties, authorities, and responsibilities. Copies of these letters shall also be furnished to the Government.

d. Procedures for scheduling, reviewing, certifying, and managing submittals, including those of subcontractors, offsite fabricators, suppliers, and purchasing agents. These procedures shall be in accordance with Section 01330 SUBMITTAL PROCEDURES.

e. Control, verification, and acceptance testing procedures for each specific test to include the test name, specification paragraph requiring test, feature of work to be tested, test frequency, and person responsible for each test. (Laboratory facilities will be approved by the Contracting Officer.)

f. Procedures for tracking preparatory, initial, and follow-up control phases and control, verification, and acceptance tests including documentation.

g. Procedures for tracking construction deficiencies from identification through acceptable corrective action. These procedures shall establish verification that identified deficiencies have been corrected.

h. Reporting procedures, including proposed reporting formats.

i. A list of the definable features of work. A definable feature of work is a task which is separate and distinct from other tasks, has separate control requirements, and may be identified by different trades or disciplines, or it may be work by the same trade in a different environment. Although each section of the specifications may generally be considered as a definable feature of work, there are frequently more than one definable features under a particular section. This list will be agreed upon during the coordination meeting.

j. Copies of sample forms to be used during documentation and reporting of quality control testing.

### 3.2.2 Acceptance of Plan

Acceptance of the Contractor's plan is required prior to the start of construction. Acceptance is conditional and will be predicated on satisfactory performance during the construction. The Government reserves the right to require the Contractor to make changes in his CQC Plan and operations including removal of personnel, as necessary, to obtain the quality specified.

### 3.2.3 Notification of Changes

After acceptance of the CQC Plan, the Contractor shall notify the Contracting Officer in writing of any proposed change. Proposed changes are subject to acceptance by the Contracting Officer.

## 3.3 PRE-CONSTRUCTION MEETING

During the Pre-construction Meeting, prior to acceptance by the Government of the CQC Plan, the Contractor shall discuss the proposed quality control system. The CQC Plan shall be submitted for review a minimum of 14 calendar days prior to the Pre-construction Meeting. During the meeting, a mutual understanding of the system details shall be developed, including the forms for recording the CQC operations, control activities, testing, administration of the system for both onsite and offsite work, and the interrelationship of Contractor's Management and control with the Government's Quality Assurance. Minutes of the meeting shall be prepared by the Government and signed by both the Contractor and the Contracting Officer. The minutes shall become a part of the contract file. There may be occasions when subsequent conferences will be called by either party to reconfirm mutual understandings and/or address deficiencies in the CQC system or procedures which may require corrective action by the Contractor.

## 3.4 QUALITY CONTROL ORGANIZATION

### 3.4.1 Personnel Requirements

The requirements for the CQC organization are a CQC System Manager and sufficient number of additional qualified personnel to ensure safety and contract compliance. The Safety and Health Manager shall receive direction and authority from the CQC System Manager and shall serve as a member of the CQC staff. Personnel identified in the technical provisions as requiring specialized skills to assure the required work is being performed properly will also be included as part of the CQC organization. The Contractor's CQC staff shall maintain a presence at the site at all times during progress of the work and have complete authority and responsibility to take any action necessary to ensure contract compliance. The CQC staff shall be subject to acceptance by the Contracting Officer. The Contractor shall provide adequate office space, filing systems and other resources as necessary to maintain an effective and fully functional CQC organization. Complete records of all letters, material submittals, show drawing submittals, schedules and all other project documentation shall be promptly furnished to the CQC organization by the Contractor. The CQC organization shall be responsible to maintain these documents and records at the site at all times, except as otherwise acceptable to the Contracting Officer.

### 3.4.2 CQC System Manager

The Contractor shall identify as CQC System Manager, an individual within the onsite work organization who shall be responsible for overall management of CQC and have the authority to act in all CQC matters for the Contractor. The CQC System Manager shall be, a construction person with a minimum of five years in related work. This CQC System Manager shall be on the site at all times during construction and shall be employed by the prime Contractor. The CQC System Manager shall be assigned as System Manager but may have duties as project superintendent in addition to quality control. An alternate for the CQC System Manager shall be identified in the plan to serve in the event of the System Manager's absence. The requirements for the alternate shall be the same as for the designated CQC System Manager.

### 3.4.3 Organizational Changes

The Contractor shall maintain the CQC staff at full strength at all times. When it is necessary to make changes to the CQC staff, the Contractor shall revise the CQC Plan to reflect the changes and submit the changes to the Contracting Officer for acceptance.

## 3.5 SUBMITTALS AND DELIVERABLES

Submittals, if needed, shall be made as specified in Section 01330 SUBMITTAL PROCEDURES. The CQC organization shall be responsible for certifying that all submittals and deliverables are in compliance with the contract requirements.

## 3.6 CONTROL

Contractor Quality Control is the means by which the Contractor ensures that the construction, including that of subcontractors and suppliers, complies with the requirements of the contract.

### 3.6.1 General

The work shall, at all times, be subject to the observation of the Contracting Officer. Observation or non-observation by the Contracting Officer shall not relieve the Contractor from the contractual obligation to furnish work and material as required and properly complete the work in accordance with these Contract Documents. If the Contracting Officer considers the work not properly accomplished, all or any part of the materials or equipment incorporated in it may be condemned or rejected. If any material, equipment, or work is condemned or rejected by the Contracting Officer, the Contractor shall bear all expenses for removal and proper replacement of such material, equipment, or work replacing any work done by others which is adversely affected by removal and proper replacement of improper work done by the Contractor shall be borne by the Contractor.

Any defective or substandard work or materials furnished by the Contractor which is discovered before the final acceptance of the work, or during the subsequent guarantee period, shall be removed immediately by the Contractor, even if initially overlooked by the Contracting Officer and recommended for payment. Any equipment or materials condemned or rejected by the Contracting Officer shall be tagged as such and shall be immediately removed from the site by the Contractor. Satisfactory work or materials shall be substituted by the Contractor for that rejected.

3.6.2 Preparatory Phase

This phase shall be performed prior to beginning work on each definable feature of work, after all required plans/documents/materials are approved/accepted, and after copies are at the work site. This phase shall include:

a. A review of each paragraph of applicable specifications, reference codes, and standards. A copy of those sections of referenced codes and standards applicable to that portion of the work to be accomplished in the field shall be made available by the Contractor at the preparatory inspection. These copies shall be maintained in the field and available for use by Government personnel until final acceptance of the work.

b. A review of the contract drawings.

c. A check to assure that all materials and/or equipment have been tested, submitted, and approved.

d. Review of provisions that have been made to provide required control inspection and testing.

e. Examination of the work area to assure that all required preliminary work has been completed and is in compliance with the contract.

f. A physical examination of required materials, equipment, and sample work to assure that they are on hand, conform to approved shop drawings or submitted data, and are properly stored.

g. A review of the appropriate activity hazard analysis to assure safety requirements are met.

h. Discussion of procedures for controlling quality of the work including repetitive deficiencies. Document construction tolerances and workmanship standards for that feature of work.

i. A check to ensure that the portion of the plan for the work to be performed has been accepted by the Contracting Officer.

j. Discussion of the initial control phase.

k. The Government shall be notified at least 48 hours in advance of beginning the preparatory control phase. This phase shall include a meeting conducted by the CQC System Manager and attended by the superintendent, other CQC personnel (as applicable), and the foreman responsible for the definable feature. The results of the preparatory phase actions shall be documented by separate minutes prepared by the CQC System Manager and attached to the daily CQC report. The Contractor shall instruct applicable workers as to the acceptable level of workmanship required in order to meet contract specifications.

### 3.6.3 Initial Phase

This phase shall be accomplished at the beginning of a definable feature of work. The following shall be accomplished:

a. A check of work to ensure that it is in full compliance with contract requirements. Review minutes of the preparatory meeting.

b. Verify adequacy of controls to ensure full contract compliance. Verify required control inspection and testing.

c. Establish level of workmanship and verify that it meets minimum acceptable workmanship standards. Compare with required sample panels as appropriate.

d. Resolve all differences.

e. Check safety to include compliance with and upgrading of the safety plan and activity hazard analysis. Review the activity analysis with each worker.

f. The Government shall be notified at least 48 hours in advance of beginning the initial phase. Separate minutes of this phase shall be prepared by the CQC System Manager and attached to the daily CQC report. Exact location of initial phase shall be indicated for future reference and comparison with follow-up phases.

g. The initial phase should be repeated for each new crew to work onsite, or any time acceptable specified quality standards are not being met.

### 3.6.4 Follow-up Phase

Daily checks shall be performed to assure control activities, including control testing, are providing continued compliance with contract requirements, until completion of the particular feature of work. The checks shall be made a matter of record in the CQC documentation. Final follow-up checks shall be conducted and all deficiencies corrected prior to the start of additional features of work which may be affected by the deficient work. The Contractor shall not build upon nor conceal non-conforming work.

### 3.6.5 Additional Preparatory and Initial Phases

Additional preparatory and initial phases shall be conducted on the same definable features of work if: the quality of on-going work is unacceptable; if there are changes in the applicable CQC staff, onsite production supervision or work crew; if work on a definable feature is resumed after a substantial period of inactivity; or if other problems develop.

## 3.7 QUALITY CONTROL TESTING

The Contractor shall employ and pay for the services of a geotechnical materials testing laboratory for soil and material testing, as necessary. The Contractor shall submit the name and qualifications of the proposed firm to the Contracting Officer for review and approval, no less than 14 days following the notice to proceed. These services shall be performed in accordance with the requirements of governing authorities, and with specified standards, to establish whether the work is in accordance with the Contract Plans and specifications. Reports of the results of soil and material testing indicating compliance or noncompliance with specified standards and with the Contract Documents shall be submitted to the Contracting Officer for review.

The Contractor shall cooperate with the Contracting Officer during all testing and sampling and furnish tools, equipment, samples of materials, and assistance as requested, and shall allow the Contracting Officer ample time and opportunity for testing of materials used in the work. The Contractor shall advise the Contracting Officer promptly upon placing orders for materials so that arrangements may be made, if desired, for inspection before shipment from the place of manufacture. The Contractor shall allow proper time for inspecting and testing of materials and workmanship, and must anticipate that possible delays in the execution of this work due to the necessity of materials being inspected and accepted for use.

### 3.7.1 Testing Procedures

The Contractor shall perform specified or required tests to verify that control measures are adequate to provide a product which conforms to contract requirements. Upon request, the Contractor shall furnish to the Government duplicate samples of test specimens for possible testing by the Government. Testing includes operation and/or acceptance tests when specified. The Contractor shall procure the services of a Corps of Engineers approved testing laboratory or establish an approved testing laboratory at the project site. The Contractor shall perform the following activities and record and provide the following data:

a. Verify that testing procedures comply with contract requirements.

b. Verify that facilities and testing equipment are available and comply with testing standards.

c. Check test instrument calibration data against certified standards.

d. Verify that recording forms and test identification control number system, including all of the test documentation requirements, have been prepared.

e. Results of all tests taken, both passing and failing tests, shall be recorded on the CQC report for the date taken. Specification paragraph reference, location where tests were taken, and the sequential control number identifying the test shall be given. If approved by the Contracting Officer, actual test reports may be submitted later with a reference to the test number and date taken. An information copy of tests performed by an offsite or commercial test facility shall be provided directly to the Contracting Officer. Failure to submit timely test reports as stated may result in nonpayment for related work performed and disapproval of the test facility for this contract.

### 3.7.2 Testing Laboratories

#### 3.7.2.1 Capability Check

The Government reserves the right to check laboratory equipment in the proposed laboratory for compliance with the standards set forth in the contract specifications and to check the laboratory technician's testing procedures and techniques. Laboratories utilized for testing soils, concrete, asphalt, and steel shall meet criteria detailed in ASTM D 3740 and ASTM E 329.

#### 3.7.2.2 Capability Recheck

If the selected laboratory fails the capability check, the Contractor will be charged to reimburse the Government for each succeeding recheck of the laboratory or the checking of a subsequently selected laboratory. Such costs will be deducted from the contract amount due the Contractor.

### 3.7.3 Onsite Laboratory

The Government reserves the right to utilize the Contractor's control testing laboratory and equipment to make assurance tests, and to check the Contractor's testing procedures, techniques, and test results at no additional cost to the Government.

### 3.7.4 Testing Requirements

#### 3.7.4.1 Common Fill Materials

Common fill materials used on the Causeway shall include satisfactory material excavated from the Causeway sideslopes and common borrow material from off-site sources. Materials from side slopes shall be visually inspected for the presence of materials over 2-feet, by the Contracting Officer. Off-site material shall be testing as follows and meet the specified requirements in Section 02300 - Earthwork.

LABORATORY TESTING

| Test | Methodology | Frequency$^{1,2}$ |
|---|---|---|
| Grain Size (to #200 Sieve) | ASTM D422 | 1 test/source/material |
| Moisture Density Curve | ASTM D698 | 1 test/source/material |

1. Testing frequency shall be as listed, or at any change in material or borrow source or as directed by the Contracting Officer, or Representative.

IN-PLACE TESTING

| Test | Methodology | Frequency[1] |
|---|---|---|
| Moisture-Density | ASTM D1556 or D2922 | 1 test/200cy/material |

1. Testing frequency shall be as listed, or at any change in material or borrow source.

### 3.7.4.2 Rock Fill

#### LABORATORY TESTING

| Test | Methodology | Frequency[1] |
|---|---|---|
| Gradation Testing | ASTM D 422 | 1 test/source |

1. Testing frequency shall be as listed or as directed by the Contracting Officer, or Representative. Other testing methods may be considered acceptable, as approved by the Contracting Officer.

### 3.7.4.3 Bedding Sand

#### LABORATORY TESTING

| Test | Methodology | Frequency[1] |
|---|---|---|
| Grain Size Analysis (to # 200 Sieve) | ASTM D422 | 1 test/source |

1. Testing frequency shall be as listed, at any change in material or borrow source, or as directed by the Contracting Officer, or Representative.

#### IN-PLACE TESTING

| Test | Methodology | Frequency[1] |
|---|---|---|
| Moisture-Density | ASTM D1556 or D2922 | 1 test/200cy/material |

1. Testing frequency shall be as listed, or at any change in material or borrow source.

### 3.7.4.4 Gravel

#### LABORATORY TESTING

| Test | Methodology | Frequency[1] |
|---|---|---|
| Grain Size (to #200 Sieve) | ASTM D422 | 1 test/source |

1. Testing frequency shall be as listed or at the request of the Contracting Officer, or Representative. Sieve shall include washing of fines from the matrix.

### 3.7.4.5 Rip Rap

LABORATORY TESTING

| Test | Methodology | Frequency[1] |
|---|---|---|
| Gradation Testing | ASTM D 422 | 1 test/source |

2. Testing frequency shall be as listed or as directed by the Contracting Officer, or Representative. Other testing methods may be considered acceptable, as approved by the Contracting

### 3.7.4.6 Vegetative Support Soil

LABORATORY TESTING

| Test | Methodology | Frequency[1,2] |
|---|---|---|
| Grain Size (to #200 Sieve)or 200 wash if 85% passing #200 | ASTM D422 | 1 test/1,000 cy |
| pH | | 1 test/1,000 cy |
| Organic Content | | 1 test/1,000 cy |

1. Testing frequency shall be as listed, or at any change in material or borrow source.
2. Testing frequency for Vegetative Support Soil shall be per borrow source, or as directed by the Engineer.

### 3.7.4.7 Geotextiles

Structural Geogrid: Two types used to fabricate Polymeric Marine Mattresses. These tests are to be performed on the individual components. Some variation is expected due to modifications in the manufacture of the composite material, acceptance shall be based on a review of the test results by Contracting Officer.

RECEIVED MATERIAL QUALITY CONTROL TESTING

| Test | Methodology | Frequency |
|---|---|---|
| True 1% Tensile Modules in Use (MD) | GRI-GG2[1] | 1 Test/ 100,000 sf |
| Junction Strength (MD) | GRI-GG2 | 1 Test/ 100,000 sf |
| Aperture Size | | 1 Test/ 100,000 sf |

1. Use GRI-GG2, as modified in Section 02380.

Biaxial Geogrid Composite: Used beneath the toe of the lower cover system and beneath modified rip rap areas.

RECEIVED MATERIAL QUALITY CONTROL TESTING

| Test | Methodology | Frequency |
|---|---|---|
| **Geogrid Component:** | | |
| True 1% Tensile Modules in Use (MD) | GRI-GG2[1] | 1 Test/100,000 sf |
| Junction Strength (MD) | GRI-GG2 | 1 Test/100,000 sf |
| Aperture Size | | 1 Test/100,000 sf |

1. Use GRI-GG2, as modified in Section 02380.

| | | |
|---|---|---|
| **Geotextile Component:** | | |
| Apparent Opening Size | ASTM D4751 | 1 Test/100,000 sf |

Woven Geotextiles:

RECEIVED MATERIAL QUALITY CONTROL TESTING

| Test | Methodology | Frequency |
|---|---|---|
| Grab Tensile Strength | ASTM D4632 | 1 test/100,000 sf |
| Puncture Resistance | ASTM D4833 | 1 test/100,000 sf |
| Apparent Opening Size | ASTM D4751 | 1 test/100,000 sf |

For manufacturer Quality Control requirements see Section 02378 GEOTEXTILES.

Non-Woven Geotextiles:

RECEIVED MATERIAL QUALITY CONTROL TESTING

| Test | Methodology | Frequency |
|---|---|---|
| Permittivity | ASTM D4491 | 1 test/100,000 sf |

| | | |
|---|---|---|
| Trapezoidal Tear | ASTM D4533 | 1 test/100,000 sf |
| Puncture Strength | ASTM D4833 | 1 test/100,000 sf |
| Apparent Opening Size | ASTM D4751 | 1 test/100,000 sf |

For manufacturer Quality Control requirements see Section 02378 GEOTEXTILES.

## 3.8 COMPLETION INSPECTION

### 3.8.1 Punch-Out Inspection

Near the end of the work, or any increment of the work, the CQC Manager shall conduct an inspection of the work. A punch list of items which do not conform to the approved drawings and specifications shall be prepared and included in the CQC documentation, as required by paragraph DOCUMENTATION. The list of deficiencies shall include the estimated date by which the deficiencies will be corrected. The CQC System Manager or staff shall make a second inspection to ascertain that all deficiencies have been corrected. Once this is accomplished, the Contractor shall notify the Government that the facility is ready for the Government Pre-Final inspection.

### 3.8.2 Pre-Final Inspection

The Government will perform the Pre-final Inspection to verify that the work is complete. A Government Pre-Final Punch List may be developed as a result of this inspection. The Contractor's CQC System Manager shall ensure that all items on this list have been corrected before notifying the Government, so that a Final Inspection can be scheduled. Any items noted on the Pre-Final Inspection shall be corrected in a timely manner. These inspections and any deficiency corrections required by this paragraph shall be accomplished within the time slated for completion of the entire work or any particular increment of the work if the project is divided into increments by separate completion dates.

### 3.8.3 Final Acceptance Inspection

The Contractor's Quality Control Inspection personnel, plus the superintendent or other primary management person, and the Contracting Officer's Representative shall be in attendance at the final acceptance inspection. Additional Government personnel including, but not limited to, those from Base/Post Civil Facility Engineer user groups, and major commands may also be in attendance. The final acceptance inspection will be formally scheduled by the Contracting Officer based upon results of the Pre-Final inspection. Notice shall be given to the Contracting Officer at least 14 days prior to the final acceptance inspection and shall include the Contractor's assurance that all specific items previously identified to the Contractor as being unacceptable, along with all remaining work performed under the contract, will be complete and acceptable by the date scheduled for the final acceptance inspection. Failure of the Contractor to have all contract work acceptably complete for this inspection will be cause for the Contracting Officer to bill the Contractor for the Government's additional inspection cost in accordance with the contract clause titled "Inspection of Construction".

## 3.9 DOCUMENTATION

The Contractor shall maintain current records providing factual evidence that required quality control activities and/or tests have been performed. These records shall include the work of subcontractors and suppliers and shall be on an acceptable form that includes, as a minimum, the following information:

a. Contractor/subcontractor and their area of responsibility.

b. Operating plant/equipment with hours worked, idle, or down for repair.

c. Work performed each day, giving location, description, and by whom. When Network Analysis (NAS) is used, identify each phase of work performed each day by NAS activity number.

d. Test and/or control activities performed with results and references to specifications/drawings requirements. The control phase shall be identified (Preparatory, Initial, Follow-up). List of deficiencies noted, along with corrective action.

e. Quantity of materials received at the site with statement as to acceptability, storage, and reference to specifications/drawings requirements.

f. Submittals and deliverables reviewed, with contract reference, by whom, and action taken.

g. Offsite surveillance activities, including actions taken.

h. Job safety evaluations stating what was checked, results, and instructions or corrective actions.

i. Instructions given/received and conflicts in plans and/or specifications.

j. Contractor's verification statement.

These records shall indicate a description of trades working on the project; the number of personnel working; weather conditions encountered; and any delays encountered. These records shall cover both conforming and deficient features and shall include a statement that equipment and materials incorporated in the work and workmanship comply with the contract. The original and one copy of these records, in report form, shall be furnished to the Government weekly. All calendar days shall be accounted for throughout the life of the contract. Reports shall be signed and dated by the CQC System Manager. The report from the CQC System Manager shall include copies of test reports and copies of reports prepared by all subordinate quality control personnel.

## 3.10 NOTIFICATION OF NONCOMPLIANCE

The Contracting Officer will notify the Contractor of any detected noncompliance with the foregoing requirements. The Contractor shall take immediate corrective action after receipt of such notice. Such notice, when delivered to the Contractor at the work site, shall be deemed sufficient for the purpose of notification. If the Contractor fails or refuses to comply promptly, the Contracting Officer may issue an order stopping all or part of the work until satisfactory corrective action has been taken. No part of the time lost due to such stop orders shall be made the subject of claim for extension of time or for excess costs or damages by the Contractor.

--End of Section--

## SECTION 01460

## SURVEY CONTROL

## PART 1 GENERAL

### 1.1 DESCRIPTION

The Contractor shall be responsible for completion of daily surveys of the work site and a final topographic survey on the Causeway following completion of Phase II activities. The daily surveys shall include surveys of the heave platforms, heave poles, and areas of work (for measurement and payment purposes). The surveys shall be conducted by a Land Surveyor licensed in the State of Connecticut and shall comply with the requirements of a Class A-1 survey.

### 1.2 REFERENCES (NOT USED)

### 1.3 SUBMITTALS

As part of the weekly progress reports, specified in Section 02111 EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL, the Contractor shall submit a copy of the original field survey book and sketches pertaining to the work, including benchmark information and calibration information. The purpose of the submittal is to allow the Contracting Officer to complete a measurement of work.

A drawing shall be generated from a final topographic survey completed following Phase II activities. The drawing shall be included as part of the Phase II Completion Report (Section 01780 CLOSEOUT SUBMITTALS) and shall show final, Phase II as-built conditions of the project. In addition, the following information shall be contained in the Phase II Completion Report:

a. A copy of the original field survey book and sketches pertaining to the work, including benchmark information, traverse station ties (when available), and calibration information.

b. A hard copy of the site plan identifying the final 1-foot contour intervals of the Causeway and surrounding area, as described above, and the horizontal locations of any designated landmarks.

c. Electronic files of the site plan on CD-ROM in the format specified in Section 01780 CLOSEOUT SUBMITTALS.

### 1.4 CONTRACTOR REQUIREMENTS

The Contractor shall complete surveys of the Causeway area during and following completion of Phase II activities. The surveys shall be conducted in compliance with the requirements of Section 01351 SAFETY HEALTH AND EMERGENCY RESPONSE and Section 01410 ENVIRONMENT PROTECTION. Surveying techniques employed in the field shall follow commonly accepted professional survey practices, which are appropriate for the task at hand. The Contractor must also adhere to the following requirements:

a. The Contractor shall utilize permanent control information provided by the Contracting Officer. Any additional control required to complete the survey shall be the responsibility of the Contractor.

b. Vertical and horizontal control shall be established with equipment capable of producing the accuracy specified herein. All surveying work shall be referenced to Connecticut State Plane NAD 83 (horizontal control) and NGVD 29 (vertical control). Calibration of leveling equipment (peg test) shall be performed each morning before initiation of activities when establishing temporary bench marks. The Contractor shall include information regarding the procedures and frequency for calibration of other survey equipment in the CQC Plan. This information shall include the equipment manufacturer's recommendations regarding calibration.

c. The Subcontractor shall meet or exceed the horizontal and vertical accuracy criteria as defined by the Standards of Accuracy and General Specifications of the Geodetic Control Surveys established by the U.S. Department of Commerce. All horizontal and vertical angles should be doubled for accuracy.

d. The Contractor shall provide a survey base line and bench marks for construction purposes. Should any of these points be destroyed, the replacement cost will be borne by the Contractor. The Contractor shall assume the entire expense of rectifying work improperly constructed due to failure to maintain and protect such established survey points and bench marks.

e. The Contractor shall provide all surveys necessary for contractual payment quantities. The Contractor will coordinate surveying of payment quantities with the Contracting Officer or his/her representative. He or she shall give the Contracting Officer three days notice of a payment survey so that the Contracting Officer may be present at the agreed upon time.

f. The Contractor shall be responsible for the layout of all grid coordinate locations, lines, grades, and levels necessary for the proper construction of the work called for on the Drawings and in the Specifications, at no additional cost to the Government. The surveyor shall also be responsible for preparation of the final Phase II topographic survey.

g. The Contractor shall employ, at his own expense, a licensed Land Surveyor in the State of Connecticut to provide surveys necessary for final contractual payment quantities and for record drawing submission.

## PART 2 PRODUCTS (NOT APPLICABLE)

## PART 3 EXECUTION

### 3.1 SURVEY

The Contractor shall provide temporary horizontal and vertical control points based upon the benchmark information provided by the Contracting Officer. The Contracting Officer will furnish site base mapping and construction drawings to be used for surveying efforts.

The Contractor shall survey the five heave platforms, the five stationary heave poles, and the temporary heave poles, as specified in Section 02110 HEAVE MONITORING, and shall conduct daily surveys in the area of work, such that measurement of work quantity can be calculated. The Contractor shall also complete a final topographic survey of approximately seven acres of area near the Causeway, following the completion of Phase II work. The drawings show the area of the Causeway for which surveying services will be required. The final topographic survey shall include elevations of 100 linear feet of the SAEP Dike on either side of the Causeway extending 50 feet toward the facility, and elevations of river sediments (i.e., tidal flats) within 75 feet of the Causeway, including the five heave platforms and five stationary heave poles. The survey shall be used to generate detailed elevation information for the Causeway and the surrounding area using 1-foot contours.

If required by the Contracting Officer, the location and elevations designated landmarks shall be obtained. Horizontal locations shall be recorded to the closest 0.1 foot and vertical elevations shall be recorded to the closest 0.01 foot.

## 3.2 SUBMITTAL

As part of the Phase II Completion Report (Section 01780 CLOSEOUT SUBMITTALS) the Contractor shall submit the following:

a. A copy of the original field survey book and sketches pertaining to the work, including benchmark information, traverse station ties (when available), and calibration information.

b. A hard copy of the site plan identifying 1-foot contour intervals of the Causeway and surrounding area as described above, and the horizontal locations of any designated landmarks.

c. Electronic files of the site plan on CD-ROM in the format specified in Section 01780 CLOSEOUT SUBMITTALS.

--End of Section--

# SECTION 01500

# CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS
02/97

## PART 1 GENERAL

### 1.1 DESCRIPTION

The Contractor shall be responsible for providing temporary construction facilities and controls necessary for this work, and removal of the facilities and controls, as necessary, following completion of the work.

### 1.2 REFERENCES (NOT USED)

### 1.3 SUBMITTALS

As part of the Work Plan, specified in Section 02111 EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL, the Contractor shall prepare a site plan indicating the proposed location and dimensions of any area to be used by the Contractor and the avenues of ingress/egress to the work areas. Any areas which may have to be graveled to prevent the tracking of mud shall be identified. The Contractor shall also indicate if the use of a supplemental or other staging area is desired.

### 1.4 CONTRACTOR REQUIRMENTS

#### 1.4.1 Identification of Employees

The Contractor shall be responsible for furnishing to each employee, and for requiring each employee engaged on the work to display, identification as approved and directed by the Contracting Officer. Prescribed identification shall immediately be delivered to the Contracting Officer for cancellation upon release of any employee. When required, the Contractor shall obtain and provide fingerprints of persons employed on the project. Contractor and subcontractor personnel shall wear identifying markings on hard hats clearly identifying the company for whom the employee works.

#### 1.4.2 Employee Parking

Contractor employees shall park privately owned vehicles in an area designated by the Contracting Officer. This area will be within reasonable walking distance of the construction site. Contractor employee parking shall not interfere with existing and established parking requirements of the facility.

#### 1.4.3 Employee Sign-in

Contractor employees shall be responsible for registering with SAEP security personnel on a daily basis, prior to arriving at the Causeway. In addition, contractor employees must also sign out from the facility on a daily basis before leaving for the day. Employee sign-in will be conducted at SAEP security headquarters in Building 1, unless otherwise directed by the Contracting Officer.

## 1.5 AVAILABILITY AND USE OF UTILITY SERVICES

### 1.5.1 Payment for Utility Services

The Government will make all reasonably required utilities available to the Contractor from existing outlets and supplies, as specified in the contract. Unless otherwise provided in the contract, the amount of each utility service consumed shall be charged to or paid for by the Contractor at prevailing rates charged to the Government. The Contractor shall carefully conserve any utilities furnished without charge.

### 1.5.2 Meters and Temporary Connections

If necessary, the Contractor, shall provide and maintain necessary temporary connection, distribution lines, and meter bases (Government will provide meters) as specified in the Phase I Section 01500 CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS.

## 1.6 BULLETIN BOARD, PROJECT SIGN, AND PROJECT SAFETY SIGN

### 1.6.1 Bulletin Board

Immediately upon beginning of work, the Contractor shall provide a weatherproof glass-covered bulletin board not less than 36 by 48 inches in size for displaying the Equal Employment Opportunity poster, a copy of the wage decision contained in the contract, Wage Rate Information poster, and other information approved by the Contracting Officer. The bulletin board shall be located at the project site in a conspicuous place easily accessible to all employees, as approved by the Contracting Officer. Legible copies of the aforementioned data shall be displayed until work is completed. Upon completion of work the bulletin board shall be removed by and remain the property of the Contractor.

### 1.6.2 Project and Safety Signs

The requirements for the signs, their content, and location shall be as directed by the Contracting Officer. The signs shall be erected within 15 days after receipt of the notice to proceed. The data required by the safety sign shall be corrected daily, with light colored metallic or non-metallic numerals. Upon completion of the project, the signs shall be removed from the site.

## 1.7 PROTECTION AND MAINTENANCE OF TRAFFIC

During construction the Contractor shall provide access and temporary relocated roads as necessary to maintain traffic. The Contractor shall maintain and protect traffic on all affected roads during the construction period except as otherwise specifically directed by the Contracting Officer. Measures for the protection and diversion of traffic, including the provision of watchmen and flagmen, erection of barricades, placing of lights around and in front of equipment and the work, and the erection and maintenance of adequate warning, danger, and direction signs, shall be as required by the State and local authorities having jurisdiction. The traveling public shall be protected from damage to person and property. The Contractor's traffic on roads selected for hauling material to and from the site shall interfere as little as possible with public traffic. The Contractor shall investigate the adequacy of existing roads and the allowable load limit on these roads. The Contractor shall be responsible for the repair of any damage to roads caused by construction operations.

### 1.7.1 Haul Roads

The Contractor shall construct access and haul roads necessary for proper execution of the work under this contract. Haul roads shall be constructed with suitable grades and widths; sharp curves, blind corners, and dangerous cross traffic shall be avoided. The Contractor shall provide necessary lighting, signs, barricades, and distinctive markings for the safe movement of traffic. The method of dust control, shall be adequate to ensure safe operation at all times (Section 01562 DUST CONTROL). Location, grade, width, and alignment of construction and hauling roads shall be subject to approval by the Contracting Officer. Lighting shall be adequate to assure full and clear visibility for full width of haul road and work areas during any night work operations. Upon completion of the work, haul roads designated by the Contracting Officer shall be removed.

### 1.7.2 Barricades

The Contractor shall erect and maintain temporary barricades to limit public access to hazardous areas. Barricades shall be securely placed, clearly visible with adequate illumination to provide sufficient visual warning of the hazard during both day and night.

## 1.8 CONTRACTOR'S TEMPORARY FACILITIES

### 1.8.1 Administrative Field Offices

The Contractor shall provide and maintain administrative field office facilities within the construction area at the designated site (Building 4). Government office and warehouse facilities will not be available to the Contractor's personnel, as designated on the drawings.

### 1.8.2 Storage Area

Trailers, materials, or equipment shall not be placed or stored outside the fenced area unless such trailers, materials, or equipment are assigned a separate and distinct storage area by the Contracting Officer away from the vicinity of the construction site but within the facility boundaries. Trailers, equipment, or materials shall not be open to public view with the exception of those items which are in support of ongoing work on any given day. Materials shall not be stockpiled outside the fence in preparation for the next day's work. Mobile equipment, such as tractors, wheeled lifting equipment, cranes, trucks, and like equipment, shall be parked within the fenced area at the end of each work day.

### 1.8.3 Supplemental Storage Area

Upon Contractor's request, the Contracting Officer will designate another or supplemental area for the Contractor's use and storage of trailers, equipment, and materials. This area may not be in close proximity of the construction site but shall be within the facility boundary. Fencing of materials or equipment will not be required at this site; however, the Contractor shall be responsible for cleanliness and orderliness of the area used and for the security of any material or equipment stored in this area. Utilities will not be provided to this area by the Government.

### 1.8.4 Appearance of Trailers

Trailers utilized by the Contractor for administrative or material storage purposes shall present a clean and neat exterior appearance and shall be in a state of good repair. Trailers which, in the opinion of the Contracting Officer, require exterior painting or maintenance will not be allowed on the facility property.

### 1.8.5 Maintenance of Storage Area

Fencing shall be kept in a state of good repair and proper alignment. Should the Contractor elect to traverse, with construction equipment or other vehicles, grassed or unpaved areas which are not established roadways, such areas shall be covered with a layer of gravel as necessary to prevent rutting and the tracking of mud onto paved or established roadways; gravel gradation shall be at the Contractor's discretion.

### 1.8.6 Security Provisions

Adequate outside security lighting shall be provided at the Contractor's temporary facilities. The Contractor shall be responsible for the security of its own equipment; in addition, the Contractor shall notify SAEP security personnel requesting periodic security checks of the temporary project field office.

## 1.9 GOVERNMENT FIELD OFFICE

The government has an existing office on the facility grounds.

## 1.10 FACILITY COMMUNICATION AND TELEPHONE SERVICE

Whenever the Contractor has the individual elements of its plant so located that operation by normal voice between these elements is not satisfactory, the Contractor shall install a satisfactory means of communication, such as two-way radios, telephone, or other suitable devices. The devices shall be made available for use by Government personnel.

The Contractor shall obtain a SAEP-approved two-way radio for communication with SAEP personnel on a daily basis. This radio must be returned to SAEP upon departure from the site, daily.

The Contractor shall provide telephone service to the field offices and shall provide and maintain a telephone or equal means of communication in an easily accessible location at each of the significant construction areas on the project. Such means of communication shall be accessible during all work hours.

### 1.11 TEMPORARY PROJECT SAFETY FENCING

The Contractor shall be responsible for maintenance of safety fencing, installed during Phase I, during the life of the contract. Upon completion and acceptance of the work, the fencing shall become the property of the Contractor and shall be removed from the work site.

### 1.12 CLEANUP

Construction debris, waste materials, packaging material and the like shall be removed from the work site daily. Any dirt or mud which is tracked onto paved or surfaced roadways shall be cleaned away. Materials resulting from demolition activities which are salvageable shall be stored within the fenced area described above or at the supplemental storage area. Stored material not in trailers, whether new or salvaged, shall be neatly stacked when stored.

### 1.13 RESTORATION OF STORAGE AREA

Upon completion of the project and after removal of trailers, materials, and equipment from within the fenced area, the fence shall be removed and will become the property of the Contractor. Areas used by the Contractor for the storage of equipment or material, or other use, shall be restored to the original or better condition. Gravel used to traverse grassed areas shall be removed and the area restored to its original condition, including top soil and seeding as necessary.

## PART 2 PRODUCTS (NOT APPLICABLE)

## PART 3 EXECUTION (NOT APPLICABLE)

--End of Section--

# SECTION 01562

# DUST CONTROL

## PART 1 GENERAL

### 1.1 DESCRIPTION

The Contractor shall furnish and apply water or calcium chloride to the Causeway or haul roads for dust control as necessary or as directed by the Contracting Officer. When no items for dust control are included in the Contract, such work shall be considered incidental.

The Contractor shall assume responsibility for any Contract delays or work stoppages due to inappropriate or ineffective dust control measures.

### 1.2 REFERENCES

The general provisions of the Contract including General and Supplementary Conditions, and General Requirements, apply to the work specified in this Section.

### 1.3 SUBMITTALS

As part of the Work Plan, specified in Section 02111 EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL, the Contractor shall submit the proposed method for dust control, including dust control material(s), application method, and monitoring.

## PART 2 PRODUCTS

### 2.1 MATERIALS

Water used for dust control shall be free from oil, acid, and injurious alkali or vegetable matter. Housatonic River water is acceptable for use as dust control water.

Calcium chloride used for dust control must conform to the requirements of AASHTO M144, except that the requirements for "total alkali chloride" and "impurities" do not apply.

## PART 3 EXECUTION

### 3.1 WATER APPLICATION - SPRINKLING

Apply dust control agents by approved methods and with equipment that includes a tank with gauge-equipped pressure pump and a nozzle-equipped spray bar. Disperse through the nozzle under a minimum pressure of 20 pounds per square inch, gauge pressure. Use when authorized by the Contracting Officer for controlling dust on the Causeway work activities, and on approved haul roads between storage areas and the Causeway, as necessary.

## 3.2 CALCIUM CHLORIDE APPLICATION - SPREADING

Apply by mechanical spreaders or by hand at the rate designated by the manufacturer. Use when authorized by the Contracting Officer for controlling dust on the Causeway during work activities, and on approved haul roads between storage areas and the Causeway, as necessary.

--End of Section--

# SECTION 01600

# MATERIAL AND EQUIPMENT CONTROL

## PART 1 GENERAL

### 1.1 DESCRIPTION

This Section covers packing and shipping, receiving, unloading, examining, and storage of materials and equipment to be used during completion of this work. Suppliers and the Contractor shall package, ship, receive, inspect, handle, and store materials and equipment in a manner that will protect such items from damage or deterioration.

### 1.2 REFERENCES (NOT USED)

### 1.3 SUBMITTALS (NOT USED)

### 1.4 PACKING AND SHIPPING

A. Suppliers' preparation of equipment shall be suitable for long term storage in the climate at the site and be such that preventative maintenance is not required during storage.

B. Identify all desiccants and inhibitors used and the required replacement frequency.

C. Any internal bracing required only for shipping purposes shall be marked to indicate the proper sequence of its removal prior to operation.

D. The outermost covering shall be clearly marked with the complete Supplier identification, including weight.

E. Boxes and crates shall be equipped with skids.

F. Indicate the weight, lifting points, and/or center of gravity on the crate, skid, or package and utilize those indications for all handling procedures.

G. Obtain from the Supplier one set of any special wrenches, tools, fixtures, slings, lifting devices, and appurtenances necessary or convenient for erection, installation or maintenance of the equipment.

### 1.5 RECEIPT AND UNLOADING

The Contractor shall handle material and equipment in accordance with these specifications and any manufacturer's handling precautions that may be applicable to specific materials and equipment. In addition, the Contractor shall supply and use all specialized equipment, such as nylon slings or special hoisting equipment, where appropriate or required.

### 1.6 ACCEPTANCE AT SITE

The Contractor shall examine all materials and equipment upon arrival. Damaged or nonconforming items shall be removed immediately to a separate storage area for expeditious removal from the site.

### 1.7 STORAGE AND PROTECTION

A. Provide open and closed storage areas for equipment and materials for protection from vandalism and weather damage.

B. Store materials and equipment in accordance with these specifications and any manufacturer's instructions for additional storing precautions that may be applicable to specific materials and equipment.

C. Store materials and equipment on blocking or pallets a sufficient distance above the ground or floor to protect from mud, standing or flowing water or similar hazards. Use waterproof covers on storage outdoors.

D. Provide indoor storage or heated indoor storage for material and equipment that normally require such protection.

E. Heat materials or equipment that are weatherproof-crated and provided with electric heaters.

F. Provide electrical energy for all heaters. Maintain temperature within enclosures above the dew point of the surrounding air. Regularly check enclosure temperatures and heaters to ensure proper operation and continuous heat.

## PART 2 PRODUCTS (NOT APPLICABLE)

## PART 3 EXECUTION (NOT APPLICABLE)

--End of Section--

# SECTION 01780

# CLOSEOUT SUBMITTALS
**11/99**

## PART 1 GENERAL

### 1.1 DESCRIPTION

The Contractor shall be responsible for development of a Phase II Completion Report detailing the results of demolition and excavation activities and presenting the final topographic survey. The Contractor shall also perform necessary site cleaning activities and maintenance activities in preparation for Phase II of this work.

### 1.2 REFERENCES (NOT USED)

### 1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals not having a "GA" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-11 Closeout Submittals

Phase II Completion Report; GA

Document the results of demolition and excavation activities completed during Phase II of the work, including, but not limited to: field notes, excavation logs, photos, and analytical results. Present a drawing generated from the final topographic survey, completed following Phase II activities. The drawing shall also show final Phase II site conditions.

### 1.4 PROJECT RECORD DOCUMENTS

This paragraph covers documents and drawings completed as a requirement of the contract. The terms "drawings", "contract drawings", and "drawing files" refer to drawings which are revised to be used for final drawings.

#### 1.4.1 Project Drawings

##### 1.4.1.1 Government-Furnished Materials

One set of electronic CADD files in the specified software and format, revised to reflect all bid amendments, will be provided by the Government at the Pre-construction Meeting (Section 01351 SAFETY, HEALTH, AND EMERGENCY RESPONSE).

##### 1.4.1.2 Working and Final Drawings

The Contractor shall revise 2 sets of paper drawings by red-line process to show the conditions during the execution of the project. These working, marked drawings shall be kept current on a weekly basis and at least one set shall be available on the job site at all times. Changes from the contract plans which are made in the work or additional information which might be uncovered in the course of construction shall be accurately and neatly recorded as they occur by means of details and notes.

The working, marked prints and final drawings will be jointly reviewed for accuracy and completeness by the Contracting Officer and the Contractor prior to submission of each monthly pay estimate. If the Contractor fails to maintain the working and final drawings as specified herein, the Contracting Officer will deduct from the monthly progress payment an amount representing the estimated cost of maintaining the drawings. This monthly deduction will continue until an agreement can be reached between the Contracting Officer and the Contractor regarding the accuracy and completeness of updated drawings. The working and final drawings shall show, but shall not be limited to, the following information:

a. The actual location, kinds, and sizes of all overhead, surface, and subsurface utility lines. In order that the location of these lines and appurtenances may be determined in the event the surface openings or indicators become covered over or obscured, the drawings shall show, by offset dimensions to two permanently fixed surface features, the end of each run including each change in direction. Valves, splice boxes, and similar appurtenances shall be located by dimensioning along the utility run from a reference point. The average depth below the surface of each run shall also be recorded.

b. Correct grade, elevations, cross section, or alignment of earthwork or utilities if any changes were made from contract plans.

c. The topography, invert elevations and grades of drainage installed or affected as part of the project construction.

d. Changes or modifications from these specifications.

e. Where contract drawings or specifications present options, only the option selected for construction shall be shown on the final as-built prints.

f. Modifications (change order price shall include the Contractor's cost to change working and final as-built drawings to reflect modifications) and compliance with the following procedures.

    (1) Directions in the modification for posting descriptive changes shall be followed.

    (2) A Modification Circle shall be placed at the location of each deletion.

    (3) For new details or sections which are added to a drawing, a Modification Circle shall be placed by the detail or section title.

    (4) For minor changes, a Modification Circle shall be placed by the area changed on the drawing (each location).

(5) For major changes to a drawing, a Modification Circle shall be placed by the title of the affected plan, section, or detail at each location.

(6) For changes to schedules or drawings, a Modification Circle shall be placed either by the schedule heading or by the change in the schedule.

(7) The Modification Circle size shall be 1/2 inch diameter unless the area where the circle is to be placed is crowded. Smaller size circle shall be used for crowded areas.

### 1.4.1.3 Drawing Preparation

The drawings shall be modified as may be necessary to correctly show the features of the project as it has been constructed by bringing the contract set into agreement with approved working prints, and adding such additional drawings as may be necessary. These working, marked prints shall be neat, legible and accurate. These drawings are part of the permanent records of this project and shall be returned to the Contracting Officer after approval by the Government. Any drawings damaged or lost by the Contractor shall be satisfactorily replaced by the Contractor at no expense to the Government.

### 1.4.1.4 Computer Aided Design and Drafting (CADD) Drawings

Only personnel proficient in the preparation of CADD drawings shall be employed to modify the contract drawings or prepare additional new drawings. Additions and corrections to the contract drawings shall be equal in quality and detail to that of the originals. Line colors, line weights, lettering, layering conventions, and symbols shall be the same as the original line colors, line weights, lettering, layering conventions, and symbols. If additional drawings are required, they shall be prepared using the specified electronic file format applying the same graphic standards specified for original drawings. The title block and drawing border to be used for any new final drawings shall be identical to that used on the contract drawings. Additions and corrections to the contract drawings shall be accomplished using CADD files.

The Contractor will be furnished Microstation 95 software and a Windows NT operating system, as necessary. The electronic files will be supplied on compact disc, read-only memory (CD-ROM). The Contractor shall be responsible for providing all program files and hardware necessary to prepare final drawings. The Contracting Officer will review final drawings for accuracy and the Contractor shall make required corrections, changes, additions, and deletions.

a. CADD colors shall be the "base" colors of red, green, and blue. Color code for changes shall be as follows:

(1) Deletions (red) - Deleted graphic items (lines) shall be colored red with red lettering in notes and leaders.

(2) Additions (Green) - Added items shall be drawn in green with green lettering in notes and leaders.

(3) Special (Blue) - Items requiring special information, coordination, or special detailing or detailing notes shall be in blue.

b. The Contract Drawing files shall be renamed in a manner related to the contract number (i.e., 98-C-10.DGN) as instructed in the Pre-Construction Meeting. Marked-up changes shall be made only to those renamed files. All changes shall be made on the layer/level as the original item. There shall be no deletions of existing lines; existing lines shall be over struck in red. Additions shall be in green with line weights the same as the drawing. Special notes shall be in blue on layer #63.

c. When final revisions have been completed, the cover sheet drawing shall show the wording "RECORD DRAWING " followed by the name of the Contractor in letters at least 3/16 inch high. Original contract drawings shall be dated in the revision block.

d. Within 10 days (for contracts less than $5 million) after Government approval of all of the working drawings for Phase I, the Contractor shall prepare the final CADD drawings for that phase of work and submit two sets of blue-lined prints of these drawings for Government review and approval. The Government will promptly return one set of prints annotated with any necessary corrections. Within 7 days the Contractor shall revise the CADD files accordingly at no additional cost and submit one set of final prints for Phase 1 to the Government. The submittal shall consist of one set of electronic files on compact disc, read-only memory (CD-ROM) and one set of the approved working drawings. They shall be complete in all details and identical in form and function to the contract drawing files supplied by the Government. Any transactions or adjustments necessary to accomplish this is the responsibility of the Contractor. The Government reserves the right to reject any drawing files it deems incompatible with the customer's CADD system. Paper prints, drawing files and storage media submitted will become the property of the Government upon final approval. Failure to submit final drawing files and marked prints as specified shall be cause for withholding any payment due the Contractor under this contract. Approval and acceptance of final drawings shall be accomplished before final payment is made to the Contractor.

### 1.4.1.5 Final Approved Shop Drawings

The Contractor shall furnish final approved project shop drawings as part of the Final Phase II Completion Report.

### 1.4.1.6 Payment

No separate payment will be made for drawings required under this contract, and all costs accrued in connection with such drawings shall be considered a subsidiary obligation of the Contractor.

### 1.4.2 As-Built Record of Equipment and Materials

The Contractor shall furnish one copy of the preliminary record of equipment and materials used on the project a minimum of 15 days prior to the final inspection. This preliminary submittal will be reviewed and returned a maximum of 2 days after final inspection with Government comments. Two sets of final record of equipment and materials shall be submitted 10 days after final inspection. The designations shall be keyed to the related area depicted on the contract drawings. The record shall list the following data, as necessary:

RECORD OF DESIGNATED EQUIPMENT AND MATERIALS DATA

| Description | Specification Section | Manufacturer and Catalog, Model, and Serial Number | Composition and Size | Where Used |
|---|---|---|---|---|

### 1.4.3 Construction Contract Specifications

The Contractor shall furnish final as-built construction contract specifications, including modifications thereto, as part of the Phase II Completion Report.

## 1.5 WARRANTY MANAGEMENT

### 1.5.1 Warranty Management Plan

As part of the Phase II Completion Report, the Contractor shall develop a warranty management plan that includes all required actions and documents to assure that the Government receives all warranties to which it is entitled. The plan shall be in narrative form and contain sufficient detail to render it suitable for use by future maintenance and repair personnel, whether tradesmen, or of engineering background, not necessarily familiar with this contract. The term "status" as indicated below shall include due date and whether item has been submitted or was accomplished. Warranty information made available during the construction phase shall be submitted to the Contracting Officer for approval prior to each monthly pay estimate. Approved information shall be assembled in a binder and shall be turned over to the Government upon acceptance of the work. The construction warranty period shall begin on the date of project acceptance and shall continue for the full product warranty period. A joint 4 month and 9 month warranty inspection shall be conducted, measured from time of acceptance, by the Contractor, Contracting Officer and the Customer Representative. Information contained in the warranty management plan shall include, but shall not be limited to, the following:

a. Roles and responsibilities of all personnel associated with the warranty process, including points of contact and telephone numbers within the organizations of the Contractors, subcontractors, manufacturers or suppliers involved.

b. Listing and status of delivery of all Certificates of Warranty for extended warranty items.

c. A list for each warranted equipment, item, feature of construction or system indicating:

   1. Name of item.
   2. Model and serial numbers.
   3. Location where installed.
   4. Name and phone numbers of manufacturers or suppliers.
   5. Names, addresses and telephone numbers of sources of spare parts.
   6. Warranties and terms of warranty. This shall include one-year overall warranty of construction. Items which have extended warranties shall be indicated with separate warranty expiration dates.
   7. Cross-reference to warranty certificates as applicable.
   8. Starting point and duration of warranty period.
   9. Summary of maintenance procedures required to continue the warranty in force.
   10. Cross-reference to specific pertinent Operation and Maintenance manuals.
   11. Organization, names and phone numbers of persons to call for warranty service.
   12. Typical response time and repair time expected for various warranted equipment.

d. The Contractor's plans for attendance at the 4 and 9 month post-construction warranty inspections conducted by the Government.

### 1.5.2 Performance Bond

The Contractor's Performance Bond shall remain effective throughout the construction period.

a. In the event the Contractor fails to commence and diligently pursue any construction warranty work required, the Contracting Officer will have the work performed by others, and after completion of the work, will charge the remaining construction warranty funds of expenses incurred by the Government while performing the work, including, but not limited to administrative expenses.

b. In the event sufficient funds are not available to cover the construction warranty work performed by the Government at the Contractor's expense, the Contracting Officer will have the right to recoup expenses from the bonding company.

c. Following oral or written notification of required construction warranty repair work, the Contractor shall respond in a timely manner. Written verification will follow oral instructions. Failure of the Contractor to respond will be cause for the Contracting Officer to proceed against the Contractor.

### 1.5.3 Contractor's Response to Construction Warranty Service Requirements

Following oral or written notification by the Contracting Officer, the Contractor shall respond to construction warranty service requirements within 3 work days. The Contractor shall submit a report on any warranty item that has been repaired during the warranty period. The report shall include the cause of the problem, date reported, corrective action taken, and when the repair was completed. If the Contractor does not perform the construction warranty within the timeframes specified, the Government will perform the work and backcharge the construction warranty payment item established.

### 1.6 OPERATION AND MAINTENANCE MANUALS

Operation manuals and maintenance manuals shall not be required for work at this site.

### 1.7 FINAL CLEANING

The premises shall be left clean following completion of work. The site shall have waste, surplus materials, rubbish, and temporary controls removed. A list of completed clean-up items shall be submitted on the day of final inspection, unless otherwise directed by the Contracting Officer. Final cleaning shall comply with the requirements of Section 01410 ENVIRONMENT PROTECTION.

## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION (NOT USED)

--End of Section--

# DIVISION 2

# SITEWORK

# SECTION 02110

# HEAVE MONITORING

## PART 1 GENERAL

### 1.1 DESCRIPTION

The Contractor shall be responsible for equipment, supplies, and personnel necessary to monitor five (5) previously installed heave platforms and five (5) previously installed stationary heave poles, as indicated on the drawings and in these specifications. In addition, the Contractor shall install and monitor temporary heave poles, as indicated in these specifications.

Monitoring of the platforms and poles shall be conducted during the completion of Phase II work to assess the impact of Phase II activities on tidal flat elevations. Background information regarding the elevations of the platforms and the stationary poles shall be collected during Phase I of this work (N.I.T.C.).

### 1.2 REFERENCES (NOT USED)

### 1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals not having a "GA" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Heave Monitoring Reports; GA

The Surveyor field records and computed measurements shall be submitted to the Engineer, at the end of each day the measurements are taken. Changes in the thickness and extent of fill between each surveyed reading of elevation shall also be reported.

On a weekly basis, the Contractor shall submit a summary of the results of heave monitoring, as indicated in this section, to the Contracting Officer. Reporting shall be provided in both hard and electronic file, and shall contain the date of monitoring and reduced survey results, along with a plot of movement versus time. Data reports shall contain data no older than 7 days, and intermediate reporting may be required due to unacceptable movements.

As part of the Work Plan (Section 02111 EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL), the Contractor shall submit a plan for monitoring and removal of the heave platforms and poles. At a minimum, the plan shall include the frequency of monitoring, as directed in the specifications and the drawings, and shall detail the processes to be used during removal of the platforms and poles, following completion of Phase II work on the Causeway.

## PART 2 PRODUCTS

### 2.1 Heave Platforms (N.I.T.C.)

Construction of the heave platforms shall be completed during Phase I work, as indicated on the Phase I drawings, and in accordance with the approved Contractor's Work Plan.

### 2.2 Heave Poles

Heave poles shall consist of pressure-treated 2 by 4 lumber, a minimum of 12 feet in length. Poles shall be provided with targets to facilitate the required survey accuracy and repeatability.

## PART 3 EXECUTION

### 3.1 Heave Platform Installation (N.I.T.C.)

Prior to initiation of Phase I work on the Causeway, the Contractor shall construct and install five (5) heave platforms at approximate locations as shown on the Drawings. The heave platforms shall be installed 30 feet from the approximate contact of the fill and riverine sediment on the South side of the Causeway, and 40 feet from the approximate contact on the North side of the Causeway.

### 3.2 Stationary Heave Pole Installation (N.I.T.C.)

Prior to initiation of Phase I work on the Causeway, the Contractor shall install five (5) stationary heave poles at approximate locations as shown on the Drawings. The stationary heave poles shall be installed 10 feet from the approximate contact of the fill and riverine sediment on the South side of the Causeway, and 15 feet from the approximate contact on the North side of the Causeway.

Stationary poles shall be installed such that the top provides for attachment of a suitable target between elevation 7 and 8. Poles shall be advanced to a minimum depth of 5 feet below ground surface.

### 3.3 Temporary Heave Pole Installation

During completion of Phase II sideslope excavation, lower cover system construction, and Rip Rap transition placement, the Contractor shall install and monitor temporary heave poles. The temporary poles shall be placed at the same distance from the Causeway as the stationary heave poles, at 50-foot intervals parallel to the contact between the fill/riverine sediments. They shall be placed up to 50 feet from the edge of an active work area, a minimum of 24 hours prior to the initiation of work in that area. The temporary poles shall be intensively monitored for a minimum of 24 hours before the initiation of work until 24 hours after the completion of work in a particular area.

The temporary poles shall be installed in a similar manner as the stationary heave poles.

### 3.4 Monitoring Frequency

During Phase II activities, the location and elevation of heave platforms and poles shall be surveyed at the following frequency:

A. All platforms and stationary poles shall be surveyed as part of an initial survey, completed one to two weeks prior to the start of Phase II work.

B. During Phase II activities, all platforms and stationary poles shall be surveyed a minimum of twice per week (i.e., general monitoring).

C. If Phase II activities are being conducted within 100 feet of a heave platform or stationary pole, that platform or pole shall be surveyed a minimum of three times daily (i.e., intensive monitoring). Intensive monitoring measurements shall be collected prior to the start of work for the day, at mid-day, and at the end of the work day.

D. Each temporary heave pole within 50 feet of an active work area, shall be surveyed a minimum of 3 times daily. Surveying shall start 24 hours prior to the initiation of work in the area and shall continue until 24 hours following the completion of work in the area.

E. Heave platform and stationary pole monitoring shall continue for two additional weeks following the completion of Phase II work.

Regular monitoring during Phase II shall be performed to a minimum accuracy of +/- 0.01 foot for elevation and +/- 0.1 foot for northing and easting.

The Contractor shall submit the results of general monitoring to the Engineer at the end of each day the measurements are taken. Changes in the thickness and extent of fill between each surveyed reading of elevation shall also be reported. On a weekly basis, the Contractor shall submit a summary of the results of heave monitoring to the Contracting Officer.

Intensive monitoring results shall be available to the Engineer on a continuous basis. If any movement (horizontal or vertical) greater than

0.5 foot is recorded within a 24 hour period, the Contractor shall STOP WORK and notify the Contracting Officer, representative, or Engineer immediately, so that the Engineer may evaluate the site conditions.

### 3.5 Heave Platform and Pole Removal

A minimum of two weeks following completion of Phase II activities, at the approval of the Contracting Officer, the heave platforms and stationary poles shall be removed from the tidal flats. Removal of the platforms and stationary poles shall comply with the requirements of Section 01351 SAFETY, HEALTH, AND EMERGENCY RESPONSE and Section 01410 ENVIROMENT PROTECTION.

--End of Section--

# SECTION 02111

# EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL

## PART 1 GENERAL

### 1.1 DESCRIPTION

The work covered in this section includes excavation of soil on the sideslopes of the Causeway below elevation 4.1 feet, placement of satisfactory excavated material above elevation 4.1 for use as Common Fill, and on-site transport of excess satisfactory and unsatisfactory excavated material to storage areas. Also included is removal and on-site transport of oversized debris identified during Phase I of this work and during sideslope excavation. Approximate locations of the areas of excavation are shown on the drawings.

### 1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

| | |
|---|---|
| ASTM D 2487 | (1993) Classification of Soils for Engineering Purposes (Unified Soil Classification System) |
| ASTM D 5434 | (1993) Guide for Field Logging of Subsurface Explorations of Soil and Rock |

CODE OF FEDERAL REGULATIONS (CFR)

| | |
|---|---|
| 40 CFR 302 | Designation, Reportable Quantities, and Notification |

CONNECTICUT DEPARTMENT OF ENVIRONMENTAL PROTECTION (CTDEP)

| | |
|---|---|
| | Remediation Standard Regulations (RSRs) |

### 1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals not having a "GA" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-01 Pre-construction Submittals

Work Plan; GA

Work Plan within 14 calendar days after notice to proceed. No work at the site, with the exception of site inspections and pre-construction surveys, shall be performed until the Work Plan is approved. The Contractor shall allow 14 calendar days in the schedule for the Government's review. No adjustment for time or money will be made if re-submittals of the Work Plan are required due to deficiencies in the plan. At a minimum, the Work Plan shall include:

a. Schedule of activities.

b. Site layout.

b. Method of excavation/grading and equipment to be used.

c. Dewatering plan, if necessary.

e. Storage methods and locations for liquid and solid contaminated material.

f. Dust control plan.

g. Waste management plan.

h. Method of cover system placement (Section 02380 POLYMERIC MARINE MATTRESSES and Section 02440 ARTICULATING CELLULAR CONCRETE BLOCK SYSTEM).

SD-06 Test Reports

Weekly Progress Reports; GA

Submit on a weekly basis, the results for quality control testing, heave platforms monitoring, and excavation quantities.

The Contractor shall submit, as part of the Phase II Completion Report (Section 01780 CLOSEOUT SUBMITTALS), the results of laboratory testing for characterization sampling and copies of field log entries completed during excavation and debris removal.

## 1.4 SURVEYS

Surveying shall be performed throughout completion of Phase II activities, and following completion of Phase II, in accordance with Section 01460 SURVEY CONTROL.

## 1.5 REGULATORY REQUIREMENTS

### 1.5.1 Permits and Licenses

The Contractor shall obtain required federal, state, and local permits for excavation and storage of contaminated material. Permits shall be obtained at no additional cost to the Government.

#### 1.5.2 Air Emissions

Air emissions shall be monitored and controlled in accordance with Section 01410 ENVIRONMENT PROTECTION.

### 1.6 CHARACTERIZATION SAMPLING AND ANALYSIS

Characterization sampling and chemical analysis for off-site disposal shall be conducted as required by the accepting disposal facility, and in accordance with Section 01411 SAMPLING PROCEDURES AND LABORATORY SERVICES.

### 1.7 SCHEDULING

The Contractor shall notify the Contracting Officer seven calendar days prior to the start of excavation of sideslope material. The Contracting Officer shall be responsible for contacting regulatory agencies in accordance with the applicable reporting requirements.

## PART 2 PRODUCTS

### 2.1 BACKFILL MATERIAL

During Phase II, satisfactory excavated material, as defined in Section 02300 EARTHWORK, shall be used to backfill the six excavation areas, excavated during Phase I work. Other borrow material, to be used on the Causeway, shall be of the quality specified in Section 02300 EARTHWORK.

### 2.2 SPILL RESPONSE MATERIALS

The Contractor shall provide spill response materials including, but not limited to, the following: containers, adsorbents, shovels, and personal protective equipment. Spill response materials shall be available at all times in which hazardous materials/wastes are being handled or transported. Spill response materials shall be compatible with the type of materials and contaminants being handled.

## PART 3 EXECUTION

### 3.1 EXISTING STRUCTURES AND UTILITIES

The Contractor shall take the necessary precautions to ensure no damage occurs to existing structures and utilities. Damage to existing structures and utilities resulting from the Contractor's operations shall be repaired at no additional cost to the Government.

### 3.2 CLEARING AND GRUBBING

Clearing and grubbing shall be performed as part of Phase I work (N.I.T.C.).

### 3.3 MATERIAL REMOVAL AND HANDLING

The work covered in this section includes excavation of an estimated 2,700 cubic yards of soil from the sideslopes of the Causeway. Excavated soil containing obvious visual or olfactory contamination, and therefore considered unsatisfactory, shall be transported to on-site stockpile areas for temporary storage and characterization sampling. In addition, excavated soil that will not meet the requirements for Common Fill, defined in Section 02300 EARTHWORK, also shall be transported to on-site stockpile areas, as unsatisfactory material. The remainder of the excavated soil (i.e., satisfactory material) shall be placed above elevation 4.1 feet on the Causeway for grading.

In addition to sideslope soil, oversized debris, greater than 2 feet in any dimension, shall be removed from the Causeway. Debris identified during Phase I activities and uncovered on the sideslopes during soil excavation, shall be excavated, cleaned on the Causeway, and transported to on-site stockpile areas for temporary storage and characterization sampling.

### 3.3.1 Sideslope Soil Excavation

The contact between Causeway fill and tidal sediment, as defined on the drawings, shall be marked by the Contractor at 50-foot intervals along the toe of the Causeway prior to initiation of excavation activities. Excavation of the Causeway sideslopes shall be between the marked contact and elevation 4.1 feet msl. The depth of excavation shall be as indicated on the Contract drawings. Excavation under standing water shall not be allowed and the area to be excavated in any given day shall be no larger than that which can be covered with the lower cover system on the same day.

The Contracting Officer shall be notified within 48 hours if gross visual or olfactory contamination that has not been previously identified is discovered, or if discrepancies between data provided and actual field conditions are discovered. Excavation shall be performed in a manner that limits the potential for satisfactory, unsatisfactory but uncontaminated, and contaminated material to be inter-mixed.

A log of the materials and any visible signs of contamination encountered during excavation shall be maintained for each area of excavation. Excavation logs shall be prepared in accordance with ASTM D 5434 and submitted as part of weekly progress reports. Excavations should be marked and secured in accordance with the requirements specified in Section 01351 SAFETY, HEALTH, AND EMERGENCY RESPONSE(HTRW/UST).

### 3.3.2 Oversized Debris Removal

Oversized debris identified during Phase I activities or encountered during sideslope excavation, that is greater than 2 feet in any dimension, shall be removed from the Causeway. It is estimated that approximately 300 cubic yards (approximately 600 tons) of solid debris will require removal from the Causeway.

Asphaltic concrete road surfaces shall also be removed from the Causeway during Phase II activities, following completion of sideslope excavation in the area of the road surfaces. These surfaces were left in place during Phase I work to provide a durable surface for Phase II sideslope excavation.

### 3.3.3 Material Handling

Unsatisfactory excavated material, as defined in Section 02300 EARTHWORK, shall be transported to on-site stockpile areas for temporary storage and characterization sampling, as necessary, prior to transportation off-site for disposal.

Oversized debris and removed road surfaces shall be cleaned of excess soil first by using mechanical methods followed by use of high-pressure washing equipment, prior to removal from the Causeway. Washing shall be performed in close proximity to the removal area, if possible, with water allowed to infiltrate the ground surface. No surfactants shall be used. The Contractor shall perform washing in such a manner to minimize the volume of water used and the potential for migration of sediments, and shall perform washing only in areas above elevation 6, and above at least one active siltation barrier.

Rubbish and debris shall be removed from the Causeway daily, unless otherwise directed. Materials that cannot be removed daily shall be stored in areas specified by the Contracting Officer.

## 3.4 CONFIRMATION SAMPLING AND ANALYSIS

The Contracting Officer, or a representative, shall be present to inspect the removal of soil containing gross visual or olfactory contamination. After all material suspected of being contaminated has been removed, the excavation shall be examined for evidence of contamination and, if appropriate, field analysis used to determine the presence of volatile contamination using a real-time vapor monitoring instrument. Excavation of additional soil shall be as directed by the Contracting Officer, or the representative.

After all suspected contaminated material is removed, confirmation samples shall be collected by the Contracting Officer, or representative. The Contractor shall assist the Contracting Officer, or the representative, as requested. It is estimated that five confirmation samples, one from each sidewall and one from the bottom of the excavation, will be collected for each excavation area. The Contracting Officer will have the samples analyzed and will provide test results to the Contractor. Based on test results, the Contracting Officer, or representative, shall propose any additional excavation that may be required to remove material contaminated above action levels. Additional excavation shall be subject to approval by the Contracting Officer.

Confirmation sampling will not be conducted for oversized debris removal.

## 3.5 MATERIAL STORAGE

Unsatisfactory excavated material and oversized debris shall be placed in temporary storage immediately after excavation and removal from the Causeway. The following paragraphs describe acceptable methods of material storage. Storage units shall be in good condition and constructed of materials that are compatible with the material to be stored. If multiple storage units are required, each unit shall be clearly labeled with an identification number and a written log shall be kept to track the source of contaminated material in each temporary storage unit.

### 3.5.1 Stockpiles

Stockpiles shall be constructed to isolate stored contaminated material from uncontaminated material and the environment. The maximum stockpile size shall be 500 cubic yards. Stockpiles shall be constructed as indicated in Phase I Section 02111 EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL (NITC).

### 3.5.2 Roll-Off Units

Water-tight roll-off units may be used to temporarily store contaminated material. An impermeable cover shall be placed over the units to prevent precipitation from contacting the stored material. The units shall be located in the Contractor storage area, as directed by the Contracting Officer. Liquid which collects inside the units shall be removed and stored in accordance with paragraph Liquid Storage.

### 3.5.3 Liquid Storage

Liquid collected from excavations and stockpiles shall be temporarily stored in 55-gallon barrels. Liquid storage containers shall be water-tight and shall be located in the Contractor storage area, as directed by the Contracting Officer.

## 3.6 SAMPLING

### 3.6.1 Sampling of Stored Material

Samples of excavated soil and oversized debris shall be collected for characterization purposes of each debris type. Sample collection rates and analytical parameters shall be determined by the Contracting Officer in conjunction with the requirements of the accepting treatment, storage, and disposal (TSD) facility.

Stored material shall be treated/disposed offsite. Analyses for contaminated material to be taken to an offsite TSD facility, shall conform to local, state, and federal criteria as well as to the requirements of the TSD facility. Documentation of all analyses performed shall be furnished to the Contracting Officer. Additional sampling and analyses, to the extent required by the accepting offsite TSD facility, shall be the responsibility of the Contractor and shall be performed at no additional cost to the Government.

### 3.6.2 Sampling Liquid

Liquid collected from storage areas and decontamination facilities shall be sampled at a frequency of once for every 500 gallons of liquid collected. Samples shall be tested for the following:

| Chemical Parameter | Action Level |
|---|---|
| Volatile Organics | 100 parts per billion |

Liquid with contaminant levels that exceed action levels shall be treated on-site using activated carbon until subsequent sampling results are below the action level. When the liquid contaminant level is below the action level, it shall be discharged to the Building 63 Chemical Waste Treatment Plant sump, provided the water does not contain surfactants. Documentation of all analyses performed shall be furnished to the Contracting Officer in the Phase II Completion Report (Section 01780 CLOSEOUT SUBMITTALS).

## 3.7 SPILLS

In the event of a spill or release of a hazardous substance (as designated in 40 CFR 302), pollutant, contaminant, or oil (as governed by the Oil Pollution Act (OPA), 33 U.S.C. 2701 et seq.), the Contractor shall notify the Contracting Officer immediately. If the spill exceeds the reporting threshold, the Contractor shall follow the pre-established procedures as described in the SSHP for immediate reporting and containment, as described in Section 01351 SAFETY, HEALTH, AND EMERGENCY RESPONSE (HTRW/UST).

## 3.8 BACKFILL

Excavations opened during Phase I work will be backfilled during Phase II with satisfactory excavated material from the sideslopes of the Causeway. Placement, grading, and compaction of backfill material shall be as specified in Section 02300 EARTHWORK.

## 3.9 DISPOSAL REQUIREMENTS

Offsite disposal of contaminated material shall be in accordance with Section 02120 TRANSPORTATION AND OFF-SITE DISPOSAL.

## 3.10 PHASE II COMPLETION REPORT

Six copies of a Phase II Completion Report shall be prepared and submitted within 21 calendar days of completing work at the site. The report shall be labeled with the contract number, project name, location, date, name of general contractor, and the Corps of Engineers District contracting for the work. The Closure Report shall include the following information as a minimum:

a. A cover letter signed by a responsible company official certifying that all services involved have been performed in accordance with the terms and conditions of the contract documents.

b. A narrative report including, but not limited to, the following:

   (1) site conditions, groundwater elevation, and cleanup criteria;

   (2) excavation logs;

   (3) field screening readings;

(4) quantity of materials removed from each area of contamination; and

(5) quantities of water/product removed during dewatering, if necessary.

c. Copies of all chemical and physical test results.

d. Copies of all manifests and land disposal restriction notifications.

e. Copies of all certifications of final disposal signed by the responsible disposal facility official.

f. Waste profile sheets.

g. Scaled drawings showing limits of each excavation, limits of contamination, and known underground utilities within 50 feet of excavation.

h. Progress Photographs. Color photographs shall be used to document progress of the work. A minimum of four views of the site showing the location of the area of contamination, entrance/exit road, and any other notable site conditions shall be taken before work begins. After work has been started, activities at each work location shall be photographically recorded weekly. Photographs shall be a minimum of 4 x 6 inches and shall include:

(1) Soil removal, handling, and sampling.

(2) Unanticipated events such as discovery of additional contaminated material.

(3) Contaminated material storage.

(4) Site or task-specific employee respiratory and personal protection.

(5) Post-construction photographs. After completion of work at each site, the Contractor shall take a minimum of four views of each excavation site.

Photographs shall be mounted back-to-back in double face plastic sleeves punched to fit standard three ring binders. Each print shall have an information box attached. The box shall be typewritten and arranged as follows:

| | |
|---|---|
| Project Name: | Direction of View: |
| Location: | Date/Time: |
| Photograph No.: | Description of View: |

--End of Section--

# SECTION 02120

# TRANSPORTATION AND OFF-SITE DISPOSAL
10/96

## PART 1 GENERAL

### 1.1 DESCRIPTION

This section covers the transportation and off-site disposal of materials generated during the completion of Phase II work at the site. Material anticipated to require disposal includes excavated sideslope soil containing gross visual or olfactory contamination, oversized debris, or otherwise unsatisfactory materials.

### 1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

CODE OF FEDERAL REGULATIONS (CFR)

| | |
|---|---|
| 40 CFR 61 | National Emission Standards for Hazardous Air Pollutants |
| 40 CFR 261 | Identification and Listing of Hazardous Waste |
| 40 CFR 262 | Standards Applicable to Generators of Hazardous Waste |
| 40 CFR 263 | Standards Applicable to Transporters of Hazardous Waste |
| 40 CFR 264 | Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities |
| 40 CFR 265 | Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities |
| 40 CFR 266 | Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities |
| 40 CFR 268 | Land Disposal Restrictions |
| 40 CFR 270 | EPA Administered Permit Programs: The Hazardous Waste Permit Program |
| 40 CFR 300 | National Oil and Hazardous Substances Pollution Contingency Plan |

| | |
|---|---|
| 40 CFR 302 | Designation, Reportable Quantities, and Notification |
| 49 CFR 107 | Hazardous Materials Program Procedures |
| 49 CFR 172 | Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements |
| 49 CFR 173 | Shippers - General Requirements for Shipments and Packagings |
| 49 CFR 178 | Specifications for Packagings |

## 1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals not having a "GA" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Recordkeeping; GA

Information necessary to file state annual or EPA biennial reports for all hazardous waste transported, treated, stored, or disposed of under this contract. The Contractor shall not forward these data directly to the regulatory agency but to the Contracting Officer at the specified time. The submittal shall contain all the information necessary for filing of the formal reports in the form and format required by the governing Federal or state regulatory agency. A cover letter shall accompany the data to include the contract number, Contractor name, and project location.

Exception Reports; GA

In the event that a manifest copy documenting receipt of hazardous waste at the treatment, storage, and disposal (TSD) facility is not received within 35 days of shipment initiation, the Contractor shall prepare and submit an exception report to the Contracting Officer within 37 days of shipment initiation.

SD-07 Certificates

EPA Off-Site Policy; GA

A letter certifying that EPA considers the facilities to be used for all off-site disposal to be acceptable in accordance with the Off-Site policy in 40 CFR 300, Section .440. This certification shall be provided for wastes from Resource Conservation and Recovery Act (RCRA), 42 U.S.C. 6901 et seq., sites as well as from Comprehensive Environmental Response Compensation and Liability Act

(CERCLA), 42 U.S.C. 9601 et seq., responses. See Attachment A, sample certification, at the end of this section.

Disposal Certificates; GA

Certificates documenting the ultimate disposal of hazardous wastes and/or asbestos within 180 days of initial shipment. Receipt of these certificates will be required for final payment.

Shipping Documents and Packagings Certification; GA

All transportation related shipping documents to the Contracting Officer, including draft hazardous waste manifests, draft land disposal restriction notifications, draft asbestos waste shipment records, draft bill of ladings for hazardous materials, lists of corresponding proposed labels, packages, marks, and placards to be used for shipment, waste profiles, and supporting waste analysis documents, for review a minimum of 14 days prior to anticipated pickup. Packaging assurances shall be furnished prior to transporting hazardous material; "generator copies" of hazardous waste manifests, land disposal restriction notifications, asbestos waste shipment records, bill of ladings, and supporting waste analysis documents shall be furnished when shipments are originated; and "receipt copies" of asbestos waste shipment records at the designated disposal facility shall be furnished not later than 35 days after acceptance of the shipment.

Notices of Non-Compliance and Notices of Violation; GA

Notices of non-compliance or notices of violation by a Federal, state, or local regulatory agency issued to the Contractor in relation to any work performed under this contract. The Contractor shall immediately provide copies of such notices to the Contracting Officer. The Contractor shall also furnish all relevant documents regarding the incident and any information requested by the Contracting Officer, and shall coordinate its response to the notice with the Contracting Officer or his designated representative prior to submission to the notifying authority. The Contractor shall also furnish a copy to the Contracting Officer of all documents submitted to the regulatory authority, including the final reply to the notice, and all other materials, until the matter is resolved.

As part of the Work Plan, specified in Section 02111 EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL, the Contractor shall submit a plan detailing the manner in which wastes generated during the work shall be managed. The plan shall, at a minimum, describe the types and volumes of wastes anticipated to be managed as well as the management practices to be utilized. The plan shall also identify the method to be used to ensure accurate piece counts and/or weights of shipments; shall identify waste minimization methods; shall propose facilities to be utilized for treatment, storage, and/or disposal; shall identify areas on-site where hazardous wastes are to be handled; shall identify whether transfer facilities are to be utilized; and if so, how the wastes will be tracked to ultimate disposal; shall contain the name and address of the proposed disposal facility and proposed haul routes; shall indicate that all material leaving the site for disposal shall be adequately characterized in accordance with the accepting facility requirements; and shall contain copies of the current certificates of registration issued to the Contractor.

In the event of a spill or release of a hazardous substance (as designated in 40 CFR 302), or pollutant or contaminant, or oil (as governed by the Oil Pollution Act [OPA], 33 U.S.C. 2701 et seq.), the Contractor shall notify the Contracting Officer immediately. The Site Safety and Health Plan shall detail reporting requirements, as specified in Section 01351 SAFETY, HEALTH, AND EMERGENCY RESPONSE.

## 1.4 QUALIFICATIONS

### 1.4.1 Transportation and Disposal Coordinator

The Contractor shall designate, by position and title, one person to act as the Transportation and Disposal Coordinator (TDC) for this contract. The TDC shall serve as the single point of contact for all environmental regulatory matters and shall have overall responsibility for total environmental compliance at the site including, but not limited to, accurate identification and classification of hazardous waste and hazardous materials; determination of proper shipping names; identification of marking, labeling, packaging and placarding requirements; completion of waste profiles, hazardous waste manifests, asbestos waste shipment records, PCB manifests, bill of ladings, exception and discrepancy reports; and all other environmental documentation. The TDC shall have, at a minimum, one year of specialized experience in the management and transportation of hazardous waste.

### 1.4.2 Training

The Contractor's hazardous materials employees shall be trained, tested, and certified to safely and effectively carry out their assigned duties in accordance with Section 01351 SAFETY, HEALTH, AND EMERGENCY RESPONSE (HTRW/UST). The Contractor's employees transporting hazardous materials or preparing hazardous materials for transportation shall be trained, tested, and certified in accordance with 49 CFR 172.

### 1.4.3 Certification

The Contractor and/or subcontractors transporting hazardous materials shall possess a current certificate of registration issued by the Research and Special Programs Administration (RSPA), U.S. Department of Transportation, when required by 49 CFR 107, Subpart G.

## 1.5 LAWS AND REGULATIONS REQUIREMENTS

Work shall meet or exceed the minimum requirements established by Federal, state, and local laws and regulations that are applicable. These requirements are amended frequently and the Contractor shall be responsible for complying with amendments as they become effective. In the event that compliance exceeds the scope of work or conflicts with specific requirements of the contract, the Contractor shall notify the Contracting Officer immediately.

## 1.6 DEFINITIONS

a. Natural Soil/Material. A soil/material in which all substances naturally occurring therein are present in concentrations not exceeding the concentrations of such substance occurring naturally in the environment and in which no other substance is analytically detectable.

b. Polluted Soil/Material. A soil waste that has been determined to have been affected by a release of a substance at a concentration above the analytical detection limit for such substance, but at levels below that which would qualify it as a hazardous waste..

c. Hazardous Material. A substance or material which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and which has been so designated pursuant to the Hazardous Materials Transportation Act, 49 U.S.C. Appendix Section 1801 et seq. The term includes materials designated as hazardous materials under the provisions of 49 CFR 172, Sections .101 and .102 and materials which meet the defining criteria for hazard classes and divisions in 49 CFR 173. EPA designated hazardous wastes are also hazardous materials.

d. Hazardous Waste. A waste which meets criteria established in RCRA or specified by the EPA in 40 CFR 261 or which has been designated as hazardous by a RCRA authorized state program.

e. Special Waste. As defined in the CTDEP RSRs, is: "special wastes" mean the following wastes, so long as they are not hazardous waste pursuant to section 22a-115 of the General Statutes or radioactive material subject to section 22a-148 of the General Statutes: (1) water treatment, sewage treatment or industrial sludges, liquids, solids and contained gases; fly-ash and casting sands or slag; and contaminated dredge spoils; (2) scrap tires; (3) bulky waste, as defined in 22a-209-1; (4) asbestos; (5) residue; and (6) biomedical waste.

## PART 2 PRODUCTS

## 2.1 MATERIALS

The Contractor shall provide all of the materials required for the packaging, labeling, marking, placarding and transportation of non-hazardous and hazardous wastes and hazardous materials in conformance with Department of Transportation standards. Details in this specification shall not be construed as establishing the limits of the Contractor's responsibility.

### 2.1.1 Packagings

The Contractor shall provide bulk and non-bulk containers for packaging hazardous materials/wastes consistent with the authorizations referenced in the Hazardous Materials Table in 49 CFR 172, Section .101, Column 8. Bulk and non-bulk packaging shall meet the corresponding specifications in 49 CFR 173 referenced in the Hazardous Materials Table, 49 CFR 172, Section .101. Each packaging shall conform to the general packaging requirements of Subpart B of 49 CFR 173, to the requirements of 49 CFR 178 at the specified packing group performance level, to the requirements of special provisions of column 7 of the Hazardous Materials Table in 49 CFR 172, Section .101, and shall be compatible with the material to be packaged as required by 40 CFR 262. The Contractor shall also provide other packaging related materials such as materials used to cushion or fill voids in overpacked containers, etc. Sorbent materials shall not be capable of reacting dangerously with, being decomposed by, or being ignited by the hazardous materials being packaged. Additionally, sorbents used to treat free liquids to be disposed of in landfills shall be non-biodegradable as specified in 40 CFR 264, Section .314.

### 2.1.2 Markings

The Contractor shall provide markings for each hazardous material/waste package, freight container, and transport vehicle consistent with the requirements of 49 CFR 172, Subpart D, 40 CFR 262, Section .32 (for hazardous waste), and 40 CFR 61, Section .149(d) (for asbestos). Markings shall be capable of withstanding, without deterioration or substantial color change, a 180 day exposure to conditions reasonably expected to be encountered during container storage and transportation.

### 2.1.3 Labeling

The Contractor shall provide primary and subsidiary labels for hazardous materials/wastes consistent with the requirements in the Hazardous Materials Table in 49 CFR 172, Section .101, Column 6. Labels shall meet design specifications required by 49 CFR 172, Subpart E including size, shape, color, printing, and symbol requirements. Labels shall be durable and weather resistant and capable of withstanding, without deterioration or substantial color change, a 180 day exposure to conditions reasonably expected to be encountered during container storage and transportation.

### 2.1.4 Placards

For each off-site shipment of hazardous material/waste, the Contractor shall provide primary and subsidiary placards consistent with the requirements of 49 CFR 172, Subpart F. Placards shall be provided for each side and each end of bulk packaging, freight containers, transport vehicles, and rail cars requiring such placarding. Placards may be plastic, metal, or other material capable of withstanding, without deterioration, a 30 day exposure to open weather conditions and shall meet design requirements specified in 49 CFR 172, Subpart F.

### 2.1.5 Spill Response Materials

The Contractor shall provide spill response materials including, but not limited to, containers, adsorbent, shovels, and personal protective equipment. Spill response materials shall be available at all times in which hazardous materials/wastes are being handled or transported. Spill response materials shall be compatible with the type of material being handled.

### 2.2 EQUIPMENT AND TOOLS

The Contractor shall provide miscellaneous equipment and tools necessary to handle hazardous materials and hazardous wastes in a safe and environmentally sound manner.

## PART 3 EXECUTION

### 3.1 ON-SITE WASTE MANAGEMENT

These paragraphs apply to Government-owned waste only. Contractors are prohibited by 10 U.S.C. 2692 from storing contractor-owned waste on site for any length of time. The Contractor shall be responsible for ensuring compliance with all Federal, state, and local hazardous waste laws and regulations and shall verify those requirements when preparing reports, waste shipment records, hazardous waste manifests, or other documents. The Contractor shall identify hazardous wastes using criteria set forth in 40 CFR 261 or all applicable state and local laws, regulations, and ordinances. When accumulating hazardous waste on-site, the Contractor shall comply with generator requirements in 40 CFR 262 and any applicable state or local law or regulations. On-site accumulation times shall be restricted to applicable time frames referenced in 40 CFR 262, Section .34 and any applicable state or local law or regulation. Accumulation start dates shall commence when waste is first generated (i.e. containerized or otherwise collected for discard).

The Contractor shall only use containers in good condition and compatible with the waste to be stored. The Contractor shall be responsible for ensuring containers are closed except when adding or removing waste. The Contractor shall be responsible for immediately marking all hazardous waste containers with the words "hazardous waste" and other information required by 40 CFR 262, Section .32 and any applicable state or local law or regulation as soon as the waste is containerized. An additional marking shall be placed on containers of "unknowns" designating the date sampled, and the suspected hazard. The Contractor shall be responsible for inspecting containers for signs of deterioration and shall be responsible for responding to any spills or leaks. The Contractor shall inspect all hazardous waste areas weekly and shall provide written documentation of the inspection. Inspection logs shall contain date and time of inspection, name of individual conducting the inspection, problems noted, and corrective actions taken.

#### 3.1.1 On-site Waste Classification

The Contractor, in consultation with the Contracting Officer and the waste transporter, shall identify all waste codes applicable to each hazardous and non-hazardous waste stream, as applicable, based on requirements in 40 CFR 261 or any applicable state or local law or regulation. The Contractor shall also identify all applicable treatment standards in 40 CFR 268 and state land disposal restrictions and shall make a determination as to whether or not the waste meets or exceeds the standards. Waste profiles, analyses, classification and treatment standards information shall be submitted to Contracting Officer for review and approval.

### 3.1.2 Waste Management Plan

As part of the Work Plan, specified in Section 02111 EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL, the Contractor shall submit a plan detailing the manner in which wastes generated during the work shall be managed. The plan shall, at a minimum, describe the types and volumes of wastes anticipated to be managed as well as the management practices to be utilized. The plan shall also identify the method to be used to ensure accurate piece counts and/or weights of shipments; shall identify waste minimization methods; shall propose facilities to be utilized for treatment, storage, and/or disposal; shall identify areas on-site where hazardous wastes are to be handled; shall identify whether transfer facilities are to be utilized; and if so, how the wastes will be tracked to ultimate disposal; shall contain the name and address of the proposed disposal facility and proposed haul routes; and shall contain copies of the current certificates of registration issued to the Contractor.

## 3.2 OFF-SITE WASTE MANAGEMENT

The Contractor shall use licensed solid waste landfills and RCRA Subtitle C permitted facilities which meet the requirements of 40 CFR 264. The Contractor may also use facilities operating under interim status which meet the requirements of 40 CFR 265. Off-site TSD facilities with significant RCRA violations or compliance problems (such as facilities known to be releasing hazardous constituents into ground water, surface water, soil, or air) shall not be used.

### 3.2.1 Description of Treatment, Storage, and Disposal Facility and Transporter

The Contractor shall provide the Contracting Officer with EPA ID numbers, names, locations, and telephone numbers of TSD facilities and transporters. This information shall be contained in the Waste Management Plan for approval prior to waste disposal.

### 3.2.2 Status of the Facility

Facilities receiving hazardous waste must be permitted in accordance with 40 CFR 270 or operating under interim status in accordance with 40 CFR 265 requirements, or must be permitted by an authorized state program. Additionally, prior to using a TSD Facility, the Contractor shall contact the EPA Regional Off-site Coordinator specified in 40 CFR 300, Section .440, to determine the facility's status, and document all information necessary to satisfy the requirements of the EPA Off-Site policy and furnish this information to the Contracting Officer.

### 3.2.3 Shipping Documents and Packagings Certification

Prior to shipment of any hazardous material off-site, the Contractor's Transportation and Disposal Coordinator (TDC) shall provide written certification to the Contracting Officer that hazardous materials have been properly packaged, labeled, and marked in accordance with Department of Transportation and EPA requirements.

### 3.2.4 Transportation

The Contractor shall use manifests for transporting hazardous wastes as required by 40 CFR 263 or any applicable state or local law or regulation. Special wastes shall be transported in accordance with applicable State regulations. Transportation shall comply with all requirements in the Department of Transportation referenced regulations in the 49 CFR series. The Contractor shall acquire manifests in accordance with the hierarchy established in 40 CFR 262, Section .21. The Contractor shall prepare hazardous waste manifests for each shipment of hazardous waste shipped off-site. Manifests shall be completed using instructions in 40 CFR 262, Subpart B and any applicable state or local law or regulation. Manifests and waste profiles shall be submitted to Contracting Officer for review and approval.

The Contractor shall prepare land disposal restriction notifications as required by 40 CFR 268 or any applicable state or local law or regulation for each shipment of hazardous waste. Notifications shall be submitted with the manifest to the Contracting Officer for review and approval. When the additional cost of sending a qualified USACE representative to a remote location for a small clean up project is unwarranted, the option of requiring the on-site Contractor to sign the manifests on behalf of the generator is permitted and should be considered. This option shall only be exercised on a project specific basis, if prior to the solicitation process, written authorization of the customer and approval of the Chief, Construction Division at the executing district has been obtained, and the technical provisions of the contract solicitation provide competing contractors notice of the requirement.

### 3.2.5 Treatment and Disposal of Hazardous Wastes

The hazardous waste shall be transported to an approved hazardous waste TSD facility within 90 days of the accumulation start date on each container. The Contractor shall ship hazardous wastes only to facilities which are properly permitted to accept the hazardous waste or operating under interim status. The Contractor shall ensure wastes are treated to meet land disposal treatment standards in 40 CFR 268 prior to land disposal. The Contractor shall propose TSD facilities via submission of the Waste Management Plan, as included in the Work Plan, subject to the approval of the Contracting Officer.

## 3.3 HAZARDOUS MATERIALS MANAGEMENT

The Contractor, in consultation with the Contracting Officer, shall evaluate, prior to shipment of any material off-site, whether the material is regulated as a hazardous waste in addition to being regulated as a hazardous material; this shall be done for the purpose of determining proper shipping descriptions, marking requirements, etc., as described below.

### 3.3.1 Identification of Proper Shipping Names

The Contractor shall use 49 CFR 172, Section .101 to identify proper shipping names for each hazardous material (including hazardous wastes) to be shipped off-site. Proper shipping names shall be submitted to the

Contracting Officer in the form of draft shipping documents for review and approval.

### 3.3.2 Packaging, Labeling, and Marking

The Contractor shall package, label, and mark non-hazardous and hazardous materials/wastes using the specified materials and in accordance with the referenced authorizations. The Contractor shall mark each container of hazardous waste of 104 gallons or less with the following:

"HAZARDOUS WASTE - Federal Law Prohibits Improper Disposal.
If found, contact the nearest police or public safety authority or the U.S. Environmental Protection Agency.
Generator's name ____________________________________
Manifest Document Number ___________________________".

### 3.3.3 Shipping Documents

The Contractor shall ensure that each shipment of non-hazardous and hazardous material sent off-site is accompanied by properly completed shipping documents.

### 3.3.3.1 Hazardous Material Shipment Documents

The Contractor shall prepare a bill of lading for each shipment of hazardous material which is not accompanied by a hazardous waste manifest or asbestos waste shipment record which fulfills the shipping paper requirements. The bill of lading shall satisfy the requirements of 49 CFR 172, Subpart C, and any applicable state or local law or regulation, and shall be submitted to the Contracting Officer for review and approval. For laboratory samples, the Contractor shall prepare bills of lading and other documentation as necessary to satisfy conditions of the sample exclusions in 40 CFR 261, Section .4(d) and (e) and any applicable state or local law or regulation. Bill of ladings requiring shipper's certifications will be signed by the Government.

## 3.4 OBTAINING EPA ID NUMBERS

The Contractor shall complete EPA Form 8700-12, Notification of Hazardous Waste Activity, and submit to the Contracting Officer for review and approval. The Contractor shall allow a minimum of 30 days for processing the application and assigning the EPA ID number. Shipment shall be made not earlier than one week after receipt of the EPA ID number.

## 3.5 SPECIAL REQUIREMENTS FOR ASBESTOS WASTES

When work involves asbestos-containing wastes, the Contractor shall manage these wastes in accordance with Section 13280 ASBESTOS ABATEMENT.

## 3.6 WASTE MINIMIZATION

The Contractor shall minimize the generation of hazardous waste to the maximum extent practicable. The Contractor shall take all necessary precautions to avoid mixing clean and contaminated wastes. The Contractor shall identify and evaluate recycling and reclamation options as alternatives to land disposal. Requirements of 40 CFR 266 shall apply to: hazardous wastes recycled in a manner constituting disposal; hazardous waste burned for energy recovery; lead-acid battery recycling; and hazardous wastes with economically recoverable precious metals.

## 3.7 RECORDKEEPING

The Contractor shall be responsible for maintaining adequate records to support information provided to the Contracting Officer regarding exception reports, annual reports, and biennial reports. The Contractor shall be responsible for maintaining asbestos waste shipment records for a minimum of 3 years from the date of shipment or any longer period required by any applicable law or regulation or any other provision of this contract.

## 3.8 SPILL RESPONSE

The Contractor shall respond to any spill of hazardous material or hazardous waste which are in the custody or care of the Contractor, pursuant to this contract. Any direction from the Contracting Officer concerning a spill or release shall not be considered a change under the contract. The Contractor shall comply with all applicable requirements of Federal, state, or local laws or regulations regarding any spill incident.

## 3.9 EMERGENCY CONTACTS

The Contractor shall be responsible for complying with the emergency contact provisions in 49 CFR 172, Section .604. Whenever the Contractor ships hazardous materials, the Contractor shall provide a 24-hour emergency response contact and phone number of a person knowledgeable about the hazardous materials being shipped and who has comprehensive emergency response and incident mitigation information for that material, or has immediate access to a person who possesses such knowledge and information. The phone must be monitored on a 24-hour basis at all times when the hazardous materials are in transportation, including during storage incidental to transportation. The Contractor shall ensure that information regarding this emergency contact and phone number are placed on all hazardous material shipping documents. The Contractor shall designate an emergency coordinator and post the following information at areas in which hazardous wastes are managed:

a. The name of the emergency coordinator.

b. Phone number through which the emergency coordinator can be contacted on a 24-hour basis.

c. The telephone number of the local fire department.

d. The location of fire extinguishers and spill control materials.

## Attachment A
## SAMPLE OFF-SITE POLICY CERTIFICATION MEMO

Project/Contract #:________________________________________________
Waste Stream:__________________________________________________________
Primary TSD Facility, EPA ID # and Location: ______________________________
Alter. TSD Facility, EPA ID # and Location:________________________________

| EPA Region | Primary Contact | Secondary Contact |
|---|---|---|
| I | (617) 565-9446 | (617) 573-1754 |
| II | (212) 637-4139 | (212) 264-2638 |
| III | (814) 566-3450 | (215) 597-8338 |
| IV | (404) 562-8589 | (404) 347-7603 |
| V | (312) 886-3587 | (312) 886-4445 |
| VI | (214) 665-2282 | (214) 655-2281 |
| VII | (913) 551-7883 | (913) 551-7667 |
| VIII | (303) 312-6419 | (303) 293-1506 |
| IX | (415) 744-2091 | (415) 744-2114 |
| X | (206) 553-1061 | (206) 553-1061 |

EPA representative contacted: _____________________________________________
EPA representative phone number: __________________________________________
Date contacted: __________________________________________________________

Comment: ______________________________________________________________
The above EPA representative was contacted on __________. As of that date the above sites were considered acceptable in accordance with the Off-Site Policy in 40 CFR 300.440.

Signature: _________________________________ Date: ________________________
Phone number: ____________________________________________________________

--End of Section--

# SECTION 02271

# EROSION AND SEDIMENT CONTROL

## PART 1 GENERAL

### 1.1 DESCRIPTION

The Contractor shall provide the equipment and labor necessary for the inspection, maintenance, removal, off-site transport, and salvage or disposal of sediment and erosion control structures, as specified herein or as required to protect surface waters. Such erosion and sediment control measures were installed during Phase I work, shall remain in place after completion of Phase I, and through completion of Phase II Causeway cover system construction. Erosion control measures shall be removed only after completion of Causeway erosion control cover system construction. Removal shall be conducted during demobilization activities.

The Contractor also shall be responsible for the removal, transportation, and disposal of disturbed sediment collected from erosion control measures, in a manner consistent with the overall intent of this specification, that does not result in additional erosion or sediment release.

### 1.2 REFERENCES

A. U.S. Environmental Protection Agency Publication 430/9-73-007 Processes, Procedures and Methods to Control Pollution Resulting from All Construction Activity.

B. U.S. Department of Agriculture Soil Conservation Service Publication dated July 1975, Standards and Specifications for Soil Erosion and Sediment Control in Developing Areas.

### 1.3 SUBMITTALS (NOT USED)

### 1.4 REVIEW AND INSPECTION OF EROSION AND SEDIMENT CONTROL MEASURES

All construction under this project shall be subject to review and inspection by the appropriate State and Federal agencies responsible for ensuring the adequacy of erosion and sediment control measures.

### 1.5 QUALITY ASSURANCE

The Contractor shall comply with the quality assurance recommendations of the manufacturer given during installation, maintenance, and removal of the erosion and sediment control measures.

## PART 2 PRODUCTS

### 2.1 MATERIALS

Materials installed during Phase I of work on the Causeway shall be inspected and maintained during Phase II work. In the event inspection identifies deficiencies, installation of additional erosion and sediment control measures may be required. The following types of erosion and sediment control materials may be used during the completion of Phase II work.

2.1.1 Matting for Erosion Control

a. Jute Matting:
   1. Open weave, single jute yarn averaging 130 pounds per spindle of 14,400 yards.
   2. Yarn: Loosely twisted construction, not varying in thickness by more than 1/2 its normal diameter.
   3. Woven Material: 48 inches wide, plus or minus 1 inch, with approximately 78 warp ends per width of cloth and 41 weft ends per linear yard, weighing 1.22 pounds per linear yard with a tolerance of plus or minus 5 percent.

b. Excelsior Mat:
   1. Wood excelsior, at least 35 inches in width, weighing 0.8 pounds per square yard plus or minus 5 percent.
   2. Covered with a netting on one side to facilitate handling and to increase strength.

c. Other Types of Matting: Those accepted by the Contracting Officer as equal in effectiveness to one of those specified above.

2.1.2 Staples

a. No. 11 (or heavier) plain iron wire, made from lengths of at least 12 inches.

2.1.3 Hay Bales

a. Consist of rectangular-shaped bales of hay or straw weighing at least 40 pounds per bale.

b. Free from primary noxious weed seeds and rough or woody materials.

c. Hay bale stakes shall be 1-inch square and constructed of oak.

2.1.5 Siltation Fence

a. Envirofence as manufactured by Mirafi Inc. or approved equal with an equivalent opening size of 30, or approved equal.

2.1.6 Floating Silt Curtain and Anchors (N.I.T.C.)

The floating silt curtain and associated anchors shall be as specified in Phase I Section 02271 - EROSION AND SEDIMENT CONTROL.

## PART 3 EXECUTION

### 3.1 PERFORMANCE

3.1.1 General

a. The CONTRACTOR shall maintain erosion and sedimentation control measures, installed during Phase I work, that effectively prevent accelerated erosion and sedimentation.

b. Earthmoving activities shall be conducted in such a manner as to prevent accelerated erosion and sedimentation.

c. Land disturbance shall be kept to a minimum.

d. The erosion and sediment control measures shall be installed and conducted in accordance with the procedures contained in the approved Erosion Control Plan, developed during Phase I.

e. Temporary erosion and sediment control measures shall be continuously maintained, and shall not be removed until permanent cover is completely established and stabilized, with the Contracting Officer approval.

f. Maintain silt fence and hay bales, as necessary for temporary erosion and pollution control at locations in accordance with the approved Erosion Control Plan, developed during Phase I.

g. Erosion control devices shall delineate the work exclusion zones for the site tidal mud flats.

h. Temporary control shall be maintained during the interim period from one month following Phase I work until the start of Phase II work activities, as necessary. Disturbed areas shall be covered with stapled or staked jute matting above elevation 6 in areas where work is not to be performed for two weeks or longer.

### 3.1.2 Diverting Surface Water

a. Maintain and operate all necessary channels, flumes, sumps, and other temporary diversion and protection works needed to divert surface water through or around the construction site and away from the construction work while construction is in progress.

b. Storm runoff from disturbed areas must be discharged through temporary erosion control measures, in accordance with the approved Erosion and Sediment Control Plan, developed during Phase I, prior to discharge into a natural water body.

### 3.1.3 Erosion Control Provisions

a. Construct all haul roads of a durable coarse granular surface material sufficiently protected from erosion through water and wind action by channeling water flow around the structure, protecting side slopes in accordance with the approved Erosion Control Plan.

b. Protect tidal areas, below elevation 6 by constructing silt fence at the top of slope to intercept storm runoff from the area.

c. The toe of slope shall be protected with floating silt curtains to be temporarily placed within the mud flats and channel.

d. Contain discharge from pumping operations during de-watering operations and washing of oversized materials by a dike constructed to prevent silt from entering the River, as necessary. Protect the area of the outlet pipe against erosion by flowing water by the construction of a rock or timber apron.

e. Prior to removal of all sediment control dikes, remove all retained silt or other materials at no additional cost to the Government.

f. Temporarily remove silt fence to allow access to work areas, replace in a timely fashion, as approved by the Contracting Officer.

### 3.1.4 Jute Matting

a. Preparation:
   1. Surfaces of Ditches and Slopes:
      (a) Conform to grades and cross sections shown in the approved Work Plan.
      (b) Finish to a smooth and even condition with all debris, roots, stones, and lumps raked out and removed.
      (c) Loosen soil surface to permit bedding of the matting.
      (d) Unless otherwise directed, apply seed prior to placement.

b. Jute:
   1. Place strips lengthwise in the direction of the flow of water.
   2. Where strips are laid parallel or meet as in a tee, overlap at least 4 inches.
   3. Ends: Overlap at least 6 inches, shingle fashion.
   4. The up-slope end of each strip of the matting shall be turned down and buried to a depth of not less than 6 inches with the soil firmly tamped against it.
   5. The Contracting Officer may require that any other edge exposed to more than normal flow of water be buried in a similar manner.
   6. Check Slots:
      (a) Build at right angles to the direction of the flow of water.
      (b) Space so that one check slot or one end occurs within each 50 foot length of slope.
      (c) Construct by placing a tight fold of the matting at least 6 inches vertically into the ground, and tamp the same as up-slope ends.
   7. Edges of Matting: Bury around the edges of catch basins and other structures.

c. Laying and Joining:
   1. Except where jute matting is turned down, spread evenly and smoothly in close contact with the ground.
   2. Cutout bulging seams and make joints as described above.
   3. When ordered, additional seed shall be spread over jute matting, particularly at those locations disturbed by building the slots. Jute matting shall then be pressed onto the ground with a light lawn roller or by other satisfactory means.
   4. Drive staples vertically into the ground flush with the surface.
   5. On slopes flatter than 4:1, space staples not more than 3 feet apart in three rows for each strip, with one row along each edge

and one row, alternately spaced, down the center, or as recommended by manufacturer.

6. On grades 4:1 or steeper, place staples in the same three rows, but spaced 2 feet apart, or as recommended by manufacturer.
7. On all overlapping or butting edges, double the number of staples, with the spacing halved; all ends of the matting and all required check slots shall likewise have staples spaced every foot.
8. Matting Placed Adjacent to Boulders or Other Obstructions: Staple with no space between the staples, to eliminate any loose edges of matting.
9. The above specified spacing of staples may be changed as ordered, depending upon varying factors such as the season of the year or the amount of water encountered or anticipated.
10. In driving the staples, take care so as not to form depressions or bulges in the surface of the matting.
11. Other Matting: Approved, alternate matting shall be applied in accordance with the recommendations of the manufacturer and as directed.

d. Siltation Fence:
   1. Install per manufacturer's requirements and in locations shown on the Drawings and as directed by the Contracting Officer.

### 3.1.6 Hay Bales

a. Hay bales shall be placed as ordered by the Contracting Officer, to provide for temporary control of erosion, or pollution, or both.

b. Bales shall be staked with the required stakes to a minimum depth of 6 inches into the underlying soil. Four stakes shall be provided per bale.

c. Upon acceptance of the Contract, the bales shall be left in place unless released to the Contractor.

## 3.2 MAINTENANCE

Erosion and sediment control maintenance activities shall be conducted in accordance with the procedures contained in the approved Erosion Control Plan, developed during Phase I. Erosion and sediment control measures shall be inspected by the Contractor at least once a week under normal weather conditions, and at least daily during prolonged rainfall events. Repair and/or maintenance of sediment and erosion control measures shall be made as soon as deficiencies are observed, throughout the construction period. Modifications to the erosion and sediment control measures may be required, as requested by the Contracting Officer, if deficiencies are observed.

Sediments removed from sediment control devices prior to final cover installation shall be placed within the limits of the cover area, above elevation 6. Sediments shall be placed so as not to interfere with surface water drainage or pose a potential erosion problem in the future.

The Contractor shall maintain the floating silt curtain to account for settlement/movement of anchors throughout the construction period (N.I.T.C.).

## 3.3 REMOVAL

Removal of erosion and sediment control measures shall be conducted following completion of Causeway cover system installation, in accordance with the procedures contained in the approved Erosion Control Plan, and shall comply with the requirements of Section 01410 ENVIRONMENT PROTECTION.

Erosion and sediment control measures shall be cleaned of gross Causeway materials (e.g., soil and sediment), prior to transportation off-site for salvage or disposal.

-- End of Section--

## SECTION 02300

## EARTHWORK
**12/97**

## PART 1 GENERAL

### 1.1 DESCRIPTION

This specification covers the procedures to be followed during Causeway grading, subgrade preparation, modifications to existing rip rap, and cover system construction. It specifies the quality of natural materials anticipated to be brought on-site during Phase II work and the procedures for placement of these materials. The development, maintenance, and closure of borrow sources is also covered in this section. Requirements for placement of the vegetative support layer, including erosion control matting, are specified in Section 02921 SEEDING.

### 1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

BACKGROUND REFERENCES

Harding ESE, Inc., December 2000. Geotechnical Investigation Summary Report for the Causeway Non-time Critical Removal Action Design.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

| | |
|---|---|
| ASTM C 136 | (1996a) Sieve Analysis of Fine and Coarse Aggregates |
| ASTM D 422 | (1963; R 1998) Particle-Size Analysis of Soils |
| ASTM D 698 | (1998) Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft) |
| ASTM D 1140 | (1997) Amount of Material in Soils Finer than the No. 200 (75-micrometer) Sieve |
| ASTM D 1556 | (1990; R 1996) Density and Unit Weight of Soil in Place by the Sand-Cone Method |
| ASTM D 2487 | (1998) Classification of Soils for Engineering Purposes (Unified Soil Classification System) |
| ASTM D 2922 | (1996) Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth) |

| | |
|---|---|
| ASTM D 3017 | (1988; R 1996el) Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth) |
| ASTM D 4318 | (1998) Liquid Limit, Plastic Limit, and Plasticity Index of Soils |

CONNECTICUT DEPARTMENT OF TRANSPORTATION (CTDOT)

State of Connecticut Department of Transportation, 1995. Standard Specification for Roads, Bridges, and Incidental Construction, Form 814A.

## 1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals not having a "GA" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Earthwork; FIO

The Contractor shall provide the proposed source(s) for borrow material prior to initiation of work and shall provide advanced notice to the Contracting Officer of the opening of excavation or borrow areas.

SD-07 Certificates

Contractor's Quality Control Testing Laboratory; GA

Qualifications of the commercial testing laboratory or Contractor's testing facilities shall be submitted to the Contracting Officer as soon as possible, but no later than 7 days after notice to proceed.

As part of the Weekly Progress Reports, specified in Section 02111 EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL, provide one copy of test results, including calibration curves and results of calibration tests shall be submitted to the Contracting Officer.

## 1.4 DEFINITIONS

### 1.4.1 Satisfactory Materials

Satisfactory materials are defined as materials for any given layer, meeting the requirements for that layer, as defined in Part 2 of this Section. In addition, a material must be free of gross visual or olfactory contamination, material greater than 2 feet in any dimension (if on-site material), or material greater than 6 inches in any dimension (if off-site borrow material), to be considered satisfactory.

### 1.4.2 Unsatisfactory, Uncontaminated Materials

Materials which are uncontaminated, but do not comply with the requirements for satisfactory materials are considered unsatisfactory, uncontaminated materials. These materials include man-made fills; trash; refuse; backfills from previous construction; frozen material, unless otherwise specified by the Contracting Officer; and material containing debris greater than the allowable size, provided it is uncontaminated. Uncontaminated material that does not meet the requirements in Part 2 of this section, shall also be considered unsatisfactory, uncontaminated material.

### 1.4.3 Unsatisfactory, Contaminated Materials

Materials containing gross visual or olfactory contamination, whether from on-site excavation or off-site borrow sources, shall be considered unsatisfactory, contaminated material. This material shall be further divided into hazardous and non-hazardous material, as per the definitions in Section 02120 TRANSPORTATION AND OFF-SITE DISPOSAL. Material containing contaminated debris greater than the allowable size, shall also be considered unsatisfactory, contaminated material. The Contracting Officer shall be notified of any materials containing gross visual or olfactory contamination, whether excavated from the work site or obtained from off-site sources.

### 1.4.3 Cohesionless and Cohesive Materials

Cohesionless materials include materials classified in ASTM D 2487 as GW, GP, SW, and SP. Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM will be identified as cohesionless only when the fines are non-plastic. Testing required for classifying materials shall be in accordance with ASTM D 4318, ASTM C 136, ASTM D 422, and ASTM D 1140.

### 1.4.4 Degree of Compaction

Degree of compaction required is expressed as a percentage of the maximum dry density, at the optimum moisture content, as obtained by the test procedure presented in ASTM D 698 abbreviated as a percent of laboratory maximum density.

### 1.4.5 Vegetative Support Layer

The vegetative support layer is defined as the material used above the upper cover system to support growth of the proposed grass. Material suitable for vegetative support shall be obtained from off-site borrow areas.

### 1.4.6 Modification of Existing Rip Rap

The existing rip rap, which is present on the berm adjacent to the facility. This rip rap will need to be expanded both vertically and horizontally, no thinning of the existing rip rap shall be allowed.

## 1.5 SUBSURFACE DATA

Subsurface soil boring logs are included in the Causeway Geotechnical Investigation Summary Report (Harding ESE, December 2000). The investigation report may be examined at Room 15, Building 1 at the Stratford Army Engine Plant, 550 Main Street, Stratford, Connecticut. These data represent the best subsurface information available; however, variations may exist in the subsurface between boring locations.

## 1.6 CLASSIFICATION OF EXCAVATION

Excavation shall include the excavation of an approximate 1.0-foot of material from all areas below the 4.1-foot mean sea level (msl) elevation (NGVD 1929) to the marked contact of Causeway fill and tidal sediment. In addition, identified material greater than 2 feet in any dimension shall be removed from the Causeway.

The excavation specified shall be done on a classified basis. Failure on the part of the Contractor to notify the Contracting Officer, and allow ample time for classification and measurement of materials will cause the forfeiture of the Contractor's right of claim to any volume of material to be paid for other than that allowed by the Contracting Officer for the areas of work in which such material has been previously identified. Excavation classification shall be in accordance with the following designations and classifications.

### 1.6.1 Satisfactory Fill Material Excavation

Material excavated from below the 4.1-foot msl contour that meets the requirements of this section and Section 01451 CONTRACTOR QUALITY CONTROL, and is subsequently used as Common Fill material during Causeway grading, shall be considered satisfactory.

### 1.6.2 Excess Satisfactory Material Excavation

Material excavated from below the 4.1-foot msl contour that is considered satisfactory, but is not needed for use as Common Fill material during Causeway grading shall be considered excess satisfactory fill material.

### 1.6.3 Unsatisfactory, Uncontaminated Material Excavation

Material excavated from below the 4.1-foot msl contour, as defined in Paragraph 1.4.2, shall be classified as unsatisfactory, uncontaminated material excavation.

### 1.6.4 Hazardous Material Excavation

Material containing gross visual or olfactory contamination, or oversized debris, determined, by sample analysis, to be hazardous shall be classified as hazardous material excavation.

### 1.6.5 Non-hazardous Material Excavation

Material containing gross visual or olfactory contamination, or oversized debris, determined, by sample analysis, to be non-hazardous shall be classified as non-hazardous material excavation.

## 1.7 UTILIZATION OF EXCAVATED MATERIALS

Unsatisfactory materials removed from excavations shall be transported to on-site stockpile areas, sampled and analyzed for characterization purposes, and disposed of at an approved off-site disposal facility. Satisfactory material removed from excavations shall be placed above elevation 4.1 msl, and used, insofar as practicable, in the grading of the upper portion of the Causeway, and for similar purposes, as necessary.

No satisfactory excavated material shall be wasted or removed from the Causeway without specific written authorization. Satisfactory material authorized to be wasted shall be transported to on-site stockpile areas, sampled and analyzed for characterization purposes, and disposed of at an approved off-site disposal facility (Section 02120 TRANSPORTATION AND OFF-SITE DISPOSAL). No excavated material shall be placed so as to be detrimental to the completed work in any way.

# PART 2 PRODUCTS

## 2.1 COMMON FILL

Common Fill material shall be used, as necessary, to achieve the subgrade elevations indicated on the drawings. Common fill material shall be obtained from below elevation 4.1 feet msl on the Causeway, when practical. Common fill material from off-site borrow sources shall not be used on the Causeway without specific written authorization from the Contracting Officer.

Common Fill, obtained from an off-site borrow source by the Contractor, shall be soil containing no stone greater than 6 inches in size. Fill materials obtained from Causeway sideslope excavation shall contain no material greater than 2 feet in any dimension.

All Common Fill material shall be free of trash, ice, snow, tree stumps, and other deleterious materials. It shall be of such a nature and character that it can be compacted to the specified density of 92% (maximum dry density as determined by ASTM D 698) or greater, in a reasonable length of time. Testing shall be performed in accordance with the requirements of this Section and Section 01451 CONTRACTOR QUALITY CONTROL.

## 2.2 ROCK FILL

Rock Fill shall be used as fill material in the polymeric marine mattresses, in the Rock Fill Toe to prevent scour at the toe of the Causeway, and in the Rock Fill Transition as a drainage layer for the upper cover system. These areas shall be constructed as indicated on the drawings.

The Rock Fill shall be consistent with material specified in Section 02380 POLYMERIC MARINE MATTRESSES.

## 2.3 GRAVEL

Gravel shall be used for two distinct purposes during Causeway cover system construction; 1) as required for polymeric marine mattress bedding following excavation, and 2) as interlocking concrete block interstitial fill material.

### 2.3.1 Polymeric Marine Mattress Bedding

Gravel may be required to provide a uniform and stable base for the placement of the polymeric marine mattresses, as necessary. If voids are created during excavation of oversized materials or large areas of high water content material are uncovered during excavation, a graded aggregate shall be used to grade the sideslopes, in preparation for placement of the mattresses.

Material used as gravel for polymeric marine mattress bedding, shall conform to the requirements CTDOT for broken or crushed stone and have a gradation consistent with a No. 8 Aggregate (Section M.01.01 - ), as follows. Gravel shall consist of sound, tough, durable stone, reasonably free from soft, thin, elongated, laminated, friable, micaceous or disintegrated pieces, mud, dirt, or other deleterious materials and shall be sized to meet the following gradation requirements:

| Square U.S. Std. Sieve Size, (mm) | Percent Passing by Dry Weight |
|---|---|
| 1/2 - inch (12.5) | 100 |
| 3/8 - inch (9.5) | 85 - 100 |
| No. 4 (4.75) | 10 - 30 |
| No. 8 (2.36) | 0 - 10 |
| No. 16 (0.046) | 0 - 5 |

### 2.3.2 Interlocking Concrete Block Interstitial Fill

Gravel shall be required to lock the interlocking concrete blocks together, thereby providing a structure that prevents access to the underlying Causeway fill materials.

Material used as gravel for interstitial fill, shall conform to the requirements CTDOT for broken or crushed stone and have a gradation consistent with a Class 114 Bituminous Concrete Mixture (Section M.04.03 - Bituminous Concrete Mixtures AC-20), as follows. Gravel shall consist of sound, tough, durable stone, reasonably free from soft, thin, elongated, laminated, friable, micaceous or disintegrated pieces, mud, dirt, or other deleterious materials and shall be sized to meet the following gradation requirements:

| Square U.S. Std. Sieve Size, (mm) | Percent Passing by Dry Weight |
|---|---|
| 1 - inch (25.4) | 100 |
| 3/4 - inch (19) | 95 - 100 |
| 1/2 - inch (12.5) | 90 - 100 |
| 3/8 - inch (9.5) | 55 - 70 |

| | |
|---|---|
| No. 4 (4.75) | 26 - 40 |
| No. 8 (2.36) | 22 - 32 |
| No. 30 (0.60) | 13 - 22 |
| No. 50 (0.30) | 8 - 18 |
| No. 200 (0.075) | 2 - 5 |

## 2.4 SAND BEDDING

A Sand Bedding layer shall be used to fine grade the subgrade and provide a smooth, dense layer capable of supporting the articulating blocks in the upper cover system. The borrow source for Sand Bedding shall be approved by the Contracting Officer prior to opening of the borrow source.

The Sand Bedding material shall consist of a well-graded sand generally meeting the CTDOT requirements for a fine aggregate (Section M.03.01 2-FINE AGGREGATE). The sand fill shall be sand consisting of clean, hard, durable, uncoated particles of quartz or other rock, free from lumps of clay, soft or flaky material, loam, organic or other deleterious materials, and shall meet the following gradation requirements:

| Square U.S. Std. Sieve Size, (mm) | Percent Passing by Dry Weight |
|---|---|
| 2 - inch (50) | 100 |
| No. 4 (4.75) | 95-100 |
| No. 8 (2.36) | 80 - 100 |
| No. 16 (1.18) | 50 - 85 |
| No. 30 (0.60) | 25 - 60 |
| No. 50 (0.30) | 10 - 30 |
| No. 100 (0.15) | 2 - 10 |
| No. 200 (0.075) | 0 - 5 |

It shall be of such a nature and character that it can be compacted to the minimum specified density of 92% or greater, in a reasonable length of time using static equipment. Borrow source and in-place testing shall be performed in accordance with the requirements of this section and Section 01451 CONTRACTOR QUALITY CONTROL.

## 2.5 VEGETATIVE SUPPORT SOIL

Vegetative support soil is defined as the material used above the upper cover system to support growth of the proposed vegetative material. Material suitable for vegetative support soil shall be obtained from off-site borrow areas. Vegetative support soil shall be as defined in ASTM D 5268 and shall have a texture of loamy sand, as defined by the USDA textural classification, with an organic matter content of at least 4%. The soil may be amended, as necessary, using recycled compost. Topsoil shall be free from slag, cinders, stones, lumps of soil, sticks, roots, trash or other material over a minimum 1-1/2 inch diameter. Topsoil shall be free from viable plants and plant parts. Unacceptable materials shall be removed from the job site.

## 2.6 RIP RAP

Rip Rap shall be used to modify existing rip rap, and in the transition between the upper and lower cover systems, as shown on the drawings. Rip Rap shall consist of broken or crushed stone of sound, tough, durable stone, reasonably free from soft, thin, elongated, laminated, friable, micaceous or disintegrated pieces, mud dirt, or other deleterious materials. Rip Rap shall have a maximum stone size of 10 inches and have an average stone size ($D_{50}$) of 6 inches, with less than 10 percent finer than 1 inch. Material shall be a clean, washed, angular stone with no recycled materials.

## PART 3 EXECUTION

### 3.1 GENERAL EXCAVATION

The Contractor shall perform sideslope excavation of the types of material encountered within the limits of the project to the lines, grades, and elevations indicated on the drawings and as specified. Grading shall be in conformity with the drawings and the tolerances specified in paragraph FINISHING.

During construction, excavation and fill shall be performed in a manner and sequence that will provide proper drainage at all times. Common fill material required for use during grading, in excess of that produced by excavation within the grading limits, shall be excavated from the borrow areas indicated or from other approved areas selected by the Contractor, as specified.

### 3.1.1 Satisfactory Fill Material Excavation

Excavated satisfactory fill material shall be placed above elevation 4.1 feet msl and graded to the elevations indicated on the drawings, as specified in this Section. If at any time during sideslope excavation, the Contractor encounters unsatisfactory material, soil containing gross visual or olfactory contamination, or oversized material, such materials shall be uncovered and the Contracting Officer notified by the Contractor. The Contractor shall not proceed with the excavation of these materials until the Contracting Officer has classified the materials and has taken measurements, as required.

### 3.1.2 Excess Satisfactory Material Excavation

Satisfactory material that is not required for use as Common Fill on the Causeway shall be considered excess satisfactory material excavation. This material shall be transported to on-site stockpile areas for temporary storage, characterization sampling and analysis, and eventual off-site transportation and disposal. Characterization sampling of this material shall be conducted as per the requirements of the accepting disposal facility.

### 3.1.3 Unsatisfactory Material Excavation

Unsatisfactory material shall be transported to on-site stockpile area for temporary storage and characterization sampling and analysis. Characterization sampling results shall be used to determine if the unsatisfactory material is uncontaminated, hazardous, or non-hazardous material. Unsatisfactory material shall be transported off-site for disposal following the receipt of characterization sampling results.

## 3.2 SELECTION OF BORROW MATERIAL

Borrow material shall be selected to meet the requirements and conditions of the particular fill layer for which it is to be used. Borrow material shall be obtained from sources selected by the Contractor, and approved by the Contracting Officer. Unless otherwise provided in the contract, the Contractor shall obtain from the owners the right to procure material, pay royalties and other charges involved, and bear the expense of developing the sources, including rights-of-way for hauling. Borrow material from approved sources on Government-controlled land may be obtained without payment of royalties. Unless specifically provided, no borrow shall be obtained within the limits of the project site without prior written approval. Necessary clearing, grubbing, and satisfactory drainage of borrow pits and the disposal of debris thereon, shall be considered related operations to the borrow excavation.

## 3.3 OPENING AND DRAINAGE OF EXCAVATION AND BORROW PITS

The Contractor shall notify the Contracting Officer sufficiently in advance of the opening of any excavation or borrow pit to permit elevations and measurements of the undisturbed ground surface to be taken. Except as otherwise permitted, borrow pits and other excavation areas shall be excavated providing adequate drainage. Overburden and other spoil material shall be transported to designated spoil areas or otherwise disposed of as directed. Borrow pits shall be neatly trimmed and drained after the excavation is completed. The Contractor shall ensure that excavation of any area, operation of borrow pits, or dumping of spoil material results in minimum detrimental effects on natural environmental conditions.

## 3.4 SUBGRADE PREPARATION

Causeway ground surface on which excavated fill or borrow materials are to be placed, shall be stripped of live, dead, or decayed vegetation, rubbish, debris, and other unsatisfactory material (N.I.T.C.). These areas shall be plowed, disked, or otherwise broken up to a depth of 6 inches; moistened or aerated as necessary; thoroughly mixed; and compacted to at least 92% laboratory maximum density. Compaction shall be accomplished by pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment that imparts minimal vibrations to the subsurface. The prepared ground surface shall be scarified and moistened or aerated as required just prior to placement of fill/borrow materials to assure adequate bond between fill/borrow material and the prepared ground surface.

## 3.5 CAUSEWAY GRADING

### 3.5.1 Excavated Fill Placement

Material excavated from the Causeway sideslopes shall be placed above elevation 4.1 feet msl on the Causeway for grading purposes, unless otherwise directed by the Contracting Officer.

### 3.5.2 Causeway Grading

Causeway subgrades, in areas above 4.1 feet msl, shall be shaped to line, grade, and cross section, and compacted as specified, following common fill placement. This operation shall include plowing, disking, and any moistening or aerating required to obtain adequate compaction. Soft or otherwise unsatisfactory material shall be removed and replaced with satisfactory excavated material or other approved material as directed. Oversized materials encountered in the cut sections shall be excavated to a minimum depth of 6 inches below finished grade for the subgrade. Low areas resulting from removal of unsatisfactory material or excavation of oversized debris shall be brought up to required grade with gravel or satisfactory materials, and the entire subgrade shall be shaped to line, grade, and cross section and compacted as specified. The elevation of the finish subgrade shall not vary more than 0.1 feet beneath the lower cover system and 0.15 feet (2 inches) beneath the upper cover system from the established subgrade elevations shown on the Drawings.

The Contractor shall maintain daily logs of soil characteristics, daily progress, and other observations. The grade of the Causeway shall be checked a minimum of twice per day. The Contractor shall submit daily progress reports to the Contracting Officer for acceptance. Layer thicknesses shall be within +/- 2 inches of the thickness shown, with a running average of +/- 2 inches for all layers.

## 3.6 MATERIALS PLACEMENT

### ~~3.5.1~~3.6.1 Rock Fill

Rock fill shall be placed in the polymeric marine mattresses as specified in Section 02380 POLYMERIC MARINE MATTRESSES. The Rock Fill Toe and Rock Fill Transition shall be constructed using standard construction methods, in the areas shown on the drawings. Compaction of this material and in-place testing shall not be required.

### ~~3.5.2~~3.6.2 Polymeric Marine Mattress Bedding Gravel

Placement of gravel used for mattress bedding shall be conducted using standard construction methods. Compaction of this material and in-place testing shall not be required.

### ~~3.5.3~~3.6.3 Interlocking Concrete Block Interstitial Gravel

Placement of gravel used for filling of interlocking concrete block interstitial spaces shall be conducted using standard construction methods. Compaction of this material shall be accomplished by completing three passes over the gravel with a static roller. Quality control testing shall not be required.

### 3.6.4 Sand Bedding

The Sand Bedding shall be placed in a single layer to the thickness indicated on the Drawings. Thickness of the layer may vary as a result of the grade of the common fill subgrade.

The Sand Bedding material shall be finished to a uniform thickness, and compacted as specified. The elevation of the subgrade layer shall not vary more than 2 inches from the established grade and cross section prior to placement of the Sand Bedding. The Sand Bedding surface shall be prepared by proof-rolling with a static roller and shall be raked to provide a smooth and firm base suitable for placement of the interlocking concrete blocks.

Periodic quality control testing of the material shall be required to assure consistency of materials to be used and placement methods. In addition, analytical testing of the material for volatile organic compounds and semi-volatile organic compounds shall be conducted at the rate specified by the Contracting Officer. The material shall be placed at a minimum of 92% of Standard Proctor (ASTM D 698). In-situ density testing shall be completed with nuclear testing equipment, using backscatter methods. Limited interference due to underlying fills may be expected and allowed, as approved by the Contracting Officer.

### 3.6.5 Vegetative Support Soil

On areas to receive vegetative support soil, soil shall be placed in a single layer to the thickness indicated on the Drawings. The support soil shall be spread evenly and graded to the slopes indicated on the drawings. Vegetative support soil shall not be spread when frozen or excessively wet or dry. Material required for the vegetative support soil layer shall be obtained from off-site borrow sources.

The vegetative support soil shall be graded to a uniform thickness and compacted by proof-rolling with a static roller until a smooth, uniform surface is achieved. The surface shall be prepared for seeding by raking prior to seed placement. Period quality control testing of the material shall be required to assure consistency of materials being placed. In addition, analytical testing of the material for volatile organic compounds and semi-volatile organic compounds shall be conducted at the rate specified by the Contracting Officer.

### 3.6.6 Rip Rap

Rip Rap used for transition from the upper to the lower cover systems shall be placed directly on the outer shell material from the polymeric marine mattress, to act as an anchor. Rip Rap to be used to modify existing rip rap, shall be placed either directly on existing rip rap to achieve final grade or in a minimum two-foot-thick layer on geogrid composite material on prepared subgrade.

Rip Rap shall be placed to its full course thickness in one operation in such a manner as to produce a reasonably well-graded mass of rock without causing displacement of the underlying material. The finished surface shall be free from pockets of small stones and clusters of large stones. Placing of this material by methods likely to cause segregation of the various sizes of stone will not be permitted. Rearranging of individual stones by mechanical or hand methods will be required to the extent necessary to obtain a reasonably well-graded distribution of the specified stone sizes.

The complete course shall be of the specified thickness and/or to the grades shown of the Drawings, and as approved by the Contracting Officer.

## 3.7 MATERIAL COMPACTION

Compaction of common fill material, Sand Bedding, interlocking concrete block interstitial gravel, and Vegetative Support Soil shall be accomplished by pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment that minimizes the vibrations imparted to the subsurface. Subgrade layers shall be compacted by proof-rolling with an appropriate compaction equipment, depending on the slope and nature of the soils. Due to the variations in existing subgrade fill materials, compaction shall be performed to provide a firm base to the placement of successive layers.

Proof-rolling shall be performed by repeatedly applying compactive effort until the materials achieve an acceptable density; however, excessive compaction of wet/saturated soils could result in pumping and loosening of soils. A qualified technician or engineer shall continuously inspect the proof-rolling for the Contractor, as approved by the Contracting Officer. Geogrid Composite, Gravel or other geosynthetic materials may be used to provide a stable subgrade over soft or spongy areas, as approved by the Contracting Officer.

## 3.8 FROZEN MATERIAL

Fill material shall not be placed on a subgrade that contains frozen material. This prohibition encompasses all prepared subgrades and all layers of previously placed and compacted earth fill which become the foundations for successive layers of earth fill. All material that freezes or has been subjected to freeze-thaw action during the construction work, or during periods of temporary shutdowns, such as, but not limited to, nights, holidays, weekends, winter shutdowns, or earthwork operations, shall be removed to a depth that is acceptable to the Contracting Officer and replaced with new material, as directed by the Contracting Officer. Alternatively, the material will be thawed, dried, reworked, and re-compacted to the specified criteria before additional material is placed. The Contracting Officer will determine when placement of fill shall cease due to cold weather. The Contracting Officer may elect to use average daily air temperatures, and/or physical observation of the soils for his determination. Fill material shall not contain frozen clumps of soil, snow, or ice.

## 3.9 FINISHING

The surface of excavations and each subgrade layer shall be finished to a smooth and compact surface in accordance with this section, and the lines, grades, and cross sections or elevations shown on the drawings, such that cover system placement can be conducted. The degree of finish for the subgrade shall be within 0.1 foot of the grades and elevations indicated. The surface of areas to be vegetated shall be finished to a smoothness suitable for the application of vegetative materials.

## 3.10 TESTING

Testing shall be performed by an approved commercial testing laboratory or by the Contractor, subject to approval, as required in this specification and in Section 01451 CONTRACTOR QUALITY CONTROL. If the Contractor elects to establish testing facilities, no work requiring testing will be permitted until the Contractor's facilities have been inspected and approved by the Contracting Officer. Field in-place density shall be determined in accordance with ASTM D 2922, with the calibration curves checked and adjusted using only the sand cone method as described in ASTM D 1556. ASTM D 2922 results in a wet unit weight of soil. When using this method, ASTM D 3017 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall also be checked along with density calibration checks as described in ASTM D 3017; the calibration checks of both the density and moisture gauges shall be made at the beginning of a job on each different type of material encountered and at intervals as directed by the Contracting Officer.

When test results indicate, as determined by the Contracting Officer, that compaction is not as specified, the material shall be removed, replaced and re-compacted to meet specification requirements. Tests on re-compacted areas shall be performed to determine conformance with specification requirements. Inspections and test results shall be certified by a registered professional civil engineer. These certifications shall state that the tests and observations were performed by or under the direct supervision of the engineer and that the results are representative of the materials or conditions being certified by the tests. The frequency of testing for each material shall be as specified in Section 01451 CONTRACTOR QUALITY CONTROL.

Analytical testing of Bedding Sand and Vegetative Support Soil for volatile organic compounds and semi-volatile organic compounds shall be conducted by an approved, off-site laboratory. The frequency of testing for each material shall be as specified by the Contracting Officer.

## 3.11 SUBGRADE PROTECTION

During construction, excavations shall be kept shaped and drained. Ditches and drains along subgrade shall be maintained to drain effectively at all times, considering placement of erosion control measures. The finished subgrade shall not be disturbed by traffic or other operation and shall be protected and maintained by the Contractor in a satisfactory condition until the cover system is placed. The storage or stockpiling of materials on the finished subgrade will be limited to less than 4 to 6 feet tall and shall be spread around the site, as approved by the Contracting Officer. No cover system material shall be placed until the subgrade has been checked and approved, and in no case shall cover system materials be placed on a muddy, spongy, or frozen subgrade.

--End of Section--

# SECTION 02378

# GEOTEXTILES

## PART 1 GENERAL

### 1.1 DESCRIPTION

This section covers installation of woven and non-woven geotextiles as part of Phase II work on the Causeway. Geotextiles shall be used under specific components of the Causeway cover system, as detailed on the drawings. A woven geotextile shall be placed beneath the polymeric marine mattresses and the rock fill toe and transition. A non-woven geotextile shall be placed beneath the interlocking concrete blocks.

### 1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

| | |
|---|---|
| ASTM D 123 | (1996a) Standard Terminology Relating to Textiles |
| ASTM D 4354 | (1996) Sampling of Geosynthetics for Testing |
| ASTM D 4355 | (1992) Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus) |
| ASTM D 4491 | (1999) Water Permeability of Geotextiles By Permittivity |
| ASTM D 4533 | (1991; R 1996) Trapezoid Tearing Strength of Geotextiles |
| ASTM D 4632 | (1991; R 1996) Grab Breaking Load and Elongation of Geotextiles |
| ASTM D 4751 | (1999) Determining Apparent Opening Size of a Geotextile |
| ASTM D 4833 | (1988; R 1996) Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products |
| ASTM D 4873 | (1997) Identification, Storage, and Handling of Geosynthetic Rolls |
| ASTM D 4884 | (1996) Strength of Sewn or Thermally Bonded Seams of Geotextiles |

ENGINEERING MANUALS (EM)

| | |
|---|---|
| EM 1110-2-1601 | (1991; Change 1-1994) Hydraulic Design of Flood Control Channels |

## 1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals not having a "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-04 Samples

Geosynthetic Samples; GA

If requested, submit geotextile samples for testing to determine compliance with the requirements in this specification. When required, submit samples a minimum of 60 days prior to the beginning of installation of the same textile. Upon delivery of geotextile, submit duplicate copies of the written cerificate of compliance signed by a legally authorized official of the manufacturer. The certificates shall state that the materials shipped to the site meets the chemical requirements and exceeds the minimum average roll value listed in TABLE 1, MINIMUM PHYSICAL REQUIREMENTS FOR GEOTEXTILE. Upon request, supply quality control and quality assurance tests for the geotextile. All samples provided shall be from the same production lot as will be supplied for the contract, and shall be the full manufactured width of the geotextile by at least 10 feet long, except that samples for seam strength may be a full width sample folded over and the edges stitched for a length of at least 5 feet. Samples submitted for testing shall be identified by manufacturers lot designation and material type. For needle punched geotextile, the manufacturer shall certify that the geotextile has been inspected using permanent on-line metal detectors and does not contain any needles.

SD-07 Certificates

Geosynthetic Certificates; GA

Submit the manufacturer's certification for the geotextile material

## 1.4 SHIPMENT, HANDLING, AND STORAGE

### 1.4.1 Shipment and Storage

Only approved geotextile rolls shall be delivered to the project site. All geotextile shall be labeled, shipped, stored, and handled in accordance with ASTM D 4873. No hooks, tongs, or other sharp instruments shall be used for handling geotextile.

## PART 2 PRODUCTS

### 2.1 GEOTEXTILE MATERIALS

Two types of geotextile shall be used during completion of work on the Causeway, including a woven and a non-woven geotextile.

The geotextiles shall be constructed of polypropylene and shall equal or exceed the minimum average roll values listed in TABLE 1, MINIMUM PHYSICAL REQUIREMENTS FOR GEOTEXTILE. Strength values indicated in the table are for the weaker principal direction.

TABLE 1
MINIMUM PHYSICAL REQUIREMENTS FOR GEOTEXTILE

| PROPERTY, (UNITS) | TEST METHOD | Woven Geotextile | Non-Woven Geotextile |
|---|---|---|---|
| GRAB STRENGTH, (lb) (MD/XMD) | ASTM D 4632 | NA | 365/200 |
| PUNCTURE, (lb) | ASTM D 3787 | NA | 115 |
| PUNCTURE, (lb) | ASTM D 4833 | 115 | NA |
| TRAPEZOID TEAR, (lb) MD/XMD | ASTM D 4533 | 80/70 | 100/75 |
| PERMEABILITY, (cm/sec) | ASTM D 4491 | NA | 0.092 |
| APPARENT OPENING SIZE, (U.S. SIEVE) | ASTM D 4751 | 30-50 | 70 |
| PERMITTIVITY, ($sec^{-1}$) | ASTM D 4491 | 0.95 | 1.36 |
| ULTRAVIOLET DEGRADATION, (%) | ASTM D 4355 | 80 @ 500 hrs. | 90 @ 500 hrs. |

### 2.2 Woven Geotextile

A woven geotextile shall be placed below the polymeric marine mattresses and the rock fill toe and transition, to limit the migration of Causeway fill material from beneath these layers during wave events.

#### 2.2.1 Geotextile Fiber

Fibers used in the manufacturing of the woven geotextile shall consist of a long-chain synthetic polymer composed of at least 85 percent by weight of polyolefins, polyesters, or polamides. Stabilizers and/or inhibitors shall be added to the base polymer if necessary to make the filaments resistant to deterioration caused by ultraviolet light, heat exposure, and saltwater exposure. Reclaimed or recycled fibers or polymer shall not be added to the formulation. Geotextile shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including the edges. The edges of the geotextile shall be finished to prevent the outer fiber from pulling away from the geotextile.

#### 2.2.2 Securing of the Geotextile

If necessary for stability reasons, the geosynthetic material may be fastened to the underside of the marine mattresses prior to installation, or preferably, staked or pinned to the surface of the prepared subgrade. Staking or pinning of the geotextile to the subgrade may allow for tidal waters to contact the subgrade prior to placement of the mattresses in limited areas, and may be beneficial during placement of the material in windy conditions.

Securing stakes or pins shall be inserted through both strips of overlapped geotextile along the line passing through midpoints of the overlap. Securing pins shall be removed as placement of revetment materials are placed to prevent tearing of geotextile or enlarging holes. Maximum spacing between securing pins depends on the steepness of the embankment slope. The maximum pins spacing shall be equal to or less than the values listed in TABLE 2, MAXIMUM SPACING FOR SECURING PINS. When windy conditions prevail at the construction site, the number of pins should be increased upon the demand of the Contracting Officer. Terminal ends of the geotextile shall be anchored with key trench or apron at crest, toe of the slope, and upstream and downstream limits of installation.

TABLE 2
MAXIMUM SPACING FOR SECURING PINS

| SLOPE | SPACING, feet |
|---|---|
| STEEPER THAN 1V ON 3H | 2 |
| 1V ON 3H TO 1V ON 4H | 3 |
| FLATTER THAN 1V ON 4H | 5 |

## 2.3 Non-Woven Geotextile

A non-woven geotextile shall be placed below the interlocking concrete blocks to limit damage to the Sand Bedding during installation of the blocks, provide additional support in the event of differential settlement, and act as additional protection against contact with the underlying, contaminated Causeway fill materials.

The geotextile material shall be resistant to clogging from marine organisms. It shall have a minimum weight of 6 ounces per square yard, and be spun-bonded.

### 2.3.1 Geotextile Fiber

Fibers used in the manufacturing of the non-woven geotextile shall consist of a long-chain synthetic polymer composed of at least 85 percent by weight of polyolefins, polyesters, or polamides. Stabilizers and/or inhibitors shall be added to the base polymer if necessary to make the filaments resistant to deterioration caused by ultraviolet light, heat exposure, and saltwater exposure. Reclaimed or recycled fibers or polymer shall not be added to the formulation. Geotextile shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including the edges. The edges of the geotextile shall be finished to prevent the outer fiber from pulling away from the geotextile.

### 2.3.2 Seams

The seams of the geotextiles shall be overlapped as recommended by the Manufacturers.

## 2.2 INSPECTIONS, VERIFICATIONS, AND TESTING

### 2.2.1 Manufacturing and Sampling

Geotextiles shall be randomly sampled in accordance with ASTM D 4354 (Procedure Method A) at a frequency of 1 sample per 20,000 square feet of materials installed.

### 2.2.2 Site Verification and Testing

Samples shall be collected at approved locations upon delivery to the site in accordance with ASTM D 4354 (Procedure Method B). Samples shall be tested to verify that the geotextile meets the requirements specified in TABLE 1, MINIMUM PHYSICAL REQUIREMENTS FOR GEOTEXTILES. Samples shall be identified by manufacturers name, type of geotextile, lot number, roll number, and machine direction. Testing shall be performed at an approved laboratory. Test results from the lot under review shall be submitted and approved prior to deployment of that lot of geotextile. Rolls which are sampled shall be immediately re-wrapped in their protective covering.

# PART 3 EXECUTION

## 3.1 SURFACE PREPARATION

Surfaces on which the geotextile will be placed shall be prepared to a relatively smooth surface condition, in accordance with the applicable portion of this specification. Surfaces shall be free from obstruction, debris, depressions, erosion feature, or vegetation. Any irregularities shall be removed so as to ensure continuous, intimate contact of the geotextile with all the surface. Any loose material, soft or low density pockets of material, will be removed and filled with gravel. Erosion features such as rills and gullies must be graded out of the surface before geotextile placement.

## 3.2 INSTALLATION OF THE GEOTEXTILES

The geotextiles shall be placed in the manner specified and at the locations shown on the drawings. At the time of installation, the geotextile shall be rejected if it has defects, rips, holes, flaws, deterioration or damage incurred during manufacture, transportation or storage or repaired as approved by the Contracting Officer.

### 3.2.1 Woven Geotextile

The woven geotextile shall be placed with the long dimension parallel to slopes (run from top to bottom of slopes). The woven geotextile shall be laid smooth and free of tension, stress, folds, wrinkles, or creases. The strips shall be placed such that the overlap length complies with the manufacturer's recommendations.

Temporary pinning of the geotextile to help hold it in place until the cover system is placed shall be allowed. The temporary pins shall be removed as the cover system is placed to relieve high tensile stress which may occur during placement of material on the geotextile. Design protection of rip rap should be in compliance with EM 1110-2-1601. Trimming shall be performed in such a manner that the geotextile shall not be damaged in any way.

### 3.2.2 Non-woven Geotextile

Non-woven geotextile shall be placed over the Sand Bedding Layer and shall be smooth and free of tension, stress or wrinkles. Geotextile shall extend into the perimeter termination trench. The geotextile shall be lapped a minimum of 18 inches at ends and sides of adjoining sheets.

Non-woven geotextile shall not be torn, punctured or shifted. All geotextile that is torn or punctured shall be repaired or replaced by Contractor at no cost to the Government. The repair shall consist of a patch of the same type of geotextile placed over the ruptured area and shall lap the existing geotextile a minimum of 36 inches from the edge of any part of the rupture, or a sewn patch with the same requirements for material and seam strength as that of the geotextile being repaired. No vehicular traffic shall be permitted directly on the geotextile, except low tire pressure equipment used to transport blocks, as approved by the Contracting Officer.

## 3.3 PROTECTION

The geotextile shall be protected at all times during construction from contamination by surface runoff and any geotextile so contaminated shall be removed and replaced with uncontaminated geotextile. Any damage to the geotextile during its installation or during placement of cover system materials shall be replaced by the Contractor at no cost to the Government. The work shall be scheduled so that the covering of the geotextile with a layer of the specified material is accomplished within 2 calendar days after placement of the geotextile. Failure to comply shall require replacement of geotextile.

The geotextile shall be protected from damage prior to and during the placement of cover system materials. This may be accomplished by limiting the height of drop to less than one foot, or by other approved methods. Before placement of cover system materials, the Contractor shall demonstrate that the placement technique will not cause damage to the geotextile. In no case shall any type of equipment be allowed on the unprotected geotextile.

## 3.5 OVERLAPPING

The overlap length of geotextile rolls shall be as recommended by the manufacturer. Appropriate measures will be taken to insure required overlap exists after cover system placement.

--End of Section--

# SECTION 02380

# POLYMERIC MARINE MATTRESS

## PART 1 GENERAL

### 1.1 DESCRIPTION

This section covers furnishing a polymeric marine mattress system, consisting of structural geogrid, braid, mechanical connection elements, and Rock Fill material. In addition, this section details the provision of a biaxial geogrid composite as specified herein and shown on the Drawings, to provide support at the toe of the polymeric marine mattress system.

The structural geogrid material used for the mattress shall include sufficient quantities to form lifting hoops for the units and anchors. Fabricating, filling, and placing of polymeric marine mattress units shall be in accordance with this section and in reasonably close conformity with the lines, grades and dimensions shown on the drawings or established by the Contracting Officer. Some pre-fabrication of the units may be accomplished prior to delivery to the site.

The Contractor shall provide a manufacturer's system representative for the pre-construction conference, during initial phase of installation, and as required during installation.

### 1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publication is referred to in the text by basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

| | |
|---|---|
| AASHTO | (1997 Interim) Standard Specification for Highway Bridges |

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

| | |
|---|---|
| ASTM D 1388 | (1996) Stiffness of Fabrics (Option A) |
| ASTM D 4355 | (1992) Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus) |
| ASTM D 4759 | (1988; R 1996) Standard Practice for Determining the Specification Conformance of Geosynthetics |
| ASTM D 5818 | (1995) Practice for Obtaining Samples of Geosynthetics from a Test Section for Assessment of Installation Damage |

GEOSYNTHETIC RESEARCH INSTITUTE (GRI)

| | |
|---|---|
| GRI GG1-87 | Standard Test Method for Geogrid Rib Tensile Strength |
| GRI GG2-87 | Standard Test for Geogrid Junction Strength |

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

| | |
|---|---|
| EPA 9090 | Compatibility Test for Wastes and Membrane Liners |

## 1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-04 Samples

Structural Geogrid; GA.

Braid; GA.

Mechanical Connection Elements; GA.

Composite Geogrid; GA.

SD-07 Certificates

Geogrid; FIO.

The Contractor shall submit geogrid product data sheets and certifications from the manufacturer, stating that the geogrid products supplied meet the requirements of the project. Provide test data for the tests listed in this section for the materials to be used on this project for each run and each material type.

SD-08 Manufacturer's Instructions

Manufacturer's Instructions; FIO.

The Contractor shall submit manufacturer's fabrication instructions, installation instructions, and general recommendations.

SD-10 Operation and Maintenance Data

Maintenance Plan; GA.

The Contractor shall submit a Maintenance Plan, detailing the procedures for inspection and maintenance of the upper and lower cover systems. The Maintenance Plan shall be submitted within 30 days of the anticipated completion of construction activities, and shall include, but not be limited to, the following information:

a. Inspection procedures

b. Inspection frequency and preliminary schedule

c. Reporting procedure, including format, distribution, and frequency

d. Coordination plan with the Town of Stratford regarding maintenance of vegetative support soil, subsurface utilities, and surface features

e. Warranty execution plan

f. Anticipated maintenance procedures, including repairs

g. Applicable manufacturer's recommended maintenance procedures

As part of the Work Plan, specified in Section 02111 EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL, the Contractor shall prepare details of the typical sections and connections to be used in construction of the Polymeric Marine Mattress System.

## 1.4 DEFINITIONS

### 1.4.1 Polymeric Marine Mattress

A non-metallic, compartmental structure filled densely and tightly with stone prior to installation. Filling is achieved with a single unit positioned on edge, prior to installation. Units are comprised of structural geogrid, braid, and mechanical connection elements fabricated to allow placement and provide containment of aggregate rock fill material.

### 1.4.2 Geogrid

An integrally formed grid structure manufactured of a stress resistant co-polymer polypropylene material with molecular weight and molecular characteristics which impart high resistance to:

a. Loss of load capacity or structural integrity when the geogrid is subjected to mechanical stress in installation.

b. Deformation when the geogrid is subjected to applied force in use.

c. Loss of load capacity or structural integrity when the geogrid is subjected to long-term environmental stress associated with, including but not limited to: waves, salt water, ice, and site contaminants.

### 1.4.3 Minimum Average Roll Value

Value based on testing and determined in accordance with ASTM D 4759.

### 1.4.4 True Tensile Modulus in Use

The ratio of tensile strength to corresponding strain (e.g., 1%). The true resistance to elongation when initially subjected to a load measured via GRI GG1-87 (tested at a strain rate of 10 percent per minute based on the greater of 2 aperture or 8-inch gauge length) without deforming test materials under load before measuring such resistance or employing "secant" or "offset" tangent methods of measurement so as to overstate tensile properties.

### 1.4.5 Junction Strength

Breaking tensile strength of junctions when tested in accordance with GRI GG2.

### 1.4.6 Flexural Stiffness (Also Known as Flexural Rigidity)

Resistance to bending force measured via ASTM D 1388, Option A, using specimen dimensions of 854 millimeters in length by 1 aperture in width.

### 1.4.7 Resistance to Installation Damage

Resistance to loss of load capacity or structural integrity when subjected to mechanical stress in installation measured via ASTM D 5818 in a clayey sand (SC), a well graded sand (SW) and crushed stone classified as a poorly graded gravel with a maximum 2 inch particle size (GP). Values shown are typical values.

### 1.4.8 Resistance to Long Term Degradation

Resistance to loss of load capacity or structural integrity when subjected to chemically aggressive environments measured via EPA 9090 immersion testing. Values shown are typical values.

### 1.4.9 Ultraviolet Stability

The ratio of tensile strength after exposure to the tensile strength prior to exposure with exposure per ASTM D 4355 and tensile strengths measured via GRI GG1 as specified in subparagraph "True Tensile Modulus in Use" of paragraph DEFINITIONS above.

### 1.4.10 Well Graded

Well graded is determined based on the results of a material size gradation test based on the materials coefficient of uniformity and coefficient of curvature, determined as follows:

$C_u = D_{60}/D_{10}$ is greater than 4 for well graded gravel

Where;
$C_u$ = Coefficient of uniformity
$D_{60}$ = The diameter corresponding to 60% finer in the particle size distribution curve.
$D_{10}$ = The diameter corresponding to 10% finer in the particle size distribution curve.

$C_c = (D_{30})^2/(D_{60} \times D_{10})$ is between 1 and 3 for well graded gravel

Where;
$C_c$ = Coefficient of curvature
$D_{30}$ = The diameter corresponding to 30% finer in the particle size distribution curve.

## 1.5 QUALITY ASSURANCE

Prior to the installation of the units, the Contractor shall arrange a meeting at the site with the system supplier and, where applicable, the system installer. The Contracting Officer shall be notified at least 5 days in advance of the time of the meeting. The Contractor shall provide a manufacturers representative on-site during initial installation as well as, as required by the Contracting Officer.

## PART 2 PRODUCTS

### 2.1 MANUFACTURERS

An approved source of the polymeric marine mattress system is Tensar Earth Technologies, Inc., or approved equivalent.

### 2.2 MATERIALS

### 2.2.1 Structural Geogrid

a. Unless otherwise specified on the contract drawings, shop drawings, or directed by the Contracting Officer, the structural geogrid type shall be:

   (1) Type 1 for the internal diaphragms of the units.

   (2) Type 2 for the top, bottom, sides and anchor of the units.

b. The structural geogrid shall be produced from virgin resin and classified as copolymer and shall possess complete continuity of all properties throughout its structure and shall be suitable for forming non-yielding marine mattresses.

c. The structural geogrid shall accept applied force in use by positive mechanical interlock (i.e., direct mechanical keying) with:

   (1) Compacted soil or construction fill materials;

   (2) Contiguous sections of itself when overlapped and embedded in compacted soil or construction fill materials; and,

   (3) Rigid mechanical connection elements such as bodkins, pins or hooks.

d. The structural geogrid shall possess sufficient cross sectional profile to present a substantial marine mattress to geotextile filter interface to resist movement relative to such materials when subjected to applied force.

e. The structural geogrid shall possess sufficient true internal modulus to cause applied force to be transferred to the grid at low strain levels without material deformation of the marine mattress.

f. The structural geogrid shall possess complete continuity of all properties throughout its structure and shall be suitable for use in maintaining structural integrity of marine mattress systems.

g. The structural geogrid shall have the following characteristics:

| PROPERTY | UNITS | TYPE 1 | TYPE 2 |
|---|---|---|---|
| True 1% Tensile Modules in Use (MD) | kN/m (lb/ft) | 750 (51,400) | 1,650 (113,090) |
| Junction Strength (MD) | kN/m (lb/ft) | 48.60 (3,330) | 100.8 (6,908) |
| Flexural Stiffness | mg-cm | 500,000 | 4,500,000 |
| Resistance to Installation Damage | %GP | 85 | 85 |
| Resistance to Long Term Degradation | % | 100 | 100 |
| Ultraviolet Stability (Retained Strength @ 500 hours) | % | 98 | 98 |
| Aperture Size | in. (MD/XMD) | 5.8/0.60 | 5.6/0.60 |
| Percent Open Area | % | 60 | 60 |
| Minimum Thickness (any dimension) | in. | 0.028 | 0.065 |

2.2.2 UV Stabilized Braid

a. The braid used for tying and lacing in the fabrication of the units shall be 8-strand hollow-core braid composed of HDPE. Each strand shall consist of a bundle of monofilament HDPE.

b. The braid shall have a nominal diameter of not less than 3/16 inch and a breaking strength of not less than 400 pounds on a test specimen 36 inches in length.

c. The braid shall be UV stabilized with a minimum carbon black content of 2.0% by weight.

2.2.3 Mechanical Connection Elements

a. The mechanical connection elements shall be as shown on the Drawings and shop drawings and shall be composed of UV stabilized high density polyethylene (HDPE), unless otherwise approved by the Contracting Officer.

b. The mechanical connection used shall be bodkin type, unless otherwise approved by the Contracting Officer.

2.2.4 Rock Fill Materials

a. The rock fill shall be sound and durable, free of cracks, soft seams, and other Structural defects impairing its durability.
b. Broken concrete and rounded stone are not acceptable.
c. Unless otherwise shown on the Drawings and shop drawings or approved by the Contracting Officer:

(1) The rock fill shall be well-graded, washed, angular, crushed stone with stones between 2 to 6 inches, having a $D_{50}$ of 3 inches and less than 2% finer than 2 inches. No flat or elongated stone will be allowed.

d. Contingent on approval of the Contracting Officer, recycles, processed concrete meeting these requirements may be used as stone fill.

### 2.2.5 Biaxial Geogrid Composite

The biaxial geogrid composite shall be an integrally formed grid structure manufactured of a stress resistant polypropylene material with molecular weight and molecular characteristics which impart: 1) high resistance to loss of load capacity or structural integrity when the geogrid is subjected to mechanical stress in installation; 2) high resistance to deformation when the geogrid is subjected to applied force in use; and 3) high resistance to loss of load capacity or structural integrity when the geogrid is subjected to long-term environmental stress. The grid structure shall be reinforced with a woven, monofilament, polypropylene geotextile.

The geogrid composite shall accept applied force in use by positive mechanical interlock with: 1) compacted soil or construction fill materials; 2) contiguous sections of itself when overlapped and embedded in compacted soil or construction fill materials; and 3) rigid mechanical connectors such as bodkins, pins, or hooks. The geogrid shall pssess sufficient flexural stiffness to enable efficient installation over weak or wet in-situ soils, and sufficient torosional stiffness to resist in-plane movement of compacted soil or construction fill materials when these a subject to rotating lateral displacement forces. The geogrid shall possess complete continuity of all properties throughout its' structure and shall have the following characteristics:

| PROPERTY | UNITS | MD Values | XMD Values |
|---|---|---|---|
| **Geogrid Composite:** | | | |
| True 1% Tensile Modules in Use | kN/m (lb/ft) | 410 (28,100) | 420 (28,780) |
| Junction Strength | kN/m (lb/ft) | 21.50 (1,474) | 21.5 (1,474) |
| Flexural Stiffness | mg-cm | 750,000 | |
| Torosional Stiffness | kg-cm/deg | 6.0 | |
| Resistance to Installation Damage | %GP | 71 | |
| Resistance to Long Term Degradation | % | 100 | |
| Ultraviolet Stability (Retained Strength @ 500 hours - ASTM D4355) | % | 98 | |
| Aperture Size | in. | 1.7(MD) | 1.9(XMD) |
| Percent Open Area | % | 75 | |

| PROPERTY | UNITS | MD Values | XMD Values |
|---|---|---|---|
| Minimum Thickness (any dimension) | in. | 0.06 | |
| **Geotextile:** | | | |
| Puncture Strength (ASTM D4833 | lbs. | 115 | |
| Trapezoidal Tear (ASTM D4533) | lbs. | 80 | 70 |
| Percent Open Area (CWO-221225) | % | 10-12 | |
| Apparent Opening Size | US Sieve | 30-50 | |
| Permittivity (ASTM D 4491) | $sec^{-1}$ | 0.95 | |
| UV Resistance (% retained (500 hours - ASTM D4355) | % | 80 | |

## PART 3 EXECUTION

### 3.1 EXAMINATION

The Contractor shall check the structural geogrid, braid, mechanical connection elements, and geogrid composite upon delivery to verify that the proper material has been received. These materials shall be inspected by the Contractor to be free of flaws or damage occurring during manufacturing, shipping, or handling. The Contracting Officer will examine materials prior to installation and may reject materials that are not uniform, flawed or damaged.

### 3.2 FINAL FABRICATION AND FILLING

#### 3.2.1 Mechanical Connections

The joints where the ends and baffles of each unit join the top or bottom of the unit shall be made with a mechanical connection between geogrid elements as shown on the Drawings and shop drawings.

#### 3.2.2 Seaming

Unless otherwise shown on the Drawings and shop drawings or approved by the Contracting Officer:

a. The joints along the sides of each unit shall be secured by seaming with braid using a lock-stitch configuration to provide complete closure of each unit.

b. Stitches shall be spaced evenly along each seam, with a minimum of 6 stitches per foot of seam. The braid material shall be securely knotted to the geogrid material at each end of each seam and at a minimum 3-foot spacing along each seam. The ends of each piece of braid used shall be knotted to prevent raveling of the braid.

c. The braiding shall be sufficiently tight to prevent openings greater than 1 inch along the seam, but shall not be cinched so tightly that overlaps and binding result.

d. Seaming to connect adjacent units is not required.

### 3.2.3 Rock Filling

Unless otherwise shown on the contract drawings and shop drawings or approved by the Contracting Officer:

a. Each unit shall be filled and the rock fill densified, as appropriate, while the unit is supported in an upright position resting on its side. The filling sequence of the compartments within each unit shall be appropriate to prevent excess deformation or displacement of the interior diaphragms.

b. Densification of the rock fill material and complete filling of each compartment shall be accomplished by rodding and/or vibration.

c. Lifting hoops shall be formed by joining the top and bottom layers of grid from each unit by means of approved mechanical connections.

d. When filling and fabrication of a unit are complete, the unit shall be rotated to a horizontal position resting on its bottom in order to facilitate subsequent lifting.

e. Filling shall be accomplished in a manner that does not cause excessive damage to the geogrid, mechanical connection elements or the braid.

## 3.3 PREPARATION

### 3.3.1 Subgrade

The subgrade shall be prepared as indicated on the contract drawings or as directed by the Contracting Officer. Voids resulting from the removal of oversized materials shall be filled with Gravel meeting the requirements of Section 02300 - EARTHWORK.

### 3.3.2 Biaxial Geogrid Composite

The biaxial geogrid composite shall be placed in the manner specified and at the locations shown on the drawings. At the time of installation, the geogrid composite shall be rejected if it has defects, rips, holes, flaws, deterioration or damage incurred during manufacture, transportation or storage or repaired as approved by the Contracting Officer.

The geogrid composite shall be placed with the long dimension perpendicular to the slope in a single, continuous roll width. The geogrid shall be laid smooth, such that the overlap length complies with the manufacturer's recommendations.

### 3.3.3 Woven Geotextile Underlayer

The Contractor shall place a woven geotextile simultaneously with the units by pre-attaching the geotextile material to each unit in accordance with manufacturer standards with provision for sufficient overlap of the geotextile. The geotextile may be placed on the subgrade and secured to reduce sediment release as approved by the Contracting Officer. The geotextile properties shall be as specified in Section 02378 GEOTEXTILES.

## 3.4 INSTALLATION

### 3.4.1 Position

The units shall be placed at the proper elevation, alignment and orientation as shown on the shop drawings.

### 3.4.2 Placement Procedures

a. The procedure used in placement of the units shall be in accordance with the recommendations of the system supplier and as approved by the Contracting Officer.

b. For lifting of each unit, a spreader beam and/or spreader bars shall be used in a manner that the unit is not subjected to severe bending or distortion and that the top and bottom layers of geogrid are tensioned uniformly across their width. Units should generally be lined from a horizontal position.

c. Personnel shall stay clear of the area beneath units and rigging during lifting. Tag lines may be required to facilitate proper placement of the units.

d. Do not place mattresses in standing water deeper than 1 foot deep. Lay mattresses such that the first portion to contact ground is at the lowest elevation, such that sediments are not squeezed out from beneath the mattresses into standing water.

### 3.4.3 Splicing and Anchoring

Where applicable, splicing and/or anchoring of the units shall be accomplished as shown on the contract drawings, the shop drawings, or as directed by the Contracting Officer.

## 3.5 REPAIR

Any units damaged during installation shall be repaired in a manner approved by the Contracting Officer or shall be replaced by the Contractor. Any such measures required shall be at no additional cost to the Government.

-- End of Section --

# SECTION 02440

# ARTICULATING CELLULAR CONCRETE BLOCK SYSTEM

## PART 1 GENERAL

### 1.1 DESCRIPTION

The articulating cellular concrete block system is a block structure installed over a geotextile as described herein. The cellular blocks, made with portland cement concrete, are cast into "lock" blocks and "key" blocks that provide a three-directional interlock resisting lateral movement. No cables shall be used to connect the system. The articulating cellular concrete block system is a "flexible" concrete revetment that allows the blocks to traverse moderate changes in terrain without disruption of the placement pattern and interlock feature.

This work shall consist of furnishing and installing the articulating cellular concrete block system. Activities shall include subgrade development, as specified in Section 02300 EARTHWORK, geotextile placement as specified in Section 02378 GEOTEXTILES, cellular concrete block placement and locking of blocks with gravel in accordance with this standard specification, at the location(s) identified on drawings and/or designated by the Contracting Officer. This work shall include all necessary materials, labor, supervision, testing and equipment for installation of a complete system.

All work of this Section shall be performed in accordance with the Conditions and Requirements of the Contract Documents.

### 1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING MATERIALS (ASTM)

| | |
|---|---|
| ASTM C 33 | Specification for Concrete Aggregates |
| ASTM C 39 | Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens |
| ASTM C 42 | Standard Methods of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete |
| ASTM C 14 | Standard Methods of Sampling and Testing Concrete Masonry Units |
| ASTM C 150 | Specification for Portland Cement |
| ASTM C 666 | Test Method for Resistance of Concrete to Rapid Freezing and Thawing |
| ASTM D 698 | Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort |
| ASTM D 1777 | Test Method for Measuring Thickness of Textile |

| | |
|---|---|
| | Materials |
| ASTM D 3776 | Test Method for Mass per Unit Area (Weight) of Woven Fabric |
| ASTM D 3786 | Test Method for Hydraulic Bursting Strength of Knitted Goods and Non-woven fabrics: Diaphragm Bursting Strength Tester Method |
| ASTM D 3884 | Test Method for Abrasion Resistance of Textile Fabrics (Rotary Platform, Double Head Method) |
| ASTM D 4491 | Test Methods for Water Permeability of Geotextiles by Permitivity |
| ASTM D 4533 | Test Method for Trapezoidal Tear Strength of Geotextiles |
| ASTM D 4632 | Test Method for Grab Breaking Load and Elongation of Geotextiles |
| ASTM D 4751 | Test Method for Determining Apparent Opening Size of a Geotextile |
| ASTM D 4833 | Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products |

## 1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals not having a "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Articulating Cellular Concrete Block; GA

Submit product data as required in this section on materials for articulating cellular concrete block system.

Alternative Materials; GA

Any alternative system submitted for approval shall include complete design and hydraulic data, including test evidence of compliance to the essential design parameters of Project per Federal Highway Administration Reports No. FHWA-RD-88-181 and FHWA-RD-89-199, and reference installations similar in size and scope to that specified for the Project.

SD-04 Samples

Articulating Cellular Concrete Block; GA

## 1.4 DELIVERY, INSPECTION, STORAGE and HANDLING

### 1.4.1 Delivery

Blocks shall be transported on 4-foot by 4-foot pallets containing approximately 74 square feet of block per pallet, including uncovered openings between the blocks, for 4-inch thick blocks. Pallets shall be stretch-wrapped with a polymer membrane, rather than banded with steel straps.

### 1.4.2 Inspection

All blocks shall be sound and free of defects that would interfere with the proper placing of the block or impair the strength or permanence of the construction. Minor cracks incidental to the usual methods of manufacture, or minor chipping resulting from customary methods of handling in shipment and delivery, may be deemed as grounds for rejection.

### 1.4.3 Storage

Blocks shall be stored by Contractor in a manner which protects them from damage by construction traffic.

### 1.4.4 Handling

Handle materials as recommended by the Manufacturer. Do not drop or pile blocks such that dama could result. Placement shall be by hand. Limit vehicle traffic as recommended by the Manufacturer on completed sections.

## 1.5 PERFORMANCE REQUIREMENTS

Based on hydraulic testing requirements of Federal Highway Administration Publication No. FHWA-RD-89-199, "Hydraulic Stability of Articulated Concrete Block Revetment Systems During Overtopping Flow", 4 inch thick blocks on a 5:1 slope shall remain stable at a maximum permissible shear stress and velocity of 7.5 pounds per square foot and 15 feet per second, respectively.

## 1.6 Quality Control Testing

### 1.6.1 Manufacturer Testing and Certification

The manufacturer of the block shall certify the following:

a. Cement supplier, cement used in the blocks shipped to the site meet the requirements of ASTM C-150.

b. Add mixture supplier, admixtures and the rates of use recommended will produce the required (50 year design life) durability with respect to saltwater exposure.

The manufacturer of the block shall weight each batch following manufacture.

The Manufacturer of the block shall provide testing results demonstrating the following, on a weekly basis during block production:

a. Gradation, aggregate and sand meet the requirements of ASTM C-33

b. Abrasion requirements.

c. Compressive Strength, the compressive strength of the completed blocks after 28-days of curing shall be a minimum of 4,500 psi and the average of 3 successive tests shall be a minimum of 5,000 psi.

### 1.6.2 Construction Phase Testing

Each pallet shall be inspected for damage visually.

Perform compressive strength testing at a minimum frequency of 1 test per 10,000 square feet.

## PART 2 PRODUCTS

### 2.1 ARTICULATING CELLULAR CONCRETE BLOCKS

Blocks shall be made of unreinforced portland cement concrete and shall have a minimum compressive strength of 4,500 pounds per square inch (psi)and a minimum avearge (of three tests) of 5,000 psi. The oven dry weight of concrete used shall be not less than 125 pounds per cubic foot. Compressive strength testing of blocks, per ASTM C-1319-95, shall be performed on intact blocks following manufacturer recommended sample preparation techniques. The average absorption of block samples shall be not greater than 7 percent, with no individual sample greater than 8 percent, in accordance with ASTM C-140.

Blocks shall be cast using block manufacturing equipment with vibratory compaction processes (dry cast). Blocks shall be a natural, non-pigmented, grayish-white concrete color.

Blocks shall be made of modular interlocking components, based on equilateral triangles with 16 inch long sides. Blocks shall be cast in pairs of "lock" and "key" blocks with each "lock" block having three equally spaced circular recesses and with each "key" block having three equally spaced interlocking knobs. Blocks shall be manufactured to allow articulation upward and downward while restricting lateral movement. The assembled block system shall articulate over three-directional vertical curves, both upward and downward, with a minimum radius of 36 inches.

Nominal block thickness shall be 4 inches. Block weights, per pair of "key" and "lock" blocks, shall be approximately 50 lbs.

Each pair of "key" and "lock" blocks shall cover approximately 1.54 square feet, including uncovered openings between the blocks. The system shall provide approximately 80 percent coverage of the area with blocks, leaving approximately 20 percent, but not less than 16 percent, uncovered area at the ground surface.

For installation purposes, the bottom of the block shall be those sides with a generally flat, unformed surface.

## PART 3 EXECUTION

### 3.1 BLOCK SUPPLIER REPRESENTATION

The Contractor shall coordinate with the block supplier for a qualified representative of the block supplier to be present on the job site at the start of installation to provide technical assistance as needed. Contractor shall remain solely responsible for the quality of installation.

### 3.2 SITE PREPARATION

Before placing the geotextile, the subgrade, consisting of a Sand Bedding (Section 02300 EARTHWORK), shall be inspected by the Contractor to ensure it has been graded smooth; has no depressed, void, soft, or uncompacted areas; and is free from obstructions, such as tree roots, projecting stones or other foreign matter. Subgrade compaction shall be achieved by compaction with a heavy smooth drum roller using a minimum of 6 passes, and shall be installed to within plus or minus 2 inches of the design elevation or to the satisfaction of the Contracting Officer. The Contractor shall not proceed until all unsatisfactory conditions have been remedied. By beginning construction, the Contractor signifies his approval of preceding work.

The Contractor shall fine grade the sand subgrade by hand dressing where necessary to remove local surface irregularities.

The perimeter of the block system shall be terminated as shown on the contract drawings.

## 3.3 GEOTEXTILE INSTALLATION

A non-woven geotextile shall be placed as specified in Section 02378 GEOTEXTILES, Paragraph 3.2.2.

## 3.4 BLOCK PLACEMENT

Block installation shall begin from a straight-line oriented perpendicular to the direction of lay, and shall proceed toward an open area and not toward a point of fixity. Blocks shall be installed with the bottom side down. Blocks shall continue to be laid in straight-lines to maintain the interlock characteristic. To maintain straight-lines, no more than two rows of blocks shall be started at a time. The extent of blocks shall include the perimeter termination trenches and shall be as shown on contract drawings.

When abutting structures, such as perimeter rip rap, concrete grout shall be furnished and installed full-depth in the void between the blocks and penetrations. Grout shall be installed, floated smooth and cured at the direction of Contracting Officer.

## 3.5 BACKFILLING

Backfilling of interstitial spaces between blocks and the termination between the upper and lower cover systems shall be completed no more than seven (7) days after placement of the non-woven geotextile to protect the geotextile from ultraviolet radiation. As the installation progresses, backfilling shall include contiguous termination and interstitial space backfilling.

Interstitial spaces shall be backfilled with Gravel, as per the drawings and Section 02300 EARTHWORK. The termination area between the upper and lower cover systems shall be backfilled with rip rap, as per the drawings and Section 02300 EARTHWORK.

## 3.6 QUALITY ASSURANCE

Based on the preceding specifications for materials and installation, the articulating cellular concrete block system shall not be defective or damaged. Any such problems shall be corrected by Contractor at no cost to Government and to the satisfaction of Contracting Officer.

## 3.7 CLEANUP

At the completion of this scope of work, Contractor shall remove from the job site and properly dispose of all remaining debris, waste materials, excess materials, and equipment required of or created by Contractor. Disposal of waste materials shall be solely the responsibility of Contractor and shall be done in accordance with the requirments of Section 02120 TRANSPORTATION AND OFF-SITE DISPOSAL.

--End Of Section--

# SECTION 02522

# MONITORING WELLS
05/98

## PART 1 GENERAL

### 1.1 DESCRIPTION

There are five existing groundwater monitoring wells, installed during previous investigations on the Causeway, including MWCD-99-01A and -01B, MWCD-99-02A and -02B, and MWCD-00-01. The work covered in this section includes the grade adjustment of four of the monitoring wells, following completion of cover system installation. Monitoring well MWCD-00-01 is scheduled to be abandoned during Phase I activities (N.I.T.C.).

### 1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

| | |
|---|---|
| ASTM D 1785 | (1996b) Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120 |

NSF INTERNATIONAL (NSF)

| | |
|---|---|
| NSF ANSI/NSF 14 | (1996) Plastics Piping Components and Related Materials |

### 1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Well casing fill material; FIO

Manufacturer's data and recommended installation instructions.

SD-06 Test Reports

Well Adjustment Records; GA

A monitoring well adjustment record, for each monitoring well which has been adjusted to final grade, within 14 working days of completion.

## 1.4 MONITORING WELL GRADE ADJUSTMENT

Existing monitoring wells scheduled for grade adjustment shall have their protective casings modified to accommodate a change in grade at the well. The top of well protective casing shall be extended to be flush with the proposed grade at the well, and a flush-mount cover shall be installed to limit access to the monitoring well, as indicated on the Drawings.

## 1.5 LICENSE REQUIREMENTS

All work related to monitoring wells is to be performed by a contractor licensed by the State of Connecticut to perform the work required under this contract.

# PART 2 PRODUCTS

## 2.1 PROTECTIVE CASINGS

Monitoring well protective casing pipe, shall be new, matching the material and diameter of the existing protective casing, meeting ASTM D 1785 or NSF ANSI/NSF 14. Required fittings shall be ASTM F 480.

## 2.2 WELL FILL MATERIAL

Well fill sealant material shall be Floseal or approved equal.

# PART 3 EXECUTION

## 3.1 GENERAL

The Contractor shall protect and adjust existing monitoring wells as indicated in these specifications and shown on the Drawings. The Contractor shall perform only the work required based on actual site conditions experienced.

The existing condition of the monitoring wells shall be recorded prior to construction of the cover system and adjustment of the wells

## 3.2 PROTECTION OF EXISTING MONITORING WELLS

The Contractor shall maintain existing monitoring wells marked to remain and protect them from damage from equipment and vehicular traffic during Phase II operations. Any items damaged by the Contractor shall be repaired by the Contractor. Protection of existing monitoring wells shall be incidental to the Work.

## 3.3 MONITORING WELL GRADE ADJUSTMENT

The top of protective casing elevation for existing monitoring wells marked to be adjusted shall be extended to be level with the proposed grade at the well, unless otherwise noted. The well casing and protective casing shall be extended, as necessary, with new casing materials that match the materials and sizes of the existing casings. The existing well casing shall be finished a maximum of 1.0 foot below the finished grade of the protective casing. A flush-mount protective casing shall be installed to limit access to the monitoring well.

--End of Section--

# SECTION 02921

# SEEDING
06/98

## PART 1 GENERAL

### 1.1 DESCRIPTION

This section covers the products and procedures to be followed during grass seed placement on the Causeway. The seeding, as described in this section, is intended to provide long-term vegetative cover and soil stabilization for the site. The seed mixes are composed of plant species that are able to tolerate the droughty conditions, and the occasional salt conditions found on the Causeway. Those areas which are to be seeded are shown on the attached project drawings. Erosion control blankets are specified to provide short-term erosion control protection during the seed establishment period.

### 1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AGRICULTURAL MARKETING SERVICE (AMS)

| | |
|---|---|
| AMS-01 | (Aug 95) Federal Seed Act Regulations Part 201 |

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

| | |
|---|---|
| ASTM C 602 | (1995a) Agricultural Liming Materials |
| ASTM D 977 | (1991) Emulsified Asphalt |
| ASTM D 2028 | (1976; R 1992) Cutback Asphalt (Rapid-Curing Type) |
| ASTM D 4972 | (1995a) pH of Soils |
| ASTM D 5268 | (1992; R 1996) Topsoil Used for Landscaping Purposes |
| ASTM D 5883 | (1996) Standard Guide for Use of Rotary Kiln Produced Expanded Shale, Clay or Slate (ESCS) as a Mineral Amendment in Topsoil Used for Landscaping and Related Purposes |

### 1.3 SUBMITTALS

The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

As part of the Work Plan, specified in Section 02111 EXCAVATION AND HANDLING OF CONTAMINATED MATERIAL, the Contractor shall detail the processes to be used during re-vegetation of the Causeway.

## 1.4 SOURCE INSPECTION

The source of delivered vegetative support soil shall be subject to inspection.

## 1.5 DELIVERY, INSPECTION, STORAGE, AND HANDLING

### 1.5.1 Delivery

A delivery schedule shall be provided at least 10 calendar days prior to the first day of delivery.

### 1.5.1.1 Delivered Vegetative Support Soil

Prior to the delivery of any vegetative support soil, quality control testing shall be conducted, and analytical testing shall be required for any soil delivered to the site, as specified in Section 02300 EARTHWORK.

### 1.5.1.2 Soil Amendments

Soil amendments shall be delivered to the site in the original, unopened containers bearing the manufacturer's chemical analysis. In lieu of containers, soil amendments may be furnished in bulk. A chemical analysis shall be provided for bulk deliveries.

### 1.5.2 Inspection

Seed shall be inspected upon arrival at the job site for conformity to species and quality. Seed that is wet, moldy, or bears a test date five months or older, shall be rejected. Other materials shall be inspected for compliance with specified requirements. The following shall be rejected: open soil amendment containers or wet soil amendments; topsoil that contains slag, cinders, stones, lumps of soil, sticks, roots, trash or other material over a minimum 1-1/2 inch diameter; and topsoil that contains viable plants and plant parts. Unacceptable materials shall be removed from the job site.

### 1.5.3 Storage

Materials shall be stored in designated areas. Seed, lime, and fertilizer shall be stored in cool, dry locations away from contaminants. Chemical treatment material shall be stored according to manufacturer's instructions and not with seeding operation materials.

### 1.5.4 Handling

Except for bulk deliveries, materials shall not be dropped or dumped from vehicles.

## PART 2 PRODUCTS

### 2.1 SEED

#### 2.1.1 Seed Classification

State-approved seed of the latest season's crop shall be provided in original sealed packages bearing the producer's guaranteed analysis for percentages of mixture, purity, germination, hard seed, weed seed content, and inert material. Labels shall be in conformance with AMS-01 and applicable state seed laws.

#### 2.1.2 Permanent Seed Species and Mixtures

Permanent seed species and mixtures shall be proportioned by weight as follows:

| **SPECIES** | **PERCENT** |
|---|---|
| Creeping Red Fescue (*Festuca rubra*) | 30 |
| Annual Rye-grass (*Lolium multiflorum*) | 25 |
| Timothy (*Phleum pratense*) | 15 |
| White Clover (*Trifolium repens*) | 10 |
| Little Bluestem (*Schizachyrium scoparius*) | 10 |
| Red Top (*Agrostis alba*) | 5 |
| Side-oats Gramma-grass (*Bouteloua curtipendula*) | 5 |
| **TOTAL** | **100** |

#### 2.1.3 Quality

Weed seed shall be a maximum 1 percent by weight of the total mixture.

#### 2.1.4 Seed Mixing

The mixing of seed may be done by the seed supplier prior to delivery, or on site as directed.

#### 2.1.5 Substitutions

Substitutions will not be allowed without written request and approval from the Contracting Officer.

### 2.2 VEGETATIVE SUPPORT SOIL

Vegetative support soil shall be of the quality defined in Section 02300 EARTHWORK.

### 2.3 SOIL AMENDMENTS

Soil amendments shall consist of pH adjustment and fertilizer, as necessary.

### 2.3.1 pH Adjustment

Recycled compost may be used, as needed to provide pH adjustment for topsoil. Compost shall be a well decomposed, stable, weed free organic matter source. Compost shall be derived from food; agricultural or industrial residuals; biosolids (treated sewage sludge); yard trimmings; or source-separated or mixed solid waste. The compost shall possess no objectionable odors and shall not resemble the raw material from which it was derived. The material shall not contain substances toxic to plants. Gradation: The compost material shall pass through a 3/8 inch screen, possess a pH of 4.0 to 5.5, and have a moisture content between 35-55 percent by weight. The material shall not contain more than 1 percent by weight of man-made foreign matter. Compost shall be cleaned of plastic materials larger than 2 inches in length.

### 2.3.2 Fertilizer

Fertilizer shall be controlled release commercial grade, free flowing, uniform in composition, and consist of a 10-10-10, nitrogen-phosphorus-potassium ratio.

## 2.5 WATER

Water supply shall be the responsibility of the Contractor, unless otherwise noted. Water shall not contain elements toxic to plant life.

## 2.6 SURFACE EROSION CONTROL BLANKET

All exposed topsoil and seeded areas shall be covered with a straw and coconut fiber erosion control blanket in a biodegradable netting (BonTerra America ENCS2 or equal).

| | |
|---|---|
| Straw: | 70% weed free wheat straw, .35 lb./SY<br>30% Coconut Fiber, .15 lb./SY |
| Netting: | Top and bottom side; 100% biodegradable woven natural fiber |
| Thread: | 100% biodegradable, high tensile natural fiber |

Manufactured from 70% wheat straw and 30% coconut fiber by weight, the erosion control blanket shall be a machine fabricated mat, covered on both sides by biodegradable netting, and sewn together with high tensile biodegradable thread on two inch centers. Straw and coconut fiber shall be homogeneously blended and evenly distributed throughout the mat. Netting shall be woven biodegradable natural fiber with mesh openings of approximately 1/2" X 3/4". The blanket shall be sewn on approximately two inch centers with high strength natural fiber biodegradable thread.

The erosion control blankets are to be fastened to the soil using wire turf staples at the overlap seams, and the top and bottom of the blanket.

## PART 3 EXECUTION

### 3.1 INSTALLING SEED TIME AND CONDITIONS

### 3.1.1 Seeding Time

Seed shall be installed from April 1 to May 30 for spring establishment. Establishment at other times of the year is not recommended.

### 3.1.2 Seeding Conditions

Seeding operations shall be performed only during periods when beneficial results can be obtained. When drought, excessive moisture, or other unsatisfactory conditions prevail, the work shall be stopped when directed. When special conditions warrant a variance to the seeding operations, proposed alternate times shall be submitted for approval.

### 3.1.3 Equipment Calibration

Immediately prior to the commencement of seeding operations, calibration tests shall be conducted on the equipment to be used. These tests shall confirm that the equipment is operating within the manufacturer's specifications and will meet the specified criteria. The equipment shall be calibrated a minimum of once every day during the operation. The calibration test results shall be provided within 1 week of testing.

### 3.1.4 Soil Test

Delivered vegetative support soil and existing soil in smooth graded areas shall be tested in accordance with ASTM D 5268 and ASTM D 4972 for determining the particle size, pH, organic matter content, textural class, chemical analysis, soluble salts analysis, and mechanical analysis. Sample collection on site shall be random over the entire site. Sample collection for stockpiled vegetative support soil shall be at different levels in the stockpile. The soil shall be free from debris, noxious weeds, toxic substances, or other materials harmful to plant growth. The test shall determine the quantities and type of soil amendments required to meet local growing conditions for the seed species specified.

### 3.2 SITE PREPARATION

### 3.2.1 Finished Grade and Vegetative Support Soil

The Contractor shall verify that finished layer thicknesses are as indicated on drawings, and the placing of vegetative support soil, smooth grading, and compaction requirements have been completed in accordance with Section 02300 EARTHWORK, prior to the commencement of the seeding operation.

### 3.2.2 Application of Soil Amendments

### 3.2.2.1 Applying pH Adjuster

The pH adjuster shall be applied as recommended by the soil test. The pH adjuster shall be incorporated into the soil to a maximum 4 inch depth or may be incorporated as part of the tillage operation.

#### 3.2.2.2 Applying Fertilizer

The fertilizer shall be applied as recommended by the soil test. Fertilizer shall be incorporated into the soil to a maximum 4 inch depth or may be incorporated as part of the tillage or hydroseeding operation.

### 3.2.3 Tillage

Soil on slopes up to a maximum 3-horizontal-to-1-vertical shall be tilled to a minimum 4 inch depth. On slopes between 3-horizontal-to-1-vertical and 1-horizontal-to-1 vertical, the soil shall be tilled to a minimum 2 inch depth by scarifying with heavy rakes, or other method. Rototillers shall be used where soil conditions and length of slope permit. On slopes 1-horizontal-to-1 vertical and steeper, no tillage is required. Drainage patterns shall be maintained as indicated on drawings. Areas compacted by construction operations shall be completely pulverized by tillage. Soil used for repair of surface erosion or grade deficiencies shall conform to topsoil requirements. The pH adjuster, fertilizer, and soil conditioner may be applied during this procedure.

### 3.2.4 Prepared Surface

#### 3.2.4.1 Preparation

The prepared surface shall be a maximum 1 inch below the adjoining grade of any surfaced area. New surfaces shall be blended to existing areas. The prepared surface shall be completed with a light raking to remove debris.

#### 3.2.4.2 Field Area Debris

Debris and stones over a minimum 3 inch in any dimension shall be removed from the surface.

#### 3.2.4.3 Protection

Areas with the prepared surface shall be protected from compaction or damage by vehicular or pedestrian traffic and surface erosion.

## 3.3 SEED INSTALLATION

Prior to installing seed, any previously prepared surface compacted or damaged shall be reworked to meet the requirements of paragraph SITE PREPARATION. Seeding operations shall not take place when the wind velocity will prevent uniform seed distribution.

### 3.3.1 Installing Seed

Seeding method shall be Broadcast Seeding. Seeding procedure shall ensure even coverage. Gravity feed applicators, which drop seed directly from a hopper onto the prepared soil, shall not be used because of the difficulty in achieving even coverage, unless otherwise approved. Absorbent polymer powder shall be mixed with the dry seed at the rate recommended by the manufacturer.

Seed shall be uniformly broadcast at the rate of 1 pound per 500 square feet using broadcast seeders. Half the total rate of seed application shall be broadcast in 1 direction, with the remainder of the seed rate broadcast at 90 degrees from the first direction. Seed shall be covered a maximum 1/4 inch depth by disk harrow, steel mat drag, cultipacker, or other approved device.

#### 3.3.2 Watering Seed

Watering shall be started immediately after completing the seeding of an area. Water shall be applied to supplement rainfall at a rate sufficient to ensure moist soil conditions to a minimum 1 inch depth. Run-off and puddling shall be prevented. Watering trucks shall not be driven over turf areas, unless otherwise directed. Watering of other adjacent areas or plant material shall be prevented.

### 3.4 SURFACE EROSION CONTROL

Where indicated or as directed, surface erosion control material shall be installed in accordance with manufacturer's instructions. Placement of the material shall be accomplished without damage to installed material or without deviation to finished grade.

The erosion control blankets are to be fastened to the soil using wire turf staples 6" x 1" at a spacing of one staple per square yard. Staples at the overlap seams, and the top and bottom of the blanket shall be at a spacing of 1 foot. The top of bottom of the blanket, and all edges are to be keyed into the soil as recommended by the erosion control blanket manufacturer

### 3.5 QUANTITY CHECK

For materials provided in bags, the empty bags shall be retained for recording the amount used. For materials provided in bulk, the weight certificates shall be retained as a record of the amount used. The amount of material used shall be compared with the total area covered to determine the rate of application used. Differences between the quantity applied and the quantity specified shall be adjusted as directed.

### 3.6 RESTORATION AND CLEAN UP

#### 3.6.1 Restoration

Existing turf areas, pavements, and facilities that have been damaged from the seeding operation shall be restored to original condition at Contractor's expense.

#### 3.6.2 Clean Up

Excess and waste material shall be removed from the seeded areas and shall be disposed offsite. Adjacent paved areas shall be cleaned.

## 3.7 PROTECTION OF INSTALLED AREAS

Immediately upon completion of the seeding operation in an area, the area shall be protected against traffic or other use by erecting barricades and providing signage as required, or as directed.

## 3.8 SEED ESTABLISHMENT PERIOD

### 3.8.1 Commencement

The seed establishment period to obtain a healthy stand of grass plants shall begin on the first day of work under this contract and shall end 3 months after the last day of the seeding operation. Written calendar time period shall be furnished for the seed establishment period. When there is more than 1 seed establishment period, the boundaries of the seeded area covered for each period shall be described. The seed establishment period shall be modified for inclement weather, shut down periods, or for separate completion dates of areas.

### 3.8.2 Satisfactory Stand of Grass Plants

Grass plants shall be evaluated for species and health when the grass plants are a minimum 1 inch high. To be acceptable, a stand of grass shall show a reasonable thick, uniform stand, free from sizable areas of thin or bare spots, with a uniform count of at least 1000 blades per square foot, as approved by the Contracting Officer.

### 3.8.3 Maintenance During Establishment Period

Maintenance of the seeded areas shall include eradicating weeds, insects and diseases; protecting embankments and ditches from surface erosion; maintaining erosion control materials and mulch; protecting installed areas from traffic; mowing; watering; and post-fertilization, as necessary.

#### 3.8.3.1 Mowing

Field areas shall be mowed once during the season to a minimum 3 inch height. Clippings shall be removed when the amount cut prevents sunlight from reaching the ground surface.

#### 3.8.3.2 Post-Fertilization

The fertilizer shall be applied as recommended by the soil test. A maximum 1/2 pound per 1000 square feet of actual available nitrogen shall be provided to the grass plants. The application shall be timed prior to the advent of winter dormancy and shall be made without burning the installed grass plants.

#### 3.8.3.3 Repair or Reinstall

Unsatisfactory stand of grass plants and mulch shall be repaired or reinstalled, and eroded areas shall be repaired in accordance with paragraph SITE PREPARATION.

3.9.3.4 Maintenance Record

A record of each site visit shall be furnished, describing the maintenance work performed; areas repaired or reinstalled; and diagnosis for unsatisfactory stand of grass plants.

--End of Section--

# APPENDIX B

## DRAWINGS

ATTACHMENT A - PHASE I DRAWINGS
ATTACHMENT B - PHASE II DRAWINGS

# ATTACHMENT A

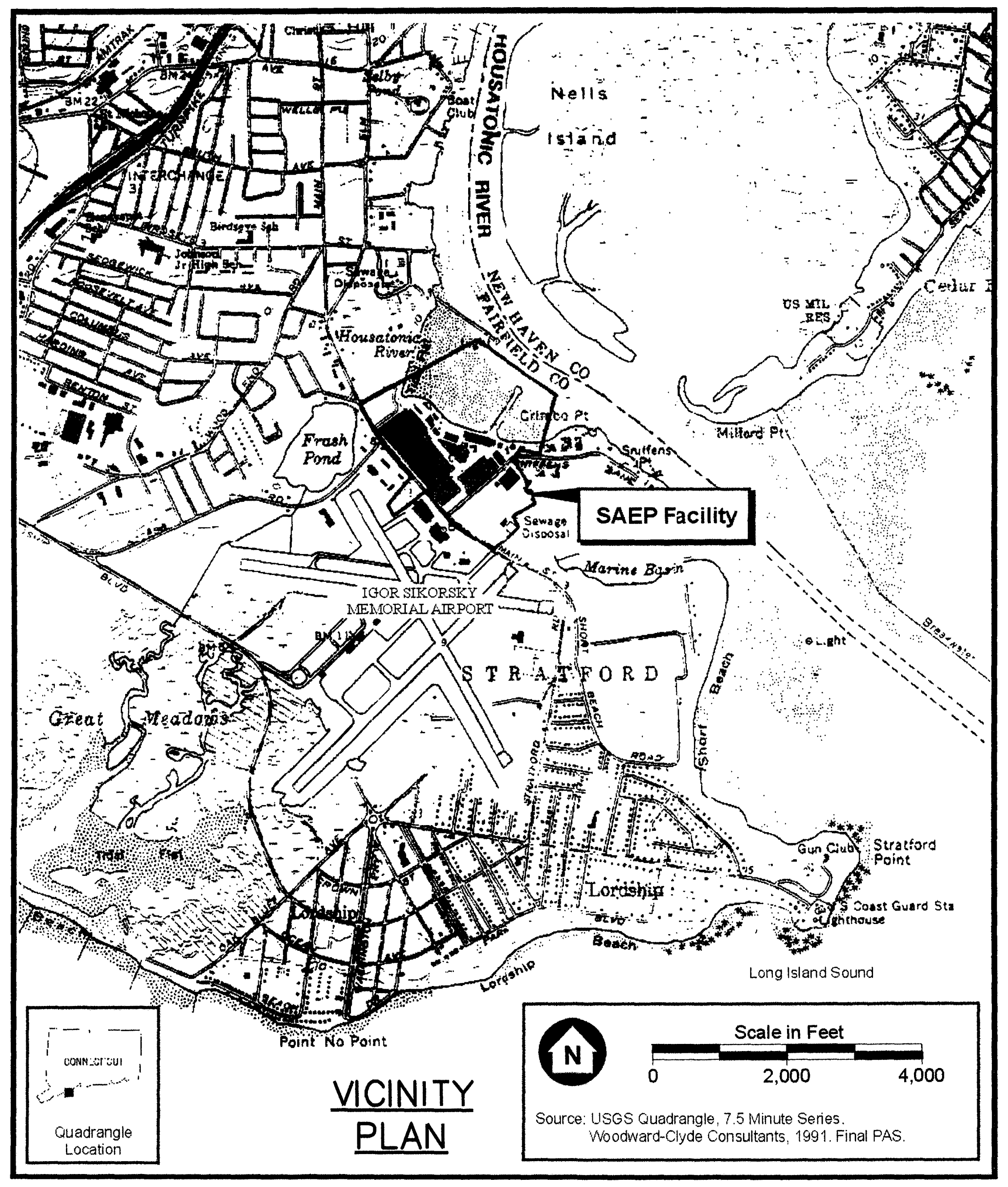
# PHASE I DRAWINGS

# NON-TIME CRITICAL REMOVAL ACTION
# STRATFORD ARMY ENGINE PLANT
# STRATFORD, CONNECTICUT

## 100% CAUSEWAY COVER DESIGN
## PHASE I

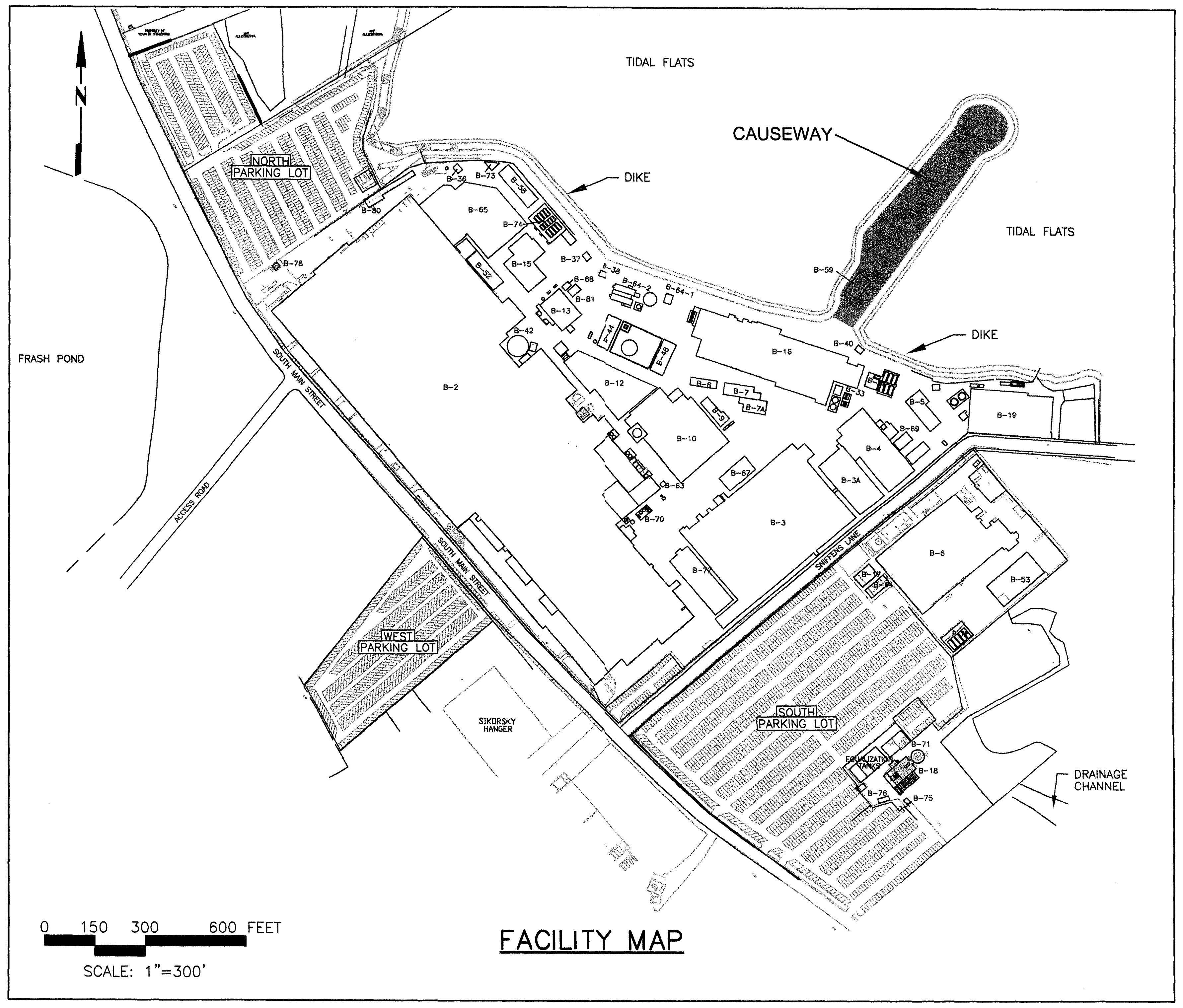
**INDEX OF SHEETS**

| Description | Sheet No. |
|---|---|
| Title Sheet | I-1 |
| Existing Conditions Plan | C-101 |
| Site Control and Building Demolition | C-102 |
| Erosion and Sediment Control | C-103 |
| Phase I Site Plan | C-104 |
| Miscellaneous Details | C-301 |
| Miscellaneous Details | C-302 |
| | |
| | |
| | |



VICINITY PLAN

Source: USGS Quadrangle, 7.5 Minute Series, Woodward-Clyde Consultants, 1991. Final PAS.



SCALE: 1"=300'

FACILITY MAP

No. 19726
BRIAN BANES JOHNSON
8/17/01

Harding ESE
A MACTEC COMPANY

US Army Corps of Engineers
New England District

| Mark | Description | Date | Appr. | Mark | Description | Date | Appr. |
|---|---|---|---|---|---|---|---|
| A | 30% CLIENT REVIEW | 1/26/01 | DRP | | | | |
| B | 90% CLIENT REVIEW | 3/30/01 | BBJ | | | | |
| 0 | 100% ISSUED FOR CONSTRUCTION | 8/17/01 | BBJ | | | | |
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U.S. ARMY CORPS OF ENGINEERS
NEW ENGLAND DISTRICT
CONCORD, MASSACHUSETTS

Harding ESE
A MACTEC COMPANY
P.O. Box 7050, 511 Congress Street
Portland, ME 04112-7050
(207) 775-5401

| | | | |
|---|---|---|---|
| Designed by: B. JOHNSON | | Date: 8/17/01 | Rev. 0 |
| Dwn by: E.J.LEDUC | Ckd by: K. Klm | Design file no. C50796COV | |
| Reviewed by: | | Drawing code: | |
| Submitted by: | | File name: C4725COV<br>Plot date:<br>Plot scale: 1=1 | |
| Chief, Arch. Branch | | | |

NON-TIME CRITICAL REMOVAL ACTION
CAUSEWAY COVER DESIGN (PHASE I)
STRATFORD ARMY ENGINE PLANT

STRATFORD, CONNECTICUT

TITLE SHEET

Sheet reference number:
I-1

SHEET 1 OF 7

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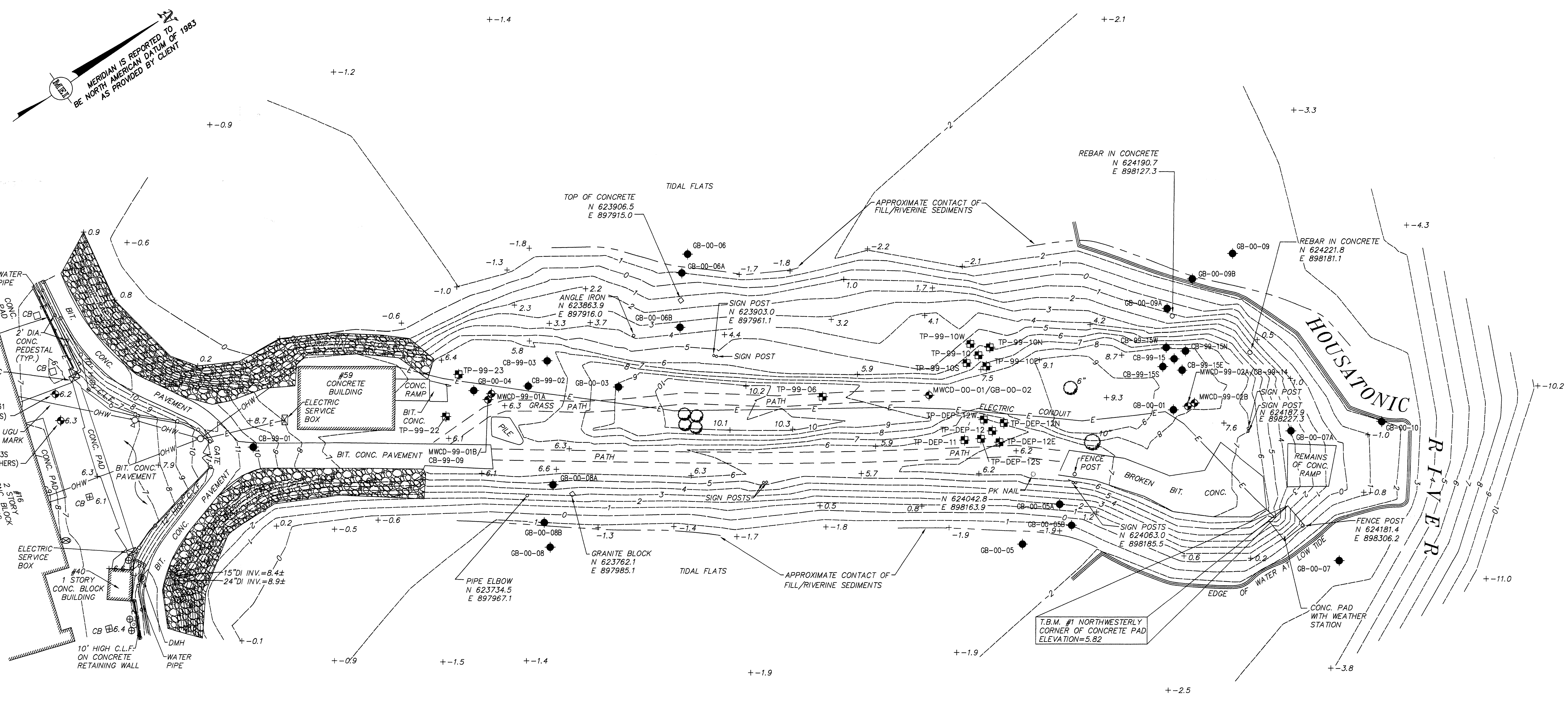


## LEGEND

| | | | |
|---|---|---|---|
| CONC. | CONCRETE | 6" | TREE |
| BIT. CONC. | BITUMINOUS CONCRETE | —OHW— | OVERHEAD WIRE |
| DIA. | DIAMETER | ⊗ | WATER GATE |
| CB ☐ | CATCH BASIN | ⊕ | BOLLARD |
| —o—C.L.F.—o— | CHAIN LINK FENCE | ⊠ | ELECTRIC BOX |
| | RETAINING WALL | —E— | ELECTRIC CONDUIT (ON GRADE) |
| ———4——— | 1' CONTOUR | ◎ | HYDRANT |
| ———5——— | 5' CONTOUR | Ⓓ | DRAIN MANHOLE |
| —— — — —— | APPROXIMATE CONTACT OF FILL/RIVERINE SEDIMENTS | D.I. | DUCTILE IRON |
| +7.9 | SPOT GRADE (ELEV. MSL) (– INDICATES NEGATIVE) | INV. | INVERT |
| ◐ | MONITORING WELL | | RIP-RAP |
| ● | SOIL BORING | ≈ | EDGE OF WATER AT LOW TIDE |
| UGU | UNDERGROUND UTILITY MARK | | |
| ▚ | TESTPIT | | |
| CB-99-01 | BORINGS INSTALLED FOR PRE-DESIGN INVESTIGATION | | |
| GB-00-08 | BORINGS INSTALLED FOR GEOTECHNICAL INVESTIGATION | | |

0 20 40 80 FEET

SCALE: 1"=40'

## NOTES:

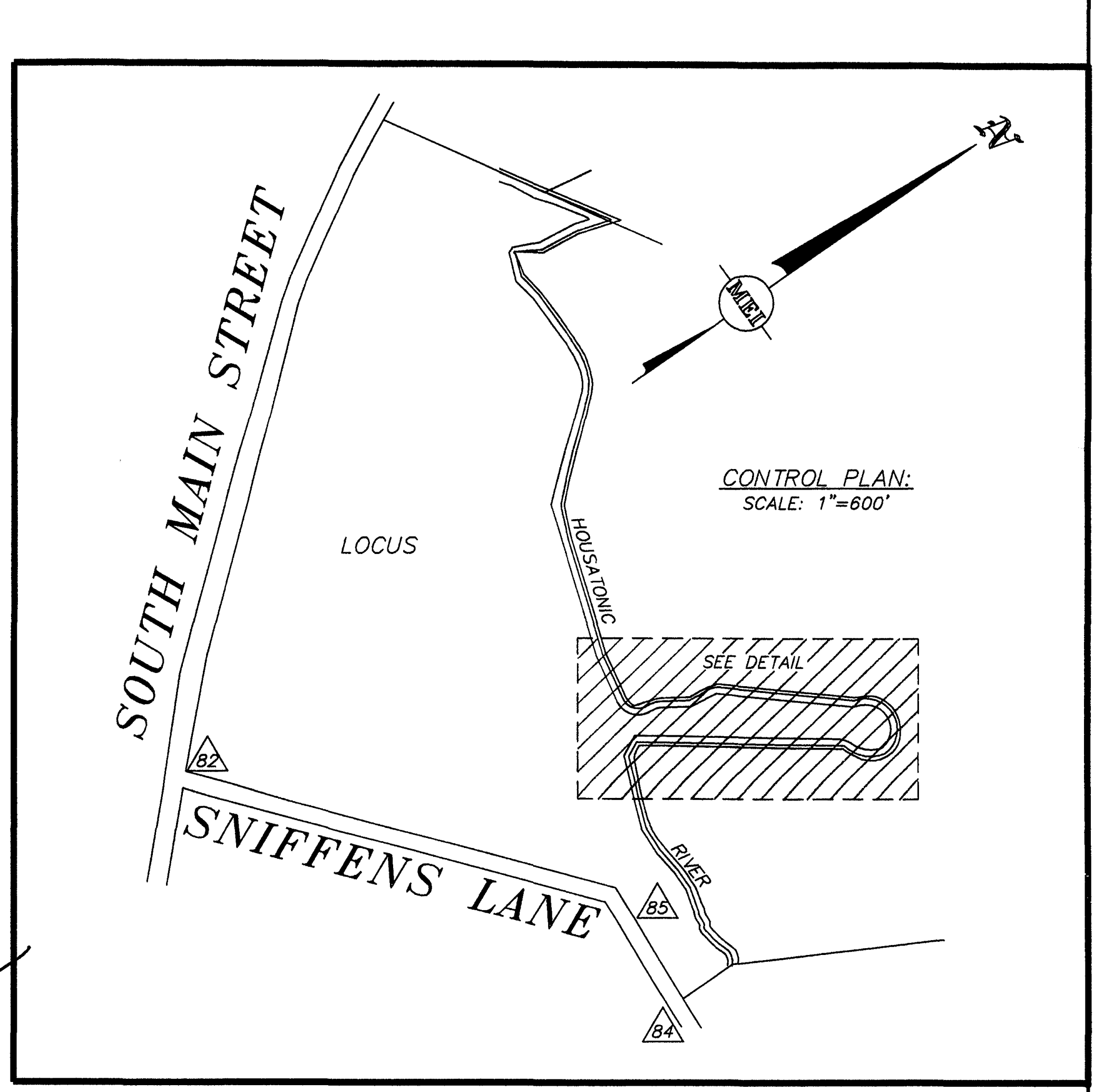
1. THIS PLAN IS A TOPOGRAPHIC SURVEY IN ACCORDANCE WITH THE MOST RECENT CONNECTICUT ASSOCIATION OF LAND SURVEYORS, RECOMMENDED STANDARDS FOR SURVEY AND MAPS IN THE STATE OF CONNECTICUT. THIS MAP CONFORMS WITH A CLASS V2 VERTICAL ACCURACY AND CLASS T-1 TOPOGRAPHIC SURVEY ACCURACY. BASE MAP PRODUCED BY MERIDIAN ENGINEERING, INC.. SHEET 1 OF 1 ENTITLED "RECORD CONDITIONS PLAN OF LAND LOCATED IN STRATFORD CONNECTICUT". DATED OCTOBER 25, 2000.
2. HORIZONTAL AND VERTICAL CONTROL POINTS WERE PROVIDED BY MICHAEL G. WILMES, L.S. OF URS GREINER WOODWARD CLYDE. THE DATUMS WERE REPORTED TO BE ON THE NORTH AMERICAN DATUM OF 1983 AND NATIONAL GEODETIC VERTICAL DATUM OF 1929.
3. CONNECTICUT GEODETIC SURVEY DESIGNATIONS.

## CONTROL POINTS:

(SEE NOTE #2)

| CONTROL POINT | NORTHING | EASTING | ELEVATION | DESCRIPTION (NOTE 3) |
|---|---|---|---|---|
| 82 | 622340.109131 | 897135.274591 | 7.240 | F-15 |
| 84 | 623142.399102 | 898645.030716 | 10.550 | F-23 |
| 85 | 623212.133802 | 898244.245717 | 7.350 | F-24 |

BRIAN BANES JOHNSON
No. 19726
8/17/01



US Army Corps
of Engineers
New England District

| Mark | Description | Date | Appr. | Mark | Description | Date | Appr. |
|---|---|---|---|---|---|---|---|
| 0 | 100% ISSUED FOR CONSTRUCTION | 8/17/01 | BBJ | | | | |
| B | 90% CLIENT REVIEW | 3/30/01 | BBJ | | | | |
| A | 30% CLIENT REVIEW | 1/26/01 | DRP | | | | |

U.S. ARMY CORPS OF ENGINEERS
NEW ENGLAND DISTRICT
CONCORD, MASSACHUSETTS

Harding ESE
A MACTEC COMPANY
P.O. Box 7050, 511 Congress Street
Portland, ME 04112-7050
(207) 775-5401

| | | | |
|---|---|---|---|
| Designed by: B. JOHNSON | | Date: 8/17/01 | Rev. 0 |
| Dwn by: E.J.LEDUC | Ckd by: K. Kern | Design file no. C47254SP01 | |
| Reviewed by: N. Wolk | | Drawing code: | |
| Submitted by: | | File name: C47254SP01<br>Plot date:<br>Plot scale: 1"=40' | |
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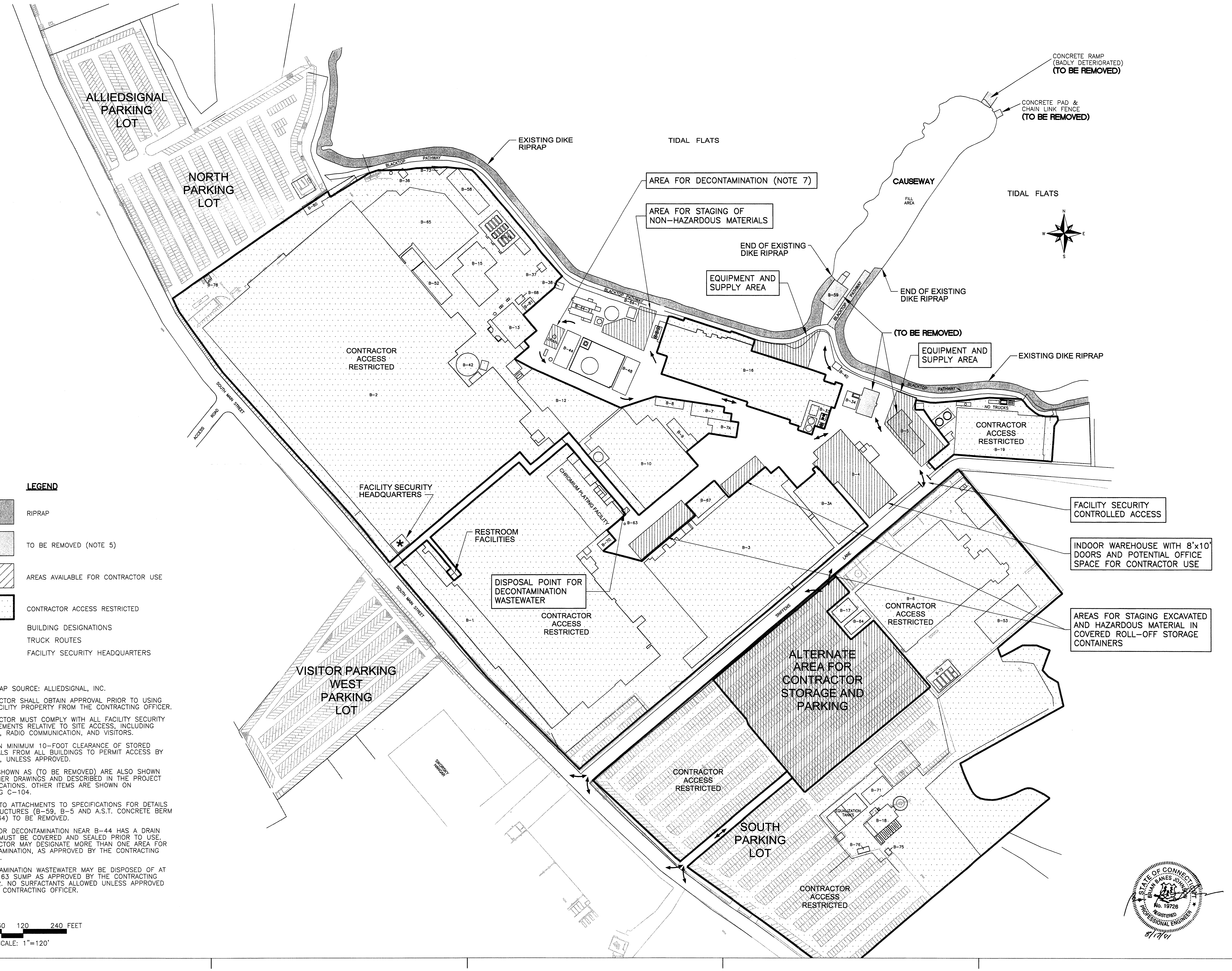
NON-TIME CRITICAL REMOVAL ACTION
CAUSEWAY COVER DESIGN (PHASE I)
STRATFORD ARMY ENGINE PLANT

STRATFORD, CONNECTICUT

**EXISTING
CONDITIONS
PLAN**

Sheet
reference
number:
C-101
SHEET 2 OF 7



**LEGEND**

| | |
|---|---|
| ▩ | RIPRAP |
| ▒ | TO BE REMOVED (NOTE 5) |
| ▨ | AREAS AVAILABLE FOR CONTRACTOR USE |
| ⬚ | CONTRACTOR ACCESS RESTRICTED |
| B-53 | BUILDING DESIGNATIONS |
| ← | TRUCK ROUTES |
| * | FACILITY SECURITY HEADQUARTERS |

**NOTES:**

1. BASE MAP SOURCE: ALLIEDSIGNAL, INC.
2. CONTRACTOR SHALL OBTAIN APPROVAL PRIOR TO USING ANY FACILITY PROPERTY FROM THE CONTRACTING OFFICER.
3. CONTRACTOR MUST COMPLY WITH ALL FACILITY SECURITY REQUIREMENTS RELATIVE TO SITE ACCESS, INCLUDING BADGES, RADIO COMMUNICATION, AND VISITORS.
4. MAINTAIN MINIMUM 10-FOOT CLEARANCE OF STORED MATERIALS FROM ALL BUILDINGS TO PERMIT ACCESS BY OTHERS, UNLESS APPROVED.
5. ITEMS SHOWN AS (TO BE REMOVED) ARE ALSO SHOWN ON OTHER DRAWINGS AND DESCRIBED IN THE PROJECT SPECIFICATIONS. OTHER ITEMS ARE SHOWN ON DRAWING C-104.
6. REFER TO ATTACHMENTS TO SPECIFICATIONS FOR DETAILS OF STRUCTURES (B-59, B-5 AND A.S.T. CONCRETE BERM BY B-34) TO BE REMOVED.
7. AREA FOR DECONTAMINATION NEAR B-44 HAS A DRAIN WHICH MUST BE COVERED AND SEALED PRIOR TO USE. CONTRACTOR MAY DESIGNATE MORE THAN ONE AREA FOR DECONTAMINATION, AS APPROVED BY THE CONTRACTING OFFICER.
8. DECONTAMINATION WASTEWATER MAY BE DISPOSED OF AT THE B-63 SUMP AS APPROVED BY THE CONTRACTING OFFICER. NO SURFACTANTS ALLOWED UNLESS APPROVED BY THE CONTRACTING OFFICER.

0 60 120 240 FEET

SCALE: 1"=120'

STATE OF CONNECTICUT
BRIAN BANES JOHNSON
No. 19726
REGISTERED PROFESSIONAL ENGINEER
8/17/01

P:\Projects\CBDCOM\SAEP\Causeway\phase1\C472545P02.dwg Tue, 28 Aug 2001 - 12:08pm delgrence

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New England District

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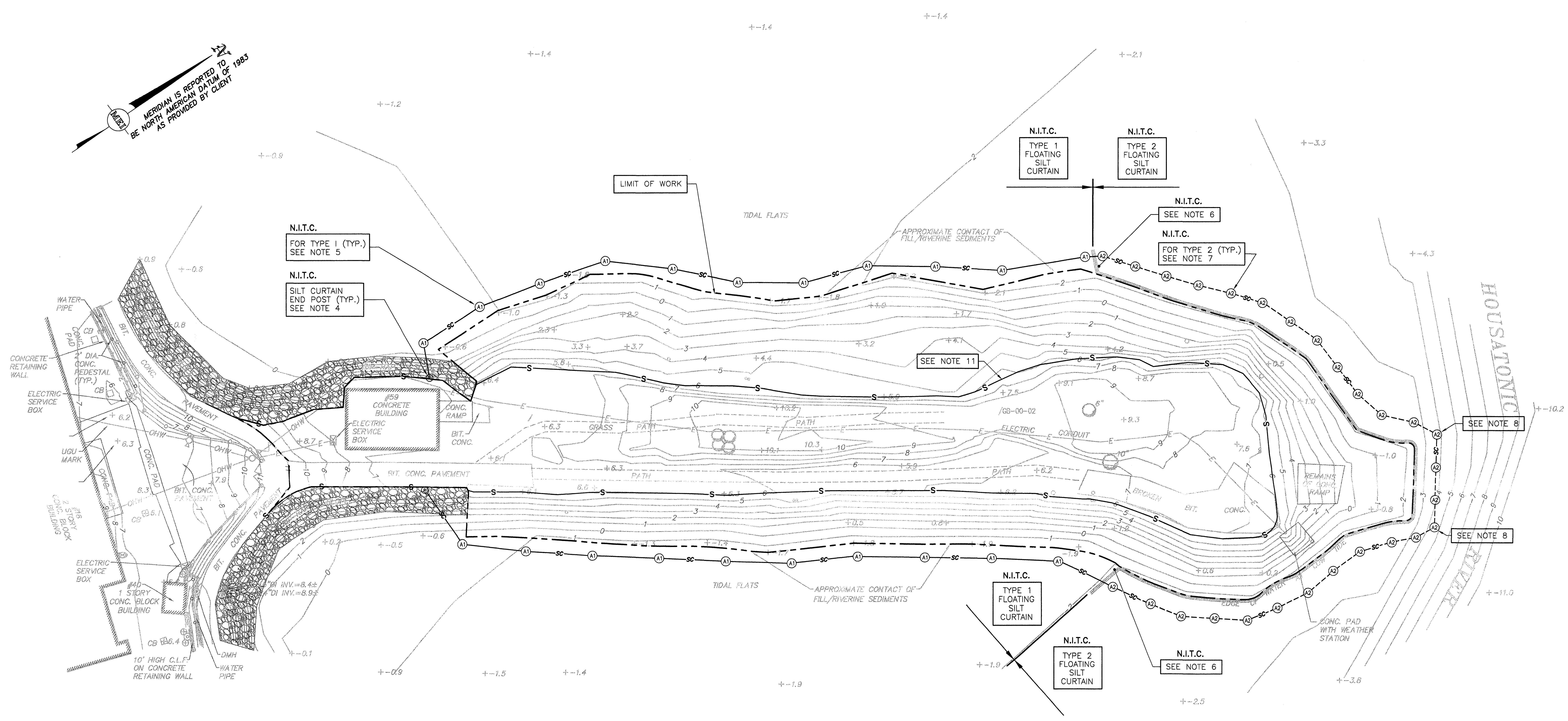
NON-TIME CRITICAL REMOVAL ACTION
CAUSEWAY COVER DESIGN (PHASE I)
STRATFORD ARMY ENGINE PLANT

STRATFORD, CONNECTICUT

**SITE CONTROL AND**
**BUILDING DEMOLITION**

Sheet reference number:
C-102
SHEET 3 OF 7



## LEGEND

| | | | |
|---|---|---|---|
| CONC. | CONCRETE | | WATER GATE BOX |
| BIT. CONC. | BITUMINOUS CONCRETE | ⊕ | BOLLARD |
| DIA. | DIAMETER | ☒ | ELECTRIC BOX |
| CB ☐ | CATCH BASIN | ◎ | HYDRANT |
| —○— C.L.F. —○— | CHAIN LINK FENCE | ○ | DRAIN MANHOLE |
| | RETAINING WALL | D.I. | DUCTILE IRON |
| ——— 4 ——— | 1' CONTOUR | INV. | INVERT |
| ——— OHW ——— | OVERHEAD WIRE | | EXISTING RIPRAP |
| ——— E ——— | ELECTRIC CONDUIT (ON GRADE) | | EDGE OF WATER AT LOW TIDE |
| ——— SC ——— | FLOATING SILT CURTAIN TYPE 1 | +7.9 | SPOT GRADE<br>(– INDICATES NEGATIVE) |
| - - - SC - - - | FLOATING SILT CURTAIN TYPE 2 | UGU | UNDERGROUND UTILITY MARK |
| ——— (A1) ——— | TYPE 1 ANCHOR | ○ 6" | TREE |
| - - - (A2) - - - | TYPE 2 ANCHOR | | |
| ——— — — ——— | LIMIT OF WORK | | |
| ——— S ——— | SILTATION FENCE | | |
| Ⓟ | END POST FOR FLOATING SILT CURTAIN | | |

0 20 40 80 FEET

SCALE: 1"=40'

## NOTES:

1. SEE DRAWING C–101 FOR SURVEY REFERENCES.
2. NO ACTIVE EXCAVATION OR BACKFILLING TO BE PERFORMED UNDER TIDAL WATERS.
3. PROVIDE FLOATING SILT CURTAIN AROUND CAUSEWAY AS SHOWN ON DRAWING. MINIMIZE SEPARATION BETWEEN LIMITS OF WORK AND FLOATING SILT CURTAIN, REFER TO C–301. **N.I.T.C.**
4. END POSTS TO BE SET AS INDICATED ON DRAWING C–301. BASE OF END POSTS SHALL BE AT OR ABOVE ELEVATION 6. **N.I.T.C.**
5. INSTALL TYPE 1 ANCHORS, SUCH THAT TYPE 1 FLOATING SILT CURTAIN SETTLES NO CLOSER THAN 5 FEET FROM LIMITS OF WORK, OR AS APPROVED. ANCHOR LOCATIONS SHOWN ARE APPROXIMATELY 10 FEET OUT FROM LIMITS OF WORK. **N.I.T.C.**
6. PROVIDE OPENING BETWEEN CONTACT OF FILL/RIVERINE SEDIMENTS AND FLOATING SILT CURTAIN TO FACILITATE TIDAL FLOW BEHIND TYPE I SILT CURTAIN DURING LOW TIDE. **N.I.T.C.**
7. INSTALL TYPE 2 ANCHORS, SUCH THAT TYPE 2 FLOATING SILT CURTAIN SETTLES NO CLOSER THAN 5 FEET FROM LIMITS OF WORK, OR AS APPROVED. ANCHOR LOCATIONS SHOWN ARE APPROXIMATELY 15 FEET OUT FROM LIMITS OF WORK. **N.I.T.C.**
8. PROVIDE ADDITIONAL TYPE 2 ANCHORS WHERE NECESSARY TO PROVIDE ADDITIONAL SUPPORT AND TENSION ON SILT CURTAIN. **N.I.T.C.**
9. INSTALL SILTATION FENCE AT THE APPROXIMATE LOCATION SHOWN. TEMPORARILY REMOVE AND RE–INSTALL TOWARD TIDAL FLATS TO FACILITATE WORK. REPLACE WHEN NO WORK IS IN PROGRESS.
10. THE LIMIT OF WORK CORRESPONDS WITH THE APPROXIMATE CONTACT OF FILL/ RIVERINE SEDIMENTS, EDGE OF WATER AT LOW TIDE, OR EDGE OF EXISTING RIPRAP. WHERE PRESENT.
11. PROVIDE SILTATION FENCE BETWEEN EXCAVATION AREA EA–5 (SEE DRAWING C–104) AND THE TIDAL FLATS, AS REQUIRED AND AS APPROVED BY THE CONTRACTING OFFICER.
12. PLACE AND MAINTAIN TEMPORARY EROSION CONTROL BLANKET IN DISTURBED AREAS, ABOVE ELEVATION OF SILTATION FENCE, IN ACCORDANCE WITH CONTRACTOR'S APPROVED WORK PLAN.

BRIAN BANES JOHNSON
No. 19726
8/17/01

US Army Corps of Engineers
New England District

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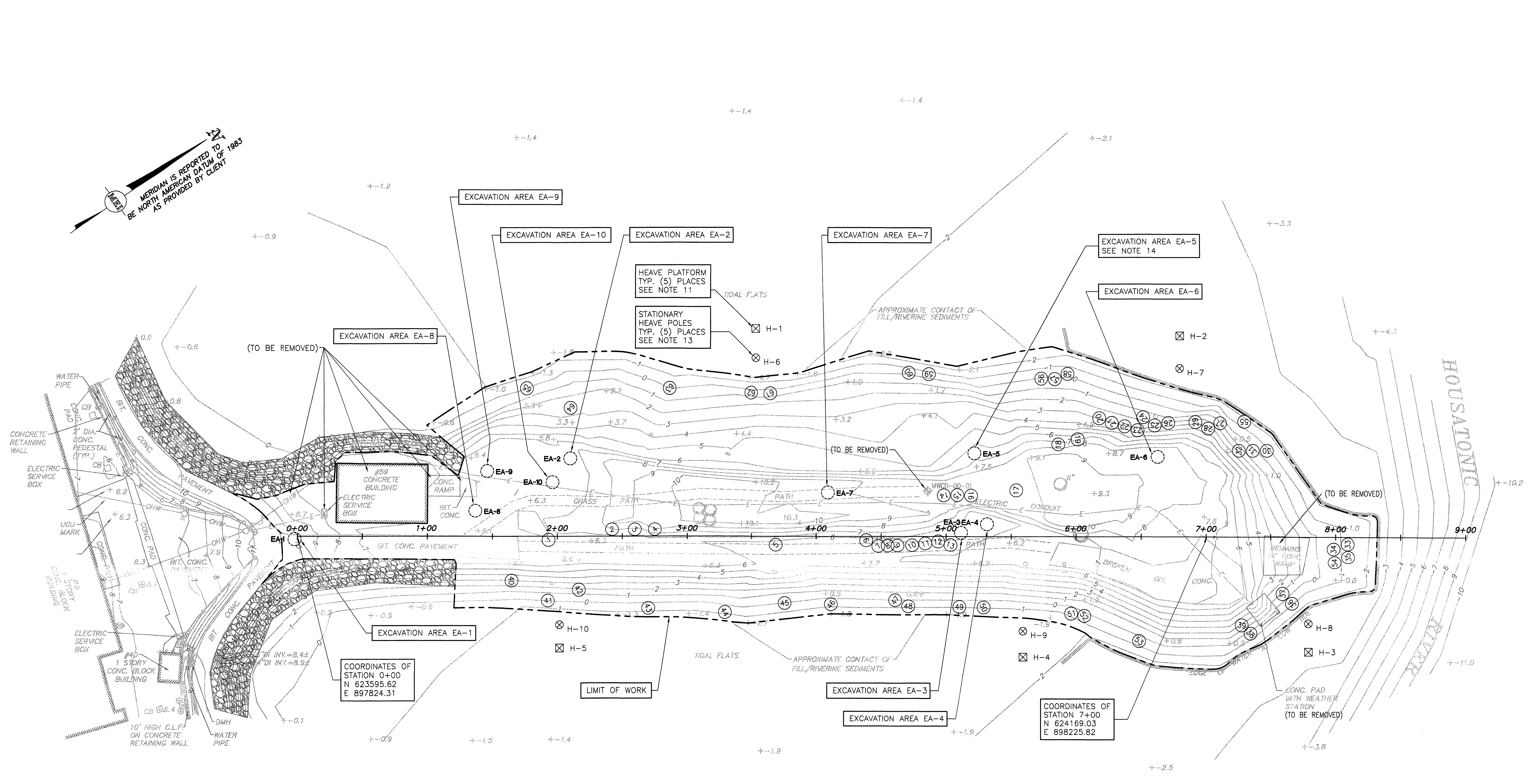
| **Dwn by:** E.J.LEDUC | **Ckd by:** | **Design file no.** C47254SP03 | |
| **Reviewed by:** N. Walter | | **Drawing code:** | |
| **Submitted by:** | | **File name:** C47254SP03<br>**Plot date:** | |
| **Chief, Arch. Branch** | | **Plot scale:** 1"=40' | |

NON–TIME CRITICAL REMOVAL ACTION
CAUSEWAY COVER DESIGN (PHASE I)
STRATFORD ARMY ENGINE PLANT

STRATFORD, CONNECTICUT

**EROSION AND SEDIMENT CONTROL**

Sheet reference number:
C–103
SHEET 4 OF 7



## LEGEND

| | | | |
|---|---|---|---|
| CONC. | CONCRETE | | WATER GATE |
| BIT. CONC. | BITUMINOUS CONCRETE | | BOLLARD |
| DIA. | DIAMETER | ☒ | ELECTRIC BOX |
| CB ☐ | CATCH BASIN | ——E—— | ELECTRIC CONDUIT (ON GRADE) |
| —o—C.L.F.—o— | CHAIN LINK FENCE | | HYDRANT |
| | RETAINING WALL | Ⓓ | DRAIN MANHOLE |
| ——4—— | 1' CONTOUR | D.I. | DUCTILE IRON |
| +7.9 | SPOT GRADE (– INDICATES NEGATIVE) | INV. | INVERT |
| | MONITORING WELL | | EXISTING RIPRAP |
| UGU | UNDERGROUND UTILITY MARK | ○ 6" | TREE |
| | APPROXIMATE CONTACT OF FILL/RIVERINE SEDIMENTS | — — — | LIMIT OF WORK |
| | EDGE OF WATER AT LOW TIDE | ○ | APPROXIMATE LIMIT OF EXCAVATION AREA |
| ——OHW—— | OVERHEAD WIRE | (40) | DIRECTION PHOTO TAKEN (SEE NOTE 12) |
| | | ☒ | HEAVE PLATFORM |
| | | ⊗ | STATIONARY HEAVE POLE |

0 20 40 80 FEET

SCALE: 1"=40'

## NOTES:

1. SEE DRAWING C-101 FOR SURVEY REFERENCES.
2. WITHIN THE LIMIT OF WORK, REMOVE OVERSIZE (>2 FT IN ANY DIMENSION) MATERIAL AND DISPOSE OFF SITE IN ACCORDANCE WITH SPECIFICATIONS.
3. DEMOLISH CONCRETE BUILDING #59 AND SLAB AND DISPOSE OFF SITE.
4. NO EXCAVATION OR BACKFILLING TO BE PERFORMED UNDER TIDAL WATERS.
5. PROVIDE SILT BOOM AROUND CAUSEWAY AS SHOWN ON DRAWING C-103 AND IN ACCORDANCE WITH THE APPROVED EROSION AND SEDIMENT CONTROL PLAN. **N.I.T.C.**
6. CLEAR AND GRUB TREES, BRUSH, ETC. CHIP TREES AND SPREAD ON SITE.
7. PROTECT ALL WELLS TO REMAIN. WELLS TO REMAIN TO BE EXTENDED AND MADE FLUSHMOUNTS AS PART OF PHASE II **(N.I.T.C.)**. WELL MWCD-00-01 TO BE DECOMMISSIONED.
8. EXCAVATE AND REMOVE CONTAMINATED MATERIALS FROM AREAS EA-1 THRU EA-10 AT LOCATIONS SHOWN AND DISPOSE AT AN APPROVED AND LICENSED OFF-SITE FACILITY. REFER TO APPENDIX F OF THE BASIS OF DESIGN FOR PREVIOUS SOIL SAMPLING RESULTS.
9. CONTRACTING OFFICER OR A REPRESENTATIVE TO SELECT LOCATIONS FOR CONFIRMATORY SAMPLING; CONTRACTOR SHALL ASSIST IN SAMPLE COLLECTION.
10. STATIONING SHOWN WILL BE USED FOR PHASE II WORK. PROVIDED FOR INFORMATION ONLY.
11. HEAVE PLATFORMS SHALL BE PLACED IN THE APPROXIMATE LOCATION SHOWN, 40 FEET FROM THE CONTACT OF FILL/RIVERINE SEDIMENTS ON THE NORTH SIDE OF THE CAUSEWAY, AND 30 FEET FROM THE CONTACT ON THE SOUTH SIDE OF THE CAUSEWAY.
12. PHOTOGRAPHS ARE PROVIDED AS AN APPENDIX TO THE SPECIFICATIONS. PHOTOGRAPHS ARE PROVIDED FOR INFORMATION ONLY. CONTRACTOR IS RESPONSIBLE FOR CONFIRMING ALL INFORMATION AND ASSUMPTIONS RELATIVE TO PHOTOGRAPHS PROVIDED.
13. STATIONARY HEAVE POLES SHALL BE PLACED IN THE APPROXIMATE LOCATION SHOWN, 15 FEET FROM CONTACT OF FILL/RIVERINE SEDIMENTS ON THE NORTH SIDE OF THE CAUSEWAY, AND 10 FEET FROM THE CONTACT ON THE SOUTH SIDE OF THE CAUSEWAY.
14. PROVIDE SILTATION FENCE AROUND EXCAVATION AREA EA-5, AS REQUIRED AND AS APPROVED BY THE CONTRACTING OFFICER.

BRIAN BANES JOHNSON
No. 19726
8/17/01

### APPROXIMATE VOLUMES OF OVERSIZE MATERIAL TO BE REMOVED FROM THE CAUSEWAY

| Photograph(s) (See Note 12) | Length (ft.) | Width (ft.) | Height (ft.) | Cubic Feet |
|---|---|---|---|---|
| 1 | 15 | 10 | 4 | 600 |
| 2 | 10 | 3 | 4 | 120 |
| 3 | 10 | 10 | 4 | 400 |
| 4 | 10 | 10 | 4 | 400 |
| 5 thru 17 | 320 | 40 | 3 | 38400 |
| 18 thru 32 | 180 | 40 | 3 | 21600 |
| 33 thru 35 | 30 | 30 | 2 | 1800 |
| 41 | 6 | 12 | 2 | 144 |
| 42 | 12 | 6 | 1 | 72 |
| 43 thru 53 | 400 | 10 | 2 | 8000 |
| 58 thru 65 | 400 | 40 | 2 | 32000 |

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| Submitted by: | | File name: C47254SP04<br>Plot date:<br>Plot scale: 1"=40' |
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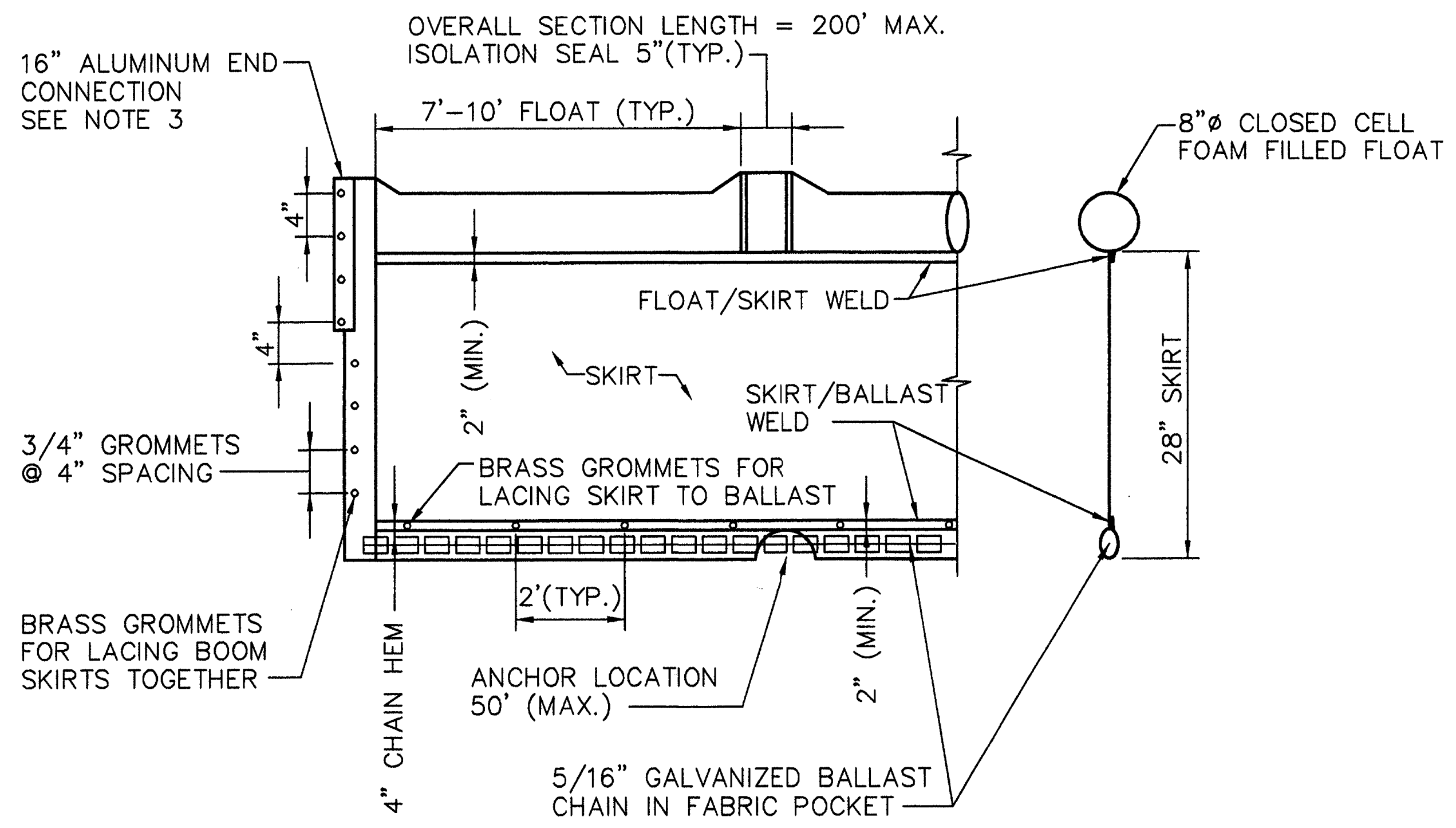
NON-TIME CRITICAL REMOVAL ACTION
CAUSEWAY COVER DESIGN (PHASE I)
STRATFORD ARMY ENGINE PLANT

STRATFORD, CONNECTICUT

PHASE I
SITE PLAN

Sheet
reference
number:
C-104
SHEET 5 OF 7

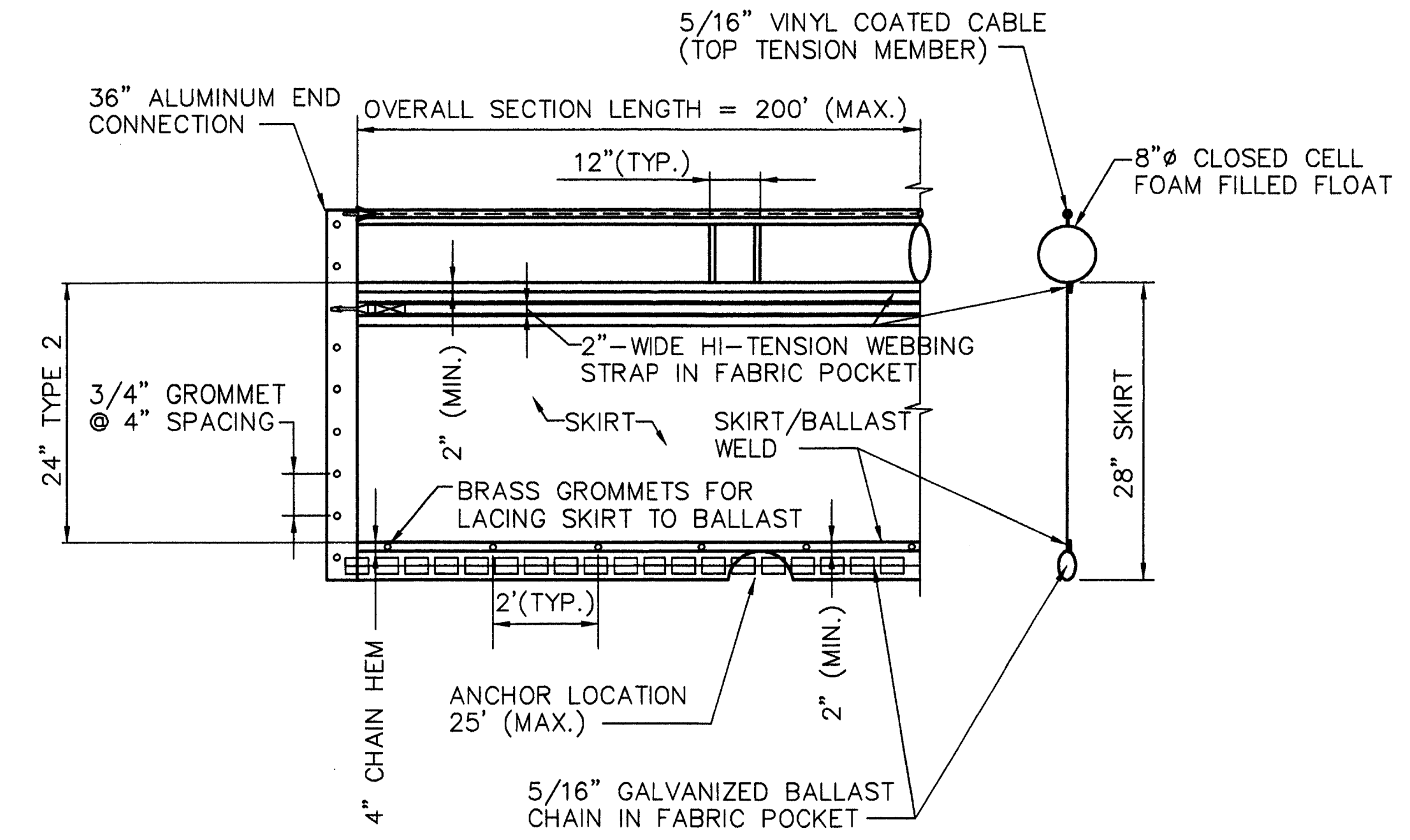


NOTES:
1. LABEL FLOAT ON BOTH SIDES WITH "CAUTION UNDERWATER CABLES KEEP AWAY 25 FEET".
2. SKIRT MATERIAL SHALL BE TYPE 1.
3. PROVIDE CONTINUOUS ALUMINUM END CONNECTION WHERE SILT CURTAIN TYPE 1 TERMINATES AT SUPPORT POST AND AT CONNECTION WITH TYPE 2 CURTAIN.

## TYPICAL FLOATING SILT CURTAIN (TYPE 1)

N.T.S.

N.I.T.C.

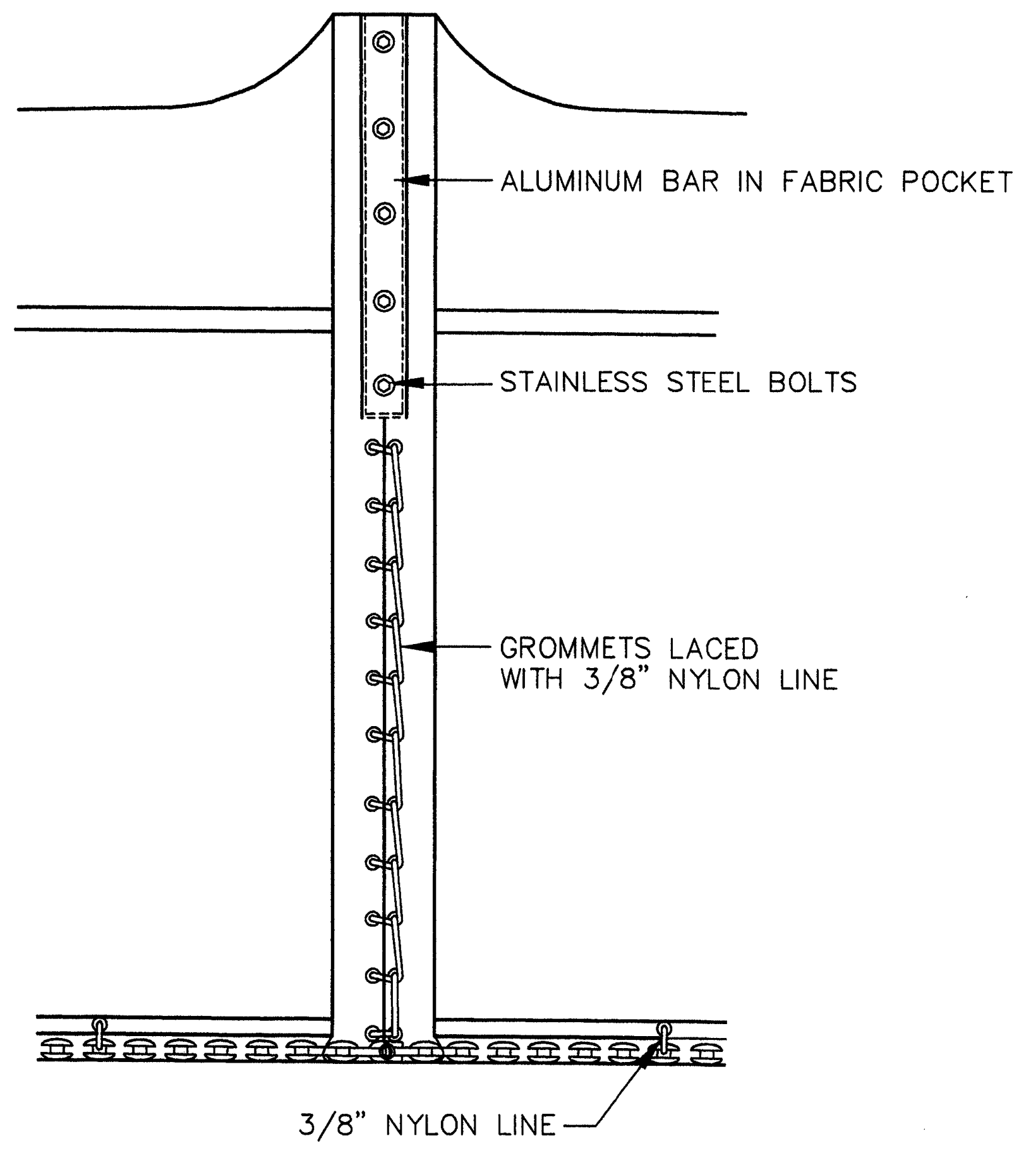


NOTES:
1. LABEL FLOAT ON BOTH SIDES WITH "CAUTION UNDERWATER CABLES KEEP AWAY 25 FEET".
2. SKIRT MATERIAL SHALL BE TYPE 2.

## TYPICAL FLOATING SILT CURTAIN (TYPE 2)

N.T.S.

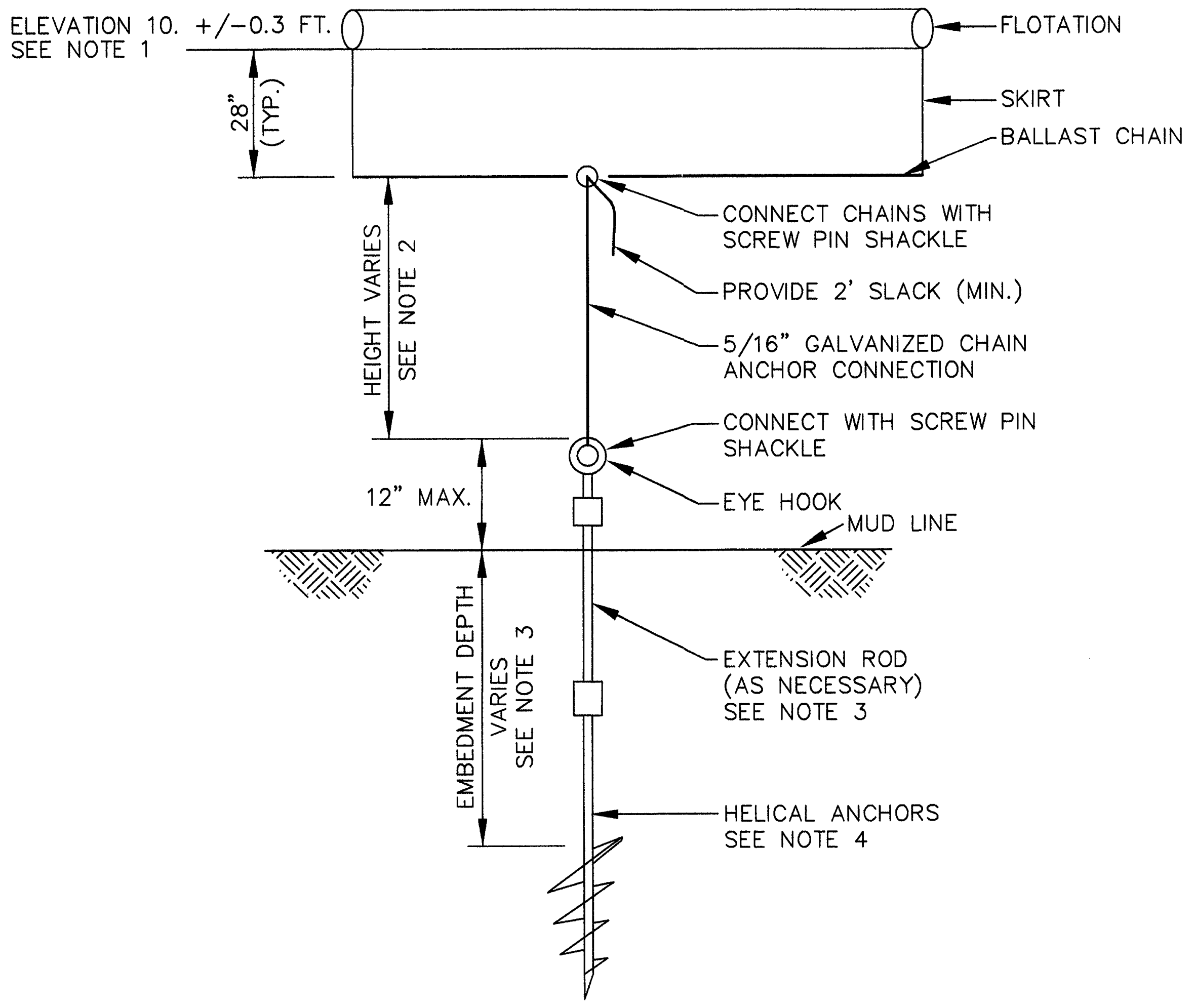
N.I.T.C.



## TYPICAL END CONNECTION (TYPE 1)

N.T.S.

N.I.T.C.

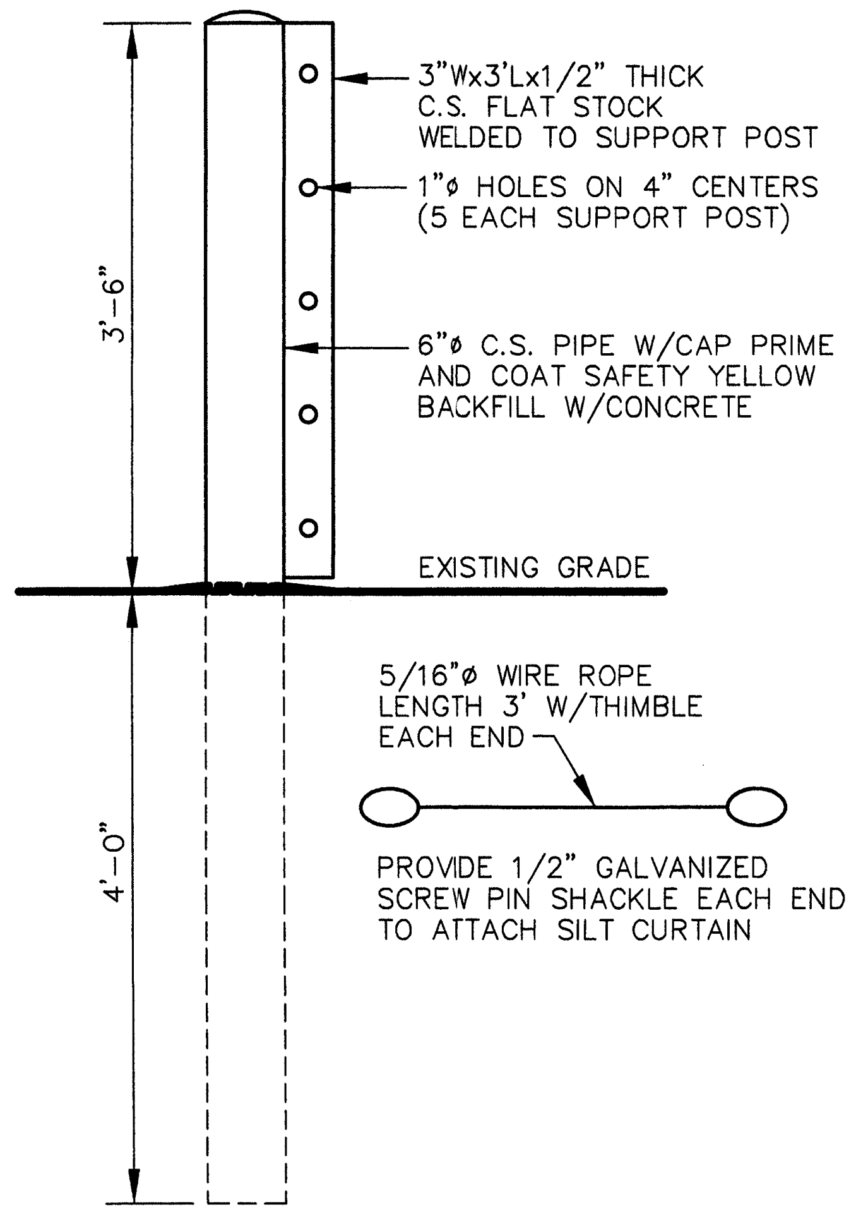


NOTES:
1. FABRICATE ANCHOR CONNECTION TO PROVIDE AN ELEVATION OF THE BOTTOM OF FLOTATION AT 10+/- 0.3 FEET.
2. VARY LENGTH OF CHAIN TO PROVIDE REQUIRED FLOAT ELEVATION, BASED ON ELEVATION OF EYEHOOK.
3. PROVIDE ANCHOR DEPTH NECESSARY TO PROVIDE REQUIRED HORIZONTAL AND VERTICAL LOAD RESISTANCE, FOR EACH ANCHOR TYPE.
4. HELICAL ANCHOR SIZE AND TYPE MAY VARY BASED ON SOIL TYPE AND ANCHOR TYPE.

## FLOATING SILT CURTAIN ANCHOR DETAIL

N.T.S.

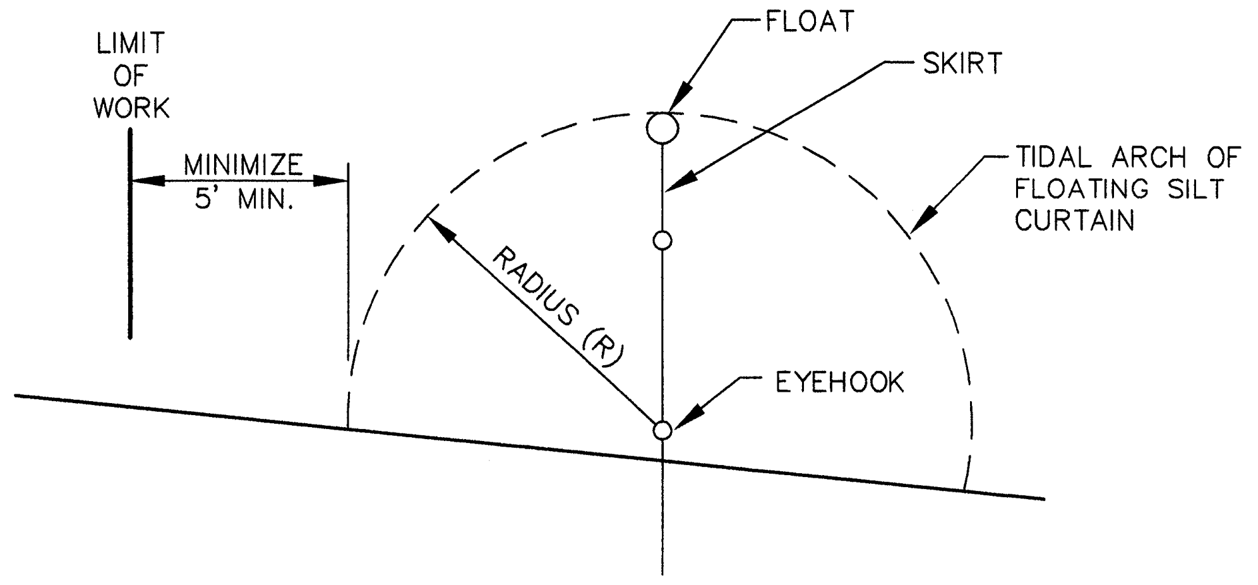
N.I.T.C.



## SILT CURTAIN SUPPORT POST

N.T.S.

N.I.T.C.



NOTES:
1. MINIMIZE THE SEPARATION OF SILT CURTAIN AT LOW TIDE BETWEEN FLOAT AND LIMIT OF WORK. MAINTAIN MINIMUM 5-FOOT SEPARATION.

## FLOATING SILT CURTAIN ANCHOR LOCATION

N.T.S.

N.I.T.C.

No. 19726

8/17/01

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| Reviewed by: | | Drawing code: | |
| Submitted by: | | File name: C47254DT01<br>Plot date:<br>Plot scale: 1=1 | |
| Chief, Arch. Branch | | | |

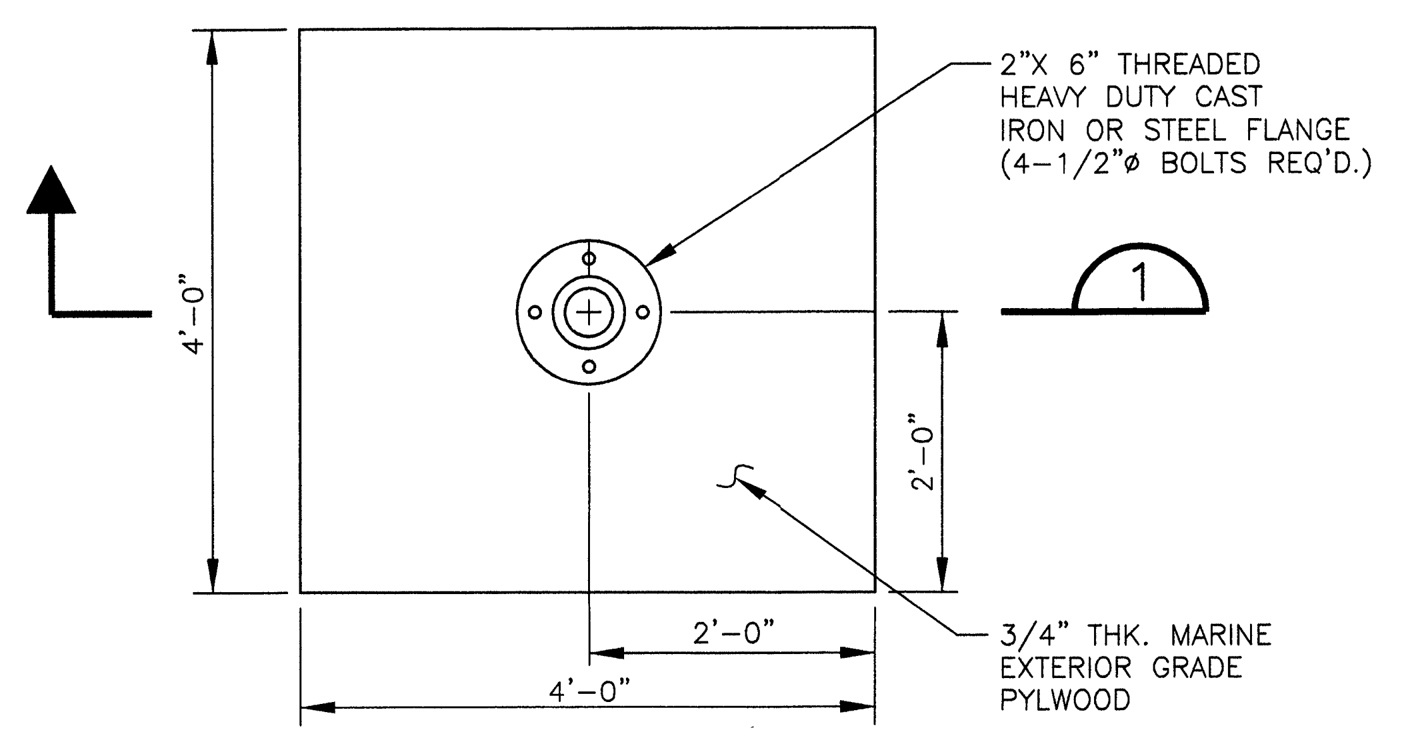
NON-TIME CRITICAL REMOVAL ACTION
CAUSEWAY COVER DESIGN (PHASE I)
STRATFORD ARMY ENGINE PLANT

STRATFORD, CONNECTICUT

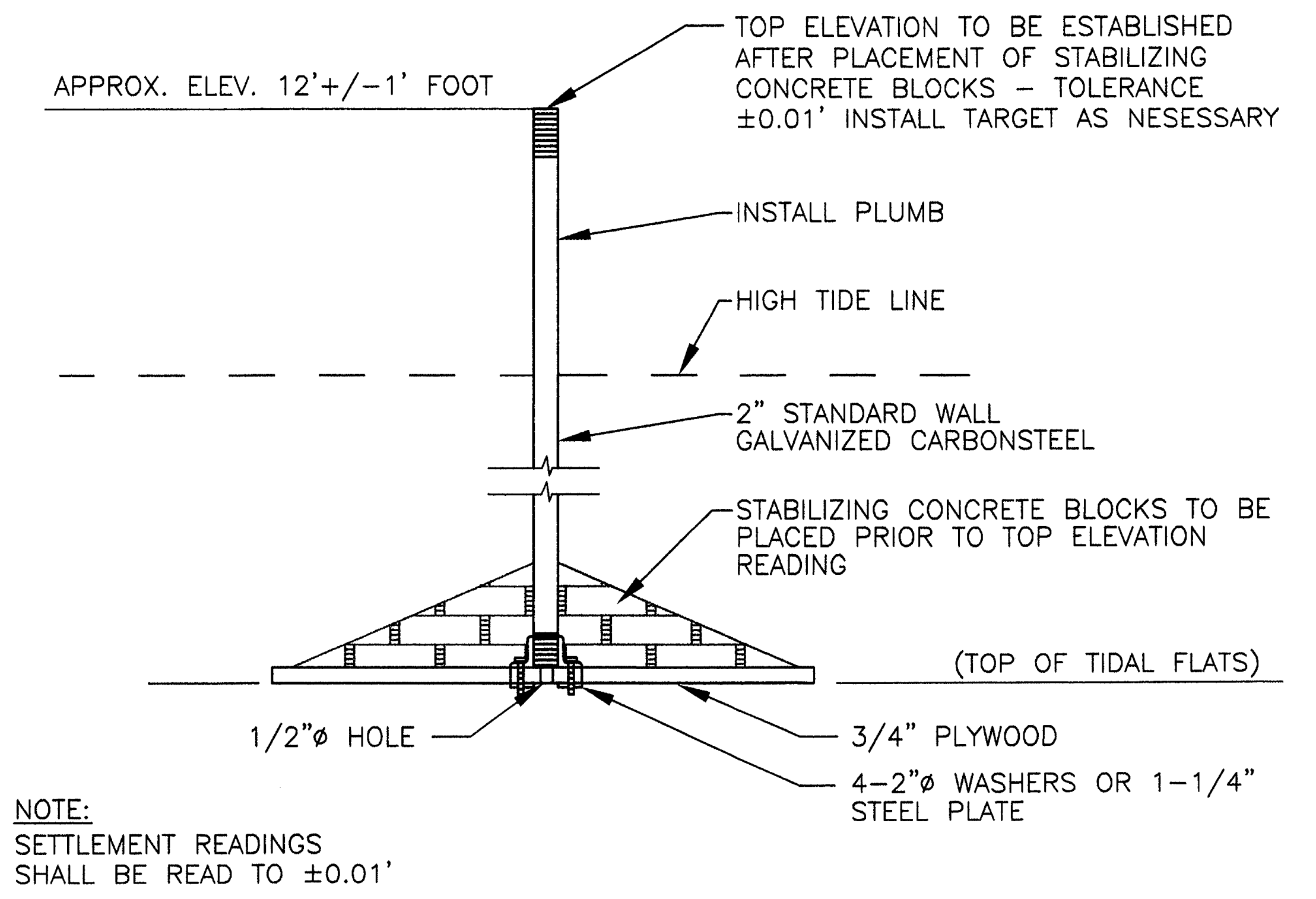
MISCELLANEOUS
DETAILS

Sheet reference number:
C-301

SHEET 6 OF 7



## PLAN

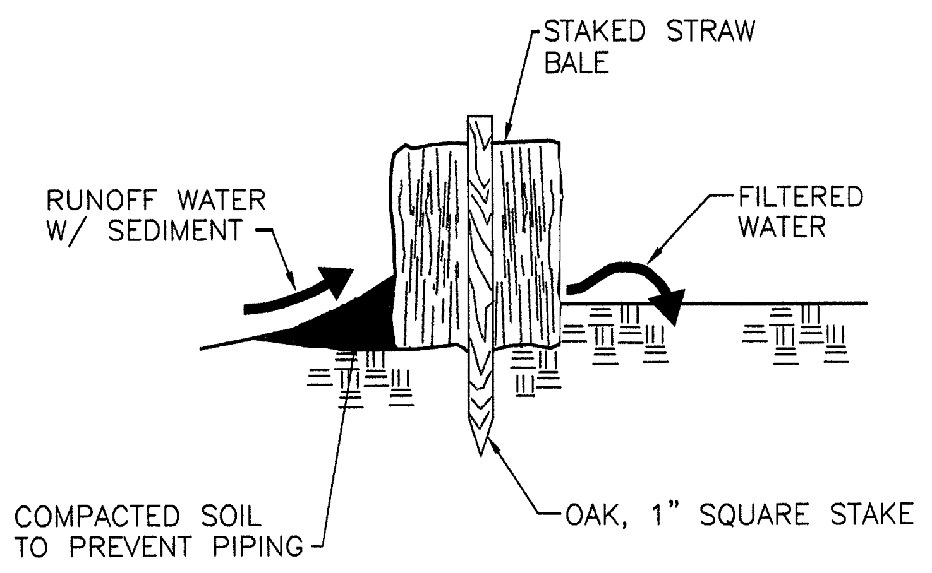


NOTE:
SETTLEMENT READINGS
SHALL BE READ TO ±0.01'

## SECTION 1

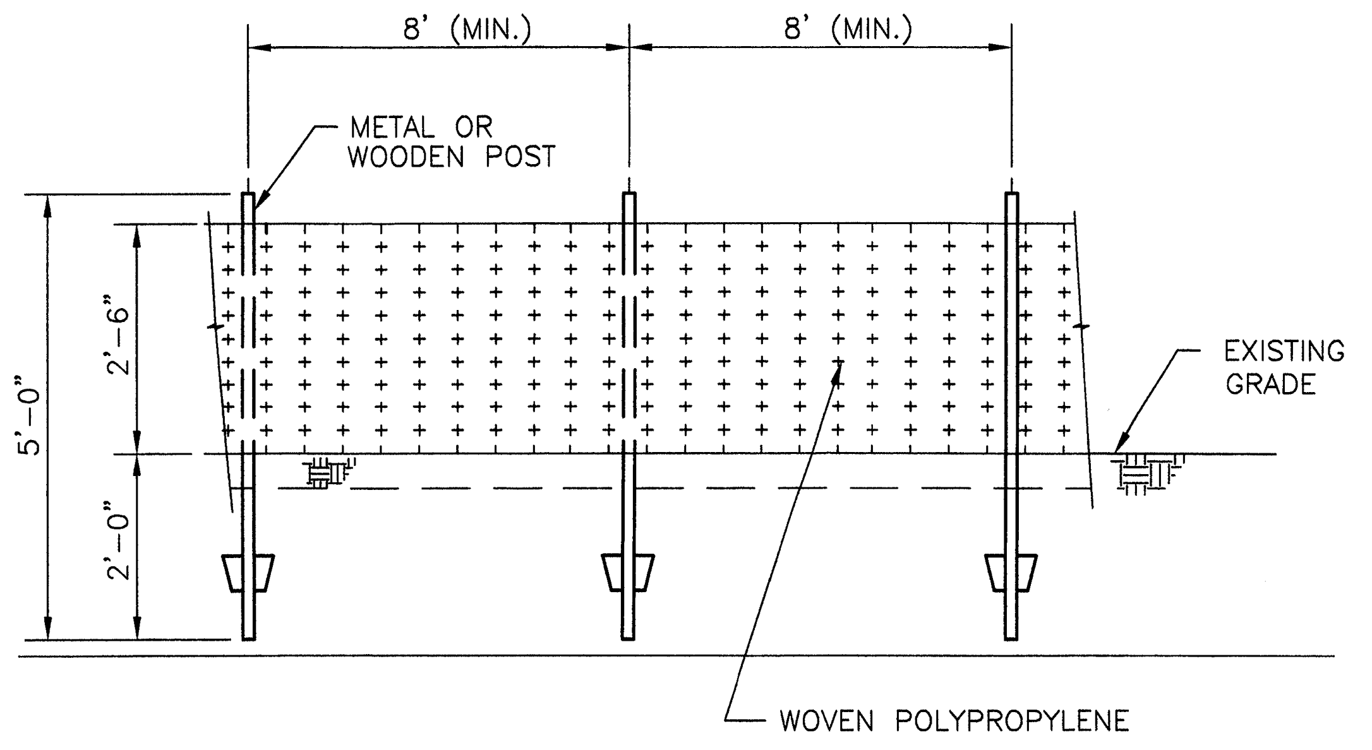
## HEAVE PLATFORMS

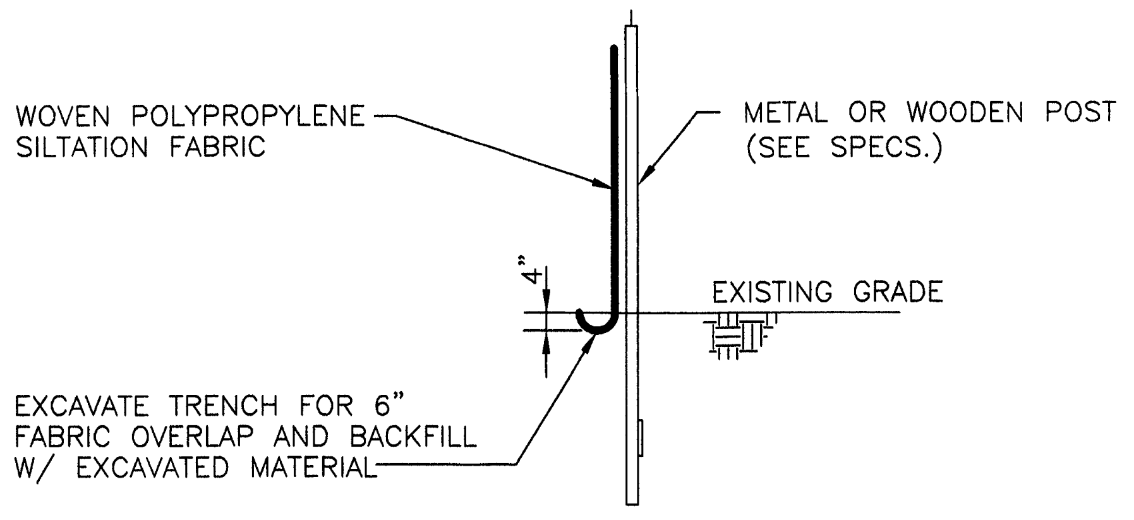
NOT TO SCALE



## HAYBALE INSTALLATION

NOT TO SCALE





## SILTATION FENCE

NOT TO SCALE

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Ckd by: K. Klenn
Reviewed by: K. Walter
Submitted by:
Chief, Arch. Branch
Date: 8/17/01
Rev. 0
Design file no. C47254DT01
Drawing code:
File name: C47254DT02
Plot date:
Plot scale: 1=1

NON-TIME CRITICAL REMOVAL ACTION
CAUSEWAY COVER DESIGN (PHASE I)
STRATFORD ARMY ENGINE PLANT
STRATFORD, CONNECTICUT

MISCELLANEOUS
DETAILS

BRIAN BARNES JOHNSON
No. 19726
8/17/01

Sheet
reference
number:
C-302
SHEET 7 OF 7

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# ATTACHMENT B

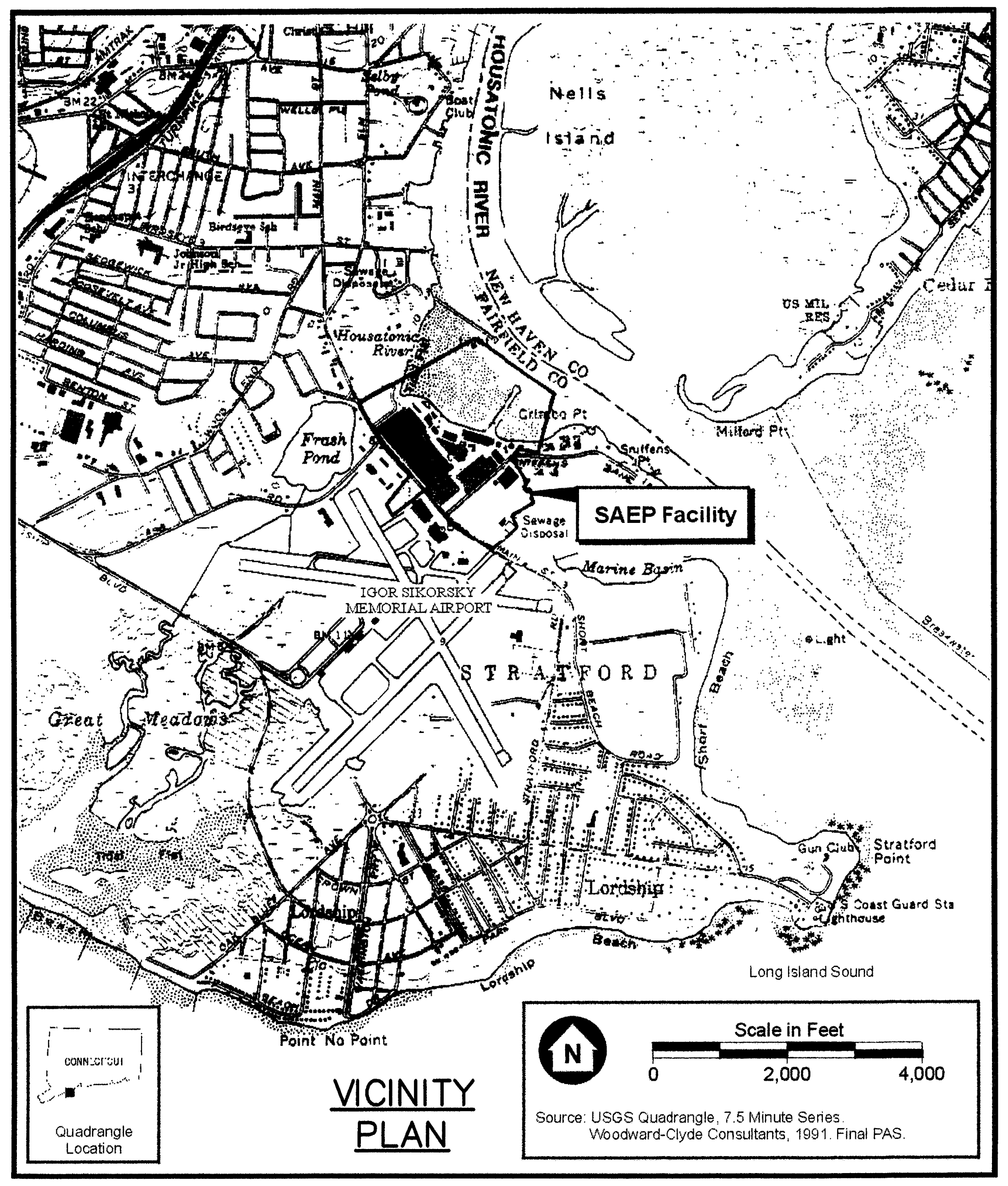
# PHASE II DRAWINGS

# NON-TIME CRITICAL REMOVAL ACTION
# STRATFORD ARMY ENGINE PLANT
# STRATFORD, CONNECTICUT

## 100% CAUSEWAY COVER DESIGN
## PHASE II

### INDEX OF SHEETS

| Description | Sheet No. |
|---|---|
| Title Sheet | I-1 |
| Pre-Phase I Conditions Plan | C-101 |
| Site Control | C-102 |
| Erosion and Sediment Control | C-103 |
| Phase II Site Plan | C-104 |
| Phase II Subgrade - Development Plan | C-105 |
| Miscellaneous Details | C-301 |
| Miscellaneous Details | C-302 |
| Miscellaneous Details | C-303 |



VICINITY PLAN

Source: USGS Quadrangle, 7.5 Minute Series.
Woodward-Clyde Consultants, 1991. Final PAS.

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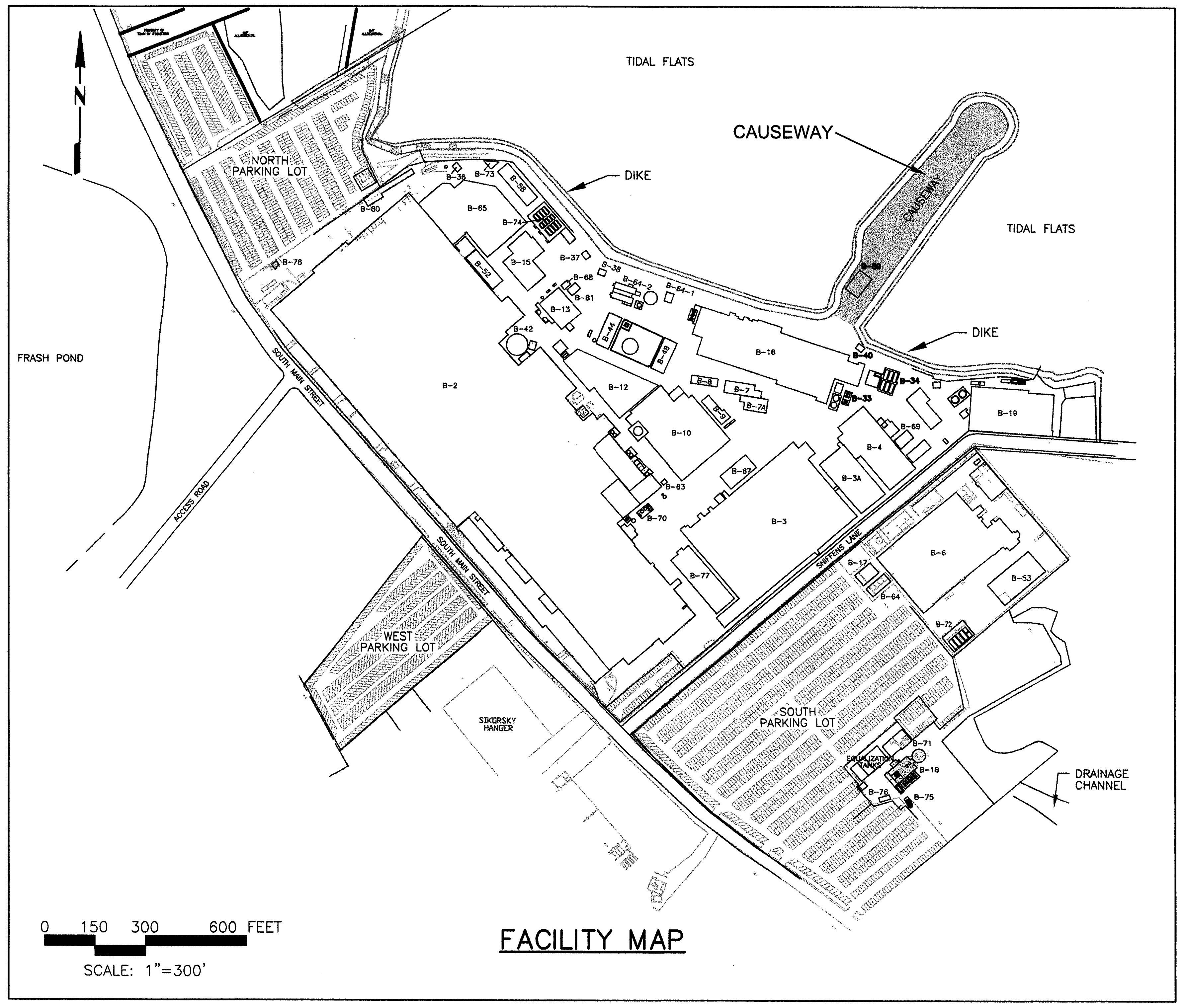

FACILITY MAP

US Army Corps
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| B | PHASE II 90% CLIENT REVIEW | 5/9/01 | BBJ |
| A | 30% CLIENT REVIEW | 1/26/01 | DRP |

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|---|---|---|---|

Designed by: B. JOHNSON
Dwn by: E.J.LEDUC
Ckd by: K. Kem
Reviewed by: R. Dalter
Submitted by:
Chief, Arch. Branch

Date: 8/30/01
Rev. 0
Design file no. C50796COV2
Drawing code:
File name: C4725COV2
Plot date:
Plot scale: 1=1

U.S. ARMY CORPS OF ENGINEERS
NEW ENGLAND DISTRICT
CONCORD, MASSACHUSETTS

Harding ESE
A MACTEC COMPANY
P.O. Box 7050, 511 Congress Street
Portland, ME 04112-7050
(207) 775-5401

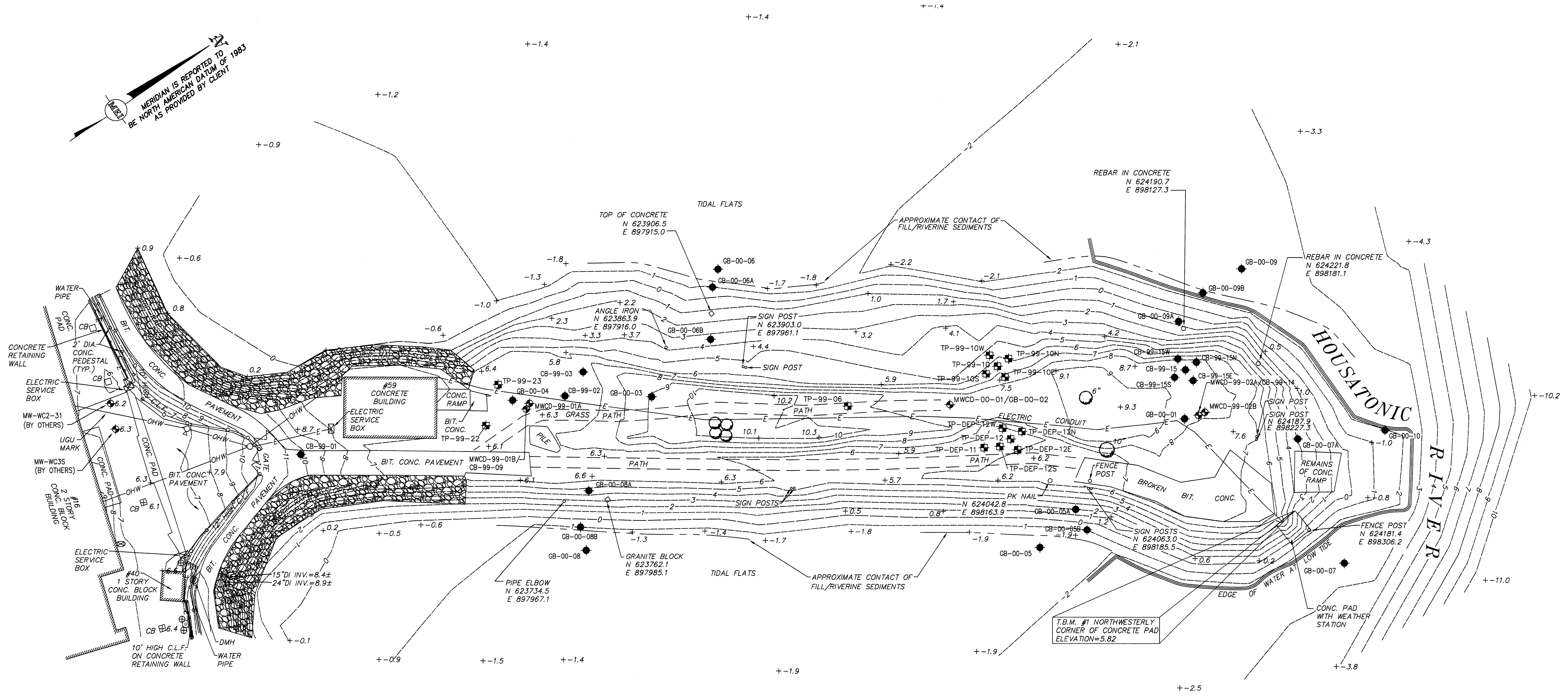
NON-TIME CRITICAL REMOVAL ACTION
CAUSEWAY COVER DESIGN (PHASE II)
STRATFORD ARMY ENGINE PLANT

STRATFORD, CONNECTICUT

**TITLE SHEET**

Sheet reference number:
I-1
SHEET 1 OF 9

P:\Projects\CBDCOM\SAEP\Causeway\PHASE2\C47254COV2.dwg Tue, 28 Aug 2001 - 12:37pm dalawrence



## LEGEND

| | | | |
|---|---|---|---|
| CONC. | CONCRETE | ○ 6" | TREE |
| BIT. CONC. | BITUMINOUS CONCRETE | ——OHW—— | OVERHEAD WIRE |
| DIA. | DIAMETER | ⊗ | WATER GATE |
| CB ☐ | CATCH BASIN | ⊕ | BOLLARD |
| —o—C.L.F.—o— | CHAIN LINK FENCE | ⊠ | ELECTRIC BOX |
| ═══ | RETAINING WALL | ——E—— | ELECTRIC CONDUIT (ON GRADE) |
| ——4—— | 1' CONTOUR | ◎ | HYDRANT |
| ——5—— | 5' CONTOUR | Ⓓ | DRAIN MANHOLE |
| —— — — —— | APPROXIMATE CONTACT OF FILL/RIVERINE SEDIMENTS | D.I. | DUCTILE IRON |
| +7.9 | SPOT GRADE (ELEV. MSL) (– INDICATES NEGATIVE) | INV. | INVERT |
| ⊕ | MONITORING WELL | ▨ | RIP RAP |
| ● | SOIL BORING | ≈ | EDGE OF WATER AT LOW TIDE |
| UGU | UNDERGROUND UTILITY MARK | | |
| ▣ | TESTPIT | | |
| CB-99-01 | BORINGS INSTALLED FOR PRE-DESIGN INVESTIGATION | | |
| GB-00-08 | BORINGS INSTALLED FOR GEOTECHNICAL INVESTIGATION | | |

0 20 40 80 FEET

SCALE: 1"=40'

## NOTES:

1. STRUCTURES AND FEATURES SHOWN ON THIS DRAWING ON THE CAUSEWAY ARE TO BE REMOVED OR CHANGED AS PART OF PHASE I ACTIVITIES. CONTOURS SHOWN REPRESENT PRE-PHASE I WORK.
2. THIS PLAN IS A TOPOGRAPHIC SURVEY IN ACCORDANCE WITH THE MOST RECENT CONNECTICUT ASSOCIATION OF LAND SURVEYORS, RECOMMENDED STANDARDS FOR SURVEY AND MAPS IN THE STATE OF CONNECTICUT. THIS MAP CONFORMS WITH A CLASS V2 VERTICAL ACCURACY AND CLASS T-1 TOPOGRAPHIC SURVEY ACCURACY. BASE MAP PRODUCED BY MERIDIAN ENGINEERING, INC.. SHEET 1 OF 1 ENTITLED "RECORD CONDITIONS PLAN OF LAND LOCATED IN STRATFORD CONNECTICUT". DATED OCTOBER 25, 2000.
3. HORIZONTAL AND VERTICAL CONTROL POINTS WERE PROVIDED BY MICHAEL G. WILMES, L.S. OF URS GREINER WOODWARD CLYDE. THE DATUMS WERE REPORTED TO BE ON THE NORTH AMERICAN DATUM OF 1983 AND NATIONAL GEODETIC VERTICAL DATUM OF 1929.
4. CONNECTICUT GEODETIC SURVEY DESIGNATIONS.

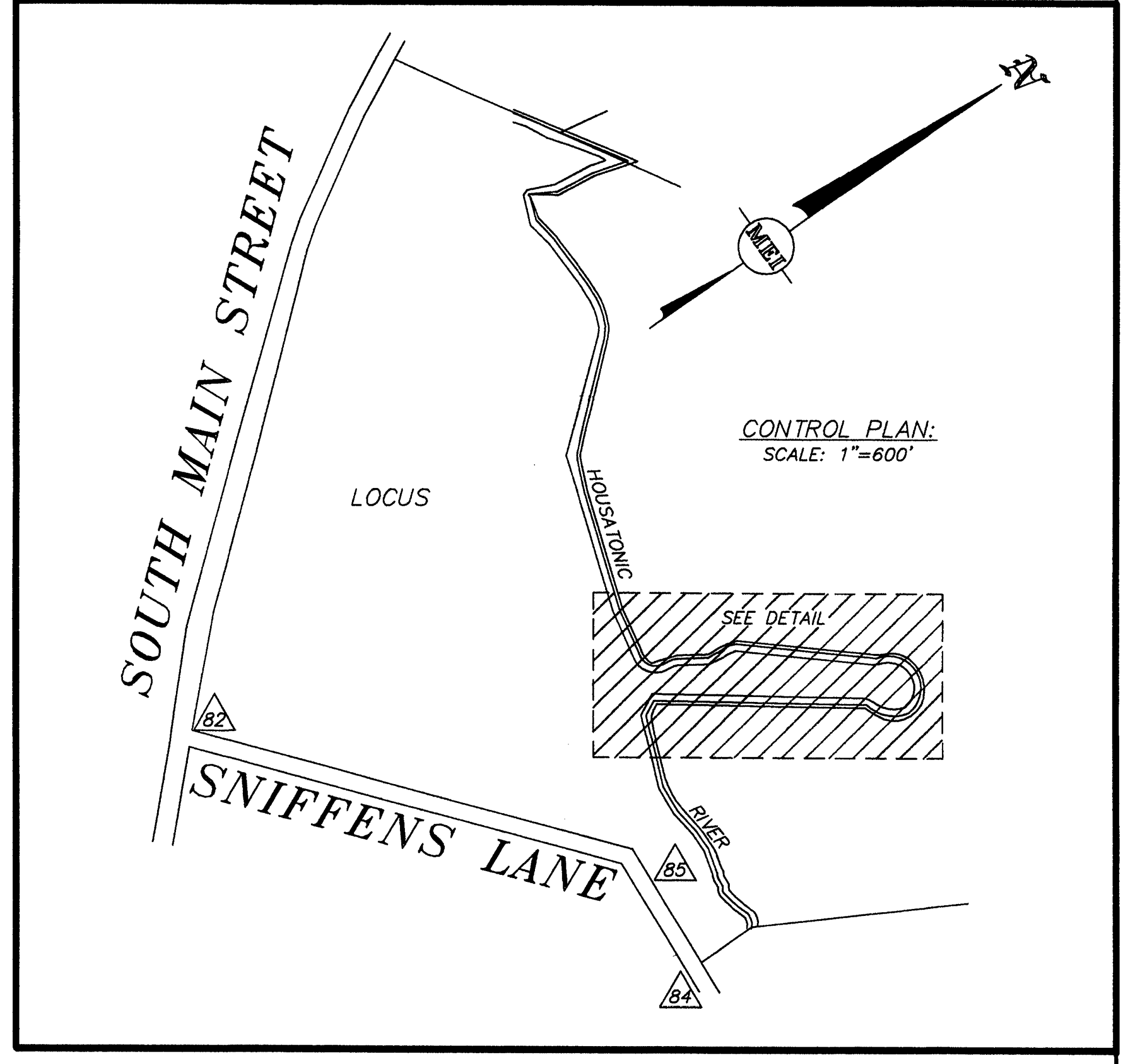
## CONTROL POINTS:

(SEE NOTE #3)

| CONTROL POINT | NORTHING | EASTING | ELEVATION | DESCRIPTION (NOTE 4) |
|---|---|---|---|---|
| △82 | 622340.109131 | 897135.274591 | 7.240 | F-15 |
| △84 | 623142.399102 | 898645.030716 | 10.550 | F-23 |
| △85 | 623212.133802 | 898244.245717 | 7.350 | F-24 |

No. 19726

8/30/01



US Army Corps
of Engineers
New England District

| Mark | Description | Date | Appr. |
|---|---|---|---|
| 0 | 100% ISSUED FOR CONSTRUCTION | 8/30/01 | BBJ |
| B | PHASE II 90% CLIENT REVIEW | 5/9/01 | BBJ |
| A | 30% CLIENT REVIEW | 1/26/01 | DRP |

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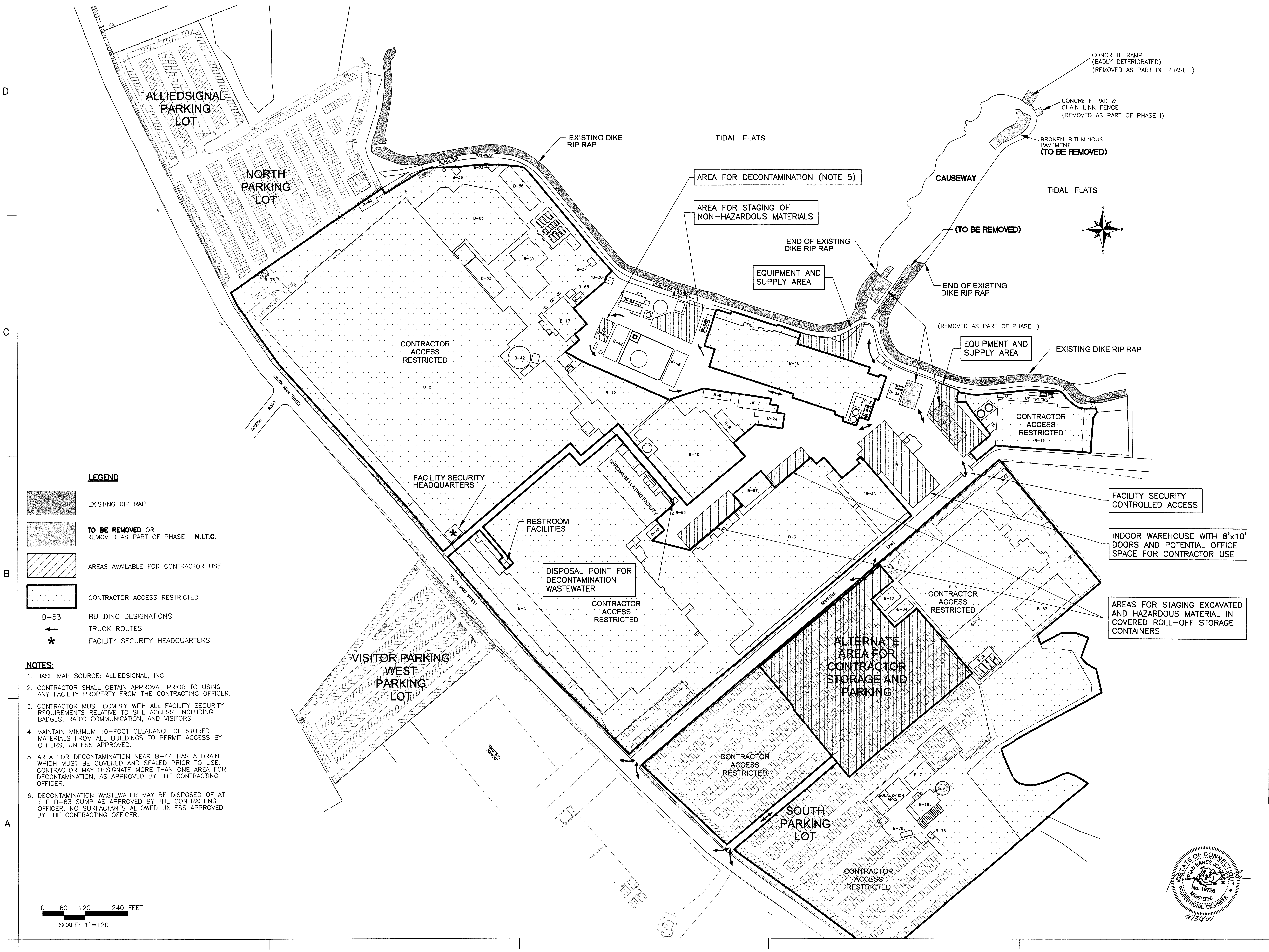
| | | |
|---|---|---|
| Designed by: B. JOHNSON | Date: 8/30/01 | Rev. 0 |
| Dwn by: E.J.LEDUC | Ckd by: K. Klem | Design file no. C47254SP01 |
| Reviewed by: N. Walter | Drawing code: | |
| Submitted by: | File name: C47254SP01<br>Plot date:<br>Plot scale: 1"=40' | |
| Chief, Arch. Branch | | |

NON-TIME CRITICAL REMOVAL ACTION
CAUSEWAY COVER DESIGN (PHASE II)
STRATFORD ARMY ENGINE PLANT

STRATFORD, CONNECTICUT

PRE-PHASE I
CONDITIONS
PLAN

Sheet
reference
number:
C-101
SHEET 2 OF 9



**LEGEND**

| | |
|---|---|
| ▩ | EXISTING RIP RAP |
| ░ | **TO BE REMOVED** OR REMOVED AS PART OF PHASE I **N.I.T.C.** |
| ▨ | AREAS AVAILABLE FOR CONTRACTOR USE |
| ☐ | CONTRACTOR ACCESS RESTRICTED |
| B-53 | BUILDING DESIGNATIONS |
| ← | TRUCK ROUTES |
| * | FACILITY SECURITY HEADQUARTERS |

**NOTES:**

1. BASE MAP SOURCE: ALLIEDSIGNAL, INC.
2. CONTRACTOR SHALL OBTAIN APPROVAL PRIOR TO USING ANY FACILITY PROPERTY FROM THE CONTRACTING OFFICER.
3. CONTRACTOR MUST COMPLY WITH ALL FACILITY SECURITY REQUIREMENTS RELATIVE TO SITE ACCESS, INCLUDING BADGES, RADIO COMMUNICATION, AND VISITORS.
4. MAINTAIN MINIMUM 10-FOOT CLEARANCE OF STORED MATERIALS FROM ALL BUILDINGS TO PERMIT ACCESS BY OTHERS, UNLESS APPROVED.
5. AREA FOR DECONTAMINATION NEAR B-44 HAS A DRAIN WHICH MUST BE COVERED AND SEALED PRIOR TO USE. CONTRACTOR MAY DESIGNATE MORE THAN ONE AREA FOR DECONTAMINATION, AS APPROVED BY THE CONTRACTING OFFICER.
6. DECONTAMINATION WASTEWATER MAY BE DISPOSED OF AT THE B-63 SUMP AS APPROVED BY THE CONTRACTING OFFICER. NO SURFACTANTS ALLOWED UNLESS APPROVED BY THE CONTRACTING OFFICER.

0 60 120 240 FEET

SCALE: 1"=120'

No. 19726

8/30/01

US Army Corps
of Engineers
New England District

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|---|---|---|---|---|---|---|---|
| 0 | 100% ISSUED FOR CONSTRUCTION | 8/30/01 | BBJ | | | | |
| A | PHASE II 90% CLIENT REVIEW | 5/9/01 | BBJ | | | | |

| | | | |
|---|---|---|---|
| Designed by: B.JOHNSON | | Date: 8/30/01 | Rev. 0 |
| Dwn by: E.J.LEDUC | Ckd by: K. Kern | Design file no. C472545P02 | |
| Reviewed by: | | Drawing code: | |
| Submitted by: | | File name: C472545P02<br>Plot date:<br>Plot scale: 1=120 | |
| Chief, Arch. Branch | | | |

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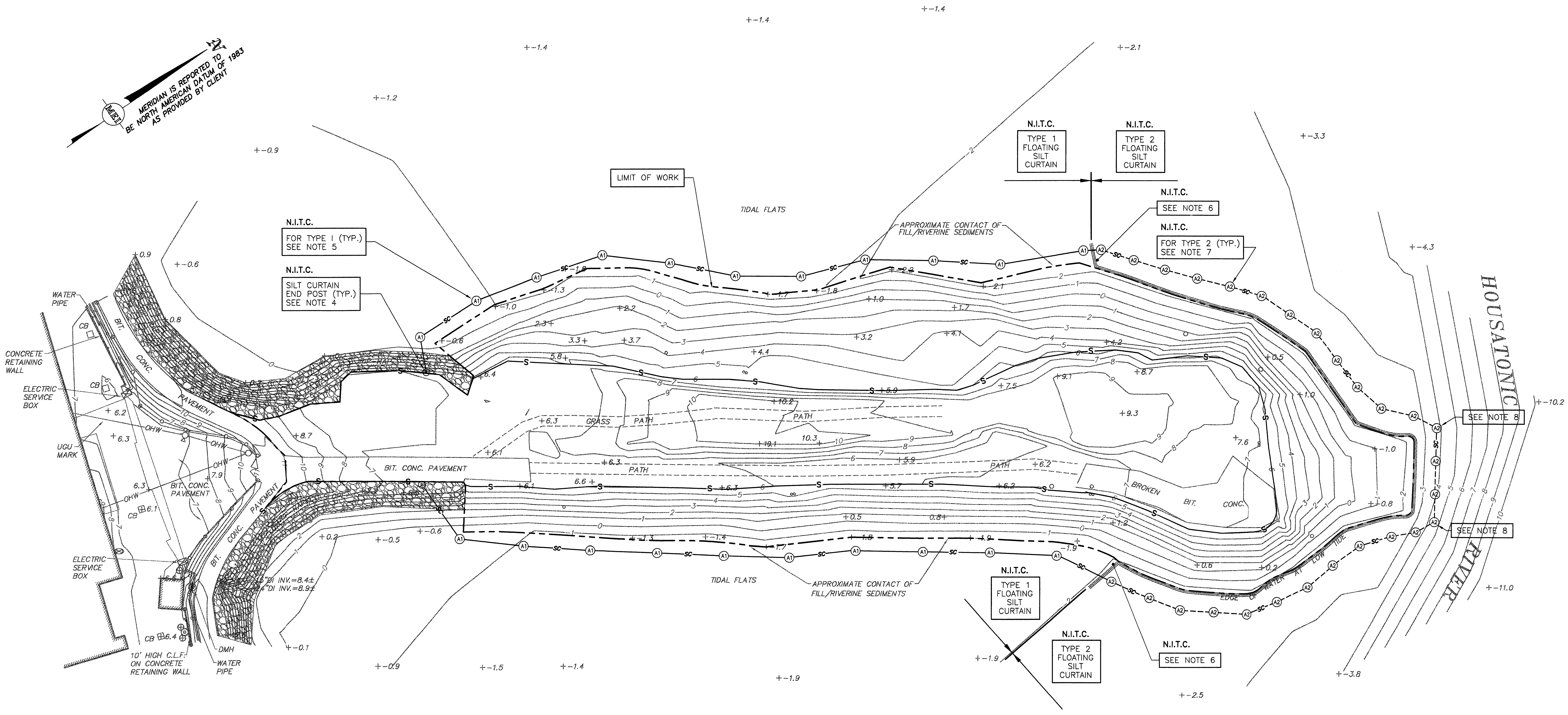
NON-TIME CRITICAL REMOVAL ACTION
CAUSEWAY COVER DESIGN (PHASE II)
STRATFORD ARMY ENGINE PLANT

STRATFORD, CONNECTICUT

SITE CONTROL

Sheet reference number:
C-102
SHEET 3 OF 9



## LEGEND

| | | | |
|---|---|---|---|
| CONC. | CONCRETE | ⊗ | WATER GATE BOX |
| BIT. CONC. | BITUMINOUS CONCRETE | ⊕ | BOLLARD |
| DIA. | DIAMETER | ☒ | ELECTRIC BOX |
| CB ☐ | CATCH BASIN | Ⓒ | HYDRANT |
| —o—C.L.F.—o— | CHAIN LINK FENCE | Ⓓ | DRAIN MANHOLE |
| ══ | RETAINING WALL | D.I. | DUCTILE IRON |
| ——4—— | 1' CONTOUR | INV. | INVERT |
| ——OHW—— | OVERHEAD WIRE | ▨ | EXISTING RIP RAP |
| ——E—— | ELECTRIC CONDUIT (ON GRADE) | ≈ | EDGE OF WATER AT LOW TIDE |
| ——SC—— | FLOATING SILT CURTAIN TYPE 1 | +7.9 | SPOT GRADE (– INDICATES NEGATIVE) |
| - - -SC- - - | FLOATING SILT CURTAIN TYPE 2 | UGU | UNDERGROUND UTILITY MARK |
| ——Ⓐ1—— | TYPE 1 ANCHOR | ○ 6" | TREE |
| - - -Ⓐ2- - - | TYPE 2 ANCHOR | | |
| — — — | LIMIT OF WORK | | |
| ——S—— | SILTATION FENCE | | |
| Ⓟ | END POST FOR FLOATING SILT CURTAIN | | |

0 20 40 80 FEET

SCALE: 1"=40'

## NOTES:

1. SEDIMENT AND EROSION CONTROL MEASURES INSTALLED AS PART OF PHASE I SHALL BE MAINTAINED AS PART OF PHASE II WORK. PROVIDE ADDITIONAL CONTROLS AS REQUIRED.
2. NO ACTIVE EXCAVATION OR BACKFILLING TO BE PERFORMED UNDER TIDAL WATERS.
3. PROVIDE FLOATING SILT CURTAIN AROUND CAUSEWAY AS SHOWN ON DRAWING. MINIMIZE SEPARATION BETWEEN LIMITS OF WORK AND FLOATING SILT CURTAIN, REFER TO PHASE I C–301. **N.I.T.C.**
4. END POSTS TO BE SET AS INDICATED ON PHASE I DRAWING C–301. BASE OF END POSTS SHALL BE AT OR ABOVE ELEVATION 6. **N.I.T.C.**
5. INSTALL TYPE 1 ANCHORS, SUCH THAT TYPE 1 FLOATING SILT CURTAIN SETTLES NO CLOSER THAN 5 FEET FROM LIMITS OF WORK, OR AS APPROVED. ANCHOR LOCATIONS SHOWN ARE APPROXIMATELY 10 FEET OUT FROM LIMITS OF WORK. **N.I.T.C.**
6. PROVIDE OPENING BETWEEN CONTACT OF FILL/RIVERINE SEDIMENTS AND FLOATING SILT CURTAIN TO FACILITATE TIDAL FLOW BEHIND TYPE I SILT CURTAIN DURING LOW TIDE. **N.I.T.C.**
7. INSTALL TYPE 2 ANCHORS, SUCH THAT TYPE 2 FLOATING SILT CURTAIN SETTLES NO CLOSER THAN 5 FEET FROM LIMITS OF WORK, OR AS APPROVED. ANCHOR LOCATIONS SHOWN ARE APPROXIMATELY 15 FEET OUT FROM LIMITS OF WORK. **N.I.T.C.**
8. PROVIDE ADDITIONAL TYPE 2 ANCHORS WHERE NECESSARY TO PROVIDE ADDITIONAL SUPPORT AND TENSION ON SILT CURTAIN. **N.I.T.C.**
9. INSTALL SILTATION FENCE AT THE APPROXIMATE LOCATION SHOWN, TEMPORARILY REMOVE TO FACILITATE WORK. REPLACE WHEN NO WORK IS IN PROGRESS.
10. THE LIMIT OF WORK CORRESPONDS WITH THE APPROXIMATE CONTACT OF FILL/RIVERINE SEDIMENTS, EDGE OF WATER AT LOW TIDE, OR EDGE OF EXISTING RIP RAP, WHERE PRESENT.
11. SEE DRAWING C–101 FOR SURVEY REFERENCES.
12. CONTOURS SHOWN REPRESENT PRE–PHASE I WORK.

Brian Banes Johnson
No. 19726

8/30/01

US Army Corps
of Engineers
New England District

| Mark | Description | Date | Appr. | Mark | Description | Date | Appr. |
|---|---|---|---|---|---|---|---|
| 0 | 100% ISSUED FOR CONSTRUCTION | 8/30/01 | BBJ | | | | |
| A | PHASE II 90% CLIENT REVIEW | 5/9/01 | BBJ | | | | |

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NEW ENGLAND DISTRICT
CONCORD, MASSACHUSETTS

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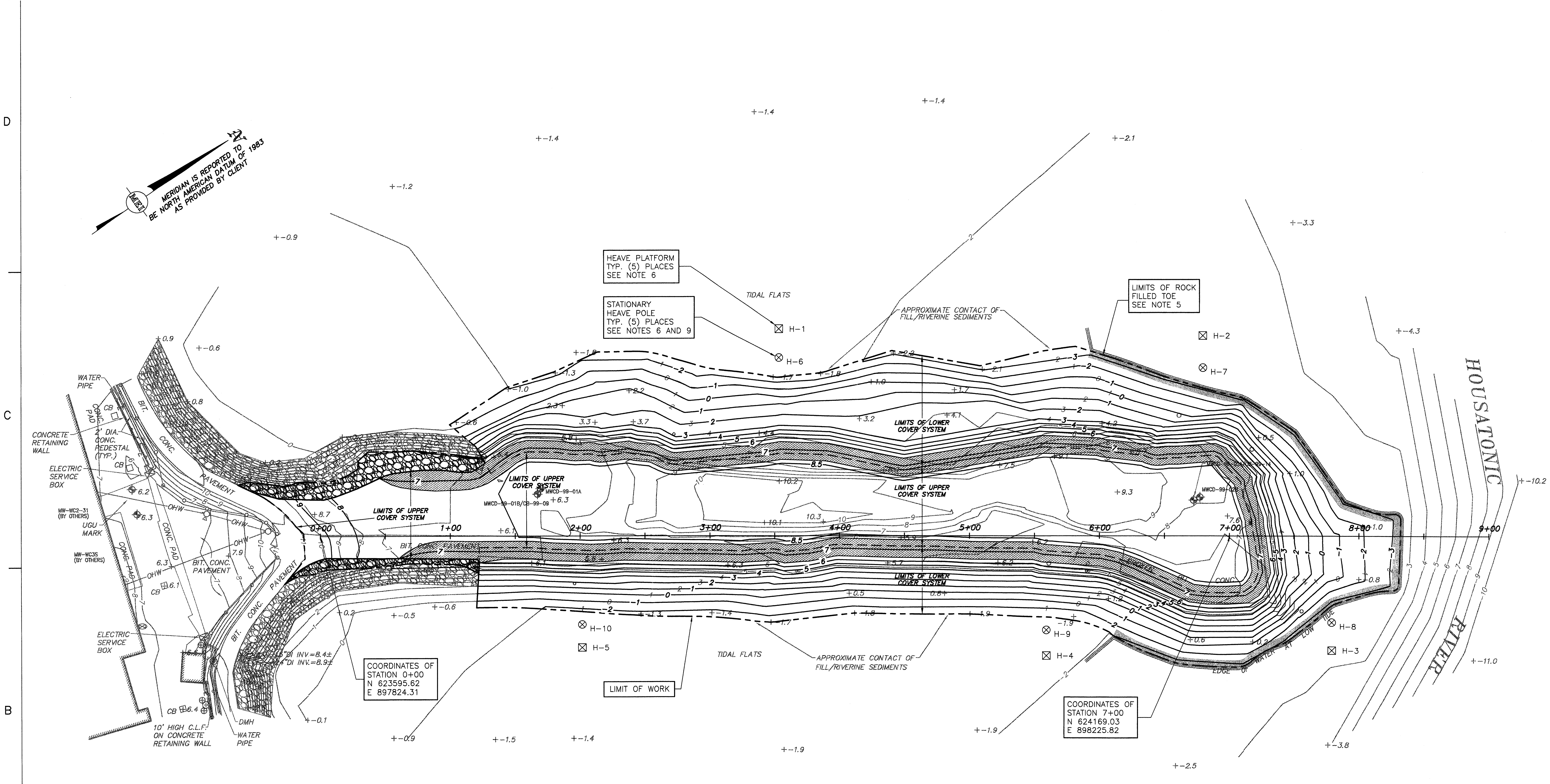
|---|---|---|
| Designed by: B. JOHNSON | Date: 8/30/01 | Rev. 0 |
| Dwn by: E.J.LEDUC | Ckd by: | Design file no. C47254SP03 |
| Reviewed by: | Drawing code: | |
| Submitted by: | File name: C47254SP03<br>Plot date:<br>Plot scale: 1"=40' | |
| Chief, Arch. Branch | | |

NON–TIME CRITICAL REMOVAL ACTION
CAUSEWAY COVER DESIGN (PHASE II)
STRATFORD ARMY ENGINE PLANT

STRATFORD, CONNECTICUT

**EROSION AND SEDIMENT CONTROL**

Sheet reference number:
C–103
SHEET 4 OF 9



## LEGEND

| | | | |
|---|---|---|---|
| CONC. | CONCRETE | ⊗ | WATER GATE |
| BIT. CONC. | BITUMINOUS CONCRETE | ⊕ | BOLLARD |
| DIA. | DIAMETER | ☒ | ELECTRIC BOX |
| CB ☐ | CATCH BASIN | ——E—— | ELECTRIC CONDUIT (ON GRADE) |
| —o— C.L.F. —o— | CHAIN LINK FENCE | ◎ | HYDRANT |
| ═══ | RETAINING WALL | Ⓓ | DRAIN MANHOLE |
| ——4—— | EXISTING 1' CONTOUR | D.I. | DUCTILE IRON |
| +7.9 | EXISTING SPOT GRADE (– INDICATES NEGATIVE) | INV. | INVERT |
| | | ▨ | EXISTING RIP RAP |
| UGU | UNDERGROUND UTILITY MARK | ☒ | HEAVE PLATFORM (INSTALLED AS PART OF PHASE I) |
| — — — — — | APPROXIMATE CONTACT OF FILL/RIVERINE SEDIMENTS | ⊗ | STATIONARY HEAVE POLE (INSTALLED AS PART OF PHASE I) |
| ═══ | EDGE OF WATER AT LOW TIDE | ○ 6" | TREE |
| ——OHW—— | OVERHEAD WIRE | —— — — —— | **LIMIT OF WORK** |
| | | ▒ | **LIMITS OF ROCK FILLED TOE** |
| | | ▨ | **LIMITS OF ROCK FILLED/RIP RAP TRANSITION** |
| | | ▩ | **MODIFIDED RIP RAP AREA** |
| | | ——7—— | |
| | | ⊕ | |

0 20 40 80 FEET

SCALE: 1"=40'

## NOTES:

1. SEE DRAWING C–101 FOR SURVEY REFERENCES.
2. NO EXCAVATION OR BACKFILLING TO BE PERFORMED UNDER TIDAL WATERS.
3. PROVIDE/MAINTAIN SILT CURTAIN AROUND CAUSEWAY AS SHOWN ON DRAWING C–103 AND IN ACCORDANCE WITH THE APPROVED EROSION AND SEDIMENT CONTROL PLAN. **N.I.T.C.**
4. PROTECT ALL WELLS TO REMAIN AS IDENTIFIED ON THIS FIGURE.
5. STATIONING SHOWN IS SUGGESTED FOR CONTRACTOR USE.
6. HEAVE PLATFORMS AND STATIONARY HEAVE POLES, PLACED AS PART OF PHASE I, SHALL BE MONITORED IN ACCORDANCE WITH SECTION 02110.
7. EXISTING CONTOURS SHOWN REPRESENT PRE–PHASE I WORK. A SITE SURVEY PERFORMED AS PART OF PHASE I SHALL BE USED TO SUPPLEMENT THIS DRAWING.
8. SUBGRADE ELEVATIONS BELOW THE ROCK FILLED TOE ARE NOT SHOWN HERE, REFER TO DRAWING C–303.
9. TEMPORARY HEAVE POLES SHALL BE INSTALLED AND MONITORED ADJACENT TO ACTIVE WORK AREAS IN ACCORDANCE WITH SECTION 02110.

BRIAN JAMES JOHNSON
No. 19726
8/30/01

US Army Corps
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New England District

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| 0 | 100% ISSUED FOR CONSTRUCTION | 8/30/01 | BBJ |
| A | PHASE II 90% CLIENT REVIEW | 5/9/01 | BBJ |

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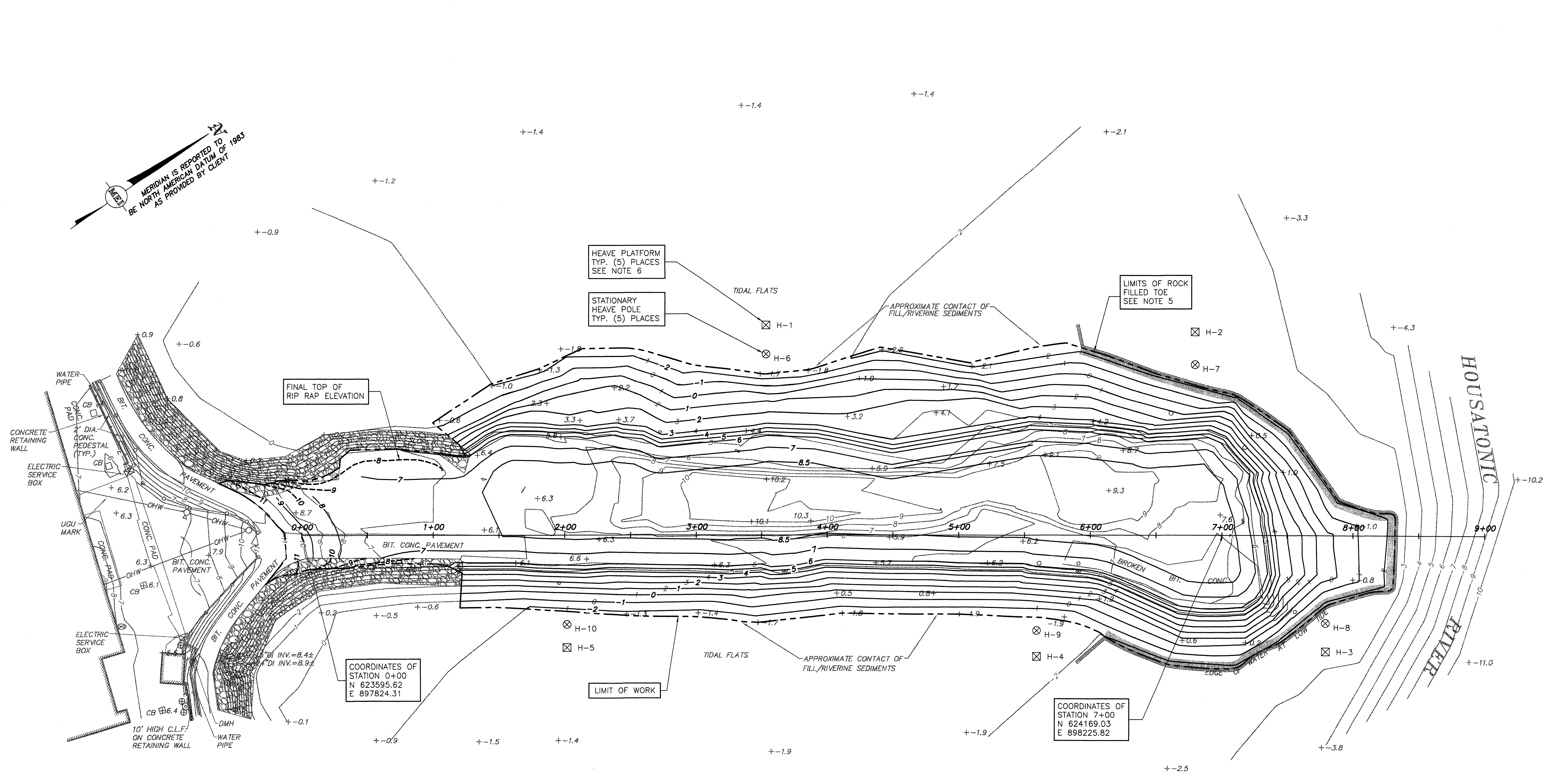
| | | |
|---|---|---|
| **Designed by:** B. JOHNSON | **Date:** 8/30/01 | **Rev.** 0 |
| **Dwn by:** D.LAWRENCE | **Ckd by:** K. Penn | **Design file no.** C47254SP05 |
| **Reviewed by:** N. Wade | | **Drawing code:** |
| **Submitted by:** | | **File name:** C47254SP05 |
| **Chief, Arch. Branch** | | **Plot date:** |
| | | **Plot scale:** 1"=40' |

NON–TIME CRITICAL REMOVAL ACTION
CAUSEWAY COVER DESIGN (PHASE II)
STRATFORD ARMY ENGINE PLANT

STRATFORD, CONNECTICUT

**PHASE II**
**SITE PLAN**

Sheet
reference
number:
C–104
SHEET 5 OF 9



## LEGEND

| | | | |
|---|---|---|---|
| CONC. | CONCRETE | ⊗ | WATER GATE |
| BIT. CONC. | BITUMINOUS CONCRETE | ⊕ | BOLLARD |
| DIA. | DIAMETER | ☒ | ELECTRIC BOX |
| CB ☐ | CATCH BASIN | ——E—— | ELECTRIC CONDUIT (ON GRADE) |
| —o— C.L.F. —o— | CHAIN LINK FENCE | ◎ | HYDRANT |
| ═══ | RETAINING WALL | Ⓓ | DRAIN MANHOLE |
| ——4—— | EXISTING 1' CONTOUR (SEE NOTE 7) | D.I. | DUCTILE IRON |
| +7.9 | EXISTING SPOT GRADE (– INDICATES NEGATIVE) | INV. | INVERT |
| | | ▨ | EXISTING RIPRAP |
| UGU | UNDERGROUND UTILITY MARK | ☒ | HEAVE PLATFORM (INSTALLED AS PART OF PHASE I) |
| —— - - —— | APPROXIMATE CONTACT OF FILL/RIVERINE SEDIMENTS | ⊗ | STATIONARY HEAVE POLE (INSTALLED AS PART OF PHASE I) |
| ≈≈≈ | EDGE OF WATER AT LOW TIDE | ○ 6" | TREE |
| ——OHW—— | OVERHEAD WIRE | —— – – —— | **LIMIT OF WORK** |
| | | ▨ | **LIMITS OF ROCK FILLED TOE** |
| | | ——7—— | **SUBGRADE ELEVATION** |
| | | ----9---- | **FINAL TOP OF RIP RAP ELEVATION** |

0 20 40 80 FEET

SCALE: 1"=40'

## NOTES:

1. SEE DRAWING C-101 FOR SURVEY REFERENCES.
2. NO EXCAVATION OR BACKFILLING TO BE PERFORMED UNDER TIDAL WATERS.
3. PROVIDE/MAINTAIN SILT CURTAIN AROUND CAUSEWAY AS SHOWN ON DRAWING C-103 AND IN ACCORDANCE WITH THE APPROVED EROSION AND SEDIMENT CONTROL PLAN. **N.I.T.C.**
4. PROTECT ALL WELLS TO REMAIN.
5. STATIONING SHOWN IS SUGGESTED FOR CONTRACTOR USE. HEAVE PLATFORMS AND POLES, PLACED AS PART OF PHASE I, SHALL BE MONITORED IN ACCORDANCE WITH SECTION 02110.
6. HEAVE PLATFORMS AND STATIONARY HEAVE POLES, PLACED AS PART OF PHASE I, SHALL BE MONITORED IN ACCORDANCE WITH SECTION 02110.
7. EXISTING CONTOURS SHOWN REPRESENT PRE-PHASE I WORK. A SITE SURVEY PERFORMED AS PART OF PHASE I SHALL BE USED TO SUPPLEMENT THIS DRAWING.
8. SUBGRADE ELEVATIONS BELOW THE ROCK FILLED TOE ARE NOT SHOWN HERE, REFER TO DRAWING C-303.

BRIAN BANES JOHNSON
No. 19726
8/30/01

US Army Corps
of Engineers
New England District

| Mark | Description | Date | Appr. | Mark | Description | Date | Appr. |
|---|---|---|---|---|---|---|---|
| A | PHASE II 90% CLIENT REVIEW | 5/9/01 | BBJ | | | | |
| 0 | 100% ISSUED FOR CONSTRUCTION | 8/30/01 | BBJ | | | | |

| | | |
|---|---|---|
| Designed by: B. JOHNSON | Date: 8/30/01 | Rev. 0 |
| Dwn by: E.J.LEDUC | Ckd by: | Design file no. C47254SP04 |
| Reviewed by: | | Drawing code: |
| Submitted by: | | File name: C47254SP04<br>Plot date:<br>Plot scale: 1"=40' |
| Chief, Arch. Branch | | |

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CONCORD, MASSACHUSETTS

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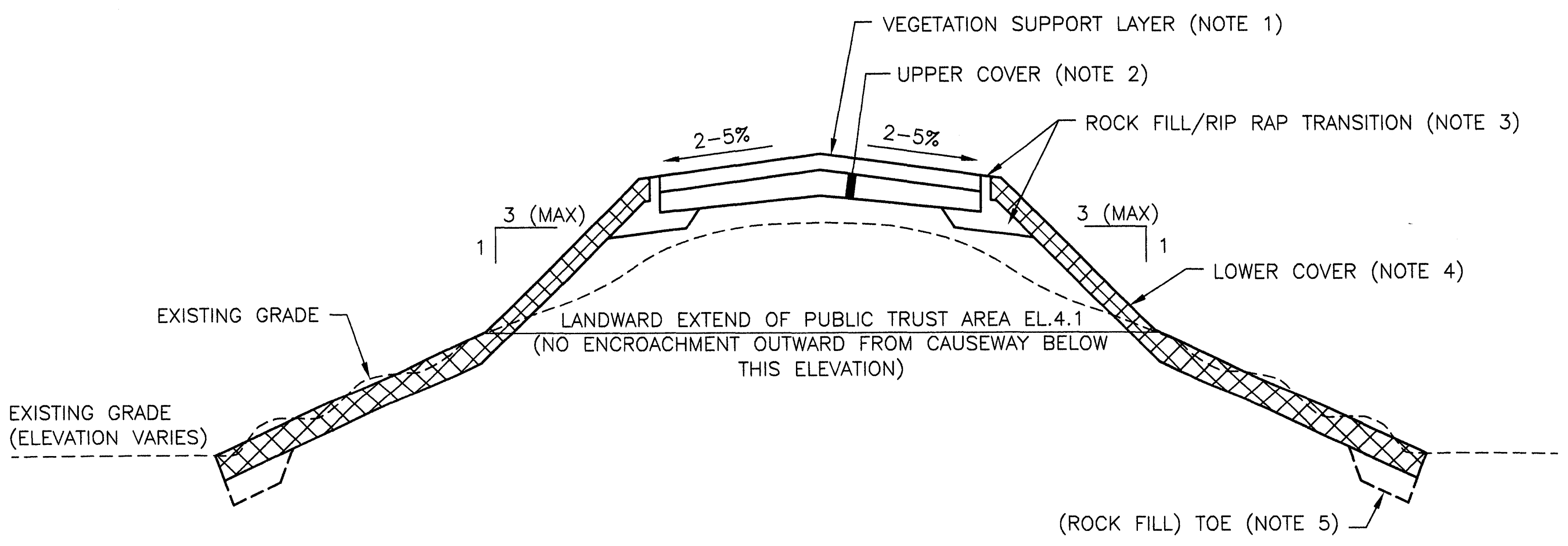
NON-TIME CRITICAL REMOVAL ACTION
CAUSEWAY COVER DESIGN (PHASE II)
STRATFORD ARMY ENGINE PLANT

STRATFORD, CONNECTICUT

PHASE II
SUBGRADE - DEVELOPMENT PLAN

Sheet reference number:
C-105
SHEET 6 OF 9

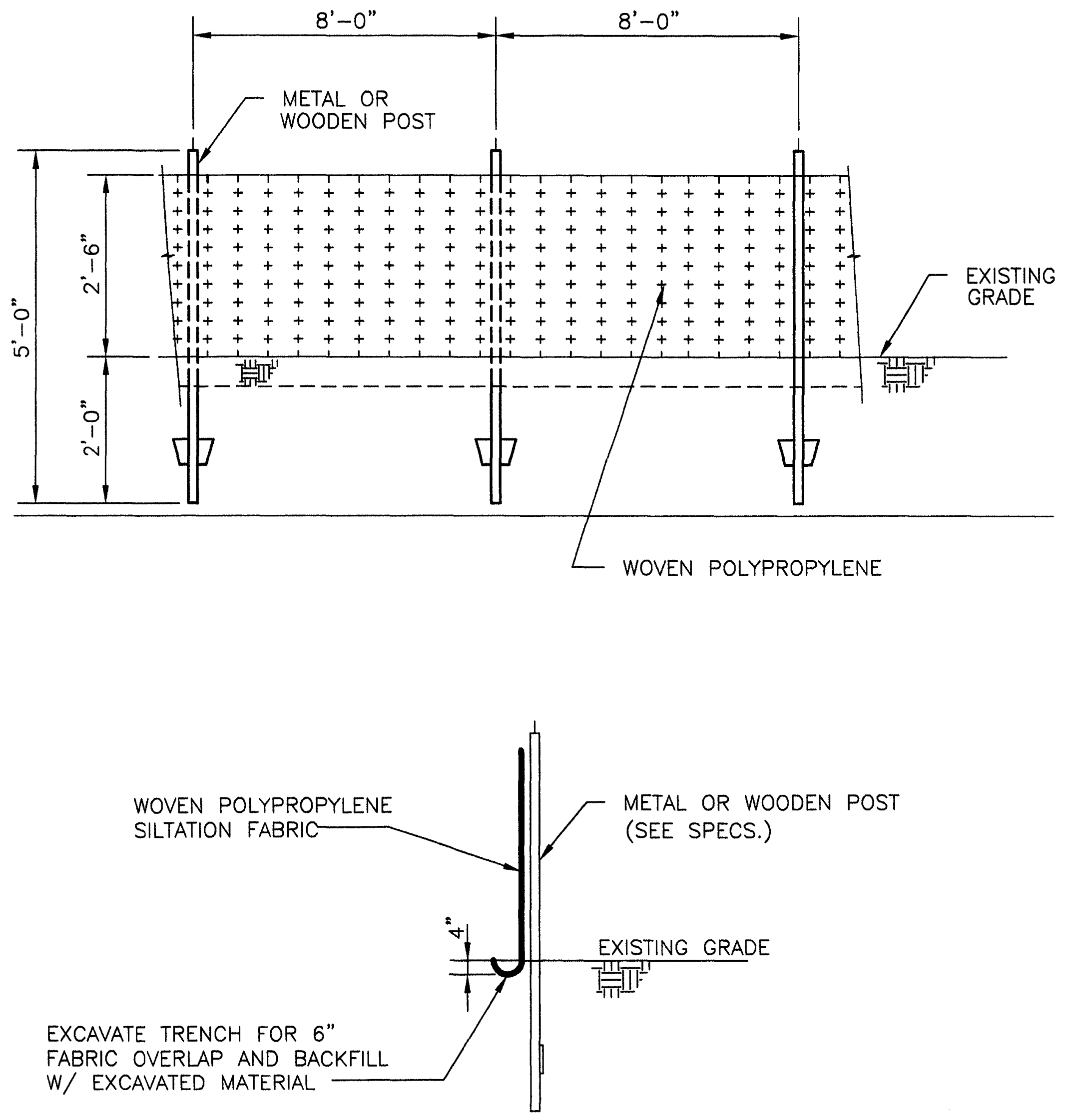


NOTES:

1. VEGETATIVE SUPPORT LAYER, IS 6 TO 8–INCHES THICK AND CONSISTS OF VEGETATIVE SUPPORT SOIL, EROSION CONTROL MAT, AND SEED.
2. UPPER COVER, IS 10 TO 12–INCHES THICK AND CONSISTS OF GRAVEL, INTERLOCKING CONCRETE BLOCKS, NON–WOVEN GEOTEXTILE, AND BEDDING SAND.
3. ROCK FILL TRANSITION, REFER TO DETAIL ON DRAWING C–303.
4. LOWER COVER, IS 12–INCHES THICK AND CONSISTS OF ROCK FILLED POLYMERIC MARINE MATTRESSES AND WOVEN GEOTEXTILE.
5. TOE, REFER TO DETAIL ON DRAWING C–303. ADDITIONAL ROCK FILL WITHIN LIMITS SHOWN ON DRAWING C–104.

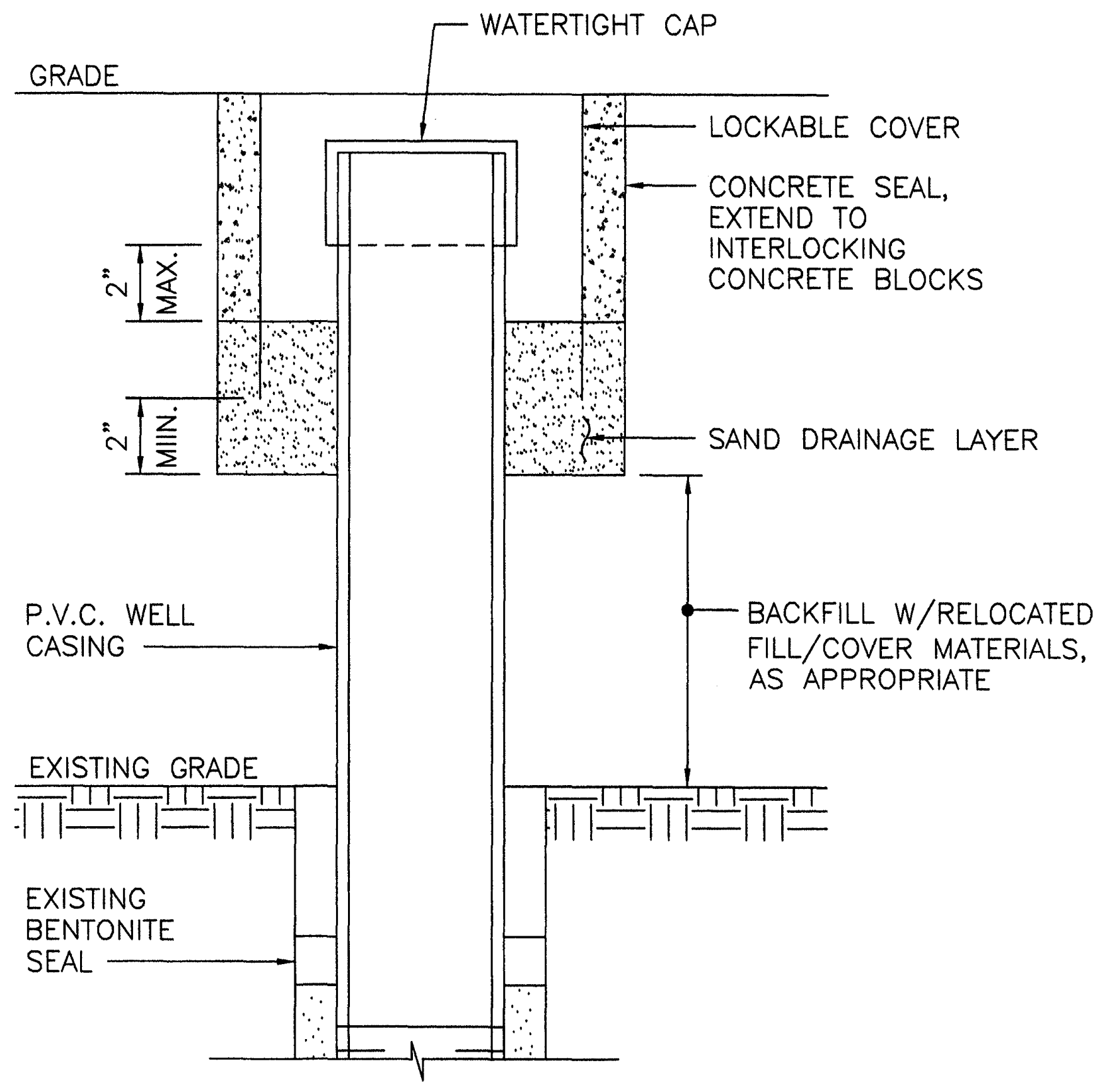
TYPICAL SECTION

NOT TO SCALE



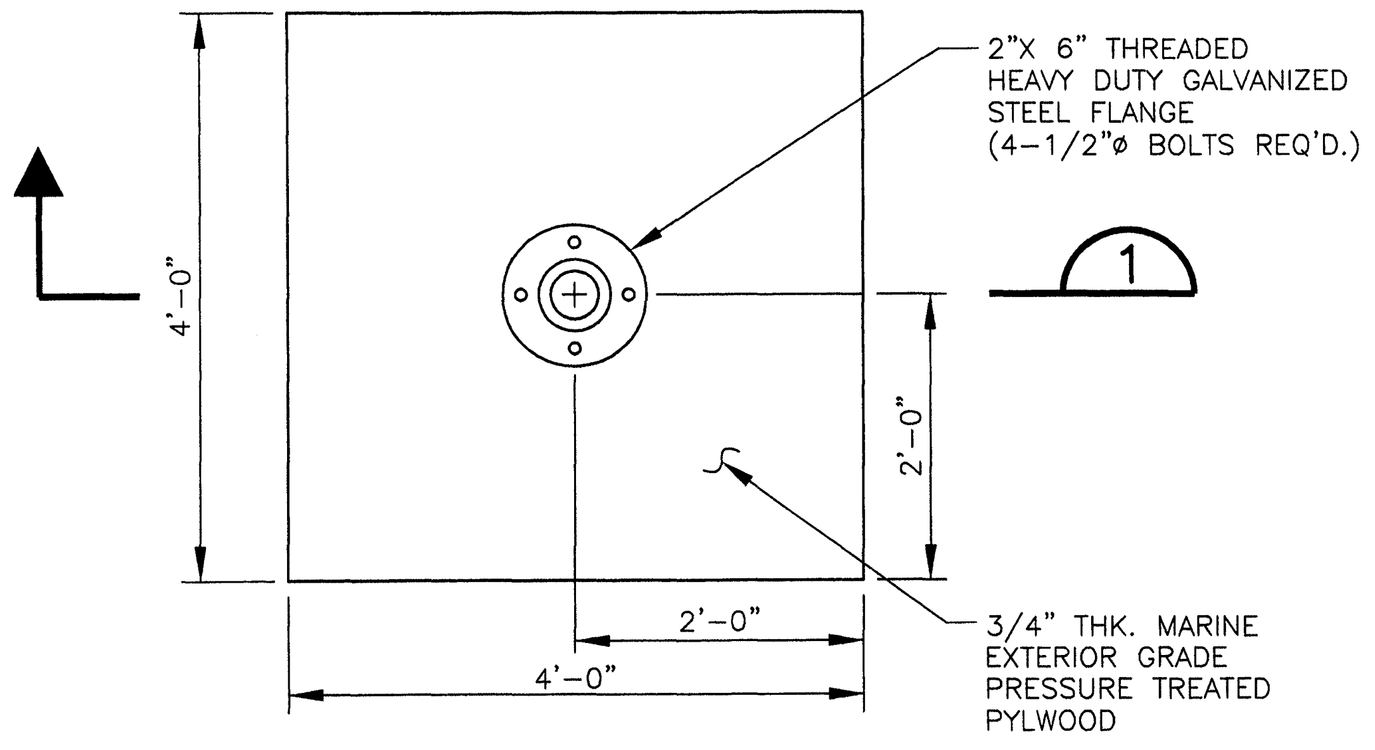
SILTATION FENCE

NOT TO SCALE

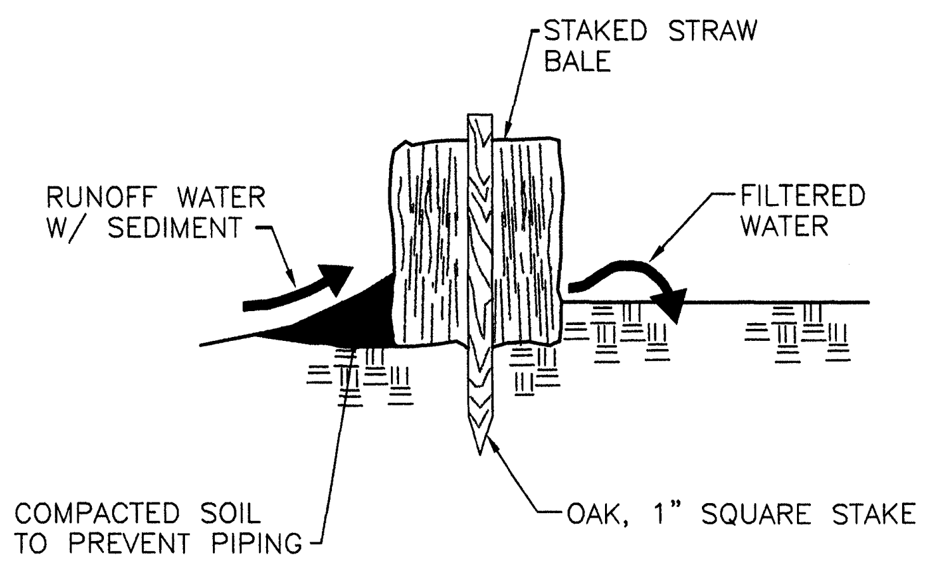


FLUSH MOUNT WELL CASING

NOT TO SCALE

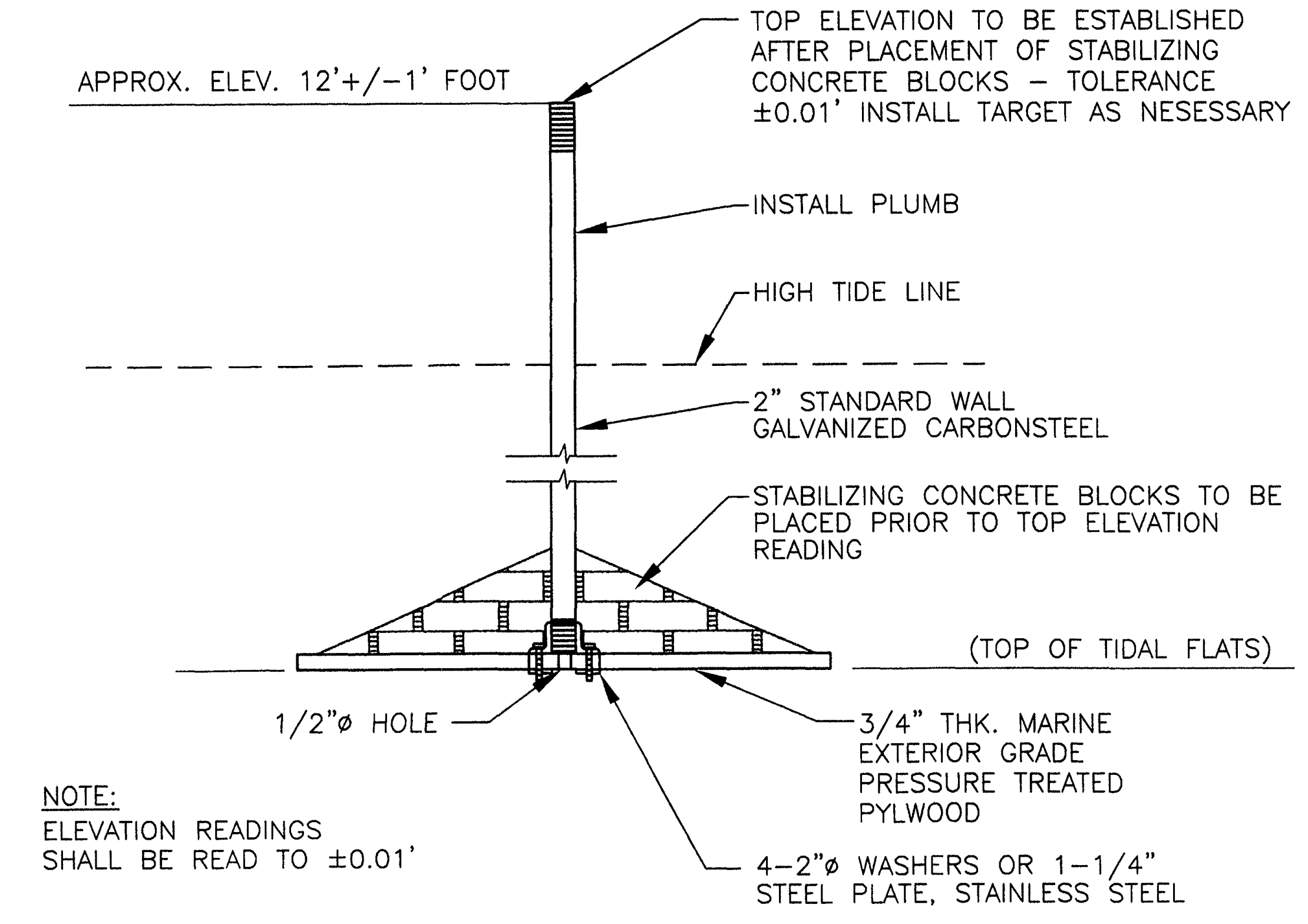


PLAN



HAYBALE INSTALLATION

NOT TO SCALE



SECTION 1

HEAVE PLATFORMS

NOT TO SCALE

US Army Corps
of Engineers
New England District

| Mark | Description | Date | Appr. | Mark | Description | Date | Appr. |
|---|---|---|---|---|---|---|---|
| 0 | 100% ISSUED FOR CONSTRUCTION | 8/30/01 | BBJ | | | | |
| B | PHASE II 90% CLIENT REVIEW | 5/9/01 | BBJ | | | | |
| A | 30% CLIENT REVIEW | 3/30/01 | DRP | | | | |

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Chief, Arch. Branch
Date: 8/30/01
Rev. 0
Design file no. C47254DT01
Drawing code:
File name: C47254DT01
Plot date:
Plot scale: 1=1

NON–TIME CRITICAL REMOVAL ACTION
CAUSEWAY COVER DESIGN (PHASE II)
STRATFORD ARMY ENGINE PLANT

STRATFORD, CONNECTICUT

MISCELLANEOUS
DETAILS

BRIAN BANES JOHNSON
No. 19726
8/30/01

Sheet
reference
number:
C–301
SHEET 7 OF 9

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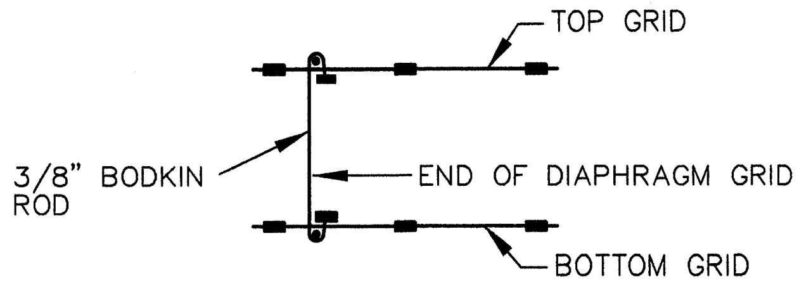
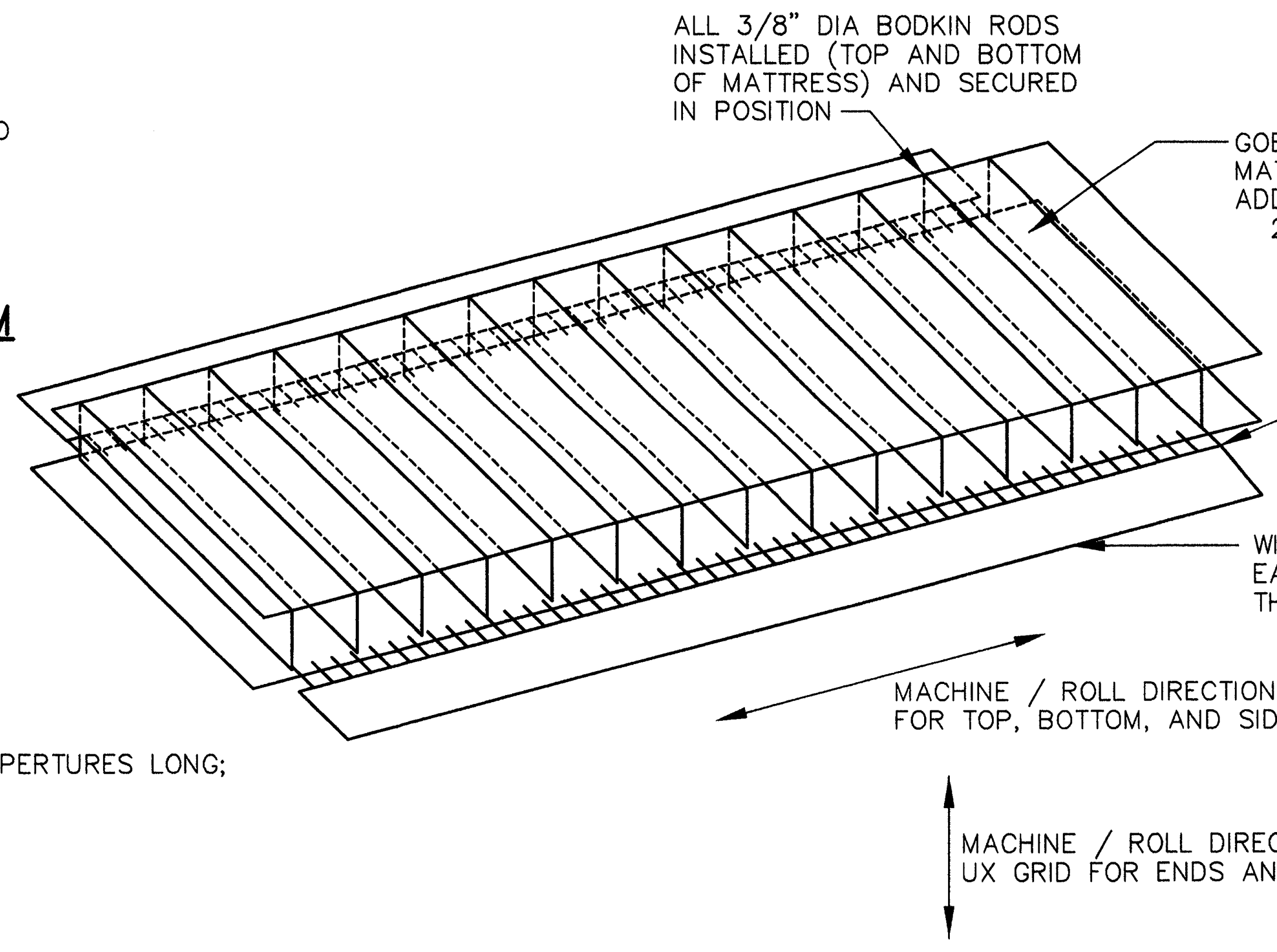


## EXPANDED SECTION AT DIAPHRAGM

NOT TO SCALE



NOTE:

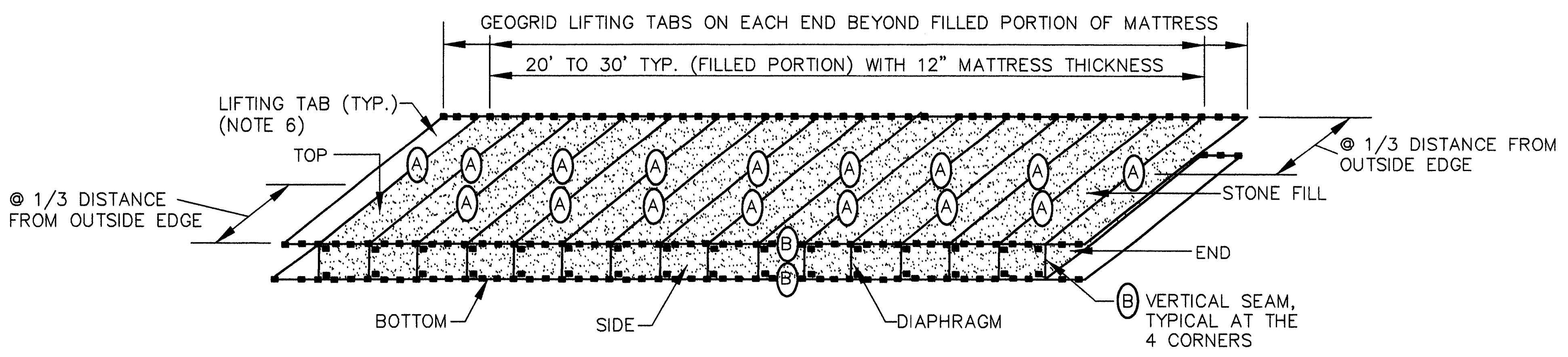
TYPICAL SPACING OF DIAPHRAGMS IS EVERY THREE APERTURE LENGTHS. A SHORTER SPACING MAY BE USED IN ORDER TO MATCH THE REQUIRED MATTRESS LENGTH.

LENGTH OF END PIECES AND INTERNAL DIAPHRAGMS PIECES SHALL BE:
FOR 12" (FILLED) MATTRESS THICKNESS: 2 GRID APERTURES LONG;

SEE TYPICAL CONFIGURATION OF FILLED MATTRESS FOR ADDITIONAL DIMENSIONS AND MATERIAL TYPES.

## TYPICAL CONFIGURATION OF FABRICATED POLYMERIC MARINE MATTRESS

NOT TO SCALE



Ⓐ INDICATES BODKIN CONNECTION USING 3/8" DIAMETER HDPE BODKIN ROD. STAGGER @ 1/3 DISTANCE FROM OUTSIDE EDGE AS INDICATED.

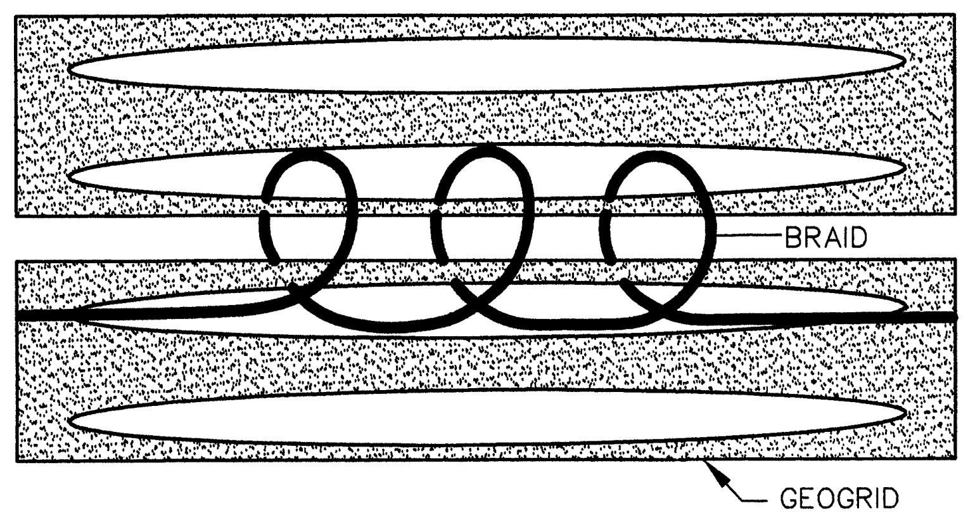
Ⓑ INDICATES BRAIDED SEAM USING 3/16" DIAMETER HIGH UV HDPE BRAID

NOTES:

1. ENDS, TOP, BOTTOM, SIDES, AND ANY EXTRA USED FOR LIFTING OR ANCHORING PURPOSES SHALL BE COMPOSED OF TENSAR UXTRITON2 GEOGRID, OR APPROVED EQUAL.
2. INTERNAL DIAPHRAGMS SHALL BE COMPOSED OF TENSAR UXTRITON1 GEOGRID, OR APPROVED EQUAL.
3. NOMINAL WIDTH OF UNITS: 5 FT. (FILLED), 4.3 FT. (UNFILLED)
4. THICKNESS (FILLED): 12 INCHES
5. PLASTIC CABLES TIES MAY BE USED TO SECURE BODKIN CONNECTORS IN POSITION PRIOR TO TENSIONING OR FILLING OF MATTRESS UNITS.
6. PROVIDE MINIMUM 5 FOOT TAB ON BOTTOM, FOR ANCHORAGE.

## TYPICAL CONFIGURATION OF FILLED POLYMERIC MARINE MATTRESS UNITS

NOT TO SCALE

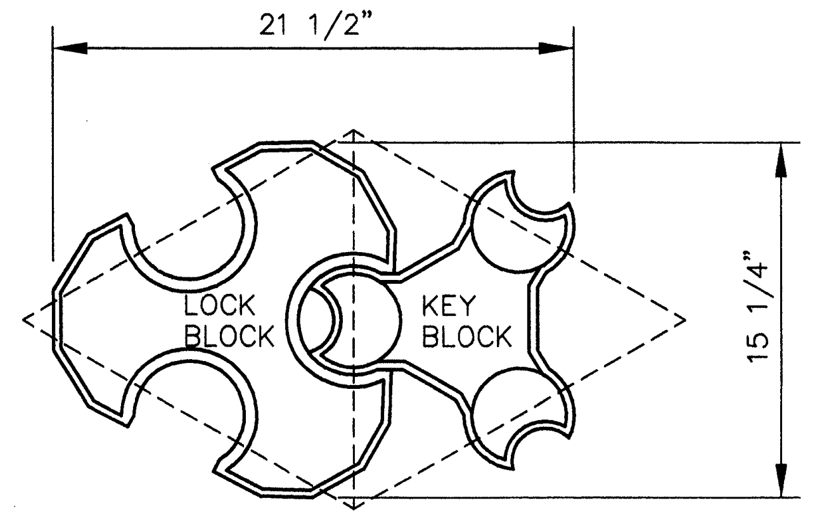


NOTES:

1. ALL CUT ENDS OF BRAID MATERIAL SHALL BE KNOTTED WITHIN 1/2" TO 2" OF THE END TO PREVENT RAVELING OF BRAID.
2. AT ALL ENDS OF ALL BRAIDED SEAMS, THE BRAID SHALL BE SECURELY KNOTTED TO THE GEOGRID.
3. AT ALL ENDS OF ALL PIECES OF BRAID MATERIAL USED, THE BRAID SHALL BE KNOTTED TO SPLICE IT TO THE NEXT PIECE OF BRAID, OR TO SECURE IT TO THE GEOGRID. EACH BRAIDED SEAM SHALL BE CONTINUOUS, WITH SECURELY KNOTTED SPLICES ALLOWED. THE BRAID SHALL BE SECURELY KNOTTED TO THE GEOGRID AT A SPACING NOT TO EXCEED 6 FEET ALONG ANY SEAM.
4. THE BRAID SHALL BE STITCHED THROUGH EACH PAIR OF APERTURES ALONG THE SEAM AT LEAST ONCE, AND THE MINIMUM NUMBER OF STITCHES PER FOOT ALONG THE SEAM SHALL BE SIX (6). THE SPACING OF STITCHES ALONG EACH SEAM SHALL BE REASONABLY UNIFORM.
5. ALL KNOTS SHALL BE TIED IN A MANNER TO PREVENT SLIPPING AND CINCHING.
6. THE WRAPS ALONG THE SEAM SHALL BE SUFFICIENTLY TIGHT TO CLOSE THE GAP BETWEEN THE ADJACENT PIECES OF GEOGRID, BUT SHALL NOT BE OVER-TIGHTENED SUCH THAT THE GEOGRID BINDS ALONG THE SEAM.

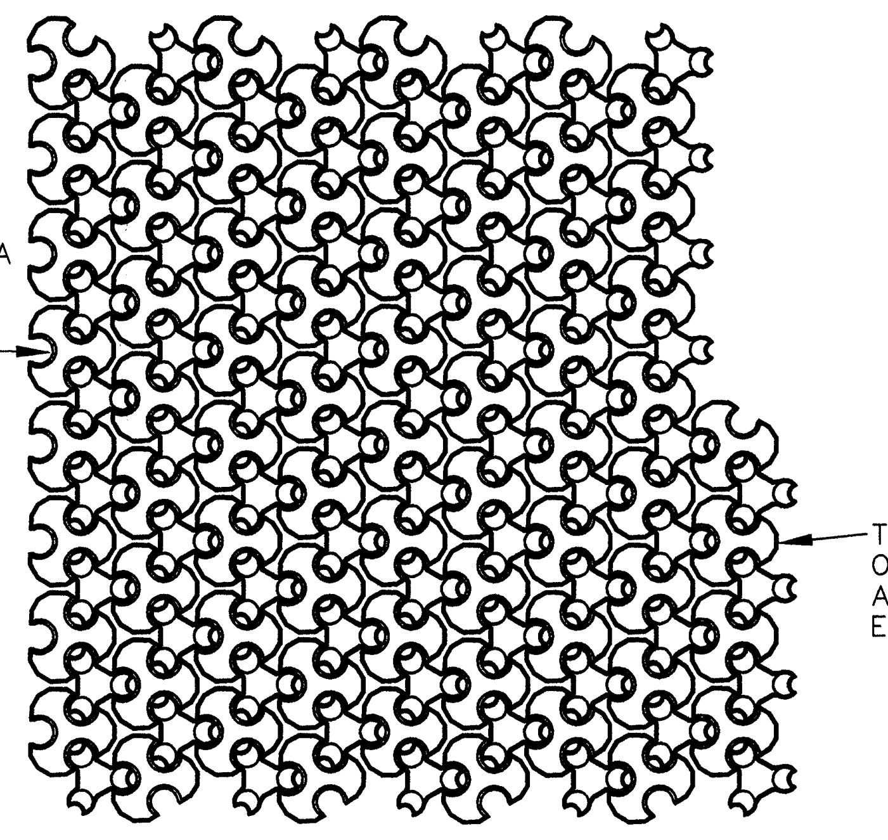
## TYPICAL LOCK-STITCH BRAIDING CONFIGURATION FOR MATTRESS FABRICATION

NOT TO SCALE



## INTERLOCKING CONCRETE BLOCK PLAN VIEW

NOT TO SCALE



## PLAN VIEW OF TYPICAL INTERLOCKING CONCRETE BLOCK INSTALLATION

NOT TO SCALE

No. 19726

8/30/01

US Army Corps
of Engineers
New England District

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| A | PHASE II 90% CLIENT REVIEW | 5/9/01 | BBJ | | | | |

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**Chief, Arch. Branch**
**Date:** 8/30/01
**Rev.** 0
**Design file no.** C47254DT01
**Drawing code:**
**File name:**
**Plot date:**
**Plot scale:** 1=1

NON-TIME CRITICAL REMOVAL ACTION
CAUSEWAY COVER DESIGN (PHASE II)
STRATFORD ARMY ENGINE PLANT

STRATFORD, CONNECTICUT

**MISCELLANEOUS**
**DETAILS**

Sheet
reference
number:
C-302
SHEET 8 OF 9

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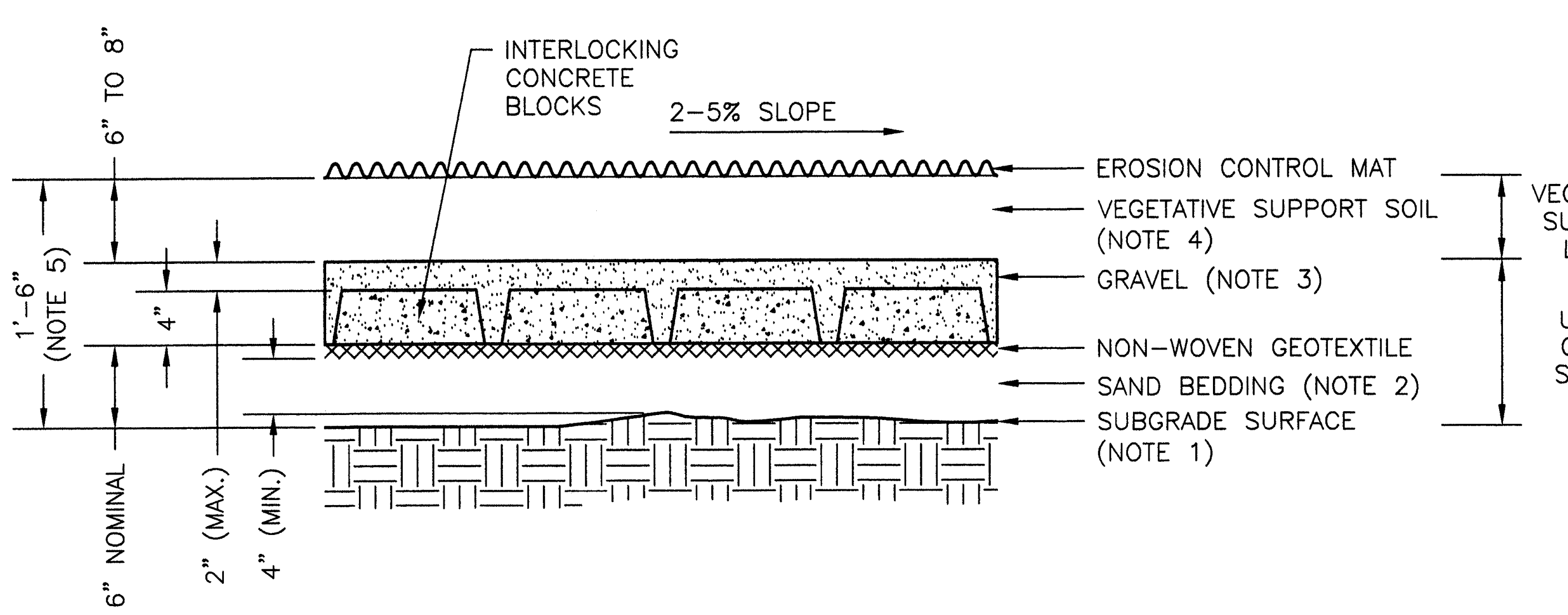
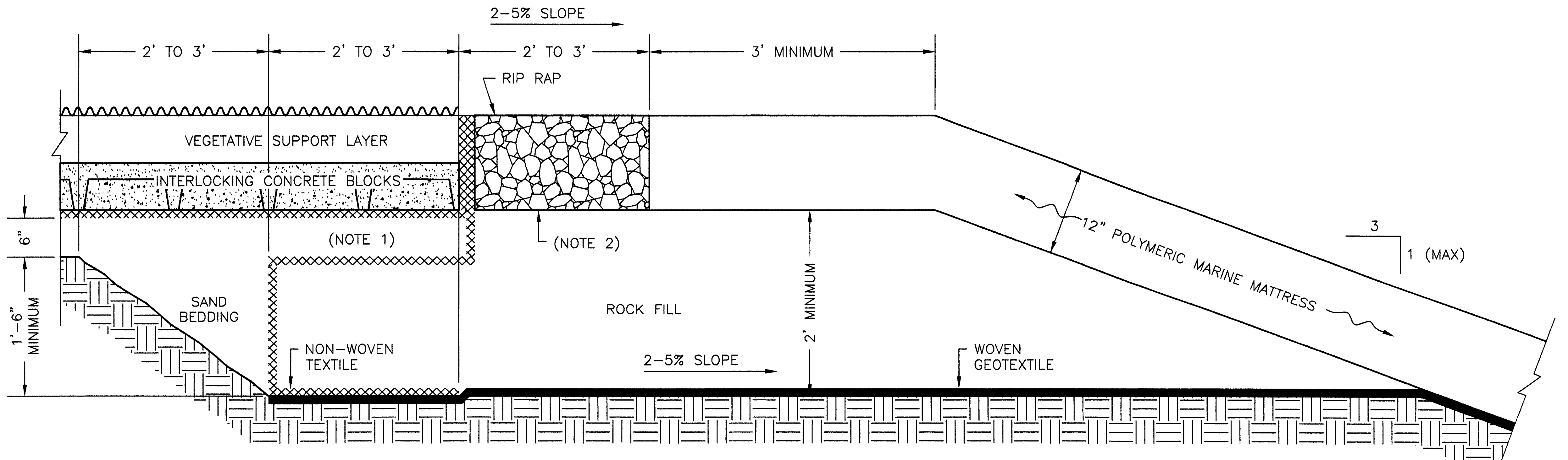


NOTES:

1. SUBGRADE SURFACE SHALL BE COMPACTED AND MAY HAVE ±2 INCHES IRREGULARITIES RESULTING FROM CAUSEWAY DEBRIS.
2. PROVIDE SAND BEDDING ABOVE SUBGRADE SURFACE WITH MINIMUM THICKNESS, ABOVE IRREGULAR SURFACE, OF 4 INCHES, 6 INCH NOMINAL THICKNESS.
3. PROVIDE GRAVEL BETWEEN INTERLOCKING CONCRETE BLOCKS. WORK BETWEEN EACH BLOCK TO LOCK BLOCKS IN PLACE, 2 INCH MAXIMUM ABOVE TOP OF BLOCKS.
4. PROVIDE VEGETATIVE SUPPORT SOIL 6" TO 8" THICK.
5. DO NOT EXCEED 1'–6" TOTAL THICKNESS.

## UPPER COVER SYSTEM AND VEGETATIVE SUPPORT LAYER TYPICAL DETAIL

NOT TO SCALE

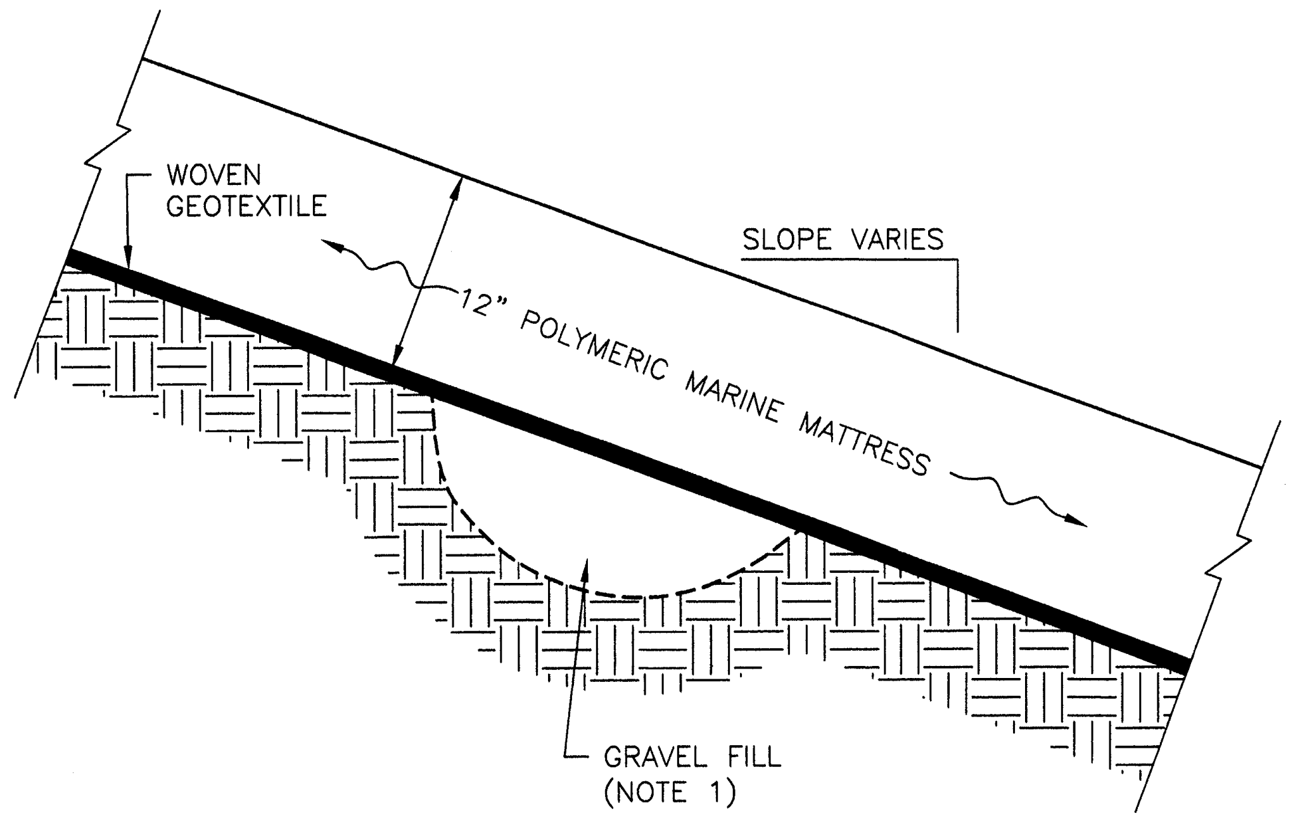


NOTES:

1. PROVIDE SAND BEDDING SUFFICIENT TO PROVIDE UNIFORM SURFACE FOR PLACEMENT OF INTERLOCKING CONCRETE BLOCKS.
2. EXTEND LOWER POLYMERIC MARINE MATTRESS SHELL MATERIAL BETWEEN ROCK FILL AND RIP RAP AND BENEATH INTERLOCKING CONCRETE BLOCKS A TOTAL OF 5 FEET MINIMUM TO SECURE MATTRESS.
3. DO NOT INSTALL BUTTED ENDS WITHIN 5 FEET OF THE BREAK IN SLOPE.

## TRANSITION DETAIL

NOT TO SCALE

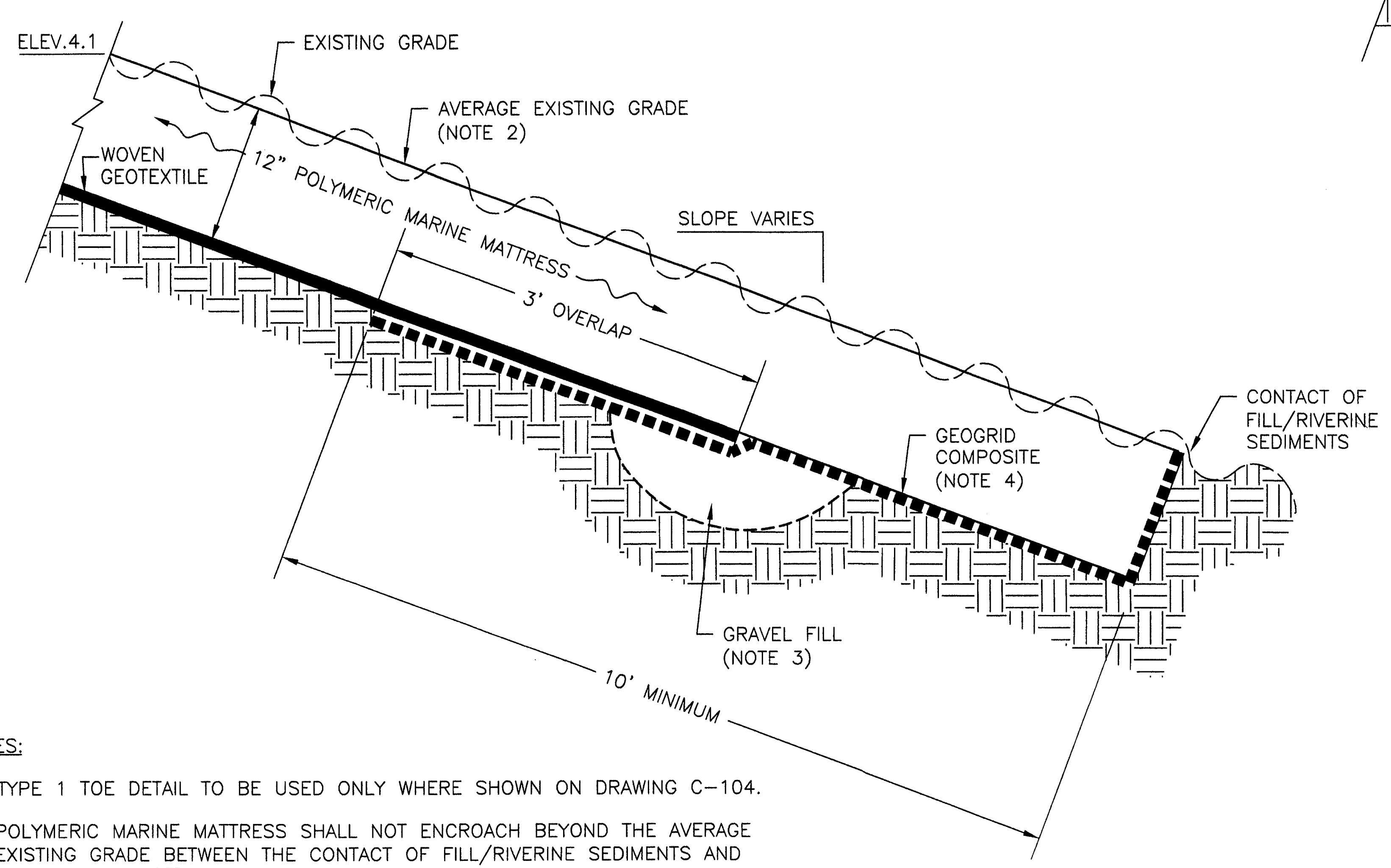


NOTES:

1. PLACE GRAVEL FILL IN VOIDS AND SOFT ZONES AS NECESSARY TO PROVIDE STABLE UNIFORM BASE FOR PLACEMENT OF POLYMERIC MARINE MATTRESS.
2. INSTALLATION SHALL START AT THE BOTTOM OF SLOPE AND PROCEED UP SLOPE.
3. AT BUTTED ENDS, PROVIDE 5 FOOT MINIMUM LENGTH OF OUTER SHELL AND INSTALL SUCCESSIVE UNITS ON TOP OF THIS TO ANCHOR LOWER UNITS.

## LOWER COVER SYSTEM – TYPICAL DETAIL

NOT TO SCALE

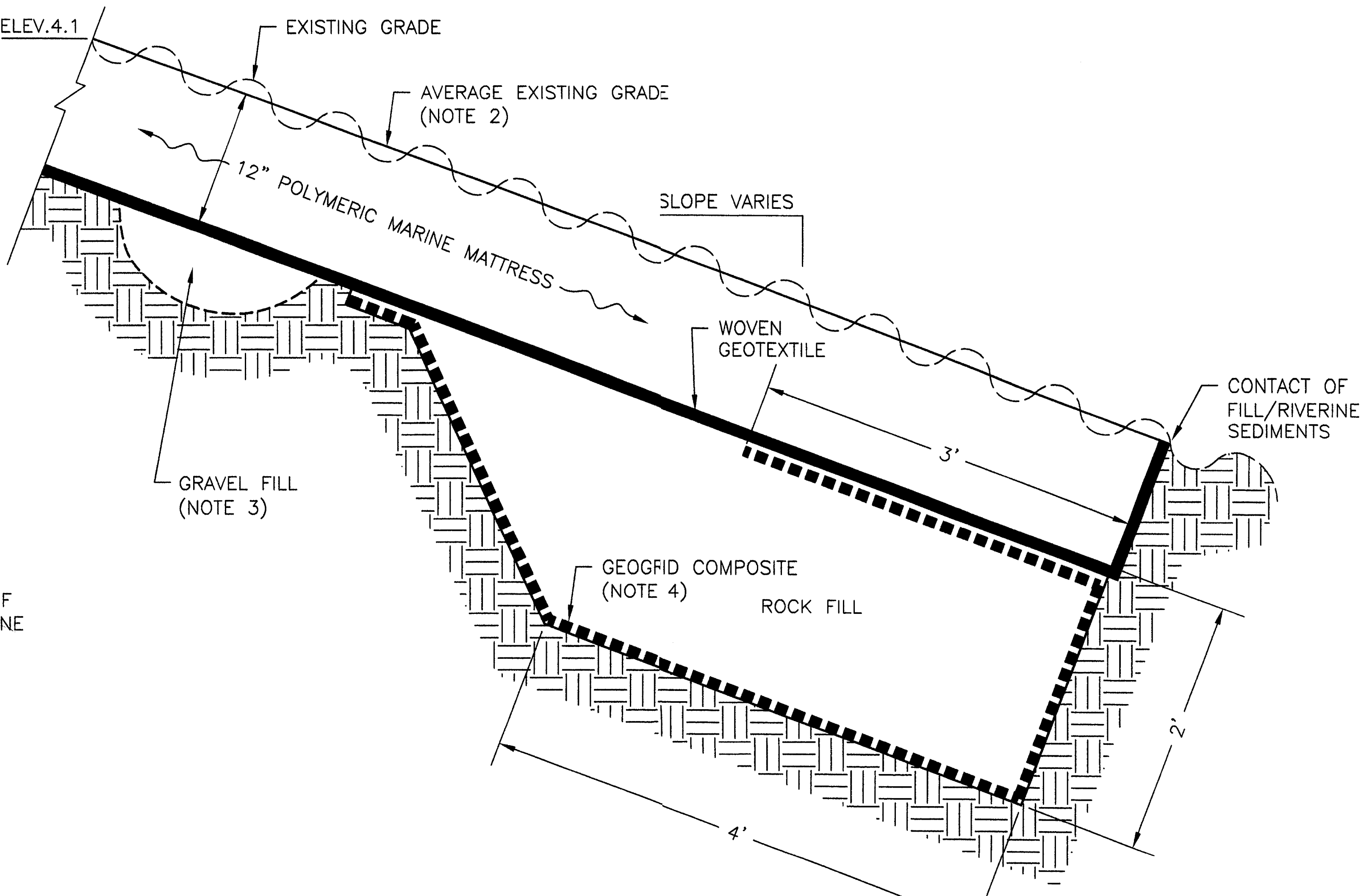


NOTES:

1. TYPE 1 TOE DETAIL TO BE USED ONLY WHERE SHOWN ON DRAWING C–104.
2. POLYMERIC MARINE MATTRESS SHALL NOT ENCROACH BEYOND THE AVERAGE EXISTING GRADE BETWEEN THE CONTACT OF FILL/RIVERINE SEDIMENTS AND ELEVATION 4.1–FEET MSL.
3. PLACE GRAVEL FILL IN VOIDS AND SOFT ZONES AS NECESSARY TO PROVIDE STABLE UNIFORM BASE FOR PLACEMENT OF POLYMERIC MARINE MATTRESS.
4. PLACE GEOGRID COMPOSITE DIRECTLY ON SUBGRADE, GEOTEXTILE SIDE DOWN, WITH MACHINE DIRECTION PERPENDICULAR TO SLOPE, WRAP AROUND END OF POLYMERIC MATTRESS. OVERLAP ENDS AND TIE AS APPROVED BY THE CONTRACTING OFFICER.

## TOE DETAIL – TYPE 1 (SEE NOTE 1)

NOT TO SCALE



NOTES:

1. TYPE 2 TOE DETAIL TO BE USED ONLY WHERE SHOWN ON DRAWING C–104.
2. POLYMERIC MARINE MATTRESS SHALL NOT ENCROACH BEYOND THE AVERAGE EXISTING GRADE BETWEEN THE CONTACT OF FILL/RIVERINE SEDIMENTS AND ELEVATION 4.1–FEET MSL.
3. PLACE GRAVEL FILL IN VOIDS AND SOFT ZONES AS NECESSARY TO PROVIDE STABLE UNIFORM BASE FOR PLACEMENT OF POLYMERIC MARINE MATTRESS.
4. PLACE GEOGRID COMPOSITE DIRECTLY ON SUBGRADE, GEOTEXTILE SIDE DOWN, WITH MACHINE DIRECTION PERPENDICULAR TO SLOPE, WRAP AROUND AND PLACE BELOW POLYMERIC MATTRESS. 3 FEET, AS SHOWN. EXTEND UP EXCAVATION AS FAR AS POSSIBLE, MAY NOT EXTEND BELOW MATTRESS. OVERLAP ENDS AND TIE AS APPROVED BY THE CONTRACTING OFFICER.

## TOE DETAIL – TYPE 2 (SEE NOTE 1)

NOT TO SCALE

Brian Barnes Johnson
No. 19726
8/30/01

US Army Corps
of Engineers
New England District

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| 0 | 100% ISSUED FOR CONSTRUCTION | 8/30/01 | BBJ |  |  |  |  |
| A | PHASE II 90% CLIENT REVIEW | 5/9/01 | BBJ |  |  |  |  |

U.S. ARMY CORPS OF ENGINEERS
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**Rev.** 0
**Design file no.** C47254DT05
**Drawing code:**
**File name:**
**Plot date:**
**Plot scale:** 1=1

NON–TIME CRITICAL REMOVAL ACTION
CAUSEWAY COVER DESIGN (PHASE II)
STRATFORD ARMY ENGINE PLANT

STRATFORD, CONNECTICUT

**MISCELLANEOUS DETAILS**

Sheet reference number:
C–303
SHEET 9 OF 9

# APPENDIX C

# REMOVAL ACTION JUSTIFICATION

ATTACHMENT A – RESPONSE TO COMMENTS ON THE EE/CA
ATTACHMENT B - COVER SYSTEM OPTION COST EVALUATION
ATTACHMENT C – CORRESPONDENCE WITH CTDEP RE: APPROVAL OF PERMANENT COVER SYSTEM
ATTACHMENT D - TRI-LOCK CONCRETE MIX EVALUATION
ATTACHMENT E - CAUSEWAY VEGETATION SELECTION
ATTACHMENT F - POLYMERIC MARINE MATTRESS EVALUATION
ATTACHMENT G - INTERSTITIAL GRAVEL FILTER ANALYSES

# ATTACHMENT A

# COMMENTS ON THE EE/CA

# RESPONSE TO COMMENTS ON
# REVISED DRAFT
# ENGINEERING EVALUATION/COST ANALYSIS FOR THE CAUSEWAY AND DIKE
# (DATED JULY 31, 2000)
# STRATFORD ARMY ENGINE PLANT
# STRATFORD, CONNECTICUT

U.S. ARMY CORPS OF ENGINEERS
NEW ENGLAND DISTRICT
CONCORD, MASSACHUSETTS

by

FOSTER WHEELER ENVIRONMENTAL CORPORATION
and
HARDING LAWSON ASSOCIATES

SEPTEMBER 2000

# RESPONSE TO COMMENTS ON
# REVISED DRAFT
# ENGINEERING EVALUATION/COST ANALYSIS FOR THE CAUSEWAY AND DIKE
# (DATED JULY 31, 2000)
# STRATFORD ARMY ENGINE PLANT
# STRATFORD, CONNECTICUT

**Comment #** **Comment/Response**

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## CTDEP Comments dated September 13, 2000 on Revised Draft EE/CA Report Causeway and Dike Area, SAEP, Stratford, CT July 2000

## General Comments

1. **Comment:** Section 2.2 describes the RCRA closure as completed, including the drum storage area, however this has not yet been finalized.

   **Response:** Section 2.2 has been revised to indicate that RCRA closure activities for the drum storage area have been initiated, but not completed.

2. **Comment:** The citation of ARARs is incorrect in detail for the Remediation Standard Regulations. The Connecticut General Statutes (CGS) Section 22a-133k required adoption of remediation standard regulations, which were promulgated as Regulations of Connecticut State Agencies (RCSA) Sections 22a-133k 1 to 22a-133k 3. Environmental Land Use Restrictions are statutorily defined in CGS Sections 22a-133n through 22a-133r, and the format for filing is detailed in RCSA Section 22a-133q.

   **Response:** Table 3-1 has been revised to reference both the Connecticut General Statutes and the Regulations of Connecticut State Agencies associated with the Remediation Standard Regulation (RSR).

3. **Comment:** Alternative 4 is the installation of a cover/structure which renders underlying soil inaccessible as specified in the definition of inaccessible soil at RCSA Section 22a-133k 1(a)(28). This definition should be cited. As provided in RCSA Section 22a 133k 2 (b)(3), the Direct Exposure Criteria do not apply to inaccessible soil which is subject to an Environmental Land Use Restriction (ELUR). Because of this exemption, the proposed remedy in alternative 4 is not strictly considered an engineered control under the Remediation Standard Regulations, thus many of the specific provisions of RCSA 22a 133k 2(f)(2) do not apply. However, DEP recommends that appropriate engineering design and postclosure care be included in the remedy to ensure long-term continued inaccessibility. The timing of and procedure for the ELUR placement should be indicated.

**Response:** Table 3-1 has been revised to provide more detail regarding the "Requirement Synopsis" and "Action to be taken to attain ARAR" relative to the RSR and the use of engineered controls, a cover or structure to render contaminated soil inaccessible, and ELURs.

Text has been added to Section 4.0 regarding the timing and procedure for establishing the ELUR.

4. **Comment:** Note that the provisions for approval of an engineered control present at RCSA Section 22a 133k 2(f)(2) do apply to alternatives 1 and 2. DEP recommends that, to ensure implementation is not delayed in the event alternative 1 or 2 is selected as the remedy, the specified Section 22a 133k 2(f)(2)(A)(iv) public notification be concurrent with other public notifications for the project. Also, the detailed design and decision documents should address all the required elements at Section 22a 133k 2(f)(2)(B) if alternative 1 or 2 is selected.

   **Response:** The public notice to announce the availability of the EE/CA for public comment, will be prepared to address the requirements of CERCLA and the NCP, as well as the requirements of the CTDEP RSR. Additionally, if Alternative 1 or 2 is the selected remedy, the decision document and design will address the requirements of the CTDEP RSR Section 22a 133k 2(f)(2)(B).

5. **Comment:** DEP notes that the activity specific ARARs will be identified during the design phase, and reserves comment until these ARARs are identified in detail. The EE/CA should include any consideration of activity specific ARARs which may affect the selection of the preferred remedy.

   **Response:** Table 3-3 presents the potential action-specific ARARs that may apply to the removal action alternatives evaluated in the EE/CA. The action-specific ARARs associated with the selected removal action alternative will be presented in the Causeway Non-Time-Critical Removal Action Decision Document and the Causeway Removal Action Design. Both of these documents will be submitted to the regulatory agencies for review.

# RESPONSE TO COMMENTS ON
# REVISED DRAFT
# ENGINEERING EVALUATION/COST ANALYSIS FOR THE CAUSEWAY AND DIKE
# (DATED JULY 31, 2000)
# STRATFORD ARMY ENGINE PLANT
# STRATFORD, CONNECTICUT

**Comment #** **Comment/Response**

6. **Comment:** The 600 pound rip-rap proposed for the side slopes of the causeway can be viewed as "another existing permanent structure", rather than soil, under the provisions of RCSA Section 22a 133k 1(a)(28)(C)(ii), since it will be existing at the time the Environmental Land Use Restriction is established. DEP can accept a final designed rip-rap thickness of less than four feet, provided the design clearly is demonstrated to meet the objective of maintaining long-term inaccessibility. The conceptual diagrams and discussion should be modified accordingly. This may reduce the proposed widening of the causeway landform at the mean high water level.

   **Response:** The Army is pleased to hear that the CTDEP can accept a riprap layer that is less than four feet thick. Alternative 4 currently projects the overall "footprint" of the Causeway to increase by approximately 0.3 acres. Using a thinner layer of riprap could potentially reduce the final Causeway "footprint". However, the thickness of this layer is somewhat dependent upon the size of the rock used for the riprap (e.g., the thickness should be approximately two times the diameter of the minimum $W_{50}$, based on the gradation of the riprap). Several details must be evaluated and addressed during the detailed design of the selected removal action alternative, including the size and thickness of the riprap to provide the necessary protection from storm surge and wave action.

   The Army prefers not to revise the "conceptual" design presented in the EE/CA at this time. The detailed design of the selected remedy will provide the recommended size and thickness of the riprap layer, as well as better define the amount, if any, of expansion of the overall Causeway "footprint".

7. **Comment:** DEP understands that groundwater quality will be addressed in a separate operational unit. RCSA section 22a 133k 3(b)(2) mandates that groundwater discharging to the tidal flat conform with surface water quality criteria. Note that these values are lower than the Remediation Standard Regulation Appendix D Surface Water Protection Criteria, which incorporate a default attenuation factor. To ensure the interim remedy is consistent with the final remedy, DEP recommends that the proposed spot removal of soils with mobile pollutants also consider potential impacts of leachable pollutants on surface water. This would limit the risk for further action in a final remedy to address soil as a pollutant source if groundwater exceeds evaluation criteria. The degree of concern depends on the difference between a pollutant's GB Pollutant Mobility Criterion (the target interim removal criterion) and its Aquatic Water Quality Benchmark value, and also on the potential for attenuation

between the soil location and the receptor tidal flat. For example, DEP recommends a value of 280 ug/l for vanadium acute toxicity in water, as compared to a GB Pollutant Mobility Criterion of 500 ug/l. A removal criterion of 280 ug/l, as opposed to 500, would ensure that, even without any attenuation on the transport path from soil to surface water, there would be no possibility of acute toxicity. Suggested Aquatic Benchmark values for identified pollutants not listed in Connecticut's Water Quality Criteria and Standards can be obtained from Traci Iott (860-424-3082).

**Response:** The Army has compared the existing (through 09/01/2000) SPLP organic and inorganic Causeway soils data to the Aquatic Water Quality Criteria (AWQC) benchmark values provided by the CTDEP. The following table provides information on the concentrations of analytes (from SPLP analyses) which exceed AWQC in Causeway soils:

| Analyte | Location ID | Result (µg/L) | AWQC (µg/L) | GB-PMC(µg/L) |
|---|---|---|---|---|
| Vanadium | CB-99-03 | 5920 | 280 | 500 |
| Vanadium | TP-DEP-11 | 807 | 280 | 500 |
| Vanadium | TP-DEP-12 | 1070 | 280 | 500 |
| Zinc | CB-99-01 | 293 | 120 | 50000 |

Of the locations listed above, CB-99-03, TP-DEP-11, and TP-DEP-12 were previously identified as areas where soil concentrations exceed the CTDEP GB PMC. At location CB-99-01, zinc does not exceed the GB PMC, but does exceed the AWQC.

The Army will consider use of the AWQC for definition of soils requiring excavation (during the Design phase of the project) to consider potential impacts of leachable pollutants on surface water.

8. **Comment:** DEP also reiterates earlier comment that polluted soils within the zone of diurnal tidally influenced groundwater fluctuation may require additional mitigation in the final remedy if they are found to be unacceptably affecting the environment.

   **Response:** Comment noted.

# RESPONSE TO COMMENTS ON
# REVISED DRAFT
# ENGINEERING EVALUATION/COST ANALYSIS FOR THE CAUSEWAY AND DIKE
# (DATED JULY 31, 2000)
# STRATFORD ARMY ENGINE PLANT
# STRATFORD, CONNECTICUT

**Comment #** **Comment/Response**

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**CTDEP (Office of Long Island Sound Programs) Comments dated September 7, 2000 on Revised Draft EE/CA Report**
**Causeway and Dike Area, SAEP, Stratford, CT**
**July 2000**

In general, we are disappointed that our prior comments have not been adequately addressed in this revision (see discussion below). We must continue to stress that it is the responsibility of the Army to minimize any structural solution at this site in order to proceed with a project that is consistent to the maximum extent practicable with the enforceable policies of Connecticut's federally approved coastal management program. Encroachment into or over the intertidal flat must avoided if possible. If avoidance is not possible, any encroachment must be minimized to the maximum extent practicable and clearly and adequately justified. Significant changes from current conditions (e.g., changes in the size and location of the footprint of the causeway and dike, the character of the face of the causeway and dike including its slope and relative make-up) must be avoided if possible and, if not possible, must be well justified. Based on the information provided to date, there is no clear justification provided for enlarging the footprint of the dike and/or causeway nor is there adequate justification for altering the angle and general makeup of the side slopes.

As stated in our previous comments, it appears that the remedial solutions under consideration essentially consist of an "under barrier" and an "over cap" and that these components may, to some extent, be interchanged from one alternative to the other. The selection of the appropriate under barrier to prevent contact with the contamination is not within OLISP's area of expertise and we defer to others to determine which under barrier is most appropriate. We are, however, concerned about the type of material used for the outermost layer(s) of the over cap, its placement on the causeway and/or dike and the final overall configurations of these project components.

While one type of under barrier may be most appropriate, the associated over cap depicted in the series of alternatives presented here may not be the most appropriate from a coastal management perspective. The apparent ability to "mix and match" under barrier and over cap may prove especially useful in designing a project that achieves all ARARs to the maximum extent practicable.

# RESPONSE TO COMMENTS ON
# REVISED DRAFT
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# (DATED JULY 31, 2000)
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# STRATFORD, CONNECTICUT

**Comment # Comment/Response**

ALTERNATIVES

The current draft EE/CA contains four alternatives, three of which are illustrated by Figures 4-1, 4-2 and 4-3. Alternative 4 has been added since the last draft EE/CA, dated February 23, 2000, and is identified as the current preferred alternative. All three of the illustrated alternatives raise concerns from a coastal management perspective and, as discussed below, it is not clear from the information provided that the preferred alternative actually meets the applicable design criteria.

General Comments – Unfortunately, the plans provided appear to be diagrammatic only and are lacking sufficient detail to enable us to make reasonable evaluation of the alternatives for consistency with the policies and standards of Connecticut's coastal management program. While cross-sections are provided for three of the four alternatives, there are no plan views provided. Plan views showing both existing and proposed conditions are necessary to evaluate the alternatives for consistency with the enforceable policies of the Connecticut Coastal Management Program.

Additionally, there are several specific and critical elevations that must be shown on all plans and cross-sections to allow for a coastal consistency determination. These elevations are the high tide line, mean high water and mean low water. The figures provided in the revised draft EE/CA depict mean high water at elevation 4.1 and "low tide" at elevation 0.8. The high tide line is not provided nor is the reference datum indicated. If the reference datum is National Geodetic Vertical Datum (NGVD), the elevation of mean high water is correct at 4.1 feet; however, the corresponding elevation of mean low water is not elevation 0.8 as shown in the figures, but rather, it is -2.7 feet NGVD.

The location of the high tide line should also be shown on all plans and cross sections. Without a careful on-site investigation, its exact elevation cannot be determined. However, based on our experience its location will be somewhat higher than elevation 5.7 feet NGVD (the one-year frequency tidal flood elevation as calculated by the Army Corps of Engineers) and may in fact, be close to elevation 7 feet NGVD. For the purposes of this project, the depiction of elevation 7 feet NGVD on all the plans will suffice to approximate the high tide line.

Please be aware that because of the diagrammatic nature of the plans, these critical elevations cannot be shown with any degree of confidence. Without a reasonable representation of the existing and proposed conditions in relation to these critical elevations, a formal coastal consistency determination will not be possible.

| Comment # | Comment/Response |
|---|---|

We have previously expressed our concern that the alternatives be designed to avoid any encroachment into the intertidal flat. Alternative 1 is described as maintaining the location of the existing toe of slope through the excavation of the side slope and toe materials with their consolidation on top of the causeway prior to construction of the under barrier and cap. The corresponding figure also includes a note that existing material will be excavated to maintain the existing toe of slope. However, since the existing condition is not shown on this figure, it cannot be verified that this approach will also maintain the existing locations of the high tide line and mean high water. Neither of the other figures appears to clearly depict the necessary excavation to ensure that the proposed alternatives will not ultimately alter the present locations of mean high water, mean low water and the high tide line. Accordingly, none of these alternatives is acceptable from a coastal management perspective without some additional refinement of the plans.

If there is confusion regarding this essential matter, I strongly recommend that we discuss it either over the phone or in person, or both. I understand that there are currently meetings of the RAB and BCT scheduled for September 28, 2000. Discussion of these issues should occur prior to those meetings. If necessary, and depending upon my schedule, I may be available to meet in Stratford when your consultant is due to be there, if it would be helpful.

Alternative 1 - Figures 4-1 - The plans do not show the existing profile(s) for this alternative. Lacking this information, it is not possible to determine either the degree, if any, of encroachment into public trust and intertidal flats that this alternative represents or whether this alternative represents an ultimate change in the type and/or angle of side slope currently present on the causeway. It is our understanding that the causeway is already armored. If this is the case, replacement in place and in kind is acceptable and consistent with our enforceable policies regarding shoreline flood and erosion control structures. Additional information regarding the existing contours and make-up of the causeway side slopes in comparison to the proposed condition is necessary to determine the acceptability of this alternative.

Alternative 2 - Figure 4-3 – Although the Army has indicated that this alternative is not the preferred project, we are compelled to reiterate our previous comments in the event that it comes under further consideration. Alternative 2 includes a vertical faced bulkhead. In prior discussion, we have discouraged the Army from considering such a structure as it constitutes a significant change from the existing condition. It also carries with it the potential to alter the localized wave energy patterns and we expect it would result in erosion of the intertidal flat.

**Comment #** **Comment/Response**

Such erosion would be unacceptable as intertidal flats are a protected resource in Connecticut and we strongly advise against any further pursuit of this alternative.

Alternative 4 - Figure 4-3 – The current draft EE/CA contains a new alternative, number 4, which is identified as the preferred alternative and is allegedly based, in part, on our prior comments. Unfortunately, the information provided regarding this alternative describes a design that is actually less consistent with Connecticut's coastal management program than some of the alternatives considered for this project.

The description of this alternative includes removal of contaminated soil "hot spot areas" and containment of the remaining contaminated fill material within the causeway by constructing an erosion control cover system. Although the text indicated that following removal of the contaminated soil hot spot areas, the causeway would be regraded by cutting and filing existing material to establish base grades, these grading activities are not evident in Figure 4-3. Unlike Alternative 1, where the plans specifically note that the existing toe will be maintained by excavating existing material, Alternative 4 appears to include simply placing riprap over the existing side slopes. This method of armoring will result in significant and unacceptable encroachment beyond the high tide line and mean high water and into intertidal flats.

Additionally, Figure 4-3 is very confusing. It shows two existing slopes and only one proposed slope. There is no clear indication of where along the length of the causeway these apparently separate profiles are found. Nor is it clear why the proposed slope would not follow and reflect the existing condition. Regardless of the original profile, as discussed above, this alternative represents significant fill and encroachment beyond both the existing mean high water and mean low water lines. Although the high tide line is not shown on the plans, presumably fill is also proposed waterward of this critical elevation. It is not likely that a convincing demonstration can be made that this alternative, as currently proposed, is consistent with applicable enforceable policies and standards regarding shoreline flood and erosion control structures, filling in coastal waters and intertidal flats.

Based on both the tentative selection of Alternative 4 as the preferred alternative and its depiction provided in Figure 4-3, it does not appear that the Army fully understands the need to design a project that: 1) will not result in degradation of sensitive coastal resources, including the intertidal flats present at this site; 2) is consistent with the enforceable policies and standards regarding the construction of shoreline flood and erosion control structures; and 3) minimizes horizontal encroachment into coastal waters (i.e., encroachment beyond the high tide line, mean high water and/or mean low water).

If Alternative 4 is to remain the preferred alternative, it must be modified to eliminate, if possible, any encroachment beyond the existing location of the high tide line, mean high water, and mean low water. We strongly encourage the Army to investigate the potential to relocate existing material to the extent necessary to maintain the current causeway footprint. If elimination of all encroachments is not possible, adequate justification must be given as to why any encroachment should be found acceptable to the State of Connecticut.

<u>Responses to Prior DEP-OLISP Comments</u>

Unfortunately, several of the Army's responses, provided in Appendix A, do not adequately address the issues that we raised in our previous comments. Specifically, we note the following outstanding issues presented in the order that they appear in Appendix A.

<u>Comment #4, pages 10 & 11</u> - The DEP-OLISP's comment was, in part, "it is important to maintain, to the extent practicable, the horizontal location of mean high water (4.1' NGVD), which is the landward extent of the public trust area." The response was to indicate on the plans the location of mean high water; however, no apparent effort was made to modify the plans to eliminate or reduce the indicated encroachment waterward of this critical line. Nor was an explanation offered as to why the project could not be designed to maintain the horizontal location of mean high water. This is a critically important issue to the State of Connecticut as we are the steward for the public trust land waterward of mean high water and, as such, must protect and preserve this area for the general public both for now and for the future. Any additional encroachment beyond the current location of mean high water must be avoided if at all possible, and if avoidance is not possible it must be both minimized to the maximum extent practicable and justified to our satisfaction.

It has recently been brought to our attention that there is concern that the proposed cap might, in fact, have to be designed with a larger footprint to spread the weight of the causeway and cap over a larger area. Apparently the issue is the potential for the extra weight of the causeway to produce an upward "bulging" of the adjacent intertidal flat. In our experience, increasing the weight on filled land has not lead to such bulging, but rather, has lead to the reverse. Increased loading, as has been seen with road construction on filled land, has more typically resulted in depressed areas alongside the filled area. In the case of the subject causeway, if depressions in the intertidal flat result from the proposed work, we expect increased sedimentation into the depressed areas until equilibrium has been reached and the surface is restored to its present state.

Comment #5, page 11 - The DEP-OLISP's comment was that the list of ARARs provided in the previous draft was incomplete. Of specific concern, in part, was that the list did not include Connecticut's Tidal Wetlands Act (Connecticut General Statutes 22a-28 through 22a-35). The response was that "the Inland Wetlands and Watercourses Act, also known as the Tidal Wetlands Act, was included" in the original list of ARARs. The Inland Wetlands Act and the Tidal Wetlands Act are separate and distinct statutes. They have never been interchangeable nor have they shared a title. To merge these two independent regulatory programs is incorrect and unacceptable. Although the current ARARs list (see Table 3-2) includes the *Tidal Wetlands Regulations*, it still fails to include the underlying statute. The Tidal Wetlands Act must be listed as an ARAR separate from both the Inland Wetlands and Watercourses Act and the Tidal Wetlands Regulations and it must be fully considered in the final development and consideration of alternatives for this action.

Additional Comments

We note that the description of the property on page ES-1 is incorrect. It is apparently carried forward from earlier property descriptions that we have continually attempted to have the Army correct. The Army does not own "48 acres of riparian rights." Riparian rights are not measured in acres or any other form of area measurement. Riparian rights are simply the rights of waterfront property owners to access navigable waters. This should be corrected in the final document.

We appreciate this opportunity to review and comment on the progress made to date on this project. We strongly encourage you to continue close coordination with this Office during the refinement of the final alternative(s) for this project. Please be aware that the formal federal consistency review will require additional detailed information including: 1) drawings that depict the existing and proposed footprint of the causeway; 2) existing and proposed locations of the high tide line, mean high water and mean low water on all plans and cross sections; 3) calculations of the total volume of fill to be placed waterward of the high tide line, mean high water and mean low water; and 4) adequate justification for such fill.

**Response:** The Army understands the issues and concerns raised by the CTDEP OLISP, which are primarily related to avoiding encroachment into the intertidal flats of the Housatonic River and waterward of the high tide line. However, much of these concerns cannot be adequately addressed at this time due to the limited amount of data available. However, the Army will conduct additional on-site investigation activities to collect the necessary data that will allow the Army to address the CTDEP OLISP issues and concerns during the detailed design of the selected removal action alternative. Harding Lawson Associates initiated on-site investigation activities at the Causeway September 14, 2000. These activities include a geotechnical investigation and topographic survey of the Causeway and adjacent area. The information obtained from these activities will be used to evaluate settlement and stability of the Causeway and proposed cover system, determine the size and thickness of the riprap/stone armor for the cover system, prepare existing and final grading plans, and prepare material specifications and quantity estimates. The removal action design will be prepared with consideration given to the issues and concerns raised in these, and previous, comments provided by the CTDEP OLISP. The 30-percent design will be submitted to the regulatory agencies (i.e., USEPA, CTDEP, and OLISP) for review.

The Army will design the selected remedy to minimize encroachment into the intertidal flats of the Housatonic River and waterward of the high tide line to the extent practicable. After the additional field investigations are completed and the data evaluated, the Army suggests a working meeting with the USEPA and CTDEP, including OLISP, to review the data evaluation and design criteria in an attempt to address the concerns raised by the CTDEP OLISP. The Army looks forward to working with the USEPA, CTDEP, and OLISP to resolve these outstanding issues and arrive at a mutually agreeable solution for the Causeway non-time-critical removal action.

# RESPONSE TO COMMENTS ON
# REVISED DRAFT
# ENGINEERING EVALUATION/COST ANALYSIS FOR THE CAUSEWAY AND DIKE
# (DATED JULY 31, 2000)
# STRATFORD ARMY ENGINE PLANT
# STRATFORD, CONNECTICUT

**Comment # Comment/Response**

## USEPA Comments dated August 31, 2000 on Revised Draft EE/CA Report Causeway and Dike Area, SAEP, Stratford, CT July 2000

## ARARs Tables 3-1 through 3-3

1. **Table 3-1**

- There should be an indication that there are no Federal chemical-specific ARARs.
- There should be some description of how contaminated soil will be remediated in accordance with CGS §§ 22a-133k and 22a-133q.

**Response:** Table 3-1 has been revised as requested.

2. **Table 3-2**

- There should be some description of how remedial activities that involve dredged or fill material will comply with 40 CFR § 230 and 33 CFR Parts 320-330.
- There should be some description of how remedial activities affecting the coastal zone of the site will be conducted in accordance with 16 USC §1451, et seq.
- There should be some description of how remedial activities will be conducted in accordance with CGS §§ 22a-28 through 22a-35 and RCSA §§ 22a-30-1 through
- 22a-30-17.
- There should be some description of how remedial activities will be conducted in accordance with CGS §§ 25-68b through 25-68h and RCSA §§ 25-68h-1 through
- 25-68h-3.
- There should be some description of how remedial activities will be concluded in accordance with CGS §§ 22a-359 through 22a-363(f).

**Response:** Table 3-2 has been revised as requested.

# RESPONSE TO COMMENTS ON
# REVISED DRAFT
# ENGINEERING EVALUATION/COST ANALYSIS FOR THE CAUSEWAY AND DIKE
# (DATED JULY 31, 2000)
# STRATFORD ARMY ENGINE PLANT
# STRATFORD, CONNECTICUT

**Comment #** **Comment/Response**

3. **Table 3-3**

- There should be some description of how remedial activities associated with design, monitoring and maintenance will comply with 40 CFR § 264.110 - 264.120.

**Response:** Table 3-3 has been revised as requested.

# RESPONSE TO COMMENTS ON THE FINAL CAUSEWAY & DIKE ENGINEERING EVALUATION/COST ANALYSIS
(DATED SEPTEMBER 2000)
STRATFORD ARMY ENGINE PLANT
STRATFORD, CONNECTICUT

U.S. ARMY CORPS OF ENGINEERS
NEW ENGLAND DISTRICT
CONCORD, MASSACHUSETTS

by

FOSTER WHEELER ENVIRONMENTAL CORPORATION
and
HARDING ESE

January 2001

# RESPONSE TO COMMENTS ON THE
# FINAL CAUSEWAY & DIKE ENGINEERING EVALUATION/COST ANALYSIS
# (DATED SEPTEMBER 2000)
# STRATFORD ARMY ENGINE PLANT
# STRATFORD, CONNECTICUT

**Comment #** **Comment/Response**

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## Local Reuse Authority Comments (dated October 24, 2000) on the Final EE/CA Report Causeway & Dike, SAEP, Stratford, CT

In addition to the human health and the environmental issues, which are addressed in the EE/CA, the LRA is still very interested in its ability to use the Causeway and Dike for the purposes described in the 1997 Redevelopment Plan and the EDC Application. The product of the EE/CA, therefore, is critical to the LRA's plans for its intended use, which is open green space for passive recreation.

## SPECIFIC COMMENTS

1. **Comment:** Page. ES-1, Para. 1, states that "the Draft RI Report is scheduled to be submitted in the summer of 2000". What is the status of the report and when will it be available to the LRA for review?

   **Response:** As of January 2001, the Draft RI Report is in regulatory agency review. Once the RI has been finalized, it will become part of the Administrative Record and will be available to the LRA for review.

2. **Comment:** Pg. ES-1, Para. 3. The SAEP is in an MA (light industrial) zone.

   **Response:** Comment noted.

3. **Comment:** Pg. ES-2, Para. 4. Same comment as number 1 regarding the RI report.

   **Response:** See response to Comment 1.

4. **Comment:** Pg. ES-3, Para. 1. The second sentence states, "exceedances were detected in three isolated hand auger explorations on the south face and edge of the Dike". It goes on to say, that because these locations are not within the dike they will be addressed by the Feasibility Study. When will the Feasibility Study be available for review by the LRA? Lack of characterization of these areas could cause problems with open space design.

   **Response:** Preparation of the Feasibility Study will commence once the RI Report is finalized and the decision documents for the Causeway and Dike and OU 2 non-time-critical removal actions have been completed. As of January 2001, a specific schedule for the Feasibility Study has not been developed.

5. **Comment:** Pg. 2-1, Section 2.1.2, Para. 1. The SAEP is in an MA (light industrial) zone.

   **Response:** Comment noted.

6. **Comment:** Pg. 2-4, Sect. 2.1.4.1. Introductory paragraph lists peat as a character of the shallow geology of the SAEP, but the following paragraphs do not describe its relevance to the geology.

   **Response:** Peat has been encountered mainly in the southern portion of SAEP, near the former lagoons. This area has no relevance to the geology associated with the Causeway and Dike.

7. **Comment:** Pg. 2-4, Sect. 2.1.4. The RAB was informed of a differential settling problem on the causeway, but the concern was neither identified nor described in this section.

   **Response:** The purpose of Subsection 2.1.4 is to summarize the geology and hydrogeology at the site, not the potential for differential settlement as a result of future construction activities. Potential differential settlement of the Causeway is being addressed in the geotechnical evaluation, which is a component of the 30-percent design for the Causeway removal action alternative.

8. **Comment:** Pg. 2-11, Sect. 2.4. The paragraph states "CTDEP has established RSR criteria for various media, including target concentrations for indoor air..." When asked for the criteria by the RAB, it is not available. Does such a criteria exist; if so, and what is it?

   **Response:** The RSR criteria for indoor air are addressed in the OU 2 EE/CA and the RSR indoor air target concentrations have been provided at several RAB meetings. In summary, the target concentrations for the primary contaminants of concern, presented in parts per billion by volume (ppbv) are as follows:

| | |
|---|---|
| tetrachloroethene | 1.61 ppbv |
| trichloroethene | 0.92 ppbv |
| 1,1-dichloroethene | 0.02 ppbv |
| 1,1,1-trichloroethane | 266 ppbv |
| vinyl chloride | 0.019 ppbv |

**Comment #** **Comment/Response**

9. **Comment:** Pg. 3-1, Sect. 3.0, Para. 2. On what basis was the causeway and dike area considered a non-critical removal action?

**Response:** As presented in the EE/CA, it is a non-time-critical removal action, rather than a "non-critical" removal action as stated in the comment. Non-time-critical removal actions are conducted to expedite environmental cleanup. The USEPA has categorized removal actions in three ways: emergency, time-critical, and non-time-critical. Non-time-critical removal actions respond to releases requiring action that can start later than six months after determination that a response is necessary.

10. **Comment:** Pg. 3-2, Sect. 3.2. Implementation of the Causeway and Dike NCRA was, "anticipated to begin in late summer or fall of 2000". What is the new anticipated start date, and what is the schedule to reach that point?

**Response:** Pre-design activities were conducted between September and November 2000. Design activities were initiated in December 2000 and are anticipated to be completed by the spring of 2001. The removal action is anticipated to commence shortly thereafter, with completion in 2001.

11. **Comment:** Pg. 4-18, Para. 3, states that the "erosion control cover system would consist of riprap armor over the entire Causeway surface; however, with a smaller size material used on the top center portion..." The proposed causeway cover suggested here does not appear to be compatible with page 2-3, "Future Land Use", which states, "The approximately 16 acres of proposed park land (i.e., recreational area) would include a landscaped park with pathways for pedestrians and bicyclists..." The Town's intended land use for the causeway, which has remained unchanged since submission of the 1987 Redevelopment Plan, has been to use it as green open space.

**Response:** The goal of the proposed non-time-critical removal action is to limit direct exposure of future users of the Causeway to contaminants on the Causeway and prevent erosion of the Causeway materials. If additional construction is needed to meet the Town's future reuse objectives, the Town and its developer would need to complete that construction after transfer of the property from the Army to the Town. Army BRAC funds are intended to address environmental risks, not to make improvements to the property.

12. **Comment:** Pg. 4-18, Para 6, discussed "a notice of intent to record an environmental land use restrictions". What are these land use restrictions, and when will they be defined?

**Response:** Land use restrictions will be established in the site-wide Record of Decision to be prepared in 2002. These may include, among other restrictions, restrictions on excavation that could expose contaminants or allow erosion of Causeway soils.

13. **Comment:** Pg. 4-22, Assumption 2. How will disturbance of the tidal flats be minimized if a portable dam is not placed around the causeway during construction?

**Response:** Temporary erosion control measures (e.g., silt fence, turbidity curtain, silt boom) will be used to minimize disturbance to the surrounding area. Additionally, excavation and backfill activities will be conducted in a manner to minimize disturbance to areas beyond the existing footprint of the Causeway to the extent practicable.

14. **Comment:** Pg. 4-22, Assumption 6. Geotechnical investigation and evaluation for settlement, slope, and global stability is planned during predesign of the causeway remediation plan. When will this information be available to the LRA for review?

**Response:** The geotechnical evaluation was presented at the January 2001 Restoration Advisory Board (RAB) meeting.

15. **Comment:** Pg. 6-1, Para. 4. This paragraph states that all material, equipment, and services are readily available to complete Alternative 1, and it would take approximately seven (7) months to complete. Is the same true for Alternative 4? When will consistency with the RI and Feasibility Study be determined for Alternative 4?

**Response:** Alternative 4 is anticipated to be completed within seven months. Alternative 4 is expected to be consistent with the long-term remedy for the site.

## GENERAL COMMENTS

a. **Comment:** The Town wants the causeway to provide access to deeper water at its end. Can sheet pilings be installed at the end off the causeway as part of its remediation?

**Response:** The Army does not anticipate any improvements to extend the Causeway to provide access to the deeper water in the river channel. Additionally, the CTDEP Office of Long Island Sound Programs (OLISP) has clearly stated on several occasions that installation of a vertical barrier (e.g., sheet pile seawall) on the Causeway is the least acceptable alternative.

b. **Comment:** The Causeway was always envisioned as open green space, which would provide opportunities for passive recreations. The current design would limit the site's usefulness and cause difficulty, particularly, for the Town's handicapped residents to use the causeway.

**Response:** The goal of the proposed non-time-critical removal action is to limit direct exposure of future users of the Causeway to contaminants on the Causeway and prevent erosion of the Causeway materials. If additional construction is needed to meet the Town's future reuse objectives, the Town and its developer would need to complete that construction after transfer of the property from the Army to the Town. Army BRAC funds are intended to address environmental risks, not to make improvements to the property.

As of January 2001, the Causeway removal action design is being prepared with consideration of construction materials other than the large riprap that was presented in the Final EE/CA. If these alternative materials are selected, these materials should provide a surface layer that may be more compatible with the proposed future use of the Causeway.

**Town of Stratford Comments (dated October 24, 2000) on the Final EE/CA Report Causeway & Dike, SAEP, Stratford, CT**

## GENERAL COMMENTS

Given the delay in receipt of the final document, which was not available until several days after it was requested, as well as the extremely limited public comment period, I am unable to furnish substantive comments on the more technical aspects of the analysis. I will confine my remarks instead to my general impressions of the plan set forth in the analysis, especially as it relates to the intended future use of the site. I should note that more detailed questions and comments regarding the EE/CA are addressed-in a separate letter, a copy of which I have attached hereto.

The proposed remedial plan calls for the removal and subsequent appropriate disposal of contaminated soil from three "hot spot" areas where soil sampling data indicates exceedances of the CTDEP remedial standards. The report then recommends the installation of a geotextile fabric and erosion control cover system over the entire causeway to prevent further migration of contaminant materials. The plan makes some relatively minor concessions to the intended reuse of the causeway/dike area by proposing to use smaller aggregate material along the top center portion of the causeway to provide a more suitable walking surface.

I understand the primary objectives of this non-critical removal action (NCRA) are to prevent present and future exposures to contaminated soils as well as to minimize the potential for leaching of remaining soil contaminants into the groundwater.

Efforts should be made to maximize treatment techniques so as to reduce to the greatest extent practicable the potential for exposure to soil contaminants. At the same time, I submit that the Army has an obligation to select an approach that is compatible with the future intended use of this site, as identified by the host community. The Town's reuse objectives regarding this area have remained unchanged since virtually the inception of this planning process and have been well documented. The causeway is expected to be part of a public recreational area, which would include a linear park, a bicycle and walking path, a dock and fishing pier in addition to other amenities consistent with its unique waterfront location.

In this regard, I believe that elements of Alternative 2, specifically the installation of a sheet pile seawall, should be incorporated into your final remedial plan. A sheet pile seawall would provide an added level of protection from tidal and wave action and serve as a hydraulic barrier to the constituent wastes that remain buried and encapsulated within the structure. A sheet pile seawall, constructed in conjunction with an appropriately designed erosion control cover system, would further reduce the possibility of migration of soluble contaminants outside the limits of the cap than simply an erosion control cover system alone. Moreover, installation of a sheet pile seawall would provide an even greater degree of consistency with the Town's reuse objectives than other alternatives under consideration since it would preserve access to this structure for the docking or mooring of vessels.

Further, bulkheading or installation of a sheet pile seawall is, as the authors readily acknowledge, a commonly used construction technique. I understand that the Office of Long Island Sound Programs (OLISP) of the CTDEP has expressed concern with regard to this approach, suggesting that this alternative will alter localized wave energy patterns and adversely impact the surrounding intertidal flats. It should be noted, firstly, that the intertidal flats in question are significantly degraded due to decades of industrial production and resultant pollution. Further, while I understand their concern about protection of this resource, such concerns must be balanced against the greater degree of protection afforded by this structure. I might add that not only would a sheet pile seawall provide an added measure of protection against exposure to or migration of contaminant materials, but also it would enhance rather than diminish the utility of this structure.

Finally, I would like to comment on the proposed treatment of the top of the structure as it relates to the intended future use of this site to provide and to enhance public access. I concur with the assessment offered by the CTDEP in its response dated March 31, 2000, in which the author states that the proposed cover "...is not likely to be very inviting to the public nor is it likely to provide a safe walking surface." I submit that not much has changed to alter that perspective in the seven months leading to the publication of this final document. I note that the reviewer recommended " ....that the Army work with the Town of Stratford to identify a reasonable, inviting treatment for the top of the causeway..." that would still provide an adequate barrier against exposure to residual contaminants. I regret that such consultations between the Army and the host community never occurred, and the resulting plan, which now calls for the placement of smaller rather than larger rocks, represents no marked improvement in addressing these concerns. I find it difficult to believe that the approach outlined in Alternative 4 represents the most progressive thinking and the best that we can do under these circumstances.

In the end, I submit that the public would be best served by an approach that combines certain elements of the alternatives presented in the EE/CA report, and further re-examines the treatment of the top of the causeway in terms of using appropriate cover material that is complimentary to the community's reuse objectives. In this regard, I assert that installation of a sheet pile seawall, following excavation of certain hot spot areas and in conjunction with an erosion control system, would clearly provide the highest level of protection to human health and the environment at a reasonable cost.

**Response:** There was no delay in providing the document for review. The Final EE/CA was provided at the beginning of the public comment period. The 30-day public comment period is a standard duration, as well as a requirement of CERCLA and the NCP. The EE/CA and the schedule for submittal and public comment were discussed at the August 2000 RAB meeting, which was attended by representatives of the LRA.

The primary purpose of the Causeway non-time-critical removal action is to provide an erosion control measure to prevent exposure to contaminated soil. Efforts will be made to make the cover system compatible with the proposed reuse plan for the Causeway; however, the primary intent of the removal action is not to construct a public recreation area on the Causeway.

Installation of a sheet pile seawall would result in encroachment into the intertidal flats and coastal waters. The CTDEP OLISP has clearly stated on several occasions that installation of a vertical barrier (e.g., sheet pile seawall), as well as encroachment into the intertidal flats and coastal waters is the least acceptable alternative.

As of January 2001, the Causeway removal action design is being prepared with consideration of construction materials other than the large riprap that was presented in the Final EE/CA. These materials, if selected, would provide a surface layer that may be more compatible with the proposed future use of the Causeway. The 30-percent design will be available in mid-February 2001 and will be discussed with the Town Planner.

## PROTECT YOUR ENVIRONMENT OF STRATFORD Comments (dated May 5, 2000) on the Draft EE/CA Report
## Causeway & Dike, SAEP, Stratford, CT

## GENERAL COMMENTS

Protect Your Environment of Stratford, Inc. criterion for selection of the remediation and clean-up of the Causeway and Dike at the old Stratford Army Engine Plant is contingent upon the effect of the remediation on the contiguous tidal flats. Since the required tidal flat impact information is not clear to us at this time we will defer our comments on the engineering and cost of four-alternative evaluation plans until a later time, with the following exceptions:

- the potential for alternatives 1 and 2 for leaching soil contaminants to groundwater (p.4-4 section 4,1.2 ) needs clarification
- consideration should be given to a 100 year flood on the causeway-dike cap and action of tidal water against sides especially as time goes on
- the long-term effect of rain water on concrete vs soil top of the causeway taking into account human use seems relevant to the selection process.

**Response:** As stated in Section 2.3 of the EE/CA, "Preliminary results of groundwater data collected in November 1999 from the four monitoring wells installed in the Causeway indicate the presence of low concentrations of chlorinated VOCs and inorganic analytes. However, the concentrations of contaminants in groundwater are below the CTDEP RSR Surface Water Protection Criteria and the Volatilization Criteria."

The cover systems provided by Alternatives 1 and 2 would provide protection from direct exposure to the contaminated Causeway fill material and minimize the leaching of contaminants due to precipitation infiltrating through the contaminated fill material. However, the Causeway is located in a tidal environment, and there is no impermeable layer beneath the Causeway to anchor the flexible membrane liner into. Therefore, although it does not appear that contaminants from the Causeway fill material are leaching to groundwater, there is a potential that soluble contaminants may be transported outside the limits of the cap in the future.

The cover system over the Causeway is being designed in accordance with U.S. Army Corps of Engineers requirements and guidance to ensure protection from storm surge or wave action.

The long-term effects of weather and erosion on the cover system are being evaluated as part of the design for the Causeway removal action alternative.

# RESPONSE TO COMMENTS ON THE
# FINAL CAUSEWAY & DIKE ENGINEERING EVALUATION/COST ANALYSIS
# (DATED SEPTEMBER 2000)
# STRATFORD ARMY ENGINE PLANT
# STRATFORD, CONNECTICUT

**Comment #** **Comment/Response**

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## CTDEP OLISP Comments (dated November 6, 2000) on the Final EE/CA Report Causeway & Dike, SAEP, Stratford, CT

## GENERAL COMMENTS

Thank you for the opportunity to review and comment on the documents noted above. We have reviewed them to identify issues that must be addressed during any subsequent review for consistency with the enforceable policies of Connecticut's federally approved coastal management program as set forth in the Connecticut Coastal Management Act [CCMA, Connecticut General Statutes (CGS) section 22a-90 through 22a-112]. We note that we commented on two prior drafts of the Engineering Evaluation/Cost Analysis (EE/CA) document: first, in a memo to Ken Feathers of this Department dated March 22, 2000 which was forwarded to you in a letter from Mr. Feathers date March 31, 2000; and second, in a letter to you dated September 7, 2000. In addition, you and I have had several discussions regarding this project.

First, the issue of formal coastal consistency must be clarified since the public notice published by the Army indicates that you are requesting coastal consistency concurrence. However, as we have discussed, you have stated that this is not your intent at this time. The Army and this Office both recognize that the level of information currently available is insufficient to support a consistency determination. It is our understanding that such information will only become available as the project design progresses. Accordingly, we are taking this opportunity to reiterate the significant issues that must be addressed during the design phase of the project to ensure that ultimate implementation is consistent to the maximum extent practicable (1) with the enforceable policies of Connecticut's federally approved coastal management program.

> (1) When used in reference to federal coastal consistency, 'consistent to the maximum extent practicable' "describes the requirement for Federal activities including development projects directly affecting the coastal zone ...to be fully consistent with such programs unless compliance is prohibited based upon the requirements of existing law applicable to the Federal agency's operations. If a Federal agency asserts that compliance with the management program is prohibited, it must clearly describe to the State agency the statutory provisions, legislative history, or other legal authority which limits the Federal agency's discretion to comply with the provisions of the management program" 15 Code of Federal Regulations 930.32.

Our concerns are as follows.

Any alteration of the causeway must avoid both significant changes from current conditions as well as encroachment into the intertidal flat. If avoidance of either of these items is not possible, any changes and/or encroachment must be minimized to the maximum extent practicable and they must be clearly and adequately justified. Based on the understandably limited information available to date, there is no clear justification provided for either altering the angle and general makeup of the side slopes or enlarging the footprint of the causeway.

It is our understanding that the remedial solutions under consideration essentially consist of an "under barrier" and an "over cap" and that these components may, to some extent, be interchanged from one alternative to the other. The apparent ability to "mix and match" under barrier and over cap may prove especially useful in designing a project that is consistent to the maximum extent practicable with Connecticut's federally approved coastal management program. The selection of the appropriate under barrier to prevent contact with the contamination is not within OLISP's area of expertise and we defer to others to determine which under barrier is most appropriate. We are, however, concerned about the type of material used for the outermost layer(s) of the over cap, its placement on the causeway, the final overall configurations of these outermost project components and their potential to adversely impact sensitive coastal resources, such as the adjoining intertidal flat.

As noted above, in order to satisfy the enforceable policies of our coastal management program, the selected alternative must be designed to avoid any encroachment into the intertidal flat. In the EE/CA, the construction methodology of Alternative 1 is described in both the narrative and the corresponding figure as maintaining the location of the existing toe of slope through the excavation of the side slope and toe materials and their consolidation on top of the causeway prior to construction of the under barrier and cap. This is an appropriate approach to avoid encroachment into the intertidal flats which is consistent with the CCMA.

The preferred alternative (#4) involves placing a cap over the existing causeway and, as presented in the EE/CA, would result in sign Significant encroachment into the intertidal flat In light of the inclusion in the EE/CA of an alternative that maintains the existing footprint of the causeway, the preferred alternative is not acceptable from a coastal management perspective and Alternative 1 should be the selected alternative as it represents the least environmentally impacting alternative when the make-up and nature of the side slopes and the footprint of the causeway are considered.

If Alternative 4 remains the Army's preferred alternative, modifications must be made to eliminate, if possible, any encroachment beyond the existing location of the high tide line, mean high water, and mean low water. To this end, we strongly encourage the Army to investigate the potential to modify the construction methodology of this alternative by relocating existing side-slope material to the extent necessary to maintain the current causeway footprint as is outlined in the description of Alternative 1. If elimination of all encroachments is not possible, substantial and adequate justification must be given as to why any encroachment is consistent with the applicable coastal management policies.

To summarize, the ultimate project must be designed such that it: 1) will not result in degradation of sensitive coastal resources, including the intertidal flats present at this site; 2) is consistent with the enforceable policies and standards regarding the construction of shoreline flood and erosion control structures; and 3) minimizes horizontal encroachment into coastal waters (i.e., encroachment beyond the high tide line, mean high water and/or mean low water). Please be aware that the formal federal consistency review will require additional detailed information including: 1) drawings that depict the existing and proposed footprint of the causeway; 2) existing and proposed locations of the high tide line, mean high water and mean low water on all plans and cross sections; 3) calculations of the total volume of fill, if any, to be placed waterward of the high tide line, mean high water and mean low water; and 4) adequate justification for such fill.

We appreciate this opportunity to review and comment on the progress made to date on this project. We appreciate your continued close coordination with this Office and anticipate that it will continue during the refinement of the final design for this project. We strongly encourage you to either reconsider Alternative 1 as the preferred alternative or modify the methodology of construction of Alternative 4 as described above and develop a final design that does not include any encroachment into intertidal flats and/or coastal waters. Should you have any questions regarding this letter, or any other coastal management matter, or if I can be of further assistance, please do not hesitate to call me at 860.424.3034, send a fax to my attention at 860.424.4054 or an e-mail to margaret.welch@po.state.ct.us.

**Response:** The 30-percent design for the Causeway is being prepared to maintain the existing Causeway footprint and to minimize encroachment into the intertidal flats and coastal waters to the extent practicable. The 30-percent design will be available in mid-February 2001 for review by the regulatory agencies.

# ATTACHMENT B

# COVER SYSTEM OPTION COST EVALUATION

# APPENDIX C
# ATTACHMENT B
# CAUSEWAY CAP OPTIONS
# STRATFORD ARMY ENGINE PLANT
# STRATFORD, CONNECTICUT

Four different options for the capping of the Causeway have been reviewed. These options are listed below, with an explanation of the assumptions associated with each. The attached tables compare the partial costs calculated for each option. These estimates include only the costs for the cover system component of the overall remedy, and do not include costs that are common to all of the options, such as mobilization, building demolition, site preparation, removal of hot spots, etc. The purpose of the presented cost estimates is to provide a quick relative cost comparison between the cover system options. A more thorough cost estimate, of the entire proposed remedy, will be performed once the desired option is identified. All options assume that construction for the Causeway cap begins at a line equal to the north end of Building #59. Costs not supplied by potential subcontractors (Tri-Lock, Triton®, sand, etc.) were obtained from RS Means Site Work and Landscaping Handbook, 1999 edition.

**Option 1: Rip-rap and Triton® - Encroaching**. This option consists of the placement of a rip-rap cover on the top of the Causeway and Triton® gabions on the sides of the Causeway. It includes an increase in the horizontal extent of the Causeway below elevation 4.1 feet mean sea level (msl); however, the existing toe of the Causeway would be maintained.

This option originally assumed a rip-rap cover thickness of 2 feet, requiring an estimated 7,800 cubic yards (CY) of stone, and a gabion thickness of 2.5 feet, requiring an estimated 3,100 yards of material. Upon consideration of the natural conditions on the Causeway, it was determined that standard gabions containing rip-rap material, would be less effective in the long-term than Triton® mats, due to weathering and salt water impacts. As a result, it was decided that all options would consider Triton® mats on the side slopes. The use of Triton® mats would likely reduce the required gabion thickness, due to the natural stone equivalent for Triton® being an approximate 3-to-1 ratio (i.e., one foot of Triton® may be equivalent to three feet of stone). Therefore, for costing purposes, a 1-foot thick Triton® gabion is assumed, at an estimated cost of $10 per square foot (SF). American Excelsior Company provided unit price estimates for synthetic materials considered in this evaluation. An increase in Triton® mat thickness would increase the unit costs.

With this option, the total square footage requirement for covering the top and sides of the Causeway is 138,500 SF. The rip-rap portion of the cover system would cover a total of 105,300 SF, and the Triton® gabion sides would cover the remaining 33,500 SF. The John J. Brennan Construction Co., Inc. (J.J. Brennan) of Shelton, Connecticut provided a quote for delivery of durable stone rip-rap material to the site, with an average diameter of 1 to 1.5 feet. In order to obtain the grades required for cover system construction on the Causeway for this option, cut and fill operations from around the Causeway totaling an estimated 3,047 CY would be performed. An additional 560 CY of fill would need to be brought on site to balance cut and fill quantities. J.J. Brennan provided a quote for delivery of sand fill material to the site.

**Option 2: Rip-rap and Triton® - Non-encroaching**. This option includes the same approach as for Option 1, except there is no encroachment into the tidal mud flats below elevation 4.1 feet msl. The non-encroaching option is considered to address comments from CTDEP Office of Long Island Sound Programs regarding maintenance, "…to the extent practicable, the horizontal location of mean high water (4.1 feet NGVD), which is the landward extent of the public trust area" (memo dated 09/07/00). Because of the non-encroachment requirement, the rip-rap and Triton® gabion square footages are different than in Option 1, but the total square footage of the construction footprint for the Causeway remains essentially the same at an estimated 135,000 SF. A total of 73,800 SF of rip-rap, 2-feet thick and totaling 5,500 CY, is needed along with 61,200 SF of Triton® gabion area. Again, the gabion thickness is assumed to be reduced from the specified 2.5-foot thickness to a 1-foot thickness because of the Triton® gabion approach.

With this option, a total of 3,530 CY of cut and fill will be completed in order to obtain the required grades for cover system construction. An extra 405 CY of cut material would have to be removed from the site.

**Option 3: Tri-Lock and Triton® - Encroaching**. This option considers the combination of a synthetic cover of Tri-Lock concrete blocks on the top of the Causeway, in conjunction with a Triton® gabion mat on the sides of the Causeway. This option assumes an increase in horizontal extent similar to that described for Option 1. The thickness of the synthetic cover system is set at 1.5 feet on the top as well as on the sides of the Causeway. A total footprint of 135,000 SF is split between an estimated 101,500 SF (5,640 CY) of top cover, and an estimated 33,500 SF of Triton® gabion sides. Gabion thickness is assumed to be 1-foot thick. The Tri-Lock material considered is a 4-inch thick, interlocking concrete block supplied by American Excelsior Company. Installation costs were provided by American Excelsior and include a woven geotextile fabric placed beneath the blocks. A base material of 6 inches of sand is necessary below the fabric, and is priced separately from the Tri-Lock. Fill between and over the blocks, would consist of pea stone, placed to a depth of 2 inches above the top of the blocks, to act as a binder between the tops of adjoining beveled blocks. The cover would be finished with 6 inches of loam and grass seed. With this option, the Causeway would require 3,530 CY of cut-and-fill of on-site material. An extra 230 CY of cut material would need to be removed from the site.

**Option 4: Tri-Lock and Triton® - Non-encroaching**. Option 4 is similar to Option 3, but would not encroach into the tidal mud flats below elevation 4.1 feet msl. The total constructed cap area remains at an estimated 135,000 SF, with the Tri-Lock portion covering 73,800 SF, and the Triton portion covering 61,200 SF. Thickness of the cover system remains at 1.5 foot for both the top and sides of the Causeway. Cut and fill operations required for this option total to 3,530 CY. An extra 404 CY of cut material would need to be removed from the site for this option.

# APPENDIX C
# ATTACHMENT B
# CAUSEWAY COSTS FOR DIFFERENT OPTIONS

| Item Description | Quantity | Units | Unit Cost | Present Worth |
|---|---|---|---|---|
| Option 1 Costs | | | | |
| Delivery of riprap material | 7,800 | Cubic Yard | $ 31.35 | $ 244,530 |
| Placement of riprap | 7,800 | Cubic Yard | $ 21.75 | $ 169,650 |
| Placement of Triton | 33,500 | Square Feet | $ 10.00 | $ 335,000 |
| Cut and Fill to obtain needed grades | 3,047 | Cubic Yard | $ 5.47 | $ 16,667 |
| Delivery of additional fill | 560 | Cubic Yard | $ 19.88 | $ 11,133 |
| Grading of additional fill | 560 | Cubic Yard | $ 3.03 | $ 1,697 |
| TOTAL OPTION 1 COSTS | | | | $ 778,677 |
| Option 2 Costs | | | | |
| Delivery of riprap material | 5,500 | Cubic Yard | $ 31.35 | $ 172,425 |
| Placement of riprap | 5,500 | Cubic Yard | $ 21.75 | $ 119,625 |
| Placement of Triton | 61,200 | Square Feet | $ 10.00 | $ 612,000 |
| Cut and Fill to obtain needed grades | 3,530 | Cubic Yard | $ 5.47 | $ 19,309 |
| Excavate and export cut material | 405 | Cubic Yard | $ 15.60 | $ 6,318 |
| TOTAL OPTION 2 COSTS | | | | $ 929,677 |
| Option 3 Costs | | | | |
| Placement of 4" Tri-Lock blocks | 101,500 | Square Feet | $ 4.50 | $ 456,750 |
| Delivery of sand (0.5 feet x 101,500 SF=50,750CF=1,880CY) | 1,880 | Cubic Yard | $ 19.88 | $ 37,374 |
| Placement of sand and compacting | 1,880 | Cubic Yard | $ 3.03 | $ 5,696 |
| Delivery of pea stone-2" thick (0.17 feet x 101,500SF=640CY) | 640 | Cubic Yard | $ 21.95 | $ 14,048 |
| Placing of pea stone-fill, spread w/dozer, no compaction | 640 | Cubic Yard | $ 1.40 | $ 896 |
| Delivery of loam-6" thick (0.5 feet x 101,500SF = 1,880CY) | 1,880 | Cubic Yard | $ 24.00 | $ 45,120 |
| Placing of loam-spread topsoil, skid steer loader, hand dress | 1,880 | Cubic Yard | $ 5.10 | $ 9,588 |
| Placing of Triton | 33,500 | Square Feet | $ 10.00 | $ 335,000 |
| Cut and Fill to obtain needed grades | 3,530 | Cubic Yard | $ 5.47 | $ 19,309 |
| Excavate and export cut material | 230 | Cubic Yard | $ 15.60 | $ 3,588 |
| TOTAL OPTION 3 COSTS | | | | $ 927,370 |
| Option 4 Costs | | | | |
| Placement of 4" Tri-Lock blocks | 73,800 | Square Feet | $ 4.50 | $ 332,100 |
| Delivery of sand (0.5 feet x 73,800 SF=36,900CF=1,370CY) | 1,370 | Cubic Yard | $ 19.88 | $ 27,236 |
| Placement of sand and compacting | 1,370 | Cubic Yard | $ 3.03 | $ 4,151 |
| Delivery of pea stone-2" thick(0.17feet x 73,800SF=465CY) | 465 | Cubic Yard | $ 21.95 | $ 10,207 |
| Placing of pea stone-fill, spread w/dozer, no compaction | 465 | Cubic Yard | $ 1.40 | $ 651 |
| Delivery of loam-6" thick (0.5 feet x 73,800SF = 1,370CY) | 1,370 | Cubic Yard | $ 24.00 | $ 32,880 |
| Placing of loam-spread topsoil, skid steer loader, hand dress | 1,370 | Cubic Yard | $ 5.10 | $ 6,987 |
| Placing of Triton | 61,200 | Square Feet | $ 10.00 | $ 612,000 |
| Cut and Fill to obtain needed grades | 3,530 | Cubic Yard | $ 5.47 | $ 19,309 |
| Excavate and export cut material | 404 | Cubic Yard | $ 15.60 | $ 6,302 |
| TOTAL OPTION 4 COSTS | | | | $ 1,051,823 |

# ATTACHMENT C

# LETTER TO CTDEP RE: APPROVAL OF PERMANENT COVER SYSTEM

Harding ESE
A MACTEC Company

**Harding ESE, Inc.**
P.O. Box 7050
Portland, ME 04112-7050

Telephone: 207/775-5401
Fax: 207/772-4762
Home Page: www.mactec.com

April 18, 2001

Mr. Kenneth Feathers
Supervising Sanitary Engineer
Connecticut Department of Environmental Protection
79 Elm Street
Hartford, CT 06106

**SUBJECT: Request for Approval of Permanent Cover System**
**Causeway Non-time Critical Removal Action**
**Stratford Army Engine Plant, Stratford, CT**

Dear Mr. Feathers,

As a result of our meeting at the U.S. Army Corps of Engineers (USACE) in Concord, Massachusetts on March 21, 2001, Harding ESE is submitting this letter as a request for Connecticut Department of Environmental Protection (CTDEP) approval of the proposed cover system for the Causeway Non-time Critical Removal Action Design at the Stratford Army Engine Plant (SAEP) as an "existing permanent structure" under the Remediation Standards Regulations (RSRs). In the meeting, CTDEP requested that the U.S. Army provide a description of the proposed Causeway cover system and its ability to render soil contaminant concentrations exceeding CTDEP RSRs Direct Exposure Criteria (DEC) "inaccessible", as defined in the RSRs.

The Final Causeway Engineering Evaluation/Cost Analysis (EE/CA) (Foster Wheeler/HLA, September 2000) presents a summary of soil contamination exceeding CTDEP RSR DEC. Causeway soil contaminants with concentrations exceeding CTDEP RSR DEC include vinyl chloride, semivolatile organic compounds, the polychlorinated biphenyl (PCB) Aroclors-1016 and –1260 (maximum concentration 2.9 parts per million by weight), and inorganics. The depth interval of identified soil vadose zone contamination is from existing ground surface to approximately 5 feet below ground surface.

Per Section 22a-133k-2 (b)(3) of the CTDEP RSRs:

> "The direct exposure criteria for substances other than PCB do not apply to inaccessible soil at a release area provided that if such inaccessible soil is less than 15 feet below ground surface an environmental land use restriction is in effect with respect to subject parcel or to the portion of such parcel containing such release area, which environmental land use restriction ensures that such soils will not be exposed as a result of excavation, demolition or other activities and that any pavement which is necessary to render such soil inaccessible is maintained in good condition unless and until such restriction is released in accordance with section 22a-133q-1…"

Per Section 22a-133k-1 (a)(28) of the CTDEP RSRs:

> "'Inaccessible soil' means polluted soil which is: (A) more than four feet below the ground surface; (B) more than two feet below a paved surface comprised of a minimum of three inches of bituminous concrete or concrete, which two feet may include the depth of any material used as

> sub-base for the pavement; or (C)(i) beneath an existing building or (ii) beneath another existing permanent structure provided written notice that such structure will be used to prevent human contact with such soil has been provided to the Commissioner."

The proposed cover for the Causeway consists of a side slope cover system and a crest cover system. The side slope cover system, which will be emplaced around the perimeter of the Causeway below the high tide elevation, contains the following materials, from bottom to top:

- A geotextile filter material
- Twelve-inch thick polymeric marine mattresses composed of high-strength geogrid gabion baskets, filled with rock

The crest cover system, which will be placed over the top portion of the Causeway, contains the following materials, from bottom to top:

- A 2-inch to 6-inch thick sand bedding layer
- A geotextile layer
- A layer of 4-inch thick interlocking concrete blocks
- Pea gravel in the gaps of the interlocking blocks, and to a depth of 2 inches over the blocks

In addition, Approximately 6 inches of vegetative support soil, seeded with suitable grass cover material will be placed on top of the interlocking concrete block covered area.

Between the side slope cover system and the crest cover system a layer of riprap will be placed as a transition between the two covers (the polymeric marine mattresses and the interlocking concrete blocks). This riprap layer will be approximately 18-inches thick and 3-feet wide, and will be composed of stone with a minimum average diameter of 6-inches. This transition area will fill the gaps between the two cover systems and is required to provide drainage for the crest cover system.

The cover thickness has been minimized due to geotechnical constraints associated with the stability and compressibility of the tidal sediments beneath the Causeway fill material. Should additional thickness be added to the causeway, calculations indicate that a failure would be more likely to occur. Due to the expected differential movement expected, the cover system needs to be flexible while still rendering the underlying soils inaccessible. The side slope cover system will consist of roughly 10-15 tons of rock in each mattress, encased in a high strength plastic webbing type material. The concrete blocks in the crest cover system are slightly wider at the top, with the pea-stone between the blocks acting to lock the blocks in-place, making their removal extremely difficult. These two types of covers will allow movement as the causeway settles and are not expected to develop cracks, such as those that would develop if a more rigid type cover system like concrete of asphalt were used.

Therefore, we believe that, in conjunction with an environmental land use restriction, the proposed cover system meets the intent of the CTDEP RSRs as an equivalent "existing permanent structure" to make the Causeway soils inaccessible. On behalf of the U.S. Army, Harding ESE is requesting written approval of the proposed Causeway cover system by CTDEP.

If you have any questions regarding this request please contact me at (207) 828-3637.

Sincerely,

**HARDING ESE, INC.**
*A MACTEC Company*

Nelson Walter

Nelson Walter
Project Manager

cc: John Burleson (TACOM)
Michelle Brock (USACE-NAE)
Jeff Frye (USACE-NYD)
Meghan Cassidy (USEPA)
File

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STATE OF CONNECTICUT
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WATER MANAGEMENT
Permitting, Enforcement and Remediation Division

May 18, 2001

Mr. John Burleson
BRAC Environmental Coordinator
Stratford Army Engine Plant
550 Main Street
Stratford, CT 06497

RE: Stratford Army Engine Plant

APPROVAL OF PERMANENT COVER SYSTEM

The Permitting Enforcement and Remediation Division of the Bureau of Water Management ("Department") has reviewed the letter titled "Request for Approval of Permanent Cover System" dated April 18, 2001. The letter was prepared by Harding ESE on behalf of the United States Army. The letter was submitted in conjunction with a "Basis of Design, Causeway Non-time Critical Removal Action Design, Stratford Army Engine Plant, Stratford, Connecticut", dated January, 2001, which was prepared by Harding ESE on behalf of the US Army Tank-automotive & Armaments Command.

The letter and referenced design document describe a permanent erosion control structure to be installed upon a coastal causeway at the Stratford Army Engine Plant, Stratford, CT.

The above referenced structure is hereby approved as an alternative permanent structure meeting the requirements of Section 22a-133k-1 (a)(28) of Connecticut's Remediation Standard Regulations, when coupled with the placement of an Environmental Land Use Restriction preventing structure disturbance.

Nothing in this approval shall affect the Commissioner's authority to institute any proceeding, or take any action to prevent or abate pollution, to recover costs and natural resource damages, and to impose penalties for violations of law. If at any time the Commissioner determines that the approved actions have not fully characterized the extent and degree of pollution or have not successfully abated or prevented pollution, the Commissioner may institute any proceeding, or take any action to require further investigation or further action to prevent or abate pollution. This approval relates only to pollution or contamination on the site's causeway that is under the erosion control structure.

In addition, nothing in this approval shall relieve any person of his or her obligations under applicable federal, state and local law. Construction in the coastal zone is subject to Connecticut's Coastal Management Act, and the technical requirements of this statute apply.

If you have any questions pertaining to this matter, please contact Kenneth Feathers at (860) 424-3770.

Sincerely,

Michael Harder

Michael J. Harder
Director

MJH:KRF
cc: Nelson Walter, Harding ESE
Margaret Welch, DEP
Meghan Cassidy, EPA

# ATTACHMENT D

# TRI-LOCK CONCRETE MIX EVALUATION

SUMMIT Ltd.

Construction Materials
Quality Control Testing Services
*Soils, Concrete, Masonry, Steel, Asphalt, Geotechnical Engineering*

3 Thompson's Point
Portland, ME 04102
tel: (207) 879-6000

7 Charlton Street
Everett, MA 02149
tel: (617) 389-3700

# REPORT OF CONCRETE MASONRY TESTING

PROJECT NO: 97141

PROJECT NAME: Miscellaneous Testing

CLIENT: Saco Brick Company DATE OF REPORT: 11-20-97

SET NO: 2 SOURCE: Saco Brick Company DATE MADE: 11-03-97

DATE RECEIVED: 11-18-97 AGE: 17 days DATE TEST COMPLETED: 11-20-97

DESCRIPTION: Tri-Lock Pavers

PROCEDURE: ASTM C140 SPECIFICATION: Project Specifications

## MASONRY TESTING RESULTS

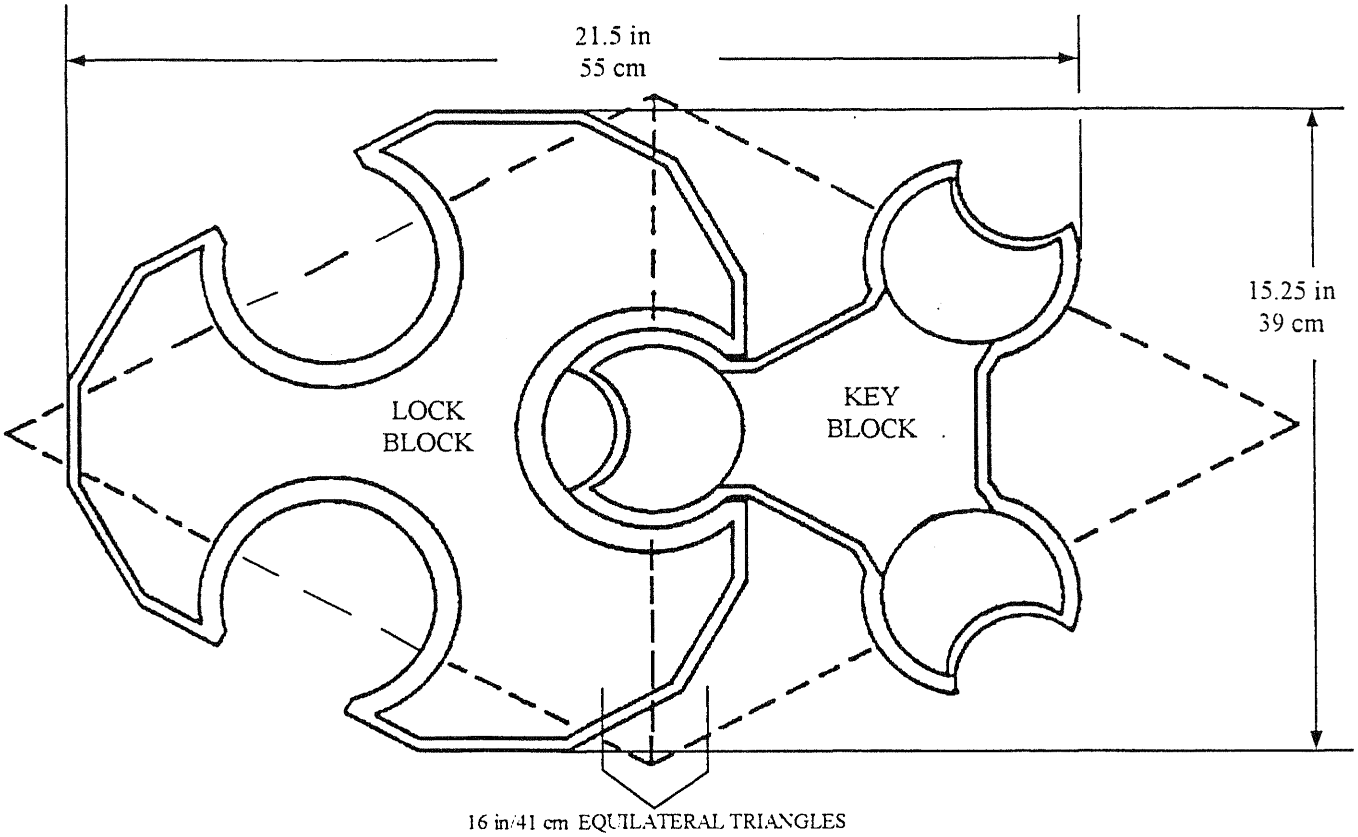
| SPECIMEN NO. | AREA (square inches) | | LOAD (kips) | COMPRESSIVE STRENGTH (psi) | PROJECT REQUIREMENTS (minimum psi) |
|---|---|---|---|---|---|
| | (gross) | (net) | | | |
| 2A | | 9.00 | 53.5 | 5,940 | 4,000 psi<br>@ 28 days |
| 2B | | 9.00 | 50.0 | 5,560 | |
| 2C | | 9.00 | 53.5 | 5,940 | |
| AVERAGE: | | | | 5,810 | |

| Spec. No. | Dimensions (inches) | | |
|---|---|---|---|
| | Length | Width | Height |
| 2A | 6.00 | 1.50 | 2.94 |
| 2B | 6.00 | 1.50 | 3.00 |
| 2C | 6.00 | 1.50 | 3.00 |

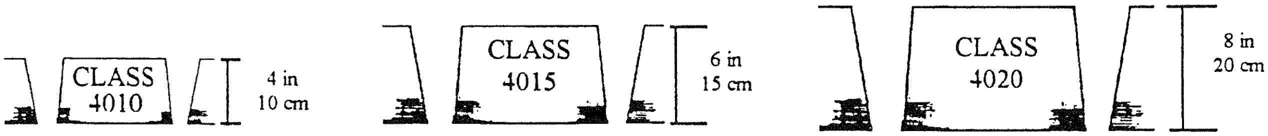
NOTES: These irregular shaped units were tested as coupons in accordance with ASTM C140 5.2.4.

SIGNED: Donald Walden

Donald C. Walden
Director of Testing Services



TRI-LOCK BLOCK PLAN VIEW



TRI-LOCK BLOCK PROFILE VIEW N.T.S.

**TRI-LOCK ARTICULATING CONCRETE BLOCK REVETMENT SPECIFICATIONS**

| | ENGLISH (SI) STANDARD | | | METRIC | | |
|---|---|---|---|---|---|---|
| BLOCK CLASS | 4010 | 4015 | 4020 | 4010 | 4015 | 4020 |
| HEIGHT (Nominal) in/cm | 4 | 6 | 8 | 10 | 15 | 20 |
| BLOCK WEIGHT (Approx.) AREA lbs-ft$^2$/kg-m$^2$ | 32 | 45 | 64 | 1.35 | 1.90 | 2.70 |
| PAIR lbs/kg | 50 | 70 | 94 | 22.70 | 31.78 | 42.68 |
| MIN. COMP. STRENGTH lbs-ft$^2$/MPa | 3,000 | 3,000 | 3,000 | 24.13 | 24.13 | 24.13 |
| AVG. % WATER ABSORPTION | 5 | 5 | 5 | 5 | 5 | 5 |
| AREA COVERAGE (APPROX.) BLOCK PAIR ft$^2$/m$^2$ | 1.54 | 1.54 | 1.54 | 0.14 | 0.14 | 0.14 |
| PALLET ft$^2$/m$^2$ | 74 | 56 | 37 | 6.87 | 5.20 | 3.44 |
| OPEN AREA %* BASE | 20 | 20 | 20 | 20 | 20 | 20 |
| TOP | 30 | 30 | 30 | 30 | 30 | 30 |

* Angle of taper from bottom to top of block varies slightly at different positions of blocks and with different block classes.

FIGURE 1.1 TRI-LOCK BLOCK DETAILS AND SPECIFICATIONS

# *Tri-Lock* Hydraulic Stability Considerations
## Wave Attack / Waterfront Environments

*Tri-Lock* blocks provide hydraulic stability against waves while the geotextile fabric provides stability for the underlying geotechnical material. The *Tri-Lock* system will also provide a safer, cleaner access area to the water that is easy to maintain, resistant to vandalism, and not conducive to breeding pests.

Large scale wave flume experiments, along with over 30 years of actual articulating concrete block shoreline applications, have been considered in developing the following generally acceptable product selection guidelines.

Tri-Lock Selection Guidelines for Shoreline Applications

| BLOCK CLASS in. / cm | WAVE HEIGHT ENGLISH STANDARD | WAVE HEIGHT METRIC |
|---|---|---|
| 4010<br>4 in / 10 cm | Up To 4 ft. | Up To 1.2 m |
| 4015<br>6 in / 15 cm | Up To 5.5 ft. | Up To 1.6 m |
| 4020<br>8 in / 20 cm | Up To 7.0 ft. | Up To 2.15 m |

The selection of the proper Tri-Lock system is affected by site or project conditions such as soil permeability, flow or wave intensity, soil compaction and slope or grade conditions. Please contact an American Excelsior Tri-Lock specialist to review site-specific considerations.

Technical Bulletin No. 24

# Manufacture of Concrete Masonry Units

*(Second Edition)*

By WILLIAM GRANT
*Chemical Engineer*
*Former Chief, Bureau of Tests*
*Department of Buildings and Safety Engineering*
*City of Detroit, Mich.*

CONCRETE PUBLISHING CORPORATION
400 W. MADISON ST., CHICAGO 6, ILL.

NOTE: —

The two columns shown on each page of this publication are actually 4 pages of the original book. One column consists of two original pages. For ease in reading, the original page numbers were removed at the lower half of each column. In using the Table of Contents and the Index it will be necessary to interpolate where page numbers have been removed.

# Table of Contents

# List of Tables

# List of Figures

# MANUFACTURE OF CONCRETE MASONRY UNITS

## Preface to Second Edition

The favorable reception accorded the original edition published in 1952, has encouraged the author to revise and enlarge the text with new material. It is hoped that these new "Recommended Practices" will serve as a guide towards accomplishing the improved control desirable in present day concrete masonry manufacture.

The entire manual has been carefully studied with the object of improving the presentation of the text wherever possible. Many new illustrations have been added.

The author wishes to acknowledge his indebtedness to Raymond R. Smith for his assistance in preparing illustrations. To Louis C. Samberg, his former colleague in the Bureau of Tests of the Building Department, City of Detroit, for his valued assistance and suggestions. To Robert M. Bonus, Hay-Con Tile Company, Detroit, for valuable suggestions and criticisms. To Benjamin Wilk, Manager, Standard Building Products Company, Detroit, for his constructive criticisms of the text, also for his assistance with many experiments and tests made at the plant.

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**Detroit, Michigan** **W. G.**

## Section 1—Portland Cement and its Reactions

**General Remarks**—Portland cement is a material admirably adapted to a great variety of uses. It is composed of a number of chemical compounds which react with water to make a plastic mass. Only part of this added water is required to combine with the cement to produce its adhesive properties. The greater portion of the water added to the mixture of cement and aggregates serves only to make the mix workable.

When portland cement and water are mixed together, dissolution of the cement grains and chemical reactions commence almost immediately. The type and extent of the reactions affect the properties developed by the cement-water mixture, as well as the lubricating qualities of the concrete mix and the bond between the materials in the hardened product.

The greater part of the literature regarding these reactions describes their effects in connection with the so-called "plastic" or "wet" mixes, such as are used in slabs, beams or columns. The chemical reactions are the same for concrete products made from the so-called "dry" or "semi-dry" mixes; their rates are somewhat modified by the conditions under which the concrete is produced and cured.

**Manufacture of Portland Cement**—It may be well to present a brief outline of the process by which portland cement is manufactured and particularly in regard to the raw materials from which it is derived.

Essentially, portland cement consists of several major compounds and several others which may be classified as minor because of the relatively small amounts present. The compounds in portland cement are derived from the interaction of the raw materials in their natural states, treated in rotary kilns and subjected to a temperature of approximately 2,700 deg. F.

Portland cement is made by fusing in rotary kilns at a temperature of around 2,700 deg. F. a properly proportioned mixture of materials; one rich in lime, as limestone, marl, or chalk; and one rich in silica and

alumina, as clay, shale, slate, or blast-furnace slag. The former are known generally as calcareous and the latter as argillaceous materials. The resultant mass of incipiently fused material is termed cement clinker.

The materials listed in these classifications are by no means complete. A raw material (for instance, cement rock) may be placed under both headings, depending on its composition. The choice of the raw materials depends generally on the availability, the chemistry of their composition, and the economy of manufacturing operations.

Portland cement manufacture may be considered as being composed of two steps:

1. Calcareous plus argillaceous materials plus 2,700 deg. F. heat equals portland cement clinker.
2. Portland cement clinker plus gypsum (interground) plus fine grinding equals portland cement.

If the finely ground clinker alone were used, it would set too rapidly. A retarding agent, gypsum, is added in amounts ranging from 3 to 7 per cent of the weight of the clinker. The gypsum is added to the clinker previous to grinding, thereby insuring a thorough mixing of the ingredients in the finished product.

**Fineness of Portland Cement**—The grinding of normal portland cement is carried to a fineness where approximately 80 per cent passes a 325-mesh sieve. The high early strength cement is ground to a fineness where 96 per cent passes a 325-mesh sieve. This finer grinding results in a surface area for the high early strength cement which is 1⅔ more than that of normal portland. Finer grinding will, to a certain extent, overcome the slow and incomplete hydration of cement; but this is only a partial solution to the problem. The fineness to which cement can be ground commercially depends on the practical limitations of the grinding methods and the equipment.

**Compound Composition**—The compounds of which portland cement is composed, when mixed with water, directly affect the quality of the products made of concrete. These compounds and their reactions determine the properties of the cement-water paste and consequently, those of the concrete mix. In the compounds, the lime acts as a basic and the silica and alumina as acidic anhydrides; therefore calcium silicates and aluminates are formed. At least two silicates and two aluminates exist in portland cement clinker.

The principal compounds are di-calcium silicate, tri-calcium silicate, and tri-calcium aluminate.

These various compounds are stable as long as they remain dry (anhydrous). Their value, when effectively pulverized as in the case of regular or high early strength grading, lies in their strong affinity for water. Their individual merit is determined by what happens when they combine with water.

**Effects of Water on Portland Cement**—When water is added to cement, a direct hydration reaction between the cement particles and the water does not actually take place. Part of the cement compounds are dissolved in the water and are redeposited as a hydrate, either in the form of a gel or in the form of crystals. In the early stages most of the redeposition is in the gel form; crystallization may eventually take place. The gel is deposited around the undissolved cement grains. The rate at which cement hydrates depends primarily on these factors:

1. The relative proportions of the chemical constituents.
2. The degree to which the gel is redeposited on the cement grains and interferes with further hydration.
3. The time required for the complete coating of all the remaining unhydrated cores with this gel, resulting in a complete stoppage of hydration. The greater the surface area of the particles of cement exposed to the water, the more rapid and complete will be the hydration.

**Hardening Periods of Portland Cement**—The chemical reactions which occur when water and portland cement are mixed may be divided into three stages:

1. The initial period of rapid reaction which usually lasts less than five minutes.
2. A second relatively dormant stage, lasting from one to two hours under normal conditions.
3. A third stage during which hardening occurs as long as water is continuously available. This stage lasts for an indefinite period.

It is during these periods that the gypsum exerts its effect. Incidentally, it may be mentioned that if there were no tri-calcium aluminate in the portland cement there would be no necessity for adding gypsum to retard the setting. But raw materials suitable for cement manufacture are not found in a natural state free from aluminum compounds.

Chemical Reactions of Portland Cement—The chemical reactions involved in the two stages, including the set retardation, are:

1. Tri-calcium aluminate hydrates to hydrous tri-calcium aluminate.
2. Hydrous tri-calcium aluminate plus gypsum gives hydrous calcium sulpho-aluminate.

A clear understanding of these reactions is essential, both in relation to the physical setting of the cement-water paste and because any interference with the normal reaction will have a direct effect on the quality of the finished concrete unit. Two reactions proceed immediately and simultaneously upon contact of the cement with water. When the water contacts the cement grains, a chemical reaction commences at once with the tri-calcium aluminate. An intermediate product of calcium hydroxide then forms and goes into solution; at the same time, the gypsum also dissolves.

As these two compounds, calcium hydroxide and gypsum dissolve in the water, the concentration of their solution increases; and as the concentration increases, the effect is to slow down the hydration of the tri-calcium aluminate.

If the tri-calcium aluminate hydration were not slowed down by the lime-gypsum solution, the effect, as previously stated would be quick setting in a matter of minutes. It can be readily seen that sufficient gypsum must be present in the cement so that during the setting period the necessary balance of lime-gypsum solution is maintained. This is especially true of the highly reactive high early strength cement, so greatly favored by products manufacturers.

The reactions should be permitted to proceed at a normal rate, both in the period of rapid initial reaction and in the period of dormant reaction. If these reactions are interfered with, for instance by the sudden application of heat, one of two things, or both may occur. Both are dangerous.

Dangers of Interruption of Normal Reactions—1. The tri-calcium aluminate and calcium sulpho-aluminate crystallize very rapidly causing premature stiffening of the paste, with resultant decrease in strength of the bond with the aggregate, and undesirable brittleness in the unit.

2. The products of early hydration may form a dense, impermeable coating around the cement grains, preventing later hydration and strength gain of the third hardening period.

It is generally assumed that the initial setting of the cement-water paste is the result of the hydration and subsequent hardening of the tri-calcium aluminate. Under normal temperature conditions, at 70 deg. F., this particular hydration is approximately 75 per cent complete in two or three hours, and is complete within 24 hours.

The third and final stage of hardening commences normally after the second hour and continues indefinitely. However, the rate of reaction of this stage reaches a peak in about 6 hours, then decreases for an indefinite period.

There is one important phase of the hardening period which must not be overlooked. This is the role which the gypsum exerts in slowing up the tri-calcium aluminate reaction. As long as gypsum is available for solution, the hardening reactions proceed at a normal rate.

In time, however, the available gypsum for solution will be used up, and immediately a very rapid reaction of the remaining tri-calcium aluminate occurs. This reaction may occur at any time up to 30 hours. If it occurs too quickly as a result of abnormal conditions, for instance a sudden temperature rise, the result may be a permanent injury to the quality of the unit, such as impaired strength, brittleness and so forth. When this delayed rapid reaction, as it is called, takes place, its effect is to seal the cement grains. It can be readily seen that if it takes place too rapidly, in any of the three stages, the subsequent hydration and hardening may be seriously affected.

This reaction is dependent upon the tri-calcium aluminate content, the fineness of the cement, the gypsum content, and the temperature. Since only the temperature is subject to immediate control after the cement and water are in contact, abnormal temperatures must be avoided.

Factors Influencing Portland Cement Reaction—The finer the degree to which the cement is ground, the greater will be the surface area of the grains exposed to contact with the added water. Hence the more complete hydration within a given time. This is one of the advantages of high early strength cement in any curing system.

Another factor is the composition of the cement, whether it is high or low in its tri-calcium aluminate content. The lower the percentage present, the slower the reaction will be in the initial or dormant stages. If the tri-calcium aluminate is high, say 14 to 15 per cent, the reaction may proceed so rapidly that sufficient lime and gypsum cannot be dissolved in time to prevent quick setting. Hence, a medium tri-calcium aluminate content in the range of 8 to 12 per cent is desirable. Concentration of lime-gypsum solution largely depends on the gypsum content of the cement. Standard specifications permit up to 3 per cent of sulphur tri-oxide, which is equivalent to approximately 7 per cent of gypsum, in high early strength cement.

Soluble Alkalies in Portland Cement—The amount of soluble alkalies (sodium and potassium) in the cement is not usually an important factor. Soluble alkalies in cement influence the amount of reaction possible because they will react with the gypsum, thus reducing the amount of gypsum available for repressing the tri-calcium aluminate reaction.

In certain types of curing it is possible for alkali carbonates to form during the curing period. Should the atmosphere of the curing rooms contain an excessive amount of carbon dioxide derived from the combustion of the fuel, certain conditions may occur. The carbon dioxide present may react with the calcium hydroxide in the units to form calcium carbonate and alkali carbonates of sodium and potassium.

Effect of Temperature on Portland Cement Paste—Any chemical reaction of the cement-water paste is speeded up by an increase in the temperature. The necessity for a normal hydration rate has been previously emphasized. Hence, elevated or sudden increases in temperature should be used only after the initial or dormant stages of the reaction have passed.

Curing of Portland Cement Paste—With any or all of the enumerated factors in play, it can readily be seen that the so-called curing period must be carefully controlled in order that the necessary reactions can proceed normally.

Silicate Reactions of Portland Cement—It is in the third, or hardening, stage that all the important silicate reactions begin. Normally these silicate reactions commence only after the tri-calcium aluminate reaction is completed, or nearly so. The tri-calcium silicate compound, present in the greatest amount in portland cement, is the first of the two silicates to react. The reaction commences within 24 hours at normal temperatures, and is generally completed within seven days.

At the elevated temperatures encountered in concrete products manufacture, especially with high early strength cement, about 85 per cent of the tri-calcium silicate hydration is completed within three days. This is the reaction which is of major importance in any kind of concrete, producing not only high early but later and permanent strength and durability. Any curing system should be designed to produce the maximum potential strength of the tri-calcium silicate in the shortest possible time, especially with the use of high early strength cement. This type of cement carries a greater percentage of the above constituent than standard or regular cement.

Considering the tri-calcium silicate reaction, with reference to the control of the tri-calcium aluminate reaction in the initial and dormant stages, these factors have to be considered:

1. If for any reason the cement grains become coated with an impervious layer of hydration products arising from a speeding up of the tri-calcium aluminate reaction, continued hydration of the tri-calcium silicate is impaired, with resultant loss of strength and durability in the units.

2. Sometime between the period of seven and 28 days, at normal temperatures, the di-calcium silicate commences to hydrate. This is the least reactive of the major compounds of the cement which at 28 days, even under elevated temperatures, is only fractionally hydrated. It is doubtful if during the usual curing cycle any of this compound is reactive.

So much for the outline of the setting and hardening of portland cement when mixed with water. Some phases are not clearly understood; there is much diversity of opinion regarding the hydration process. However, the reactions of the tri-calcium aluminate, the tri-calcium and di-calcium silicates seem to follow a defined pattern. Therefore it is with the reactions of these three major compounds of cement that we are mainly concerned.

**Colloidal Theory of Cement Hardening***—The hardening of the paste, and consequently the concrete, may be explained according to the theory that as the reactions proceed, a colloidal mass is formed which cements or binds the crystals formed into a mass of mineral glue.

This theory holds that the hydration products are produced in a colloidal condition. A colloidal solution, sometimes described as a "glue solution", is one in which the particles exist in an extremely fine state of dispersion in water. As water is removed from such a solution a solid jelly-like mass is produced; and to this mass the term "gel" is applied. These gels become very hard as they dry out. The preceding statement explains the significance of the term "cement gel."

Assuming that the hydration products are colloidal, and that hydration begins at the surface of the cement grains; then these grains become covered with a coating of colloidal gel which possesses adhesive properties and causes the grains to adhere to each other. As the gel is not very permeable in water, the centers of the grains may not become hydrated quickly. They can only become hydrated as water slowly diffuses through the surrounding coating. Here again is an advantage of high early strength cement; with its smaller grain size.

The hardening of the cement paste depends on the drying of this gel. It is not necessary that the water evaporate, although some water is usually lost in this way when the cement hardens in air. The free water of the gel may be taken up by the unhydrated centers of the grains and converted into chemically combined water. This occurs when cement hardens under water. Water cannot pass between the cement grains since the colloidal coatings adhere, nor can it readily pass

through the colloid itself because of its low permeability.

As the centers of the cement grains, by continued hydration, use up the free water in the gel faster than it can be supplied from the outside, the gel becomes hard and dry. Once the gel becomes hard it cannot be softened again by water absorption because the gel is an irreversible colloid.

Such, briefly, is the theory of colloidal hardening as it is generally accepted. In the products industry we are concerned only in one way with the theory—to so control the chemical reactions that the colloidal hardening be permitted to proceed normally, and thus assure the desired quality in the finished product.

**Types of Portland Cement**—The American Society for Testing Materials, Designation C 150-52, covers five types of portland cement. For block production, however, we may confine ourselves to the following types which are generally used: high early strength cement, air entraining, and normal portland cements.

**High Early Strength Cement**—The valuable properties of portland cement depend primarily on its surface reactions. Thus the greater the surface area, the more rapid and complete the hydration of the cement. As its name implies, high early strength cement is one in which strength is rapidly developed through finer grinding of the clinker so that 96 per cent of the material will pass a 325-mesh screen. Where speed in developing strength is a primary requirement, the use of high early strength cement is a means of obtaining it. Whether it is the least costly way of obtaining the desired strength at early stages will depend on individual plant conditions.

A report by Committee 710 of the American Concrete Institute (Feb. 1936) indicated that 70 lb. of high-early-strength cement gave better strength results during the first 28 days than 94 lb. of regular cement. The relative strengths were greatly in favor of high-early-strength cement during the first few days. Due to the variations in strengths of different high early and regular cements, it is important that comparative tests be made on available cements.

The use of high early strength cement offers these advantages:

1. Where yard storage or kiln capacities are limited, the speed with which the units may be handled is an important factor.
2. Good strength units may be produced even with a poor grading of aggregate. It should not, however, be considered as a cure-all for the bad effects induced by poor aggregate grading.

**Air Entraining Cement**—Air entraining portland cement differs from normal portland cement in that it contains a very small quantity of air entraining agent which is interground with the clinker during manufacture. As the name implies, this agent produces innumerable very small air pockets in the concrete when the components are mixed together.

This type of portland cement was designed primarily for use in wet cast concrete mixes, such as pavement slabs. It does not differ in chemical composition from the standard type except for the presence of the air entraining agent. Air entraining cement, a comparatively new product on the market, is used in ever-expanding volume in concrete products plants. However, because the mixture employed in products plants is of the "semi-dry" consistency, its action does not parallel that of the "wet" mixes.

The principal advantages gained by its use in products plants are:

1. It imparts a lubricating effect to the mix, tending to give a more dense and heavier unit as a result of easier compaction during molding.
2. The fully molded unit is more elastic or rubbery. In other words it will sustain a greater amount of shock and distortion without cracking, than units made from regular cement.
3. Because of the harsh qualities generally present

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*For further study of the subject, see: Taylor, "Chemistry of Colloids"; Bogue, "Theory and Application of Colloidal Behavior."

in lightweight aggregates, air entraining cement may, because of its lubricating action, give slightly smoother texture and higher compressive strength units, than can be obtained by the use of normal portland cement.

Compared with high early strength cement, air entraining cement is at a disadvantage for these reasons:

1. Its hardening rate is slower. Thus the units produced cannot be handled as quickly. In present-day manufacturing methods where speed is essential the item of handling time is of paramount importance.
2. In the event of nonuniformity of grading of aggregates, air entraining cement will not offset the effects of such variation to the degree obtained with high early strength cement.

## STANDARD SPECIFICATIONS FOR PORTLAND CEMENT

### Designation C 150-52

| *Types* | *General Uses* |
|---|---|
| Type I, for use in general concrete construction when the special properties specified for Types II, III, IV and V are not required. | Normal portland cement, as used in masonry unit manufacture, also for pavements, concrete buildings and other structures. |
| Type II, for use in general concrete construction exposed to moderate sulphate action, or where moderate heat of hydration is required. | Modified portland cement, as used in heavy construction such as retaining walls and piers. |
| Type III, for use when high early strength is required. | High early strength portland cement as used in form constructional work or where high early strength concrete is desired. |
| Type IV, for use when a low heat of hydration is required. | Low heat portland cement as used where large masses of concrete are placed as in gravity dams. |
| Type V, for use when high sulphate resistance is required. | Sulphate resistant portland cement as used for structures which are subjected to high sulphate or alkali conditions. |

Air-entraining portland cement ASTM Serial Designation C 175-51T is classified under three headings, namely IA, IIA and IIIA, corresponding to Types I, II and III in Serial Designation C 150-52.

In these cements, small amounts of air-entraining materials are interground with the clinker during the process of manufacture. Among the uses for which certain of these cements are specially adapted are the manufacture of masonry units and for pavement construction subjected to severe frost and salt action.

## Section 2—Heavyweight Aggregates

Because of the increasing importance of concrete masonry units as a building material it is essential that the manufacturer be in a position to accurately control the quality and have definite knowledge of the effect of the constituents entering into the production of high

Aggregate—Aggregate is a general term applied to inert materials of suitable strength which when mixed with portland cement and water, and allowed to harden produce a product termed concrete.

Aggregates for concrete products may be made from either heavyweight or lightweight materials. The heavyweight materials generally, are natural river or bank sand and gravel, crushed rock, crushed limestone and unprocessed air-cooled blast furnace slag.

The gravels frequently contain dirt and silt and require washing and screening to render them suitable for use as an aggregate. Bank run gravel should not be used in block production unless it has been thoroughly tested and found satisfactory.

The important characteristics of aggregate are: (1) Cleanness, (2) Durability, (3) Grading.

Cleanness—Aggregates, to be suitable for making concrete units, must be clean and free from clay, loam, silt, or organic matter the presence of which reduce the strength of the concrete. A film of clay or other foreign matter on the particles of the aggregate may prevent the proper bonding of the aggregate with the cement-water paste thus producing a lower strength concrete unit.

A rough test for the presence of silt may be made by rubbing a small amount of the material in the palm of the hand and observing whether the palm is stained. A stain denotes the presence of clay or loam, and requires further test. Organic impurities are more harmful than clay or loam. For a detailed testing for these impurities see Section 5.

Durability—Aggregates must be free from harmful amounts of soft and friable particles which will break up readily under stress and abrasion and which may disintegrate under exposure to weather conditions. If an aggregate fails to meet these requirements it is worthless regardless of its other properties.

Rocks such as shales, sandstones and very soft limestones are unsuitable as aggregate for concrete products.

Shale is unsuitable because of its weak stratified structure, sandstone, on account of its friable nature, and limestone if it possesses a high clay content. An aggregate possessing any of these properties may be inherently weak or may deteriorate through saturation, alternate wetting or drying, freezing or temperature changes.

Grading—Well graded aggregates are essential to the production of economical concrete. Poorly graded aggregate will produce a low strength concrete or require an excess of cement to obtain the necessary strength units.

In natural gravel deposits it is practically impossible to obtain aggregate so graded in size as to produce a mix of maximum density without regrading. In order to obtain maximum density, aggregates are divided into various sizes, which, when used in varying proportions may be blended to produce concrete units of the desired strength.

The use of well-graded aggregate cannot be overemphasized, when considered from the standpoint of economy. The character and grading of the aggregate play an important part in the quantity of cement required and in the quality of the concrete after it has solidified. If the grading of the aggregate varies from batch to batch, the quality of the concrete will likewise vary unless each mix is proportioned differently. Such a procedure is highly impracticable. Consequently, some batches will be below strength requirements, while other batches will be stronger than necessary. Under these varying conditions, the same amount of cement would be in use in a mix of the poorer quality aggregate as would be used where the grading of the material is satisfactory. In the latter case, this would result in the concrete being of higher strength than necessary, indicating a wastage of cement.

Aggregates—Aggregates are usually classified by an arbitrary division of "coarse" and "fine." Generally, in block manufacture, material passing the 3/8 inch screen and remaining on the No. 4 screen is taken as the line of demarcation between the coarse and fine material. It is well to bear in mind that, other things being equal, a coarse grading of aggregate produces stronger concrete. Therefore, the ideally graded aggregate is that mixture which contains as much coarse material as can be used, short of producing harshness in the mix and a too rough textured block.

Sharp, angular or flat or elongated particles require more fine material to produce workable concrete mixtures than is required where aggregate particles are more rounded. When the aggregates are made up largely of such undesirable particle shapes, more cement may therefore be required to produce units with equivalent workability and strength. Good concrete can be made from crushed stone or other crushed materials but the particles should be more or less cubical in shape. The gradation or particle size distribution of aggregate is determined by sieve analysis as outlined in Section 6. Aggregates which do not have a large deficiency or excess of any size and give a smooth grading curve produce the most satisfactory results.

Fine aggregate is usually considered as that material which will pass a No. 4 screen, and at least 15 per cent should be retained on a No. 8 screen. While excessive quantities of extremely fine sand are undesirable, 10 to 20 per cent of the material passing the No. 48 screen and at least 4 or 5 per cent passing the No. 100 screen increases the density of the concrete and results in a smoother block than when there is a deficiency of extreme fines.

Natural sand is the most widely used fine aggregate. It is important to make sure that the sand is not too fine. An exceedingly fine or flat sand will require more cement than a coarser sand without increasing the strength of the resultant concrete. Also when the sand particles are all approximately the same size, the strength of the concrete made from such sand is not as great as when the particles are of different sizes.

In well graded aggregate the particles vary in size from the smallest to the largest. The fine particles are necessary for workability and smoothness of mixes.

Stone sand, made by crushing stone, consists of more angular particles and when used as fine aggregate it is important that such materials having an abundance of thin, sharp or slivery particles be avoided. A greater amount of fine material passing the No. 48 screen is required to produce workability in stone sand than with natural sand, because the angular particles in stone sand do not pack to the same extent as natural sand. The more angular the particles the greater will be the void content in the concrete. The presence of deleterious materials such as shale or light porous chert adversely affect the durability of stone sand.

The following data shows the various gradations of sand and coarse aggregate (pea gravel) and the fineness modulus or F.M. of each.

I. Fine drift or beach sand graded up to the No. 28 screen with an F.M. of 1.50.
II. Medium sand graded up to No. 8 screen with an F.M. of 2.50.
III. Coarse sand graded up to the No. 4 screen with an F.M. of from 3.00 to 3.25.
IV. Coarse aggregate graded from No. 4 to the ⅜" screen with an F.M. of approximately 5.50.

*Figure I illustrates the gradation of typical sands.

**Sand #1.** A sample of well graded sand before and after separating into its various sizes. The particles vary from fine to those just passing the No. 4 sieve. Each strip in the figure indicates a different size.

**Sand #2.** Shows a sample of fine sand which lacks particles larger in size than the No. 14 sieve. More cement is required when the sand is fine.

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*A Practical Course in Concrete by H. Giese, published by Portland Cement Association.

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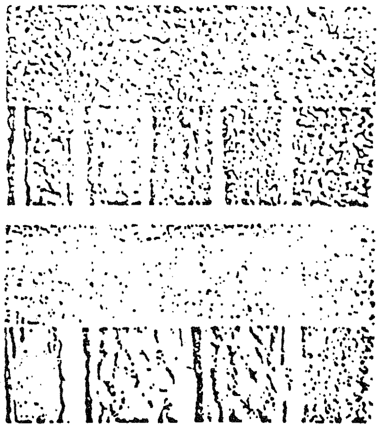

Figure I—Typical Sands

Combination of Coarse and Fine Aggregates—The relative proportions of coarse and fine aggregate which can be used are definitely affected by the grading and the shape and size of the particles which make up the aggregate. Aggregates made up largely of coarse particles have less surface area to be coated with cement paste than aggregates consisting of fine particles.

Increasing the proportion of coarse aggregate will give a greater strength of concrete for a given amount of cement.

Application of Grading Principles—The screen analysis and fineness modulus findings are employed to evaluate an aggregate for its suitability from the standpoint of its grading. When plant conditions permit the handling of separate aggregates, provided the aggregates measure up to standard requirements, the producer is in an enviable position.

Once the producer has decided upon a definite blend of coarse, medium and fine aggregate, he can manufacture a quality block with a minimum of cement.

For a mixed sand and combined aggregate for plant use, the per cent retained on the separate sieves should approximate the limits shown in Tables I and II.

TABLE I—RECOMMENDED GRADING FOR MIXED SANDS

| Percent Retained on Separate Sieves | | |
|---|---|---|
| Sieve Size | Limits | Recommended Grading |
| ⅜ | 0 | 0 |
| #4 | 0-5 | 2.5 |
| #8 | 10-20 | 12.5 |
| #14 | 10-20 | 14.0 |
| #28 | 20-30 | 24.0 |
| #48 | 15-30 | 26.0 |
| #100 | 12-25 | 16.0 |

Coarse aggregate passing the 3/8 inch sieve and retained on the No. 4 sieve should be added to the mixed sands in proportions of 25 per cent coarse material to 75 per cent mixed sands to give good results.

For mixed aggregate the following gradings will prove satisfactory for block mixes.

TABLE II—RECOMMENDED GRADING FOR COMBINED AGGREGATE

| Percent Retained on Separate Sieves | | |
|---|---|---|
| Sieve Size | Limits | Recommended Grading |
| ⅜ | 0-5 | 0 |
| #4 | 20-35 | 25 |
| #8 | 10-30 | 15 |
| #14 | 10-20 | 15 |
| #28 | 10-20 | 15 |
| #48 | 10-20 | 15 |
| #100 | 5-15 | 10 |

The same data are presented graphically in Figures 2 and 3.

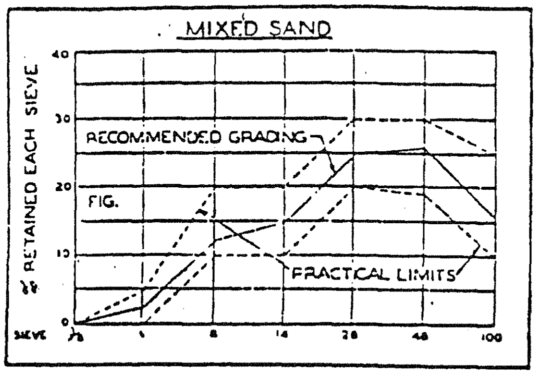

Figure 2—Practical limits and recommended gradings for mixed sands.

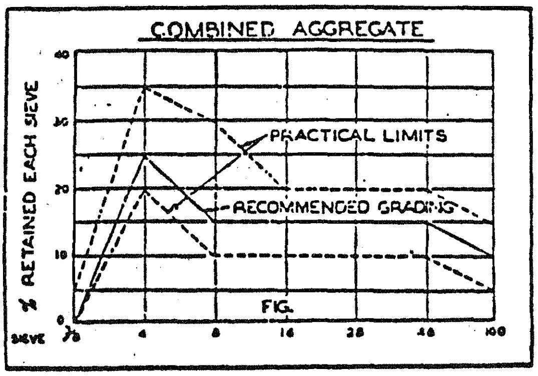

Figure 3—Practical limits and recommended gradings for combined aggregates.

**Limestone**—Limestone is a stratified, fine-grained, sedimentary type of rock consisting essentially of calcium carbonate.

Limestone constitutes a considerable part of the earth's crust and occurs in a great variety of forms, strengths and colors. They are variable in hardness, some types being so soft that they can be cut with a saw; others being considerably harder.

The harder types, when crushed and graded, are satisfactory for the production of block. Limestone screenings alone are difficult to handle, and for that reason sand is added.

**Limestone Aggregate With Sand Admixture**—The use of a combination of limestone screenings and siliceous sands presents many possibilities. The permissible gradings of a combination of siliceous materials, such as sand, pea gravel, etc., fall within a relatively narrow range. However, when limestone screenings are mixed with siliceous sands, it is practical to widen the range of gradings which can be economically employed. To illustrate, consider the gradings in Table III which have been successfully used in two modern plants:

TABLE III—GRADING OF LIMESTONE AND SAND AGGREGATE

| | Grading #1 | | | Grading #2 | | |
|---|---|---|---|---|---|---|
| Sieve | Cumulative % Retained | % Retained Each Screen | % Passing | Cumulative % Retained | % Retained Each Screen | % Passing |
| 3/8" | 5.7 | 5.7 | 94.3 | 0 | 0 | 100.0 |
| #4 | 43.1 | 37.4 | 56.9 | 4.1 | 4.1 | 95.9 |
| #8 | 48.2 | 5.1 | 51.8 | 22.6 | 18.5 | 77.4 |
| #14 | 53.2 | 5.0 | 46.8 | 48.7 | 26.1 | 51.3 |
| #28 | 61.2 | 8.0 | 38.8 | 66.0 | 17.3 | 34.0 |
| #48 | 82.1 | 20.9 | 17.9 | 78.5 | 12.5 | 21.5 |
| #100 | 94.7 | 12.6 | 5.3 | 90.6 | 12.1 | 9.4 |
| Pan | | 5.3 | | | 9.4 | |
| F.M. | 3.88 | | | 3.11 | | |

The compressive strengths obtained from units made

ranged from 1,170 to 2,150 psi at 28 days (air-cured) from mix proportions of 1 to 11 to 1 to 14.

The determining grading factor apparently is the texture desired in the units; where a "rough" texture is required, the coarser grading of No. 1 can be used. Grading No. 2 is usable when a "fine" texture is needed.

In the case where hard, tough limestone screenings are available at reasonable cost, the combination with siliceous sands gives a very economical aggregate.

Since the final results obtained are the true criterion as to whether the grading is satisfactory or otherwise, the following factors must be considered as having a bearing on the outcome:

I. The surface characteristics of the limestone screenings which provide an interlocking effect within the block structure.

II. The type of cement used, which in this case was high early strength cement.

III. The system of curing. The strength results indicated for this series of tests were obtained by air or weather curing. The results are in keeping with those produced under accelerated temperature and humidity conditions.

IV. The type of machine on which units are made. Modern vibrating types have revolutionized the industry.

In a series of tests made under plant conditions the components of the mix consisted of equal proportions of limestone screenings and combined sands, mixed as follows:

(a) The limestone screenings and all of the mixing water required were mixed for 1-1/2 minutes.

(b) The sand mix and all of the cement were added to the pretreated contents of the mixer. The agitation of the total contents of the mixer was continued for from five to five and one-half minutes more, after which the mixer was discharged.

The first step (a) saturates the stone screenings and at the same time produces a certain amount of flour caused by abrasion. Apparently the pore saturation and production of additional fine material contribute to the bond between the cement and the aggregate particles. Besides, the mixing cycle outlined eliminates any balling of the materials in the mixer and keeps the interior of the mixer clean.

Results bear out the fact that where proper attention is paid to detail, low cost production of quality units can be accomplished.

**Recommended Proportions**—A specification for blend of limestone screenings and sands would be as follows: screenings, 30 to 50 per cent; sharp sand, 25 to 35 per cent; fine sand, 25 to 35 per cent.

**Characteristics of Sand and Coarse Aggregates**—Natural deposits of sand and coarse aggregates are to be found in most parts of the country. However this material in its natural state does not as a rule lend itself to use as a suitable concrete aggregate without washing and regrading.

Crushed stone or crushed rock of proper quality may be used as an aggregate.

There are 3 general classifications of rock.

(1) Igneous or volcanic rock, formed by the action of heat; granite is an example of such rock. It is hard, tough and granular, with practically no bedding planes, or strata.

(2) Sedimentary rock, formed from the consolidation of sediment deposited by water. Limestone and sandstone are examples of such rock.

(3) Metamorphic rock, of igneous or sedimentary origin, whose character and structure have been changed by the action of heat, pressure or movement.

In the foliated or layered types are included gneiss, schist and slate, while quartzite and marble are included in the non-foliated type.

Trap rock and fine grained basic and volcanic rocks are generally hard and are suitable for aggregate purposes.

Granite, trap rock and limestone are the rocks from which crushed stone is usually prepared. Some limestones are too soft, and only occasionally is sandstone sufficiently hard.

Because of its characteristically sharp and angular nature, crushed stone requires more care in processing than does sand and coarse aggregate with its well rounded particles.

Glacial Deposits—Glacial deposits are usually found in northern latitudes. They may be divided into two types, having very different characteristics.

(1) True glacial deposits usually occur in the form of small hills or ridges (moraines) which have been subjected to abrasion, though not to the sorting action peculiar to river transportation. Such deposits will usually contain material having a variety of shapes and sizes.

(2) Fluvial glacial deposits consist of glacial materials which have been subsequently subjected to stream action. Such deposits occur mainly in stream channels, downstream from moraines. These deposits are intermediate between the true glacial and normal stream deposits. As a rule such deposits yield a satisfactory aggregate material.

Stream Deposits—Stream deposits are generally the most satisfactory source of sand and coarse aggregate, because —

(1) The individual pieces are usually rounded.

(2) Streams impart a sorting action which may improve grading.

(3) Abrasion resulting from stream transportation and deposition tends to eliminate the weaker particles.

Alluvial Fan Deposits—These deposits are usually in the form of sloping plains extending from the foot of mountain areas into adjacent valleys. They are characteristic of arid regions. Sands and coarse aggregates of this type are quite different from those of normal stream deposition: the particles are angular, the material poorly stratified and graded, and the deposit irregular. Material from such deposits is frequently used as a source of aggregate, but successful results are obtained only after special processing.

Suitability of Aggregates—Aggregates, in order to be suitable for block production, should be clean, uncoated and have particles of strong, dense and durable material, highly resistant to the effects of chemical and physical changes.

Mineral or rock particles which are structurally weak, extremely absorptive, easily cleavable, or which swell when saturated, are more or less susceptible to breakdown when exposed to natural weathering processes. The existence of these characteristics in an aggregate may cause cracking, spalling "popouts" in the finished product.

Aggregates in their natural state may contain clay, silt, organic or other deleterious material. These foreign substances unless removed by washing will produce a weak and unsuitable product.

Aggregates containing soft fragments, thin and friable particles, various porous cherts, clayey sandstone or limestone are not suitable for concrete.

These characteristics may be divided into two general classes.

(1) Those which break down with little volume change.

(2) Those which have a high rate of volume change and exert a disruptive force.

Aggregates subject to volume change resulting from wetting and drying of the material can cause injury to the block.

The identification of the various materials herein mentioned requires a general familiarity with minerals. Their identities may be determined by visual examination, by the microscope or by tests for strength, hardness, soundness and absorption.

When excessive quantities of flat or elongated particles are present in aggregate, they produce a detrimental effect on the workability of the concrete mix, necessitating the use of more highly sanded mixes and more cement.

The following A.S.T.M. designations provide methods by which coarse aggregates may be tested for their relative qualities.

Soundness of aggregates determined by the use of sodium sulphate or magnesium sulphate A.S.T.M. C 88-46T. outlines the procedure for determining the resistance of the material to disintegration and weathering.

The quantity of soft particles in coarse aggregate ASTM C 235-49T. outlines the method for determining the quantity of soft particles on the basis of scratch hardness.

## Section 3—Lightweight Concrete Aggregates

During the past decade considerable development has been accomplished in the field of lightweight aggregate production. The rapid expansion in the use of block made from lightweight aggregates and their acceptance for building construction, indicates a growing trend which is likely to continue as the advantages of lightweight materials become better known and accepted by architects and builders.

Lightweight aggregate materials may be classified into three divisions: natural, by-product and manufactured.

The natural lightweight aggregates are of volcanic origin and include such materials as pumice, perlite and some cinders.

By-product aggregates include cinders from power plants and processed slag from steel mills.

Manufactured lightweight aggregates are produced from clay or shale.

Physical Properties—The physical properties of the aggregate should be given especial attention, since in lightweight concrete high absorption, irregularities in the shape of the particles and low density are factors which must be considered in the determination of the final grading. For this reason it is impractical to recommend a specific grading suitable for all types of lightweight aggregates since too many variables exist in the aggregates as commercially used.

The particles of the aggregate should be sufficiently strong to withstand pressure or tamping. Otherwise they may be broken down in the mixer or in the mold box of the machine, thus presenting new surfaces which are not coated with cement-water paste.

Because of the friable nature of some of the lightweight aggregates modification of the mixing technique may be necessary. Overloading the mixer is especially bad since the aggregate may be pulverized through grinding action.

When aggregate contains an excess of coarse material (3/8 to 1/2 inch) delivery of the concrete mix to the block machine is an important factor because of the possibility of segregation taking place in the mix. An excess of coarse material tends to cause bridging of the particles, especially in units having thin face shells and webs. Good plant practice demands that the largest size aggregate should not exceed one-third the thickness of the thinnest bearing section of the unit produced.

Absorptive Qualities—Most lightweight aggregates have high water absorptive qualities. For this reason certain precautions should be taken when processing such aggregates.

The water content must be carefully controlled. Many failures of lightweight aggregate block can be

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References—"Handbook of Rocks for use without the Microscope" by J. F. Kemp.

"Rocks, Rock Weathering and Soils" by G. P. Merrill attributed to this cause. The amount of water necessary for a mix is governed to a great extent by the absorptive qualities of the aggregate. The volume of water required in some instances may be several times the amount necessary for sand-gravel aggregate mixes.

With some types of aggregate it is difficult to incorporate the required amount of water in the time allotted to the mixing operation. Under these circumstances, presaturation of the aggregate in the stockpile should be resorted to. After thoroughly mixing the aggregate, the cement and the balance of the required water should be added and the mixing operation continued.

Cement Requirements—Generally, more cement is required to produce compressive strengths equivalent to those of dense concrete mixes. The selection of the type of cement best suited to the requirements must be given consideration in order to produce the type of unit having the desired qualities.

In lean mixes of lightweight concrete, the factors of workability and segregation may be improved by plasticizing agents in amounts necessary for the aggregate being used. The amount of air-entraining agent required to produce a workable mix may run several times the amount of that required for a sand-gravel mix.

Drying shrinkage is an undesirable characteristic in some types of lightweight aggregate block especially in aggregates having high absorptive qualities and which, require high cement content to produce the necessary compressive strengths.

Lightweight aggregates for concrete masonry units are covered by ASTM "Standard Specifications" C 331-53T.

Lightweight aggregates meeting the grading specification when tested in a dry loose state are to weigh not more than the following:

Fine Aggregate 70 lbs. per cu. ft.
Coarse Aggregate 55 lbs. per cu. ft.
Combined Aggregate 65 lbs. per cu. ft.

A lightweight unit may be defined as one manufactured from concrete which when bone dry, shall not weigh less than 70 lbs. per cu. ft. nor more than 100 lbs. per cu. ft. Standard weight units are considered to be manufactured from concrete weighing in excess of 100 lbs. per cu. ft.

Composition of Cinders—Cinders are the residue from high temperature combustion of coal under forced draft in industrial furnaces. They consist chiefly of fused ash containing varying amounts of unburned coal or coke.

Clinkers and ash together comprise about 70 to 80 per cent of the total and are composed mainly of silica, iron, alumina, lime and magnesia in the form of oxides, along with sulphur compounds. The remaining portion of commercial cinders consists of unconsumed coal or coke.

Classification of Cinders—It may be well to define and classify the types of materials as follows:

I. *Coke.* The residue containing more or less carbonaceous material in the form of coke, derived from high-temperature, forced-draft combustion of coal.

II. *Clinker.* That portion of the cinders which has been partly or completely fused during the combustion process. The clinker may be dense or more or less cellular.

Clinkers are formed from the fusion of the ash constituents of the coal. The type of coal and the temperature of burning have a decided effect on the strength of the resultant clinker.

Clinker obtained from the burning of anthracite coal differs from that obtained from bituminous coal, in that the former type is structurally weaker. This is due to the fact that the residue from anthracite coal is not as thoroughly fused as that obtained from bituminous

coal, when burned under similar conditions.

Cinders from both types of coal are used in the manufacture of masonry units.

Coke cinders weigh approximately 55 lb. per cubic foot, and clinker, 70 lb. Standard specifications require that cinders contain no more than 35 per cent of combustible material by dry weight.

Also, there should not be more than 0.45 per cent of sulphur as sulphide; nor more than 1.00 per cent sulphur trioxide as sulphate.

Physical Characteristics—The physical characteristics of cinders are more important in judging their suitability for aggregate purposes than are the chemical constituents. A quick method of evaluating the properties of cinders is to select a good representative sample of the material, then transfer a small portion of the sample to a container and wash off all the fine contents by decantation, then spread out the washed sample on a flat surface and proceed to separate the clinker particles from the coke particles.

From this separation of the materials a good idea of the type of aggregate is obtained. The greatest objection to the use of cinders as an aggregate is their lack of uniform quality. However, where cinders are procurable from a source at which the combustion process is carefully controlled, a reasonably uniform grade of material is assured.

Popping and Staining Characteristics of Cinders—In the selection of cinders it should be borne in mind that there is a considerable difference between the residue of combustion from a power producing plant where selected coals are generally used and the cinders obtained from heat-producing plants.

(a) *Popping.* A characteristic of cinders of the latter type is that they may contain small particles of free lime. Certain types of coals and the methods by which they are consumed give rise to these small lumps of free lime. The presence of such lumps causes the objectional feature of popping.

In the general run of clinkers the lime is fused with the silica and alumina of the ash to form inert compounds. Small lumps of lime may remain in the clinker, partially hydrated or partially combined on the outside, leaving a nucleus of calcium oxide surrounded by a dense shell of hydroxide, carbonate, or silicate. When moisture penetrates this shell and hydrates the calcium oxide, "popping" may take place. This condition is similar to lime spots in a clay brick.

(b) *Staining.* Another objectionable feature which confronts the manufacturer of cinder block is that of staining. This condition is brought about by the more finely divided iron compounds which escape the initial separation treatment. In processing cinders for aggregate purposes, most operators are satisfied if only the "tramp" iron is removed by subjecting the material to magnetic separation. Where additional separatory measures are taken it is surprising to note the volume of finely divided iron compounds which can be removed along with a portion of the fine particles of the cinders. To discard this volume of ostensibly good material, collected over a day's run, may seem a wasteful practice. Investigation has proved, however, that such material is fit only for the dump. If a manufacturer is really interested in producing units as free as possible from such stain producing defects, time spent in testing the cinders will amply reward him for his trouble.

The Portland Cement Association has done considerable development work on this subject and publishes a pamphlet entitled "Simple Method for Detecting Substances in Cinders which May Cause Popping and Staining in Masonry Units." This pamphlet sets forth in a clear and concise manner the operational details for conducting the tests.

(c) *Tarry spots.* A troublesome feature which manifests itself periodically is the presence of dark tarry spots which appear on the surface of the units. Even when the units are broken in testing, spots are also apparent throughout the internal structure. Whether

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*See Lightweight Aggregate for Concrete—F. T. Moyer—Bureau of Mines Circular #7195* this condition is produced by some physical characteristic of or through the improper burning of the coal is not easily determined. These pockets, however, are found only in the coke residue from the combustion process. There is not much that can be done regarding this objectionable feature. Even painting fails to hide the defects in the units. The logical course to pursue is to separate the worst units and exercise judgment in their disposition.

Weathering the cinders is recommended as a partial cure for some of these detrimental features. Many manufacturers stockpile the cinders as they are received, then allow them to weather.

A better course would be to process the material as soon as it is received and then stockpile the prepared aggregate. Weathering the smaller particles of aggregate would be more advantageous. Besides, in the event of unforeseen difficulties arising in the crushing plant, necessitating a lengthy shut down, block manufacture could proceed at a normal rate by drawing from the supply of processed cinders.

**Preparation of Cinder Aggregate**—One advantage of cinders used as an aggregate in block manufacture is that all the cinder mass, treated only by crushing, can be used. To obtain the maximum compressive strength, careful grading of the aggregate is necessary.

**Grading of Aggregates**—Grading by separation into the various screenings and recombination of such screenings would be the ideal method, were it feasible. Since it is impossible satisfactorily to separate damp cinders on the screens which must be used for the grading of aggregate suitable for cinder units, the following course would seem to be the most logical one.

To process the cinders in their natural state to conform, as closely as possible, to a grading developed under laboratory controlled conditions. Then to reproduce these findings under actual plant operation.

**Recommended Gradings**—The gradings shown in Table IV developed from experiment and duplicated in plant practice have proved satisfactory.

**Water Content of Raw Cinders**—The details of processing cinder aggregate into blocks is somewhat different from that used for the manufacture of gravel-sand aggregate units. Usually half or more of the necessary mixing water is present in the cinders as received from the original source. When cinders are stockpiled, the moisture content will vary considerably from time to time. Cinders have a strong affinity for water and dry cinders especially so. Thus, if too dry a cinder is being processed the cement-water paste, instead of exerting its adhesive qualities on the surface of the particles, may be sucked into the interstices, ceasing to serve as a binder.

In the average cinder block plant too little attention is given to the determination of the water content in the cinder just before it is used. Only that portion of the water added at the mixer is measured and this generally in a perfunctory manner. Little thought is given to the amount of water actually contained in the cinders.

Experience shows that where insufficient water has been used in the mix, the units will present a dull gray color and dry textural appearance with incidental lower compressive strengths. Units prepared under proper conditions as to water content show a good "water web" induced by the drag on the cement paste during stripping.

Much depends, however, on the type of machine on which the units are made. Certain types do not permit the use of "wet" mixes; others do. It is best to carry a mix with the maximum amount of water, short of producing slumping of the units as they come from the machine.

The results of experimental and actual plant operations compared with each other would indicate that an absorbed water content ranging between 11 and 15 per cent by weight of dry material is about correct for the general run of cinder aggregate.

**TABLE IV—RECOMMENDED GRADINGS FOR CINDER AGGREGATES**

**#1 Recombined Screenings**

| | Cumulative | | % Retd | % |
|---|---|---|---|---|
| Screen | Grams | % Retd | each size | Passed |
| ⅜" | 0 | 0 | 0 | 100.0 |
| #4 | 246 | 24.6 | 24.6 | 75.4 |
| #8 | 472 | 47.2 | 22.6 | 52.8 |
| #14 | 634 | 63.4 | 16.2 | 36.6 |
| #28 | 763 | 76.3 | 12.9 | 23.7 |
| #48 | 865 | 86.5 | 10.2 | 13.5 |
| #100 | 920 | 92.0 | 5.5 | 8.0 |
| Pan | | | 8.0 | |
| Fineness Modulus | | 3.90 | | |

**#2 Recombined Screenings**

| | Cumulative | | % Retd | % |
|---|---|---|---|---|
| Screen | Grams | % Retd | each size | Passed |
| ⅜" | 0 | 0 | 0 | 100.0 |
| #4 | 355 | 35.5 | 35.5 | 64.5 |
| #8 | 561 | 56.1 | 20.6 | 43.9 |
| #14 | 705 | 70.5 | 14.4 | 29.5 |
| #28 | 810 | 81.0 | 10.5 | 19.0 |
| #48 | 890 | 89.0 | 8.0 | 11.0 |
| #100 | 934 | 93.4 | 4.4 | 6.6 |
| Pan | | | 6.6 | |
| Fineness Modulus | | 4.25 | | |

**⅜" Material Retained**

| | Cumulative | | % Retd | % |
|---|---|---|---|---|
| Screen | Grams | % Retd | each size | Passed |
| ⅜" | 50 | 5.0 | 5.0 | 95.0 |
| #4 | 350 | 35.0 | 30.0 | 65.0 |
| #8 | 530 | 53.0 | 18.0 | 47.0 |
| #14 | 630 | 63.0 | 10.0 | 37.0 |
| #28 | 730 | 73.0 | 10.0 | 27.0 |
| #48 | 850 | 85.0 | 12.0 | 15.0 |
| #100 | 950 | 95.0 | 10.0 | 5.0 |
| Pan | | | 5.0 | |
| Fineness Modulus | | 4.09 | | |

NOTE: If it is found desirable to have a portion of ⅜-in. material in the aggregate, its amount should be limited to a maximum of 5 per cent for best results. A content of over 5 per cent of this size tends to produce too coarse a texture with incidental reduction in strength, due to bridging effect. . . . Good plant practice demands that the largest size aggregate should not exceed one-third the thickness of the thinnest bearing section of the unit produced.

### Proportioning Cinders

The variable nature of cinders as an aggregate presents a problem relative to their proportioning.

**Batching By Weight**—If the aggregate is to be measured by weight, two variables must be considered in order to obtain uniform concrete.

The variables involved are moisture content and specific gravity of the material, which must be corrected. If accurate quantities of aggregate are to be delivered to the mixer, the moisture content of the cinders should be determined periodically.

In order to satisfy the natural absorptive properties of the cinders, an endeavor should be made to maintain the water content of the material between 11 per cent and 15 per cent before delivering to the mixer.

The specific gravity or weight per unit volume varies considerably depending on the structure of the cinders, whether predominantly coke or hard clinker. For this reason, it may be necessary to make frequent changes in the batch weights in order to obtain uniform quality of product.

**Batching By Volume**—In volume batching, the factor of specific gravity may be disregarded.

Tests have shown that within a range of from 10 per cent to 30 per cent of moisture content in the cinders, the bulking factor remains reasonably constant at 25 per cent. This characteristic may also be disregarded.

Where the moisture content of the cinders falls below 10 per cent, the bulking factor may vary considerably, in which case, the mix should then be calculated on a dry volume basis and making the necessary corrections.

These observations with respect to batching by weight and by volume also apply to other lightweight aggregates.

**Control of Crushing Plant Through Screen Analysis***—All crushing, pulverizing, and screening equipment

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For further study see—E. Christensen—Journal A.C.I., Feb., 1931.

has a point of most desirable production. Where the product is too coarse or too fine it may be unsatisfactory for use; also, where the product is too fine the production output of both crusher and screens is reduced. To maintain the most profitable production, frequent sieve tests should be made of the products of both crusher and screens.

The performance of a crusher changes from day to day. Sieve analyses made at regular intervals will immediately show up any changes which occur in the performance of the various phases of the crushing plant operation.

Definite information cannot be obtained by feeling or rubbing the material between the fingers; the only dependable way is to make tests.

Sieve analyses provide a permanent record; they tell the superintendent what his equipment and operators are doing. The judgment of the operator may change, or, if there is a change of operators, the new operator will have no means of knowing what has previously constituted a satisfactory performance of the plant. Through screen analyses, accurate control is assured, provided proper sampling methods are followed. Poor sampling of the material can lead to dangerous conclusions.

Tests of the crusher material have shown that it is profitable to install a screen ahead of the crusher. The material fed to the crusher usually contains a percentage of fine aggregate which does not require treatment. If this fine material is passed into the crusher it acts as a cushion for the coarse particles and interferes with the crushing action. Removal of this fine material increases the output of the plant.

If the crusher product is too coarse and the necessary amount of fine material is not produced, the quality of the finished product will be affected.

In the screening operation, only particles which are smaller in size than the openings in the screen will pass. The angle at which the screen is operated, the rate of flow of material over the screen, the moisture content of the cinder, the shape of the particles, and various other factors affect the screen performance. Variations in the fineness of the processed cinders may cause undesirable properties in the subsequent processing of the units.

Coke Breeze—Coke breeze is a cellular product obtained by screening metallurgical or household coke. It is composed chiefly of combustible matter with a small percentage of inorganic material known as ash.

The use of straight coke breeze as an aggregate in concrete block is rather new in this country, hence not very much technical information is available. Coke breeze should be free from the deleterious substances that make so many cinder aggregates unsuitable, especially from the point of iron staining.

The grading of breeze varies, depending on the locality from which it comes, but may be considered as the fine screenings from crushed coke which pass a ⅛ or ¼-in. screen opening.

Breeze obtained from metallurgical coke is stronger than breeze made for household furnace use. Units made from coke breeze have about the same weight as cinder units.

If the use of coke breeze as a lightweight aggregate is contemplated, units from trial batch mixes should be thoroughly tested for volume change characteristics after repeated wetting and drying tests have been conducted. The American Society for Testing Materials limits the combustible content of cinders to 35 per cent maximum. Since coke breeze contains from 75 to 85 per cent combustible matter, it would seem advisable, therefore, to ascertain the fire rating of masonry units, made from this material, before proceeding with extensive manufacture.

The serious shortage of cinders and slag aggregate in many localities has necessitated the processing of more easily obtainable raw materials, such as clay and shale into block making aggregates. These materials are to be found quite extensively in most regions.

Manufactured Aggregates—Lightweight aggregates manufactured from naturally occurring materials may be divided into two groups.* In the first group reliance is placed on the fact that certain clays, shales or slates bloat or puff up when heated to the point of incipient fusion. In the second, lightness is obtained primarily by sintering a granular material in such a manner that a solid structure is formed in which the interstices are preserved as pores or voids; the original solid may bloat during firing, and add to the pore volume.

There are several methods by which this type of aggregate may be produced, chief of which are the rotary kiln and the horizontal traveling grate sintering system.

The rotary kiln can be fired by powdered coal, oil or natural gas. Kilns are approximately 50 ft. long, 6 ft. to 6 ft. 6 in. in diameter and lined with 6 in. fire brick. Kiln speed can be varied between 1 and 3 r.p.m.

The raw clay or shale after preliminary treatment, is fed into the kiln. The contents of the kiln are then rapidly heated to a temperature which causes a certain degree of fusion of the material. The cellular structure of the product is produced by the evolution of gases during the heating period.

After the clinker is discharged from the kiln it is crushed, screened and graded into the standard commercial sizes used in concrete block manufacture.

The Dwight-Lloyd process of sintering fine particles of ore on a flat grate, which has been in use in the metallurgical industry for many years, has now been adapted to the production of lightweight aggregate made from clay or shale.

The sintering process may be likened to smoking a pipe. The raw material is lighted by a flame from above while a stream of air is drawn downwards. The resultant product is a cake.

The process involves mixing the raw clay with pulverized coal or coke, intimately mixed with the requisite amount of water. The mass is then fed onto a continuous series of pans traveling through a gas or oil fired ignition chamber.

The mass is heated until the coal is ignited, and incipient fusion commences. Gases and steam from the burning coal puff up the heated clay leaving a cellular mass. A fan furnishes the down draft through wind boxes. The resultant product from this burning operation is a fused clay.

It is during this period of fusion that the liberated occluded gases and steam determine the type and extent of the bloating of the material.

These occluded gases are derived from the natural gas forming constituents, coupled with the free carbon, carbonaceous substances, carbonates, sulphur and its compounds, or any other compound which will liberate gas directly or through the interaction between the various constituents.

The basic requirement for the successful production of this type of aggregate is that the incipient fusion point of the material and the evolution of the gas be approximately coincident.

Lightweight aggregates under various trade names are being produced successfully from many types of raw materials among which may be mentioned: Haydite, Rocklite, Lelite, Aglite and Beslite are typical of aggregates produced by the fore-mentioned processes.

Haydite Aggregate—Haydite is an expanded aggregate made from a wide variety of clays and shales. The raw clay or shale after preliminary treatment, is fed into a rotary kiln. The contents of the kiln are then rapidly heated to a temperature which causes a certain degree of fusion of the material. The cellular structure of the product is produced by the evolution

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* W. S. TYLER CO. Catalog #48.

For further study see Ralston & Conley Publication #23—National Ready Mixed Concrete Association.

of gases during the heating period.

After the clinker is discharged from the kiln it is crushed, screened and graded into the standard commercial sizes used in concrete block manufacture.

Units of any texture can be obtained by proper blending of the aggregates. A 60 per cent coarse to 40 per cent fines ratio is common.

It is advisable to have at least 75 per cent of the total required mixing water present in the aggregate either in the stockpile or in the mixer before the cement is added.

Haydite concrete should be mixed until the mass is uniform in color and homogeneous. Longer mixing of the concrete renders it more workable. Units made from Haydite have a low heat conductivity and lighter weight than cinder units. An 8 in. unit weighs between 25 and 28 lbs.

The use of units made from mixes of Haydite aggregate and high alumina content cement, such as Lumnite, Fondu or equivalent make, has proved very effective for lining the test cells for jet engine testing, where sound deadening and resistance to high temperature (around 2,000 degrees F.) qualities are required.

[*]Rocklite Aggregate—This aggregate is produced from a natural blue shale deposit found at Ventura and Napa, California.

Crushing and preliminary sizing is done before the material is expanded in the kiln. This assures well rounded, cellular particles having a smooth coated surface hard enough to scratch glass. The interior of the particles is a mass of tiny cells.

Because of this hard surface, and its consequently low absorptive quality, Rocklite concrete, if desired, may be mixed dry with the portland cement and the water added later.

It is claimed, for concrete units made from Rocklite, that they are low in curing-shrinkage and volume change from thermal or moisture conditions. Standard size 8 x 8 x 16 inch units weigh around 25 lbs.

**Lelite Aggregate**—This lightweight aggregate is obtained by expanding or bloating metamorphic carbonaceous shale mined in conjunction with anthracite coal and processed in the vicinity of Lansford, Pa.

Bloating of the shale is done in especially designed traveling grate furnaces, heated to a temperature of approximately 2800 degrees F. The sinter emerges from the furnace as a cake or slab. The cake is reduced in size by crushing and screening to specific sized gradings for its various applications.

It is marketed in commercial sizes as coarse, 3/4 inch, weighing 40 lbs. per cu. ft.; intermediate, 3/8 inch, weighing 45 lbs. per cu. ft.; and fine weighing 60 lb. per cu. ft.

A combination of intermediate and fine size aggregate for block manufacture has a weight of approximately 56 lbs. per cu. ft. Standard sized 8 x 8 x 16 inch units range in weight from 28 to 32 lbs. Units made from Lelite and Lumnite cement produce a concrete of high refractory quality capable of withstanding a temperature up to 2000 degrees F.

**Aglite and Beslite Aggregates** are produced from clay deposits at Marietta, Ohio and Detroit, Michigan respectively.

**Beslite Aggregate**—Beslite is the trade name given to a type of lightweight, cellular aggregate made by sintering. Modular 8 inch units made from this material graded to a fineness modulus of 3.70 to 4.00 have a weight of approximately 26 lbs.

In processing this, as well as all other lightweight aggregates having an affinity for water, care must be taken to see that at least 75 per cent of the total amount of water required in a batch of concrete is mixed with the aggregate before the cement is added to the mix.

Even when sand is substituted in the mix to the extent of 25 per cent by volume, the units will generally weigh less than 30 lbs. When sand is substituted it is important to remember to compensate for the difference in weight of the sand as compared with Beslite. In a 50 cu. ft. mixer the substitution of 25 per cent sand for Beslite would mean that 12.5 cu. ft. of sand would replace 12.5 cu. ft. of Beslite. Where the sand weighs approximately 100 lbs. per cu. ft. and the Beslite weighs 60 lbs. per cu. ft. 1250 lbs. of sand would be substituted for 750 lbs. Beslite.

This emphasizes the need for being very careful in determining the proportions of materials where aggregates of different weights per cu. ft. are used. The proportioning is basically in terms of volume but the volume must be transposed into weight per unit volume so that the correct amount of each material is used.

Taking into consideration the fact that the more lightweight aggregate used, the more cement will be required to obtain the desired strength it may be found that a 30 lb. unit may cost from 1 to 2 cents less to produce than a 26 lb. unit.

The cost of the unit is affected by the difference in cost between sand and prepared aggregate, plus the difference in the amount of cement necessary to produce a required strength.

Following are approximate weights of units obtained from the use of Beslite alone and also Beslite with varying proportions of mixes of coarse and fine sand.

| Type of Mix | Weight of Unit |
|---|---|
| Beslite Only | 26 lb. |
| Beslite and 12.5% Mixed Sand | 28 lb. |
| Beslite and 25% Mixed Sand | 30 lb. |

**Pumice Aggregate**—Pumice and other volcanic rocks are vesicular lavas in which the cells have been formed by the gases escaping from the molten materials. Some grades of this material, because of their wide variation in physical and chemical characteristics, are unsuited for concrete block manufacture. Deposits suitable for concrete are found in California, Utah, Oregon and New Mexico.

Pumice used as an aggregate in block manufacture presents definite problems, some closely related to those found in regular aggregates, others peculiar to pumice alone.

Block manufacturers have overcome many of these difficulties by perfecting their mixes, tightening down on specifications for lightweight aggregates and conducting periodic tests on their finished products. Other characteristics of pumice aggregate are the tendency to segregate during shipment, in the stockpile as well as in the block machine. This feature is induced, apparently due to its low specific gravity. Pumice also possesses variable absorptive properties.

Another feature of pumice block is their tendency towards excessive shrinkage. However, the use of properly cured and dried block in conjunction with some form of reinforcing, or the inclusion of adequate control joints will tend to minimize cracking of units in wall structures.

**Physical Properties**—Pumice has a fusion point of approximately 2450 degrees F. It possesses high heat insulating values, fire resistant qualities and lightness of weight of the finished units. The weight of the conventional 8 inch unit ranges from 20 to 25 lbs.

**Grading of Aggregate**—Grading of the aggregate is an important factor. Varying textures of block may be produced from either straight use or blends of aggregate, based on American Society for Testing Materials, Specification C331-53T.

The following range for Pumice is presented merely as a guide for a combined aggregate.

| Sieve Sizes | Specification Range |
|---|---|
| % Retained ⅜ in. | 0-10 |
| #4 | 15-25 |
| #8 | 30-40 |
| #14 | 45-55 |
| #28 | 60-70 |
| #48 | 75-85 |
| #100 | 85-90 |
| Fineness Modulus | 2.30-2.75 |

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Basalt Rock Makes Pelletized Aggregates — Concrete, April 1953.

In pumice as with sand-gravel aggregate the minus No. 48 and No. 100 sieve fractions seem to play an important role.

Grade "A" load bearing units of 1000 lb. per sq. in., may be obtained with a lower yield of units per sack of cement. Mix proportions for load bearing units range from 1-5 to 1-7 mixes.

The effect of too much fine material in the aggregate tends to gum up the cement. Premixing the pumice aggregate for too long a period can produce what may prove to be an undesirable increase in the amount of fine material, minus No. 100 to No. 200 mesh, due to the resulting excessive abrasion of the aggregate. Removal of the fine material from the No. 28 mesh sieve down, with substitution of sand to produce a fineness modulus of about 3.70, may be resorted to as a corrective measure without adding materially to the weight or impairment of the other qualities of the unit.

Processing Aggregate—For best results the aggregate should be batched on a volume basis though delivered to the mixer by weight.

The moisture content should be determined and compensated for in order to have a uniform volume in each batch.

Aggregate if not sufficiently wet in the stock pile, should be brought to a proper state of saturation in the mixer. Ample time should be allowed for the saturation to take place before the cement is added to the mix. Bone dry pumice will absorb up to about one-third its weight of water.

The mix should be as wet as possible, short of causing slump of the units as they come from the machine. Excessive "bleeding" from the block indicates the presence of too much water, which should be reduced in quantity. The maximum possible vibration of the machine should be utilized in molding the units.

**Curing Units**—The time required to steam cure pumice units is greater than that needed for sand-gravel units. This is accounted for by the fact that lightweight concrete generally has a higher equilibrium temperature; and consequently a longer period of time is required to reach this point.

**Blast Furnace Slag**—Blast furnace slag aggregates in the several forms at present marketed offer an excellent material for the production of masonry units.

**Definition of Slag**—According to American Society for Testing Materials, designation C125-48, blast furnace slag is defined as "the non-metallic product consisting essentially of silicates and alumino-silicates of lime and other bases, which is developed simultaneously with iron in a blast furnace."

**Types of Slag**—Three general types of slag aggregate are produced. These types are known to the trade respectively as air cooled, granulated and expanded. Each type of product is characterized by the manner in which the slag is cooled.

1. The air cooled type is formed through slow cooling in dry pits, after which it is crushed and screened. In the trade it is termed crushed and screened air cooled slag.

2. Granulated slag is a cellular product produced when molten slag is suddenly chilled by contact with a jet of water. In this process, one or more high pressure jets of water impinge on a stream of molten slag. The product of this operation falls into a pit containing water. Granulation takes place partly in mid-air and partly in the water pit. For marketing it is screened to remove oversize pieces.

3. Expanded Slag is a lightweight product formed when molten slag is treated by applying a controlled amount of water. This type of product may be produced by mechanical devices, or by direct application of controlled amounts of water to the molten slag by

means of water jets, with or without the addition of compressed air. The amount of water needed is less than that required for granulation, consequently, a relatively dry cellular lump is formed possessing a small cell structure.

The product of this operation is then crushed and screened to lightweight aggregate sizes. Large amounts of expanded slag are produced by the pit process. This form of lightweight aggregate has become very popular, since the conventional eight-inch units produced from this aggregate weigh only about 30 lbs. compared with the 40 lb. weight of the heavy concrete units.

**Trade Names**—Expanded slag is marketed under such trade names as Celocrete, Superock, Waylite, Enslite and other designations.

**Removal of Iron**—In the conveying system magnetic pulley separators are used to remove the metallic iron. Generally only very small quantities of free iron are present. Experience has shown that under modern conditions of slag processing, this iron presents no insuperable problems.

**Physical Properties**—One outstanding advantage in using expanded slag in concrete products is that because of its cellular structure, it possesses a lower heat transmission coefficient and a greater fire resistance quality than concrete made from heavy aggregates.

With mixes made from expanded slag, it is most desirable to have the aggregate properly wetted before the cement is added. It should be wetted with about 75 per cent of the total required mixing water, either in the stockpile or in the mixer before the cement is added. After thoroughly mixing the aggregate, the cement and the balance of the required water should be added and the mixing operation completed.

**Mixing Procedure**—The wet mixing period is especially desirable where expanded slag is used. With this treatment the surface cells are filled with water and when the cement is added it remains on the surface of the particles where it is used to best advantage.

A good rule to follow in all cases is to use the maximum amount of mixing water necessary to produce a "water web" or "sheen" on the surface of the units without causing the block to slump.

**Weight of Units**—The weight and strength of concrete units are influenced by the type and grading of the aggregate as well as the quantity of water used and the cement content of the mix.

The weight of slag block made from the same aggregate may vary in different manufacturing plants. The factors which influence this condition depend on the type of machine used, the volume of core space, and the concrete mix.

The weight of 8 x 8 x 16 inch units with a nominal wall thickness of 1-1/4 inches and a core volume of approximately 45 per cent, are generally within the following range:

| Type of Slag Unit | Weight, Pounds |
|---|---|
| Expanded Slag | 25-33 |
| Granulated Slag-Blends | 30-38 |
| Air Cooled Slag | 35-43 |

**Recommendations**—For best results in processing slag block, the following points should be observed:

1. Slag, because of its absorptive qualities, should not be mixed dry with cement for masonry unit mixtures.

2. Approximately 75 per cent of the required water for a batch of concrete should be mixed with the dry aggregate before the cement is added.

3. Concrete mixtures should be made as wet as possible consistent with desired textural features.

4. A fineness modulus of approximately 3.40 to 4.00 is best for general purpose units. Acoustical units may have a higher fineness modulus. Texture is controlled by the ratio of fine to coarse aggregates used in the block mixture.

5. Length of mixing time is important as it affects

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Lightweight Aggregate Industry in Oregon—Dept. Geology & Mineral Industries Paper #21—R. G. Mason, 1951

Lightweight Aggregates for Concrete—F. T. Meyer—U. S. Bureau of Mines Circular 7195, 1942 the strength and other physical characteristics of the units.

6. In general, units cured for a period of two hours in low pressure steam reaching a temperature of 170 degrees F. and followed by a slow soaking and cooling period in the damp atmosphere of the kiln will be satisfactorily cured. The units should be stockpiled for drying prior to use.

The following typical sieve analyses of coarse and fine aggregates are based on a study of average sieve analyses of Expanded Slags from all sources in the United States.[*]

Table V COARSE AGGREGATE

| Sieve Sizes | Cumulative Percent | % Retained Each Sieve | Percent Passed |
|---|---|---|---|
| 1/2 in. | 0.0 | 0.0 | 100.0 |
| 3/8 in. | 22.0 | 22.0 | 78.0 |
| #4 | 90.0 | 68.0 | 10.0 |
| #8 | 94.0 | 4.0 | 6.0 |
| F.M. | 6.06 | | |

FINE AGGREGATE

| Sieve Sizes | Cumulative Percent | % Retained Each Sieve | Percent Passed |
|---|---|---|---|
| 3/8 in. | 0.0 | 0.0 | 100.0 |
| #4 | 3.0 | 3.0 | 97.0 |
| #8 | 19.0 | 16.0 | 81.0 |
| #14 | 39.0 | 20.0 | 61.0 |
| #28 | 64.0 | 25.0 | 36.0 |
| #48 | 80.0 | 16.0 | 20.0 |
| #100 | 89.0 | 9.0 | 11.0 |
| F.M. | 2.94 | | |

For good block textural results, aggregate should be proportioned to approximate the Theoretical Grading, with a fineness modulus of 3.70 as shown in Table XI.

The method of calculating a desired F.M. from a known F.M. is outlined on Page 50. For instance for a F.M. of 3.70 derived from a grading of aggregates as shown above, the proportions are approximately 25 per cent coarse to 75 per cent fine aggregate. The calculated combined aggregate analysis from these percentage proportions is shown in Table VI.

Table VI COMBINED AGGREGATE

| Sieve Sizes | Cumulative Percent | % Retained Each Sieve | Percent Passed |
|---|---|---|---|
| 3/8 in. | 5.5 | 5.5 | 94.5 |
| #4 | 24.5 | 19.0 | 75.5 |
| #8 | 38.5 | 14.0 | 61.5 |
| #14 | 53.5 | 15.0 | 46.5 |
| #28 | 72.5 | 19.0 | 27.5 |
| #48 | 84.5 | 12.0 | 15.5 |
| #100 | 92.0 | 7.5 | 8.0 |
| Pan | | 8.0 | |
| F.M. | 3.71 | | |

**Sawdust Aggregate**—Sawdust alone has been tried out as an aggregate for load bearing units by many experimenters. The strength results on block have generally been so low as to preclude their use for this purpose.

Because of the varied physical characteristics of sawdust obtained from different types of wood, uniformity in strength of the concrete is difficult to attain for these reasons:

1. The uniform size of the particles.
2. The presence of chips or lumps which fail to pass a No. 4 screen, nor should it be so fine that it will all pass a No. 14 screen.
3. The fact that some wood (cedar for instance) may contain as much as 2% tannin (tannic acid) which is considered detrimental to concrete.
4. The variable length of time of set of concrete depending on the coarseness or fineness of the sawdust.
5. The presence of appreciable amounts of bark in the sawdust exerts a retarding and weakening effect on the concrete.

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[*] Typical Slag Analyses Supplied by H. T. Williams, Standard Slag Company—Youngstown.

Iron Blast Furnace Slag—Production, Processing, Properties and Uses. Bureau of Mines Bulletin 479.

Slag Concrete Masonry Units—National Slag Association, Washington, D.C.

Sand as an addition to a mix of equal parts, by volume, of portland cement, sand and fine wood sawdust will produce, after a few days' curing, a concrete strong enough to hold nails. Sand tends to produce workability and strength in the mix.

Expansion or contraction features must be considered if the concrete is to be exposed to weathering conditions.

In view of the variable behavior of the different kinds of sawdust it is advisable to experiment with the material before proceeding with any large scale use of this type of concrete.

Calculating Desired F.M. from Known F.M.—When it is necessary to calculate the percentages of fine and coarse aggregates of known fineness modulus required to produce a combined aggregate of a desired fineness modulus, proceed as follows:

*Method 1.* The general equation is:

$$XF.M._f + (100 - X)\ F.M._c = 100\ F.M.$$

Where X is the percentage of fine aggregrate, and 100 minus X is the percentage of coarse aggregate.

$F.M._f$, $F.M._c$ and F.M. are, respectively, the fineness moduli of fine, coarse, and combined aggregates.

Assume a fine aggregate of 3.15 F.M.; a coarse aggregate of 5.55 F.M.

Required, a combined aggregate of 4.00 F.M. Then, applying the equation,

$$X\ (3.15) + (100 - X)\ 5.55 = 100\ (4.00)$$

Or,

$$3.15X + 555 - 5.55X = 400$$

Clearing this equation, it is found that

$$X = \frac{155}{2.40} = 64.6,$$ which is the percent of fine aggregate. Then,

$$100 - X = 100 - 64.6 = 35.4,$$ which is the percentage of coarse aggregate.

*Method 2.*

$$X = 100 \left(\frac{A - B}{A - C}\right)$$

Where X is the desired percentage of fine aggregate,
A is the F.M. of the coarse aggregate (5.55),
B is the F.M. of the combined aggregate (4.00), and
C is the F.M. of the fine aggregate. Then,

$$X = 100 \left(\frac{5.55 - 4.00}{5.55 - 3.15}\right) = 100 \left(\frac{1.55}{2.40}\right)$$

= 64.6, or the percentage of fine aggregate. Then, 100 − 64.6 = 35.4, or the percentage of coarse aggregate.

## Section 4—Segregation of Aggregates

Segregation of the aggregates is one of the most troublesome problems with which the block manufacturer has to contend. Effective control of segregation makes for economy since it uses aggregates to their best advantage, thereby obviating the need for additional cement. This is accomplished by maintaining grading which gives the least surface area to be coated with cement paste. Without control the amount of a particular size aggregate in a block will vary considerably. The result will be too wide a variation in the strength of the finished product. Using proper controls, high strength products can be produced with a minimum of cement.

Aggregate, when being transferred to the storage bin, should be handled in such a manner as to insure that the larger particles will not be separated from the smaller ones. The material should be delivered to the center of the bin, and the bin kept as full as practicable at all times by maintaining a balance of the incoming and outgoing material.

When material is delivered to a bin by conveyor belt, the vibration of the belt is likely to produce considerable segregation. The larger particles of the aggregate remain on top of the mass, the finer aggregate tends to settle to the bottom and when discharged into a bin from a chute, still further separation in the stream of incoming material takes place.

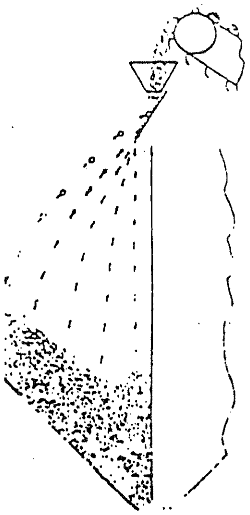

Figure 4. Graphic explanation of how segregation of aggregates takes place.*

Segregation occurs almost exclusively in the coarse aggregate. When coarse aggregate is discharged into a square bin by means of a bucket elevator and delivered at one corner of the bin onto a chute placed at an angle, the coarser particles as they hit the chute tend to bounce to the outside of the delivery stream, then in streams of ever lessening sized particles. A point is reached where the finest material slides down

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* R. E. Robb, Rock Products, February, 1947.

the chute and falls in an almost vertical stream into the bin, thus producing further segregation.

The larger particles build up faster in the bin than the smaller ones and eventually roll back over the smaller particles, until the latter catch up with operations. The result is an aggregate deposited in the bin in layers of irregularly graded sizes. Baffles properly placed in bins have in some instances proved helpful in preventing rolling and segregation of the aggregate.

Many plants overcome much of the segregation problem through the use of separate bins for the storage of the respective sized aggregates.

Fine aggregate such as sand, which has different sized particles and which is more or less damp at all times, does not segregate readily because of the effect of the surface tension of the water contained in the sand. When dry enough to flow freely, it is liable to segregate without evidence of segregation being too obvious. If such a condition exists, it may be remedied by dampening the sand, keeping in mind that corrections must be made for water content and bulking factor.

The amount of moisture that can be held by sand with reasonable stability depends on its grading, particle shape, surface texture, storage and drainage facilities and is usually between 3 and 6 per cent.

Individual plant mechanical devices may be developed to overcome difficulty of segregation.

Building a Stockpile of Aggregate — Correct stockpiling of coarse and fine aggregates is an important factor in any block plant and one to which too little attention is given. Unless proper attention is provided for, this phase of operation may prove to be one of the most important causes of variation in the strength of the finished product, due to segregation or contamination of the aggregate.

Generally, the material to be stockpiled is laid directly on the ground. Therefore, care must be taken when removing the material adjacent to the ground

surface to prevent contamination by the soil or other foreign material. Adjacent piles of the different sized aggregates should be kept definitely separated.

Another factor which must be guarded against is dropping coarse aggregate from great heights, since segregation or breakage may result. In many instances a crane and bucket is used for stockpiling aggregate and also in removing the material from the stockpile. This method of handling material may be good or poor depending largely upon the skill of the crane operator.

A cone shaped pile, resulting from discharging material over the end of a conveyor belt or by placing with a crane bucket dumping continuously in one place, is not a correct way to build a stockpile. Dumping from a truck, and letting the material roll down an incline is also productive of segregation of the aggregates.

A stockpile should be built up in horizontal layers by depositing the aggregate in small adjacent piles. Then continue operations by filling in the depressions between the piles. This procedure is followed until the stockpile is of sufficient size.

A cone shaped pile may eventually result, as the perimeter of the bed is reduced, but the aggregate, having actually been placed in flat layers, will not be segregated. In dumping from a truck, not over a truckload should be deposited in a place in order to keep the surface level. Figure 5 following illustrates these points.

Storage Bins — The style and size of storage bins are governed by several factors — the purchaser's finances, the size and layout of the plant, and the probable future business expansion which may be expected in the locality.

Bins may be square, rectangular or circular in shape. Square bins are less expensive to construct, but cylindrical bins are preferable for the storage of materials. Whatever form of bin is decided upon, one common factor applies to all types; that is, the horizontal dimension should be as small as practicable in relation to the height of the bin.

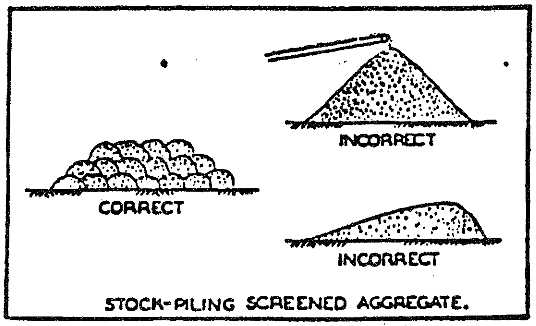

Figure 5. Stockpiling Screened Aggregate.

Bins should have a bottom sloping at least 45 to 50 deg. from the horizontal towards the center, with the outlet at the apex of the pyramid or cone. The pyramidal bottom of a square bin will sometimes cause damp material to "hang" in the corners. Such a condition may produce segregated distribution of the material as it is withdrawn from the bin. Bin shape and moisture content will affect the degree of segregation.

One method of overcoming the possibility of material "hanging" is to fit into each corner a diamond-shaped plate arrangement. The plate assembly extends upwards from the discharge, thus eliminating the shallow corners by giving the discharge section an octagonal shape. These assemblies may either be bolted or welded onto the sides of the bin. It is advisable to fill the spaces between the bin sides and the added plates with concrete to give support. The concrete may be introduced through openings provided by removing the apex of each plate.

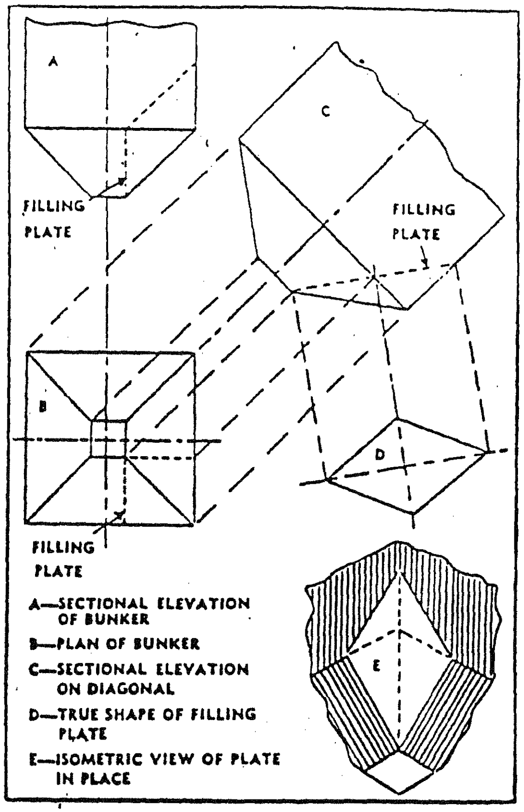

Figure 6. Method of avoiding material "hanging" in bins.*

When it is necessary to divide a bin, the dividing plate should be carried above the rim to prevent the intermingling of material. Bins for aggregate should be loaded in such a manner as to avoid coning of the materials, and should be kept as full as practicable at all times.

The bin for bulk storage of cement should be given special attention. It should be weathertight, and covered with a steel roof provided with a manhole and air vent. All joints should be periodically checked for weathertightness.

The hopper slopes should be set at not less than 50 deg. but preferably at 60 deg. angles from the horizontal in order to render the bin self-cleaning. If different brands of cement are used, the bin should be divided, and each brand of cement kept separate.

Formula for computing sizes of bins and tanks will be found in Section 21 — Technical Notes.

**Determination of Contents of Storage Bins** — Because of the large volume of aggregates used in concrete block plants, it is always desirable to know the volume of aggregate available in the storage bins. An effective and simple system has been developed which registers volumes in bins quickly and accurately.

The principle on which the system operates is based on the fact that pressure from the aggregate in the bin will actuate an electric switch. Such switches can be set in the wall of the bin at predetermined levels. In installations now in use the switches were set at quarter points in the height of the bin. There were therefore, switches at the top of the bin, at the ¾ point, at the ½ and the ¼ points. The system is illustrated in Figure 7.

Along the edges of an ordinary electrical outlet box and extending an inch out from the box, strips of one inch by ¼ inch steel are welded to form a continuous flange. Another flange is formed from strips of steel ⅜ inch by ⅛ inch welded at the corners, making an opening of approximately 5 ins. by 3¼ ins. The two

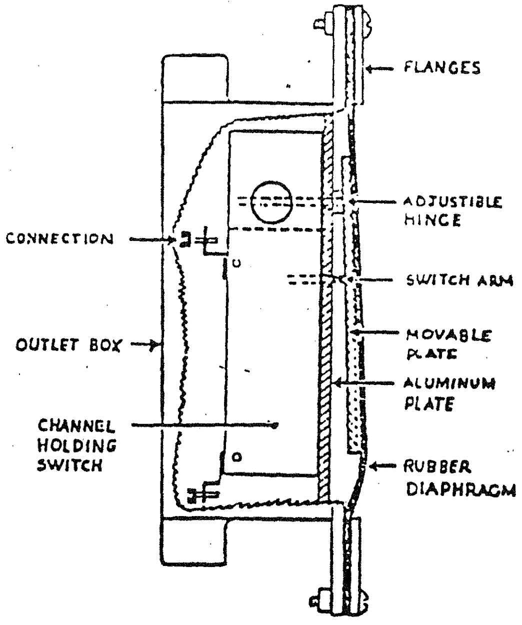

Figure 7. Device for registering bin contents.

flanges are drilled at suitable points. A piece of rubber inner tube is inserted between the flanges, which when bolted together, provides protection against dust and moisture affecting the operating assembly which is mounted under the rubber diaphragm.

The operating assembly consists of any suitable type of precision limit switch which will fit in the outlet box. The switch is mounted in a section of commercially available extruded aluminum channel, which in turn is mounted on an aluminum plate. The aluminum plate, approximately 3¾ inch by 2¼ inch fits inside the lip of the outlet box and is held in place by screws. The switch arm which extends through this plate is operated by means of another suitably hinged and adjusted plate 3 inches by 1½ inches.

The hinging arrangement is constructed as follows: In this case the channel is divided into two parts. In the lower portion the switch is mounted. In the upper portion holes are drilled through the flanges with sufficient play to allow for a section of ⅜ inch round aluminum bar to be passed through the holes.

The bar is cut long enough to extend beyond the flanges and allow for the drilling and threading of holes which will be approximately 7/16 inch outside the flanges of the channel.

Holes sufficiently large and in alignment with those in the bar are also drilled through the aluminum plates. Suitable length screws are inserted through the outer plate and reaching through the bar. These screws are held tight by means of nuts placed behind the front aluminum plate.

Adjustment is made by turning the screws, then locking the movable plate by tightening the nuts.

The pressure of the material in the bin against the rubber diaphragm relays the pressure necessary to operate the switch making contact with the central control panel of signal lights.

These assemblies are connected by suitable lengths of ½ inch heavy conduit pipe. They are mounted along one side of the total height of the vertical section of the bin.

The switches are connected by multi-conductor plastic covered wire as used in rotary T.V. antenna controls to a light panel installed at a convenient point for easy observation. This light panel is protected by a low voltage transformer of sufficient rated amperage to care for the number of light bulbs used in the circuit. A series of 6-volt radio pilot bulbs controlled by a switch are installed in the panel. A multi-station

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* Rock Products, July, 1948.

rotary switch should be mounted to by-pass the circuit to the bin switches so that the bulbs in the panel may be quickly checked to determine if they are in working order.

Lights on the central control panel become incandescent and remain so until the level of the aggregate ceases to exert force on the upper switches. The volume of the bin contents is readily determined by the number of incandescent bulbs in the row of the control panel.

Heating Aggregate in Bins – As aggregate bins are rarely insulated it is not unusual for the contents of the bins to freeze in those sections of the country subject to low temperatures. When freezing takes place, delays and inconveniences in the production schedule manifest themselves.

Since gravel-sand aggregate used in block manufacture must be free from impurities, it is customary to wash the aggregate previous to its transfer to the storage bin. Consequently, a substantial volume of water must be dealt with at all times.

With lightweight aggregates it is advisable to have at least 50 percent or more of the total mixing water present before mixing. Under these circumstances when the temperature drops below 32 degrees F. conditions may arise which will cause trouble unless the aggregate is thawed out. By maintaining the bin contents at a temperature above 32 degrees F. a more even flow of material is assured.

The customary method of thawing aggregate is done by injecting live steam through the material by means of a pipe connected to the steam supply. The operation is conducted from the top of the bin where the pipe is inserted at various points into the aggregate. This is a time-consuming and wasteful practice, since considerable heat is lost before it can warm the aggregate. The reason for this condition is that a considerable volume of the injected steam is used to warm the air in the interstices of the aggregate from which it rises by convection before it can even assist in heating the surfaces of the material it passes. Also wet aggregate permits heat to pass through more freely than when the aggregate is dry. Steam heats the aggregate at the point of contact, but to heat the entire contents of the bin takes time because of the resistance of the drier aggregate to the flow of heat and the speed at which the aggregate is used.

The addition of large quantities of water caused by the condensation of steam makes it difficult to determine the exact water content of the aggregate. Besides, there is no assurance that the water will be evenly distributed through the entire mass of aggregate.

A closed steam coil system in which the steam is passed through suitable sized pipe arranged in the form of coils is sometimes used. This system is advantageous where high pressure steam is the source of heat, since it tends to bring about a more even moisture content in the aggregate. A comparison of the degree of heating efficiency between high pressure steam at 125 psi and a temperature of approximately 340 degrees F. and low pressure steam with a temperature of 212 to 220 degrees F. is readily apparent. Whatever method is used the aggregate should not be heated to a higher temperature than about 125 deg. F.

The objectionable feature to this system of drying is, that in order to provide the necessary heating surface to maintain a flow of unfrozen aggregate in proportion to the volume of aggregate required to maintain the production rate may result in considerable decrease in the capacity of the bin. Also the coils may tend to impair the flow of material.

The following method as outlined in Figure 8 is presented as a guide in outlining the basic features of a system which has proved successful.

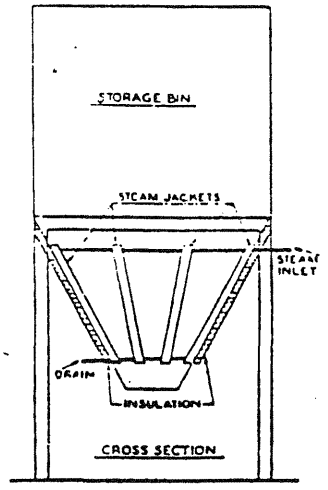

Figure 8. Heating Aggregate in Bin.

Various mediums of heat transfer may be used depending on the source of heat available. On no account should high pressure steam be used, nor should high pressure be allowed to build up within the jackets.

The jackets are fabricated from steel plate of requisite thickness depending on the pressure which may be encountered. The plate sections are welded at the seams and are set in such position as to offer the minimum resistance to the flow of material. Steam jackets may also be fitted to the sides of the bin and the whole system inter-connected by pipe.

Sections of pipe of 1½ inch diameter are placed inside similar sections of 2 inch diameter pipe, which serve as protection for connecting the horizontal steam lines.

Whatever heat escapes or is transferred from the system to the surrounding aggregate must go entirely through the material and the heat lost is that which flows to the surrounding atmosphere from the outside of the bin. If the loss of heat appears substantial, it may be retarded by applying layers of low cost insulating board to the outside of the bin.

The bin capacity and the daily volume of material required will govern the heat requirements, since the transfer of heat varies with the material and the temperature difference.

The temperature rise is considered as the degrees necessary to raise the temperature of the stored material to a condition above freezing. If the outside temperature is zero degrees F. a 40 degrees F. rise is necessary to bring the aggregate above freezing. If the outside temperature is 32 degrees F. a temperature rise of 5 degrees F. may be sufficient.

The amount of heat necessary to thaw the aggregate is a function of the specific heat of the aggregate used, the amount of entrained moisture, the percent of moisture present as a solid and liquid, the temperature rise desired and the volume of aggregate flow.

When material is withdrawn its place is taken by aggregate which has been at the top of the bin. This aggregate is warm and upon coming in contact with the heat transfer surfaces continues to take on heat gradually until time of its discharge.

As the aggregate approaches the discharge gate, the intensity of the heat and its shorter distance to travel insures its suitability for all practical purposes.

General practice is such that the capacity of the bin is equal to at least a normal 4 hours production. It is possible to fill the bin at night and have dry aggregate ready for use in the morning.

Considering the difficulties attendant upon the design and layout of a heating system of piping and steam plant, it is advisable to have a competent consultant, familiar with the thermodynamics of heat transfer conduct a survey of the requirements necessary.

## Section 5–Testing of Concrete Aggregates

Sampling Aggregate–Irrespective of how carefully a test is conducted, it will have failed to serve its purpose unless the test is made on a sample which is truly representative of the entire supply. Samples may be taken from stockpiles, from conveyor belts or chutes, or from railroad cars. The method of taking samples varies somewhat in each of these cases.

Samples from Stockpiles–The amount of the material selected from the stockpile should weigh from 2 to 3 kilograms (4.4 to 6.6 lb.). Stockpile samples of sand should be taken while the material is damp, since, in this condition, the possibility of segregation is reduced.

Sampling Methods*–The tube sampler consists of a steel pipe about 2 in. in diameter and 6 ft. long, pointed at one end and having a handle at the other. A series of openings is punched along the pipe in such a manner that a line of "ears" projects from one side of the openings. The tube is forced into the aggregate as far as possible, turned until the ears have scooped enough material into the tube for a sample. The tube is then withdrawn, keeping the openings on top.

Sand is easily sampled by means of a sampling tube driven into the pile at different points, from top to bottom. When samples are taken for moisture determination, it is well to bear in mind that material taken from the bottom of the pile is likely to contain more water than one taken from the top.

When sampling coarse aggregate, the surface material should be scraped off to a depth of several inches at the selected points around the pile. By holding a short piece of board against the pile just above the point of sampling, the inclusion of unwanted surface material may be avoided. Care must be exercised to avoid taking segregated material.

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*Concrete Manual, Bureau of Reclamation

Samples from Belts or Chutes–To obtain the most representative sample of aggregate from a belt or chute, a complete cross-section of the stream should be taken over short periods of time, rather than just a portion of the stream over a longer period. Portions of the material should be taken at regular intervals until the whole supply has been sampled. The number and size of the samples will depend on the quantity and uniformity of the aggregate.

Samples from Railroad Cars–Selection of a representative sample from a railroad car requires careful manipulation on the part of the sampler. Surface samples may be taken from a number of selected points. The size of the total sample depends on the capacity of the car.

The sampler, starting at one corner of the car, proceeds in a criss-cross fashion over the surface of the aggregate. At the selected points, the sampler digs down well under the surface and selects a sufficient amount of material. Accumulations resulting from repetitions of this operation are mixed and prepared for the requisite tests.

Samples may also be taken while cars are being unloaded. Whether cars are unloaded manually or mechanically, representative shovelsful may be taken at regular intervals.

Preparing Samples for Test–Sand samples may be reduced for test either by (1) quartering or by (2) riffle-type splitter methods.

1. When using the quartering method, the sample should be thoroughly mixed on a flat surface and then brought into a conical pile. The pile is then flattened out into a layer 3 or 4 in. deep by drawing the material outward from the center. The pile is then cut roughly into four pie-shaped sections by a shovel or trowel. Two opposite quarters are discarded after carefully including all the fines and dust with each quarter. The remaining quarters are again thoroughly mixed, coned, and treated as before. This time the pair of opposite

quarters is discarded. The principle of selecting opposite quarters alternately is to compensate for any unequal distribution of the particles. When the sample is sufficiently reduced in size and dried, tests are conducted for the respective determinations required.

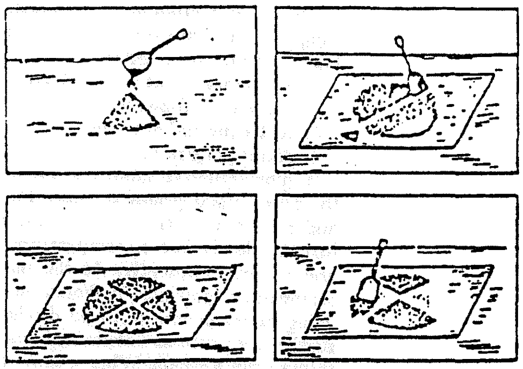

Fig. 9–Quartering Method of Preparing Sample

2. When employing the riffle-type sample splitter, a special device is used. This consists of a hopper with the bottom perforated in longitudinal sections which deliver material into two receiving pans through chutes alternately faced in opposite directions. The sample introduced into the hopper is delivered in two equal portions, each part receiving an approximately equal fraction of the material from all points of the hopper area. The entire sample is passed through the splitter, one-half is set aside, and the other half is split again. The procedure is repeated until the sample is reduced to the desired size.

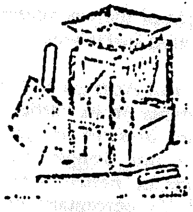

Fig. 10–Details of riffle sampler for preparing aggregate samples for test.

Gravel aggregate for block manufacture may be sampled and prepared as outlined in the quartering method.

Moisture in Aggregate–The moisture content of an aggregate is very important. Most aggregates used in block plant practice may contain moisture in one or both of two forms, namely, surface moisture and/or absorbed moisture.

The amount of moisture varies with atmospheric conditions, the method of production, and the length of time the aggregate has been in transit or in storage.

Surface moisture may be defined as the moisture which adheres to the outside of the particles.

Absorbed moisture is the moisture contained within the solid portion of the material itself and cannot be detected by the naked eye.

In the case of sand, tests show that the surface moisture content may range from one to 8 per cent. This free or surface water dilutes the cement-water paste and allowance should, therefore, be made for it in determining the total water required in the mix. This surface moisture also creates a bulking problem which must be considered in the design of the mix.

In heavy aggregates the small amount of absorbed moisture is rarely more than one or two per cent, and need not be considered in the design of the mix. However, in the case of cinders, processed slag, burned clay, or other porous aggregates, the absorbed moisture may be as much as 15 per cent or over.

Thoroughly dry porous aggregate having a strong affinity for water will absorb the cement-water paste into the pores where its cementing qualities will not be available in producing strength. Such aggregates should be wetted before being processed.

Since it is difficult to determine the surface moisture of porous aggregates, it is advisable to ascertain the total moisture content and include this amount of water in the total quantity of water required in the mix.

Hot plate and oven drying are among the several methods which may be used for the determination of moisture content.

Hot Plate Method—For all practical purposes, satisfactory results are obtained by the hot-plate method. The apparatus required is:

1. A balance sensitive to 1/2 gram or less.
2. A small, shallow, pan.
3. A stirring rod or spoon.
4. A hot plate or stove.

A representative sample of the aggregate (500 grams for sand; 1,000 grams or more for gravel) is weighed and spread in a thin layer in the pan. The sample is heated slowly (at a temperature not over 220° F.) and stirred frequently. As the material approaches a surface-dry condition, it should be stirred continuously, using extreme care to avoid driving off more than the surface moisture as determined when the sand will flow freely from a spoon. When a saturated, surface-dry condition is obtained, the sample is allowed to cool to room temperature, after which it is weighed. The amount of surface moisture is computed by the formula:

$$\text{Surface moisture, \%} = \frac{(A-B)\,100}{B} \text{ in which}$$

*A* is the weight of the wet aggregate tested and
*B* is the saturated surface-dry weight of the aggregate tested.

Sieve Analysis of Aggregate—The value of an aggregate, with reference to its particle size, may be determined by means of sieve analysis. This analysis consists of sifting a dry, weighed sample of the material through a series of nested sieves. From the results, recorded either in percentage by weight retained or passed by the individual screens, much information may be derived relative to the aggregate before it is processed.

Experiments have shown that the densest mixture is obtained with particles of graded sizes, also that the least density occurs when grains are all of similar size. A coarse sand has less total grain surface in a unit of volume than a fine sand, even when the sands contain the same proportions of solid material and voids. Coarse sands or fine sands alone are inferior to graded sands for block manufacture. Of the two extremes, however, the coarse sand is preferable because its particles are more readily coated with cement paste. Fine sand calls for more cement and water in the mix to produce a strength equivalent to that resulting from the use of a properly graded aggregate.

The ideal aggregate is one which contains as much coarse material, short of producing harshness in the mix, as will produce acceptable compressive strength and surface texture. The foregoing conditions are controlled by the use of standard mesh sieves in which the opening in each sieve is twice the size of the succeeding one. For an explanation of this refer to Table VII.

TABLE VII—SIEVES USED FOR SCREENING AGGREGATE FOR CONCRETE BLOCK

| Approximate Size Each Opening, Inches | Openings per Linear Inch | SIZE NUMBER Bureau of Standards | Tyler Standard* |
|---|---|---|---|
| 0.371 | 2-2/3 | 3/8" | 3/8" |
| 0.185 | 4 | #4 | #4 |
| 0.093 | 8 | #8 | #8 |
| 0.046 | 16 | #16 | #14 |
| 0.0232 | 30 | #30 | #28 |
| 0.0116 | 50 | #50 | #48 |
| 0.0058 | 100 | #100 | #100 |

*Catalogue #53

The sieves are arranged in one nest, the coarsest opening at the top, followed in sequence by the others. A tight pan is fitted to the bottom of the lowest sieve and a cover on the top of the highest sieve.

Several samples should be prepared for check tests if necessary. The samples contained in suitable sized pans are subjected to a temperature of approximately 220 deg. F. in order to drive off the surface moisture.

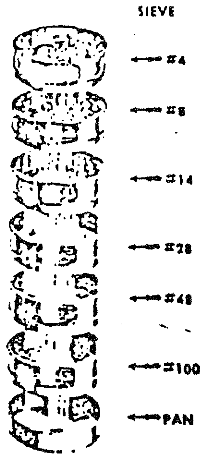

Figure 11—Arrangement of sieves for screening aggregate for concrete block.

A weight of 1,000 grams (2.20 lb.) of dried sample is placed in the top sieve. The whole nest of sieves is then given a preliminary shaking for two or three minutes. After shaking, each sieve, commencing with the coarsest, is shaken separately to complete the separation. Material passing any individual screen is transferred to the next smaller sized screen.

The time required for shaking the sieves will vary with the fineness of the sieve and the character of the material to be sieved. Where tests are made for the purpose of comparison, a standard procedure should be adopted which will include the weight of the samples, the condition as to the state of dryness, the method of shaking the sieves and the time required to make the test. More consistent results may be obtained by the use of a mechanical shaker, which also is advantageous as a time and labor saver.

Method of Screening—The method of screening, based on ASTM Designation C 136-46, will serve as a guide to procedures.

The screens are shaken by means of a lateral and vertical motion, accompanied by a jarring action so as to keep the sample moving continuously. In no case should fragments in the sample be turned or manipulated through the sieve by the hand. Sieving is continued until not more than one per cent by weight of the residue passes any sieve during one minute.

The weight of material from each screen should be determined on a scale or balance with a capacity of two (2) kilograms, and sensitive to within 0.1 per cent of the weight of the sample being tested.

The weighing is to be cumulative, starting with the material retained on the No. 3/8-in. sieve and continuing in order of decreasing screen size until the material in the pan has been weighed. The weighing is to be made to the nearest gram. To prevent spilling, the material on each screen should be poured into an auxiliary pan of sufficient size (or onto a paper) and then transferred to the balance pan.

Component Weights—The weighing operation is conducted in the following manner: Any material remaining on the 3/8 in. sieve is weighed and the weight recorded. To any material on the scale pan, add that retained on the No. 4 sieve and record the cumulative weight of both portions. The No. 8 sieve material is added to the pan content and the cumulative total weight of all three portions is recorded. The process is repeated in like manner with the other sieves, and the cumulative weights recorded in each instance.

Computation of Results—I. The cumulative per cent retained is derived from the cumulative weights transposed to percentage. II. The percentage of each size retained is the difference between the cumulative per cent retained on that sieve and the cumulative per cent of the preceding sieve. III. The per cent passing any particular sieve is the difference between the cumulative per cent of the material retained on that sieve and 100 per cent.

A typical example of sieve analysis is contained in Table VIII.

Definition of Fineness Modulus—The fineness modulus is an index number which is roughly proportional to the average size of the particles in a given aggregate; thus, the coarser the aggregate the higher the fineness

TABLE VIII—SIEVE ANALYSIS OF TYPICAL MATERIALS

Gravel

| Screen | Cumulative Grams | Cumulative % Retd | % Retd each size | % Passed |
|---|---|---|---|---|
| 3/8" | 0 | 0 | 0 | 100.0 |
| #4 | 362 | 36.2 | 36.2 | 63.8 |
| #8 | 915 | 91.5 | 55.3 | 8.5 |
| #14 | 985 | 98.5 | 7.0 | 1.5 |
| #28 | 1000 | 100.0 | 1.5 | |
| #48 | 1000 | 100 0 | | |
| #100 | 1000 | 100.0 | | |
| Pan | | | | |
| Fineness Modulus | | 5.26 | | |

Sharp Sand

| Screen | Cumulative Grams | Cumulative % Retd | % Retd each size | % Passed |
|---|---|---|---|---|
| 3/8" | 0 | 0 | 0 | 100.0 |
| #4 | 10 | 1.0 | 1.0 | 99.0 |
| #8 | 120 | 12.0 | 11.0 | 88.0 |
| #14 | 338 | 33.8 | 21.8 | 66.2 |
| #28 | 610 | 61.0 | 27.2 | 39.0 |
| #48 | 910 | 91.0 | 30.0 | 9.0 |
| #100 | 970 | 97.0 | 6.0 | 3.0 |
| Pan | | | 3.0 | |
| Fineness Modulus | | 2.96 | | |

Flat Sand

| Screen | Cumulative Grams | Cumulative % Retd | % Retd each size | % Passed |
|---|---|---|---|---|
| 3/8" | 0 | 0 | 0 | 100.0 |
| #4 | 3 | .3 | .3 | 99.7 |
| #8 | 6 | .6 | .3 | 99.4 |
| #14 | 15 | 1.5 | .9 | 98.5 |
| #28 | 100 | 10.0 | 8.5 | 90.0 |
| #48 | 435 | 43.5 | 33.5 | 56.5 |
| #100 | 930 | 93.0 | 49.5 | 7.0 |
| Pan | | | 7.0 | |
| Fineness Modulus | | 1.49 | | |

modulus will be.

Fineness modulus is computed by adding the cumulative percentages coarser than each of the following specific standard sieves: 3/8 in., 4, 8, 14, 28, 48 and 100 and dividing the sum by 100.

If 100 per cent is retained on any sieve, each succeeding sieve being smaller would necessarily retain 100 per cent of material. Hence, 100 per cent must be added for each of the smaller sieves used.

Although it does not distinguish between a single-size aggregate and a graded aggregate having the same average size, it is useful in connection with normally graded aggregate. It may be used for setting forth specifications, for record purposes, and for controlling grading and uniformity.

**Deleterious Materials**—In order that the cement may adhere to the grains of sand and particles of coarse aggregate, each grain or particle of material must be free from any coating which prevents a proper bond between the cement and the aggregates. Freedom from contamination of the aggregate, particularly the fine material, is very important. Sand in its natural state is more likely to contain an excess of impurity than the gravel.

(a) Clay and silt are the most frequent impurities in sand and gravel. These contaminations result from the decomposition of various types of natural rock.

A rough method of determining this impurity is to rub a small amount of the fine aggregate in the palm of the hand and note whether it causes a dark stain or spot. Such a stain indicates the presence of silt.

A more exact method is to take a quart fruit jar and add, to a depth of 2 in., a representative sample of the sand to be tested. Add water until the jar is 3/4 full. Screw on the cap and shake vigorously for one minute, the last few shakes to be made in such a manner as to level off the sand. Allow the jar and contents to stand for one hour, by which time the clay content will be deposited in a layer on top of the sand. The line of demarcation between the clay and the sand is clearly indicated by the difference in color and fineness. A clay layer of more than 1/8 in. in thickness indicates that the sand is unsatisfactory for use unless it is subjected to washing.

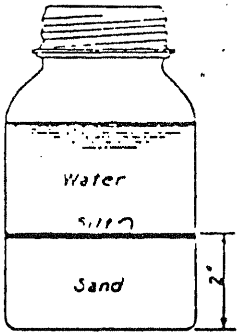

Figure 12—Determination of silt in sand.

In the decantation method, a representative sample slightly in excess of 500 grams (1.10 lb.) is transferred to a suitable sized baking pan (9 in. x 5 in. x 3 in.). The sample is then dried to constant weight at a temperature not over 220 deg. F.; after which the pan and contents are allowed to cool.

A sample of 500 grams of the dried sand is weighed and returned to the pan after it has been brushed out. Sufficient water is added to cover the sample which is agitated vigorously for 10 seconds, then allowed to settle for 15 seconds. The water and very fine material is gently decanted, care being taken not to pour off any sand. The operation is repeated till the wash water is clear.

The washed sample of sand is again dried to constant weight, cooled, transferred to the scale pan and weighed. The difference in weight between the original dry sample and the dry sample after washing is the amount of clay and silt. It is customary to express this quantity as a per cent by weight of the original dry sample. The maximum content of this impurity should be limited to 3 per cent.

$$\text{Percentage} = 100 \times \frac{\text{Original dry weight} - \text{dry weight after washing}}{\text{Original dry weight}}$$

(b) Organic matter is readily determined by a colorometric test. A very small amount of this impurity in the fine aggregate may greatly reduce the strength and soundness of the concrete units. It is therefore important to determine the presence of organic matter in the aggregate. Silt (earthy matter) is liable to contain organic matter, and fine aggregate with a higher content than 3 per cent of silt should not be used without first testing for organic matter.*

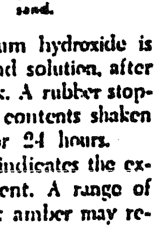

Figure 13—Determination of organic matter in sand.

In making the test, a 12-oz. glass prescription bottle is filled to the 4-1/2-oz. mark with the sand to be tested. A 3-per cent solution of sodium hydroxide is added until the volume of the sand and solution, after gentle agitation, reaches the 7-oz. mark. A rubber stopper is inserted in the bottle and the contents shaken vigorously, then allowed to stand for 24 hours.

The depth of color of the solution indicates the extent to which organic matter is present. A range of color from clear or colorless to a dark amber may result. Any solution darker than a straw color should be considered as a warning that the sand is unsatisfactory and should not be used until the organic matter is reduced. Sodium hydroxide solution is made by dissolving one ounce of caustic soda in a quart of distilled water. The solution is kept in a bottle with a tight

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*Based on ASTM C40-48.

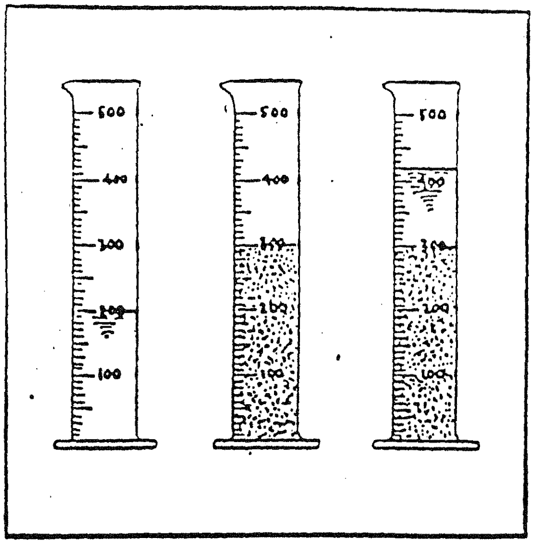

Figure 14—Determination of Voids

rubber stopper and should not be used if more than three months old. Caution must be used in handling this solution on account of its corrosive properties.

Determination of Voids in Aggregates—The percentage of voids in an aggregate may be determined as follows:

Fill a 500 cc cylindrical graduate as shown in Figure 14 to the 200 cc mark with water and another 500 cc cylinder to the 300 cc mark with the aggregate to be tested. Pour the 300 cc of aggregate slowly into the water. The combination of the 200 cc of water and the 300 cc of aggregate will give a mixture which is less than 500 cc in volume.

This volume subtracted from 500 cc is equivalent to the number of cc of voids in the original 300 cc of aggregate. The percentage of voids in the original aggregate is determined by the following formula.

$$\frac{500\text{ cc} - \text{cc volume of mixture}}{300\text{ cc}} \times 100 = \text{percent Voids}$$

This method applies to sand and pebble aggregates. Where lightweight aggregates are used this method of determining voids must be modified because of the varying specific gravities of the different sized particles. See A.S.T.M. Specification C30-37.

## Section 6—Grading and Proportioning Aggregate

Determination of Economical Mix—Experience demonstrates the fact that the densest concrete mix is obtained from aggregate containing well-graded particles, while least density results from aggregate in which the particles are of a uniform size.

For the development of strength in concrete block, the best mixture of coarse and fine aggregate should be so graded in particle size that the percentage of voids or hollow spaces in the finished unit is reduced to a minimum.

Since cement is the most expensive material contained in the concrete mix, its use merely as a void filler is expensive and wasteful. In order to eliminate such a condition and produce a strong concrete with a minimum of cement, it is necessary to use an aggregate in which the various sizes of the material are properly proportioned in order to fill all the interstices or voids in the mix.

The proportions of each of the various sized particles of the coarse and fine aggregate should be present in sufficient amount to fill the spaces between the particles of the next larger size. Thus satisfactory grading

is obtained which results in a concrete mix of such density that a minimum of voids is present. Then the function of the cement is simply to coat the particles adjacent to each other, resulting in the most economical mix producing maximum strength concrete with the least amount of cement.

A strong economical concrete cannot be produced from a mix containing an excess of fine material because the smaller the particles in a given volume of aggregate, the greater will be the surface area to be coated with cement paste, and consequently more cement will be required to bind the mass.

Thus by careful attention to the grading of the aggregate a concrete of equal or greater strength may be produced from a smaller amount of cement than one from a richer mix in which the aggregates are improperly graded.

Where lightweight aggregate is used it may be necessary to sacrifice some of the unit strength in order to obtain lighter weight and better textural, acoustical and insulating qualities. This is accomplished by reducing the density of the aggregate combination through a reduction of the percentage of fine material.

If an aggregate is poorly graded, it means that it either contains too much coarse material or an over abundance of fines. A coarse graded aggregate has less total particle surface per unit volume than a well-graded aggregate. Coarse material, while presenting less surface area, introduces bridging, which tends to lessen the resultant strength of the units. Units produced from aggregate containing an excessive amount of fines require more careful handling through all phases of operation to eliminate undue breakage because of the reduction of strength of the units.

It is advisable that the manufacturer install the necessary equipment to test thoroughly the aggregate for its suitability, remembering that aggregate received from different sources is likely to vary considerably. It may even pay a block manufacturer to use a more expensive, but better graded aggregate.

A record should be kept of the screen analyses of the aggregates received at the plant, and data pertaining to the mixes. From such information the operator will be in a position to readjust quickly his mix proportions as conditions demand.

Figure 15 outlines a form for recording the necessary data from which the most economical combination of materials may be determined. Changes to meet the individual needs may be introduced.

A systematic method of expressing the quantities used should be employed, if comparisons are to be made. It is usual to express the proportions as volumes of dry materials with cement as a basis. The amount of mixing water is generally expressed in gallons per 94 lb. sack of cement.

For regular production purposes proportions should be computed on a basis of dry material by weight. One advantage of weight proportioning is the ease of making proper allowance for the moisture content of the aggregate. However, whether measurement by weight or volume is used, it is important that operations are conducted with maximum accuracy.

Trial batches, produced under operating conditions, should be made on varying combinations of aggregate and cement. These will indicate to the producer what combination of materials is best suited to his requirements.

An outline of suggested ranges of trial mixes for various types of aggregates and their proportions in relationship of cement to total aggregate follows.

| Type of Aggregate | Range of Mixes |
|---|---|
| Gravel—Sand | 1-8 — 1-12 |
| Cinders | 1-6 — 1-8 |
| Clay (Expanded) | 1-6 — 1-9 |
| Limestone | 1-7 — 1-12 |
| Pumice | 1-4 — 1-6 |
| Slag (Expanded) | 1-5 — 1-7 |
| Slag (Air Cooled) | 1-8 — 1-12 |

PROCEDURE FOR DETERMINING ECONOMICAL COMBINATION OF MATERIALS

| BATCH NO. | AGGREGATES GRAVEL | AGGREGATES SHARP SAND | AGGREGATES FINE SAND | CEMENT | TOTAL BATCH COST | UNITS PER BATCH | UNITS PER SACK | UNIT COST | COMP. STR. P.S.I. | ABSORPTION % | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LBS. OR CU. FT. | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| 1 CU. FT. CEMENT = 94 LBS. | | | | | | | | | | | |

Fig. 15—Record for Economical Combination of Materials.

A direct method of test which reproduces actual conditions is always preferable to an indirect test based on assumptions which may be subject to variation. The result desired in proportioning concrete is a mixture of maximum density; the most direct means to this end is the testing of trial mixtures.

The appearance of the units as they come from the machine will give an indication of the suitability of the aggregate combination proportions. If the appearance of the surface and edges is satisfactory and the units can be handled easily and quickly without broken webs and corners the mixture is probably suitable.

With the coarse aggregate (pea gravel) graded from 1/4 to 3/8 in. and all fine aggregates passing the No. 4 sieve the maximum proportion of coarse material that can be advantageously used is about 50 per cent of the total aggregate used in the mix. Generally not more than 40 per cent of coarse aggregate gives the desired combination, while under certain conditions 25 per cent of coarse aggregate will produce a unit which has the greatest strength for a given amount of cement.

**Workability of Mix**—Workability may be defined as the ease with which a given variety of materials in certain proportions can be mixed into concrete and subsequently handled.

Its control depends upon the personal judgment of the mixer operator, since there is no generally recognized form of test for the determination of this characteristic. The principal factors affecting workability in block mixes are: (1) The cement factor; (2) Characteristics of the cement (portland cements vary in their water requirements and hence in their influence on workability) (3) Characteristics as regards surface and shape of the aggregate particles (4) Gradation of the aggregates (5) Consistency of the mix.

**Design of Concrete Block Mixes***— A vital problem in the concrete block industry today is the design and

control of the concrete mix. Many block manufacturers would realize a greater yield of block per sack of cement by the proper selection and proportioning of the various sized aggregates.

The fact that a particular grading range will produce a saleable product in one locality is no guarantee that it will do so in another locality. Variations in the manufacturing processes and the curing technique, will affect the density, absorptive, and textural qualities and ultimate strength.

The operator must generally utilize the aggregates at hand, rather than contend with the added expense of importing from a distance a specially graded material. Under these conditions the manufacturer can never reach the ideal gradation. He can, however, obtain the maximum results from the particular materials he must use by following certain fundamentals.

Theoretically, maximum density is the point to work to. That is a combination of particles which gives the most weight in a given volume.

Suppose 1 cu. ft. of coarse dry rodded aggregate (1/4 in. to 3/8 in. sieves) weighs 92.0 lb. A certain percentage of this volume is air due to the voids created by contact of the particles. The addition of a finer aggregate (No. 28 to 1/4 in. sieves) can be rodded into the 1 cu. ft. volume to fill the voids of the larger particles. The 1 cu. ft. volume is still retained, but the weight is now increased to 100 lb. The finer aggregate creates many more voids than the coarse material contained, but they are much smaller. The addition of a finer material (minus No. 100 to No. 28 sieves) rodded into the same volume will increase the unit weight still further, say to 105 lb. This procedure constitutes a complete test, using certain percentages of the three sizes of aggregate.

Tests should be repeated exhaustively using various percentages until a maximum weight is obtained.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| No. 1 | Percentage by weight—coarse material | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 |
| | Percentage by weight—medium material | 100 | 90 | 80 | 70 | 60 | 50 | 40 | 30 |
| | Unit weight of mixture "A" | | | | | | | | |
| No. 2 | Percentage by weight of Mixture "A" giving greatest weight | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 |
| | Percentage by weight fine material | 100 | 90 | 80 | 70 | 60 | 50 | 40 | 30 |
| | Unit weight of mixture "B" | | | | | | | | |

Plot the results of No. 2 with per cent of Mixture "A" as abscissa (horizontal line) and unit weight of Mixture "B" as ordinate (perpendicular line) and draw a representative curve through the plotted points as shown in Figure 16.

The percentage of Mixture "A" giving the highest weight will be readily apparent, and the shape of the curve will indicate whether the percentage is critical.

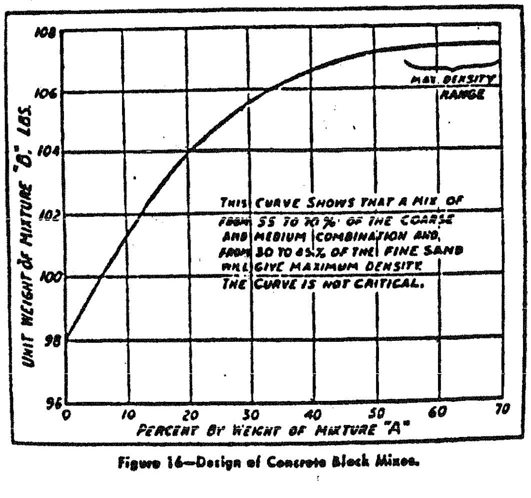

Figure 16—Design of Concrete Block Mixes.

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*Leo C. Jensen, Pit & Quarry, Feb. 1949.

**Influence of Grading of Aggregate on Strength of Concrete**—An extensive series of controlled laboratory experiments involving a suitable number of tests and mixes was made to determine (1) a good grading for general plant practice, (2) to ascertain the influence of fine sand additions on the various mixes, (3) to determine at what point the fine sand commenced to show weakening effect on the concrete.

Special attention was given to water additions, plasticity of mix, mixing time, thoroughness of mixing the materials, manner of filling the cylinder test molds and the length of time of vibration performed on a specially designed, syntron-controlled apparatus.*

Compression tests were made at 28 days after curing in water for 21 days and drying to constant weight. The testing machine was adjusted to a capacity of 30,000 lbs. After the compression tests the broken specimens were studied to determine by observation the effect of varying amounts of fine material in the mix.

The grading and fineness modulus of the aggregate used throughout the series is indicated in Table IX.

The amount of cement used was in the ratio of 1 part high early strength cement to 10.5 parts aggregate or the equivalent of 300 lbs. cement to 3150 lbs. mixed aggregate, as in plant practice.

In these experiments the coarse aggregate and sharp sand were kept in balance to each other with the fine sand content as the variable component of the mixes. The total amount of sand in each mix was increased by the addition of fine sand in increments of 50 parts or 5 per cent, while the gravel and sharp sand contents were decreased by 25 parts or 2.5 per cent each.

A study of Table X shows that the coarser mixes produce the greater strength concrete. However, since they also produce a range of rough textured concrete, it is necessary to have a certain amount of fine sand present to smooth out the texture.

TABLE IX—SCREEN ANALYSIS OF AGGREGATE—EXPERIMENTAL TESTS

**Gravel**

| Screen | Cumulative Grams | Cumulative % Retd | % Retd each size | % Passed |
|---|---|---|---|---|
| 3/8" | 10 | 1.0 | 1.0 | 99.0 |
| #4 | 700 | 70.0 | 69.0 | 30.0 |
| #8 | 950 | 95.0 | 25.0 | 5.0 |
| #14 | 982 | 98.2 | 3.2 | 1.8 |
| #28 | 995 | 99.5 | 1.3 | .5 |
| #48 | 998 | 99.8 | .3 | .2 |
| #100 | 1000 | 100.0 | .2 | 0 |
| Pan | | | | |
| Fineness Modulus | | 5.64 | | |

**Sharp Sand**

| Screen | Cumulative Grams | Cumulative % Retd | % Retd each size | % Passed |
|---|---|---|---|---|
| 3/8" | 0 | 0 | 0 | 100.0 |
| #4 | 10 | 1.0 | 1.0 | 99.0 |
| #8 | 120 | 12.0 | 11.0 | 88.0 |
| #14 | 338 | 33.8 | 21.8 | 66.2 |
| #28 | 610 | 61.0 | 27.2 | 39.0 |
| #48 | 910 | 91.0 | 30.0 | 9.0 |
| #100 | 970 | 97.0 | 6.0 | 3.0 |
| Pan | | | 3.0 | |
| Fineness Modulus | | 2.96 | | |

**Fine Sand**

| Screen | Cumulative Grams | Cumulative % Retd | % Retd each size | % Passed |
|---|---|---|---|---|
| 3/8" | 0 | 0 | 0 | 100.0 |
| #4 | 3 | .3 | .3 | 99.7 |
| #8 | 6 | .6 | .3 | 99.4 |
| #14 | 15 | 1.5 | .9 | 98.5 |
| #28 | 100 | 10.0 | 8.5 | 90.0 |
| #48 | 435 | 43.5 | 33.5 | 56.5 |
| #100 | 930 | 93.0 | 49.5 | 7.0 |
| Pan | | | 7.0 | |
| Fineness Modulus | | 1.49 | | |

TABLE X—EFFECT OF GRADING AND PROPORTIONING ON STRENGTH OF MOLDED CONCRETE

| Test # | Pea Gravel | Sharp Sand | Fine Sand | F.M. of Mixed Agg. | Pea Gravel | Sharp Sand | Fine Sand | Gals Water per 3150# Batch | Average (12 tests) P.S.I. |
|---|---|---|---|---|---|---|---|---|---|
| | Parts by Wt. Dry | | | | Agg. percent of Total | | | | |
| 1 | 500 | 500 | 0 | 4.30 | 50.00 | 50.00 | 0 | 26.4 | 3440 |
| 2 | 475 | 475 | 50 | 4.16 | 47.50 | 47.50 | 5.00 | 26.4 | 3395 |
| 3 | 450 | 450 | 100 | 4.02 | 45.00 | 45.00 | 10.00 | 26.4 | 3404 |
| 4 | 425 | 425 | 150 | 3.88 | 42.50 | 42.50 | 15.00 | 26.4 | 3462 |
| 5 | 400 | 400 | 200 | 3.74 | 40.00 | 40.00 | 20.00 | 28.3 | 3215 |
| 6 | 375 | 375 | 250 | 3.59 | 37.50 | 37.50 | 25.00 | 28.3 | 2654 |
| 7 | 350 | 350 | 300 | 3.44 | 35.00 | 35.00 | 30.00 | 28.3 | 2180 |
| 8 | 325 | 325 | 350 | 3.30 | 32.50 | 32.50 | 35.00 | 28.3 | 1858 |
| 9 | 300 | 300 | 400 | 3.16 | 30.00 | 30.00 | 40.00 | 30.3 | 1535 |
| 10 | 275 | 275 | 450 | 3.02 | 27.50 | 27.50 | 45.00 | 32.1 | 1398 |

Visual examination of the specimens after compression tests revealed these facts:

Test No. 1. Decidedly coarse textured concrete.

Tests Nos. 2 and 3. Good mixes, slightly finer in texture than Test No. 1.

Test No. 4. Very satisfactory in all respects. In several instances mixes of this type have been recommended for plant operation. The results obtained have been satisfactory as to texture and compressive strength of units.

Test No. 5, in which the mix proportions were 40 per cent gravel, 40 per cent sharp sand and 20 per cent fine sand, produced a good strength and marketable product. The increase of total sand content coupled with the additional fine sand causes the latter to show its presence in the concrete. If a "good" appearing block is desired, this mix would be satisfactory from strength and textural standpoints. A feature of Test No. 5 shows that this is the high limit of fine sand from which good compressive strength and texture can be obtained.

Tests Nos. 6-10. By the addition of more fine sand in increments of 50 parts or 5 per cent, with corresponding reductions of the other constituents of the mix up to a total of 45 per cent, a marked decrease in strength of the concrete is noted until at 45 per cent fine sand addition, the concrete showed a strength of only 1398 p.s.i. Thus, when too much fine sand is used, strengths are decreased considerably and cement is wasted. The difference in strength between Tests No. 9 and 5 is approximately 50 per cent.

While an exact 40-40-20 mix is not easily obtained in practice, approaching it as closely as practicable will improve the quality and strength of product.

The successive decrease shown in the compression strengths of the various mixes can be attributed entirely to the increasing use of fine sand. Therefore, the percentage of fine sand should be kept as low as possible. If used in excess it will lower the compressive strength of the units.

One point must be stressed, however, with reference to the grading of the mixed aggregate; that is, a certain amount of fine material (approximately 5 per cent passing the No. 100 sieve and 15 per cent passing the No. 48 sieve) is needed.

From the results of the various tests as compiled in Table X, it would seem that by using three separate materials, such as course aggregate (pea gravel), coarse sand and fine sand, a combination of aggregates may be obtained which will give satisfactory strength concrete at a minimum cost.

It is interesting to compare the actual combined grading of Test No. 5 (3.73 F.M.) with a proposed theoretical grading (3.70 F.M.) as shown in Table XI in which 25 per cent of the aggregate remains on the No. 4 sieve and 15 per cent remains on the next four sizes of sieves. There would be 85 per cent on the No. 48 sieve and on the No. 100 sieve there would be 95 per cent of the aggregate with 5 per cent through the No. 100 sieve.

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*Detailed in "Concrete" Dec. 1950, Page 30.

TABLE XI—ACTUAL COMBINED AND THEORETICAL GRADING OF AGGREGATES

| | Actual Combined Grading Test No. 5 | | | Proposed Theoretical Grading | | |
|---|---|---|---|---|---|---|
| Sieve Sizes | Cumulative percent | % Retained each sieve | % Passing | Cumulative percent | % Retained each sieve | % Passing |
| # 4 | 28.5 | 28.5 | 71.5 | 25.0 | 25.0 | 75.0 |
| # 8 | 42.9 | 14.4 | 57.1 | 40.0 | 15.0 | 60.0 |
| # 14 | 53.0 | 10.1 | 47.0 | 55.0 | 15.0 | 45.0 |
| # 28 | 66.2 | 13.2 | 33.8 | 70.0 | 15.0 | 30.0 |
| # 48 | 85.0 | 18.8 | 15.0 | 85.0 | 15.0 | 15.0 |
| #100 | 97.4 | 12.4 | 2.6 | 95.0 | 10.0 | 5.0 |
| F.M. | 3.73 | | | 3.70 | | |

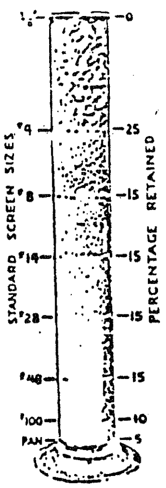
The theoretical grading of 3.70 F.M. is based on tests made by A.C.I. Committee 710, and reported in A.C.I. Journal (1936).

Figure 17 shows the percentages of aggregate retained on the separate sieves as outlined in the Proposed Theoretical Grading Table XI.

Experience has demonstrated that a very fine or very coarse sand or aggregate, having either a large deficiency or excess of any size is generally undesirable and that aggregate having a smooth grading will produce more satisfactory concrete.

In order to compare the compressive strength of Test No. 5 concrete with specimens made from a mix as outlined under theoretical grading, a series of cylinder tests was conducted in which all conditions of mixing and molding closely approximated those of the experimental series.

The average compressive strength results follow:



FINENESS MODULUS

Figure 17—Percentages of aggregate retained on each sieve.

| | Theoretical Grading | Test No. 5 |
|---|---|---|
| Average of 12 Specimens | 3488 psi | 3215 psi |

**Requirements for Aggregates**—From these experiments come two conclusions:

1. A range of fineness modulus from 2.50 to 2.90 for the mixed sands may be successfully processed in conjunction with coarse aggregate ranging from 5.00 to 5.50 fineness modulus.

2. For the combined aggregate, a range of 3.50 to 3.70 fineness modulus is recommended. Some manufacturers have found it more economical, however, to use a combined aggregate ranging from 3.70 to 4.00 fineness modulus.

The problem confronting the individual manufacturer is to produce a uniform product from the local aggregate at the lowest operating cost. This factor may be solved by careful study of the aggregates and testing units from trial batches made under plant conditions.

**Proportioning Aggregate**—The method of proportioning aggregate in concrete block is determined by choice or necessity. It may be done either by volume or by weight. In all cases, however, the effect of moisture in the materials must be taken into consideration.

In proportioning by volume, it is an established fact that serious error may be introduced into the measurement of the aggregates if the bulking of the materials is disregarded. For coarse aggregate, this factor is negligible, but for sand or other fine material it becomes an important consideration.

**Effect of Grading on Yield Per Sack of Cement**—These data, resulting from several series of tests made under actual plant practice are presented to show how uniformity of strength and other qualities of masonry units may be produced from well-graded and well-proportioned aggregates.

These data also show the comparison in yield per sack of cement when using regular and high early

strength cements. These results must not be taken as representative of such cements in all parts of the country because of the variation in characteristics of cements.

Another factor which must be considered is the variation in strength of units manufactured at different seasons of the year. Tests have shown that wide variations are obtained even with the same aggregates and cement, primarily due to differences in temperature during the manufacturing and curing periods.

Care was given to the weighing of the separate aggregates, the determination of the amount of surface moisture, the volume and quality of the mixing water (which was metered) and the mixing time, together with carefully controlled curing conditions.

The 8 inch, 3-core modular units with 1 inch thick face shells and 1-1/4 inch center webs weighed 38 lb. The relative advantages of regular and high early strength cements were compared. It was found that strengths resulting from the use of 400 lb. regular cement could be achieved with 305 lb. high early strength cement.

The cost of 305 lb. high early strength cement in this particular area (Detroit) was slightly less than the cost of 400 lb. regular cement. In addition to the savings in direct cost there was also a saving in that less cement is handled when using high early strength cement than when regular cement is used.

Figuring the yield per sack of cement in the tests under consideration it was found that approximately 30 block were obtained per sack of regular cement and 40 block per sack of high early strength cement.

These yields may seem much higher than is obtained in the majority of plants. Comparisons by the same plant management with results obtained in former years where control of grading and curing was not possible, prove that the yields obtained were due primarily to more accurate control of the grading and also of the curing.

It must be pointed out also, that the mixing time used in the series of tests is a total of 8 minutes and that the maximum steaming temperature was 160 deg. F. The compressive strength of the block obtained averaged slightly more than 1000 psi at 7 days. It should be noted that the strength of units made during winter months was lower than that obtained in summer under similar plant conditions.

The mix proportions were:

2510 lbs. Pea Gravel
1710 lbs. Sharp Sand
805 lbs. Fine Sand

The mix was designed to give a fineness modulus as close to 3.70 as possible but not exceeding 4.00. A mix of this grading will produce the maximum number of marketable block having the required strength for a given amount and type of cement.

Since the quantity of sand, like other materials in the concrete, is either proportioned by volume or by weight, the amount of water in the sand becomes an important factor. A moist sand containing 5 per cent of water will occupy about 25 to 30 per cent more volume than the same sand when air dry. When air dry, the grains of sand pack closely together. Conversely, when the sand is damp, the droplets of water between the grains push the grains of sand apart. This condition causes bulking of the sand.

**Effect of Moisture on Sand**—Moisture exerts a considerable effect on the per cent of voids in sand. When water surrounds a grain of sand it occupies space and separates this grain from the grains adjacent to it. Since fine sand has a larger number of grains for a specific volume it is more affected than a coarse sand. If water is added to dry sand and the resultant mass is moved, the mixture will be found to increase considerably in volume and weigh less per cu. ft. A maximum volume will be obtained with the addition of from approximately 5 to 7.50 per cent by weight. Larger percentages of water will give a decrease in volume until at the point where the sand is thoroughly inundated it will have a volume slightly less than the original volume.

Bulking of sand is particularly important when volumetric measurement of aggregate is used. Unless this factor is given strict attention, unsatisfactory results will be produced. Besides more cement than needed will be used in the mix.

Bulking values vary depending upon the grading of the sand, the percentage of free moisture and the method of determination. Greater bulking occurs with fine sand than with coarse sand. Consequently large changes in the voids in the sand occur with bulking. These conditions are shown in the accompanying Figure 18.

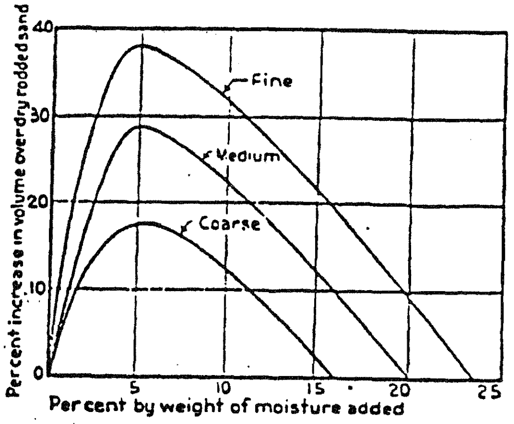


**Figure 18—Effects of Moisture on Sand.***

When damp sand with a 25 per cent bulking factor is used, a compensation must be made by increasing the volume of the sand compartment 25 per cent. This volume of damp material if dried would be equivalent to the volume of dry sand as established in the designed mix. Similarly, when proportioning is done by weight, the moisture content of the material must be considered and be compensated for.

Since the percentage of moisture in the sand fluctuates from day to day and sometimes from load to load, it is difficult, without an actual test, to determine the amount of dry sand in a specific quantity of wet sand. The variation in the water content of the sand may be caused by the prevalence or absence of rains. The sand at the base of the stockpile is likely to contain more water than that at the top.

The following table shows what volume change takes place due to variation in water content in sands. Because of this volume change, corrections must be made in the proportionate amounts of pea gravel, coarse and fine sand in a concrete mix to be sure that the solid volumes of each aggregate are the same for each batch.

A study of the table shows that the actual solid amount of sand in a cubic foot containing 5 to 7.5 per cent of moisture is only 80 per cent of the actual amount of a sand containing 1 per cent moisture.

**Range of Moisture Content in Sand**—Sand may be in four states as shown in Figure 19.

1. Oven dry—no moisture on the surface or in the interior of the particles.
2. Air dry—dry at the surface but containing some interior moisture, less than the amount required to saturate the particles.
3. Saturated and surface dry—dry at the surface but wet in the inside.
4. Damp or wet—wet on the surface as well as wet in the inside.

**Control of Materials**—After the materials have been selected and their relative proportions determined

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*Design and Control of Concrete Mixes—P.C.A.

TABLE XII—EFFECT OF MOISTURE ON SANDS*

Medium Sand 0—#8
Fineness Modulus 2.30

| | Dry Rodded | Dry Loose | Loose | Loose | Loose | Loose | Loose | Loose | Inundated |
|---|---|---|---|---|---|---|---|---|---|
| % Water by Weight | 0 | 0 | 1 | 2.5 | 5 | 7.5 | 10 | 15 | 20 |
| % Bulking | 0 | 5.8 | 15.2 | 34.5 | 43.3 | 41.0 | 35.6 | 24.6 | 2.3 |
| % Loss per cu. ft. | 0 | 5.5 | 13.2 | 25.6 | 30.2 | 29.0 | 27.7 | 19.7 | 2.2 |
| Wt. per cu. ft. including water | 108.0# | 102.0# | 94.5# | 82.4# | 79.3# | 82.4# | 85.8# | 99.5# | 127.0# |
| Wt. dry sand in 1 cu. ft. | 108.0# | 102.0# | 93.6# | 80.4# | 75.5# | 76.6# | 78.0# | 86.6# | 106.0# |

*from Blaw-Knox Inundation System

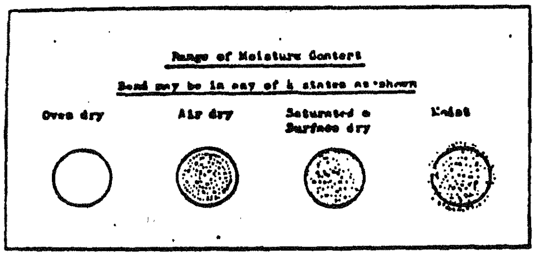

**Figure 19—Range of Moisture Content in Sand.***

their use should be carefully controlled. Much of the potential value of well-graded materials and good proportioning is frequently lost through inefficient batching.

**Proportioning Aggregate by Volume**—This system, while not considered as up to date as the weighing method, is still extensively used. It is capable of producing good results provided certain fundamental principles are given attention.

The aggregate proportions of 60 per cent coarse aggregate and 40 per cent mixed sands as used in the following example are taken from actual plant practice. While the block is of a slightly coarser texture than usual, it is favored to quite an extent by the building industry.

The coarse aggregate has a fineness modulus of 5.26, while that of the mixed sands shows a 2.50 FM. The compressive strengths on 8 inch units ranges from 1,200 to 1,400 psi, using 2 sacks high early strength cement per batch of 15.83 cu. ft. of coarse aggregate and 13.20 cu. ft. of mixed sands.

The Batcher—Figure 20 shows various batcher dimensions and is selected with a view to clarifying the fundamentals as mentioned. It will be noted that a

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*Adapted from ACI Manual of Concrete Inspection.

reserve section is shown at the extreme left. This has been done in order to illustrate a factor to be presented later. The dividing plates should be arranged so as to allow their being moved toward either end of the batcher. This permits changes being made in the volume of the compartments to accommodate any desired combination of the aggregate.

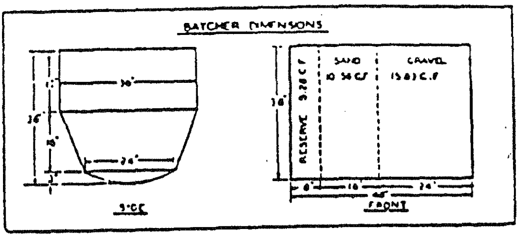

Figure 20—Batcher Dimensions.

A method of calculating the cubical content of the batcher, cross-sectional area follows:

1. Top section—36 in. wide x 17 in. high .................... equals 612 sq. in.
2. Middle section—36 in. top width plus 24 in. bottom width equals 60 in. divided by 2 equals 30 in. average width then 30 in. avg. width times 16 in., the height ............ equals 480 sq. in.
3. Arc section—⅔ x 24 in. x 3 in. 48 sq. in.

   Total cross section: 1.140 sq. in.
4. 1,140 sq. in. x 48 in. (length). equals 54,720 cu. in. 54,720 divided by 1,728 cu. in. (1 cu. ft.) .......... equals 31.66 cu. ft.

   Total capacity of batcher is, then, 31.66 cu. ft.

The coarse aggregate compartment occupying a length of 24 in. or 1/2 the length of the entire batcher will have a capacity of 1/2 the total capacity of the batcher, or 31.66 divided by 2 equals 15.83 cu. ft.

Similarly, the mixed sand compartment, having a length of 16 in. or 1/3 the length of the entire batcher, will have a capacity of 1/3 the total capacity of the batcher or 31.66 divided by 3 equals 10.56 cu. ft.

The reserve space, 8 in. long, will have a capacity of 31.66 divided by 6 or 5.28 cu. ft.

The effect of moisture and bulking having been discussed, the problem then is to apply these principles to this case. In plant practice, the sand is more or less wet at all times. Incidentally, the bulking factor will vary. For example, assume the damp sand has a bulking factor of 25 per cent. Since the coarse aggregate does not bulk to any appreciable extent due to surface moisture, consider it as dry material. This leaves only the bulking of the sand to be considered.

Since the bulking factor is taken as 25 per cent or one-fourth more in volume for damp sand, it follows that one-fourth more volume of bulked sand must be added to give the equivalent volume of dry sand. Therefore, one-fourth of 10.56 cu. ft. or 2.64 cu. ft. is the extra volume of sand measured in a damp bulked condition necessary to produce the equivalent volume of dry sand.

As the length of the mixed sand compartment was originally 16 in. the length must be increased 25 per cent of 16 in., or 4 in. thus changing the length to

20 in. This increase in total length to 20 in. changes the volume of the compartment from 10.56 cu. ft. to 13.20 cu. ft.

The length of the reserve compartment is consequently reduced by 4 inches.

The adjustments of the batcher are shown in Figure 21.

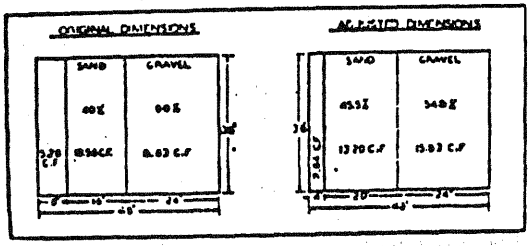

Figure 21—Adjustment of Batcher Dimensions.

In most plants the batcher is operated at its full holding capacity and, therefore, does not allow for any reserve space. Under these circumstances, an alternate course may be taken to accommodate the extra volume of damp sand required.

This consists of welding the necessary height of container onto the sand compartment.

Increasing the height of the sand compartment 9 in. will accommodate the 2.64 cu. ft. of sand required for adjustment.

The mix which was originally based on a 60 per cent coarse aggregate to 40 per cent (dry) sand has been changed in its proportions. It now becomes a 54.5 per cent coarse aggregate to 45.5 per cent (damp) sand combination. The relationship between this combination and the original mix are exactly the same as regards volume content of dry materials. The volume of cement used is still 2 cu. ft. (188 lb.) from which the operator is deriving these benefits:

1. Under this adjusted scheme of proportioning of the aggregates, the original designed mix is maintained. Hence, less cement is used in proportion to the actual amount of damp aggregate than in the case where the bulking factor is not considered.
2. If the bulking of the sand is not taken into consideration, there would be an excess of coarse aggregate in the mix, which would produce too coarse a texture. The extra amount of cement in relation to the combined aggregate would give a greater strength, but strength which is not needed.
3. With the addition of 2.64 cu. ft. of damp sand, the texture of the units would be smoothed out to the approximate texture obtained in the original designed mix of dry materials. The strength would be reduced slightly, but still remain high enough to meet requirements.
4. The greatest advantage to be gained by the adjustment in the proportioning would be the production of more units, approximately four 8-in. units more per batcherful of aggregate. It would seem then that such increased production, at small extra cost, would be desirable.

These advantages, however, are predicated on the fact that well-graded aggregates are being processed, coupled with proper curing of the units.

If a producer is satisfied with the blend of aggregate he is using but wants greater yield of block from the volume of cement used, he may maintain his coarse aggregate and combined sand in the same proportions, but increase the total amount of aggregate to the volume of cement used, by adjusting the capacity of both compartments.

Where a blend of mixed aggregate is used, the volume of aggregate should be increased gradually by making trial mixes and testing the units so produced until the minimum strength requirement decided upon is obtained.

**Proportioning Aggregate by Weight**—In plants where proportioning is done by weighing the separate materials, the operational problems are greatly minimized. Where conservation of cement and maximum production of units are desired, it is essential that moisture tests be run on the separate aggregates.

Likewise, the success of operations is predicated upon the use of well-graded and well-proportioned aggregates.

Since wet sand contains more water than wet coarse aggregate and when fixed weights of cement and wet sand and coarse aggregate are being used, a change from dry sand to wet sand will result in a lower percentage of sand grains in the concrete mix. The change in the coarse aggregate will not be affected to any appreciable extent. This change may be brought about suddenly by a heavy rain, in which case an undersanded, harsh mix, containing too much coarse aggregate may result. If the sand is wet, the weighed batch will be short by the weight of the water included. Since the weight of cement does not change, the batch will be richer, that is the weight of cement per batch will be greater than required.

A regular plant mix based on the use of dry materials consisting of 1,750 lb. of coarse aggregate to 1,250 lb. of mixed sands, and 300 lb. of cement, shows a ratio of one part cement to 10 parts aggregate by weight.

The term "dry material" refers to aggregate in a moisture-free or oven dried condition. It is not expected, of course, that aggregates in this ideal condition would actually occur in the batch, but it serves nicely as a basis for correcting weight of material due to varying moisture contents.

For example, it is assumed that the coarse aggregate has 2 per cent surface water while the mixed sand has 6 per cent of surface water. It is evident that if the weights of the original charge were used there would be a shortage of aggregate for a specific amount of cement. Corrections are as follows:

|  | Original Dry Weights — Lb. |  | Moisture Factor |  | Corrected Weights for Damp Materials — Lb. |
|---|---|---|---|---|---|
| Coarse Aggregate | 1,750 | × | 1.02 | = | 1,785 |
| Mixed Sands | 1,250 | × | 1.06 | = | 1,325 |
| Total Weight | 3,000 |  |  |  | 3,110 |
| Cement | 300 |  |  |  | 300 |

In figuring the amount of water necessary for a batch the surface water in the aggregate should be taken into consideration. This amount of surface water figured in gallons should be subtracted from the total number of gallons that would be used if surface dry aggregates were used.

From these batch figures it will be seen that if no consideration is given to the moisture in the aggregate, the charge of dry aggregate weighed in a damp condition is actually 110 lb. short on account of the surface moisture of the aggregate. This shortage is equivalent to a loss in yield of three block per 300 lb. of cement, or practically one block per sack of cement.

An important factor, which unfortunately, is too frequently overlooked, is the proper care of the weighing scale. Hopper scales, though ruggedly constructed, must be considered as a precision instrument. The normal working conditions under which a scale must operate are extremely bad. The volume of dust and high humidity content of the average plant atmosphere can in time cause conditions conducive to weighing errors. Reasonable care of the weighing mechanism can do much to overcome these naturally unfavorable conditions. The following factors are important: (1) Keep the scale on zero balance, (2) Scale should be set and kept level, (3) Scale should be kept clean and dry as possible, (4) Scale should be adjusted at periodic intervals by a qualified repairman, (5) Scale should not be overloaded or abused.

Remember the scale is an important factor in the profit and loss account. It should have reasonable care each day.

An item of block production which does not receive sufficient attention is in the manufacture of 8 in. and 12 in. units. Most operators decide on a definite mix and operate on this basis, regardless. The fact that 12 in. units enclose approximately 52 per cent more area, with the bearing area increased by approximately 25 to 30 per cent, introduces factors not met with in the production of 8 in. block.

In testing the compressive strength of a block the calculation is generally made on the gross area instead of the net area. Hence the unit strength of a 12 in. block is considerably less than that of an 8 in. block. The higher attendant handling loss and the fact that 12 in. units are subjected to greater loads in actual field construction would indicate the following course.

The producer should determine what strength of 12 in. units is most economical for his production requirements, keeping in mind code specifications. If any cement saving is to be made it should be done by adjusting the 8 in. block mix rather than at the expense of the 12 in. block mix. However, test samples should be taken from production runs to confirm these factors.

## Section 7—Admixtures to Concrete Mixes

The addition of various materials as admixtures for use in mass concrete has been employed with varying degrees of success for many years. Their addition does not entail any revolutionary practice in the use of portland cement, but are added primarily as a means of obtaining better concrete under average conditions of production.

The practice of using admixtures in concrete block mixes has been gaining momentum, and block manufacturers are confronted by problems in the selection of such materials because of claims such as greater plasticity in the mix, accelerated curing time, improved water resistance and greater strength.

A number of new chemical plasticizing and wetting agent preparations in solid and liquid forms are now on the market. Tests have shown that some of these preparations produce beneficial results but the benefits obtained can only be ascertained by actual plant experiment.

Where the use of admixtures or substitute materials is contemplated, they should be investigated individually to determine whether they are applicable to the particular aggregate used, and also whether they perform satisfactorily under individual plant conditions. It should not be assumed that the same admixture, used with different aggregate, curing conditions, and other manufacturing technique will perform exactly the same in all cases.

There seems to be difference of opinion among block manufacturers as to the merits of admixtures in general, and particularly in respect to different types and proprietary brands.

Research on the use of admixtures in block manufacture has been neglected, and the results given by admixture manufacturers in their advertising literature apply mostly to plastic concrete cured under normal conditions. For that reason it is doubtful if these results are applicable to the relatively dry mixes cured at high temperature.

From the results of an extended series of tests made under plant conditions on both solid and liquid admixtures, it was found in some cases that beneficial effects were obtained in concrete block mixes.

However, where only slightly greater compressive strengths were obtained over those of plain concrete, an equivalent increase in strength resulted from the addition of extra cement in place of the admixture at about the same cost.

It is a proven fact that often the benefits claimed for the use of admixtures for block concrete can be obtained by simply giving more attention to the grading and proportioning of the aggregate being used.

**FLY ASH**—The use of fly ash as an admixture to masonry unit concrete has aroused a rapidly growing interest in this material in recent years. Many fly ashes have been found to be highly pozzolanic, that is, while they are not cements by themselves, they have the property of combining with the hydrated lime released during the hydration of the cement to form insoluble cementitious compounds. The pozzolanic activity of different fly ashes varies greatly, but all have the same characteristics, namely, that at normal atmospheric temperature the reaction takes place slowly but continuously for a long period.

The properties of an individual fly ash are largely determined by the type of coal burned, the pulverizing equipment, the make and type of boiler, the air-fuel ratio and the type of collectors used. Therefore, fly ash may be defined as that portion of the finely divided residue (ash) resulting from the burning of pulverized coal, normally carried in suspension in the flue gas and collected by precipitators. It is comprised largely of nearly spherically shaped, smooth, glassy particles. The fineness and partially spherical shaped particles of which many fly ashes are composed contribute to increased workability and cohesiveness of the fresh concrete.

Fly ash should have a fineness equal to or finer than portland cement. The color ranges from dark gray to light gray or tan.

Fly ash varies in chemical and physical properties which determine whether a particular fly ash will be suitable for a specific purpose.

No large scale use of fly ash should be undertaken without a laboratory check on the particular material available, as to definite evidence of its uniformity. This does not mean that every fly ash which meets the ASTM specifications will have a similar effect in a concrete products plant.

Some fly ash like some poor cinders, may prove of little value and may even be harmful to the concrete. Stoker fly ash should not be used because of its high carbon content, usually around 50 per cent, and because of its coarse grading.

ASTM tentative specification for fly ash as an admixture for use in portland cement concrete, C 350-54 T, designates 12 per cent as the maximum loss on ignition (carbon content). Less than 6 per cent is considered advisable. A fineness of approximately 80 per cent passing the 325 mesh sieve is acceptable. Its fineness is probably one of its most important characteristics.

Following are shown the minimum and maximum percentage ranges of the various chemical constituents found in samples of fly ash from different plants throughout the country:

| Chemical Constituents | Minimum Percentage | Maximum Percentage |
|---|---|---|
| $SiO_2$ — Silicon dioxide | 35.68 | 49.27 |
| $Al_2O_3$ — Alumina oxide | 18.52 | 28.01 |
| $Fe_2O_3$ — Ferric oxide | 9.57 | 27.16 |
| $CaO$ — Calcium oxide | 0.85 | 7.55 |
| $MgO$ — Magnesium oxide | 0.20 | 1.29 |
| $SO_3$ — Sulphur trioxide | 0.46 | 2.97 |
| Alkalies | 0.84 | 2.25 |
| Loss on Ignition — Carbon | 1.79 | 29.17 |
| Retained on 325 mesh sieve | 11.10 | 37.80 |

*Fly ash high in $SiO_2$ and $Al_2O_3$ content is preferred.*

In view of all the possible variations which can affect the chemical and physical properties of a fly ash, fly ashes should be considered as individual materials rather than being a class of materials whose properties are similar.

Laboratory and plant experiments have demonstrated that the order and manner in which the materials of the charge are mixed have a decided effect on the strength and texture of the block.

With sand-gravel aggregate it is recommended that the fly ash be added gradually to the ordinarily damp aggregate already in the mixer and the mass mixed for one minute. The cement is then added also in a gradual stream and mixing continued for another minute. Next the predetermined approximate total volume of mixing water is added in a fine spray and mixing continued for an additional six minutes, a total mixing time of eight minutes per batch. The volume of finishing water should be held to a minimum.

With porous or lightweight aggregate, the approximate total volume of mixing water should be incorporated with the aggregate before the addition of fly ash or cement is made. The precautions as outlined above should be observed. See Section 8, Mixing and Processing Concrete.

The economy of using fly ash is greatest when it

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can be purchased and handled in bulk rather than by the sack.

Results with fly ash either as an addition to or as a partial replacement of cement vary depending on the qualities of the fly ash, type of aggregate, curing temperature, length of curing cycle and on the type of cement. Besides fly ash has been found particularly beneficial where the concrete is lacking in fines. It is therefore advisable for the block producer to conduct tests before deciding whether or not fly ash may be used to advantage in his operation.

When a good grade of fly ash is available, its special characteristics should be taken advantage of for betterment of product.

These advantages, under proper plant operation are; improvement in strength, surface texture, workability of mix and reduced cracking and breaking of units in handling. Other features are, less tendency of concrete to stick to pallets and molds besides a reduction in abrasion of mold boxes, mixer liners and blades when abrasive aggregate is used.

Fly ash may also be used to replace moderate percentages of portland cement. No general rule can be set forth for an established amount of fly ash to be used in all block plant concrete mixes. Variations in the type and grading of the aggregate and other factors, also the fly ash itself make it necessary to ascertain the amount of fly ash which will give the most satisfactory results.

The usual method is to redesign the mix by including fly ash to replace up to 25 per cent of the cement. Such replacement is usually on a pound for pound basis though some operators use 1-1/4 to 1-1/2 lbs. to replace 1 lb. cement. The weight per cu. ft. for fly ash is approximately 75 lbs., for cement 94 lbs.

The strength and rate of strength gain of the concrete is largely dependent on the moisture present and the temperature under which the reaction is promoted and the reactivity of the fly ash being used.

The temperature at which block are cured has an important influence on the amount of fly ash which may be used in a mix without adversely affecting the strength of the block.

Since low temperatures slow down the hardening rate of the concrete it is important that block manufacturers using fly ash should test their products frequently during the winter months. This is particularly true where high early cement is used.

The substitution of fly ash for high early strength cement will have a greater slowing effect on the rate of hardening during the colder months than during the warmer months.

At normal temperatures the pozzolanic action of fly ash is generally slower than that of the cement hydration, but continues for a longer time. Hence a weight for weight substitution of even a small amount of fly ash for portland cement may result in lower early strengths under normal 70 deg. F. curing temperature. However, at temperatures of approximately 160 to 190 deg. F. amounts of fly ash ranging up to 30 per cent of the cement content may be used, because the pozzolanic action is greatly accelerated.

With a steaming temperature of 190 deg. F., certain precautions must be observed (See Section 10, Curing Concrete Units). In general practice steam is delivered in a dry saturated condition. As the temperature of the air rises above the equilibrium temperature of the kiln, say to 190 deg. F., this would cause a transfer of moisture from the block to the air. It is therefore necessary to supply additional moisture to the kiln atmosphere, either by fog spray or other means in order to avoid drawing moisture required for proper curing from the block.

Where high pressure steam curing is used, the accompanying temperatures are generally in excess of 300 deg. F. At these elevated temperatures (in saturated steam) the pozzolanic reaction between fly ash and cement is further accelerated. In some high pressure curing plants fly ash and cement are used on a fifty-fifty basis.

Therefore, the temperature of curing block has an important influence on the amount of fly ash which may be used in a mix. These factors can be determined by experiment for the individual plant.

HYDRATED LIME—When added as a plasticizer in block mixes, hydrated lime produces optimum results when the weight of the quantity added is limited to 5 per cent of the weight of the portland cement content. When this quantity of lime is exceeded, the result will be a decrease in strength of the finished product. Hydrated lime is a diluent and must not replace any part of the cement content.

NATURAL CEMENTS—Natural cements were produced for many years prior to the development of portland cement.

These cements are produced from natural "cement rock" which has a composition similar to that of the portland cement raw mix. The cementing properties of this type of rock are developed by burning at a temperature slightly below that used for the production of portland cement.

The properties of natural cements, however, vary widely among themselves, but generally, when used as an admixture to block concrete mixes, they produce cohesiveness or fattiness and increase the factor of workability of harsher mixes.

Their disadvantages are slower setting and hardening properties, lower strength results and a higher water requirement for a given consistency.

Plant experiments using natural cement as a replacement up to 20 per cent of the portland cement in the mix, produce good textured units without materially impairing the compressive strength.

CALCIUM CHLORIDE—The addition of calcium chloride to portland cement does not change the general process of hydration. It permits an earlier start of the hydration process provided there is an adequate moisture supply.

The addition of calcium chloride reduces loss of moisture during the early hydration by releasing the normal heat of hydration at an earlier period thereby accelerating the hydration. This reaction develops a greater strength than normal during the early hardening period, and may be used in conjunction with steam or outdoor curing.

The reactions between calcium chloride and cement are given as follows:

*Calcium chloride used as an admixture in concrete is absorbed by the cement grains and is partly used up in the hydration of the cement. What probably happens is a chemical combination of calcium chloride and the tri-calcium aluminate to form calcium chloro-aluminate. The addition of calcium chloride increases the heat contributed by di-calcium silicate and tetra-calcium alumino-ferrite. It decreases the heat from tri-calcium aluminate, but has little or no effect on the heat contributed by tri-calcium silicate.

Too much dependence should not be placed on calcium chloride as a freezing preventative. It is not an adequate anti-freeze agent in any concentration permissible in the concrete mix. Its use should be considered rather as an accelerator to hasten hardening.

When used in the dry form it is preferably added directly to the aggregate rather than to the cement.

Calcium chloride is best introduced into the mix in a liquid form as part of the mixing water.

A convenient strength solution is obtained by dissolving 100 lb. flake calcium chloride in 25 gal. or 100 quarts of water. This produces a solution containing one pound of the salt to one quart of solution. The salt should be added in successive quantities to the water for best results.

For average conditions using two quarts of this solution per sack of cement will give the proper pro-

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*Effect of Calcium Chloride on Major Compounds of Portland Cement—Ohio State University, Bulletin #61.

portion. During freezing temperatures and with cold aggregates, amounts up to four pounds may be used with safety.

When used either as flake or in a concentrated solution care should be taken to avoid its coming in direct contact with the cement; otherwise flash set may occur with that portion of the cement with which it is in contact.

Contact with air for an appreciable time will cause calcium chloride to take up moisture and become lumpy. Lumpy calcium chloride should not be used other than in solution for use in concrete.

Calcium chloride may be satisfactorily used in conjunction with the various types of cement normally used in block manufacture.

DIATOMACEOUS EARTH—The effect of this inert siliceous material as an admixture to semi-dry concrete mixes has been demonstrated by laboratory and plant testing. It is a finely divided lightweight mineral powder sold under several trade names. Though it does not possess any cementing qualities of its own, yet in combination with the free lime of the cement it accomplishes its desired purpose of adding strength and workability to the harsher aggregates with the attendant advantages of uniform distribution of the cement, giving an even coating of the matrix and thus produces a uniformly homogeneous and dense concrete. The lubricating action causes the particles of aggregate to arrange themselves so as to produce maximum density thus eliminating honeycombing or bridging. Its advantages as an admixture are best obtained when used in quantities of 3 to 4 per cent by weight of the cement content.

SAND—Though sand is one of the basic constituents of concrete it may under certain conditions be considered as an admixture when used in conjunction with lightweight aggregates. Sand addition gives a stronger and more workable concrete and tends to prevent segregation of the coarse and fine aggregates.

Likewise the sand combines with the cement to form a more plastic matrix which coats and binds the coarse aggregate together.

Unlike lightweight aggregate fines, the sand tends to hold water in suspension where it can combine freely with the cement particles. A characteristic of sand-cinder or other lightweight aggregate concrete is that its consistency is different from that of similar concrete without the addition of sand. The sand produces workability and density in the mix and though sand increases the weight of the unit over that of plain concrete made from similar aggregates, its judicious use is beneficial.

When concrete with sand addition is to be used, it is advisable to have the mix in as wet a consistency as the machine can handle but short of producing slump of the finished units.

Actual plant experience indicates that approximately a 20 per cent by volume addition of sand will increase the strength of the units considerably, while the weight will be increased approximately 3 pounds in the conventional 8 x 8 x 16 inch unit.

A well graded medium coarse sand ranging in fineness modulus from 2.50 to 2.70 is recommended.

An exceedingly fine sand should not be used since it will require considerably more cement than a coarser sand to obtain a similar increase in strength.

Admixture materials may be classified in various groups of agents, which in some cases overlap each other as follows:

Accelerators, cementitious, plasticizing, pozzolanic, waterproofing and other inert powders.

Accelerators—Calcium chloride, because it is economical and easily procured, is the most widely used material which is typical of this group. Many liquid preparations sold as integral hardeners under special brand names are essentially calcium chloride solutions.

Cementitious—Such as natural cement and hydraulic lime react with water to form cementitious hydrated compounds. Hydraulic lime is more or less impure lime which has been subjected to higher burning temperature than for ordinary lime. Pure lime is not hydraulic, but falls in the class of inert admixtures. Their use is uneconomical compared with additional cement.

Plasticizers—Little information is to be found on these materials. Such materials are sold under trade names without disclosure of their contents. Generally, they are protective colloids or surface tension reducing agents.

Pozzolans—Are either of natural or artificial origin and are highly siliceous materials. They are not cementitious in themselves, but have the property of combining with lime (in the presence of water at normal temperature) freed by the hydration of the cement to contribute strength to the concrete. Therefore any siliceous material having this property may be termed pozzolanic. Pozzolanic admixtures react in the same manner as the finely divided powders. Fly ash is an artificial pozzolan. Diatomaceous silica, sold under several trade names, is a material of natural origin.*

Waterproofers—These preparations are essentially made from stearic acid in emulsion or other form combined with calcium, sodium or other salts. Cheaper preparations may contain fatty acid compounds.

Inert Materials—Finely divided materials of natural origin such as Diatomaceous silica, Hydrated Lime and Bentonite in small percentages of the weight of the cement have been recommended for the improvement of plasticity and workability of concrete.

## Section 8—Mixing and Processing Concrete

Mixing Concrete—All concrete should be mixed thoroughly until the components of the mix are uniformly distributed. Since thorough mixing adds to the workability as well as to the strength of the concrete, sufficient time for this operation should always be provided.

The relatively dry mixes used in the manufacture of concrete units require longer time than is necessary with ordinary concrete for monolithic work. Since the units are stripped immediately after being molded, the concrete must have no slump. However, the water-cement-ratio law still applies and adequate strength can be obtained only if the mixing time is sufficiently long to coat each particle of aggregate with cement paste.

Where the aggregates are properly proportioned and the minimum amount of cement is used, the amount of water needed to make good block is such as to give the greatest strength for the amount of cement.

Such an amount of water will make a concrete which will show a water web mark on the finished block and still will not cause slump.

Batch and continuous types of mixers are used in the manufacture of concrete products. The batch mixer is the more popular. Since the function of the mixing operation is to obtain a thorough blending of the materials, any of the mixers produced by several of the reputable manufacturers will give satisfactory results and good service. Rugged construction in a mixer is most desirable and this feature should be kept in mind when purchasing a unit. This quality will insure a minimum of maintenance and loss of time due to shut down.

Batch mixers may be obtained in a wide range of sizes and with various combinations of mechanical features. A very important point in operating a mixer is to adhere strictly to the manufacturers' recommendations regarding capacity and speed. Overloading or increasing the speed may cause serious damage to the machine.

With continuous mixers, the materials are introduced from a focal point into the mixing trough, where mixing goes on continuously during the passage of the materials through the machine.

The effectiveness of the mixing action of any mixer depends on the shape and arrangement of the blades and the method of charging the materials. If the consistency of the concrete produced in a specific mixing time is not reasonably uniform throughout the mass, it may be that the blades are worn, or the manner in which the concrete materials are charged may require changing.

Allowing hardened concrete to build up on the blades or in the inner surface of the drum will affect the mixing action. Such accumulations should be removed at frequent intervals and disposed of as waste. Blades which are worn below the manufacturers recommended minimum standard should not be used.

If a delay is experienced between the mixing and molding operations, the concrete may be safely used without suffering a loss in strength, provided it retains the workability necessary to allow its satisfactory compaction in the machine. This is an important point, for if the concrete stands for so long a period that remixing will not restore its plasticity, it should be rejected. Timing devices should be installed at the mixer so the operator does not have to guess how long the concrete is being mixed, as the tendency is to under-mix rather than over-mix the charge.

Where it is desired to keep closer control on the mixing time operations, an office installation may be set up as follows:

A General Electric Recording Ammeter, type CD-3 with a chart speed of 4 in. per hour is wired to a G.E. type JKR-3 Current Transformer connected to one leg of the mixer motor supply line.

A dampening device is installed between the ammeter and transformer to prevent damage to the ammeter when starting the mixer.

The recordings made on the chart show these factors:

1. It eliminates criticism of the conscientious mixer man who is endeavoring to do a proper job.
2. It satisfies the owner that his instructions on mixing time are carried out, besides providing a permanent record to which he may refer.

Batch Mixing Concrete—In batch mixing concrete a sufficient mixing time is particularly desirable in order to produce a homogenous mixture. This time should be measured after all materials are in the mixer. Adequate strength can be obtained only if the mixing time is sufficiently long to coat each aggregate particle with cement paste. Considerable difference of opinion exists as to the length of mixing time necessary to thoroughly coat the particles. Some operators agree that the increase in strength for mixing beyond 6 minutes is not sufficient to be economically justifiable.

For concrete of semi-dry consistency made from sand-gravel or other dense aggregate, it is very important to dry mix the cement and the fine and coarse aggregates for at least 2 minutes to insure uniform dispersion of the cement through the batch. The necessary amount of mixing water should then be added and the concrete mixed for the balance of the time required to produce a uniform mix.

With porous or lightweight aggregate there is no preliminary dry mixing. All of the water is added to the aggregate at the beginning of the mixing cycle and the contents mixed for one minute or more. The aggregate becomes saturated and the porous particles filled with water.

If fly ash is to be a component of the mix it should be added at this time and mixed for one minute or more. The cement is then added and mixing continued for an over-all total time of 8 minutes.

If any additional mixing water is needed to obtain

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*See Cement Dispersion & Admixtures—E. W. Scripture, Jr. Research Paper #35—Master Builders Company.

the proper workability it should be added at least 2 minutes before the mixer is emptied.

A competent mixer man can readily determine the amount of mixing water needed from observation of the first daily batches. After this observation it will generally be found that the water content of the aggregate will remain reasonably uniform throughout the day.

If the cement is mixed with ordinarily dry aggregate a portion of the cement may enter the porous particles where it will lose its effectiveness. Then upon addition of mixing water a further portion of the cement-water paste may be sucked into the pores because of the absorptive properties of the aggregate. Due to these factors, the ultimate strength of the units may be seriously affected unless care is taken to see that the mixing water is used at the right time.

Experimental tests have been run using regular plant mix in the proportions of 50 per cent coarse aggregate, 34 per cent sharp sand and 16 per cent fine sand, with a fineness modulus of 3.83 for the combined mix. The mixes were made in a 50-cu. ft. fully charged batch mixer. The water additions were controlled by metering while the timing was done by means of a stop watch.

Two distinct series of tests were conducted as shown in Table XIII, Series 1 and 2.

Series 1 was run to determine the effect on strength by varying the time of mixing the concrete. (The aggregates and cement were mixed for 2 minutes before adding the water.)

Series 2 was designed to show the effect of mixing action by varying the time of dry and wet mixing.

Results of Tests—Series 1 indicates an increase in the strength of the concrete as the length of time of mixing is increased. However, the strength of the concrete is not directly proportional to the line of mixing so that there is not much to be gained by mixing for too long a time. The size of the mixer and the number of block per minute will usually control the mixing time of the mix.

TABLE XIII: SERIES 1—EFFECT OF MIXING TIME ON STRENGTH

| | Length of Mixing Time | | | | | |
|---|---|---|---|---|---|---|
| | 5 Minutes | | 10 Minutes | | 15 Minutes | |
| | lb. Per Sq. Inch | | lb. Per Sq. Inch | | lb. Per Sq. Inch | |
| | 2 Days | 7 Days | 2 Days | 7 Days | 2 Days | 7 Days |
| | 815 | 980 | 1011 | 1195 | 1082 | 1310 |
| | 800 | 940 | 933 | 1163 | 1092 | 1295 |
| | 790 | 963 | 998 | 1130 | 1055 | 1275 |
| Avg. | 801 | 961 | 1001 | 1162 | 1080 | 1293 |

TABLE XIII: SERIES 2—EXPERIMENTS TO DETERMINE EFFECTS OF MIXING TIME AND ACTION

| Mixing Time | Test No. 1 | | Test No. 2 | | Test No. 3 | | Test No. 4 | |
|---|---|---|---|---|---|---|---|---|
| Dry | 0 Min. | | 2 Min. | | 4 Min. | | 6 Min. | |
| Wet | 8 Min. | | 6 Min. | | 4 Min. | | 2 Min. | |
| | 2 Days p.s.i. | 7 Days p.s.i. | 2 Days p.s.i. | 7 Days p.s.i. | 2 Days p.s.i. | 7 Days p.s.i. | 2 Days p.s.i. | 7 Days p.s.i. |
| | 869 | 1159 | 1028 | 1135 | 867 | 1045 | 921 | 1193 |
| | 822 | 1259 | 1066 | 1254 | 932 | 1013 | 845 | 1097 |
| | 904 | 1136 | 916 | 1149 | 862 | 965 | 882 | 982 |
| Avg. | 865 | 1185 | 1003 | 1179 | 887 | 1008 | 880 | 1091 |

A total time of dry and wet mixing of 8 minutes per batch is economical and adequate. Two minutes dry and six minutes wet mixing gave best results. If the machine takes concrete at a rate which does not permit of an eight minutes mixing time, the machine should be slowed down, or a mixer of larger capacity be installed.

Before using a mixing time shorter than the 2 minutes dry and 6 minutes wet, it would be advisable for the manufacturer to make tests using his particular aggregate and facilities with attention being given to the density and compressive strength of the units. In making such tests all conditions except mixing time should be kept as constant as possible. Keeping the machine in proper adjustment and checking the units for proper dimensions are important factors. Discarding worn mold boxes, and keeping pallets clean, are among the steps necessary for efficient operation.

Continuous Mixing—Continuous mixers were quite popular in the block industry some years ago. Their use, however, was for a while materially curtailed when requirements demanding more accurate proportioning of the materials became necessary, and where there was frequent change from one type of aggregate to another.

Another objection to their more extended use was the length of trough controlling the mixing time of the concrete. However, where these mixers have been equipped with troughs of greater length (10 ft. or more) thus extending the mixing time, excellent results have been obtained.

The advantages claimed for this system of mixing concrete follow: (1) economy in initial cost; (2) low consumption of electricity; (3) minimum of operating manpower; and (4) smaller space required for the installation of the complete equipment.

Besides these advantages is the fact that only a small portion of the mix is contained in the hopper above the machine at any time. Thus if the operator detects anything wrong with the concrete mix as it comes through the machine, he can call for corrective changes which may be accomplished quickly.

The same principles found in volume batching are applicable in this case. Adjustment of the delivery apertures of the stock bins to compensate for the flow rate of the materials under varying conditions must be considered. The openings must be set to deliver specific amounts of material per unit of time, or a rate at which the block machine can handle the concrete. Continuous mixing machinery properly designed and operated offers a satisfactory method of mixing concrete for block manufacture.

Pressure Reducing Valves—Since the cement-water paste is the binding medium of the concrete, and since each mix requires a definite amount of paste for best results, it follows that in the continuous mixing process, it is very essential to have a supply of water delivered at a uniform pressure at all times.

It is an established fact that a continuous flow of water delivered from a given sized nozzle, under certain set conditions, is entirely a function of the pressure behind the nozzle. Thus the pressure of the water, unless controlled by a pressure reducing valve, will vary over a wide range depending on the demand for water at other points in the plant at any time.

Influence of Aggregates on Water Content—The grading of the aggregate plays an important role in fixing the cement and water requirements of the mix. The finer the aggregate, the greater the proportion of cement-paste necessary to produce maximum strength for these reasons: (1) Since the total surface area of a fine aggregate is greater than the total surface area of the same quantity (by volume) of a coarse aggregate, it follows that more cement-paste will be required to coat all the surfaces of the fine grains. (2) More water must be added to the fine aggregate because of the greater surface area to be covered, therefore, more cement-paste is necessary. If no more cement is added to the mix and the extra paste is obtained by adding water only, the cement-paste will be more dilute and consequently weaker. As the surface area increases with finer aggregates more water is required to wet all the surfaces of the grains, hence more cement must be added to keep the cement-paste from becoming diluted and weakened, therefore, a richer mix is required when an excess of finer aggregate is present in the mix.

The use of well graded sand containing sufficient fines has a material effect on the workability of the mix. Not only is the grading of the coarse and fine aggregates important but also the combination of the two. An excessive amount of any particular size or a high percentage of voids in the combined grading will tend to produce harshness. Likewise surface characteristics and the shape and size of the aggregate may produce undesirable qualities in the mix.

Tests should be made to determine the amount of water necessary per batch to give the desired strength and workability, and further occasional tests should be made to insure that this consistency is maintained.

Quantity of Mixing Water—Each concrete mix requires a certain amount of water in order to obtain maximum strength. The proper amount of water is dependent on the length of mixing time and on the thoroughness of mixing operations.

Peculiarities in the block manufacturing processes do not always permit the use of the amount of water which produces maximum strength in the concrete mix. Good practice, however, calls for the use of that amount of water necessary to produce plasticity in the mix, short of causing sag in the freshly molded units.

The web markings on the units as they come from the machine give a good indication whether the proper amount of water is being used in the mix. The volume of water required for a mix is determined to an extent by the type of machine on which the units are produced. The tendency is to use too little water on tamping machines. Experienced operators are able to judge the consistency of the mix by squeezing a handful of it. The following "balling" test will give a good indication of the mix consistency.

"Balling" a sample of concrete in the hand should wet the hand slightly, and the ball should hold together. If the ball wets the hand considerably, there is obviously too much water in the mix; and if the ball falls apart, there is too much fine sand present.

Whatever volume of water is decided upon as necessary for the mix, it should be measured as carefully as the cement. Some form of easily adjustable measuring device should be installed if a uniform consistency of mix is desired. It is important to check water measuring devices frequently for leaky pipes or valves.

Determining the proper amount of mixing water necessary for gravel-sand concrete does not present any special difficulty. Better control may be maintained if the surface water of the aggregate is known. With natural or manufactured lightweight aggregates, the situation is more complex, for these reasons:

1. It is more difficult to obtain a mix of the proper plasticity.
2. Aggregates may or may not have highly absorptive properties. Thus, for a given aggregate and a given mix, the amount of mixing water required depends largely on the character of the aggregate.
3. The absorbed moisture content must be closely watched since all porous materials must be sufficiently wet before being mixed with the cement.

Consider the water requirements of cinders from power plant generation as a typical example. Generally, half or more of the necessary mixing water is present in the cinders as received from the source of production. It would seem, therefore, that in the manufacturing operation the moisture content of the cinders should be determined in all instances under plant conditions. Too little attention is given to the control of the water content when processing cinders. Only that portion of the water added to the mixer is measured, and this is generally done in a most perfunctory manner. No thought is given to how much moisture is actually contained in the cinders.

When cinders are in a dry condition, their tendency to absorb water may cause trouble in processing. Dry cinders in the course of processing will tend to absorb the cement-water paste into the pores where its bonding quality serves no useful purpose. At times, the cinder aggregate may be sufficiently wet, in which case no additional water is required in the mixer. Other times, the addition of water may be necessary in varying amounts.

For best results, the absorbed water in the cinders should range from 11 to 15 per cent by weight of the dry cinders.

Determining Total Water—Following is an example of calculation for converting percentage to gallons of

water per batch. Assume a mix of 225 lb. cement to 1,720 lb. of damp cinders, which requires a total content of 18 per cent of water based on a dry cinder content.

A moisture determination made on the cinders showed a content of 13.9 per cent on a dry cinder basis.

Thus, the 1,720 lb. of damp cinders, when dried, weigh only 1,510 lb. Otherwise expressed, the 1,720 lb. of damp cinders contain 210 lb. of water, which is part of the 18 per cent of the total water necessary for the mix.

The rest of the 18 per cent of required water (18 minus 13.9) must be added to the dry cinders. Therefore, water added at the mixer will be 4.1 per cent (18 minus 13.9) times the 1,510 lb., or 62 lb.

The number of gallons of water contained in the moist cinders is, therefore, obtained by dividing 210 by 8.33 (weight of one gallon of water) or 25.21. Similarly, the amount of water that is to be added to make up the 18 per cent is 7.44 gal. (62 divided by 8.33). Total required mixing water, then is 32.65 gal. If the cement in the charge is varied, more or less water will have to be added to obtain the proper cement paste consistency.

These same principles regarding absorbed water apply in the use of processed aggregates such as those produced from furnace slag, clays and shales and in the use of natural aggregates of high water absorptive characteristics.

Quality of Mixing Water—Water used for mixing concrete should be of a quality pure enough for drinking purposes. Water containing vegetable matter, acid, alkali or other injurious substances should not be used without first ascertaining its effects upon the concrete to be produced.

Should the water be suspected of causing trouble due to the effect of impurities on the strength and setting qualities of the cement, this factor can be determined by direct test upon trial batch mixes; or the water may be subjected to chemical analysis.

## Section 9—Construction of Kilns

The construction of a bank of kilns represents a sizeable investment. Since many years of service can be expected from such an installation, careful study of the important phases having a material bearing on the successful operation of the plant is warranted. It is an unfortunate circumstance that many of the curing systems throughout the industry are today operating far below their potential capacities. This situation is brought about through construction and other imperfections which are either too difficult or too costly to remedy.

The average block manufacturer is seldom a technically trained or technically minded person and in the past has been content to follow and reproduce the mistakes and faults of others in the construction of his kilns. Before proceeding with his construction plans he should enlist the services of a competent engineer to assist him in the solution of the many problems with which he is sure to be confronted. These problems if not properly handled may eventually prove to be costly mistakes.

The engineer should be thoroughly conversant with general plant layout, construction, curing technique, and steam boiler operation. The result of his advice and labors should be a plant capable of operating at a high state of efficiency.

Factors which should be considered are: (1) plant layout; (2) proximity of kilns to block machine; (3) shape and size of kilns; (4) materials and methods of construction; (5) size of racks; (6) number of units per rack and per kiln; (7) production rate of block machine; (8) capacity of lift truck; (9) boiler capacity; and (10) flow and distribution of the steam for curing.

Another important item generally overlooked in most plants is safeguarding the health of the operators. It is advisable to provide an exhaust system in the kilns for the dual purpose of eliminating noxious fumes from gasoline lift trucks and for exhausting the steam and drying the units after curing.

Kiln Sizes—Kilns should be no longer, higher nor wider than needed. There is no advantage in oversized kilns.

The consensus among manufacturers seems to favor the medium-sized kiln with a holding capacity from 900 to 1500 units per charge. One factor in favor of the medium-sized kiln is the shorter period of time per unit required for charging. A good practical standard for the determination of the size of the kiln is that the loading time should not exceed the steaming time; about two hours when units of one type only are charged.

Table XIV indicates variations in dimensions with corresponding block capacities of kilns which may be considered in the medium-sized class. Computation of the kiln capacity is based on racks holding 72 eight inch units, with racks 64 inches long and 38 inches wide.

TABLE XIV—KILN SIZES AND UNIT CAPACITY

| Wall to Wall Width | | Length | | Block Capacity | Number of Racks |
|---|---|---|---|---|---|
| Ft. | In. | Ft. | In. | | |
| 4 | 6 | 68 | 8 | 864 | 12 |
| 8 | 0 | 68 | 8 | 1728 | 24 |
| 8 | 0 | 85 | 8 | 2160 | 30 |
| 11 | 6 | 29 | 0 | 1080 | 15 |
| 11 | 6 | 40 | 4 | 1512 | 21 |

The height of the kiln is a variable dimension ranging from 7 ft. 4 in. to 7 ft. 8 in., and depends upon the type of lift truck being used in any particular plant. To minimize the possibility of breakage while loading the kiln with freshly made block, the kiln dimensions shown provide a 4 in. clearance around the racks, in addition to a 4 in. curb protection on each side.

**Kiln Construction**—A concrete curing kiln normally requires only sufficient roof strength to support a snow load and a wall strength sufficient to support the roof. It should be of the lightest type of construction with the highest degree of insulation. It must be watertight from the inside and outside. The materials must be corrosion proof and acid vapor proof.

In the construction of a curing kiln the importance of insulation of the enclosing areas cannot be overstressed. Heat is lost from the kiln continuously during the heating up and curing cycles, the loss increases as the temperature of the block rises. In the final stages of the heating up period difficulty may be encountered in raising the end temperature and holding it. When high winds and cold outside temperature prevails, heating the block and holding them at high heat during the time they are in the kiln can present a problem.

The following Figure 22 shows a front elevation of the footings; the exterior and interior kiln walls; and the construction of the roof. Figure 23 shows a side elevation of door jamb and drain system. The illustrations are presented merely as guides in outlining the basic points of acceptable construction. Other materials and ideas may be used to advantage. There are, however, certain fundamentals which must be observed and when incorporated in any size of kiln, will insure satisfactory results.

**Footings Construction**—Footings should be carried to a depth of 6 in. below the frost line for the locality in which the kilns are being erected. In Figure 22 the footings are shown to a depth of 3 ft. 6 in. below ground level. A footing width of 1 ft. 6 in. for the outside walls and 1 ft. 4 in. for the dividing walls should prove satisfactory, unless poor soil conditions

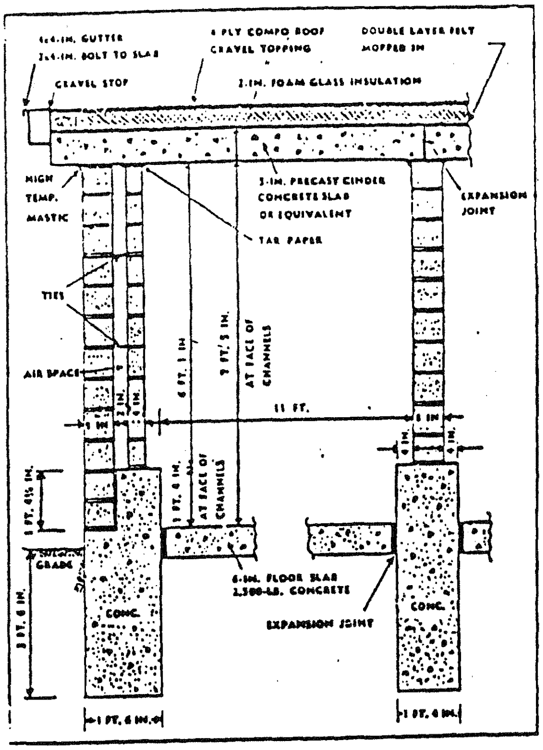

Fig. 22—Front Elevation of Kiln Walls.

necessitate wider footings. The footings should be carried to a height of 1 ft. 4 in. above the floor level of the kiln. The walls are set back a distance of 4 in. from the edge of the footings, thereby providing a substantial curb. This curb affords protection to the kiln walls against damage resulting from contact with the racks or from other causes.

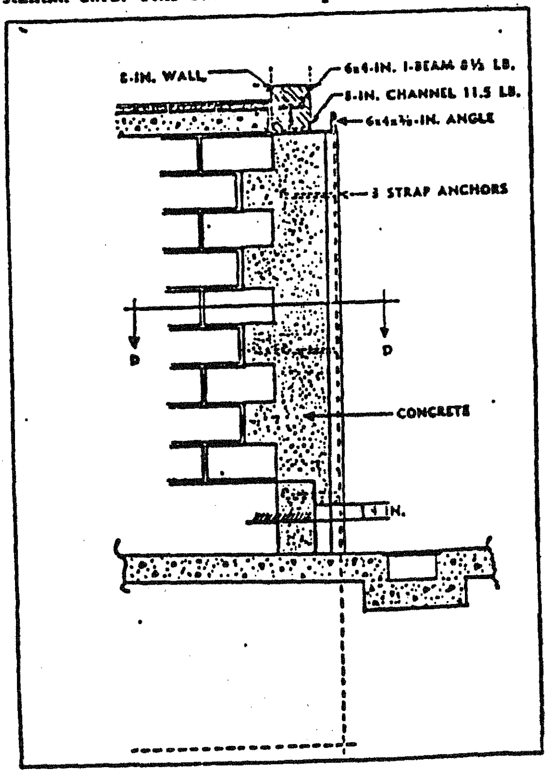

Fig. 23—Side Elevation of Door Jamb and Drain.

**Wall Construction**—Experience shows that a form of double or cavity wall construction in which the walls are separated by a continuous air space and securely tied together with non-corroding metal ties embedded in the mortar joints affords the maximum in insulating value from the use of hollow masonry units. During construction the cavity is kept clean by laying a 1 x 2 in. board across a level of wall ties to catch the mortar droppings. The board is raised, cleaned and laid in the wall at the respective tie levels as work progresses. Weep holes are formed by placing well-greased sash cord or rubber tubing in the horizontal mortar joints and pulling them out after the mortar has hardened.

An alternative method of construction is to lay up the 4 in. inner wall section to the required height. The wall ties are embedded in their positions with respect to the height of the courses of the 8 in. outer wall. This method permits treating the outer face of the inner wall with a brush coat of high temperature asphaltum paint or other sealer to provide a vapor barrier. The use of a vapor barrier to render the kiln impervious to the seepage of moisture through the walls and roof should be given consideration. A good vapor-tight kiln is essential in order to maintain the necessary saturated atmosphere required during the curing cycle.

A single course of 8 in. hollow units serves as the dividing walls of the kilns.

If additional light is desired in the kiln, it may be obtained through windows of sufficient size constructed of translucent glass block built into end walls and sealed with mastic.

Kilns are frequently built with openings at both ends. This arrangement, when considered with respect to the over-all plant layout, offers many advantages, particularly in plants having more than one machine. The movement of racks into and out of the kilns creates a great deal of traffic in plants of high production. In such plants it is frequently desirable to fill the kiln from one opening and empty it from the other.

With temperature changes in the kilns, normal contraction and expansion may be expected in all directions. The possibility of walls cracking may be held to a minimum through the use of one of the several types of metal reinforcing.

**Kiln Wall Insulation**—Since heat is one of the prime essentials for the curing of block, the production and retention of heat within the kiln during the curing cycle is very important, both from the operating and economic standpoints. Heat lost through the walls and roof of the kiln may be held to a minimum by selection and proper use of the materials of construction. Proper insulation does not necessarily mean massive construction of the kiln.

Heavy construction slows down the heating of the block since heat penetrates the walls, roof and floor as well as the block, racks and pallets.

Approximately one-half of the heat from the steam injected into the kiln is utilized in bringing up the temperature of the block, racks and pallets to a predetermined point, while the balance is absorbed by the interior walls, roof and floor slabs. Some heat eventually passes through the walls and roof slab to the outside atmosphere at varying rates of speed depending on the type of material used in construction. This heat represents a definite loss and may amount to 50 per cent of the steam injected into the kiln.

The cavity wall system as previously outlined offers a good medium of insulation and costs less than a single unit type of wall with insulation added.

This method of construction utilizes the scientific principle, that a "dead" air space offers one of the best means of slowing down the passage of heat. The cores of a concrete unit serve a similar purpose as an insulator. Nothing is gained by filling the cores of the unit with concrete.

The advantages of having kilns so constructed as to hold heat losses to a minimum, is reflected not only in reduced fuel consumption, but higher temperature from a lesser amount of steam, better heat distribution throughout the kiln and a slower temperature drop during the soaking period.

Insulation applied on the outside of the kilns is of little practical value. It does cut down heat transmission losses but the saving is negligible.

**Door Jamb Construction**—Door jambs and top front plates should be given careful consideration before the kilns are built, otherwise it may prove costly to rectify any imperfections once the facings are in position. Door jambs should be incorporated into the kiln structure. Steel channels of requisite dimensions and to which anchors are attached are used as facing for the protection of kiln walls. Figure 23 shows how the steel frame is securely anchored to the wall by stopping off the masonry and toothing it a sufficient distance back, then filling the space between the channel and the masonry with concrete.

Utmost care should be taken in setting the steel facing perpendicularly. Such precautions will help insure tight contact between the door and the facing. Besides, a frame constructed in this fashion should be able to withstand considerable shock and rough treatment.

A steel angle lintel running the length of the face of the kiln, serves not only to support the door but also contains the steam header pipe from which the injector pipe is taken off into the top of the kiln. When the steel members have been placed, they should be welded at their points of contact.

**Injector Pipe**—The injector pipe of predetermined dimension may vary from 3/4 to 2-1/2 inches in diameter. The size of the injector pipe is a function of the steam pressure at the nozzle, the physical dimensions, materials of construction and the arrangement of the kiln itself. The physical load of the kiln, such as racks, pallets, the block being cured together with their water content, and leakage from and into the kiln must be considered. In other words, it is a simple problem in thermo-dynamics.

**Steam Lines**—The steam line from the boiler to the kilns should be as short and direct as possible. If the line is too long the steam may become wet, thereby impairing its heating value.

The line should be well insulated and be trapped in order to drain off any condensate formed during periods of steam flow.

The line must be of ample diameter to prevent loss of pressure and insure a uniform nozzle pressure discharge along the line irrespective of the kiln distance from the boiler. The steaming of two or three kilns simultaneously should cause no appreciable change in pressure at the discharge nozzles.

If the diameter of the line is insufficient, a loss of pressure may result which in turn cuts down the amount of steam entering the kiln. This will necessitate a longer steaming period in order to properly cure the block.

If the pressure in the steam line tends to be erratic, a thermostatically controlled automatic or other type valve in the steam line entering each kiln may be used to advantage. This type of valve throttles the steam and holds the temperature at the desired point until the steam is cut off.

**Roof Construction**—Precast slabs suitably reinforced to carry a predetermined load makes a satisfactory form of roof construction. The slabs are cast from 4 to 6 inches thick and of a length and width which will permit of easy handling. The slabs may be cast with various forms of joint. The butt joint is the easiest to cast but has several disadvantages.

A good form of joint is the so-called lap joint, molded to leave an expansion space between the tongue and groove. All edges should be treated with a coating of asphaltum or other materials to insure a good vapor barrier and to prevent steam leaks. When the slabs are properly set, this form of joint provides for expansion throughout the roof section.

The slabs are set so that they project over the outside wall for a distance of 2 or 3 inches. Where the slab ends abut each other on the inside kiln walls, a 1/2 in. semi-rigid expansion joint should be placed between the sections for the full length of the kiln. A double layer of roofing felt is laid over the entire roof section, each ply being mopped with asphaltum to act as a barrier protecting the insulating material from the penetration of moisture from below. Insulating material of any type must be kept dry if it is to function efficiently.

Sections of 2 x 4 inch lumber are placed and nailed securely along the edge of the roof for the full distance of the kiln structure. This procedure serves a double purpose: (1) as a base to which 4 inch gutters may be attached; and (2) as a protection for the edges of the insulating material covering the roof.

Several forms of insulating material may be used. Because of its high efficiency foam glass is very satisfactory and is obtainable in convenient sized sections, 2 ft. wide by 4 ft. long and 2 in. thick. When the insulating blanket is in place, it is covered with a four ply composition roof with gravel topping which extends over the wooden members along the edge to protect them from the effects of the weather.

The face of the slab subjected to the effects of the steam may be well tarred or roofing paper tarred only in spots may be applied to the surface. This permits the roof slabs to expand without breaking the paper used to provide a vapor seal. At the points of contact between the walls and the roof, an application of high temperature mastic should be used to seal the joints.

The speed and simplicity of construction which is obtained from the use of one of several forms of prefabricated plank is well worth considering. Irrespective of the type of roof construction used, the roof should never be tied in with the walls, but should be free to move with temperature or moisture changes.

**Floor Slab Construction**—The kiln floors are constructed of 2,500 psi concrete, not less than 6 inches thick and reinforced with wire mesh. The concrete should be placed in sections 15 to 20 ft. long, depending on the length of the kiln. Expansion joints should be inserted transversely between the slabs and between the walls and the slab sections, thus reducing to a minimum destructive movement due to temperature changes. A gradient of 1 inch in 20 ft. which slopes toward the open end of the kiln will take care of the moisture resulting from the condensation of the steam.

**Drain System Construction**—Formerly a system of water-sealed drainage, which had many disadvantages, was generally installed at the rear of the kiln. Many of the troubles arising from such a system may be eliminated by having the drainage system outside the kiln as shown in Figure 23.

The drain is situated in front of and extends the full length of the bank of kilns. These drains are 15 inches wide by 5 inches deep and have a pitch of 1 inch in every 20 ft. The open drain is covered with a sectional steel grating of sufficient strength to sustain the weight of a loaded lift truck. At the lower end of the drain is a sump 30 inches in diameter, constructed to collect the drainage from each bank of kilns. The sump, connecting the sewer, is furnished with a catch basin to prevent debris from clogging the sewer line.

**Door Construction**—The selection of the type of door for the kiln is generally one of the last items of construction to receive consideration.

The style and type of door to be installed should be selected well in advance. The door should fit tightly around the full perimeter of the opening and be sufficiently tight to prevent excessively rapid heat loss. If the door fails to effectively cover, seal and insulate the opening it will allow steam to escape and cold air to enter the kiln. The absence of insulating qualities results in lack of uniform quality of block.

Many of the failures of which block manufacturers complain can be attributed directly to defects in the kiln doors. Therefore, uniform conditions so essential to quality production cannot be achieved with improper fitting doors, since temperature and vapor density will be reduced near the openings. The racks and contents near the door will therefore be improperly cured.

Various materials such as canvas, boiler plate steel, wood, wood framing with steel plate and galvanized metal are used. These materials are unsatisfactory from the standpoint of insulators, this is especially true with steel doors through which heat passes continuously.

Fabricated aluminum metal doors are becoming very popular and offer many advantages because of their lightweight and insulating qualities. The small additional cost of installing aluminum doors is offset through reduction in fuel costs and better curing results.

Where door butts or hinges are to be used special attention should be given to their selection. These butts or hinges should be of extra heavy construction and be of bronze, stainless steel or other metal which does not rust.

**Kiln Temperature Measurement**—In order to operate the kilns at their maximum capacity provision should be made for the installation of proper temperature indicating or recording instruments which will show the conditions at all times, within the kilns.

The importance of knowing the kiln temperature will be readily understood by the operator who desires to make a careful study of general curing conditions, and ways and means of improving them. This is an all too frequently neglected function in the production of block.

In the live steam curing of masonry products many plant operators have arbitrarily assumed a steaming time of a predetermined period for their plants without realizing that from day to day temperature conditions in the kiln may vary over a considerable range, thus affecting curing results. It thus becomes expedient to keep a close check on the temperature changes. This can be accomplished through the use of various types of heat recording instruments among which are the following:

(1) The dial thermometer which is actuated either through a thermocouple or by vapor pressure. The dial section of the assembly is located outside and above the charging door while the mechanism controlling the instrument is located inside the kiln. Observations of general temperature conditions within the kiln may be made anytime during the curing cycle.

With this system of installation the instrument is subject to shocks and jars which frequently cause the pointer movement to break down. For this reason the dials should be checked frequently for accuracy.

(2) The remote type of indicator, or temperature indicator controller which signals the operator when the predetermined curing temperature is reached, may be either of the visual type or controlled by an alarm bell or light.

(3) The potentiometer, a high grade and expensive instrument, can be had in either the indicator type or recording type. If of the recording type, it will give a continuous and permanent record of all phases during the curing cycle. However, to be of practical, every day use, it requires the constant attention of some person to compare the recordings with the results obtained. Its use is invaluable in experimental work.

(4) Armored thermometers for those who prefer glass thermometers of the maximum recording type are satisfactory. The metal point end of the assembly may be inserted into the block and the temperature read on the glass scale. The glass thermometer is totally protected by the metal sheath.

Thermometers of this type have a wide application in the curing of block. A series of thermometers placed at strategic points throughout the kiln or embedded in the block itself, will give an indication of the uniformity of the steam temperature distribution throughout the kiln.

Exhausting Steam from the Kilns—Opening the kiln doors and allowing dense volumes of steam vapor to permeate the work area is objectionable to the operators and detrimental to the machinery.

It is therefore, desirable to make special provision for exhausting the steam vapor, and at the same time cooling and partially drying the block, through an opening either in the roof or the back wall of the kiln. The opening is normally closed tightly by means of a manually operated damper which is opened during the time the kiln is being exhausted.

The location of the exhausting mechanism depends on the number of doors into the kiln. With a single door the vent is usually placed at the opposite end of the kiln. For a two door kiln the vent should be placed in the center of the roof.

Each kiln exhaust duct of adequate dimensions, at least 24 by 24 inches, is connected by sheet metal ducts to a centrally located exhaust fan located on the roof.

In exhausting the steam vapor and partially cooling and drying the block the door is opened to a height of 8 inches. The high velocity of air produced by a comparatively small opening will remove excess moisture better than with a slow moving current of air produced when the door is wide open.

Since each plant presents its own problems these can best be solved by the engineer.

System for Exhausting Steam from Curing Kilns—An inexpensive and practical system for exhausting steam from curing kilns and later used as a medium for drying block has been used successfully for several years at the Haycon Tile Company, Detroit, Michigan.

The system is readily adaptable to existing plants where no air drying is now being used. Its adoption eliminates the costly installation of metal ducts. One exhausting unit will service a bank of seven kilns of approximately 1,440 8-inch units capacity each.

A truck tire rim embedded to sufficient depth and projecting approximately 10 inches above the kiln roof is the medium used to make the necessary contact between the exhauster and the kiln.

A circular opening several inches larger than the rim is cut in the roof at the rear of the kiln. Cutting is continued through the remaining section of concrete in a dimension sufficient to provide a lip of 2 inches on which the rim eventually rests.

Mortar is spread around the 2 inch ledge onto which the rim is placed. The space between the rim and the concrete is filled with mortar, thus obtaining a good seal, while the under side of the concrete opening is smoothed up. A water tight joint between the concrete surface and the rim is obtained by means of a sealing compound.

Into the semi-circular cavity of the rim a section of hose or other sealing material is placed. The opening is covered with a section of 1/2 inch steel plate which when resting on the hose provides a seal during the curing cycle. When it is desired to exhaust the steam from the kiln, the steel plate is removed from the rim of the kiln to be exhausted and the exhaust fan assembly lowered into place.

The exhauster assembly consists of a section of steel pipe approximately 25 inches in diameter, and 30 inches high. Flanges are welded on top and bottom of the pipe which insures a tight joint when the exhauster rests on the seal embedded in the rim.

*A 4-blade belt driven, 24 in. diameter spread duct fan with blades 1-1/2 in. wide with a speed of 1750 r.p.m. and a free air capacity of 9,200 c.f.m. is mounted in the interior of the steel pipe. To the outside of the pipe is secured an "all weather tight" type motor of 1 h.p. capacity with a speed of 1750 r.p.m. This arrangement operated on kilns 7 x 7 x 60 feet permits of 3 changes of air per minute. After steam is exhausted, units are subjected to a drying cycle ranging

from 30 to 45 minutes after which units show an approximate 20 per cent moisture content.

A mono-rail structure on which the exhauster travels is constructed from materials easily procured. The rail may consist of a 4 inch junior I beam or fabricated from 2 sections of angle iron welded together. The rail should extend for the total length of the kilns being served. Stops to prevent the trolley from coming off should be welded to the ends. Six rail suspension members of angle iron approximately 2-1/4 x 1-3/4 x 1/4 inch are cut to a length about 74 inches for the uprights and 54 inches for the cross members. The sections of angle iron are then welded together as shown in the illustration. Steel plates are welded to the ends of the upright sections. The structure may be bolted to the roof if desired, but the weight in itself is sufficient to keep it in place.

A trolley arrangement, consisting of 2 pulleys held in place by suitable means, runs along the flanges of the rail. From this trolley the exhauster is suspended by means of a chain binder which is used for raising or lowering. The finer adjustment for closer contact with the tire rim is obtained by means of a turn-buckle.

When it is desired to exhaust steam from a kiln, the door is opened sufficiently to allow a brick to be placed under it and air is exhausted through the kiln for the necessary period of time after which in this case the kiln doors are removed and the contents of the kiln subjected to the drying action of the atmosphere drawn through the kiln.

After an adequate period the block are removed from the kiln in a sufficiently dry state to meet general standard requirements for moisture content as low as 20 per cent.

Surface kiln-drying of units must be determined for each plant. It is recommended that face velocity should not exceed 100 feet per minute.

To remove moisture naturally and efficiently from a masonry unit the vapor pressure and of the moisture in the block must be higher than the vapor pressure of the surrounding air. In other words, the relative humidity of the air must be sufficiently low to extract water from the surface of the unit. An excessive velocity of the air stream, may cause too rapid an elimination of the surface moisture, which causes a hardened surface to form on the block. This hardened surface retards the flow of moisture from the interior to the surface of the block, thereby tending to increase the drying time.

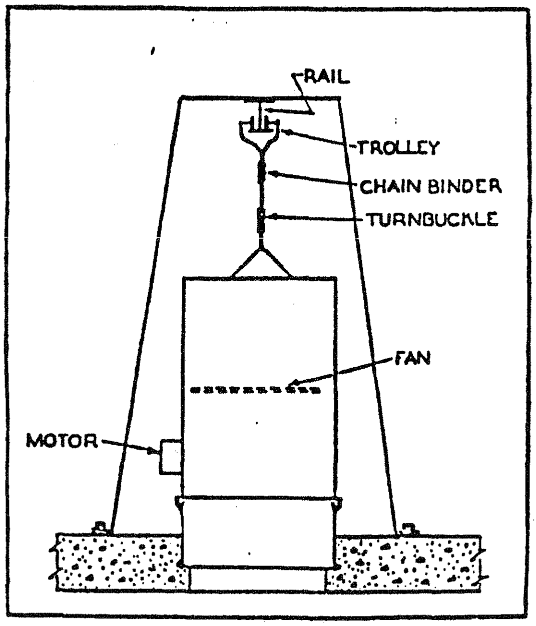

Fig. 24—System For Exhausting Steam From Kilns.

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*See Harvey P. Bertram, Cincinnati, Ohio, Catalog.

## Section 10—Curing Concrete Units

The term curing as applied to concrete units may be considered as the period between the molding operation and the time when the units are strong enough to be used.

Hydration or hardening of cement takes place through chemical reaction between the cement and water. If water is not present in sufficient quantity, the hardening reaction is impeded. Sufficient moisture must be present during the entire period after molding until the required strength is attained.

Experience and tests have demonstrated that the minimum amount of water necessary to effect hydration of the normal compounds in portland cement is in the ratio of 0.44 by weight of cement, otherwise expressed, approximately 5 gal. of water per sack of cement.

Since the water content of a concrete block mix generally runs between 3 to 4 gal. per sack of cement, which is below the minimum water-cement ratio required for hydration, it follows, that whatever method of curing is adopted, at least the water incorporated in the concrete during mixing be retained.

In the early years of block manufacture, the units were usually placed in yard storage where they were subjected to a perfunctory wetting. In most cases, however, the application of the moisture so necessary for hydration of the cement was left to chance depending on weather conditions.

Improvements in the methods of curing indicated that if units were subjected to the effects of low pressure saturated steam or to a system producing a fog of atomized water in a heated atmosphere, satisfactory compressive strengths were obtained. From these beginnings the present day methods of accelerated curing have been developed. The ever-increasing demand for masonry units has resulted in the development of accelerated curing to its present state of efficiency.

Though with present day forms of curing, a product capable of meeting strength specification requirements can be produced and cured within a period of twenty-four hours, units should be yard-stored for further curing and drying to minimize cracking when they are placed in the wall.

Irrespective of the care exercised in the selection of aggregates, the amount of cement used, and the processing of these materials, the resultant product may not reach its maximum strength due to improper curing of the units. Since plants differ in kiln shape, size, boiler capacity, block per rack and per kiln, production rate, type of cement, and aggregate along with other details incidental to live steam curing, the subject must, therefore, be treated in a very general manner.

With all methods of curing block three essential factors are involved; namely, time, temperature and moisture. In selecting the method of curing, the important consideration is to maintain the concrete in a moist condition until the cement has properly hydrated or hardened.

Masonry units may be cured in one of several ways, such as by natural curing, heat with fog spray, high pressure steam or high temperature steam.

**Natural Curing**—Natural curing means the curing that takes place when units are subjected to the atmospheric conditions existing at the time the units are made without special heating or wetting.

If natural curing is used, weather conditions must be taken into consideration during the different seasons, depending on the section of the country in which the plant is located. In any case, provision should be made for an enclosed storage room in which units may be placed for a part of their curing time, or until they attain sufficient hardness, after which they may be removed to yard storage.

In those localities of the country where a warm moist atmosphere prevails, along with occasional showers, and and where temperatures do not drop much below 50 degrees F., units upon attaining sufficient strength may be yarded. However, they should be protected from drying winds and sun, since these tend to remove moisture which is so essential for the proper hardening of the units.

After yarding, the piles of units should be kept thoroughly wetted down for a few days, either by means of a hose or by a sprinkling system. Care must be taken to see that all units in the pile are thoroughly wetted.

Outdoor curing in southern climates eliminates the necessity for steam curing and will prove just as effective provided the units are kept continuously wet for at least forty-eight hours after they are made.

In colder localities, freshly made units should not be placed in an unheated enclosure, since either frost or excessive cold prevents the proper hardening of the concrete. Cold drafts may also be harmful, since these tend to dry out the surface of the units and produce brittleness.

Under such conditions the use of an addition of from two to three per cent of calcium chloride by weight of the cement will help to accelerate hardening of the concrete.

Frozen aggregates should not be used until thoroughly defrosted. Where provisions for heating the preliminary curing room are lacking, heat may be applied to the units by means of salamanders over which pans of water are set. The objective is to produce a warm moisture laden atmosphere while hydration is taking place. Rapid drying out of the units, no matter how induced, should be avoided. A dry heat will prove to be detrimental by producing a brittleness of the units.

**Heat with Fog Spray**—With this form of curing the heat and moisture necessary to maintain a proper kiln atmosphere may be produced as follows.

I. By passing low pressure steam through a series of coils of pipe placed adjacent to the walls and slightly above the floor level of the kiln.

II. By burning gas in a specially designed burner located within the kiln and to which a blower is attached. Thus all of the heat of combustion is available for raising the temperature of the kiln. The products of combustion are carbon dioxide, water vapor, and nitrogen, all of which become a part of the kiln atmosphere. In the process of combustion the oxygen of the air combines with the carbon of the fuel to form carbon dioxide. The maximum amount of carbon dioxide by volume varies according to the type of fuel used; for natural gas 12 percent, fuel oil 15.5 percent and bituminous coal 18.2 percent.

When carbon dioxide from the combustion of the fuel becomes a part of the kiln atmosphere, and when this atmosphere becomes highly saturated with carbon dioxide the results, under certain conditions, may prove detrimental to the concrete units.

Carbonation of the concrete is a chemical reaction in which the carbon dioxide combines with the calcium hydroxide freed from the calcium silicates and aluminates in the cement during hydration. In the presence of carbon dioxide the calcium hydroxide combines with the calcium portion of these compounds to form calcium carbonate.

The moisture necessary to keep the kiln atmosphere in a saturated condition is produced by forcing water through a spray nozzle. The nozzle is located in front of the burner and converts the water into a fine fog. Where city water pressure is not available or is too low to produce a fog, air pressure may be used to force the water through the nozzle.

Since it is difficult to obtain the maximum (100 percent) humidity by this method of supplying moisture, every precaution should be taken to insure that the humidity of the kiln atmosphere is maintained at a point as high as possible. When there is a deficiency of moisture, the water in the pores of the units is absorbed into the kiln atmosphere, resulting in drying out the surface of the units.

If the surface of the units becomes dry, due to low humidity content of the kiln atmosphere the rate of carbonation is accelerated. Whereas in a moisture saturated condition, a skin of calcium carbonate[1] is formed on the wet surface of the block, which prevents penetration by carbon dioxide. Either one of these conditions can be detrimental or beneficial to the units.

If carbonation occurs before the cement hydration compounds are formed and the cement gel is in an unstable condition, the results will be detrimental. While the strength of the block may be sufficiently high, the surface and corners being brittle may cause excessive breakage in handling the units.

If carbonation occurs following hydration, and the gel is in a stable condition, the result can be beneficial. The units will have a tough surface and possess good strength qualities. In view of the effects of carbonation during hydration of the cement, caution should be observed in selecting the curing method developing the heat and moisture.

Carbon monoxide gas may be produced, under certain conditions, during combustion of the fuel. This gas is detrimental to the health of anyone subjected to its effects. According the the U. S. Bureau of Industrial Hygiene, a concentration of 100 parts of carbon monoxide per million parts of air may prove lethal. It is therefore very important that the kiln be aired out before allowing anyone to enter.

**Autoclave Curing**[*]—The principles of high pressure-high temperature steam are involved in this method of curing units. Manufacturers using autoclave curing claim the following advantages for the system:

I. Units are more stable and less subject to the effects of expansion and contraction due to moisture gain or loss than those produced by other methods.

II. High pressure curing bleaches the natural color of the products to an almost white color.

III. Danger from various disruptive forces due to impurities in the aggregate are eliminated during the curing period.

IV. Substantially drier products are obtained upon removal from the kiln, compared with the moist cured or air cured product.

V. Greater economy of curing, since leaner mixes for the same strength may be used.

VI. Smaller yard space requirements, since units can be delivered in a shorter time.

High pressure curing kilns are cylindrical steel drums capable of withstanding high pressures. The cylinders vary from 6 ft. 6 in. to 8 ft. in diameter and from 50 to over 100 ft. in length. They may have access door openings at one or both ends. They are fitted with pressure tight doors, either of the quick locking type or bolted type.

The curing cycle is from 12 to 16 hours, with 8 hours steaming at maximum temperature and pressure. A heating up period of 3 to 5 hours is required to bring the cylinder and contents up to maximum temperature, and a reasonable amount of time should be allowed for reducing pressure and cooling the cylinder before it is opened.

Steam is introduced into the cylinder at a temperature of approximately 350 degrees F. with a corresponding saturated steam pressure of approximately 125 p.s.i.

Blocks cured by the autoclave method reach a high strength quickly, and generally can be used at the end of 24 hours. However, the cost and installation of cylinders and the necessary boiler equipment have up to the present time been considered expensive, in comparison with low pressure equipment.

The manufacturer thinking in terms of producing a unit of comparatively low moisture content, should consider the cost of high-pressure steam curing as compared with covered storage or special drying rooms for obtaining a unit of low moisture content.

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[1] Effects of Carbon Dioxide on Hydrated Cement and Concrete—S. L. Meyers—Rock Products, Jan. 1949.

Effects of Carbon Dioxide on Fresh Concrete—Kauer & Freeman—A.C.I. Dec. 1955.

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[*] See Jackson & Church Bulletin on High Pressure Curing. Some Notes on High-Pressure Steam Curing—Concrete, July, 1953.

Autoclave curing is done under pressures of 120 to 150 psi or in a temperature range of 350 to 365 deg. F. Under these conditions of temperature and pressure, the rate of chemical reaction of the cement differs widely from that in a temperature range of 140 to 160 deg. F.

In curing under pressure, time and temperature are of vital importance. If the curing cycle is accelerated above the safe limit, the purpose for which autoclaving was installed may be defeated, namely that of securing a block in which the hydration of the cement gel is complete. In autoclaving as likewise in the high temperature curing method it is mandatory that the block be allowed to attain its initial set before the application of heat and moisture. If steam under pressure is allowed to enter the autoclave too soon, or the pressure is brought up too fast thermal shock may result. This in turn can cause crazing or cracking of the surface, distortion of shape, or the production of brittle units.

The temperature in the autoclave is a function of the pressure in the vessel only if the vessel has been completely purged of air. The relationship between temperature and pressure is not a direct function, that is, if the pressure of steam is doubled, the temperature is not doubled but only increased slightly.

For example consider the following table showing the properties of dry saturated steam only.

| Absolute Pressure | Corresponding Temperature |
|---:|---:|
| 0 lbs. | 212.00 deg. F. |
| 20 lbs. | 227.96 deg. F. |
| 40 lbs. | 267.25 deg. F. |
| 60 lbs. | 292.71 deg. F. |
| 80 lbs. | 312.03 deg. F. |
| 100 lbs. | 327.81 deg. F. |
| 120 lbs. | 341.25 deg. F. |
| 140 lbs. | 353.02 deg. F. |

These relationships do not hold true of wet or superheated steam or with air in the vessel. With any of these conditions existing an entirely different set of thermodynamic properties may be present within the vessel.

**High Temperature Steam Curing**—In high temperature steam curing, saturated steam is used to produce an equilibrium temperature ranging from 140 to approximately 170 deg. F. It is not enough for a block manufacturer to use live steam curing, he must know how the live steam affects the masonry units. Frequently it is assumed that all that is necessary is to turn live steam into the kiln and continue to inject steam till it is time to empty the kiln. Only then is the steam turned off.

Careful study of live steam curing indicates that excellent results can be obtained economically if the products manufacturer understands what is happening in the kiln.

Many plant operators have arbitrarily assumed a steaming time of a predetermined period for their plants without giving due consideration to the fact that from day to day conditions may vary over a considerable range depending on the season of the year.

For instance, a steaming time of two hours will in one case raise the temperature of the kiln to 160 deg. F., while in another instance in the same length of time the kiln temperature may reach 190 deg. F. With such conditions, a cement which will give satisfactory curing results at the lower temperature may be adversely affected at the higher temperature.

Such varying conditions of curing may, in a measure, be responsible for the differences in compressive strengths obtained under what may seem to be uniform plant practice.

An important factor is the variation in the characteristics of different brands of cement. This is due to the fact that the raw materials used by the cement companies vary in the chemical and physical makeup of the constituents entering into cement manufacture, which has a bearing on rates of cement setting and hardening.

This point is frequently lost sight of by the producer who must through necessity use several brands of cement in his operations. Therefore, for best results, the producer should study the peculiarities of each brand of cement and evolve the most suitable type of curing technique.

In many instances the manufacturer is remiss in not providing himself with the proper types of instruments for the measurement of temperature within the kiln during the curing cycle. This loose practice may be corrected through the use of some form of visual or audible indicating or recording temperature device.

Steam Boiler—The selection of the boiler for a live steam curing system is of prime importance. The size of the boiler is dependent upon the load requirements of the kilns, the number of kilns to be steamed simultaneously, and the plant load other than steam needed for curing.

The boiler capacity should be sufficient to bring the block up to maximum temperature in approximately the time required to load the kiln. A boiler in excess of requirements is advisable since the efficiency is improved when not operated at maximum load. Besides, the extra available steam may be used to advantage for other purposes throughout the plant. The cost of excess boiler capacity per horse power is but a fraction of what an additional boiler would cost.

The larger the water capacity and heating surface of the boiler, the less will be the concentration of the scale forming elements and the thinner the scale deposit for a given period of time. Also, the heat transmission loss through the tubes will be less, resulting in a higher rate of boiler efficiency.

Practically all of the boiler feed water is used to develop live steam and enters the boiler at an average temperature of 50 deg. F. The amount of boiler make-up water may vary over a range from 300 to 900 gal. per hour.

As a precautionary measure when determining the size of the water main necessary to feed the boiler, it is well to consider other water requirements for the plant, and to install adequate sized mains for all purposes. Future expense and delay may be avoided if the hourly requirements of water, whether drawn from a central source or from a well, are accurately established.

Steam—Matter exists in one of three forms: solid, liquid and gaseous. Under normal atmospheric conditions, substances exist in any one of these three states, and when the outside conditions are varied they may change from one state to another.

Water under average conditions exists in liquid form. When a volume of water is heated by means of some external medium, the temperature of the water rises. Additional heat causes the water to boil, releasing bubbles of gas (Steam) which rise to the surface. This condition is described as boiling.

The amount of heat necessary to raise the temperature of the water is expressed in British Thermal Units (B.T.U.) where a B.T.U. is the quantity of heat required to raise the temperature of 1 lb. of water 1 deg. F. (60 to 61 deg. F.).

The amount of heat necessary to raise the temperature of 1 lb. of water from 32 deg. F. (freezing point) to 212 deg. F. (boiling point) is 180.1 B.T.U. This quantity of heat is called sensible heat. In order to change the liquid into a vapor at atmospheric pressure (14.7 lb. per sq. in. absolute), 970.4 B.T.U. must be added to each lb. of water after the temperature of 212 deg. F. is reached. During this transition period the temperature remains constant. The added quantity of heat is called the latent heat of evaporation. Consequently the total heat of the vapor formed when water boils at atmospheric pressure, is the sum of the two quantities 180.1 B.T.U. and 970.4 B.T.U., or 1150.5 B.T.U. per pound.

When water is heated in a closed vessel, not completely filled, the pressure will rise after the steam begins to form accompanied by an increase in temperature.

Saturated Steam—Saturated steam is steam in contact with liquid water from which it was generated, at a

temperature which is the boiling point of water and the condensing point of the steam. It may be either dry or wet, depending upon the generating conditions.

1. Dry saturated steam is steam which is free from mechanically mixed water particles. Saturated steam at any pressure has a definite temperature.

2. Wet saturated steam, on the other hand, contains water particles in suspension.

Superheated Steam—Superheated steam is steam at any given pressure which is heated to a temperature higher than the temperature of saturated steam at that pressure. Water cannot exist in the presence of superheated steam.

Capacity of Boiler—From calculations made of plants using heavy as well as lightweight aggregates and having different kiln sizes and constructions an average value of 15 Btu's per block has been arrived at as the factor to determine the horsepower requirements for curing. This value, coupled with the desired temperature rise per hour, is used in the following formula.

Multiply the factor 15 by the number of kilns to be cured simultaneously, then by the number of racks per kiln and the number of block per rack. This product should be multiplied by the number of degrees of temperature rise desired per hour to bring the kiln up to optimum steam temperature. Divide this end product by the number of Btu's per boiler horsepower. Then divide the result by 0.86, which is the factor to be used to determine horsepower when the temperature of the water entering the boiler is 50 deg. F.

The 15 Btu factor was determined after considering many variables, among which are: (1) rack and pallet weight per kiln; (2) total weight of units, including water content; (3) kiln surface heated; (4) air volume in loaded kiln; (5) radiation loss; and (6) heat of hydration of cement.*

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* Details for calculating heat requirements will be found in "Technical Notes" Section.

Heat Requirements—A block manufacturer has kilns with a capacity of 1,440 8-in. units per kiln and desires to steam three kilns simultaneously.

The heat required in Btu's for curing is 15 x 3 x 1,440 x 60 (degrees temperature rise per hour) = 3,880,000 Btu.

One boiler horsepower is defined as the heat required to evaporate 34.5 lb. of water from and at 212 deg. F. (atmospheric pressure) and equals 33,478 Btu's. If the make-up water was at 212 deg. F., the heat required would be a certain amount (latent heat of evaporation). Additional heat is required to raise the water from 50 deg. F. to 212 deg. F. Assume make-up water at a temperature of 50 deg. F.

Latent heat of evaporation (heat required to evaporate 1 lb. of water from and at 212 deg. F. at atmospheric pressure) equals 970.4 Btu's. Heat required to raise 1 lb. of water from 50 deg. F. to 212 deg. F. equals 162.0 Btu's. The total heat required to change 1 lb. of water from 50 deg. F. to steam at 212 deg. F. is the sum of these two (970.4 plus 162.0) or 1,132.4 Btu's.

The factor to use in determining horsepower when using 50 deg. F. entering water instead of water at 212 deg. F. is found by dividing the latent heat of evaporation (970.4 Btu's) by 1,132.4. This is 0.857. For practical purposes this factor is considered to be 0.86.

The horsepower required will then be a fraction in which the numerator will be the total heat required to cure the units under the conditions given above (3,880,000 Btu's) and in which the denominator will be the product of the amount of heat required to produce 1 boiler horsepower (33,478 Btu's) and the factor used when 50 deg. F. entering water is assumed (0.86).

Expressed as the fraction this is $\dfrac{3{,}880{,}000}{33{,}478 \times 0.86} = 135,$ or the number of horsepower required to steam three

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* Principles Underlying the Steam Curing of Concrete at Atmospheric Pressure—by A. G. A. Saul, Magazine of Concrete Research (England) March, 1951.

kilns simultaneously, each kiln holding 1,440 equivalent 8 x 8 x 16-in. units.

Under average conditions the above formula can be simplified by combining the figures which usually do not vary, as follows:

$$\frac{15 \times 60}{33{,}478 \times 0.86} \doteq \frac{900}{28{,}791} = 0.03125$$

The boiler horsepower requirements will therefore equal the number of block to be cured simultaneously multiplied by the factor 0.03125.

TABLE XV—NET HORSEPOWER LOAD REQUIREMENTS OF BOILER

| Kiln Capacity 8-in. Units | H.P. Required for 1 Kiln | H.P. Required for 2 Kilns Simultaneously | H.P. Required for 3 Kilns Simultaneously |
|---|---|---|---|
| 864 | 30 | 60 | 90 |
| 1080 | 35 | 70 | 105 |
| 1200 | 40 | 80 | 120 |
| 1440 | 45 | 90 | 135 |
| 1728 | 55 | 110 | 165 |
| 2160 | 70 | 140 | 210 |

For example:

3 kilns each with a capacity of 1,440 block = 4,320 block.

then 4.320 times 0.03125 = 135, horsepower required.

**Steam Application**—There is a great difference of opinion among operators on the best method of introducing steam to the kiln. Some advocate introducing the steam at the ceiling at one end of the kiln, others, for introducing it at the floor level, while some contend that the best method is to introduce it through orifices in continuous pipes running the length of the kiln and situated slightly above the floor level.

Steam introduced at the ceiling level, from a single large pipe, being heavier than air, will tend to settle on the units as it descends to the floor.

Steam injected at or near the floor level through a series of small orifices has a high moisture condensation factor. This condensation reduces the moisture which should be deposited on the units.

**Steam Distribution**—In order to cure block successfully, it is necessary to know the proper volume, velocity and quality of the steam being delivered to the kiln. The volume of the steam must be known in order to obtain the recommended temperature rise not to exceed 60 deg. F. per hour in the kiln.

The velocity of the steam must be such that it will result in the desired action or turbulence to mix thoroughly the air in the kiln in order to distribute heat and moisture uniformly.

Different degrees of heat and moisture throughout the kiln will result in different degrees of curing between units situated in front and back of kiln as well as top and bottom of the same.

Turbulence within the kiln is obtained from the proper pressure at the terminal of the steam nozzle. This pressure must not be confused with boiler pressure since there is a drop in pressure of the steam between the boiler and the kiln.

This drop in pressure depends on the physical length of pipe between the boiler and kiln, number of fittings in the steam line, diameter of steam line and the pounds of steam being used.

A good practical assumption, determined from experience follows:

The velocity of the steam injected should vary from 750 to 1,000 feet per minute per linear foot of kiln.

**Quality of Steam**—The quality of the steam must be such that no entrained water is carried along with it when leaving the nozzle. This is to prevent over-wetting the block and to eliminate the possibility of washing the surface of the block. The importance of keeping the steam in as dry and saturated a condition as possible is demonstrated by the fact that steam carrying 1 per cent of moisture at the nozzle will still be slightly superheated and will therefore contain no entrained water, whereas the addition of another 1 per cent (2 per cent total) will result in steam that entrains 43 lb. of water.

Steam that carries 5 per cent moisture at the nozzle will entrain 153 lb. of water. These calculations are based on a 2-in. nozzle, 10 psi gage pressure at the nozzle, and a discharge of 4,300 lb. of steam per hour.

**Effect of Velocity of Steam**—The velocity of the steam entering the kiln may be a deciding factor on the uniformity of the results obtained. If the velocity is too great, the steam will impinge directly on the backwall of the kiln, inducing condensation of the water vapor. Such a condition would release part of the total heat available into sensible heat, thus raising the dry bulb temperature of the air in the kiln and reducing the absolute humidity and vapor pressure of the air in the kiln.

When too low a steam velocity is used, the temperature gradient of the air in the kiln will vary considerably from top to bottom and from front to rear.

The distribution and velocity of the steam is dependent on the physical dimensions and the internal load of the kiln; the velocities for various shapes of kilns range from 10,000 to 60,000 ft. and upwards per minute.

Since there is a limit to the velocity of the steam supplied to the kiln, the dimensions are of primary importance. Too long a kiln will not permit uniform distribution of the steam throughout its entire length unless special piping arrangements are made.

The entrained water in the form of solid particles when carried along with the steam, traveling at a velocity in excess of 60.000 ft. per minute, can do considerable damage to the units being cured. It is essential that pipe lines and insulation be designed and installed so that the steam leaves the nozzle in a dry saturated, or slightly superheated condition.

Steam at a higher nozzle pressure than the existing kiln pressure, may produce, when entering the kiln, a temporary condition of sudden expansion of the saturated vapor, in which the steam continues to expand in a superheated condition, without any condensation taking place.

Superheated steam of this nature is not stable and dissipates through condensation of part of the vapor. The temperature of the mass in the kiln is raised by the latent heat given off during the condensation, until the thermal equilibrium is restored. This condensation takes place throughout the kiln because of the velocity of the steam employed. Moisture is therefore deposited on all units present in the kiln.

The solution of these steam problems can best be undertaken by a processing engineer, well versed in the thermodynamic properties of steam and air. They are best determined only after a thorough survey of the proposed plant layout.

**Steam Leaks**—Few operators give sufficient attention to the effects of steam leaks in their boiler plant and attendant piping. Leaks if not promptly attended to can amount to quite a sizeable loss of fuel over a period of time.

Suppose a boiler operating at 15 lbs. pressure with an accumulated steam leakage area of 0.10 sq. in. and operating for 4,000 hours over a period of 12 months, the approximate loss is 30 tons of coal or 5,400 gallons of fuel oil. With a pressure of 125 lbs. and for a similar leakage area, the approximate loss can amount to 140 tons of coal or 25,500 gallons of fuel oil. If the leakage area is greater than 0.10 sq. in. the loss will be in direct relation to the area. With an area of 0.50 sq. in. the loss can amount to five times that from an area of 0.10 sq. in.

**Thermodynamics of Curing**—High temperature curing in the past has been considered more from a heating and humidity standpoint rather than a processing problem.

As the dry bulb temperature increases, the greater will be the number of grains of moisture required per pound of dry air to maintain a condition of 100 per cent relative humidity.

Table XVI shows the relative amounts of moisture required to maintain 100 per cent relative humidity, for various degrees of temperature.

TABLE XVI—THERMODYNAMIC [illegible] OF DRY AIR*

| Column A<br>Temperature<br>Degrees F. | Column B<br>Lb. Moisture per<br>Lb. Dry Air | Column C<br>Vapor Pressure<br>P.S.I. |
|---|---|---|
| 80 | 0.022 | 0.51 |
| 100 | 0.043 | 0.95 |
| 120 | 0.081 | 1.69 |
| 140 | 0.153 | 2.89 |
| 160 | 0.299 | 4.74 |
| 170 | 0.433 | 5.99 |
| 180 | 0.658 | 7.51 |
| 200 | 2.295 | 11.53 |

Relative Humidity—In steam curing block it is important to maintain as high a moisture content (relative humidity) as possible in the kiln atmosphere. As the temperature in the kiln rises, the air in the kiln is rendered capable of holding more moisture, hence more evaporated water (steam) must be introduced to bring the kiln atmosphere to a saturated condition (100 per cent relative humidity).

Relative Humidity is defined by Webster as "the ratio of the quantity of vapor actually present to the greatest amount possible at the given temperature."

Relative Humidity is determined by the use of two thermometers. One thermometer known as the "dry bulb" thermometer has its bulb exposed to the air, the other known as the "wet bulb" thermometer has its bulb covered with wicking or muslin, the end of which is immersed in a suitable container of distilled water.

Through capillary attraction of the wick, the bulb is kept constantly moist and as the water evaporates the bulb is cooled. The drier the air, the faster the water evaporates, accompanied by a lowering of the "wet bulb" thermometer reading. The difference in the readings of the "dry bulb" and "wet bulb" thermometers is a measure of the relative humidity and this can be determined from tables prepared for this purpose. When the air is saturated (100 per cent relative humidity) both thermometers will read the same.

These instruments are known as hygrometers.

I. With a dry bulb temperature of 120 deg. F. and a wet bulb temperature of 120 deg. F. the result would be 100 per cent relative humidity. This atmospheric condition would require 567 grains or 0.081 lb. moisture per pound of dry air.

II. If the dry bulb temperature be raised to 180 deg. F. without any increase in grains of moisture per pound of dry air, the wet bulb thermometer will indicate a temperature of 135.5 deg. F. with a resultant relative humidity of 29.7 per cent. In order to obtain 100 per cent relative humidity at 180 deg. the atmospheric moisture content would have to be adjusted to 4,604 grains or 0.658 lb. of moisture for each pound of dry air.

III. If the curing temperature were elevated so that the dry bulb registered a temperature of 200 deg. F. without increase of moisture the resultant relative humidity would be reduced to 19.3 per cent. In order to obtain 100 per cent relative humidity in this case, the atmosphere would require a content of 16,065 grains or 2.295 lb. of moisture for each pound of dry air.

From this data it can readily be seen how necessary it is to supply moisture to the atmosphere in the kiln in order to avoid drawing moisture from the block.

Vapor Pressure—An important factor which must be considered is the saturation pressure of the moisture in the kiln atmosphere. This is commonly known as vapor pressure and is the pressure exerted by the moisture in the form of vapor.

It will be noted from Table XVI Column "C" that, with a relative humidity of 100 per cent, at,

170 deg. F. the force is 3½ times as great as the force at 120 deg. F.

180 deg. F. the force is 4½ times as great as the force at 120 deg. F.

200 deg. F. the force is approximately 7 times as great as the force at [illegible] deg. F.

Vapor pressure is exerted within the kiln at all times during the curing cycle. It is higher inside than outside the kiln. These two conditions are not in equilibrium, thus moisture will be forced to the outside atmosphere.

The voids in concrete are practically filled with water or moisture at the time block are made. If no moisture is added to the air of the kiln, the saturated block begins to lose moisture by evaporation to the surrounding air in the kiln, the degree of moisture removal being dependent upon the temperature of the curing atmosphere, and the length of time the units are subjected to such temperatures and differentials in saturation pressures.

Relative humidity measurements of the kiln atmosphere, when made under these conditions may lead to false conclusions.

Such measurements can indicate 100 per cent relative humidity in the kiln atmosphere, when actually the chemically combined water is being removed from the units.

Moisture becomes a part of the kiln atmosphere and while indicating ideal curing conditions, the binding ingredient, portland cement, is being damaged through lack of moisture so necessary for its hydration.

Measurement of Heat—The steam curing process is a technical and scientific one. For successful results certain precautions must be observed in order to maintain uniformity of quality in the finished product.

Temperature is one of the important essentials in the process of curing, yet it is a factor to which too little attention is given.

A study of heat distribution to steam curing kilns shows that part of the heat applied goes into the block, pallets and racks, the other portion goes into the roof, sidewalls and floor. One of the reasons it takes so much steam and time to heat the block is that the roof and other sections of the kiln absorbs heat at the same time as the block is being heated.

The installation of proper temperature indicating and recording equipment will show the kiln conditions at all times and permit the operator to make changes necessary to improve operation.

Another reason for the use of thermometers is that makers do not fully appreciate the importance of a definitely controlled processing cycle. In many instances the block are either not heated enough or heated for too long a period. If heat comes up too slowly it may be due to insufficient steam pressure or quality, or due to leakage in the kiln.

No phase of plant practice varies as widely as it does with respect to curing. This condition reflects the controversial nature of the entire subject of curing.

Curing Cycle—The curing cycle is made up of several phases:

I. The kiln is filled and closed.

II Presetting Period— A presetting period of one to four hours or longer, depending on the type of aggregate, the type of cement used and the season of the year. It is during this period that the initial reaction of the cement-water paste takes place. If this reaction is interfered with by the sudden application of heat, a brittleness may be produced in the units along with the formation of hair cracks. Low initial block and kiln temperatures during the winter season can have a detrimental effect on the ultimate strength of the units. Therefore, preheating the kiln before and during charging to a minimum temperature between 70 to 100 deg. F. is recommended.

Outdoor temperature in winter time must be considered in anticipating strength of units at various ages. Strengths should be developed during the curing cycle. A wide difference in results can exist between summer and winter operations even though procedures are the same.

III Steaming Period—The steaming period is the length of time the steam is introduced into the kiln. This period is best determined for each individual plant

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* From American Society of Heating & Ventilating Engineers "Guide".

by ascertaining the time required to bring the units and the kiln air to equal temperature, coupled with the point at which the block cease to increase in weight. This is termed the point of equilibrium. The procedure for determining the equilibrium temperature follows:

Through a small hole, drilled at a convenient point in the kiln roof, a chain is passed. The upper end of the chain is attached to an arrangement resting on the platform of the scale which is located above the roof. It is important to see that the apparatus functions properly. The scale should be accurate to 0.01 lb. At the lower end of the chain a pallet containing three units is suspended midway between the ceiling and the floor of the kiln. By means of this arrangement the increase in weight of the units during steaming is determined from readings made at intervals of fifteen minutes, until such time as the block does not show further increase in weight.

Direct temperature readings are obtained from a series of thermocouples inserted in the shells of the units on the pallet and also in units located on different tiers of a rack adjacent to the suspended pallet. The leads of the couples are connected to a potentiometer fitted with a quick change switch which records directly in degrees of temperature within seconds of each other.

When dry saturated steam enters the kiln at high velocity it causes a rapid temperature rise. Since the temperature rise of the block lags behind the temperature of the kiln air, this difference in temperature causes moisture to deposit on the surfaces of the block, with the result that moisture is added to the concrete. The block will continue to take on moisture as long as they remain at or below the dew point temperature of the kiln air.

When the temperature of the units and the kiln air are equal the units will commence losing water and will continue to do so as long as the steam remains on.

The loss of moisture will be accelerated as the block temperature increases above the kiln air temperature.

TABLE XVII—KILN CONDITIONS DURING A CURING CYCLE

| Time | Thermocouple Temperatures | | | | | | Suspended Weight | |
|---|---|---|---|---|---|---|---|---|
| | #1 | #2 | #3 | #4 | #5 | #6 | Assembly | Net change Per Block |
| 8:15 A.M. | 72 | 68 | 69 | 97 | 82 | 79 | 187.62 lb. | — |
| 10:00 | 97 | 79 | 77 | 99 | 87 | 81 | 187.50 lb. | — 0.04 |
| 10:15 | 114 | 109 | 114 | 125 | 123 | 122 | 188.59 lb. | + 0.32 |
| 10:30 | 130 | 128 | 134 | 137 | 134 | 135 | 189.34 lb. | + 0.57 |
| 10:45 | 142 | 142 | 144 | 149 | 147 | 147 | 189.75 lb. | + 0.71 |
| 11:00 | 155 | 154 | 156 | 159 | 157 | 157 | 190.38 lb. | + 0.92 |
| 11:15 | 164 | 164 | 165 | 168 | 167 | 167 | 190.87 lb. | + 1.08 |
| 11:20 | 170 | 170 | 169 | 171 | 170 | 170 | 191.01 lb. | + 1.13 |
| 11:25 | 168 | 166 | 155 | 164 | 163 | 153 | 191.01 lb. | + 1.08 |
| 11:30 | 168 | 166 | 151 | 164 | 162 | 147 | 190.85 lb. | + 1.04 |
| 12:00 | 163 | 162 | 136 | 161 | 157 | 132 | 190.75 lb. | + 1.04 |
| 12:30 P.M. | 159 | 156 | 132 | 157 | 154 | 125 | 190.75 lb. | + 1.04 |
| 1:00 | 158 | 153 | 127 | 154 | 150 | 122 | 190.75 lb. | + 1.04 |
| 1:30 | 155 | 150 | 127 | 152 | 148 | 119 | 190.75 lb. | + 1.04 |
| 2:00 | 154 | 147 | 127 | 153 | 147 | 119 | 190.75 lb. | + 1.04 |
| 4:30 | 146 | 134 | 118 | 143 | 140 | 118 | 190.75 lb. | + 1.04 |

If the temperature of the air in the kiln is allowed to rise above the equilibrium temperature, the vapor pressure of the block is greater than the vapor pressure of the kiln atmosphere, thereby causing transfer of moisture from the block to the air. This moisture contains water already chemically combined with the cement, thereby retarding the hardening of the cement-water paste.

This indicates the importance of determining the point at which the steam should be shut off.

The equilibrium temperature may vary considerably with the kind of block, the size of the kiln and other factors, but is somewhere between 160 and 180 deg. F.

The equilibrium temperature of each kiln though of similar construction, varies with the type of aggregate being cured, the capacity of the kiln, or unless the conditions are changed due to cracks, broken walls or other circumstances causing steam leaks.

Once the equilibrium temperature of a kiln is established, it need not be checked unless the type of aggregate is changed. That is, the same kiln used to cure units of two different types of aggregate will have different equilibrium temperatures.

Table XVII* gives an example of kiln temperatures in deg. F. during a curing cycle until a temperature of 170 deg. F. was reached when steam was turned off.

Thermocouples were located as follows: No. 1, in the shell of a block on the top pallet; No. 2, in the shell of a block on the fourth pallet; No. 3, in the shell of a block on the sixth or bottom pallet; No. 4, kiln air at ceiling; No. 5, kiln air midway between the ceiling and the floor; No. 6, kiln air at the floor.

IV Soaking Period—The soaking period is as important as the steaming time. It is usually governed by the number of kilns available, keeping in mind the fact that the longer the units are allowed to soak the better will be the final results.

As the kiln air temperature decreases, the humidity condition then becomes a factor, since the contents of the kiln are thoroughly saturated with moisture. As long as the air in the kiln is not disturbed by changing, the humidity of the kiln increases as the temperature decreases because the moisture content is relatively constant. An accelerated curing condition is maintained in the kiln during the entire time the temperature is falling to 70 deg. F. Therefore, the longer the soaking period is extended, the better will be the ultimate product.

The temperature drop in a well constructed kiln will be approximately 4 to 7 deg. F. per hour.

V Drying Period—A drying period can be added to follow the soaking period to reduce the moisture content of the units to acceptable standards.

Figure 25 outlines curing conditions of the various phases of the cycle.

Kiln-Curing of Block—An extensive series of curing tests was conducted to ascertain the effectiveness of different curing cycles on heavyweight aggregate block produced under actual plant conditions during the months of June and December.

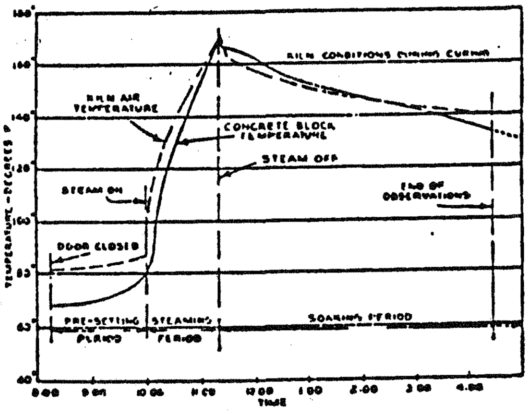

Figure 25. Graph showing curing conditions.

The variations studied in the curing cycle were:

1. Temperature of kiln at time of charging.
2. Length of holding period.
3. Maximum steam temperature.
4. Length of steaming time at maximum temperature.
5. Length of soaking time.

Every effort was used to keep the variables in manufacture to a minimum. All block tested in the June series, except the high early strength cement specimens, came from a single batch. This was also true for block tested in the December series.

The separate aggregates consisting of pea gravel, sharp and fine sands were blended in such proportions to produce a fineness modulus of approximately 3.70 as recommended in Table XI. under Proposed Theoretical Grading.

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* Concrete Products Feb. 1947

Air entraining and high early strength cements were used for comparison with each other, for strength results and yield of block per batch. Surface moisture and water added per batch were carefully gaged. A total mixing time of 8 minutes (2 minutes dry and 6 minutes wet) was decided on as determined from experimental results outlined in Table XIII, series 2, section 8.

The results indicate that weather conditions have an important bearing on the strength of the units and that curing is of much greater importance during the winter months than during the warmer summer months.

The results of the summer series of tests showed very slight differences in strength even with the variations of curing techniques adopted, ranging from 140 to 180 degrees F.

In winter, because of the relatively low outdoor temperature the block do not gain strength after being stacked outside.

It is, therefore, necessary during the winter to develop as much strength as possible in the curing room.

The objective of the manufacturer is the economical production of a uniform quality unit throughout the year. This requirement necessitates a study of the seasonal curing conditions coupled with the judicious adjustment of the cement factor in accordance with the outdoor temperature and also with the size and type of the unit being produced.

The test results indicate that the curing room temperature should be brought up close to 100 deg. F. before the blocks are placed in the curing room. Tests have proved that a low initial concrete temperature along with a low curing room temperature during the charging and holding periods in winter time have detrimental effects on the strength of the units.

In general, the holding time should not be less than two hours after the kiln doors are closed. In some instances a holding time of four hours will be required.

The conclusions drawn from the test results indicate that an hour or two extra holding time at the beginning of the curing cycle is more productive of good results than the same amount of time in the soaking period.

Where heavyweight aggregate is used, a maximum curing temperature of 160 to 165 deg. F. will usually be sufficient. With lightweight aggregate a maximum temperature of approximately 170 deg. F. will be ample.

With well insulated curing rooms, the steam can be shut off immediately after the maximum temperature has been reached, if the velocity of the steam is sufficient to yield a uniform maximum temperature through the kiln.

The steam should be exhausted at the end of the soaking period of approximately 12 hours, at which time the temperature, in a well constructed kiln, will have dropped to approximately 120 deg. F.

After exhausting the steam from the kiln, it is again closed tightly. The block should be held as long as possible in the kiln before yarding.

An outline of the details of this series of tests and compression results made by the author is to be found in Report #39, issued January 13, 1953 and Report #47, issued May 28, 1954 by the National Concrete Masonry Association.

## Section 11—Drying and Storage of Concrete Block

It has been found by test that shrinkage of concrete units is one of the major causes of cracking in block walls and that such shrinkage of units depends to a great extent on the moisture content.

The ever increasing demand for concrete block with a low moisture content (40 per cent or less of its total absorptive capacity), is causing block manufacturers to give more thought to the problem of satisfactorily drying the units and to provide the facilities for the removal of excess moisture.

At the end of the steam curing cycle the block are saturated with moisture to approximately 70 per cent of their total moisture capacity. It is from this condition that the block must be dried to meet a specified moisture requirement.

Specifications of the Federal Government and the American Society for Testing Materials limit the moisture content at time of delivery to 40 per cent of the total absorptive capacity of the units. The U. S. Corps of Engineers asks for a further reduction to 30 per cent in moisture content. This is a considerably stiffer requirement than that of the Federal Government and A.S.T.M. specifications.

To meet the 30 per cent or less moisture requirement some manufacturers may have to introduce new techniques and equipment to accomplish this end. Some now produce block of this type with the equipment they have. Some go even less than the 30 per cent content. It is a matter of proper procedure and equipment to do the job.

Most manufacturers will have to add some additional steps to those they now take. It may mean some additional equipment and extra handling of the block. Covered storage areas may have to be provided, especially for units which are to be delivered to a job where the more rigid specification is being enforced.

Tarpaulin protection should be used during truck delivery and also on the job in wet weather. As the units dry from 100 per cent absorption to equilibrium with normal air humidity, the units shorten. It is apparent that a block has only shrunk a small fraction of its potential total shrinkage when dried to a 40 per cent moisture content.

When a unit has dried to 40 per cent, there is still considerable drying and shrinkage which may occur before the block meets equilibrium with the air at 75 per cent relative humidity. This represents a 20 per cent moisture content. In order to reach equilibrium with 50 per cent relative humidity, considerably more shrinkage occurs. This latter is a humidity condition which is likely to exist in warm heated buildings. From these observations it appears that even less than 20 per cent moisture may be necessary to obtain best results.

There are several methods of treatment used to remove moisture from cured units.

1. Drying is commenced immediately following curing while the block are still in the kiln.
2. The units after curing are removed from the kiln and subjected to a period of normal air-curing and drying in the yard, preferably under cover.
3. The units after a normal air-drying period may be returned to dry, heated kilns for further accelerated drying at elevated temperatures.
4. The units after normal air-drying may be subjected to accelerated drying either in cube form or in stockpiles, in the yard or at the job.

At plants where accelerated drying has been adopted in order that block will comply with dryness requirement specifications, the technique of such procedures has been set up into what may be termed a 2 or 3 step curing-drying operation.

In the 2 step operation the units are cured and drying is commenced immediately following while the block are still in the kiln.

The 3 step operation consists of (1) regular curing technique followed by (2) a period of normal air-curing and drying in the yard, preferably under cover, with a (3) final accelerated drying period at an elevated temperature applied either in dry, heated kilns to which the block have been returned for the purpose or in stockpiles, or cube form.

Where units are dried before removal from the kilns several important factors must be considered.

1. The units must have attained sufficient strength during the steaming and soaking periods since little gain is likely to occur after drying. Exposing improperly cured block to the effects of dry heat for an appre-

ciable length of time may reduce the compressive strength besides introducing other harmful effects.

2. Unless certain precautions are taken during the drying period, the units may be damaged.

Theory of Kiln-Drying Units—The method involved in the successful kiln-drying of units must be determined for each plant. In the design of a drying system, the thermodynamic properties of moist air must be considered.

To remove moisture naturally and efficiently from a masonry unit the vapor pressure of the moisture in the concrete must be higher than the vapor pressure of the surrounding air. In other words, the relative humidity of the air must be sufficiently low to extract water from the surface of the unit by evaporation.

Theoretically, when air is passed over a saturated unit, evaporation of the surface water takes place. The removal of the surface water will continue at a constant rate, so long as the water in the unit comes to the surface rapidly enough to keep the surface of the unit thoroughly wet.

The constant rate period continues until the moisture ceases to come to the surface as fast as it is evaporated. This point is termed the critical moisture content in the drying process. During the constant rate period, the velocity of the air stream must be at such a rate of flow that the surface moisture will not be removed at a greater rate than the movement of the water from within the unit to its surface.

As the process continues, the surface of the unit gradually drys out, thus the rate of moisture removed decreases at a uniformly falling rate, as the wet surface decreases in area.

As the surface becomes thoroughly dry, the water in the interior of the unit is transformed into a vapor and comes to the surface in that form.

The drying continues until the vapor pressure in the block equals the vapor pressure in the air. This is the point of equilibrium at which point drying ceases for a specific kiln condition.

Raising the temperature of the passing air will decrease the viscosity of the water and increase the drying rate. Increasing the drying temperature above 221 deg. F. will cause a loss of chemically combined water, which in turn will be detrimental to the units.

The use of excessively heated air, or an excessive velocity of the air stream, or both, may cause too rapid an elimination of the surface moisture, which causes a hardened surface to form on the block. This hardened surface retards the flow of moisture from the interior to the surface of the block, thereby tending to increase the drying time.

Natural Drying—When units are removed from the kiln in a damp condition for drying out-of-doors, with or without cover, a sufficient curing-drying period should be allowed. This drying period ranging from 14 to 28 days or longer, will generally, under favorable atmospheric conditions bring the units to a 40 per cent moisture specification.

Such drying out-of-doors will allow the units to reach a higher strength than would have been possible, had the units been dried in the kiln immediately after the steam curing cycle. Such slow curing-drying tends to bring the units to an equilibrium with the atmosphere.

Figures 26 & 27 show the arrangement for stockpiling units in order to obtain a flue effect.

In localities which experience heavy rain or snow combined with freezing temperature it is advisable to protect the block against freezing. This can be accomplished in several ways with varying degrees of success depending upon the extent to which the plant operator wishes to carry the protection.

If the block are piled in the open it is advisable to turn the top layer of block sidewise so that the cells are horizontal. Wood strips should be used to separate the top layers. This arrangement permits of a free circulation of air throughout the pile. As a further precaution it is advisable to cover the top of the pile of block with heavy roofing paper or tarpaulin.

Piling block in an orderly and predetermined fashion will result in less time being required for drying.

Accelerated Stockpile Drying—Accelerated drying in the stockpile involves the use of some form of portable heater and a canvas cover.

There are several forms of portable heaters on the market which will produce satisfactory results.

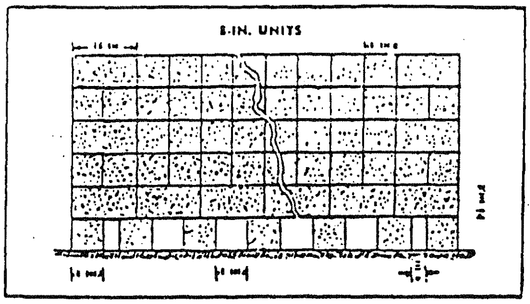

Figure 26. Method of block storage to obtain flue effect, 8-in. units.

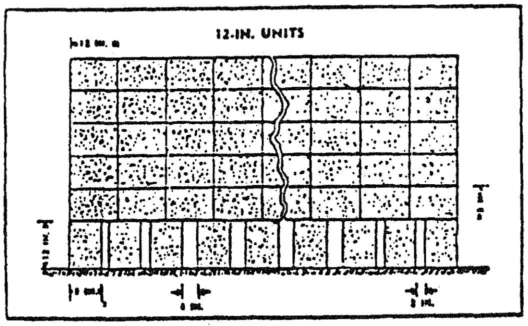

Figure 27. Method of block storage to obtain flue effect, 12-in units.

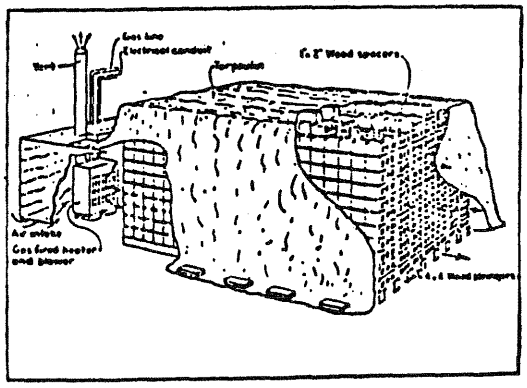

Figure 28. A suggested Method for Drying Concrete Block.

Figure 28 illustrates the fundamentals of a drying system for block.*

The block are stacked with the cores laid horizontally in front of the heater, thus permitting the warm air to circulate freely through the pile.

The block courses are separated by 1 x 2 in. wood strips laid horizontally between the layers. The vertical tiers of blocks are spaced 1 in. apart to permit of the free circulation of air around each unit.

As a trial set up, a stack of 4 block wide, 6 courses high and 16 ft. long is suggested. The stack of units is enclosed in a frame work 6 in. higher, 12 in. wider and as long as the stack itself plus the length of the heater. The frame work is then covered by a light tarpaulin which concentrates the direction of flow of the heated air.

This method of drying is adaptable to indoor or outdoor use and may even be used on the job site. After drying, the units when stored on the job site should be

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* From P.C.A. Handbook of Concrete Masonry.

protected from rain or snow.

Handling and Storage of Units—The method of handling and storage of block is governed by a number of factors among which are the following:

1. Economic considerations or the ability of a company to finance an investment in labor saving equipment and modern storage facilities.
2. Labor market.
3. Climatic conditions.
4. Type of Curing adopted.
5. Adherence to specifications relative to moisture content of block as delivered.

It is evident that paved storage yards or runways will expedite the safe handling of concrete block in all seasons of the year. Covered storage is also desirable, particularly in sections of the country were much rain or snow prevails.

Labor saving devices such as air hoists, lift trucks, and cubing equipment are already an integral part of many modern concrete product plants.

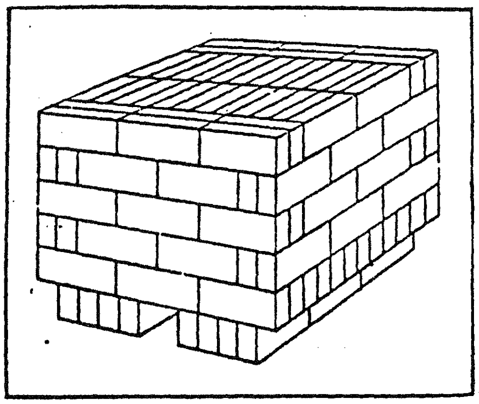

Figure 29. Method of cubing 4-in. block, 204 units.

Cubing Concrete Units—During the past few years, the use of lift trucks has spread to the block manufacturing industry where the machines afford a very efficient means of handling a number of block at one time. The usual shape of the stacked block to be lifted is in the form of a 4 ft. cube. Such a cube may contain as many as 204 4-in., 102 8-in. or 56 12-in. block. Figures 29-30-31 show typical cubes of 4-in., 8-in. and 12-in. block.

The original lift trucks were provided with fingers or tines which entered the cores of the bottom row of block.

Block manufacturers soon learned that besides requiring considerable time to line up the cores of the block with the fingers of the lift truck, there was the possibility of damaging the interior webs of the bottom row of block.

As a result of this experience lift truck manufacturers

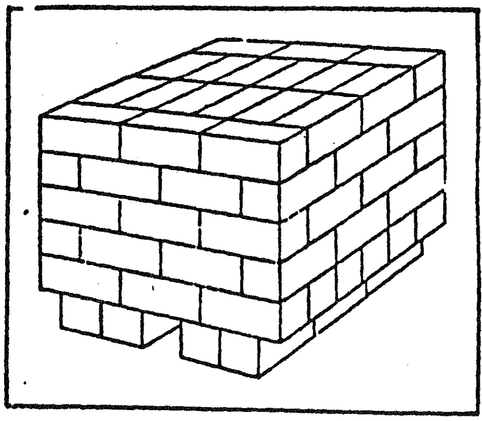

Figure 30.* Method of cubing 8-in. block, 102 units.

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* From Schmidgall Mfg. Co. Advertising Catalogue.

developed a method of carrying the load in the form of air expanding forks.

Each fork has pneumatic tubes on both sides of the forks. These tubes are expanded by compressed air supplied by a compressor on the lift truck. Treads on the expanding tubes effectively grip the adjacent block by side pressure.

When the air expanding fork is used, either two or three rows of block can be used as a base for the cube.

When two rows of block are used, the 16-in. length of the block is laid at right angles to the length of the forks and when three rows of block are used, the 8-in. dimension is laid at right angles to the length of the forks.

The original type of lift truck produces a cube which greatly restricts the movement of air through it, because the bottom layer of block, laid with the cells horizontal prevents adequate flue effect.

With the expanding fork type of lift truck a ventilated cube with continuous flue action for air movement through the cores of the block is obtained. Types of cubes are shown in Figure 32.

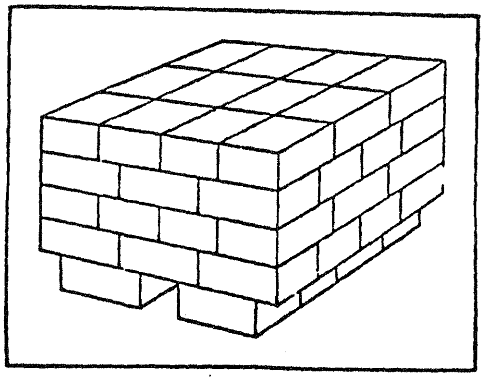

Figure 31. Method of cubing 12-in. block, 56 units.

It is a fundamental requirement in drying block

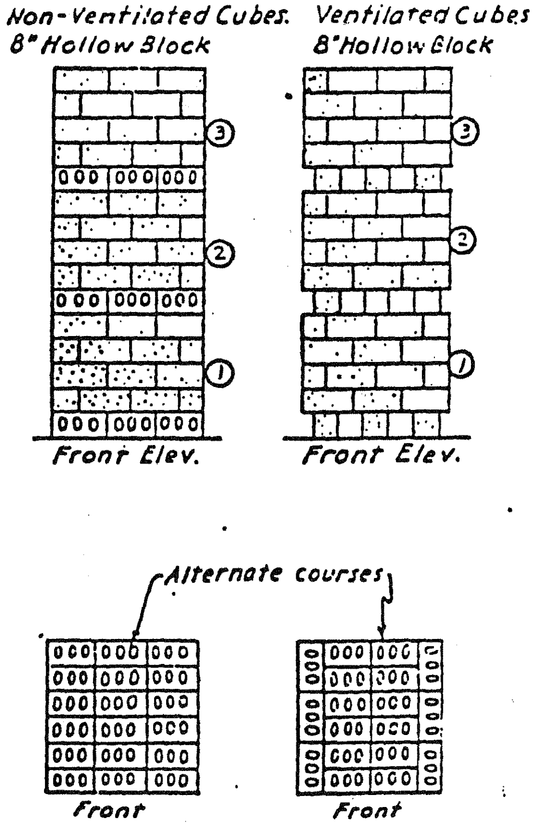

Figure 32. Forms of non-ventilated and ventilated cubes—3 core 8-in. block.

either by natural or artificial methods that a maximum surface area be exposed to an adequate air movement in order to obtain best results, otherwise drying of the block will be extremely slow.

Ventilated cubes permit of air movement through the cores of each stack, thus hastening the interior drying action.

With non-ventilated cubes the air is more or less stagnant, therefore, its capacity for carrying off moisture is negligible.

The stacks of cubes should be separated for a distance of 8 to 12 inches from each other. This permits of air movement around each stack, thus hastening the drying action which is impeded if the cubes are piled tight against each other. The length of time required to bring the moisture content of the units down to 40 per cent or less of the total absorption is greatly extended.

The capacity of moving air to carry away moisture is a well established fact. The drier the air and the greater its volume and velocity, the more effective it is.

The drying rate will be greater when the temperature of the air and concrete is high and the relative humidity of the air is low.

Some block manufacturers use pallets of wood on which to lay the cubes but there are several valid objections to their use, such as cost of maintenance and handling of pallets to and from the job.

Whether or not to cube in a concrete block plant will depend on the plant layout and also on the type of delivery equipment and method of unloading. Where large loads are used, cubing is proving to be economical. On long hauls it has been found desirable to lash the cubes to the truck so as to prevent shifting of the load.

Where new plants have been designed to take advantage of the savings derived from cubing, it has been found desirable to enlarge the space in front or in back of the block machine to make room for a cubing area. In such cases, the cured block are brought directly to the cubing area and the empty racks are then located close to the block machine. In mechanizing a block plant, cubing or palletizing should be given serious consideration because

1. It eliminates excessive handling of the racks.
2. It minimizes lift truck movement.
3. It speeds yarding of the units.
4. It saves yard space.
5. It speeds loading.

Block Drying Kilns—The growing emphasis by architects, engineers and city Building Departments on the limitation of moisture content in concrete block, has caused many manufacturers to seriously consider methods of reducing the moisture content of masonry units as delivered to the job.

These methods are usually covered storage or block drying kilns. Covered storage has been used with success for many years to bring block down to 40 per cent of total absorption when weather conditions are favorable.

If specifications call for a moisture content lower than 40 per cent, special drying kilns should be seriously considered.

## Section 12—Cracks in Block Walls

With the increased use of concrete units in large as well as small buildings, the many advantages possessed by this type of masonry construction are sometimes offset by the characteristics inherent in concrete.

The occurence of unsightly cracks in walls is the concern of each individual manufacturer, as well as the industry at large.

That this condition warrants careful consideration is attested by the fact that several national technical organizations have taken cognizance of the situation

and have adopted standard specifications for Hollow Load Bearing Masonry Units. These specifications limit the maximum moisture content to 40 percent of the total absorption at the time the units are delivered to the job.

Progressive manufacturers also realize the seriousness of the situation and are endeavoring to overcome the problem by means which will not greatly change present manufacturing methods or increase the cost of concrete block construction.

Most of the causes for cracks in walls are beyond the responsibility of the block manufacturer; except insofar as his product is properly cured and dried, and is of sufficient strength to meet all standard requirements.

Concrete masonry structures marred by cracking indicate that there are various causes which may be responsible for the condition. Cracks may be produced by any one or a combination of the following factors.

(1) Uneven settlement of the foundations; (2) poor workmanship by the mason; (3) construction carried on under unfavorable weather conditions; (4) back filling too soon; (5) overloading the structure before the mortar in the walls has hardened properly; (6) improper design at openings and points of concentrated load; (7) volume change due to temperature and moisture.

If masonry units are laid up in a wall before they are approximately air dried tensile stresses will develop wherever the wall is restrained from shrinking and cracking may be expected.

During the production cycle, the volume of a masonry unit changes. It expands during the steaming period and contracts while it is drying. Therefore, the unit cannot be considered a finished product until the moisture content is reduced to meet the desired specifications.

The manufacturer should endeavor to supply block complying with the present recommended specifications which limit the moisture content at time of delivery.

Some specifications call for a maximum of 40 percent of the total absorption. In considering the term moisture content, this is construed to mean moisture content in terms of total absorption of the unit.

When a specification requires that a unit have less than 40 percent moisture content, it does not mean that the moisture in the block weighs 40 percent of the total weight of the block; it means 40 percent of the total absorption of the block.

In order to lessen the tendency of wall cracking in Government projects the U. S. Corps of Engineers has specified that concrete units as delivered on the job should have a moisture content not exceeding 30 percent of total moisture absorption.

To meet the 30 percent moisture content limitation in areas where the average relative humidity exceeds 70 percent, the manufacturer will probably have to have a minimum of 30 days under cover, drying in loose cubes or specially built artificial drying kilns.

In hot dry climates it may be possible to meet a moisture limit below 30 percent without special drying facilities.

A considerable amount of experimental work has been done in recent years, particularly by Carl Menzel of Portland Cement Association on a method of determining the dryness of a concrete unit by a so-called Relative Humidity Method.* It is possible that this method may some day supersede the present method for determining the relative dryness of various units.

In some areas in the United States the 40 percent moisture limitation will probably be adequate, especially where the relative humidity of the air does not average less than 60 to 70 percent. Where the relative humidity averages less than this amount, it would be desirable to deliver the units with moisture content as low as 25 to 30 percent of the total absorption of the units.

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* For details of method see Concrete, October, 1956.

Some manufacturers have been producing sand-gravel units from graded aggregate so as to obtain a total absorption of 5 percent of the total weight of the unit, compared with Standard Specifications which allow a maximum water absórption of 15 lbs. per cu. ft. for sand-gravel units, or approximately 10 percent. It means that these manufacturers are producing units with half the allowable total moisture absorption.

There are two schools of thought as to what is the true measure of the moist condition desired in a concrete masonry unit.

I. One school contends that moisture content as a percentage of the total absorption is logical.

II. The other school advocates that the actual volume of water in the unit is a better method of evaluation.

This poses a question—Is the moisture content as expressed by current specifications a true measure of the condition desired in a concrete masonry unit?

Practically all specifications are based on the premise that volume change is related to the percent of moisture in a unit when delivered on the job as compared to the total absorption of a unit.

Volume change or drying shrinkage of concrete units is a function of their moisture content which is subject to gain or loss of moisture. Conditions of curing and drying should be such that the moisture content be related as closely as possible to the atmospheric conditions under which they are laid in the wall.

The results of a series of tests on cinder concrete block taken directly from the racks after removal from the kiln and immediately weighed for the determination of absorption and moisture content are as follows:

The averages of tests are:

| | Average | Range |
|---|---|---|
| Total Absorption — lbs. per cu. ft. | 7.86 | 9.60 to 7.10 |
| Moisture Content — lbs. per cu. ft. | 4.38 | 5.25 to 3.95 |
| Moisture Content — percent of total absorption | 56.00 | 67.00 to 50.00 |

The absorption determinations were all within specification limits, whereas the moisture content percentages were above maximum requirements. This indicates that the block would have to be dried either naturally or by artificial means in order to meet Standard Specifications.

It would seem then that the amount of water contained in the unit would be the factor controlling shrinkage rather than the percent of moisture content. A specification limiting moisture to 4.5 lbs. per cubic ft. which is equivalent to 30 percent moisture content as per specifications, would be more practical.

It has been found that block made from lightweight aggregates have a considerably higher total absorption than block made under the same manufacturing conditions using heavyweight aggregate.

Recent tests indicate that volume change of block made from heavyweight aggregate have about one-half the volume change of a block made from lightweight aggregate. This would indicate that the volume change is more likely due to the actual amount of water in the unit than on the percentage of total absorption.

This idea is the thinking of the second school of thought regarding moisture and volume change.

As more factual data is accumulated on the relationship of volume change to moisture content in concrete units, it is reasonable to assume that standard specifications will then be amended to meet the conditions.

A factor which the manufacturer must consider carefully if he is to produce a product which will meet specifications is the use of well graded and proportioned aggregate to obtain maximum strength of unit for the amount of cement used.

Another factor in the resistance of concrete block walls to volume change is the thickness of the face shell and webs. In an effort to obtain lighter weight units, there has been a tendency to decrease the face shell and web thicknesses, thereby reducing the effective mortar bedding and also the tensile strength of

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the unit. Some manufacturers, in order to overcome this reduction in strength, have found it desirable to have a thicker face shell at the center core of the three-cell unit than in the end cores. Increasing the thickness of the face shell at this point adds strength to the section of greatest stress.

Walls constructed of concrete block like other walls are affected by temperature changes from summer heat to winter cold. The movement induced by these variables may be considered as a normal condition.

When laid up in wall structures, units are subjected to compressive and tensile stresses due to temperature and moisture changes. This is in addition to stresses due to loads to which the units are subjected. Since concrete is approximately 10 times as strong in compression as it is in tension it is quite evident that tensile stresses induced by shrinkage are more destructive than compressive stresses due to expansion.

These stresses causing contraction or expansion are due to temperature changes and wetting or drying, which may occur simultaneously. It has been found by experiment that shrinkage or expansion of the units due to temperature changes is more serious than changes caused by variations in the moisture content.

Figure 33 shows the approximate change in length of a wall 100 ft. long for various moisture content changes.

In a concrete block wall 100 ft. long, the theoretical movement caused by a variation in temperature of 100 degrees F. is approximately ⅝ in.; while the drying shrinkage from the time the blocks are laid in the wall until they attain moisture equilibrium with the air, seldom exceeds ⅜ in.

Various methods of minimizing these changes in the structure may be accomplished by introduction in the walls of control joints, reinforcing, or bond beams which are free to move.

When the units are laid up air dry, their moisture volume change due to rewetting from rain generally does not exceed more than ⅛ in. per 100 ft. of wall. This subsequent moisture volume change occurs gradually and tends to diminish as the concrete units age.

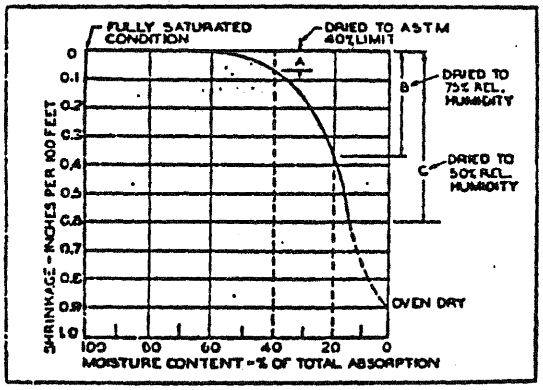

Figure 33. Relationship between moisture content and extent of shrinkage.

The following factors from Mr. R. E. Copeland's paper* to which the manufacturer should give strict attention are:

1. The use of sufficient cement to insure block compressive strengths which safely exceed the ASTM requirements. In general, the stronger the concrete the greater will be its resistance to cracking.
2. Where possible, adjust the gradation of the aggregate to give maximum strength consistent with a reasonable yield and surface texture desired.
3. Sufficient length of curing time regardless of the type of curing.
4. Reduce the moisture content of the block to equil-

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* "Problem of Shrinkage Cracking" by R. E. Copeland, N.C.M.A. "Relation of Shrinkage to Moisture Content in Concrete Masonry Units"—Housing Research, Paper 25.

ibrium with the air or to 40 percent of the total absorption.

5. Retain present face-shell thicknesses. If additional cracking resistance is required, consider thickening the face shells.

Control Joints*—Control joints are advocated to prevent irregular and unsightly cracks which may occur in walls. Such joints relieve contraction and other stresses, and provide a continuous vertical separation through the wall.

Built in control joints are less costly to install than is the cost of patching or repairing irregular cracks once they have made their appearance in a wall.

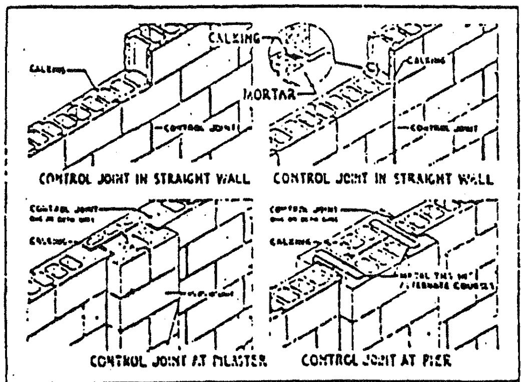

Figure 34. Various Forms of Control Joints.*

Control joints in exterior walls should be provided at approximately every 20 to 25 feet and never over 50 feet apart. Thus a wall of any length becomes a series of separate panels. It may be desirable to add horizontal reinforcements to strengthen the panels, but such reinforcements will not prevent stresses which cause cracks. Horizontal reinforcement should not be carried from panel to panel.

Control joints may be either staggered, that is following the mortar joints or vertical in which case the joint is a straight line.

In building control joints, units are laid in the wall in the usual manner, after which the mortar at the control joint should be raked out to a depth not less than ⅝ in. after the wall is finished. The joint is then caulked with an elastic compound matching the color of the mortar used. Control joints are advantageous at pilasters and piers. They are also very effective in the wall as a continuation of the sides of doors and windows.

Another form of control joint construction shows a joint intended to give lateral stability to the wall and to provide a continuous vertical separation through the wall.

The simplicity of construction of the joint is emphasized by the fact that it is composed of materials normally found on masonry jobs. No special shape of unit is required and the laying time is on a par with a wall without control joints.

Figure 35 outlines the details of construction produced from regular type units. The mortar mix from which the joint key is made may be the same as that used in the vertical and horizontal joints of the wall.

If lateral stability is not a factor in the design of the control joint, the same section may be used without the mortar or concrete key.

Experience in Michigan and other sections of the country having similar climatic conditions indicates the necessity for placing control joints in exterior concrete masonry walls at approximately 25 foot intervals.

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* See Concrete Masonry Construction Details, N.C.M.A.

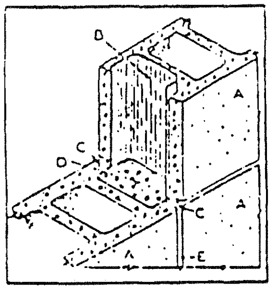

Figure 35. Form of Control Joint for Lateral Stability.**

The details of this form of control joint follow:

A: Indicates units of both wall sections of concontrol joint.

B. Building paper or a coat of asphalt paint may be substituted for building paper if desired. It is recommended that one side of the control joint be built to approximately 6 courses in height at a time, to receive the building paper.

C. Joint treatment the same on both sides of the wall.

D. Then lay opposite unit and fill key one course at a time to complete the control joint. On one section of wall a bond between the concrete masonry and key material is provided. The approximate width of the concrete mortar key provided, when 8-in. and 12-in. units are used is 5-in. and 8½-in. respectively.

E. After contraction has taken place any mortar in the control joints is raked out to a depth of at least ⅞ in. after which the joints are filled with caulking or self-expanding joint material.

Horizontal Reinforcement***—There are several types of steel reinforcement systems, under various trade names, on the market. These systems of reinforcement come in prefabricated form and are dimensioned for use in walls of varying thicknesses and in lengths suitable for easy handling on the job.

A new type of reinforcement has been developed. It consists of two 3/16 in. wire stretchers held apart by means of cross ties of #9 wire. The stretcher members are deformed on opposite sides and on top and bottom the wire is knurled. Tests have shown that this form of reinforcement has advantages over systems with stringers of plain round bar stock. A better bond is obtained between the concrete and steel thereby eliminating the possibility of slippage likely to occur when plain bar stock is used.

Reinforcement placed in mortar joints between the courses of units, provides a relatively inexpensive means of strengthening masonry walls and aids materially in the distribution of stresses. Placing horizontal reinforcement above and below openings in masonry walls is recommended.

The frequency with which it is placed in unbroken sections of the wall will, in general, be determined by the type of construction, the loading conditions and by other requirements for strength and durability.

### Section 13—Prefabricated Floor Systems

Prefabricated concrete floor and roof systems have been in use for a number of years but within the past 10 years considerable development has taken place in this field.

Floor systems utilizing concrete units as filler or soffit block are absorbing a considerable volume of present day block production. Many block manufacturers have invested heavily in new buildings and special equipment for the manufacture and erection of floor systems.

Concrete masonry floor systems are a definite part of modern construction, and the use of machine made units in such systems is becoming increasingly popular. This is due to the savings in initial cost and speed of erection when compared with other firesafe construc-

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**See Concrete Masonry Construction Details—N.C.M.A.

***See "Concrete Masonry Construction Details"—N.C.M.A. See "Block Can't Be Blamed For All Cracks"—D. L. Cheney—Concrete, Dec. 1951.

tion methods. In fact, some of these floor systems are economically competitive with non-firesafe construction.

Basically, there are two types of concrete floor systems. One is the hand placing of machine made units on the job, the other is the plant fabrication of the units into job required slab lengths.

The plain type of floor system is developed on the job by the use of shores, setting the units by hand on the shoring, laying the design specified reinforcing steel and placing the required thickness of concrete. the end result is a joist-tile floor system.

The machine made concrete units ordinarily used are either the filler block or soffit block.

The filler block units are usually placed on the shoring centers at such a distance apart as to provide a sufficient width concrete joist. In the space for the joist, reinforcing is placed depending on the load and span. Concrete is then poured between the rows and also on top of the filler block. The resultant floor is a closely knit joist and filler block system which has maximum strength.

The soffit block construction is a modification of the filler block type floor.

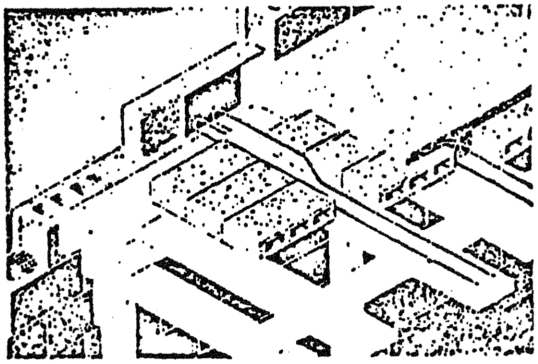
It helps to produce an exposed ceiling of continuous masonry because the soffit is so formed as to provide a thin shell of concrete masonry under the concrete joist.

When placed end to end the proper width of joist is obtained automatically at 21 inch centers. Both types of floor can be obtained in thicknesses from 4 to 12 inches. The variation in depth of unit and the resultant depth of beam permits a wide range in superimposed loads and span length.

**Plant Prefabricated Types**—Another basic type of floor system is plant fabricated and consists of machine made units with contact faces precision ground and assembled into slabs or planks to lengths required for any specific project.

The important factor in this type of floor system is to provide planks that will conform to the plans and working drawings. The system is prefabricated in lengths to cover the required span and bearing specified. Any variation in the dimensions plus or minus from the plans could result in serious difficulty because in neither case can a satisfactory adjustment be made on the job site. Too much emphasis cannot be placed on the accuracy of construction in conformance with the plans.

Following are brief outlines along with illustrations of several of the popular floor systems.



* Figure 36. Plain Type Concrete Block Joist Floor.

**Dox Block System**—The Dox system is prefabricated from units of special design with two semi-circular, 1½ inch deep grooves in the tension side of the block. The units are 16 inches long by 6 inches deep and cast with a groove on one end and a tongue on the other so that, when assembled, a tight mechanical interlock is obtained.

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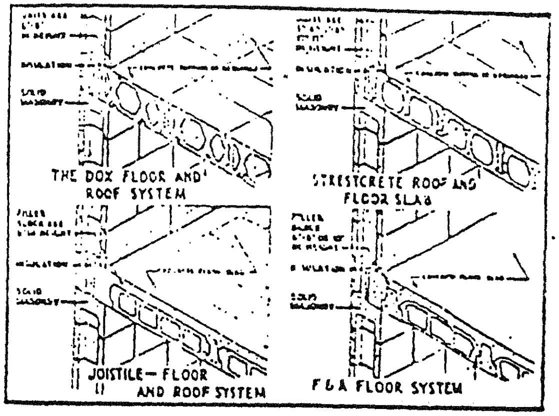
* Concrete Block Joist Floors — Portland Cement Association.



** Figure 37. Typical Roof and Floor Systems.

The blocks are run through a precision grinder and assembled into plank of the desired length. The assembled block are drawn into alignment by a threaded tension rod, run through the center of the plank and drawn tight. In the manufacturing process reinforcing rods are placed in the grooves at the top of the plank. Tension rod plates are placed at each end and the requisite amount of tension is then applied to the assembly.

The top of the plank as manufactured becomes the bottom of the plank when installed on the job. The reinforcing rods then act in tension as in normal practice.

A mixture of concrete grout is poured in each groove, after which the entire assembly is vibrated to provide a good bond between the grout, the rod and the block.

After an adequate curing period the tension rod plates are removed. The planks are carefully inspected before shipment. The full load carrying capacity of the plank is developed by the addition of a concrete topping thoroughly bonded into the block and forming a rigid structural plank.

**F and A System**—This system is a combination of precast concrete joists and filler blocks in conjunction with a poured in place concrete top slab. The basic priniple of this system introduces a hollow block as a void filler to reduce the dead weight of the slab construction. The concrete top slab is poured so that the upper portions of the joists are embedded in the concrete to develop the necessary bond to produce "T" beam action in the joists.

**Flexicore System**—In this system the primary units are 6 inches high, 12 inches wide with varying lengths. These units are reinforced and have 2 cores each 4⅜ inches in diameter. The cores are produced by collapsible hollow rubber tubes.

The top and bottom reinforcing rods, threaded at both ends are held in a fixed position by means of steel stirrups. The rods between the bulkheads are subjected to a tension of 16,000 p.s.i. by means of a special torsion wrench adjusted to apply the requisite amount of tension to the assembly.

When installed, the side grooves in the slab provide a key for the grout applied during construction. The bond created by the grout between the adjacent units helps to form a continuous flat slab 6 inches in depth.

**Joistile System**—The Joistile system was developed to minimize the use of expensive form work and shores in the construction of concrete floors.

The filler tile used in this system consists of four core units, 5⅝ x 7⅝ x 24⅝ inches, of special design and made from some form of lightweight aggregate. The precast concrete joist of the "T" section is 6 inches in depth and is reinforced by top and bottom bars with connecting stirrups. All of the reinforcing is electrically welded into one unit.

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** Concrete Masonry Construction Details — National Concrete Masonry Association.

The complete assembly consists of the joist, the block or filler tile, and a concrete slab which together make a floor thickness of 8 inches.

Stresterete System—In this system the units have a surface area measuring 7⅝ x 16 inches. They have a depth of 4, 6, 8, 10 and 12 inches depending on the intended span and designed superimposed load. Manufactured from heavy or lightweight aggregates, units are steam cured and yard dried for a minimum of 28 days.

They are then precision ground so that the contacting faces of the adjoining units will have complete and uniform bearing. Planks are assembled from units with steel washers at the end of each assembly. Threaded reinforcing rods are placed in the side splines of the units and through the end washers. Tension not exceeding the allowable working stress of the reinforcing rods is applied by hydraulic jack or torque wrench.

Floor Systems—The promotion and successful application of these various floor systems depend upon the employment of engineering principles and tests throughout all phases of manufacturing technique. In order to obtain approval by building departments each system must be considered upon its load carrying characteristics.

Prestressed Concrete Units—Another field open to progressive manufacturers alert for new products or new uses for units which may be produced on high production block machines is that of prestressed construction.

Prestressing or post-stressing concrete units opens up new fields in the fabrication of bridges, buildings, stadiums and other structures. Structures using prestressed concrete and concrete block in the form of beams strung together on wire cables and then stressed are now in demand.

Up to a few years ago prestressed concrete in the United States, had to be justified from an engineering standpoint. It has passed from this phase and since it is a practicable competitive method it frequently offers the advantage of speedy erection.

As more field experience is gained in prestressed concrete construction, its competitive position will be improved, especially from the cost standpoint.

## Section 14—Specifications and Testing

Federal Government and American Society for Testing Materials specifications outline the performance requirements which must be met by hollow load-bearing masonry units; namely, strength, moisture content, and absorption.

Federal Government specifications outline the minimum compressive strengths for units of specific face shell thickness.

The ASTM Specifications C 90-52 also sets up two grades but in a more specific manner.

Grade A units for use below grade or for unprotected exterior walls above grade should have a compressive strength of 1,000 psi of gross area.

Grade B units for general use above grade where protected from the weather by two coats of portland cement paint, or other satisfactory waterproofing treatment, must have a compressive strength of 700 psi of gross area.

Grade A units are limited in total water absorption to not more than 15 lb. (Federal Government, 16 lb.) per cubic foot of concrete. When delivered the block must not have a moisture content of more than 40 per cent of the total absorption.

Grade B block are required to meet the 40 per cent moisture content requirement only.

Following is an outline of the Federal Government Specifications SS-C-621 and details for conducting the tests.

E1-A. Load bearing units shall meet these compressive strengths when tested according to Section F2-A.

| Minimum Thickness of Shells | Compressive Strength, psi |
|---|---|
| 1¼ in. or more | 700 lb. |
| ¾ in. to 1¼ in. | 1000 lb. |

In determining the minimum thickness of the shells, only the outer parallel shells of the units shall be considered.

E1-B. The absorption shall not exceed 16 lb. per cubic foot of concrete when tested as in F2-B.

E1-C. The average percentage of moisture in units at time of delivery shall not exceed 40 per cent of the total absorption of the units when tested as in F2-C.

F2-A. Compression test—regular routine.

F2-B. Absorption test:

F2-B-1. Units shall be weighed then dried to constant weight. They shall then be immersed in water at room temperature for 24 hours.

F2-B-2. The units shall then be weighed while suspended and completely submerged in water. They shall then be allowed to drain for 60 seconds by placing on a ⅜ in. or coarser mesh and immediately weighed in air.

F2-B-3. The weight and absorption per cubic foot of concrete shall be calculated as follows:

Weight in lb. per cu. ft. of concrete =

$$\frac{62.4 \times A}{B - C}$$

Absorption in lb. per cu. ft. of concrete $= \dfrac{62.4 \times (B - A)}{B - C}$

Where A = Dry weight of unit in lb.
B = Wet weight of unit in lb.
C = Weight of unit suspended in water in lb.
D = Weight of unit as delivered in lb.

F2-B-4. The total absorption referred to in E1-C is calculated thus:

Total absorption, per cent =

$$100 \times \frac{B - A}{A}$$

F2-C. Percentage of moisture in units as delivered is the difference between the weight of the units as delivered (D) and the dry weight (A) as determined in F2-B divided by the dry weight (A) and multiplied by 100. Then the per cent of moisture as delivered, divided by the per cent of total absorption, gives moisture as delivered in relationship to the total absorption.

A typical example of computation with lightweight aggregate is as follows:

A = Weight of unit dry = 27.81 lb.
B = Weight of unit saturated = 30.87 lb.
C = Weight of unit suspended in water = 13.20 lb.
D = Weight of unit as delivered = 29.27 lb.

24-hr. absorption, per cent $= 100 \times \dfrac{B - A}{A} =$

$$100 \times \frac{30.87 - 27.81}{27.84} = 10.88\%$$

Moisture as delivered, per cent =

$$100 \times \frac{D - A}{A} = 100 \times \frac{29.27 - 27.84}{27.84} =$$

5.136%

Moisture content (% of total absorption) =

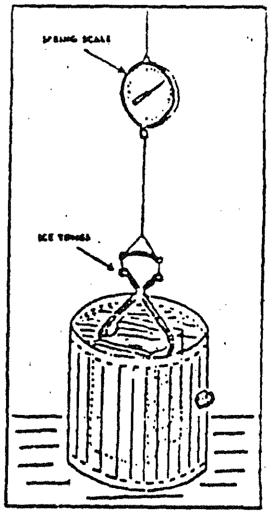
$$\frac{\%\ \text{Moisture as delivered}}{\%\ \text{Total absorption}} = \frac{5.14}{10.88} = 47.25\%$$

$$\text{Weight per cu. ft. lb.} = \frac{62.4 \times A}{B - C} =$$

$$\frac{62.4 \times 27.81}{30.87 - 13.20} = \frac{1737.21}{17.67} = 98.31 \text{ lb.}$$

$$\text{Absorption per cu. ft., lb.} = \frac{62.4 \times (B - A)}{B - C} =$$

$$\frac{62.4\,(30.87 - 27.81)}{30.87 - 13.20} = \frac{189.07}{17.67} = 10.70 \text{ lb.}$$



Method of Obtaining Suspended Weights—Fig. 38, which is self explanatory, outlines the details of the arrangement of a scale for obtaining the suspended weights. Other types of scales, however, may be adapted to the requirements if it is more convenient to use them.

In the procedure outlined for making the tests, all weights are recorded in pounds and hundredths of pounds. The conversion Table XVIII shows weights in ounces and fractions of ounces and their decimal equivalents. Viewing the situation from the block producers standpoint, there is nothing onerous about meeting the specifications set forth for his guidance. He should endeavor to produce a quality product which will be a credit to his reputation, thereby helping to advance the interests of the block industry at large.

TABLE XVIII—OUNCES AND FRACTIONS TO DECIMAL EQUIVALENTS

Ounces and Fractions to Approximate Decimal Equivalents

| Ounces | Decimal Equivalent | ¼ oz. | ½ oz. | ¾ oz. |
|---|---|---|---|---|
| | | .02 | .03 | .05 |
| 1 | .06 | .08 | .09 | .11 |
| 2 | .12 | .14 | .15 | .17 |
| 3 | .18 | .20 | .21 | .23 |
| 4 | .25 | .27 | .28 | .30 |
| 5 | .31 | .33 | .34 | .36 |
| 6 | .37 | .39 | .40 | .42 |
| 7 | .43 | .45 | .46 | .48 |
| 8 | .50 | .52 | .53 | .55 |
| 9 | .56 | .58 | .59 | .61 |
| 10 | .62 | .64 | .65 | .67 |
| 11 | .68 | .70 | .71 | .73 |
| 12 | .75 | .77 | .78 | .80 |
| 13 | .81 | .83 | .84 | .86 |
| 14 | .87 | .89 | .90 | .92 |
| 15 | .93 | .95 | .96 | .98 |
| 16 | 1.00 | | | |

Example: 2½ oz. (.12 + .03) = .15

**Plant Testing of Concrete Block**—The installation of a block testing machine in any size plant can prove a good investment for the owner.

Simple routine quality control of product should not be confused with complex laboratory testing for certification performed on an expensive machine operated by highly-trained help. With present day plant testers any member of the force can be readily trained to perform the necessary tests, the results of which are read in psi direct from the dial of the machine.

With the customers and the owners interests considered, the prestige and satisfaction gained in knowing his block is of standard quality will assure better customer satisfaction. Besides, he can maintain constant control over mix ratios and cement ratio content to the practical and profitable minimum. Likewise, many block plants are also ready-mixed concrete producers. A tester can be used to good advantage for obtaining the strength of 6 x 12 inch cylinder specimens as occasion arises.

Some manufacturers boast the fact "that their block is stronger than any of their competitors' products, so what use would testing equipment be to them?"

The strength basis, even in large plants, is often determined by "tapping" the unit with a hammer. This general misunderstanding seems to be in differentiating between surface hardness and compressive strength. Hardness can mean brittleness rather than strength and a brittle block is very likely to crack and cause trouble. Sometimes "hammer" tested block which are harder than usual when machine tested "explode" rather than crush. "Hammer" testing along with perhaps a commercial laboratory test made once or twice a year is the extent of the testing generally done.

While old time ideas and experiences are valuable, they are not all that it takes to produce good building units in this competitive day and age. Some block manufacturers have not yet learned that science has a quaint habit of bestowing her benefits upon those who recognize their values.

A.S.T.M. specifications requirements call for 1000 psi for Grade A Hollow Load Bearing Units, with local Building Codes often much lower. Many manufacturers continue, year after year, to make block which consistently test around 1800 psi. To maintain such a margin of safety over code requirements, which already contains a reasonable margin of safety is a costly procedure for which no premium is received. Today as never before, a small increase in plant efficiency can make the difference between success or failure.

Compression tests, even if run once a week, constitute a test of such minute percentage of the whole production as to be practically worthless.

A properly operated plant compression testing set up permits testing to be done every day on the previous day's production. Hence, it becomes impossible in the event of mistakes or carelessness for the plant to produce more than a day's run before the error is detected and corrected. Thus plant compression testing equipment can be, and is exceedingly low cost insurance against errors.

In setting up a plant testing routine a form of record sheet should be drawn up. Tests should be made on several sets of block at 1, 7, 14 and 28 day intervals. This procedure is repeated so that mixes of several different days are checked. The resultant figures averaged out give simple standards by which it becomes routine thereafter to run a compression test every day on the previous day's run and know within very close limits, what each day's production will test at any period up to and including 28 days.

A.S.T.M. specifications C140 outlines details for Sampling and Testing Concrete Masonry Units, while specification C31 outlines the details for concrete cylinder compression tests.

Certain precautions must be taken in preparing test specimens. (1) All high points and loose particles must be removed from top and bottom surfaces of the block. Under compression, high points may set up strains giving false results. (2) Caps should be made as thin as possible. (3) Imperfect caps should not be patched, but removed and replaced with new ones. (4) The specimen must be placed in the capping material so that its axis is at right angles to the capping surface. (5) Plate glass ¼ inch thick or a machined plate not less than ½ inch thick may be used as mediums for capping.

Various materials may be used for capping specimens. (1) For quick test results building board 3/16 inch thick is frequently used. The commercial type of Upson Board is satisfactory. Compression readings with this type of board range from 5 to 7 percent lower than results obtained with regular caps. Block with mortar grooves must be capped for best results. (2) Fast setting sulphur base compounds may be used. Generally, these compounds soften sufficiently for use at temperatures around 300 deg. F. The hot compound is applied to the surfaces of the unit and when sufficiently hardened test may be applied. (3) A mixture of one part (by volume) of portland cement to one part of calcined gypsum (plaster of paris) made into a workable paste with water may be used. A cap setting time, at least over night must be allowed before testing.

The machine manufacturer's recommendations regarding placement of unit, rate of compression load and other points should be carefully followed.

The advantages of having a plant testing machine manifest themselves in many ways: (a) The saving of time in packing and transportation of samples to outside sources for test. (b) Waiting for a report when it is a question of competitive selling. An actual test which the prospect can personally see or may even perform himself is a more convincing sales argument than results weeks or months old. (c) The control over mixes and other plant operations from an efficiency standpoint would indicate the installation of a plant tester to be a good investment.

**Bearing Area of Units**—The compressive strength of the block is generally computed on the gross area. The gross cross sectional area is the total area enclosed by the outside dimensions of the unit.

In some instances, the strength requirements are calculated on the net bearing area. This is found by measuring the area of the core spaces and subtracting this figure from the gross area.

The net bearing area is calculated as follows:

Dimensions of cores 2¾ in. x 4⅞ in. = 13.4 sq. in. x 4 = 53.6 sq. in. voids.

Gross area 122 sq. in. — 53.6 sq. in. voids = 68.4 sq. in. net bearing area.

The net bearing area for 8-in. and 12-in. block ranges from 38 to 56 per cent. Some codes require a bearing area of only 33 per cent of the gross area.

GROSS AREA OF UNITS

| Sizes | Older Type Units Inches | Gross Area Sq. In. | New or Modular Units Inches | Gross Area Sq. In. |
|---|---|---|---|---|
| 8 in. block | 7¾ x 15¾ | 122 | 7⅝ x 15⅝ | 119.1 |
| 12 in. block | 11¾ x 15¾ | 185 | 11⅝ x 15⅝ | 181.6 |

**Modular Planning System**—The modular planning system is nothing particularly new, since it was a method used centuries ago by the Greeks. According to authorities, the famed Parthenon of ancient Greece was designed in conformity to a module relating to the unit of measure at that time. The idea of the modular system is to simplify the design and construction of buildings by using a unit of measure known as a module.

A 4-in. module is quite commonly used. With such a system, it is easy to determine the number of units required within a certain dimension.

The unit as manufactured has already been designed with full consideration of the thickness of mortar joint. In other words, the nominal 8 x 8 x 16-in. unit has a modular size of 7⅝ x 7⅝ x 15⅝-in., which allows for a ⅜-in. mortar joint.

## Section 15—Steam Boilers and Their Care

The steam boiler, like all other equipment in the block plant, demands a certain amount of attention if it is to function at its greatest efficiency. Generally, however, no piece of equipment in the plant is subjected to as much abuse and neglect as the steam boiler.

**The New Boiler**—Before placing a new boiler in operation, the setting and refractory linings should be thoroughly dry.

Any grease or oil left from the process of fabrication should be removed. Oil acts as an insulating medium and may cause overheating of the tubes with resultant leakage at the seams and tube ends.

**The Established Boiler**—Before returning an established boiler to service, a thorough inspection should be made to see that (1) the furnace and gas passages are clean and in good repair; (2) that all cleanout doors fit properly and are closed tight; (3) all breeching and

chimney joints and cracks are sealed gas tight, using boiler putty or cement for the purpose; and (4) that dampers are in good condition and operate freely. Dampers in the breeching, when closed, should have a free opening of about 10 per cent of the full breeching area to guard against gas explosions.

**Water Level**—The water column should be set so that the lowest visible portion of the water glass is 2 in. above the fusible plug. A check should be made to see that the blow-off valves, water column, water glass drain, gage cocks, and feed valve are in good working condition and that they are closed. A vent valve should be open.

The required water level should be maintained in the boiler at all times, and too much dependence should not be placed on automatic alarms or feed-water regulators. If the water level falls below the water glass, corrective measures must be taken immediately. The air and fuel supplies must be stopped and the dampers and ash pit doors closed. No adjustment should be made which may cause a sudden change in the stresses acting on the boiler.

In a hand-fired boiler, the fire should not be disturbed except to cover it with wet ashes, then leave the firing door open. Where a stoker is used, stop the fuel and air supplies and open the firing door.

Determine the cause of the low water and remedy it before again placing the boiler in use. The boiler should be examined for the effects of overheating.

As an added precaution it is advisable to have a remote disconnect switch placed in an accessible location other than in the boiler room proper. This switch may even be the master switch for that section of the plant.

**Firing Equipment**—Whatever form of heating is adopted, whether by stoker, oil or gas burner, the burner and controls should be examined to see that they are in good working order. In oil burning equipment, the strainers and nozzles must be kept thoroughly clean.

When lighting a fire using gas or oil as the heating medium, the fuel supply should never be turned on until the furnace has been thoroughly ventilated with all dampers in the wide open position. The lighted torch or other means of ignition should then be properly placed to insure the instant ignition of the fuel.

In the event of flare-back or the snapping out of the burner, the furnace must again be thoroughly ventilated before attempting to resume firing.

After starting the fire, a light fire is maintained until the boiler setting is dried out. The fire is then built up slowly to develop the required steam pressure. When the steam pressure approaches the working pressure and the water level is too high, blow it down to the proper level.

It is not advisable to raise the steam pressure too rapidly unless it is a case of emergency. Firing should always be maintained in a uniform manner to hold the steam pressure as steady as possible.

**Steam Leaks**—All gaskets should be in good condition or replaced by new ones.

The blow-off pipe nipple should be examined periodically at the point of contact with the shell. If corrosion is apparent, the nipple should be replaced.

Leaky plugs in the boiler shell should be replaced, preferably with ones made of brass. Small leaks should be located and then repaired as soon as the boiler is withdrawn from service.

Should a serious leak occur, shut down the boiler immediately by gradually reducing the steam pressure. The boiler should be thoroughly examined before resteaming.

Repairs on the boiler should be done only by an experienced mechanic, or under an engineer skilled in this class of work.

**Removing Boiler from Service**—If it is necessary to take a boiler out of service for a period of time, certain procedures must be carefully followed to reduce deterioration to a minimum.

If the water is to be left in the boiler for a longer period than a week, the water should first be boiled, with the boiler vented, to drive off occluded gases. The water should then be rendered alkaline with the addition of about 1½ oz. of caustic soda for each 100 lb. or each 12 gal. of water contained in the boiler. A gallon of water weighs 8.33 lbs.

If the boiler is to be down for an indefinite time it is advisable to proceed as follows: The manhole and handhole covers should be removed along with all wash out plugs so that the interior surfaces can be thoroughly cleaned. Water from a hose delivered at sufficient pressure or hand scraping may be used to remove any deposits, commencing at the top and working down.

## Section 16—Fuels and Combustion

Plant costs, whether hidden or otherwise, are a prime factor in shaping operating efficiency. When the efficiency of any phase of steam plant operation drops below normal, costs become unbalanced. It should therefore, be a matter of grave concern to the block manufacturer to see that he obtains maximum results from the fuel used.

The following data are set forth in an attempt to point out salient features in the proven use of fuel, which if followed, should make for a high degree of efficiency.

**Combustion**—Chemical combination is generally attended with the evolution of heat. When there is sufficient heat to raise the combining bodies or the products of combustion to the temperature at which they evolve light, combustion is said to take place.

Combustion may therefore be defined as vigorous chemical combination, attended by the evolution of heat. In practice the combination is always between a combustible, or fuel, and the oxygen of the air, which is therefore necessary to support combustion.

**Conditions Favoring Combustion**—For combustion to begin, the fuel must be brought in contact with air at a suitable temperature. In order that it may continue, the temperature must be kept up and a sufficient supply of oxygen maintained; also the products of combustion must be removed.

Combustible solids burn more readily when the pieces are of such a size as to allow of proper air supply and draft conditions and at the same time expose a large surface of contact. If the lumps are too large, the contact surface is too small compared with the volume and the rate of combustion is therefore reduced.

The gases evolved, if they are combustible, usually burn readily because of the large amount of contact surface they present.

Liquids do not burn readily in mass because the air cannot penetrate them, due to the relatively small surface area presented by the liquid. If a combustible liquid is broken up into a fine spray, by some means, it will burn in the same manner as if it were a gas and will form an explosive mixture.

Irrespective of the type of fuel being burned, one requisite is common to all. A positive and adequate supply of air for combustion must be maintained at all times.

**Complete and Incomplete Combustion**—Combustibles in common use are composed principally of carbon, (C), usually combined with hydrogen (H), oxygen, (O), and sometimes small quantities of other elements. However, carbon and hydrogen are the valuable constituents. Carbon is a solid and hydrogen is a gas, yet the compounds of carbon and hydrogen may exist as solids, liquids or gases, thus making possible three types of fuel.

When a combustible material burns, the combustion may be either complete or incomplete. It may be considered complete when all the combustible constituents are burned to their highest state of oxidation.

It is incomplete when any of the fuel is left unconsumed or passes away with less oxygen than the maximum amount with which it is capable of combining.

With carbon, the highest state of oxidation is carbon dioxide ($CO_2$); there is also another oxide, carbon monoxide ($CO$), a highly toxic gas which contains, for the same amount of carbon, only one-half as much oxygen. When carbon is incompletely burned, either the carbon may be left unconsumed or carbon monoxide may be formed and pass away with the products of combustion. Under some conditions, carbon may be separated in the solid form as soot.

**Condition for Complete Combustion**—To insure complete combustion, three things are essential: (1) the air supply must be adequate; (2) the air must be brought into intimate contact with the fuel, and (3) the temperature must be kept up to the ignition point until combustion is complete.

Thus an insufficient air supply or too rapid cooling are the usual causes for incomplete combustion. Incomplete combustion of any kind always means considerable loss of heat and incidentally adds to the fuel cost, having a direct bearing on the economy of operation of the plant.

TABLE XIX—APPROXIMATE THEORETICAL AIR REQUIREMENTS*

| Solid Fuel | lb. Air Per lb. Fuel |
|---|---|
| Anthracite Coal | 9.6 |
| Semi-Bituminous Coal | 11.2 |
| Bituminous Coal | 10.3 |
| **Fuel Oil** | |
| Commercial Standard #1 | 102.6 |
| Commercial Standard #2 | 104.5 |
| Commercial Standard #3 | 106.5 |
| Commercial Standard #5 | 112.0 |
| Commercial Standard #6 | 114.2 |
| **Gaseous Fuel** | |
| Natural Gas | 10.0 |
| Mixed Natural and Water Gas | 4.4 |
| Carb. Water Gas | 4.4 |
| Coke Oven Gas | 5.2 |

**Unit of Heat of Fuels**—Since all thermo-chemical problems necessitate the measurement of quantities of heat, it is necessary to select a unit with which measurements may be made. The unit used for all practical purposes is called the British Thermal Unit (Btu). This is the amount of heat required to raise 1 lb. of water 1 deg. Fahrenheit (from 60 deg. F. to 61 deg. F.).

Heating values of solid fuels are reported as Btu per pound of fuel. The unit for liquid fuels is the heating value in Btu's per pound. Heating values of gaseous fuel are reported in Btu's per cubic foot of the gas saturated with water vapor under standard conditions (30 in. of mercury and 60 deg. F.).

**Products of Combustion**—In combustion the oxygen of the air is changed into carbon dioxide and water vapor. The air used in the combustion process contains 23 per cent of oxygen and 77 per cent nitrogen by weight. Nitrogen plays no active part in the combustion process. It goes into the furnace and out the stack as an inert material, carrying appreciable heat with it.

Time is an important factor in the combustion of fuels. Combustion should be rapid and the heat evolved transferred immediately to the steam boiler if the greatest use is to be made of the fuel. If the heat is not used rapidly, it escapes to the outside air and is lost. The ability of gaseous or liquid fuels to mix more easily with the air accounts for their greater efficiencies.

**Classification of Fuels**—Fuels may be classified as sold, liquid and gaseous. All types of fuel contain impurities which have undesirable effects.

Free oxygen mixed in gaseous fuel acts as a diluting material and lowers the heating value. If it is chemically combined as an oxide, this means that a certain portion of the fuel has already been burned and its heat dissipated. Nitrogen, a non-combustible gas, acts as a diluting agent.

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*A. S. H. & Ve. Guide.

**Effect of Moisture in Fuel**—The presence of moisture in a coal may be an advantage or otherwise, depending on the style of boiler being fired by the fuel, whether of the tubular or shell types.

Sometimes coal is intentionally wetted because an idea persists that this practice makes the fuel go further.

Since 970.4 Btu's are carried away for each pound of water evaporated from and at 212 deg. F. it is questionable whether the decomposition of the steam produced from the moisture in the fuel, in breaking up into hydrogen and carbon monoxide, compensate for the loss mentioned. If the gases are eventually burned, the hydrogen itself produces 9 lb. of water for each pound of hydrogen and the carbon monoxide, unless provided with sufficient air for combustion, may be carried off with the flue gas. The wetting of the coal before firing is a questionable practice.

Ash of coal is also a non-combustible material and should be present in as low a percentage as possible. Ash is troublesome in that it forms clinkers. This formation is aided by the presence of iron sulphide or pyrites. While sulphur is combustible, its presence should be kept as low as possible because of its corrosive properties.

**Hand-Firing**—In the generation of steam by hand-firing one of the common causes of smoke is bad stoking. When a heavy layer of coal is thrown on the fire, tarry matters, in considerable volume, begin to distill from it. The volatile products, mainly hydrocarbons, may not even be ignited because after passing through the layer of cold coal, they are separated by it from the heat and consequently escape unburned, thereby producing smoke. If the volatile matter being evolved in large quantity should become ignited, it will soon cease to burn because sufficient air cannot be supplied fast enough to support combustion. Therefore, the flame gradually cools by radiation, which results in the production of a heavy black cloud of smoke containing considerable carbon.

**Stoker-Firing**—The advantage with stoker-firing lies in the fact that a cheap grade of fuel may be used. The coal is fed to the furnace at a predetermined rate and is mixed with sufficient air to obtain complete combustion of the fuel. The hydrocarbons which are distilled combine with the air and are burned in the fire-box.

The total heating value of coal is never attained because heat is lost in various ways, as follows:

1. The latent heat absorbed in evaporating the water contained in the fuel—if the coal is very wet, the loss of heat from this cause will be considerable.
2. Heat represented by the unburned fuel removed with the clinkers.
3. Heat lost through the escape of fuel in the form of smoke which contains carbon and hydrocarbons.
4. Heat loss resulting from the formation of carbon monoxide instead of carbon dioxide.
5. Heat lost through radiation.
6. Heat carried away by hot flue gases.

These losses vary, depending on the kind of coal, the type of stoker, boiler, and other factors. The loss under certain conditions may be a considerable part of the total heating value of the fuel.

**Liquid Fuel**—The most important of the liquid fuels is petroleum and its products. These petroleums are mixtures of hydrocarbons containing approximately 86 per cent carbon and 14 per cent hydrogen.

The heating value averages from 17,000 to 21,000 Btu's per pound and has about 1½ times the heating value of good bituminous coal.

The advantages of liquid fuel are:

1. Reduction in weight and bulk.
2. Prompt kindling of the fire and easy attainment of maximum temperature.
3. Fire can be extinguished instantly.
4. Uniformity of combustion, heating power, and control of the flame.

The disadvantages of liquid fuel are:

1. Danger of explosion.
2. Loss of fuel by evaporation.
3. Unpleasant odor.
4. Rationing during war or other emergencies.

It is necessary that fuel oil be free of water in as much as the heating value of the oil is reduced approximately 200 Btu's for each one per cent of water present. Water in fuel oil is difficult to remove because the densities of the two are not far apart.

**Gaseous Fuel**—Natural gas consists primarily of methane ($CH_4$), and some heavier hydrocarbons. Its heating value is around 1,000 Btu's per cubic foot.

Natural gas offers these advantages in burning: cleanliness, economy of labor, and exact control of heat.

It is a cheap and efficient fuel when properly burned, but requires a large amount of air, though less than does oil, for satisfactory combustion.

**Explosion Hazard**—The operator should always be on the alert for the potential hazard of explosion which may be encountered in dealing with combustible gas in a boiler furnace. The possibility of accident can be avoided by never introducing a lighted torch into the furnace unless it is thoroughly ventilated.

The length of time necessary for this operation depends on the type of fuel used, the size of the furnace, and the provisions for adequately ventilating it.

**Flue Gas**—Much information relative to the efficiency of the boiler combustion may be obtained from an analysis and study of the flue gas passing into the stack.

In order to insure the complete combustion of any fuel, more air than the amount theoretically required must be passed through the combustion chamber. Although an excess of air is desirable, the excess should not be too great since all air passing through the fire box becomes heated and an undue loss of heat may result. An analysis of the escaping gases, commonly called flue gas analysis, will determine whether or not the proper amount of air is being admitted. The percentage of oxygen present shows the amount of excess air passing through the fire. The presence of carbon monoxide (CO) indicates incomplete combustion and insufficient air.

The carbon dioxide ($CO_2$) analyzer, of which there are several types, measures the percentage of carbon dioxide ($CO_2$), carbon monoxide (CO) and oxygen (O) in the products of combustion. However for ordinary purposes in a block plant an analyzer which measures the carbon dioxide ($CO_2$) will suffice. The percentages obtained, together with the stack temperature reading, found by simple calculation, will give the combustion efficiency of the boiler.

A slight variation in the correct fuel-air ratio will cause a considerable change in the combustion efficiency. A poor efficiency means a loss of fuel and incidentally a loss of money.

Since the fuel-air ratio can vary considerably over a wide range due to temperature and weather conditions, the importance of using an instrument to measure the combustion efficiency can be appreciated.

If oil is being used as fuel, gas with a stack temperature of 500 deg. F. and with a carbon dioxide ($CO_2$) reading of 8 per cent will represent a combustion efficiency of 75.5 per cent; whereas on the same boiler if the stack temperature was to rise to 525 deg. F. and the carbon dioxide ($CO_2$) were to drop to 6 per cent, the combustion efficiency would drop to around 68.5 per cent. This means that over 30 per cent of the fuel cost is being wasted. Again if the stack temperature is reduced to about 475 deg. F. and at the same time the carbon dioxide ($CO_2$) in the gas increases to 10 per cent, the combustion efficiency will rise to 80.5 per cent. This condition more approximates a boiler efficiency approaching the ultimate.

While these percentage differences may seem small, it must be remembered that besides decreasing the fuel bill proportionately, higher efficiencies mean an increase in the amount of boiler H. P. made available for useful work.

In contrast with the above results the variations with coal as a fuel are even more marked.

A stack temperature of 500 deg. F. and a content of 8 per cent carbon dioxide ($CO_2$) in the gas, will give an efficiency of only 71.5 per cent. Where the stack temperature increases to 525 deg. F. and carbon dioxide ($CO_2$) content of the gas drops to 6 per cent, the over all efficiency will be around 60 per cent.

If the stack temperature is reduced to 475 deg. F. and the carbon dioxide ($CO_2$) content of the gas is raised to 10 per cent, an efficiency of approximately 78.5 per cent is obtained. This is about the average maximum obtainable in a boiler using coal as a fuel.

If the plant superintendent would make intelligent use of a carbon dioxide ($CO_2$) analyzer and on an average of once a day make an anlysis of the flue gas in the stack, and be guided by the results, a real saving in fuel could be accomplished

Boiler Efficiency—From the brief discussion of the important points on combustion, it is evident that the plant owner should endeavor to obtain the highest efficiency possible from the money he spends on fuel.

Since the boiler room is just as important a part of the business operation as the production room, every effort should be made to operate it in as efficient and economical a manner as possible.

In order to effect maximum over-all boiler efficiency the steam pressure should be kept as constant as possible irrespective of the amount of steam generated.

The first requisite towards efficiency in the boiler plant is to have the equipment in the best physical condition.

1. Furnaces should be kept free of clinkers; 2. heat transmitting surfaces should be kept free of soot and other deposits; 3. stack and draft passages, breeching and ash pits should be kept clean; 4. the water side of the heat transmitting surfaces should be kept free from scale. When these conditions have been accomplished care should be taken to maintain them.

As additional precautions, 1. cracks in masonry walls should be repaired and all joints through which air can leak into the systems should be sealed; 2. air infiltration beyond the last heating surface, as in the breeching or stack, does not represent a loss in itself, but impairs the draft and incidentally affects the efficiency of the combustion; 3. defective grate bars should be replaced and all tubes, valves and pipe fittings made tight against leakage.

If, after attention to the foregoing factors, the plant owner is convinced that the acquisition of further equipment will produce added efficiency, the installation of a Feed Water Regulator, a Flow Meter, Automatic Damper Control and a $CO_2$ Hand Analyzer may be given consideration.

Automatic controls should be checked periodically. Considerable damage to boilers has occurred when automatic controls have failed to work. Particular attention should be given to shut off controls affected by height of water. It seems advisable to have a double set of controls to shut off the boiler when the water level drops too low for safe operation.

It must be remembered, however, that since each plant presents its own problems a careful study must be made of the various influencing factors before any conclusion can be drawn to the over-all boiler efficiency best suited for a given set of conditions.

## Section 17—Boiler Feed Water

The difficulties which attend the successful operation of steam boilers are due in a large measure to the impurities in the water available for use.

The cost and danger of feeding untreated water to the boilers brings forth the question whether means for purifying the water should be a part of the original plan, whether it should be taken up subsequently, or whether the problem should be left to the owner to solve as best he can after the plant is completed.

Water Sources—Rain is the purest form of natural water, but even before it reaches the earth it becomes contaminated with impurities, such as dissolved oxygen and carbon dioxide found in the air. With such impurities present, the water may possess some corrosive properties. As the water permeates the soil it dissolves in varying amounts the mineral constituents and organic matter with which it comes in contact. All water obtained from the earth, whether from surface or lower depths, contains dissolved substances taken up from the rocks and soils with which it has been in contact. Water from sandstone or granite formations contains less dissolved mineral matter than that obtained from limestone regions. Water from limestone regions contains scale-forming impurities such as calcium and magnesium sulphates or bicarbonates and silica. Such water, sometimes termed "hard" water must be subjected to one of the several softening processes before being suitable for boiler use.

All natural waters contain solid matter in solution. These impurities are confined to a small number of substances which may be classified roughly under two headings, those causing "temporary hardness" and those causing "permanent hardness."

Temporary hardness is so called because it disappears upon heating or boiling water. It is due to the presence in solution of the bicarbonates of lime and magnesia, plus carbonic acid gas.

Permanent hardness is generally due to the presence in a solution of the sulphates of lime and magnesia. Other substances which may be present in small quantities, are chlorides, nitrates, organic acid, silica, and alumina. Natural water also holds in solution air and carbonic acid gas, both tending to cause corrosion in the boiler, but easily driven off by preliminary heating.

The cost of producing steam from a feed-water system which forms hard scale can be very expensive, for the following reasons:

1. The extra fuel consumed in order to force heat through the scale which forms in the boiler.
2. The cost of boiler cleaning, replacements and repairs.
3. The cost of firing up a boiler which has been out of service due to repairing and cleaning.
4. The cost represented by the yearly depreciation on the life of the boiler due to forcing, cleaning, and other detrimental factors.

**Treatment of Boiler Water—The general methods by which water may be treated to render it suitable for boiler use are namely:**

1. Cold water softening in which the water is treated at its usual temperature. In this process the soluble bicarbonates, sulphates and chlorides are removed by converting them into the more insoluble normal carbonates and hydroxides by the use of soda ash (sodium carbonate) and lime.

2. The Zeolite method is a comparatively new cold water softening process. Zeolite, either natural or artificial is a double silicate of alumina and soda, which possesses the property of exchanging bases with other compounds. When hard water, containing calcium and magnesium salts is filtered through it, calcium and magnesium silicates are formed and the corresponding sodium salts go into solution. An objectionable feature of the process is the high sodium carbonate alkalinity obtained when treating water high in bicarbonate content. The alkalinity may be modified by the addition of acid, a step which must be very carefully controlled. When the accumulation of calcium and magnesium renders the process inactive, the Zeolite is reactivated

by allowing a solution of sodium chloride to stand in contact with it. The sodium content is replenished and the absorbed calcium and magnesium are removed as chlorides.

3. Hot water softening consists of heating with or without the use of chemical reagents. Several forms of closed or open feed-water heaters operated either on waste heat from flue gas or exhaust steam may be used. Open heaters operate at atmospheric pressure and are more serviceable than the closed type because the gases can escape and the bicarbonates are to a greater extent removed, although sulphates are not greatly affected.

4. Conditioning water within the boiler — Most systems of external softening, irrespective of their degree of efficiency, should be supplemented with internal chemical treatment. The prevention of calcium and magnesium scale formation requires the forming of a sludge precipitated in a non-adherent fluid state. The sludge thus produced may be removed by the boiler blow-down.

Present day knowledge of internal or external chemical treatment dictates the use of salts with known chemical properties from which specific objectives are obtained. However, unless close control is exercised by means of daily chemical tests properly interpreted, the results may prove valueless. Outlines of systems for feeding corrective solutions to the boiler are outlined in Technical Paper No. 98 — Betz Engineering Company.

5. Boiler compounds — Unless the compounds are specifically prepared for the particular type of water on which they are to be used they may cause injury to a boiler. A great variety of chemicals are marketed under the name of boiler compounds, the merit of which is sometimes questionable. The value they possess is due to the presence of such reagents as sodium carbonate, phosphate, hydroxide and silicate, which chemicals may be used more effectively in accordance with up-to-date principles proposed for water treatment.

Solids Deposited in the Boiler—During the conversion of water into steam, all the dissolved and suspended matter carried by the water is deposited within the boiler. These are cumulative in effect. The nature of the deposits concentrated in the boiler will determine the physical form of the scale in the boiler depending upon the composition of the deposit, the operating temperature and pressure, and other factors.

Scale deposits form faster on the front row of the tube walls than on other parts of the boiler because at these points evaporation is more rapid and scale formation is directly proportional to the rate of evaption.

Preheating Feed Water—The introduction of a preheater into the boiler water system will materially add to the operating efficiency of the boiler.

1. Where large volumes of make-up water are required and where the temperature of the incoming water is approximately 50 deg.F., these additions of colder water affect the efficiency of the boiler operation. On the other hand, extra fuel is required to raise the temperature of the make-up water from 50 deg.F. to 212 deg.F.

2. Should the make-up water contain bicarbonate of lime or magnesia which create the condition of "temporary hardness" and which contribute to the formation of a soft scale, preheating will help eliminate this undesirable feature.

Removal of Sludge or Suspended Solids—The solid matter produced either by evaporation or by methods of conditioning the water must be removed from the boiler. This is accomplished either by "blowing-down", that is changing periodically a part of the water in the boiler, or by means of a "deconcentrator", which is essentially a filtering device operated in conjunction with the boiler.

In order to obtain maximum efficiency and develop full capacity of the boiler, only water softened by treatment which will eliminate the formation of scale in the boiler should be used.

## Section 18—Selection of the Block Machine

The concrete block industry, though a relatively new field of operation as compared to brick and lumber, is rapidly approaching a degree of perfection surpassing that of its older competitive industries. This status is in no small measure brought about by the phenomenal development of the high production machinery used by this industry.

The selection of block machine best suited to the individual plant requirement presents many complex problems, each of which must be given careful study by the prospective buyer. It is advisable to select a machine of rugged construction whose critical parts are readily accessible and for which replacement parts are procurable with a minimum of delay and expense.

The capacity of the machine should be such as to care for the economically available market, plus a generous allowance for future operational expansion. The premier requisite to be demanded from any block machine, regardless of its capacity or cost, should be the ability to produce units of first class quality.

Concrete units may be molded by machines employing vibration, pressure, dry tamping or by a combination of these methods.

Within the past few years block machines of high, medium, and low capacities have been introduced to satisfy various price ranges. Such machines embody the principles of vibration and pressure, to compact the contents of the mold box.

Vibrating machines handle either the "drier" or "wetter" concrete mixes more satisfactorily than is possible with "tamp" machines; particularly from the standpoint of producing more uniform packing and incidentally higher strength, lower absorptive qualities and better textural appearance.

There are still many "dry tamp" machines in use, but very few machines of this type are now being manufactured.

All block machines, whether of the tamp or vibrating types may be divided roughly into two classes:

a. Those using plain pallets.

b. Those using cored pallets.

The average block machine is usually operated under severe conditions, due frequently to damp plant atmosphere and highly abrasive dust accumulations on the finer mechanisms and wearing parts.

In order to overcome these detrimental features, it is necessary to employ skilled help to keep such machines in good repair.

Care of the Block Machine—The manufacturer of the block machine makes certain recommendations for its lubrication and care. If the plant operator will follow these instructions, many years of trouble-free operations may be reasonably expected, except of course for the replacement of parts subjected to excessive wear.

The machine should be inspected regularly to see that its bearings are functioning properly and that its bearings are receiving the necessary lubrication. Compressed air should be used periodically to remove any accumulations from the finer mechanisms. These and other essential duties should not be left to chance but should be made a part of the established routine of the manufacturing process.

Many block manufacturers have come to realize that only mechanics skilled in the care and maintenance of this style of machine should be given the responsibility of the periodic inspections required to maintain operations at a maximum. It is hardly necessary to say, that casual inspection by a handy man or one who may be a good operator, but not necessarily a good maintenance man, is just a waste of time and invitation to trouble.

**Maintenance of Block Machine**—Lack of inspections will result in break downs at inopportune times.

Maintenance must be organized and adapted to the particular plant.

Daily inspection of all parts of the machine should be followed by immediate correction where necessary.

Points most likely to cause complete shut down should be most carefully inspected.

Having a supply of repair parts on hand and scheduling replacement of parts for down periods is a must.

A card index system of parts on hand, source of supply, manufacturer's specifications, etc., should be maintained.

Vibrating motors should be frequently checked, since the eccentrics tend to loosen.

Worn out mold boxes and cores should be changed frequently in order to obtain accurate dimensions of the units, also because worn parts mean considerable loss of materials.

Rough pallets are a contributing factor to varying dimensions of units.

Machinery should be greased on every shift or a continuously operating oiling and greasing system may be installed.

Compressed air delivered from a hose fitted with a 2-ft. length of pipe may be used to blow dirt accumulations from inaccessible and critical parts.

## Section 19—Miscellaneous Equipment

**The Tachometer and Its Functions**—The operating machinery of the average block plant is of a rotary type. The power supplied to operate such machinery is delivered through direct-connected or belt-driven motors. Pulleys and gears in varying ratios are also used to quite an extent. An alert operator will therefore, want to know whether his motors are performing at their rated capacities; whether the belt-driven machines are receiving a full quota of power; whether the proper gear ratio is being used.

Any doubt relating to these factors may be quickly disposed of by the use of an instrument called a tachometer, which will determine the number of revolutions per minute of a rotating part. Tachometers are of two types, either indicating or cumulative. Either is suitable for plant use, but the successful operation of the cumulative type is dependent on accurate timing of the revolutions made in a given unit of time.

Production of a uniform product depends partially upon all parts of the product being subjected to uniform pressure and vibration within the mold box. This is facilitated by the synchronization of the rotating mechanism, producing the vibratory cycle. The planes of vibration must be in perfect balance with each other, and the density of the aggregate being vibrated should be the same in all cases. Thus a variation in the vibrating motor speeds of a popular type of block machine can readily produce a block of uneven density. Its nominal cost, coupled with the many applications to which a tachometer may be put, renders it an indispensible piece of apparatus in any block plant.

**Electric Motors and Their Installation**—All electrical equipment is rated for a given performance at a definite voltage. For example, a motor rated at 5 hp., 110 v., single-phase 60 cycle a.c. current will normally deliver 5 hp. when connected to a 110-v., 60-cycle alternating current circuit.

Too often, however, the plant operator will tap in on an existing circuit and run an extension to a new piece of equipment without regard to the existing load on the circuit. Good practice calls for the installation of cable large enough in size to supply the amount of current

in amperes required by the motor.

The wire, in turn, should be connected to the proper size of fuse to protect the cable and motor. When additional equipment is wired to the motor circuit, the circuit is subjected to these possibilities:

1. Constant blowing of fuses.
2. A drop in voltage.
3. Serious damage to the insulation of the cable when over-fused.
4. Inefficient starting torque of the motor.
5. Loss of units produced, which in reality increases the cost of the units.

Suppose by tapping the circuit the voltage at the motor terminals drops to 100 volts. The resulting torque of the motor will be in the ratio of the square of the ratio of the impressed voltage to the square of the normal voltage.

$$\frac{100^2}{110^2}, \text{ or } 82.7 \text{ per cent.}$$

Not only does the torque decrease, but the current in the motor increases and causes overheating.

The increased load will cause an increased voltage drop on the line, materially decreasing the voltage available at the terminals of the other equipment connected to the same circuit.

This results in a decrease in the power transmitted, causing overheating of the motor, and in some cases, may even cause the motor to burn out.

Motors are usually guaranteed by the manufacturer to operate at 10 per cent above or below normal voltage. A motor, installed by a competent electrician and connected to a sufficient capacity cable, will seldom cause trouble due to low voltage.

**Hints on Motor Care**—

1. Clean the motor frequently where it is exposed to the effects of dust and grit. The use of a hand bellows or a blast of air free from moisture and delivered at low pressure is recommended. Since many motors are of the open type, it is not necessary to dismantle the motor, as most of the dust in the windings may be blown out.
2. On sleeve-type bearing motors, drain the oil from the wells after the motor has been in operation for a period of 90 days. Oil has a tendency to gum up, and the oil ring, which rides on the shaft to supply oil to the bearings, might not rotate freely. Likewise, dust and grit may be collected by the oil.
3. Never fill the oil wells to an overflowing point, as the overflow may get into the motor windings and cause possible damage.
4. On repulsion or repulsion induction motors, the commutator should be kept free of scum or grit which is produced from contact between the commutator and the brushes. This may be done by the aid of crocus cloth or fine grit sand paper.
5. All electric motors have an air gap between the laminations of the rotor (armature) and stator. When a motor tends to heat excessively without any load on it, or tends to blow fuses, it is a sign that the air gap is being closed, due to worn bearings. To avoid large re-winding bills, or possible injury to the laminations thereby necessitating the scrapping of the motor, check the bearings occasionally to see whether they are worn excessively. Sleeve or ball bearings are easily replaced at small cost with a minimum loss of production hours.
6. All electrical connections under terminal screws should be installed tight against the post. All electrical splices should be made secure and be soldered to insure the proper supply of electricity to the motor.

The electric motor, after all, is the heart of the equipment and should be given periodical attention to insure economical and satisfactory performance.

**Pressure Gages**—Pressure gages are used in various phases of operation throughout the block plant, particularly in conjunction with the steam boiler system.

Since it is essential that these gages be kept accurate at all times, provision should be made for their being checked frequently.

Gages are sensitive instruments and should be handled carefully. They should never be removed or set up by means other than using a wrench on the square base. Each instrument should be provided with a stopcock placed in the piping ahead of the gage, thus permitting its removal for any reason without causing loss of pressure in the system.

The most accurate method of checking a gage is by means of a dead weight tester. In this type of tester, a hand pump is used to build up the pressure; and a series of weights of various sizes are used to determine the pounds of pressure exerted on the gage. Check testing is done by mounting the gage on the dead weight tester and comparing the readings on the gage when known pressures are built up.

If readjustment is necessary, the glass front is taken off and the indicator is removed manually. Adjustment generally may be made by replacing the pointer in proper position in the operating range. The gage is again checked for accuracy by a series of readings over the entire scale range. When satisfactory results are obtained, the date of test should be marked in pencil on the dial, and the gage remounted.

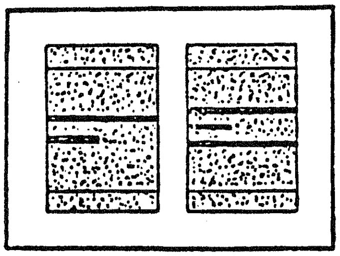
If the gage cannot be adjusted properly, it is best to discard it and replace it with a new one. Either fatigue in the metal of which the Bourdon tube is constructed or excessive wear on the pinions may render calibration impossible. If a gage is used on a high pressure air or oxygen system, every precaution should be taken to remove all traces of oil to avoid spontaneous combustion.

## Section 20—Notes on the Block Itself

**Branding Concrete Units**—Building departments in some localities allot to each licensed block manufacturer a distinctive brand mark which must appear on the individual units. This is intended to facilitate the work of the building inspector in identifying the block manufacturer.

It may be that a producer who is justly proud of his product, wishes to adopt a trade mark for his block, although not required to do so. The following suggestions for such a type of mark are offered for consideration.

Figure 39. Brand Marks



Most of the up-to-date block machines are of the stripper type which lend themselves admirably to branding by a series of raised or indented lines located on the end of the units.

To produce a system of raised lines, it is necessary to cut into the end plate for a depth and width of approximately ⅜-in., and to the desired length. Indented lines are obtained through welding on sections of ⅜-in. round bar stock long enough to produce the desired results.

**Number of Block Per Course**—The number of block per course required for an 8 in. wall is found by taking the length and the width of the structure and applying the following table. The figure derived from the table multiplied by the number of courses gives the total number of units required. The number of units of door and window openings are deducted from the above total.

For 12-in. walls, one block per course should be deducted from the figure indicated in the accompanying table.

Table XX. Block per course with length and width known.

| Ft. | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 28 | 31 | 34 | 37 | 40 | 43 | 46 | 49 | 52 | 55 | 58 | 61 | 64 | 67 | 70 | 73 |
| 12 | 31 | 34 | 37 | 40 | 43 | 46 | 49 | 52 | 55 | 58 | 61 | 64 | 67 | 70 | 73 | 76 |
| 14 | 34 | 37 | 40 | 43 | 46 | 49 | 52 | 55 | 58 | 61 | 64 | 67 | 70 | 73 | 76 | 79 |
| 16 | 37 | 40 | 43 | 46 | 49 | 52 | 55 | 58 | 61 | 64 | 67 | 70 | 73 | 76 | 79 | 82 |
| 18 | 40 | 43 | 46 | 49 | 52 | 55 | 58 | 61 | 64 | 67 | 70 | 73 | 76 | 79 | 82 | 85 |
| 20 | 43 | 46 | 49 | 52 | 55 | 58 | 61 | 64 | 67 | 70 | 73 | 76 | 79 | 82 | 85 | 88 |
| 22 | 46 | 49 | 52 | 55 | 58 | 61 | 64 | 67 | 70 | 73 | 76 | 79 | 82 | 85 | 88 | 91 |
| 24 | 49 | 52 | 55 | 58 | 61 | 64 | 67 | 70 | 73 | 76 | 79 | 82 | 85 | 88 | 91 | 94 |
| 26 | 52 | 55 | 58 | 61 | 64 | 67 | 70 | 73 | 76 | 79 | 82 | 85 | 88 | 91 | 94 | 97 |
| 28 | 55 | 58 | 61 | 64 | 67 | 70 | 73 | 76 | 79 | 82 | 85 | 88 | 91 | 94 | 97 | 100 |
| 30 | 58 | 61 | 64 | 67 | 70 | 73 | 76 | 79 | 82 | 85 | 88 | 91 | 94 | 97 | 100 | 103 |

An optional method of calculation of the block requirements particularly suitable for an irregularly shaped building is as follows:

> Add together the total length of all wall sections, the result of which gives total linear feet. This, multiplied by three and the product divided by four is the number of block required per course. The number of block per course multiplied by the number of courses in height gives the total number of units. Correction is made for any door or window openings to obtain the exact number of units.

Another method of calculation is as follows:

Multiply the length plus the width by two. This gives linear feet. Then multiply by the height of the building to obtain total square feet of wall area.

All window and door openings calculated in square feet are subtracted from the above, which gives the actual square feet of wall surface. Then this result times 1.13 equals number of block required.

The factor of 1.13 blocks per square foot is derived from the division of 144 sq. in. by 128 sq. in. (length times height of block).

EXAMPLE:

A building 24 ft. x 30 ft. = 108 linear ft. x
8 ft. = 864 sq. ft.
4 windows 3 ft. x 4 ft. = 48 sq. ft.
1 door 3 ft. x 7 ft. = 21 sq. ft.
Total square feet of openings = 69 sq. ft.
Actual wall surface = 795 sq. ft.
Then 795 x 1.13 = 898 blocks required.

The following Table XXI shows the number of concrete block units to be omitted and jamb block substituted for window openings of the sizes indicated, this avoids cutting the block.

Table XXI—Jamb Block Required for Window Openings

| * O.S. | U.O. | F.J. | ½J. | O.S. | U.O. | F.J. | ½J. |
|---|---|---|---|---|---|---|---|
| 1'-4" x 2'-0" | 8 | 4 | 2 | 2'-8" x 3'-4" | 18 | 6 | 4 |
| 1'-4" x 2'-8" | 10 | 4 | 4 | 2'-8" x 4'-0" | 21 | 6 | 6 |
| 1'-4" x 3'-4" | 13 | 6 | 4 | 2'-8" x 4'-8" | 25 | 8 | 6 |
| 1'-4" x 4'-0" | 15 | 6 | 6 | 2'-8" x 5'-4" | 28 | 8 | 8 |
| 1'-4" x 4'-8" | 18 | 8 | 6 | 2'-8" x 6'-0" | 32 | 10 | 8 |
| 2'-0" x 1'-4" | 6 | 2 | 2 | 3'-4" x 3'-4" | 20½ | 6 | 4 |
| 2'-0" x 2'-0" | 9½ | 4 | 2 | 3'-4" x 4'-0" | 24 | 6 | 6 |
| 2'-0" x 2'-8" | 11 | 4 | 4 | 3'-4" x 4'-8" | 28 | 8 | 6 |
| 2'-0" x 3'-4" | 14½ | 6 | 4 | 3'-4" x 5'-4" | 29 | 8 | 8 |
| 2'-0" x 4'-0" | 16½ | 6 | 6 | 4'-0" x 3'-4" | 23 | 6 | 4 |
| 2'-0" x 4'-8" | 18½ | 6 | 8 | 4'-0" x 4'-0" | 27 | 6 | 6 |
| 2'-0" x 5'-4" | 24 | 8 | 8 | 4'-0" x 4'-8" | 32 | 8 | 6 |
| 2'-8" x 1'-4" | 7 | 2 | 2 | 4'-0" x 5'-4" | 36 | 8 | 8 |
| 2'-8" x 2'-0" | 11 | 4 | 2 | | | | |

* O.S. Indicates—Opening Sizes.
U.O. Indicates—Units Out.
F.J. Indicates—Full Jambs.
½J. Indicates—½ Jambs.

**Acoustical Properties of Block**—The development of more uniform surface textures, accurate dimensions, sharper edges and corners, and the attractive designs into which concrete units may be arranged has materially advanced their use in walls. Their adoption in the construction of interior facings of churches, schools and other buildings in which sound absorption is an important factor is now firmly established.

The sound absorbing property of a block is dependent upon its surface texture. The most effective texture is a medium rough surface. Deep depressions are not as effective as small depressions. Smooth surfaces are also less effective than medium depressions. The character of the surface is more important than the type of aggregate.

Masonry units with their varied surface textures and their inherent porosity produced by tiny crevices or depressions, offer a dual purpose medium (attractive and sound absorbent) when used in their natural state in wall construction.

The myriads of minute air-cells which fill the entire block, produce the acoustical or sound absorbing properties, and also give the units another important quality, namely, their heat and cold insulating value.

Formerly, it was customary to use block for back-up purposes, after which the interior wall surfaces were faced by one of the various forms of acoustical board to absorb sound and for textural appearance. With the advancements made in the technique of block production the use of such board is no longer necessary, thus eliminating the cost of special treatments of walls.

Tests show that there is a distinct relationship between surface texture, porosity and void characteristics of a unit and its sound absorbent capacity. Also that exposed concrete masonry units will absorb sound much faster than a plastered wall.

Sound waves upon striking a surface are partly reflected, absorbed and transmitted in varying amounts depending on the character of the surface. A smooth, dense surface such as plaster, glass or wood will absorb about 3 per cent (0.03 absorbing coefficient) of the sound that strikes it, whereas walls constructed of the ordinary run of lightweight block will absorb approximately 50 per cent (0.50 coefficient) of the incident sound. A material capable of absorbing 15 per cent (0.15 coefficient) or more may be considered as satisfactory for sound control.

Practically any kind of surface texture may be produced from the various types of aggregate, depending on the control of grading of the aggregate, the mix and the degree of compaction at the time of molding.

The use of decorative paint on block walls will not materially reduce the sound absorptive qualities or insulative value. If the pores are completely closed by paint, the acoustical properties will be reduced. Spray painting has less effect in closing the pores of masonry than brush painting. Oil paints reduce sound absorption more than cement base paint.

Some interesting data are presented in "Facts About Concrete Masonry" published by NCMA, showing details of aggregates, mixes, and physical properties of concrete in units used in a series of sound absorption tests from which the following data are taken.

Range of Absorption Coefficients of Concrete:

| Type | Coefficient Range |
|---|---|
| Cinder Aggregate Concrete—unpainted | 0.51-0.55 |
| painted | 0.44-0.49 |
| Sand-Gravel Aggregate Concrete—unpainted | 0.27-0.37 |
| painted | 0.18-0.27 |
| Limestone Aggregate Concrete | 0.21 |
| Haydite Aggregate Concrete | 0.50 |

Efflorescence On Block—Efflorescence is a surface precipitation which might occur on any kind of masonry, and while not serious structurally, it does detract from the appearance of a building. The cause of efflorescence or as it is sometimes called "fuzz" or "bloom" is known but often misunderstood.

Frequently the trouble is attributed to lime, since dry lime and the crystals of efflorescence appears alike, both being white and powdery. However the two materials are entirely different.

When a somewhat porous material like concrete block absorbs water, the absorbed water readily dissolves certain salts, such as carbonate of lime, sulphates or chlorides which may be present. The chlorides may be derived either from the use of an excess of calcium chloride or sodium chloride (table salt) added during cold weather to lower the freezing temperature of the water for the concrete mix.

Other sources from which these salts come are contaminated gravel or sand or from a mineral water used in processing the units, which may contain high concentrations of sulphates or chlorides.

Efflorescence indicates the presence of excess water within the wall. The water must come to an exposed surface where it will deposit any material which is carried in solution.

When first deposited, efflorescence may be washed off with water, either by a hose or brush. When efflorescence is heavy or when it has dried it may be necessary to use a solution of approximately 10 per cent of commercial muriatic acid. When acid is used the wall should be thoroughly washed down with water immediately afterwards.

The length of time required for the acid solution to dissolve off the efflorescence will depend upon the amount of the latter. In most cases the acid can be washed off within 4 or 5 minutes. If some of the deposit remains after the first application, a second can be made. The acid solution should be brushed on smoothly, using the least amount possible for each application.

Colored Concrete Masonry Units—Attractively colored units of various types are gaining in popularity. If certain factors are observed in the production of such units satisfactory results are assured. Coloring pigment suitable for use in concrete should meet certain requirements as follows:

1. It should be of a composition which will not react chemically with the lime of the cement to the detriment of either cement or color.
2. It should be durable under exposure to direct sunlight and also in a lesser degree to diffused daylight.
3. It should possess adequate tinting qualities.

These requirements may best be met by the use of either natural mineral or manufactured mineral oxide colors. Organic dyes are sometimes used but these colors tend to fade when exposed to sunlight, or they may be decomposed by chemical action. However, for concrete products for interior use, these may be satisfactory inasmuch as there is not enough strong sunlight to cause appreciable fading. These pigments are characterized by brilliance of hues not otherwise obtainable. This type of coloring pigment is generally described as "interior color."

Natural mineral pigments are prepared from ores by grinding or calcining (heating), washing and subsequent grinding of the ore.

Manufactured (synthetic) mineral pigments are obtained from metal salts by precipitation, calcination or other methods.

Where dull colors are acceptable natural mined oxides may be used. More of the natural pigment will be required than of the manufactured pigment, in the approximate ratio of 2-5 lbs. of natural pigment of the same hue, to 1 lb. of the manufactured pigment.

Pigments which are manufactured for coloring mortar are generally unsuitable for coloring concrete because they sometimes contain filler material.

Manufactured oxide pigments produce brighter hues and have stronger tinting qualities but are slightly more costly. They can be more rigidly controlled as to shade, particle size and purity. The finer the pigment the more easily dispersed it will be through the cement and other materials in the concrete.

Colors which may be incompatible with one another or through improper handling can result in streaking or fading or in unattractive shades in the finished product.

The following outline will serve as a guide for the selection of pigments for use in coloring concrete.

Iron oxides either of natural or synthetic origin are used to obtain shades of red, yellow, black, brown, buff or tan. These oxides are relatively unaffected by sunlight or by alkali and are reasonably low in cost.

The synthetic oxides are preferable because of their attractive shades, purity and higher tinting strength. Natural oxides vary in strength of color and purity and may contain soluble salts which might develop efflorescence on the face of the finished units.

For a brilliant dark green shade, chromium oxide, when pure, is unequaled for permanence and is not affected by acid or alkali. This pigment, however, should not be confused with a group of pigments commercially known as chrome greens which are not alkali resistant.

In the range of blue pigments there is nothing completely satisfactory in the low price class. Blue cobalt oxide has greater permanency of color than any of the other blue pigments, but its high cost limits its use. The pigment most commonly used is known as ultramarine blue. This pigment frequently undergoes a slow reaction with concrete during curing and may tend to fade from the inside to the outer surface of the unit. For concrete, only pigments specially manufactured, should be used.

For a black color, the manufactured pigment is most frequently used. Natural black iron oxide is also satisfactory but is usually more costly. When selecting this color, a jet black hue, because of its non-fading qualities, rather than a blue toned black should be used. Another form of black coloring material is a specially treated carbonaceous black which mixes readily with water and has good coloring strength.

Certain manufactured pigments should be avoided. These are weak iron oxide colors, prussian blue, chrome green, chrome yellow and certain forms of black pigments are unsatisfactory because of their fading tendencies.

Whether or not a pigment is affected by alkali (lime) can be easily determined by shaking a sample of the color material with lime water and allowing it to stand for several hours. Pronounced fading of the color indicates the material is unsuitable for use in concrete. Prussian blue is an example of a pigment thus affected.

Mixtures of coloring pigments will produce any desired shade. Depth of color or varying shades from light to dark are obtained by controlling the amount of pigment or by mixing two or more basic colors such as red, yellow, blue and black.

For instance, green hues are produced from a blend of blue and yellow; orange hues are blends of red and yellow; while brown hues are the product of blends of red and black.

Variations in the color of the materials and the pigments themselves, make the color formulas only approximate. Best results can be obtained by experiment or trial, keeping in mind that test panels of concrete will be darker when they are damp. Arrangements can usually be made with the pigment manufacturer to supply any special color developed.

When dark colors of concrete are desired, ordinary portland cement may be used in the concrete mix. For the lighter shades such as blue, green, tan and orange, white cement must be used to obtain maximum color value.

It is desirable to keep a detailed permanent record of each blend, also data relating to the treatment as well as the materials used in making the concrete. Such information is necessary if results are to be duplicated.

Pigment should always be added by weight not by volume. The amount of pigment expressed by percentage or pounds is always based on the weight per sack of cement only. The weight of the aggregate is not computed.

In coloring concrete units, pigment should be used integrally. If surface coatings are applied, any chipping or breaking would be visible in the uncolored portion of the block, thereby spoiling the over-all color effect.

When the color manufacturer's specifications and advice mention weight of coloring pigment per sack of cement, such advice should be followed carefully.

Generally, pigments may be safely used in amounts up to 10 percent of the weight of the cement; that is, 9 lbs. of pigment per 94 lb. sack of cement. It is not advisable to exceed the 10 percent addition of color in any concrete mix, since large quantities may reduce the final strength of the product. This limit, however, may be exceeded with some pigments and under certain conditions.

Pigment should be at least of the same fineness as the cement. The finer the pigment the greater will be the coloring power.

The successful use of color pigment requires thorough dry mixing with the cement to insure that it is uniformly distributed. The colored cement is added to the aggregate and again thoroughly mixed before the water is added.

Control of the amount of water in a colored concrete mix is very important. Fluctuations in the amount of water per batch will give variations in the intensity and shade of the resultant concrete. In additon to affecting the color, too much water will tend to increase the possibility of efflorescence. Therefore, it is important that the mixes be kept as dry as possible to minimize efflorescence. Too much water also tends to cause "gumming" of the cement paste which slows up machine production.

If sufficient curing space is available units should be cured for as long a time as possible at a temperature between 70 and 100 deg. F. In high production plants, however, units may be steam cured at a temperature above 100 deg. F. provided the curing and subsequent drying conditions are carefully controlled.

Experience shows that even where high temperature curing is used satisfactory results are obtained provided attention is given to the presetting of the units. A presetting time of 6 hours is much better than a 2 hour period. Where units can be held for any period up to 24 hours before steaming, the stronger will be the intensity of color and other qualities. Units should be yarded off the ground and preferably under cover.

It is evident that in order to obtain uniform and good results there should be control by weighing the aggregate and color, proper mixing and metering or weighing the water and proper curing.

### Testing Cement Colors*

**Test for Fading**—To 2 ounces of dry color in a suitable sized bottle, add sufficient distilled water to make a creamy mixture after thorough shaking.

If the coloring material floats on top of the water, it will be unsatisfactory for use. Next divide the contents of the bottle, pouring half the solution onto a glass plate. To that portion remaining in the bottle, add ½ ounce of chloride of lime, shake well and pour this solution onto another glass plate. Compare the solutions on the separate plates to determine what effect the chloride of lime has on the color. Any fading or mottling is cause for rejection of the pigment.

**Test for Light Resistance**—Prepare a stiff paste of the pigment with distilled water. Pour a portion of the paste onto a glass plate and cover with another glass plate. Press the plates together until there is a layer of about ⅛ in. thick, then bind edges of the assembly with adhesive tape. Cover one half of the plate with black paper, then subject the assembly to sunlight or artificial rays for a week or more. When the covered and uncovered sections of the pigment are compared, the light resistant quality is readily apparent.

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*Concrete Products and Cast Stone—Childe

Tests for Fineness and Impurity—Half fill a cup with dry color, add sufficient distilled water and stir. When contents of cup have settled, draw off the water and dry the cake by artificial heat. Break the pat and view the fracture by means of a magnifying glass.

If the pigment has been finely and evenly ground the pat should not show evidence of stratification between the coarse and fine material, nor any change in color. If the pat is not readily friable between the fingers, the indication is that the pigment may be adulterated. Next add a few drops of diluted hydrochloric acid to the face of the fracture, any evidence of effervescence (fizzing) is indicative of chalk or lime which is an adulterant. If any of these detrimental factors are apparent the pigment should be rejected.

Portland Cement Paint—Cement base paint, obtainable in a variety of colors, is frequently applied to masonry walls to enhance their appearance and also to render them water repellent. This can be accomplished most economically by the application of cement paint which, when properly applied gives lasting and satisfactory results. In fact, when unsatisfactory results do occur, the trouble may be traced directly to the method of application of the paint.

The certain precautions which should be observed for the application of this type of paint are as follows:

1. The paint should be mixed according to the instructions furnished by the manufacturer.

2. The block surfaces must be clean, free from dirt, dust or any substance which will prevent the paint from properly bonding to the surface. When it becomes necessary to repaint block previously treated with oil or caesin type paints, it is essential that the old coatings be removed.

This may be done by means of a moderately strong solution of trisodium phosphate or caustic soda, after which the surface is treated with a 10 per cent concentration of muriatic acid and finally washed down with water to remove salts. Otherwise efflorescence may take place. After this treatment the walls are allowed to thoroughly dry.

3. Paint should not be applied to frosted surfaces, nor at a temperature below 40 deg. F. during the following 12 hours.

4. Before starting to paint, the walls should be moistened by using a very fine spray of water. Do-not-soak. Too much attention cannot be given to the exact procedure for dampening the walls only slightly in advance of painting, otherwise the wall will absorb mixing water from the paint, thereby impairing its hardening qualities.

If too much water is applied to the walls either before painting or for curing, shrinkage cracks may be produced after the walls dry out. Too little water, particularly for curing, will tend to cause the paint to chalk or dust when it is dry, caused by lack of bond.

5. The painted surfaces should be kept slightly damp for 24 hours by spraying lightly with water. Spraying should be commenced as soon as the paint sets sufficiently enough that it will not be damaged by this treatment.

6. Starting at the top of the wall and working down, cement paint may be applied in one or two coats depending on the requirements. The paint should first be scrubbed into the mortar joints around each block. When the first coat has hardened, which takes about 12 hours, the wall surface is again dampened and the second coat of paint applied with horizontal strokes for best results.

7. Where non-uniform coverage results, the cause may be attributed to applying too much water spray in dampening the walls before painting or to failure to stir the paint frequently enough to keep the solids in suspension.

8. While a paint itself may be presumed to be uniform, considerable variation in appearance may result with the same brand and color of paint when applied to units made from different kinds of aggregates, different surface textures and also when painted walls are exposed to strong daylight or to artificial light.

## Section 21—Technical Notes

Water and Pressure—A gallon of water (U. S. Standard) weighs 8.33 lb. and contains 231 cu. in.

A cubic foot of water contains 7.48 gal., 1,728 cu. in., and weighs 62.4 lb.

To find the pressure in pounds per square inch of a column of water, multiply the height of the column in feet by 0.434.

Well water may be pumped from a depth of 34 ft. (theoretically): practically, however, 28 to 30 ft. is the average for a vacuum lift pump.

Doubling the diameter of a pipe increases its capacity four times.

2.0416 in. mercury at 62 deg. F. = 1 lb. per sq. in.
2.309 ft. water at 62 deg. F. = 1 lb. per sq. in.
1 in. mercury = 13.6 in. water
12 U.S. gallons of water = 1 cwt. (100 lb.)
240 U.S. gallons of water = 1 ton (2,000 lb.)
1.6 cu. ft. of water = 1 cwt. (100 lb.)
32.0 cu. ft. of water = 1 ton (2,000 lb.)
1 cu. ft. of snow, closely packed, weighs approximately 25 lb. and gives approximately 3 gal. of water.

Boiler Practice—Generally in a boiler there are 9 sq. ft. of heating surface to each square foot of grate surface.

Each nominal horsepower of a boiler requires the evaporation of 34.5 lb. of water per hour.

One horsepower is equivalent to raising 33,000 lb. 1 ft. per minute, or 550 lb. 1 ft. per second.

Steam rising from water at its normal boiling point (212 deg. F.) has a pressure equal to the atmosphere (14.7 lb. per square inch).

The average consumption of coal for steam boilers is 12 pounds per hour for each square foot of grate surface.

Combustion—The composition of air for ordinary purposes may be taken as:

Oxygen 21 per cent; nitrogen 79 per cent, by volume.
Oxygen 23 per cent; nitrogen 77 per cent, by weight.
2.666 lb. oxygen are required to burn 1 lb. carbon.
11.52 lb. air are required to burn 1 lb. carbon.
8.0 lb. oxygen are required to burn 1 lb. hydrogen.
34.0 lb. air are required to burn 1 lb. hydrogen.
4 lb. oxygen are required to burn 1 lb. methane.
17.24 lb. air are required to burn 1 lb. methane.
9.52 cu. ft. of air are required to burn 1 cu. ft. methane.
12.387 cu. ft. = volume of 1 lb. of air at 32 deg. F.
13.144 cu. ft. = volume of 1 lb. of air at 62 deg. F.

Unit of Heat—A British Thermal Unit is the quantity of heat required to raise 1 lb. water 1 deg. F.

Conversion of thermometer scales where "C" and "F" denote the readings on the Centigrade and Fahrenheit scales, respectively, for the same temperature, then

$$\text{Degrees C} \times 1.8 + 32 = \text{degrees F.}$$

$$\text{Degrees } \frac{F - 32}{1.8} = \text{degrees C.}$$

Relative Humidity—Relative humidity is the ratio usually expressed as a percentage used to indicate the amount of water vapor held in the air at a given temperature in relation to the maximum vapor holding power or saturation point at that temperature.

Dew Point—The dew point is that temperature at which the atmospheric air is saturated with moisture and begins, in consequence, to deposit it.

Miscellaneous—Micron is a unit of length, the thousandth part of one millimeter or one millionth of a meter. It may also be expressed as 0.00004 in.

1 board foot = 144 cu. in. = volume of board 1 ft. square and 1 in. thick.

Specific gravity is the ratio of the mass of a substance to the mass of an equal volume of water at some standard temperature. Specific gravity of water equals 1.

## OUTLINE OF CALCULATIONS OF HEAT REQUIREMENTS FOR CURING BLOCK—DATA SHEET FOR CINDER UNITS

KILN DIMENSIONS—Length = 75'0" : Width = 8'0" : Height = 7'6"

KILN CONSTRUCTION—Walls—8" hollow sand-gravel units.
Floor—6" thick reinforced concrete slabs.
Roof—4" thick concrete slabs with 2" foam glass built-up roof.

KILN CONTENTS—26 racks holding 1,872—8" cinder units.
Weight of racks—500 lb.; pallets 42 lb.
Weight of cinder block (molded) 35 lb.
Weight of cinder block (dry content) 31.5 lb.

KILN TEMPERATURE—At start 70° F. and 50% relative humidity.
Block temperature at start 70° F.

CONSTANTS—Specific heat of steel .................... 0.12
Specific heat of water .................... 1.00
Specific heat of cinder concrete .................... 0.18
Specific heat sand-gravel concrete (for 160 deg. F.) .. 0.19

DATA—Weight of cinders (assumed) .................... 100 lb/cu. ft.
Weight of steel .................... 475 lb/cu. ft.
Weight of concrete .................... 144 lb/cu. ft.
Temperature rise desired .................... 100° F.

Yield of block per sack cement .................... 25 units

Final humidity .................... 100%
Assumed hydration of cement during steaming .... 35%

1. Weight of block in kiln—1,872 × 31.5 ........... = 58,968 lb.
2. Weight of racks in kiln—26 × 500 lb. ....... = 13,000 lb.
3. Weight of pallets in kiln—26 × 42 lb. = 26,208 lb.
4. Weight of water in block—3.5 × 1,872 ....... = 6,552 lb.
5. Volume occupied by block—1,872 × 31.5 ÷ 100 .. = 590 cu. ft.
6. Volume occupied by steel—13,000 + 26,208 + 475 = 83 cu. ft.
7. Total volume of kiln contents—590 + 83 ......... = 673 cu. ft.
8. Gross volume of kiln—75' × 8' × 7.5 ........... = 4 500 cu. ft.
9. Net volume of kiln—4,500 − 673 ........... = 3,827 cu. ft.
10. Data from ASH and VE, 1951 Guide
    Cu. ft./lb. of air at 70° F. and 50% relative humidity .................... = 13.5 cu. ft.
    Cu. ft./lb. of air at 170° F. and 100% relative humidity .................... = 26.8 cu. ft.
    Total heat/lb. of air at 70° F. and 50% relative humidity .................... = 25.45 Btu
    Total heat/lb. of air at 170° F. and 100% relative humidity .................... = 531.5 Btu
11. Lb. of air in kiln at initial condition—3,827 + 13.5 = 283 lb.
12. Lb. of air in kiln at final condition—3,827 + 26.8 = 142 lb.
13. Total heat of air in kiln at initial condition—
    283 × 25.45 .................... = 7,202 Btu
14. Total heat of air in kiln at final condition—
    142 × 531.5 .................... = 75,473 Btu
15. Heat gain in kiln air—75,473 − 7,202 ............ = 68,271 Btu
16. Heat required to raise water in block 100° F.—
    6,552 × 100 × 1.0 .................... = 655,200 Btu
17. Heat required to raise cinders in kiln 100° F.—
    58,968 × 100 × 0.18 .................... = 1,061,425 Btu
18. Heat required to raise steel in kiln 100° F.—
    39,208 × 100 × 0.12 .................... = 470,500 Btu
19. Total heat of hydration of cement (assumed) ...... = 180 Btu/lb.
20. Heat released by hydration of cement .......... = 180 Btu/lb.
    Sacks of cement contained in kiln—1,872 + 25 .... = 75 sacks
    Total weight of cement contained in kiln—75 × 94 = 7,050 lb.
    Total heat of hydration—7,050 × 180 × 0.35 .... = 444,150 Btu
21. Kiln surfaces (ceiling, walls and floor) calculated as being heated to a uniform depth of 2".
    Kiln volume heated .................... = 400 cu. ft.
    Weight of kiln surface heated—400 × 144 ....... = 57,600 lb.
22. Heat absorbed by kiln surfaces—
    57,600 × 100 × 0.19 .................... = 1,094,400 Btu
23. Total heat requirements obtainable by adding items No. 15, No. 16, No. 17, No. 18, No. 22, then subtracting item No. 20 shown as follows:
    68,271 + 655,200 + 1,061,425 + 470,500 + 1,094,400 − 444,150 .................... = 2,905,646 Btu
24. If the temperature rise is assumed to be 60° F. per hour, it will take 1.67 hours to obtain a 100° F. temperature rise.
    U factors from ASH and VE, 1951 Guide.
    Roof—0.1 Btu/hr./sq. ft./deg. temp. difference.
    Floor—0.1 Btu/hr./sq. ft./deg. temp. difference.
    Walls—0.41 Btu/hr./sq. ft./deg. temp. difference.
    Mean temperature = 100° F. + 1.67 = 60° F.
    Roof area—75' × 8' = 600 sq. ft.
    Floor area—75' × 8' = 600 sq. ft.
    Wall area—75' × 7.5' × 2 = 1,125 sq. ft.
    End area—8' × 7.5' × 2 = 120 sq. ft.
    Roof heat loss—600 × 0.1 × 1.67 × 60 ......... = 6,000 Btu
    Floor heat loss—600 × 0.1 × 1.67 × 60 ....... = 6,000 Btu
    Wall heat loss—1,245 × 0.41 × 1.67 × 60 ....... = 51,147 Btu
    Total Heat Loss .................... = 63,147 Btu
25. Total heat requirement for one steaming cycle—
    2,905,646 + 63,147 .................... = 2,968,793 Btu

---

## SUPPLEMENTARY DATA FOR SAND—GRAVEL UNITS.

Molded weight—40 lb.; dry weight, 38 lb.
Then—
Item No. 1 becomes 1,872 × 38 .......... = 71,136 lb.
Item No. 4 becomes 1,872 × 2 ..... = 3,744 lb.
Item No. 16 becomes 3,744 × 1.0 × 100 . = 374,400 Btu
Item No. 17 becomes 71,136 × 0.19 × 100 = 1,351,584 Btu
Yield of block/sack of cement ........ = 30 units
Item No. 20 becomes 1,872 ÷ 30 .......... = 62.4 sacks
Total weight of cement contained in kiln—
62.4 × 94 .................... = 5,865 lb.
Total heat of hydration—5,865 × 180 × 0.35 .. = 369,500 Btu
Item No. 23, Total heat requirements obtained by adding items No. 15, No. 16, No. 17, No. 18, No. 22 then subtracting item No. 20, as follows:
68,271 + 374,400 + 1,351,584 + 470,500 + 1,094,400 − 369,500 .................... = 2,999,255 Btu
Item No. 25 becomes 2,999,255 + 63,147 ...... = 3,062,402 Btu
Therefore total heat requirements for one steaming cycle .................... = 3,062,402 Btu

## AVERAGE WEIGHT OF VARIOUS SUBSTANCES PER CUBIC FOOT

| MATERIALS | Average Weight Per Cubic Foot: Lb. |
|---|---|
| Ashes—bituminous (packed) | 40-45 |
| Ashes—anthracite (packed) | 30 |
| Brick—common | 120-125 |
| Brick—pressed | 150 |
| Brick—fire | 150 |
| Cement—portland (per sack) | 94 |
| Cement—portland (per barrel) | 376 |
| Cement—prepared mortar (per sack) | 70 |
| Cement—prepared mortar (per barrel) | 280 |
| Cinders—bituminous | 55-70 |
| Coke (loose) | 25-35 |
| Concrete—stone | 130-150 |
| Concrete—cinder | 100-110 |
| Coal—anthracite (loose) | 47-58 |
| Coal—bituminous (loose) | 40-56 |
| Fire clay | 85 |
| Gravel—dry | 100-112 |
| Gravel—wet | 115-125 |
| Lime—hydrated (50-lb. sack) | 45 |
| Lime—unslaked (loose lumps) | 53 |
| Lime—unslaked (shaken lumps) | 75 |
| Limestone (solid) | 145-170 |
| Limestone (crushed) | 90-110 |
| Marble | 165-175 |
| Mortar—lime (set) | 103 |
| Mortar—cement (set) | 95-100 |
| Plaster of paris (loose) | 60-70 |
| Quartz | 165 |
| Sand—dry (loose) | 90-112 |
| Sand—inundated | 118-130 |
| Sandstone (loose) | 100-110 |
| Shale (loose) | 105 |
| Slag—furnace | 70-100 |
| Stone—crushed | 100-110 |
| Water | 62.5 |

## MENSURATION FORMULAS

Area of circle = square of diameter × 0.7854
Area of cylinder surface = circumference × length
Total area of cylinder = circumference × length plus 2 end areas
Area of rectangle = length × breadth
Area of sector = area of circle × $\frac{\text{number of deg. in arc}}{360}$
Area of square = one side × the other side
Area of sphere = square of diameter × 3.1416
Area of triangle = base × ½ altitude
Circumference of circle = diameter × 3.1416
Cubic contents of a cylinder = area of base × length
Diameter of circle = radius × 2
Diagonal of a square = one side × 1.414
Volume of a sphere = cube of diameter × 0.5236
Volume of a cone = altitude × ⅓ area of base
Side of a square = diagonal × 0.7071
Surface of a cube = area of one face × 6.0

## CONVERSION TABLES

### Area Equivalents

| Multiply | By | To Obtain |
|---|---|---|
| Acres | 43,560 | Square feet |
| | 4,840.0 | Square yards |
| | 0.0015625 | Square miles |
| Square inches | 0.00694 | Square feet |
| | 0.0007716 | Square yards |
| Square feet | 144.0 | Square inches |
| | 0.1111 | Square yards |
| Square yards | 1,296.0 | Square inches |
| | 9.0 | Square feet |
| | 0.0002066 | Acres |
| Square miles | 640 | Acres |

### Length Equivalents

| Multiply | By | To Obtain |
|---|---|---|
| Inches | 2.540 | Centimeters |
| | 0.8333 | Feet |
| | 0.02778 | Yards |
| | 0.0254 | Meters |
| | 0.0000254 | Kilometers |

| | | |
|---|---|---|
| Feet | 12 | Inches |
| | 0.3333 | Yards |
| | 0.3048 | Meters |
| | 0.0003048 | Kilometers |
| | 0.0001894 | Miles |
| Yards | 36 | Inches |
| | 3 | Feet |
| | 0.9144 | Meters |
| | 0.0009144 | Kilometers |
| | 0.0005682 | Miles |
| Miles | 63,360.0 | Inches |
| | 5,280.0 | Feet |
| | 1,760.0 | Yards |
| | 1,609.0 | Meters |
| | 1.609 | Kilometers |
| Kilometers | 39,370.0 | Inches |
| | 3,281.0 | Feet |
| | 1,093.6 | Yards |
| | 0.6214 | Miles |
| Feet per Min. | 0.01667 | Feet per sec. |
| | 0.01136 | Miles per hr. |
| Feet per Sec. | 0.6818 | Miles per hr. |
| | 0.01136 | Miles per min. |

### Volume and Capacity Equivalents

| Multiply | By | To Obtain |
|---|---|---|
| Bushels | 2,150.42 | Cubic inches |
| | 1.2444 | Cubic feet |
| | 0.0461 | Cubic yards |
| Cubic inches | 0.0004650 | Bushels |
| Cubic feet | 0.8036 | Bushels |
| Cubic yards | 21.70 | Bushels |
| Cubic inches | 0.0005787 | Cubic feet |
| | 0.00002143 | Cubic yards |
| Cubic feet | 1,728.0 | Cubic inches |
| | 0.03704 | Cubic yards |
| Cubic yards | 46,656.0 | Cubic inches |
| | 27.0 | Cubic feet |
| Cubic inches | 0.004329 | Gallons |
| Cubic feet | 7.481 | Gallons |
| Gallons | 231.0 | Cubic inches |
| | 0.1337 | Cubic feet |
| | 4 | Quarts, liquid |

### Water—Volume and Capacity Equivalents

| Multiply | By | To Obtain |
|---|---|---|
| Cubic feet per Min. | 472.0 | Cubic cm. per sec. |
| | 0.1247 | Gallons per sec. |
| | 62.43 | Pounds water per min. |
| Cubic feet per Sec. | 0.6463 | Million gallons per day |
| | 448.831 | Gallons per min. |
| Feet of Water | 0.02950 | Atmospheres |
| | 0.8826 | Inches mercury |
| | 62.43 | Pounds per sq. ft. |
| | 0.4335 | Pounds per sq. in. |
| Gallons of Water | 8.3453 | Pounds water |
| Pounds | 0.12 | Gallons |
| Gallons per Min. | 0.002228 | Cubic feet per sec. |
| | 8.0208 | Cubic feet per hr. |
| | 6.0086 | Tons water per 24 hr. |
| Liters | 1,000.0 | Cubic centimeters |
| | 61.02 | Cubic inches |
| | 0.2642 | Gallons |
| Pounds Water | 27.681 | Cubic inches |
| | 0.01602 | Cubic feet |
| | 0.1198 | Gallons |
| Parts per Million | 0.0584 | Grains per gallon |
| | 8.345 | Pounds per million gal. |
| Million Gallons per 24 Hr. | 1.54723 | Cubic feet per sec. |
| Tons Water per 24 Hr. | 83.333 | Pounds water per hr. |
| | 0.16643 | Gallons per min. |
| | 1.3349 | Cubic feet per hr. |
| Cubic inches | 0.03617 | Pounds (avoir.) |
| Cubic feet | 62.42 | Pounds (avoir.) |
| Pounds | 0.01602 | Cubic feet |

### Mass or Weight Equivalents

| Multiply | By | To Obtain |
|---|---|---|
| Grains | 0.0648 | Grams |
| | 0.002286 | Ounces |
| Grams | 15.432 | Grains |
| | 0.0353 | Ounces |
| | 0.002205 | Pounds |
| Ounces | 437.5 | Grains |
| | 28.35 | Grams |
| | 0.0625 | Pounds |
| Pounds | 16.0 | Ounces |
| | 7,000.0 | Grains |
| | 453.59 | Grams |
| | 0.4536 | Kilograms |
| Kilograms | 2.205 | Pounds |
| | 0.001102 | Tons |
| Tons | 907.2 | Kilograms |
| | 2,000.0 | Pounds |
| Metric Ton | 1,000 | Kilograms |
| | 2,204.6 | Pounds |

### Energy and Power Equivalents

| Multiply | By | To Obtain |
|---|---|---|
| Foot Pounds | 0.001285 | Btu. |
| Foot Pounds per Sec. | 0.001818 | Horsepower |
| Btu. | 778.2 | Foot-pounds |
| | 0.0003985 | Horsepower-hours |
| | 0.0002930 | Kilowatt-hours |
| | 1.8 | Calories |
| Btu. per Min. | 12.96 | Foot pounds per sec. |
| | 0.02356 | Horsepower |
| | 0.01757 | Kilowatts |
| | 17.57 | Watts |
| Calories | 0.003968 | Btu. |
| Kilowatt per Hr. | 3,413.0 | Btu. |
| | 1.341 | Horsepower-hours |
| Watt-Hours | 3.415 | Btu. |
| Horsepower-Hours | 2,509.0 | Btu. |
| Horsepower | 550.0 | Foot-pounds per sec. |
| | 0.7457 | Kilowatts |
| | 745.7 | Watts |
| | 2,545.0 | Btu. per hr. |
| Boiler Horsepower | 33,476.0 | Btu. per hr. |

Btu. (British Thermal Unit) is the quantity of heat required to raise 1 lb. water 1 deg. F.

### Pressure Equivalents at Sea Level

| Multiply | By | To Obtain |
|---|---|---|
| Atmosphere | 76.0 | Cm. of mercury |
| | 29.92 | Inches of mercury |
| | 33.90 | Feet of water |
| | 14.70 | Pounds per sq. in. |
| | 1.058 | Tons per sq. ft. |
| Centimeters Mercury | 0.01316 | Atmospheres |
| | 0.4461 | Feet of water |
| | 0.1934 | Pounds per sq. in. |
| | 27.85 | Pounds per sq. ft. |
| Inches Mercury | 0.03342 | Atmospheres |
| | 1.134 | Feet of water |
| | 0.4912 | Pounds per sq. in. |
| Inches Water | 0.002456 | Atmospheres |
| | 0.07349 | Inches of mercury |
| | 0.03609 | Pounds per sq. in. |
| | 5.1969 | Pounds per sq. ft. |
| Pounds per Sq. In. | 0.06804 | Atmospheres |
| | 2.307 | Feet of water |
| | 2.036 | Inches of mercury |
| | 0.072 | Tons per sq. ft. |
| Pounds per Sq. Ft. | 0.01602 | Feet of water |
| Tons per Sq. Ft. | 13.89 | Pounds per sq. in. |
| | 0.94504 | Atmospheres |

**Computing Sizes of Bins and Tanks**—Containers for dry materials such as sand and gravel are usually called "bins" and their capacities are given in cubic feet, cubic yards or tons. Containers for liquids such as water or oil are called "tanks" and their capacities are given in gallons or barrels.

Bins of a rectangular shape are usually preferred by the industry because this shape lends itself best to space saving.

Following are formulas for the volumes of various shapes of bins and tanks:

L = length in feet.
B = breadth in feet.
H = height in feet.
v = volume or capacity in cubic feet.
V = volume or capacity in cubic yards.
W = weight in pounds per cubic foot.
T = capacity in tons.

#### Rectangular Bins

Equation 1: $v = L \times B \times H$ gives capacity in cu. ft.

$$2: V = \frac{L \times B \times H}{27}$$ gives capacity in cu. yd.

$$3: T = \frac{L \times B \times H \times W}{27 \times 2{,}000}$$ gives cap. in tons.

*Problem 1.*

What is the capacity of a rectangular bin 30 ft. long, 20 ft. wide and 10 ft. high?

From Equation 1, $v = 30 \times 20 \times 10 = 6{,}000$ cu. ft.

From Equation 2, $V = \frac{30 \times 20 \times 10}{27} = \underline{222.22}$ cu. yd.

If material weighing 3,000 lb. per cubic yard is to be stored in a bin of the above dimensions, how many tons will it hold?

From Equation 3, $T = \frac{30 \times 20 \times 10 \times 3{,}000}{27 \times 2{,}000} = 333.33$ tons

### Rectangular Bins with Sloping Bottom Sections

The size and style of bin for holding aggregate are governed by the needs of the plant and the space available.

A conventional style of bin is one in which the upper part has vertical sides, while the sides of the lower section converge to a control orifice. The pitch of the sides is such that the material flows freely.

Consider a bin the top section of which measures $13\frac{1}{2}$ ft. in both length and width by 7 ft. in height. The lower section is tapered uniformly on all sides to a dimension of $1\frac{1}{2}$ ft. square at the orifice. The height of this section is also 7 ft. What is the total capacity of the bin?

According to the prismatoid formula:

$V = \frac{1}{6}h\,(B + B_1 + 4\,M)$

Where $V$ = volume
$h$ = height
$B$ = area of top
$B_1$ = area of bottom
$M$ = area of the cross section at mid-height and parallel with the base and top

Calculation of top section:

$V = 13.5 \text{ ft.} \times 13.5 \text{ ft.} \times 7 \text{ ft.} = 1{,}275.75$ cu. ft.

Calculation of bottom section:

$B = 13.5 \text{ ft.} \times 13.5 \text{ ft.} = 182.25$ sq. ft. for top area
$B_1 = 1.5 \text{ ft.} \times 1.5 \text{ ft.} = 2.25$ sq. ft. for orifice area
$M = 7.5 \text{ ft.} \times 7.5 \text{ ft.} = 56.25$ sq. ft. for average center area

Therefore:

Volume $= \frac{1}{6}h\,(B + B_1 + 4M)$ or
$V = \frac{1}{6} \times 7\,(182.25 + 2.25 + 225.0)$
$= 7/6 \times 409.5 = 477.75$ cu. ft.

Adding the volumes of both sections of the bin (round numbers):

$1{,}276 + 478 = 1{,}754$ cu. ft.
$1{,}754 \div 27 = 64.90$ cu. yd. capacity.

*Problem 2.*

It is desired to store 100 tons of material weighing 2,000 lb. per cubic yard in the end of a building 20 ft. of which is available for the length of the bin. Shafting overhead limits the height of the bin to 8 ft. How wide must the bin be made?

From Equation 3,

$$100 = \frac{20 \times B \times 8 \times 2{,}000}{27 \times 2{,}000} = 5.926 \times B$$

$$B = \frac{100}{5.926} = 16.89 \text{ ft., or } 16 \text{ ft. } 10\tfrac{1}{2} \text{ in.}$$

### Cylindrical Bins

$H$ = Height in feet.
$D$ = Diameter in feet.
$v$ = Volume or capacity in cubic feet.
$V$ = Volume or capacity in cubic yards.
$W$ = Weight in pounds per cubic foot.
$T$ = Capacity in tons.

Equation 4: $v = .7854 \times D^2 \times H$ gives cap. in cu. ft.

Equation 5: $V = \dfrac{.7854 \times D^2 \times H}{27}$ gives cap. in cu. yd.

Equation 6: $T = \dfrac{.7854 \times D^2 \times H \times W}{27 \times 2{,}000}$ gives cap. in tons

*Problem 3.*

What is the capacity of a cylindrical bin 10 ft. in diameter and 20 ft. high?

From Equation 4: $v = 0.07854 \times 10^2 \times 20 = 1{,}570.8$ cu. ft.

From Equation 5: $V = \dfrac{0.7854 \times 10^2 \times 20}{27} = 58.18$ cu. yd.

*Problem 4.*

It is desired to build a cylindrical bin 20 ft. high with a capacity of 50 tons of material weighing 2,700 lb. per cubic yard. What is the diameter of the bin?

From Equation 6: $50 = \dfrac{0.7854 \times D^2 \times 20 \times 2{,}700}{27 \times 2{,}000}$

$50 = 0.7854 \times D^2$
$D^2 = 50 \div 0.7854 = 63.65$
Diameter $= 7.98$ ft.

### Rectangular Tanks

The volume of a tank is calculated in like manner as if it were a bin. The capacity in gallons is the volume in cubic feet multiplied by 7.48 (number of gallons in 1 cu. ft.)

$L$ = Length in feet.
$B$ = Breadth in feet.
$H$ = Height in feet.
$G$ = Volume or capacity in gallons.
$Ba$ = Volume or capacity in barrels.

Equation 7: $G = L \times B \times H \times 7.48$ gives cap. in gal.

Equation 8: $Ba = \dfrac{L \times B \times H \times 7.48}{42}$ gives cap. in bbl.

*Problem 5.*

How many gallons will a tank 10 ft. long, 6 ft. wide and 4 ft. high hold?

From Equation 7: $C = 10 \times 6 \times 4 \times 7.48 = 1975.2$ gal.

### Cylindrical Tanks

$H$ = Height in feet.
$D$ = Diameter in feet.
$G$ = Volume or capacity in gallons.
$Ba$ = Volume or capacity in barrels.

Equation 9: $G = 0.7854 \times D^2 \times H \times 7.48$ gives cap. in gal.

Equation 10: $Ba = \dfrac{0.7854 \times D^2 \times H \times 7.48}{42}$ gives cap. in bbl.

7.48 gal. per cubic foot
42 gal. per barrel

**Belts and Pulleys**—The speed at which a machine is operated materially affects the quality and cost of production of the product. Correct speed is desirable and is dependent upon variable conditions, which conditions must be studied carefully in order to obtain an optimum of efficiency from the machine. The following data give a general outline of procedure.

To Determine the Speed of a Belt.

The circumference of driving pulley in feet multiplied by the number of revolutions per minute = Foot speed per minute.

To Determine the Approximate Length of Belt Required.

The sum of the diameters of both pulleys divided by 2; and this result multiplied by 3.1416; plus twice the distance in inches between the center of the shafts = Length required.

To Determine the Diameter of Driven Pulley.

When the horsepower and width of belt are given.

a. The horsepower multiplied by the constant and
b. The revolutions of the pulley multiplied by width of belt

Then the result from (a) divided by the result from (b) = Diameter of pulley

or:

Diameter of pulley on drive shaft multiplied by its number of revolutions.
This product divided by number of revolutions on driven pulley = Diameter of pulley

To determine Width of Belt for Given Horsepower.

a. Horsepower multiplied by constant
b. Diameter of driven pulley multiplied by number of revolutions

Then result from (a) divided by the result from (b) = Width of belt required.

To Determine the Horsepower a Leather Belt Will Transmit.

a. Multiply width of belt in inches by the diameter of driven pulley in inches

b. Result from (a) multiplied by the revolutions per minute and divided by the constant = Horsepower.

To Determine Number of Revolutions of Driven Pulley.
Diameter of pulley on drive shaft multiplied by its number of revolutions divided by the diameter of the pulley on driven shaft = Revs. of driven pulley.

To Determine the Circumference of a Pulley.
Diameter of pulley multiplied by 3.1416 divided by 12 = Result in feet.

# Index

# ATTACHMENT E

# CAUSEWAY VEGETATION SELECTION

**NEW ENGLAND ENVIRONMENTAL, INC.**

ironmental Consulting Services

800 Main Street
Amherst, MA 01002
(413) 256-0202
FAX (413) 256-1092

24 May 2001

Ms. Gina Rustad
Harding ESE, Inc.
511 Congress Street
P.O. Box 7050
Portland, ME 04112-7050

RE: Additional Information for Seed Specifications
Stratford Causeway, Stratford, CT
NEE file 01-1858

Dear Ms. Rustad:

New England Environmental, Inc. (NEE) has been retained by Harding ESE, Inc. as a sub consultant to provide specifications for the seeding and erosion control measures to be incorporated into the reconstruction of the Stratford Causeway.

A site visit to the causeway was conducted on April 24, 2001 by Karro Frost, Senior Botanist, and myself to identify the plant species associated with the causeway, particularly at the elevation which will require future seeding. Since the Housatonic River is tidal at the location of the causeway, particular attention was focused on those plants which can tolerate salt spray, and occasional innundation by salt water.

Our findings indicated that the areas exposed to daily tidal fluctuations were restricted to the lower elevations in the location of the stone rip rap. The dominant plant species found in this area was salt marsh grass (*Spartina alterniflora*), with salt marsh shrubs along the upper boundary (i.e. *Iva fructosa*). Salt tolerant shrub species such as *Myrica pennsylvanica*, *Clethra alnifolia*, and *Rosa rugosa* were also found along this tidal zone.

In the upper elevations of the causeway, we found a variety of both cool season and warm season grasses, most of which are not particularly salt tolerant (e.g. poas and clovers). Willow trees and shrubs (*Salix* spp.) which are also not salt tolerant were growing very vigorously. Based on the existing vegetative cover on the higher elevations of the causeway, it is our assessment that an erosion control seed mix composed of both warm and cool season grasses, with some moderately salt tolerant species, would be required for this site. It is our opinion that a 100% salt tolerant species <u>is not</u> required.

It is preferable to establish the seed during the Spring months so that the plants can be well established prior to the onset of winter storms when severe erosion is most likely to occur. We have recommended that the seed bed be covered with a 100% biodegradable erosion control blanket composed of 70% straw and 30% coconut fibers. A recommended mat is BonTerra America ENCS2, or equal. This erosion control blanket is intended to hold the soil in place, provide additional moisture close to the ground surface, and protect the young plants while they are becoming established. The recommended biodegradable netting will not interfere with future mowing.

Should the construction schedule dictate that the seeding will not occur until the Fall, it may be necessary to place a permanent erosion control matting (turf reinforcement mat) over the soil. We recommend a non-biodegradable mat such as Landlok 1060, or equal. The installed mat is in-filled with topsoil, and then seeded and covered. It is likely that additional over-seeding the following spring will be required as the young seedlings are not likely to survive winter storm events.

An advantage of using the selected seed mixes is that the top of the causeway can be mown if desired and maintained as a lawn for public use, or it may be allowed to naturalize. As a minimum maintenance requirement, we recommend at least one mowing each year, preferably in the fall, to eliminate any woody vegetation which becomes established. Woody species with long root systems can interfere with the underlaying concrete blocks and the structural integrity of the re-constructed Causeway.

I hope that these comments are helpful to you.

Sincerely,
New England Environmental, Inc.

Michael J. Marcus
Senior Scientist
Certified Professional in Sediment & Erosion Control

MJM/sl

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# ATTACHMENT F

# POLYMERIC MARINE MATTRESS EVALUATION

TENSAR Earth Technologies, Inc.

**Jeff Fiske**
*Sales Representative*
*Coastal & Waterway Systems*

5883 Glenridge Drive
Suite 200
Atlanta, GA 30328
Tel. 404•250•1290
Fax. 404•250•9185
*email: jfiske@tensarcorp.com*

April 20, 2001

Mr. Brian Johnson
Harding ESE
511 Congress Street
Portland, ME, 04101

RE: Test Data

Dear Brian:

In response to your e-mail message questioning the test data sent to you on April 19, 2001 the best response I can provide at this time is that I have responded to your questions in a qualitative manner as the limits of time and available data were prohibitive of a full quantitative response.

- The modified version of the LA Abrasion test which was run was not intended to be representative but rather to be exaggerated. The primary purpose of the test was to measure the strength of the grid vs. the potential for damage due to ice flow and impact. To that end, the test indicates that the UXTRITON 200 grid fares well even in these exaggerated conditions. If it would be beneficial, I could copy you on the results of the strength testing which was run after the abrasion test.
- The rebound test was performed on a single strand, thus the indication of 16kN vs. the 1% tensile modulus indicated on the cut sheet. The reason you only received one plot of one test is because that is all we ran for this particular test. As referenced in the letter, the overall change was a net .88% strain indicating that the grid rebounded almost completely overnight.
- As to the 2001 GFR Specifiers Guide, Tensar has had issues with various test methods & whether they accurately reflect performance properties and felt that GFR was publishing claimed properties without appropriate steps to verify claims and assure consistency of reported properties. For this reason Tensar has withdrawn from the GFR.
- For materials published strength values and material values for the baskets, refer to the specification sheets provided earlier.
- TET's standard product warranty is attached.

Durability in a saltwater environment is a valid and important consideration in the selection of materials for tidal and coastal applications. Tensar grids are essentially inert to saltwater and to a wide range of aggressive chemical environments and are therefore the material of choice in many such cases. Note that the previous users of Tensar grids for marine mattress type applications in these types of environments includes the USACE, the US Department of the Navy, the states of New Jersey, Georgia and Florida, and the Panama Canal Authority. Further, for soil reinforcement applications, FHWA documents the suitability of polyethylene and polypropylene materials in saline soils (see FHWA-SA-96-072); Tensar grids are the only soil reinforcement allowed (and are used extensively) by the Florida Department of Transportation for MSE panel walls constructed in areas which may become flooded by seawater.

Let me know if there is anything else I can do for you.

Sincerely,

Jeff Fiske
Sales Representative
Coastal & Waterway Systems

cc: Steve Maher, TET
enc: 1

Standard warranty as described in paragraph 9 under Terms and Conditions of Sale.

The Seller warrants that the product supplied hereunder will be of good and workmanlike quality manufactured in accordance with applicable specifications. THE FOREGOING LIMITED WARRANTY IS IN LIEU OF AND EXCLUDES ALL OTHER WARRANTIES WHETHER EXPRESSED OR IMPLIED BY OPERATION OF LAW OR OTHERWISE, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF MERCHANTIBILITY OR FITNESS, AND INCLUDING BUT NOT LIMITED TO ANY ORAL OR WRITTEN DESCRIPTION OF THE PRODUCT SUPPLIED HEREUNDER, ITS CHARACTERISTICS OR PROPERTIES.

The Seller shall not be liable in any circumstances whatsoever for loss or damage of any kind suffered to or by any third party howsoever caused unless the same shall relate to property damage, personal injury or death arising out of the Sellers negligence or defects in products sold by the Seller.

The Seller shall not be liable for incidental or consequential damages, including but not limited to, any losses or expenses or other damages directly or indirectly arising from the sale, handling or use of the product or from any other cause relating to the sale, handling or use of the Product.

In the event the Product does not conform to the provisions of the foregoing limited warranty or, if for any other reasons the Seller may be liable as a result of the sale, handling or use of the product, the Purchaser's exclusive remedy shall be and is expressly limited to repayment of the purchase price of the Product or, at the Sellers option, replacement of the non-conforming product with a conforming Product.

TENSAR Earth Technologies, Inc.

**Jeff Fiske**
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April 13, 2001

Mr. Brian Johnson
Harding ESE, Inc
P.O Box 7050
Portland, ME. 04112

RE: Triton® Marine Mattress for
Riverbank Protection for
Stratford Army Engine Plant

Dear Brian:

I am writing in response to the questions that have been raised regarding the suitability of the Triton Marine Mattress system for use on the Stratford Army Engine Plant Causeway. The concerns, as stated in previous conversations, are primarily related to potential ice related failure modes for the mattresses and materials. Since you do not anticipate sheets of ice being either transported down the river or forming along the shoreline this response is geared toward ±6" chunks of ice moved by tidal river conditions with possible wave heights of up to 3.7 feet.

- Shearing of the grid: not expected to be a limiting factor in this anticipated use of the grid and the marine mattress system. This may be a valid concern if large sheets of ice were frozen into the mattress voids and then ripped away, but as noted above this is not expected to be the case.

- Pressure against the grids: This issue has been evaluated from two different aspects. The first relates to the potential for permanent strains in the grid caused by high pressures against the face of the mattress. In this scenario, the pressure against the grid would cause a tension membrane effect in areas where the grid would be unsupported (between contact points of the stone infill). Tensile testing and strain measurements were performed on the grid to determine the rebound effect and to evaluate whether the grid would sustain significant long-term elongation in the case of excessive stress and strain. Tensile load was applied to a sample of grid to produce a 7.28% strain, and the sample was then removed from the tensioning apparatus and allowed to sit overnight, then measured again. These measurements showed 0.88% net strain, i.e. the grid rebounded almost completely overnight. See the attached graph. Further, it is noted that as ice pressure caused the grid to deflect downward into a void in the stone infill, the adjacent areas (where the grid would be supported on the underlying stone infill) would carry an increasing portion of the load. Therefore it is doubtful that such high strains would develop in the grid.

The second aspect relates to the potential pressure at contact points where the grid could become pinched between the stone infill below and the ice above. Based on our experience with the grid, including typical clamping procedures used for gripping grid samples during tensile testing, and considering the compressive strength of ice, this mode is not expected to be a limiting factor in this anticipated use of the grid and the marine mattress system. However, to limit the potential void size, it appears prudent to specify a maximum size $D_{50}$ = 3 inches for the stone infill. Also note that the typical requirements for minimum particle size (2 inches) and maximum particle size (6 inches) would still apply for the stone infill.

- Abrasion and impact loads (ice against grid): This mode appears to be the primary concern. In order to respond to this concern we have performed testing on the UXTriton grid with ice in a setup typically used to run the L.A Abrasion Test. The setup for this test was modified In order to assess an exaggerated combination of abrasion and impact with ice. In a standard LA Abrasion test, the tested material would be tumbled together with steel balls in the rotating drum. In this setup the grid was instead used to line the drum such that the ice chunk(s) not only slid along the grid, but also were lifted on the shelf and dropped onto the grid, pinching it against the steel wall of the drum, with each rotation. Although the test procedure was set up to be severe in comparison to the anticipated project conditions, and the ice (typical retail 10-lb solid block) was broken up by the test, the grid sustained little or no damage visible to the naked eye or measurable by tensile testing. See the attached memo.

In conclusion, based on the information available, the Marine Mattress System appears to be well suited for the intended use on the Stratford Army Engine Plant Causeway. In addition, let us refer you to the repair procedures document provided to you last month. It is our intent to suggest materials and configurations that will perform and be forgiving to a range of anticipated conditions, and also to readily facilitate repairs as a contingency.

I look forward to working with you as this project progresses. Meanwhile, if there is anything I can do for you please let me know.

Sincerely,

Jeff Fiske
Sales Representative
Coastal & Waterway Systems

cc: Steve Maher, TET
enc: 1

# MEMO

Date: 4/17/01

To: Jeff Fiske

From: Andy Anderson

Subject: Abrasion Tests Results, Triton 200

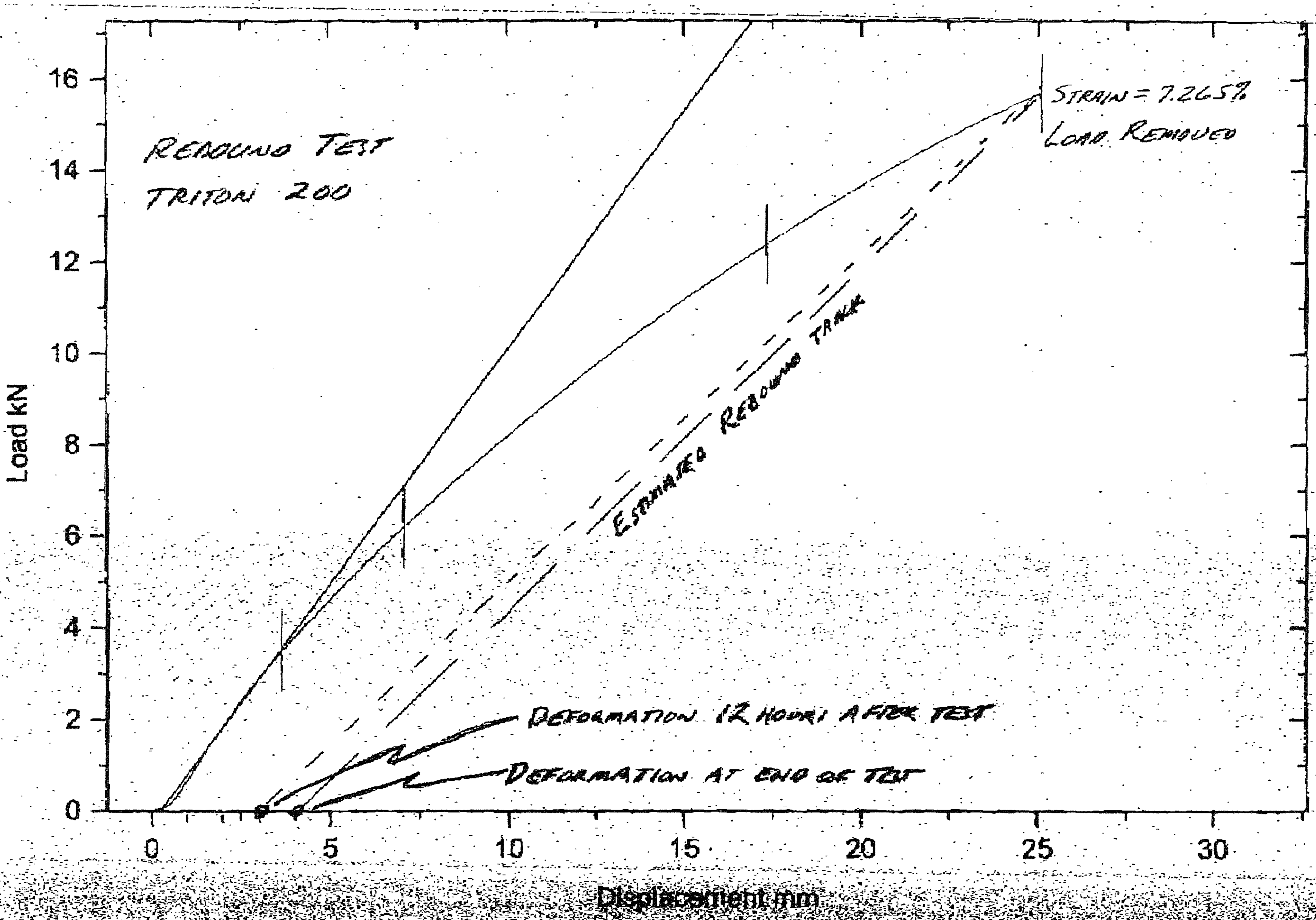
To address the concern about the abrasion resistance of Triton grid to small chunks of floating ice, a modified L A Abrasion test was conducted by Qore Property Services at their materials testing lab in Duluth, Georgia on 12 April. Control and "abraded" samples were tested tensile tested at our QC lab on 13 April.

The test apparatus consists of a steel drum about 28 inches in diameter and 20 inches in length. It has a small shelf, about 4 inches wide, attached to the inside of the drum. The drum rotates on its horizontal axis. In the conventional test used to test abrasion resistance of aggregate, the aggregate and 12 steel balls are placed in the drum. The materials are picked up on the shelf then dropped as the drum rotates and the shelf spills the materials onto the bottom of the drum.

For this test, Triton 200 grid was placed around the parameter of the drum. A 10-pound block of ice, 4 inches by 6 inches by 12 inches, was placed in the drum. The drum was rotated 50 cycles causing the block to drop off the shelf and tumble on the grid. It took about two minutes to run the test. The grid sample was removed, visually inspected, and taken to The Tensar Corporation's quality control lab for tensile testing. Four wide width, (six ribs, 5.5" wide), tensile tests and three single rib tensile tests were conducted on the sample. A reduction in these properties would indicate the amount of damage inflicted by the ice.

Visual inspection found no areas of physical damage to the grid. The ice block had broken during the 50 cycles into fist-sized chunks that were well rounded. The attached test data show similar stress-strain and ultimate strength properties for the abraded and control samples for three of the wide width and all of the single rib tests. One wide width sample, #3, had an ultimate strength of 107.8 pounds per foot which is about 94% of the average value for the six control samples. The other three wide width ultimate tensile strengths were slightly higher than the control average. The tests indicate that Triton 200 grid is very resistant to abrasion by flowing ice and should provide a durable mattress in the expected environment.

Sample ID: 2936123wwcycle



# ULTRA-VIOLET STABILITY
# OF
# TENSAR® GEOGRIDS

®Registered Trademark

TTN: PT8.0
March, 1987

## EXECUTIVE SUMMARY

TENSAR® Geogrids maintain their integrity after prolonged exposure to ultra-violet (UV) radiation. This is a result of the type, concentration and excellent dispersion of the carbon black additive package.

Research by the Mitsui Petrochemical Research Center confirmed TENSAR Product UV protection. Accelerated UV testing of TENSAR SS1, SS2, SR1, and SR2 shows no significant strength loss after 13,000 hours exposure in a carbon arc light source weatherometer.

Results of this UV/weatherometer testing are graphically attached.

Note that 1000 hours of weatherometer exposure is equivalent to 1 year of outdoor exposure (Figure 2).

The worst case shows that TENSAR SS1 maintains 80% of its ultimate strength following 13,000 hours of carbon arc weatherometer testing; whereas the SS2, SR1, and SR2 maintain their ultimate strength after 13,000 hours, or 13 year exposure equivalent in a moderate to heavy UV exposure climate.

®Registered Trademark

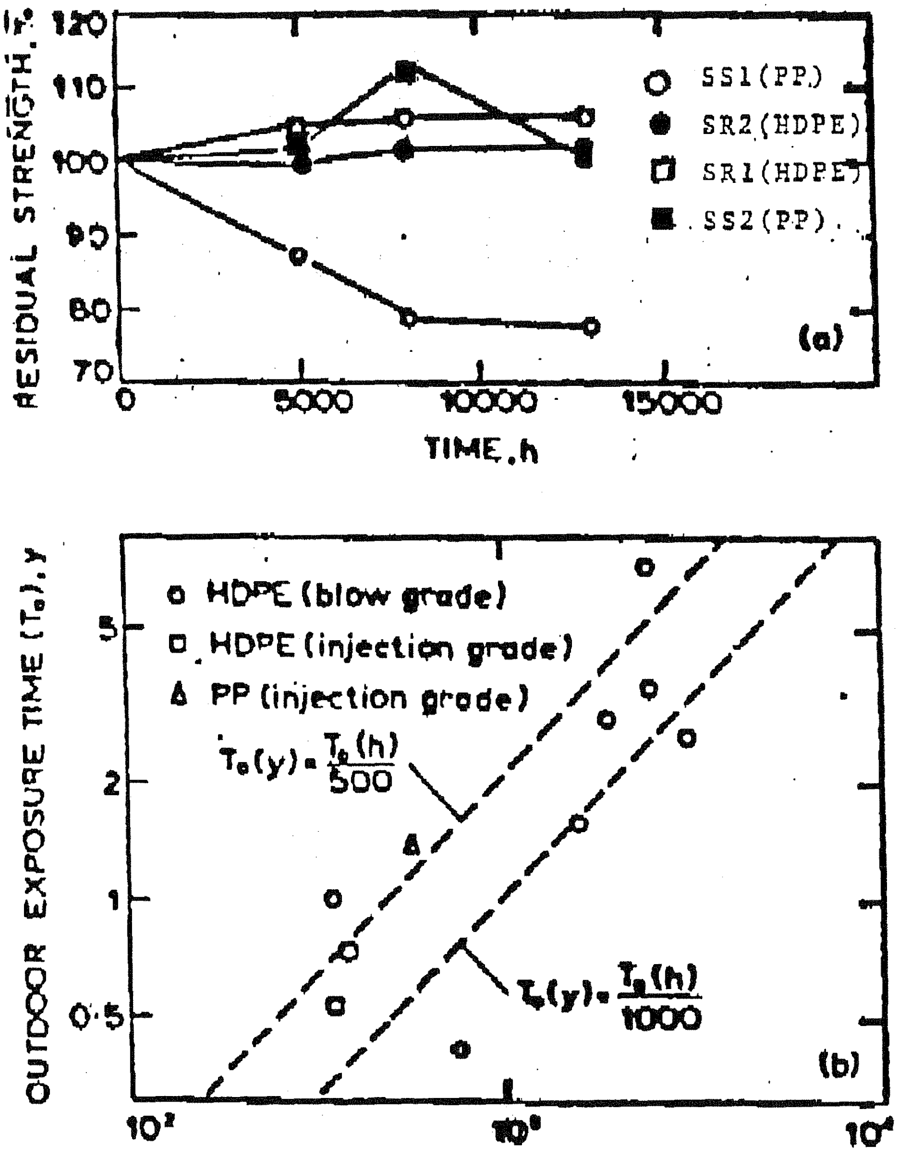


FIGURE 5

ACCELERATED EXPOSURE TIME ($T_a$), h

$_a$effect of accelerated weathering on residual strength of TENSAR Geogrids; $_b$ comparison of outdoor weathering with accelerated weathering (carbon arc light source, black panel temperature 63±3°C, 9 min water spray every hour) of polypropylene and polyethylene.

Weathering of geogrid materials (Courtesy Mitsui Petrochemical Research Centre)

# An Unique Opportunity to Assess Product Stability and Performance

Donald G. Bright, Ph.D., P.E., The Tensar Corporation
United States of America

Mark H. Wayne, Ph.D., P.E., Tensar Earth Technologies
United States of America

## ABSTRACT

In 1985-1986, the tallest reinforced soil slope (RSS) to date was constructed in Southern California as part of a land development project for future home sites upon adverse geologic conditions. Uniaxial geogrids were used as the primary reinforcement, and biaxial geogrids provide surficial stability and secondary reinforcement. The slope and reinforcement was instrumented to monitor performance.

The site was revisited in 1997 to check instrumentation and record readings, and to retrieve samples of geogrid and soil. Geogrid resins and mechanical properties were characterized to assess change after 11 years of exposure to weathering and soil chemistries.

The uniaxial geogrid exhibited no significant difference in properties between the weathered and exhumed samples, and current production. The high concentration of a soil transition metal found in the soil has had no impact on performance properties. There is no significant difference in properties between the weathered and current production for the biaxial geogrid.

## INTRODUCTION

In 1985-1986, the tallest reinforced soil slope (RSS) to date was constructed in the La Jolla area of Southern California as part of a land development project for future home sites. As reported by Chu and Poormand (1989) mass grading began in 1980 to provide building pads for residential home construction. In 1981, adverse geologic conditions were encountered along the steep natural slopes along the southern boundary of the site. These slopes supported 21 rim lots and the only access road into the subdivision. Slope stability analysis revealed an unacceptable factor of safety which in turn led to the denial of a permit for the entire subdivision of 168 lots. A geogrid reinforced RSS was designed and constructed, in 1985 - 1986, to save these 21 lots and support the access road. Additional details regarding the design and construction of the RSS are discussed by Chu and Poormand (1989).

Uniaxial geogrids fabricated of high density polyethylene (HDPE) were used as the primary reinforcement, and biaxial geogrids fabricated of homopolymer polypropylene (PP) provided surficial stability and secondary reinforcement. The slope and reinforcement was instrumented to monitor performance.

The site was revisited in 1997 to check instrumentation and record readings. A view of two adjacent, undeveloped rim lots is shown the foreground of Figure 1 with the access road.

Figure 1. View North of Access Road and Ridgegate Development

It was determined that the instrumentation was damaged, and thus no readings were possible. During survey of the undeveloped rim lots, a 1.5+ meter length of uniaxial geogrid was found extending out of a southern exposed slope in-between two adjacent home site elevations as shown in Figure 2. It was then decided to exhume a length of the buried portion of the weathered geogrid for evaluation after 11+ years of exposure. This paper reports the results of this evaluation.

Figure 2. View North with the Exposed Sample Highlighted

## PRODUCT RETRIEVAL & SOIL SAMPLING

A close up of the weathered portion of the uniaxial geogrid extending out of the southern exposed slope is shown in Figure 3. Exhumation began from the front face northward into the slope as depicted in Figure 4 and yielded a contiguous 3+ meter section of uniaxial geogrid, half weathered and half buried for 11+ years. The exhumed portion was replaced with current production of the same geogrid. A bodkin bar was used to connect the remaining to the replacement piece of geogrid. Soil samples were taken during the exhumation process.

Smaller samples of weathered biaxial geogrid were retrieved from the immediate area. However, retrieval of buried biaxial geogrid was not possible due to concerns with sufficient connection between the remaining and replacement pieces of biaxial geogrid to maintain adequate surfacial stability and secondary reinforcement.

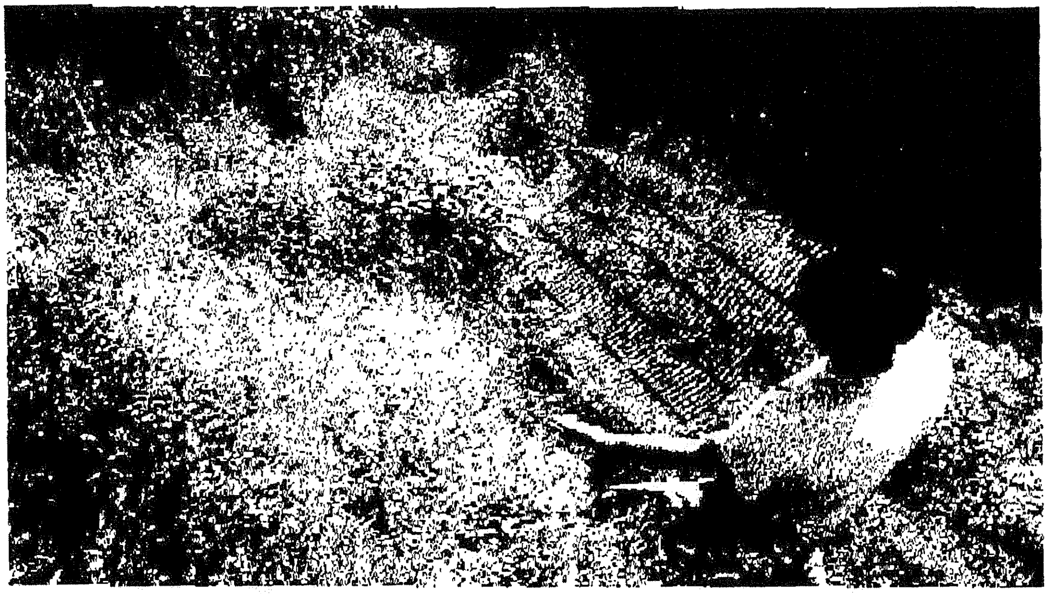


Figure 3. Weathered Portion of the Uniaxial Geogrid

Figure 4. Exhumation Process of the Uniaxial Geogrid

## ASSESSMENT PROGRAM

An analysis of both the uniaxial and biaxial geogrids included resin, short-term strength, and long-term performance properties:

- melt flow, melt point, density, and carbon black loading,
- strength @ 2%, 5%, and ultimate, and
- creep response.

Soil samples were analyzed for pH, transition metals and dissolved iron, chlorides, sulfides, carbonates, calcium and sodium.

## RESULTS

Tables 1 - 4 highlight the resin and strength properties of the uniaxial geogrid.

Table 1. Resin Properties of Uniaxial Geogrid

| Resin Property | ASTM | Weathered | Exhumed | 1997 Production |
|---|---|---|---|---|
| Melt Flow (gm/10 min.) | D 1238 | 0.095 | 0.094 | 0.090 |
| Melt Point (° C) | | 136.0 | 134.5 | 135 |
| Density (gm/cc) | D 792 | 0.935 | 0.956 | 0.94 |
| Carbon Black (%) | D 4218 | 2.64 | 2.70 | 2.71 |

Table 2. Single Rib Strength Properties of Uniaxial Geogrid

| Strength Property | GSI / GRI | Weathered | Exhumed | 1997 Production |
|---|---|---|---|---|
| Load @ 2% Strain (kN/m) | GG1 | 40.8 | 40.5 | 39.6 |
| Load @ 5% Strain (kN/m) | GG1 | 74.9 | 74.7 | 71.3 |
| Ultimate Strength (kN/m) | GG1 | 126 | 127 | 129 |
| Strain @ Peak Load (%) | GG1 | 13.1 | 12.7 | 13.6 |

Table 3. Junction Strength Properties of Uniaxial Geogrid

| Strength Property | GSI / GRI | Weathered | Exhumed |
|---|---|---|---|
| Load @ 2% Strain (kN/m) | GG2 | 41.0 | 40.3 |
| Load @ 5% Strain (kN/m) | GG2 | 74.5 | 73.5 |
| Ultimate Strength (kN/m) | GG2 | 126 | 121 |
| Strain @ Peak Load (%) | GG2 | 13.3 | 12.3 |

Table 4. Wide Width Strength Properties of Uniaxial Geogrids

| Strength Property | ASTM | Weathered | Exhumed |
|---|---|---|---|
| Load @ 2% Strain (kN/m) | D 4595 | 35.8 | 32.5 |
| Load @ 5% Strain (kN/m) | D 4595 | 65.6 | 63.5 |
| Ultimate Strength (kN/m) | D 4595 | 105 | 116 |
| Strain @ Peak Load (%) | D 4595 | 11.3 | 13.0 |

Tables 5 - 6 highlight the resin and strength properties of the biaxial geogrid.

Table 5. Resin Properties of the Biaxial Geogrid

| Property | ASTM | Weathered | 1997 Production |
|---|---|---|---|
| Melt Flow (gm/10 min.) | D 1238 | 2.043 | 2.10 |
| Melt Point (° C) | - | 164 | 165 |
| Density (gm/cc) | | 0.912 | 0.908 |
| Carbon Black (%) | D 4218 | 1.11 | 1.01 |

Table 6. Single Rib Strength Properties of Biaxial Geogrid

| Property | | GSI / GRI | Weathered | 1997 Production |
|---|---|---|---|---|
| Load @ 2% Strain (kN/m) | MD | GG1 | 5.67 | 5.00 |
| | TD | | 8.36 | 7.95 |
| Load @ 5% Strain (kN/m) | MD | GG1 | 10.7 | 9.61 |
| | TD | | 16.8 | 15.9 |
| Ultimate Strength (kN/m) | MD | GG1 | 14.3 | 13.3 |
| | TD | | 21.6 | 21.4 |
| Strain @ Peak Load (%) | MD | GG1 | 11.6 | 12.0 |
| | TD | | 8.6 | - |

The soil sample were sent to a soils laboratory for grain size analysis (ASTM D 422), atterberg limits (ASTM D 4318), and pH evaluation (ASTM D 4972). The soil has a pH of 7.7 and contained the following amounts of transition metals:

|  |  |  |
|---|---|---|
| Copper | 14.45 | mg/kg |
| Iron | 18137.77 | mg/kg |
| Chromium | 9.30 | mg/kg |
| Manganese | 236.6 | mg/kg |
| Cobalt | 7.1 | mg/kg |

According to test results, the soil is classified as a sandy fat clay (CH). Visual description is a moist, light yellowish, brown sandy clay. The grain size analysis for this soil is found in Figure 5.

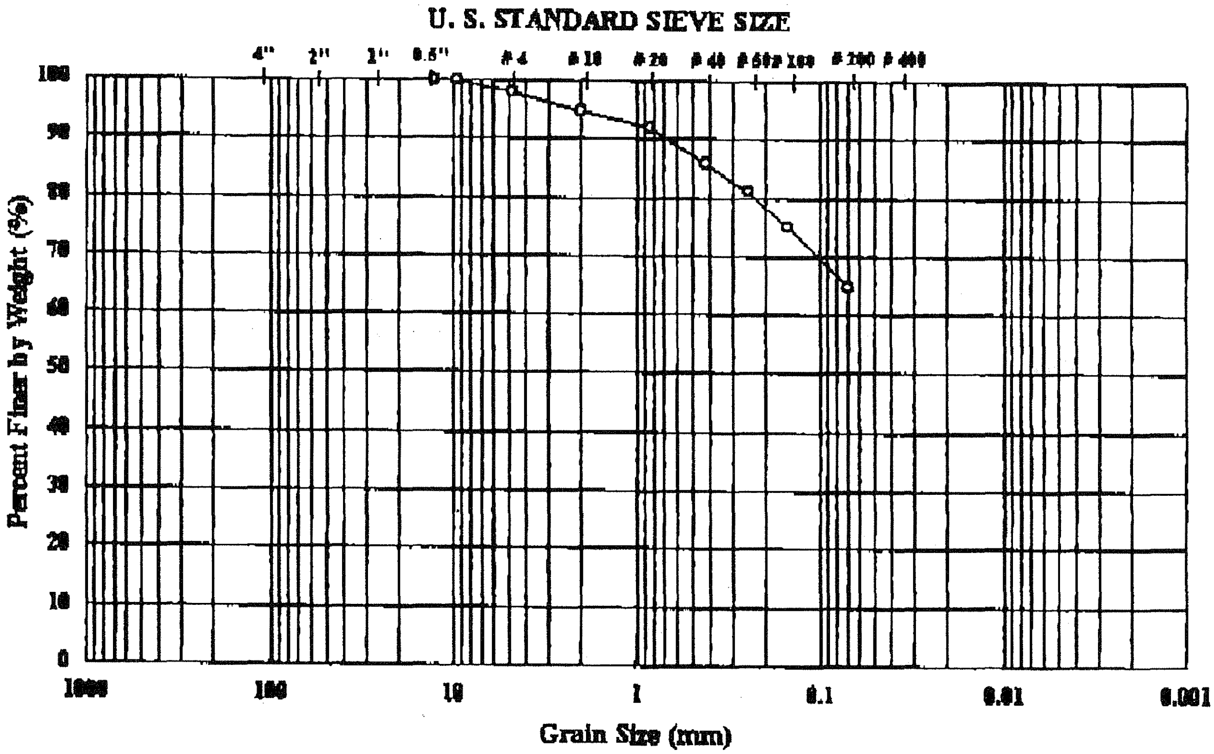


Figure 5. Grain Size Analysis of Ridgegate Soil Sample

Creep testing was performed at the Morrow manufacturing facility of Atlantic International. Testing was performed in accordance with ASTM D5262. Figure 6 shows the creep response of the weathered, exhumed, and control specimens of uniaxial geogrid. The control specimen is the same uniaxial geogrid manufactured in the same circa.

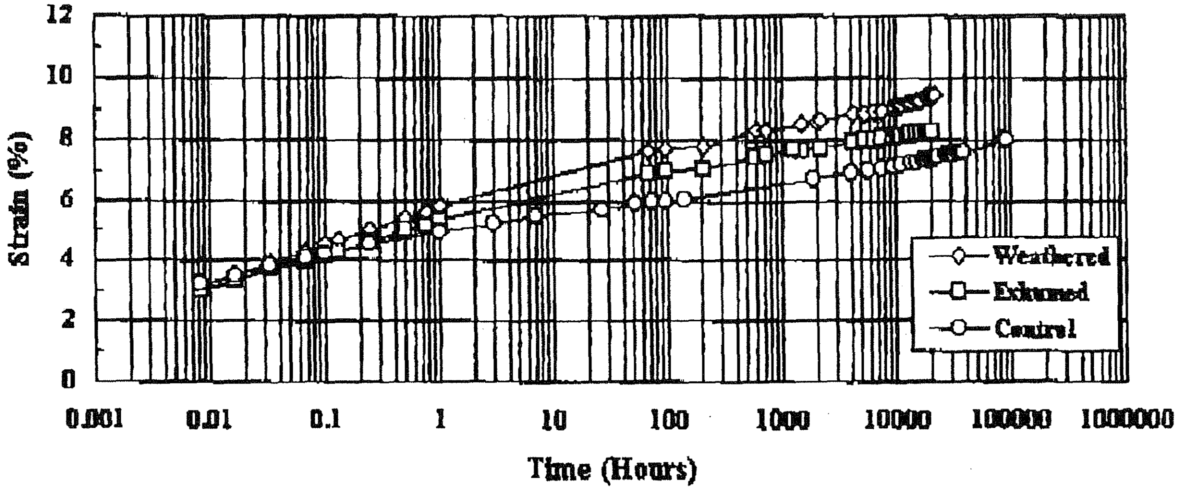


Figure 6. Creep Response of Weathered, Exhumed, and Control Specimens

## DISCUSSION OF RESULTS

For the uniaxial geogrid, test results show no significant differences in resin and strength properties between the weathered and exhumed samples, and the 1997 control. The resin, production, and product specifications are the same today as for the 1997 control and the 1985 - 1986 production campaign for the Ridgegate project for both the uniaxial HDPE and biaxial PP geogrids.

As for creep response for the uniaxial geogrid, accumulative strain has plateaued at 8.01% through 94,300 hours for the control specimen, and 8.25% and 9.42% through 21,600 hours for the exhumed specimen and weathered specimen, respectively. Beyond 100,000 hours, the exhumed and control specimen creep curves would appear to converge at < 9% accumulative strain. When comparing all three creep curves, it is questionable as to whether there is any statistical difference between the creep responses of the three specimens.

Based upon analysis, the soil environment is neutral and rich in iron content. The soil's yellowish, brown color suggest the presence of sulfides and sulfates which complexes with iron in its ferrous state (i.e., $Fe^{+2}$). According to the Federal Highway Administration [FHWA] (1997, 1999), a high concentration of a transition metal (i.e., copper, iron, chromium, manganese, or cobalt) can potentially have an adverse effect on polyolefin based geosynthetics (i.e., PP and HDPE) by accelerating oxidative degradation causing molecular breakdown and resulting lower strength. The retention of resin and strength properties of the exhumed uniaxial PE geogrid after 11+ years of soil exposure do not support this contention.

There is no significant difference in resin and strength properties between the weathered and current production for the biaxial geogrid either.

Based upon retained resin and strength properties, a 0.75% and 2.5% by weight loading of carbon black in the biaxial and uniaxial geogrids, respectively, has proven sufficient to protect each base resin from degradation by ultraviolet light.

## CONCLUSIONS

No significant change was found in resin and strength properties of the HDPE or PP based geogrids used in the Ridgegate project after 11+ years exposure to natural weathering or soil chemistries from the properties of 1997 production of either geogrid product.

Transition metals in soils are purported to have an accelerating affect on oxidation degradation of polyolefins, but the results reported herein clearly do not support this contention. The absence of oxidative effects on HDPE and PP geogrids is believed to be due to the high molecular weight of the base resins, high crystallinity induced by molecular orientation during geogrid manufacture, and adequate performance of a long-term antioxidant package. Equally important is that the long-term creep performance of the uniaxial geogrid has not been adversely affected by soil chemistries and only minimally by natural weathering over a period of 11+ years exposure.

## REFERENCES

Chu, D. and Poormand, I., (1989) "Reinforcement of an Earthen Buttress with Polymer Geogrid," Proceedings of Geosynthetics '89, Vol. 1, San Diego, CA, IFAI, 1989, pp. 243 – 254.

FHWA (1997) " Demonstration Project 82: Corrosion/Degradation of Soil Reinforcements for Mechanically Stabilized Earth Walls and Reinforced Soil Slopes," Publication No. FHWA-SA-96-072, Federal Highway Administration, Washington, D.C.; 105 pp.

FHWA (1999) " Demonstration Project 82: Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines," Publication No. FHWA-SA-96-072, Federal Highway Administration, Washington, D.C., 105 pp.

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March 20, 2001

Brian Johnson
Harding ESE, Inc
P.O Box 7050
Portland, ME. 04112

RE: Stratford Army Engine Plant

Dear Brian:

In response to our conversation from March 12 I am sending you a copy of the standard warranty that accompanies our Tensar grid materials. Since American Excelsior Company would be handling the sale of materials to the contractor any further warranty would be the responsibility of AEC rather than that of Tensar Earth Technologies.

We are currently preparing a response to some of the concerns you have expressed in relation to ice issues.

As for the layout concerns, intentional staggering of the mats does not appear to be necessary. The undulation and curvature of the site will also leave unavoidable, irregular shaped gaps between the mats. For the smaller gaps (+/-12") there are some simple procedures to be followed to connect the mats and fill with stone. In the enclosed "Suggested Repair Guidelines for Triton Marine Mattress Units" document there are instructions for filling these smaller spaces. For larger spaces left by irregularities in grade, in-field construction will be the only realistic solution. Small, irregular mats can be fabricated and lifted in place in much the same manner as the full size mats. Side to side lacing of the irregular mats can be used to help maintain the integrity of the overall system.

I hope that this has answered some of your questions about the layout issues we discussed. As I mentioned, as soon as the information is available on the ice issues I will let you know. Meanwhile, if there is anything I can do for you please feel free to call.

Sincerely,

Jeff Fiske
Sales Representative
Coastal & Waterway Systems

enc:2

Standard warranty as described in paragraph 9 under Terms and Conditions of Sale.

The Seller warrants that the product supplied hereunder will be of good and workmanlike quality manufactured in accordance with applicable specifications. THE FOREGOING LIMITED WARRANTY IS IN LIEU OF AND EXCLUDES ALL OTHER WARRANTIES WHETHER EXPRESSED OR IMPLIED BY OPERATION OF LAW OR OTHERWISE, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF MERCHANTIBILITY OR FITNESS, AND INCLUDING BUT NOT LIMITED TO ANY ORAL OR WRITTEN DESCRIPTION OF THE PRODUCT SUPPLIED HEREUNDER, ITS CHARACTERISTICS OR PROPERTIES.

The Seller shall not be liable in any circumstances whatsoever for loss or damage of any kind suffered to or by any third party howsoever caused unless the same shall relate to property damage, personal injury or death arising out of the Sellers negligence or defects in products sold by the Seller.

The Seller shall not be liable for incidental or consequential damages, including but not limited to, any losses or expenses or other damages directly or indirectly arising from the sale, handling or use of the product or from any other cause relating to the sale, handling or use of the Product.

In the event the Product does not conform to the provisions of the foregoing limited warranty or, if for any other reasons the Seller may be liable as a result of the sale, handling or use of the product, the Purchaser's exclusive remedy shall be and is expressly limited to repayment of the purchase price of the Product or, at the Sellers option, replacement of the non-conforming product with a conforming Product.

# Suggested Repair Guidelines for Triton™ Marine Mattress Units

## General:

Marine mattress units can sustain many types of minor damage without compromising their overall performance. See Figure 1. In addition to any special considerations for the specific application, the importance of repairs should be evaluated based on these criteria:

1. The suitability of each filled mattress unit for safe lifting, handling and placement;
2. The ability of individual compartments to confine and retain the stone fill securely throughout the service life of the unit;
3. The suitability of the geogrid and connections to carry any anticipated long-term tensile loads due to steep slopes or other special conditions.

With respect to Item 2, above, the timeliness of repairs is important for minimizing the quantity of stone which must be replaced. Note that "roll direction" of the geogrid on the exterior of a marine mattress unit, is typically the same as the lengthwise direction along a marine mattress unit.

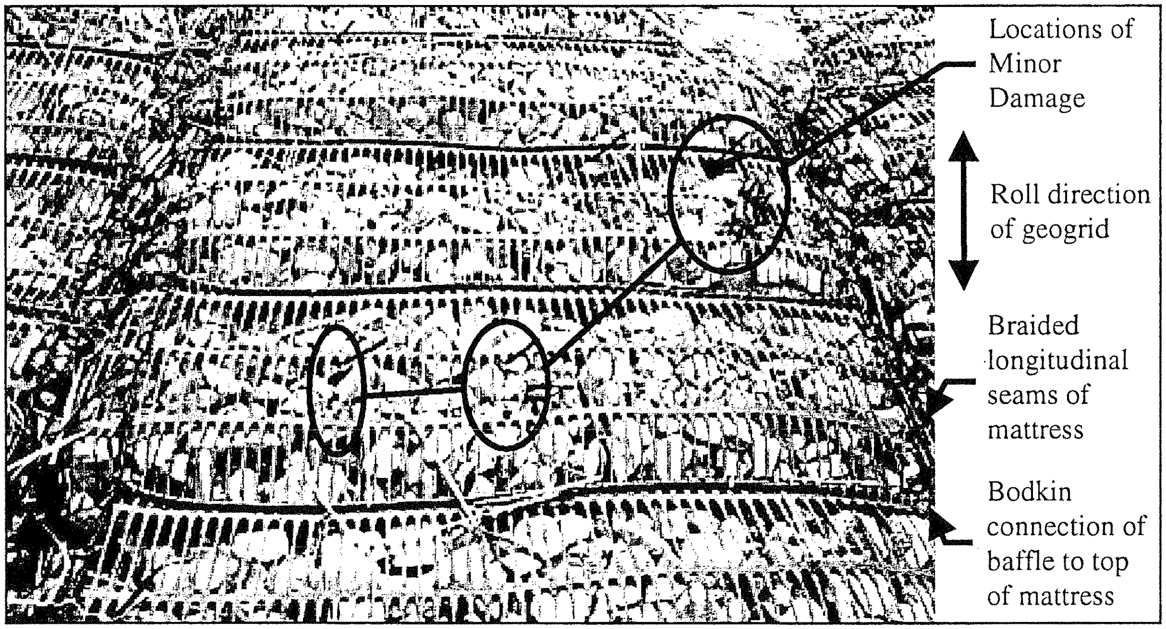


Figure 1: Properly functioning Triton™ Marine Mattress which has sustained minor damage. One of the three highlighted areas warrants repair for the photographed revetment installation.

Splits in geogrid along its roll direction:

Splitting of the geogrid in the roll direction can generally be avoided by the use of proper technique in the fabrication, filling and handling of the units. Infrequent splitting of the geogrid in the roll direction (the long direction of the marine mattress unit) is typically not a major concern for Items 1 or 3, above. Repairs are typically made for the purposes of Item 2, above, by replacing any stone lost from the compartment and then using the OP229500 braid to securely knot around each split junction of the geogrid. See Figure 2.

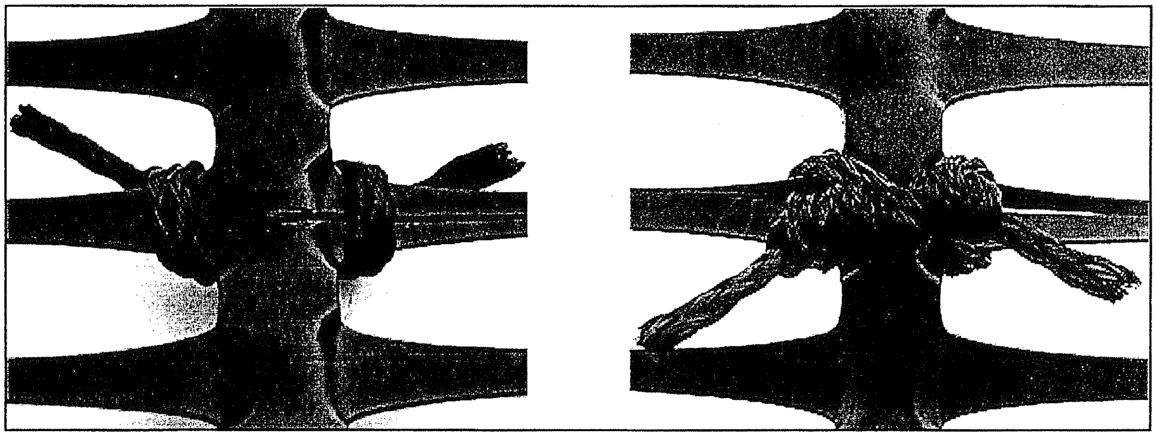


Figure 2: Photographs showing the front and back views of a knotted braid repair of a split through the geogrid. A square knot is tied taut and the free ends of the braid are each secured by an overhand loop tightened to prevent slippage. Behind the knot the braid forms an "X" along the diagonals of the junction.

Cuts in geogrid across its roll direction:

If the hole created by a severed rib or "finger" of geogrid is large enough to create a potential for loss of stone as discussed in Item 2, above, then a patch should be installed. A patch of similar geogrid material should be secured over the damaged geogrid by seaming with the braid. The braided seams to attach the patch should be accomplished per the seam specification for the initial construction, except that the stitch spacing should be reduced to about one inch. The patch should extend to the edge of the damaged piece of geogrid, or at least six inches beyond the damaged area.

If small size stone (1-1/2 inch to 2 inch) is used for the fill material, then a single severed rib (see Figure 3) could create the potential for loss of stone. Otherwise, the occurrence of multiple, consecutive, severed ribs could create the potential for loss of stone.

Cuts across the roll direction of the geogrid, such as the severing of ribs, reduce the tensile strength of the geogrid. Items 1 and 3, above, are typically not of major concern if a single rib is cut, but should be evaluated if multiple ribs across the width of the unit are cut. Of course, Item 1 is not of concern after the final placement of the unit.

The tensile capacity of the braid is much lower than the tensile capacity of the bodkin connections or of the geogrid in its roll direction; therefore, braided seams are generally not suitable for patches or splices which are subjected to high tensile loads.

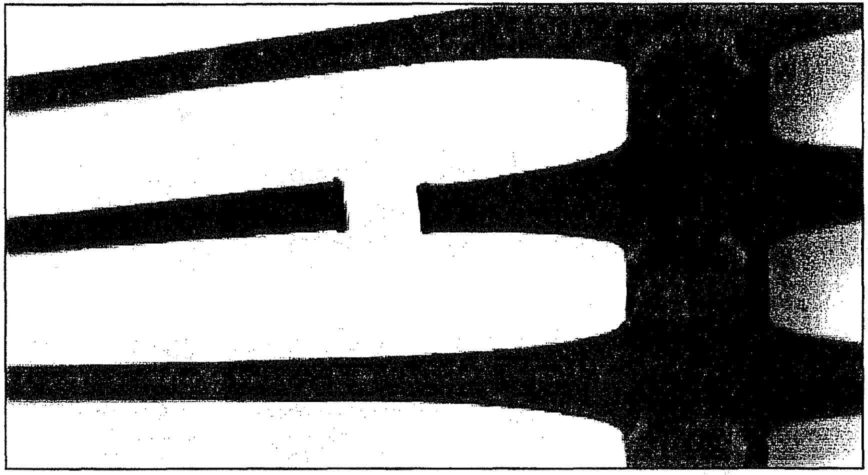


Figure 3: Photograph showing a severed rib of the geogrid.

Cuts in braid material of seams:

The stress carried by the braided seams is typically low in relation to the strength of the braid material, and therefore the braid material can typically sustain minor damage (see Figure 4) without significantly affecting Items 1, 2, or 3. If the damage to the braid is sufficient to compromise these functions, then the damaged section of braided seam should be replaced with a new section of braided seam accomplished per the seam specification for the initial construction.

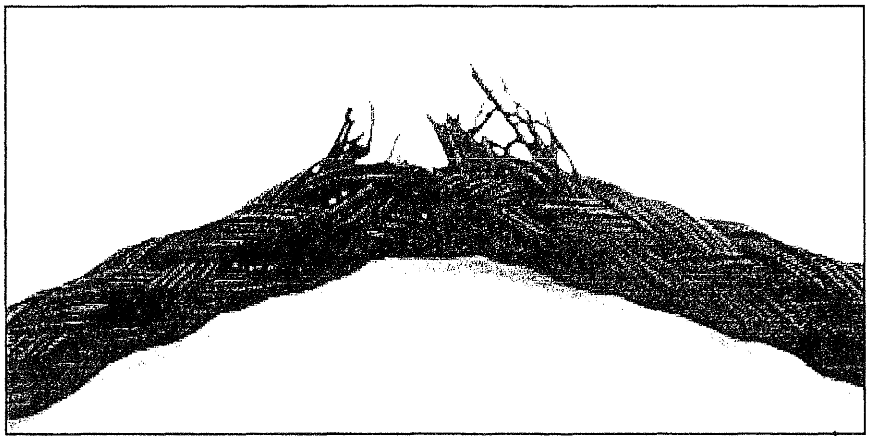


Figure 4: Photograph showing braid with some severed filaments.

Loss of bodkin connector:

Replacement of lost bodkin connectors is typically easy to accomplish prior to filling and placement. Once a bodkin connection is tightened, such as by proper filling of a compartment or by pulling a splice taut, the bodkin connector is typically secure in place. However, bodkin connections which are not tightened, such as may occur at splices (see Figure 5) or lifting hoops or incompletely filled compartments, should be secured in their proper position using suitable cable ties or other connectors as approved by the supplier and the Engineer. Lost bodkin connectors should be replaced and secured in place.

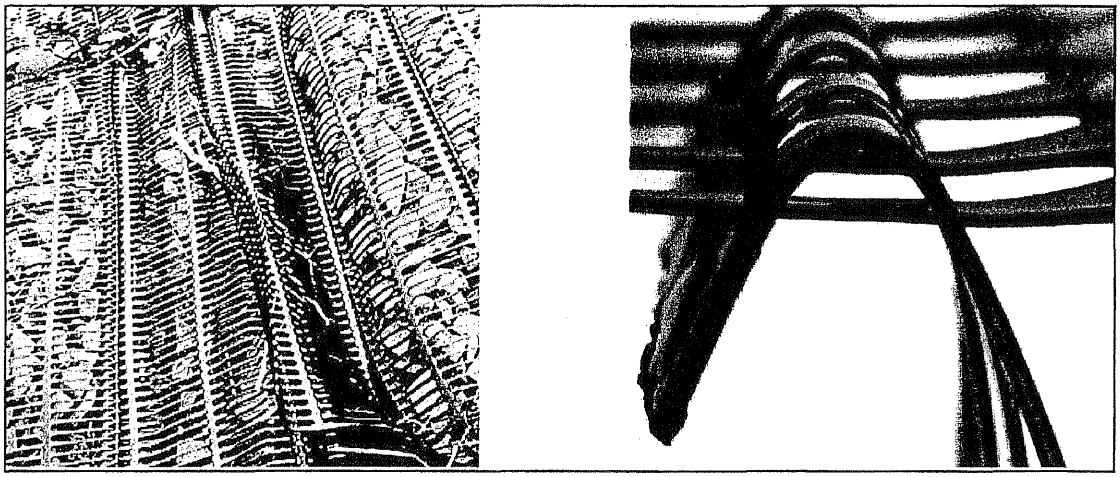


Figure 5: Photographs showing missing bodkin connectors. In the left photo the bodkin bar, which was used to form a splice at an end-to-end joint of two mattresses, is gradually sliding out toward the top of the photograph. As shown in the close-up view on the right, the mechanical interlock of the splice is lost when the bodkin rod or bar is removed.

*After filling and final placement*, braided seams may generally be used instead of bodkin connections for joining the interior baffles to the top and bottom sections of the units. However, for high tensile strength splices of the geogrid, such as those for forming lifting hoops or attaching anchor tails or joining mattresses end-to-end, lost bodkin connectors must be replaced with similar bodkin connectors and not with braided seams.

<u>Gaps between marine mattress units in place</u> (see the following and Table 1):

Gap treatments are not important for some types of applications. The following gap tolerances and treatments, summarized in Table 1, are for erosion control applications with a requirement for continuous coverage.

*End-to-end* gaps between mattresses (see Figure 5): When mattresses are placed end to end with a gap of one foot or less, the geogrid splice is typically adequate with no other special steps. If the gap size is between one and two feet, then stone similar to the mattress fill material should be slightly overfilled in the gap and geogrid should be secured over the stone by seaming with braid to the mattress units to form a tightly filled compartment in the gap. In this case the geogrid used to form the closure should be the geogrid lifting tabs or a patch of similar geogrid material.

*Side-to-side* gaps between mattresses (see Figure 6): When mattresses are placed with a side-to-side gap of two inches or less, then no remedial steps are typically required at the joint. If the gap size is between two inches and six inches wide, then geogrid baffles should be secured across the gap at the ends of the joint by braiding to the mattress units. Then stone similar to the mattress fill material should be slightly overfilled in the gap and geogrid should be secured over the stone by seaming with braid to the mattress units to form a tightly filled compartment in the gap. When the gap is between six inches and one foot, similar steps should be used, and additional geogrid baffles should be positioned across the gap at a spacing not to exceed five feet along the joint. Side-to-side gap widths exceeding one foot are generally not allowed for these types of applications.

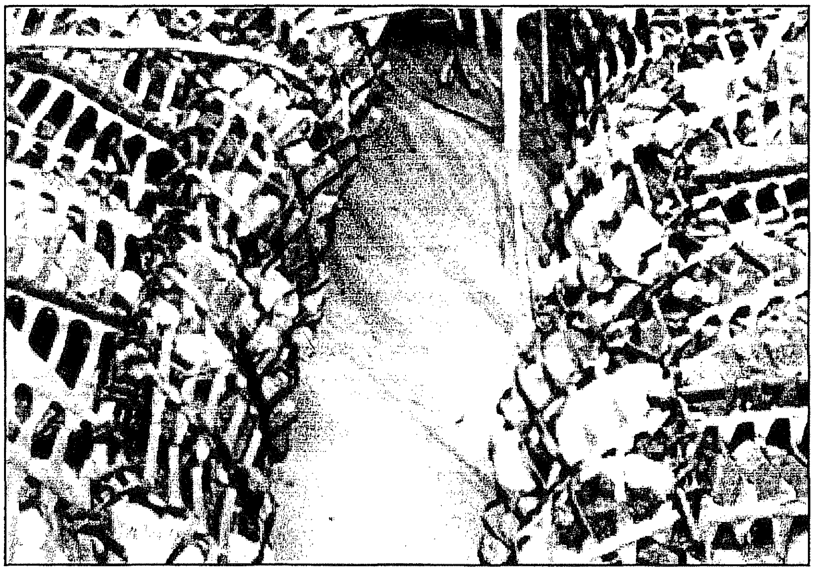


Figure 6: Photograph showing a wide gap along the side-to-side joint of two marine mattresses.

| Joint Location | Gap Width | Treatment |
|---|---|---|
| | | |
| End-to-End | < 1 ft | No special steps. |
| | 1 ft – 2 ft | Fill with stone and braid geogrid over top. |
| | > 2 ft | Generally not allowed. |
| | | |
| Side-to-Side | < 2 inches | No special steps. |
| | 2-6 inches | Fill with stone and braid geogrid over top and ends. |
| | 6 inches –1 ft | Same as above but add baffles at 5 foot spacing. |
| | > 1 ft | Generally not allowed. See "non-rectangular shapes." |

Table 1: Summary of Gap Treatments

Non-rectangular shapes:

The geometry of some layouts requires a portion of the marine mattress units to be non-rectangular. Special prefabricated units may facilitate prefilling and placing of the non-rectangular units similar to the rectangular units. Otherwise, special-shaped marine mattress units may be assembled and filled in place to fill large gaps; the materials and general configuration of the special-shaped units should be identical to those of the typical rectangular units. However, when the units are filled in place and will not be lifted, braided seams should be substituted for the bodkin connections of the baffles to the top and bottom sections of the units. This assists in tightly filling the compartments. In order to achieve tight filling, each compartment should be slightly overfilled and closed tightly around the stone by seaming before proceeding to fill the next compartment. Each special-shaped unit should be attached to the adjacent units by a braided seam around its perimeter.

Contact the supplier for specific suggestions in any of these conditions:

Multiple splits occur through a single transverse bar of the geogrid;
The upper or lower layers of geogrid or the lifting tabs become damaged prior to lifting of the filled units;
Multiple ribs across the width of an individual marine mattress unit are cut prior to placement of the unit;
Other materials, configurations, or methods are proposed.

Methods not recommended:

The use of thermal welding and / or adhesives is not an acceptable substitute for the use of mechanical connections (braiding, bodkin connections). The geogrid and braid materials should not be heated to temperatures near their melting point.

# ATTACHMENT G

# INTERSTITIAL GRAVEL FILTER ANALYSES

| | | |
|---|---|---|
| PROJECT<br>SAEP CAUSEWAY - FILTER ANALYSIS | COMP. BY<br>GLR | JOB NO.<br>50796 1042 |
| | CHK. BY<br>PBZ | DATE<br>7-5-01 |

I. PURPOSE: To evaluate the ability of the proposed gravel layer to act as a sufficient filter for the proposed vegetative support soil (i.e., base soil)

II. REFERENCE: The procedure used was that outlined in "U.S. Department of Agriculture, Soil Conservation Service Engineering Division, Guide for Determining the Gradation of Sand and Gravel Filters, Soil Mechanics Note No. 1, 210-VI, Revised Jan. 1986." (presented on pages 9 - 15)

III. PROCEDURE:

A. Section 02300 EARTHWORK of the Phase II 90% design specifies the following gravel (CTDOT # 8)

| U.S. Standard Sieve Size (mm) | Percent Passing by Dry Weight |
|---|---|
| ½ inch (12.5) | 100 % |
| 3/8 inch (9.5mm) | 85 - 100% |
| No. 4 (4.75mm) | 10 - 30% |
| No. 8 (2.36mm) | 0 - 10% |
| No. 16 (1.18mm) | 0 - 5% |

Does this gravel meet the required gradation for filter material given the following base soil?

B. Section 02921 SEEDING specifies a "loamy sand" for topsoil (base soil), as defined by USDA textural classification. It also specifies a maximum particle size of 1-½ inch.
Based on the USDA textural classification chart (Das, 1998) (pgs 5 and 6)

STEP 1

| US Standard Sieve Size (mm) | Percent Passing by Dry Weight |
|---|---|
| 1½ inch | 100% |
| 2.0 mm | 70 - 100% |
| 0.05 mm | 0 - 30% |
| 0.002 mm | 0 - 15% |

See Attachment 1 for grain size distribution. This soil is the base soil. An average soil will be used for the filter analysis (dashed green line; sketched between maximum and minimum boundaries)

| | | |
|---|---|---|
| PROJECT<br>SAEP CAUSEWAY- FILTER ANALYSIS | COMP. BY<br>GLR | JOB NO.<br>50796 1042 |
| | CHK. BY<br>BDG | DATE<br>7-5-01 |

STEP 2 Base Soil contains gravel

STEP 3. Correction factor for base soil particles > No. 4 Sieve = 100/90 = 1.111 (% passing No. 4)

| Sieve No | % Passing | Corrected % Passing |
|---|---|---|
| No 4 | 90 % (x1.11) → | 100% |
| No. 10 | 85% (x1.11) → | 94% |
| No. 20 | 70% | 78% |
| No. 40 | 57% | 63% |
| No. 60 | 47% | 52% |
| No. 200 | 23% | 26% |

STEP 4 % passing No. 200 = 26% ∴ Base Soil = Category 3 (See Table 1, page 12)

STEP 5 Filter Maximum $D_{15} \leq \left[\frac{40-A}{40-15}\right](4 \times d_{85} - 0.7) + 0.7$

$A = 26$ (% passing No. 200)

$d_{85} = 1.2\text{ mm}$ $D_{15\,MAX} \leq \left[\frac{40-26}{40-15}\right](4 \times 1.2 - 0.7) + 0.7$

$\boxed{D_{15} \leq 3.00\text{ mm}}$ (see Table 2, page 13)

STEP 6 Filter Minimum $D_{15} > 4 \times d_{15} = 4 \times 0.04\text{ mm}$

$\boxed{D_{15} \geq 0.16\text{ mm}}$

STEP 7 Filter Max. Particle = 3 inches; however, for Tri-Lock block assume ≤ 1½ inches due to the limited open area in a connected block.

Maximum % passing No 200 = 5% (for drainage)

STEP 8 From Attachment #1 Filter Minimum $D_{10} \simeq 0.11\text{ mm}$

∴ Filter Maximum $D_{90} = 20\text{ mm}$ (see Table 3, pg. 14)

Also, considering the gravel/sand texture of the necessary Filter

$C_u = D_{60}/D_{10} \geq 6$ (Das, 1998)

$D_{60} \geq 6(D_{10})$

$D_{60}\text{ max} = 6(2.5\text{ mm}) = 15.0\text{ mm}$

$D_{60}\text{ min} = 6(0.11\text{ mm}) = 0.66\text{ mm}$

$D_{10}$ approximated from Attachment 1

A comparison of the specified gravel (e.g ▩) to the required filter material (e.g ▨) indicates the specified gravel somewhat matches the range of the required material (see page 7)

FORM 00.01 REV. 2/2001

**Harding ESE** a MACTEC Company

| PROJECT | COMP. BY | JOB NO. |
|---|---|---|
| SAEP CAUSEWAY - FILTER ANALYSIS | GLR | 50796-1042 |
| | CHK. BY | DATE |
| | BBJ | 7-5-01 |

The following details the required gradation for the filter material

| U.S. Standard Sieve Size | % Passing by Dry Weight |
|---|---|
| 1½ inch (38mm) | 100% |
| ¾ inch (19mm) | 90-100% |
| ½ inch (12.5mm) | 70-100% |
| ⅜ inch (9.5mm) | 35-100% |
| No. 4 (4.75mm) | 25% - 85% |
| No. 8 (2.36mm) | 15% - 75% |
| No. 16 (1.18mm) | 0% - 55% |
| No. 40 (0.43mm) | 0% - 30% |
| No. 200 (0.075mm) | < 5% |

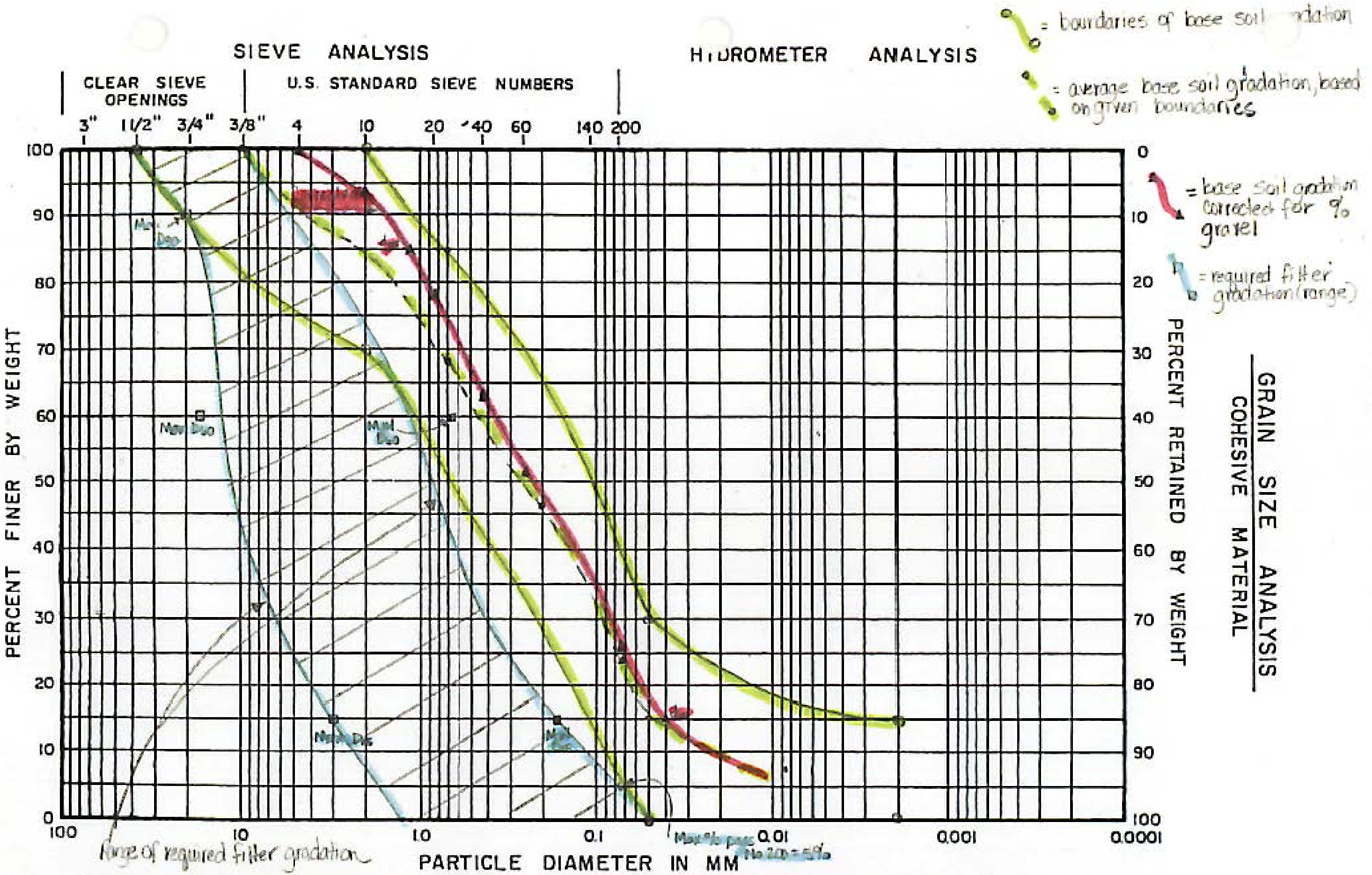
As specified in the Phase II 90% design, a CTDOT No. 8 aggregate will somewhat meet the criteria (Section M.01)

In addition, Class 1 and Class 114 of Bituminous Concrete Mixtures (M.04.03) are acceptable, provided % passing No. 200 < 5%.

## IV. Recommendations

It is recommended that a CTDOT Class 114 Bituminous concrete mixture (M.04.03) with less than 5% passing No. 200 Sieve be used to backfill between the articulated concrete blocks. This material provides the best match with the calculated required filter material (see page 8, Attachment 4).

Alternately, CTDOT Class 1 Bituminous Concrete would be acceptable (see page 7, Attachment 3), provided the gradation falls within the required boundaries (< 5% passing No. 200)



## GRAIN SIZE ANALYSIS
## COHESIVE MATERIAL

| COBBLES | GRAVEL | | SAND | | | SILT AND CLAY | |
|---|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | SILT FRACTION | CLAY FRACTION |

| BORING | SAMPLE, DEPTH | SOIL DESCRIPTION | USCS | L.L. | P.L. | WC, % |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
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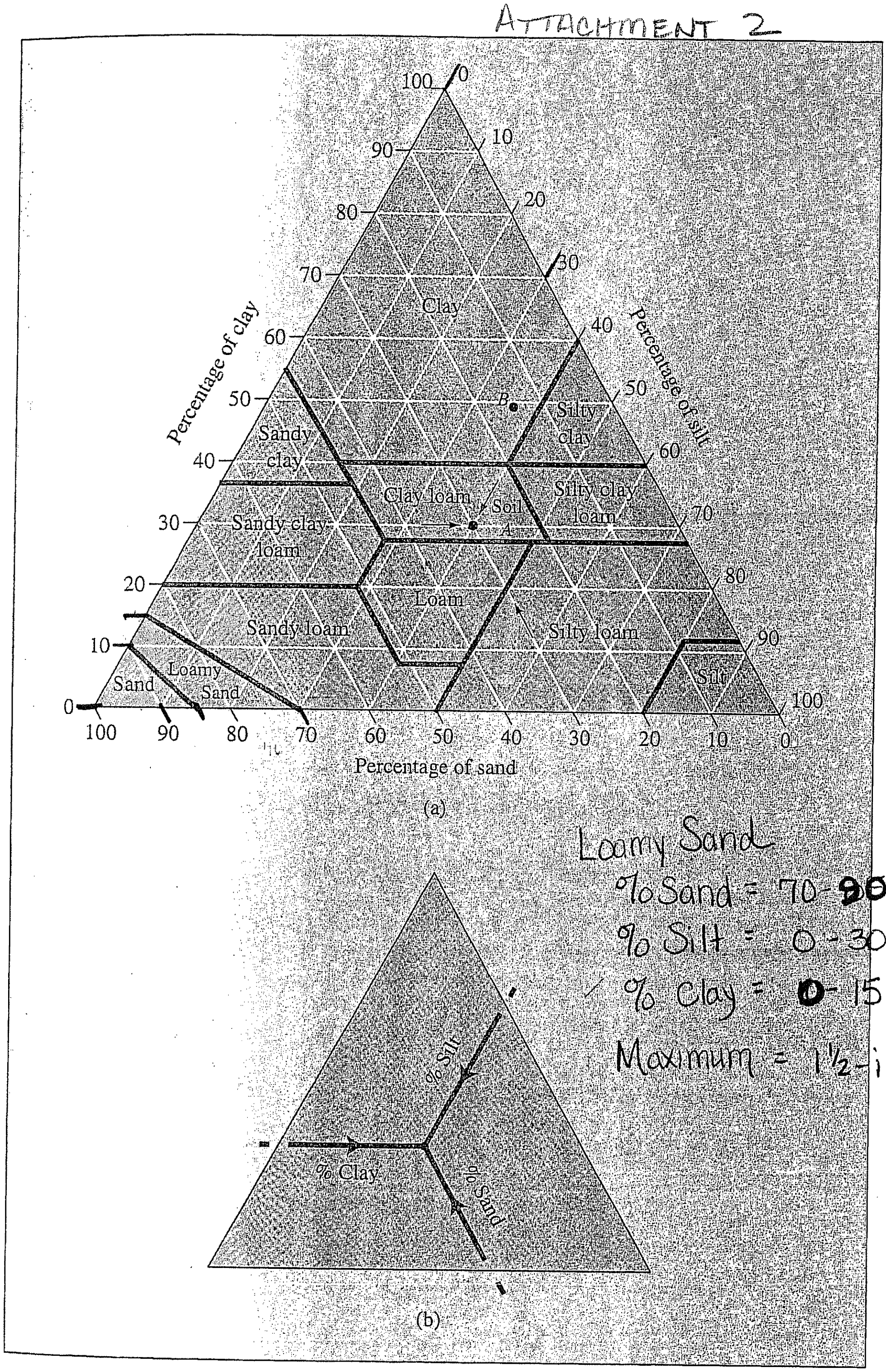
ATTACHMENT 2



(a)

(b)

Loamy Sand
%Sand = 70-90% (2.0 to 0.05mm)
% Silt = 0-30% (0.05 to 0.002mm)
% Clay = 0-15% (< 0.002 mm)
Maximum = 1½-inch

**FIGURE 3.1** (a) USDA textural classification chart; (b) key to use of part (a)

Das, Braja M., 1998. Principles of Geotechnical Engineering, Fourth Edition. PWS Publishing Company.

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## CHAPTER THREE

# CLASSIFICATION OF SOIL

Different soils with similar properties may be classified into groups and subgroups according to their engineering behavior. Classification systems provide a common language to concisely express the general characteristics of soils, which are infinitely varied, without detailed descriptions. Most of the soil classification systems that have been developed for engineering purposes are based on simple index properties such as particle-size distribution and plasticity. Although several classification systems are now in use, none is totally definitive of any soil for all possible applications because of the wide diversity of soil properties.

## 3.1 TEXTURAL CLASSIFICATION

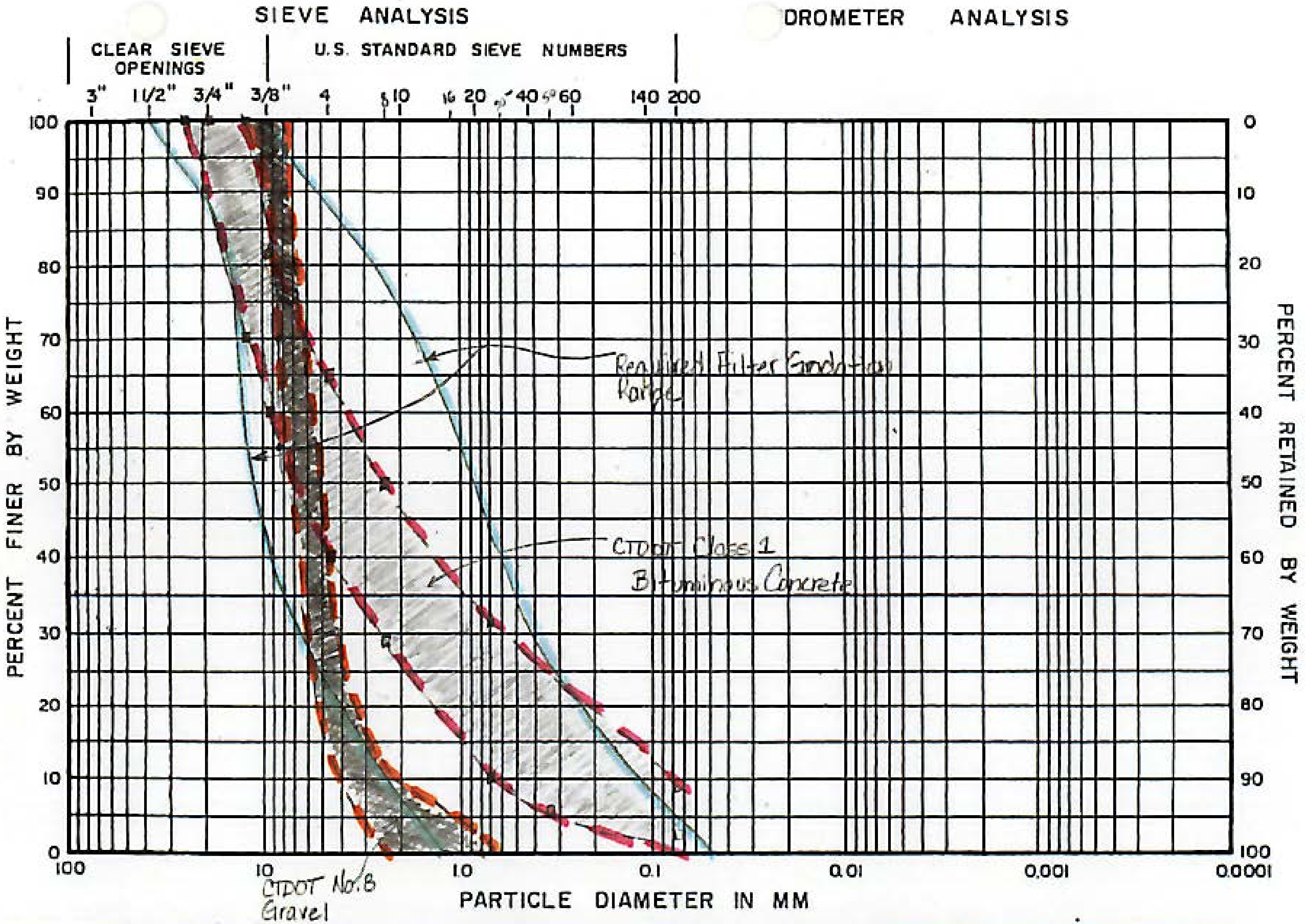
In a general sense, *texture* of soil refers to its surface appearance. Soil texture is influenced by the size of the individual particles present in it. Table 1.3 divided soils into gravel, sand, silt, and clay categories on the basis of particle size. In most cases, natural soils are mixtures of particles from several size groups. In the textural classification system, the soils are named after their principal components, such as sandy clay, silty clay, and so forth.

A number of textural classification systems were developed in the past by different organizations to serve their needs, and several of those are in use today. Figure 3.1 shows the textural classification system developed by the U.S. Department of Agricultura (USDA). This classification method is based on the particle-size limits as described under the USDA system in Table 1.3; that is:

- *Sand size:* 2.0 to 0.05 mm in diameter
- *Silt size:* 0.05 to 0.002 mm in diameter
- *Clay size:* smaller than 0.002 mm in diameter

The use of this chart can best be demonstrated by an example. If the particle-size distribution of soil *A* shows 30% sand, 40% silt, and 30% clay-size particles, its textural classification can be determined by proceeding in the manner indicated by the arrows in Figure 3.1. This soil falls into the zone of

# GRAIN SIZE ANALYSIS
## COHESIVE MATERIAL



| COBBLES | GRAVEL | | SAND | | | SILT AND CLAY | |
|---|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | SILT FRACTION | CLAY FRACTION |

| BORING | SAMPLE, DEPTH | SOIL DESCRIPTION | USCS | L.L. | P.L. | WC, % |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
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ATTACHMENT 3

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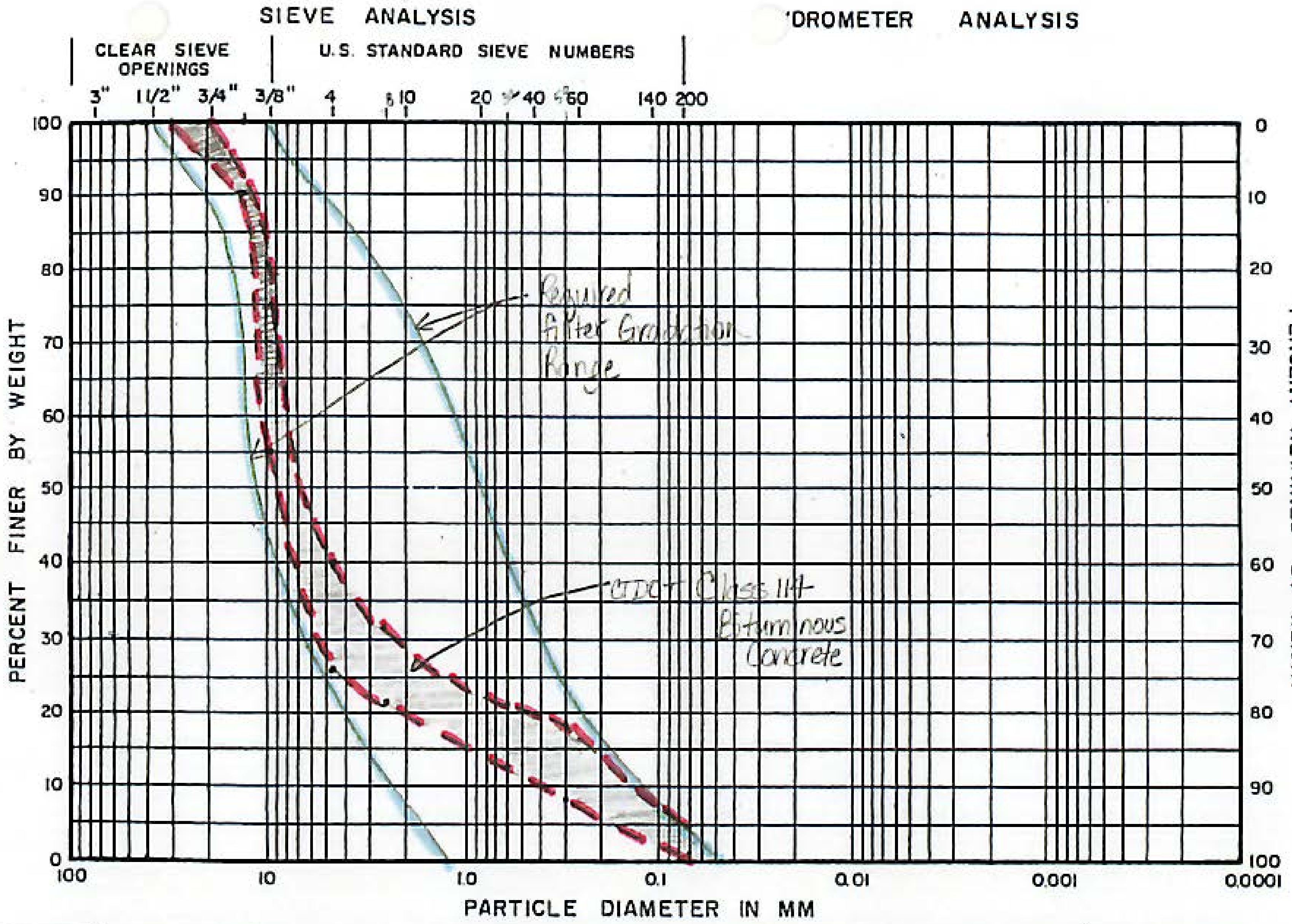
# GRAIN SIZE ANALYSIS
## COHESIVE MATERIAL



| COBBLES | GRAVEL | | SAND | | | SILT AND CLAY | |
|---|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | SILT FRACTION | CLAY FRACTION |

| BORING | SAMPLE, DEPTH | SOIL DESCRIPTION | USCS | L.L. | P.L. | WC,% |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

ATTACHMENT 4

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U.S. Department of Agriculture
Soil Conservation Service
Engineering Division

# SOIL MECHANICS NOTE NO. 1

210-VI

# GUIDE FOR DETERMINING THE GRADATION OF SAND AND GRAVEL FILTERS

Revised January 1986

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## I. Purpose

This note presents criteria for determining the grain-size distribution (gradation) of sand and gravel filters needed to prevent internal erosion or piping of soil in embankments or foundations of hydraulic structures.

These criteria are results of an extensive laboratory filter study carried out by the Soil Conservation Service at the Soil Mechanics Laboratory in Lincoln, Nebraska, during the period 1980-1985. ( 1, 2, 3, 4).

## II. Definitions

Base Soil - Any soil through which water moves into a filter or drainage system.

$d_{85}$ and $d_{100}$ sizes - Particle sizes (mm) corresponding respectively to 85 and 100 percent finer by dry weight from the gradation curve of the base soil.

for base soil or
(regraded)

$D_5$, $D_{10}$, $D_{15}$, $D_{60}$, $D_{85}$, and $D_{100}$ sizes - Particle sizes (mm) corresponding to the 5, 10, 15, 60 85, and 100 percent finer by dry weight from the gradation curve of the filter.

Gradation curve (grain-size distribution) - Plot of the distribution of particle sizes in a base soil or material used for filters or drains.

Drain - A designed pervious zone, layer, or other feature used to reduce seepage pressures and carry water.

Filter - Sand or sand and gravel having a gradation designed to prevent movement of a base soil by flowing water. Fabrics or other filter materials are not included in this note.

Fines - That portion of a soil finer than a No. 200 (0.075 mm) U.S. Standard sieve.

Soil category - One of four types of base soil materials based on the percentage finer than the No. 200 (0.075 mm) U.S. Standard sieve.

## III. Basic Purpose of Filters and Drains

Filters are placed in embankment zones, foundations or other areas of hydraulic structures for two purposes:

1. To intercept cracks or openings in the soil to prevent the erosion of soil particles by water passing through the openings. The filter is graded so that soil particles cannot pass through the filter voids. They are caught at the filter face, preventing further erosion and concentrated flow through cracks or openings.

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2. To intercept seepage passing through the pores of the soil, thereby preventing the movement of soil particles at the discharge point (piping). Piping occurs when seepage gradients or pressures are high enough to produce erosive discharge velocities in the base soil. The filter zone is usually placed upstream of the discharge point where sufficient confinement prevents uplift or blow-off of the filter.

Drains consist of sand, sand and gravel, or gravel mixtures placed in embankments, foundations, and backfill of hydraulic structures, or in other locations to reduce seepage pressure. A drain's most important design feature is its capacity to reduce seepage pressures and carry collected water to a safe outlet. Drains are often used downstream of or in addition to a filter to provide outlet capacity.

## IV. Permeability and Capacity

The laboratory filter study clearly demonstrated that a graded filter designed in accordance with the criteria contained in this note will seal a crack. The sealing begins whenever water runs through a crack or opening and carries soil particles to the filter face or causes filling or closing of the crack. Any subsequent flow is through the pores of the soil. Therefore, when filters are designed to intercept cracks, the permeability used to determine drain capacity is computed for saturated steady state flow through the pores of the base soil material.

Where it can be demonstrated that saturated steady state flow will not develop (i.e., dry dams having a normal drawdown within 10 days), capacity is not a necessary design requirement. Filters designed to protect against leakage and erosion in cracks are to have a thickness that compensates for the negative effects of material segregation and contamination during construction and ensures continuity (will not sustain a crack) during differential movements.

A drain of coarser materials immediately downstream of the filter or a perforated pipe in the filter is needed if seepage through the pores of the base soil material exceeds the capacity of the filter. The coarser materials must be properly graded using filter criteria in this note to prevent movement of the filter. Perforated pipes may also be used in the coarser materials to increase the capacity of the drain.

## V. Determining Filter Gradation Limits

Determine filter gradation limits using the following steps:

STEP 1. Determine the gradation curve (grain-size distribution) of the base soil material. Use enough samples to define the range of grain-size for the base soil or soils and design the filter gradation based on the soil that requires the smallest $D_{15}$ size.

STEP 2. Proceed to step 4 if the base soil contains no gravel (material larger than No. 4 sieve).

STEP 3. Prepare adjusted gradation curves for soils with particles larger than the No. 4 (4.75 mm) sieve:

a. Obtain a correction factor by dividing 100 by the percent passing the No. 4 (4.75 mm) sieve size.

b. Multiply the percentage passing each sieve size of the base soil smaller than No. 4 (4.75 mm) by the correction factor from step 3a.

c. Plot these adjusted percentages to obtain a new gradation curve.

d. Use the adjusted curve to determine the percent passing the No. 200 (0.75 mm) sieve in step 4.

STEP 4. Place the base soil in category based on the percent passing the No. 200 (0.75 mm) sieve in accordance with table 1.

Table 1 - Categories of base soil materials

| Category | Present finer than the No. 200 (75 micron) sieve |
|---|---|
| 1 | > 85 |
| 2 | 40-85 |
| 3 | 15-40 |
| 4 | < 15 |

STEP 5. Determine the maximum $D_{15}$ size for the filter in accordance with table 2. Note that the maximum $D_{15}$ is not required to be smaller than 0.20 mm.

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Table 2.--Criteria for filters

| Base soil category | Base soil description, and percent finer than No. 200 (0.075 mm) sieve 1/ | Filter criteria 2/ |
|---|---|---|
| 1 | Fine silts and clays; more than 85% finer. | 3/ $D_{15} \leq 9 \times d_{85}$ |
| 2 | Sands, silts, clays, and silty and clayey sands; 40 to 85% finer. | $D_{15} \leq 0.7$ mm |
| 3 | Silty and clayey sands and gravels; 15 to 40% finer. | 4,5/ $D_{15} \leq \left[\frac{40 - A}{40 - 15}\right](4 \times d_{85} - 0.7 \text{ mm}) + 0.7 \text{ mm}$ |
| 4 | Sands and gravels; less than 15% finer. | $D_{15} \leq 4 \times d_{85}$ |

1/ Category designation for soil containing particles larger then 4.75 mm is determined after the base soil is regraded to 100% passing the No. 4 (4.75 mm) sieve.

2/ Filters are to have a maximum particle size of 3-inches (75-mm) and a maximum of 5% passing the No. 200 (0.075 mm) sieve with the plasticity index (PI) of the fines equal to zero. PI is determined on the material passing the No. 40 (0.425 mm) sieve in accordance with ASTM-D-4318. To ensure sufficient permeability, filters are to have a $D_{15}$ size equal to or greather than 4 x $d_{15}$ but no smaller than 0.1 mm.

3/ When 9 x $d_{85}$ is less than 0.2 mm, use 0.2 mm.

4/ A = percent passing the No. 200 (0.075 mm) sieve after any regarding.

5/ When 4 x $d_{85}$ is less than 0.7 mm, use 0.7 mm.

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STEP 6. To ensure sufficient permeability, set the minimum $D_{15}$ greater than or equal to 4 x $d_{15}$ of the base soil but no less than 0.1 mm.

STEP 7. Set the maximum particle size at 3 in. (75 mm) and the maximum passing the No. 200 (0.075 mm) sieve at 5 percent. The portion of the filter material passing the No. 40 (0.425 mm) sieve must have plasticity index (PI) of zero when tested in accordance with ASTM D-4318.

STEP 8. Design the filter limits within the maximum and minimum values determined in steps 5, 6, and 7. Standard gradations may be used if desired. Plot the limit values on Form SCS ENG 130 and connect all the minimum and maximum points with straight lines. To minimize segregation and related effects, filters should have relatively uniform grain-size distribution curves, without "gap grading"--sharp breaks in curvature indicating absence of certain particle sizes. This may require setting limits that reduce the broadness of filters within the maximum and minimum values determined. Sand filters with $D_{90}$ less than about 20 mm generally do not need limitations on filter broadness to prevent segregation. For coarser filters and gravel zones that serve both as filters and drains, the ratio $D_{90}/D_{10}$ should decrease rapidly with increasing $D_{10}$ size. The limits in table 3 are suggested for preventing segregation during construction of these coarser filters.

Table 3 - $D_{10}$ and $d_{90}$ limits for preventing segregation.

| Minimum $D_{10}$ | Maximum $D_{90}$ |
|---|---|
| <0.5 | 20 |
| 0.5 - 1.0 | 25 |
| 1.0 - 2.0 | 30 |
| 2.0 - 5.0 | 40 |
| 5.0 - 10 | 50 |
| 10 - 50 | 60 |

STEP 9. Design filters adjacent to perforated pipe to have a $D_{85}$ size no smaller than the perforation diameter. For critical structure drains where rapid gradient reversal (surging) is probable, it is recommended that the $D_{15}$ size of the material surrounding the pipe be no smaller than the perforation size.

## VI. References

1. Sherard, J. L. and Dunnigan, L. P., 1985, Filters and Leakage Control in Embankment Dams. In R. L. Volpe and W. E. Kelly (ed.), Seepage and Leakage from Dams and Impoundments. Proceedings of a Geotechnical Engineering Division symposium in Denver, Colorado, May 5, 1985. American Society of Civil Engineers. New York, N. Y. p. 1-30.

2. Sherard, J. L., Dunnigan, L. P. and Talbot, J. R., 1984, Basic Properties of Sand and Gravel Filters. American Society of Civil Engineers, Journal of Geotechnical Engineering 110(6) June 1984: p. 684-700.

3. Sherard, J. L., Dunnigan, L. P. and J. R. Talbot., 1984, Filters for Silts and Clays. American Society of Civil Engineers. Journal of Geotechnical Engineering 110(6) June 1984: p. 701-718.

4. Talbot, J. R. and Ralston., 1985, Earth Dam Seepage Control, SCS Experience. In R. L. Volpe and W. E. Kelly (ed.), Seepage and Leakage from Dams and Impoundments. Proceedings of a Geotechnical Engineering Division Symposium in Denver, Colorado, May 5, 1985. American Society of Civil Engineers. New York, N.Y. p. 44-65.

# APPENDIX D

# GLOBAL STABILITY ANALYSES AND SETTLEMENT EVALUATION

ATTACHMENT A - GLOBAL STABILITY ANALYSES CALCULATIONS

ATTACHMENT B - SETTLEMENT EVALUATION CALCULATIONS

# TECHNICAL MEMORANDUM

**PROJECT NUMBER:** 50796 1032

**FROM:** Gina Rustad, P.E.

Checked By: ____________________, Date: ___________

Approved By: ____________________, Date: ___________

**DATE:** May 2, 2001

**PROJECT:** Causeway Non-time Critical Removal Action
Stratford Army Engine Plant
Stratford, Connecticut

**SUBJECT:** Results of Stability and Settlement Analysis
for the Causeway Proposed Cover System

## 1.0 INTRODUCTION

Harding ESE, Inc., A MACTEC Company (Harding), formerly Harding Lawson Associates (HLA) has completed slope stability and settlement analyses for the Stratford Army Engine Plant (SAEP) Non-time Critical Removal Action (NCRA) on the Causeway. Geotechnical parameters used in the stability and settlement analyses have been developed and are presented in the Geotechnical Investigation Summary for the Causeway (Harding, 2000).

The stability analyses included determination of the factor of safety with respect to static loading conditions for both rotational global and infinite slope (localized/surficial failure mode) stability of the proposed Causeway cover system. ***Seismic*** stability evaluations were not performed. The global analyses were performed for one selected cross section (including both east and west slopes), estimated to be the worst case location. Infinite slope analyses were performed for the cover system to assess the stability of the maximum final cover grade of 3 horizontal to 1 vertical (3H:1V). The analyses were based on a preliminary final grading plan dated January 26, 2001 prepared by Harding.

The settlement analyses included estimates of primary consolidation settlement and secondary settlement of the organic sediments encountered beneath the Causeway. Elastic settlement of the fill and deep sand and gravel deposit was also calculated; however, the values were insignificant when compared to the primary and secondary settlement and have not been included in the total estimate. Fill and cover thickness and organic sediment characteristics used for settlement estimates were based on information provided in the Geotechnical Investigation Summary (Harding, 2000). Maximum fill thickness of the Causeway cover were based on a preliminary final grading plan dated January 26, 2001 prepared by Harding.

# 2.0 STABILITY ANALYSIS

## 2.1 PHYSICAL PROPERTIES OF MATERIALS USED IN STABILITY ANALYSIS

The physical properties of the soil materials used in the stability analyses were those provided in the Geotechnical Investigation Summary (Harding, 2000). The values selected for the analysis are described in detail on the attached calculation sheets, and summarized as follows:

### 2.1.1 Cover System Characteristics

Two cover systems were evaluated as follows:

<u>Cover System</u>:

The cover option consists of two material profiles, as follows:

On the side slopes of the Causeway:

- Triton® Polymeric Marine Mattresses, composed of rock-filled gabion baskets with an outer shell of high tensile strength geogrid. An overall thickness of 18 inches was assigned.

On the upper, flatter portion of the Causeway:

- Interlocking concrete blocks, consisting of the following components (starting at ground surface, with an overall thickness of 20 inches): topsoil, pea-gravel, 6-inch thick interlocking concrete blocks, a non-woven geotextile, and bedding sand.

<u>Rip-Rap Cover System</u>:

The rip-rap cover option consists of two material profiles, as follows:

On the side slopes of the Causeway:

- Triton® Polymeric Marine Mattresses, composed of rock-filled gabion baskets with an outer shell of high tensile strength geogrid. An overall thickness of 18 inches was assigned.

On the upper, flatter portion of the Causeway:

- Stone rip-rap, with a thickness of 24 inches.

The physical properties of the cover system materials used in the stability analyses were developed based on literature sources and manufacturer information, refer to Attachment A. A parametric study was performed to assess the effects of variations in these assumed values.

### 2.1.2 Causeway Fill Characteristics

The Causeway fill material can be described as having the following estimated engineering characteristics:

- Total Unit Weight = 140 pounds per cubic foot (pcf)
- Submerged Unit Weight = 77.6 pcf

- Internal Friction Angle = 33 degrees (°)
- Cohesion = 0 pounds per square foot (psf) (conservative assumption, since large quantities of slag and semi-cemented ash were encountered along with large pieces of concrete).
- Relative Density = moderately dense to very dense
- Consistency = granular and non-cohesive

### 2.1.3 Organic Sediment Characteristics

The organic sediments are divided into two main categories, those under the Causeway and those off the Causeway (i.e., in the tidal flats). The main categories are typically further divided into 10-foot thick layers. Total unit weights and average undrained shear strengths were developed in the Geotechnical Investigation Summary (Harding, 2000), and are summarized in the attached calculations (Attachment A).

- Unit weights range from: 78 to 96 pcf
- Undrained shear strength range from 180 to 380 psf off the Causeway and from 630 to 900 psf under the Causeway

## 2.2 GEOMETRY USED IN STABILITY ANALYSIS

The stability analyses performed evaluated two cover system geometries, refer to attached calculations (Attachment A), as follows:

- Encroaching: The proposed cover system is keyed in at the existing toe with no encroachment into the tidal flats at this point. The entire Causeway is re-graded and sloped at 3 horizontal to 1 vertical (3H:1V) to elevation 6.5 feet mean sea level (msl) then graded to a 2% slope on the upper portion of the Causeway to a maximum height of 8 feet msl (top of cover system).

- Non-encroaching: The proposed cover system is keyed in at the existing toe and mimics existing grades up to elevation 4.1 feet msl, with no encroachment into the tidal flats. The remainder of the Causeway, above elevation 4.1 feet msl, is re-graded using a 3H:1V slope to elevation 10 feet msl and a 2% slope on the upper portion of the Causeway to a maximum height of 11 feet msl (top of cover system).

The subsurface geometry used to perform the stability analyses, including the division of the organic sediments into seven separate layers, is presented in the attached calculations (see Attachment A). The cover system was input as a 1.5 foot thick layer (cover), and equivalent properties for a 2-foot thick rip-rap layer were inputted for the rip-rap cover option.

Groundwater was typically included in the analyses at the following conditions:

- Low tide (i.e., a groundwater surface coincident with the top of the tidal mud)
- Undrained conditions in the Causeway fill (i.e., groundwater at elevation 4.1 feet msl)

The parametric analysis also considered an extreme low-tide condition, with the groundwater surface in the tidal flats and in the Causeway at an elevation of –3 feet msl.

## 2.3 PROCEDURE USED IN STABILITY ANALYSIS

The computer program SLOPE/W, Version 4.20, was used to determine factors of safety with respect to circular and wedge type failure surfaces. The analytical technique used was moment equilibrium, commonly referred to as the Simplified Bishop Method of Slices. The program utilizes a grid of circle centers and radii to evaluate the circular slip surface combinations requested. For each run the program generates contours of minimum factors of safety for each circle center. These contours are used to focus in on the area where the center of the critical (minimum factor of safety) circular surface is located.

The two sides (up-river, or north) and (Sound side, or south) have different surface configurations, and therefore were considered separately in the analysis.

The selected cross-section, which included the width of the entire Causeway, was input to the program and the geometry confirmed. The program identified willow, intermediate, and deep circle failures as those with the minimum factors of safety, dependent upon the configuration and the location of the grid and radii (up-river or Sound side). Following initial computer runs, a parametric study was performed to evaluate the sensitivity of the reported minimum factors of safety to variations in the following input parameters:

- Failure along the top of the sand layer, a non-circular failure (similar to a wedge)
- The presence of a zone of tension cracks, filled with low-strength fill and sediment
- Changes in the actual shear strength of the native sediments
- Changes in the unit weight and friction angle of the fill material
- Static water level in the fill and tidal flats (i.e., low-tide condition)
- Allowable surcharge on the top of the Causeway

Following computer analyses, a hand check was performed. A true scale drawing was used to check Slip Circle # 667 of Run # 7 (i.e., Non-encroaching, cover system), which produced a factor of safety of 1.86 using the computer model. The hand check was performed using the Simplified Bishop Method of Slices. The hand check yielded a factor of safety of 1.70, which indicates that the computer model was developed and executed consistent with the hand check (see Attachment A). Where this electronic file was modified slightly and used to perform the other evaluations, the computer results are considered valid.

## 2.4 SUMMARY OF STABILITY ANALYSES

Two types of stability analyses were performed: global and infinite slope (localized/surficial failure modes).

Global Stability:

The following table summarizes the results of the global stability analyses (refer to Attachment A):

| Model Parameters | Parametric Study [1] | Calculated FS Right to Left (Sound Side) | Calculated FS Left to Right (Up-River Side) | Required FS |
|---|---|---|---|---|
| Cover Encroaching | Initial Run | 1.85 | 1.83 | 1.3 |
| Cover Non-encroaching | Initial Run | 1.80 | 2.26 | 1.3 |
| Rip-rap Cover Encroaching | Initial Run | 1.79 | 1.70 | 1.3 |
| Rip-rap Cover Non-encroaching | Initial Run<br>Wedge Failure<br>Tension Cracks<br>Low-tide | 1.70<br>1.81<br>1.48<br>1.73 | 2.12 | 1.3<br>1.3<br>1.1<br>1.3 |

Notes:
1 – The factor of safety reported is the range for the given range of the varied parameter.
FS: factor of safety
Right to Left: Failures from right to left, or toward the south.
Left to Right: Failures from left to right, or toward the north.

Infinite Slope:

An infinite slope analysis was performed to evaluate localized types of willow surface failure. The critical location for these types of failures is where the side slopes are the longest and steepest. In this analysis no passive resistance is generated and the failure mode is representative of a surface sloughing. A manual evaluation was performed and is presented in the attached calculations. The results of the evaluation indicate a factor of safety of 1.8 associated with the 3H:1V slope and that the maximum slope to maintain a factor of safety of 1.3 is approximately 2H:1V.

# 3.0 SETTLEMENT ANALYSIS

## 3.1 APPROACH

Settlement analyses have been performed to estimate the magnitude of ground surface settlement that may be expected to occur due to construction of the proposed cover system on the Causeway. Settlement is expected to occur primarily due to the additional weight of cover materials and relocated fill, resulting in consolidation of the soft organic sediments underlying the Causeway. The purpose of these evaluations was to provide a means to estimate changes in finish grades after the completion of the cover system. At this time, Harding is not aware of any requirements regarding allowable settlement.

Soil mechanics and settlement theory typically attribute consolidation to three distinct phases: elastic deformation, primary consolidation settlement, and secondary consolidation settlement (i.e., creep). The analyses performed were as follows:

- Elastic deformation: The fill materials are typically granular and non-cohesive, as are the sand and gravel deposits beneath the organic sediments. These materials were evaluated for their potential elastic deformation due to the applied cover system load.
- Primary consolidation settlement: The organic sediments are considered slow draining and are expected to develop some excess pore-water pressures during cover placement. The release of these pore pressures (i.e., dewatering) will result in primary consolidation settlement, as accounted for in the analyses performed. The fill and sand and gravel deposits are not expected to develop excess pore pressures and are therefore not expected to exhibit primary consolidation settlement.
- Secondary consolidation settlement: Due to the nature of the organic sediments, they exhibit considerable tendency to continue to deform (i.e., settle) following consolidation. Secondary consolidation settlement is negligible in granular soils.

The Causeway is underlain by a relatively thick layer of organic sediments, which according to several researchers, does not follow the standard theories of soil settlement, due primarily to the relatively large change in permeability that occurs during consolidation. Typically, however, these standard theories are applied, as was done here, with clarification that the numerical results are estimates.

The following paragraphs provide some brief background as to the meaning of the settlement parameters used in the evaluations.

Primary Compression: This is the amount of soil compression that occurs while excess pore pressures dissipate after a new load is applied (i.e., dewatering). Primary compression is evaluated using the Compression Index ($C_c$), and/or the Compression Ratio ($C_\varepsilon$), parameters determined from the consolidation test, as well as the Recompression Index ($C_r$), and/or the Recompression Ratio ($C_{r\varepsilon}$). $C_c$ is the slope of the virgin compression (steep) portion of the void ratio versus the log of the applied load curve, obtained from the test. $C_\varepsilon$ is the slope of the virgin compression portion of the percent strain versus the log of the applied load curve, also obtained from the test. The recompression parameters represent the flatter portion of the curve, generated when loads are being re-applied. The void ratios and strains used to develop the laboratory test curves used for this project reflect conditions near the end of consolidation, and were constructed to separate the effects of secondary compression.

Rate of Compression: The rate of primary compression is evaluated through the use of the Coefficient of Consolidation Parameter ($c_v$), which can be derived from consolidation tests. This parameter reflects how fast the soil consolidates when loaded.

Secondary Compression: Secondary compression is the slow, continued compression that occurs after the excess pore pressures have substantially dissipated. This compression occurs over long periods of time and is often more pronounced for organic soils. The magnitude of secondary compression is expressed by the slope of the final portion of the log of time versus percent strain compression curve (i.e., Coefficient of Secondary Compression [$C_\alpha$]) for each load increment applied during the consolidation test.

### 3.1.1 Properties of Organic Sediments

Testing performed on samples from the site provided soil parameters for the three following characteristics:

- $C_c$, (virgin compression): 0.57 to 0.99
- $C_c$' (over stress range of concern): 0.37 to 0.51 (reflecting the slope of the curve over the anticipated stress range imposed by the proposed cover system)

- $C_\varepsilon$, (virgin compression): 0.12 to 0.15
- $C_\varepsilon$', (over stress range of concern): 0.07 to 0.11

- $C_r$: 0.04 to 0.11
- $C_{r\varepsilon}$: 0.011 to 0.017

- $c_v$ (under Causeway): 0.006 to 0.0008 square inches per second ($in^2/sec$) (3.5 to 0.5 square feet per day [$ft^2/day$])
- $c_v$ (off Causeway): 0.01 $in^2$ /sec (6.5 $ft^2/day$)

Values of the Secondary Compression ratio ($C_\alpha$' = (ΔH/H)/(Δlog t) symbols defined later), determined from the tests include the following:

- $C_\alpha$' (all 3 tests, at highest applied load): 0.015 to 0.044
- $C_\alpha$' (under Causeway samples, at design applied load): 0.001 to 0.011

- $C_\alpha$': (off Causeway samples, at design applied loads): 0.003.

### 3.1.2 Geometry and Loading

Due to the aerial extent of the Causeway and the relatively small increase in applied load that will result from cover construction, a simplified geometry was used in the settlement analysis. For the purposes of the analysis, it was assumed that an applied load ranging from 2.3 to 4.5 pounds per square inch (psi) would be applied at ground surface, including up to 3.2 feet of relocated fill and a 1.5-foot thick cover. Further, due to the relatively uniform thickness and character of the organic sediments (the largest contributor to settlement) a 33-foot thick layer was assumed. The organic sediments were given the range of properties identified in the investigation (see Subsection 3.1.1) to assess the likely range in expected settlement.

## 3.2 PROCEDURE

Settlement of native soil beneath the landfill was estimated to evaluate the potential impact to the proposed Causeway cover system. Elastic and consolidation settlements were evaluated.

Elastic (initial) settlement ($S_e$) for the fill was estimated using standard formulas (Das, 1998 pg. 351) and (Oweis & Khera, p. 53). Primary consolidation settlement of the organic sediment layer was estimated using standard consolidation Theory (Das, 1995). Secondary consolidation settlement within the organic sediments was estimated using the following approach:

$$T_v = \{(C_v * t_1)/H_{dr}^2\}$$

Where:

$T_v$ = Average degree of consolidation
$C_v$ = Coefficient of consolidation
$t_1$ = Time
$H_{dr}^2$ = Average longest drainage path during consolidation

The time to reach the end of primary consolidation was determined, and used as input into the secondary settlement equation:

$$S_s = C_\alpha H \log (t_2/t_1)$$

Where:

$S_s$ = Secondary compression
$C_\alpha$ = Secondary compression index
H = Thickness of layer
$t_2$ = time, where secondary settlement estimate is required
$t_1$ = time to the end of primary consolidation

Total settlement is the sum of all three components of settlement, as follows:

$S_T = S_e + S_{primary} + S_s$

Where:

$S_T$ = Total Settlement
$S_e$ = Elastic settlement
$S_{primary}$ = Primary consolidation settlement
$S_s$ = Secondary consolidation settlement

### 3.3 SUMMARY OF ANALYSES

The elastic settlement expected within the fill material, due to construction of the cover is expected to be minimal (<0.1 inches). Due to the random nature of the fill materials, a more refined estimate is not considered feasible or warranted due to the relatively large settlements attributable to primary consolidation and secondary settlement.

Primary consolidation settlement was evaluated at two locations beneath the Causeway (at soil boring locations GB-00-02 and GB-00-04), using the expected range in material properties. The results are summarized in the following table.

| **Settlement Type** | **Estimated Settlement in Inches** | |
|---|---|---|
| | **GB-00-02** | **GB-00-04** |
| Primary: | 2 | 6 |
| | | |
| Secondary: | | |
| 5 years | 2 | 2 |
| 20 years | 3 | 3 |
| 50 years | 4 | 4 |
| | | |
| Total Settlement: | | |
| 1 year | 2 | 6 |
| 5 years | 4 | 8 |
| 20 years | 5 | 9 |
| 50 years | 6 | 10 |

## 4.0 CONCLUSIONS AND RECOMMENDATIONS

### 4.1 STABILITY ANALYSIS

Based on the results of the above analyses, the Causeway cover system, as currently designed, is anticipated to be stable with respect to rotational and infinite slope stability under static loading conditions. The critical condition from a stability standpoint for the Causeway cover system, as currently designed, is a deep (massive) type failure (the lowest minimum factor of safety for the proposed configuration).

The exact vertical extent of the toe of the Causeway fill is unknown, primarily on the north side of the Causeway where uncontrolled filling occurred. As a result, the near surface stability of this region during construction of the proposed cover system is also unknown. During excavation, attention to the conditions at the base of the excavation should be made, and the potential for the excavation to penetrate through the fill and into the organic sediments must be observed.

| **Failure Mode and Condition** | **Required Factor of Safety** | **Minimum Estimated Factor of Safety** |
|---|---|---|
| Global, Static | 1.3 | 1.48 (with tension cracks) |
| Infinite Slope, Static | 1.5 | 1.8 |

The following recommendations are made with respect to the overall stability of the proposed Causeway cover system:

- Cover materials to be used in cover construction and excavated materials should not be stockpiled on the Causeway for over a period of one days' work, and should not be stockpiled greater than four to six feet tall.

- The use of vibratory equipment on the Causeway will be limited (i.e., no vibratory rollers to compact materials should be used).

- Should tidal sediments, vertical cracking and or voids be encountered in the fill material, (indicating possible tension cracks), during excavation of the toe of the Causeway, the design engineer should be notified, such that modifications to the design can be made, if deemed necessary.

- During excavation, attention should be given to the conditions at the base of the excavation. If the excavation penetrates into the native sediment, the design engineer should be notified, such that modifications to the design can be made, if deemed necessary.

- A minimum of four heave platforms should be placed in the tidal flats prior to the initiation of construction of the proposed cover system. The elevations of the platforms should be regularly monitored to determine the magnitude of heave in the sediment during construction. If the tidal sediments appear to be heaving in excess of 3 to 5 inches during construction, the design engineer should be notified, such that modifications to the design can be made, if deemed necessary.

- Monitoring for the development of a heave in the mud flats should be performed.

### 4.2 SETTLEMENT ANALYSIS

Based on the above settlement analysis with the stated assumptions, the Causeway is expected to demonstrate the following settlement related characteristics.

- The Causeway should be expected to settle approximately 7 inches within the first year, following construction.
- The Causeway should be expected to continue to settle at a decreasing rate and may settle an additional 1 to 5 inches over the ensuing 50 years.
- Abrupt surficial differential settlements are not expected to result, except where existing fill materials may be loose.

| | |
|---|---|
| $C_\alpha$ | Coefficient of Secondary Compression |
| $C_c$ | Compression Index |
| $C_\varepsilon$ | Compression Ratio |
| $C_r$ | Recompression Index |
| $C_{r\varepsilon}$ | Recompression Ratio |
| $c_v$ | Coefficient of Consolidation Parameter |
| ° | degrees |
| $ft^2$/day | square feet per day |
| Harding | Harding ESE, Inc., A MACTEC Company |
| HLA | Harding Lawson Associates |
| $in^2$/sec | square inches per second |
| msl | mean sea level |
| NCRA | Non-Time-Critical Removal Action |
| pcf | pounds per cubic foot |
| psf | pounds per square foot |
| psi | pounds per square inch |
| SAEP | Stratford Army Engine Plant |
| $S_e$ | elastic settlement |
| $S_{primary}$ | primary settlement |
| $S_s$ | secondary settlement |
| $S_t$ | total settlement |

Harding, 2000. "Geotechnical Investigation Summary, Causeway Non-Time Critical Removal Action Design, Stratford Army Engine Plant, Stratford, Connecticut", prepared for U.S. Army Tank-automotive and Armaments Command, Stratford Connecticut, Contract DAAAM-02-97-D-005, December 2000.

Das, Braja M. Principles of Foundation Engineering; PWS Engineering, 1995.

Das, Braja M. Principles of Geotechnical Engineering; Fourth Edition, PWS Engineering, 1998.

Oweis, I.S. and R.P. Khera, 1990. Geotechnology of Waste Management; Butterworth & Co. Ltd. (Note: a 1998 version of this text was reviewed, but no substantive changes were identified relative to the assumptions or calculations presented here).

# ATTACHMENT A

# GLOBAL STABILITY ANALYSES CALCULATIONS

**Harding Lawson Associates**
Engineering
and
Environmental Services

SHEET 1 OF 51
JOB NO. 50796 1032
DATE 1-5-01
PROJECT SAEP Causeway Design
COMPUTED BY GLR
SUBJECT Stability Analysis
CHECKED BY

PURPOSE: To evaluate the global stability of the Causeway at the SAEP site under various cover system scenarios.

RESULTS SUMMARY:

| RUN NUMBER | COVER TYPE | COVER THICKNESS | ENCROACHING? | FS R→L SLIP | FS L→R SLIP |
|---|---|---|---|---|---|
| RUN #1/#2 | TRI-LOCK/TRITON | 1.5 ft | YES | 1.85 (RUN#1) | 1.83 (RUN#2) |
| RUN #3/#4 | TRI-LOCK/TRITON | 1.5 ft | NO | 1.80 (RUN#3) | 2.26 (RUN#4) |
| RUN #5/#6 | RIP-RAP/TRITON | 2.0 ft | YES | 1.79 (RUN#5) | 1.70 (RUN#6) |
| RUN #7/#8 | RIP-RAP/TRITON | 2.0 ft | NO | 1.70 (RUN#7) | 2.12 (RUN#8) |
| RUN #9 | RIP-RAP/TRITON ALONG SAND | 2.0 ft | NO | 1.81 (RUN#9) | NA* |
| RUN #10 | RIP-RAP/TRITON TENSION CRACKS | 2.0 ft | NO | 1.48 (RUN#10) | NA* |
| RUN # 11 | RIP-RAP/TRITON LOW-TIDE | 2.0 ft | NO | 1.73 (RUN#11) | NA* |

* NA = Not Analyzed - Parametric analysis only

I. Development of Model

A. References

1. Harding ESE, Inc., 2000a. Geotechnical Investigation Summary Causeway Non-time Critical Removal Action Design. Prepared for TACOM, December 2000.

2. Harding ESE, Inc., 2000b. Premliminary grading plans.

3. Naval Facilities Engineering Command, 1982. Soil Mechanics. NAVFAC DM-7.1, May 1982.

B. Procedure

1. Visually inspected the cross sections provided from the preliminary grading plans to determine the section of the Causeway most likely to fail when loaded (largest Δload) (See Pg.
2. Developed a cross sections based on the preliminary grading plans, the proposed cover system thickness, and the interpreted subsurface condition.
3. Cross sections were developed for both encroaching and non-encroaching conditions (see pages 14 and 15)
4. Soil properties were assigned based on field observations and literature values. Equivalent properties were used for synthetic vs. rip-rap cover systems to allow use of the same profile for analyses.

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Environmental Services

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JOB NO. 50796 1032
DATE 1-3-01
PROJECT SAEP Causeway Design
COMPUTED BY GLR
SUBJECT Stability Analysis - Synthetic Encronching
CHECKED BY BB

## C. Definition of Geometry and Parameters - Encraching

| # | X | Y |
|---|---|---|
| 11 | 0 | 98 |
| 12 | 100 | 98 |
| 13 | 126 | 106.5 |
| 14 | 200 | 108 |
| 15 | 274 | 106.5 |
| 16 | 300 | 98 |
| 17 | 360 | 98 |
| 21 | 100.5 | 96.5 |
| 22 | 126 | 105 |
| 23 | 200 | 106.5 |
| 24 | 274 | 105 |
| 25 | 299.5 | 96.5 |

| # | X | Y |
|---|---|---|
| 31 | 106 | 93 |
| 32 | 200 | 93 |
| 33 | 274 | 90 |
| 34 | 292 | 93 |
| | | |
| 41 | 0 | 90 |
| 42 | 103 | 90 |
| 43 | 295 | 90 |
| 44 | 360 | 90 |

| # | X | Y |
|---|---|---|
| 51 | 0 | 80 |
| 52 | 93 | 80 |
| 53 | 305 | 80 |
| 54 | 360 | 80 |
| | | |
| 61 | 0 | 70 |
| 62 | 88 | 70 |
| 63 | 310 | 70 |
| 64 | 360 | 70 |

| # | X | Y |
|---|---|---|
| 71 | 0 | 60 |
| 72 | 85 | 60 |
| 73 | 313 | 60 |
| 74 | 360 | 60 |

| # | X | Y |
|---|---|---|
| 81 | 0 | 40 |
| 82 | 360 | 40 |

LINE #1 : 11, 12, 13, 14, 15, 16, 17
SOIL #1 : Synthetic Cover

LINE #2: 11, 12, 21, 22, 23, 24, 25, 16, 17
SOIL #2 : FILL Material*

*NOTE: REWORKED & IN-PLACE FILL CONSIDERED TO BE THE SAME LAYER.

LINE #3: 11, 12, 21, 31, 32, 33, 34, 25, 16, 17
SOIL #3: 0 to -10 msl / off

LINE #4: 41, 42, 31, 32, 33, 34, 43, 44
SOIL #4: -10 to -20 msl / off

LINE #5: 51, 52, 42, 31, 32, 33, 34, 43, 53, 54
SOIL #5: -10 to -20 msl / Under

LINE #6 : 51, 52, 53, 54
SOIL #6 : -20 to -30 msl / off

LINE #7: 61, 62, 52, 53, 63, 64
SOIL #7: -20 to -30 msl / Under

**Harding Lawson Associates**
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SHEET 3 OF 51
JOB NO. 50796 1032
DATE 1-3-01
PROJECT SAEP Causeway Design
COMPUTED BY GLR
SUBJECT Stability Analysis - Synthetic Encroaching
CHECKED BY BBG

LINE #8: 61, 62, 63, 64
SOIL #8: -30 to -40 msl/ off
LINE #9: 71, 72, 62, 63, 73, 74
SOIL #9: -30 to -40 ft MSL | Under
LINE #10: 71, 72, 73, 74
SOIL #10: Sand & Gravel
LINE #11: 81, 82
SOIL #11 Bedrock (Depth to bedrock actually ≥ -60 ft MSL, but assigned this value for model to limit profile size)

See Profile, Page 14

Piezometric surface for base run (encroaching) was placed at low-tide, undrained condition

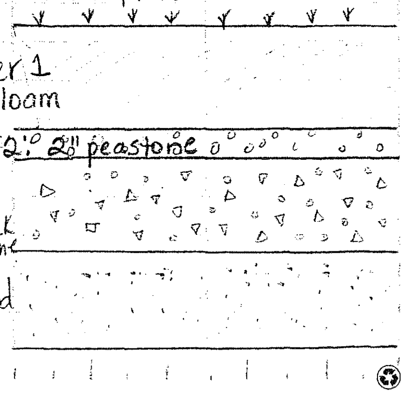
Piezometric surface 11, 12, 3, 9, 16, 17

| # | X | Y |
|---|---|---|
| 3 | 117.5 | 102 |
| 9 | 282.5 | 102 |

| SOIL # | DESCRIPTION | $\gamma$ (pcf) | $\phi$ | C (psf) |
|---|---|---|---|---|
| 1 | Synthetic Cover | 129* | 32* | 0 |
| 2 | Fill Material | 140 | 33 | 0 |
| 3 | 0 to -10 msl \| Off | 94 | 0 | 180 |
| 4 | -10 to -20 msl \| Off | 88 | 0 | 240 |
| 5 | -10 to -20 msl \| Under | 96 | 0 | 630 |
| 6 | -20 to -30 msl \| Off | 78 | 0 | 310 |
| 7 | -20 to -30 msl \| Under | 86 | 0 | 770 |
| 8 | -30 to -40 msl \| off | 80 | 0 | 380 |
| 9 | -30 to -40 msl \| Under | 80 | 0 | 900 |
| 10 | Sand and Gravel | 130 | 32+ | 0 |

+ Conservative value based on densities observed in field and NAVFAC, 1982.
* Equivalent $\gamma$ & $\phi$ for Synthetic Cover (See below)

Calculation of Equivalent $\gamma$ & $\phi$ for Cover System



$\gamma_1$ = 115 pcf
$\gamma_2$ = 130 pcf
$\gamma_3$ = 150 pcf (conservative)
$\gamma_4$ = 120 pcf

$\phi_1$ = 31°
$\phi_2$ = 32°
$\phi_3$ = 38°
$\phi_4$ = 32°

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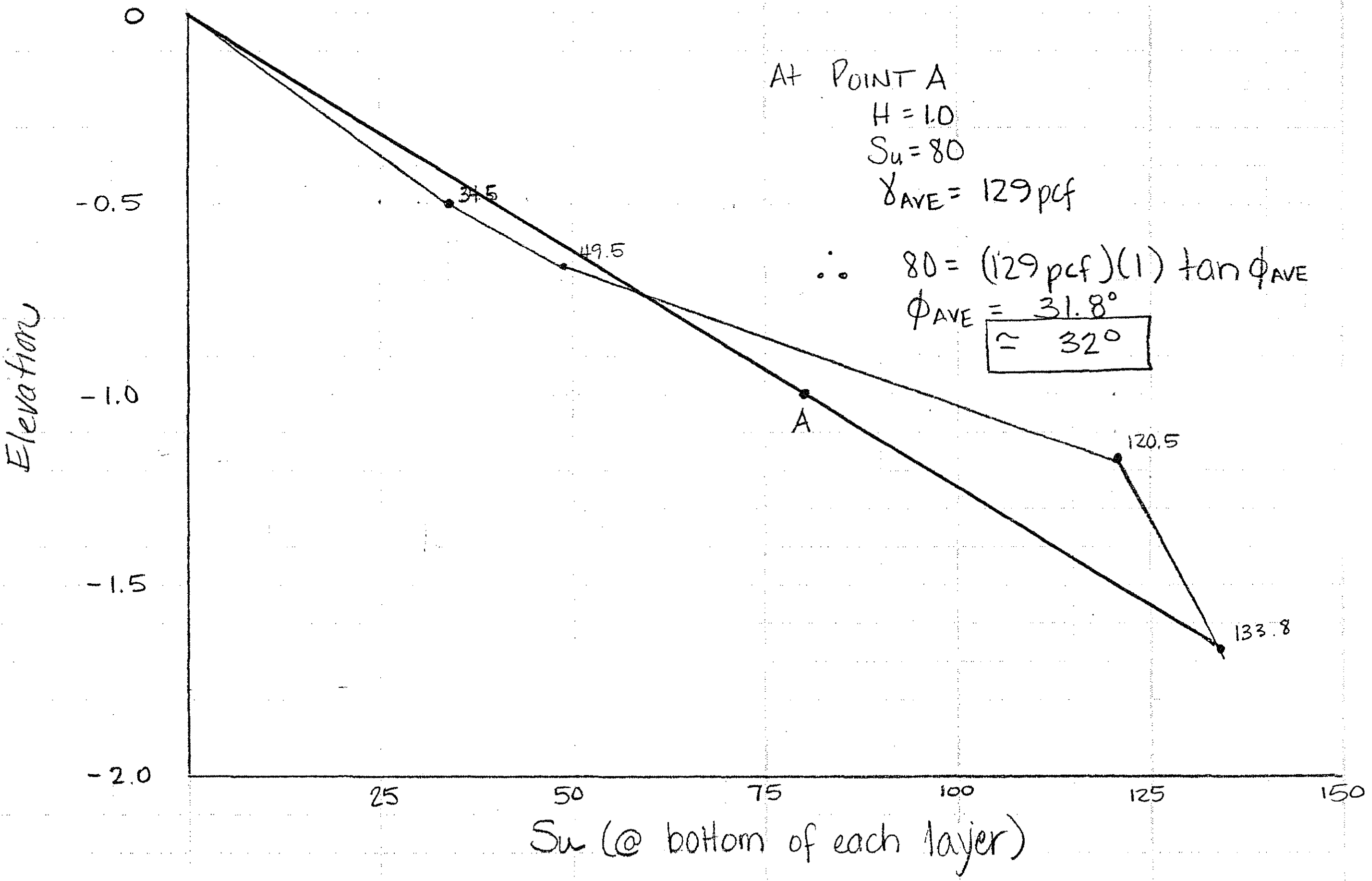
JOB NO. 50796 1032
DATE 1-4-01
PROJECT SAEP Causeway Design
COMPUTED BY GLR
SUBJECT Stability Analysis- Synthetic Encroaching
CHECKED BY

$$\gamma_{AVE} = \frac{(0.5ft)(115pcf) + (0.167ft)(130pcf) + (0.5ft)(150pcf) + (0.5ft)(120pcf)}{1.667ft}$$

$$\boxed{\gamma_{AVE} \simeq 129\ pcf}$$

$S = c + \sigma' \tan\phi$

assuming $C = 0$; $S = \sigma' \tan\phi$ with $\sigma' = \gamma H$ (above water)



At POINT A
$H = 1.0$
$S_u = 80$
$\gamma_{AVE} = 129 pcf$

$\therefore$ $80 = (129 pcf)(1) \tan\phi_{AVE}$
$\phi_{AVE} = 31.8°$
$\boxed{\simeq 32°}$

At bottom of Layer 1: $\sigma_1' = \gamma_1 H_1 = 57.5 psf$
$S_1 = 57.5 \tan 31° = 34.5 psf$

At bottom of Layer 2: $\sigma_2' = (\gamma_1 H_1 + \gamma_2 H_2) = 57.5 psf + 21.7 psf$
$S_2 = 79.2 psf \tan 32° = 49.5$

At bottom of Layer 3: $\sigma_3' = (\gamma_1 H_1 + \gamma_2 H_2 + \gamma_3 H_3) = 79.2 psf + 75 psf$
$S_3 = 154.2 \tan 38° = 120.5$

At bottom of Layer 4: $\sigma_4' = (\gamma_1 H_1 + \gamma_2 H_2 + \gamma_3 H_3 + \gamma_4 H_4) = 154.2 + 60$
$S_4 = 214.2 \tan 32° = 133.8$

SHEET 5 OF 51
JOB NO. 50796 1032
DATE 1-4-01
PROJECT SAEP Causeway Design
COMPUTED BY GLR
SUBJECT Stability Analysis - Synthetic Non-encroaching
CHECKED BY

D. Definition of Geometry and Parameters- Non-encroaching

| # | X | Y |
|---|---|---|
| 11 | 0 | 98.5 * |
| 12 | 100 | 98.5 * |
| 13 | 130 | 104 |
| 14 | 148 | 110 |
| 15 | 187.5 | 111 |
| 16 | 227 | 110 |
| 17 | 245 | 104 |
| 18 | 272 | 102 |
| 19 | 297 | 99 |
| 20 | 305 | 98.5 * |
| 21 | 400 | 98.5 * |

| # | X | Y |
|---|---|---|
| 31 | 100.5 | 97 |
| 32 | 130 | 102.5 |
| 33 | 148 | 108.5 |
| 34 | 187.5 | 109.5 |
| 35 | 227 | 108.5 |
| 36 | 245 | 102.5 |
| 37 | 272 | 100.5 |
| 38 | 297 | 97.5 |
| 39 | 304.5 | 97 |

| # | X | Y |
|---|---|---|
| 41 | 105 | 95 |
| 42 | 133 | 89 |
| 43 | 200 | 94 |
| 44 | 260 | 90 |
| 45 | 300 | 93 |
| | | |
| 51 | 0 | 90 |
| 52 | 100 | 90 |
| 53 | 303 | 90 |
| 54 | 400 | 90 |

*See correction on page 12

| # | X | Y |
|---|---|---|
| 61 | 0 | 80 |
| 62 | 90 | 80 |
| 63 | 312.5 | 80 |
| 64 | 400 | 80 |
| | | |
| 71 | 0 | 70 |
| 72 | 85 | 70 |
| 73 | 318 | 70 |
| 74 | 400 | 70 |

| # | X | Y |
|---|---|---|
| 81 | 0 | 60 |
| 82 | 82 | 60 |
| 83 | 321 | 60 |
| 84 | 400 | 60 |
| | | |
| 91 | 0 | 40 |
| 92 | 400 | 40 |

| # | X | Y |
|---|---|---|
| 101 | 92 | 118 |
| 102 | 96 | 130 |
| 103 | 96 | 160 |
| 104 | 92 | 176 |

Values use for tension cracks

LINE #1: 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21
SOIL #1 : Synthetic Cover

LINE #2 : 11, 12, 31, 32, 33, 34, 35, 36, 37, 38, 39, 20, 21
SOIL #2: FILL Material* Note: Reworked and in-place fill considered to be the same layer

LINE #3: 11, 12, 31, 41, 42, 43, 44, 45, 39, 20, 21
SOIL #3: 0 to -10 msl / Off

LINE #4: 51, 52, 41, 42, 43, 44, 45, 53, 54
SOIL #4 : -10 to -20 msl / off

LINE #5: 61, 62, 52, 41, 42, 43, 44, 45, 53, 63, 64
SOIL #5: -10 to -20 msl / Under

LINE #6: 61, 62, 63, 64
SOIL #6: -20 to -30 msl / Off

LINE #7: 71, 72, 62, 63, 73, 74

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Engineering
and
Environmental Services

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SOIL #7: -20 to -30ft MSL | under
LINE #8: 71, 72, 73, 74
SOIL #8: -30 to -40 ft MSL | off
LINE #9: 81, 82, 72, 73, 83, 84
SOIL #9: -30 to -40 ft MSL | under
LINE #10: 81, 82, 83, 84
SOIL # 10: Sand and Gravel
LINE #11: 91, 92
SOIL #11: Bedrock (Depth to bedrock actually > -60ft MSL, but assigned this value for model to limit profile size)

See Profile Page 15

Tension Crack line: 11, 12, 31, 41, 101, 102, 103, 104, 43, 44, 45, 39, 20, 21
This line was inserted as LINE # 3 in the Cracks model.

For base model runs, the piezometric surface was placed at low-tide | undrained condition
Piezometric line: 11, 12, 32, 36, 20, 21

| SOIL # | DESCRIPTION | $\gamma$ (pcf) | $\phi$ | c (psf) |
|---|---|---|---|---|
| 1 | Synthetic Cover | 129* | 32* | 0 |
| 2 | Fill Material | 140 | 33 | 0 |
| 3 | 0 to -10 msl \| off | 94 | 0 | 180 |
| 4 | -10 to -20 msl \| off | 88 | 0 | 240 |
| 5 | -10 to -20 msl \| Under | 96 | 0 | 630 |
| 6 | -20 to -30 msl \| off | 78 | 0 | 310 |
| 7 | -20 to -30 msl \| Under | 86 | 0 | 770 |
| 8 | -30 to -40 msl \| off | 80 | 0 | 380 |
| 9 | -30 to -40 msl \| Under | 80 | 0 | 900 |
| 10 | Sand & Gravel | 130 | 32+ | 0 |
| — | Cracked Fill | 110 | 150 | 0 |

* See calculations pages 4 and 5
\+ Conservative value based on densities observed in field and NAVFAC 1982

Pages 16-19 present the input files for RUNS #1 to #4, including geometry, grid, & radii
subsequent runs have similar inputs.
Pages 20 to 23 present the output files for Runs #1 to #4

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E. Definition of Geometry and Parameters - Rip-Rap vs. Synthetic

Geometry for the Rip-rap option will be identical to that for the synthetic options. Unit weight and $\phi$ will be evaluated for the rip-rap to account for the lesser thickness (i.e., 1.5ft $\neq$ 2.0ft)

For Rip-rap: Assume $\gamma = 155\,pcf$ $\phi = 32°$ $c = 0$ (conservative assumption)

If Rip-rap is 2.0 ft; at bottom of layer

$$\gamma z \Rightarrow (155pcf)(2ft) = 310\,psf$$

To be the same @ 1.5ft thick:

$$310psf = (\gamma_{EQ})(1.5ft)$$

$$\gamma_{EQ} = 207\,pcf \quad \simeq \boxed{210\,pcf = \gamma_{EQ}}$$

$\phi$ independent of thickness, $\therefore$ $\boxed{\phi_{EQ} = 32°}$

Pages 24 through 27 present the analyses associated with the rip-rap options, Runs#5 - 8

II. Additional Considerations

A. Consider a wedge-type failure along the top of the sand and gravel (not including the shear strength of the sand and gravel) See Slip #790 from Run#7 (Page 28), which passes through the sand and gravel layer, with F.S. = 1.82. Will a wedge-type failure along the contact produce a **lower** F.S.?

$$S_{SOIL\,9} = c + \sigma' \tan\phi = 900 + 0 = 900\,psf$$

$$S_{SOIL\,10} = c + \sigma' \tan\phi \quad \text{if } c = 0\text{, then}$$

$$S = \sigma' \tan\phi \quad \text{at } -42'\,msl$$

$$\sigma' = \gamma_1 h_1 + \gamma'_2 h_2 + \gamma'_5 h_5 + \gamma'_7 h_7 + \gamma'_9 h_9 + \gamma'_{10} h_{10}$$

$$= (210)(1.5) + (140-62.4)(4) + (96-62.4)(15) + (86-62.4)(10) + (80-62.4)(10) + (130-62.4)(2)$$

$$= 1{,}676\,psf$$

$$S_{SOIL\,10} = (1{,}676)\tan 32 = 1{,}047\,psf$$

Since $S_{SOIL10} > S_{SOIL9}$, wedge failure should have lower F.S.

Page 29 presents the input file for Run#9, including geometry, grid, & radii

Page 30 depicts a failure (Slip#790) along the surface of Soil #10, defined as bedrock in this run to produce a wedge failure. Resulting F.S., although lower, is still >1.8, and is not the minimum F.S. for this configuration.

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## B. TENSION CRACKS

1. The presence of tension cracks at the base of the fill material could impact the global stability of the Causeway.
2. Cracks could be filled with tidal sediment or water.
3. Include tension cracks in the model as a separate layer through which the failure surface may pass (See profile, Pg. 15)
4. Cracked fill properties:

   $\gamma$: Assume cracks contain a mixture of fill ($\gamma$ = 140 pcf); tidal sediment ($\gamma$ = 96 pcf); & additional water ($\gamma$ = 62.4 pcf) at a ratio of 45%, 45%, 10%

   $$\gamma_{AVE} = 0.45(140) + 0.45(96) + 0.1(62.4)$$
   $$\approx 110 \text{ pcf}$$

   $\phi$: Assume $\phi = 0$

   c: Similar to underlying mud (prior to strength gain); however, disturbed
   C = 150 psf (conservative assumption)

5. Pages 31 and 32 present the input and result files for Run #10, respectively. The resulting F.S. = 1.48 indicates tension cracks may significantly reduce the F.S.; however, the result is still > the necessary 1.3.
6. For purposes of this model, tension cracks were inputted as a large weak zone in the fill (conservative). Cracks are more likely to be discreet vertical lines of weak material. Because the failure surface with the min. F.S is horizontal, the actual slip would likely be larger w/ higher F.S.

## C. IMPACT OF REDUCED STRENGTHS

1. Consideration was given to the possibility that actual soil strength could be less than the assigned values in the model.
2. The lowest F.S. calculated with the assigned soil strengths is 1.70. The required F.S. immediately following construction is 1.3, or ~24% lower.

   $$\boxed{\left(\frac{1.7-1.3}{1.7}\right) \times 100 = 24\%}$$

3. The strength values corresponding to a 24% reduction from the assigned values are listed in the following table:

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| UNDER CAUSEWAY | | | OFF CAUSEWAY | |
|---|---|---|---|---|
| C (psf) Assigned | C (psf) Reduced (24%) | LAYER Elevation (ft MSL) | C (psf) Assigned | C (psf) Reduced (24%) |
| NA | NA | 0 - -10 | 180 | 137 |
| 630 | 479 | -10 - -20 | 240 | 182 |
| 770 | 585 | -20 to -30 | 310 | 235 |
| 900 | 684 | -30 to -40 | 380 | 290 |

4. Pages 33 and 34 present the input and output files for this configuration, respectively. These files show that a 24% reduction in the inputted soil strengths result in min. F.S.=1.33

5. The reduced strength vaules have been plotted on Figures 4-1 and 4-2, presented on Pages 35 and 36. These plots show that a 24% reduction in the assigned strength values, which would result in an acceptable F.S. of 1.3, would give strengths near or below the values obtained in the field for 5% strain. Compared to the peak values and the reduced values suggested by the literature (Bjerrum and Duncan), the values listed above would appear to be overly conservative.

D. IMPACT OF CHANGES IN FILL PROPERTIES

1. Consideration was given to the effect variations in the properties of the fill material may have on global stability.

2. The unit weight and friction angle of the fill material were adjusted until the F.S. was below 1.3. The unit weight was increased and the friction angle decreased (see output file on page 37).

3. Analysis using Slope/W indicated $\gamma > 175$ pcf and $\phi < 27°$ would be necessary for the F.S. to be lower than 1.3. This unit weight is greater than that for reinforced concrete and the friction angle is less than that for rounded, loose sand. These conditions do not, and will not likely exist in the Causeway fill, based on available information.

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E. LOW TIDE CONDITION

1. Analysis of the low tide condition was conducted to evaluate the impact on Causeway stability (RUN #11)

2. The Slope/W model was modified by changing the location of the piezometric surface from elevated in the Causeway, to -3.0 ft MSL (in model, Y = 97ft)

3. The F.S. for the most critical base scenario (i.e., RUN #7 Right → Left failure of the non-encroaching Rip-rap option) was 1.73, higher than the base condition. This indicates that the base conditions, low-tide with an undrained Causeway is the most critical water condition. See output file on Page 38.

F. Static analyses only, were run. Pseudostatic conditions were not considered during analyses, as suggested in the Causeway Design Proposal.

G. INFINITE SLOPE ANALYSIS

1. Under the non-encroaching option, the most critical slope will be approximately 3:1. This slope will likely be covered with the synthetic cover system, which has an average $\phi = 32°$. The uppermost layer of this system would be loam, with an estimated $\phi = 31°$

For infinite slope $\dfrac{\tan\phi}{\tan\beta} = \text{F.S.}$ w/ β = slope angle

3:1 slope = 18.4°

$\text{F.S.} = \dfrac{\tan 31}{\tan 18.4} = 1.8$ Acceptable

Acceptable F.S. = 1.5

∴ Maximum slope w/ $\phi = 31°$ is:

$1.3 = \tan 31 / \tan\beta$

$\tan\beta = 0.462$ → $\beta = 24.8\%$ or ~ 2H:1V

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## III. RESULTS OF THE GLOBAL STABILITY ANALYSIS

| RUN NUMBER | COVER TYPE | COVER THICKNESS | ENCROACHING? | F.S. R→L SLIP | F.S. L→R SLIP |
|---|---|---|---|---|---|
| RUN #1/#2 | TRI-LOCK W/ TRITON | 1.5 ft | YES | 1.85 (#1) | 1.83 (#2) |
| RUN #3/#4 | TRI-LOCK W/ TRITON | 1.5 ft | NO | 1.80 (#3) | 2.26 (#4) |
| RUN #5/#6 | RIP-RAP W/ TRITON | 2.0 ft | YES | 1.79 (#5) | 1.70 (#6) |
| RUN #7/#8 | RIP-RAP W/ TRITON | 2.0 ft | NO | 1.70 (#7) | 2.12 (#8) |
| RUN #9 | RIP-RAP/TRITON ALONG SAND | 2.0 ft | NO | 1.82 (#9) | NA |
| RUN #10 | RIP-RAP/TRITON TENSION CRACKS | 2.0 ft | NO | 1.48 (#10) | NA |
| RUN #11 | RIP-RAP/TRITON LOW-TIDE | 2.0 ft | NO | 1.73 (#11) | NA |

1. The run with the minimum F.S. is RUN #10 - Non-encroaching rip-rap and Triton, assuming tension cracks. This F.S. is above the required 1.3, immediately following construction and is likely conservative, because the associated slip surface (see Page 32) is horizontal with a significant portion of the surface passing through the zone of low-strength material modelled as "tension cracks". In reality, the tension cracks would be vertical, the failure would be larger, and the associated F.S. would likely be higher.

2. These results indicate the considered cover system options are feasible from a geotechnical standpoint.

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3. Pages 39 through 45 are the input file for the Tri-lock and Triton cover option, non-encroaching with right to left slip direction. The input geometry is shown on page 18 This is RUN #3 in the model

4. Verification of the model results was completed by evaluating a graph of Strength vs X-coordinate and verifying the strengths used by the model for RUN #3. This graph is presented on Page 46 and the associated output file is shown on Page 22.

5. Pages 47 to 49 present a hand calculation of the F.S. for Slip # 667 of Run #3. The F.S. calculated in the hand check was 1.70 compared to the Slope/W estimate of 1.86. Page 50 presents the output file for this slip surface.

## IV. MODEL CORRECTIONS

1. Page 5 identifies an input error to the initial model. The elevation of the tidal flats for this scenario (non-encroaching) was inputted as 98.5 feet rather than 98.0 feet, as for the encroaching option. To check the impact of this error, corrections were made to run #3. The following points were added/modified and the geometry changed accordingly:

| # | X | Y |
|---|---|---|
| 10 | 0 | 98 |
| 11 | 99.5 | 98 |
| 12 | 100 | 98.5 |
| 20 | 305 | 98.5 |
| 21 | 305.5 | 98 |
| 22 | 400 | 98 |

Slope/W calculated an F.S. = 1.75 for this run (#12) (see page 51) as compared to Run #3 F.S. = 1.80. Because this reduction is minor, no additional changes will be made to previous model runs.

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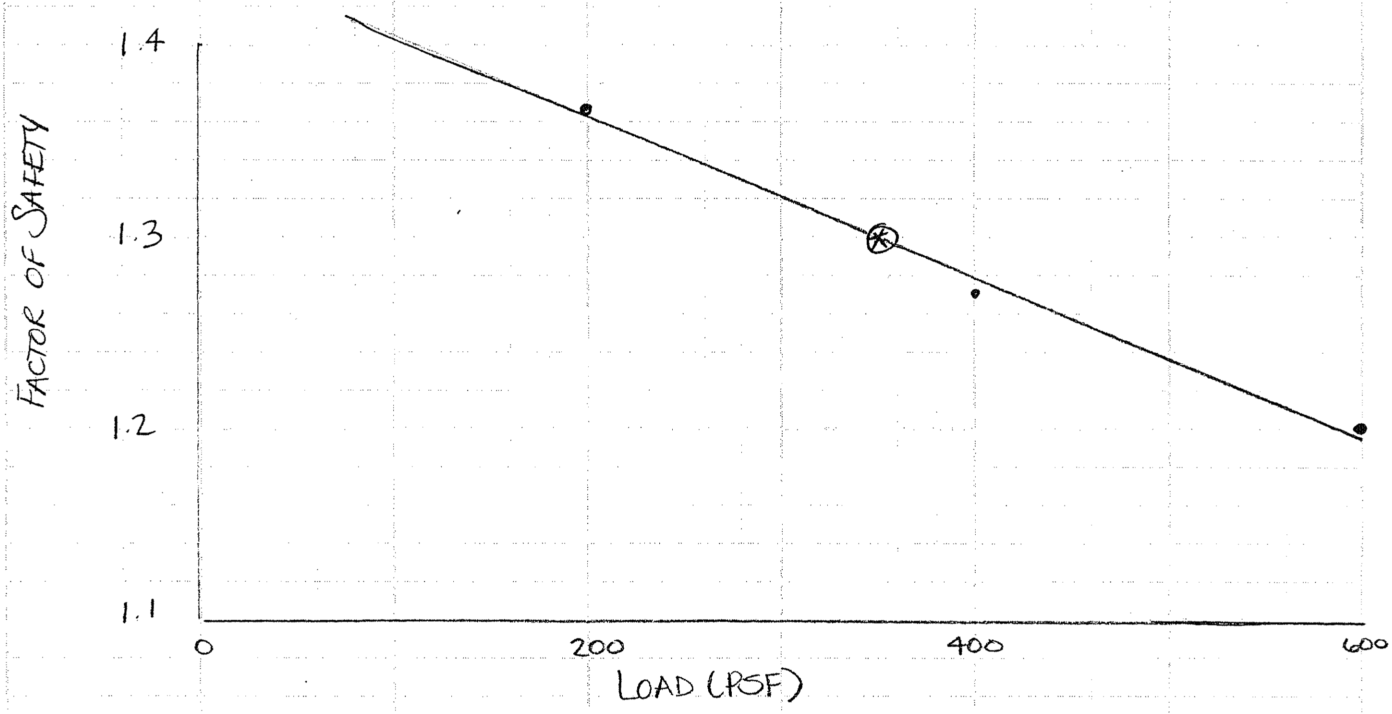
## V ADDITIONAL LOADING ON THE CAUSEWAY



A. An analysis of how much additional load placed on the Causeway may cause an unacceptable F.S. was completed.

B. A uniform, 1-foot thick layer was added to the model to simulate an additional load. The unit weight of this layer was incrementally increased & the above plot was generated.

C. Model runs assumed that tension cracks were present in the fill material, and that load was only applied to the upper, less steeply sloped portion of the Causeway.

D. Results indicate uniform loads should be restricted to < 350 psf on top of the Causeway to maintain an F.S. > 1.3.

E. Due to the highly variable nature of the Causeway fill material and the potential for large voids or tension cracks, it is not recommended that point loads or strip loads (e.g., buildings) be placed on the Causeway without significant investigation as to subsurface conditions in the area.

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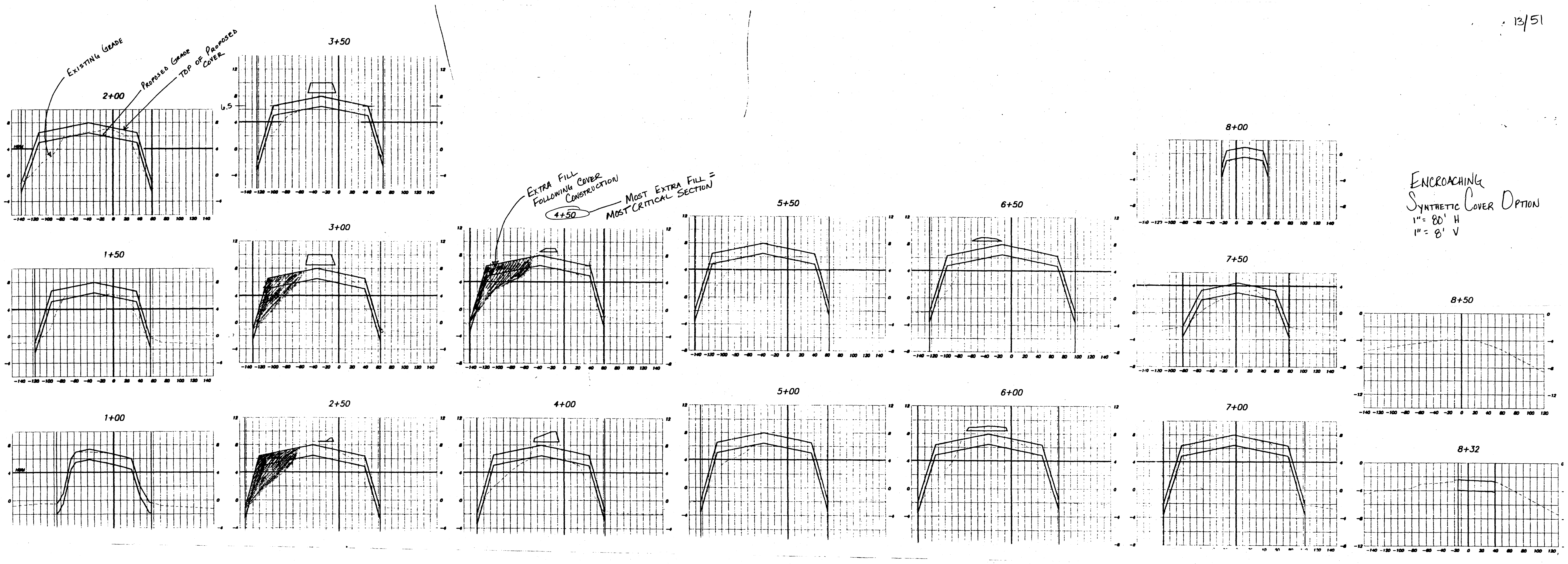
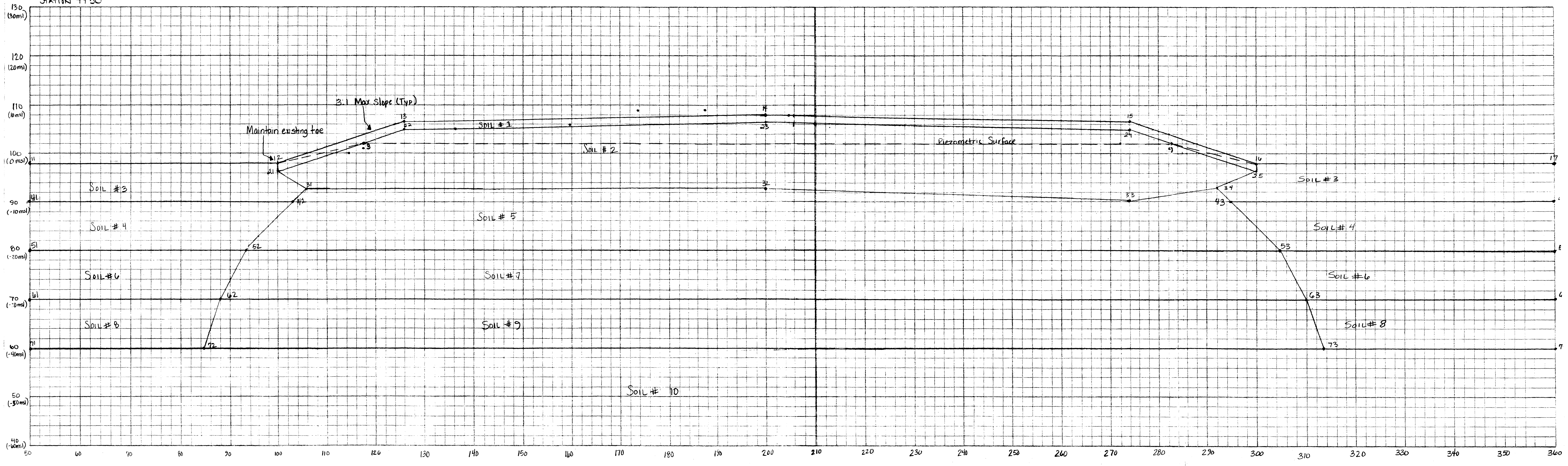


ENCROACHING SYNTHETIC COVER OPTION
1" = 80' H
1" = 8' V

|  | PROJECT | COMP BY | JOB NO. |
|---|---|---|---|
| [redacted] |  | CHK BY | DATE |

| TRILOCK/TRITON<br>ENCROACHING<br>[redacted] | PROJECT<br>CAUSEWAY NON-TIME CRITICAL REMOVAL ACTION DESIGN<br>STRATFORD ARMY ENGINE PLANT | COMP BY<br>GLR | JOB NO.<br>50796 - 1032 |
|---|---|---|---|
|  |  | CHK BY<br>BBJ | DATE<br>1-2-01 |

STATION 4+50



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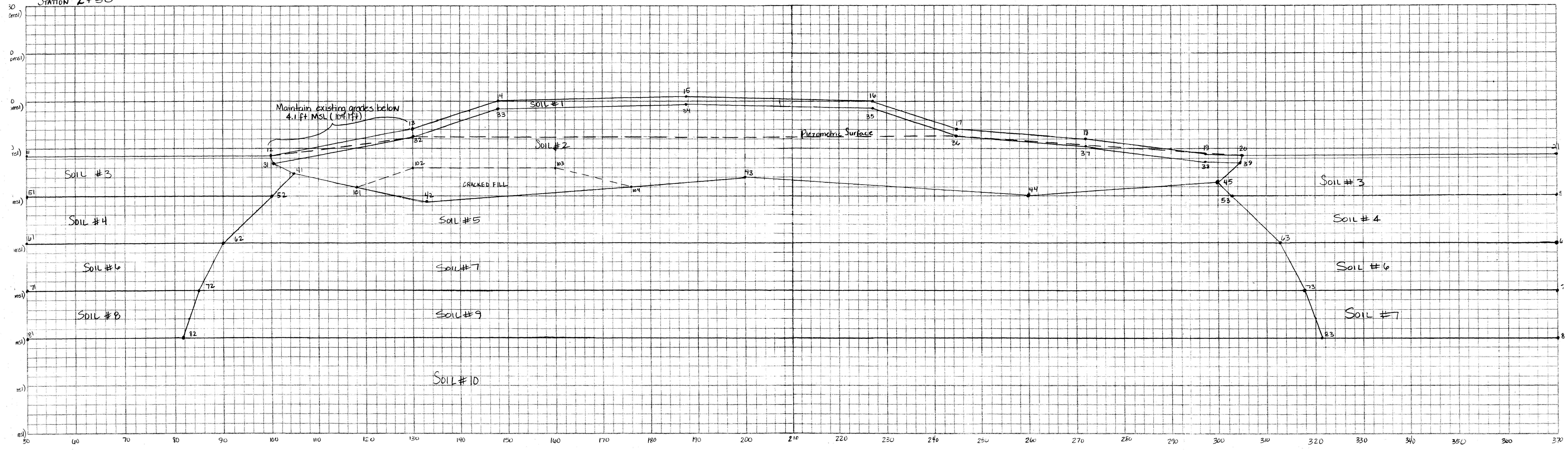
| [redacted] | PROJECT | COMP BY | JOB NO. |
|---|---|---|---|
| | | CHK BY | DATE |

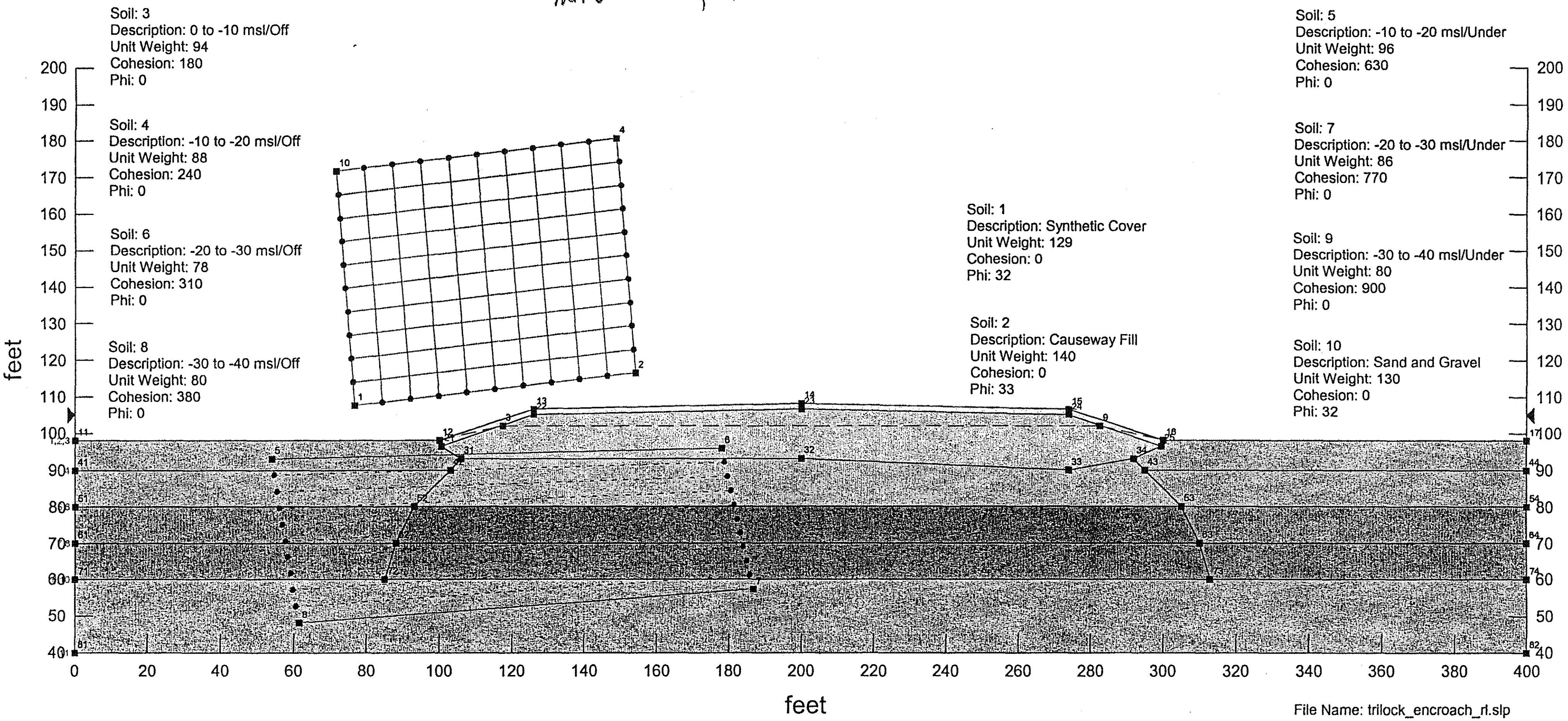
| Synthetic Cover<br>Non-encroaching<br>[redacted] | PROJECT<br>Causeway Non-Time Critical Removal Action Design<br>Stratford Army Engine Plant | COMP BY<br>GLR | JOB NO.<br>50796 1032 |
|---|---|---|---|
| | | CHK BY<br>BB | DATE<br>1-3-00 |

Station 2+50



Description: SAEP Causeway Geotechnical Analysis - Synthetic Cover System - Encroaching
Analysis Method: Bishop (with Ordinary & Janbu)

INPUT FILE, RUN #1



Soil: 3
Description: 0 to -10 msl/Off
Unit Weight: 94
Cohesion: 180
Phi: 0

Soil: 4
Description: -10 to -20 msl/Off
Unit Weight: 88
Cohesion: 240
Phi: 0

Soil: 6
Description: -20 to -30 msl/Off
Unit Weight: 78
Cohesion: 310
Phi: 0

Soil: 8
Description: -30 to -40 msl/Off
Unit Weight: 80
Cohesion: 380
Phi: 0

Soil: 1
Description: Synthetic Cover
Unit Weight: 129
Cohesion: 0
Phi: 32

Soil: 2
Description: Causeway Fill
Unit Weight: 140
Cohesion: 0
Phi: 33

Soil: 5
Description: -10 to -20 msl/Under
Unit Weight: 96
Cohesion: 630
Phi: 0

Soil: 7
Description: -20 to -30 msl/Under
Unit Weight: 86
Cohesion: 770
Phi: 0

Soil: 9
Description: -30 to -40 msl/Under
Unit Weight: 80
Cohesion: 900
Phi: 0

Soil: 10
Description: Sand and Gravel
Unit Weight: 130
Cohesion: 0
Phi: 32

File Name: trilock_encroach_rl.slp
Last Saved Date: 1/23/01

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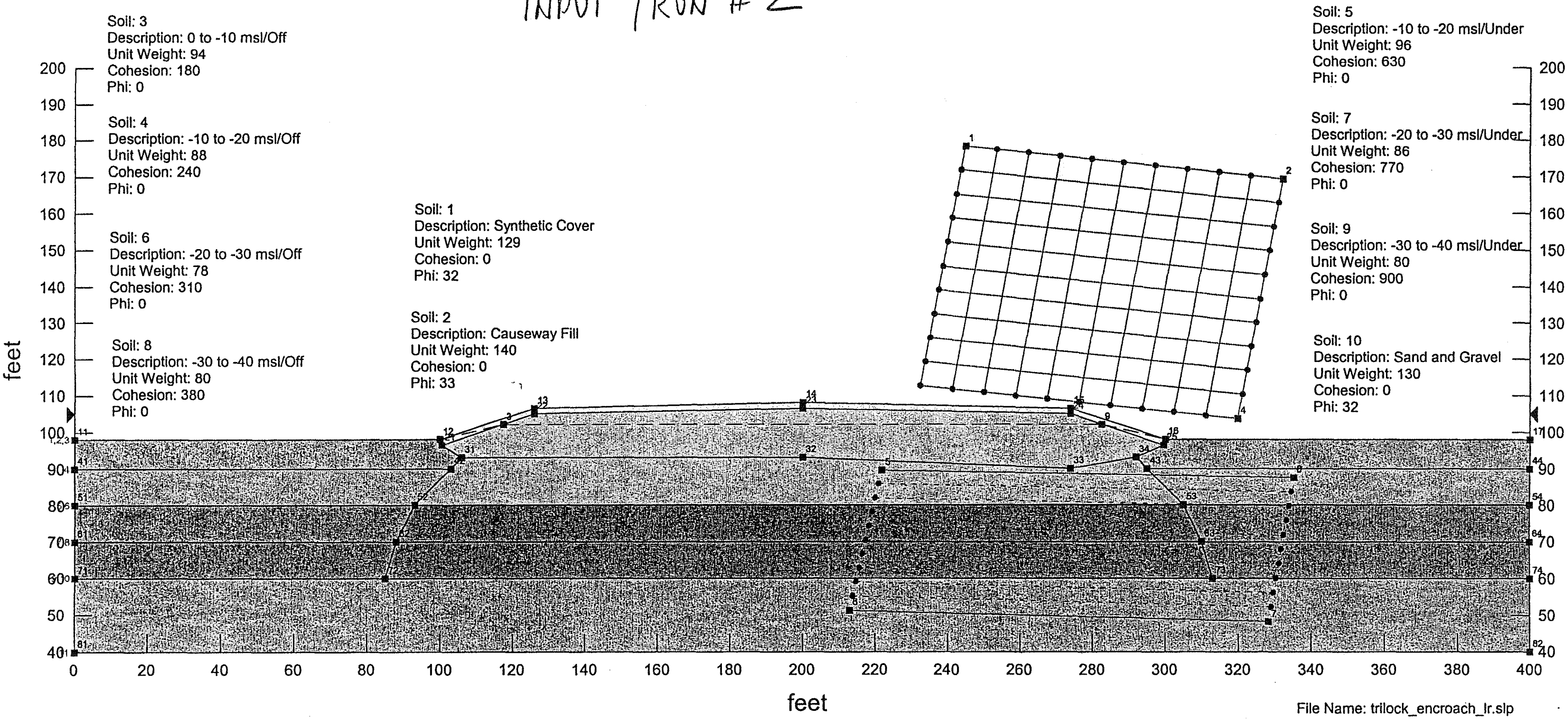
Description: SAEP Causeway Geotechnical Analysis - Synthetic Cover System - Encroaching
Analysis Method: Bishop (with Ordinary & Janbu)

INPUT / RUN #2



Soil: 3
Description: 0 to -10 msl/Off
Unit Weight: 94
Cohesion: 180
Phi: 0

Soil: 4
Description: -10 to -20 msl/Off
Unit Weight: 88
Cohesion: 240
Phi: 0

Soil: 6
Description: -20 to -30 msl/Off
Unit Weight: 78
Cohesion: 310
Phi: 0

Soil: 8
Description: -30 to -40 msl/Off
Unit Weight: 80
Cohesion: 380
Phi: 0

Soil: 1
Description: Synthetic Cover
Unit Weight: 129
Cohesion: 0
Phi: 32

Soil: 2
Description: Causeway Fill
Unit Weight: 140
Cohesion: 0
Phi: 33

Soil: 5
Description: -10 to -20 msl/Under
Unit Weight: 96
Cohesion: 630
Phi: 0

Soil: 7
Description: -20 to -30 msl/Under
Unit Weight: 86
Cohesion: 770
Phi: 0

Soil: 9
Description: -30 to -40 msl/Under
Unit Weight: 80
Cohesion: 900
Phi: 0

Soil: 10
Description: Sand and Gravel
Unit Weight: 130
Cohesion: 0
Phi: 32

File Name: trilock_encroach_lr.slp
Last Saved Date: 1/4/01

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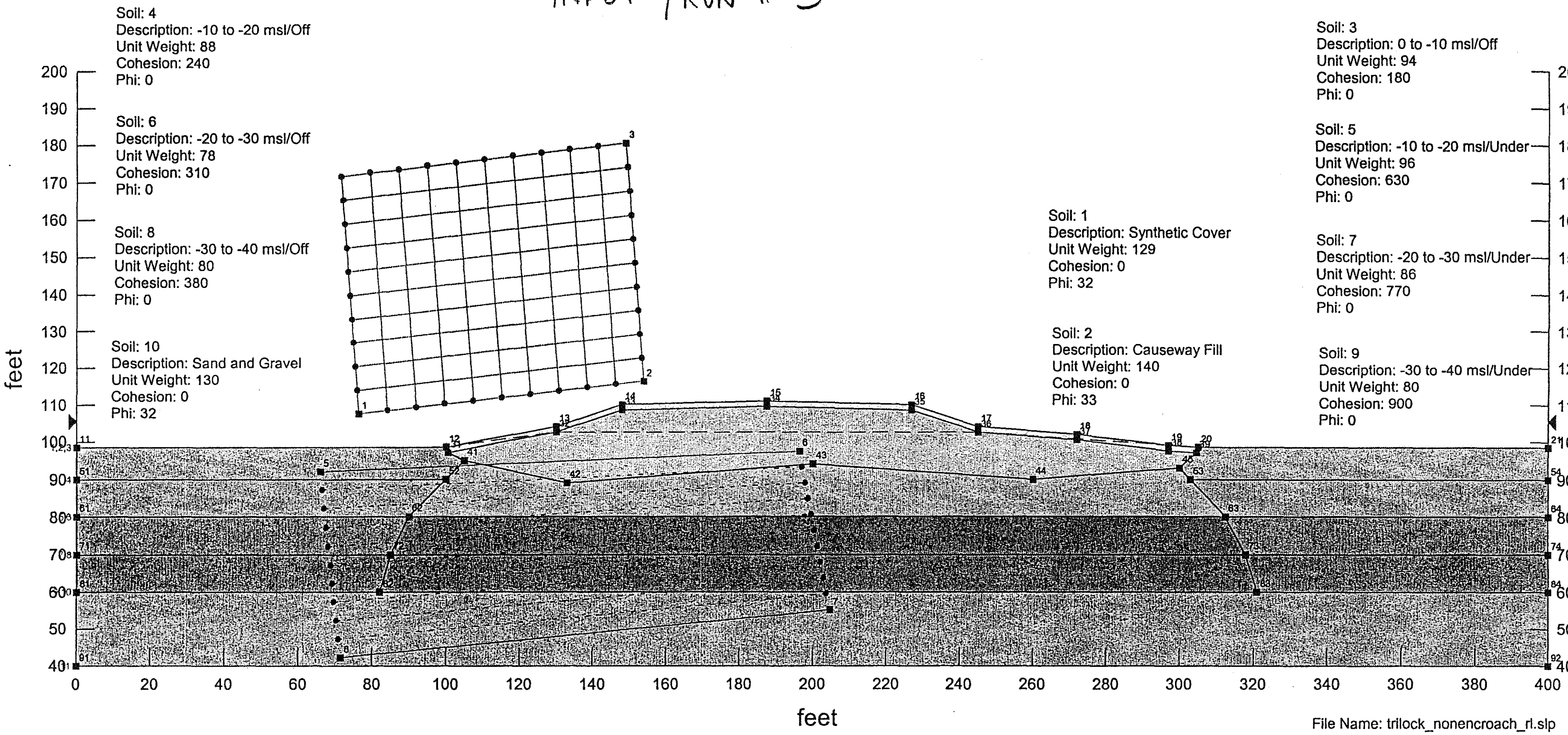
Description: SAEP Causeway Geotechnical Analysis - Synthetic Cover System - Non-encroaching
Analysis Method: Bishop (with Ordinary & Janbu)

INPUT / RUN #3



Soil: 4
Description: -10 to -20 msl/Off
Unit Weight: 88
Cohesion: 240
Phi: 0

Soil: 6
Description: -20 to -30 msl/Off
Unit Weight: 78
Cohesion: 310
Phi: 0

Soil: 8
Description: -30 to -40 msl/Off
Unit Weight: 80
Cohesion: 380
Phi: 0

Soil: 10
Description: Sand and Gravel
Unit Weight: 130
Cohesion: 0
Phi: 32

Soil: 1
Description: Synthetic Cover
Unit Weight: 129
Cohesion: 0
Phi: 32

Soil: 2
Description: Causeway Fill
Unit Weight: 140
Cohesion: 0
Phi: 33

Soil: 3
Description: 0 to -10 msl/Off
Unit Weight: 94
Cohesion: 180
Phi: 0

Soil: 5
Description: -10 to -20 msl/Under
Unit Weight: 96
Cohesion: 630
Phi: 0

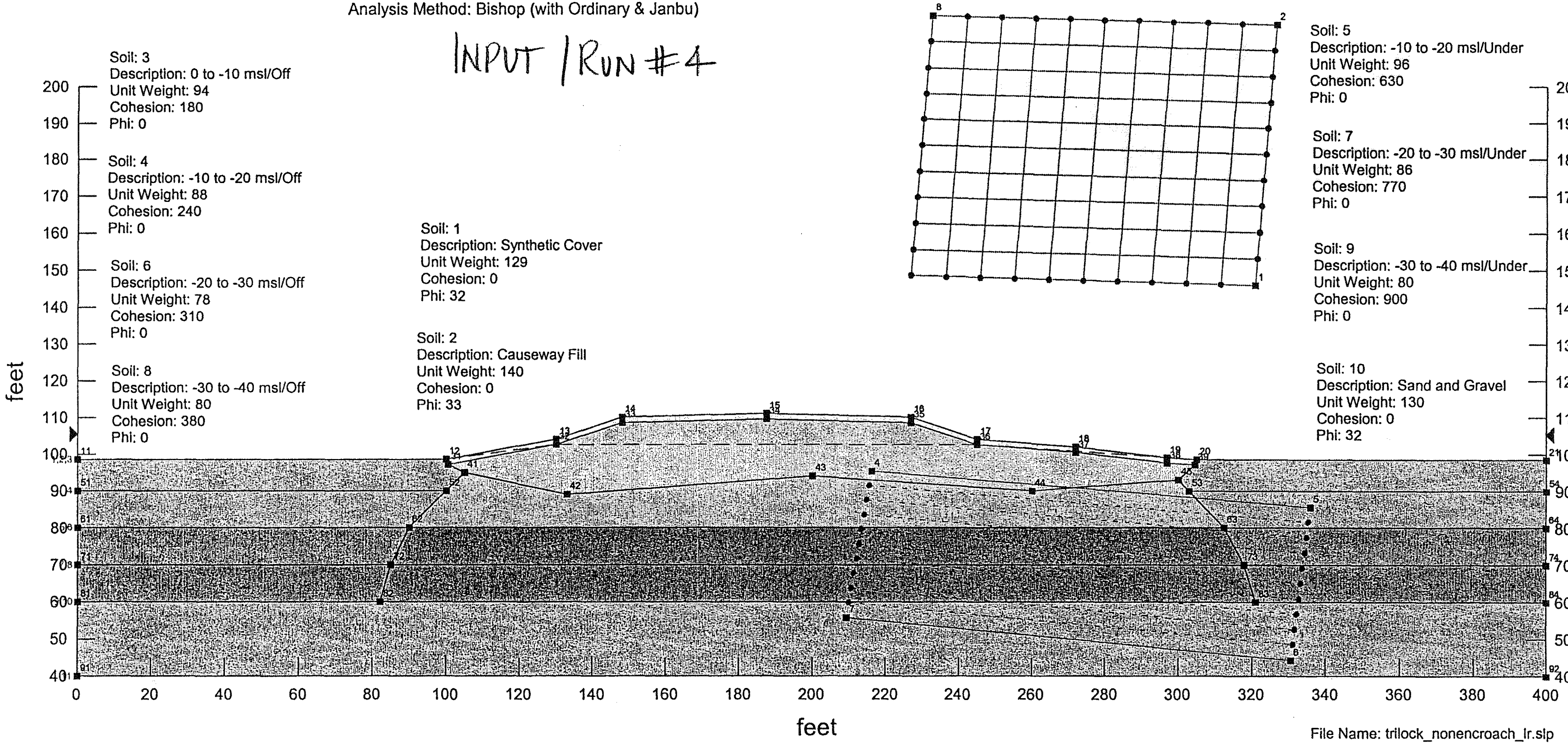
Soil: 7
Description: -20 to -30 msl/Under
Unit Weight: 86
Cohesion: 770
Phi: 0

Soil: 9
Description: -30 to -40 msl/Under
Unit Weight: 80
Cohesion: 900
Phi: 0

File Name: trilock_nonencroach_rl.slp
Last Saved Date: 1/4/01

Description: SAEP Causeway Geotechnical Analysis - Synthetic Cover System - Non-encroaching
Analysis Method: Bishop (with Ordinary & Janbu)

INPUT / RUN #4



Soil: 3
Description: 0 to -10 msl/Off
Unit Weight: 94
Cohesion: 180
Phi: 0

Soil: 4
Description: -10 to -20 msl/Off
Unit Weight: 88
Cohesion: 240
Phi: 0

Soil: 6
Description: -20 to -30 msl/Off
Unit Weight: 78
Cohesion: 310
Phi: 0

Soil: 8
Description: -30 to -40 msl/Off
Unit Weight: 80
Cohesion: 380
Phi: 0

Soil: 1
Description: Synthetic Cover
Unit Weight: 129
Cohesion: 0
Phi: 32

Soil: 2
Description: Causeway Fill
Unit Weight: 140
Cohesion: 0
Phi: 33

Soil: 5
Description: -10 to -20 msl/Under
Unit Weight: 96
Cohesion: 630
Phi: 0

Soil: 7
Description: -20 to -30 msl/Under
Unit Weight: 86
Cohesion: 770
Phi: 0

Soil: 9
Description: -30 to -40 msl/Under
Unit Weight: 80
Cohesion: 900
Phi: 0

Soil: 10
Description: Sand and Gravel
Unit Weight: 130
Cohesion: 0
Phi: 32

File Name: trilock_nonencroach_lr.slp
Last Saved Date: 1/4/01

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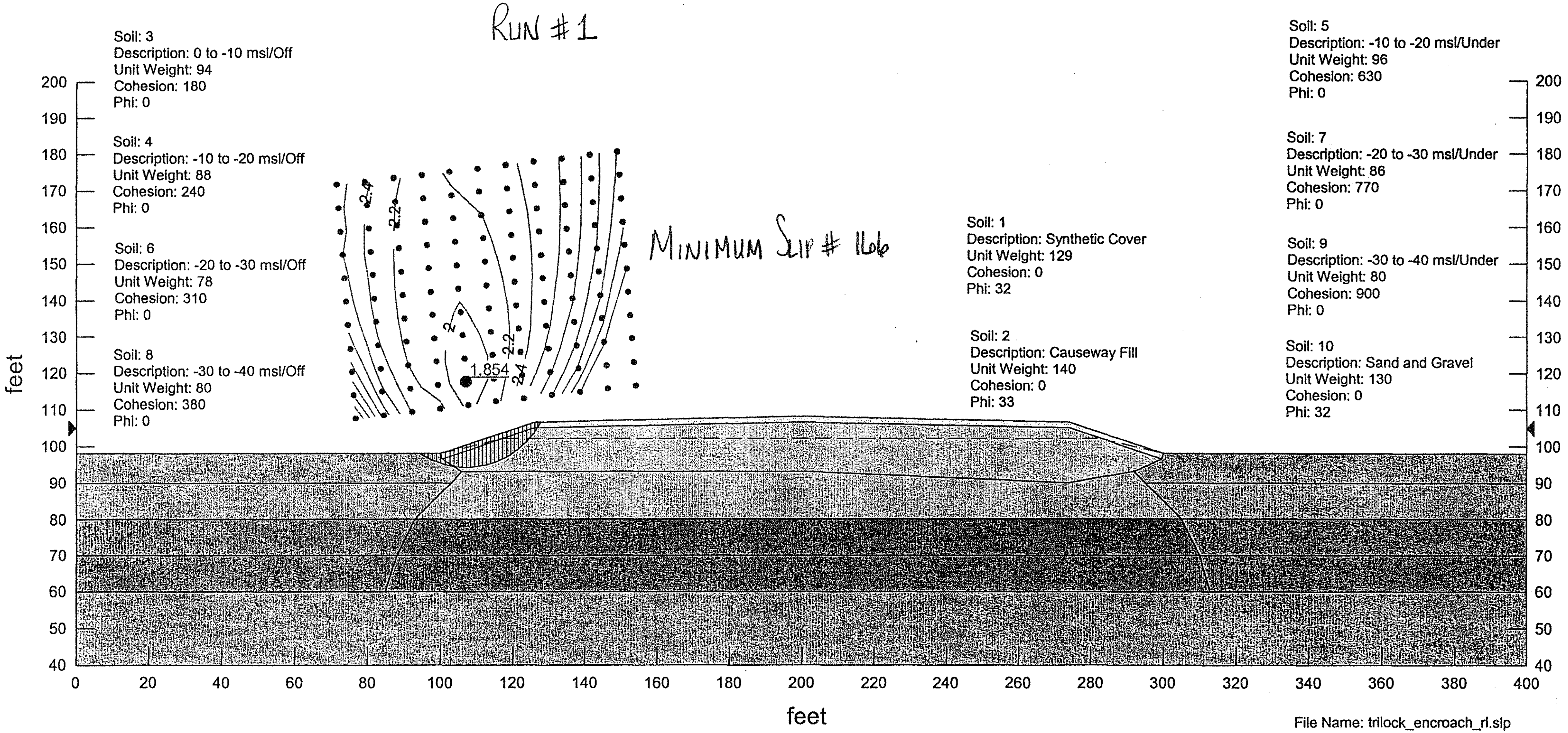
Description: SAEP Causeway Geotechnical Analysis - Synthetic Cover System - Encroaching
Analysis Method: Bishop

RUN #1



MINIMUM SLIP # 166

Soil: 3
Description: 0 to -10 msl/Off
Unit Weight: 94
Cohesion: 180
Phi: 0

Soil: 4
Description: -10 to -20 msl/Off
Unit Weight: 88
Cohesion: 240
Phi: 0

Soil: 6
Description: -20 to -30 msl/Off
Unit Weight: 78
Cohesion: 310
Phi: 0

Soil: 8
Description: -30 to -40 msl/Off
Unit Weight: 80
Cohesion: 380
Phi: 0

Soil: 1
Description: Synthetic Cover
Unit Weight: 129
Cohesion: 0
Phi: 32

Soil: 2
Description: Causeway Fill
Unit Weight: 140
Cohesion: 0
Phi: 33

Soil: 5
Description: -10 to -20 msl/Under
Unit Weight: 96
Cohesion: 630
Phi: 0

Soil: 7
Description: -20 to -30 msl/Under
Unit Weight: 86
Cohesion: 770
Phi: 0

Soil: 9
Description: -30 to -40 msl/Under
Unit Weight: 80
Cohesion: 900
Phi: 0

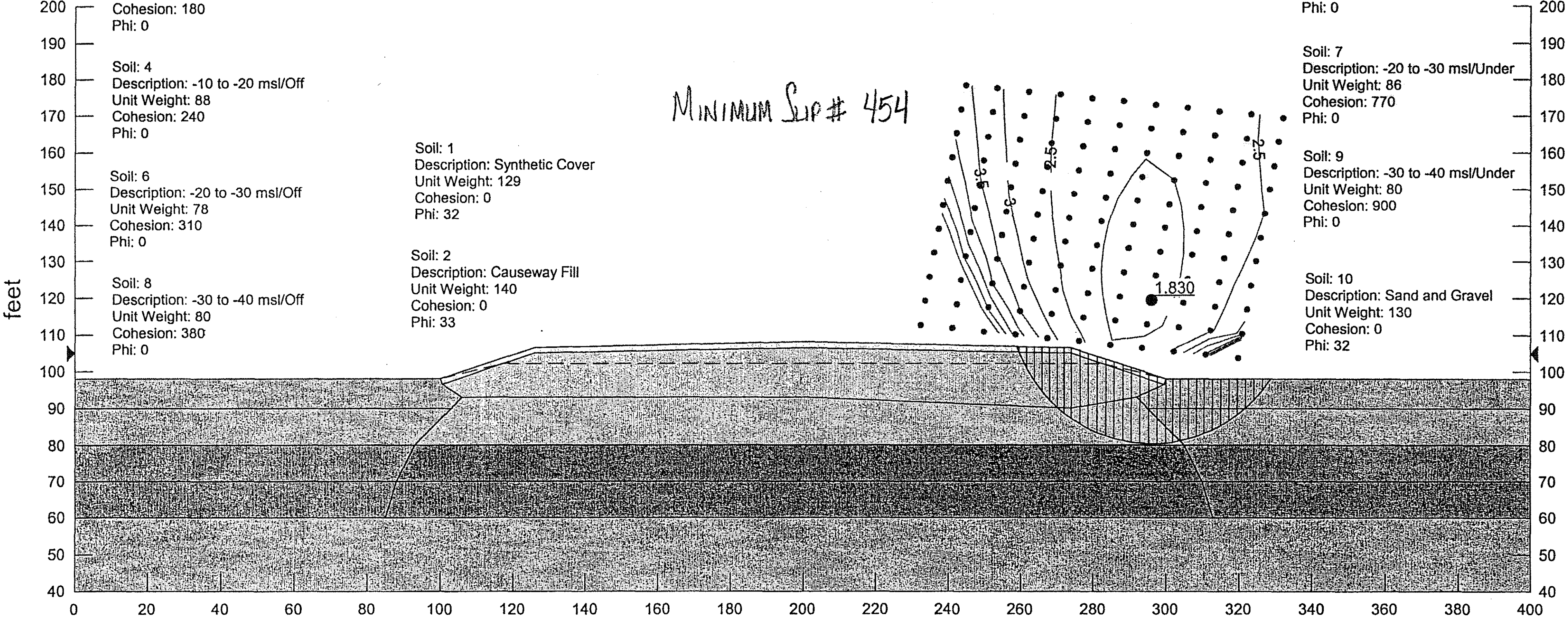
Soil: 10
Description: Sand and Gravel
Unit Weight: 130
Cohesion: 0
Phi: 32

File Name: trilock_encroach_rl.slp
Last Saved Date: 1/9/01

Description: SAEP Causeway Geotechnical Analysis - Synthetic Cover System - Encroaching
Analysis Method: Bishop

Run #2

Minimum Slip # 454



Soil: 3
Description: 0 to -10 msl/Off
Unit Weight: 94
Cohesion: 180
Phi: 0

Soil: 4
Description: -10 to -20 msl/Off
Unit Weight: 88
Cohesion: 240
Phi: 0

Soil: 6
Description: -20 to -30 msl/Off
Unit Weight: 78
Cohesion: 310
Phi: 0

Soil: 8
Description: -30 to -40 msl/Off
Unit Weight: 80
Cohesion: 380
Phi: 0

Soil: 1
Description: Synthetic Cover
Unit Weight: 129
Cohesion: 0
Phi: 32

Soil: 2
Description: Causeway Fill
Unit Weight: 140
Cohesion: 0
Phi: 33

Soil: 5
Description: -10 to -20 msl/Under
Unit Weight: 96
Cohesion: 630
Phi: 0

Soil: 7
Description: -20 to -30 msl/Under
Unit Weight: 86
Cohesion: 770
Phi: 0

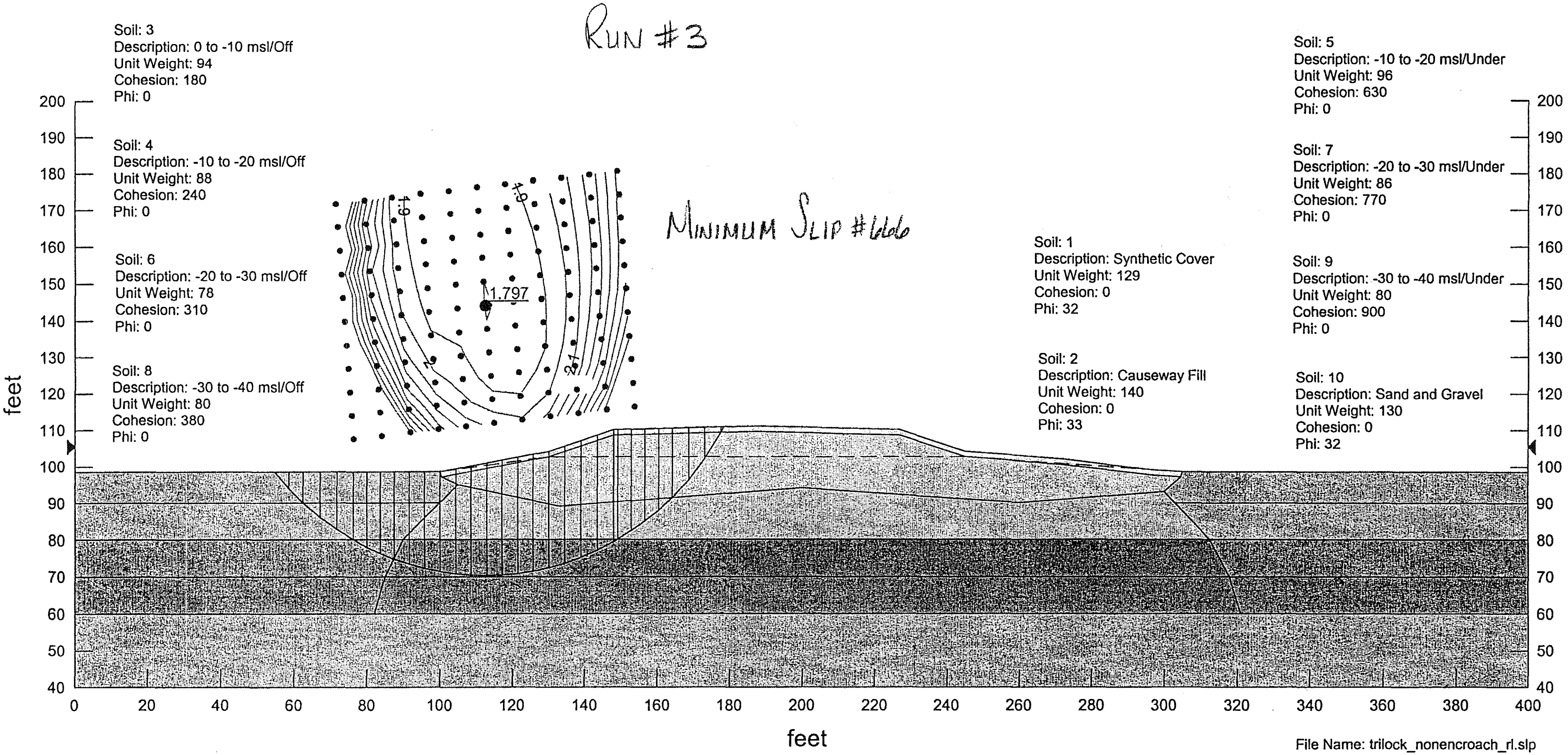
Soil: 9
Description: -30 to -40 msl/Under
Unit Weight: 80
Cohesion: 900
Phi: 0

Soil: 10
Description: Sand and Gravel
Unit Weight: 130
Cohesion: 0
Phi: 32

File Name: trilock_encroach_lr.slp
Last Saved Date: 1/4/01

Description: SAEP Causeway Geotechnical Analysis - Synthetic Cover System - Non-encroaching
Analysis Method: Bishop

RUN #3



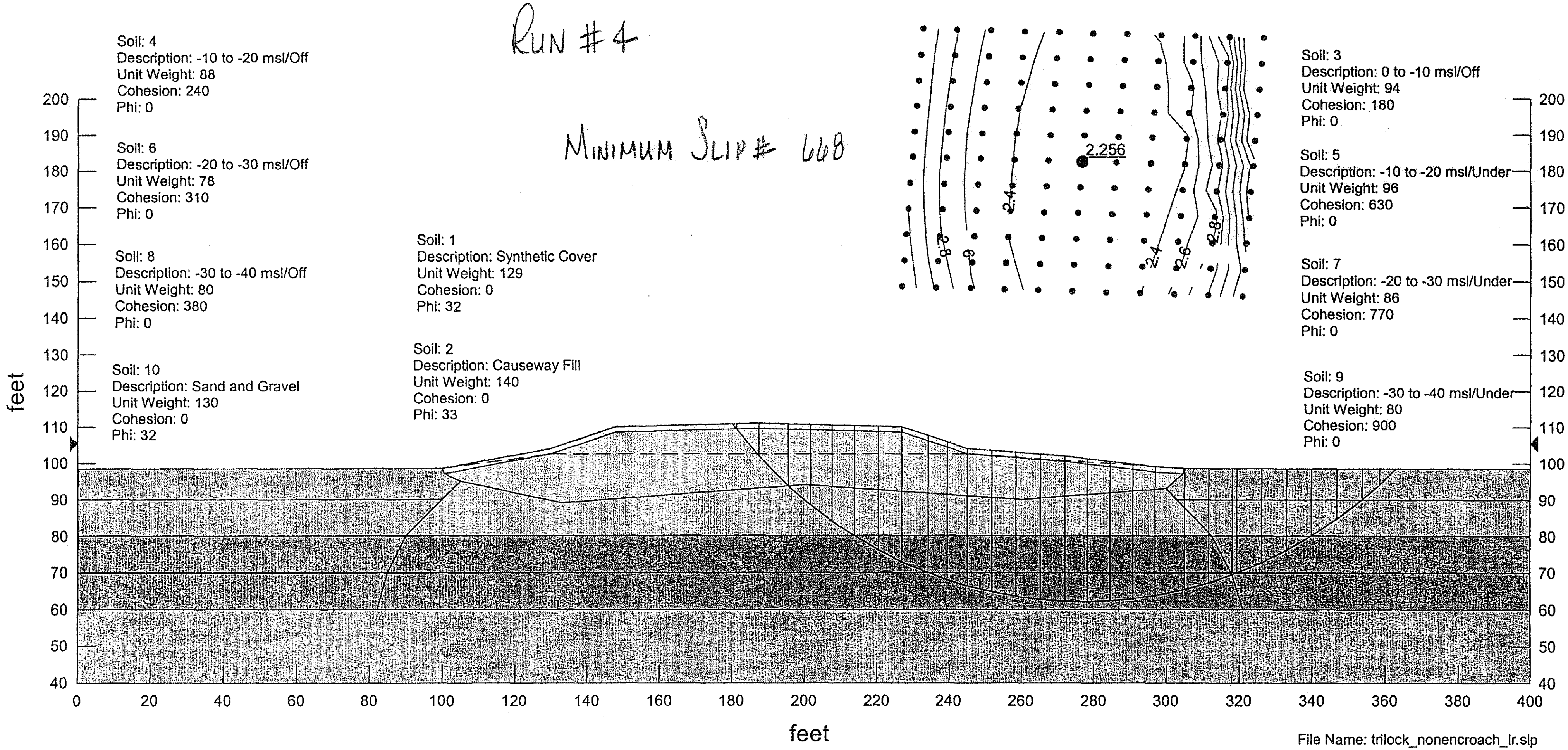
MINIMUM SLIP #666

File Name: trilock_nonencroach_rl.slp
Last Saved Date: 1/4/01

Description: SAEP Causeway Geotechnical Analysis - Synthetic Cover System - Non-encroaching
Analysis Method: Bishop

RUN #4

MINIMUM SLIP # 668



Soil: 4
Description: -10 to -20 msl/Off
Unit Weight: 88
Cohesion: 240
Phi: 0

Soil: 6
Description: -20 to -30 msl/Off
Unit Weight: 78
Cohesion: 310
Phi: 0

Soil: 8
Description: -30 to -40 msl/Off
Unit Weight: 80
Cohesion: 380
Phi: 0

Soil: 10
Description: Sand and Gravel
Unit Weight: 130
Cohesion: 0
Phi: 32

Soil: 1
Description: Synthetic Cover
Unit Weight: 129
Cohesion: 0
Phi: 32

Soil: 2
Description: Causeway Fill
Unit Weight: 140
Cohesion: 0
Phi: 33

Soil: 3
Description: 0 to -10 msl/Off
Unit Weight: 94
Cohesion: 180
Phi: 0

Soil: 5
Description: -10 to -20 msl/Under
Unit Weight: 96
Cohesion: 630
Phi: 0

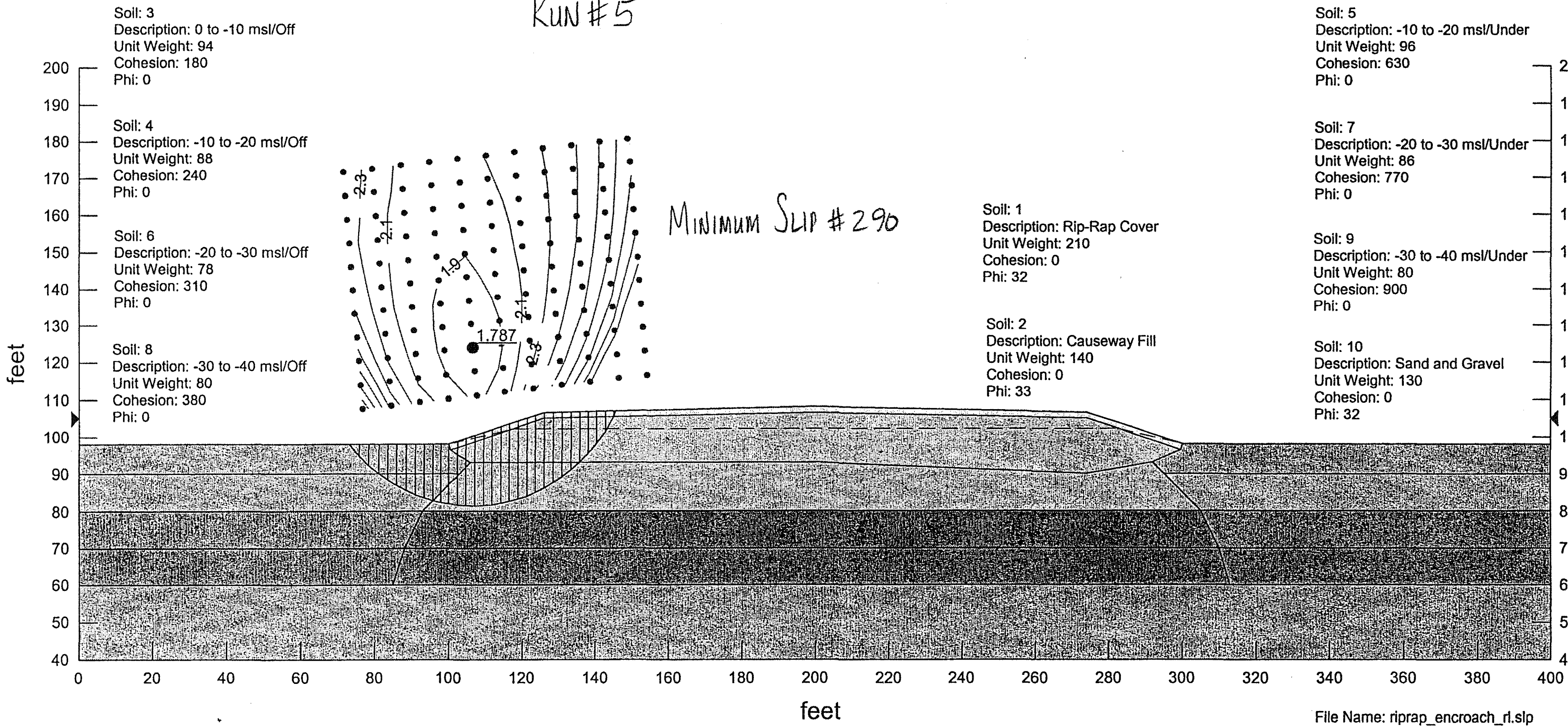
Soil: 7
Description: -20 to -30 msl/Under
Unit Weight: 86
Cohesion: 770
Phi: 0

Soil: 9
Description: -30 to -40 msl/Under
Unit Weight: 80
Cohesion: 900
Phi: 0

File Name: trilock_nonencroach_lr.slp
Last Saved Date: 1/4/01

Description: SAEP Causeway Geotechnical Analysis - Rip-Rap Cover System - Encroaching
Analysis Method: Bishop

RUN #5



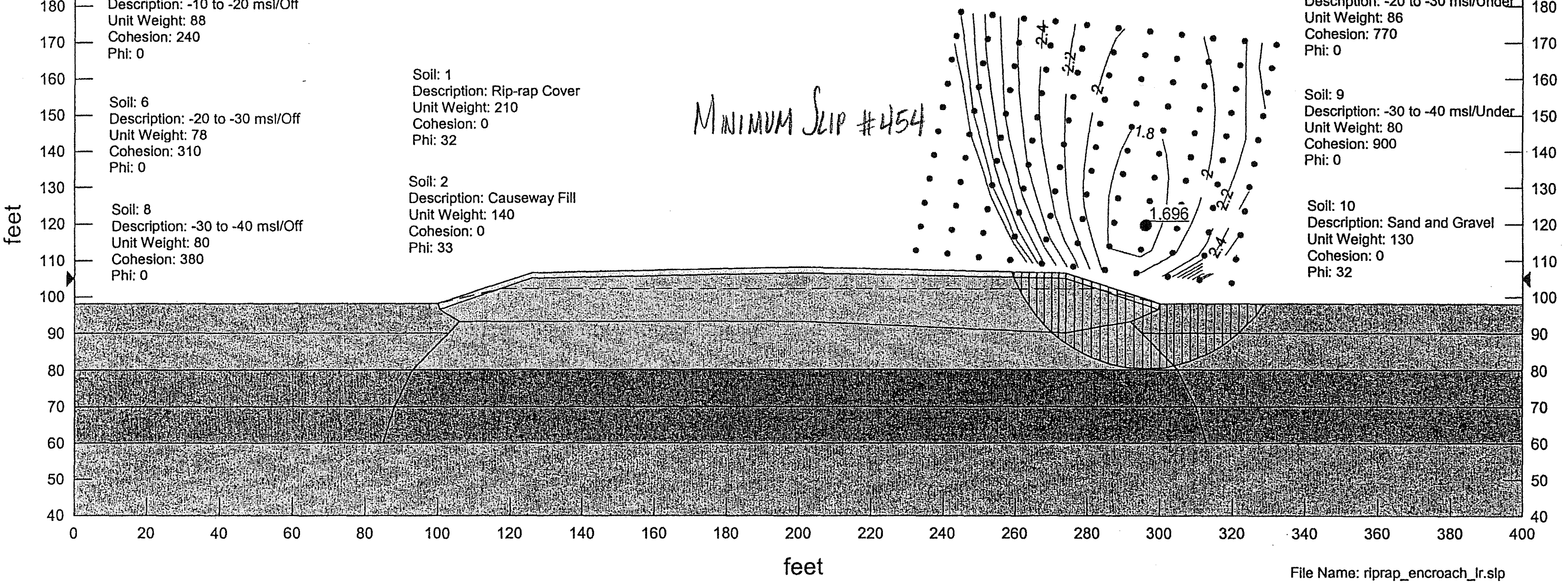
MINIMUM SLIP #290

File Name: riprap_encroach_rl.slp
Last Saved Date: 1/9/01

24/51

Description: SAEP Causeway Geotechnical Analysis - Rip-rap Cover System - Encroaching
Analysis Method: Bishop

RUN #6



Soil: 3
Description: 0 to -10 msl/Off
Unit Weight: 94
Cohesion: 180
Phi: 0

Soil: 4
Description: -10 to -20 msl/Off
Unit Weight: 88
Cohesion: 240
Phi: 0

Soil: 6
Description: -20 to -30 msl/Off
Unit Weight: 78
Cohesion: 310
Phi: 0

Soil: 8
Description: -30 to -40 msl/Off
Unit Weight: 80
Cohesion: 380
Phi: 0

Soil: 1
Description: Rip-rap Cover
Unit Weight: 210
Cohesion: 0
Phi: 32

Soil: 2
Description: Causeway Fill
Unit Weight: 140
Cohesion: 0
Phi: 33

Soil: 5
Description: -10 to -20 msl/Under
Unit Weight: 96
Cohesion: 630
Phi: 0

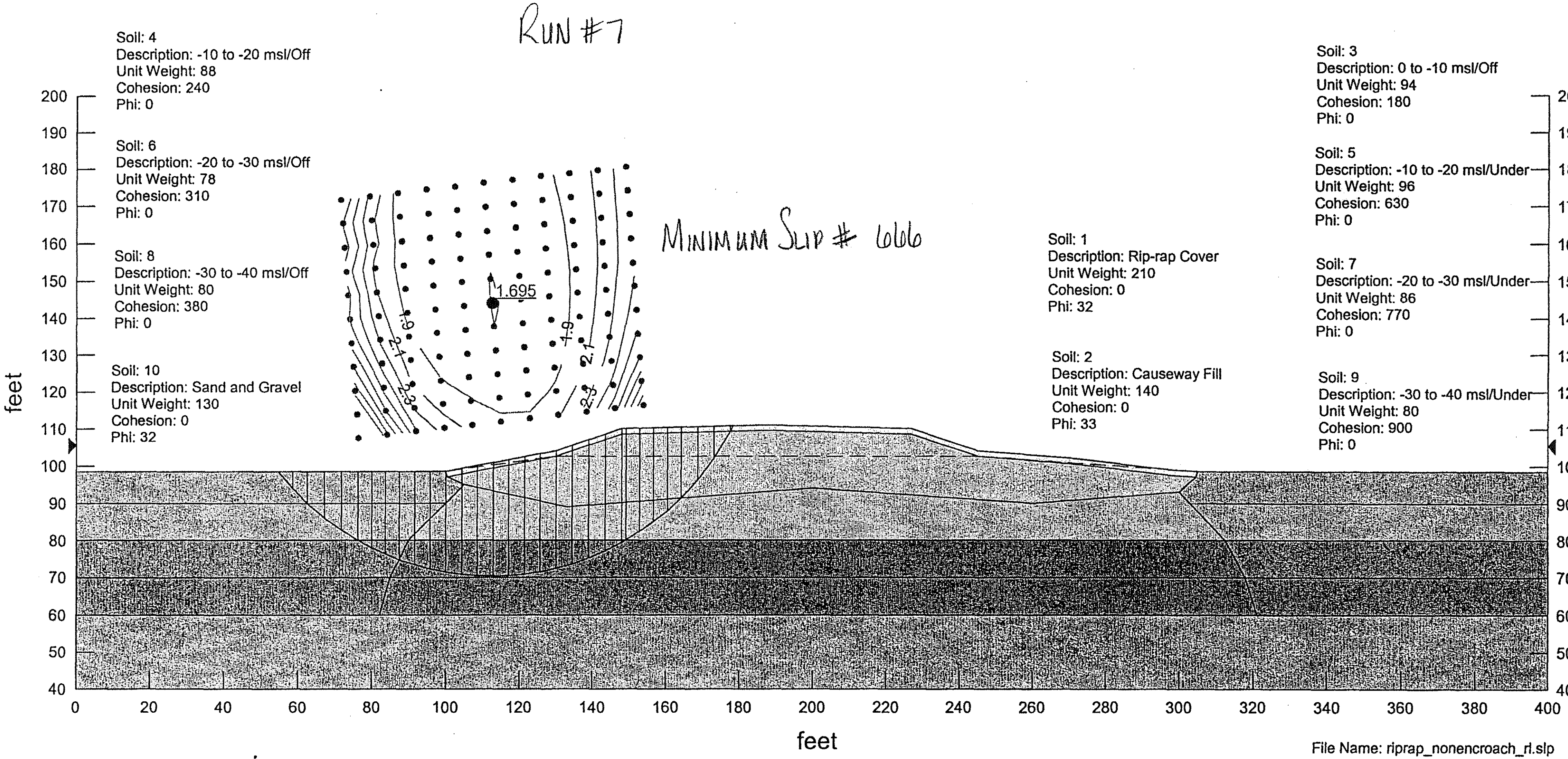
Soil: 7
Description: -20 to -30 msl/Under
Unit Weight: 86
Cohesion: 770
Phi: 0

Soil: 9
Description: -30 to -40 msl/Under
Unit Weight: 80
Cohesion: 900
Phi: 0

Soil: 10
Description: Sand and Gravel
Unit Weight: 130
Cohesion: 0
Phi: 32

File Name: riprap_encroach_lr.slp
Last Saved Date: 1/9/01

Description: SAEP Causeway Geotechnical Analysis - Rip-rap Cover System - Non-encroaching
Analysis Method: Bishop



RUN #7

MINIMUM SLIP # 666

Soil: 4
Description: -10 to -20 msl/Off
Unit Weight: 88
Cohesion: 240
Phi: 0

Soil: 6
Description: -20 to -30 msl/Off
Unit Weight: 78
Cohesion: 310
Phi: 0

Soil: 8
Description: -30 to -40 msl/Off
Unit Weight: 80
Cohesion: 380
Phi: 0

Soil: 10
Description: Sand and Gravel
Unit Weight: 130
Cohesion: 0
Phi: 32

Soil: 1
Description: Rip-rap Cover
Unit Weight: 210
Cohesion: 0
Phi: 32

Soil: 2
Description: Causeway Fill
Unit Weight: 140
Cohesion: 0
Phi: 33

Soil: 3
Description: 0 to -10 msl/Off
Unit Weight: 94
Cohesion: 180
Phi: 0

Soil: 5
Description: -10 to -20 msl/Under
Unit Weight: 96
Cohesion: 630
Phi: 0

Soil: 7
Description: -20 to -30 msl/Under
Unit Weight: 86
Cohesion: 770
Phi: 0

Soil: 9
Description: -30 to -40 msl/Under
Unit Weight: 80
Cohesion: 900
Phi: 0

File Name: riprap_nonencroach_rl.slp
Last Saved Date: 1/9/01

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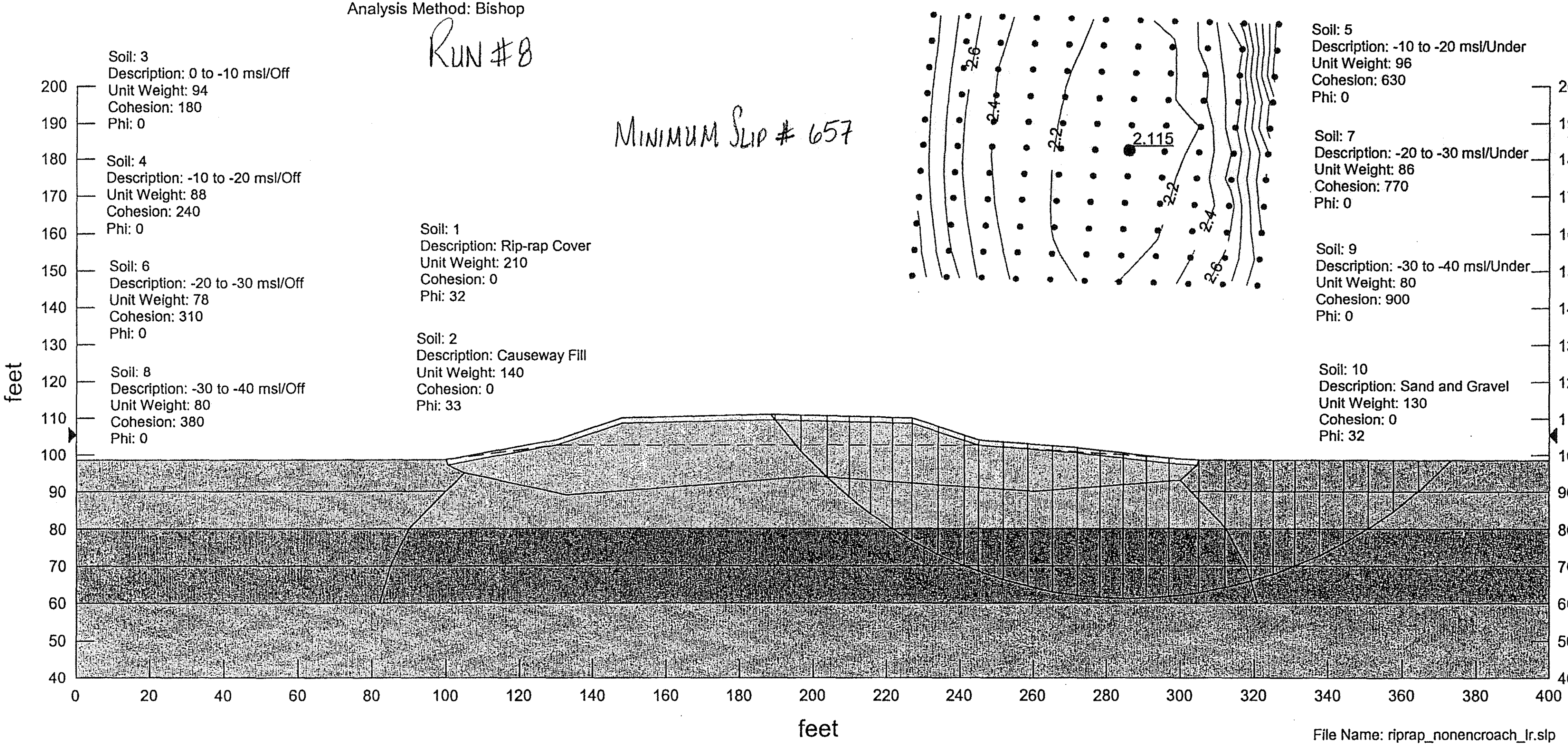
Description: SAEP Causeway Geotechnical Analysis - Rip-Rap Cover System - Non-encroaching
Analysis Method: Bishop

RUN #8

MINIMUM SLIP # 657



Soil: 3
Description: 0 to -10 msl/Off
Unit Weight: 94
Cohesion: 180
Phi: 0

Soil: 4
Description: -10 to -20 msl/Off
Unit Weight: 88
Cohesion: 240
Phi: 0

Soil: 6
Description: -20 to -30 msl/Off
Unit Weight: 78
Cohesion: 310
Phi: 0

Soil: 8
Description: -30 to -40 msl/Off
Unit Weight: 80
Cohesion: 380
Phi: 0

Soil: 1
Description: Rip-rap Cover
Unit Weight: 210
Cohesion: 0
Phi: 32

Soil: 2
Description: Causeway Fill
Unit Weight: 140
Cohesion: 0
Phi: 33

Soil: 5
Description: -10 to -20 msl/Under
Unit Weight: 96
Cohesion: 630
Phi: 0

Soil: 7
Description: -20 to -30 msl/Under
Unit Weight: 86
Cohesion: 770
Phi: 0

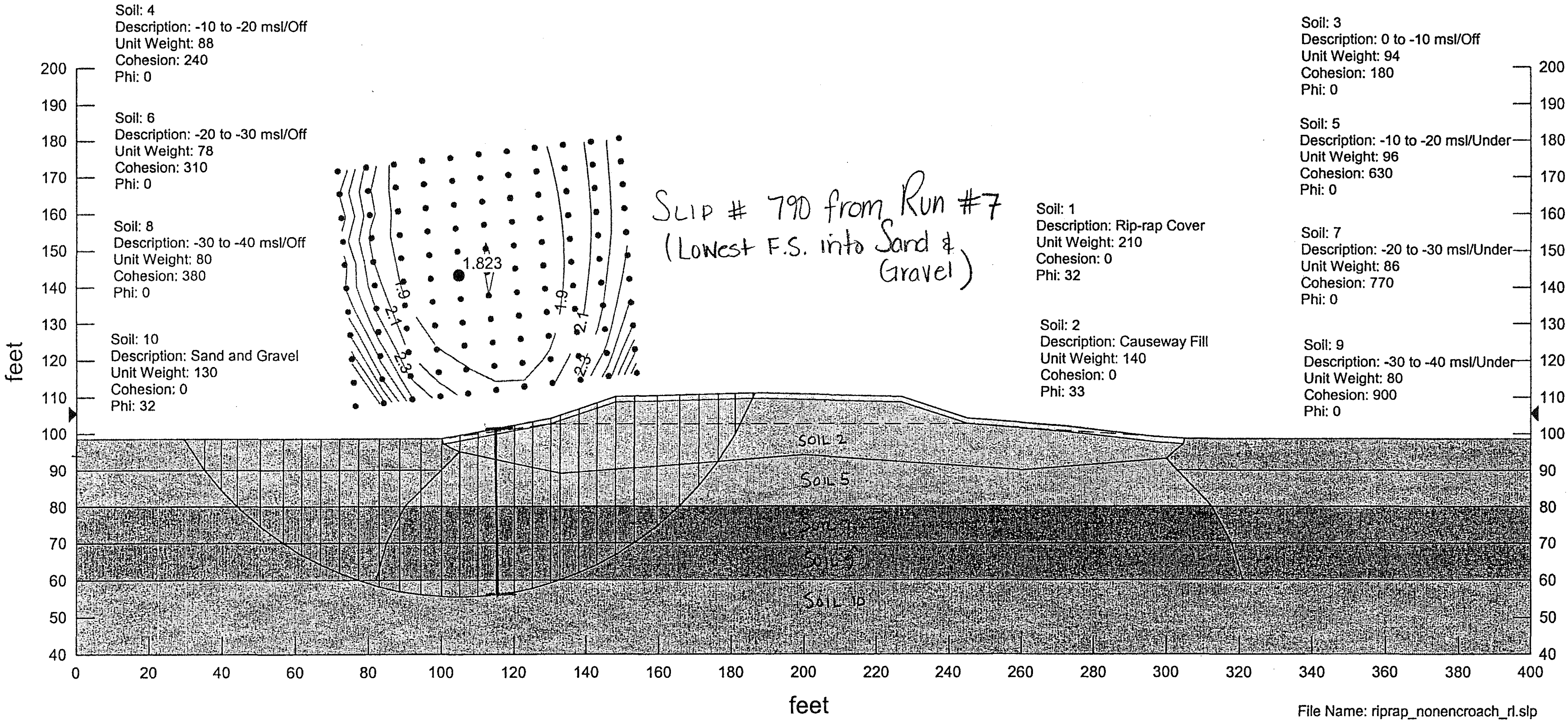
Soil: 9
Description: -30 to -40 msl/Under
Unit Weight: 80
Cohesion: 900
Phi: 0

Soil: 10
Description: Sand and Gravel
Unit Weight: 130
Cohesion: 0
Phi: 32

File Name: riprap_nonencroach_lr.slp
Last Saved Date: 1/9/01

27/51

Description: SAEP Causeway Geotechnical Analysis - Rip-rap Cover System - Non-encroaching
Analysis Method: Bishop



Soil: 4
Description: -10 to -20 msl/Off
Unit Weight: 88
Cohesion: 240
Phi: 0

Soil: 6
Description: -20 to -30 msl/Off
Unit Weight: 78
Cohesion: 310
Phi: 0

Soil: 8
Description: -30 to -40 msl/Off
Unit Weight: 80
Cohesion: 380
Phi: 0

Soil: 10
Description: Sand and Gravel
Unit Weight: 130
Cohesion: 0
Phi: 32

SLIP # 790 from Run #7
(Lowest F.S. into Sand & Gravel)

Soil: 1
Description: Rip-rap Cover
Unit Weight: 210
Cohesion: 0
Phi: 32

Soil: 2
Description: Causeway Fill
Unit Weight: 140
Cohesion: 0
Phi: 33

Soil: 3
Description: 0 to -10 msl/Off
Unit Weight: 94
Cohesion: 180
Phi: 0

Soil: 5
Description: -10 to -20 msl/Under
Unit Weight: 96
Cohesion: 630
Phi: 0

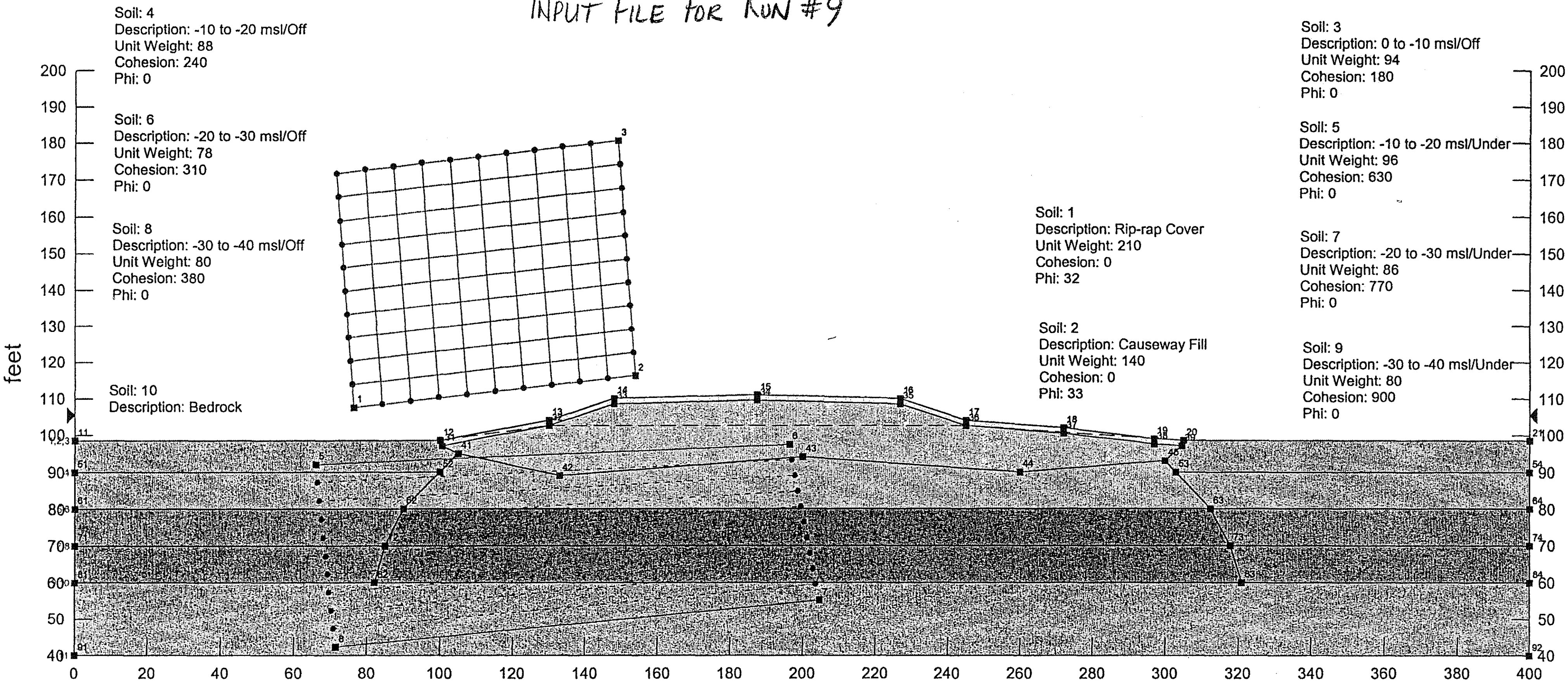
Soil: 7
Description: -20 to -30 msl/Under
Unit Weight: 86
Cohesion: 770
Phi: 0

Soil: 9
Description: -30 to -40 msl/Under
Unit Weight: 80
Cohesion: 900
Phi: 0

File Name: riprap_nonencroach_rl.slp
Last Saved Date: 1/9/01

Description: SAEP Causeway Geotechnical Analysis - Rip-rap with Wedge- Non-encroaching
Analysis Method: Bishop (with Ordinary & Janbu)

INPUT FILE FOR RUN #9



Soil: 4
Description: -10 to -20 msl/Off
Unit Weight: 88
Cohesion: 240
Phi: 0

Soil: 6
Description: -20 to -30 msl/Off
Unit Weight: 78
Cohesion: 310
Phi: 0

Soil: 8
Description: -30 to -40 msl/Off
Unit Weight: 80
Cohesion: 380
Phi: 0

Soil: 10
Description: Bedrock

Soil: 3
Description: 0 to -10 msl/Off
Unit Weight: 94
Cohesion: 180
Phi: 0

Soil: 5
Description: -10 to -20 msl/Under
Unit Weight: 96
Cohesion: 630
Phi: 0

Soil: 1
Description: Rip-rap Cover
Unit Weight: 210
Cohesion: 0
Phi: 32

Soil: 7
Description: -20 to -30 msl/Under
Unit Weight: 86
Cohesion: 770
Phi: 0

Soil: 2
Description: Causeway Fill
Unit Weight: 140
Cohesion: 0
Phi: 33

Soil: 9
Description: -30 to -40 msl/Under
Unit Weight: 80
Cohesion: 900
Phi: 0

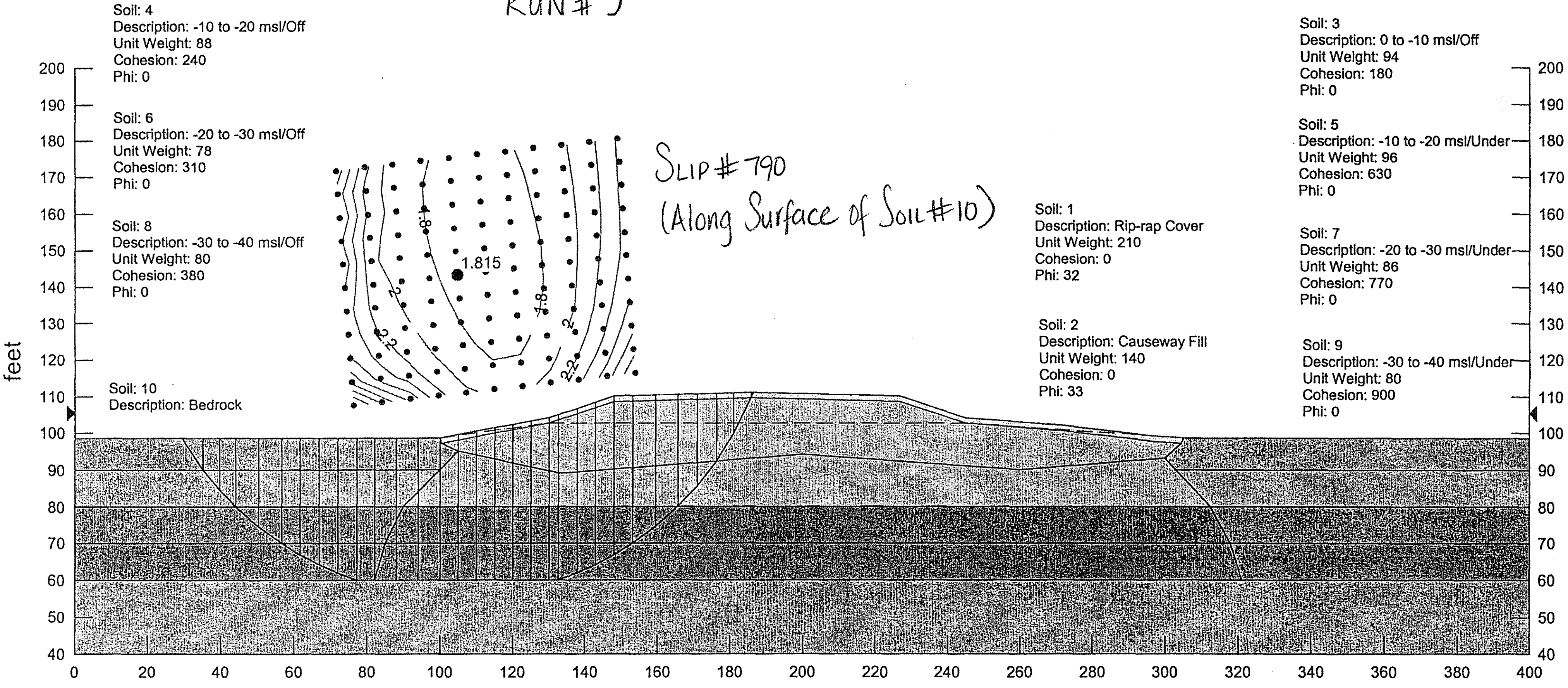
File Name: nonencroachbedrock_rl.slp
Last Saved Date: 1/9/01

29/51

Description: SAEP Causeway Geotechnical Analysis - Rip-rap with Wedge- Non-encroaching
Analysis Method: Bishop

RUN #9

SLIP #790
(Along Surface of Soil #10)



Soil: 4
Description: -10 to -20 msl/Off
Unit Weight: 88
Cohesion: 240
Phi: 0

Soil: 6
Description: -20 to -30 msl/Off
Unit Weight: 78
Cohesion: 310
Phi: 0

Soil: 8
Description: -30 to -40 msl/Off
Unit Weight: 80
Cohesion: 380
Phi: 0

Soil: 10
Description: Bedrock

Soil: 1
Description: Rip-rap Cover
Unit Weight: 210
Cohesion: 0
Phi: 32

Soil: 2
Description: Causeway Fill
Unit Weight: 140
Cohesion: 0
Phi: 33

Soil: 3
Description: 0 to -10 msl/Off
Unit Weight: 94
Cohesion: 180
Phi: 0

Soil: 5
Description: -10 to -20 msl/Under
Unit Weight: 96
Cohesion: 630
Phi: 0

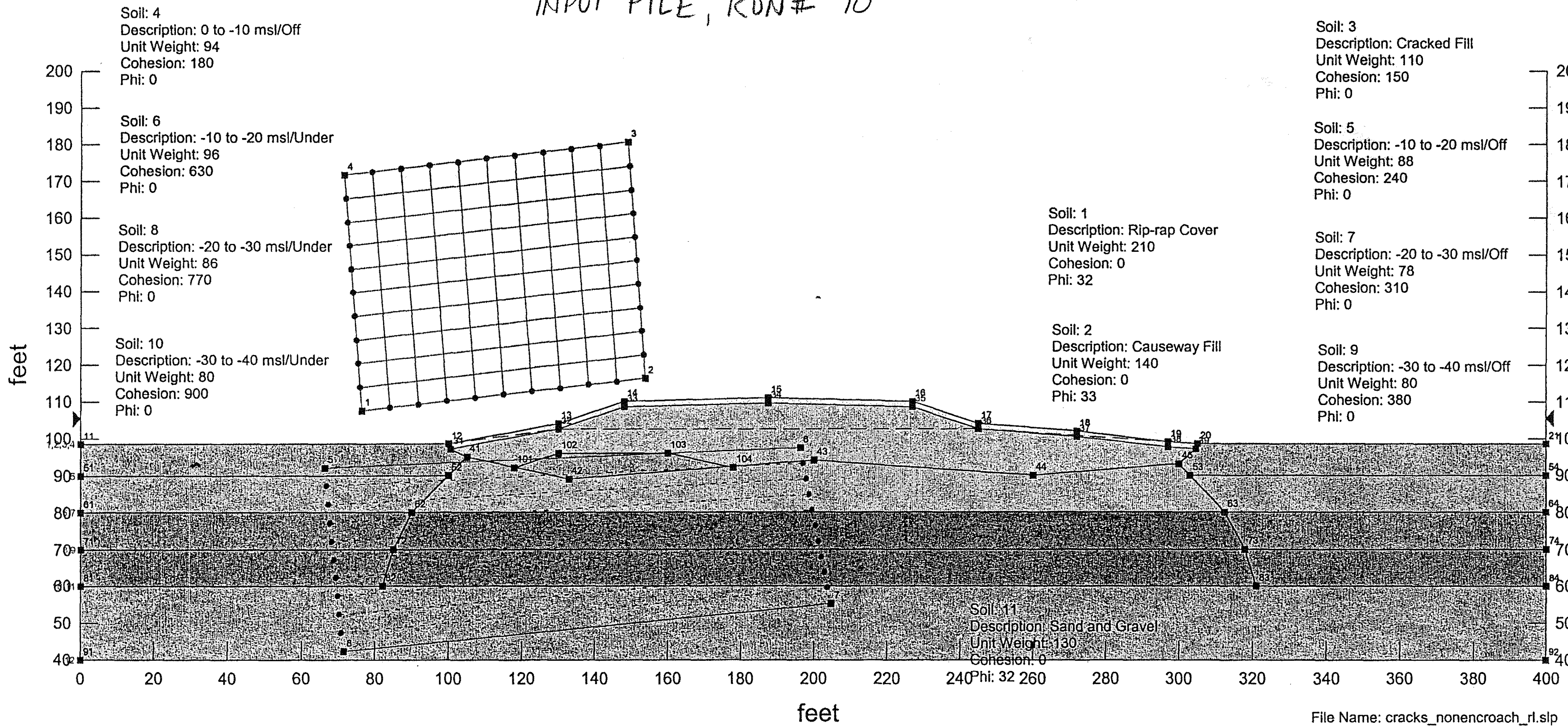
Soil: 7
Description: -20 to -30 msl/Under
Unit Weight: 86
Cohesion: 770
Phi: 0

Soil: 9
Description: -30 to -40 msl/Under
Unit Weight: 80
Cohesion: 900
Phi: 0

File Name: nonencroachbedrock_rl.slp
Last Saved Date: 1/9/01

Description: SAEP Causeway Geotechnical Analysis - Rip-rap with Cracks- Non-encroaching
Analysis Method: Bishop (with Ordinary & Janbu)

INPUT FILE, RUN# 10

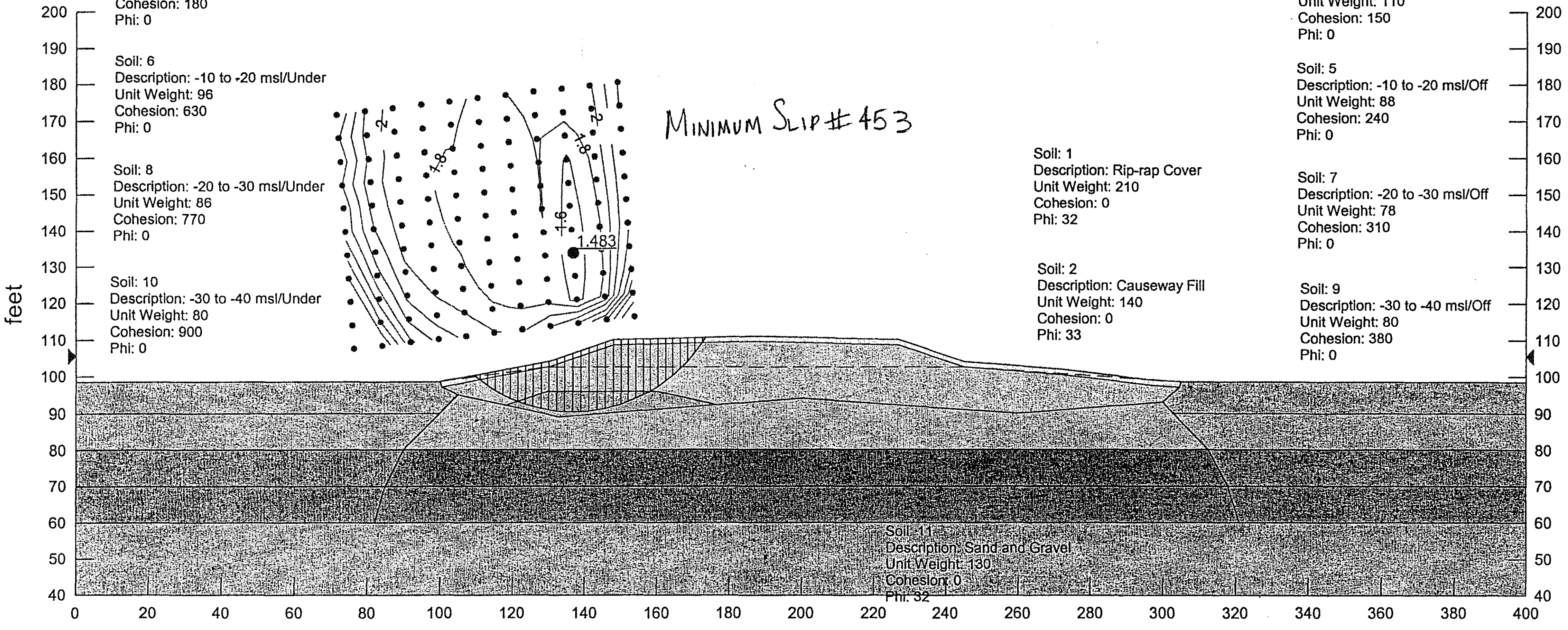


File Name: cracks_nonencroach_rl.slp
Last Saved Date: 1/23/01

Description: SAEP Causeway Geotechnical Analysis - Rip-rap with Cracks- Non-encroaching
Analysis Method: Bishop

RUN #10

MINIMUM SLIP #453



Soil: 4
Description: 0 to -10 msl/Off
Unit Weight: 94
Cohesion: 180
Phi: 0

Soil: 6
Description: -10 to -20 msl/Under
Unit Weight: 96
Cohesion: 630
Phi: 0

Soil: 8
Description: -20 to -30 msl/Under
Unit Weight: 86
Cohesion: 770
Phi: 0

Soil: 10
Description: -30 to -40 msl/Under
Unit Weight: 80
Cohesion: 900
Phi: 0

Soil: 1
Description: Rip-rap Cover
Unit Weight: 210
Cohesion: 0
Phi: 32

Soil: 2
Description: Causeway Fill
Unit Weight: 140
Cohesion: 0
Phi: 33

Soil: 3
Description: Cracked Fill
Unit Weight: 110
Cohesion: 150
Phi: 0

Soil: 5
Description: -10 to -20 msl/Off
Unit Weight: 88
Cohesion: 240
Phi: 0

Soil: 7
Description: -20 to -30 msl/Off
Unit Weight: 78
Cohesion: 310
Phi: 0

Soil: 9
Description: -30 to -40 msl/Off
Unit Weight: 80
Cohesion: 380
Phi: 0

Soil: 11
Description: Sand and Gravel
Unit Weight: 130
Cohesion: 0
Phi: 32

File Name: cracks_nonencroach_rl.slp
Last Saved Date: 1/9/01

32151

Description: SAEP Causeway Geotechnical Analysis - Rip-rap Cover System - Non-encroaching
Analysis Method: Bishop (with Ordinary & Janbu)

24% REDUCED STRENGTH INPUT

Soil: 4
Description: -10 to -20 msl/Off
Unit Weight: 88
Cohesion: 182
Phi: 0

Soil: 6
Description: -20 to -30 msl/Off
Unit Weight: 78
Cohesion: 235
Phi: 0

Soil: 8
Description: -30 to -40 msl/Off
Unit Weight: 80
Cohesion: 290
Phi: 0

Soil: 10
Description: Sand and Gravel
Unit Weight: 130
Cohesion: 0
Phi: 32

Soil: 3
Description: 0 to -10 msl/Off
Unit Weight: 94
Cohesion: 137
Phi: 0

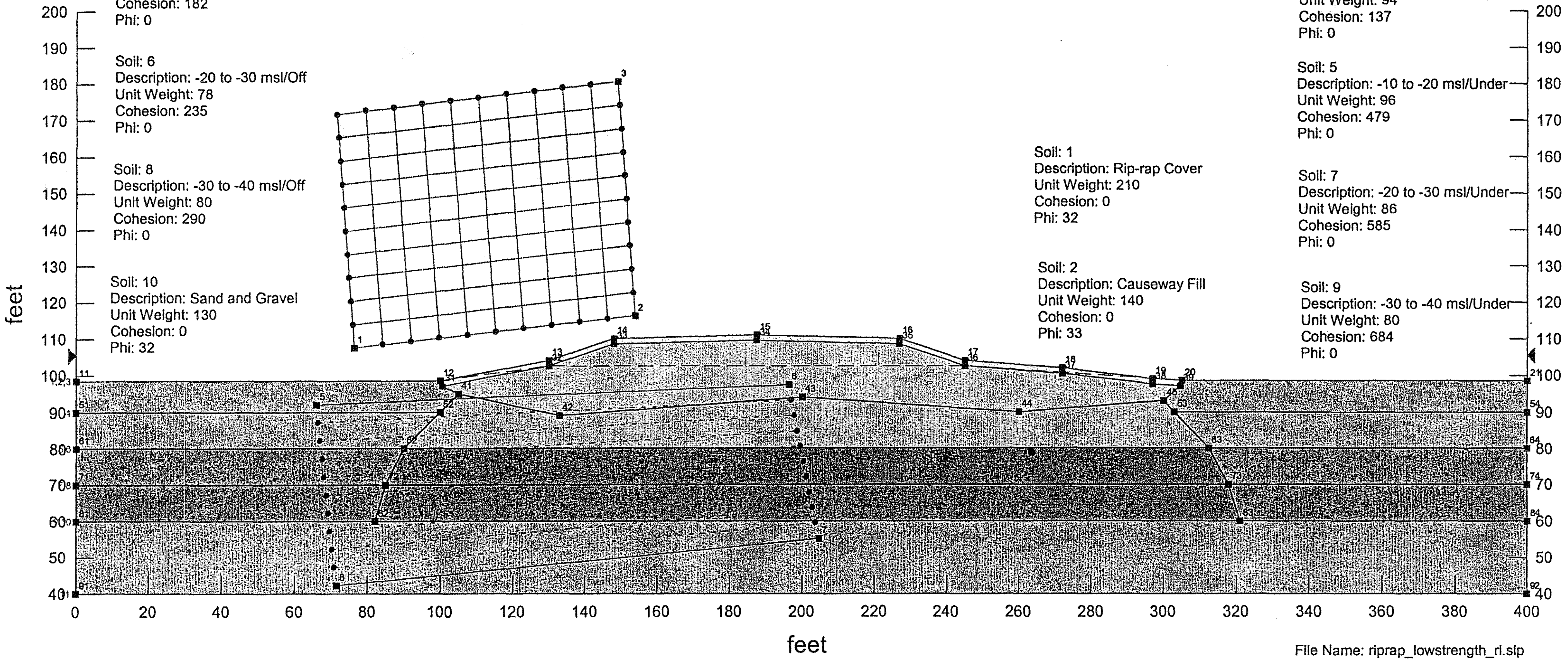
Soil: 5
Description: -10 to -20 msl/Under
Unit Weight: 96
Cohesion: 479
Phi: 0

Soil: 1
Description: Rip-rap Cover
Unit Weight: 210
Cohesion: 0
Phi: 32

Soil: 7
Description: -20 to -30 msl/Under
Unit Weight: 86
Cohesion: 585
Phi: 0

Soil: 2
Description: Causeway Fill
Unit Weight: 140
Cohesion: 0
Phi: 33

Soil: 9
Description: -30 to -40 msl/Under
Unit Weight: 80
Cohesion: 684
Phi: 0

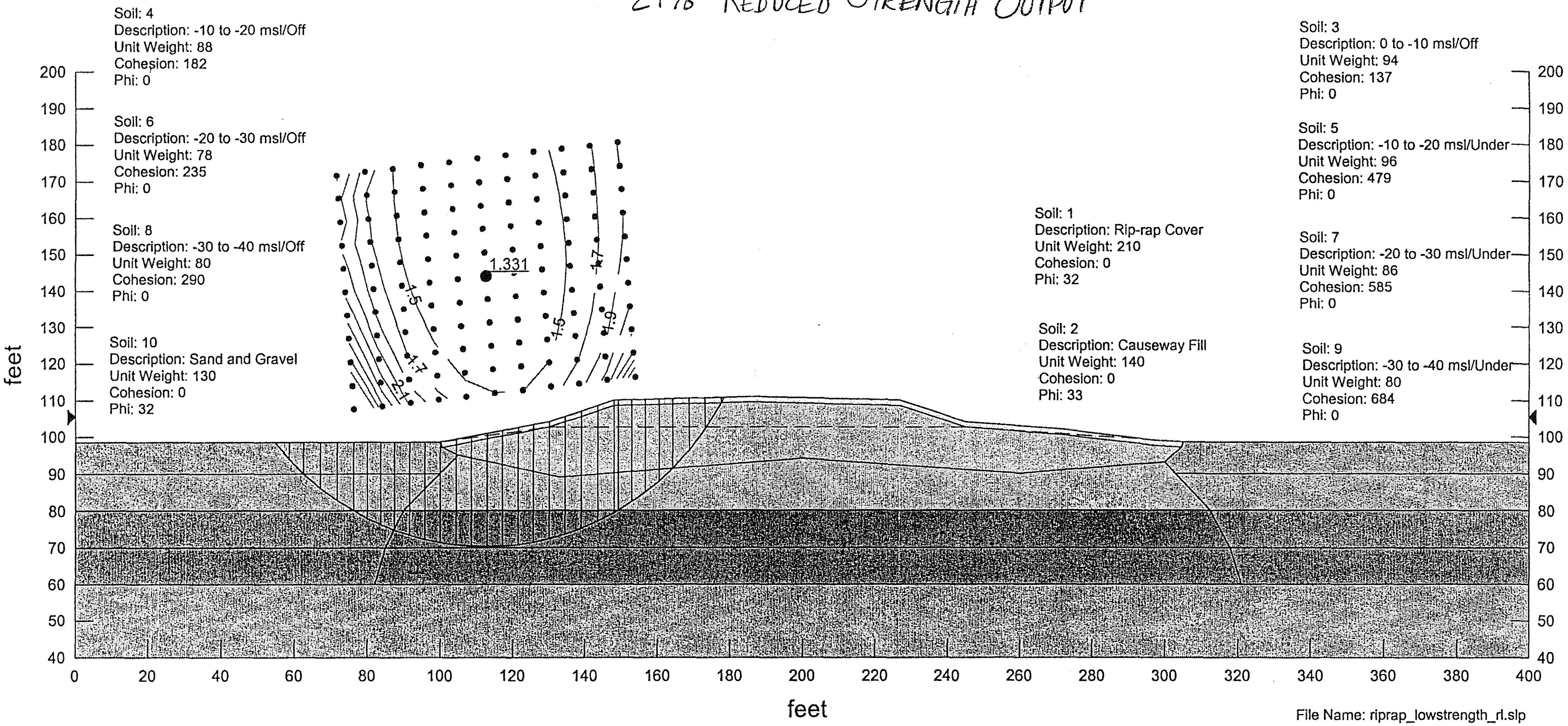


File Name: riprap_lowstrength_rl.slp
Last Saved Date: 1/23/01

33/51

Description: SAEP Causeway Geotechnical Analysis - Rip-rap Cover System - Non-encroaching
Analysis Method: Bishop

24% REDUCED STRENGTH OUTPUT



Soil: 4
Description: -10 to -20 msl/Off
Unit Weight: 88
Cohesion: 182
Phi: 0

Soil: 6
Description: -20 to -30 msl/Off
Unit Weight: 78
Cohesion: 235
Phi: 0

Soil: 8
Description: -30 to -40 msl/Off
Unit Weight: 80
Cohesion: 290
Phi: 0

Soil: 10
Description: Sand and Gravel
Unit Weight: 130
Cohesion: 0
Phi: 32

Soil: 1
Description: Rip-rap Cover
Unit Weight: 210
Cohesion: 0
Phi: 32

Soil: 2
Description: Causeway Fill
Unit Weight: 140
Cohesion: 0
Phi: 33

Soil: 3
Description: 0 to -10 msl/Off
Unit Weight: 94
Cohesion: 137
Phi: 0

Soil: 5
Description: -10 to -20 msl/Under
Unit Weight: 96
Cohesion: 479
Phi: 0

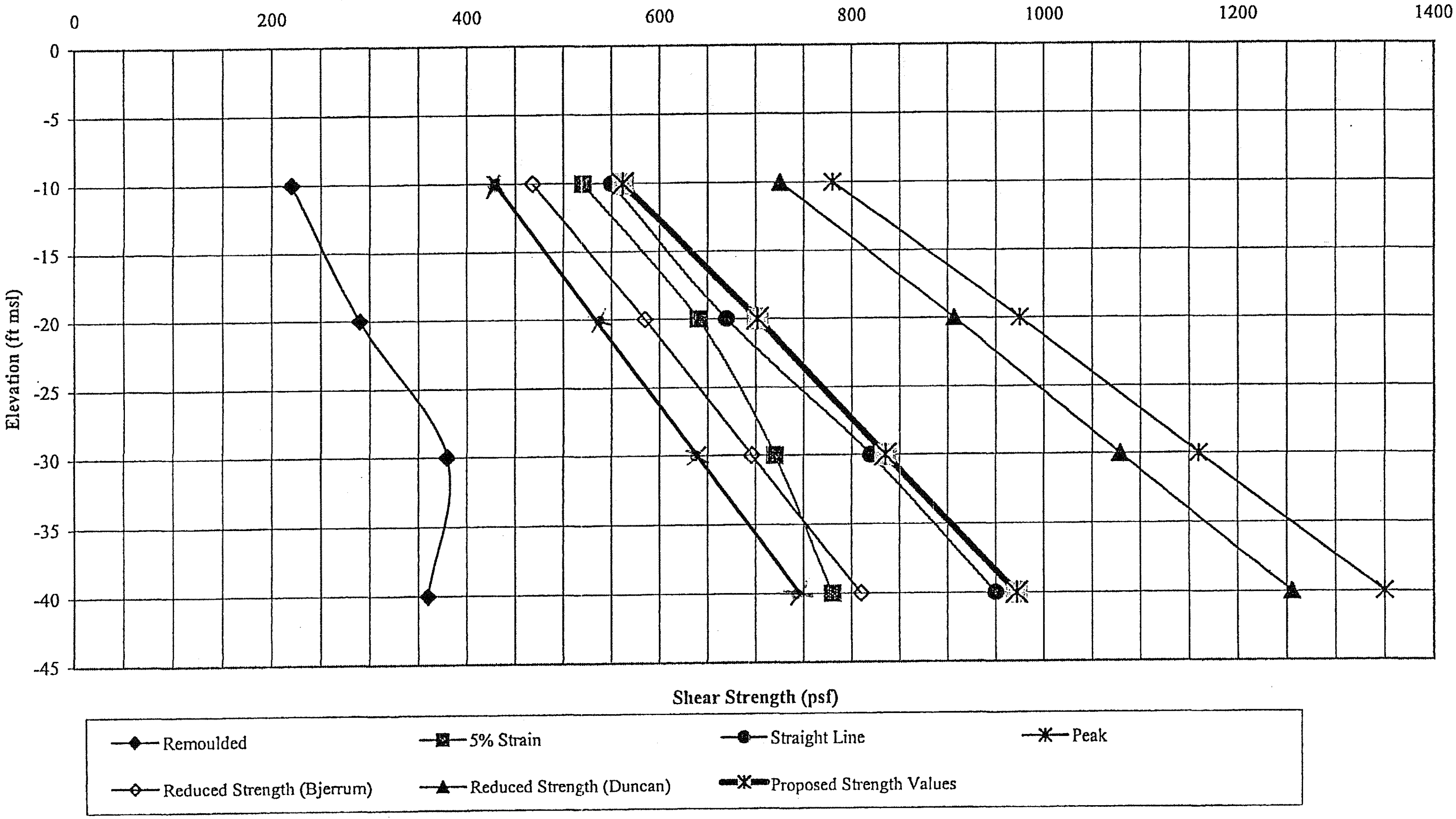
Soil: 7
Description: -20 to -30 msl/Under
Unit Weight: 86
Cohesion: 585
Phi: 0

Soil: 9
Description: -30 to -40 msl/Under
Unit Weight: 80
Cohesion: 684
Phi: 0

File Name: riprap_lowstrength_rl.slp
Last Saved Date: 1/23/01

## Figure 4-1
## Design Shear Strength Values Under the Causeway

## Geotechnical Investigation Summary
## Causeway Non-time Critical Removal Action Design



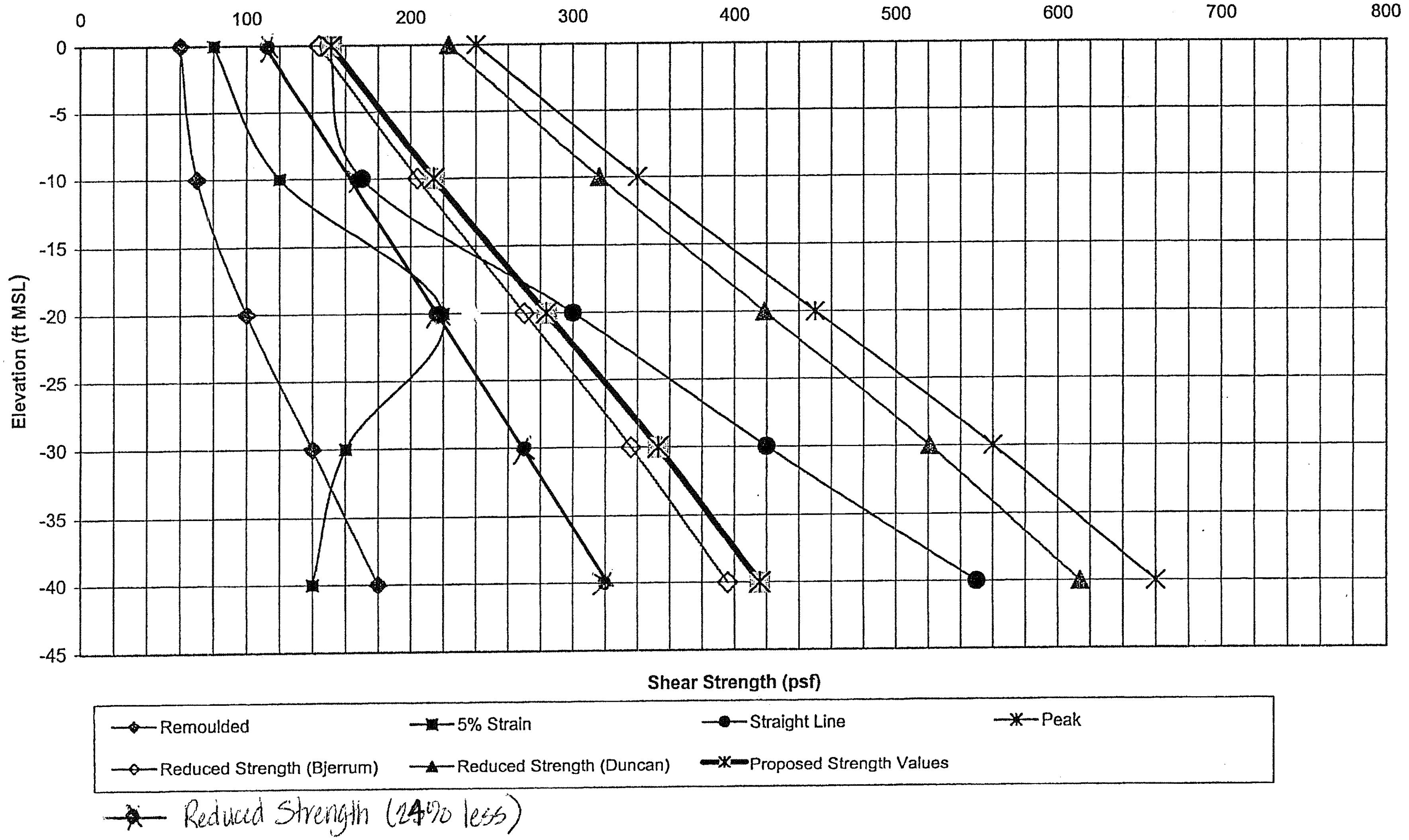
Reduced Strength (24% less)

Strength necessary to have F.S. = 1.3

Design

## Figure 4-2
## Design Shear Strength Values Off of the Causeway

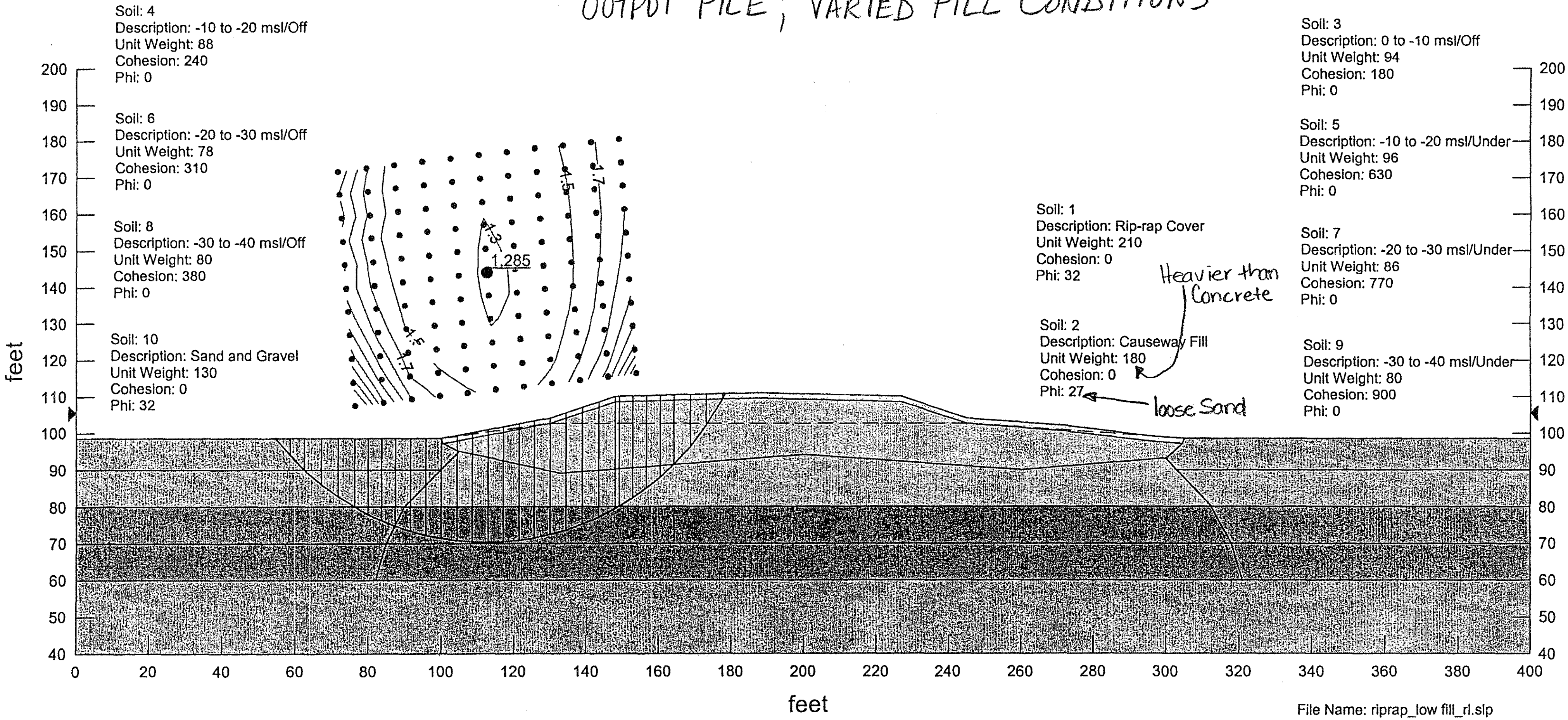
## Geotechnical Investigation Summary
## Causeway Non-time Critical Removal Action Design



p:\project\cbdcom\saep\causeway\geotech\field vanes\Table4-1.xls
Design Off

Description: SAEP Causeway Geotechnical Analysis - Rip-rap with Low Fill Strength
Analysis Method: Bishop

OUTPUT FILE; VARIED FILL CONDITIONS



Soil: 4
Description: -10 to -20 msl/Off
Unit Weight: 88
Cohesion: 240
Phi: 0

Soil: 6
Description: -20 to -30 msl/Off
Unit Weight: 78
Cohesion: 310
Phi: 0

Soil: 8
Description: -30 to -40 msl/Off
Unit Weight: 80
Cohesion: 380
Phi: 0

Soil: 10
Description: Sand and Gravel
Unit Weight: 130
Cohesion: 0
Phi: 32

Soil: 1
Description: Rip-rap Cover
Unit Weight: 210
Cohesion: 0
Phi: 32

Heavier than Concrete

Soil: 2
Description: Causeway Fill
Unit Weight: 180
Cohesion: 0
Phi: 27

loose Sand

Soil: 3
Description: 0 to -10 msl/Off
Unit Weight: 94
Cohesion: 180
Phi: 0

Soil: 5
Description: -10 to -20 msl/Under
Unit Weight: 96
Cohesion: 630
Phi: 0

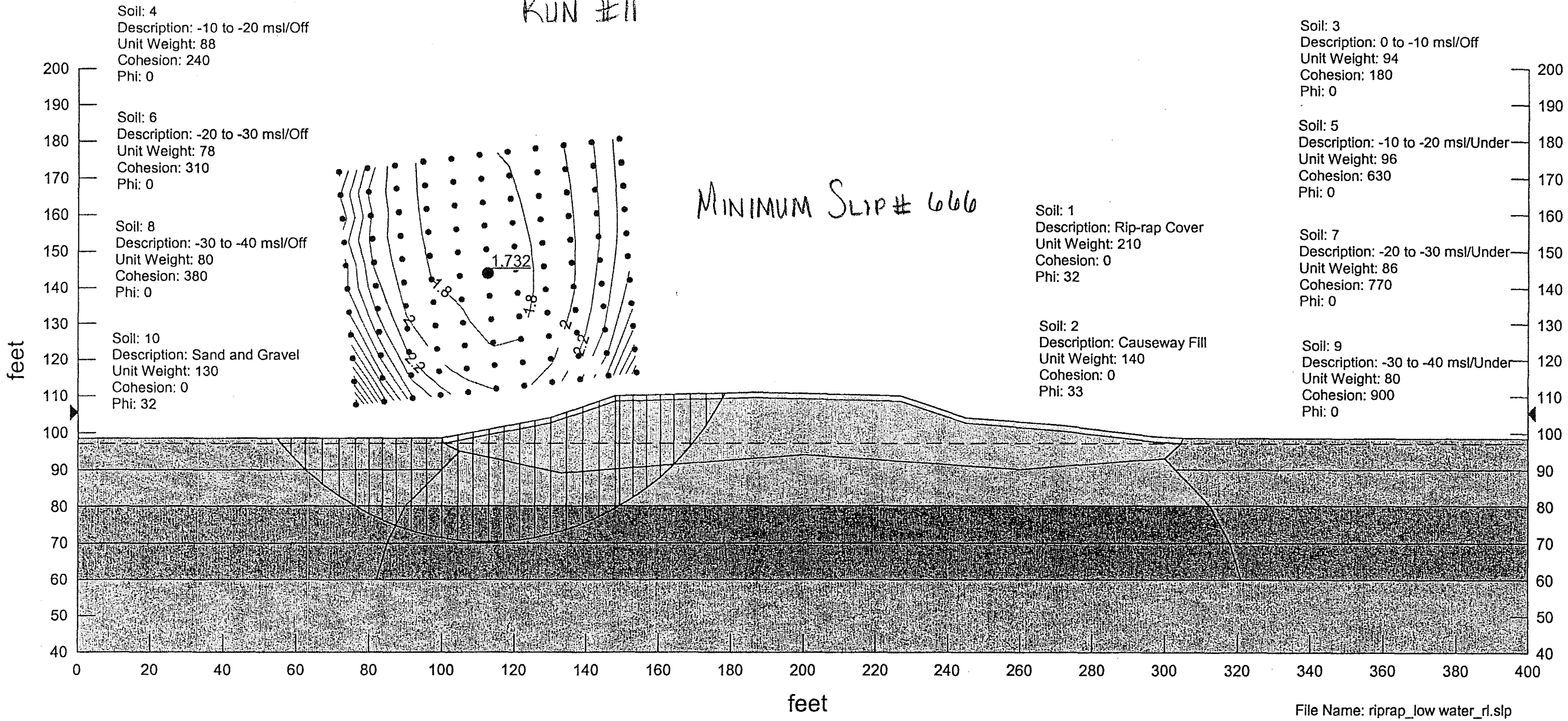
Soil: 7
Description: -20 to -30 msl/Under
Unit Weight: 86
Cohesion: 770
Phi: 0

Soil: 9
Description: -30 to -40 msl/Under
Unit Weight: 80
Cohesion: 900
Phi: 0

File Name: riprap_low fill_rl.slp
Last Saved Date: 1/23/01

Description: SAEP Causeway Geotechnical Analysis - Rip-rap Low Water- Non-encroaching
Analysis Method: Bishop

RUN #11



MINIMUM SLIP # 666

File Name: riprap_low water_rl.slp
Last Saved Date: 1/12/01

```
 FILEINFO
 SLOPEW 4.20
 TITLE
 SAEP Causeway Geotechnical Analysis - Synthetic Cover System - Non-encroaching

 1/4/01
 3:39:28 PM
 ANALYSIS
     1     2     1 +6.2400e+001     1     0
 CONVERGE
    30 +1.0000e-002  1000
 SIDE
     1
 LAMBDA
 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
 SOIL          11
     1 +1.2900e+002 +0.0000e+000 +3.2000e+001 +0.0000e+000 +0.0000e+000
+0.0000e+000   1  0
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000    0    0
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000
 Synthetic Cover
     2 +1.4000e+002 +0.0000e+000 +3.3000e+001 +0.0000e+000 +0.0000e+000
+0.0000e+000   1  0
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000    0    0
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000
 Causeway Fill
     3 +9.4000e+001 +1.8000e+002 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000   1  0
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000    0    0
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000
 0 to -10 msl/Off
     4 +8.8000e+001 +2.4000e+002 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000   1  0
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000    0    0
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000
 -10 to -20 msl/Off
     5 +9.6000e+001 +6.3000e+002 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000   1  0
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000    0    0
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000
 -10 to -20 msl/Under
```

```
     6 +7.8000e+001 +3.1000e+002 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000   1  0
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000    0    0
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000
 -20 to -30 msl/Off
     7 +8.6000e+001 +7.7000e+002 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000   1  0
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000    0    0
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000
 -20 to -30 msl/Under
     8 +8.0000e+001 +3.8000e+002 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000   1  0
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000    0    0
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000
 -30 to -40 msl/Off
     9 +8.0000e+001 +9.0000e+002 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000   1  0
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000    0    0
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000
 -30 to -40 msl/Under
    10 +1.3000e+002 +0.0000e+000 +3.2000e+001 +0.0000e+000 +0.0000e+000
+0.0000e+000   1  0
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000    0    0
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000
 Sand and Gravel
    11 -1.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000   4  0
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000    0    0
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000
       +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
+0.0000e+000
 Bedrock
 SFUNCTION      0
 AFUNCTION      0
 POINT         92
     1 +7.6353e+001 +1.0753e+002
     2 +1.5382e+002 +1.1635e+002
     3 +1.4894e+002 +1.8053e+002
     5 +6.6036e+001 +9.2000e+001
     6 +1.9640e+002 +9.7398e+001
     7 +2.0484e+002 +5.5173e+001
```

```
     8 +7.1476e+001 +4.2224e+001
    11 +0.0000e+000 +9.8500e+001
    12 +1.0000e+002 +9.8500e+001
    13 +1.3000e+002 +1.0400e+002
    14 +1.4800e+002 +1.1000e+002
    15 +1.8750e+002 +1.1100e+002
    16 +2.2700e+002 +1.1000e+002
    17 +2.4500e+002 +1.0400e+002
    18 +2.7200e+002 +1.0200e+002
    19 +2.9700e+002 +9.9000e+001
    20 +3.0500e+002 +9.8500e+001
    21 +4.0000e+002 +9.8500e+001
    31 +1.0050e+002 +9.7000e+001
    32 +1.3000e+002 +1.0250e+002
    33 +1.4800e+002 +1.0850e+002
    34 +1.8750e+002 +1.0950e+002
    35 +2.2700e+002 +1.0850e+002
    36 +2.4500e+002 +1.0250e+002
    37 +2.7200e+002 +1.0050e+002
    38 +2.9700e+002 +9.7500e+001
    39 +3.0450e+002 +9.7000e+001
    41 +1.0500e+002 +9.5000e+001
    42 +1.3300e+002 +8.9000e+001
    43 +2.0000e+002 +9.4000e+001
    44 +2.6000e+002 +9.0000e+001
    45 +3.0000e+002 +9.3000e+001
    51 +0.0000e+000 +9.0000e+001
    52 +1.0000e+002 +9.0000e+001
    53 +3.0300e+002 +9.0000e+001
    54 +4.0000e+002 +9.0000e+001
    61 +0.0000e+000 +8.0000e+001
    62 +9.0000e+001 +8.0000e+001
    63 +3.1250e+002 +8.0000e+001
    64 +4.0000e+002 +8.0000e+001
    71 +0.0000e+000 +7.0000e+001
    72 +8.5000e+001 +7.0000e+001
    73 +3.1800e+002 +7.0000e+001
    74 +4.0000e+002 +7.0000e+001
    81 +0.0000e+000 +6.0000e+001
    82 +8.2000e+001 +6.0000e+001
    83 +3.2100e+002 +6.0000e+001
    84 +4.0000e+002 +6.0000e+001
    91 +0.0000e+000 +4.0000e+001
    92 +4.0000e+002 +4.0000e+001
 LINE           11
     1     11
    11
    12
    13
    14
    15
    16
    17
    18
    19
    20
    21
```

```
   2     13
  11
  12
  31
  32
  33
  34
  35
  36
  37
  38
  39
  20
  21
   3     11
  11
  12
  31
  41
  42
  43
  44
  45
  39
  20
  21
   4      9
  51
  52
  41
  42
  43
  44
  45
  53
  54
   5     11
  61
  62
  52
  41
  42
  43
  44
  45
  53
  63
  64
   6      4
  61
  62
  63
  64
   7      6
  71
  72
  62
```

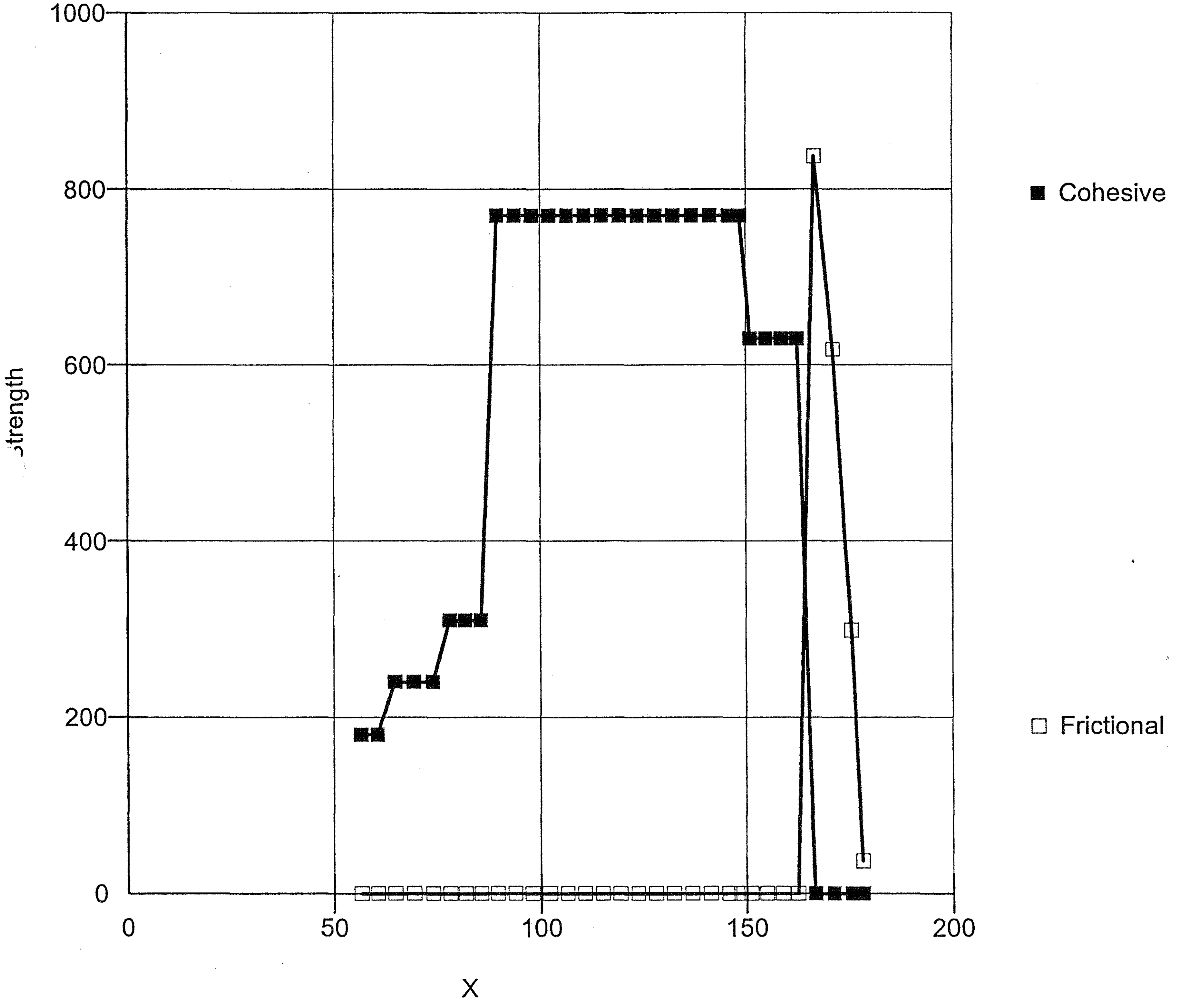
```
   63
   73
   74
    8     4
   71
   72
   73
   74
    9     6
   81
   82
   72
   73
   83
   84
   10     4
   81
   82
   83
   84
   11     2
   91
   92
TENSION
    0 +9.8070e+000 +0.0000e+000 +0.0000e+000     0
GRID
    2     3     1    10    10 0 +0.0000e+000 0 +0.0000e+000
RADIUS
    5     6     8     7    10     5     7
AXIS
    0
LIMIT
0 +0.0000e+000 +4.0000e+002
SLIP           0
BLOCK
    0     0     0     0     0 +1.3500e+002 +1.3500e+002 0 0
    0     0     0     0     0 +4.5000e+001 +4.5000e+001 0 0
PORU           11 +0.0000e+000
    1 +0.0000e+000     0
    2 +0.0000e+000     0
    3 +0.0000e+000     0
    4 +0.0000e+000     0
    5 +0.0000e+000     0
    6 +0.0000e+000     0
    7 +0.0000e+000     0
    8 +0.0000e+000     0
    9 +0.0000e+000     0
   10 +0.0000e+000     0
   11 +0.0000e+000     0
PIEZ           11 +0.0000e+000
    1     6     1
   11
   12
   32
   36
   20
   21
```

```
  2     6     1
 11
 12
 32
 36
 20
 21
  3     6     1
 11
 12
 32
 36
 20
 21
  4     6     1
 11
 12
 32
 36
 20
 21
  5     6     1
 11
 12
 32
 36
 20
 21
  6     6     1
 11
 12
 32
 36
 20
 21
  7     6     1
 11
 12
 32
 36
 20
 21
  8     6     1
 11
 12
 32
 36
 20
 21
  9     6     1
 11
 12
 32
 36
 20
 21
 10     6     1
```

```
   11
   12
   32
   36
   20
   21
   11     6     1
   11
   12
   32
   36
   20
   21
PCON            0 +0.0000e+000
POGH            0 +0.0000e+000
POGP            0 +0.0000e+000
POGR            0 +0.0000e+000
PORA           11
    1 +0.0000e+000
    2 +0.0000e+000
    3 +0.0000e+000
    4 +0.0000e+000
    5 +0.0000e+000
    6 +0.0000e+000
    7 +0.0000e+000
    8 +0.0000e+000
    9 +0.0000e+000
   10 +0.0000e+000
   11 +0.0000e+000
LOAD            0
ANCHOR          0
PBOUNDARY       0
SEISMIC
+0.0000e+000 +0.0000e+000 +0.0000e+000 +0.0000e+000
NODE            0
ELEMENT         0
MATLCOLOR      11
    1   255   255   128
    2   191   255   128
    3   128   255   128
    4   128   255   191
    5   128   255   255
    6   128   191   255
    7   191   128   255
    8   255   128   191
    9   255   128   128
   10   255   191   128
   11   255   255   128
```

RUN #3

Strength vs. X



HARDING ESE.
GEOTECHNICAL DEPARTMENT
GINA RUSTAD

01/12/01

SLOPE STABILITY ANALYSIS CHECK OF SLOPE W
STRATFORD ARMY ENGINE PLANT
GLOBAL, SELECTED COVER SYSTEM, HAND CHECK

50796 1032

+++++++++ ++++++++ ++++++++ ++++++++ +++++++++++ ++++++++ ++++++++ ++++++++

THEORY: SIMPLIFIED BISHOP'S METHOD OF SLICES
AS EXPLAINED IN LAMBE AND WHITMAN

*STATIC*

EARTHQUAKE COEF.= 0.000

FS(assumed) = 1.710
FS (SLOPEW) = 1.860
FS (SLOPEW) EQ = 1.860

HAND FS = 1.710
HAND EQ FS= 1.710

ERROR = {[FS (SLOPEW) - FS (HAND)] / FS (SLOPEW)}
ER(HAND)= 8.08%
ER(EQUA)= 8.08%

| SLICE # | dXi (ft.) | Slice Ht (ft.) | Unit Wt (pcf) | Wi (kips) | THETA (degr) | Wi*sin6 (kips) | c (ksf) | c*dXi (kips) | Water Ht. (ft.) | Ui (ksf) | Ui*dXi (kips) | Wi-12 (kips) | PHI (degr) | 13*TAN14 (kips) | 9 + 15 (kips) | Mi | 16/17 (kips) | EQ (kips) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 1a | 8.000 | 4.250 | 94.000 | 3.20 | -50.000 | -2.448 | 0.180 | 1.440 | 4.500 | 0.281 | 2.246 | 0.950 | 0.000 | 0.000 | 1.440 | 0.643 | 2.240 | 0.000 |
| 2a | 12.000 | 8.500 | 94.000 | 9.59 | -40.000 | -6.163 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 9.588 | 0.000 | 0.000 | 0.000 | 0.766 | 0.000 | 0.000 |
| 2b | 12.000 | 5.000 | 88.000 | 5.28 | -40.000 | -3.394 | 0.240 | 2.880 | 14.000 | 0.874 | 10.483 | -5.203 | 0.000 | 0.000 | 2.880 | 0.766 | 3.760 | 0.000 |
| 3a | 8.500 | 8.500 | 94.000 | 6.79 | -30.000 | -3.396 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 6.792 | 0.000 | 0.000 | 0.000 | 0.866 | 0.000 | 0.000 |
| 3b | 8.500 | 10.000 | 88.000 | 7.48 | -30.000 | -3.740 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 7.480 | 0.000 | 0.000 | 0.000 | 0.866 | 0.000 | 0.000 |
| 3c | 8.500 | 2.750 | 78.000 | 1.82 | -30.000 | -0.912 | 0.310 | 2.635 | 21.500 | 1.342 | 11.404 | -9.580 | 0.000 | 0.000 | 2.635 | 0.866 | 3.043 | 0.000 |
| 4a | 8.750 | 8.500 | 94.000 | 6.99 | -23.000 | -2.732 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 6.991 | 0.000 | 0.000 | 0.000 | 0.921 | 0.000 | 0.000 |
| 4b | 8.750 | 10.000 | 88.000 | 7.70 | -23.000 | -3.009 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 7.700 | 0.000 | 0.000 | 0.000 | 0.921 | 0.000 | 0.000 |
| 4c | 8.750 | 7.500 | 78.000 | 5.12 | -23.000 | -2.000 | 0.310 | 2.713 | 26.000 | 1.622 | 14.196 | -9.077 | 0.000 | 0.000 | 2.713 | 0.921 | 2.947 | 0.000 |
| 5a | 1.750 | 8.500 | 94.000 | 1.40 | -19.000 | -0.455 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.398 | 0.000 | 0.000 | 0.000 | 0.946 | 0.000 | 0.000 |
| 5b | 1.750 | 10.000 | 88.000 | 1.54 | -19.000 | -0.501 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.540 | 0.000 | 0.000 | 0.000 | 0.946 | 0.000 | 0.000 |
| 5c | 1.750 | 8.000 | 78.000 | 1.09 | -19.000 | -0.356 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.092 | 0.000 | 0.000 | 0.000 | 0.946 | 0.000 | 0.000 |
| 5d | 1.750 | 2.000 | 86.000 | 0.30 | -19.000 | -0.098 | 0.770 | 1.348 | 28.000 | 1.747 | 3.058 | -2.757 | 0.000 | 0.000 | 1.348 | 0.946 | 1.425 | 0.000 |
| 6a | 3.000 | 8.500 | 94.000 | 2.40 | -17.000 | -0.701 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 2.397 | 0.000 | 0.000 | 0.000 | 0.956 | 0.000 | 0.000 |
| 6b | 3.000 | 10.000 | 88.000 | 2.64 | -17.000 | -0.772 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 2.640 | 0.000 | 0.000 | 0.000 | 0.956 | 0.000 | 0.000 |
| 6c | 3.000 | 3.000 | 78.000 | 0.70 | -17.000 | -0.205 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.702 | 0.000 | 0.000 | 0.000 | 0.956 | 0.000 | 0.000 |
| 6d | 3.000 | 7.000 | 86.000 | 1.81 | -17.000 | -0.528 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.806 | 0.000 | 0.000 | 0.000 | 0.956 | 0.000 | 0.000 |
| 6e | 3.000 | 0.500 | 80.000 | 0.12 | -17.000 | -0.035 | 0.900 | 2.700 | 29.000 | 1.810 | 5.429 | -5.309 | 0.000 | 0.000 | 2.700 | 0.956 | 2.823 | 0.000 |
| 7a | 10.000 | 8.500 | 94.000 | 7.99 | -12.500 | -1.729 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 7.990 | 0.000 | 0.000 | 0.000 | 0.976 | 0.000 | 0.000 |
| 7b | 10.000 | 5.000 | 88.000 | 4.40 | -12.500 | -0.952 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 4.400 | 0.000 | 0.000 | 0.000 | 0.976 | 0.000 | 0.000 |
| 7c | 10.000 | 5.000 | 96.000 | 4.80 | -12.500 | -1.039 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 4.800 | 0.000 | 0.000 | 0.000 | 0.976 | 0.000 | 0.000 |
| 7d | 10.000 | 10.000 | 86.000 | 8.60 | -12.500 | -1.861 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 8.600 | 0.000 | 0.000 | 0.000 | 0.976 | 0.000 | 0.000 |
| 7e | 10.000 | 2.375 | 80.000 | 1.90 | -12.500 | -0.411 | 0.900 | 9.000 | 31.000 | 1.934 | 19.344 | -17.444 | 0.000 | 0.000 | 9.000 | 0.976 | 9.219 | 0.000 |
| 8a | 5.000 | 1.500 | 129.000 | 0.97 | -7.000 | -0.118 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.968 | 0.000 | 0.000 | 0.000 | 0.993 | 0.000 | 0.000 |
| 8b | 5.000 | 0.750 | 140.000 | 0.53 | -7.000 | -0.064 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.525 | 0.000 | 0.000 | 0.000 | 0.993 | 0.000 | 0.000 |
| 8c | 5.000 | 3.500 | 94.000 | 1.65 | -7.000 | -0.200 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.645 | 0.000 | 0.000 | 0.000 | 0.993 | 0.000 | 0.000 |
| 8d | 5.000 | 12.375 | 96.000 | 5.94 | -7.000 | -0.724 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 5.940 | 0.000 | 0.000 | 0.000 | 0.993 | 0.000 | 0.000 |
| 8e | 5.000 | 10.000 | 86.000 | 4.30 | -7.000 | -0.524 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 4.300 | 0.000 | 0.000 | 0.000 | 0.993 | 0.000 | 0.000 |
| 8f | 5.000 | 3.750 | 80.000 | 1.50 | -7.000 | -0.183 | 0.900 | 4.500 | 32.750 | 2.044 | 10.218 | -8.718 | 0.000 | 0.000 | 4.500 | 0.993 | 4.534 | 0.000 |
| 9a | 7.600 | 0.750 | 129.000 | 0.74 | -2.000 | -0.026 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.735 | 0.000 | 0.000 | 0.000 | 0.999 | 0.000 | 0.000 |
| 9b | 7.600 | 0.750 | 129.000 | 0.74 | -2.000 | -0.026 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.735 | 0.000 | 0.000 | 0.000 | 0.999 | 0.000 | 0.000 |
| 9c | 7.600 | 2.750 | 140.000 | 2.93 | -2.000 | -0.102 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 2.926 | 0.000 | 0.000 | 0.000 | 0.999 | 0.000 | 0.000 |
| 9d | 7.600 | 13.875 | 96.000 | 10.12 | -2.000 | -0.353 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 10.123 | 0.000 | 0.000 | 0.000 | 0.999 | 0.000 | 0.000 |
| 9e | 7.600 | 10.000 | 86.000 | 6.54 | -2.000 | -0.228 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 6.536 | 0.000 | 0.000 | 0.000 | 0.999 | 0.000 | 0.000 |
| 9f | 7.600 | 4.100 | 80.000 | 2.49 | -2.000 | -0.087 | 0.900 | 6.840 | 33.750 | 2.106 | 16.006 | -13.513 | 0.000 | 0.000 | 6.840 | 0.999 | 6.844 | 0.000 |
| 10a | 8.400 | 0.750 | 129.000 | 0.81 | 4.000 | 0.057 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.813 | 0.000 | 0.000 | 0.000 | 0.998 | 0.000 | 0.000 |
| 10b | 8.400 | 0.750 | 129.000 | 0.81 | 4.000 | 0.057 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.813 | 0.000 | 0.000 | 0.000 | 0.998 | 0.000 | 0.000 |
| 10c | 8.400 | 7.750 | 140.000 | 9.11 | 4.000 | 0.636 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 9.114 | 0.000 | 0.000 | 0.000 | 0.998 | 0.000 | 0.000 |
| 10d | 8.400 | 12.000 | 96.000 | 9.68 | 4.000 | 0.675 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 9.677 | 0.000 | 0.000 | 0.000 | 0.998 | 0.000 | 0.000 |
| 10e | 8.400 | 10.000 | 86.000 | 7.22 | 4.000 | 0.504 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 7.224 | 0.000 | 0.000 | 0.000 | 0.998 | 0.000 | 0.000 |
| 10f | 8.400 | 4.000 | 80.000 | 2.69 | 4.000 | 0.188 | 0.900 | 7.560 | 34.750 | 2.168 | 18.215 | -15.527 | 0.000 | 0.000 | 7.560 | 0.998 | 7.578 | 0.000 |
| 11a | 9.000 | 1.250 | 129.000 | 1.45 | 10.500 | 0.264 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.451 | 0.000 | 0.000 | 0.000 | 0.983 | 0.000 | 0.000 |
| 11b | 9.000 | 0.250 | 129.000 | 0.29 | 10.500 | 0.053 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.290 | 0.000 | 0.000 | 0.000 | 0.983 | 0.000 | 0.000 |
| 11c | 9.000 | 11.000 | 140.000 | 13.86 | 10.500 | 2.526 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 13.860 | 0.000 | 0.000 | 0.000 | 0.983 | 0.000 | 0.000 |
| 11d | 9.000 | 10.500 | 96.000 | 9.07 | 10.500 | 1.653 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 9.072 | 0.000 | 0.000 | 0.000 | 0.983 | 0.000 | 0.000 |
| 11e | 9.000 | 10.000 | 86.000 | 7.74 | 10.500 | 1.411 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 7.740 | 0.000 | 0.000 | 0.000 | 0.983 | 0.000 | 0.000 |
| 11f | 9.000 | 3.250 | 80.000 | 2.34 | 10.500 | 0.426 | 0.900 | 8.100 | 34.500 | 2.153 | 19.375 | -17.035 | 0.000 | 0.000 | 8.100 | 0.983 | 8.238 | 0.000 |
| 12a | 3.000 | 1.500 | 129.000 | 0.58 | 14.500 | 0.145 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.581 | 0.000 | 0.000 | 0.000 | 0.968 | 0.000 | 0.000 |
| 12b | 3.000 | 0.375 | 140.000 | 0.16 | 14.500 | 0.039 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.158 | 0.000 | 0.000 | 0.000 | 0.968 | 0.000 | 0.000 |
| 12c | [illegible] | 13.250 | 140.000 | 5.57 | 14.500 | 1.393 | 0.000 | 0.000 | [illegible] | 0.000 | 0.000 | 5.565 | 0.000 | 0.000 | 0.000 | 0.968 | 0.000 | [illegible] |
| 12d | [illegible] | 9.250 | 96.000 | 2.66 | 14.500 | 0.667 | 0.000 | 0.000 | [illegible] | 0.000 | 0.000 | 2.664 | 0.000 | 0.000 | 0.000 | 0.968 | 0.000 | [illegible] |
| 12e | 3.000 | 10.000 | 86.000 | 2.58 | 14.500 | 0.646 | 0.000 | 0.000 | [illegible] | 0.000 | 0.000 | 2.580 | 0.000 | 0.000 | 0.000 | 0.968 | 0.000 | [illegible] |

| SLICE # |  | Slice Ht (ft.) | Unit Wt (pcf) | Wi (kips) | THETA (degr) | Wi*sin6 (kips) | c (ksf) | c*dXI (kips) | Water (ft.) | Ui (ksf) | Ui*dXi (kips) | Wi-12 (kips) | PHI (degr) | 13*TAN14 (kips) | 9 + 15 (kips) | Mi | 16/17 (kips) | (ki |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 12f | 3.000 | 2.000 | 80.000 | 0.48 | 14.500 | 0.120 | 0.900 | 2.700 | 34.500 | 2.153 | 6.458 | -5.978 | 0.000 | 0.000 | 2.700 | 0.968 | 2.789 | 0.000 |
| 13a | 5.500 | 1.500 | 129.000 | 1.06 | 18.000 | 0.329 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.064 | 0.000 | 0.000 | 0.000 | 0.951 | 0.000 | 0.000 |
| 13b | 5.500 | 1.875 | 140.000 | 1.44 | 18.000 | 0.446 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.444 | 0.000 | 0.000 | 0.000 | 0.951 | 0.000 | 0.000 |
| 13c | 5.500 | 13.500 | 140.000 | 10.40 | 18.000 | 3.212 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 10.395 | 0.000 | 0.000 | 0.000 | 0.951 | 0.000 | 0.000 |
| 13d | 5.500 | 9.000 | 96.000 | 4.75 | 18.000 | 1.468 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 4.752 | 0.000 | 0.000 | 0.000 | 0.951 | 0.000 | 0.000 |
| 13e | 5.500 | 10.000 | 86.000 | 4.73 | 18.000 | 1.462 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 4.730 | 0.000 | 0.000 | 0.000 | 0.951 | 0.000 | 0.000 |
| 13f | 5.500 | 0.750 | 80.000 | 0.33 | 18.000 | 0.102 | 0.900 | 4.950 | 33.000 | 2.059 | 11.326 | -10.996 | 0.000 | 0.000 | 4.950 | 0.951 | 5.205 | 0.000 |
| 14a | 9.500 | 1.500 | 129.000 | 1.84 | 23.500 | 0.733 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.838 | 0.000 | 0.000 | 0.000 | 0.917 | 0.000 | 0.000 |
| 14b | 9.500 | 4.250 | 140.000 | 5.65 | 23.500 | 2.254 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 5.653 | 0.000 | 0.000 | 0.000 | 0.917 | 0.000 | 0.000 |
| 14c | 9.500 | 13.000 | 140.000 | 17.29 | 23.500 | 6.894 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 17.290 | 0.000 | 0.000 | 0.000 | 0.917 | 0.000 | 0.000 |
| 14d | 9.500 | 9.500 | 96.000 | 8.66 | 23.500 | 3.455 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 8.664 | 0.000 | 0.000 | 0.000 | 0.917 | 0.000 | 0.000 |
| 14e | 9.500 | 8.000 | 86.000 | 6.54 | 23.500 | 2.606 | 0.770 | 7.315 | 30.500 | 1.903 | 18.080 | -11.544 | 0.000 | 0.000 | 7.315 | 0.917 | 7.977 | 0.000 |
| 15a | 11.000 | 1.500 | 129.000 | 2.13 | 31.500 | 1.112 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 2.129 | 0.000 | 0.000 | 0.000 | 0.853 | 0.000 | 0.000 |
| 15b | 11.000 | 6.000 | 140.000 | 9.24 | 31.500 | 4.828 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 9.240 | 0.000 | 0.000 | 0.000 | 0.853 | 0.000 | 0.000 |
| 15c | 11.000 | 12.250 | 140.000 | 18.87 | 31.500 | 9.857 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 18.865 | 0.000 | 0.000 | 0.000 | 0.853 | 0.000 | 0.000 |
| 15d | 11.000 | 10.250 | 96.000 | 10.82 | 31.500 | 5.656 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 10.824 | 0.000 | 0.000 | 0.000 | 0.853 | 0.000 | 0.000 |
| 15e | 11.000 | 3.000 | 86.000 | 2.84 | 31.500 | 1.483 | 0.770 | 8.470 | 25.750 | 1.607 | 17.675 | -14.837 | 0.000 | 0.000 | 8.470 | 0.853 | 9.934 | 0.000 |
| 16a | 12.000 | 1.500 | 129.000 | 2.32 | 42.000 | 1.554 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 2.322 | 0.000 | 0.000 | 0.000 | 0.743 | 0.000 | 0.000 |
| 16b | 12.000 | 6.250 | 140.000 | 10.50 | 42.000 | 7.026 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 10.500 | 0.000 | 0.000 | 0.000 | 0.743 | 0.000 | 0.000 |
| 16c | 12.000 | 11.500 | 140.000 | 19.32 | 42.000 | 12.928 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 19.320 | 0.000 | 0.000 | 0.000 | 0.743 | 0.000 | 0.000 |
| 16d | 12.000 | 5.500 | 96.000 | 6.34 | 42.000 | 4.240 | 0.630 | 7.560 | 16.250 | 1.014 | 12.168 | -5.832 | 0.000 | 0.000 | 7.560 | 0.743 | 10.173 | 0.000 |
| 17a | 9.000 | 1.500 | 129.000 | 1.74 | 53.500 | 1.400 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.742 | 33.000 | 1.131 | 1.131 | 0.900 | 1.256 | 0.000 |
| 17b | 9.000 | 6.500 | 140.000 | 8.19 | 53.500 | 6.584 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 8.190 | 33.000 | 5.319 | 5.319 | 0.900 | 5.909 | 0.000 |
| 17c | 9.000 | 5.500 | 140.000 | 6.93 | 53.500 | 5.571 | 0.000 | 0.000 | 5.500 | 0.343 | 3.089 | 3.841 | 33.000 | 2.495 | 2.495 | 0.900 | 2.771 | 0.000 |
| 18a | 4.000 | 1.500 | 129.000 | 0.77 | 61.500 | 0.680 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.774 | 33.000 | 0.503 | 0.503 | 0.811 | 0.620 | 0.000 |
| 18b | 4.000 | 3.375 | 140.000 | 1.89 | 61.500 | 1.661 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.890 | 33.000 | 1.227 | 1.227 | 0.811 | 1.514 | 0.000 |
| 19a | 0.750 | 0.750 | 129.000 | 0.07 | 65.000 | 0.066 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.073 | 32.000 | 0.045 | 0.045 | 0.754 | 0.060 | 0.000 |
|  |  |  |  |  | ST SUM = | 58.993 |  |  |  |  |  |  |  |  |  | SUM 18= | 100.858 |  |
|  |  |  |  |  | EQ SUM= | 58.993 |  |  |  |  |  |  |  |  |  |  | SUM 19= | 0.000 |

KEY:
1: Slice number.
2: Slice width, feet. (Lambe: Table E24.5, Column 2) (SLOPEW: W-SLICE)
3: Slice height, feet. (Lambe: used to get slice weight) (SLOPEW: {Y-TOP minus Y-BOT})
4: Unit Weight of soil in Slice, lb/ft^3. (Lambe: Table E24.5, used to calculate Wi in column 5) (SLOPEW: used to calculate WEIGHT, Unit Weight = WEIGHT/[(W-SLICE*{(Y-TOP)-(Y-BOT)}], lb/ft^3)
5: Weight of soil in Slice, kips. (Lambe: Table E24.5, Wi used in column 5 calculation) (SLOPEW: {WEIGHT, pounds})
6: Slice angle to center of rotation, degrees. (Lambe: Table E24.4, theta) (SLOPEW: ALPHA)
7: Weight of soil in Slice * sin(THETA), kips. (Lambe: Table E24.4, Wi sin(theta)) (SLOPEW: not given in output).
8: Soil cohesion, ksf. (Lambe: Table E24.5, used in Column 3) (SLOPEW: Cohesion given as input parameter)
9: Resistance due to cohesion, kips. (Lambe: Table E24.5, Column 3) (SLOPEW: COHES-N = B-LEN * Cohesion {B-LEN = sloping length})
10: Height of vertical water column at base of Slice, feet. (Lambe: Table E24.5, used to get Ui in Column 4) (SLOPEW: used to get WATER, WATER = 62.4 * (Water height) * slice width)
11: Water pressure at base of Slice, ksf. (Lambe: Table E24.5, used to get Ui in Column 4) (SLOPEW: used to get WATER, WATER = (62.4 * Water height) * slice width)
12: Water force at base of Slice, kips. (Lambe: Table E24.5, Column 4) (SLOPEW: WATER)
13: Weight of soil in Slice minus Weight of water in Slice (Effective weight), kips. (Lambe:Table E24.5, Column 5) (SLOPEW: not given in output)
14: PHI, Soil friction angle at base of slice, degrees. (Lambe: Table E24.5, phi used in Column 6) (SLOPEW: PHI)
15: Effective normal stress at base of SLICE, kips. (Lambe: TAble E24.5, Column 6) (SLOPEW: not given in output)
16: Total resisting forces on the Slice (column 10 plus column 15), kips. (Lambe: Table E24.5, Column 7) (SLOPEW: not given in output)
17: Mi = [cos(PHI) * ( 1 + {tan(THETA) * tan(PHI) / Assumed F.S.})]. (Lambe: Table E24.5, Column 8) (SLOPEW: not given in output)
18: ratio of Effective normal stress to Total resisting force (column 16/17), kips. (LAmbe: TAble E24.5, Column 9) (SLOPEW: not given in output)
19: Earthquake load applied horizontally to Slice, kips. (Lambe: not given) (SLOPEW: not given in output)

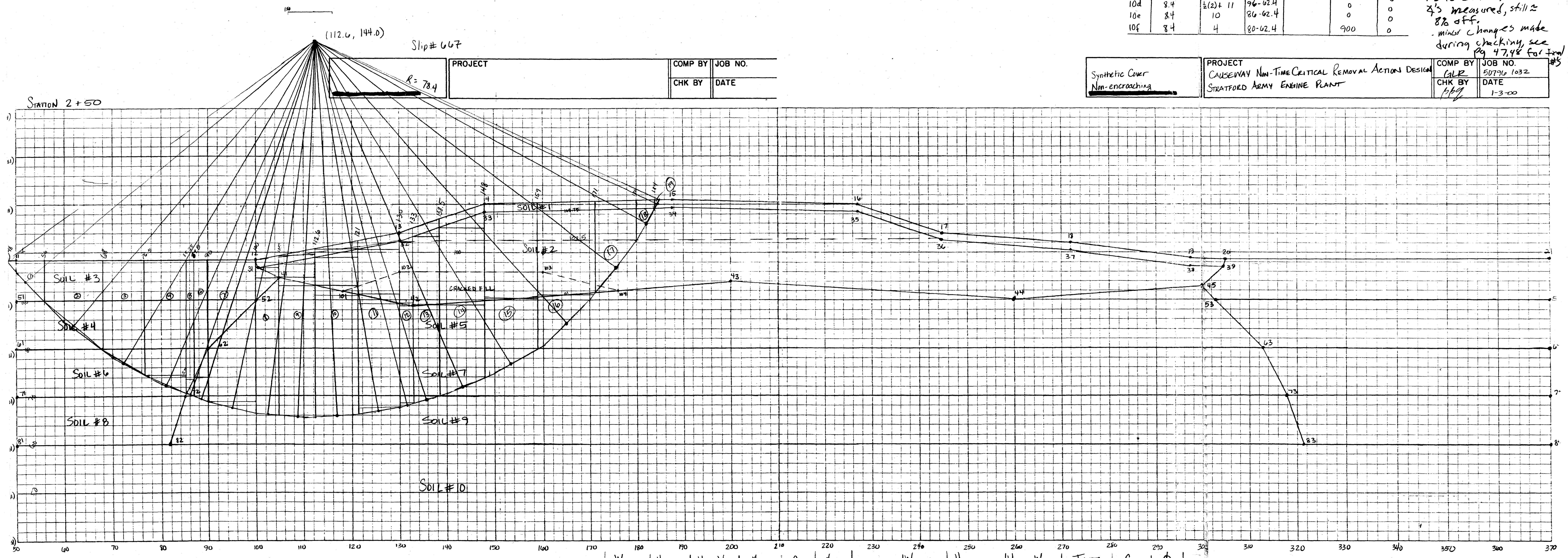
HAND FS = (SUM (Column 18)) / (SUM (Column 6))
HAND EQ FS = (SUM (Column 18)+ (Column 19)) / (SUM (Column 6))

Enter Ht
Width
γ for each separately
ϕ = ϕ from base layer into each
c for only the bottom layer of the slice (all others = 0).
Water = height for only the bottom layer of the slice

| | W | H | Unit Wt | Theta | C | ϕ |
|---|---|---|---|---|---|---|
| 1a | 8 | 4.1 | 94-62.4 | 50 | 180 | 0 |
| All others for 1 = 0. | | | | | | |
| 2a | 12 | 8.5 | 94-62.4 | 40 | 0 | 0 |
| 2b | 12 | 10/2 | 88-62.4 | 40 | 240 | 0 |
| All others for 2 = 0 | | | | | | |
| 3a | 8.5 | 8.5 | 94-62.4 | 30 | 0 | 0 |
| 3b | 8.5 | 10 | 88-62.4 | 30 | 0 | 0 |
| 3c | 8.5 | 5.5/2 | 78-62.4 | 30 | 310 | 0 |
| All others for 3 = 0 | | | | | | |
| 4a | 8.75 | 8.5 | 94-62.4 | 23 | 0 | 0 |
| 4b | 8.75 | 10 | 88-62.4 | 23 | 0 | 0 |
| 4c | 8.75 | 5.5+½(4) | 78-62.4 | 23 | 310 | 0 |
| 4d | 0 | 0 | 0 | 23 | 0 | |
| All others for 4 = 0 | | | | | | |
| 5a | 1.75 | 8.5 | 94-62.4 | 19 | 0 | 0 |
| 5b | 1.75 | 10 | 88-62.4 | 19 | 0 | 0 |
| 5c | 1.75 | 6.25+½(3.25) | 78-62.4 | 19 | 0 | 0 |
| 5d | 1.75 | ½(2.75) | 86-62.4 | 19 | 770 | 0 |
| 5e | 0 | 0 | | 19 | 0 | |
| 5f | 0 | 0 | 0 | 19 | 0 | |

| Slice | Width | Height | γ | Theta | C | ϕ |
|---|---|---|---|---|---|---|
| 6a | 3 | 8.5 | 94-62.4 | 17 | 0 | 0 |
| 6b | 3 | 10 | 88-62.4 | | 0 | 0 |
| 6c | 3 | ½(6) | 78-62.4 | | 0 | 0 |
| 6d | | 4+½(6) | 86-62.4 | | 0 | 0 |
| 6e | 3 | ½(1) | 80-62.4 | | 900 | 0 |
| 6f | 0 | 0 | 0 | | 0 | 0 |
| 7a | 10 | 8.5 | 94-62.4 | 12.5 | 0 | 0 |
| 7b | 10 | ½(10) | 88-62.4 | | 0 | 0 |
| 7c | 10 | ½10 | 96-62.4 | | 0 | 0 |
| 7d | 10 | 10 | 86-62.4 | | 0 | 0 |
| 7e | 10 | 1.25+½(2.25) | 80-62.4 | | 900 | 0 |
| 7f | 0 | 0 | 0 | | 0 | 0 |
| 8a | 5 | 1.5 | 129-62.4 | 7 | 0 | 0 |
| 8b | 5 | ½(.5)+½(1) | 140-62.4 | | 0 | 0 |
| 8c | 5 | ½(2.25)+½(4.75) | 94-62.4 | | 0 | 0 |
| 8d | 5 | ½(4.75)+10 | 96-62.4 | | 0 | 0 |
| 8e | 5 | 10 | 86-62.4 | | 0 | 0 |
| 8f | 5 | 3.75 | 80-62.4 | | 900 | 0 |
| 9a | 7.6 | ½(1.5) | 129 | 2 | 0 | 0 |
| 9b | 7.6 | ½(1.5) | 129-62.4 | | 0 | 0 |
| 9c | 7.6 | 1.5+2(½)(1.25) | 140-62.4 | | 0 | 0 |
| 9d | 7.6 | 13+½(1.75) | 96-62.4 | | 0 | 0 |
| 9e | 7.6 | 10 | 86-62.4 | | 0 | 0 |
| 9f | 7.6 | 4.1 | 80-62.4 | | 900 | |
| 10a | 8.4 | ½(1.5) | 129 | 4 | 0 | 0 |
| 10b | 8.4 | ½(1.5) | 129-62.4 | | 0 | 0 |
| 10c | 8.4 | ½(1.5)+6+½(2) | 140-62.4 | | 0 | 0 |
| 10d | 8.4 | ½(2)+11 | 96-62.4 | | 0 | 0 |
| 10e | 8.4 | 10 | 86-62.4 | | 0 | 0 |
| 10f | 8.4 | 4 | 80-62.4 | | 900 | 0 |

- likely cause of Δ in FS is scale, Theta ∡'s measured, still ≈ 8% off.
- minor changes made during checking, see pg 47,48 for final #5



[redacted]

Synthetic Cover
Non-encroaching

[redacted]

PROJECT
CAUSEWAY NON-TIME CRITICAL REMOVAL ACTION DESIGN
STRATFORD ARMY ENGINE PLANT

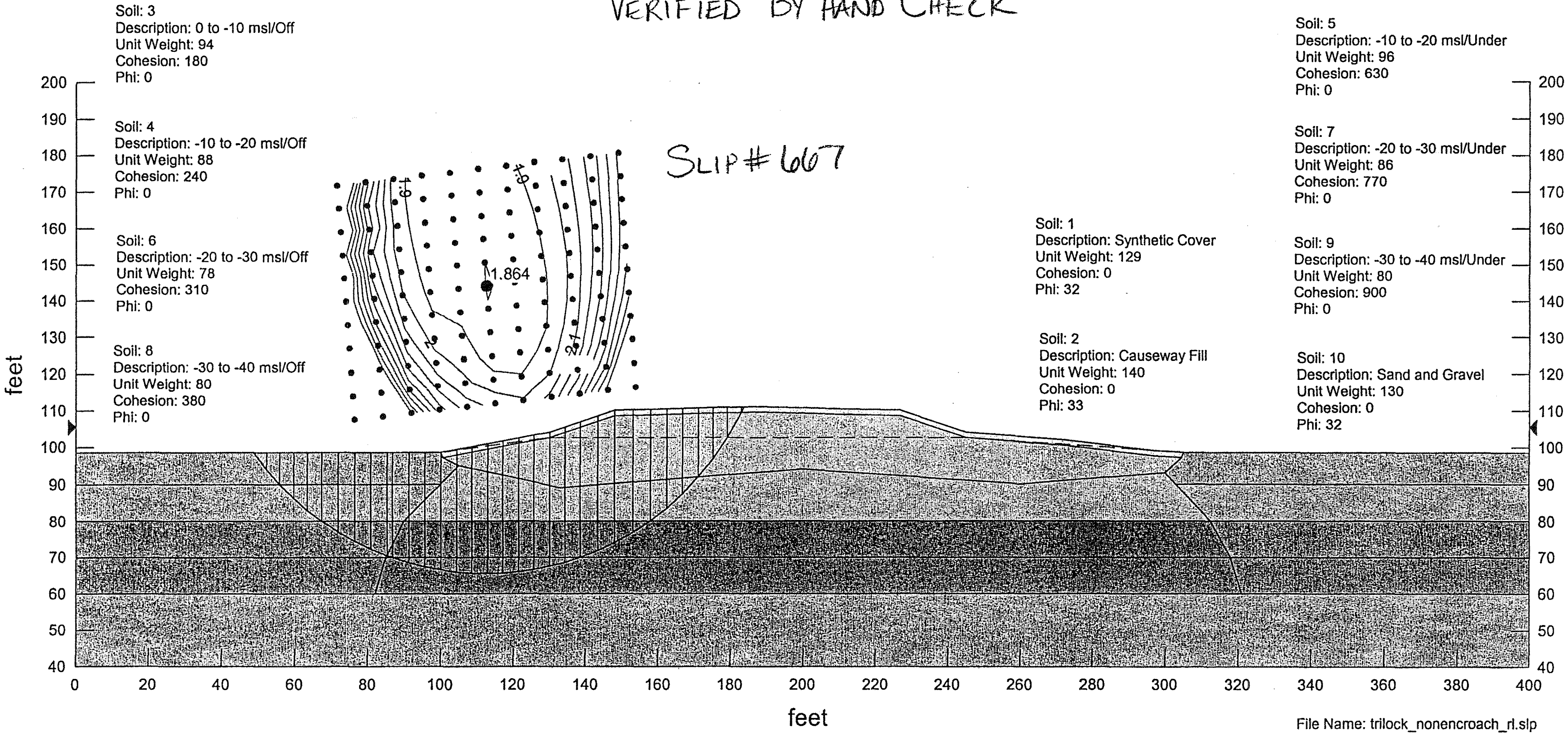
COMP BY GLR
CHK BY pbg
JOB NO. 50796 1032
DATE 1-3-00

| | Width | Height | Unit Wt. | Theta | C | ϕ |
|---|---|---|---|---|---|---|
| 11a | 9 | 1.25 | 129 | 10.5 | 0 | 0 |
| 11b | 9 | 0.25 | 129-62.4 | | 0 | 0 |
| 11c | 9 | ½(2)+9+½(2) | 140-62.4 | | 0 | 0 |
| 11d | 9 | ½(2)+9.5 | 96-62.4 | | 0 | 0 |
| 11e | 9 | 10 | 86-62.4 | | 0 | 0 |
| 11f | 9 | 2.5+½(1.5) | 80-62.4 | | 900 | 0 |
| 12a | 3 | 1.5 | 129 | 14.5 | 0 | 0 |
| 12b | 3 | ½(0.75) | 140 | | 0 | 0 |
| 12c | 3 | 13+½(0.5) | 140-62.4 | | 0 | 0 |
| 12d | 3 | ½(0.5)+9 | 96-62.4 | | 0 | 0 |
| 12e | 3 | 10 | 86-62.4 | | 0 | 0 |
| 12f | 3 | 1.5+½(1) | 80-62.4 | | 900 | 0 |
| 13a | 5.5 | 1.5 | 129 | 18 | 0 | 0 |
| 13b | 5.5 | ½(1.75)+1 | 140 | | 0 | 0 |
| 13c | 5.5 | 13.5 | 140-62.4 | | 0 | 0 |
| 13d | 5.5 | 9 | 96-62.4 | | 0 | 0 |
| 13e | 5.5 | 10 | 86-62.4 | | 0 | 0 |
| 13f | 5.5 | ½(1.5) | 80-62.4 | | 900 | 0 |
| 14a | 9.5 | 1.5 | 129 | 23.5 | 0 | 0 |
| 14b | 9.5 | ½(3.5)+2.5 | 140 | | 0 | 0 |
| 14c | 9.5 | 12.5+½(1) | 140-62.4 | | 0 | 0 |
| 14d | 9.5 | ½(1)+9 | 96-62.4 | | 0 | 0 |
| 14e | 9.5 | 6+½(4) | 86-62.4 | | 770 | 0 |

| | Width | Height | Unit Wt. | Theta | C | ϕ |
|---|---|---|---|---|---|---|
| 15a | 11 | 1.5 | 129 | 31 | 0 | 0 |
| 15b | 11 | 6 | 140 | | 0 | 0 |
| 15c | 11 | 12.25 | 140-62.4 | | 0 | 0 |
| 15d | 11 | 10.25 | 96-62.4 | | 0 | 0 |
| 15e | 11 | ½(6) | 86-62.4 | | 770 | 0 |
| 16a | 12 | 1.5 | 129 | 42 | 0 | 0 |
| 16b | 12 | 6.25 | 140 | | 0 | 0 |
| 16c | 12 | 11.5 | 140-62.4 | | 0 | 0 |
| 16d | 12 | ½(11) | 96-62.4 | | 630 | 0 |
| 17a | 9 | 1.5 | 129 | 54 | 0 | 33 |
| 17b | 9 | 6.5 | 140 | | 0 | 33 |
| 17c | 9 | ½(11) | 140-62.4 | | 0 | 33 |
| 18a | 4 | 1.5 | 129 | 61.5 | 0 | 33 |
| 18b | 4 | ½(6.75) | 140 | | 0 | 33 |
| 19a | 1 | ½(1.5) | 129 | 65 | 0 | 32 |

Description: SAEP Causeway Geotechnical Analysis - Synthetic Cover System - Non-encroaching
Analysis Method: Bishop

VERIFIED BY HAND CHECK



Soil: 3
Description: 0 to -10 msl/Off
Unit Weight: 94
Cohesion: 180
Phi: 0

Soil: 4
Description: -10 to -20 msl/Off
Unit Weight: 88
Cohesion: 240
Phi: 0

Soil: 6
Description: -20 to -30 msl/Off
Unit Weight: 78
Cohesion: 310
Phi: 0

Soil: 8
Description: -30 to -40 msl/Off
Unit Weight: 80
Cohesion: 380
Phi: 0

Soil: 1
Description: Synthetic Cover
Unit Weight: 129
Cohesion: 0
Phi: 32

Soil: 2
Description: Causeway Fill
Unit Weight: 140
Cohesion: 0
Phi: 33

Soil: 5
Description: -10 to -20 msl/Under
Unit Weight: 96
Cohesion: 630
Phi: 0

Soil: 7
Description: -20 to -30 msl/Under
Unit Weight: 86
Cohesion: 770
Phi: 0

Soil: 9
Description: -30 to -40 msl/Under
Unit Weight: 80
Cohesion: 900
Phi: 0

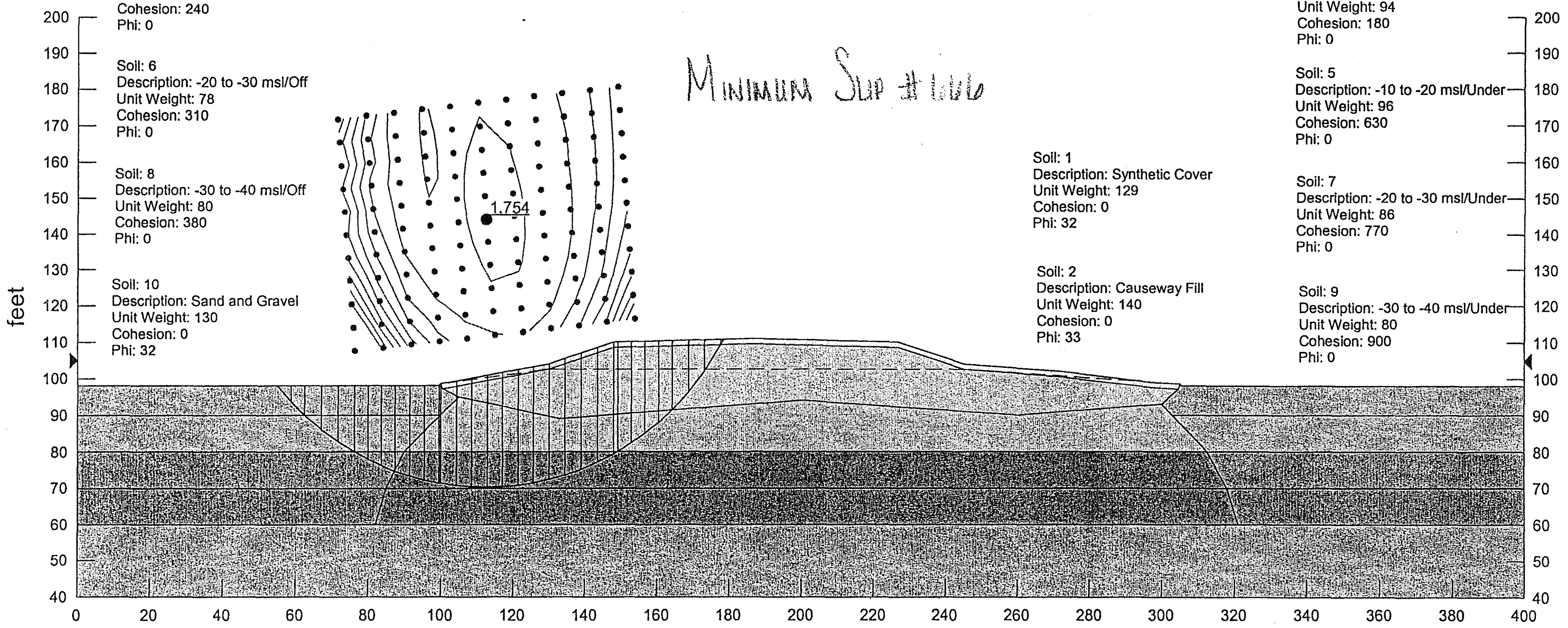
Soil: 10
Description: Sand and Gravel
Unit Weight: 130
Cohesion: 0
Phi: 32

File Name: trilock_nonencroach_rl.slp
Last Saved Date: 1/4/01

Description: SAEP Causeway Geotechnical Analysis - Synthetic Cover System - Non-encroaching2
Analysis Method: Bishop

Run#12

MINIMUM SLIP #666



Soil: 4
Description: -10 to -20 msl/Off
Unit Weight: 88
Cohesion: 240
Phi: 0

Soil: 6
Description: -20 to -30 msl/Off
Unit Weight: 78
Cohesion: 310
Phi: 0

Soil: 8
Description: -30 to -40 msl/Off
Unit Weight: 80
Cohesion: 380
Phi: 0

Soil: 10
Description: Sand and Gravel
Unit Weight: 130
Cohesion: 0
Phi: 32

Soil: 1
Description: Synthetic Cover
Unit Weight: 129
Cohesion: 0
Phi: 32

Soil: 2
Description: Causeway Fill
Unit Weight: 140
Cohesion: 0
Phi: 33

Soil: 3
Description: 0 to -10 msl/Off
Unit Weight: 94
Cohesion: 180
Phi: 0

Soil: 5
Description: -10 to -20 msl/Under
Unit Weight: 96
Cohesion: 630
Phi: 0

Soil: 7
Description: -20 to -30 msl/Under
Unit Weight: 86
Cohesion: 770
Phi: 0

Soil: 9
Description: -30 to -40 msl/Under
Unit Weight: 80
Cohesion: 900
Phi: 0

File Name: trilock_nonencroach2_rl.slp
Last Saved Date: 1/23/01

# ATTACHMENT B

# SETTLEMENT EVALUATION CALCULATIONS

**Harding Lawson Associates**
Engineering
and
Environmental Services

SHEET 1 OF 7
JOB NO. 50796 1032
DATE 1-22-01
COMPUTED BY GLR
CHECKED BY BBZ

PROJECT SAEP CAUSEWAY DESIGN
SUBJECT SETTLEMENT EVALUATION

PURPOSE: To calculate the settlement that may occur on the Causeway as a result of re-grading and placement of the proposed cover system

RESULTS SUMMARY:

| DURATION | EST. MIN(in.) | EST. MAX(in) |
|---|---|---|
| 5 years | 1.97 | 11.0 |
| 20 years | 2.21 | 13.6 |
| 50 years | 2.37 | 15.3 |

REFERENCES:

Harding ESE, 2000. Geotechnical Investigation Summary Causeway Non-time Critical Removal Action Design. Prepared for TACOM. December 2000.

Das, 1998. Principals of Geotechnical Engineering, Fourth Edition.

Das, Braja M., 1983. Advanced Soil Mechanics.

METHODOLOGY:

$$S_{TOTAL} = S_{ELASTIC} + S_{PRIMARY} + S_{SECONDARY}$$

I. Elastic Settlement

$$S_e = \Delta P B \frac{1-\mu^2}{E} I_p \qquad \Delta P = (129)(1.5\,ft)(I_z = 1.0) = 194$$

B = 200ft *
$\mu$ = 0.3
E = 5,000 psi
$I_p$ = 0.094 H/b for H/b < 4
= 0.094 20/200 = 0.0094

$$S_e = \left(194 \frac{\#}{ft^2}\right)(200\,ft)\left(\frac{1-(0.3)^2}{(5{,}000\,\#/in^2)(144\,in^2/ft^2)}\right) 0.0094$$

$= 0.00046\,ft = \boxed{0.006\,in = S_e}$ for upto 45' fill = 0.020 in

Note: * B = 200ft, the width of the Causeway, is a conservative assumption. Although the cover system is wide, the elastic settlement will occur only within the fairly thin layer of fill material, so used $I_p$ for 20' layer, not infinite half space.

Elastic settlement will occur during construction of the cover system and additional fill material can be use to adjust for this settlement

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SUBJECT Settlement Calculations
CHECKED BY BBZ

## II. PRIMARY CONSOLIDATION SETTLEMENT

A. Determine the magnitude of settlement between point A and point B on Page 7, for the range of Cc given in the Geotechnical Investigation Summary Report

B. Assume:

1. Elevation: Point A = -7ft MSL ; Point B = -40ft MSL ; Point 0 = -23.5ft MSL
2. $C_c$ range = 0.37 to 0.51
3. Pressures calculated at middle of sediment layers
4. Subsidence at the toe of the Causeway is minimal (due to pre-excavation)
5. Sediment under the Causeway is normally consolidated.
6. $C_c$ value is consistent over the full depth range.
7. High tide condition - Water elevation = 4.0ft MSL (lower $p_o$ ∴ higher $\left(\frac{p_o+\Delta p}{p_o}\right)$ and higher $S_p$)

C. Given: $C_c = 0.37$

$$S_p = \frac{C_c H}{1+e_o} \log\left(\frac{p_o + \Delta p}{p_o}\right)$$

1. Near GB-00-04
   Existing surface elevation = 6.3 ft MSL
   Proposed surface elevation = 11.0 ft MSL

$e_o = 2.86$

$$\Delta p = (\gamma_{cover})(\text{depth}) + (\gamma_{fill})(\text{depth})$$
$$= (129\text{pcf})(1.5\text{ft}) + (140\text{pcf})(3.2\text{ft}) = 642\text{psf}$$

$$p_{o_B} = (140\text{pcf})(2.3\text{ft}) + (140-62.4)(11) + (96-62.4)(13) + (86-62.4)(3.5)$$

$$= 322 + 854 + 437 + 83$$

$$= 1{,}696\text{ psf}$$

$$S_{primary} = \frac{(0.37)(33\text{ft})}{1+2.86} \log\left(\frac{1{,}696 + 642}{1{,}696}\right)$$

$$= 3.16 \log(1.38)$$

$$= 0.44\text{ ft} = \boxed{5.29\text{ inches}}$$

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2. Near GB-00-02
Existing surface elevation = 8.5 ft MSL
Proposed surface elevation = 11.0 ft MSL
$e_0 = 4.96$

$$\Delta p = (\gamma_{cover})(depth) + (\gamma_{fill})(depth)$$
$$= (129 pcf)(1.5 ft) + (140 pcf)(1.0 ft) = 334 psf$$

$$p_{OB} = (140 pcf)(4.5) + (140-62.4)(11) + (96-62.4)(13) + (86-62.4)(3.5)$$
$$= 630 + 854 + 437 + 83 = 2,004$$

$$S_{primary} = \frac{(0.37)(33 ft)}{1+4.96} \log\left(\frac{2,004+334}{2,004}\right) = 0.14 ft = \boxed{1.64 \text{ inches}}$$

D. Given: $C_c = 0.51$

1. Near GB-00-04
$H = 33 ft$
$e_0 = 2.86$
$\Delta p = 642$ psf
$p_0 = 1,696$

$$S_{primary} = \frac{(0.51)(33 ft)}{1+2.86} \log\left(\frac{1,696+642}{1,696}\right) = 0.608 ft = \boxed{7.29 \text{ inches}}$$

2. Near GB-00-02
$H = 33 ft$
$e_0 = 4.96$
$\Delta p = 334 psf$
$p_0 = 2,004$ psf

$$S_{primary} = \frac{(0.51)(33 ft)}{1+4.96} \log\left(\frac{2,004+334}{2,004}\right) = 0.189 ft = \boxed{2.27 \text{ Inches}}$$

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## III. SECONDARY CONSOLIDATION SETTLEMENT

A. Determine the magnitude of settlement between Point A and Point B on Page 7, for the range of Ca given in the Geotechnical Investigation Summary Report. Calculate for 5, 20, 50 years

B. Assume:

1. Elevation: POINT A = -7 ft MSL; POINT B = -40 ft MSL
2. Ca (under Causeway) range = 0.001 to 0.011
3. Subsidence at the toe of the Causeway is minimal (due to pre-excavation
4. Sediment under the Causeway is normally consolidated
5. Ca is consistent over the entire depth range
6. High tide condition - Water elevation = 4.0 ft MSL
7. $t_2 =$ 5, 20, or 50 years
8. $t_1 \Rightarrow T_v = C_v t_1 / H_{dr}^2$ with $T_v$ (for $t_{90}$) = 0.848

$C_v$ = 3.5 to 0.5 ft²/day
$H_{dr}$ = 33ft/2 = 16.5ft

$$0.848 = \frac{(3.5\,ft^2/d)\,t_1}{(16.5ft)^2}$$

$t_1$ = 66 days

$$0.848 = \frac{(0.5\,ft^2/d)\,t_1}{(16.5ft)^2}$$

$t_1$ = 462 days

$t_1$ = 66 days to 462 days → Average = 264 days
= 0.723 YR

C. Given Ca = 0.001

5 YRS: $S_s = (0.001)(33)\log(5/0.723)$ = 0.028ft = 0.33 inch

20 YRS: $S_s = (0.001)(33)\log(20/0.723)$ = 0.048ft = 0.57 inch

50 YRS $S_s = (0.001)(33)\log(50/0.723)$ = 0.061ft = 0.73 inch

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D. Given $C_a = 0.011$

5 YRS: $S_s = (0.011)(33)\log(5/0.723) = 0.305\text{ft} = 3.66\text{ inches}$

20 YRS: $S_s = (0.011)(33)\log(20/0.723) = 0.523\text{ft} = 6.28\text{ inches}$

50 YRS: $S_s = (0.011)(33)\log(50/0.723) = 0.668\text{ft} = 8.01\text{ inches}$

## IV. RESULTS

### A. Primary Consolidation Settlement

| | Location | $C_c$ | $S_{primary}$ | |
|---|---|---|---|---|
| $e_o = 4.96$ | GB-00-02 | 0.37 | 1.64 inches | |
| | GB-00-02 | 0.51 | 2.27 inches * | |
| $e_o = 2.86$ | GB-00-04 | 0.37 | 5.29 inches * | |
| | GB-00-04 | 0.51 | 7.29 inches | |

*most likely scenarios, given void ratio data

1. The settlement at location GB-00-04 is greater than that at GB-00-02, primarily because the existing surface elevation is ~2 ft lower at GB-00-04; however, the proposed surface elevations are equal. This means that an extra 2 ft of fill material will be placed at location GB-00-04, increasing significantly the change in overburden pressure at this location.
2. This information suggests potential differential settlement under the Causeway; however, because the loading area is large and the proposed cover is flexible, the impacts should not be significant.

### B. Secondary Consolidation Settlement

| Duration | $C_a = 0.001$ | $C_a = 0.011$ |
|---|---|---|
| 5 years | 0.33 inch | 3.66 inches |
| 20 years | 0.57 inch | 6.28 inches |
| 50 years | 0.73 inch | 8.01 inches |

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## C. Total Settlement

1. Total settlement on the Causeway following cover placement will be the sum of primary & secondary settlement. This value could range as summarized below:

| Duration | Est. Min. (in) | Est Max (in) |
|---|---|---|
| 5 years | 1.97 | 10.95 |
| 20 years | 2.21 | 13.57 |
| 50 years | 2.37 | 15.30 |

Note: Elastic settlement not included because extra fill will likely be added during construction to account for settlement.

2. There will likely be differential settlement on the Causeway, in the ranges specified above, as a result of variations in void ratios, and differences in fill depths following grading. However, the effects will not be significant because of the flexibility of the cover system & the large loading area.

## V. ADDITIONAL CONSIDERATIONS

Consider the relationship suggested in Das, 1983 and 1998 for organic soil and peats: $C_c = 0.0115\ W\%$

Sample GB-00-04; 26-28ft bgs is in SOIL # 7.

$e_0 = 2.86$
$C_c = 0.37$
$W\% = 105.82$

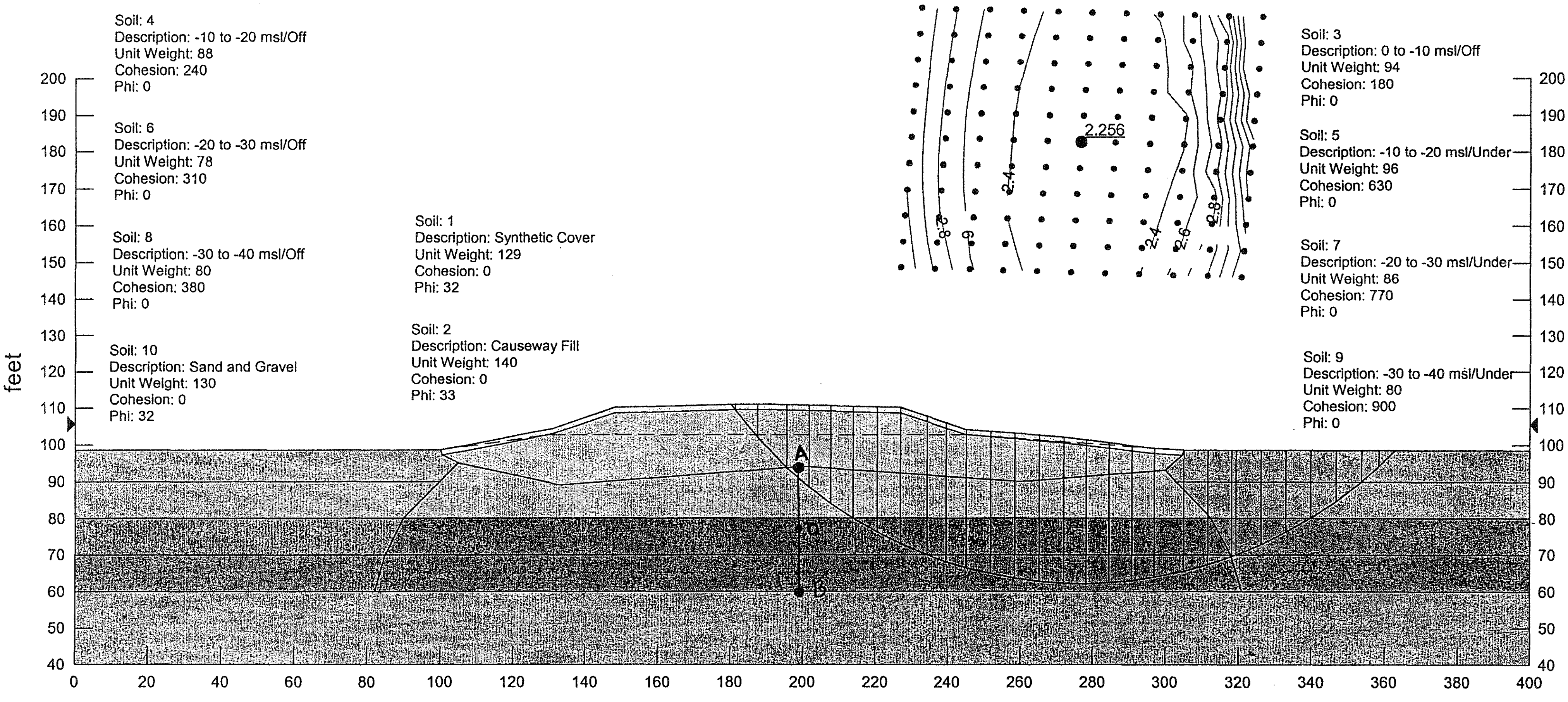
Sample GB-00-02, 40-42ft bgs is in SOIL # 9.

$e_0 = 4.96$
$C_c = 0.51$
$W\% = 169.85$

GB-00-04: $C_c = 0.0115 (105.82) = 1.22$
GB-00-02: $C_c = 0.0115 (169.85) = 1.95$

This empirical relationship suggests $C_c$ values > the values calculated from testing. This may be due to the relatively low organic content for SAEP sediments.

Description: SAEP Causeway Geotechnical Analysis - Synthetic Cover System - Non-encroaching
Analysis Method: Bishop



File Name: trilock_nonencroach_lr.slp
Last Saved Date: 1/4/01

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# APPENDIX E

# WAVE ANALYSIS

**PROJECT NUMBER:** 50796 1041

**FROM:** Jeff Hillson , P.E.

Checked By: ______________________, Date: ____________

Approved By: _____________________, Date: ____________

**DATE:** May 2, 2001

**PROJECT:** Causeway Non-time Critical Removal Action
Stratford Army Engine Plant
Stratford, Connecticut

**SUBJECT:** Wave Analysis

Review of this analysis is currently being conducted and will be finalized in the 90% Design Submittal

**To: Brian Johnson P.E. Harding ESE Inc., Portland Maine**

**From: Jeff Hillson P.E.**

**Date: April 18, 2001**

**Subject: Stratford Causeway**
**90%Submittal - Design Memomorandum for Wave Analysis used for Cover System Revetment Design**
**Project Number: 50796 Task 1042**

# BASIS FOR DEVELOPMENT OF WAVE ANALYSIS

A wave analysis has been performed, the results of which provide a basis for design of the revetment portion of the Causeway Cover System. The Cover System is described elsewhere in the main body of the report. A detailed list of data and their references are located in Appendix A of this Memorandum. The wave analysis and their results are in Appendix B of this Memorandum. Since no wave measurement data was available for this site, the following types of data and information were collected for the development of input data for the wave analysis:

- Site Location and Fetch Length(s)
- Tidal Datum
- Tidal Data
- Site Topography
- Water Levels and Bathymetric
- Meteorological
- Current

### General Site Location and Fetch Length Description

The Stratford Causeway (Causeway) is located in a tidal flat area off the southwest bank approximately 1.9 miles upstream from the beginning of the Housatonic River Entrance Channel (Channel) and ¼ mile northwest (upstream) of Crimbo Point. A breakwater extends from Milford Point on the eastside of the Channel entrance. The Channel Entrance between Milford and Crimbo Points is approximately 1000 feet wide. The Causeway point, at Mean Lower Low Water (MLLW), extends approximately 800 feet into adjacent tidal flats from the southwest bank and is approximately 500 feet southwest from the Channel centerline. The dredged Channel is approximately 200-feet wide and 20-feet deep from MLLW at this location. The Housatonic River is navigable to a point about one mile above Shelton, Connecticut, approximately 11.5 miles upstream from the Channel entrance.

Using Reference 6, fetch radial distances were estimated from the Causeway point to points on land, above tidal flats, within windward directional range (12.5° to 112.5° from North). Generally, due to the breakwater located on the east side of the Entrance Channel, the Causeway point is in a sheltered, limited-fetch condition for all radials. From the map on page, B.1-9, the average fetch length for radials 1 through 6 is 1.83 miles. For fetch radial 6, however, the breakwater may be awash above Mean High Water, thereby causing a fetch length (land-fall) to increase from approximately 1 mile to 35 miles to the shore of Long Island.

## Comparison of Tidal Datums: MLLW and NGVD 1929

Benchmarks and tidal datum information are well documented for both Bridgeport and Sniffens Point, see Appendix A.3-7 and 8. The wave analysis performed uses water level elevations relative to the vertical tidal datum-Mean Lower Low Water (MLLW= 0.00). For this site, MLLW resides 2.72 feet lower relative to National Geodetic Datum of 1929 (NGVD 1929). Thus, the wave analysis defines Mean High Water (MHW) at 6.67, which corresponds to 3.95 (NGVD 1929). MHW elevations 4.1 NGVD 1929 and the evaluated 6.67 MLLW are essentially the same (6.67-2.72=3.95). The slight difference between 4.1 and 3.95 is attributable to the slight variations from different references (locations) throughout Long Island Sound.

## Tidal Data

Tidal range and tidal datums are well documented for both Bridgeport and Sniffens Point and are located within Appendix A. Using elevation 3.45 MTL and 6.67 MHW as references, water level fluctuations (above and below) in the intertidal zone occur approximately every 6 hours. Tidal occurances above MHW are less frequent and of short duration. Tidal occurances (events) above 7.01 MHHW appear to return approximately every 14 days with a duration of 7 days. Randomly chosen samples of '6 Minute Water Level' plots (Ref. 8) are shown Appendix A.3 8.

## General Site Topographic and Near-Shore Geometry Description

The average highest elevation of the top of proposed Causeway revetment is '+10' from MLLW. The average highest elevation of the proposed Causeway crest is '+11'. The general description of the topography from the Causeway point (point) to the center line of the Channel is as follows: highest elevation of the point is '+11', the toe of the point is elevation '0', the near-shore mudline slopes approximately 10 percent for 120 feet to elevation '-11', then slopes approximately 2 percent to elevation '-18' at the Channel dredgeline. The centerline of channel is approximately '-20'.

## General Water Level and Bathymetric Description

Design Still Water Level(s) (SWL) used in the wave analysis are based on approximate water depths at the toe of the point which are referenced in MLLW tidal datum: Mean Higher High Water plus three feet (MHHW+3'); MHHW; Mean Tide Level (MTL); MLLW and feet: 10, 7, 3.5 and 0, respectively. Average depths over the fetch length for radials 1-5 are: 12, 9.5, 6.8 and 5.2 feet, respectively.

## Meteorological Data

Wind speed and direction are from various references and considered to be inland-observation type at 30 feet above the ground. Winds with expected 100 year return period were obtained from Reference 13. Wind duration in the analysis has been given sufficient duration such that waves generated are not duration-limited. Sea and air temperatures are from references: A.3 4. Storm surge (flood) events have not been specifically addressed in the different still water levels (SWL). To develop a range of wave heights, up to a water elevation that does not submerge the Causeway, a 10-feet range of SWL has been created by starting at 0.00 MLLW and extending to the maximum recorded tidal level 10.01 MHHW+3'.

## Current Data

Ebb/Flood currents are 1.2 knots (2 feet per second) from Reference 4.

# WAVE ANALYSIS

### Introduction

Analysis of wind adjustment, wave growth and wave distribution for: fetch-limited; shallow-water; non-breaking waves was performed using 'ACES', by the USACE, see Reference F, Appendix B. Adjustments for refraction, shoaling in the near-shore region and diffraction through the Channel Entrance were made after determining significant, irregular wave height ($H_{1/3}$) and the highest 1/10 of wave heights: the **design wave height** $1.27H_s$ ($H_{1/10}$). Other references for wave analysis are shown in Appendix A.

### Input Data

From the data and other information collected, a range of parameters for wind speed and water depth was developed to provide sufficient input for sensitivity analysis utilizing wind adjustment and wave growth equations. The wave growth equations used were for restricted fetch, shallow-water and fetch-limited waves. Non-variable input data including: fetch radials 1 through 5 and sea-air temperature differential had negligible effects on the results of early analysis runs, therefore these were kept constant throughout the analysis. The range of variable input data are summarized as follows:

Water Depth: 5.2 to 12 feet (MLLW to MHHW+3')
Wind Speed/Duration: 81 mph to 28 mph/ 8minutes to 8 hours
Windward Direction: 90°- East (E) and 60°- East North East (ENE)
Fetch Radial 6 (facing Channel Entrance): 1 mile and 35 miles (see Appendix B.1-9)

## Results of Wave Analysis

Summarized results of the overall wind adjusted/wave growth analysis are located on pages 1 through 3, Appendix B.2. The results of Beta-Raleigh analysis for the non-breaking, irregular-wave, adjusted for refraction and shoaling is located on page B.2-3, Appendix B, summarized as follows:

| | |
|---|---|
| Significant wave height: | $H_{1/3} = 3.03$ feet @ 34° (from North) |
| **Design wave height** ($1.27H_s$): | $H_{1/10} = 3.87$ feet @ 34° (from North) |

### Discussion of Results of Wave Analysis

For the two primary and governing windward directions, ENE and E, the resulting wave growth is limited by: wind-duration for fetch-limited condition and open-water wave diffraction through the Channel Entrance, respectively. For the fetch-limited condition, ENE, the duration of higher wind speeds were upwardly adjusted throughout the analysis so as to fully develop the potential wave height. From the primary windward wind directions, the resulting primary wave directions were 34° and 106° (from North), respectively. See page B.2-1, Appendix B for graphic.

For fetch radials 1-6 and windward direction from ENE, the resulting **design wave height**, $H_{1/10} = 3.87$ feet @ 34° (from North). This condition, with average fetch length of 1.83 miles, has a wind generating area basically enclosed by the breakwater (Radial 6 $\approx$ 1mile) at the Channel Entrance. Ebb-flood velocity of 2 feet/sec and approximately 90° incident to the design wave direction has a negligible effect on the design wave properties. For ebb conditions, there was slight increase in wave celerity (celerity) , slight shortening of wave length and slight change in effective angle of incidence (to Causeway point). The effect on wave height was very small. Therefore, the design wave has not been modified. See calculations in Appendix B.5.

For fetch radials 1-6, windward direction from the E and water level above MHW, submerging the breakwater, the fetch length of radial 6 increases from approximately 1 mile to 35 miles. The open-water wave from Long Island Sound is approximately 5 feet and from the E (Reference 15). Due to the combination of diffraction effect of the Channel Entrance width (approximately 1,000 feet) and approach angle relative to the Channel Entrance opening, the wave height reaching the Causeway point approximately 1 foot. Even when this diffracted wave celerity (speed) is increased for flood current (2 ft./sec) with an accompanying shortening of wavelength, there is only a negligible change in the diffraction coefficient. This diffracted wave is still less than the **design wave height**, $H_{1/10} = 3.87$ feet @ 34° (from North). See calculations in Appendix B.4.

### Wave Runup and Overtopping

Analysis of wave runup and overtopping rates for: fetch-limited; shallow-water; non-breaking waves adjusted for shoaling and refraction was performed using 'ACES', by the USACE, see Reference F, Appendix A. Varying the parameters of the slope surface profile between 'smooth' and 'rough' an overtopping rate of 0.30 cubic feet/ sec/foot width of revetment was calculated. See calculations in Appendix B.6.

**-- End of Report Text--**

# APPENDIX

# TABLE OF CONTENTS

# INPUT DATA FOR ENGINEERING WAVE ANALYSIS FOR REVETMENT DESIGN

| Data | References No. |
|---|---|
| **Wind Velocity Type/Wind Velocity/Duration/Direction Information** | |
| 100yr return/64mph/1minute/ENE | Ref 14., Table 8 |
| 100yr return/52mph/1hour/ENE | Ref 14., Table 8 |
| 100yr return/37mph/3hours/ENE | Ref 14., Table 8 |
| 100yr return/28mph/8hours/ENE | Ref 14., Table 8 |
| 100yr return/74mph/1minute/E | Ref 14., Table 8 |
| 100yr return/60mph/1hour/E | Ref 14., Table 8 |
| 100yr return/55mph/3hours/E | Ref 14., Table 8 |
| 100yr return/52mph/8hours/E | Ref 14., Table 8 |
| Peak Gust Velocity/81 mph/(2-3 sec)/na | Ref 1., Table 7 |
| Fastest Mile/62 mph/ /E** | Ref 2., Fastest Mile… |
| Fastest Mile/38 mph/ /ESE** | Ref 2., Fastest Mile… |
| Fastest Mile/30 mph/ /SSE** | Ref 2., Fastest Mile… |
| Annual Mean Wind Speed/9.8 mph/na/270° to 350° | Ref 2., Wind Roses… |
| Max 5-sec Velocity/44 mph/5 sec/ESE (100-120°)*** | Ref. 3 |
| Max 2-min Velocity/39 mph/2-min/ESE(100-120°)*** | Ref. 3 |
| Max 5-sec Velocity/56 mph/5 sec/ENE (60-80°)*** | Ref. 3 |
| Max 2-min Velocity/48 mph/2-min/ENE(60-80°)*** | Ref. 3 |
| Max 5-sec Velocity/43 mph/5 sec/NE (50-60°)*** | Ref. 3 |
| Max 2-min Velocity/33 mph/2-min/NE(50-60°)*** | Ref. 3 |
| Max 5-sec Velocity/43 mph/5 sec/NNE (10-30°)*** | Ref. 3 |
| Max 2-min Velocity/31 mph/2-min/NNE(10-30°)*** | Ref. 3 |
| **Mean Sea Level Pressure:** | |
| 1017.1 millibars / 30.04 inches of mercury | Ref. 4 |
| **Mean Sea Temperature/Density:** | |
| 14.8°C/1.019 specific gravity | Ref. 4 |
| 58.6°F/64.0 pcf (Engineering Property) | |
| **Mean Atmospheric Temperature:** | |
| 52.2°F 11.2°C | Ref. 4 |
| **ΔT (air-sea) for Wind/Wave Analysis** | |
| -6.4°F | |
| **Soundings for Channel Cross Section** | |
| Drawings provided by: | Ref. 5 |

## INPUT DATA FOR ENGINEERING ANALYSIS FOR RIPRAP REVETMENT

| Data | Reference No. |
|---|---|
| **(continued)** | |

### Tidal Datum Benchmark: MLLW

| | |
|---|---|
| **(Used for for Soundings in Ref. 5)** | |
| Benchmark 67913B (1993) at Sniffens Point (NAVD'88) | Ref. 7 |

**Horizontal Survey Datum:**

| | |
|---|---|
| NAD'83 | Ref. 12 |

**Tidal Data:**

| | |
|---|---|
| Tidal Datum Benchmark, Bridgeport: MLLW | Ref 7 |
| Tidal Datum Benchmark, Sniffens Pt. MLLW | Ref. 7 |
| Historic (1979-2000) Tidal Data from Bridgeport | Ref. 8 |
| Tide elevations adjusted for Stratford from Bridgeport | Ref. 9 |
| Tidal range 5.5 ft. (not used) | Ref. 4 |

**Tidal/Flood Data at Sniffens Point, in feet (MLLW):**

| | | | |
|---|---|---|---|
| 100yr Frequency Tidal Flood | 12.83 | | Ref 13 |
| 50yr Frequency Tidal Flood | 12.31 | | Ref 13 |
| Highest Observed Event | 10.2 | (adjusted from Bridgeport Highest-Observed) | Ref. 9 and 10 |
| 10yr Frequency Tidal Flood | 8.31 | | Ref 13 |
| MHHW | 7.01 | | Ref 7 and 8 |
| MHW | 6.67 | (3.95 NGVD 1929) | Ref 7 and 8 |
| MTL | 3.45 | | Ref 7 and 8 |
| MSL | 3.40 | | Ref 7 and 8 |
| MLW | 0.24 | | Ref 7 and 8 |
| MLLW | 0.00 | (-2.72 NGVD 1929) | Ref 7 and 8 |
| Lowest Observed Event: | -3.52 | (adjusted from Bridgeport Lowest Observed) | Ref. 9 and 10 |

Spring Freshets 10 ft above Mean High Tide

**Tidal Currents:**

| | |
|---|---|
| 1.2 knots = 2.00 ft/sec | Ref. 4 |
| Average speed/direction @ maximum flood: 1.2 knots/ 330° | Ref. 11 |
| Average speed/direction @ maximum ebb: 1.2 knots/ 135° | |

Tidal currents are approximately 90 degrees incident to the mean wave directions for fetch radials 1 through 5 and approximately coincident to the mean wave direction for fetch radials 1-6.

### Notations:

** Windward directions (away from Causway point) ( between 140° < 360°) are not considered and therefore not listed above. For purposes of wind/wave analysis, windward directions are considered from North (northerly - 0°) through SSE (160°). Wind direction points are approximate.

*** same as ** , but, additionally wind speeds are concurrent (same-day) readings.
na – not available

## REFERENCES FOR WAVE ANALYSIS FOR DESIGN OF REVETMENT:

**A.** EM 1110-2-1412 'STORM SURGE ANALYSIS AND DESIGN WATER LEVEL DETERMINATIONS' by USACE, 15 April 1986

**B.** EM 1110-2-1414 'WATER LEVELS AND WAVE HEIGHT DETERMINATIONS FOR COASTAL ENGINEERING DESIGN', by USACE, 5 July 1989

**C.** EM 1110-21614 'DESIGN OF COASTAL REVETMENTS, SEAWALLS, AND BULKHEADS' by USACE, 20 June 1995

**D.** EM 1110-2-2302 ,.Chapter 2, 24 October 90

**E.** EM 1110-2-2904 , 'DESIGN OF BREAKWATERS AND JETTIES' by USACE, 8 August 1986.

**F.** ACES, ver 1.07f by USACE , 1994 (computer program)

**G.** Shore Protection Manual, Vol I and II, (Fourth Edition) by USACE, 1984

**H.** Coastal Engineering Technical Note (CETN-I-10), 'CLARIFICATION OF WAVE HEIGHT PARAMETERS', (11/83).

# REFERENCES FOR ENVIRONMENTAL/GEODETIC DATA AND INFORMATION,

1. NAVFAC DM 2.2, Nov. 1981
2. Environmental Data Service, NOAA 1983
3. NCDC Weather Station Data for Bridgeport Sikorsky Memorial 7/96 to 9/00
4. U.S. Coastal Pilot, Atlantic Coast: Cape Cod to Sandy Hook, 30th edition for Bridgeport, CT.
5. USACE, New England Division 'Preliminary - Housatonic River Condition Survey', Nov. and Dec 1999.
6. NOAA Chart 12370, 'Housatonic River and Milford Harbor', 6/93
7. Downloaded Benchmark Publication from: http://www.co-ops.nos.noaa.gov/bench_mark.shtml?region=ct
8. http:/tidesonline.nos.noaa.gov/geographic.html
9. Tidal Differences and Other Constants CONNECTICUT, Long Island Sound http://www.co-ops.nos.noaa.gov/tab2ec2a.html#15
10. Retrieve Verified / Historic (Tides) Water Level Data for 8467150 BRIDGEPORT, BRIDGEPORT HARBOR, CT, http://co- ops.nos.noaa.gov/data_retrieve.shtml?input_code=100111111vwl
11. Excerpt Table 2, page 131 from 'Tidal Current tables--Atlantic Coast of North America'
12. 'RECORD CONDITIONS PLAN OF LAND LOCATED IN STRATFORD, CONNECTICUT' topographic survey of Causeway prepared by 'MERIDIAN ENGINEERING,INC., October 25, 2000.
13. 'Tidal Flood Profiles New England Coastline', September 1988, USACE, New England Dvision
14. 'Tidal Flood Management West Central Connecticut', June 1988, USACE, New England Division
15. 'Northeast US Analysis Wave Map', March 2001, by Oceanweather inc.

# APPENDIX A

**A1**

## INPUT DATA FOR ENGINEERING ANALYSIS FOR RIPRAP REVETMENT

| Data | Reference No. |
|---|---|
| **(continued)** | |
| **Tidal Datum Benchmark: MLLW** | |
| **(Used for for Soundings in Ref. 5)** | |
| Benchmark 67913B (1993) at Sniffens Point (NAVD'88) | Ref. 7 |
| **Horizontal Survey Datum:** | |
| NAD'83 | Ref. 12 |
| **Tidal Data:** | |
| Tidal Datum Benchmark, Bridgeport: MLLW | Ref 7 |
| Tidal Datum Benchmark, Sniffens Pt. MLLW | Ref. 7 |
| Historic (1979-2000) Tidal Data from Bridgeport | Ref. 8 |
| Tide elevations adjusted for Stratford from Bridgeport | Ref. 9 |
| Tidal range 5.5 ft. (not used) | Ref. 4 |

**Tidal/Flood Data at Sniffens Point, in feet (MLLW):**

| | | | |
|---|---|---|---|
| 100yr Frequency Tidal Flood | 12.83 | | Ref 13 |
| 50yr Frequency Tidal Flood | 12.31 | | Ref 13 |
| Highest Observed Event | 10.2 | (adjusted from Bridgeport Highest-Observed) | Ref. 9 and 10 |
| 10yr Frequency Tidal Flood | 8.31 | | Ref 13 |
| MHHW | 7.01 | | Ref 7 and 8 |
| MHW | 6.67 | (3.95 NGVD 1929) | Ref 7 and 8 |
| MTL | 3.45 | | Ref 7 and 8 |
| MSL | 3.40 | | Ref 7 and 8 |
| MLW | 0.24 | | Ref 7 and 8 |
| MLLW | 0.00 | (-2.72 NGVD 1929) | Ref 7 and 8 |
| Lowest Observed Event: | -3.52 | (adjusted from Bridgeport Lowest Observed) | Ref. 9 and 10 |

Spring Freshets 10 ft above Mean High Tide

| | |
|---|---|
| **Tidal Currents:** | |
| 1.2 knots = 2.00 ft/sec | Ref. 4 |
| Average speed/direction @ maximum flood: 1.2 knots/ 330°<br>Average speed/direction @ maximum ebb: 1.2 knots/ 135° | Ref. 11 |

Tidal currents are approximately 90 degrees incident to the mean wave directions for fetch radials 1 through 5 and approximately coincident to the mean wave direction for fetch radials 1-6.

### Notations:

** Windward directions (away from Causway point) ( between 140° < 360°) are not considered and therefore not listed above. For purposes of wind/wave analysis, windward directions are considered from North (northerly - 0°) through SSE (160°). Wind direction points are approximate.

*** same as ** , but, additionally wind speeds are concurrent (same-day) readings.
na – not available

# INPUT DATA FOR ENGINEERING WAVE ANALYSIS FOR REVETMENT DESIGN

| Data | References No. |
|---|---|
| **Wind Velocity Type/Wind Velocity/Duration/Direction Information** | |
| 100yr return/64mph/1minute/ENE | Ref 14., Table 8 |
| 100yr return/52mph/1hour/ENE | Ref 14., Table 8 |
| 100yr return/37mph/3hours/ENE | Ref 14., Table 8 |
| 100yr return/28mph/8hours/ENE | Ref 14., Table 8 |
| 100yr return/74mph/1minute/E | Ref 14., Table 8 |
| 100yr return/60mph/1hour/E | Ref 14., Table 8 |
| 100yr return/55mph/3hours/E | Ref 14., Table 8 |
| 100yr return/52mph/8hours/E | Ref 14., Table 8 |
| Peak Gust Velocity/81 mph/(2-3 sec)/na | Ref 1., Table 7 |
| Fastest Mile/62 mph/ /E** | Ref 2., Fastest Mile... |
| Fastest Mile/38 mph/ /ESE** | Ref 2., Fastest Mile... |
| Fastest Mile/30 mph/ /SSE** | Ref 2., Fastest Mile... |
| Annual Mean Wind Speed/9.8 mph/na/270° to 350° | Ref 2., Wind Roses... |
| Max 5-sec Velocity/44 mph/5 sec/ESE (100-120°)*** | Ref. 3 |
| Max 2-min Velocity/39 mph/2-min/ESE(100-120°)*** | Ref. 3 |
| Max 5-sec Velocity/56 mph/5 sec/ENE (60-80°)*** | Ref. 3 |
| Max 2-min Velocity/48 mph/2-min/ENE(60-80°)*** | Ref. 3 |
| Max 5-sec Velocity/43 mph/5 sec/NE (50-60°)*** | Ref. 3 |
| Max 2-min Velocity/33 mph/2-min/NE(50-60°)*** | Ref. 3 |
| Max 5-sec Velocity/43 mph/5 sec/NNE (10-30°)*** | Ref. 3 |
| Max 2-min Velocity/31 mph/2-min/NNE(10-30°)*** | Ref. 3 |
| **Mean Sea Level Pressure:** | |
| 1017.1 millibars / 30.04 inches of mercury | Ref. 4 |
| **Mean Sea Temperature/Density:** | |
| 14.8°C/1.019 specific gravity | Ref. 4 |
| 58.6°F/64.0 pcf (Engineering Property) | |
| **Mean Atmospheric Temperature:** | |
| 52.2°F 11.2°C | Ref. 4 |
| **$\Delta T$ (air-sea) for Wind/Wave Analysis** | |
| -6.4°F | |
| **Soundings for Channel Cross Section** | |
| Drawings provided by: | Ref. 5 |

# A2

# REFERENCES FOR WAVE ANALYSIS FOR DESIGN OF REVETMENT:

**A.** EM 1110-2-1412 'STORM SURGE ANALYSIS AND DESIGN WATER LEVEL DETERMINATIONS' by USACE, 15 April 1986

**B.** EM 1110-2-1414 'WATER LEVELS AND WAVE HEIGHT DETERMINATIONS FOR COASTAL ENGINEERING DESIGN', by USACE, 5 July 1989

**C.** EM 1110-21614 'DESIGN OF COASTAL REVETMENTS, SEAWALLS, AND BULKHEADS' by USACE, 20 June 1995

**D.** EM 1110-2-2302 , Chapter 2, 24 October 90

**E.** EM 1110-2-2904 , 'DESIGN OF BREAKWATERS AND JETTIES' by USACE, 8 August 1986.

**F.** ACES, ver 1.07f by USACE , 1994 (computer program)

**G.** Shore Protection Manual, Vol I and II, (Fourth Edition) by USACE, 1984

**H.** Coastal Engineering Technical Note (CETN-I-10), 'CLARIFICATION OF WAVE HEIGHT PARAMETERS', (11/83).

## REFERENCES FOR ENVIRONMENTAL/GEODETIC DATA AND INFORMATION,

1. NAVFAC DM 2.2, Nov. 1981
2. Environmental Data Service, NOAA 1983
3. NCDC Weather Station Data for Bridgeport Sikorsky Memorial 7/96 to 9/00
4. U.S. Coastal Pilot, Atlantic Coast: Cape Cod to Sandy Hook, 30th edition for Bridgeport, CT.
5. USACE, New England Division 'Preliminary - Housatonic River Condition Survey', Nov. and Dec 1999.
6. NOAA Chart 12370, 'Housatonic River and Milford Harbor', 6/93
7. Downloaded Benchmark Publication from: http://www.co-ops.nos.noaa.gov/bench_mark.shtml?region=ct
8. http:/tidesonline.nos.noaa.gov/geographic.html
9. Tidal Differences and Other Constants CONNECTICUT, Long Island Sound http://www.co-ops.nos.noaa.gov/tab2ec2a.html#15
10. Retrieve Verified / Historic (Tides) Water Level Data for 8467150 BRIDGEPORT, BRIDGEPORT HARBOR, CT, http://co- ops.nos.noaa.gov/data_retrieve.shtml?input_code=100111111vwl
11. Excerpt Table 2, page 131 from 'Tidal Current tables--Atlantic Coast of North America'
12. 'RECORD CONDITIONS PLAN OF LAND LOCATED IN STRATFORD, CONNECTICUT' topographic survey of Causeway prepared by 'MERIDIAN ENGINEERING,INC., October 25, 2000.
13. 'Tidal Flood Profiles New England Coastline', September 1988, USACE, New England Dvision
14. 'Tidal Flood Management West Central Connecticut', June 1988, USACE, New England Division
15. 'Northeast US Analysis Wave Map', March 2001, by Oceanweather inc.

# A3.1

# WIND GUSTS

(Hard copy not included)

**Harding Lawson Associates**
Engineering,
Environmental and
Construction Services

SHEET ____ OF ____
JOB NO. ____
DATE ____
COMPUTED BY ____
CHECKED BY ____

PROJECT Stratford Causeway
SUBJECT ____

Appendix

A.3 2.

Wind Roses (NOAA)

U.S. DEPARTMENT OF COMMERCE
C. R. Smith, Secretary

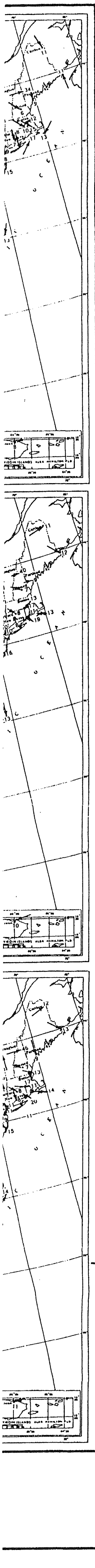
ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION
Robert M. White, Administrator

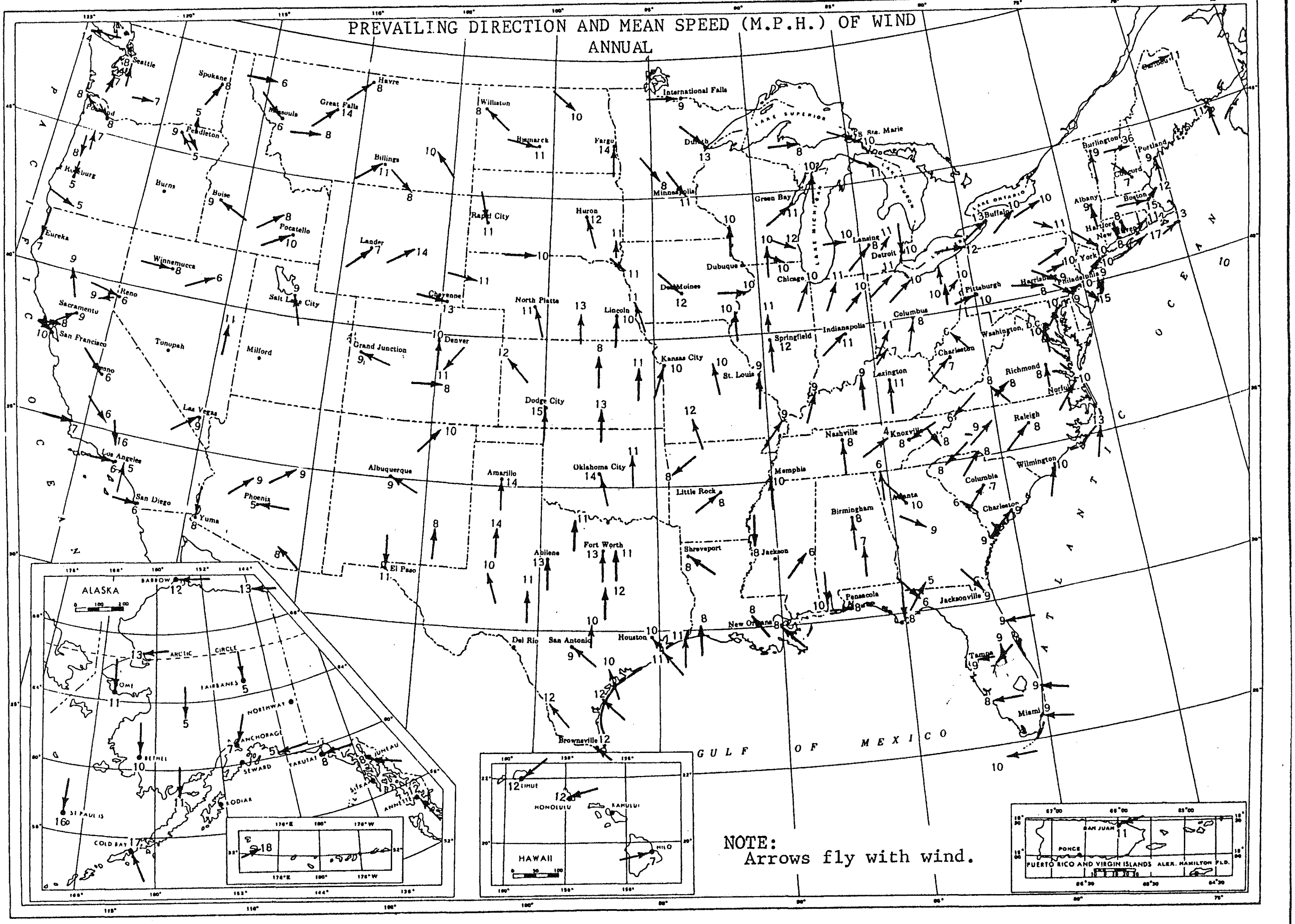
ENVIRONMENTAL DATA SERVICE
Woodrow C. Jacobs, Director

JUNE 1968

REPRINTED BY THE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
1989

# N, MEA. SPEED (m.p.h.), AND FASTEST M E OF WIND, MONTHLY AND ANI AL - Cont





PREVAILING DIRECTION AND MEAN SPEED (M.P.H.) OF WIND
ANNUAL

NOTE:
Arrows fly with wind.

## FASTEST MILE AND DIRECTION OF WIND

| STATE & STATION | YRS | JAN | FEB | MAR | APR | MAY | JUNE | JULY | AUG | SEPT | OCT | NOV | DEC. | YEAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ALA. BIRMINGHAM | 50 | 49 SW | 59 SE | 65 SW | 56 SW | 65 NW | 56 SW | 57 SW | 50 NW | 50 SE | 43 W | 52 N | 45 SE | 65 SW |
| MOBILE | 28 | 45 SW | 44 E | 48 SE | 56 SE | 44 E | 47 E | 81 E | 49 NE | 75 N | 87 E | 47 E | 42 E | 87 E |
| MONTGOMERY | 50 | 47 SW | 47 W | 60 SW | 54 SE | 50 W | 51 NW | 51 E | 43 SW | 40 NE | 40 W | 46 S | 46 SW | 60 SW |
| ALASKA ANCHORAGE | 10 | 60 NE | 62 S | 49 N | 66 S | 31 S | 33 S | 32 S | 45 S | 49 SE | 59 S | 66 NE | 56 SW | 66 NE |
| BARROW | 30 | 56 E | 58 W | 48 - | 52 - | 43 SW | 38 W | 56 SW | 47 E | 56 W | 51 - | 63 W | 70 W | 70 W |
| FAIRBANKS | 11 | 41 SW | 57 W | 60 SW | 35 SW | 42 SE | 40 SW | 50 SW | 34 W | 49 SW | 50 SW | 50 SW | 45 WSW | 60 SW |
| JUNEAU | 15 | 68 SE | 66 SE | 49 SE | 57 SE | 47 SE | 45 SE | 32 SE | 33 SE | 48 SE | 61 SE | 59 SE | 50 SE | 68 SE |
| ST. PAULS ISLAND | 14 | 70 SE | 69 NE | 59 SW | 60 NE | 46 NW | 38 NE | 35 SE | 52 SW | 51 NE | 60 S | 114 NE | 84 SE | 114 NE |
| NOME | 21 | 75 E | 74 W | 72 E | 50 E | 68 NE | 37 S | 36 SE | 45 S | 52 SE | 73 SW | 73 SW | 54 NE | 75 E |
| SHEMYA | 16 | 99 WSW | 81 SW | 79 SSE | 73 SSE | 62 WSW | 55 SW | 50 WSW | 55 S | 71 SW | 79 WNW | 89 W | 139 SW | 139 SW |
| ARIZ. PHOENIX | 24 | 41 WNW | 49 SSE | 50 WNW | 45 NW | 59 SSE | 46 NE | 71 N | 60 SSW | 75 SW | 48 SSW | 45 SSW | 68 W | 75 SW |
| PRESCOTT | 17 | 47 SW | 65 SW | 65 SW | 65 SW | 60 SE | 54 SW | 54 NW | 44 SW | 56 SW | 61 S | 72 SW | 52 W | 72 SW |
| TUCSON | 14 | 40 E | 59 E | 41 SE | 46 SE | 40 SW | 50 SE | 54 S | 54 E | 54 SE | 47 SE | 55 E | 44 W | 59 E |
| YUMA | 51 | 36 W | 42 NW | 56 NW | 47 NW | 38 W | 41 E | 52 NE | 54 S | 42 SE | 39 NW | 47 N | 47 W | 56 NW |
| ARK. FORT SMITH | 16 | 42 SW | 56 W | 41 SW | 42 NW | 57 NW | 58 N | 37 W | 44 NE | 52 NE | 54 W | 56 W | 45 SW | 58 N |
| LITTLE ROCK | 20 | 44 S | 46 WSW | 56 SE | 65 NW | 61 NW | 60 NE | 56 NW | 54 NW | 50 NW | 58 SSW | 49 SW | 42 SE | 65 NW |
| CALIF. BAKERSFIELD | 18 | 47 ESE | 50 ESE | 35 WNW | 60 NNW | 40 WNW | 37 NW | 28 NW | 30 WNW | 32 NNW | 32 E | 45 WNW | 40 SSE | 60 NNW |
| BLUE CANYON | 4 | 46 WSW | 64 SSW | 67 ENE | 42 ENE | 37 SW | 49 ENE | 32 E | 30 ENE | 49 E | 70 NE | 47 ENE | 51 ENE | 70 NE |
| BURBANK | 5 | 40 NE | 36 NNW | 32 NW | 38 NNW | 28 N | 25 NE | 19 S | 20 SE | 19 ESE | 30 NNW | 38 NNW | 45 NE | 45 NE |
| EUREKA | 51 | 54 S | 48 SW | 48 SW | 49 N | 40 NW | 39 NW | 35 N | 34 N | 44 N | 43 SW | 43 S | 56 S | 56 S |
| FRESNO | 12 | 32 SE | 38 W | 31 SE | 36 NW | 38 N | 34 W | 25 NE | 31 S | 29 SW | 40 NE | 27 SE | 43 NW | 43 NW |
| LOS ANGELES | 21 | 49 N | 40 NW | 40 NW | 40 NW | 39 NW | 32 N | 21 W | 24 E | 27 NW | 43 N | 42 N | 44 SE | 49 N |
| RED BLUFF | 17 | 59 SE | 61 SE | 63 SE | 50 SE | 40 SE | 38 NW | 34 SE | 30 SW | 43 W | 56 SE | 47 SE | 60 SE | 63 SE |
| SACRAMENTO | 85 | 60 SE | 58 SE | 66 S | 45 SW | 40 SE | 47 SW | 36 SW | 38 SW | 37 NW | 68 SE | 70 SE | 70 SE | 70 SE |
| SANDBERG | 7 | 85 NW | 91 NW | 90 NNW | 77 NW | 77 NNW | 77 NW | 56 NNW | 52 S | 68 NNW | 87 NW | 81 NNW | 97 E | 97 E |
| SAN DIEGO | 18 | 39 SW | 35 SW | 46 SW | 37 S | 27 SW | 26 S | 18 SW | 23 SW | 25 W | 31 N | 51 SE | 34 S | 51 SE |
| SAN FRANCISCO | 24 | 60 SW | 62 SW | 52 NW | 48 W | 56 W | 48 W | 50 W | 45 WNW | 48 S | 51 SW | 55 SSW | 53 S | 62 SW |
| COLO. COLO. SPRINGS | 7 | 74 NW | 74 SW | 84 WNW | 59 W | 68 SSW | 90 SSW | 70 SE | 54 W | 74 SW | 62 NW | 80 W | 80 WNW | 90 SSW |
| DENVER | 89 | 51 SW | 50 W | 53 NW | 56 NW | 65 W | 56 SE | 57 NE | 47 N | 50 NW | 47 S | 58 NE | 51 NW | 65 W |
| GRAND JUNCTION | 64 | 54 S | 50 NW | 65 S | 59 W | 61 SW | 66 S | 56 SE | 56 NW | 61 S | 61 NW | 56 W | 48 NW | 66 S |
| PUEBLO | 21 | 80 W | 56 N | 68 N | 72 N | 66 NW | 63 N | 61 W | 54 NE | 56 N | 65 N | 61 N | 57 N | 80 W |
| CONN. BRIDGEPORT | 5 | 40 NW | 47 WNW | 45 WNW | 45 SSW | 32 W | 40 WSW | 40 WSW | 32 S | 30 SSE | 38 ESE | 62 E | 35 S | 62 E |
| HARTFORD | 45 | 51 SW | 50 W | 57 SE | 47 NE | 41 NW | 52 N | 42 SW | 56 NE | 62 N | 57 S | 70 E | 54 NW | 70 E |
| NEW HAVEN | 18 | 38 S | 38 SE | 42 E | 40 SE | 31 SW | 32 SW | 33 NW | 38 NE | 41 N | 44 E | 57 E | 45 SW | 57 E |
| D. C. WASHINGTON | 13 | 56 NW | 57 SW | 60 E | 56 N | 48 S | 57 NW | 54 E | 49 NE | 56 SE | 78 SE | 60 E | 62 SW | 78 SE |
| WASHINGTON U | 87 | 47 NW | 47 NW | 56 NW | 50 NW | 47 NW | 47 NW | 54 NE | 49 NW | 62 SE | 54 NW | 47 SW | 40 NW | 62 SE |
| FLA. APALACHICOLA | 29 | 48 E | 40 SE | 54 E | 51 SE | 47 SE | 47 NE | 63 N | 59 NE | 67 E | 56 NW | 47 SE | 42 SE | 67 E |
| DAYTONA BEACH | 12 | 38 W | 40 S | 40 SW | 46 S | 32 S | 35 WSW | 40 NNW | 50 ESE | 45 ESE | 59 SE | 23 ENE | 40 NNW | 59 SE |
| FORT MYERS | 10 | 39 SSE | 40 SSE | 40 NW | 40 SSE | 30 SW | 45 SSE | 45 S | 47 WNW | *90 E | *58 ENE | 30 NW | 30 SSW | *90 E |
| JACKSONVILLE | 90 | 51 SW | 76 W | 66 SW | 54 NW | 57 SE | 59 SW | 53 W | 51 SW | 76 SE | 72 E | 60 S | 54 SW | 76 W,SE |
| KEY WEST | 50 | 71 N | 63 WNW | 52 W | 50 W | 51 E | 48 S | 52 ESE | 56 S | 122 NW | 66 SE | 76 NW | 49 NW | 122 NW |
| FLA. (CON'T) MIAMI | 51 | 50 SW | 68 SE | 53 S | 70 N | 48 SW | 48 NE | 53 SE | 62 SW | 132 E | 122 S | 94 SE | 52 S | 132 E |
| PENSACOLA | 22 | 35 NW | 42 SE | 49 NW | 41 NW | 40 NW | 33 SW | 35 SE | 57 W | 91 SE | 32 NW | 35 SW | 36 SE | 91 SE |
| TAMPA | 51 | 47 SE | 59 SW | 56 SW | 50 SW | 56 NE | 56 NE | 62 SE | 57 S | 84 SE | 68 NE | 40 NW | 51 NW | 84 SE |
| GA. ATLANTA | 50 | 54 NW | 59 W | 66 NW | 68 SE | 59 NW | 70 NE | 56 SE | 49 NW | 49 N | 47 NW | 46 NE | 63 W | 70 NE |
| AUGUSTA | 40 | 46 - | 43 - | 37 - | 41 - | 46 SSW | 43 - | 48 - | 46 - | 44 - | 37 - | 40 W | 39 - | 48 - |
| MACON | 62 | 47 SE | 60 NE | 60 S | 57 SE | 65 SE | 56 NW | 59 SW | 70 S | 43 SE | 36 N | 54 SW | 38 W | 70 S |
| SAVANNAH | 51 | 57 SW | 62 SW | 60 S | 64 SW | 69 W | 66 E | 54 W | 90 N | 56 NW | 85 NE | 57 SE | 51 SW | 90 N |
| HAWAII HONOLULU | 27 | 67 SW | 63 W | 59 SE | 40 NE | 35 E | 39 E | 34 E | 52 SE | 35 NE | 41 NE | 65 NE | 59 NE | 67 SW |
| LIHUE | 11 | 36 SW | 34 E | 36 N | 29 NE | 49 NE | 30 NE | 31 NE | 73 NE | 30 NE | 32 E | 43 S | 58 NE | 73 NE |
| IDAHO BOISE | 22 | 50 SE | 56 W | 52 W | 50 W | 50 W | 50 SW | 61 W | 50 SE | 50 SE | 56 SE | 57 NW | 56 NW | 61 W |
| IDAHO FALLS (46W) | 11 | 39 WSW | 36 SW | 51 WSW | 39 WSW | 41 SW | 36 SW | 35 WSW | 33 SW | 38 WSW | 44 WSW | 40 SW | 43 SW | 51 WSW |
| POCATELLO | 49 | 61 SE | 54 W | 72 W | 61 S | 61 W | 50 W | 47 S | 56 SW | 57 W | 54 W | 67 W | 56 SE | 72 W |
| ILL. CAIRO | 71 | 56 SW | 56 SW | 59 SW | 59 SW | 62 N | 52 N | 59 N | 56 N | 37 NW | 40 NW | 50 SW | 43 S | 62 N |
| CHICAGO | 90 | 58 NE | 87 NE | 76 NE | 69 SW | 69 SW | 62 NW | 69 SW | 62 SW | 69 SW | 62 SW | 76 SE | 66 SW | 87 NE |
| MOLINE | 33 | 56 SW | 58 NW | 66 SW | 73 SW | 68 SW | 77 SW | 65 W | 61 SW | 66 NW | 56 SW | 60 W | 61 SW | 77 SW |
| PEORIA | 50 | 54 S | 52 W | 56 S | 66 SW | 61 SW | 66 N | 75 NW | 65 W | 60 W | 60 SW | 56 SW | 58 SW | 75 NW |
| SPRINGFIELD | 83 | 65 SW | 63 SE | 66 SW | 56 W | 58 W | 75 SW | 59 NW | 58 W | 52 SW | 44 S | 68 SW | 66 SW | 75 SW |
| IND. EVANSVILLE | 50 | 51 SW | 76 W | 62 SW | 61 SW | 56 SW | 113 S | 60 W | 80 SW | 51 W | 41 SW | 62 SW | 54 N | 113 S |
| FORT WAYNE | 50 | 59 SW | 52 W | 65 S | 60 W | 54 SW | 65 SE | 61 NW | 47 N | 56 W | 41 NW | 57 SW | 52 SW | 65 SE |
| INDIANAPOLIS | 90 | 90 W | 65 SW | 68 NW | 60 W | 68 W | 111 NW | 72 NE | 68 W | 62 W | 56 NW | 59 SW | 53 W | 111 NW |
| SOUTH BEND | 11 | 42 W | 47 SSW | 47 SW | 42 SW | 40 WNW | 50 W | 45 NNW | 63 NW | 35 WSW | 38 WSW | 45 S | 43 SW | 63 NW |
| IOWA BURLINGTON | 20 | 49 W | 46 NW | 56 SW | 73 W | 68 SW | 70 NW | 56 NW | 73 N | 45 W | 63 W | 47 W | 72 SW | 73 N |
| DES MOINES | 30 | 66 NW | 56 W | 70 NW | 63 NW | 71 SW | 76 NW | 66 NW | 60 SSE | 55 NW | 56 W | 72 W | 61 SW | 76 NW |
| DUBUQUE | 76 | 31 NW | 30 NW | 34 SW | 32 NW | 32 SE | 47 NW | 44 NW | 36 NE | 35 NE | 30 NW | 34 NW | 34 NW | 47 NW |
| SIOUX CITY | 50 | 59 NW | 62 NW | 69 NW | 68 W | 80 W | 91 W | 61 N | 91 SW | 66 S | 70 W | 59 NW | 56 NW | 91 W,SW |
| KANS. CONCORDIA | 50 | 37 N | 44 NW | 54 NW | 47 NW | 40 NW | 65 W | 50 NW | 47 NE | 34 SW | 41 NW | 47 N | 40 NW | 65 W |
| DODGE CITY | 18 | 56 NW | 72 NW | 74 NW | 70 N | 71 W | 73 S | 78 SW | 72 NW | 66 N | 63 SW | 59 NW | 57 NW | 78 SW |
| TOPEKA | 50 | 43 SW | 50 N | 66 SW | 63 SE | 67 SE | 57 NW | 81 N | 57 N | 57 N | 63 NE | 49 S | 61 S | 81 N |
| WICHITA | 73 | 51 NW | 56 NW | 82 NW | 68 NW | 70 SW | 73 NE | 100 N | 59 NW | 59 NW | 52 NE | 72 S | 52 S | 100 N |
| KY. LEXINGTON | 45 | 52 W | 47 SW | 53 SW | 50 SW | 50 SW | 47 SW | 49 NW | 56 S | 53 W | 40 NW | 52 NW | 47 S | 56 S |
| LOUISVILLE | 49 | 53 S | 62 W | 62 SW | 66 SW | 68 NW | 66 NW | 57 SW | 63 NW | 57 NW | 50 NW | 60 SE | 61 SW | 68 NW |
| LA. LAKE CHARLES | 21 | 46 SSE | 42 SSE | 55 NW | 46 SSE | 50 WNW | 69 SE | 45 S | 43 SSE | 50 NE | 42 NNE | 46 WSW | 50 S | 69 SE |
| NEW ORLEANS | 47 | 41 NE | 44 E | 43 NW | 35 SE | 43 SE | 40 NE | 37 NW | 41 SE | 98 SE | 31 SE | 28 NW | 31 SW | 98 SE |
| SHREVEPORT | 82 | 47 NW | 45 NW | 57 S | 52 N | 47 NW | 50 E | 46 NW | 52 W | 59 E | 47 NW | 50 SW | 52 NW | 59 E |
| MAINE CARIBOU | 8 | 76 NW | 52 W | 63 W | 46 NW | 53 WNW | 50 WNW | 66 N | 45 WSW | 45 W | 48 NW | 48 W | 55 WNW | 76 NW |
| PORTLAND | 62 | 50 S | 58 N | 76 NE | 57 S | 64 NW | 48 NW | 51 S | 69 E | 62 SE | 47 SE | 76 NE | 62 SE | 76 NE |
| MD. BALTIMORE | 39 | 56 NW | 65 NW | 66 W | 65 W | 57 NE | 61 N | 61 NE | 60 SW | 54 SW | 49 NW | 57 S | 56 NW | 66 W |
| MASS. BLUE HILL | 53 | 72 SW | 74 NNW | 69 SE | 57 W | 59 S | 76 WNW | 67 NW | 93 SE | 121 S | 63 SE | 70 S | 82 WNW | 121 S |
| BOSTON | 43 | 66 SW | 58 NE | 73 E | 63 NE | 55 W | 46 NW | 52 NW | 52 NE | 87 S | 63 NW | 80 SE | 73 W | 87 S |
| NANTUCKET | 75 | 69 NE | 71 NE | 91 E | 61 NE | 52 NE | 68 NE | 62 NE | 79 SW | 73 SE | 69 E | 70 NW | 62 NE | 91 E |
| WORCESTER | 4 | 60 WSW | 76 NW | 76 WNW | 54 NE | 48 W | 39 WSW | 43 NW | 34 W | 34 SW | 43 WSW | 54 SSW | 51 SW | 76 WNW |
| MICH. ALPENA | 45 | 56 E | 50 NW | 56 E | 52 W | 47 NW | 50 NW | 49 S | 52 S | 49 SE | 50 NW | 61 SW | 49 NW | 61 SW |
| MICH. (CON'T) DETROIT | 28 | 57 SW | 49 W | 68 SW | 56 N | 61 NW | 56 SW | 77 NW | 50 NW | 52 SW | 56 S | 66 W | 59 NW | 77 NW |
| ESCANABA | 30 | 52 NE | 56 N | 68 N | 47 N | 57 NW | 50 SE | 49 N | 43 NW | 47 NW | 52 NE | 56 N | 47 NW | 68 N |
| FLINT | 19 | 76 SW | 65 SSW | 63 SW | 67 SSW | 81 NW | 68 S | 44 NNW | 60 WSW | 46 NNW | 52 WSW | 56 WSW | 46 SW | 81 NW |
| GRAND RAPIDS | 58 | 72 SW | 65 SW | 69 SW | 79 SW | 73 SW | 68 S | 62 SW | 51 SW | 65 SW | 69 SW | 80 SW | 68 SW | 80 SW |
| LANSING | 22 | 46 S | 41 SW | 38 SW | 38 S | 49 NW | 38 NW | 42 NW | 29 NW | 37 NW | 44 SW | 50 SW | 33 W | 50 SW |
| MARQUETTE | 49 | 52 - | 56 SW | 57 SW | 47 SW | 91 S | 59 SW | 61 S | 52 SW | 45 S | 66 SW | 50 SW | 57 S | 91 S |
| S. STE. MARIE | 71 | 50 NW | 72 NW | 60 SE | 72 SW | 49 SE | 54 W | 56 W | 56 SW | 62 SW | 62 W | 66 W | 58 NW | 72 SW |
| MINN. DULUTH | 35 | 65 NW | 67 E | 75 NW | 75 NE | 61 W | 59 NW | 72 W | 68 N | 60 NW | 61 S | 68 E | 72 NW | 75 NE |
| INTERN'L FALLS | 9 | 32 SW | 35 W | 42 WNW | 52 SW | 52 SSW | 36 S | 46 WNW | 36 NW | 35 SW | 29 NW | 35 W | 32 W | 52 SW |
| MINNEAPOLIS | 50 | 47 NW | 52 NW | 56 SW | 58 N | 56 NW | 63 NW | 92 W | 57 NW | 50 NW | 73 S | 60 SW | 52 W | 92 W |
| MISS. JACKSON | 14 | 56 NW | 45 NW | 68 S | 49 S | 56 NW | 52 SE | 54 N | 51 NW | 54 NE | 39 NW | 51 S | 59 NW | 68 S |
| MERIDIAN | 55 | 42 - | 41 - | 47 - | 44 - | 40 - | 40 - | 40 | 36 - | 32 - | 32 - | 31 - | 38 - | 47 - |
| VICKSBURG | 50 | 38 NW | 47 NW | 40 NW | 56 W | 49 NW | 38 SW | 46 N | 41 SE | 47 S | 35 SW | 47 SW | 49 SW | 56 W |
| MO. COLUMBIA | 50 | 56 NW | 45 NW | 56 SW | 57 NW | 58 SW | 58 NW | 61 NW | 56 NW | 63 NW | 49 NW | 49 NW | 56 NW | 63 NW |
| KANSAS | 71 | 66 NE | 49 NW | 70 SW | 61 W | 68 SW | 68 NW | 70 NW | 72 NW | 50 NW | 56 W | 56 SW | 57 SW | 72 NW |
| ST. JOSEPH | 48 | 46 NW | 46 W | 64 S | 61 NW | 63 W | 60 NW | 52 W | 57 NW | 43 SW | 42 NW | 56 NW | 59 S | 64 S |
| ST. LOUIS U | 45 | 59 SW | 57 SW | 82 SW | 61 SW | 61 SW | 60 SW | 56 SW | 60 SW | 73 W | 62 SW | 65 SE | 56 SW | 82 SW |
| SPRINGFIELD | 16 | 55 SW | 59 S | 65 SW | 60 NW | 66 W | 57 N | 56 NW | 59 W | 54 S | 49 S | 59 SE | 55 W | 66 W |
| MONT. BILLINGS | 18 | 66 W | 68 NW | 61 NW | 72 NW | 68 - | 65 SE | 73 N | 66 N | 61 NW | 68 NW | 63 NW | 66 NW | 73 N |
| GREAT FALLS | 18 | 65 SW | 72 W | 73 W | 70 W | 65 SW | 70 W | 73 W | 71 SW | 73 NW | 73 W | 73 SW | 82 SW | 82 SW |
| HAVRE | 48 | 52 SW | 56 SW | 47 SW | 59 SW | 59 NW | 54 W | 53 - | 50 SW | 70 SW | 53 - | 54 SW | 47 - | 70 SW |
| HELENA | 50 | 73 SW | 73 W | 61 SW | 52 W | 62 S | 59 SW | 60 SW | 65 S | 54 NW | 62 W | 59 SW | 59 NW | 73 W |
| MISSOULA | 26 | 52 S | 53 E | 53 NE | 51 NW | 57 SW | 51 S | 72 SE | 58 SW | 41 W | 51 SW | 42 NW | 56 W | 72 SE |
| NEBR. LINCOLN U | 50 | 49 NW | 56 NW | 63 NW | 56 NW | 60 W | 66 NW | 65 NW | 62 NW | 50 N | 44 S | 52 NW | 54 NW | 66 NW |
| NORTH PLATTE | 50 | 57 N | 68 N | 72 N | 63 NW | 70 S | 72 N | 60 NW | 56 SW | 53 N | 72 SW | 64 NW | 59 NW | 72 N |
| OMAHA | 89 | 60 NW | 59 N | 73 NW | 65 NW | 73 NW | 72 N | 109 N | 66 N | 51 N | 59 SW | 58 NW | 52 NW | 109 N |
| SCOTTSBLUFF | 10 | 40 NW | 60 WNW | 48 W | 46 NW | 80 NW | 80 WNW | 52 WSW | 41 NNW | 46 NW | 44 WNW | 52 NW | 47 NW | 80 WNW |
| VALENTINE | 50 | 45 N | 56 N | 49 NW | 55 N | 62 NW | 56 W | 56 SW | 65 NW | 57 S | 49 SE | 56 W | 50 N | 65 NW |
| NEV. ELY | 18 | 66 SE | 56 S | 59 SE | 59 S | 74 S | 63 SW | 50 S | 57 E | 57 S | 65 S | 51 S | 61 SE | 74 S |
| RENO | 56 | 66 SW | 66 SW | 68 S | 66 SW | 63 SW | 66 S | 43 W | 57 S | 48 S | 66 S | 59 SW | 72 S | 72 S |
| WINNEMUCCA | 46 | 56 W | 59 W | 63 W | 49 S | 61 N | 53 W | 56 W | 51 W | 57 W | 54 NE | 59 SW | 69 E | 69 E |
| N. H. CONCORD | 50 | 43 NW | 42 N | 71 NE | 52 NW | 48 NW | 38 SW | 37 NW | 56 E | 61 SE | 39 NW | 72 NE | 51 NE | 72 NE |
| MT. WASHINGTON | 29 | 170 W | 144 SE | 180 W | 231 SE | 164 W | 136 NW | 110 - | 142 ENE | 157 SE | 161 W | 160 SE | 175 W | 231 SE |
| N. J. ATLANTIC CITY | 37 | 80 E | 77 SE | 72 SE | 80 NE | 59 NE | 57 NE | 61 SW | 76 E | 91 NE | 72 NE | 72 E | 70 NE | 91 NE |
| NEWARK | 10 | 46 WSW | 50 WSW | 55 WSW | 52 WSW | 40 W | 55 ENE | 45 S | 46 E | 43 NW | 48 ESE | 82 E | 42 SSW | 82 E |
| TRENTON | 49 | 62 NE | 60 W | 60 NW | 54 NE | 56 W | 57 NW | 73 NE | 47 N | 56 NW | 60 NW | 64 E | 56 W | 73 NE |
| N. MEX. ALBUQUERQUE | 30 | 61 E | 68 NW | 80 NW | 72 S | 72 W | 82 SE | 68 E | 61 SE | 62 SE | 66 N | 57 NW | 90 SE | 90 SE |
| ROSWELL | 57 | 67 NW | 70 NW | 66 NW | 75 W | 72 N | 66 W | 66 SW | 72 W | 54 NW | 66 W | 65 W | 72 W | 75 W |
| N. Y. ALBANY | 50 | 57 W | 71 NW | 55 W | 49 W | 50 W | 45 W | 43 NW | 38 S | 48 S | 45 NW | 70 E | 54 W | 71 NW |
| BINGHAMTON | 18 | 59 NW | 66 NW | 61 NW | 52 W | 54 W | 60 NW | 58 W | 58 N | 42 NW | 72 S | 57 SE | 59 NW | 72 S |
| BUFFALO | 50 | 91 SW | 73 SW | 84 SW | 73 W | 63 SW | 73 W | 62 SW | 60 W | 68 SW | 71 W | 76 SW | 85 SW | 91 SW |
| NEW YORK CITY | 46 | 76 SW | 91 SW | 91 SW | 95 NW | 74 W | 94 W | 95 NW | 74 NW | 99 N | 113 SE | 87 W | 91 NW | 113 SE |

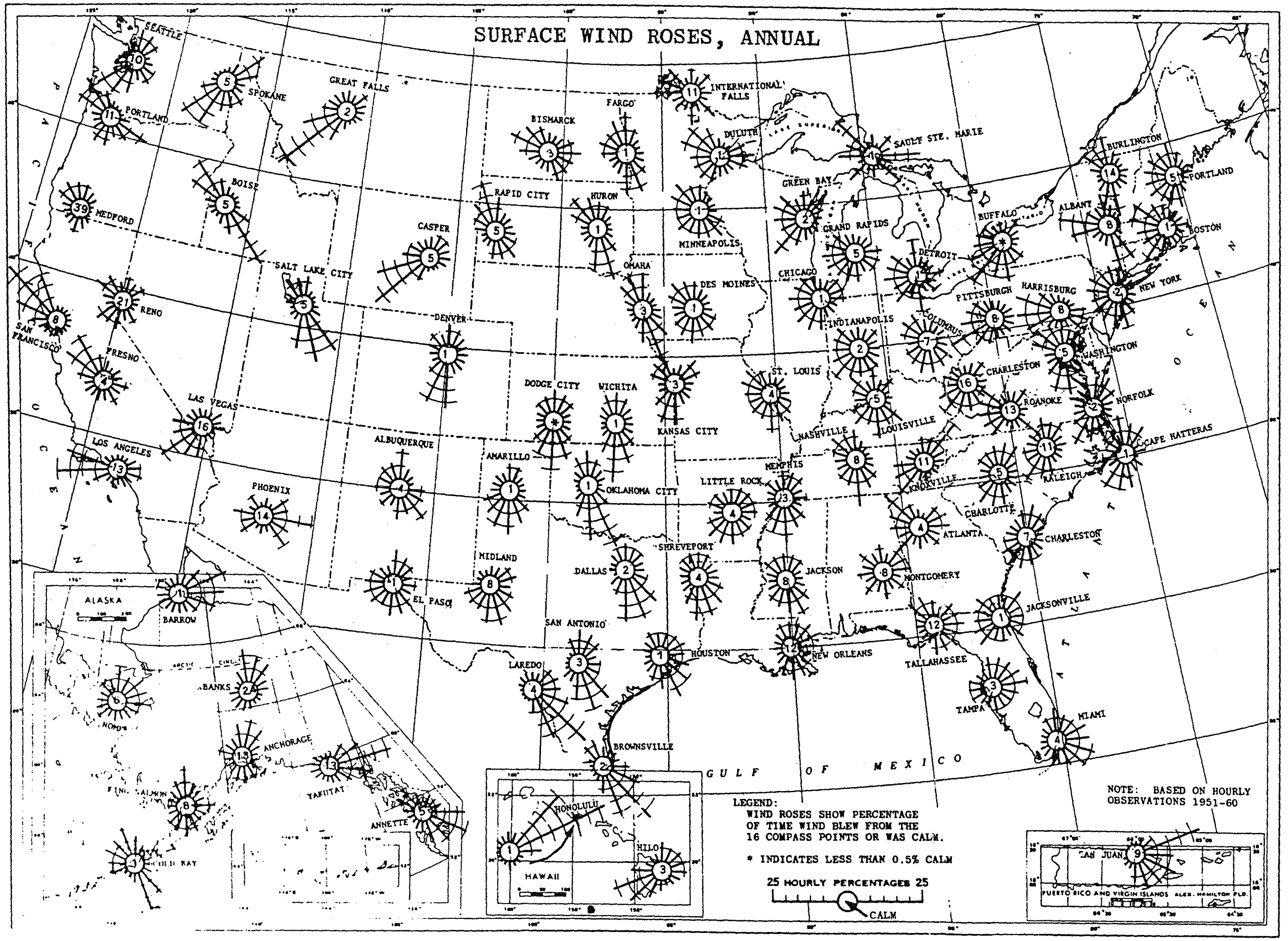
Scale for the 48 Contiguous States in Map Above:

200 0 200 400 600 800 1000 Miles

SCALE 1:20,000,000

ALBERS EQUAL AREA PROJECTION-STANDARD PARALLELS 29½° AND 45½°

# SURFACE WIND ROSES, MONTHLY AND ANNUAL; RESULTANT SURFACE WINDS, MIDSEASONAL - C



LEGEND:
WIND ROSES SHOW PERCENTAGE OF TIME WIND BLEW FROM THE 16 COMPASS POINTS OR WAS CALM.

* INDICATES LESS THAN 0.5% CALM

25 HOURLY PERCENTAGES 25

CALM

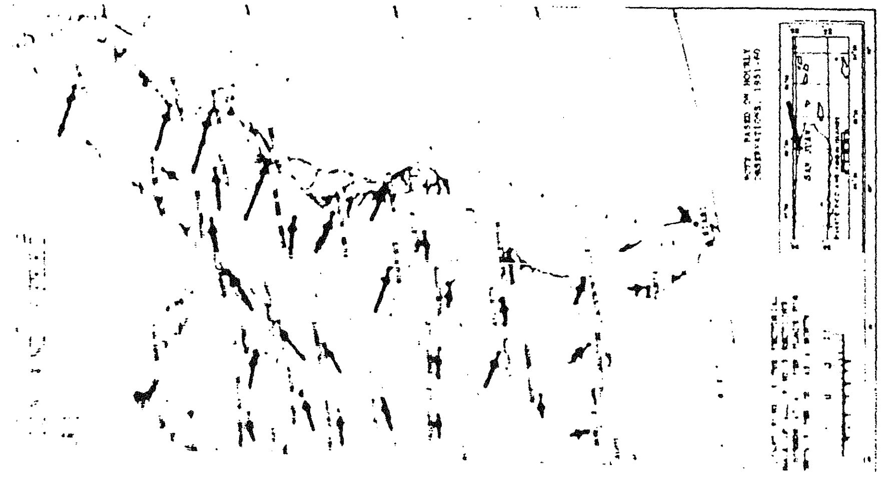
NOTE: BASED ON HOURLY OBSERVATIONS 1951-60

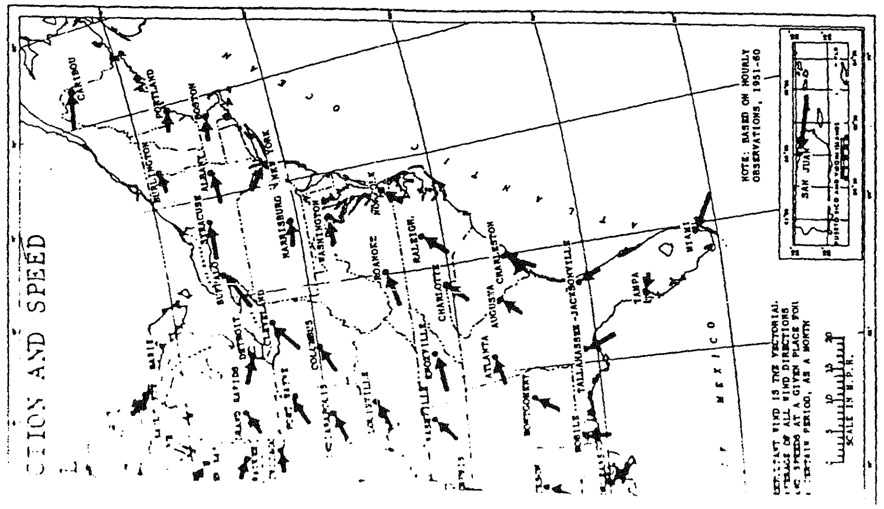
ANNUAL PERCENTAGE FREQUENCY
AND THE ME

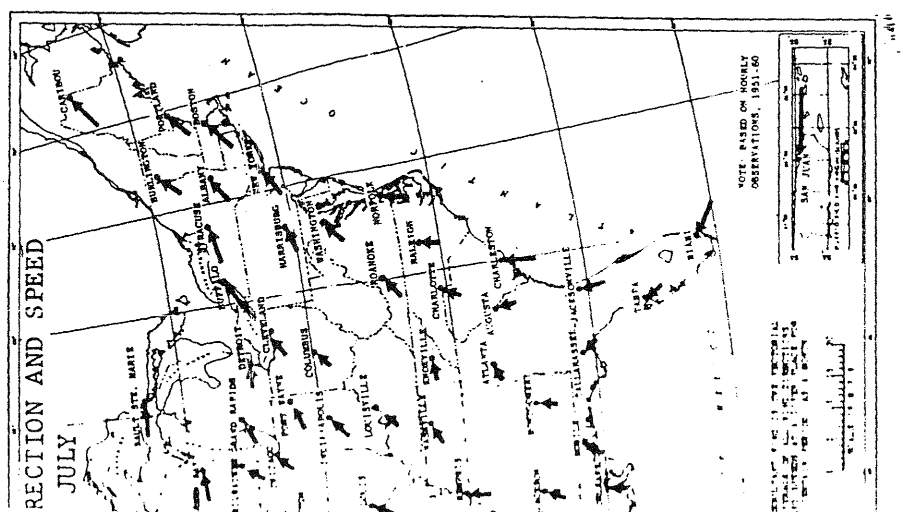
| STATE AND STATION | 0 - 3 m.p.h. | 4 - 7 m.p.h. | 8 - 12 m.p.h. | 13 - 18 m.p.h. | 19 - 24 m.p.h. | 25 - 31 m.p.h. | 32 - 38 m.p.h. | 39 - 46 m.p.h. | 47 m.p.h. and over | Mean speed m.p.h. |
|---|---|---|---|---|---|---|---|---|---|---|
| ALA. Birmingham | 27 | 22 | 30 | 17 | 3 | 1 | * | * | * | 7.9 |
| Mobile | 7 | 28 | 38 | 20 | 6 | 1 | * | * | * | 10.0 |
| Montgomery | 31 | 29 | 27 | 12 | 2 | * | * |  |  | 6.9 |
| ALASKA, Anchorage | 28 | 35 | 25 | 11 | 2 | * | * | * |  | 6.8 |
| Cold Bay | 4 | 9 | 18 | 27 | 21 | 14 | 5 | 2 | * | 17.4 |
| Fairbanks | 40 | 35 | 19 | 5 | 1 | * | * | * |  | 5.2 |
| King Salmon | 11 | 20 | 30 | 24 | 10 | 4 | 1 | * | * | 11.4 |
| ARIZ. Phoenix | 38 | 36 | 20 | 5 | 1 | * | * | * |  | 5.4 |
| Tucson | 18 | 35 | 30 | 14 | 3 | 1 | * | * |  | 8.1 |
| ARK. Little Rock | 12 | 30 | 39 | 16 | 2 | * | * | * |  | 8.7 |
| CALIF. Bakersfield | 35 | 30 | 24 | 10 | 1 | * | * |  |  | 5.8 |
| Burbank | 52 | 26 | 18 | 4 | 1 | * | * | * |  | 4.5 |
| Fresno | 30 | 41 | 22 | 7 | 1 | * | * |  |  | 6.1 |
| Los Angeles | 28 | 33 | 27 | 11 | 1 | * | * |  |  | 6.8 |
| Oakland | 26 | 28 | 28 | 16 | 2 | 1 | * | * | * | 7.5 |
| Sacramento | 15 | 28 | 31 | 18 | 5 | 1 | * | * | * | 9.3 |
| San Diego | 28 | 38 | 28 | 6 | * | * | * |  |  | 6.3 |
| San Francisco | 16 | 21 | 26 | 22 | 11 | 3 | * | * | * | 10.6 |
| COLO. Colorado Springs | 9 | 27 | 38 | 19 | 6 | 2 | * | * | * | 10.0 |
| Denver | 11 | 27 | 34 | 22 | 5 | 2 | * | * | * | 10.0 |
| CONN. Hartford | 13 | 26 | 32 | 24 | 6 | 1 | * | * | * | 9.8 |
| D.C. Washington | 11 | 26 | 35 | 22 | 5 | 1 | * | * | * | 9.7 |
| DEL. Wilmington | 15 | 31 | 30 | 19 | 4 | 1 | * | * | * | 8.8 |
| FLA. Jacksonville | 10 | 33 | 35 | 18 | 3 | * | * | * |  | 8.9 |
| Miami | 14 | 30 | 34 | 20 | 2 | * | * | * | * | 8.8 |
| Orlando | 18 | 28 | 32 | 17 | 4 | * | * | * |  | 8.6 |
| Tallahassee | 33 | 36 | 23 | 7 | * | * |  |  |  | 6.1 |
| Tampa | 9 | 31 | 40 | 16 | 2 | * | * | * | * | 8.8 |
| West Palm Beach | 9 | 22 | 36 | 27 | 6 | 1 | * | * |  | 10.5 |
| GA. Atlanta | 13 | 24 | 36 | 21 | 6 | 1 | * | * |  | 9.7 |
| Augusta | 36 | 29 | 25 | 9 | 1 | * | * |  |  | 6.3 |
| Macon | 10 | 26 | 46 | 16 | 2 | * | * | * | * | 8.9 |
| Savannah | 12 | 34 | 37 | 14 | 3 | * | * | * | * | 8.4 |
| HAWAII, Hilo | 7 | 34 | 43 | 15 | 2 | * | * |  |  | 8.7 |
| Honolulu | 9 | 17 | 27 | 32 | 12 | 2 | * | * | * | 12.1 |
| IDAHO, Boise | 15 | 30 | 32 | 18 | 4 | 1 | * | * |  | 8.9 |
| ILL. Chicago (O'Hare) | 8 | 22 | 33 | 27 | 8 | 2 | * | * | * | 11.2 |
| Chicago (Midway) | 7 | 26 | 36 | 25 | 5 | 1 | * | * | * | 10.2 |
| Moline | 14 | 23 | 32 | 24 | 7 | 2 | * | * | * | 10.0 |
| Springfield | 7 | 22 | 28 | 27 | 12 | 3 | 1 | * | * | 12.0 |
| IND. Evansville | 19 | 23 | 32 | 21 | 5 | 1 | * | * |  | 9.1 |
| Fort Wayne | 9 | 23 | 33 | 25 | 8 | 2 | * | * | * | 10.9 |
| Indianapolis | 9 | 22 | 34 | 26 | 7 | 2 | * | * | * | 10.8 |
| South Bend | 7 | 21 | 35 | 30 | 7 | 1 | * | * |  | 10.9 |
| IOWA, Des Moines | 3 | 17 | 38 | 29 | 10 | 3 | 1 | * | * | 12.1 |
| Sioux City | 10 | 20 | 31 | 25 | 10 | 4 | 1 | * | * | 11.7 |

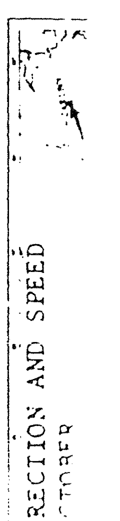
| STATE AND STATION | 0 - 3 m.p.h. | 4 - 7 m.p.h. | 8 - 12 m.p.h. | 13 - 18 m.p.h. | 19 - 24 m.p.h. |
|---|---|---|---|---|---|
| KANS. Topeka | 11 | 19 | 30 | 27 | 10 |
| Wichita | 4 | 12 | 30 | 31 | 16 |
| KY. Lexington | 8 | 25 | 39 | 22 | 6 |
| Louisville | 17 | 28 | 31 | 20 | 3 |
| LA. Baton Rouge | 17 | 29 | 34 | 17 | 3 |
| Lake Charles | 19 | 31 | 29 | 17 | 4 |
| New Orleans | 16 | 27 | 32 | 19 | 5 |
| Shreveport | 12 | 26 | 37 | 21 | 4 |
| MAINE, Portland | 10 | 30 | 33 | 22 | 4 |
| MD. Baltimore | 7 | 24 | 39 | 22 | 6 |
| MASS. Boston | 3 | 12 | 33 | 35 | 12 |
| MICH. Detroit (City AP) | 8 | 23 | 37 | 26 | 5 |
| Flint | 16 | 26 | 32 | 22 | 3 |
| Grand Rapids | 14 | 23 | 32 | 25 | 5 |
| MINN. Duluth | 6 | 15 | 33 | 31 | 11 |
| Minneapolis | 8 | 21 | 34 | 28 | 9 |
| MISS. Jackson | 33 | 25 | 26 | 14 | 2 |
| MO. Kansas City | 9 | 29 | 35 | 23 | 5 |
| St. Louis | 10 | 29 | 36 | 21 | 3 |
| Springfield | 4 | 13 | 34 | 32 | 13 |
| MONT. Great Falls | 7 | 19 | 24 | 24 | 15 |
| NEBR. Omaha | 12 | 17 | 29 | 28 | 11 |
| NEV. Las Vegas | 18 | 26 | 25 | 20 |  |
| Reno | 52 | 20 | 13 | 10 | 4 |
| N. J. Newark | 11 | 25 | 34 | 24 |  |
| N. MEX. Albuquerque | 17 | 36 | 26 | 13 |  |
| N. Y. Albany | 23 | 24 | 27 | 21 |  |
| Binghamton | 11 | 23 | 35 | 25 |  |
| Buffalo | 5 | 17 | 34 | 27 |  |
| New York (Kennedy) | 6 | 17 | 35 | 28 |  |
| New York (La Guardia) | 6 | 15 | 30 | 31 |  |
| Rochester | 8 | 22 | 34 | 25 |  |
| Syracuse | 14 | 27 | 30 | 23 |  |
| N. C. Charlotte | 20 | 32 | 31 | 14 |  |
| Greensboro | 20 | 32 | 31 | 14 |  |
| Raleigh | 18 | 33 | 34 | 14 |  |
| Winston-Salem | 19 | 22 | 33 | 21 |  |
| N. DAK. Bismarck | 14 | 20 | 27 | 24 |  |
| Fargo | 4 | 13 | 28 | 31 |  |
| OHIO, Akron-Canton | 7 | 25 | 35 | 26 |  |
| Cincinnati | 11 | 27 | 36 | 22 |  |
| Cleveland | 7 | 18 | 35 | 29 |  |
| Columbus | 26 | 23 | 29 | 18 |  |
| Dayton | 8 | 25 | 36 | 23 |  |
| Youngstown | 7 | 26 | 36 | 24 |  |
| OKLA. Oklahoma City | 2 | 11 | 34 | 34 |  |

Source: Climatography of the United States
the United States Climate -- Summary of Hourly

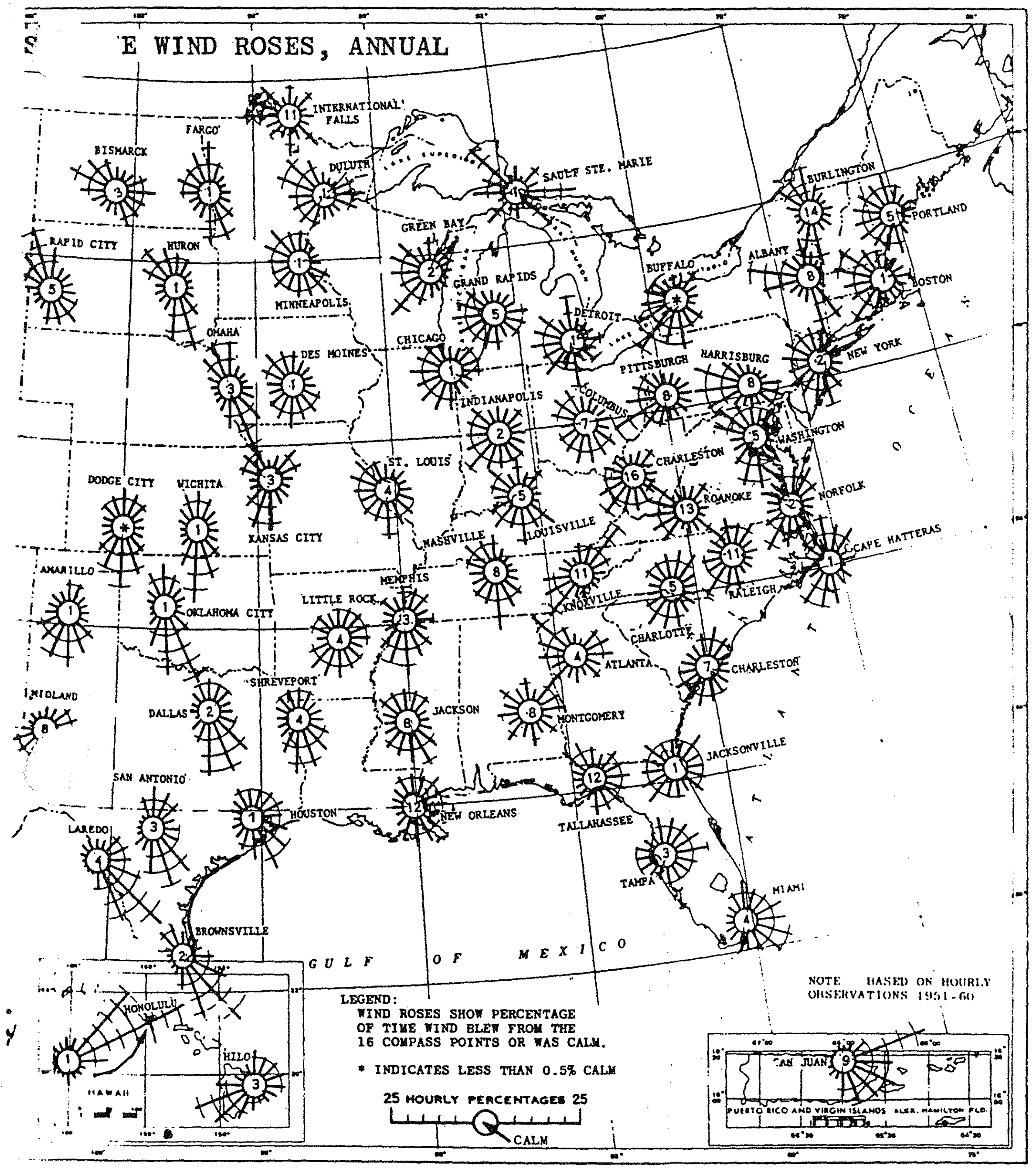








# RFACE WIND ROSES, MONTHLY AND ANNUAL; RESULTANT SURFACE WINDS, MIDSEASONAL - Continued


E WIND ROSES, ANNUAL

LEGEND:
WIND ROSES SHOW PERCENTAGE OF TIME WIND BLEW FROM THE 16 COMPASS POINTS OR WAS CALM.
* INDICATES LESS THAN 0.5% CALM

25 HOURLY PERCENTAGES 25

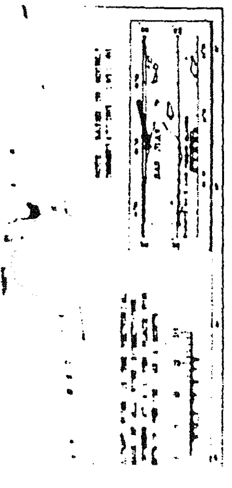
CALM

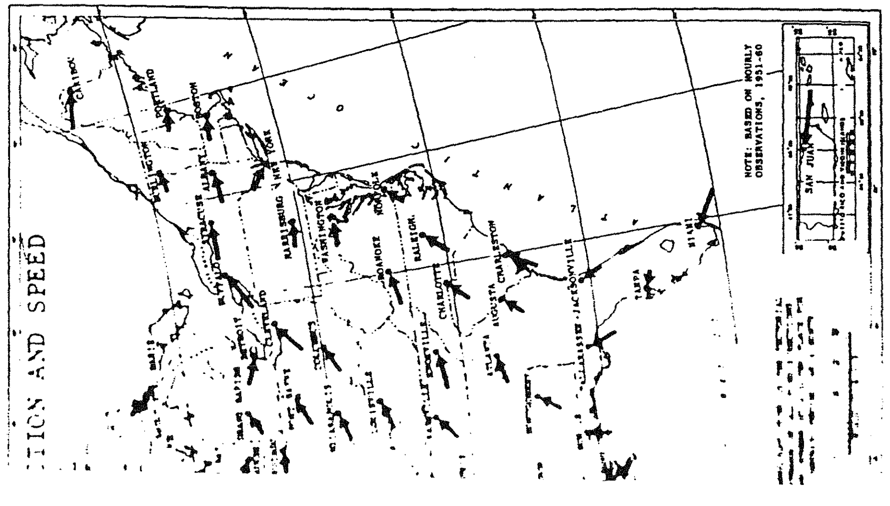
NOTE: BASED ON HOURLY OBSERVATIONS 1951-60

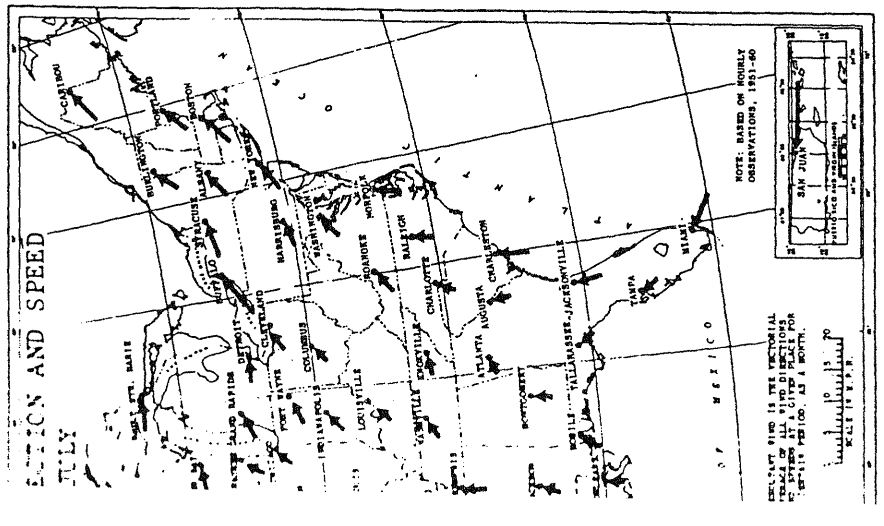
## ANNUAL PERCENTAGE FREQUENCY OF WIND BY SPEED GROUPS AND THE MEAN SPEED

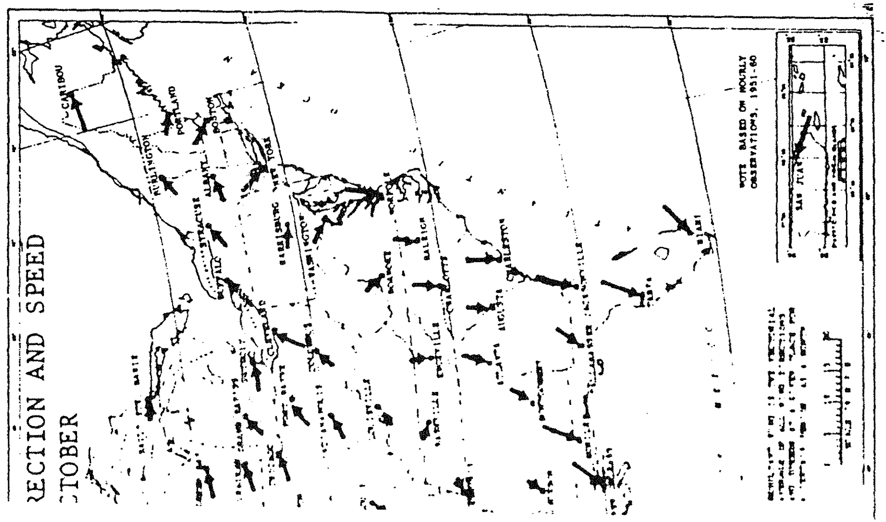
| STATE AND STATION | 0 - 3 m.p.h. | 4 - 7 m.p.h. | 8 - 12 m.p.h. | 13 - 18 m.p.h. | 19 - 24 m.p.h. | 25 - 31 m.p.h. | 32 - 38 m.p.h. | 39 - 46 m.p.h. | 47 m.p.h. and over | Mean speed m.p.h. |
|---|---|---|---|---|---|---|---|---|---|---|
| ALA. Birmingham | 27 | 22 | 30 | 17 | 3 | 1 | * | * | * | 7.9 |
| Mobile | 7 | 28 | 38 | 20 | 6 | 1 | * | * | * | 10.0 |
| Montgomery | 31 | 29 | 27 | 12 | 2 | * | * |  |  | 6.9 |
| ALASKA, Anchorage | 28 | 35 | 25 | 11 | 2 | * | * | * |  | 6.8 |
| Cold Bay | 4 | 9 | 18 | 27 | 21 | 14 | 5 | 2 | * | 17.4 |
| Fairbanks | 40 | 35 | 19 | 5 | 1 | * | * | * |  | 5.2 |
| King Salmon | 11 | 20 | 30 | 24 | 10 | 4 | 1 | * | * | 11.4 |
| ARIZ. Phoenix | 38 | 36 | 20 | 5 | 1 | * | * | * |  | 5.4 |
| Tucson | 18 | 35 | 30 | 14 | 3 | 1 | * | * |  | 8.1 |
| ARK. Little Rock | 12 | 30 | 39 | 16 | 2 | * | * | * |  | 8.7 |
| CALIF. Bakersfield | 35 | 30 | 24 | 10 | 1 | * | * |  |  | 5.8 |
| Burbank | 52 | 26 | 18 | 4 | 1 | * | * | * |  | 4.5 |
| Fresno | 30 | 41 | 22 | 7 | 1 | * | * |  |  | 6.1 |
| Los Angeles | 28 | 33 | 27 | 11 | 1 | * | * |  |  | 6.8 |
| Oakland | 26 | 28 | 28 | 16 | 2 | 1 | * | * | * | 7.5 |
| Sacramento | 15 | 28 | 31 | 18 | 5 | 1 | * | * | * | 9.3 |
| San Diego | 28 | 38 | 28 | 6 | * | * | * |  |  | 6.3 |
| San Francisco | 16 | 21 | 26 | 22 | 11 | 3 | * | * | * | 10.6 |
| COLO. Colorado Springs | 9 | 27 | 38 | 19 | 6 | 2 | * | * | * | 10.0 |
| Denver | 11 | 27 | 34 | 22 | 5 | 2 | * | * | * | 10.0 |
| CONN. Hartford | 13 | 26 | 32 | 24 | 6 | 1 | * | * | * | 9.8 |
| D.C. Washington | 11 | 26 | 35 | 22 | 5 | 1 | * | * | * | 9.7 |
| DEL. Wilmington | 15 | 31 | 30 | 19 | 4 | 1 | * | * | * | 8.8 |
| FLA. Jacksonville | 10 | 33 | 35 | 18 | 3 | * | * | * |  | 8.9 |
| Miami | 14 | 30 | 34 | 20 | 2 | * | * | * | * | 8.8 |
| Orlando | 18 | 28 | 32 | 17 | 4 | * | * | * |  | 8.6 |
| Tallahassee | 33 | 36 | 23 | 7 | * | * |  |  |  | 6.1 |
| Tampa | 9 | 31 | 40 | 16 | 2 | * | * | * | * | 8.8 |
| West Palm Beach | 9 | 22 | 36 | 27 | 6 | 1 | * | * |  | 10.5 |
| GA. Atlanta | 13 | 24 | 36 | 21 | 6 | 1 | * | * |  | 9.7 |
| Augusta | 36 | 29 | 25 | 9 | 1 | * | * |  |  | 6.3 |
| Macon | 10 | 26 | 46 | 16 | 2 | * | * | * | * | 8.9 |
| Savannah | 12 | 34 | 37 | 14 | 3 | * | * | * | * | 8.4 |
| HAWAII, Hilo | 7 | 34 | 43 | 15 | 2 | * | * |  |  | 8.7 |
| Honolulu | 9 | 17 | 27 | 32 | 12 | 2 | * | * | * | 12.1 |
| IDAHO, Boise | 15 | 30 | 32 | 18 | 4 | 1 | * | * |  | 8.9 |
| ILL. Chicago (O'Hare) | 8 | 22 | 33 | 27 | 8 | 2 | * | * | * | 11.2 |
| Chicago (Midway) | 7 | 26 | 36 | 25 | 5 | 1 | * | * | * | 10.2 |
| Moline | 14 | 23 | 32 | 24 | 7 | 2 | * | * | * | 10.0 |
| Springfield | 7 | 22 | 28 | 27 | 12 | 3 | 1 | * | * | 12.0 |
| IND. Evansville | 19 | 23 | 32 | 21 | 5 | 1 | * | * |  | 9.1 |
| Fort Wayne | 9 | 23 | 33 | 25 | 8 | 2 | * | * | * | 10.9 |
| Indianapolis | 9 | 22 | 34 | 26 | 7 | 2 | * | * | * | 10.8 |
| South Bend | 7 | 21 | 35 | 30 | 7 | 1 | * | * |  | 10.9 |
| IOWA, Des Moines | 3 | 17 | 38 | 29 | 10 | 3 | 1 | * | * | 12.1 |
| Sioux City | 10 | 20 | 31 | 25 | 10 | 4 | 1 | * | * | 11.7 |
| KANS. Topeka | 11 | 19 | 30 | 27 | 10 | 2 | * | * | * | 11.2 |
| Wichita | 4 | 12 | 30 | 31 | 16 | 5 | 1 | * | * | 13.7 |
| KY. Lexington | 8 | 25 | 39 | 22 | 6 | 1 | * | * |  | 10.1 |
| Louisville | 17 | 28 | 31 | 20 | 3 | 1 | * | * |  | 8.8 |
| LA. Baton Rouge | 17 | 29 | 34 | 17 | 3 | * | * | * |  | 8.3 |
| Lake Charles | 19 | 31 | 29 | 17 | 4 | 1 | * | * | * | 8.5 |
| New Orleans | 16 | 27 | 32 | 19 | 5 | 1 | * | * | * | 9.0 |
| Shreveport | 12 | 26 | 37 | 21 | 4 | 1 | * | * | * | 9.5 |
| MAINE, Portland | 10 | 30 | 33 | 22 | 4 | 1 | * | * | * | 9.6 |
| MD. Baltimore | 7 | 24 | 39 | 22 | 6 | 2 | * | * | * | 10.4 |
| MASS. Boston | 3 | 12 | 33 | 35 | 12 | 4 | 1 | * | * | 13.3 |
| MICH. Detroit (City AP) | 8 | 23 | 37 | 26 | 5 | 1 | * | * | * | 10.3 |
| Flint | 16 | 26 | 32 | 22 | 3 | 1 | * | * | * | 9.0 |
| Grand Rapids | 14 | 23 | 32 | 25 | 5 | 1 | * | * | * | 9.8 |
| MINN. Duluth | 6 | 15 | 33 | 31 | 11 | 4 | 1 | * | * | 12.6 |
| Minneapolis | 8 | 21 | 34 | 28 | 9 | 2 | * | * | * | 11.2 |
| MISS. Jackson | 33 | 25 | 26 | 14 | 2 | * | * | * |  | 7.1 |
| MO. Kansas City | 9 | 29 | 35 | 23 | 5 | 1 | * |  |  | 9.8 |
| St. Louis | 10 | 29 | 36 | 21 | 3 | 1 | * | * | * | 9.3 |
| Springfield | 4 | 13 | 34 | 32 | 13 | 3 | 1 | * | * | 12.9 |
| MONT. Great Falls | 7 | 19 | 24 | 24 | 15 | 9 | 3 | 1 | * | 13.9 |
| NEBR. Omaha | 12 | 17 | 29 | 28 | 11 | 3 | * | * |  | 11.6 |
| NEV. Las Vegas | 18 | 26 | 25 | 20 | 8 | 3 | 1 | * | * | 9.7 |
| Reno | 52 | 20 | 13 | 10 | 4 | 1 | * | * | * | 5.9 |
| N. J. Newark | 11 | 25 | 34 | 24 | 5 | 1 | * | * | * | 9.8 |
| N. MEX. Albuquerque | 17 | 36 | 26 | 13 | 5 | 2 | * | * | * | 8.6 |
| N. Y. Albany | 23 | 24 | 27 | 21 | 4 | 1 | * | * |  | 8.6 |
| Binghamton | 11 | 23 | 35 | 25 | 5 | 1 | * | * | * | 10.0 |
| Buffalo | 5 | 17 | 34 | 27 | 13 | 3 | 1 | * | * | 12.4 |
| New York (Kennedy) | 6 | 17 | 35 | 28 | 10 | 3 | * | * | * | 12.0 |
| New York (La Guardia) | 6 | 15 | 30 | 31 | 12 | 4 | 1 | * | * | 12.9 |
| Rochester | 8 | 22 | 34 | 25 | 9 | 2 | 1 | * | * | 11.2 |
| Syracuse | 14 | 27 | 30 | 23 | 5 | 1 | * | * | * | 9.7 |
| N. C. Charlotte | 20 | 32 | 31 | 14 | 2 | * | * | * |  | 7.9 |
| Greensboro | 20 | 32 | 31 | 14 | 2 | * | * | * | * | 8.0 |
| Raleigh | 18 | 33 | 34 | 14 | 2 | * | * | * | * | 7.7 |
| Winston-Salem | 19 | 22 | 33 | 21 | 4 | 1 | * | * |  | 9.0 |
| N. DAK. Bismarck | 14 | 20 | 27 | 24 | 12 | 3 | 1 | * | * | 11.2 |
| Fargo | 4 | 13 | 28 | 31 | 15 | 7 | 2 | * | * | 14.4 |
| OHIO, Akron-Canton | 7 | 25 | 35 | 26 | 5 | 1 | * | * | * | 10.4 |
| Cincinnati | 11 | 27 | 36 | 22 | 4 | 1 | * | * | * | 9.6 |
| Cleveland | 7 | 18 | 35 | 29 | 9 | 2 | * | * | * | 11.6 |
| Columbus | 26 | 23 | 29 | 18 | 4 | 1 | * | * | * | 8.2 |
| Dayton | 8 | 25 | 36 | 23 | 6 | 2 | * | * | * | 10.3 |
| Youngstown | 7 | 26 | 36 | 24 | 6 | 1 | * | * | * | 10.3 |
| OKLA. Oklahoma City | 2 | 11 | 34 | 34 | 13 | 6 | 1 | * | * | 14.0 |
| OKLA. (Cont.) Tulsa | 9 | 24 | 34 | 26 | 7 | 1 | * | * | * | 10.6 |
| OREG. Medford | 47 | 31 | 14 | 6 | 2 | * | * | * | * | 4.6 |
| Portland | 28 | 27 | 25 | 16 | 4 | 1 | * | * | * | 7.7 |
| Salem | 25 | 32 | 28 | 13 | 2 | * | * |  |  | 7.1 |
| PA. Harrisburg | 28 | 31 | 25 | 13 | 3 | 1 | * | * |  | 7.3 |
| Philadelphia | 11 | 27 | 35 | 21 | 5 | 1 | * | * | * | 9.6 |
| Pittsburgh | 12 | 26 | 34 | 22 | 4 | 1 | * | * |  | 9.4 |
| Scranton | 11 | 33 | 35 | 18 | 2 | * | * | * |  | 8.8 |
| R. I. Providence | 11 | 20 | 32 | 28 | 7 | 2 | * | * | * | 10.7 |
| S. C. Charleston | 12 | 28 | 35 | 19 | 4 | 1 | * | * |  | 9.2 |
| Columbia | 25 | 35 | 26 | 12 | 2 | * | * |  |  | 7.0 |
| S. DAK. Huron | 10 | 18 | 29 | 29 | 10 | 3 | 1 | * | * | 11.9 |
| Rapid City | 15 | 22 | 28 | 21 | 10 | 4 | 1 | * | * | 11.0 |
| TENN. Chattanooga | 39 | 25 | 24 | 11 | 1 | * | * |  |  | 6.1 |
| Knoxville | 29 | 29 | 25 | 12 | 4 | 1 | * | * | * | 7.5 |
| Memphis | 14 | 26 | 34 | 20 | 5 | 1 | * | * |  | 9.4 |
| Nashville | 27 | 31 | 25 | 14 | 2 | * | * | * | * | 7.2 |
| TEX. Amarillo | 5 | 15 | 32 | 32 | 12 | 4 | 1 | * | * | 12.9 |
| Austin | 13 | 25 | 34 | 23 | 5 | 1 | * | * |  | 9.7 |
| Brownsville | 10 | 17 | 25 | 30 | 14 | 3 | * | * | * | 12.3 |
| Corpus Christi | 11 | 16 | 26 | 33 | 12 | 2 | * | * |  | 11.9 |
| Dallas | 9 | 21 | 32 | 28 | 9 | 1 | * | * |  | 11.0 |
| El Paso | 10 | 22 | 32 | 22 | 9 | 4 | 1 | * | * | 11.3 |
| Ft. Worth | 4 | 14 | 34 | 34 | 10 | 3 | * | * | * | 12.5 |
| Galveston | 4 | 13 | 39 | 33 | 10 | 2 | 1 | * | * | 12.5 |
| Houston | 6 | 18 | 36 | 28 | 10 | 2 | * | * | * | 11.8 |
| Laredo | 6 | 15 | 32 | 34 | 12 | 1 | * | * |  | 12.3 |
| Lubbock | 4 | 11 | 33 | 34 | 13 | 5 | 1 | * | * | 13.6 |
| Midland | 9 | 22 | 38 | 26 | 4 | 1 | * | * |  | 10.1 |
| San Antonio | 18 | 23 | 32 | 22 | 4 | 1 | * | * |  | 9.3 |
| Waco | 3 | 14 | 36 | 35 | 10 | 2 | * | * |  | 12.5 |
| Wichita Falls | 5 | 22 | 41 | 27 | 5 | 1 | * | * | * | 10.5 |
| UTAH, Salt Lake City | 12 | 33 | 36 | 14 | 4 | 1 | * | * | * | 8.7 |
| VT. Burlington | 24 | 24 | 28 | 22 | 2 | * | * |  |  | 8.3 |
| VA. Norfolk | 14 | 23 | 30 | 25 | 6 | 1 | * | * | * | 10.2 |
| Richmond | 14 | 37 | 36 | 11 | 1 | * | * | * |  | 7.8 |
| Roanoke | 31 | 22 | 23 | 17 | 5 | 2 | * | * |  | 8.3 |
| WASH. Seattle-Tacoma AP | 13 | 16 | 35 | 26 | 8 | 2 | * | * | * | 10.7 |
| Spokane | 17 | 38 | 27 | 14 | 3 | 1 | * | * |  | 8.1 |
| W. VA. Charleston | 29 | 37 | 25 | 8 | 1 | * | * |  |  | 6.2 |
| WIS. Green Bay | 8 | 22 | 32 | 26 | 10 | 2 | * | * | * | 11.2 |
| Madison | 15 | 22 | 30 | 23 | 7 | 2 | * | * | * | 10.1 |
| Milwaukee | 8 | 17 | 31 | 30 | 11 | 3 | 1 | * | * | 12.1 |
| WYO. Casper | 8 | 16 | 27 | 27 | 13 | 7 | 2 | * | * | 13.3 |
| PACIFIC, Wake Island | 1 | 6 | 27 | 48 | 17 | 2 | * | * |  | 14.6 |
| P. R. San Juan | 15 | 28 | 27 | 25 | 4 | * | * | * | * | 9.1 |

Source: Climatography of the United States Series 82; Decennial Census of the United States Climate -- Summary of Hourly Observations, 1951-60 (Table B)

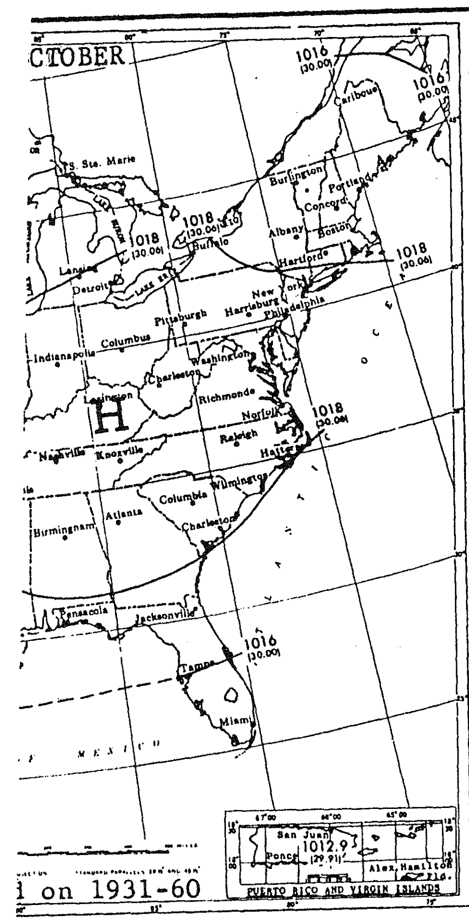


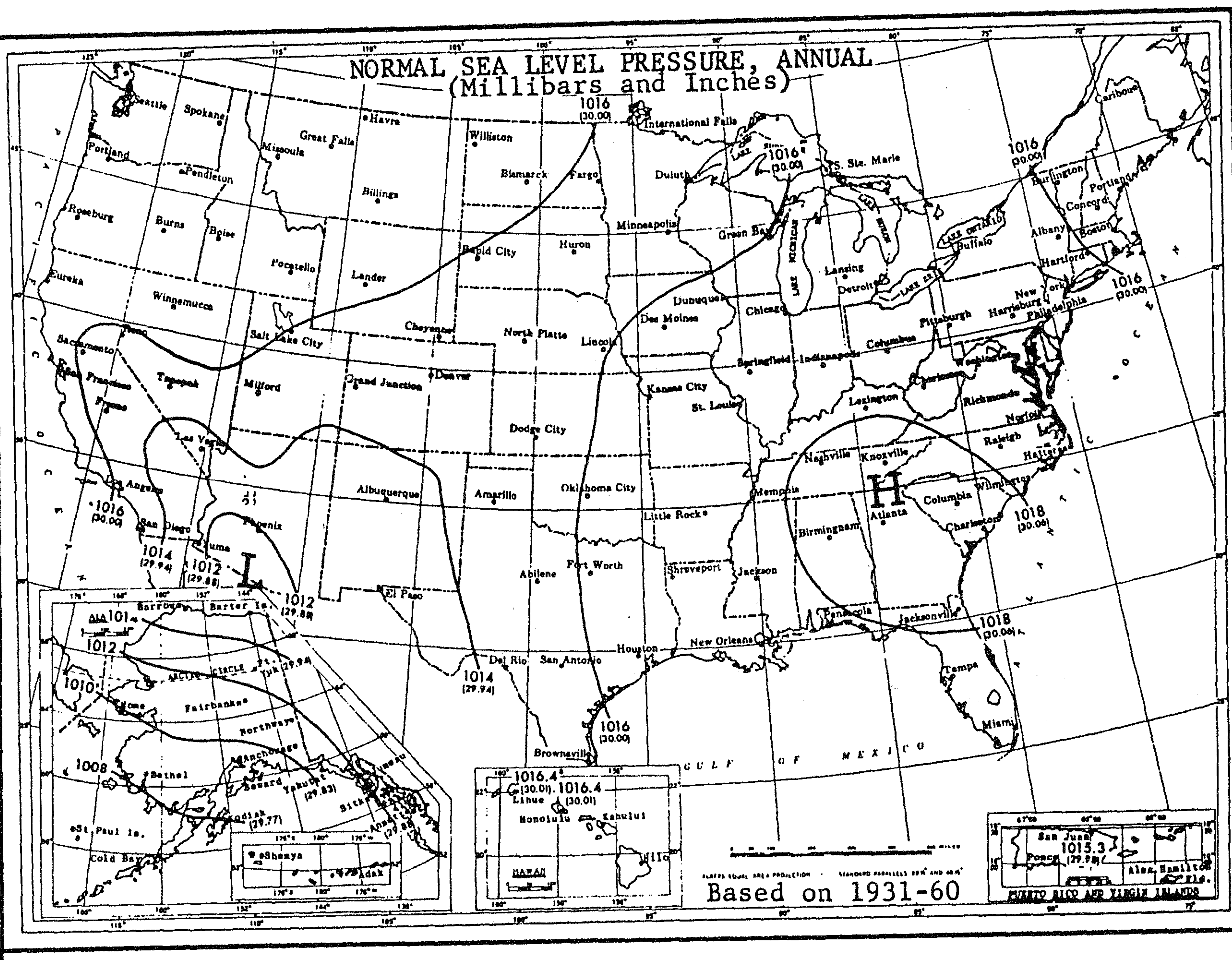


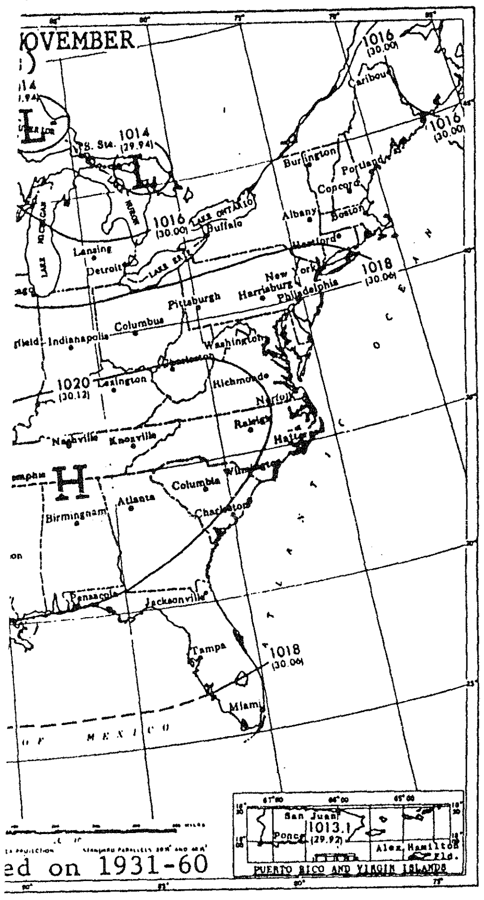


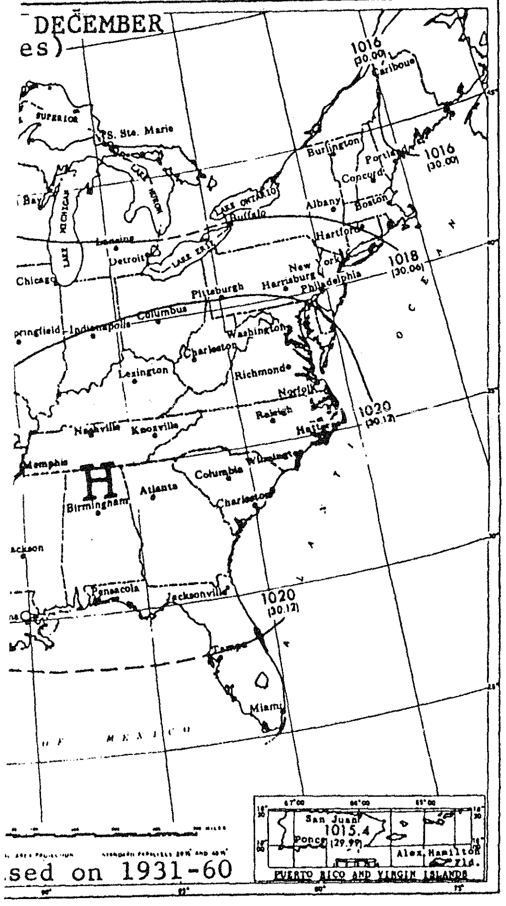


# NORMAL SEA LEVEL PRESSURE, MONTHLY AND ANNUAL -Continued









## MEAN SEA LEVEL PRESSURE
(Millibars and Inches)

| STATE AND STATION | JAN. | FEB. | MAR. | APR. | MAY | JUNE | JULY | AUG. | SEPT. | OCT. | NOV. | DEC. | ANNUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ALA. Birmingham | 1021 | 1019 | 1018 | 1017 | 1016 | 1016 | 1017 | 1017 | 1017 | 1019 | 1021 | 1021 | 1018 |
| " | 30.15 | 30.19 | 30.06 | 30.03 | 30.00 | 30.00 | 30.03 | 30.03 | 30.03 | 30.09 | 30.15 | 30.15 | 30.06 |
| ALASKA Anchorage | 1007 | 1008 | 1008 | 1009 | 1012 | 1014 | 1014 | 1012 | 1009 | 1002 | 1004 | 1002 | 1009 |
| " | 29.74 | 29.77 | 29.77 | 29.80 | 29.88 | 29.94 | 29.94 | 29.88 | 29.80 | 29.59 | 29.65 | 29.59 | 29.80 |
| Annette | 1010 | 1012 | 1011 | 1014 | 1016 | 1016 | 1018 | 1017 | 1015 | 1011 | 1010 | 1008 | 1013 |
| " | 29.83 | 29.88 | 29.86 | 29.94 | 30.00 | 30.00 | 30.06 | 30.03 | 29.97 | 29.86 | 29.83 | 29.77 | 29.91 |
| Barrow | 1019 | 1021 | 1021 | 1018 | 1018 | 1015 | 1012 | 1011 | 1013 | 1010 | 1016 | 1016 | 1016 |
| " | 30.09 | 30.15 | 30.15 | 30.06 | 30.06 | 29.97 | 29.88 | 29.86 | 29.91 | 29.83 | 30.00 | 30.00 | 30.00 |
| Barter Island | 1019 | 1020 | 1019 | 1018 | 1018 | 1015 | 1012 | 1011 | 1013 | 1010 | 1016 | 1016 | 1016 |
| " | 30.09 | 30.12 | 30.09 | 30.06 | 30.06 | 29.97 | 29.88 | 29.86 | 29.91 | 29.83 | 30.00 | 30.00 | 30.00 |
| Bethel | 1007 | 1008 | 1010 | 1009 | 1009 | 1012 | 1013 | 1011 | 1008 | 1003 | 1005 | 1005 | 1008 |
| " | 29.74 | 29.77 | 29.83 | 29.80 | 29.80 | 29.88 | 29.91 | 29.86 | 29.77 | 29.62 | 29.68 | 29.68 | 29.77 |
| Cold Bay | 1004 | 1005 | 1010 | 1008 | 1007 | 1012 | 1016 | 1013 | 1008 | 1003 | 999 | 1002 | 1007 |
| " | 29.65 | 29.68 | 29.83 | 29.77 | 29.74 | 29.88 | 30.00 | 29.91 | 29.77 | 29.62 | 29.50 | 29.59 | 29.74 |
| Cordova | 1005 | 1006 | 1007 | 1009 | 1013 | 1014 | 1015 | 1014 | 1010 | 1003 | 1003 | 1001 | 1008 |
| " | 29.68 | 29.71 | 29.74 | 29.80 | 29.91 | 29.94 | 29.97 | 29.94 | 29.83 | 29.62 | 29.62 | 29.56 | 29.77 |
| Fairbanks | 1014 | 1014 | 1013 | 1011 | 1011 | 1011 | 1012 | 1012 | 1010 | 1006 | 1011 | 1010 | 1011 |
| " | 29.94 | 29.94 | 29.91 | 29.86 | 29.86 | 29.86 | 29.88 | 29.88 | 29.83 | 29.71 | 29.86 | 29.83 | 29.86 |
| Juneau | 1011 | 1012 | 1011 | 1012 | 1015 | 1015 | 1017 | 1016 | 1014 | 1009 | 1009 | 1008 | 1012 |
| " | 29.86 | 29.88 | 29.86 | 29.88 | 29.97 | 29.97 | 30.03 | 30.00 | 29.94 | 29.80 | 29.80 | 29.77 | 29.88 |
| King Salmon | 1007 | 1006 | 1009 | 1008 | 1009 | 1012 | 1014 | 1012 | 1009 | 1002 | 1002 | 1003 | 1008 |
| " | 29.74 | 29.71 | 29.80 | 29.77 | 29.80 | 29.88 | 29.94 | 29.88 | 29.80 | 29.59 | 29.59 | 29.62 | 29.77 |
| Kotzebue | 1015 | 1015 | 1014 | 1013 | 1013 | 1012 | 1011 | 1009 | 1010 | 1005 | 1010 | 1011 | 1012 |
| " | 29.97 | 29.97 | 29.94 | 29.91 | 29.91 | 29.88 | 29.86 | 29.80 | 29.83 | 29.68 | 29.83 | 29.86 | 29.88 |
| McGrath | 1013 | 1013 | 1012 | 1010 | 1011 | 1012 | 1013 | 1011 | 1009 | 1004 | 1008 | 1009 | 1010 |
| " | 29.91 | 29.91 | 29.88 | 29.83 | 29.86 | 29.88 | 29.91 | 29.86 | 29.80 | 29.65 | 29.77 | 29.80 | 29.83 |
| Nome | 1011 | 1011 | 1012 | 1011 | 1011 | 1012 | 1012 | 1009 | 1008 | 1004 | 1007 | 1008 | 1010 |
| " | 29.86 | 29.86 | 29.88 | 29.86 | 29.86 | 29.88 | 29.88 | 29.80 | 29.77 | 29.65 | 29.74 | 29.77 | 29.83 |
| St. Paul Island | 1005 | 1004 | 1008 | 1007 | 1007 | 1011 | 1013 | 1011 | 1008 | 1003 | 1003 | 1002 | 1007 |
| " | 29.68 | 29.65 | 29.77 | 29.74 | 29.74 | 29.86 | 29.91 | 29.86 | 29.77 | 29.62 | 29.62 | 29.59 | 29.74 |
| Shemya Island | 999 | 999 | 1006 | 1011 | 1007 | 1012 | 1011 | 1011 | 1013 | 1006 | 1000 | 999 | 1006 |
| " | 29.50 | 29.50 | 29.71 | 29.86 | 29.74 | 29.88 | 29.86 | 29.86 | 29.91 | 29.71 | 29.53 | 29.50 | 29.71 |
| Yakutat | 1007 | 1009 | 1008 | 1011 | 1014 | 1015 | 1017 | 1015 | 1012 | 1005 | 1005 | 1004 | 1010 |
| " | 29.74 | 29.80 | 29.77 | 29.86 | 29.94 | 29.97 | 30.03 | 29.97 | 29.88 | 29.68 | 29.68 | 29.65 | 29.83 |
| ARIZ. Phoenix | 1018 | 1016 | 1013 | 1011 | 1008 | 1007 | 1008 | 1009 | 1009 | 1012 | 1016 | 1018 | 1012 |
| " | 30.06 | 30.00 | 29.91 | 29.86 | 29.77 | 29.74 | 29.77 | 29.80 | 29.80 | 29.88 | 30.00 | 30.06 | 29.88 |
| Yuma | 1018 | 1017 | 1014 | 1011 | 1009 | 1007 | 1008 | 1009 | 1008 | 1011 | 1016 | 1019 | 1012 |
| " | 30.06 | 30.03 | 29.94 | 29.86 | 29.80 | 29.74 | 29.77 | 29.80 | 29.77 | 29.86 | 30.00 | 30.09 | 29.88 |
| ARK. Little Rock | 1021 | 1020 | 1017 | 1015 | 1015 | 1014 | 1016 | 1015 | 1016 | 1018 | 1020 | 1021 | 1017 |
| " " | 30.15 | 30.12 | 30.03 | 29.97 | 29.97 | 29.94 | 30.00 | 29.97 | 30.00 | 30.06 | 30.12 | 30.15 | 30.03 |
| CALIF. Eureka | 1020 | 1019 | 1019 | 1019 | 1019 | 1018 | 1018 | 1017 | 1016 | 1018 | 1020 | 1020 | 1019 |
| " | 30.12 | 30.09 | 30.09 | 30.09 | 30.09 | 30.06 | 30.06 | 30.03 | 30.00 | 30.06 | 30.12 | 30.12 | 30.09 |
| Los Angeles | 1019 | 1018 | 1016 | 1015 | 1014 | 1013 | 1013 | 1013 | 1012 | 1015 | 1017 | 1018 | 1015 |
| " " | 30.09 | 30.06 | 30.00 | 29.97 | 29.94 | 29.91 | 29.91 | 29.91 | 29.88 | 29.97 | 30.03 | 30.06 | 29.97 |
| Mt. Shasta | 1020 | 1020 | 1018 | 1016 | 1016 | 1015 | 1015 | 1015 | 1016 | 1018 | 1021 | 1022 | 1018 |
| " " | 30.12 | 30.12 | 30.06 | 30.00 | 30.00 | 29.97 | 29.97 | 29.97 | 30.00 | 30.06 | 30.15 | 30.18 | 30.06 |
| Oakland | 1020 | 1019 | 1018 | 1017 | 1016 | 1014 | 1014 | 1014 | 1014 | 1016 | 1019 | 1020 | 1017 |
| " | 30.12 | 30.09 | 30.06 | 30.03 | 30.00 | 29.94 | 29.94 | 29.94 | 29.94 | 30.00 | 30.09 | 30.12 | 30.03 |
| Sacramento | 1020 | 1019 | 1018 | 1016 | 1014 | 1012 | 1012 | 1012 | 1012 | 1015 | 1019 | 1020 | 1016 |
| " | 30.12 | 30.09 | 30.06 | 30.00 | 29.94 | 29.88 | 29.88 | 29.88 | 29.88 | 29.97 | 30.09 | 30.12 | 30.00 |
| San Diego | 1018 | 1018 | 1017 | 1015 | 1014 | 1013 | 1013 | 1013 | 1012 | 1014 | 1017 | 1018 | 1015 |
| " " | 30.06 | 30.06 | 30.03 | 29.97 | 29.94 | 29.91 | 29.91 | 29.91 | 29.88 | 29.94 | 30.03 | 30.06 | 29.97 |
| San Francisco | 1020 | 1019 | 1018 | 1017 | 1016 | 1014 | 1014 | 1014 | 1014 | 1016 | 1019 | 1020 | 1017 |
| " " | 30.12 | 30.09 | 30.06 | 30.03 | 30.00 | 29.94 | 29.94 | 29.94 | 29.94 | 30.00 | 30.09 | 30.12 | 30.03 |
| Santa Maria | 1020 | 1019 | 1018 | 1017 | 1016 | 1014 | 1015 | 1015 | 1014 | 1016 | 1018 | 1020 | 1017 |
| " " | 30.12 | 30.09 | 30.06 | 30.03 | 30.00 | 29.94 | 29.97 | 29.97 | 29.94 | 30.00 | 30.06 | 30.12 | 30.03 |
| COLO. Denver | 1018 | 1016 | 1014 | 1013 | 1012 | 1011 | 1014 | 1014 | 1014 | 1016 | 1018 | 1018 | 1015 |
| " | 30.06 | 30.00 | 29.94 | 29.91 | 29.88 | 29.86 | 29.94 | 29.94 | 29.94 | 30.00 | 30.06 | 30.06 | 29.97 |
| Grand Junction | 1021 | 1018 | 1014 | 1012 | 1011 | 1010 | 1012 | 1013 | 1013 | 1017 | 1021 | 1022 | 1015 |
| " " | 30.15 | 30.06 | 29.94 | 29.88 | 29.86 | 29.83 | 29.88 | 29.91 | 29.91 | 30.03 | 30.15 | 30.18 | 29.97 |
| CONN. New Haven | 1016 | 1016 | 1015 | 1015 | 1015 | 1014 | 1015 | 1016 | 1018 | 1018 | 1017 | 1017 | 1016 |
| " " | 30.00 | 30.00 | 29.97 | 29.97 | 29.97 | 29.94 | 29.97 | 30.00 | 30.06 | 30.06 | 30.03 | 30.03 | 30.00 |
| D. C. Washington | 1020 | 1019 | 1017 | 1016 | 1016 | 1015 | 1016 | 1016 | 1019 | 1019 | 1020 | 1020 | 1018 |
| " | 30.12 | 30.09 | 30.03 | 30.00 | 30.00 | 29.97 | 30.00 | 30.00 | 30.09 | 30.09 | 30.12 | 30.12 | 30.06 |
| FLA. Jacksonville | 1021 | 1020 | 1018 | 1018 | 1017 | 1016 | 1018 | 1017 | 1016 | 1017 | 1020 | 1021 | 1018 |
| " | 30.15 | 30.12 | 30.06 | 30.06 | 30.03 | 30.00 | 30.06 | 30.03 | 30.00 | 30.03 | 30.12 | 30.15 | 30.06 |
| Key West | 1019 | 1018 | 1017 | 1016 | 1015 | 1015 | 1017 | 1015 | 1013 | 1014 | 1017 | 1019 | 1016 |
| " " | 30.09 | 30.06 | 30.03 | 30.00 | 29.97 | 29.97 | 30.03 | 29.97 | 29.91 | 29.94 | 30.03 | 30.09 | 30.00 |
| Miami | 1020 | 1019 | 1018 | 1017 | 1016 | 1016 | 1017 | 1016 | 1014 | 1015 | 1017 | 1019 | 1017 |
| " | 30.12 | 30.09 | 30.06 | 30.03 | 30.00 | 30.00 | 30.03 | 30.00 | 29.94 | 29.97 | 30.03 | 30.09 | 30.03 |
| Pensacola | 1021 | 1020 | 1018 | 1017 | 1016 | 1016 | 1016 | 1016 | 1016 | 1018 | 1020 | 1020 | 1018 |
| " | 30.15 | 30.12 | 30.06 | 30.03 | 30.00 | 30.00 | 30.00 | 30.00 | 30.00 | 30.06 | 30.12 | 30.12 | 30.06 |
| GA. Atlanta | 1021 | 1019 | 1017 | 1017 | 1016 | 1016 | 1017 | 1016 | 1017 | 1019 | 1021 | 1021 | 1018 |
| " | 30.15 | 30.09 | 30.03 | 30.03 | 30.00 | 30.00 | 30.03 | 30.00 | 30.03 | 30.09 | 30.15 | 30.15 | 30.06 |
| Macon | 1020 | 1018 | 1017 | 1016 | 1016 | 1015 | 1016 | 1015 | 1016 | 1017 | 1020 | 1021 | 1017 |
| " | 30.12 | 30.06 | 30.03 | 30.00 | 30.00 | 29.97 | 30.00 | 29.97 | 30.00 | 30.03 | 30.12 | 30.15 | 30.03 |
| HAWAII Hilo | 1016 | 1016 | 1017 | 1018 | 1018 | 1018 | 1017 | 1016 | 1015 | 1016 | 1016 | 1016 | 1017 |
| " | 30.00 | 30.00 | 30.03 | 30.06 | 30.06 | 30.06 | 30.03 | 30.00 | 29.97 | 30.00 | 30.00 | 30.00 | 30.03 |
| Honolulu | 1016 | 1016 | 1017 | 1018 | 1018 | 1017 | 1017 | 1016 | 1015 | 1016 | 1016 | 1016 | 1016 |
| " | 30.00 | 30.00 | 30.03 | 30.06 | 30.06 | 30.03 | 30.03 | 30.00 | 29.97 | 30.00 | 30.00 | 30.00 | 30.00 |
| Lihue | 1015 | 1016 | 1017 | 1018 | 1018 | 1018 | 1017 | 1016 | 1016 | 1016 | 1016 | 1016 | 1016 |
| " | 29.97 | 30.00 | 30.03 | 30.06 | 30.06 | 30.06 | 30.03 | 30.00 | 30.00 | 30.00 | 30.00 | 30.00 | 30.00 |
| IDAHO Boise | 1023 | 1020 | 1017 | 1015 | 1013 | 1012 | 1012 | 1012 | 1015 | 1018 | 1022 | 1023 | 1017 |
| " | 30.21 | 30.12 | 30.03 | 29.97 | 29.91 | 29.88 | 29.88 | 29.88 | 29.97 | 30.06 | 30.18 | 30.21 | 30.03 |
| ILL. Cairo | 1021 | 1020 | 1017 | 1016 | 1015 | 1014 | 1016 | 1016 | 1017 | 1019 | 1020 | 1021 | 1017 |
| " | 30.15 | 30.12 | 30.03 | 30.00 | 29.97 | 29.94 | 30.00 | 30.00 | 30.03 | 30.09 | 30.12 | 30.15 | 30.03 |
| Chicago | 1019 | 1019 | 1016 | 1016 | 1015 | 1014 | 1015 | 1016 | 1017 | 1018 | 1018 | 1019 | 1017 |
| " | 30.09 | 30.09 | 30.00 | 30.00 | 29.97 | 29.94 | 29.97 | 30.00 | 30.03 | 30.06 | 30.06 | 30.09 | 30.03 |

MEA

| STATE AND STATION | JAN. |
|---|---|
| IOWA Des Moines | 1020 |
| " " | 30.12 |
| KANS. Concordia | 1020 |
| " | 30.12 |
| Dodge City | 1020 |
| " " | 30.12 |
| Topeka | 1021 |
| " | 30.15 |
| Wichita | 1020 |
| " | 30.12 |
| LA. New Orleans | 1021 |
| " " | 30.15 |
| Shreveport | 1021 |
| " | 30.15 |
| MAINE Caribou | 1015 |
| " | 29.97 |
| MASS. Boston | 1017 |
| " | 30.03 |
| Blue Hill | 1017 |
| " " | 30.03 |
| Nantucket | 1016 |
| " | 30.00 |
| MICH. Alpena | 1018 |
| " | 30.06 |
| Marquette | 1018 |
| " | 30.06 |
| Sault Ste. Marie | 1017 |
| " " " | 30.03 |
| MINN. Duluth | 1018 |
| " | 30.06 |
| Internat'l Falls | 1019 |
| " " | 30.09 |
| Mnpls-St. Paul | 1020 |
| " " | 30.12 |
| St. Cloud | 1019 |
| " | 30.09 |
| MISS. Vicksburg | 1021 |
| " | 30.15 |
| MO. Columbia | 1020 |
| " | 30.12 |
| St. Louis | 1020 |
| " | 30.12 |
| MONT. Great Falls | 1020 |
| " " | 30.12 |
| Havre | 1020 |
| " | 30.12 |
| Helena | 1021 |
| " | 30.15 |
| NEBR. North Platte | 1020 |
| " " | 30.12 |
| Omaha | 1021 |
| " | 30.15 |
| NEV. Ely | 1021 |
| " | 30.15 |
| Las Vegas | 1019 |
| " | 30.09 |
| Winnemucca | 1022 |
| " | 30.18 |
| N. Mex. Albuquerque | 1019 |
| " " | 30.09 |
| N. Y. Albany | 1017 |
| " | 30.03 |
| Buffalo | 1018 |
| " | 30.06 |
| New York | 1018 |
| " | 30.06 |
| N.C. Asheville | 1021 |
| " | 30.15 |
| Cape Hatteras | 1020 |
| " | 30.12 |
| N. DAK. Bismarck | 1020 |
| " | 30.12 |
| OHIO Cincinnati | 1020 |
| " | 30.12 |
| Columbus | 1020 |
| " | 30.12 |
| Dayton | 1020 |
| " | 30.12 |
| OKLA. Oklahoma City | 1020 |
| " " | 30.12 |
| ORE. Medford | 1021 |
| " | 30.15 |
| Portland | 1019 |
| " | 30.09 |
| PA. Philadelphia | 1017 |
| " | 30.03 |
| Pittsburgh | 1019 |
| " | 30.09 |
| R. I. Block Is. | 1017 |
| " " | 30.03 |
| S. C. Charleston | 1021 |
| " | 30.15 |
| Columbia | 1021 |
| " | 30.15 |
| S. Dak. Huron | 1020 |
| " | 30.12 |
| Rapid City | 1019 |
| " " | 30.09 |
| TENN. Bristol | 1021 |
| " | 30.15 |
| Nashville | 1021 |
| " | 30.15 |
| TEX. Abilene | 1019 |
| " | 30.09 |
| Brownsville | 1018 |
| " | 30.06 |
| El Paso | 1018 |
| " " | 30.06 |
| Galveston | 1020 |
| " | 30.12 |
| Midland | 1018 |
| " | 30.06 |
| San Antonio | 1020 |
| " " | 30.12 |
| UTAH Salt Lake City | 1022 |
| " " " | 30.18 |
| VT. Burlington | 1018 |
| " | 30.06 |
| VA. Lynchburg | 1020 |
| " | 30.12 |
| WASH. Olympia | 1018 |
| " | 30.06 |
| Spokane | 1020 |
| " | 30.12 |
| Tatoosh Is. | 1015 |
| " " | 29.97 |
| Walla Walla | 1020 |
| " " | 30.12 |
| WIS. Madison | 1019 |
| " | 30.09 |
| WYO. Sheridan | 1020 |
| " | 30.12 |
| P. R. San Juan | 1017 |
| " " | 30.03 |

**Harding Lawson Associates**
Engineering,
Environmental and
Construction Services

SHEET ___ OF ___
JOB NO. ___
DATE ___
COMPUTED BY ___
CHECKED BY ___

PROJECT Stratford Causeway
SUBJECT ___

# Appendix

## A.3 3.

"NCPC Weather Station Data for Brideport Sikorsky Memorial"

*NCDC / Climate-Radar Data Inventories / Locate Station / Search*

# Bridgeport Sikorsky Memorial

**Bridgeport, CT, United States**

Other Stations in Bridgeport
List Stations in Division CT-03
List Stations in Fairfield County
Surrounding Stations (+/- 30' Lat/Lon)

Type* : **ASOS-NWS**
Call Sign/ICS* : **BDR / KBDR**
WBAN* : **94702**
COOP ID* : **060806**
Climate Division* : **CT-03 - Coastal**
WMO ID* : **72504**
In Service* : **01 Dec 1941 to Present**
Elevation* : **3.0m (9.8') above s/l**
Lat/Lon* : **41°11'N / 73°09'W**
County* : **Fairfield**

- **About this Station**
- **Data Inventories**
- **DATA**
- **Station History**
- **State Climatologist**
- **Regional Climate Center**

**Information at Other Sites**

- **National Weather Service**
  - **- Eastern Region Headquarters**
  - **- Regional Forecast Office**
  - **- Current Weather Conditions**
  - **- Current Weather Forecast**
  - **- Current Precipitation/Flood Warning**
- **Current Radar**
- **Current Satellite**
- **Sunrise/Sunset**

* *Disclaimer*
* *List of NCDC Datasets*
* *Please report any Data Errors found.*
* *Note to webmasters: you can link directly to this page.*

## Other Stations in Bridgeport

**Bridgeport**

## About this Station

The airport is located on Stratford Point, a peninsula jutting out into Long Island Sound. Station instrumentation is located approximately 1 mile from the sound. Land around the airport is flat, with marshes to the south. The terrain is of glacial origin, rising in a rolling, mostly wooded manner, to the foothills of the Berkshires, 30 miles to the north and northwest.

Cities in close proximity to the station are Bridgeport, Fairfield, and Milford, while Danbury, New Haven, Norwalk and Stamford are located within a 35-mile radius.

The most pronounced topographical effect is the land-sea breeze, an occurrence generally associated with the spring through early autumn months. Mean monthly temperatures during the summer months average 3 to 5 degrees lower than nearby inland stations because of the sea-breeze effect. Temperatures during the fall and winter months are moderated because of the proximity of Long Island Sound.

Winter snowfall is generally around 10 inches less than areas a few miles inland, also due to the proximity of the station to Long Island Sound.

One of the hazards along the coastal areas is the flooding of low-lying areas (usually during periods of high tide) with the approach of slow-moving deepening low pressure systems, resulting in 3 to 5 feet higher tides than normal.

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## Data Inventories

*Please note that additional data (digital and non-digital) may be available for this station. Contact NCDC if additional details are needed.*

*Click on the following where available:*
- ○ *DAT to obtain digital ascii data (charges may apply),*
  *Please do not order these data if you do not know what a Digital ASCII File is.*
- ○ *INV to view inventory, or*
- ○ *DOC to view documentation*

**Surface**
DAT INV DOC 3200 -Cooperative Summary Of The Day
DAT INV DOC 3210 -Summary Of The Day - First Order
DAT INV DOC SOD -Daily Surface Data (TD3200/3210 combined)
DAT INV DOC 3220 -Summary Of The Month (SOM) Cooperative
DAT INV DOC 3240 -Hourly Precipitation Data
DAT INV DOC 3280 -Surface Airways Hourly And Airways Solar Radiation
DAT INV DOC 3290 -Summary Observation
DAT INV DOC 3292 -Weather Duration
DAT INV DOC 9950 -DATSAV2 Surface, Global Surface Hourly Data (see Global Surface Station Information).

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## DATA

**Additional data products may be available for this station. Contact NCDC if you are unable to locate what you are looking for.**

**Forms, Publications, and Web Pages**

**Graphs and Other Images**

**CD-ROMs**

**Digital ASCII Files**

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### Forms, Publications, and Web Pages

**Most of these products are publications that have been converted to on-line access. As such, these documents have column headings and are displayed in an easy-to-read format.**

**For additional information and product samples, click on the ? icon next to the desired product.**

**? Hourly Surface Weather Observations (Form 10A/B)**
**? Hourly Precipitation Data for New England**
**? Hourly/Daily Data, Local Climatological Data (Unedited)**

- Hourly/Daily Data, Local Climatological Data (Edited)
- Daily/Monthly/Annual New England Climatological Data
- Coop Data/Record of Climatological Observations
- Storm Data Publication

- Miscellaneous Storm Events in Fairfield County

*All ▾ List Storms

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## Graphs and Other Images

**Includes contour maps, time series, NEXRAD radar mosaics, and satellite images.**

**For additional information and product samples, click on the ? icon next to the desired product.**

- National Mosaic Reflectivity Images
- Miscellaneous Satellite Images
- Graph Weather Elements using CLIMVIS

| Period of Record | Elements Available |
|---|---|
| 1948-07 thru 1998-07: | ABCDEFGHIJKLMNOP |

**Please ensure that the parameters you enter are within the parameters specified in the above table. Otherwise you will receive no data.**

**Element 1** (A) Daily Maximum Temperature ▾

**Element 2** (B) Daily Minimum Temperature ▾

**Year/Month** ☐ January ▾

Submit Graph Values

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## CD-ROMs

**The following are some of the more popular CD-ROMs that contain data for this station. Others are available that may contain summarized data for this station. A complete list of CD-ROMs is available in the OnLine Store.**

**For additional information, click on the ? icon next to the desired product.**

- Hourly U.S. Weather Observations, 1990-1995
- NCDC Cooperative Station Data
- Solar and Meteorological Surface Observational Network
- U.S. Hourly Precipitation Data

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## Digital ASCII Files

**These files may or may not contain column headers. In order to use these files, you will need to import them into a spreadsheet or database package for presentation. Please do not order these data if you do not know what a Digital ASCII File is. A sample Digital ASCII File is available for viewing but content varies a great deal depending on your request. Other digital files are available Offline that may contain data for this station.**

For additional information and product samples, click on the ? icon next to the desired product.

- ? SOD -Daily Surface Data (TD3200/3210 combined)
- ? 3220 -Summary Of The Month (SOM) Cooperative
- ? 3240 -Hourly Precipitation Data

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## Station History

# Bridgeport Sikorsky Memorial

| Date Began | Date Ended | Lat/Lon | Elevation meters/feet | COOP ID | WBAN | Call Sign | WMO ID | Type |
|---|---|---|---|---|---|---|---|---|
| **BRIDGEPORT SIKORSKY MEMORIAL** | | | | | | | | |
| 01 May 1996 | Present | 41°11'N / 73°09'W | 3.0m / 9.8' | 060806 | 94702 | BDR | 72504 | ASOS-NWS |
| 01 Jan 1995 | 01 May 1996 | 41°10'N / 73°08'W | 3.0m / 9.8' | 060806 | 94702 | BDR | 72504 | . |
| 01 Jan 1982 | 01 Jan 1995 | 41°10'N / 73°08'W | 3.0m / 9.8' | 060806 | 94702 | BDR | 72504 | . |
| 01 Dec 1973 | 01 Jan 1982 | 41°10'N / 73°08'W | 2.1m / 6.9' | 060806 | 94702 | BDR | 72504 | WSO |
| **BRIDGEPORT MUNICIPAL ARPT** | | | | | | | | |
| 01 Jan 1973 | 01 Dec 1973 | 41°10'N / 73°08'W | 2.1m / 6.9' | 060806 | 94702 | BDR | 72504 | WSO |
| 01 Jan 1961 | 01 Jan 1973 | 41°10'N / 73°08'W | 2.1m / 6.9' | 060806 | 94702 | BDR | 72504 | WBAS |
| 30 Jun 1948 | 01 Jan 1961 | 41°10'N / 73°08'W | 7.9m / 25.9' | 060806 | 94702 | . | . | WBAS |
| 01 Jun 1948 | 30 Jun 1948 | 41°10'N / 73°08'W | 7.9m / 25.9' | 060806 | 94702 | . | . | WBAS |
| 01 Jan 1948 | 01 Jun 1948 | 41°10'N / 73°08'W | 7.9m / 25.9' | . | 94702 | . | . | WBAS |
| 01 Jan 1945 | 01 Jan 1948 | 41°10'N / 73°08'W | 4.0m / 13.1' | . | 94702 | . | . | SAWRS |
| 01 Jan 1944 | 01 Jan 1945 | 41°10'N / 73°08'W | 4.0m / 13.1' | . | 94702 | . | . | A |
| 30 Nov 1942 | 01 Jan 1944 | 41°10'N / 73°08'W | 4.0m / 13.1' | . | 94702 | . | . | . |
| 01 Dec 1941 | 30 Nov 1942 | 41°10'N / 73°08'W | 4.0m / 13.1' | . | 94702 | . | . | A |

## Top of Page

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***NCDC / Climate-Radar Data Inventories / Locate Station / Search***

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*NCDC / Most Popular Products / Conversion Charts / Metar Key / Search / Help*

# Key to METAR Surface Weather Observations

| Unedited Surface Weather Observations (METAR/SPEC) | Latitude | Longitude | Station Elev. (ft) | Time Conversion | Day | Mon. | Year | SID |
|---|---|---|---|---|---|---|---|---|
| | 41° 59' | -87° 55' | 658 | | 02 | 01 | 1999 | ORD |

| | | WIND | | | | VISIBILITY | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TYPE | TIME (LST) | DIR TRUE | SPD KTS | GUST KTS | VARIABILITY TRUE | SURFACE STATUTE MILES | RUNWAY VISUAL RANGE (FT) | PRESENT WEATHER | SKY CONDITIONS | TEMP °C | DEW POINT °C | ALTI-METER INS. |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| S | 0049 | 100 | 21 | | | 3/4 | R14R/4000VP6000FT | -SN BR | BKN005 OVC015 | -08 | -09 | A3024 |

| |
|---|
| Station (Type, Name, State) |
| ASOS CHICAGO, IL |
| |
| REMARKS AND SUPPLEMENTAL CODED DATA |
| 14 |
| PRESFR P0000 (CG) |

| Column Number | | | |
|---|---|---|---|
| 1 | TYPE | Type of Observation | S - routine (standard) hourly observation.<br>Non-standard time observation will also show type S on these forms, although they are not. |
| 2 | TIME(LST) | Time of Observation | reported as "Local Standard Time" |
| 3 | DIR TRUE | Wind Direction | reported to nearest degree, 0 to 359, from true north. Based on a 2-minute average just prior to observation time. |
| 4 | SPD KTS | Wind Speed | reported in knots. Based on a 2-minute average just prior to observation time. |
| 5 | GUST KTS | Wind Gust | highest recorded wind speed during a 5-second period since last observation. Reported when wind speed exceeds 25 knots. |
| 6 | VARIABILITY TRUE | Variable Wind Direction Indicator | determined if during the 2-minute evaluation period it varies by 60 degrees or more regardless of wind speed. |
| 7 | SURFACE STATUTE MILES | Prevailing Surface Visibility | reported in statute miles & fractions. Max reported visibiltiy is 10 statute miles. Derived by sensors. Reported as variable is prevailing visibility varies by 1/2 mile or more and the average visibility is less than 3 miles. |
| 8 | RUNWAY VISUAL RANGE (FT) | Secondary Visibility Measurements | reported when surface visibility 1 mile or less. Runway Visual Range: R; 2-digit runway designator Left, Center, or Right as needed; "/"; Minus or Plus, 4-digit value; 4-digit value Varialbility 4-digit value and tendency Down, Up or No change) |
| 9 | PRESENT WEATHER | See Table of Significant Weather and Obscurations Reported by ASOS (below) | |
| 10 | SKY CONDITION | Cloud amount, height and type | SKy Clear 0/8, **FEW** >0/8-2/8, SCaTtered 3/8-4/8, BroKeN 5/8-7/8, OVerCast 8/8; 3-digit height in hundreds of ft; Towering CUmulus or CumulonimBus in **METAR**. Vertical Visibility for obscured sky and height "VV004". More than 1 layer may be reported. ASOS stations report only, CLeaR for "clear below 12,000 feet" |
| 11 | TEMP | Dry Bulb Temperature | reported in whole degrees Celsius |
| 12 | DEW POINT | Dew Point Temperature | reported in whole degrees Celsius |
| 13 | ALTIMETER (INS.) | Altimeter Setting in Inches of Mercury | reported to nearest hundreth of an inch. Altimeter setting is the computed pressure value to which an aircraft altimeter scale is set so that it will indicate the altitude above mean sea level of an aircraft on the ground at the location for which the value was determined. |
| 14 | REMARKS AND SUPP'L CODED DATA | See table xxx below for details | |

## Table of Significant Weather and Obscurations Reported under "Present Weather" Column

| | | | |
|---|---|---|---|
| **QUALIFIER: Intensity or Proximity** | | | |
| "-" Light | **"no sign"** Moderate | "+" Heavy | |
| VC Vicinity: but not at aerodrome. Between 5 and 10SM of the point(s) of observation | | | |
| **Descriptor** | | | |
| MI Shallow | BC Patches | PR Partial | TS Thunderstorm |
| BL Blowing | SH Showers | DR Drifting | FZ Freezing |
| **WEATHER PHENOMENA** | | | |
| **Precipitation** | | | |
| DZ Drizzle | RA Rain | SN Snow | SG Snow grains |
| IC Ice crystals | PL Ice pellets | GR Hail | GS Small hail/snow pellets |
| UP Unknown precipitation in automated observations | | | |
| **Obscuration** | | | |
| BR Mist(>= 5/8SM) | FG Fog(< 5/8SM) | FU Smoke | VA Volcanic Ash |
| SA Sand | HZ Haze | PY Spray | DU Widespread dust |
| **Other** | | | |
| SQ Squall | SS Sandstorm | DS Duststorm | PO Well developed dust/sand whirls |
| FC Funnel cloud | +FC tornado/waterspout | | |

## Table of Remarks and Supplemental Coded Data

The following groups are reported in the **Remarks** section of the SWO reports. Remarks include clarifying or augmenting data concerning elements in the body of the SWO reports, additive coded data, and maintenance data. If an element or phenomena does not occur, is missing, or cannot be observed, the corresponding group and space are omitted (body and/or remarks) from that particular report, except for Sea-level Pressure (SLPppp). SLPNO shall be reported in a METAR when the SLP is not available. The left most column are examples.

| | | |
|---|---|---|
| **TORNADO, FUNNEL CLOUD or WATERSPOUT** | TORNADIC ACTIVITY | Augmented; report should include TORNADO, FUNNEL CLOUD or WATERSPOUT, time (after the hour) of beginning/end, location, movement; e.g.,TORNADO B25 N MOVE E |
| **AO2** | TYPE OF AUTOMATED STATION | AO1; automated station without a precipitation descriminator. AO2; automated station with precipitation descriminator. |
| **PK WND 20032/25** | PEAK WIND | PK WND dddff(F)/(hh)mm; direction in tens of degrees, speed in whole knots, time (reported in UTC) in minutes after the hour. Only minutes after the hour is included if the hour can be inferred from the report. |
| **WSHFT 1715** | WIND SHIFT,/FONT> | WSHFT followed by hours and minutes of occurrence. The term FROPA may be entered after the time if it is reasonably certain that the wind shift was a result of a frontal passage. |
| **TWR VIS 2** | TOWER OR SURFACE VISIBILITY | TWR VIS vvvvv: visibility reported by tower personnel,e.g., TWR VIS 2; SFC VIS vvvvv: visibility reported by ASOS or observer. |
| **VIS 3/4V1 1/2** | VARIABLE PREVAILING VISIBILITY | VIS $v_nv_nv_nv_nv_nVv_xv_xv_x\ v_xv_x$; reported if prevailing visibility is <3 statute miles and variable. |
| **VIS 3/4 RWY11** | VISIBILITY AT SECOND LOCATION | VIS vvvvv(LOC); reported if different than the reported prevailing visibility in the body of the report. |
| **FRQ LTG NE** | LIGHTNING | (FREQUENCY) LTG (LOCATION); when detected the frequency and location is reported, e.g., FRQ LTG NE, meaning frequent lightning to northeast of station.<br>(See code details in table below) |
| **RAB07** | BEGINNING AND ENDING TIME OF PRECIPITATION AND THUNDERSTORMS | w'w'B(hh)mmE(hh)mm; TSB(hh)mmE(hh)mm, where w'w' is the present weather precipitation contraction, B indicates began, E indicates ended; (hh)indicates the hour (reported in UTC) the phenomena began or ended and can be omitted if the hour can be inferred from the report, mm indicates the minutes after the hour the phenomenon began or ended. |
| | VIRGA | Augmented to report by human observer; indicates precipitation not reaching the ground is observed. |
| **CIG 013V017** | VARIABLE CEILING | CIG $h_nh_nh_nVh_xh_xh_x$;<br>reported if the ceiling in the body of the report is < 3000 feet and variable. |
| **CIG 017 RWY11** | CEILING HEIGHT AT SECOND LOCATION | CIG hhh[LOC]; Ceiling height reported if secondary ceilometer site ceiling value is different than the ceiling height in the body of the report. |
| **PRESFR** | PRESSURE RISING OR FALLING RAPIDLY | PRESRR or PRESFR; pressure rising or falling rapidly at time of observation. |
| **SLP125** | SEA LEVEL PRESSURE | SLPppp; sea level pressure reported for ppp in tens, units, and tenths of hPa. |
| **P0003** | HOURLY PRECIPITATION AMOUNT | Prrrr; in tens, units, tenths and hundredths of an inch since last regular hourly METAR. A trace is reported as P0000. |
| **60009** | 3- AND 6-HOUR PRECIPITATION AMOUNT | 6RRRR; precipitation amount, including water equivalent, to nearest 0.01 inches for past 6 hours reported in 00, 06, 12, and 18 UTC observations and for past 3 hours in 03, 09, 15, and 21 UTC observations. A trace is 60000. |

| | | |
|---|---|---|
| 70015 | 24-HOUR PRECIPITATION AMOUNT | $7R_{24}R_{24}R_{24}R_{24}$; precipitation amount to nearest 0.01 inches for past 24 hours reported in 12 UTC observation; e.g., 70015 indicates 0.15 inches of precipitation for past 24 hours. |
| T00640036 | HOURLY TEMPERATURE AND DEW POINT | $Ts_nT_aT_aT_as_nT'_aT'_aT'_a$; reported to nearest tenth of °C; $s_n$: 1 if temperature or dew point below 0°C and 0 if temperature/dew point 0°C or higher. |
| 10066 | 6-HOUR MAXIMUM TEMPERATURE | $1s_nT_xT_xT_x$; maximum temperature for past 6 hours reported to nearest tenth of degree Celsius; reported on 00, 06, 12, 18 UTC reports; $s_n = 1$ if temperature below 0°C and 0 if temperature 0°C or higher. |
| 21012 | 6-HOUR MINIMUM TEMPERATURE | $2s_nT_nT_nT_n$; minimum temperature for past 6 hours reported to nearest tenth of degree Celsius; reported on 00, 06, 12, 18 UTC reports; $s_n = 1$ if temperature below 0°C and 0 if temperature 0°C or higher. |
| 400461006 | 24-HOUR MAXIMUM AND MINIMUM TEMPERATURE | $4s_nT_xT_xT_xs_nT_nT_nT_n$; maximum temperature for past 6 hours reported to nearest tenth of degree Celsius; reported on midnight local standard time reports; $s_n = 1$ if temperature below 0°C and 0 if temperature 0°C or higher; e.g., 400461006 indicates a 24-hour maximum temperature of 4.6°C and a 24-hour minimum temperature of -0.6°C. |
| 58033 | PRESSURE TENDENCY | 5appp; the character (a) and amount of change in pressure (ppp) in tenths of hPa for the past 3 hours. (See code details in table below) |
| TSNO | SENSOR STATUS INDICATORS | RVRNO: RVR missing; PWINO: precipitation identifier information not available; PNO: precipitation amount not available; FZRANO: freezing rain information not available; TSNO: thunderstorm information not available (may indicate augmenting weather observer not logged on); VISNO [LOC} visibility at second location not available, e.g. VISNO RWY06; CHINO [LOC}: (cloud-height- indicator) sky condition at secondary location not available, e.g., CHINO RWY06. |
| $ | MAINTENANCE CHECK INDICATOR | Maintenance is needed on the system. |

## Table of Remarks Referring to Type and Frequency of Lightning

| Type of Lightning | | |
|---|---|---|
| **Type** | **Contraction** | **Definition** |
| Cloud-ground | CG | Lightning occurring between cloud and ground. |
| In-cloud | IC | Lightning which takes place within the cloud. |
| Cloud-cloud | CC | Streaks of lightning reaching from one cloud to another. |
| Cloud-air | CA | Streaks of lightning which pass from a cloud to the air, but do not strike the ground. |
| **Frequency of Lightning** | | |
| **Frequency** | **Contraction** | **Definition** |
| Occasional | OCNL | Less than 1 flash per minute. |
| Frequent | FRQ | About 1 to 6 flashes per minute. |
| Continuous | CONS | More than 6 flashes per minute. |

## Table of Remarks Referring to Characteristics of Pressure Tendency

| Primary Requirement | Description | Code Figure |
|---|---|---|
| Atmospheric pressure now higher than 3 hours ago. | Increasing, then decreasing | 0 |
| | Increasing, then then steady, or increasing then increasing more slowly. | 1 |
| | Increasing steadily or unsteadily. | 2 |
| | Decreasing or steady, then increasing; or increasing, then increasing more rapidly. | 3 |
| Atmospheric pressure now same as 3 hours ago. | Increasing, then decreasing | 0 |
| | Steady | 4 |
| | Decreasing, then increasing. | 5 |
| Atmospheric pressure now lower than 3 hours ago. | Decreasing, then increasing. | 5 |
| | Decreasing then steady; or decreasing then decreasing more slowly. | 6 |
| | Decreasing steadily or unsteadily. | 7 |
| | Steady or increasing, then decreasing; or decreasing then decreasing moe rapidly. | 8 |

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**May 2000**
**UNITED STATES DEPARTMENT OF COMMERCE**
**National Oceanic and Atmospheric Administration**
National Climatic Data Center
NOAA/PA 96052

This document is provided to help users decode airport observations archived at the National Climatic Data Center. Any updates or amendments to the METAR reporting practices can be viewed at the National Weather Service Office of Systems Operations.

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*http://www.ncdc.noaa.gov/ol/climate/conversion/swometardecoder.html*
*Last updated 25 May 2000 by webmaster@ncdc.noaa.gov*
*Please see the NCDC Contact Page if you have questions or comments.*

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 07/1996**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) | | | | | | Deg Days Base 65 Degrees | | Significant Weather | Snow/Ice on Gnd(In) | | Precipitation (In) | | Pressure (inches of Hg) | | Wind Speed=mph Dir=tens of degrees | | | | | | | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Heating | Cooling | | 0600 LST | 1200 LST | 2400 LST | 2400 LST | Avg. Station | Avg. Sea level | Resultant Speed | Res Dir | Avg. Speed | max 5-sec | | max 2-min | | |
| | | | | | | | | | | Depth | Water Equiv | Snow Fall | Water Equiv | | | | | | Speed | Dir | Speed | Dir | |
| 01 | 75 | 64 | 70 | -1 | 66 | 67 | 0 | 5 | FG | M | - | - | 0.00 | 29.81 | 29.87 | 6.8 | 21 | 7.2 | 18 | 20 | 16 | 20 | 01 |
| 02 | 79 | 66 | 73 | 1 | 66 | 68 | 0 | 8 | FG+ FG BR HZ | M | - | - | 0.00 | 29.71 | 29.76 | 6.8 | 21 | 7.1 | 16 | 20 | 14 | 20 | 02 |
| 03 | 68 | 65 | 67 | -5 | 65 | 66 | 0 | 2 | TS TSRA RA FG+ FG | M | - | - | 0.19 | 29.50 | 30.77 | 4.2 | 9 | 6.5 | 20 | 11 | 15 | 10 | 03 |
| 04 | 75 | 62 | 69 | -3 | 60 | 63 | 0 | 4 | - | M | - | - | 0.01 | 29.52 | 30.32 | 8.5 | 27 | 9.4 | 26 | 29 | 21 | 30 | 04 |
| 05 | 83 | 63 | 73 | 1 | 55 | 62 | 0 | 8 | - | M | - | - | 0.00 | 29.83 | 29.88 | 8.3 | 26 | 9.3 | 24 | 29 | 17 | 29 | 05 |
| 06 | 82 | 63 | 73 | 0 | 60 | 65 | 0 | 8 | FG HZ | M | - | - | 0.00 | 29.85 | 29.93 | 8.8 | 24 | 8.4 | 21 | 24 | 16 | 24 | 06 |
| 07 | 74 | 68 | 71 | -2 | 63 | 66 | 0 | 6 | FG HZ | M | - | - | 0.00 | 29.81 | 29.86 | 7.0 | 9 | 7.5 | 18 | 9 | 16 | 10 | 07 |
| 08 | 83 | 66 | 75 | 2 | 68 | 70 | 0 | 10 | TS TSRA FG+ FG HZ | M | - | - | 0.69 | 29.61 | 29.66 | 5.4 | 19 | 6.6 | 22 | 20 | 18 | 20 | 08 |
| 09 | 80 | 69 | 75 | 2 | 68 | 70 | 0 | 10 | TS TSRA RA FG HZ | M | - | - | 0.30 | 29.60 | 29.64 | 3.6 | 17 | 5.4 | 26 | 32 | 21 | 32 | 09 |
| 10 | 79 | 63 | 71 | -2 | 53 | 60 | 0 | 6 | - | M | - | - | 0.00 | 29.89 | 29.94 | 10.0 | 31 | 10.3 | 25 | 30 | 20 | 31 | 10 |
| 11 | 78 | 58* | 68 | -5 | 54 | 61 | 0 | 3 | - | M | - | - | 0.00 | 30.18 | 30.24 | 5.7 | 22 | 7.3 | 17 | 20 | 15 | 20 | 11 |
| 12 | 76 | 61 | 69 | -4 | 61 | 64 | 0 | 4 | RA FG | M | - | - | 0.05 | 30.17 | 30.24 | 3.1 | 14 | 4.9 | 11 | 10 | 10 | 10 | 12 |
| 13 | 73 | 67 | 70 | -4 | 66 | 68 | 0 | 5 | RA FG | M | - | - | 2.41 | 29.71 | 29.26 | 4.1 | 12 | 13.6 | 39 | 15 | 31 | 15 | 13 |
| 14 | 79 | 65 | 72 | -2 | 68 | 69 | 0 | 7 | FG HZ | M | - | - | 0.00 | 29.88 | 29.93 | 3.4 | 11 | 5.8 | 15 | 9 | 14 | 9 | 14 |
| 15 | 77 | 69 | 73 | -1 | 69 | 70 | 0 | 8 | TS TSRA RA FG+ FG HZ | M | - | - | 0.10 | 29.88 | 29.95 | 10.9 | 21 | 11.6 | 30 | 20 | 23 | 20 | 15 |
| 16 | 84 | 69 | 77 | 3 | 67 | 70 | 0 | 12 | RA FG HZ | 0.0 | - | - | 0.00 | 29.96 | 30.01 | 9.1 | 24 | 8.8 | 18 | 23 | 16 | 23 | 16 |
| 17 | 86 | 72 | 79 | 5 | 52 | 63 | 0 | 14 | FG HZ | M | - | - | T | 30.00 | 30.05 | 7.1 | 24 | 7.6 | 18 | 22 | 16 | 22 | 17 |
| 18 | 88* | 69 | 79* | 5 | 67 | 70 | 0 | 14 | FG HZ | M | - | - | 0.09 | 29.95 | 30.01 | 3.0 | 22 | 5.4 | 20 | 27 | 16 | 22 | 18 |
| 19 | 81 | 70 | 76 | 2 | 70 | 72 | 0 | 11 | RA FG HZ | M | - | - | 0.09 | 29.56 | 30.84 | 8.9 | 23 | 11.3 | 28 | 23 | 23 | 22 | 19 |
| 20 | 78 | 65 | 72 | -2 | 50 | 59 | 0 | 7 | - | M | - | - | T | 29.61 | 29.68 | 14.0 | 31 | 14.8 | 36 | 30 | 30 | 30 | 20 |
| 21 | 82 | 62 | 72 | -2 | 52 | 60 | 0 | 7 | - | M | - | - | 0.00 | 29.76 | 29.82 | 10.2 | 31 | 11.1 | 28 | 31 | 24 | 30 | 21 |
| 22 | 75 | 62 | 69 | -5 | 57 | 62 | 0 | 4 | - | M | - | - | 0.00 | 29.90 | 29.94 | 1.3 | 27 | 5.6 | 15 | 23 | 13 | 23 | 22 |
| 23 | 69 | 65 | 67 | -8 | 63 | 64 | 0 | 2 | RA FG | M | - | - | 0.31 | 29.82 | 29.89 | 5.2 | 3 | 7.0 | 16 | 7 | 14 | 8 | 23 |
| 24 | 71 | 63 | 67 | -8 | 63 | 65 | 0 | 2 | FG | M | - | - | 0.00 | 29.95 | 30.00 | 2.6 | 10 | 5.9 | 14 | 15 | 11 | 14 | 24 |
| 25 | 75 | 67 | 71 | -4 | 66 | 67 | 0 | 6 | FG HZ | M | - | - | 0.00 | 29.97 | 30.01 | 6.7 | 16 | 7.5 | 14 | 17 | 11 | 16 | 25 |
| 26 | 74 | 66 | 70 | -5 | 64 | 66 | 0 | 5 | RA FG | M | - | - | 0.40 | 29.89 | 29.93 | 4.3 | 15 | 6.5 | 17 | 2 | 14 | 11 | 26 |
| 27 | 80 | 62 | 71 | -4 | 60 | 64 | 0 | 6 | - | M | - | - | 0.00 | 30.01 | 30.07 | 6.2 | 29 | 7.1 | 22 | 31 | 18 | 31 | 27 |
| 28 | 78 | 63 | 71 | -4 | 61 | 65 | 0 | 6 | - | M | - | - | 0.00 | 30.18 | 30.22 | 2.8 | 22 | 5.5 | 13 | 20 | 10 | 23 | 28 |
| 29 | 75 | 64 | 70 | -5 | 65 | 66 | 0 | 5 | FG | M | - | - | 0.00 | 30.19 | 30.23 | 5.7 | 10 | 6.9 | 15 | 10 | 14 | 9 | 29 |
| 30 | 72 | 66 | 69 | -6 | 63 | 65 | 0 | 4 | - | M | - | - | 0.00 | 30.11 | 30.17 | 9.2 | 11 | 10.4 | 16 | 10 | 15 | 9 | 30 |
| 31 | 67 | 63 | 65* | -10 | 62 | 63 | 0 | 0 | TS TSRA RA FG | M | - | - | 1.30 | 30.00 | 30.05 | 11.1 | 10 | 12.7 | 26 | 11 | 23 | 11 | 31 |
| | 77.3 | 65.1 | 71.2 | -------- | 62.1 | 65.5 | .0 | 6.4 | <Monthly Averages | Totals> | | | 2.19 | 29.87 | 30.01 | 2.2 | 22 | 8.2 | <Monthly Average | | | | |
| | -4.4 | -.6 | -2.5 | -------- | <---------------------Departure From Normal----------------------> | | | | | | | | -1.59 | | | | | | | | | | |

| Degree Days | Monthly Total | Monthly Departure | Season to Date Total | Season to Date Departure |
|---|---|---|---|---|
| Heating: | 0 | 0 | | |
| Cooling: | 199 | -71 | | |

Greatest 24-hr Precipitation: 1.30date: 31
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.30 | 12 | 1114 |
| Minimum : | 29.39 | 13 | 1621 |

Number of Days with ----->
Max temp >= 90: 0
Max temp <= 32: 0
Thunderstorms : 5
Min temp <= 32: 0
Min temp <= 0 : 0
Heavy Fog : 4
Precipitation >= .01 inch: M
Precipitation >= .10 inch : M
Snowfall >= 1.0 inch : 0

71.2°F

Avg. speed/dir 8.2 mph / 220°

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 08/1996**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Deg Days Base 65 Degrees Heating | Cooling | Significant Weather | Snow/Ice on Gnd(In) 0600 LST Depth | 1200 LST Water Equiv | Precipitation (In) 2400 LST Snow Fall | 2400 LST Water Equiv | Pressure (inches of Hg) Avg. Station | Avg. Sea level | Wind Speed=mph Dir=tens of degrees Resultant Speed | Res Dir | Avg. Speed | max 5-sec Speed | Dir | max 2-min Speed | Dir | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 71 | 63 | 67 | -8 | 65 | 66 | 0 | 2 | FG | M | - | - | 0.10 | 29.90 | 29.93 | 4.7 | 9 | 5.3 | 17 | 17 | 10 | 13 | 01 |
| 02 | 77 | 66 | 72 | -3 | 56 | 63 | 0 | 7 | FG+ FG HZ | 0.0 | - | - | 0.28 | 29.93 | 29.99 | 3.3 | 15 | 5.0 | 14 | 18 | 13 | 18 | 02 |
| 03 | 72 | 68 | 70 | -5 | 66 | 67 | 0 | 5 | RA FG HZ | M | - | - | T | 30.06 | 30.11 | 4.7 | 14 | 5.5 | 10 | 16 | 9 | 16 | 03 |
| 04 | 78 | 68 | 73 | -2 | 67 | 69 | 0 | 8 | FG HZ | M | - | - | 0.00 | 30.10 | 30.18 | 4.1 | 19 | 6.0 | 14 | 20 | 11 | 20 | 04 |
| 05 | 83 | 69 | 76 | 2 | 68 | 70 | 0 | 11 | FG HZ | M | - | - | 0.00 | 30.14 | 30.20 | 3.4 | 20 | 4.6 | 11 | 21 | 9 | 22 | 05 |
| 06 | 84 | 69 | 77 | 3 | 69 | 71 | 0 | 12 | FG HZ | M | - | - | 0.00 | 30.16 | 30.21 | 3.7 | 20 | 5.5 | 15 | 19 | 13 | 19 | 06 |
| 07 | 80 | 70 | 75 | 1 | 69 | 70 | 0 | 10 | FG HZ | M | - | - | 0.00 | 30.14 | 30.20 | 4.2 | 19 | 5.8 | 14 | 20 | 11 | 19 | 07 |
| 08 | 83 | 69 | 76 | 2 | 66 | 67 | 0 | 11 | FG HZ | M | - | - | 0.00 | 30.06 | 30.12 | 8.8 | 22 | 9.1 | 20 | 20 | 15 | 21 | 08 |
| 09 | 82 | 70 | 76 | 2 | 68 | 70 | 0 | 11 | FG HZ | M | - | - | T | 29.91 | 29.97 | 7.5 | 24 | 8.2 | 21 | 21 | 17 | 21 | 09 |
| 10 | 81 | 69 | 75 | 1 | 60 | 66 | 0 | 10 | FG HZ | M | - | - | 0.00 | 29.92 | 29.97 | 3.6 | 31 | 8.0 | 17 | 33 | 14 | 22 | 10 |
| 11 | 77 | 63 | 70 | -4 | 56 | 62 | 0 | 5 | - | M | - | - | 0.00 | 30.08 | 30.12 | 0.8 | 2 | 8.0 | 21 | 2 | 15 | 2 | 11 |
| 12 | 73 | 63 | 68 | -6 | 60 | 63 | 0 | 3 | - | M | - | - | T | 30.10 | 30.16 | 6.3 | 11 | 8.0 | 17 | 8 | 15 | 9 | 12 |
| 13 | 68 | 59 | 64* | -10 | 59 | 61 | 1 | 0 | RA FG | M | - | - | 0.73 | 29.94 | 30.00 | 9.4 | 4 | 9.4 | 18 | 5 | 16 | 5 | 13 |
| 14 | 77 | 57* | 67 | -7 | 62 | 65 | 0 | 2 | FG | M | - | - | 0.01 | 29.99 | 30.05 | 2.3 | 18 | 3.4 | 10 | 19 | 9 | 20 | 14 |
| 15 | 77 | 66 | 72 | -1 | 65 | 67 | 0 | 7 | FG HZ | M | - | - | 0.00 | 30.08 | 30.12 | 3.7 | 13 | 5.5 | 14 | 15 | 13 | 12 | 15 |
| 16 | 75 | 66 | 71 | -2 | 65 | 67 | 0 | 6 | - | M | - | - | T | 30.03 | 30.09 | 5.5 | 18 | 7.2 | 16 | 21 | 14 | 21 | 16 |
| 17 | 78 | 69 | 74 | 1 | 67 | 69 | 0 | 9 | FG HZ | M | - | - | 0.00 | 30.00 | 30.07 | 4.4 | 18 | 6.2 | 14 | 22 | 11 | 22 | 17 |
| 18 | 84 | 67 | 76 | 3 | 63 | 68 | 0 | 11 | FG HZ | M | - | - | 0.00 | 30.09 | 30.13 | 2.1 | 35 | 5.0 | 18 | 1 | 15 | 2 | 18 |
| 19 | 80 | 68 | 74 | 1 | 61 | 66 | 0 | 9 | - | M | - | - | 0.00 | 30.24 | 30.29 | 2.3 | 13 | 7.4 | 15 | 20 | 11 | 20 | 19 |
| 20 | 79 | 66 | 73 | 0 | 63 | 67 | 0 | 8 | - | M | - | - | 0.00 | 30.26 | 30.30 | 9.6 | 21 | 10.2 | 21 | 21 | 17 | 21 | 20 |
| 21 | 79 | 70 | 75 | 2 | 67 | 69 | 0 | 10 | FG HZ | M | - | - | 0.00 | 30.08 | 30.13 | 11.4 | 24 | 11.5 | 21 | 23 | 18 | 23 | 21 |
| 22 | 85 | 67 | 76 | 4 | 68 | 70 | 0 | 11 | FG+ FG HZ | M | - | - | 0.00 | 30.07 | 30.12 | 5.2 | 23 | 6.7 | 16 | 20 | 13 | 21 | 22 |
| 23 | 88* | 71 | 80* | 8 | 68 | 71 | 0 | 15 | TS TSRA FG HZ | M | - | - | 0.14 | 29.98 | 30.04 | 6.6 | 23 | 8.6 | 29 | 33 | 25 | 34 | 23 |
| 24 | 79 | 68 | 74 | 2 | 68 | 70 | 0 | 9 | TS TSRA RA FG HZ | M | - | - | 0.36 | 29.94 | 30.00 | 3.9 | 29 | 5.3 | 34 | 30 | 28 | 32 | 24 |
| 25 | 80 | 67 | 74 | 2 | - | - | 0 | 9 | FG | 0.0 | - | - | 0.00 | - | - | - | - | 5.4 | 16 | 20 | 14 | 21 | 25 |
| 26 | 85 | 67 | 76 | 4 | 64 | 68 | 0 | 11 | FG HZ | M | - | - | 0.00 | 29.93 | 29.99 | 4.4 | 22 | 6.3 | 15 | 21 | 13 | 21 | 26 |
| 27 | 78 | 67 | 73 | 2 | 68 | 70 | 0 | 8 | FG HZ | 0.0 | - | - | 0.00 | 29.98 | 30.03 | 3.8 | 12 | 7.2 | 22 | 9 | 20 | 9 | 27 |
| 28 | 72 | 66 | 69 | -2 | 62 | 65 | 0 | 4 | FG HZ | M | - | - | 0.00 | 30.02 | 30.08 | 8.8 | 4 | 8.7 | 18 | 4 | 16 | 5 | 28 |
| 29 | 80 | 62 | 71 | 0 | 63 | 66 | 0 | 6 | FG HZ | M | - | - | 0.00 | 29.96 | 30.01 | 4.7 | 24 | 5.4 | 15 | 22 | 14 | 23 | 29 |
| 30 | 76 | 64 | 70 | -1 | 60 | 64 | 0 | 5 | - | M | - | - | 0.00 | 30.01 | 30.07 | 0.7 | 18 | 7.4 | 15 | 23 | 13 | 20 | 30 |
| 31 | 81 | 60 | 71 | 0 | 59 | 63 | 0 | 6 | FG | M | - | - | 0.00 | 30.06 | 30.10 | 1.2 | 20 | 5.0 | 13 | 17 | 10 | 20 | 31 |
|  | 78.8 | 66.3 | 72.6 | -------- | 64.1 | 67.0 | .0 | 7.8 | <Monthly Averages | Totals> |  |  | 0.00 | 30.04 | 30.09 | 2.1 | 19.4 | 6.8 | <Monthly Average |  |  |  |  |
|  | -2.1 | 1.2 | -.5 | -------- | <--------Departure From Normal--------> |  |  |  |  |  |  |  | -3.25 |  |  |  |  |  |  |  |  |  |  |

**Degree Days** Monthly Season to Date

| | Monthly Total | Monthly Departure | Season to Date Total | Season to Date Departure |
|---|---|---|---|---|
| Heating: | 1 | 1 | | |
| Cooling: | 241 | -10 | | |

Greatest 24-hr Precipitation: 0.00date:
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

Sea Level PressureDateTime

| | Sea Level Pressure | Date | Time |
|---|---|---|---|
| Maximum: | 30.36 | 20 | 0930 |
| Minimum : | 29.90 | 1 | 1803 |

Number of Days with ----->
Max temp >= 90: 0
Max temp <= 32: 0
Thunderstorms : 2
Min temp <= 32: 0
Min temp <= 0 : 0
Heavy Fog : 2
Precipitation >= .01 inch: M
Precipitation >= .10 inch : M
Snowfall >= 1.0 inch : 0

72.6°F

Avg. speed/dir. 6.8 mph / 194°

8/96

UNEDITED LOCAL CLIMATOLOGICAL DATA
[NOAA, National Climatic Data Center] MONTH: 09/1996

Station Location: BRIDGEPORT, CT (BDR) lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) | | | | | | Deg Days Base 65 Degrees | | Significant Weather | Snow/Ice on Gnd(In) | | Precipitation (In) | | Pressure (inches of Hg) | | Wind Speed=mph Dir=tens of degrees | | | | | | | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Heating | Cooling | | 0600 LST | 1200 LST | 2400 LST | 2400 LST | Avg. Station | Avg. Sea level | Resultant Speed | Res Dir | Avg. Speed | max 5-sec | | max 2-min | | |
| | | | | | | | | | | Depth | Water Equiv | Snow Fall | Water Equiv | | | | | | Speed | Dir | Speed | Dir | |
| 01 | 80 | 61 | 71 | 1 | 58 | 63 | 0 | 6 | - | M | - | - | 0.00 | 29.93 | 29.98 | 8.0 | 3 | 9.2 | 24 | 2 | 18 | 1 | 01 |
| 02 | 87* | 71 | 79* | 9 | 58 | 65 | 0 | 14 | - | M | - | - | 0.00 | 29.83 | 29.88 | 10.4 | 35 | 11.0 | 28 | 2 | 20 | 2 | 02 |
| 03 | 84 | 66 | 75 | 5 | 64 | 68 | 0 | 10 | - | M | - | - | 0.00 | 29.96 | 30.00 | 2.4 | 25 | 5.8 | 15 | 21 | 14 | 22 | 03 |
| 04 | 79 | 67 | 73 | 4 | 68 | 70 | 0 | 8 | FG HZ | M | - | - | T | 30.00 | 30.05 | 1.9 | 7 | 2.9 | 8 | 15 | 8 | 13 | 04 |
| 05 | 83 | 71 | 77 | 8 | 69 | 71 | 0 | 12 | FG HZ | M | - | - | T | 30.07 | 30.12 | 2.6 | 18 | 4.2 | 11 | 21 | 10 | 21 | 05 |
| 06 | 80 | 67 | 74 | 5 | 64 | 68 | 0 | 9 | FG HZ | M | - | - | 0.00 | 30.04 | 30.07 | 6.6 | 9 | 8.2 | 18 | 10 | 16 | 10 | 06 |
| 07 | 73 | 68 | 71 | 2 | 54 | 62 | 0 | 6 | RA FG+ FG HZ | M | - | - | 0.05 | 29.87 | 29.92 | 18.5 | 10 | 18.7 | 37 | 10 | 31 | 10 | 07 |
| 08 | 71 | 64 | 68 | 0 | 61 | 63 | 0 | 3 | RA FG HZ | M | - | - | 0.11 | 29.83 | 29.88 | 8.7 | 8 | 8.8 | 25 | 9 | 22 | 9 | 08 |
| 09 | M | M | M | M | - | 45 | M | M | FG+ FG HZ | M | - | - | 0.01 | 29.80 | 29.84 | 6.4 | 24 | 6.1 | 18 | 24 | 15 | 23 | 09 |
| 10 | M | M | M | M | - | 43 | M | M | RA FG HZ | M | - | - | T | 29.82 | 29.89 | 3.0 | 26 | 6.1 | 18 | 36 | 15 | 23 | 10 |
| 11 | M | M | M | M | - | - | M | M | - | M | - | - | 0.00 | - | - | - | - | 5.9 | 13 | 16 | 10 | 15 | 11 |
| 12 | 70 | 64 | 67 | 0 | 60 | 63 | 0 | 2 | FG | M | - | - | T | 29.85 | 29.89 | 11.2 | 7 | 11.7 | 24 | 8 | 21 | 8 | 12 |
| 13 | M | M | M | M | - | 51 | M | M | FG HZ | M | - | - | 0.25 | 29.65 | 29.71 | 10.7 | 6 | 10.9 | 21 | 6 | 17 | 8 | 13 |
| 14 | 74 | 57 | 66 | -1 | 56 | 59 | 0 | 1 | - | M | - | - | 0.00 | 29.65 | 29.71 | 5.2 | 32 | 8.8 | 18 | 28 | 15 | 28 | 14 |
| 15 | 71 | 53 | 62 | -5 | 54 | 58 | 3 | 0 | - | M | - | - | 0.00 | 29.83 | 29.89 | 0.9 | 11 | 3.2 | 14 | 13 | 13 | 13 | 15 |
| 16 | 72 | 58 | 65 | -1 | 57 | 61 | 0 | 0 | - | M | - | - | 0.01 | 29.90 | 29.96 | 4.7 | 24 | 5.9 | 20 | 22 | 17 | 22 | 16 |
| 17 | 64 | 57 | 61 | -4 | 57 | 59 | 4 | 0 | RA FG | M | - | - | 2.41 | 29.68 | 28.62 | 17.8 | 8 | 20.3 | 47 | 9 | 39 | 9 | 17 |
| 18 | 63 | 55 | 59 | -6 | 54 | 56 | 6 | 0 | RA FG | M | - | - | 0.25 | 29.60 | 29.65 | 12.4 | 35 | 12.7 | 29 | 2 | 20 | 35 | 18 |
| 19 | 72 | 57 | 65 | 0 | 51 | 57 | 0 | 0 | - | M | - | - | 0.00 | 29.73 | 29.79 | 9.6 | 35 | 9.4 | 29 | 34 | 23 | 1 | 19 |
| 20 | 75 | 53 | 64 | -1 | 53 | 58 | 1 | 0 | - | M | - | - | 0.00 | 29.88 | 29.92 | 5.4 | 31 | 7.4 | 17 | 29 | 15 | 31 | 20 |
| 21 | 76 | 54 | 65 | 1 | 57 | 61 | 0 | 0 | - | M | - | - | 0.00 | 29.87 | 29.94 | 6.2 | 23 | 7.8 | 18 | 22 | 16 | 22 | 21 |
| 22 | 67 | 57 | 62 | -2 | 60 | 61 | 3 | 0 | RA FG | M | - | - | 0.89 | 29.66 | 29.71 | 3.0 | 18 | 5.4 | 28 | 16 | 23 | 16 | 22 |
| 23 | 66 | 53 | 60 | -4 | 53 | 55 | 5 | 0 | RA FG | M | - | - | 0.01 | 29.73 | 29.79 | 7.6 | 1 | 8.0 | 24 | 2 | 18 | 1 | 23 |
| 24 | 61 | 47 | 54* | -9 | 50 | 53 | 11 | 0 | RA FG | M | - | - | 0.45 | 29.89 | 29.95 | 1.3 | 17 | 5.8 | 16 | 16 | 14 | 21 | 24 |
| 25 | 67 | 53 | 60 | -3 | 52 | 56 | 5 | 0 | FG | M | - | - | 0.01 | 29.95 | 30.00 | 7.6 | 30 | 7.9 | 21 | 33 | 18 | 32 | 25 |
| 26 | 63 | 47* | 55 | -7 | 48 | 52 | 10 | 0 | - | M | - | - | 0.00 | 30.29 | 30.35 | 1.3 | 17 | 6.4 | 14 | 22 | 10 | 20 | 26 |
| 27 | 65 | 59 | 62 | 0 | 55 | 58 | 3 | 0 | - | M | - | - | 0.00 | 30.35 | 30.39 | 10.1 | 18 | 10.3 | 23 | 18 | 18 | 19 | 27 |
| 28 | 74 | 61 | 68 | 6 | 62 | 65 | 0 | 3 | RA FG | M | - | - | 0.13 | 30.05 | 28.98 | 15.9 | 20 | 17.3 | 37 | 20 | 28 | 20 | 28 |
| 29 | 67 | 55 | 61 | 0 | 56 | 58 | 4 | 0 | RA FG | M | - | - | 0.23 | 30.01 | 30.06 | 5.0 | 27 | 7.0 | 15 | 24 | 13 | 23 | 29 |
| 30 | 70 | 53 | 62 | 1 | 50 | 55 | 3 | 0 | - | M | - | - | 0.00 | 30.24 | 30.30 | 5.3 | 32 | 5.8 | 22 | 1 | 16 | 1 | 30 |
| | 72.1 | 58.8 | 65.5 | -------- | | 59.1 | | | <Monthly Averages | Totals> | | | 4.81 | 29.90 | 29.87 | 1.3 | 4.9 | 8.6 | <Monthly Average | | | | |
| | -2.1 | 1.2 | -.4 | -------- | <--------------------Departure From Normal-----------------------> | | | | | | | | 1.74 | | | | | | | | | | |

| Degree Days | Monthly Total | Monthly Departure | Season to Date Total | Season to Date Departure |
|---|---|---|---|---|
| Heating: | 58 | 4 | | |
| Cooling: | 74 | -7 | | |

Greatest 24-hr Precipitation: 2.41 date: 17
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.45 | 27 | 0938 |
| Minimum : | 29.57 | 23 | 0253 |

Number of Days with ----->
Max temp >= 90: M
Max temp <= 32: M
Thunderstorms : 0
Min temp <= 32: M
Min temp <= 0 : M
Heavy Fog : 2
Precipitation >= .01 inch: 13
Precipitation >= .10 inch : 8
Snowfall >= 1.0 inch : 0

Avg. WIND speed / DIR => 8.6 mph / 49° ENE

9/96

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 10/1996**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) | | | | | | Deg Days Base 65 Degrees | | Significant Weather | Snow/Ice on Gnd(In) | | | Precipitation (In) | Pressure (inches of Hg) | | Wind Speed=mph Dir=tens of degrees | | | | | | | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Heating | Cooling | | 0600 LST | 1200 LST | 2400 LST | 2400 LST | Avg. Station | Avg. Sea level | Resultant Speed | Res Dir | Avg. Speed | max 5-sec | | max 2-min | | |
| | | | | | | | | | | Depth | Water Equiv | Snow Fall | Water Equiv | | | | | | Speed | Dir | Speed | Dir | |
| 01 | 70 | 50 | 60 | -1 | 54 | 56 | 5 | 0 | - | M | - | - | 0.00 | 30.38 | 30.43 | 2.6 | 13 | 7.5 | 14 | 21 | 11 | 20 | 01 |
| 02 | 68 | 61 | 65* | 5 | 59 | 61 | 0 | 0 | RA FG | M | - | - | 0.08 | 30.17 | 30.22 | 8.5 | 21 | 9.2 | 17 | 21 | 15 | 22 | 02 |
| 03 | 66 | 41 | 54 | -6 | 41 | 49 | 11 | 0 | - | M | - | - | T | 30.10 | 30.15 | 11.7 | 35 | 14.1 | 32 | 2 | 26 | 1 | 03 |
| 04 | 55 | 34 | 45 | -15 | 30 | 39 | 20 | 0 | - | M | - | - | 0.00 | 30.45 | 30.50 | 7.8 | 36 | 8.7 | 22 | 1 | 18 | 2 | 04 |
| 12 | 57 | 33* | 45* | -11 | 38 | 42 | 20 | 0 | - | M | - | - | 0.00 | 30.26 | 30.33 | 3.7 | 24 | 4.9 | 17 | 21 | 15 | 23 | 12 |
| 13 | 64 | 45 | 55 | -1 | 50 | 53 | 10 | 0 | FG | M | - | - | 0.04 | 30.11 | 30.17 | 7.8 | 23 | 8.7 | 20 | 22 | 16 | 22 | 13 |
| 14 | 75* | 46 | 61 | 5 | 47 | 54 | 4 | 0 | FG | M | - | - | 0.00 | 29.86 | 29.90 | 9.4 | 30 | 11.5 | 29 | 31 | 24 | 31 | 14 |
| 15 | 58 | 38 | 48 | -8 | 28 | 40 | 17 | 0 | - | M | - | - | 0.00 | 30.05 | 30.12 | 6.9 | 33 | 7.5 | 24 | 1 | 18 | 36 | 15 |
| 16 | 68 | 47 | 58 | 3 | 51 | 55 | 7 | 0 | FG HZ | M | - | - | 0.00 | 29.89 | 29.95 | 8.3 | 26 | 8.1 | 17 | 25 | 15 | 24 | 16 |
| 17 | 69 | 51 | 60 | 5 | 56 | 58 | 5 | 0 | FG HZ | M | - | - | 0.00 | 29.93 | 29.98 | 1.4 | 17 | 3.9 | 17 | 9 | 15 | 9 | 17 |
| 18 | 61 | 53 | 57 | 2 | 49 | 52 | 8 | 0 | FG | M | - | - | 0.00 | 29.95 | 30.02 | 18.3 | 10 | 18.7 | 34 | 9 | 30 | 10 | 18 |
| 19 | M | M | M | M | - | 40 | M | M | RA FG HZ | M | - | - | 4.12 | 29.62 | 28.56 | 29.7 | 8 | 30.4 | 56 | 8 | 48 | 8 | 19 |
| 20 | M | M | M | M | - | 38 | M | M | - | M | - | - | 0.25 | 29.70 | 29.75 | 1.9 | 18 | 6.5 | 31 | 7 | 25 | 6 | 20 |
| 21 | 58 | 48 | 53 | -1 | 48 | 51 | 12 | 0 | RA FG | M | - | - | 0.48 | 29.86 | 29.91 | 1.7 | 25 | 5.8 | 14 | 24 | 13 | 1 | 21 |
| 22 | 61 | 49 | 55 | 1 | 50 | 52 | 10 | 0 | RA FG HZ | M | - | - | 0.11 | 29.92 | 29.99 | 4.7 | 25 | 6.1 | 16 | 24 | 13 | 24 | 22 |
| 23 | 64 | 49 | 57 | 4 | 56 | 57 | 8 | 0 | RA FG | M | - | - | 0.25 | 29.82 | 29.89 | 5.0 | 12 | 6.8 | 20 | 22 | 16 | 20 | 23 |
| 24 | 66 | 54 | 60 | 7 | 47 | 53 | 5 | 0 | FG | M | - | - | 0.00 | 29.77 | 29.82 | 9.7 | 27 | 10.0 | 25 | 28 | 20 | 28 | 24 |
| 25 | 68 | 49 | 59 | 6 | 46 | 51 | 6 | 0 | - | M | - | - | 0.00 | 30.02 | 30.08 | 7.3 | 27 | 8.7 | 22 | 24 | 18 | 24 | 25 |
| 26 | 61 | 41 | 51 | -1 | 44 | 48 | 14 | 0 | - | M | - | - | 0.00 | 30.31 | 30.37 | 0.7 | 20 | 3.8 | 11 | 24 | 10 | 24 | 26 |
| 27 | 65 | 44 | 55 | 3 | 52 | 54 | 10 | 0 | TS FG HZ | M | - | - | 0.00 | 30.19 | 30.25 | 1.4 | 21 | 3.9 | 14 | 22 | 13 | 22 | 27 |
| 28 | 63 | 46 | 55 | 3 | 51 | 55 | 10 | 0 | RA FG | M | - | - | 0.29 | 29.78 | 29.83 | 7.7 | 29 | 9.4 | 30 | 31 | 24 | 31 | 28 |
| 29 | 59 | 40 | 50 | -1 | 35 | 43 | 15 | 0 | - | M | - | - | 0.00 | 29.90 | 29.96 | 6.6 | 31 | 6.0 | 21 | 32 | 18 | 30 | 29 |
| 30 | 60 | 43 | 52 | 1 | 49 | 52 | 13 | 0 | RA FG | M | - | - | 0.19 | 29.67 | 30.20 | 6.7 | 18 | 8.7 | 23 | 22 | 20 | 18 | 30 |
| 31 | 60 | 49 | 55 | 4 | 36 | 46 | 10 | 0 | - | M | - | - | 0.00 | 29.70 | 29.75 | 10.5 | 27 | 11.1 | 28 | 30 | 23 | 30 | 31 |
| | 62.7 | 45.4 | 54.1 | -------- | | | | | <Monthly Averages | Totals> | | | 6.64 | | | | | | <Monthly Average | | | | |
| | -1.4 | -1.7 | -1.5 | -------- | <--------------------Departure From Normal----------------------> | | | | | | | | 3.53 | | | | | | | | | | |

| Degree Days | Monthly Total | Monthly Departure | Season to Date Total | Season to Date Departure |
|---|---|---|---|---|
| Heating: | 300 | -2 | | |
| Cooling: | 0 | -11 | | |

Greatest 24-hr Precipitation: 4.37 date: 19-20
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.68 | 5 | 1159 |
| Minimum : | 29.26 | 8 | 2348 |

Number of Days with ----->
Max temp >= 90: M
Max temp <= 32: M
Thunderstorms : 1
Min temp <= 32: M
Min temp <= 0 : M
Heavy Fog : 0
Precipitation >= .01 inch: M
Precipitation >= .10 inch : M
Snowfall >= 1.0 inch : 0

56 @ 80° 5 sec
48 @ 80° 2-min

10/96

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 11/1996**

Station Location: BRIDGEPORT, CT (BDR) lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) |  |  |  |  |  | Deg Days Base 65 Degrees |  | Significant Weather | Snow/Ice on Gnd(In) |  | Precipitation (In) |  | Pressure (inches of Hg) |  | Wind Speed=mph Dir=tens of degrees |  |  |  |  |  |  | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  |  |  | 0600 LST | 1200 LST | 2400 LST | 2400 LST |  |  |  |  |  | max 5-sec |  | max 2-min |  |  |
|  | Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Heating | Cooling |  | Depth | Water Equiv | Snow Fall | Water Equiv | Avg. Station | Avg. Sea level | Resultant Speed | Res Dir | Avg. Speed | Speed | Dir | Speed | Dir |  |
| 01 | 48 | 38 | 43 | -8 | 32 | 39 | 22 | 0 | - | M | - | - | T | 29.78 | 29.84 | 8.3 | 27 | 9.3 | 31 | 28 | 22 | 28 | 01 |
| 02 | 49 | 34 | 42 | -8 | 30 | 36 | 23 | 0 | - | M | - | - | 0.00 | 29.73 | 29.79 | 3.6 | 30 | 6.1 | 23 | 34 | 18 | 33 | 02 |
| 03 | 48 | 33 | 41 | -9 | 25 | 34 | 24 | 0 | - | M | - | - | 0.00 | 30.03 | 30.09 | 11.4 | 30 | 11.7 | 26 | 29 | 22 | 32 | 03 |
| 04 | 53 | 34 | 44 | -6 | 32 | 40 | 21 | 0 | - | M | - | - | 0.00 | 30.29 | 30.35 | 10.2 | 25 | 10.8 | 23 | 24 | 20 | 24 | 04 |
| 05 | 56 | 46 | 51 | 2 | 42 | 47 | 14 | 0 | - | M | - | - | T | 30.30 | 30.36 | 2.8 | 27 | 5.3 | 15 | 23 | 13 | 23 | 05 |
| 06 | 54 | 49 | 52 | 3 | 47 | 50 | 13 | 0 | RA FG | M | - | - | 0.07 | 30.35 | 30.41 | 9.2 | 9 | 10.4 | 18 | 11 | 16 | 11 | 06 |
| 07 | 66 | 53 | 60 | 11 | 58 | 58 | 5 | 0 | RA FG | M | - | - | 0.07 | 30.16 | 30.21 | 7.3 | 14 | 10.9 | 25 | 19 | 18 | 19 | 07 |
| 08 | 68* | 61 | 65* | 17 | 63 | 63 | 0 | 0 | RA FG | M | - | - | 0.24 | 29.76 | 29.82 | 20.6 | 19 | 20.8 | 36 | 18 | 29 | 18 | 08 |
| 09 | 66 | 41 | 54 | 6 | 49 | 52 | 11 | 0 | RA FG | M | - | - | 0.73 | 29.68 | 29.72 | 12.0 | 22 | 14.6 | 40 | 19 | 32 | 18 | 09 |
| 10 | 49 | 39 | 44 | -4 | 35 | 41 | 21 | 0 | FG | M | - | - | 0.02 | 29.89 | 29.94 | 7.2 | 27 | 9.8 | 21 | 24 | 17 | 24 | 10 |
| 11 | 45 | 33 | 39 | -8 | 28 | 34 | 26 | 0 | - | M | - | - | 0.00 | 30.03 | 30.09 | 9.1 | 28 | 9.4 | 21 | 29 | 18 | 30 | 11 |
| 12 | 43 | 30 | 37 | -10 | 22 | 31 | 28 | 0 | - | M | - | - | 0.00 | 30.32 | 30.37 | 11.2 | 30 | 11.5 | 30 | 29 | 24 | 29 | 12 |
| 13 | 40 | 26 | 33 | -14 | 21 | 29 | 32 | 0 | - | M | - | - | 0.00 | 30.50 | 30.55 | 4.7 | 31 | 5.9 | 18 | 31 | 16 | 31 | 13 |
| 14 | 37 | 28 | 33 | -13 | 18 | 28 | 32 | 0 | - | M | - | - | 0.00 | 30.52 | 30.56 | 8.0 | 2 | 8.5 | 18 | 5 | 15 | 5 | 14 |
| 15 | 38 | 23 | 31 | -15 | 14 | 25 | 34 | 0 | - | M | - | - | 0.00 | 30.71 | 30.77 | 8.2 | 1 | 8.4 | 22 | 2 | 18 | 1 | 15 |
| 16 | 46 | 21 | 34 | -12 | 11 | 26 | 31 | 0 | - | M | - | - | 0.00 | 30.67 | 30.72 | 6.2 | 35 | 5.9 | 13 | 32 | 11 | 1 | 16 |
| 17 | 53 | 26 | 40 | -5 | 21 | 33 | 25 | 0 | - | M | - | - | 0.00 | 30.40 | 30.45 | 2.2 | 31 | 4.7 | 13 | 25 | 11 | 23 | 17 |
| 18 | 51 | 32 | 42 | -3 | 28 | 38 | 23 | 0 | - | M | - | - | 0.00 | 29.99 | 30.04 | 2.8 | 5 | 4.1 | 9 | 2 | 9 | 9 | 18 |
| 19 | 46 | 37 | 42 | -2 | 38 | 41 | 23 | 0 | RA FG | M | - | - | 0.03 | 29.76 | 29.80 | 6.2 | 34 | 7.3 | 20 | 33 | 16 | 34 | 19 |
| 20 | 43 | 32 | 38 | -6 | 28 | 33 | 27 | 0 | - | M | - | - | T | 29.75 | 29.79 | 7.7 | 31 | 8.5 | 25 | 34 | 22 | 32 | 20 |
| 21 | 41 | 31 | 36 | -8 | 26 | 32 | 29 | 0 | - | M | - | - | 0.00 | 29.77 | 29.82 | 7.4 | 30 | 7.8 | 20 | 30 | 17 | 30 | 21 |
| 22 | 43 | 31 | 37 | -6 | 26 | 33 | 28 | 0 | - | M | - | - | 0.00 | 29.84 | 29.91 | 11.8 | 35 | 12.0 | 25 | 33 | 20 | 33 | 22 |
| 23 | 47 | 29 | 38 | -5 | 25 | 35 | 27 | 0 | - | M | - | - | 0.00 | 29.98 | 30.04 | 5.5 | 28 | 8.3 | 20 | 36 | 16 | 26 | 23 |
| 24 | 44 | 35 | 40 | -3 | 23 | 34 | 25 | 0 | - | M | - | - | 0.00 | 30.13 | 30.17 | 4.3 | 36 | 5.8 | 21 | 2 | 15 | 1 | 24 |
| 25 | 53 | 39 | 46 | 4 | 30 | 39 | 19 | 0 | HZ | M | - | - | T | 30.10 | 30.15 | 2.0 | 14 | 6.2 | 16 | 21 | 14 | 21 | 25 |
| 26 | 54 | 34 | 44 | 2 | 41 | 43 | 21 | 0 | RA FG HZ | M | - | - | 2.17 | 29.71 | 29.89 | 6.8 | 2 | 11.5 | 32 | 33 | 25 | 33 | 26 |
| 27 | 34 | 23 | 29 | -12 | 17 | 25 | 36 | 0 | - | M | - | - | 0.00 | 30.21 | 30.26 | 16.5 | 35 | 16.7 | 34 | 35 | 28 | 35 | 27 |
| 28 | 30 | 19* | 25* | -16 | 15 | 22 | 40 | 0 | - | M | - | - | T | 30.33 | 30.39 | 5.0 | 33 | 7.1 | 18 | 36 | 15 | 1 | 28 |
| 29 | 41 | 22 | 32 | -8 | 22 | 28 | 33 | 0 | - | M | - | - | 0.00 | 30.30 | 30.36 | 6.3 | 33 | 5.8 | 21 | 33 | 16 | 34 | 29 |
| 30 | 47 | 27 | 37 | -3 | 33 | 36 | 28 | 0 | FG | M | - | - | 0.02 | 30.29 | 30.34 | 1.9 | 17 | 6.8 | 18 | 18 | 15 | 21 | 30 |
|  | 47.8 | 33.5 | 40.7 | -------- | 30.0 | 36.8 | 24.0 | .0 | <Monthly Averages | Totals> |  |  | 3.35 | 30.11 | 30.17 | 3.6 | 30.6 | 9.1 | <Monthly Average |  |  |  |  |
|  | -5.2 | -4.7 | -4.9 | -------- | <---------------------Departure From Normal-----------------------> |  |  |  |  |  |  |  | -.46 |  |  |  |  |  |  |  |  |  |  |

**Degree Days** Monthly Season to Date

| | Total | Departure | Total | Departure |
|---|---|---|---|---|
| Heating: | 721 | 139 | | |
| Cooling: | 0 | 0 | | |

Greatest 24-hr Precipitation: 2.17 date: 26
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.83 | 15 | 2057 |
| Minimum : | 29.51 | 26 | 1055 |

Number of Days with ----->
Max temp >= 90: 0
Max temp <= 32: 1
Thunderstorms : 0
Min temp <= 32: 15
Min temp <= 0 : 0
Heavy Fog : 0
Precipitation >= .01 inch: 8
Precipitation >= .10 inch : 3
Snowfall >= 1.0 inch : 0

Avg. temp = 40.7°F

Avg speed/dir = 9.1/306°

11/96

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 12/1996**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) |  |  |  |  |  | Deg Days Base 65 Degrees |  | Significant Weather | Snow/Ice on Gnd(In) |  | Precipitation (In) |  | Pressure (inches of Hg) |  | Wind Speed=mph Dir=tens of degrees |  |  |  |  |  |  | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Heating | Cooling |  | 0600 LST Depth | 1200 LST Water Equiv | 2400 LST Snow Fall | 2400 LST Water Equiv | Avg. Station | Avg. Sea level | Resultant Speed | Res Dir | Avg. Speed | max 5-sec Speed | max 5-sec Dir | max 2-min Speed | max 2-min Dir |  |
| 01 | 57 | 47 | 52* | 13 | 51 | 52 | 13 | 0 | RA FG | M | - | - | 0.44 | 29.93 | 29.99 | 14.2 | 19 | 14.5 | 30 | 21 | 23 | 20 | 01 |
| 02 | 57* | 36 | 47 | 8 | 39 | 44 | 18 | 0 | RA FG | M | - | - | 1.20 | 29.75 | 30.05 | 8.4 | 27 | 13.5 | 38 | 20 | 32 | 20 | 02 |
| 03 | 45 | 30 | 38 | -1 | 30 | 36 | 27 | 0 | - | M | - | - | T | 30.11 | 30.16 | 2.3 | 20 | 4.8 | 14 | 18 | 10 | 19 | 03 |
| 04 | 43 | 36 | 40 | 2 | 37 | 38 | 25 | 0 | RA FG | M | - | - | 0.06 | 30.05 | 30.11 | 4.9 | 2 | 5.8 | 11 | 33 | 10 | 33 | 04 |
| 05 | 44 | 32 | 38 | 0 | 33 | 36 | 27 | 0 | - | M | - | - | 0.00 | 30.13 | 30.18 | 2.9 | 12 | 6.8 | 23 | 13 | 20 | 13 | 05 |
| 06 | 45 | 34 | 40 | 3 | 35 | 37 | 25 | 0 | TS TSRA TSSN RA SN FG | M | - | - | 0.87 | 29.67 | 29.84 | 13.5 | 5 | 18.4 | 46 | 8 | 39 | 8 | 06 |
| 07 | 43 | 33 | 38 | 1 | 35 | 37 | 27 | 0 | RA SN FG | M | - | - | 1.73 | 29.78 | 30.06 | 6.8 | 9 | 9.7 | 24 | 2 | 21 | 3 | 07 |
| 08 | 46 | 30 | 38 | 1 | 32 | 35 | 27 | 0 | SN FG | M | - | - | 0.08 | 29.52 | 30.43 | 8.2 | 29 | 8.9 | 23 | 31 | 18 | 32 | 08 |
| 09 | 43 | 29 | 36 | 0 | 28 | 32 | 29 | 0 | FG | M | - | - | 0.00 | 29.76 | 29.82 | 6.9 | 36 | 7.6 | 18 | 34 | 13 | 33 | 09 |
| 10 | 41 | 26 | 34 | -2 | 27 | 32 | 31 | 0 | - | M | - | - | 0.00 | 29.98 | 30.04 | 4.4 | 25 | 7.4 | 22 | 25 | 20 | 24 | 10 |
| 11 | 44 | 38 | 41 | 5 | 35 | 38 | 24 | 0 | RA FG | M | - | - | 0.20 | 29.93 | 30.00 | 1.7 | 3 | 6.6 | 18 | 24 | 15 | 24 | 11 |
| 12 | 44 | 39 | 42 | 7 | 39 | 40 | 23 | 0 | RA FG | M | - | - | 0.03 | 30.16 | 30.21 | 12.5 | 5 | 12.6 | 24 | 8 | 20 | 8 | 12 |
| 13 | 44 | 38 | 41 | 6 | 37 | 40 | 24 | 0 | FG | M | - | - | 0.00 | 30.15 | 30.20 | 14.9 | 8 | 16.6 | 29 | 9 | 25 | 9 | 13 |
| 14 | 41 | 38 | 40 | 5 | 37 | 39 | 25 | 0 | RA FG | M | - | - | 0.07 | 30.15 | 30.20 | 15.2 | 3 | 15.3 | 28 | 1 | 22 | 2 | 14 |
| 15 | 43 | 38 | 41 | 7 | 36 | 39 | 24 | 0 | - | M | - | - | 0.03 | 30.31 | 30.38 | 12.1 | 3 | 12.6 | 25 | 1 | 18 | 2 | 15 |
| 16 | 44 | 40 | 42 | 8 | 38 | 40 | 23 | 0 | FG | M | - | - | 0.00 | 30.22 | 30.25 | 7.1 | 5 | 7.5 | 16 | 9 | 14 | 9 | 16 |
| 17 | 55 | 42 | 49 | 15 | 48 | 48 | 16 | 0 | RA FG | M | - | - | 0.62 | 29.85 | 29.91 | 4.8 | 18 | 10.6 | 25 | 22 | 20 | 20 | 17 |
| 18 | 54 | 47 | 51 | 18 | 47 | 48 | 14 | 0 | RA FG HZ | M | - | - | 0.02 | 29.85 | 29.91 | 3.3 | 21 | 4.0 | 10 | 20 | 8 | 30 | 18 |
| 19 | 49 | 32 | 41 | 8 | 36 | 39 | 24 | 0 | DZ SN FG HZ | M | - | - | 0.38 | 29.66 | 29.71 | 4.6 | 1 | 6.5 | 26 | 33 | 20 | 33 | 19 |
| 20 | 32 | 22 | 27 | -6 | 12 | 22 | 38 | 0 | SN FG | M | - | - | T | 30.02 | 30.08 | 15.7 | 29 | 16.1 | 34 | 30 | 28 | 29 | 20 |
| 21 | 32 | 20 | 26 | -6 | 15 | 23 | 39 | 0 | - | M | - | - | 0.00 | 30.46 | 30.50 | 6.4 | 27 | 7.5 | 20 | 24 | 16 | 23 | 21 |
| 22 | 38 | 26 | 32 | 0 | 23 | 30 | 33 | 0 | - | M | - | - | 0.00 | 30.35 | 30.42 | 8.3 | 26 | 8.6 | 21 | 24 | 17 | 24 | 22 |
| 23 | 43 | 31 | 37 | 5 | 32 | 36 | 28 | 0 | - | M | - | - | 0.00 | 30.24 | 30.29 | 0.9 | 29 | 2.8 | 9 | 13 | 8 | 13 | 23 |
| 24 | 55 | 40 | 48 | 16 | 45 | 47 | 17 | 0 | RA FG | M | - | - | 0.39 | 29.82 | 29.87 | 15.7 | 22 | 16.4 | 39 | 29 | 32 | 20 | 24 |
| 25 | 46 | 28 | 37 | 5 | 18 | 29 | 28 | 0 | - | M | - | - | T | 30.05 | 30.10 | 14.2 | 30 | 14.6 | 31 | 29 | 26 | 29 | 25 |
| 26 | 41 | 27 | 34 | 3 | 23 | 29 | 31 | 0 | FG | M | - | - | 0.01 | 30.39 | 30.45 | 4.2 | 25 | 5.9 | 17 | 27 | 14 | 27 | 26 |
| 27 | 48 | 32 | 40 | 9 | 33 | 37 | 25 | 0 | RA FG | M | - | - | 0.01 | 30.18 | 30.24 | 2.8 | 36 | 5.5 | 14 | 2 | 11 | 20 | 27 |
| 28 | 47 | 30 | 39 | 8 | 36 | 38 | 26 | 0 | RA FG HZ | M | - | - | 0.01 | 30.16 | 30.22 | 0.9 | 17 | 4.3 | 11 | 20 | 10 | 21 | 28 |
| 29 | 51 | 44 | 48 | 17 | 47 | 47 | 17 | 0 | RA FG+ FG | M | - | - | 0.29 | 29.92 | 29.98 | 7.0 | 23 | 7.7 | 21 | 30 | 15 | 29 | 29 |
| 30 | 50 | 31 | 41 | 10 | 28 | 36 | 24 | 0 | - | M | - | - | 0.00 | 30.12 | 30.18 | 8.8 | 34 | 10.5 | 23 | 30 | 18 | 30 | 30 |
| 31 | 31 | 14* | 23* | -7 | 13 | 21 | 42 | 0 | SN FG FZFG | M | - | - | 0.03 | 30.19 | 30.25 | 11.6 | 3 | 12.4 | 29 | 1 | 23 | 1 | 31 |
|  | 45.0 | 33.2 | 39.1 | -------- | 33.1 | 36.9 | 25.6 | .0 | <Monthly Averages | Totals> |  |  | 6.47 | 30.03 | 30.13 | 1.9 | 34.2 | 9.8 | <Monthly Average |  |  |  |  |
|  | 4.0 | 5.6 | 4.8 | -------- | <--------------------Departure From Normal----------------------> |  |  |  |  |  |  |  | 2.97 |  |  |  |  |  |  |  |  |  |  |

**Degree Days** Monthly Season to Date

| Degree Days | Monthly Total | Departure | Season to Date Total | Departure |
|---|---|---|---|---|
| Heating: | 794 | -158 |  |  |
| Cooling: | 0 | 0 |  |  |

Greatest 24-hr Precipitation: 1.81 date: 7-8
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.57 | 21 | 1039 |
| Minimum : | 29.42 | 7 | 2323 |

Number of Days with ----->
Max temp >= 90: 0
Max temp <= 32: 3
Thunderstorms : 1
Min temp <= 32: 16
Min temp <= 0 : 0
Heavy Fog : 1
Precipitation >= .01 inch: 19
Precipitation >= .10 inch : 9
Snowfall >= 1.0 inch : 0

39.1°F

9.8/342°

12/96

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 01/1997**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) | | | | | | Deg Days Base 65 Degrees | | Significant Weather | Snow/Ice on Gnd(In) | | Precipitation (In) | | Pressure (inches of Hg) | | Wind Speed=mph Dir=tens of degrees | | | | | | | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Heating | Cooling | | 0600 LST Depth | 1200 LST Water Equiv | 2400 LST Snow Fall | 2400 LST Water Equiv | Avg. Station | Avg. Sea level | Resultant Speed | Res Dir | Avg. Speed | max 5-sec Speed | max 5-sec Dir | max 2-min Speed | max 2-min Dir | |
| 01 | 32 | 8 | 20 | -10 | 3 | 14 | 45 | 0 | FG | M | - | - | T | 30.27 | 30.32 | 3.4 | 1 | 6.5 | 22 | 2 | 16 | 2 | 01 |
| 02 | 40 | 28 | 34 | 4 | 30 | 33 | 31 | 0 | SN FG HZ | M | - | - | 0.05 | 29.75 | 29.81 | 4.5 | 27 | 5.6 | 17 | 26 | 14 | 20 | 02 |
| 03 | 53* | 38 | 46* | 16 | 37 | 41 | 19 | 0 | FG HZ | M | - | - | 0.03 | 29.61 | 29.66 | 4.0 | 26 | 6.1 | 17 | 24 | 14 | 24 | 03 |
| 04 | 44 | 36 | 40 | 10 | 38 | 40 | 25 | 0 | RA FG | M | - | - | T | 29.90 | 29.97 | 4.9 | 10 | 6.9 | 16 | 11 | 14 | 9 | 04 |
| 05 | 48 | 42 | 45 | 15 | 45 | 45 | 20 | 0 | FG+ FG | M | - | - | 0.10 | 29.54 | 31.13 | 4.4 | 10 | 7.8 | 17 | 8 | 15 | 8 | 05 |
| 06 | 49 | 33 | 41 | 11 | 28 | 36 | 24 | 0 | FG+ FG | M | - | - | 0.00 | 29.62 | 30.18 | 13.9 | 29 | 14.4 | 33 | 30 | 30 | 30 | 06 |
| 07 | 36 | 26 | 31 | 1 | 14 | 26 | 34 | 0 | - | M | - | - | 0.00 | 29.79 | 29.84 | 17.8 | 30 | 18.5 | 38 | 31 | 31 | 30 | 07 |
| 08 | 38 | 26 | 32 | 3 | 14 | 25 | 33 | 0 | - | M | - | - | 0.00 | 29.92 | 29.97 | 14.8 | 31 | 15.9 | 33 | 32 | 28 | 31 | 08 |
| 09 | 39 | 23 | 31 | 2 | 19 | 26 | 34 | 0 | FZRA SN FG | M | - | - | 0.10 | 29.79 | 30.24 | 3.2 | 8 | 7.4 | 40 | 11 | 34 | 11 | 09 |
| 10 | 41 | 35 | 38 | 9 | 28 | 34 | 27 | 0 | RA SN FG | M | - | - | 0.03 | 29.31 | 31.68 | 10.7 | 27 | 15.3 | 38 | 28 | 30 | 27 | 10 |
| 11 | 35 | 20 | 28 | -1 | 15 | 24 | 37 | 0 | SN FG FZFG HZ | M | - | - | 0.13 | 29.61 | 30.43 | 11.0 | 29 | 12.8 | 32 | 28 | 25 | 29 | 11 |
| 12 | 27 | 18 | 23 | -6 | 9 | 19 | 42 | 0 | - | M | - | - | 0.00 | 30.01 | 30.06 | 13.6 | 27 | 14.6 | 26 | 31 | 23 | 30 | 12 |
| 13 | 34 | 20 | 27 | -2 | 16 | 23 | 38 | 0 | - | M | - | - | 0.00 | 30.15 | 30.20 | 8.6 | 29 | 9.5 | 23 | 32 | 18 | 31 | 13 |
| 14 | 34 | 22 | 28 | -1 | 17 | 24 | 37 | 0 | - | M | - | - | 0.00 | 30.22 | 30.26 | 8.2 | 30 | 9.3 | 21 | 34 | 17 | 32 | 14 |
| 15 | 35 | 20 | 28 | -1 | 21 | 26 | 37 | 0 | - | M | - | - | 0.00 | 30.17 | 30.21 | 5.9 | 23 | 7.4 | 17 | 21 | 15 | 22 | 15 |
| 16 | 47 | 26 | 37 | 8 | 32 | 37 | 28 | 0 | RA FG | M | - | - | 0.84 | 29.46 | 31.68 | 9.6 | 26 | 13.3 | 46 | 31 | 33 | 29 | 16 |
| 17 | 26 | 10 | 18 | -11 | -5 | 11 | 47 | 0 | HZ | M | - | - | T | 29.81 | 29.87 | 17.4 | 30 | 18.8 | 44 | 30 | 37 | 30 | 17 |
| 18 | 17 | 5 | 11 | -18 | -4 | 8 | 54 | 0 | FG | M | - | - | T | 29.92 | 29.96 | 9.8 | 31 | 11.8 | 28 | 30 | 22 | 31 | 18 |
| 19 | 20 | 2* | 11* | -18 | -3 | 9 | 54 | 0 | - | M | - | - | 0.00 | 30.05 | 30.11 | 8.8 | 28 | 10.0 | 25 | 26 | 18 | 26 | 19 |
| 20 | 32 | 18 | 25 | -4 | 17 | 23 | 40 | 0 | - | M | - | - | T | 29.88 | 29.93 | 8.9 | 26 | 9.7 | 24 | 25 | 18 | 24 | 20 |
| 21 | 36 | 24 | 30 | 2 | 13 | 25 | 35 | 0 | - | M | - | - | 0.00 | 30.31 | 30.35 | 7.6 | 34 | 8.9 | 26 | 36 | 20 | 35 | 21 |
| 22 | 45 | 31 | 38 | 10 | 31 | 35 | 27 | 0 | HZ | M | - | - | 0.08 | 30.07 | 30.12 | 8.6 | 24 | 9.0 | 21 | 23 | 17 | 23 | 22 |
| 23 | M | M | M | M | - | 33 | M | M | FG HZ | M | - | - | 0.00 | 29.94 | 30.00 | 7.0 | 32 | 11.0 | 26 | 1 | 23 | 1 | 23 |
| 24 | 37 | 19 | 28 | 0 | 19 | 26 | 37 | 0 | - | M | - | - | 0.13 | 30.38 | 30.44 | 15.6 | 9 | 17.6 | 33 | 11 | 29 | 10 | 24 |
| 25 | 50 | 35 | 43 | 15 | 38 | 41 | 22 | 0 | RA FG+ FG | M | - | - | 0.95 | 29.69 | 29.74 | 7.4 | 24 | 11.4 | 30 | 19 | 24 | 18 | 25 |
| 26 | 35 | 21 | 28 | 0 | 10 | 23 | 37 | 0 | - | M | - | - | T | 30.24 | 30.29 | 13.9 | 31 | 15.3 | 36 | 30 | 28 | 31 | 26 |
| 27 | 37 | 18 | 28 | 0 | 12 | 22 | 37 | 0 | SN FG | M | - | - | T | 30.54 | 30.59 | 5.6 | 10 | 8.9 | 18 | 14 | 14 | 14 | 27 |
| 28 | 46 | 26 | 36 | 8 | 28 | 35 | 29 | 0 | RA FG | M | - | - | 0.43 | 30.00 | 30.05 | 9.6 | 27 | 14.2 | 36 | 22 | 30 | 31 | 28 |
| 29 | 29 | 19 | 24 | -4 | 7 | 20 | 41 | 0 | - | M | - | - | 0.00 | 30.44 | 30.49 | 8.2 | 34 | 10.5 | 31 | 31 | 24 | 31 | 29 |
| 30 | 30 | 15 | 23 | -5 | 12 | 20 | 42 | 0 | - | M | - | - | 0.00 | 30.37 | 30.44 | 9.3 | 7 | 11.3 | 22 | 9 | 20 | 9 | 30 |
| 31 | 35 | 26 | 31 | 2 | 28 | 30 | 34 | 0 | FG HZ | M | - | - | 0.08 | 29.86 | 29.92 | 3.9 | 5 | 7.2 | 17 | 2 | 15 | 3 | 31 |
| | 36.9 | 23.0 | 30.0 | -------- | 18.8 | 26.9 | 34.9 | .0 | <Monthly Averages | Totals> | | | 2.95 | 29.96 | 30.25 | 5.7 | 29.4 | 11.2 | <Monthly Average | | | | |
| | .9 | 1.1 | 1.1 | -------- | <--------------------Departure From Normal----------------------> | | | | | | | | -.29 | | | | | | | | | | |

**Degree Days** Monthly Season to Date
Total Departure Total Departure
Heating: 1047 -72
Cooling: 0 0

Greatest 24-hr Precipitation: 1.08 date: 24-25
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.72 | 27 | 1023 |
| Minimum : | 29.20 | 10 | 0511 |

Number of Days with ----->
Max temp >= 90: M
Max temp <= 32: M
Thunderstorms : 0
Min temp <= 32: M
Min temp <= 0 : M
Heavy Fog : 3
Precipitation >= .01 inch: 12
Precipitation >= .10 inch : 5
Snowfall >= 1.0 inch : 0

30°F

11.2 mph / 294°

1/97

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 02/1997**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Deg Days Base 65 Degrees Heating | Cooling | Significant Weather | Snow/Ice on Gnd(In) 0600 LST Depth | 1200 LST Water Equiv | Precipitation (In) 2400 LST Snow Fall | 2400 LST Water Equiv | Pressure (inches of Hg) Avg. Station | Avg. Sea level | Wind Speed=mph Dir=tens of degrees Resultant Speed | Res Dir | Avg. Speed | max 5-sec Speed | Dir | max 2-min Speed | Dir | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 49 | 35 | 42 | 14 | 35 | 38 | 23 | 0 | RA FG UP HZ | M | - | - | 0.16 | 29.70 | 29.75 | 7.8 | 28 | 9.2 | 30 | 31 | 23 | 31 | 01 |
| 02 | 41 | 30 | 36 | 7 | 29 | 33 | 29 | 0 | - | M | - | - | 0.00 | 30.12 | 30.16 | 2.6 | 25 | 4.8 | 10 | 18 | 10 | 31 | 02 |
| 03 | 44 | 34 | 39 | 10 | 35 | 37 | 26 | 0 | RA FG UP HZ | M | - | - | 0.02 | 30.25 | 30.29 | 0.3 | 9 | 4.3 | 24 | 1 | 20 | 1 | 03 |
| 04 | 36 | 30 | 33 | 4 | 29 | 32 | 32 | 0 | RA SN FG | M | - | - | 0.04 | 30.46 | 30.51 | 11.0 | 9 | 12.5 | 26 | 10 | 23 | 10 | 04 |
| 05 | 51 | 36 | 44 | 15 | 38 | 40 | 21 | 0 | RA FG+ FG | M | - | - | 1.35 | 29.89 | 29.94 | 5.8 | 28 | 10.4 | 30 | 22 | 24 | 22 | 05 |
| 06 | 44 | 30 | 37 | 8 | 27 | 34 | 28 | 0 | - | M | - | - | 0.00 | 30.01 | 30.07 | 8.8 | 32 | 8.9 | 24 | 33 | 20 | 33 | 06 |
| 07 | 39 | 27 | 33 | 4 | 23 | 29 | 32 | 0 | - | M | - | - | 0.00 | 30.17 | 30.22 | 4.4 | 27 | 5.8 | 15 | 30 | 13 | 31 | 07 |
| 08 | 33 | 30 | 32 | 3 | 22 | 28 | 33 | 0 | - | M | - | - | T | 30.20 | 30.25 | 10.0 | 5 | 10.4 | 22 | 6 | 18 | 4 | 08 |
| 09 | 38 | 25 | 32 | 3 | 12 | 25 | 33 | 0 | - | M | - | - | 0.00 | 30.11 | 30.18 | 8.6 | 35 | 10.3 | 25 | 1 | 20 | 1 | 09 |
| 10 | 36 | 21 | 29 | 0 | 14 | 24 | 36 | 0 | - | M | - | - | 0.00 | 30.12 | 30.16 | 5.6 | 31 | 7.7 | 18 | 24 | 16 | 23 | 10 |
| 11 | 37 | 27 | 32 | 3 | 24 | 30 | 33 | 0 | - | M | - | - | T | 30.06 | 30.11 | 5.4 | 1 | 9.3 | 22 | 2 | 18 | 2 | 11 |
| 12 | 37 | 29 | 33 | 3 | 27 | 31 | 32 | 0 | SN FG HZ | M | - | - | T | 30.05 | 30.08 | 7.9 | 25 | 9.2 | 22 | 27 | 18 | 24 | 12 |
| 13 | 34 | 23 | 29 | -1 | 12 | 24 | 36 | 0 | SN FG | M | - | - | T | 30.43 | 30.49 | 6.1 | 35 | 10.6 | 31 | 1 | 25 | 1 | 13 |
| 14 | 43 | 30 | 37 | 7 | 31 | 34 | 28 | 0 | RA SN FG HZ | M | - | - | 0.38 | 30.08 | 30.13 | 8.7 | 9 | 13.5 | 28 | 8 | 25 | 10 | 14 |
| 15 | 46 | 35 | 41 | 11 | 32 | 37 | 24 | 0 | RA FG UP HZ | M | - | - | 0.06 | 29.88 | 29.95 | 6.7 | 29 | 8.2 | 20 | 30 | 16 | 29 | 15 |
| 16 | 35 | 27 | 31 | 1 | 19 | 27 | 34 | 0 | SN FG | M | - | - | T | 30.25 | 30.31 | 1.8 | 25 | 7.8 | 25 | 31 | 21 | 31 | 16 |
| 17 | 33 | 22 | 28 | -3 | 19 | 26 | 37 | 0 | SN FG HZ | M | - | - | 0.01 | 30.38 | 30.43 | 4.5 | 35 | 11.7 | 29 | 2 | 23 | 1 | 17 |
| 18 | 48 | 33 | 41 | 10 | 28 | 35 | 24 | 0 | - | M | - | - | 0.00 | 30.22 | 30.27 | 13.7 | 24 | 14.0 | 25 | 23 | 22 | 24 | 18 |
| 19 | 61 | 38 | 50 | 19 | 36 | 42 | 15 | 0 | - | M | - | - | T | 29.90 | 29.94 | 10.1 | 26 | 11.0 | 56 | 31 | 45 | 31 | 19 |
| 20 | 51 | 34 | 43 | 12 | 26 | 35 | 22 | 0 | - | M | - | - | 0.00 | 30.23 | 30.30 | 4.8 | 31 | 10.4 | 38 | 31 | 31 | 31 | 20 |
| 21 | 52 | 32 | 42 | 11 | 41 | 42 | 23 | 0 | FG+ FG | M | - | - | 0.00 | 29.95 | 30.00 | 6.1 | 23 | 7.3 | 31 | 21 | 26 | 22 | 21 |
| 22 | 61 | 37 | 49 | 17 | 40 | 45 | 16 | 0 | FG+ FG | M | - | - | 0.04 | 29.60 | 29.91 | 9.8 | 26 | 13.1 | 40 | 30 | 31 | 30 | 22 |
| 23 | 42 | 30 | 36 | 4 | 21 | 31 | 29 | 0 | - | M | - | - | 0.00 | 30.21 | 30.25 | 9.4 | 27 | 11.7 | 30 | 30 | 23 | 29 | 23 |
| 24 | 46 | 24 | 35 | 3 | 20 | 31 | 30 | 0 | - | M | - | - | 0.00 | 30.22 | 30.27 | 9.7 | 30 | 11.5 | 32 | 32 | 26 | 32 | 24 |
| 25 | 33 | 16* | 25* | -8 | 9 | 21 | 40 | 0 | - | M | - | - | 0.00 | 30.26 | 30.32 | 6.4 | 28 | 11.9 | 23 | 24 | 21 | 23 | 25 |
| 26 | 49 | 33 | 41 | 8 | 29 | 36 | 24 | 0 | HZ | M | - | - | 0.04 | 30.03 | 30.09 | 13.8 | 24 | 14.2 | 24 | 25 | 20 | 24 | 26 |
| 27 | 67* | 41 | 54* | 21 | 44 | 47 | 11 | 0 | FG+ FG HZ | M | - | - | 0.05 | 29.63 | 29.69 | 5.4 | 23 | 7.6 | 37 | 30 | 30 | 30 | 27 |
| 28 | 61 | 34 | 48 | 15 | - | - | 17 | 0 | - | M | - | - | 0.00 | - | - | - | - | 7.4 | 28 | 32 | 23 | 31 | 28 |
|  | 44.5 | 30.1 | 37.3 | -------- | 26.8 | 33.1 | 27.4 | .0 | <Monthly Averages | Totals> |  |  | 2.15 | 30.09 | 30.15 | 3.8 | 28.2 | 9.8 | <Monthly Average |  |  |  |  |
|  | 6.9 | 6.9 | 6.9 | -------- | <----------------------Departure From Normal----------------------> |  |  |  |  |  |  |  | -.86 |  |  |  |  |  |  |  |  |  |  |

| Degree Days | Monthly Total | Monthly Departure | Season to Date Total | Season to Date Departure |
|---|---|---|---|---|
| Heating: | 768 | -201 |  |  |
| Cooling: | 0 | 0 |  |  |

Greatest 24-hr Precipitation: 1.39date: 4-5
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.63 | 13 | 1830 |
| Minimum : | 29.49 | 22 | 1342 |

Number of Days with ----->
Max temp >= 90: 0
Max temp <= 32: 0
Thunderstorms : 0
Min temp <= 32: 17
Min temp <= 0 : 0
Heavy Fog : 4
Precipitation >= .01 inch: 10
Precipitation >= .10 inch : 3
Snowfall >= 1.0 inch : 0

37.3° F

9.8 / 282°

2/97

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 03/1997**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Deg Days Base 65 Degrees Heating | Cooling | Significant Weather | Snow/Ice on Gnd(In) 0600 LST Depth | 1200 LST Water Equiv | Precipitation (In) 2400 LST Snow Fall | 2400 LST Water Equiv | Pressure (inches of Hg) Avg. Station | Avg. Sea level | Wind Speed=mph Dir=tens of degrees Resultant Speed | Res Dir | Avg. Speed | max 5-sec Speed | Dir | max 2-min Speed | Dir | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 41 | 35 | 38 | 4 | 37 | 38 | 27 | 0 | RA SN FG+ FG | M | - | - | 0.01 | 30.18 | 30.24 | 9.5 | 9 | 9.3 | 17 | 9 | 15 | 10 | 01 |
| 02 | 59 | 38 | 49 | 15 | 40 | 42 | 16 | 0 | RA FG+ FG | M | - | - | 0.07 | 29.70 | 29.75 | 4.9 | 25 | 7.9 | 30 | 32 | 24 | 32 | 02 |
| 03 | 42 | 32 | 37 | 2 | 29 | 34 | 28 | 0 | SN FG | M | - | - | 0.14 | 30.09 | 30.14 | 7.8 | 7 | 10.6 | 25 | 7 | 20 | 8 | 03 |
| 04 | 37 | 31 | 34 | -1 | 31 | 33 | 31 | 0 | SN FG HZ | M | - | - | 0.02 | 30.10 | 30.15 | 4.4 | 6 | 7.8 | 21 | 5 | 17 | 6 | 04 |
| 05 | 43 | 34 | 39 | 4 | 36 | 37 | 26 | 0 | RA FG HZ | M | - | - | 0.17 | 30.06 | 30.10 | 2.4 | 21 | 7.1 | 18 | 8 | 16 | 8 | 05 |
| 06 | 45 | 33 | 39 | 4 | 27 | 35 | 26 | 0 | RA FG | M | - | - | 0.11 | 29.51 | 31.04 | 18.2 | 30 | 23.0 | 62 | 30 | 47 | 31 | 06 |
| 07 | 40 | 26 | 33 | -3 | 14 | 28 | 32 | 0 | - | M | - | - | 0.00 | 30.11 | 30.16 | 15.2 | 30 | 14.4 | 33 | 27 | 26 | 30 | 07 |
| 08 | 50 | 27 | 39 | 3 | 27 | 33 | 26 | 0 | - | M | - | - | T | 30.13 | 30.19 | 6.2 | 26 | 10.5 | 37 | 36 | 25 | 36 | 08 |
| 09 | 33 | 23 | 28* | -8 | 12 | 24 | 37 | 0 | - | M | - | - | 0.00 | 30.47 | 30.53 | 3.6 | 11 | 10.1 | 23 | 1 | 20 | 36 | 09 |
| 10 | 51 | 32 | 42 | 5 | 30 | 36 | 23 | 0 | RA SN FG UP | M | - | - | 0.39 | 29.88 | 29.94 | 3.2 | 27 | 7.7 | 23 | 32 | 20 | 32 | 10 |
| 11 | 49 | 31 | 40 | 3 | 28 | 35 | 25 | 0 | - | M | - | - | T | 29.78 | 29.85 | 3.0 | 25 | 7.8 | 29 | 32 | 24 | 32 | 11 |
| 12 | 44 | 29 | 37 | 0 | 13 | 28 | 28 | 0 | - | M | - | - | 0.00 | 30.08 | 30.13 | 13.6 | 32 | 14.0 | 36 | 34 | 29 | 35 | 12 |
| 13 | 38 | 22 | 30 | -8 | 5 | 23 | 35 | 0 | - | M | - | - | 0.00 | 30.38 | 30.42 | 10.8 | 34 | 11.7 | 26 | 33 | 22 | 33 | 13 |
| 14 | 50 | 28 | 39 | 1 | 24 | 32 | 26 | 0 | PE FG | M | - | - | 1.28 | 30.00 | 30.06 | 8.0 | 11 | 12.4 | 29 | 13 | 24 | 12 | 14 |
| 15 | 49 | 29 | 39 | 1 | 22 | 33 | 26 | 0 | HZ | M | - | - | T | 29.83 | 29.89 | 15.3 | 32 | 16.3 | 39 | 30 | 33 | 31 | 15 |
| 16 | 33 | 24 | 29 | -10 | 8 | 22 | 36 | 0 | - | M | - | - | 0.00 | 30.29 | 30.32 | 13.1 | 31 | 13.5 | 31 | 31 | 25 | 32 | 16 |
| 17 | 42 | 22 | 32 | -7 | 21 | 30 | 33 | 0 | - | M | - | - | 0.00 | 30.22 | 30.27 | 11.8 | 24 | 12.7 | 28 | 22 | 23 | 22 | 17 |
| 18 | 47 | 34 | 41 | 2 | 21 | 34 | 24 | 0 | - | M | - | - | 0.00 | 30.18 | 30.24 | 5.9 | 35 | 8.7 | 21 | 1 | 17 | 36 | 18 |
| 19 | 39 | 33 | 36 | -4 | 22 | 31 | 29 | 0 | - | M | - | - | 0.00 | 30.15 | 30.20 | 6.6 | 8 | 9.2 | 18 | 9 | 16 | 9 | 19 |
| 20 | 40 | 30 | 35 | -5 | 33 | 35 | 30 | 0 | RA FG | M | - | - | 0.11 | 29.79 | 29.84 | 5.3 | 22 | 8.0 | 21 | 22 | 18 | 21 | 20 |
| 21 | 46 | 26 | 36 | -4 | 28 | 34 | 29 | 0 | FG HZ | M | - | - | 0.00 | 29.69 | 29.99 | 5.3 | 23 | 6.5 | 23 | 22 | 20 | 21 | 21 |
| 22 | 52 | 30 | 41 | 0 | 32 | 39 | 24 | 0 | RA FG HZ | M | - | - | 0.20 | 29.45 | 31.34 | 7.1 | 33 | 10.9 | 33 | 32 | 25 | 33 | 22 |
| 23 | 38 | 25 | 32 | -9 | 8 | 24 | 33 | 0 | - | M | - | - | 0.00 | 29.93 | 29.99 | 11.2 | 33 | 11.7 | 29 | 29 | 22 | 30 | 23 |
| 24 | 46 | 22* | 34 | -7 | 15 | 28 | 31 | 0 | - | M | - | - | 0.11 | 30.32 | 30.37 | 7.7 | 31 | 9.3 | 24 | 32 | 21 | 32 | 24 |
| 25 | 49 | 28 | 39 | -2 | 28 | 35 | 26 | 0 | - | M | - | - | 0.01 | 30.26 | 30.32 | 4.0 | 19 | 8.5 | 29 | 23 | 23 | 23 | 25 |
| 26 | 51 | 39 | 45 | 3 | 35 | 42 | 20 | 0 | RA FG | 0.0 | - | - | 0.00 | 29.69 | 29.75 | 16.1 | 28 | 20.1 | 40 | 30 | 31 | 31 | 26 |
| 27 | 65 | 35 | 50 | 8 | 31 | 40 | 15 | 0 | - | M | - | - | 0.00 | 29.81 | 29.86 | 8.5 | 24 | 9.5 | 21 | 23 | 18 | 21 | 27 |
| 28 | 57 | 38 | 48 | 6 | 33 | 41 | 17 | 0 | HZ | M | - | - | 0.00 | 29.93 | 29.98 | 6.3 | 9 | 7.8 | 17 | 8 | 15 | 9 | 28 |
| 29 | 53 | 43 | 48 | 5 | 34 | 41 | 17 | 0 | RA FG+ FG HZ | M | - | - | 0.13 | 29.58 | 30.50 | 8.4 | 8 | 8.4 | 16 | 9 | 14 | 8 | 29 |
| 30 | 66* | 44 | 55* | 12 | 44 | 50 | 10 | 0 | FG | M | - | - | 0.01 | 29.60 | 29.66 | 8.0 | 35 | 9.8 | 25 | 1 | 21 | 33 | 30 |
| 31 | 49 | 33 | 41 | -2 | 38 | 39 | 24 | 0 | TS TSRA RA SN FG | M | - | - | 1.82 | 29.35 | 31.49 | 18.1 | 5 | 19.8 | 46 | 4 | 34 | 2 | 31 |
|  | 46.6 | 30.8 | 38.7 | -------- | 26.0 | 34.1 | 26.1 | .0 | <Monthly Averages | Totals> |  |  | 1.96 | 29.95 | 30.22 | 3.5 | 32 | 11.1 | <Monthly Average |  |  |  |  |
|  | .4 | -.1 | .1 | -------- | <--------------------Departure From Normal----------------------> |  |  |  |  |  |  |  | -1.79 |  |  |  |  |  |  |  |  |  |  |

**Degree Days** Monthly Season to Date

| | Monthly Total | Monthly Departure | Season to Date Total | Season to Date Departure |
|---|---|---|---|---|
| Heating: | 810 | -8 | | |
| Cooling: | 0 | 0 | | |

Greatest 24-hr Precipitation: 1.82date: 31
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.66 | 9 | 0903 |
| Minimum : | 29.21 | 31 | 1434 |

Number of Days with ----->

Max temp >= 90: 0
Max temp <= 32: 0
Thunderstorms : 1
Min temp <= 32: 19
Min temp <= 0 : 0
Heavy Fog : 3
Precipitation >= .01 inch: M
Precipitation >= .10 inch : M
Snowfall >= 1.0 inch : 0

38.7 °F

11.1 / 320°

3/97

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 04/1997**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Deg Days Base 65 Degrees Heating | Cooling | Significant Weather | Snow/Ice on Gnd(In) 0600 LST Depth | 1200 LST Water Equiv | Precipitation (In) 2400 LST Snow Fall | 2400 LST Water Equiv | Pressure (inches of Hg) Avg. Station | Avg. Sea level | Wind Speed=mph Dir=tens of degrees Resultant Speed | Res Dir | Avg. Speed | max 5-sec Speed | Dir | max 2-min Speed | Dir | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 46 | 30 | 38 | -6 | 25 | 33 | 27 | 0 | SN FG FZFG | M | - | - | 0.02 | 29.69 | 30.35 | 18.4 | 1 | 18.6 | 49 | 1 | 37 | 1 | 01 |
| 02 | 57 | 35 | 46 | 2 | 19 | 36 | 19 | 0 | - | M | - | - | 0.00 | 29.98 | 30.04 | 13.1 | 34 | 13.0 | 44 | 33 | 31 | 36 | 02 |
| 03 | 57 | 31 | 44 | 0 | 26 | 37 | 21 | 0 | - | M | - | - | 0.00 | 29.99 | 30.02 | 5.0 | 24 | 7.6 | 23 | 21 | 20 | 21 | 03 |
| 04 | 65 | 45 | 55 | 11 | 37 | 47 | 10 | 0 | - | M | - | - | 0.00 | 29.92 | 29.96 | 7.6 | 34 | 8.8 | 26 | 32 | 23 | 32 | 04 |
| 05 | 54 | 42 | 48 | 3 | 34 | 42 | 17 | 0 | - | M | - | - | T | 30.21 | 30.25 | 2.9 | 15 | 6.4 | 16 | 20 | 14 | 21 | 05 |
| 06 | 56 | 44 | 50 | 5 | 32 | 41 | 15 | 0 | RA FG HZ | M | - | - | T | 29.94 | 29.99 | 4.6 | 13 | 7.9 | 18 | 21 | 15 | 9 | 06 |
| 07 | 73* | 45 | 59* | 14 | 41 | 50 | 6 | 0 | FG+ FG HZ | M | - | - | 0.01 | 29.67 | 29.72 | 7.8 | 27 | 10.3 | 29 | 30 | 25 | 29 | 07 |
| 08 | 57 | 36 | 47 | 1 | 21 | 37 | 18 | 0 | - | M | - | - | 0.00 | 29.85 | 29.91 | 14.6 | 31 | 16.9 | 40 | 30 | 34 | 31 | 08 |
| 09 | 41 | 29 | 35* | -11 | 15 | 28 | 30 | 0 | SN FG | M | - | - | T | 29.96 | 30.01 | 13.2 | 34 | 14.1 | 31 | 36 | 26 | 32 | 09 |
| 10 | 49 | 26* | 38 | -8 | 9 | 29 | 27 | 0 | - | M | - | - | 0.00 | 30.12 | 30.18 | 11.7 | 34 | 12.3 | 36 | 34 | 28 | 34 | 10 |
| 11 | 51 | 32 | 42 | -5 | 23 | 35 | 23 | 0 | - | M | - | - | 0.00 | 30.20 | 30.25 | 7.4 | 23 | 9.0 | 22 | 23 | 20 | 23 | 11 |
| 12 | 51 | 41 | 46 | -1 | 32 | 39 | 19 | 0 | HZ | M | - | - | 1.27 | 29.95 | 30.00 | 10.4 | 8 | 10.5 | 21 | 19 | 18 | 8 | 12 |
| 13 | 65 | 47 | 56 | 9 | 34 | 46 | 9 | 0 | FG+ FG HZ | M | - | - | 0.01 | 29.52 | 30.07 | 3.8 | 25 | 7.9 | 25 | 30 | 21 | 31 | 13 |
| 14 | 56 | 39 | 48 | 0 | 21 | 38 | 17 | 0 | - | M | - | - | 0.00 | 29.96 | 30.00 | 13.7 | 33 | 14.3 | 33 | 31 | 26 | 31 | 14 |
| 15 | 58 | 34 | 46 | -2 | 25 | 37 | 19 | 0 | - | M | - | - | 0.00 | 30.19 | 30.24 | 4.0 | 26 | 8.5 | 20 | 23 | 18 | 21 | 15 |
| 17 | 50 | 44 | 47 | -2 | 42 | 45 | 18 | 0 | RA FG HZ | M | - | - | 0.21 | 29.62 | 30.05 | 2.5 | 15 | 5.2 | 16 | 1 | 13 | 36 | 17 |
| 18 | 47 | 36 | 42 | -7 | 32 | 36 | 23 | 0 | SN FG HZ | M | - | - | 0.44 | 29.18 | 32.18 | 19.2 | 36 | 19.3 | 39 | 35 | 30 | 36 | 18 |
| 19 | 49 | 35 | 42 | -7 | 32 | 38 | 23 | 0 | - | M | - | - | 0.06 | 29.33 | 31.60 | 15.4 | 35 | 15.5 | 36 | 33 | 26 | 33 | 19 |
| 20 | 56 | 39 | 48 | -2 | 33 | 41 | 17 | 0 | - | M | - | - | 0.00 | 29.63 | 29.69 | 2.5 | 27 | 8.1 | 20 | 36 | 15 | 36 | 20 |
| 21 | 57 | 41 | 49 | -1 | 33 | 42 | 16 | 0 | - | M | - | - | 0.00 | 29.70 | 29.76 | 6.8 | 29 | 8.1 | 24 | 29 | 18 | 29 | 21 |
| 22 | 58 | 38 | 48 | -2 | 32 | 41 | 17 | 0 | - | M | - | - | 0.00 | 29.61 | 29.68 | 4.1 | 11 | 5.0 | 13 | 12 | 11 | 11 | 22 |
| 23 | M | M | M | M | - | 38 | M | M | HZ | M | - | - | 0.00 | 29.61 | 29.67 | 3.3 | 18 | 4.8 | 15 | 8 | 11 | 7 | 23 |
| 24 | 52 | 46 | 49 | -2 | 35 | 42 | 16 | 0 | - | M | - | - | 0.02 | 29.59 | 29.65 | 11.4 | 5 | 12.5 | 32 | 2 | 28 | 2 | 24 |
| 25 | 60 | 45 | 53 | 2 | 38 | 45 | 12 | 0 | - | M | - | - | 0.00 | 29.90 | 29.95 | 5.7 | 25 | 7.8 | 24 | 34 | 15 | 21 | 25 |
| 26 | 66 | 43 | 55 | 3 | 30 | 45 | 10 | 0 | - | M | - | - | 0.00 | 30.06 | 30.12 | 7.7 | 34 | 7.6 | 26 | 33 | 21 | 32 | 26 |
| 27 | 61 | 42 | 52 | 0 | 34 | 45 | 13 | 0 | - | M | - | - | T | 30.12 | 30.18 | 3.7 | 14 | 6.7 | 18 | 15 | 15 | 16 | 27 |
| 28 | 57 | 46 | 52 | 0 | 45 | 47 | 13 | 0 | RA FG | M | - | - | 1.00 | 29.65 | 29.69 | 5.3 | 11 | 13.1 | 31 | 10 | 26 | 10 | 28 |
| 29 | 69 | 44 | 57 | 4 | 36 | 47 | 8 | 0 | HZ | M | - | - | 0.00 | 29.70 | 29.75 | 8.5 | 34 | 10.0 | 33 | 1 | 24 | 1 | 29 |
| 30 | 67 | 44 | 56 | 3 | 42 | 48 | 9 | 0 | - | M | - | - | 0.00 | 29.81 | 29.86 | 5.8 | 20 | 7.9 | 29 | 21 | 22 | 21 | 30 |
|  | 56.7 | 39.1 | 47.9 | -------- | 30.8 | 40.6 | 16.9 | .0 | <Monthly Averages | Totals> |  |  | 3.04 | 29.82 | 30.10 | 3.9 | 33.6 | 10.3 | <Monthly Average |  |  |  |  |
|  | .1 | -.7 | -.3 | -------- | <----------------------Departure From Normal-----------------------> |  |  |  |  | -.71 |  |  |  |  |  |  |  |  |  |

**Degree Days** Monthly Season to Date

| | Monthly Total | Departure | Season to Date Total | Departure |
|---|---|---|---|---|
| Heating: | 489 | -15 | | |
| Cooling: | 0 | 0 | | |

Greatest 24-hr Precipitation: 1.28date: 12-13
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.34 | 11 | 0859 |
| Minimum : | 29.12 | 18 | 1541 |

Number of Days with ----->

Max temp >= 90: M
Max temp <= 32: M
Thunderstorms : 0

Min temp <= 32: M
Min temp <= 0 : M
Heavy Fog : 2

Precipitation >= .01 inch: 9
Precipitation >= .10 inch : 4
Snowfall >= 1.0 inch : 0

10.3 / 336°

47.9° F

11/0

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 05/1997**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Deg Days Base 65 Degrees Heating | Cooling | Significant Weather | Snow/Ice on Gnd(In) 0600 LST Depth | 1200 LST Water Equiv | Precipitation (In) 2400 LST Snow Fall | 2400 LST Water Equiv | Pressure (inches of Hg) Avg. Station | Avg. Sea level | Wind Speed=mph Dir=tens of degrees Resultant Speed | Res Dir | Avg. Speed | max 5-sec Speed | Dir | max 2-min Speed | Dir | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 63 | 46 | 55 | 2 | 48 | 51 | 10 | 0 | TS TSRA RA FG | M | - | - | 0.31 | 29.55 | 30.59 | 7.1 | 21 | 10.0 | 25 | 27 | 20 | 27 | 01 |
| 02 | 66 | 46 | 56 | 2 | 29 | 44 | 9 | 0 | - | M | - | - | 0.00 | 29.83 | 29.88 | 14.9 | 31 | 14.3 | 40 | 30 | 31 | 30 | 02 |
| 03 | 58 | 49 | 54 | 0 | 50 | 51 | 11 | 0 | RA FG | M | - | - | 0.69 | 29.69 | 30.24 | 5.7 | 18 | 9.5 | 29 | 19 | 23 | 20 | 03 |
| 04 | 63 | 46 | 55 | 1 | 33 | 45 | 10 | 0 | FG | M | - | - | 0.01 | 29.71 | 29.88 | 13.8 | 31 | 13.1 | 34 | 29 | 25 | 31 | 04 |
| 05 | 64 | 42 | 53 | -2 | 33 | 44 | 12 | 0 | - | M | - | - | 0.00 | 29.98 | 30.04 | 9.5 | 23 | 11.4 | 24 | 20 | 21 | 20 | 05 |
| 06 | 60 | 45 | 53 | -2 | 43 | 48 | 12 | 0 | TS TSRA RA FG | M | - | - | 0.30 | 29.79 | 29.83 | 8.0 | 26 | 11.5 | 38 | 29 | 29 | 29 | 06 |
| 07 | 56 | 41 | 49* | -6 | 23 | 38 | 16 | 0 | - | M | - | - | 0.00 | 29.93 | 29.99 | 15.0 | 31 | 15.9 | 37 | 32 | 30 | 31 | 07 |
| 08 | 63 | 40* | 52 | -4 | 31 | 43 | 13 | 0 | - | M | - | - | 0.00 | 29.99 | 30.05 | 8.0 | 27 | 10.4 | 26 | 30 | 20 | 31 | 08 |
| 09 | 53 | 46 | 50 | -6 | 47 | 48 | 15 | 0 | RA FG | M | - | - | 0.34 | 29.71 | 29.77 | 3.8 | 16 | 6.2 | 17 | 22 | 15 | 23 | 09 |
| 10 | 62 | 48 | 55 | -2 | 43 | 49 | 10 | 0 | FG | M | - | - | 0.06 | 29.58 | 29.64 | 8.6 | 31 | 9.9 | 29 | 30 | 25 | 30 | 10 |
| 11 | 68 | 45 | 57 | 0 | 35 | 46 | 8 | 0 | - | M | - | - | 0.00 | 29.73 | 29.78 | 12.1 | 29 | 12.4 | 32 | 32 | 26 | 32 | 11 |
| 12 | 68 | 48 | 58 | 1 | 47 | 52 | 7 | 0 | - | M | - | - | 0.00 | 29.68 | 29.72 | 9.3 | 20 | 10.4 | 29 | 18 | 23 | 21 | 12 |
| 13 | 63 | 50 | 57 | -1 | 47 | 51 | 8 | 0 | FG HZ | M | - | - | T | 29.62 | 29.67 | 1.5 | 8 | 4.7 | 18 | 35 | 16 | 34 | 13 |
| 14 | 67 | 46 | 57 | -1 | 44 | 50 | 8 | 0 | - | M | - | - | 0.00 | 29.73 | 29.78 | 10.0 | 23 | 11.2 | 25 | 20 | 21 | 20 | 14 |
| 16 | 61 | 49 | 55 | -3 | 36 | 47 | 10 | 0 | - | M | - | - | 0.03 | 29.62 | 29.92 | 16.0 | 29 | 16.3 | 44 | 32 | 36 | 31 | 16 |
| 17 | 61 | 47 | 54 | -5 | 42 | 48 | 11 | 0 | - | M | - | - | 0.03 | 29.74 | 29.79 | 7.0 | 25 | 7.7 | 21 | 25 | 17 | 23 | 17 |
| 18 | 64 | 44 | 54 | -5 | 38 | 47 | 11 | 0 | - | M | - | - | 0.03 | 29.88 | 29.92 | 6.8 | 24 | 10.6 | 22 | 21 | 20 | 22 | 18 |
| 19 | 76* | 50 | 63* | 4 | 52 | 54 | 2 | 0 | RA FG HZ | M | - | - | 0.42 | 29.67 | 29.73 | 3.9 | 10 | 9.4 | 26 | 9 | 23 | 8 | 19 |
| 20 | 68 | 49 | 59 | -1 | - | 45 | 6 | 0 | RA FG+ FG HZ | M | - | - | 0.03 | 29.69 | 29.75 | 4.9 | 35 | 6.7 | 22 | 36 | 16 | 36 | 20 |
| 21 | 61 | 45 | 53 | -7 | 36 | 46 | 12 | 0 | HZ | M | - | - | T | 29.82 | 29.87 | 11.8 | 31 | 12.5 | 36 | 32 | 28 | 33 | 21 |
| 22 | 61 | 46 | 54 | -6 | 36 | 46 | 11 | 0 | - | M | - | - | T | 29.85 | 29.92 | 14.9 | 31 | 15.0 | 37 | 32 | 31 | 31 | 22 |
| 23 | 69 | 47 | 58 | -3 | 39 | 49 | 7 | 0 | - | M | - | - | 0.00 | 30.02 | 30.07 | 9.5 | 33 | 9.8 | 26 | 1 | 21 | 32 | 23 |
| 24 | 72 | 50 | 61 | 0 | 47 | 53 | 4 | 0 | - | M | - | - | 0.00 | 30.03 | 30.06 | 4.6 | 22 | 6.4 | 21 | 21 | 16 | 21 | 24 |
| 25 | 60 | 55 | 58 | -4 | 57 | 57 | 7 | 0 | RA FG | M | - | - | 0.76 | 29.74 | 29.79 | 2.5 | 14 | 4.3 | 11 | 20 | 10 | 20 | 25 |
| 26 | 71 | 53 | 62 | 0 | 45 | 53 | 3 | 0 | FG HZ | M | - | - | 0.00 | 29.81 | 29.86 | 6.9 | 1 | 9.8 | 28 | 6 | 22 | 6 | 26 |
| 27 | 61 | 47 | 54 | -8 | 42 | 48 | 11 | 0 | - | M | - | - | 0.00 | 30.21 | 30.27 | 4.6 | 8 | 9.1 | 18 | 4 | 15 | 15 | 27 |
| 28 | 71 | 46 | 59 | -3 | 46 | 52 | 6 | 0 | - | M | - | - | 0.00 | 30.31 | 30.37 | 4.9 | 22 | 6.5 | 21 | 21 | 17 | 21 | 28 |
| 29 | 69 | 49 | 59 | -4 | 48 | 53 | 6 | 0 | HZ | M | - | - | 0.00 | 30.32 | 30.38 | 5.6 | 21 | 6.2 | 18 | 21 | 16 | 21 | 29 |
| 30 | 67 | 53 | 60 | -3 | 55 | 56 | 5 | 0 | - | M | - | - | T | 30.22 | 30.26 | 5.0 | 12 | 7.0 | 18 | 6 | 14 | 10 | 30 |
| 31 | 67 | 57 | 62 | -1 | 59 | 60 | 3 | 0 | FG | M | - | - | 0.00 | 30.01 | 30.06 | 7.1 | 10 | 7.6 | 16 | 12 | 14 | 12 | 31 |
|  | 64.6 | 47.6 | 56.1 | -------- | 42.7 | 49.3 | 8.8 | .0 | <Monthly Averages | Totals> |  |  | 3.05 | 29.84 | 29.95 | 4.1 | 27.5 | 9.9 | <Monthly Average |  |  |  |  |
|  | -2.1 | -2.4 | -2.3 | -------- | <---------------------Departure From Normal----------------------> |  |  |  |  |  |  |  | -.88 |  |  |  |  |  |  |  |  |  |  |

| Degree Days | Monthly Total | Departure | Season to Date Total | Departure |
|---|---|---|---|---|
| Heating: | 268 | 49 |  |  |
| Cooling: | 0 | -15 |  |  |

Greatest 24-hr Precipitation: 0.76date: 25
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure |  | Date | Time |
|---|---|---|---|
| Maximum: | 30.42 | 29 | 0839 |
| Minimum : | 29.41 | 1 | 1735 |

Number of Days with ----->

Max temp >= 90: 0
Max temp <= 32: 0
Thunderstorms : 2

Min temp <= 32: 0
Min temp <= 0 : 0
Heavy Fog : 1

Precipitation >= .01 inch: 13
Precipitation >= .10 inch : 6
Snowfall >= 1.0 inch : 0

56.1°F

9.9/275°

5/97

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 06/1997**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) | | | | | | Deg Days Base 65 Degrees | | Significant Weather | Snow/Ice on Gnd(In) | | Precipitation (In) | | Pressure (inches of Hg) | | Wind Speed=mph Dir=tens of degrees | | | | | | | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Heating | Cooling | | 0600 LST | 1200 LST | 2400 LST | 2400 LST | Avg. Station | Avg. Sea level | Resultant Speed | Res Dir | Avg. Speed | max 5-sec | | max 2-min | | |
| | | | | | | | | | | Depth | Water Equiv | Snow Fall | Water Equiv | | | | | | Speed | Dir | Speed | Dir | |
| 01 | 68 | 59 | 64 | 0 | 60 | 61 | 1 | 0 | FG | M | - | - | 0.01 | 29.90 | 29.93 | 10.7 | 8 | 11.0 | 24 | 8 | 20 | 7 | 01 |
| 02 | 62 | 52 | 57 | -7 | 53 | 55 | 8 | 0 | RA FG | M | - | - | 0.17 | 29.97 | 30.01 | 14.6 | 6 | 14.8 | 30 | 8 | 24 | 7 | 02 |
| 03 | 62 | 50 | 56 | -8 | 44 | 49 | 9 | 0 | - | M | - | - | 0.09 | 30.03 | 30.08 | 9.8 | 7 | 11.5 | 23 | 11 | 20 | 9 | 03 |
| 04 | 63 | 51 | 57 | -7 | 45 | 51 | 8 | 0 | - | M | - | - | 0.00 | 29.95 | 30.00 | 8.8 | 7 | 10.7 | 25 | 3 | 20 | 7 | 04 |
| 05 | 68 | 49 | 59 | -6 | 46 | 51 | 6 | 0 | - | M | - | - | 0.00 | 30.02 | 30.07 | 3.6 | 17 | 9.2 | 17 | 16 | 15 | 12 | 05 |
| 06 | 66 | 55 | 61 | -5 | 50 | 54 | 4 | 0 | - | M | - | - | 0.00 | 30.15 | 30.20 | 3.6 | 16 | 5.9 | 15 | 16 | 13 | 12 | 06 |
| 07 | 60 | 52 | 56* | -10 | 50 | 53 | 9 | 0 | - | M | - | - | 0.00 | 30.13 | 30.18 | 2.4 | 9 | 5.9 | 11 | 20 | 10 | 20 | 07 |
| 08 | 68 | 53 | 61 | -5 | 49 | 54 | 4 | 0 | - | M | - | - | 0.00 | 30.09 | 30.13 | 2.5 | 17 | 7.5 | 16 | 21 | 15 | 22 | 08 |
| 09 | 71 | 49* | 60 | -6 | 49 | 54 | 5 | 0 | - | M | - | - | 0.00 | 30.10 | 30.14 | 4.7 | 17 | 7.4 | 17 | 20 | 14 | 20 | 09 |
| 10 | 90 | 55 | 73 | 7 | 58 | 63 | 0 | 8 | - | M | - | - | 0.00 | 29.96 | 30.02 | 7.1 | 25 | 7.8 | 21 | 23 | 17 | 23 | 10 |
| 11 | 85 | 62 | 74 | 8 | 61 | 66 | 0 | 9 | - | M | - | - | 0.00 | 29.83 | 29.87 | 6.5 | 24 | 7.1 | 17 | 22 | 14 | 22 | 11 |
| 12 | 85 | 68 | 77 | 11 | 62 | 66 | 0 | 12 | - | M | - | - | T | 29.66 | 29.72 | 8.3 | 23 | 9.1 | 26 | 20 | 21 | 21 | 12 |
| 13 | 75 | 65 | 70 | 3 | 66 | 67 | 0 | 5 | TS TSRA RA FG HZ | M | - | - | 0.58 | 29.55 | 29.60 | 6.1 | 22 | 6.9 | 15 | 18 | 13 | 18 | 13 |
| 14 | 81 | 62 | 72 | 4 | 55 | 61 | 0 | 7 | RA FG | M | - | - | 0.01 | 29.63 | 29.70 | 5.6 | 33 | 7.9 | 22 | 31 | 17 | 31 | 14 |
| 15 | 72 | 53 | 63 | -5 | 46 | 54 | 2 | 0 | - | M | - | - | 0.00 | 29.94 | 29.99 | 4.0 | 20 | 8.1 | 18 | 21 | 15 | 21 | 15 |
| 16 | 68 | 53 | 61 | -7 | 53 | 57 | 4 | 0 | HZ | M | - | - | 0.00 | 29.93 | 29.97 | 5.8 | 12 | 7.3 | 20 | 10 | 17 | 9 | 16 |
| 17 | 71 | 53 | 62 | -6 | 57 | 59 | 3 | 0 | - | M | - | - | 0.00 | 29.83 | 29.89 | 0.9 | 15 | 4.5 | 9 | 10 | 8 | 10 | 17 |
| 18 | 65 | 60 | 63 | -5 | 61 | 62 | 2 | 0 | RA FG+ FG | M | - | - | 0.11 | 29.83 | 29.89 | 8.2 | 9 | 8.8 | 18 | 9 | 16 | 9 | 18 |
| 19 | 84 | 62 | 73 | 4 | 63 | 67 | 0 | 8 | RA FG | M | - | - | 0.23 | 29.79 | 29.85 | 4.3 | 34 | 6.2 | 20 | 1 | 15 | 32 | 19 |
| 20 | 81 | 62 | 72 | 3 | 61 | 65 | 0 | 7 | - | M | - | - | 0.00 | 29.91 | 29.97 | 3.5 | 21 | 6.2 | 15 | 22 | 13 | 22 | 20 |
| 21 | 86 | 68 | 77 | 8 | 67 | 70 | 0 | 12 | FG HZ | M | - | - | 0.00 | 29.85 | 29.90 | 7.1 | 23 | 8.7 | 23 | 20 | 18 | 20 | 21 |
| 22 | 85 | 68 | 77 | 8 | 67 | 69 | 0 | 12 | RA FG HZ | M | - | - | 0.12 | 29.77 | 29.82 | 7.1 | 25 | 9.3 | 23 | 24 | 18 | 24 | 22 |
| 23 | 86 | 63 | 75 | 6 | 56 | 64 | 0 | 10 | - | M | - | - | 0.00 | 29.94 | 30.00 | 6.8 | 33 | 7.7 | 23 | 31 | 17 | 34 | 23 |
| 24 | 78 | 64 | 71 | 1 | 59 | 63 | 0 | 6 | - | M | - | - | 0.00 | 29.99 | 30.05 | 2.0 | 9 | 5.7 | 13 | 33 | 10 | 12 | 24 |
| 25 | 85 | 67 | 76 | 6 | 66 | 69 | 0 | 11 | HZ | M | - | - | 0.00 | 29.82 | 29.88 | 1.6 | 21 | 5.8 | 13 | 23 | 10 | 22 | 25 |
| 26 | 87 | 67 | 77 | 7 | 67 | 70 | 0 | 12 | RA FG HZ | M | - | - | 0.13 | 29.76 | 29.82 | 4.0 | 27 | 8.5 | 41 | 1 | 33 | 1 | 26 |
| 27 | 82 | 63 | 73 | 3 | 55 | 62 | 0 | 8 | - | M | - | - | 0.00 | 29.92 | 29.98 | 8.8 | 35 | 9.7 | 28 | 32 | 22 | 35 | 27 |
| 28 | 82 | 62 | 72 | 1 | 54 | 61 | 0 | 7 | - | M | - | - | 0.00 | 30.06 | 30.11 | 2.9 | 21 | 6.9 | 15 | 21 | 13 | 20 | 28 |
| 29 | 104* | 61 | 83* | 12 | 59 | 65 | 0 | 18 | - | M | - | - | 0.00 | 30.05 | 30.10 | 6.2 | 22 | 6.4 | 21 | 20 | 17 | 21 | 29 |
| 30 | 87 | 65 | 76 | 5 | 62 | 66 | 0 | 11 | - | M | - | - | 0.00 | 30.03 | 30.07 | 7.0 | 22 | 7.7 | 18 | 22 | 16 | 21 | 30 |
| | 76.9 | 59.1 | 68.0 | -------- | 56.7 | 60.9 | 2.2 | 5.4 | <Monthly Averages | Totals> | | | 1.45 | 29.91 | 29.97 | 0.8 | 17.9 | 8.0 | <Monthly Average | | | | |
| | .9 | .0 | .4 | -------- | <----------------------Departure From Normal-----------------------> | | | | | | | | -2.01 | | | | | | | | | | |

Degree Days Monthly Season to Date
Total DepartureTotal Departure
Heating: 65 47
Cooling: 163 67

Greatest 24-hr Precipitation: 0.59date: 13-14
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

Sea Level PressureDateTime
Maximum: 30.24 7 0752
Minimum : 29.54 13 1815

Number of Days with ----->
Max temp >= 90: 2
Max temp <= 32: 0
Thunderstorms : 1
Min temp <= 32: 0
Min temp <= 0 : 0
Heavy Fog : 1
Precipitation >= .01 inch: 9
Precipitation >= .10 inch : 6
Snowfall >= 1.0 inch : 0

68 %

8/179° F

6/97

UNEDITED LOCAL CLIMATOLOGICAL DATA
[NOAA, National Climatic Data Center] MONTH: 07/1997

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) | | | | | | Deg Days Base 65 Degrees | | Significant Weather | Snow/Ice on Gnd(In) | | Precipitation (In) | | Pressure (inches of Hg) | | Wind Speed=mph Dir=tens of degrees | | | | | | | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Heating | Cooling | | 0600 LST Depth | 1200 LST Water Equiv | 2400 LST Snow Fall | 2400 LST Water Equiv | Avg. Station | Avg. Sea level | Resultant Speed | Res Dir | Avg. Speed | max 5-sec Speed | max 5-sec Dir | max 2-min Speed | max 2-min Dir | |
| 01 | 81 | 66 | 74 | 3 | 65 | 68 | 0 | 9 | - | M | - | - | 0.00 | 29.88 | 29.95 | 5.2 | 20 | 6.6 | 18 | 21 | 15 | 20 | 01 |
| 02 | 76 | 68 | 72 | 0 | 66 | 68 | 0 | 7 | - | M | - | - | 0.08 | 29.80 | 29.86 | 2.9 | 17 | 6.2 | 13 | 23 | 11 | 23 | 02 |
| 03 | 78 | 70 | 74 | 2 | 69 | 70 | 0 | 9 | - | M | - | - | 0.11 | 29.61 | 29.68 | 9.8 | 21 | 10.4 | 23 | 20 | 18 | 21 | 03 |
| 04 | 86 | 69 | 78 | 6 | 58 | 65 | 0 | 13 | FG | M | - | - | 0.00 | 29.57 | 29.63 | 11.0 | 28 | 12.4 | 31 | 30 | 25 | 29 | 04 |
| 05 | 78 | 60 | 69 | -3 | 55 | 61 | 0 | 4 | - | M | - | - | 0.00 | 29.84 | 29.90 | 7.3 | 24 | 9.9 | 20 | 28 | 17 | 30 | 05 |
| 06 | 81 | 60 | 71 | -2 | 56 | 62 | 0 | 6 | - | M | - | - | 0.00 | 29.99 | 30.06 | 4.2 | 21 | 6.3 | 15 | 21 | 13 | 20 | 06 |
| 07 | 80 | 63 | 72 | -1 | 63 | 65 | 0 | 7 | TS RA FG HZ SQ | M | - | - | 0.74 | 30.04 | 30.10 | 1.7 | 20 | 4.5 | 36 | 33 | 28 | 33 | 07 |
| 08 | 80 | 62 | 71 | -2 | 63 | 67 | 0 | 6 | FG HZ | M | - | - | 0.00 | 30.05 | 30.09 | 2.7 | 19 | 6.1 | 20 | 24 | 15 | 23 | 08 |
| 09 | 83 | 67 | 75 | 2 | 67 | 69 | 0 | 10 | TS TSRA FG HZ | M | - | - | 0.30 | 29.88 | 29.94 | 7.0 | 22 | 9.7 | 47 | 31 | 33 | 33 | 09 |
| 10 | 80 | 63 | 72 | -1 | 57 | 63 | 0 | 7 | - | M | - | - | 0.01 | 29.99 | 30.04 | 6.5 | 36 | 8.1 | 21 | 2 | 17 | 4 | 10 |
| 11 | 82 | 63 | 73 | 0 | 57 | 63 | 0 | 8 | - | M | - | - | 0.00 | 30.08 | 30.13 | 5.0 | 24 | 7.1 | 17 | 22 | 15 | 23 | 11 |
| 12 | 84 | 62 | 73 | 0 | 59 | 65 | 0 | 8 | - | M | - | - | 0.00 | 29.98 | 30.05 | 4.9 | 24 | 6.9 | 17 | 23 | 15 | 23 | 12 |
| 13 | 87 | 66 | 77 | 3 | 64 | 68 | 0 | 12 | FG HZ | M | - | - | 0.00 | 29.85 | 29.91 | 6.0 | 23 | 6.8 | 17 | 23 | 14 | 23 | 13 |
| 14 | 92 | 69 | 81 | 7 | 65 | 70 | 0 | 16 | FG HZ | M | - | - | 0.00 | 29.80 | 29.86 | 5.8 | 23 | 6.6 | 17 | 23 | 15 | 23 | 14 |
| 15 | M | M | M | M | - | 57 | M | M | RA FG HZ | M | - | - | 0.38 | 29.83 | 29.90 | 1.6 | 20 | 7.1 | 24 | 34 | 20 | 33 | 15 |
| 16 | 81 | 70 | 76 | 2 | 71 | 72 | 0 | 11 | FG HZ | M | - | - | 0.00 | 29.88 | 29.94 | 3.1 | 11 | 5.0 | 13 | 8 | 11 | 9 | 16 |
| 17 | 92* | 71 | 82* | 8 | 70 | 73 | 0 | 17 | FG+ FG HZ | M | - | - | T | 29.76 | 29.82 | 7.0 | 22 | 8.0 | 29 | 28 | 18 | 26 | 17 |
| 18 | 87 | 71 | 79 | 5 | 69 | 72 | 0 | 14 | TS TSRA FG HZ | M | - | - | 0.07 | 29.67 | 29.72 | 5.7 | 26 | 7.0 | 21 | 31 | 17 | 30 | 18 |
| 19 | 81 | 61 | 71 | -3 | 56 | 63 | 0 | 6 | - | M | - | - | 0.00 | 29.79 | 29.84 | 8.6 | 33 | 10.6 | 31 | 30 | 25 | 31 | 19 |
| 20 | 76 | 56* | 66 | -8 | 51 | 58 | 0 | 1 | - | M | - | - | 0.00 | 30.01 | 30.07 | 5.0 | 26 | 9.1 | 17 | 24 | 15 | 23 | 20 |
| 21 | 81 | 61 | 71 | -3 | 62 | 66 | 0 | 6 | - | M | - | - | 0.01 | 29.98 | 30.05 | 2.7 | 21 | 7.4 | 22 | 21 | 18 | 20 | 21 |
| 22 | 75 | 62 | 69 | -5 | 61 | 64 | 0 | 4 | RA FG HZ | M | - | - | 0.83 | 30.02 | 30.08 | 1.2 | 5 | 7.2 | 21 | 1 | 18 | 1 | 22 |
| 23 | 74 | 63 | 69 | -6 | 61 | 64 | 0 | 4 | - | M | - | - | 0.00 | 30.16 | 30.20 | 7.3 | 9 | 9.0 | 21 | 9 | 18 | 9 | 23 |
| 24 | 66 | 60 | 63* | -12 | 58 | 60 | 2 | 0 | RA FG | M | - | - | 1.43 | 30.10 | 30.15 | 13.4 | 6 | 14.3 | 33 | 8 | 29 | 8 | 24 |
| 25 | 79 | 60 | 70 | -5 | 59 | 62 | 0 | 5 | FG | M | - | - | 0.24 | 29.89 | 29.94 | 8.7 | 2 | 10.2 | 25 | 2 | 20 | 2 | 25 |
| 26 | 85 | 57 | 71 | -4 | 59 | 64 | 0 | 6 | - | M | - | - | 0.00 | 29.85 | 29.91 | 5.0 | 22 | 6.2 | 17 | 20 | 15 | 20 | 26 |
| 27 | 83 | 67 | 75 | 0 | 70 | 71 | 0 | 10 | FG HZ | M | - | - | 0.00 | 29.76 | 29.82 | 3.6 | 20 | 5.3 | 20 | 20 | 16 | 20 | 27 |
| 28 | 88 | 72 | 80 | 5 | 69 | 72 | 0 | 15 | FG HZ | M | - | - | 0.00 | 29.69 | 29.75 | 5.4 | 28 | 8.0 | 20 | 31 | 16 | 30 | 28 |
| 29 | 80 | 66 | 73 | -2 | 51 | 61 | 0 | 8 | - | M | - | - | 0.00 | 29.88 | 29.94 | 10.0 | 36 | 10.6 | 28 | 36 | 22 | 1 | 29 |
| 30 | 79 | 60 | 70 | -5 | 52 | 60 | 0 | 5 | - | M | - | - | 0.00 | 30.12 | 30.18 | 2.9 | 26 | 8.2 | 17 | 22 | 15 | 22 | 30 |
| 31 | 84 | 61 | 73 | -2 | 59 | 65 | 0 | 8 | - | M | - | - | 0.00 | 30.11 | 30.17 | 4.5 | 25 | 7.3 | 17 | 22 | 16 | 23 | 31 |
| | 81.3 | 64.2 | 72.8 | -------- | 61.4 | 65.4 | .1 | 8.1 | <Monthly Averages | Totals> | | | 4.20 | 29.90 | 29.96 | 2.2 | 24.9 | 8.0 | <Monthly Average | | | | |
| | -.4 | -1.5 | -.9 | -------- | <--------------------Departure From Normal----------------------> | | | | | | | | 0.42 | | | | | | | | | | |

Degree Days Monthly Season to Date
Total Departure Total Departure
Heating: 2 2
Cooling: 242 -28

Greatest 24-hr Precipitation: 1.63 date: 24-25
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

Sea Level Pressure Date Time
Maximum: 30.23 23 2318
Minimum : 29.57 4 0242

Number of Days with ----->
Max temp >= 90: M
Max temp <= 32: M
Thunderstorms : 3
Min temp <= 32: M
Min temp <= 0 : M
Heavy Fog : 1
Precipitation >= .01 inch: 11
Precipitation >= .10 inch : 7
Snowfall >= 1.0 inch : 0

8/249°

72.8

7/97

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 08/1997**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) | | | | | | Deg Days Base 65 Degrees | | Significant Weather | Snow/Ice on Gnd(In) | | Precipitation (In) | | Pressure (inches of Hg) | | Wind Speed=mph Dir=tens of degrees | | | | | | | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Heating | Cooling | | 0600 LST | 1200 LST | 2400 LST | 2400 LST | Avg. Station | Avg. Sea level | Resultant Speed | Res Dir | Avg. Speed | max 5-sec | | max 2-min | | |
| | | | | | | | | | | Depth | Water Equiv | Snow Fall | Water Equiv | | | | | | Speed | Dir | Speed | Dir | |
| 01 | 86 | 65 | 76 | 1 | 62 | 67 | 0 | 11 | - | M | - | - | 0.00 | 30.06 | 30.09 | 6.1 | 24 | 6.8 | 16 | 24 | 15 | 23 | 01 |
| 02 | 86 | 72 | 79 | 4 | 65 | 69 | 0 | 14 | FG HZ | M | - | - | 0.00 | 29.86 | 29.92 | 7.5 | 24 | 8.7 | 20 | 25 | 16 | 24 | 02 |
| 03 | 86 | 68 | 77 | 2 | 67 | 69 | 0 | 12 | TS TSRA FG HZ | M | - | - | 0.01 | 29.80 | 29.86 | 4.7 | 26 | 7.3 | 25 | 36 | 21 | 1 | 03 |
| 04 | 74 | 64 | 69 | -6 | 65 | 67 | 0 | 4 | TS RA FG HZ | M | - | - | 0.58 | 29.80 | 29.85 | 4.2 | 8 | 7.1 | 14 | 4 | 11 | 4 | 04 |
| 05 | 75 | 61 | 68 | -6 | 60 | 63 | 0 | 3 | RA FG | M | - | - | 0.41 | 29.81 | 29.86 | 5.2 | 4 | 9.1 | 20 | 2 | 16 | 2 | 05 |
| 06 | 76 | 59 | 68 | -6 | 58 | 62 | 0 | 3 | - | M | - | - | 0.01 | 30.00 | 30.04 | 1.1 | 26 | 5.9 | 15 | 3 | 13 | 23 | 06 |
| 07 | 78 | 59 | 69 | -5 | 56 | 61 | 0 | 4 | - | M | - | - | 0.00 | 30.11 | 30.17 | 2.4 | 20 | 5.1 | 13 | 23 | 11 | 23 | 07 |
| 08 | 77 | 60 | 69 | -5 | 59 | 63 | 0 | 4 | - | M | - | - | 0.00 | 30.10 | 30.17 | 2.7 | 35 | 4.6 | 16 | 1 | 9 | 1 | 08 |
| 09 | 85 | 67 | 76 | 2 | 65 | 68 | 0 | 11 | HZ | M | - | - | 0.00 | 30.09 | 30.13 | 4.9 | 21 | 7.8 | 18 | 12 | 15 | 20 | 09 |
| 10 | 84 | 69 | 77 | 3 | 65 | 69 | 0 | 12 | FG HZ | M | - | - | 0.00 | 30.10 | 30.17 | 7.5 | 23 | 8.7 | 21 | 20 | 17 | 20 | 10 |
| 11 | 82 | 71 | 77 | 3 | 66 | 70 | 0 | 12 | - | M | - | - | 0.00 | 30.05 | 30.11 | 8.4 | 22 | 9.2 | 21 | 19 | 17 | 20 | 11 |
| 12 | 79 | 70 | 75 | 1 | 64 | 68 | 0 | 10 | - | M | - | - | 0.04 | 30.08 | 30.12 | 4.3 | 10 | 9.2 | 18 | 6 | 15 | 5 | 12 |
| 13 | 76 | 69 | 73 | -1 | 69 | 70 | 0 | 8 | FG HZ | M | - | - | 0.14 | 29.85 | 29.91 | 6.2 | 18 | 8.5 | 20 | 22 | 17 | 21 | 13 |
| 14 | 82 | 69 | 76 | 2 | 61 | 66 | 0 | 11 | HZ | M | - | - | 0.00 | 29.85 | 29.89 | 2.1 | 2 | 6.6 | 18 | 36 | 16 | 36 | 14 |
| 15 | 80 | 68 | 74 | 1 | 66 | 69 | 0 | 9 | - | M | - | - | 0.00 | 29.88 | 29.94 | 5.6 | 14 | 7.9 | 16 | 17 | 14 | 17 | 15 |
| 16 | 91* | 72 | 82* | 9 | 71 | 74 | 0 | 17 | TS TSRA RA FG HZ | M | - | - | 0.43 | 29.81 | 29.87 | 10.0 | 24 | 10.4 | 38 | 28 | 28 | 28 | 16 |
| 17 | 88 | 72 | 80 | 7 | 70 | 72 | 0 | 15 | - | M | - | - | 0.18 | 29.80 | 29.85 | 4.7 | 26 | 8.6 | 23 | 30 | 18 | 31 | 17 |
| 18 | 76 | 61 | 69 | -4 | 57 | 62 | 0 | 4 | - | M | - | - | 0.87 | 29.87 | 29.91 | 5.4 | 2 | 8.9 | 24 | 2 | 18 | 2 | 18 |
| 19 | 75 | 59 | 67 | -6 | 52 | 59 | 0 | 2 | - | M | - | - | 0.00 | 30.00 | 30.06 | 4.9 | 36 | 7.0 | 18 | 2 | 15 | 2 | 19 |
| 20 | 72 | 60 | 66 | -7 | 56 | 58 | 0 | 1 | - | M | - | - | 0.41 | .00 | - | 7.1 | 11 | 9.8 | 34 | 9 | 30 | 10 | 20 |
| 21 | 69 | 60 | 65* | -8 | 63 | 64 | 0 | 0 | - | M | - | - | 1.53 | 29.69 | 29.74 | 12.4 | 9 | 17.1 | 40 | 9 | 33 | 10 | 21 |
| 22 | 75 | 60 | 68 | -4 | 62 | 63 | 0 | 3 | - | M | - | - | 0.01 | .00 | - | 1.7 | 11 | 5.2 | 16 | 24 | 13 | 25 | 22 |
| 23 | 76 | 60 | 68 | -4 | 56 | 61 | 0 | 3 | - | M | - | - | 0.00 | 29.89 | 29.93 | 7.3 | 27 | 8.5 | 20 | 23 | 17 | 23 | 23 |
| 24 | 74 | 58* | 66 | -6 | 56 | 61 | 0 | 1 | - | M | - | - | 0.00 | 30.02 | 30.08 | 4.0 | 26 | 6.3 | 16 | 22 | 15 | 23 | 24 |
| 25 | 76 | 60 | 68 | -4 | 58 | 62 | 0 | 3 | - | M | - | - | 0.00 | 30.10 | 30.13 | 2.9 | 12 | 4.3 | 11 | 16 | 10 | 16 | 25 |
| 26 | 78 | 60 | 69 | -3 | 60 | 64 | 0 | 4 | - | M | - | - | 0.00 | 30.06 | 30.11 | 4.8 | 21 | 6.9 | 15 | 20 | 13 | 22 | 26 |
| 27 | 79 | 65 | 72 | 1 | 61 | 65 | 0 | 7 | - | M | - | - | 0.00 | 29.96 | 30.01 | 8.1 | 22 | 8.7 | 18 | 19 | 16 | 20 | 27 |
| 28 | 71 | 66 | 69 | -2 | 64 | 66 | 0 | 4 | RA FG | M | - | - | 0.20 | 29.78 | 29.84 | 0.3 | 17 | 3.7 | 13 | 20 | 10 | 21 | 28 |
| 29 | 75 | 65 | 70 | -1 | 63 | 64 | 0 | 5 | TS TSRA RA FG | M | - | - | 0.20 | .00 | - | 4.1 | 3 | 5.0 | 17 | 5 | 14 | 2 | 29 |
| 30 | 78 | 61 | 70 | -1 | 62 | 65 | 0 | 5 | - | M | - | - | 0.00 | 29.89 | 29.95 | 3.0 | 26 | 7.0 | 16 | 22 | 15 | 22 | 30 |
| 31 | 80 | 64 | 72 | 1 | 64 | 67 | 0 | 7 | FG | M | - | - | 0.00 | 30.02 | 30.07 | 4.1 | 21 | 4.9 | 17 | 20 | 14 | 20 | 31 |
| | 78.7 | 64.3 | 71.5 | -------- | 62.0 | 65.4 | .0 | 6.8 | <Monthly Averages | Totals> | | | 5.02 | 27.04 | | 1.5 | 21.3 | 7.6 | <Monthly Average | | | | |
| | -2.2 | -.8 | -1.6 | -------- | <---------------------Departure From Normal-----------------------> | | | | | | | | 1.77 | | | | | | | | | | |

**Degree Days** Monthly Season to Date
Total Departure Total Departure
Heating: 0 0
Cooling: 209 -42

Greatest 24-hr Precipitation: 1.94 date: 20-21
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.21 | 10 | 1002 |
| Minimum : | 29.67 | 21 | 1550 |

Number of Days with ----->
Max temp >= 90: 1
Max temp <= 32: 0
Thunderstorms : 4
Min temp <= 32: 0
Min temp <= 0 : 0
Heavy Fog : 0
Precipitation >= .01 inch: M
Precipitation >= .10 inch : M
Snowfall >= 1.0 inch : 0

7.6/213°

71.5°F

8/97

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 09/1997**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) | | | | | | Deg Days Base 65 Degrees | | Significant Weather | Snow/Ice on Gnd(In) | | Precipitation (In) | | Pressure (inches of Hg) | | Wind Speed=mph Dir=tens of degrees | | | | | | | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Heating | Cooling | | 0600 LST | 1200 LST | 2400 LST | 2400 LST | Avg. Station | Avg. Sea level | Resultant Speed | Res Dir | Avg. Speed | max 5-sec | | max 2-min | | |
| | | | | | | | | | | Depth | Water Equiv | Snow Fall | Water Equiv | | | | | | Speed | Dir | Speed | Dir | |
| 01 | 81 | 70 | 76* | 6 | 68 | 70 | 0 | 11 | RA FG HZ | M | - | - | 0.04 | 30.10 | 30.16 | 5.5 | 22 | 6.8 | 14 | 21 | 13 | 21 | 01 |
| 02 | 83* | 67 | 75 | 5 | 70 | 71 | 0 | 10 | FG HZ | M | - | - | 0.00 | 30.01 | 30.07 | 3.9 | 23 | 5.7 | 18 | 21 | 16 | 22 | 02 |
| 03 | 75 | 56 | 66 | -4 | 51 | 58 | 0 | 1 | RA FG HZ | M | - | - | T | 29.84 | 29.90 | 10.8 | 35 | 12.6 | 34 | 1 | 26 | 1 | 03 |
| 04 | 68 | 51 | 60 | -9 | 40 | 50 | 5 | 0 | - | M | - | - | 0.00 | 29.91 | 29.97 | 9.4 | 35 | 9.9 | 26 | 36 | 20 | 36 | 04 |
| 05 | 75 | 50 | 63 | -6 | 48 | 56 | 2 | 0 | - | M | - | - | 0.00 | 29.98 | 30.02 | 5.0 | 27 | 7.1 | 20 | 23 | 16 | 22 | 05 |
| 06 | 76 | 56 | 66 | -3 | 56 | 61 | 0 | 1 | - | M | - | - | 0.00 | 29.96 | 30.03 | 3.8 | 22 | 4.7 | 16 | 20 | 14 | 20 | 06 |
| 07 | 77 | 59 | 68 | -1 | 61 | 63 | 0 | 3 | HZ | M | - | - | 0.00 | 29.85 | 29.91 | 0.5 | 24 | 3.3 | 10 | 36 | 8 | 2 | 07 |
| 08 | 73 | 63 | 68 | 0 | 61 | 63 | 0 | 3 | - | M | - | - | 0.00 | 29.90 | 29.95 | 9.1 | 4 | 9.7 | 18 | 4 | 16 | 3 | 08 |
| 09 | 68 | 61 | 65 | -3 | 57 | 60 | 0 | 0 | - | M | - | - | 0.00 | 30.00 | 30.05 | 5.8 | 7 | 7.5 | 21 | 10 | 17 | 9 | 09 |
| 10 | 72 | 61 | 67 | -1 | 58 | 61 | 0 | 2 | HZ | M | - | - | T | 30.00 | 30.05 | 10.4 | 9 | 12.7 | 24 | 10 | 21 | 9 | 10 |
| 11 | 73 | 65 | 69 | 2 | 66 | 67 | 0 | 4 | RA FG | M | - | - | 0.24 | 29.96 | 30.02 | 12.9 | 12 | 15.5 | 28 | 10 | 24 | 10 | 11 |
| 12 | 80 | 68 | 74 | 7 | 65 | 68 | 0 | 9 | FG HZ | M | - | - | T | 29.96 | 30.01 | 6.8 | 22 | 7.7 | 15 | 25 | 13 | 24 | 12 |
| 13 | 77 | 61 | 69 | 2 | 59 | 63 | 0 | 4 | FG HZ | M | - | - | 0.00 | 29.97 | 30.02 | 3.6 | 26 | 5.2 | 17 | 24 | 16 | 23 | 13 |
| 14 | 80 | 63 | 72 | 5 | 59 | 64 | 0 | 7 | - | M | - | - | 0.00 | 29.99 | 30.02 | 5.3 | 34 | 6.4 | 17 | 36 | 14 | 1 | 14 |
| 15 | 78 | 61 | 70 | 3 | 56 | 62 | 0 | 5 | - | M | - | - | 0.00 | 29.95 | 29.99 | 3.5 | 30 | 6.5 | 17 | 30 | 14 | 31 | 15 |
| 16 | 81 | 61 | 71 | 5 | 58 | 63 | 0 | 6 | HZ | M | - | - | 0.00 | 29.91 | 29.96 | 2.8 | 33 | 5.3 | 21 | 32 | 15 | 32 | 16 |
| 17 | 73 | 57 | 65 | 0 | 59 | 62 | 0 | 0 | FG HZ | M | - | - | 0.00 | 29.94 | 29.99 | 5.4 | 10 | 8.8 | 16 | 9 | 14 | 9 | 17 |
| 18 | 79 | 60 | 70 | 5 | - | - | 0 | 5 | FG HZ | M | - | - | 0.00 | - | - | - | - | 4.9 | 16 | 2 | 13 | 1 | 18 |
| 19 | 80 | 56 | 68 | 3 | 56 | 62 | 0 | 3 | - | M | - | - | 0.00 | 29.94 | 29.98 | 5.0 | 23 | 6.4 | 16 | 24 | 14 | 23 | 19 |
| 20 | 80 | 56 | 68 | 3 | 61 | 65 | 0 | 3 | FG HZ | M | - | - | T | 29.71 | 29.75 | 8.2 | 27 | 13.0 | 44 | 36 | 31 | 36 | 20 |
| 22 | 67 | 42* | 55 | -9 | 43 | 50 | 10 | 0 | - | M | - | - | 0.00 | 30.18 | 30.23 | 7.1 | 24 | 8.1 | 22 | 22 | 20 | 22 | 22 |
| 23 | 64 | 54 | 59 | -5 | 51 | 55 | 6 | 0 | - | M | - | - | T | 29.90 | 29.96 | 7.5 | 29 | 8.8 | 22 | 26 | 16 | 24 | 23 |
| 24 | 60 | 47 | 54* | -9 | 37 | 46 | 11 | 0 | - | M | - | - | 0.00 | 30.03 | 30.09 | 2.7 | 33 | 6.6 | 17 | 36 | 14 | 23 | 24 |
| 25 | 67 | 43 | 55 | -8 | 46 | 52 | 10 | 0 | - | M | - | - | 0.01 | 29.69 | 29.74 | 4.9 | 23 | 6.3 | 16 | 22 | 15 | 22 | 25 |
| 26 | 72 | 54 | 63 | 1 | 50 | 56 | 2 | 0 | - | M | - | - | 0.00 | 29.76 | 29.81 | 7.6 | 34 | 8.7 | 25 | 31 | 17 | 1 | 26 |
| 27 | 64 | 48 | 56 | -6 | 46 | 51 | 9 | 0 | - | M | - | - | 0.00 | 30.08 | 30.12 | 2.8 | 5 | 5.4 | 16 | 3 | 14 | 1 | 27 |
| 28 | 67 | 51 | 59 | -3 | 54 | 56 | 6 | 0 | RA FG | M | - | - | 0.21 | 29.90 | 29.95 | 15.2 | 8 | 16.3 | 34 | 9 | 29 | 9 | 28 |
| 29 | 71 | 61 | 66 | 5 | 58 | 62 | 0 | 1 | RA FG | M | - | - | 0.10 | 29.29 | 32.29 | 8.7 | 24 | 16.1 | 40 | 8 | 34 | 9 | 29 |
| 30 | 74 | 59 | 67 | 6 | 51 | 58 | 0 | 2 | - | M | - | - | T | 29.36 | 31.98 | 13.1 | 27 | 14.5 | 34 | 29 | 29 | 29 | 30 |
| | 73.3 | 57.0 | 65.2 | -------- | 54.6 | 59.4 | 2.1 | 2.8 | <Monthly Averages | Totals> | | | 0.60 | 29.90 | 30.14 | 1.2 | 32.3 | 8.6 | <Monthly Average | | | | |
| | -.9 | -.6 | -.7 | -------- | <---------------------Departure From Normal-----------------------> | | | | | | | | -2.47 | | | | | | | | | | |

**Degree Days** Monthly Season to Date

| | Monthly Total | Monthly Departure | Season to Date Total | Season to Date Departure |
|---|---|---|---|---|
| Heating: | 70 | 16 | | |
| Cooling: | 80 | -1 | | |

Greatest 24-hr Precipitation: 0.31 date: 28-29
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.33 | 22 | 0932 |
| Minimum : | 29.22 | 29 | 0843 |

Number of Days with ----->

Max temp >= 90: 0
Max temp <= 32: 0
Thunderstorms : 0

Min temp <= 32: 0
Min temp <= 0 : 0
Heavy Fog : 0

Precipitation >= .01 inch: 5
Precipitation >= .10 inch : 2
Snowfall >= 1.0 inch : 0

65.2°F

8.6 / 323°

alan

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 10/1997**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Deg Days Base 65 Degrees Heating | Cooling | Significant Weather | Snow/Ice on Gnd(In) 0600 LST Depth | 1200 LST Water Equiv | Precipitation (In) 2400 LST Snow Fall | 2400 LST Water Equiv | Pressure (inches of Hg) Avg. Station | Avg. Sea level | Wind Speed=mph Dir=tens of degrees Resultant Speed | Res Dir | Avg. Speed | max 5-sec Speed | max 5-sec Dir | max 2-min Speed | max 2-min Dir | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 60 | 41 | 51 | -10 | 37 | 45 | 14 | 0 | - | M | - | - | 0.00 | 29.77 | 29.81 | 8.8 | 34 | 9.6 | 25 | 33 | 21 | 1 | 01 |
| 02 | 62 | 37 | 50 | -10 | 34 | 43 | 15 | 0 | - | M | - | - | 0.00 | 30.00 | 30.05 | 5.5 | 29 | 6.8 | 18 | 22 | 15 | 22 | 02 |
| 03 | 65 | 51 | 58 | -2 | 46 | 52 | 7 | 0 | - | M | - | - | T | 29.99 | 30.03 | 6.2 | 21 | 7.0 | 18 | 20 | 16 | 20 | 03 |
| 04 | 67 | 55 | 61 | 1 | 55 | 58 | 4 | 0 | - | M | - | - | 0.00 | 30.03 | 30.10 | 4.0 | 11 | 6.3 | 14 | 9 | 13 | 9 | 04 |
| 05 | 73 | 58 | 66 | 7 | 60 | 62 | 0 | 1 | FG HZ | M | - | - | 0.03 | 29.98 | 30.04 | 3.5 | 23 | 5.4 | 14 | 23 | 11 | 23 | 05 |
| 06 | 86* | 56 | 71 | 12 | 57 | 62 | 0 | 6 | HZ | M | - | - | 0.00 | 29.96 | 30.02 | 4.6 | 29 | 5.9 | 22 | 28 | 17 | 30 | 06 |
| 07 | 78 | 56 | 67 | 8 | 49 | 57 | 0 | 2 | - | M | - | - | 0.00 | 30.11 | 30.16 | 4.0 | 35 | 6.8 | 18 | 36 | 14 | 35 | 07 |
| 08 | 65 | 53 | 59 | 0 | 50 | 55 | 6 | 0 | - | M | - | - | 0.00 | 30.25 | 30.31 | 3.2 | 7 | 4.2 | 15 | 9 | 13 | 9 | 08 |
| 09 | 70 | 56 | 63 | 5 | 60 | 62 | 2 | 0 | FG HZ | M | - | - | 0.00 | 30.21 | 30.26 | 2.3 | 12 | 5.0 | 14 | 9 | 11 | 9 | 09 |
| 10 | 84 | 57 | 71* | 13 | 53 | 61 | 0 | 6 | FG HZ | M | - | - | 0.00 | 30.07 | 30.12 | 6.9 | 30 | 9.3 | 25 | 1 | 20 | 1 | 10 |
| 11 | M | M | M | M | - | 40 | M | M | - | M | - | - | 0.00 | 30.24 | 30.30 | 3.1 | 36 | 7.1 | 17 | 1 | 14 | 4 | 11 |
| 12 | 64 | 44 | 54 | -2 | 41 | 48 | 11 | 0 | - | M | - | - | 0.00 | 30.26 | 30.32 | 1.1 | 7 | 7.0 | 15 | 22 | 14 | 22 | 12 |
| 13 | 66 | 47 | 57 | 1 | 50 | 54 | 8 | 0 | FG | M | - | - | 0.00 | 30.21 | 30.25 | 3.1 | 20 | 4.5 | 13 | 19 | 10 | 19 | 13 |
| 14 | 66 | 53 | 60 | 4 | 55 | 58 | 5 | 0 | FG | M | - | - | 0.00 | 30.10 | 30.16 | 5.5 | 13 | 6.5 | 17 | 10 | 15 | 11 | 14 |
| 15 | 63 | 54 | 59 | 3 | 52 | 54 | 6 | 0 | RA FG | M | - | - | 0.06 | 30.12 | 30.19 | 9.5 | 1 | 9.6 | 18 | 1 | 14 | 1 | 15 |
| 16 | 55 | 51 | 53 | -2 | 45 | 49 | 12 | 0 | RA FG | M | - | - | 0.05 | 30.12 | 30.19 | 10.5 | 2 | 10.6 | 22 | 1 | 17 | 1 | 16 |
| 17 | 60 | 41 | 51 | -4 | 32 | 42 | 14 | 0 | - | M | - | - | 0.00 | 30.12 | 30.17 | 6.0 | 35 | 7.6 | 21 | 2 | 17 | 2 | 17 |
| 18 | 58 | 45 | 52 | -3 | 37 | 44 | 13 | 0 | - | M | - | - | T | 30.08 | 30.13 | 5.9 | 5 | 7.8 | 20 | 3 | 16 | 2 | 18 |
| 19 | 53 | 45 | 49 | -6 | 41 | 46 | 16 | 0 | - | M | - | - | 0.00 | 29.88 | 29.93 | 12.2 | 3 | 12.3 | 23 | 1 | 18 | 2 | 19 |
| 20 | 65 | 44 | 55 | 1 | 36 | 46 | 10 | 0 | - | M | - | - | 0.00 | 29.75 | 29.81 | 8.4 | 35 | 9.0 | 24 | 35 | 20 | 36 | 20 |
| 21 | 57 | 40 | 49 | -5 | 34 | 42 | 16 | 0 | - | M | - | - | 0.00 | 29.86 | 29.92 | 6.5 | 30 | 8.2 | 22 | 35 | 18 | 34 | 21 |
| 22 | 54 | 33 | 44 | -10 | 25 | 37 | 21 | 0 | - | M | - | - | 0.00 | 29.86 | 29.90 | 9.4 | 30 | 10.2 | 31 | 32 | 26 | 31 | 22 |
| 23 | 51 | 30* | 41* | -12 | 23 | 35 | 24 | 0 | - | M | - | - | 0.00 | 29.98 | 30.02 | 9.1 | 28 | 9.6 | 23 | 24 | 20 | 23 | 23 |
| 24 | 56 | 44 | 50 | -3 | 28 | 41 | 15 | 0 | - | M | - | - | 0.01 | 30.00 | 30.07 | 2.5 | 32 | 7.0 | 17 | 27 | 14 | 27 | 24 |
| 25 | 48 | 42 | 45 | -8 | 43 | 45 | 20 | 0 | RA FG HZ | M | - | - | 0.55 | 29.91 | 29.96 | 9.3 | 2 | 9.9 | 25 | 1 | 22 | 2 | 25 |
| 26 | 51 | 34 | 43 | -9 | 37 | 42 | 22 | 0 | RA FG | M | - | - | 0.50 | 30.07 | 30.12 | 9.4 | 9 | 12.6 | 34 | 10 | 29 | 10 | 26 |
| 27 | 56 | 45 | 51 | -1 | 45 | 49 | 14 | 0 | RA FG | M | - | - | 0.71 | 29.49 | 31.03 | 5.1 | 3 | 12.6 | 39 | 9 | 33 | 9 | 27 |
| 28 | 50 | 34 | 42 | -10 | 26 | 37 | 23 | 0 | - | M | - | - | 0.00 | 29.78 | 29.83 | 12.7 | 30 | 12.9 | 31 | 32 | 25 | 30 | 28 |
| 29 | 55 | 32 | 44 | -7 | 31 | 38 | 21 | 0 | - | M | - | - | 0.00 | 30.00 | 30.05 | 5.5 | 26 | 6.9 | 20 | 24 | 16 | 24 | 29 |
| 30 | 61 | 36 | 49 | -2 | 39 | 44 | 16 | 0 | FG | M | - | - | 0.00 | 30.08 | 30.14 | 3.7 | 22 | 4.3 | 17 | 22 | 16 | 23 | 30 |
| 31 | 63 | 41 | 52 | 1 | 48 | 50 | 13 | 0 | RA FG HZ | M | - | - | 0.16 | 30.13 | 30.17 | 4.5 | 9 | 6.9 | 16 | 8 | 14 | 8 | 31 |
| | 62.1 | 45.2 | 53.7 | -------- | 43.0 | 48.8 | | | <Monthly Averages | Totals> | | | 2.07 | 30.02 | 30.13 | 2.6 | 35.1 | | <Monthly Average | | | | |
| | -2.0 | -1.9 | -1.9 | -------- | <---------------------Departure From Normal-----------------------> | | | | | | | | -1.04 | | | | | | | | | | |

**Degree Days** Monthly Season to Date
Total DepartureTotal Departure
Heating: 348 46
Cooling: 15 4

Greatest 24-hr Precipitation: 1.21date: 26-27
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.38 | 12 | 0858 |
| Minimum : | 29.47 | 27 | 1359 |

Number of Days with ----->
Max temp >= 90: M
Max temp <= 32: M
Thunderstorms : 0
Min temp <= 32: M
Min temp <= 0 : M
Heavy Fog : 0
Precipitation >= .01 inch: 8
Precipitation >= .10 inch : 4
Snowfall >= 1.0 inch : 0

10/97

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 11/1997**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Deg Days Base 65 Degrees Heating | Cooling | Significant Weather | Snow/Ice on Gnd(In) 0600 LST Depth | 1200 LST Water Equiv | Precipitation (In) 2400 LST Snow Fall | 2400 LST Water Equiv | Pressure (inches of Hg) Avg. Station | Avg. Sea level | Wind Speed=mph Dir=tens of degrees Resultant Speed | Res Dir | Avg. Speed | max 5-sec Speed | max 5-sec Dir | max 2-min Speed | max 2-min Dir | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 60 | 57 | 59* | 8 | 57 | 57 | 6 | 0 | RA FG | M | - | - | 0.91 | 29.68 | 30.72 | 16.2 | 9 | 18.3 | 52 | 8 | 44 | 9 | 01 |
| 02 | 65* | 50 | 58 | 8 | 54 | 56 | 7 | 0 | RA FG | M | - | - | 0.05 | 29.46 | 31.05 | 10.6 | 22 | 13.4 | 36 | 20 | 30 | 20 | 02 |
| 03 | 64 | 41 | 53 | 3 | 45 | 50 | 12 | 0 | - | M | - | - | 0.00 | 29.87 | 29.91 | 7.5 | 20 | 9.1 | 25 | 20 | 21 | 21 | 03 |
| 04 | 64 | 45 | 55 | 5 | 45 | 49 | 10 | 0 | - | M | - | - | 0.00 | 29.94 | 30.01 | 2.4 | 28 | 10.0 | 29 | 26 | 22 | 26 | 04 |
| 05 | 55 | 37 | 46 | -3 | 35 | 41 | 19 | 0 | - | M | - | - | 0.00 | 30.36 | 30.40 | 2.5 | 24 | 6.1 | 15 | 20 | 13 | 21 | 05 |
| 06 | 56 | 39 | 48 | -1 | 35 | 42 | 17 | 0 | - | M | - | - | 0.00 | 30.34 | 30.38 | 10.0 | 6 | 11.0 | 24 | 8 | 20 | 8 | 06 |
| 07 | 57 | 46 | 52 | 3 | 40 | 45 | 13 | 0 | - | M | - | - | T | 30.00 | 30.06 | 16.1 | 6 | 17.9 | 32 | 5 | 26 | 6 | 07 |
| 08 | 49 | 46 | 48 | 0 | 43 | 45 | 17 | 0 | TS TSRA RA FG HZ | M | - | - | 0.85 | 29.72 | 29.76 | 15.2 | 5 | 16.4 | 36 | 5 | 24 | 5 | 08 |
| 09 | 47 | 45 | 46 | -2 | 44 | 45 | 19 | 0 | RA FG | M | - | - | 0.65 | 29.48 | 30.83 | 7.2 | 2 | 9.9 | 28 | 4 | 22 | 4 | 09 |
| 10 | 55 | 41 | 48 | 0 | 36 | 42 | 17 | 0 | - | M | - | - | 0.01 | 29.69 | 29.73 | 7.6 | 31 | 8.8 | 20 | 31 | 16 | 30 | 10 |
| 11 | 50 | 34 | 42 | -5 | 29 | 38 | 23 | 0 | - | M | - | - | 0.00 | 29.85 | 29.91 | 7.3 | 32 | M | 0 | - | M | M | 11 |
| 12 | 48 | 31 | 40 | -7 | 22 | 32 | 25 | 0 | - | M | - | - | 0.00 | 29.90 | 29.97 | 4.3 | 31 | M | 0 | - | M | M | 12 |
| 13 | 46 | 26 | 36 | -11 | 17 | 29 | 29 | 0 | - | M | - | - | 0.04 | 30.07 | 30.12 | 6.0 | 5 | M | 0 | - | M | M | 13 |
| 14 | 36 | 31 | 34 | -12 | 28 | 31 | 31 | 0 | RA DZ FZRA FZDZ SN FG | M | - | - | 0.44 | 29.62 | 30.16 | 11.8 | 4 | 12.2 | 24 | 6 | 20 | 6 | 14 |
| 15 | 36 | 31 | 34 | -12 | 28 | 32 | 31 | 0 | SN FG | M | - | - | 0.01 | 29.72 | 29.77 | 5.3 | 31 | 7.1 | 18 | 33 | 16 | 33 | 15 |
| 16 | 40 | 27 | 34 | -12 | 24 | 31 | 31 | 0 | SN FG | M | - | - | 0.01 | 29.79 | 29.84 | 12.8 | 30 | 13.0 | 31 | 30 | 26 | 30 | 16 |
| 17 | 42 | 27 | 35 | -10 | 21 | 29 | 30 | 0 | - | M | - | - | 0.00 | 30.10 | 30.14 | 10.0 | 29 | 11.0 | 31 | 30 | 25 | 31 | 17 |
| 18 | 43 | 29 | 36 | -9 | 23 | 31 | 29 | 0 | - | M | - | - | 0.00 | 30.22 | 30.26 | 3.5 | 29 | 5.4 | 14 | 23 | 11 | 23 | 18 |
| 19 | 47 | 25 | 36 | -8 | 25 | 32 | 29 | 0 | FG HZ | M | - | - | 0.00 | 30.04 | 30.10 | 4.4 | 25 | 5.8 | 16 | 24 | 14 | 22 | 19 |
| 20 | 48 | 30 | 39 | -5 | 25 | 34 | 26 | 0 | - | M | - | - | 0.00 | 30.00 | 30.05 | 6.3 | 30 | 7.1 | 23 | 30 | 18 | 29 | 20 |
| 21 | 54 | 28 | 41 | -3 | 37 | 41 | 24 | 0 | RA FG | M | - | - | 0.15 | 30.04 | 30.09 | 1.6 | 21 | 3.5 | 17 | 20 | 14 | 20 | 21 |
| 22 | 47 | 36 | 42 | -1 | 38 | 40 | 23 | 0 | RA FG | M | - | - | 0.52 | 29.83 | 29.89 | 10.1 | 5 | 10.4 | 22 | 4 | 17 | 4 | 22 |
| 23 | 41 | 35 | 38 | -5 | 34 | 36 | 27 | 0 | FG UP | M | - | - | T | 29.95 | 30.01 | 6.5 | 4 | 7.2 | 14 | 3 | 13 | 5 | 23 |
| 24 | 41 | 29 | 35 | -8 | 24 | 32 | 30 | 0 | RA FG | M | - | - | 0.03 | 29.93 | 29.99 | 11.7 | 32 | 12.0 | 32 | 30 | 25 | 31 | 24 |
| 25 | 42 | 23* | 33* | -9 | 18 | 28 | 32 | 0 | - | M | - | - | 0.00 | 30.08 | 30.14 | 9.1 | 27 | 10.7 | 29 | 27 | 21 | 26 | 25 |
| 26 | 52 | 40 | 46 | 4 | 33 | 41 | 19 | 0 | - | M | - | - | 0.11 | 29.65 | 30.44 | 12.0 | 25 | 13.0 | 25 | 26 | 21 | 24 | 26 |
| 27 | 47 | 32 | 40 | -1 | 17 | 33 | 25 | 0 | - | M | - | - | 0.01 | 29.77 | 30.41 | 14.4 | 31 | 16.1 | 44 | 29 | 36 | 29 | 27 |
| 28 | 46 | 32 | 39 | -2 | 26 | 35 | 26 | 0 | - | M | - | - | 0.01 | 29.93 | 30.00 | 4.2 | 26 | 6.0 | 18 | 24 | 14 | 24 | 28 |
| 29 | 50 | 34 | 42 | 2 | 27 | 36 | 23 | 0 | FG | M | - | - | 0.00 | 29.96 | 30.01 | 4.0 | 34 | 5.3 | 20 | 1 | 16 | 2 | 29 |
| 30 | 44 | 30 | 37 | -3 | 30 | 35 | 28 | 0 | RA FG HZ | M | - | - | 0.09 | 29.65 | 30.37 | 3.8 | 5 | 4.7 | 11 | 7 | 10 | 8 | 30 |
|  | 49.1 | 35.2 | 42.2 | -------- | 32.0 | 38.3 | 22.6 | .0 | <Monthly Averages | Totals> |  | 0.0 | 0.00 | 29.89 | 30.15 | 2.9 | 34 |  | <Monthly Average |  |  |  |  |
|  | -3.9 | -3.0 | -3.4 | -------- | <---------------------Departure From Normal-----------------------> |  |  |  |  |  |  |  | 0.00 |  |  |  |  |  |  |  |  |  |  |

**Degree Days** Monthly Season to Date
Total DepartureTotal Departure
Heating: 0 0
Cooling: 0 0

Greatest 24-hr Precipitation: 0.00date:
Greatest 24-hr Snowfall: 0.0 date:
Greatest Snow Depth: 0 date: -@@

Sea Level PressureDateTime
Maximum: .00 0 0000
Minimum : .00 0 0000

Number of Days with ----->
Max temp >= 90: 0
Max temp <= 32: 0
Thunderstorms : 1
Min temp <= 32: 0
Min temp <= 0 : 0
Heavy Fog : 0
.Precipitation >= .01 inch: 0
Precipitation >= .10 inch : 0
Snowfall >= 1.0 inch : 0

UNEDITED LOCAL CLIMATOLOGICAL DATA
[NOAA, National Climatic Data Center] MONTH: 12/1997

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) | | | | | | Deg Days Base 65 Degrees | | Significant Weather | Snow/Ice on Gnd(In) | | Precipitation (In) | | Pressure (inches of Hg) | | Wind Speed=mph Dir=tens of degrees | | | | | | | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Heating | Cooling | | 0600 LST | 1200 LST | 2400 LST | 2400 LST | Avg. Station | Avg. Sea level | Resultant Speed | Res Dir | Avg. Speed | max 5-sec | | max 2-min | | |
| | | | | | | | | | | Depth | Water Equiv | Snow Fall | Water Equiv | | | | | | Speed | Dir | Speed | Dir | |
| 01 | 44 | 31 | 38 | -1 | 26 | 33 | 27 | 0 | RA FG | M | - | - | 0.03 | 29.39 | 31.64 | 13.1 | 34 | 15.8 | 38 | 32 | 30 | 34 | 01 |
| 02 | 43 | 30 | 37 | -2 | 18 | 29 | 28 | 0 | - | M | - | - | 0.00 | 29.78 | 29.83 | 11.8 | 32 | 13.0 | 33 | 30 | 25 | 32 | 02 |
| 03 | 50 | 28 | 39 | 0 | 27 | 34 | 26 | 0 | - | M | - | - | 0.00 | 29.93 | 30.00 | 6.1 | 28 | 7.6 | 18 | 31 | 15 | 31 | 03 |
| 04 | 46 | 42 | 44 | 6 | 40 | 42 | 21 | 0 | RA FG HZ | 0.0 | - | - | T | 29.58 | 29.65 | 4.5 | 25 | 6.2 | 16 | 22 | 14 | 23 | 04 |
| 05 | 44 | 34 | 39 | 1 | 33 | 36 | 26 | 0 | RA SN FG | M | - | - | 0.16 | 29.46 | 32.08 | 5.8 | 33 | 7.9 | 16 | 27 | 14 | 30 | 05 |
| 06 | 39 | 30 | 35 | -2 | 22 | 30 | 30 | 0 | - | M | - | - | T | 29.50 | 30.54 | 10.2 | 28 | 10.3 | 22 | 28 | 18 | 28 | 06 |
| 07 | 40 | 29 | 35 | -2 | 23 | 31 | 30 | 0 | - | M | - | - | 0.00 | 29.62 | 29.68 | 10.1 | 29 | 10.8 | 22 | 31 | 18 | 30 | 07 |
| 08 | 46 | 30 | 38 | 1 | 26 | 33 | 27 | 0 | - | M | - | - | 0.00 | 29.90 | 29.96 | 5.5 | 33 | 7.6 | 24 | 33 | 20 | 33 | 08 |
| 09 | 39 | 24 | 32 | -4 | 25 | 30 | 33 | 0 | - | M | - | - | 0.00 | 29.96 | 30.02 | 2.7 | 2 | 3.7 | 13 | 4 | 10 | 4 | 09 |
| 10 | 39 | 31 | 35 | -1 | 27 | 32 | 30 | 0 | SN FG | M | - | - | 0.48 | 29.80 | 29.84 | 4.6 | 5 | 5.3 | 17 | 5 | 15 | 4 | 10 |
| 11 | 34 | 31 | 33 | -3 | 24 | 29 | 32 | 0 | SN FG HZ | M | - | - | T | 29.97 | 30.01 | 7.9 | 4 | 8.0 | 17 | 2 | 13 | 4 | 11 |
| 12 | 37 | 31 | 34 | -1 | 29 | 32 | 31 | 0 | RA FZRA SN FG UP HZ | M | - | - | 0.10 | 29.96 | 30.00 | 3.2 | 36 | 5.3 | 11 | 5 | 9 | 3 | 12 |
| 13 | 39 | 28 | 34 | -1 | 24 | 31 | 31 | 0 | - | M | - | - | 0.00 | 29.83 | 29.86 | 7.7 | 27 | 8.0 | 20 | 24 | 15 | 28 | 13 |
| 14 | 41 | 24 | 33 | -2 | 17 | 28 | 32 | 0 | - | M | - | - | T | 29.79 | 29.86 | 10.7 | 30 | 12.6 | 40 | 31 | 32 | 31 | 14 |
| 15 | 40 | 19 | 30 | -4 | 17 | 26 | 35 | 0 | - | M | - | - | 0.00 | 30.02 | 30.07 | 8.0 | 24 | 9.2 | 24 | 24 | 18 | 24 | 15 |
| 16 | 47 | 27 | 37 | 3 | 27 | 34 | 28 | 0 | FG HZ | M | - | - | 0.00 | 29.95 | 29.99 | 4.3 | 26 | 5.7 | 20 | 26 | 15 | 26 | 16 |
| 17 | 51* | 27 | 39 | 5 | 26 | 34 | 26 | 0 | FG | M | - | - | 0.00 | 29.81 | 29.86 | 1.8 | 32 | 3.3 | 16 | 34 | 13 | 34 | 17 |
| 18 | 45 | 29 | 37 | 4 | 25 | 32 | 28 | 0 | - | M | - | - | 0.00 | 29.98 | 30.02 | 3.1 | 36 | 5.0 | 22 | 1 | 16 | 1 | 18 |
| 19 | 47 | 29 | 38 | 5 | 30 | 37 | 27 | 0 | HZ | M | - | - | 0.00 | 29.89 | 29.95 | 7.1 | 26 | 7.9 | 18 | 27 | 15 | 26 | 19 |
| 20 | 46 | 32 | 39 | 6 | 28 | 36 | 26 | 0 | - | M | - | - | 0.00 | 29.90 | 29.95 | 3.7 | 32 | 5.6 | 21 | 1 | 16 | 36 | 20 |
| 21 | 35 | 22 | 29 | -3 | 9 | 24 | 36 | 0 | - | M | - | - | 0.00 | 30.21 | 30.26 | 8.1 | 35 | 9.3 | 30 | 36 | 23 | 36 | 21 |
| 22 | 35 | 20 | 28 | -4 | 14 | 24 | 37 | 0 | FZRA | M | - | - | 0.04 | 30.28 | 30.34 | 6.3 | 6 | 8.3 | 23 | 7 | 21 | 8 | 22 |
| 23 | 38 | 33 | 36 | 4 | 31 | 34 | 29 | 0 | RA SN FG | M | - | - | 0.79 | 29.85 | 29.92 | 9.8 | 3 | 12.7 | 31 | 5 | 28 | 1 | 23 |
| 24 | 42 | 30 | 36 | 4 | 27 | 33 | 29 | 0 | - | M | - | - | 0.00 | 30.07 | 30.13 | 1.4 | 9 | 6.3 | 22 | 2 | 20 | 3 | 24 |
| 25 | 47 | 38 | 43 | 11 | 39 | 41 | 22 | 0 | RA FG | M | - | - | 0.58 | 29.68 | 29.74 | 3.6 | 8 | 11.4 | 26 | 10 | 23 | 10 | 25 |
| 26 | 49 | 38 | 44* | 13 | 33 | 39 | 21 | 0 | - | M | - | - | 0.00 | 29.76 | 29.82 | 8.6 | 27 | 9.0 | 25 | 29 | 22 | 30 | 26 |
| 27 | 40 | 32 | 36 | 5 | 29 | 33 | 29 | 0 | RA SN FG HZ | M | - | - | 0.13 | 29.71 | 29.76 | 3.3 | 34 | 6.5 | 20 | 4 | 15 | 4 | 27 |
| 28 | 37 | 25 | 31 | 0 | 21 | 28 | 34 | 0 | FG | M | - | - | 0.01 | 29.78 | 29.84 | 7.9 | 35 | 8.5 | 26 | 35 | 21 | 35 | 28 |
| 29 | 42 | 24 | 33 | 2 | 26 | 31 | 32 | 0 | - | M | - | - | 0.89 | 29.72 | 30.51 | 11.7 | 5 | 12.5 | 41 | 6 | 33 | 6 | 29 |
| 30 | 46 | 33 | 40 | 9 | 28 | 34 | 25 | 0 | SN FG | M | - | - | 0.02 | 29.03 | 32.03 | 17.2 | 25 | 20.6 | 44 | 23 | 36 | 23 | 30 |
| 31 | 34 | 16* | 25* | -5 | 8 | 21 | 40 | 0 | - | M | - | - | T | 29.78 | 30.32 | 15.3 | 30 | 16.1 | 34 | 30 | 30 | 30 | 31 |
| | 42.0 | 28.9 | 35.5 | -------- | 25.1 | 32.0 | 29.3 | .0 | <Monthly Averages | Totals> | | | 3.20 | 29.80 | 30.18 | 4.3 | 31.6 | 9.0 | <Monthly Average | | | | |
| | 1.0 | 1.3 | 1.2 | -------- | <--------------------Departure From Normal----------------------> | | | | | | | | -.30 | | | | | | | | | | |

36@230

Degree Days Monthly Season to Date
Total DepartureTotal Departure
Heating: 908 -44
Cooling: 0 0

Greatest 24-hr Precipitation: 0.91date: 29-30
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| | Sea Level Pressure | Date | Time |
|---|---|---|---|
| Maximum: | 30.45 | 22 | 1055 |
| Minimum : | 28.92 | 30 | 0701 |

Number of Days with ----->

Max temp >= 90: 0
Max temp <= 32: 0
Thunderstorms : 0

Min temp <= 32: 25
Min temp <= 0 : 0
Heavy Fog : 0

.Precipitation >= .01 inch: M
Precipitation >= .10 inch : M
Snowfall >= 1.0 inch : 0

35.5 °F

9/316°

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 01/1998**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Deg Days Base 65 Degrees Heating | Cooling | Significant Weather | Snow/Ice on Gnd(In) 0600 LST Depth | 1200 LST Water Equiv | Precipitation (In) 2400 LST Snow Fall | 2400 LST Water Equiv | Pressure (inches of Hg) Avg. Station | Avg. Sea level | Wind Speed=mph Dir=tens of degrees Resultant Speed | Res Dir | Avg. Speed | max 5-sec Speed | Dir | max 2-min Speed | Dir | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 32 | 12* | 22* | -8 | 6 | 18 | 43 | 0 | - | M | - | - | 0.00 | 30.31 | 30.37 | 11.9 | 26 | 13.7 | 39 | 24 | 32 | 23 | 01 |
| 02 | 43 | 31 | 37 | 7 | 23 | 32 | 28 | 0 | - | M | - | - | 0.00 | 30.18 | 30.25 | 9.5 | 26 | 9.8 | 28 | 23 | 22 | 27 | 02 |
| 03 | 52 | 34 | 43 | 13 | 31 | 39 | 22 | 0 | - | M | - | - | T | 30.15 | 30.20 | 7.2 | 25 | 7.4 | 16 | 23 | 13 | 24 | 03 |
| 04 | 59* | 42 | 51* | 21 | 37 | 43 | 14 | 0 | FG | M | - | - | 0.04 | 30.28 | 30.32 | 1.4 | 15 | 7.3 | 25 | 8 | 22 | 7 | 04 |
| 05 | 43 | 40 | 42 | 12 | 39 | 40 | 23 | 0 | FG+ FG | M | - | - | 0.00 | 30.33 | 30.38 | 5.5 | 8 | 6.4 | 18 | 9 | 16 | 8 | 05 |
| 06 | 51 | 40 | 46 | 16 | 12 | 36 | 19 | 0 | RA FG+ FG HZ | M | - | - | 0.06 | 30.08 | 30.13 | 3.3 | 24 | 3.8 | 10 | 24 | 9 | 23 | 06 |
| 07 | M | M | M | M | - | 32 | M | M | RA SN FG UP HZ | M | - | - | 0.84 | 30.01 | 30.08 | 9.9 | 8 | 10.8 | 25 | 10 | 22 | 10 | 07 |
| 08 | M | M | M | M | - | 32 | M | M | RA FG+ FG | M | - | - | 0.16 | 29.66 | 29.73 | 3.0 | 16 | 8.1 | 20 | 22 | 17 | 22 | 08 |
| 09 | M | M | M | M | - | 35 | M | M | RA FG+ FG MIFG | M | - | - | 0.01 | 29.62 | 29.68 | 3.2 | 7 | 7.3 | 20 | 33 | 16 | 7 | 09 |
| 10 | 46 | 30 | 38 | 9 | 36 | 38 | 27 | 0 | FG | M | - | - | 0.01 | 29.98 | 30.04 | 3.8 | 25 | 4.4 | 15 | 23 | 13 | 24 | 10 |
| 11 | 46 | 31 | 39 | 10 | 32 | 36 | 26 | 0 | - | M | - | - | 0.00 | 30.03 | 30.09 | 4.1 | 26 | 6.3 | 18 | 23 | 16 | 23 | 11 |
| 12 | 38 | 28 | 33 | 4 | 20 | 28 | 32 | 0 | - | M | - | - | 0.00 | 30.26 | 30.32 | 1.0 | 7 | 7.6 | 21 | 1 | 17 | 1 | 12 |
| 13 | 46 | 30 | 38 | 9 | 34 | 39 | 27 | 0 | RA FG | M | - | - | 0.12 | 30.03 | 30.08 | 7.3 | 26 | 10.9 | 30 | 30 | 25 | 30 | 13 |
| 14 | 32 | 23 | 28 | -1 | 16 | 24 | 37 | 0 | - | M | - | - | 0.00 | 30.33 | 30.37 | 7.7 | 34 | 9.7 | 29 | 32 | 24 | 32 | 14 |
| 15 | 34 | 22 | 28 | -1 | 17 | 27 | 37 | 0 | FZRA FZDZ | M | - | - | 0.31 | 30.16 | 30.21 | 12.1 | 6 | 12.5 | 25 | 9 | 22 | 9 | 15 |
| 16 | 35 | 31 | 33 | 4 | 26 | 32 | 32 | 0 | DZ FG | M | - | - | 0.16 | 29.70 | 29.73 | 19.0 | 4 | 19.1 | 37 | 1 | 30 | 3 | 16 |
| 17 | 45 | 28 | 37 | 8 | 25 | 31 | 28 | 0 | - | M | - | - | 0.00 | 29.81 | 29.87 | 6.3 | 2 | 9.1 | 26 | 1 | 23 | 2 | 17 |
| 18 | 33 | 30 | 32 | 3 | 26 | 29 | 33 | 0 | SN FG | M | - | - | T | 29.97 | 30.02 | 8.7 | 4 | 8.9 | 18 | 4 | 15 | 4 | 18 |
| 19 | 35 | 29 | 32 | 3 | 29 | 31 | 33 | 0 | SN FG | M | - | - | 0.01 | 29.97 | 30.03 | 4.7 | 3 | 5.9 | 11 | 6 | 10 | 6 | 19 |
| 20 | 38 | 29 | 34 | 5 | 25 | 30 | 31 | 0 | - | M | - | - | T | 29.91 | 29.95 | 11.0 | 35 | 11.4 | 28 | 34 | 22 | 34 | 20 |
| 21 | 38 | 28 | 33 | 5 | 18 | 27 | 32 | 0 | - | M | - | - | 0.00 | 30.12 | 30.18 | 10.8 | 35 | 11.1 | 25 | 36 | 20 | 35 | 21 |
| 22 | 33 | 27 | 30 | 2 | 16 | 26 | 35 | 0 | - | M | - | - | 0.00 | 30.36 | 30.42 | 6.6 | 5 | 8.9 | 18 | 11 | 15 | 10 | 22 |
| 23 | 44 | 31 | 38 | 10 | 31 | 34 | 27 | 0 | RA SN PE FG | M | - | - | 2.48 | 30.19 | 30.25 | 21.4 | 9 | 22.5 | 37 | 9 | 32 | 10 | 23 |
| 24 | 46 | 37 | 42 | 14 | 35 | 38 | 23 | 0 | RA SN FG | M | - | - | 0.38 | 29.66 | 29.72 | 9.2 | 1 | 10.2 | 28 | 36 | 22 | 36 | 24 |
| 25 | 41 | 31 | 36 | 8 | 22 | 31 | 29 | 0 | RA SN FG | M | - | - | 0.04 | 29.82 | 29.87 | 12.8 | 32 | 13.8 | 36 | 34 | 28 | 31 | 25 |
| 26 | 38 | 28 | 33 | 5 | 21 | 29 | 32 | 0 | - | M | - | - | 0.00 | 30.30 | 30.35 | 2.3 | 25 | 6.7 | 14 | 27 | 11 | 22 | 26 |
| 27 | 37 | 24 | 31 | 3 | 20 | 28 | 34 | 0 | - | M | - | - | 0.00 | 30.33 | 30.40 | 14.4 | 8 | 14.9 | 28 | 9 | 23 | 8 | 27 |
| 28 | 36 | 32 | 34 | 6 | 27 | 31 | 31 | 0 | - | M | - | - | T | 29.84 | 29.89 | 19.3 | 4 | 20.0 | 36 | 5 | 28 | 3 | 28 |
| 29 | 51 | 32 | 42 | 14 | 25 | 35 | 23 | 0 | - | M | - | - | 0.00 | 29.70 | 29.74 | 8.1 | 36 | 9.2 | 29 | 1 | 23 | 2 | 29 |
| 30 | 46 | 33 | 40 | 12 | 35 | 37 | 25 | 0 | FG | M | - | - | T | 29.64 | 29.70 | 4.0 | 2 | 6.0 | 15 | 32 | 13 | 33 | 30 |
| 31 | 42 | 31 | 37 | 8 | 26 | 32 | 28 | 0 | - | M | - | - | 0.00 | 29.88 | 29.93 | 10.9 | 35 | 11.3 | 25 | 1 | 20 | 1 | 31 |
|  | 41.4 | 30.1 | 35.8 | -------- |  | 32.3 |  |  | <Monthly Averages | Totals> |  |  | 4.62 | 30.02 | 30.08 | 4.0 | 2.1 | 10.2 | <Monthly Average |  |  |  |  |
|  | 5.4 | 8.2 | 6.9 | -------- | <--------------------Departure From Normal----------------------> |  |  |  |  |  |  |  | 1.38 |  |  |  |  |  |  |  |  |  |  |

32 @ 100

**Degree Days** Monthly Season to Date
Total Departure Total Departure

| Degree Days | Monthly Total | Monthly Departure | Season to Date Total | Season to Date Departure |
|---|---|---|---|---|
| Heating: | 811 | -308 |  |  |
| Cooling: | 0 | 0 |  |  |

Greatest 24-hr Precipitation: 2.86 date: 23-24
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.52 | 22 | 2301 |
| Minimum : | 29.56 | 9 | 1401 |

Number of Days with ----->
Max temp >= 90: M
Max temp <= 32: M
Thunderstorms : 0
Min temp <= 32: M
Min temp <= 0 : M
Heavy Fog : 4
Precipitation >= .01 inch: M
Precipitation >= .10 inch : M
Snowfall >= 1.0 inch : 0

35.8 °F

10.2/21°

1/98

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 02/1998**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) | | | | | | Deg Days Base 65 Degrees | | Significant Weather | Snow/Ice on Gnd(In) | | Precipitation (In) | | Pressure (inches of Hg) | | Wind Speed=mph Dir=tens of degrees | | | | | | | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Heating | Cooling | | 0600 LST Depth | 1200 LST Water Equiv | 2400 LST Snow Fall | 2400 LST Water Equiv | Avg. Station | Avg. Sea level | Resultant Speed | Res Dir | Avg. Speed | max 5-sec Speed | max 5-sec Dir | max 2-min Speed | max 2-min Dir | |
| 01 | 39 | 26 | 33 | 5 | 25 | 30 | 32 | 0 | - | M | - | - | 0.00 | 30.18 | 30.23 | 0.6 | 4 | 3.8 | 11 | 19 | 9 | 17 | 01 |
| 02 | 48 | 24 | 36 | 7 | 29 | 33 | 29 | 0 | FG HZ | M | - | - | 0.00 | 30.20 | 30.25 | 1.0 | 20 | 2.3 | 10 | 19 | 9 | 19 | 02 |
| 03 | 48 | 38 | 43 | 14 | 32 | 38 | 22 | 0 | - | M | - | - | 0.00 | 30.10 | 30.15 | 2.6 | 36 | 5.4 | 16 | 1 | 14 | 2 | 03 |
| 04 | 41 | 34 | 38 | 9 | 29 | 35 | 27 | 0 | RA FG | M | - | - | 0.22 | 29.91 | 29.98 | 16.8 | 5 | 16.9 | 33 | 5 | 28 | 5 | 04 |
| 05 | 35 | 32 | 34 | 5 | 27 | 31 | 31 | 0 | FZRA PE FG | M | - | - | 0.48 | 29.60 | 29.65 | 14.6 | 4 | 14.7 | 38 | 5 | 29 | 4 | 05 |
| 06 | 45 | 31 | 38 | 9 | 18 | 30 | 27 | 0 | - | M | - | - | 0.00 | 29.81 | 29.87 | 4.3 | 3 | 6.3 | 20 | 5 | 15 | 4 | 06 |
| 07 | 41 | 29 | 35 | 6 | 25 | 31 | 30 | 0 | - | M | - | - | 0.00 | 30.01 | 30.04 | 8.0 | 6 | 9.2 | 21 | 7 | 17 | 8 | 07 |
| 08 | 41 | 28 | 35 | 6 | 24 | 30 | 30 | 0 | - | M | - | - | 0.00 | 30.01 | 30.04 | 11.5 | 5 | 11.9 | 22 | 2 | 18 | 2 | 08 |
| 09 | 39 | 25 | 32 | 3 | 27 | 30 | 33 | 0 | - | M | - | - | 0.00 | 30.10 | 30.14 | 1.2 | 35 | 5.1 | 11 | 21 | 10 | 21 | 09 |
| 10 | 43 | 27 | 35 | 6 | 31 | 34 | 30 | 0 | FG | M | - | - | 0.00 | 30.18 | 30.25 | 4.2 | 9 | 5.4 | 15 | 9 | 14 | 9 | 10 |
| 11 | 47 | 36 | 42 | 13 | 39 | 39 | 23 | 0 | RA FG+ FG | M | - | - | 0.34 | 30.07 | 30.12 | 5.0 | 10 | 6.3 | 17 | 8 | 15 | 7 | 11 |
| 12 | 52 | 42 | 47 | 17 | 43 | 45 | 18 | 0 | RA FG | M | - | - | 0.59 | 29.45 | 31.47 | 9.5 | 26 | 13.7 | 39 | 17 | 31 | 17 | 12 |
| 13 | 46 | 29 | 38 | 8 | 24 | 34 | 27 | 0 | - | M | - | - | 0.00 | 29.83 | 29.88 | 12.5 | 32 | 13.5 | 32 | 29 | 26 | 29 | 13 |
| 14 | 34 | 21 | 28 | -2 | 2 | 21 | 37 | 0 | - | M | - | - | 0.00 | 30.10 | 30.14 | 10.3 | 36 | 11.2 | 28 | 36 | 22 | 1 | 14 |
| 15 | 30 | 13* | 22* | -8 | -3 | 17 | 43 | 0 | - | M | - | - | 0.00 | 30.44 | 30.48 | 3.6 | 34 | 7.5 | 20 | 2 | 16 | 1 | 15 |
| 16 | 35 | 20 | 28 | -2 | 11 | 24 | 37 | 0 | - | M | - | - | 0.00 | 30.50 | 30.55 | 3.0 | 8 | 4.5 | 10 | 14 | 9 | 5 | 16 |
| 17 | 41 | 34 | 38 | 7 | 31 | 35 | 27 | 0 | RA FG | M | - | - | 0.20 | 30.18 | 30.23 | 19.6 | 9 | 19.9 | 44 | 8 | 37 | 8 | 17 |
| 18 | 45 | 39 | 42 | 11 | 40 | 41 | 23 | 0 | RA FG | M | - | - | 1.03 | 29.63 | 29.69 | 15.3 | 6 | 16.0 | 45 | 8 | 36 | 8 | 18 |
| 19 | 46 | 38 | 42 | 11 | 38 | 39 | 23 | 0 | FG | M | - | - | 0.11 | 29.63 | 29.69 | 2.3 | 27 | 5.2 | 14 | 31 | 11 | 31 | 19 |
| 20 | 48 | 35 | 42 | 11 | 38 | 40 | 23 | 0 | RA FG | M | - | - | 0.05 | 29.63 | 29.69 | 3.6 | 27 | 4.8 | 14 | 31 | 11 | 30 | 20 |
| 21 | 48 | 37 | 43 | 12 | 31 | 38 | 22 | 0 | FG | M | - | - | 0.00 | 29.66 | 29.71 | 9.7 | 31 | 10.4 | 28 | 31 | 23 | 32 | 21 |
| 22 | 50 | 33 | 42 | 10 | 29 | 37 | 23 | 0 | - | M | - | - | 0.00 | 29.99 | 30.05 | 4.2 | 29 | 7.1 | 20 | 33 | 16 | 34 | 22 |
| 23 | 41 | 34 | 38 | 6 | 34 | 37 | 27 | 0 | RA FG | M | - | - | 0.20 | 29.89 | 29.94 | 14.5 | 7 | 15.4 | 36 | 5 | 28 | 6 | 23 |
| 24 | 42 | 36 | 39 | 7 | 37 | 38 | 26 | 0 | RA SN FG | M | - | - | 0.65 | 29.23 | 32.12 | 18.3 | 2 | 19.9 | 43 | 6 | 33 | 4 | 24 |
| 25 | 47 | 36 | 42 | 9 | 34 | 39 | 23 | 0 | - | M | - | - | T | 29.43 | 31.34 | 19.1 | 35 | 19.2 | 43 | 33 | 33 | 34 | 25 |
| 26 | 55 | 40 | 48* | 15 | 30 | 40 | 17 | 0 | - | M | - | - | 0.00 | 29.77 | 29.81 | 13.9 | 34 | 14.2 | 34 | 33 | 25 | 32 | 26 |
| 27 | 55* | 34 | 45 | 12 | 31 | 38 | 20 | 0 | - | M | - | - | 0.00 | 29.78 | 29.84 | 5.7 | 31 | 8.1 | 25 | 1 | 20 | 1 | 27 |
| 28 | 47 | 38 | 43 | 10 | 39 | 41 | 22 | 0 | RA FG | M | - | - | 0.13 | 29.83 | 29.88 | 8.8 | 8 | 9.0 | 22 | 8 | 17 | 8 | 28 |
| | 43.9 | 31.8 | 37.9 | -------- | 28.4 | 34.5 | 26.9 | .0 | <Monthly Averages | Totals> | | | 4.00 | 29.90 | 30.19 | 5.3 | 2.5 | 10.3 | <Monthly Average | | | | |
| | 6.3 | 8.6 | 7.5 | -------- | <----------------------Departure From Normal-----------------------> | | | | | | | | 0.99 | | | | | | | | | | |

**Degree Days** Monthly Season to Date

| | Monthly Total | Monthly Departure | Season to Date Total | Season to Date Departure |
|---|---|---|---|---|
| Heating: | 752 | -217 | | |
| Cooling: | 0 | 0 | | |

Greatest 24-hr Precipitation: 1.23date: 17-18
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.59 | 16 | 1126 |
| Minimum : | 29.18 | 24 | 1536 |

Number of Days with ----->

Max temp >= 90: 0
Max temp <= 32: 1
Thunderstorms : 0
Min temp <= 32: 12
Min temp <= 0 : 0
Heavy Fog : 1
Precipitation >= .01 inch: 1
Precipitation >= .10 inch : 0
Snowfall >= 1.0 inch : 0

37.9°F

10.3/25

2/98

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 03/1998**

Station Location: BRIDGEPORT, CT (BDR) lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) | | | | | | Deg Days Base 65 Degrees | | Significant Weather | Snow/Ice on Gnd(In) | | Precipitation (In) | | Pressure (inches of Hg) | | Wind Speed=mph Dir=tens of degrees | | | | | | | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Heating | Cooling | | 0600 LST | 1200 LST | 2400 LST | 2400 LST | Avg. Station | Avg. Sea level | Resultant Speed | Res Dir | Avg. Speed | max 5-sec | | max 2-min | | |
| | | | | | | | | | | Depth | Water Equiv | Snow Fall | Water Equiv | | | | | | Speed | Dir | Speed | Dir | |
| 01 | 46 | 35 | 41 | 7 | 38 | 41 | 24 | 0 | RA FG+ FG MIFG BR | M | - | - | T | 29.70 | 29.76 | 3.0 | 8 | 6.7 | 25 | 9 | 22 | 9 | 01 |
| 02 | 45 | 35 | 40 | 6 | 38 | 39 | 25 | 0 | FG+ FG | M | - | - | 0.00 | 29.61 | 29.66 | 3.5 | 9 | 4.5 | 11 | 13 | 9 | 13 | 02 |
| 03 | 46 | 40 | 43 | 8 | 36 | 40 | 22 | 0 | FG | M | - | - | 0.03 | 29.46 | 31.49 | 1.8 | 2 | 5.7 | 16 | 33 | 13 | 33 | 03 |
| 04 | 48 | 36 | 42 | 7 | 31 | 37 | 23 | 0 | - | M | - | - | 0.00 | 29.71 | 29.75 | 6.0 | 27 | 7.6 | 17 | 24 | 15 | 23 | 04 |
| 05 | 45 | 35 | 40 | 5 | 30 | 36 | 25 | 0 | - | M | - | - | T | 29.90 | 29.94 | 4.4 | 31 | 5.5 | 20 | 33 | 16 | 36 | 05 |
| 06 | 45 | 33 | 39 | 4 | 31 | 36 | 26 | 0 | - | M | - | - | 0.00 | 30.14 | 30.19 | 2.9 | 21 | 8.0 | 16 | 19 | 13 | 19 | 06 |
| 07 | 46 | 37 | 42 | 6 | 38 | 40 | 23 | 0 | - | M | - | - | 0.00 | 30.16 | 30.21 | 3.9 | 19 | 5.7 | 15 | 20 | 13 | 20 | 07 |
| 08 | 43 | 37 | 40 | 4 | 36 | 38 | 25 | 0 | RA FG | M | - | - | 0.38 | 30.13 | 30.19 | 16.6 | 9 | 17.7 | 33 | 9 | 29 | 10 | 08 |
| 09 | 58 | 40 | 49 | 13 | 48 | 48 | 16 | 0 | RA FG+ FG | M | - | - | 2.14 | 29.54 | 31.07 | 6.4 | 17 | 15.2 | 45 | 18 | 32 | 19 | 09 |
| 10 | 49 | 29 | 39 | 2 | 29 | 37 | 26 | 0 | FG+ FG | M | - | - | 0.00 | 29.57 | 30.61 | 12.9 | 29 | 15.7 | 30 | 30 | 25 | 31 | 10 |
| 11 | 33 | 20 | 27 | -10 | 4 | 21 | 38 | 0 | - | M | - | - | 0.00 | 30.02 | 30.08 | 15.9 | 32 | 16.3 | 31 | 29 | 24 | 31 | 11 |
| 12 | 30 | 17 | 24* | -13 | 2 | 18 | 41 | 0 | - | M | - | - | T | 30.14 | 30.19 | 15.7 | 30 | 16.3 | 40 | 32 | 33 | 30 | 12 |
| 13 | 35 | 16 | 26 | -12 | 12 | 23 | 39 | 0 | - | M | - | - | 0.00 | 30.33 | 30.37 | 8.1 | 22 | 11.8 | 26 | 21 | 22 | 21 | 13 |
| 14 | 42 | 34 | 38 | 0 | 27 | 33 | 27 | 0 | RA | M | - | - | 0.17 | 29.93 | 29.98 | 10.0 | 22 | 14.8 | 45 | 28 | 36 | 28 | 14 |
| 15 | 43 | 29 | 36 | -2 | 19 | 30 | 29 | 0 | - | M | - | - | 0.00 | 30.12 | 30.17 | 8.3 | 33 | 10.3 | 25 | 36 | 21 | 36 | 15 |
| 16 | 39 | 26 | 33 | -6 | 19 | 28 | 32 | 0 | - | M | - | - | 0.00 | 30.41 | 30.47 | 2.9 | 35 | 7.5 | 18 | 2 | 15 | 2 | 16 |
| 17 | 41 | 26 | 34 | -5 | 20 | 30 | 31 | 0 | - | M | - | - | 0.00 | 30.48 | 30.54 | 3.7 | 20 | 7.6 | 17 | 21 | 14 | 22 | 17 |
| 18 | 38 | 35 | 37 | -2 | 34 | 36 | 28 | 0 | RA FG | M | - | - | 0.30 | 30.28 | 30.32 | 5.4 | 11 | 9.3 | 20 | 8 | 17 | 9 | 18 |
| 19 | 40 | 37 | 39 | -1 | 36 | 38 | 26 | 0 | RA FG | M | - | - | 1.38 | 29.89 | 29.95 | 10.6 | 6 | 10.8 | 18 | 4 | 16 | 4 | 19 |
| 20 | 44 | 36 | 40 | 0 | 36 | 38 | 25 | 0 | FG | M | - | - | 0.00 | 29.80 | 29.87 | 6.4 | 9 | 8.9 | 24 | 8 | 21 | 8 | 20 |
| 21 | 38 | 32 | 35 | -5 | 31 | 33 | 30 | 0 | RA DZ FZRA SN PE FG | M | - | - | 0.25 | 29.63 | 29.93 | 17.9 | 7 | 18.4 | 37 | 7 | 29 | 7 | 21 |
| 22 | 38 | 30 | 34 | -7 | 27 | 31 | 31 | 0 | RA FZRA SN FG | M | - | - | 0.06 | 29.51 | 31.04 | 8.8 | 34 | 12.4 | 29 | 5 | 23 | 4 | 22 |
| 23 | 46 | 30 | 38 | -3 | 25 | 33 | 27 | 0 | - | M | - | - | 0.00 | 29.89 | 29.93 | 7.6 | 26 | 8.8 | 26 | 23 | 21 | 23 | 23 |
| 24 | 48 | 29 | 39 | -2 | 21 | 32 | 26 | 0 | - | M | - | - | 0.00 | 30.12 | 30.18 | 3.6 | 25 | 7.8. | 23 | 23 | 20 | 23 | 24 |
| 25 | 45 | 27 | 36 | -5 | 19 | 31 | 29 | 0 | - | M | - | - | 0.00 | 30.48 | 30.53 | 4.2 | 21 | 7.8 | 17 | 23 | 15 | 23 | 25 |
| 26 | 55 | 39 | 47 | 5 | 39 | 43 | 18 | 0 | HZ | M | - | - | 0.00 | 30.26 | 30.31 | 8.7 | 22 | 9.3 | 20 | 21 | 16 | 20 | 26 |
| 27 | 69 | 42 | 56 | 14 | 45 | 50 | 9 | 0 | HZ | M | - | - | 0.00 | 29.98 | 30.03 | 7.5 | 25 | 8.0 | 21 | 24 | 16 | 24 | 27 |
| 28 | 71 | 49 | 60 | 18 | 48 | 52 | 5 | 0 | FG HZ | M | - | - | 0.00 | 29.87 | 29.93 | 10.6 | 22 | 11.5 | 30 | 21 | 23 | 20 | 28 |
| 29 | 80* | 47 | 64* | 21 | 45 | 54 | 1 | 0 | - | M | - | - | 0.00 | 29.81 | 29.85 | 7.5 | 29 | 10.2 | 25 | 30 | 21 | 29 | 29 |
| 30 | 65 | 47 | 56 | 13 | 46 | 51 | 9 | 0 | - | M | - | - | 0.00 | 29.87 | 29.93 | 2.8 | 11 | 5.0 | 13 | 10 | 11 | 9 | 30 |
| 31 | 74 | 50 | 62 | 19 | 51 | 55 | 3 | 0 | FG HZ | M | - | - | 0.00 | 29.81 | 29.86 | 5.7 | 22 | 6.9 | 22 | 20 | 18 | 20 | 31 |
| | 47.9 | 34.0 | 41.0 | -------- | 31.0 | 37.2 | 23.8 | .0 | <Monthly Averages | Totals> | | | 4.71 | 29.95 | 30.21 | 1.6 | 27.2 | 10.1 | <Monthly Average | | | | |
| | 1.7 | 3.1 | 2.4 | -------- | <--------------------Departure From Normal----------------------> | | | | | | | | 0.96 | | | | | | | | | | |

**Degree Days** Monthly Season to Date
Total Departure Total Departure
Heating: 739 -79
Cooling: 0 0

Greatest 24-hr Precipitation: 2.29 date: 8-9
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.62 | 17 | 0958 |
| Minimum : | 29.33 | 10 | 0212 |

Number of Days with ----->
Max temp >= 90: 0
Max temp <= 32: 1
Thunderstorms : 0
Min temp <= 32: 12
Min temp <= 0 : 0
Heavy Fog : 4
Precipitation >= .01 inch: M
Precipitation >= .10 inch : M
Snowfall >= 1.0 inch : 0

41.0°F

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 04/1998**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) | | | | | | Deg Days Base 65 Degrees | | Significant Weather | Snow/Ice on Gnd(In) | | Precipitation (In) | | Pressure (inches of Hg) | | Wind Speed=mph Dir=tens of degrees | | | | | | | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Heating | Cooling | | 0600 LST | 1200 LST | 2400 LST | 2400 LST | Avg. Station | Avg. Sea level | Resultant Speed | Res Dir | Avg. Speed | max 5-sec | | max 2-min | | |
| | | | | | | | | | | Depth | Water Equiv | Snow Fall | Water Equiv | | | | | | Speed | Dir | Speed | Dir | |
| 01 | 55 | 44 | 50 | 6 | 47 | 48 | 15 | 0 | TS TSRA RA FG | M | - | - | 1.84 | 29.81 | 29.86 | 10.1 | 9 | 12.8 | 32 | 9 | 28 | 9 | 01 |
| 02 | 50 | 45 | 48 | 4 | 34 | 41 | 17 | 0 | FG HZ | M | - | - | 0.01 | 29.72 | 29.79 | 5.1 | 8 | 6.8 | 17 | 1 | 15 | 2 | 02 |
| 03 | 58 | 39 | 49 | 5 | 33 | 42 | 16 | 0 | HZ | M | - | - | 0.00 | 29.77 | 29.82 | 7.9 | 33 | 9.5 | 26 | 29 | 23 | 30 | 03 |
| 04 | 49 | 38 | 44 | 0 | 31 | 38 | 21 | 0 | - | M | - | - | 0.00 | 29.66 | 29.70 | 8.7 | 4 | 10.3 | 26 | 1 | 22 | 1 | 04 |
| 05 | 50 | 37 | 44 | -1 | 25 | 36 | 21 | 0 | - | M | - | - | T | 29.64 | 29.69 | 13.0 | 36 | 13.3 | 33 | 33 | 25 | 36 | 05 |
| 06 | 57 | 37 | 47 | 2 | 26 | 39 | 18 | 0 | - | M | - | - | 0.00 | 29.69 | 29.73 | 10.3 | 32 | 10.9 | 28 | 31 | 22 | 31 | 06 |
| 07 | 60 | 38 | 49 | 4 | 29 | 41 | 16 | 0 | - | M | - | - | 0.00 | 29.83 | 29.88 | 6.2 | 27 | 8.7 | 21 | 23 | 17 | 23 | 07 |
| 08 | 50 | 41 | 46 | 0 | 38 | 42 | 19 | 0 | - | M | - | - | T | 29.84 | 29.87 | 7.5 | 8 | 7.9 | 20 | 9 | 17 | 9 | 08 |
| 09 | 49 | 37 | 43* | -3 | 40 | 42 | 22 | 0 | TS TSRA RA FG | M | - | - | 1.19 | 29.54 | 30.71 | 14.5 | 7 | 16.3 | 39 | 4 | 32 | 4 | 09 |
| 10 | 54 | 36 | 45 | -1 | 27 | 38 | 20 | 0 | RA FG | M | - | - | 0.37 | 29.55 | 30.35 | 10.8 | 35 | 11.6 | 29 | 36 | 22 | 36 | 10 |
| 11 | 54 | 34 | 44 | -3 | 24 | 37 | 21 | 0 | - | M | - | - | 0.00 | 29.98 | 30.03 | 2.1 | 21 | 7.4 | 16 | 1 | 14 | 1 | 11 |
| 12 | 57 | 36 | 47 | 0 | 30 | 40 | 18 | 0 | - | M | - | - | 0.00 | 30.18 | 30.23 | 1.7 | 13 | 5.6 | 16 | 16 | 13 | 17 | 12 |
| 13 | 64 | 36 | 50 | 3 | 31 | 42 | 15 | 0 | - | M | - | - | 0.00 | 30.11 | 30.16 | 4.6 | 21 | 5.4 | 16 | 21 | 14 | 21 | 13 |
| 14 | 54 | 41 | 48 | 0 | 38 | 44 | 17 | 0 | - | M | - | - | 0.00 | 29.86 | 29.92 | 11.0 | 9 | 11.5 | 26 | 8 | 22 | 8 | 14 |
| 15 | 53 | 46 | 50 | 2 | 45 | 47 | 15 | 0 | RA FG HZ | M | - | - | 0.04 | 29.78 | 29.83 | 0.2 | 16 | 6.0 | 17 | 8 | 15 | 8 | 15 |
| 16 | 50 | 45 | 48 | 0 | 47 | 47 | 17 | 0 | FG+ FG | M | - | - | 0.01 | 29.88 | 29.94 | 12.0 | 9 | 11.8 | 25 | 9 | 22 | 9 | 16 |
| 17 | 57 | 49 | 53 | 4 | 53 | 54 | 12 | 0 | RA FG | M | - | - | 0.50 | 29.79 | 29.84 | 3.9 | 21 | 7.4 | 22 | 22 | 18 | 21 | 17 |
| 18 | 64 | 42 | 53 | 4 | 37 | 45 | 12 | 0 | - | M | - | - | 0.00 | 30.08 | 30.14 | 6.7 | 27 | 9.9 | 22 | 22 | 18 | 22 | 18 |
| 19 | 53 | 47 | 50 | 1 | 45 | 48 | 15 | 0 | RA FG | M | - | - | 0.60 | 30.00 | 30.05 | 7.3 | 10 | 8.7 | 23 | 9 | 20 | 10 | 19 |
| 20 | 58 | 44 | 51 | 1 | 42 | 47 | 14 | 0 | RA FG | M | - | - | 0.05 | 29.82 | 29.87 | 8.4 | 32 | 9.3 | 29 | 32 | 23 | 36 | 20 |
| 21 | 66 | 41 | 54 | 4 | 39 | 46 | 11 | 0 | - | M | - | - | 0.00 | 30.02 | 30.08 | 4.9 | 23 | 6.5 | 20 | 23 | 17 | 22 | 21 |
| 22 | 65 | 43 | 54 | 4 | 40 | 47 | 11 | 0 | - | M | - | - | 0.00 | 29.99 | 30.05 | 3.0 | 12 | 6.3 | 17 | 20 | 14 | 21 | 22 |
| 23 | 52 | 44 | 48 | -3 | 41 | 45 | 17 | 0 | RA FG | M | - | - | 0.59 | 29.65 | 29.71 | 14.6 | 2 | 16.3 | 40 | 36 | 33 | 2 | 23 |
| 24 | 66 | 46 | 56 | 5 | 32 | 44 | 9 | 0 | - | M | - | - | 0.01 | 29.61 | 29.66 | 6.5 | 27 | 11.5 | 36 | 29 | 30 | 29 | 24 |
| 25 | 65 | 49 | 57 | 6 | 29 | 44 | 8 | 0 | - | M | - | - | T | 29.77 | 29.82 | 11.5 | 32 | 12.7 | 33 | 30 | 28 | 31 | 25 |
| 26 | 49 | 42 | 46 | -6 | 36 | 42 | 19 | 0 | RA FG | M | - | - | 0.29 | 29.93 | 29.97 | 5.2 | 7 | 6.7 | 22 | 9 | 18 | 9 | 26 |
| 27 | 54 | 41 | 48 | -4 | 28 | 40 | 17 | 0 | - | M | - | - | 0.00 | 30.01 | 30.06 | 10.6 | 36 | 11.0 | 30 | 36 | 22 | 32 | 27 |
| 28 | 61 | 39 | 50 | -2 | 28 | 41 | 15 | 0 | - | M | - | - | 0.00 | 30.20 | 30.24 | 7.6 | 36 | 8.7 | 26 | 32 | 23 | 32 | 28 |
| 29 | 66 | 43 | 55 | 2 | 39 | 47 | 10 | 0 | - | M | - | - | 0.00 | 30.12 | 30.18 | 8.5 | 23 | 9.3 | 24 | 21 | 20 | 21 | 29 |
| 30 | 66* | 52 | 59* | 6 | 51 | 54 | 6 | 0 | HZ | M | - | - | T | 29.95 | 29.98 | 7.7 | 24 | 7.9 | 18 | 24 | 16 | 23 | 30 |
| | 56.9 | 41.7 | 49.3 | -------- | 36.2 | 43.6 | 15.5 | .0 | <Monthly Averages | Totals> | | | 5.50 | 29.86 | 29.97 | 2.6 | 1.2 | 9.6 | <Monthly Average | | | | |
| | .3 | 1.9 | 1.1 | -------- | <--------------------Departure From Normal----------------------> | | | | | | | | 1.75 | | | | | | | | | | |

| Degree Days | Monthly Total | Monthly Departure | Season to Date Total | Season to Date Departure |
|---|---|---|---|---|
| Heating: | 464 | -40 | | |
| Cooling: | 0 | 0 | | |

Greatest 24-hr Precipitation: 1.85date: 1-2
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.29 | 29 | 0757 |
| Minimum : | 29.29 | 9 | 2151 |

Number of Days with ----->
Max temp >= 90: 0
Max temp <= 32: 0
Thunderstorms : 2
Min temp <= 32: 0
Min temp <= 0 : 0
Heavy Fog : 1
Precipitation >= .01 inch: 2
Precipitation >= .10 inch : 0
Snowfall >= 1.0 inch : 0

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 06/1998**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) | | | | | | Deg Days Base 65 Degrees | | Significant Weather | Snow/Ice on Gnd(In) | | Precipitation (In) | | Pressure (inches of Hg) | | Wind Speed=mph Dir=tens of degrees | | | | | | | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Heating | Cooling | | 0600 LST | 1200 LST | 2400 LST | 2400 LST | Avg. Station | Avg. Sea level | Resultant Speed | Res Dir | Avg. Speed | max 5-sec | | max 2-min | | |
| | | | | | | | | | | Depth | Water Equiv | Snow Fall | Water Equiv | | | | | | Speed | Dir | Speed | Dir | |
| 01 | 74 | 56 | 65 | 1 | 53 | 59 | 0 | 0 | RA FG | M | - | - | 0.36 | 29.58 | 29.64 | 5.1 | 34 | 9.2 | 23 | 1 | 18 | 2 | 01 |
| 02 | 70 | 50 | 60 | -4 | 49 | 55 | 5 | 0 | RA FG | M | - | - | 0.35 | 29.65 | 29.95 | 4.1 | 20 | 8.2 | 29 | 31 | 24 | 31 | 02 |
| 03 | 67 | 54 | 61 | -3 | 44 | 53 | 4 | 0 | FG | M | - | - | 0.05 | 29.53 | 30.33 | 11.9 | 31 | 13.1 | 36 | 31 | 26 | 31 | 03 |
| 04 | 68 | 49 | 59 | -5 | 37 | 48 | 6 | 0 | - | M | - | - | 0.00 | 29.67 | 29.72 | 11.8 | 30 | 12.2 | 34 | 30 | 28 | 31 | 04 |
| 05 | 70 | 51 | 61 | -4 | 37 | 49 | 4 | 0 | - | M | - | - | 0.00 | 29.63 | 29.68 | 12.1 | 30 | 12.6 | 30 | 31 | 23 | 31 | 05 |
| 06 | 70 | 53 | 62 | -4 | 42 | 51 | 3 | 0 | - | M | - | - | 0.00 | 29.73 | 29.79 | 6.9 | 33 | 8.4 | 26 | 32 | 21 | 30 | 06 |
| 07 | 66 | 52 | 59 | -7 | 41 | 50 | 6 | 0 | - | M | - | - | T | 29.83 | 29.90 | 7.2 | 30 | 8.5 | 29 | 29 | 22 | 29 | 07 |
| 08 | 68 | 49 | 59* | -7 | 46 | 53 | 6 | 0 | - | M | - | - | 0.00 | 29.94 | 29.99 | 8.5 | 32 | 9.7 | 24 | 2 | 20 | 2 | 08 |
| 09 | 67 | 53 | 60 | -6 | 52 | 56 | 5 | 0 | - | M | - | - | 0.00 | 30.09 | 30.16 | 4.9 | 17 | 8.3 | 17 | 22 | 15 | 21 | 09 |
| 10 | 69 | 52 | 61 | -5 | 53 | 56 | 4 | 0 | FG+ FG | M | - | - | 0.00 | 30.10 | 30.15 | 2.5 | 16 | 4.6 | 16 | 20 | 14 | 20 | 10 |
| 11 | 67 | 59 | 63 | -3 | 58 | 60 | 2 | 0 | FG | M | - | - | 0.00 | 30.10 | 30.16 | 8.2 | 10 | 8.9 | 18 | 9 | 16 | 9 | 11 |
| 12 | 63 | 60 | 62 | -4 | 61 | 61 | 3 | 0 | RA FG | M | - | - | 1.78 | 29.95 | 30.00 | 10.7 | 10 | 11.2 | 20 | 11 | 16 | 8 | 12 |
| 13 | 66 | 60 | 63 | -4 | 63 | 63 | 2 | 0 | TS TSRA RA FG+ FG | M | - | - | 0.70 | 29.58 | 30.24 | 5.0 | 9 | 6.6 | 20 | 8 | 16 | 9 | 13 |
| 14 | 71 | 61 | 66 | -2 | 62 | 63 | 0 | 1 | RA FG | M | - | - | 1.03 | 29.42 | 31.93 | 4.2 | 14 | 8.1 | 23 | 11 | 20 | 10 | 14 |
| 15 | 66 | 60 | 63 | -5 | 63 | 63 | 2 | 0 | RA FG+ FG | M | - | - | 0.20 | 29.54 | 29.60 | 7.6 | 9 | 8.5 | 18 | 8 | 16 | 8 | 15 |
| 16 | 80 | 62 | 71 | 3 | 65 | 67 | 0 | 6 | RA FG+ FG HZ | M | - | - | 0.02 | 29.59 | 29.64 | 5.2 | 19 | 9.0 | 20 | 20 | 16 | 20 | 16 |
| 17 | 80 | 65 | 73 | 5 | 64 | 67 | 0 | 8 | TS TSRA RA FG HZ | M | - | - | 0.03 | 29.73 | 29.79 | 7.9 | 24 | 8.5 | 34 | 32 | 29 | 34 | 17 |
| 18 | 79 | 64 | 72 | 4 | 65 | 67 | 0 | 7 | FG | M | - | - | 0.02 | 29.80 | 29.84 | 3.9 | 24 | 5.7 | 17 | 23 | 15 | 23 | 18 |
| 19 | 83 | 65 | 74 | 5 | 64 | 68 | 0 | 9 | - | M | - | - | 0.00 | 29.75 | 29.79 | 5.2 | 23 | 6.9 | 20 | 23 | 16 | 23 | 19 |
| 20 | 80 | 67 | 74 | 5 | 67 | 69 | 0 | 9 | FG | M | - | - | 0.00 | 29.75 | 29.81 | 4.2 | 11 | 5.7 | 17 | 9 | 15 | 9 | 20 |
| 21 | 78 | 65 | 72 | 3 | 67 | 68 | 0 | 7 | FG HZ | M | - | - | 0.00 | 29.98 | 30.02 | 7.3 | 10 | 8.3 | 17 | 9 | 15 | 8 | 21 |
| 22 | 67 | 63 | 65 | -4 | 62 | 63 | 0 | 0 | FG | M | - | - | 0.00 | 30.10 | 30.14 | 6.4 | 12 | 8.0 | 14 | 8 | 13 | 9 | 22 |
| 23 | 71 | 65 | 68 | -1 | 66 | 66 | 0 | 3 | FG | M | - | - | 0.00 | 30.02 | 30.07 | 4.9 | 19 | 5.8 | 11 | 21 | 10 | 22 | 23 |
| 24 | 80 | 67 | 74 | 4 | 68 | 70 | 0 | 9 | FG HZ | M | - | - | 0.00 | 29.98 | 30.03 | 5.5 | 21 | 6.1 | 16 | 20 | 14 | 20 | 24 |
| 25 | 88 | 66 | .77 | 7 | 69 | 71 | 0 | 12 | FG HZ | M | - | - | 0.00 | 29.93 | 29.98 | 5.7 | 23 | 6.0 | 16 | 23 | 14 | 21 | 25 |
| 26 | 94* | 72 | 83* | 13 | 70 | 73 | 0 | 18 | FG HZ | M | - | - | 0.00 | 29.68 | 29.74 | 8.2 | 25 | 8.6 | 22 | 21 | 18 | 20 | 26 |
| 27 | 84 | 65 | 75 | 5 | 65 | 68 | 0 | 10 | FG HZ | M | - | - | T | 29.64 | 29.69 | 5.2 | 34 | 11.7 | 32 | 6 | 25 | 30 | 27 |
| 28 | 76 | 62 | 69 | -2 | 59 | 63 | 0 | 4 | - | M | - | - | 0.00 | 29.96 | 30.01 | 7.4 | 20 | 10.9 | 22 | 21 | 18 | 22 | 28 |
| 29 | 71 | 65 | 68 | -3 | 64 | 66 | 0 | 3 | FG | M | - | - | T | 29.82 | 29.89 | 10.9 | 22 | 11.1 | 21 | 21 | 17 | 22 | 29 |
| 30 | 77 | 64 | 71 | 0 | 67 | 68 | 0 | 6 | TS TSRA RA FG | M | - | - | 0.54 | 29.46 | 31.36 | 6.3 | 24 | 8.0 | 29 | 31 | 25 | 30 | 30 |
| | 73.7 | 59.9 | 66.8 | -------- | 58.1 | 61.8 | 1.7 | 3.7 | <Monthly Averages | Totals> | | | 5.08 | 29.79 | 30.04 | 1.7 | 23.8 | 8.6 | <Monthly Average | | | | |
| | -2.3 | .8 | -.8 | -------- | <----------------------Departure From Normal----------------------> | | | | | | | | 1.62 | | | | | | | | | | |

| Degree Days | Monthly | | Season to Date | |
|---|---|---|---|---|
| | Total | Departure | Total | Departure |
| Heating: | 52 | 34 | | |
| Cooling: | 112 | 16 | | |

Greatest 24-hr Precipitation: 1.97date: 12-13
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.20 | 9 | 1145 |
| Minimum : | 29.36 | 30 | 1853 |

Number of Days with ----->

Max temp >= 90: 1
Max temp <= 32: 0
Thunderstorms : 3
Min temp <= 32: 0
Min temp <= 0 : 0
Heavy Fog : 4
Precipitation >= .01 inch: 1
Precipitation >= .10 inch : 0
Snowfall >= 1.0 inch : 0

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 02/1999**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Deg Days Base 65 Degrees Heating | Cooling | Significant Weather | Snow/Ice on Gnd(In) 0600 LST Depth | 1200 LST Water Equiv | 2400 LST Snow Fall | Precipitation (In) 2400 LST Water Equiv | Pressure (inches of Hg) Avg. Station | Avg. Sea level | Wind Speed=mph Dir=tens of degrees Resultant Speed | Res Dir | Avg. Speed | max 5-sec Speed | Dir | max 2-min Speed | Dir | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 39 | 20 | 30 | 2 | 18 | 26 | 35 | 0 | - | M | - | - | 0.00 | 30.41 | 30.45 | 7.6 | 25 | 8.1 | 20 | 24 | 16 | 24 | 01 |
| 02 | 49 | 34 | 42 | 13 | 40 | 41 | 23 | 0 | RA FG+ FG | M | - | - | 1.17 | 29.95 | 30.00 | 6.4 | 12 | 8.9 | 26 | 18 | 22 | 17 | 02 |
| 03 | 53* | 33 | 43 | 14 | 35 | 40 | 22 | 0 | FG+ FG | M | - | - | 0.01 | 29.87 | 29.92 | 3.9 | 32 | 6.7 | 20 | 32 | 16 | 36 | 03 |
| 04 | 44 | 29 | 37 | 8 | 35 | 37 | 28 | 0 | RA FG+ FG | M | - | - | 0.22 | 29.83 | 29.89 | 3.6 | 4 | 6.7 | 18 | 8 | 15 | 7 | 04 |
| 05 | 42 | 30 | 36 | 7 | 17 | 30 | 29 | 0 | - | M | - | - | 0.00 | 30.01 | 30.07 | 13.9 | 35 | 14.5 | 39 | 33 | 29 | 34 | 05 |
| 06 | 38 | 29 | 34 | 5 | 17 | 28 | 31 | 0 | - | M | - | - | 0.00 | 29.89 | 29.94 | 3.8 | 27 | 5.8 | 15 | 34 | 11 | 31 | 06 |
| 07 | 39 | 32 | 36 | 7 | 26 | 32 | 29 | 0 | SN FG | M | - | - | 0.19 | 29.86 | 29.91 | 4.6 | 35 | 6.8 | 17 | 32 | 15 | 32 | 07 |
| 08 | 38 | 26 | 32 | 3 | 18 | 28 | 33 | 0 | SN FG | M | - | - | 0.02 | 29.91 | 29.95 | 6.1 | 1 | 8.0 | 18 | 2 | 16 | 2 | 08 |
| 09 | 40 | 21 | 31 | 2 | 28 | 31 | 34 | 0 | FG | M | - | - | 0.00 | 29.99 | 30.02 | 5.8 | 24 | 6.1 | 20 | 23 | 16 | 22 | 09 |
| 10 | 50 | 32 | 41 | 12 | 27 | 35 | 24 | 0 | FG | M | - | - | 0.00 | 30.00 | 30.05 | 8.7 | 32 | 10.2 | 26 | 31 | 23 | 31 | 10 |
| 11 | 44 | 26 | 35 | 6 | 28 | 34 | 30 | 0 | - | M | - | - | 0.00 | 30.22 | 30.26 | 2.1 | 17 | 3.8 | 18 | 20 | 16 | 20 | 11 |
| 12 | 52 | 35 | 44* | 14 | 45 | 45 | 21 | 0 | RA FG+ FG | M | - | - | 0.09 | 29.83 | 29.89 | 5.9 | 23 | 10.1 | 31 | 34 | 26 | 35 | 12 |
| 13 | 42 | 27 | 35 | 5 | 22 | 30 | 30 | 0 | - | M | - | - | T | 29.92 | 29.98 | 9.3 | 29 | 11.0 | 24 | 30 | 22 | 28 | 13 |
| 14 | 29 | 21 | 25 | -5 | 7 | 20 | 40 | 0 | - | M | - | - | 0.00 | 30.13 | 30.19 | 12.9 | 36 | 13.2 | 31 | 33 | 25 | 32 | 14 |
| 15 | 39 | 19 | 29 | -1 | 15 | 25 | 36 | 0 | - | M | - | - | 0.00 | 30.16 | 30.23 | 4.8 | 24 | 6.6 | 17 | 23 | 15 | 23 | 15 |
| 16 | 43 | 26 | 35 | 5 | 31 | 33 | 30 | 0 | FG | M | - | - | 0.00 | 30.06 | 30.12 | 4.7 | 8 | 5.0 | 13 | 8 | 11 | 9 | 16 |
| 17 | 46 | 36 | 41 | 10 | 40 | 41 | 24 | 0 | FG | M | - | - | 0.00 | 29.94 | 29.97 | 12.4 | 7 | 12.7 | 25 | 8 | 21 | 8 | 17 |
| 18 | 43 | 35 | 39 | 8 | 38 | 39 | 26 | 0 | RA FG | M | - | - | 1.01 | 29.79 | 29.86 | 8.4 | 2 | 9.0 | 20 | 1 | 16 | 1 | 18 |
| 19 | 43 | 32 | 38 | 7 | 27 | 33 | 27 | 0 | - | M | - | - | 0.00 | 29.89 | 29.93 | 6.5 | 2 | 8.6 | 20 | 36 | 15 | 1 | 19 |
| 20 | 41 | 31 | 36 | 5 | 22 | 30 | 29 | 0 | - | M | - | - | 0.00 | 29.81 | 29.88 | 10.8 | 36 | 11.4 | 23 | 1 | 17 | 36 | 20 |
| 21 | 36 | 25 | 31 | 0 | 17 | 26 | 34 | 0 | FG HZ | M | - | - | T | 29.88 | 29.93 | 10.7 | 36 | 11.7 | 25 | 33 | 21 | 36 | 21 |
| 22 | 27 | 15 | 21 | -11 | -6 | 15 | 44 | 0 | - | M | - | - | 0.00 | 30.13 | 30.20 | 15.0 | 1 | 15.0 | 33 | 1 | 26 | 1 | 22 |
| 23 | 28 | 11 | 20* | -12 | -3 | 16 | 45 | 0 | - | M | - | - | 0.00 | 30.39 | 30.45 | 2.2 | 36 | 6.6 | 22 | 1 | 18 | 1 | 23 |
| 24 | 34 | 22 | 28 | -4 | 11 | 24 | 37 | 0 | - | M | - | - | 0.00 | 30.36 | 30.43 | 9.7 | 7 | 11.1 | 21 | 10 | 18 | 9 | 24 |
| 25 | 33 | 26 | 30 | -3 | 26 | 28 | 35 | 0 | SN FG FZFG | M | - | - | 0.11 | 30.03 | 30.09 | 10.3 | 1 | 11.0 | 23 | 5 | 18 | 4 | 25 |
| 26 | 47 | 29 | 38 | 5 | 20 | 31 | 27 | 0 | - | M | - | - | 0.00 | 29.83 | 29.89 | 12.7 | 34 | 12.9 | 31 | 33 | 25 | 33 | 26 |
| 27 | 48 | 28 | 38 | 5 | 24 | 32 | 27 | 0 | - | M | - | - | 0.00 | 29.93 | 29.98 | 3.8 | 28 | 5.8 | 22 | 29 | 18 | 30 | 27 |
| 28 | 46 | 30 | 38 | 5 | 38 | 38 | 27 | 0 | RA FG+ FG HZ | M | - | - | 1.20 | 29.54 | 30.83 | 8.0 | 8 | 9.6 | 28 | 8 | 23 | 7 | 28 |
|  | 41.2 | 27.1 | 34.2 | -------- | 23.7 | 31.0 | 30.6 | .0 | <Monthly Averages | Totals> |  |  | 4.02 | 29.99 | 30.08 | 4.3 | 35.8 | 9.2 | <Monthly Average |  |  |  |  |
|  | 3.6 | 3.9 | 3.8 | -------- | <--------------------Departure From Normal----------------------> |  |  |  |  |  |  |  | 1.01 |  |  |  |  |  |  |  |  |  |  |

**Degree Days** Monthly Season to Date

|  | Monthly Total | Departure | Season to Date Total | Departure |
|---|---|---|---|---|
| Heating: | 857 | -112 |  |  |
| Cooling: | 0 | 0 |  |  |

Greatest 24-hr Precipitation: 1.20date: 28
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.64 | 1 | 0003 |
| Minimum : | 29.15 | 28 | 2359 |

Number of Days with ----->

Max temp >= 90: 0
Max temp <= 32: 3
Thunderstorms : 0
Min temp <= 32: 23
Min temp <= 0 : 0
Heavy Fog : 5
Precipitation >= .01 inch: 0
Precipitation >= .10 inch : 0
Snowfall >= 1.0 inch : 0

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 03/1999**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Deg Days Base 65 Degrees Heating | Cooling | Significant Weather | Snow/Ice on Gnd(In) 0600 LST Depth | 1200 LST Water Equiv | Precipitation (In) 2400 LST Snow Fall | 2400 LST Water Equiv | Pressure (inches of Hg) Avg. Station | Avg. Sea level | Wind Speed=mph Dir=tens of degrees Resultant Speed | Res Dir | Avg. Speed | max 5-sec Speed | Dir | max 2-min Speed | Dir | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 48 | 38 | 43 | 9 | 37 | 39 | 22 | 0 | RA FG | M | - | - | 0.07 | 29.21 | 32.22 | 10.2 | 26 | 11.7 | 26 | 30 | 22 | 30 | 01 |
| 02 | 47 | 31 | 39 | 5 | 24 | 33 | 26 | 0 | - | M | - | - | 0.00 | 29.66 | 30.21 | 11.2 | 29 | 11.8 | 29 | 30 | 23 | 30 | 02 |
| 03 | 55 | 28 | 42 | 7 | 38 | 40 | 23 | 0 | TS TSRA RA FG | M | - | - | 0.13 | 29.75 | 30.18 | 9.4 | 11 | 11.7 | 39 | 18 | 31 | 17 | 03 |
| 04 | 53 | 31 | 42 | 7 | 30 | 36 | 23 | 0 | RA SN FG | M | - | - | 0.34 | 29.45 | 31.35 | 15.5 | 24 | 22.1 | 40 | 24 | 33 | 22 | 04 |
| 05 | 42 | 28 | 35 | 0 | 19 | 29 | 30 | 0 | - | M | - | - | 0.00 | 30.19 | 30.26 | 5.3 | 28 | 8.6 | 23 | 22 | 21 | 23 | 05 |
| 06 | 41 | 31 | 36 | 1 | 29 | 34 | 29 | 0 | RA FG | M | - | - | 0.46 | 30.04 | 30.09 | 10.5 | 8 | 12.0 | 29 | 10 | 24 | 10 | 06 |
| 07 | 35 | 17 | 26 | -10 | 13 | 22 | 39 | 0 | RA SN FG FZFG HZ BLSN | M | - | - | 0.13 | 30.06 | 30.11 | 18.5 | 36 | 18.8 | 43 | 33 | 33 | 33 | 07 |
| 08 | 32 | 14 | 23* | -13 | 2 | 18 | 42 | 0 | - | M | - | - | 0.00 | 30.37 | 30.43 | 15.6 | 35 | 16.0 | 40 | 36 | 30 | 33 | 08 |
| 09 | 38 | 18 | 28 | -8 | 3 | 22 | 37 | 0 | - | M | - | - | 0.00 | 30.11 | 30.16 | 7.6 | 35 | 9.4 | 24 | 36 | 21 | 36 | 09 |
| 10 | 40 | 25 | 33 | -4 | 7 | 25 | 32 | 0 | - | M | - | - | 0.00 | 29.80 | 29.85 | 10.8 | 36 | 11.3 | 23 | 36 | 18 | 31 | 10 |
| 11 | 40 | 24 | 32 | -5 | 14 | 25 | 33 | 0 | - | M | - | - | 0.00 | 29.68 | 29.73 | 16.3 | 35 | 16.6 | 32 | 32 | 26 | 36 | 11 |
| 12 | 34 | 24 | 29 | -8 | 19 | 25 | 36 | 0 | SN FG | M | - | - | T | 29.74 | 29.80 | 17.8 | 36 | 17.9 | 32 | 32 | 26 | 36 | 12 |
| 13 | 48 | 27 | 38 | 0 | 23 | 31 | 27 | 0 | - | M | - | - | 0.00 | 30.00 | 30.07 | 12.2 | 36 | 13.4 | 29 | 31 | 23 | 36 | 13 |
| 14 | 41 | 31 | 36 | -2 | 31 | 34 | 29 | 0 | RA SN FG | M | - | - | 0.42 | 30.02 | 30.07 | 7.9 | 8 | 9.8 | 21 | 10 | 18 | 10 | 14 |
| 15 | 40 | 32 | 36 | -2 | 30 | 33 | 29 | 0 | SN FG UP | M | - | - | 0.43 | 29.59 | 29.77 | 14.2 | 1 | 16.2 | 38 | 1 | 29 | 1 | 15 |
| 16 | 49 | 30 | 40 | 1 | 25 | 34 | 25 | 0 | - | M | - | - | 0.00 | 29.71 | 29.76 | 11.7 | 27 | 12.9 | 30 | 30 | 24 | 30 | 16 |
| 17 | 58 | 38 | 48 | 9 | 37 | 42 | 17 | 0 | - | M | - | - | 0.00 | 29.73 | 29.78 | 8.6 | 24 | 9.5 | 21 | 23 | 18 | 23 | 17 |
| 18 | 68 | 36 | 52 | 13 | 35 | 43 | 13 | 0 | - | M | - | - | 0.00 | 29.60 | 29.90 | 11.1 | 30 | 12.9 | 40 | 31 | 33 | 32 | 18 |
| 19 | 48 | 34 | 41 | 1 | 26 | 35 | 24 | 0 | - | M | - | - | T | 29.93 | 29.98 | 14.0 | 32 | 14.8 | 33 | 31 | 25 | 31 | 19 |
| 20 | 50 | 30 | 40 | 0 | 24 | 34 | 25 | 0 | - | M | - | - | 0.00 | 30.10 | 30.15 | 3.5 | 29 | 7.3 | 25 | 33 | 21 | 31 | 20 |
| 21 | 48 | 31 | 40 | 0 | 35 | 38 | 25 | 0 | RA FG | M | - | - | 0.23 | 30.01 | 30.06 | 10.0 | 10 | 11.3 | 31 | 15 | 24 | 14 | 21 |
| 22 | 50 | 39 | 45 | 4 | 36 | 41 | 20 | 0 | RA FG | M | - | - | 0.69 | 29.61 | 30.64 | 12.3 | 23 | 17.8 | 39 | 15 | 30 | 15 | 22 |
| 23 | 49 | 37 | 43 | 2 | 32 | 38 | 22 | 0 | - | M | - | - | 0.00 | 30.08 | 30.13 | 10.2 | 24 | 11.1 | 24 | 20 | 20 | 20 | 23 |
| 24 | 51 | 36 | 44 | 3 | 44 | 44 | 21 | 0 | RA FG+ FG | M | - | - | 0.10 | 29.91 | 29.98 | 1.3 | 13 | 4.4 | 14 | 22 | 11 | 22 | 24 |
| 25 | 51 | 35 | 43 | 2 | 24 | 36 | 22 | 0 | FG | M | - | - | 0.00 | 29.98 | 30.02 | 10.4 | 36 | 11.3 | 24 | 1 | 18 | 32 | 25 |
| 26 | 45 | 30 | 38 | -4 | 25 | 33 | 27 | 0 | - | M | - | - | 0.00 | 30.15 | 30.20 | 1.3 | 35 | 6.7 | 23 | 1 | 18 | 1 | 26 |
| 27 | 52 | 32 | 42 | 0 | 32 | 38 | 23 | 0 | - | M | - | - | 0.04 | 30.11 | 30.15 | 9.9 | 7 | 12.0 | 32 | 6 | 25 | 6 | 27 |
| 28 | 48 | 38 | 43 | 1 | 39 | 41 | 22 | 0 | RA FG | M | - | - | 0.20 | 29.87 | 29.93 | 14.7 | 4 | 15.3 | 32 | 4 | 24 | 4 | 28 |
| 29 | 68* | 43 | 56* | 13 | 36 | 45 | 9 | 0 | - | 0.0 | - | - | 0.00 | 29.83 | 29.88 | 10.3 | 33 | 11.0 | 32 | 31 | 25 | 32 | 29 |
| 30 | 61 | 43 | 52 | 9 | 25 | 41 | 13 | 0 | - | M | - | - | 0.00 | 30.08 | 30.12 | 12.3 | 31 | 14.0 | 38 | 30 | 31 | 30 | 30 |
| 31 | 63 | 36 | 50 | 7 | 37 | 44 | 15 | 0 | - | M | - | - | 0.00 | 30.05 | 30.10 | 8.8 | 24 | 9.5 | 28 | 23 | 22 | 24 | 31 |
|  | 48.2 | 31.2 | 39.7 | -------- | 26.8 | 34.6 | 25.2 | .0 | <Monthly Averages | Totals> |  |  | 0.00 | 29.89 | 30.16 | 5.3 | 33.4 | 12.6 | <Monthly Average |  |  |  |  |
|  | 2.0 | .3 | 1.1 | -------- | <--------------------Departure From Normal----------------------> |  |  |  |  |  |  |  | -3.75 |  |  |  |  |  |  |  |  |  |  |

33 @ 220°

**Degree Days** Monthly Season to Date

|  | Monthly Total | Monthly Departure | Season to Date Total | Season to Date Departure |
|---|---|---|---|---|
| Heating: | 780 | -38 |  |  |
| Cooling: | 0 | 0 |  |  |

Greatest 24-hr Precipitation: 0.00date:
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.48 | 8 | 0941 |
| Minimum : | 29.08 | 1 | 0325 |

Number of Days with ----->
Max temp >= 90: 0
Max temp <= 32: 1
Thunderstorms : 1
Min temp <= 32: 19
Min temp <= 0 : 0
Heavy Fog : 1
.Precipitation >= .01 inch: M
Precipitation >= .10 inch : M
Snowfall >= 1.0 inch : 0

39.7°

12.6 / 334°

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 04/1999**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) | | | | | | Deg Days Base 65 Degrees | | Significant Weather | Snow/Ice on Gnd(In) | | Precipitation (In) | | Pressure (inches of Hg) | | Wind Speed=mph Dir=tens of degrees | | | | | | | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Heating | Cooling | | 0600 LST | 1200 LST | 2400 LST | 2400 LST | Avg. Station | Avg. Sea level | Resultant Speed | Res Dir | Avg. Speed | max 5-sec | | max 2-min | | |
| | | | | | | | | | | Depth | Water Equiv | Snow Fall | Water Equiv | | | | | | Speed | Dir | Speed | Dir | |
| 01 | 58 | 43 | 51 | 7 | 37 | 47 | 14 | 0 | RA FG+ FG HZ | M | - | - | 0.01 | 29.94 | 29.99 | 5.1 | 24 | 5.7 | 16 | 23 | 13 | 23 | 01 |
| 02 | 54 | 42 | 48 | 4 | 34 | 44 | 17 | 0 | FG+ FG | M | - | - | 0.00 | 30.00 | 30.07 | 5.5 | 11 | 6.9 | 17 | 14 | 15 | 13 | 02 |
| 03 | 51 | 43 | 47 | 3 | 40 | 43 | 18 | 0 | - | M | - | - | T | 30.06 | 30.13 | 3.8 | 17 | 5.6 | 15 | 19 | 13 | 19 | 03 |
| 04 | 57 | 39 | 48 | 4 | 31 | 43 | 17 | 0 | RA FG | M | - | - | 0.01 | 29.81 | 29.86 | 8.3 | 1 | 11.3 | 32 | 1 | 25 | 2 | 04 |
| 05 | 55 | 32 | 44 | -1 | 28 | 38 | 21 | 0 | - | M | - | - | 0.00 | 30.17 | 30.23 | 2.5 | 36 | 8.7 | 22 | 4 | 17 | 4 | 05 |
| 06 | 56 | 36 | 46 | 1 | 38 | 43 | 19 | 0 | RA FG | M | - | - | 0.04 | 30.15 | 30.20 | 3.9 | 15 | 7.5 | 21 | 21 | 16 | 20 | 06 |
| 07 | 71 | 43 | 57 | 12 | 42 | 50 | 8 | 0 | FG HZ | M | - | - | 0.00 | 29.90 | 29.95 | 8.1 | 30 | 9.3 | 31 | 30 | 26 | 31 | 07 |
| 08 | 80* | 45 | 63* | 17 | 42 | 51 | 2 | 0 | - | M | - | - | 0.00 | 29.71 | 29.77 | 6.0 | 28 | 9.8 | 36 | 29 | 29 | 29 | 08 |
| 09 | 57 | 42 | 50 | 4 | 39 | 44 | 15 | 0 | RA FG | M | - | - | 0.53 | 29.60 | 29.68 | 5.7 | 4 | 7.0 | 18 | 3 | 16 | 8 | 09 |
| 10 | 56 | 41 | 49 | 3 | 33 | 42 | 16 | 0 | - | M | - | - | 0.00 | 29.81 | 29.87 | 12.1 | 36 | 12.8 | 34 | 31 | 23 | 1 | 10 |
| 11 | 45 | 35 | 40* | -7 | 31 | 36 | 25 | 0 | RA FG | M | - | - | 0.28 | 29.95 | 30.00 | 4.9 | 9 | 6.8 | 16 | 3 | 13 | 3 | 11 |
| 12 | 57 | 37 | 47 | 0 | 33 | 41 | 18 | 0 | - | M | - | - | T | 29.65 | 29.71 | 12.5 | 35 | 13.2 | 34 | 33 | 25 | 33 | 12 |
| 13 | 57 | 37 | 47 | 0 | 26 | 39 | 18 | 0 | - | M | - | - | 0.00 | 29.65 | 29.70 | 12.4 | 34 | 14.3 | 38 | 31 | 28 | 34 | 13 |
| 14 | 64 | 41 | 53 | 5 | 29 | 42 | 12 | 0 | - | M | - | - | 0.00 | 29.60 | 29.66 | 9.9 | 32 | 11.5 | 36 | 32 | 28 | 30 | 14 |
| 15 | 64 | 38 | 51 | 3 | 37 | 45 | 14 | 0 | - | M | - | - | 0.00 | 29.64 | 29.69 | 6.3 | 24 | 9.1 | 20 | 9 | 17 | 8 | 15 |
| 16 | 49 | 41 | 45 | -3 | 42 | 44 | 20 | 0 | RA FG HZ | M | - | - | 0.32 | 29.53 | 29.58 | 8.2 | 9 | 9.9 | 22 | 9 | 18 | 10 | 16 |
| 17 | 57 | 39 | 48 | -1 | 42 | 46 | 17 | 0 | FG HZ | M | - | - | T | 29.63 | 29.68 | 7.6 | 26 | 8.2 | 26 | 28 | 21 | 28 | 17 |
| 18 | 63 | 43 | 53 | 4 | 40 | 46 | 12 | 0 | - | M | - | - | 0.00 | 29.76 | 29.82 | 9.8 | 28 | 10.6 | 25 | 28 | 21 | 29 | 18 |
| 19 | 59 | 42 | 51 | 2 | 42 | 46 | 14 | 0 | - | M | - | - | 0.00 | 29.92 | 29.97 | 7.1 | 25 | 8.3 | 24 | 31 | 22 | 31 | 19 |
| 20 | 48 | 38 | 43 | -7 | 43 | 44 | 22 | 0 | RA FG | M | - | - | 0.06 | 29.89 | 29.94 | 0.9 | 30 | 3.5 | 10 | 36 | 9 | 2 | 20 |
| 21 | 60 | 38 | 49 | -1 | 42 | 46 | 16 | 0 | - | M | - | - | 0.00 | 29.95 | 30.01 | 6.0 | 22 | 8.4 | 20 | 21 | 16 | 21 | 21 |
| 22 | 55 | 46 | 51 | 1 | 48 | 49 | 14 | 0 | RA FG HZ | M | - | - | 0.01 | 29.93 | 29.99 | 2.4 | 22 | 3.0 | 10 | 21 | 9 | 20 | 22 |
| 23 | 56 | 41 | 49 | -2 | 48 | 49 | 16 | 0 | RA FG HZ | M | - | - | 0.55 | 29.86 | 29.92 | 6.4 | 3 | 8.0 | 18 | 36 | 14 | 36 | 23 |
| 24 | 57 | 36 | 47 | -4 | 23 | 38 | 18 | 0 | - | M | - | - | 0.00 | 30.05 | 30.09 | 12.8 | 35 | 13.0 | 31 | 36 | 24 | 36 | 24 |
| 25 | 59 | 38 | 49 | -2 | 32 | 42 | 16 | 0 | - | M | - | - | 0.00 | 30.02 | 30.09 | 5.6 | 27 | 9.6 | 23 | 23 | 20 | 22 | 25 |
| 26 | 72 | 47 | 60 | 8 | 39 | 48 | 5 | 0 | - | M | - | - | 0.00 | 29.70 | 29.75 | 6.9 | 29 | 12.8 | 32 | 1 | 25 | 1 | 26 |
| 27 | 64 | 41 | 53 | 1 | 36 | 45 | 12 | 0 | - | M | - | - | 0.00 | 29.94 | 30.01 | 7.1 | 1 | 9.4 | 24 | 1 | 20 | 1 | 27 |
| 28 | 58 | 45 | 52 | 0 | 42 | 47 | 13 | 0 | - | M | - | - | 0.00 | 30.15 | 30.21 | 2.3 | 19 | 8.0 | 15 | 26 | 13 | 22 | 28 |
| 29 | 68 | 44 | 56 | 3 | 37 | 46 | 9 | 0 | - | M | - | - | 0.00 | 30.11 | 30.18 | 5.4 | 4 | 9.2 | 31 | 12 | 25 | 12 | 29 |
| 30 | 60 | 41 | 51 | -2 | 42 | 46 | 14 | 0 | - | M | - | - | 0.00 | 30.22 | 30.29 | 4.4 | 10 | 6.9 | 18 | 3 | 15 | 17 | 30 |
| | 58.9 | 40.5 | 49.7 | -------- | 37.3 | 44.3 | 15.1 | .0 | <Monthly Averages | Totals> | | | 1.81 | 29.88 | 29.94 | 2.7 | 33 | 9.0 | <Monthly Average | | | | |
| | 2.3 | .7 | 1.5 | -------- | <--------------------Departure From Normal----------------------> | | | | | | | | -1.94 | | | | | | | | | | |

**Degree Days** Monthly Season to Date
Total Departure Total Departure
Heating: 452 -52
Cooling: 0 0

Greatest 24-hr Precipitation: 0.55 date: 23
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.32 | 6 | 0715 |
| Minimum : | 29.53 | 16 | 1758 |

Number of Days with ----->
Max temp >= 90: 0
Max temp <= 32: 0
Thunderstorms : 0
Min temp <= 32: 1
Min temp <= 0 : 0
Heavy Fog : 2
Precipitation >= .01 inch: 0
Precipitation >= .10 inch : 0
Snowfall >= 1.0 inch : 0

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 05/1999**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Deg Days Base 65 Degrees Heating | Cooling | Significant Weather | Snow/Ice on Gnd(In) 0600 LST Depth | 1200 LST Water Equiv | Precipitation (In) 2400 LST Snow Fall | 2400 LST Water Equiv | Pressure (inches of Hg) Avg. Station | Avg. Sea level | Wind Speed=mph Dir=tens of degrees Resultant Speed | Res Dir | Avg. Speed | max 5-sec Speed | max 5-sec Dir | max 2-min Speed | max 2-min Dir | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 62 | 41 | 52* | -1 | 40 | 46 | 13 | 0 | - | M | - | - | 0.00 | 30.20 | 30.26 | 5.0 | 9 | 8.1 | 16 | 15 | 14 | 9 | 01 |
| 02 | 62 | 43 | 53 | -1 | 42 | 48 | 12 | 0 | - | M | - | - | 0.00 | 30.13 | 30.18 | 10.4 | 8 | 12.0 | 25 | 5 | 20 | 6 | 02 |
| 03 | 62 | 49 | 56 | 2 | 47 | 51 | 9 | 0 | RA FG | M | - | - | 0.13 | 29.97 | 30.03 | 16.0 | 5 | 16.2 | 33 | 6 | 28 | 6 | 03 |
| 04 | 62 | 49 | 56 | 2 | 54 | 55 | 9 | 0 | RA FG | M | - | - | 0.14 | 29.90 | 29.95 | 10.2 | 3 | 10.4 | 22 | 3 | 17 | 4 | 04 |
| 05 | 64 | 54 | 59 | 4 | 57 | 58 | 6 | 0 | FG | M | - | - | 0.00 | 29.92 | 29.97 | 2.5 | 20 | 3.9 | 11 | 12 | 11 | 12 | 05 |
| 06 | 63 | 53 | 58 | 3 | 56 | 56 | 7 | 0 | FG+ FG | M | - | - | 0.00 | 29.98 | 30.03 | 5.3 | 10 | 6.5 | 15 | 9 | 13 | 10 | 06 |
| 07 | 55 | 52 | 54 | -1 | 53 | 53 | 11 | 0 | RA FG+ FG | M | - | - | 0.02 | 30.00 | 30.04 | 12.7 | 9 | 12.7 | 20 | 9 | 17 | 9 | 07 |
| 08 | 56 | 50 | 53 | -3 | 53 | 53 | 12 | 0 | RA FG+ FG | M | - | - | 0.08 | 29.86 | 29.92 | 11.9 | 9 | 13.0 | 24 | 8 | 22 | 8 | 08 |
| 09 | M | M | M | M | - | 37 | M | M | FG+ FG HZ | M | - | - | 0.01 | 29.83 | 29.90 | 5.0 | 26 | 6.4 | 21 | 23 | 18 | 23 | 09 |
| 10 | M | M | M | M | - | 45 | M | M | - | M | - | - | 0.00 | 29.94 | 30.02 | 8.6 | 36 | 9.0 | 26 | 33 | 21 | 36 | 10 |
| 11 | 66 | 49 | 58 | 1 | 41 | 49 | 7 | 0 | - | M | - | - | 0.00 | 30.14 | 30.18 | 4.0 | 20 | 8.8 | 21 | 21 | 17 | 21 | 11 |
| 12 | 69 | 48 | 59 | 2 | 40 | 50 | 6 | 0 | - | M | - | - | 0.00 | 29.93 | 29.99 | 2.2 | 18 | 6.0 | 16 | 22 | 14 | 21 | 12 |
| 13 | 65 | 50 | 58 | 0 | 34 | 46 | 7 | 0 | - | M | - | - | 0.00 | 29.93 | 29.96 | 4.9 | 10 | 9.2 | 20 | 1 | 16 | 2 | 13 |
| 14 | 63 | 44 | 54 | -4 | 39 | 47 | 11 | 0 | - | M | - | - | 0.00 | 30.18 | 30.21 | 2.8 | 16 | 8.5 | 17 | 21 | 15 | 21 | 14 |
| 15 | 66 | 45 | 56 | -2 | 42 | 49 | 9 | 0 | - | M | - | - | 0.00 | 30.28 | 30.34 | 5.4 | 9 | 6.2 | 15 | 10 | 13 | 10 | 15 |
| 16 | 64 | 45 | 55 | -3 | 46 | 50 | 10 | 0 | - | M | - | - | 0.00 | 30.30 | 30.35 | 6.6 | 9 | 8.4 | 16 | 11 | 14 | 11 | 16 |
| 17 | 67 | 48 | 58 | -1 | 50 | 53 | 7 | 0 | - | M | - | - | 0.00 | 30.24 | 30.29 | 9.0 | 8 | 9.6 | 17 | 9 | 15 | 9 | 17 |
| 18 | 62 | 53 | 58 | -1 | 57 | 57 | 7 | 0 | RA FG+ FG | M | - | - | 0.17 | 30.13 | 30.17 | 9.1 | 8 | 9.4 | 20 | 7 | 15 | 8 | 18 |
| 19 | 63 | 56 | 60 | 1 | 59 | 59 | 5 | 0 | RA FG+ FG | M | - | - | 1.33 | 29.94 | 29.98 | 8.0 | 7 | 9.4 | 23 | 2 | 20 | 1 | 19 |
| 20 | 71 | 56 | 64 | 4 | 46 | 54 | 1 | 0 | FG | M | - | - | 0.07 | 29.94 | 30.00 | 12.8 | 36 | 13.1 | 30 | 36 | 24 | 1 | 20 |
| 21 | 77 | 50 | 64 | 4 | 41 | 52 | 1 | 0 | - | M | - | - | 0.00 | 29.98 | 30.04 | 8.8 | 34 | 9.5 | 23 | 31 | 18 | 32 | 21 |
| 22 | 70 | 53 | 62 | 2 | 51 | 56 | 3 | 0 | - | M | - | - | 0.00 | 29.94 | 30.00 | 4.5 | 11 | 5.2 | 15 | 9 | 13 | 9 | 22 |
| 23 | 59 | 57 | 58 | -3 | 58 | 58 | 7 | 0 | RA FG+ FG | M | - | - | 0.71 | 29.81 | 29.86 | 11.3 | 9 | 11.6 | 22 | 9 | 18 | 9 | 23 |
| 24 | 63 | 56 | 60 | -1 | 58 | 59 | 5 | 0 | TS TSRA RA FG+ FG | M | - | - | 1.12 | 29.57 | 29.99 | 3.5 | 14 | 8.1 | 22 | 21 | 20 | 8 | 24 |
| 25 | 68 | 54 | 61 | -1 | 48 | 54 | 4 | 0 | - | M | - | - | 0.00 | 29.69 | 29.74 | 10.8 | 23 | 11.7 | 23 | 21 | 21 | 23 | 25 |
| 26 | 70 | 57 | 64 | 2 | 47 | 55 | 1 | 0 | - | M | - | - | 0.00 | 29.72 | 29.76 | 10.5 | 25 | 12.5 | 25 | 28 | 21 | 24 | 26 |
| 27 | 72 | 54 | 63 | 1 | 45 | 53 | 2 | 0 | - | M | - | - | 0.00 | 29.78 | 29.83 | 6.2 | 33 | 8.0 | 25 | 29 | 18 | 35 | 27 |
| 28 | 78 | 56 | 67 | 5 | 47 | 56 | 0 | 2 | - | M | - | - | 0.00 | 29.90 | 29.95 | 4.0 | 31 | 7.7 | 24 | 33 | 20 | 33 | 28 |
| 29 | 88* | 55 | 72* | 9 | 55 | 60 | 0 | 7 | - | M | - | - | 0.00 | 30.01 | 30.06 | 4.8 | 22 | 5.8 | 21 | 30 | 17 | 21 | 29 |
| 30 | 82 | 58 | 70 | 7 | 57 | 62 | 0 | 5 | - | M | - | - | 0.00 | 30.10 | 30.15 | 2.1 | 21 | 3.9 | 10 | 22 | 8 | 23 | 30 |
| 31 | 82 | 59 | 71 | 8 | 58 | 63 | 0 | 6 | FG HZ | M | - | - | 0.00 | 30.05 | 30.10 | 2.2 | 18 | 4.1 | 15 | 22 | 13 | 22 | 31 |
| | 67.3 | 51.5 | 59.4 | -------- | 49.0 | 53.0 | 5.9 | .7 | <Monthly Averages | Totals> | | | 3.78 | 29.98 | 30.04 | 2.9 | 6.9 | 8.9 | <Monthly Average | | | | |
| | .6 | 1.5 | 1.0 | -------- | <--------------------Departure From Normal----------------------> | | | | | | | | -.15 | | | | | | | | | | |

**Degree Days** Monthly Season to Date
Total Departure Total Departure
Heating: 172 -47
Cooling: 20 5

Greatest 24-hr Precipitation: 1.39 date: 19-20
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.40 | 16 | 1137 |
| Minimum : | 29.50 | 24 | 1700 |

Number of Days with ----->
Max temp >= 90: M
Max temp <= 32: M
Thunderstorms : 1
Min temp <= 32: M
Min temp <= 0 : M
Heavy Fog : 8
Precipitation >= .01 inch: 0
Precipitation >= .10 inch : 0
Snowfall >= 1.0 inch : 0

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 06/1999**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) | | | | | | Deg Days Base 65 Degrees | | Significant Weather | Snow/Ice on Gnd(In) | | Precipitation (In) | | Pressure (inches of Hg) | | Wind Speed=mph Dir=tens of degrees | | | | | | | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Heating | Cooling | | 0600 LST | 1200 LST | 2400 LST | 2400 LST | Avg. Station | Avg. Sea level | Resultant Speed | Res Dir | Avg. Speed | max 5-sec | | max 2-min | | |
| | | | | | | | | | | Depth | Water Equiv | Snow Fall | Water Equiv | | | | | | Speed | Dir | Speed | Dir | |
| 01 | 81 | 62 | 72 | 8 | 62 | 65 | 0 | 7 | FG HZ | M | - | - | 0.00 | 29.95 | 30.00 | 3.6 | 16 | 6.6 | 22 | 24 | 17 | 20 | 01 |
| 02 | 82 | 67 | 75 | 11 | 64 | 68 | 0 | 10 | RA FG HZ | M | - | - | T | 29.86 | 29.93 | 5.4 | 21 | 6.5 | 20 | 20 | 16 | 20 | 02 |
| 03 | 85 | 66 | 76 | 12 | 61 | 66 | 0 | 11 | FG HZ | M | - | - | T | 29.78 | 29.82 | 8.0 | 28 | 11.5 | 28 | 33 | 23 | 29 | 03 |
| 04 | 77 | 60 | 69 | 5 | 47 | 57 | 0 | 4 | - | M | - | - | 0.00 | 30.00 | 30.04 | 9.8 | 36 | 10.7 | 29 | 2 | 22 | 3 | 04 |
| 05 | 75 | 56 | 66 | 1 | 53 | 58 | 0 | 1 | - | M | - | - | 0.00 | 30.22 | 30.28 | 4.6 | 16 | 6.8 | 18 | 19 | 15 | 18 | 05 |
| 06 | 74 | 55 | 65 | -1 | 57 | 61 | 0 | 0 | - | M | - | - | 0.00 | 30.16 | 30.21 | 6.8 | 22 | 7.5 | 20 | 22 | 17 | 21 | 06 |
| 07 | 88 | 65 | 77 | 11 | 66 | 69 | 0 | 12 | FG HZ | M | - | - | 0.00 | 29.89 | 29.95 | 8.7 | 24 | 8.8 | 18 | 24 | 16 | 23 | 07 |
| 08 | 93* | 69 | 81* | 15 | 63 | 69 | 0 | 16 | HZ | M | - | - | 0.00 | 29.75 | 29.79 | 9.1 | 28 | 10.9 | 29 | 30 | 24 | 31 | 08 |
| 09 | 80 | 60 | 70 | 4 | 60 | 63 | 0 | 5 | - | M | - | - | 0.02 | 29.94 | 29.99 | 6.9 | 10 | 9.8 | 22 | 11 | 18 | 11 | 09 |
| 10 | 67 | 59 | 63 | -3 | 52 | 57 | 2 | 0 | - | M | - | - | 0.00 | 30.23 | 30.29 | 8.2 | 10 | 9.7 | 17 | 9 | 15 | 11 | 10 |
| 11 | 71 | 55 | 63 | -3 | 53 | 57 | 2 | 0 | - | M | - | - | 0.00 | 30.27 | 30.33 | 7.0 | 10 | 8.6 | 17 | 13 | 15 | 13 | 11 |
| 12 | 71 | 55 | 63 | -3 | 60 | 62 | 2 | 0 | FG | M | - | - | 0.00 | 30.23 | 30.29 | 8.1 | 7 | 9.8 | 18 | 9 | 15 | 9 | 12 |
| 13 | 71 | 64 | 68 | 1 | 65 | 66 | 0 | 3 | RA FG+ FG | M | - | - | T | 30.15 | 30.19 | 10.3 | 10 | 10.4 | 20 | 11 | 17 | 10 | 13 |
| 14 | 76 | 66 | 71 | 3 | 66 | 67 | 0 | 6 | RA FG HZ | M | - | - | 0.19 | 29.91 | 29.97 | 5.5 | 17 | 7.7 | 18 | 21 | 15 | 20 | 14 |
| 15 | 81 | 62 | 72 | 4 | 54 | 61 | 0 | 7 | FG | M | - | - | 0.01 | 29.91 | 29.98 | 5.3 | 32 | 10.6 | 28 | 2 | 21 | 1 | 15 |
| 16 | 69 | 57 | 63 | -5 | 48 | 55 | 2 | 0 | - | M | - | - | 0.01 | 30.06 | 30.11 | 6.9 | 8 | 9.2 | 20 | 6 | 16 | 4 | 16 |
| 17 | 64 | 58 | 61* | -7 | 54 | 57 | 4 | 0 | - | M | - | - | 0.06 | 30.01 | 30.08 | 5.8 | 8 | 7.3 | 17 | 10 | 13 | 11 | 17 |
| 18 | 74 | 56 | 65 | -3 | 52 | 58 | 0 | 0 | - | M | - | - | 0.00 | 30.12 | 30.19 | 5.3 | 1 | 6.3 | 18 | 33 | 14 | 35 | 18 |
| 19 | 76 | 55 | 66 | -3 | 52 | 58 | 0 | 1 | - | M | - | - | 0.00 | 30.31 | 30.38 | 3.7 | 19 | 6.0 | 15 | 19 | 13 | 20 | 19 |
| 20 | 70 | 58 | 64 | -5 | 56 | 60 | 1 | 0 | FG | M | - | - | 0.00 | 30.34 | 30.38 | 5.7 | 11 | 7.0 | 16 | 12 | 14 | 12 | 20 |
| 21 | 69 | 58 | 64 | -5 | 55 | 59 | 1 | 0 | RA FG | M | - | - | 0.11 | 30.23 | 30.27 | 3.1 | 7 | 4.6 | 13 | 1 | 11 | 1 | 21 |
| 22 | 80 | 56 | 68 | -1 | 57 | 62 | 0 | 3 | - | M | - | - | 0.00 | 30.07 | 30.14 | 4.2 | 22 | 5.1 | 13 | 21 | 11 | 22 | 22 |
| 23 | 87 | 63 | 75 | 6 | 58 | 65 | 0 | 10 | - | M | - | - | 0.00 | 30.02 | 30.07 | 5.9 | 22 | 6.4 | 15 | 21 | 13 | 22 | 23 |
| 24 | 85 | 65 | 75 | 5 | 57 | 64 | 0 | 10 | - | M | - | - | 0.00 | 29.99 | 30.04 | 8.5 | 23 | 8.8 | 22 | 20 | 18 | 21 | 24 |
| 25 | 79 | 67 | 73 | 3 | 62 | 66 | 0 | 8 | - | M | - | - | T | 29.91 | 29.96 | 8.7 | 23 | 8.9 | 24 | 21 | 21 | 21 | 25 |
| 26 | 88 | 70 | 79 | 9 | 66 | 70 | 0 | 14 | HZ | M | - | - | 0.00 | 29.89 | 29.93 | 6.8 | 22 | 7.5 | 18 | 20 | 16 | 20 | 26 |
| 27 | 87 | 67 | 77 | 7 | 67 | 71 | 0 | 12 | FG HZ | M | - | - | 0.00 | 29.88 | 29.95 | 5.2 | 19 | 7.0 | 20 | 21 | 16 | 20 | 27 |
| 28 | 85 | 72 | 79 | 8 | 71 | 73 | 0 | 14 | FG HZ | M | - | - | 0.00 | 29.69 | 29.74 | 10.8 | 21 | 11.2 | 28 | 22 | 22 | 20 | 28 |
| 29 | 84 | 72 | 78 | 7 | 71 | 73 | 0 | 13 | TS TSRA RA FG+ FG HZ | M | - | - | 0.43 | 29.57 | 29.63 | 6.5 | 22 | 8.4 | 33 | 27 | 26 | 28 | 29 |
| 30 | 76 | 65 | 71 | 0 | 61 | 65 | 0 | 6 | RA FG | M | - | - | 0.15 | 29.91 | 29.96 | 4.5 | 7 | 7.4 | 21 | 1 | 16 | 1 | 30 |
| | 78.2 | 62.0 | 70.1 | -------- | 59.0 | 63.4 | .5 | 5.8 | <Monthly Averages | Totals> | | | 0.98 | 30.01 | 30.06 | 1.7 | 18.1 | 8.2 | <Monthly Average | | | | |
| | 2.2 | 2.9 | 2.5 | -------- | <---------------------Departure From Normal-----------------------> | | | | | | | | -2.48 | | | | | | | | | | |

**Degree Days** Monthly Season to Date

| | Total | Departure | Total | Departure |
|---|---|---|---|---|
| Heating: | 14 | -4 | | |
| Cooling: | 173 | 77 | | |

Greatest 24-hr Precipitation: 0.43 date: 29
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.43 | 20 | 0806 |
| Minimum : | 29.55 | 29 | 1340 |

Number of Days with ----->
Max temp >= 90: 1
Max temp <= 32: 0
Thunderstorms : 1
Min temp <= 32: 0
Min temp <= 0 : 0
Heavy Fog : 2
Precipitation >= .01 inch: 0
Precipitation >= .10 inch : 0
Snowfall >= 1.0 inch : 0

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 07/1999**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) | | | | | | Deg Days Base 65 Degrees | | Significant Weather | Snow/Ice on Gnd(In) | | Precipitation (In) | | Pressure (inches of Hg) | | Wind Speed=mph Dir=tens of degrees | | | | | | | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Heating | Cooling | | 0600 LST | 1200 LST | 2400 LST | 2400 LST | Avg. Station | Avg. Sea level | Resultant Speed | Res Dir | Avg. Speed | max 5-sec | | max 2-min | | |
| | | | | | | | | | | Depth | Water Equiv | Snow Fall | Water Equiv | | | | | | Speed | Dir | Speed | Dir | |
| 01 | 75 | 68 | 72 | 1 | 69 | 70 | 0 | 7 | RA FG+ FG HZ | M | - | - | 0.06 | 30.00 | 30.05 | 6.8 | 20 | 10.5 | 25 | 21 | 21 | 21 | 01 |
| 02 | 82 | 71 | 77 | 5 | 70 | 71 | 0 | 12 | TS TSRA RA FG HZ | M | - | - | 0.38 | 29.96 | 30.01 | 11.4 | 21 | 12.2 | 28 | 21 | 23 | 20 | 02 |
| 03 | 86 | 69 | 78 | 6 | 62 | 68 | 0 | 13 | FG HZ | M | - | - | 0.00 | 30.06 | 30.10 | 2.7 | 17 | 4.7 | 14 | 22 | 11 | 22 | 03 |
| 04 | 94 | 73 | 84 | 12 | 73 | 75 | 0 | 19 | RA FG HZ | M | - | - | 0.04 | 29.92 | 29.96 | 5.9 | 26 | 7.1 | 24 | 29 | 18 | 30 | 04 |
| 05 | 100* | 74 | 87 | 15 | 74 | 78 | 0 | 22 | FG HZ | M | - | - | 0.00 | 29.82 | 29.87 | 7.3 | 27 | 8.0 | 23 | 30 | 18 | 30 | 05 |
| 06 | 98 | 76 | 87* | 14 | 71 | 75 | 0 | 22 | FG HZ | M | - | - | 0.00 | 29.73 | 29.79 | 6.8 | 26 | 8.7 | 36 | 34 | 29 | 35 | 06 |
| 07 | 91 | 74 | 83 | 10 | 57 | 67 | 0 | 18 | - | M | - | - | 0.00 | 29.79 | 29.84 | 9.0 | 31 | 10.4 | 29 | 28 | 22 | 30 | 07 |
| 08 | 85 | 65 | 75 | 2 | 52 | 62 | 0 | 10 | - | M | - | - | 0.00 | 29.83 | 29.88 | 9.1 | 30 | 10.8 | 29 | 34 | 23 | 33 | 08 |
| 09 | 78 | 67 | 73 | 0 | 58 | 64 | 0 | 8 | FG HZ | M | - | - | T | 29.85 | 29.91 | 3.3 | 21 | 4.5 | 15 | 19 | 11 | 19 | 09 |
| 10 | 83 | 64 | 74 | 1 | 62 | 67 | 0 | 9 | FG HZ | M | - | - | T | 29.73 | 29.78 | 6.6 | 28 | 10.0 | 28 | 30 | 21 | 31 | 10 |
| 11 | 80 | 58 | 69 | -4 | 49 | 58 | 0 | 4 | - | M | - | - | 0.00 | 30.07 | 30.11 | 6.9 | 36 | 7.8 | 26 | 1 | 22 | 1 | 11 |
| 12 | 77 | 56 | 67* | -6 | 54 | 60 | 0 | 2 | - | M | - | - | 0.03 | 30.20 | 30.27 | 3.9 | 11 | 5.7 | 15 | 11 | 13 | 11 | 12 |
| 13 | 73 | 62 | 68 | -6 | 57 | 61 | 0 | 3 | - | M | - | - | 0.04 | 30.15 | 30.20 | 6.6 | 11 | 9.3 | 21 | 8 | 18 | 9 | 13 |
| 14 | 75 | 60 | 68 | -6 | 59 | 62 | 0 | 3 | - | M | - | - | 0.00 | 30.17 | 30.22 | 3.9 | 21 | 4.6 | 13 | 22 | 10 | 23 | 14 |
| 15 | 84 | 59 | 72 | -2 | 60 | 65 | 0 | 7 | - | M | - | - | 0.00 | 30.06 | 30.13 | 6.4 | 22 | 6.8 | 23 | 21 | 18 | 21 | 15 |
| 16 | 92 | 67 | 80 | 6 | 66 | 70 | 0 | 15 | HZ | M | - | - | 0.00 | 30.03 | 30.09 | 6.3 | 23 | 6.8 | 20 | 21 | 16 | 21 | 16 |
| 17 | 94 | 73 | 84 | 10 | 68 | 72 | 0 | 19 | HZ | M | - | - | 0.00 | 30.03 | 30.08 | 8.7 | 23 | 9.2 | 23 | 21 | 18 | 20 | 17 |
| 18 | 93 | 74 | 84 | 10 | 70 | 73 | 0 | 19 | TS FG HZ | M | - | - | T | 29.98 | 30.04 | 5.8 | 23 | 7.3 | 21 | 20 | 18 | 20 | 18 |
| 19 | 88 | 72 | 80 | 6 | 70 | 73 | 0 | 15 | TS TSRA RA FG HZ | M | - | - | 0.22 | 29.87 | 29.94 | 1.4 | 3 | 4.4 | 20 | 23 | 15 | 23 | 19 |
| 20 | 81 | 67 | 74 | 0 | 63 | 67 | 0 | 9 | - | M | - | - | 0.00 | 29.98 | 30.03 | 2.7 | 21 | 7.3 | 14 | 20 | 11 | 21 | 20 |
| 21 | 78 | 66 | 72 | -2 | 60 | 65 | 0 | 7 | - | M | - | - | 0.00 | 30.07 | 30.13 | 3.0 | 13 | 8.4 | 18 | 20 | 14 | 21 | 21 |
| 22 | M | M | M | M | - | 45 | M | M | HZ | M | - | - | 0.01 | 29.95 | 30.00 | 5.7 | 20 | 6.7 | 20 | 16 | 15 | 18 | 22 |
| 23 | M | M | M | M | - | 61 | M | M | FG HZ | M | - | - | 0.00 | 29.85 | 29.88 | 6.9 | 21 | 7.7 | 21 | 21 | 17 | 21 | 23 |
| 24 | 88 | 72 | 80 | 5 | 73 | 75 | 0 | 15 | FG HZ | M | - | - | 0.00 | 29.72 | 29.76 | 5.6 | 22 | 6.7 | 23 | 20 | 18 | 21 | 24 |
| 25 | 90 | 73 | 82 | 7 | 67 | 72 | 0 | 17 | FG HZ | M | - | - | T | 29.64 | 29.70 | 3.4 | 20 | 6.8 | 29 | 21 | 25 | 22 | 25 |
| 26 | 85 | 73 | 79 | 4 | 67 | 71 | 0 | 14 | TS FG HZ | M | - | - | T | 29.68 | 29.73 | 2.5 | 8 | 7.2 | 15 | 10 | 13 | 12 | 26 |
| 27 | 91 | 73 | 82 | 7 | 67 | 72 | 0 | 17 | FG HZ | M | - | - | 0.00 | 29.73 | 29.79 | 3.9 | 23 | 6.9 | 16 | 21 | 14 | 22 | 27 |
| 28 | 94 | 70 | 82 | 7 | 56 | 66 | 0 | 17 | - | M | - | - | 0.00 | 29.75 | 29.79 | 6.1 | 31 | 8.5 | 31 | 30 | 21 | 30 | 28 |
| 29 | 85 | 68 | 77 | 2 | 66 | 70 | 0 | 12 | FG | M | - | - | 0.00 | 29.64 | 29.69 | 3.2 | 11 | 7.0 | 14 | 21 | 13 | 10 | 29 |
| 30 | 85 | 72 | 79 | 4 | 72 | 74 | 0 | 14 | FG HZ | M | - | - | 0.00 | 29.63 | 29.70 | 5.2 | 12 | 7.2 | 17 | 11 | 14 | 12 | 30 |
| 31 | 86 | 74 | 80 | 5 | 73 | 75 | 0 | 15 | FG HZ | M | - | - | 0.00 | 29.73 | 29.79 | 4.3 | 16 | 7.4 | 16 | 20 | 13 | 20 | 31 |
| | 85.9 | 68.6 | 77.3 | -------- | 64.3 | 67.9 | .0 | 12.6 | <Monthly Averages | Totals> | | | 0.78 | 29.89 | 29.94 | 2.9 | 22.8 | 7.6 | <Monthly Average | | | | |
| | 4.2 | 2.9 | 3.6 | -------- | <----------------------Departure From Normal------------------------> | | | | | | | | -3.00 | | | | | | | | | | |

**Degree Days** Monthly Season to Date
Total Departure Total Departure
Heating: 0 0
Cooling: 364 94

Greatest 24-hr Precipitation: 0.38 date: 2
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.30 | 12 | 1057 |
| Minimum : | 29.63 | 29 | 1757 |

Number of Days with ----->
Max temp >= 90: M
Max temp <= 32: M
Thunderstorms : 4
Min temp <= 32: M
Min temp <= 0 : M
Heavy Fog : 1
Precipitation >= .01 inch: 0
Precipitation >= .10 inch : 0
Snowfall >= 1.0 inch : 0

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 08/1999**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) | | | | | | Deg Days Base 65 Degrees | | Significant Weather | Snow/Ice on Gnd(In) | | Precipitation (In) | | Pressure (inches of Hg) | | Wind Speed=mph Dir=tens of degrees | | | | | | | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Heating | Cooling | | 0600 LST | 1200 LST | 2400 LST | 2400 LST | Avg. Station | Avg. Sea level | Resultant Speed | Res Dir | Avg. Speed | max 5-sec | | max 2-min | | |
| | | | | | | | | | | Depth | Water Equiv | Snow Fall | Water Equiv | | | | | | Speed | Dir | Speed | Dir | |
| 01 | 91* | 77 | 84* | 9 | 70 | 74 | 0 | 19 | RA FG HZ | M | - | - | T | 29.69 | 29.73 | 6.0 | 24 | 9.4 | 21 | 1 | 17 | 1 | 01 |
| 02 | 86 | 70 | 78 | 3 | 55 | 65 | 0 | 13 | - | M | - | - | 0.00 | 29.89 | 29.93 | 3.3 | 4 | 8.9 | 18 | 2 | 15 | 1 | 02 |
| 03 | 82 | 67 | 75 | 0 | 56 | 64 | 0 | 10 | - | M | - | - | 0.00 | 30.01 | 30.05 | 2.1 | 22 | 9.0 | 17 | 19 | 15 | 20 | 03 |
| 04 | 83 | 65 | 74 | -1 | 64 | 68 | 0 | 9 | - | M | - | - | 0.00 | 29.91 | 29.97 | 4.4 | 16 | 6.7 | 17 | 15 | 15 | 17 | 04 |
| 05 | 83 | 68 | 76 | 2 | 65 | 68 | 0 | 11 | FG | M | - | - | 0.01 | 29.74 | 29.79 | 4.2 | 22 | 6.5 | 21 | 21 | 17 | 21 | 05 |
| 06 | 84 | 64 | 74 | 0 | 61 | 66 | 0 | 9 | - | M | - | - | 0.00 | 29.78 | 29.85 | 4.2 | 22 | 8.2 | 23 | 36 | 20 | 1 | 06 |
| 07 | 83 | 64 | 74 | 0 | 57 | 64 | 0 | 9 | - | M | - | - | 0.00 | 29.92 | 29.96 | 3.9 | 21 | 8.7 | 23 | 19 | 18 | 20 | 07 |
| 08 | 83 | 71 | 77 | 3 | 70 | 72 | 0 | 12 | RA FG HZ | M | - | - | 0.96 | 29.66 | 29.71 | 6.2 | 25 | 8.3 | 26 | 24 | 21 | 24 | 08 |
| 09 | 79 | 60 | 70 | -4 | 46 | 57 | 0 | 5 | - | M | - | - | 0.00 | 29.73 | 29.79 | 10.2 | 36 | 10.6 | 30 | 32 | 22 | 32 | 09 |
| 10 | 75 | 56 | 66 | -8 | 51 | 58 | 0 | 1 | - | M | - | - | 0.00 | 29.81 | 29.88 | 5.7 | 21 | 6.4 | 17 | 19 | 14 | 21 | 10 |
| 11 | 72 | 69 | 71 | -3 | 67 | 69 | 0 | 6 | RA FG | M | - | - | 0.69 | 29.80 | 29.85 | 6.7 | 13 | 8.5 | 17 | 7 | 15 | 7 | 11 |
| 12 | 85 | 70 | 78 | 4 | 70 | 72 | 0 | 13 | FG HZ | M | - | - | 0.00 | 29.89 | 29.94 | 3.5 | 19 | 7.3 | 14 | 22 | 13 | 21 | 12 |
| 13 | 85 | 73 | 79 | 5 | 74 | 75 | 0 | 14 | RA FG HZ | M | - | - | 0.01 | 29.85 | 29.90 | 10.5 | 20 | 11.0 | 26 | 21 | 20 | 22 | 13 |
| 14 | 81 | 70 | 76 | 2 | 72 | 72 | 0 | 11 | TS TSRA RA FG HZ | M | - | - | 1.79 | 29.76 | 29.81 | 4.4 | 22 | 7.3 | 28 | 23 | 21 | 24 | 14 |
| 15 | 74 | 67 | 71 | -2 | 66 | 68 | 0 | 6 | FG | M | - | - | 0.02 | 29.96 | 30.01 | 6.9 | 3 | 8.0 | 20 | 1 | 14 | 4 | 15 |
| 16 | 81 | 63 | 72 | -1 | 64 | 67 | 0 | 7 | - | M | - | - | 0.00 | 30.13 | 30.17 | 5.5 | 21 | 6.8 | 16 | 20 | 14 | 20 | 16 |
| 17 | 84 | 71 | 78 | 5 | 71 | 73 | 0 | 13 | FG HZ | M | - | - | 0.00 | 29.89 | 29.94 | 9.8 | 23 | 10.3 | 22 | 20 | 18 | 20 | 17 |
| 18 | 87 | 72 | 80 | 7 | 64 | 69 | 0 | 15 | FG HZ | M | - | - | 0.00 | 29.73 | 29.80 | 5.8 | 34 | 7.2 | 22 | 30 | 16 | 32 | 18 |
| 19 | 78 | 67 | 73 | 0 | 60 | 64 | 0 | 8 | - | M | - | - | 0.00 | 29.95 | 30.00 | 4.8 | 12 | 8.7 | 16 | 16 | 14 | 16 | 19 |
| 20 | 73 | 58 | 66 | -7 | 59 | 62 | 0 | 1 | RA FG | M | - | - | 0.47 | 30.04 | 30.09 | 14.5 | 9 | 15.2 | 32 | 9 | 28 | 8 | 20 |
| 21 | 65 | 57 | 61* | -12 | 57 | 59 | 4 | 0 | FG | M | - | - | 0.04 | 29.94 | 30.00 | 11.7 | 4 | 12.1 | 24 | 9 | 21 | 8 | 21 |
| 22 | 70 | 61 | 66 | -6 | 58 | 61 | 0 | 1 | - | M | - | - | T | 29.93 | 30.00 | 5.4 | 1 | 6.3 | 14 | 4 | 11 | 5 | 22 |
| 23 | 84 | 59 | 72 | 0 | 61 | 65 | 0 | 7 | - | M | - | - | 0.00 | 29.98 | 30.02 | 3.3 | 25 | 5.3 | 16 | 24 | 14 | 24 | 23 |
| 24 | 81 | 61 | 71 | -1 | 62 | 66 | 0 | 6 | - | M | - | - | 0.00 | 30.03 | 30.09 | 2.7 | 16 | 4.3 | 15 | 20 | 11 | 20 | 24 |
| 25 | 78 | 64 | 71 | -1 | 66 | 68 | 0 | 6 | FG HZ | M | - | - | 0.00 | 30.05 | 30.09 | 4.7 | 13 | 5.5 | 14 | 17 | 11 | 17 | 25 |
| 26 | 73 | 69 | 71 | -1 | 69 | 70 | 0 | 6 | RA FG | M | - | - | 0.27 | 29.89 | 29.93 | 12.2 | 8 | 12.4 | 23 | 7 | 20 | 9 | 26 |
| 27 | 80 | 70 | 75 | 4 | 71 | 72 | 0 | 10 | RA FG | M | - | - | 0.08 | 29.81 | 29.88 | 5.5 | 11 | 9.0 | 25 | 9 | 22 | 9 | 27 |
| 28 | 85 | 70 | 78 | 7 | 69 | 72 | 0 | 13 | FG HZ | M | - | - | 0.00 | 29.78 | 29.83 | 7.9 | 24 | 8.4 | 18 | 23 | 16 | 23 | 28 |
| 29 | 87 | 64 | 76 | 5 | 60 | 66 | 0 | 11 | FG HZ | M | - | - | 0.00 | 29.83 | 29.86 | 5.9 | 33 | 9.8 | 31 | 2 | 25 | 1 | 29 |
| 30 | 71 | 57 | 64 | -7 | 33 | 48 | 1 | 0 | - | M | - | - | 0.00 | 30.09 | 30.14 | 11.4 | 2 | 11.7 | 25 | 2 | 22 | 3 | 30 |
| 31 | 73 | 60 | 67 | -4 | 49 | 57 | 0 | 2 | - | M | - | - | 0.02 | 30.17 | 30.22 | 9.3 | 7 | 11.6 | 22 | 3 | 18 | 4 | 31 |
| | 79.9 | 65.6 | 72.8 | -------- | 61.8 | 66.2 | .2 | 8.2 | <Monthly Averages | Totals> | | | 4.36 | 29.89 | 29.94 | 0.8 | 12.5 | 8.7 | <Monthly Average | | | | |
| | -1.0 | .5 | -.3 | -------- | <---------------------Departure From Normal-----------------------> | | | | | | | | 1.11 | | | | | | | | | | |

**Degree Days** Monthly Season to Date

| | Monthly Total | Departure | Season to Date Total | Departure |
|---|---|---|---|---|
| Heating: | 5 | 5 | | |
| Cooling: | 254 | 3 | | |

Greatest 24-hr Precipitation: 1.80date: 14-15
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.26 | 31 | 1046 |
| Minimum : | 29.59 | 8 | 1751 |

Number of Days with ----->
Max temp >= 90: 1
Max temp <= 32: 0
Thunderstorms : 1
Min temp <= 32: 0
Min temp <= 0 : 0
Heavy Fog : 0
Precipitation >= .01 inch: 1
Precipitation >= .10 inch : 0
Snowfall >= 1.0 inch : 0

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 09/1999**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Deg Days Base 65 Degrees Heating | Cooling | Significant Weather | Snow/Ice on Gnd(In) 0600 LST Depth | 1200 LST Water Equiv | Precipitation (In) 2400 LST Snow Fall | 2400 LST Water Equiv | Pressure (inches of Hg) Avg. Station | Avg. Sea level | Wind Speed=mph Dir=tens of degrees Resultant Speed | Res Dir | Avg. Speed | max 5-sec Speed | Dir | max 2-min Speed | Dir | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 75 | 58 | 67 | -3 | 50 | 58 | 0 | 2 | - | M | - | - | 0.00 | 30.10 | 30.16 | 8.5 | 7 | 10.0 | 20 | 11 | 17 | 11 | 01 |
| 02 | 80 | 59 | 70 | 0 | 57 | 62 | 0 | 5 | - | M | - | - | 0.00 | 30.02 | 30.08 | 5.3 | 6 | 7.1 | 16 | 13 | 13 | 15 | 02 |
| 03 | 78 | 58 | 68 | -2 | 58 | 63 | 0 | 3 | - | M | - | - | 0.00 | 30.00 | 30.05 | 1.8 | 7 | 3.8 | 10 | 17 | 10 | 2 | 03 |
| 04 | 77 | 66 | 72 | 3 | 68 | 69 | 0 | 7 | FG | M | - | - | 0.00 | 30.08 | 30.14 | 7.5 | 8 | 8.5 | 15 | 10 | 14 | 9 | 04 |
| 05 | 75 | 69 | 72 | 3 | 70 | 71 | 0 | 7 | RA FG | M | - | - | 0.13 | 30.08 | 30.14 | 13.5 | 9 | 13.7 | 24 | 9 | 22 | 9 | 05 |
| 06 | 82* | 72 | 77* | 8 | 73 | 74 | 0 | 12 | RA FG | M | - | - | 0.06 | 29.96 | 30.02 | 7.1 | 14 | 8.4 | 18 | 10 | 16 | 10 | 06 |
| 07 | 80 | 72 | 76 | 7 | 72 | 73 | 0 | 11 | RA FG HZ | M | - | - | 0.03 | 29.85 | 29.90 | 8.3 | 18 | 9.5 | 20 | 17 | 16 | 17 | 07 |
| 08 | 79 | 70 | 75 | 7 | 71 | 72 | 0 | 10 | TS TSRA RA FG HZ | M | - | - | 0.28 | 29.79 | 29.84 | 5.5 | 21 | 6.5 | 22 | 22 | 18 | 22 | 08 |
| 09 | 79 | 72 | 76 | 8 | 71 | 72 | 0 | 11 | FG HZ | M | - | - | 0.00 | 29.80 | 29.87 | 3.2 | 18 | 4.3 | 13 | 17 | 10 | 21 | 09 |
| 10 | 75 | 67 | 71 | 3 | 69 | 70 | 0 | 6 | RA FG | M | - | - | 1.67 | 29.72 | 29.77 | 0.8 | 13 | 4.6 | 15 | 26 | 13 | 26 | 10 |
| 11 | 79 | 63 | 71 | 4 | 55 | 61 | 0 | 6 | FG | M | - | - | 0.00 | 29.88 | 29.93 | 6.6 | 35 | 7.4 | 20 | 31 | 15 | 28 | 11 |
| 12 | 78 | 60 | 69 | 2 | 56 | 62 | 0 | 4 | - | M | - | - | 0.00 | 30.12 | 30.18 | 1.3 | 32 | 6.9 | 22 | 36 | 14 | 22 | 12 |
| 13 | 75 | 59 | 67 | 0 | 60 | 63 | 0 | 2 | FG HZ | M | - | - | 0.00 | 30.15 | 30.19 | 4.6 | 13 | 6.5 | 16 | 11 | 14 | 11 | 13 |
| 14 | 74 | 60 | 67 | 0 | 61 | 64 | 0 | 2 | FG | M | - | - | T | 30.06 | 30.12 | 2.6 | 6 | 4.1 | 11 | 3 | 10 | 2 | 14 |
| 15 | 71 | 67 | 69 | 2 | 66 | 67 | 0 | 4 | RA FG | M | - | - | 0.41 | 30.00 | 30.06 | 6.5 | 5 | 6.8 | 14 | 8 | 11 | 4 | 15 |
| 16 | 76 | 60 | 68 | 2 | 67 | 67 | 0 | 3 | RA FG | M | - | - | 3.00 | 29.47 | 30.88 | 14.0 | 9 | 20.5 | 45 | 14 | 33 | 11 | 16 |
| 17 | 72 | 57 | 65 | 0 | 47 | 55 | 0 | 0 | - | M | - | - | 0.00 | 29.67 | 30.34 | 17.1 | 31 | 17.9 | 41 | 33 | 34 | 31 | 17 |
| 18 | 75 | 52 | 64 | -1 | 47 | 54 | 1 | 0 | - | M | - | - | 0.00 | 30.00 | 30.05 | 5.2 | 31 | 6.8 | 23 | 30 | 20 | 31 | 18 |
| 19 | 73 | 53 | 63 | -2 | 54 | 58 | 2 | 0 | - | M | - | - | 0.00 | 30.10 | 30.14 | 4.4 | 12 | 8.7 | 15 | 20 | 14 | 12 | 19 |
| 20 | 73 | 59 | 66 | 1 | 57 | 61 | 0 | 1 | - | M | - | - | 0.00 | 29.96 | 30.02 | 6.2 | 19 | 6.8 | 17 | 18 | 13 | 20 | 20 |
| 21 | 68 | 54 | 61 | -3 | 60 | 61 | 4 | 0 | RA FG | M | - | - | 0.79 | 29.76 | 29.83 | 2.8 | 35 | 7.7 | 20 | 35 | 16 | 35 | 21 |
| 22 | 57 | 49 | 53* | -11 | 47 | 50 | 12 | 0 | FG | M | - | - | 0.01 | 29.65 | 29.71 | 12.6 | 35 | 12.9 | 30 | 36 | 23 | 1 | 22 |
| 23 | 73 | 46 | 60 | -4 | 47 | 54 | 5 | 0 | - | M | - | - | 0.00 | 29.76 | 29.81 | 7.6 | 27 | 10.3 | 24 | 33 | 20 | 32 | 23 |
| 24 | 74 | 57 | 66 | 3 | 56 | 60 | 0 | 1 | - | M | - | - | 0.00 | 29.84 | 29.89 | 11.4 | 23 | 12.1 | 26 | 21 | 22 | 22 | 24 |
| 25 | 77 | 57 | 67 | 4 | 54 | 59 | 0 | 2 | RA FG HZ | M | - | - | 0.02 | 29.93 | 29.98 | 4.4 | 30 | 9.5 | 18 | 1 | 16 | 32 | 25 |
| 26 | 66 | 50 | 58 | -4 | 51 | 55 | 7 | 0 | - | M | - | - | 0.00 | 30.23 | 30.28 | 4.6 | 8 | 7.8 | 16 | 2 | 13 | 16 | 26 |
| 27 | 70 | 55 | 63 | 1 | 58 | 60 | 2 | 0 | - | M | - | - | 0.00 | 30.30 | 30.34 | 3.5 | 11 | 6.2 | 11 | 19 | 10 | 18 | 27 |
| 28 | 73 | 62 | 68 | 6 | 63 | 65 | 0 | 3 | FG | M | - | - | 0.00 | 30.24 | 30.29 | 2.7 | 17 | 4.8 | 10 | 23 | 9 | 22 | 28 |
| 29 | 73 | 66 | 70 | 9 | 63 | 66 | 0 | 5 | FG | M | - | - | 0.00 | 30.02 | 30.08 | 8.3 | 18 | 9.1 | 20 | 16 | 15 | 16 | 29 |
| 30 | 71 | 53 | 62 | 1 | 53 | 57 | 3 | 0 | RA FG HZ | M | - | - | 0.49 | 29.70 | 29.75 | 7.3 | 26 | 14.5 | 36 | 19 | 26 | 18 | 30 |
|  | 74.3 | 60.1 | 67.2 | -------- | 59.4 | 62.8 | 1.2 | 3.6 | <Monthly Averages | Totals> |  |  | 6.89 | 29.94 | 30.06 | 0.9 | 9 | 8.8 | <Monthly Average |  |  |  |  |
|  | .1 | 2.5 | 1.3 | -------- | <---------------------Departure From Normal-----------------------> |  |  |  |  |  |  |  | 3.82 |  |  |  |  |  |  |  |  |  |  |

**Degree Days** Monthly Season to Date

|  | Monthly Total | Departure | Season to Date Total | Departure |
|---|---|---|---|---|
| Heating: | 36 | -18 |  |  |
| Cooling: | 107 | 26 |  |  |

Greatest 24-hr Precipitation: 3.05date: 15-16
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.38 | 27 | 0932 |
| Minimum : | 28.99 | 16 | 2054 |

Number of Days with ----->
Max temp >= 90: 0
Max temp <= 32: 0
Thunderstorms : 1
Min temp <= 32: 0
Min temp <= 0 : 0
Heavy Fog : 0
Precipitation >= .01 inch: 1
Precipitation >= .10 inch : 0
Snowfall >= 1.0 inch : 0

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 10/1999**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) Max | Temperature Min | Temperature Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Deg Days Base 65 Degrees Heating | Deg Days Cooling | Significant Weather | Snow/Ice on Gnd(In) 0600 LST Depth | 1200 LST Water Equiv | Precipitation (In) 2400 LST Snow Fall | 2400 LST Water Equiv | Pressure (inches of Hg) Avg. Station | Avg. Sea level | Wind Speed=mph Dir=tens of degrees Resultant Speed | Res Dir | Avg. Speed | max 5-sec Speed | max 5-sec Dir | max 2-min Speed | max 2-min Dir | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 70 | 48 | 59 | -2 | 46 | 52 | 6 | 0 | - | M | - | - | 0.00 | 29.94 | 29.99 | 6.7 | 24 | 8.3 | 26 | 22 | 22 | 21 | 01 |
| 02 | 69 | 49 | 59 | -1 | 53 | 57 | 6 | 0 | - | M | - | - | 0.00 | 30.11 | 30.16 | 4.4 | 21 | 7.8 | 25 | 22 | 22 | 22 | 02 |
| 03 | 73* | 59 | 66* | 6 | 58 | 61 | 0 | 1 | FG | M | - | - | 0.00 | 30.16 | 30.20 | 3.4 | 27 | 9.9 | 23 | 23 | 18 | 23 | 03 |
| 04 | 66 | 45 | 56 | -4 | 53 | 54 | 9 | 0 | TS TSRA RA FG | M | - | - | 0.64 | 30.01 | 30.06 | 9.2 | 5 | 9.9 | 25 | 10 | 20 | 7 | 04 |
| 05 | 52 | 44 | 48 | -11 | 44 | 46 | 17 | 0 | FG | M | - | - | 0.04 | 30.01 | 30.08 | 8.6 | 1 | 9.0 | 22 | 2 | 17 | 2 | 05 |
| 06 | 64 | 39 | 52 | -7 | 41 | 46 | 13 | 0 | FG MIFG | M | - | - | 0.01 | 30.00 | 30.05 | 6.8 | 30 | 9.3 | 26 | 32 | 21 | 30 | 06 |
| 07 | 53 | 37 | 45* | -14 | 27 | 38 | 20 | 0 | - | M | - | - | 0.00 | 30.31 | 30.36 | 6.9 | 36 | 7.9 | 23 | 36 | 20 | 36 | 07 |
| 08 | 61 | 36 | 49 | -10 | 43 | 47 | 16 | 0 | - | M | - | - | 0.00 | 30.36 | 30.42 | 5.4 | 21 | 10.5 | 25 | 22 | 22 | 22 | 08 |
| 09 | 68 | 59 | 64 | 6 | 59 | 61 | 1 | 0 | FG | M | - | - | T | 30.12 | 30.18 | 10.2 | 24 | 10.7 | 29 | 23 | 24 | 23 | 09 |
| 10 | 65 | 59 | 62 | 4 | 63 | 63 | 3 | 0 | RA FG | M | - | - | 0.40 | 29.99 | 30.04 | 6.7 | 23 | 7.3 | 26 | 21 | 22 | 21 | 10 |
| 11 | 68 | 51 | 60 | 3 | 50 | 56 | 5 | 0 | FG HZ | M | - | - | 0.01 | 29.98 | 30.04 | 6.4 | 33 | 8.5 | 26 | 33 | 21 | 35 | 11 |
| 12 | 62 | 43 | 53 | -3 | 42 | 49 | 12 | 0 | - | M | - | - | 0.00 | 30.24 | 30.31 | 4.4 | 21 | 7.8 | 17 | 21 | 15 | 21 | 12 |
| 13 | 70 | 49 | 60 | 4 | 56 | 59 | 5 | 0 | - | M | - | - | T | 29.98 | 30.02 | 10.3 | 21 | 11.4 | 24 | 21 | 22 | 22 | 13 |
| 14 | 65 | 40 | 53 | -3 | 40 | 47 | 12 | 0 | RA FG | M | - | - | 0.33 | 29.78 | 30.45 | 10.8 | 32 | 15.4 | 43 | 29 | 34 | 30 | 14 |
| 15 | 56 | 36 | 46 | -10 | 38 | 44 | 19 | 0 | - | M | - | - | 0.00 | 30.26 | 30.31 | 4.1 | 21 | 6.5 | 17 | 20 | 15 | 20 | 15 |
| 16 | 67 | 44 | 56 | 1 | 53 | 55 | 9 | 0 | FG | M | - | - | 0.00 | 30.15 | 30.22 | 2.7 | 22 | 4.3 | 18 | 23 | 13 | 23 | 16 |
| 17 | 68 | 53 | 61 | 6 | 60 | 61 | 4 | 0 | RA FG+ FG | M | - | - | 0.48 | 29.86 | 29.90 | 0.5 | 20 | 4.4 | 16 | 2 | 14 | 2 | 17 |
| 18 | 61 | 44 | 53 | -2 | 43 | 49 | 12 | 0 | RA FG | M | - | - | 0.34 | 29.78 | 29.83 | 14.5 | 1 | 14.6 | 43 | 1 | 31 | 2 | 18 |
| 19 | 54 | 37 | 46 | -9 | 38 | 43 | 19 | 0 | - | M | - | - | 0.00 | 30.31 | 30.37 | 3.7 | 6 | 6.2 | 18 | 3 | 16 | 4 | 19 |
| 20 | 56 | 48 | 52 | -2 | 51 | 52 | 13 | 0 | RA FG | M | - | - | 0.58 | 30.09 | 30.14 | 3.9 | 1 | 5.8 | 17 | 9 | 14 | 9 | 20 |
| 21 | 59 | 42 | 51 | -3 | 41 | 46 | 14 | 0 | FG MIFG | M | - | - | 0.01 | 29.98 | 30.04 | 3.0 | 33 | 5.8 | 16 | 30 | 13 | 22 | 21 |
| 22 | 61 | 40 | 51 | -3 | 47 | 50 | 14 | 0 | RA FG | M | - | - | 0.37 | 29.66 | 30.09. | 3.7 | 17 | 7.7 | 21 | 15 | 17 | 16 | 22 |
| 23 | 57 | 46 | 52 | -1 | 41 | 46 | 13 | 0 | FG | M | - | - | 0.05 | 29.46 | 31.48 | 12.1 | 28 | 12.7 | 32 | 28 | 23 | 29 | 23 |
| 24 | 57 | 39 | 48 | -5 | 38 | 43 | 17 | 0 | - | M | - | - | 0.00 | 29.78 | 29.82 | 8.9 | 30 | 9.5 | 22 | 33 | 18 | 30 | 24 |
| 25 | 57 | 39 | 48 | -5 | 37 | 44 | 17 | 0 | - | M | - | - | 0.00 | 30.04 | 30.09 | 8.0 | 26 | 8.6 | 21 | 25 | 17 | 24 | 25 |
| 26 | 64 | 44 | 54 | 2 | 48 | 51 | 11 | 0 | - | M | - | - | 0.00 | 29.96 | 30.03 | 9.6 | 24 | 10.5 | 23 | 21 | 20 | 22 | 26 |
| 27 | 61 | 43 | 52 | 0 | 38 | 45 | 13 | 0 | - | M | - | - | 0.00 | 30.12 | 30.16 | 7.7 | 1 | 8.1 | 24 | 35 | 18 | 36 | 27 |
| 28 | 54 | 37 | 46 | -6 | 40 | 43 | 19 | 0 | - | M | - | - | 0.00 | 30.31 | 30.36 | 1.9 | 2 | 8.2 | 22 | 1 | 17 | 23 | 28 |
| 29 | 62 | 45 | 54 | 3 | 47 | 50 | 11 | 0 | FG | M | - | - | 0.00 | 30.25 | 30.31 | 3.6 | 27 | 5.4 | 14 | 26 | 10 | 26 | 29 |
| 30 | 62 | 50 | 56 | 5 | 55 | 56 | 9 | 0 | FG+ FG | M | - | - | 0.00 | 30.38 | 30.42 | 4.7 | 8 | 7.6 | 15 | 8 | 14 | 9 | 30 |
| 31 | 66 | 56 | 61 | 10 | 57 | 59 | 4 | 0 | FG HZ | M | - | - | 0.00 | 30.15 | 30.21 | 7.8 | 25 | 8.4 | 18 | 23 | 16 | 24 | 31 |
|  | 62.2 | 45.2 | 53.7 | -------- | 46.7 | 50.8 | 11.1 | .0 | <Monthly Averages | Totals> |  |  | 3.26 | 30.05 | 30.20 | 2.8 | 28.7 | 8.7 | <Monthly Average |  |  |  |  |
|  | -1.9 | -1.9 | -1.9 | -------- | <---------------------Departure From Normal-----------------------> |  |  |  |  |  |  |  | 0.15 |  |  |  |  |  |  |  |  |  |  |

34 @ 300°

**Degree Days** Monthly Season to Date

|  | Monthly Total | Monthly Departure | Season to Date Total | Season to Date Departure |
|---|---|---|---|---|
| Heating: | 343 | 41 |  |  |
| Cooling: | 1 | -10 |  |  |

Greatest 24-hr Precipitation: 0.82date: 17-18
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.50 | 8 | 0659 |
| Minimum : | 29.39 | 23 | 0355 |

Number of Days with ----->
Max temp >= 90: 0
Max temp <= 32: 0
Thunderstorms : 1
Min temp <= 32: 0
Min temp <= 0 : 0
Heavy Fog : 2
Precipitation >= .01 inch: 2
Precipitation >= .10 inch : 0
Snowfall >= 1.0 inch : 0

53.7°F

8.7/28.7

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 11/1999**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Deg Days Base 65 Degrees Heating | Cooling | Significant Weather | Snow/Ice on Gnd(In) 0600 LST Depth | 1200 LST Water Equiv | Precipitation (In) 2400 LST Snow Fall | 2400 LST Water Equiv | Pressure (inches of Hg) Avg. Station | Avg. Sea level | Wind Speed=mph Dir=tens of degrees Resultant Speed | Res Dir | Avg. Speed | max 5-sec Speed | max 5-sec Dir | max 2-min Speed | max 2-min Dir | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 63 | 49 | 56 | 5 | 49 | 53 | 9 | 0 | FG | M | - | - | 0.00 | 30.11 | 30.18 | 1.8 | 9 | 5.6 | 11 | 21 | 9 | 18 | 01 |
| 02 | 67 | 48 | 58 | 8 | 59 | 60 | 7 | 0 | RA FG | M | - | - | 1.04 | 29.75 | 30.32 | 12.1 | 15 | 14.6 | 53 | 16 | 36 | 16 | 02 |
| 03 | 64 | 42 | 53 | 3 | 39 | 46 | 12 | 0 | - | M | - | - | T | 29.58 | 30.52 | 15.2 | 25 | 16.7 | 32 | 28 | 25 | 28 | 03 |
| 04 | 51 | 39 | 45 | -5 | 27 | 38 | 20 | 0 | - | M | - | - | 0.00 | 30.07 | 30.14 | 13.5 | 27 | 13.8 | 29 | 29 | 23 | 29 | 04 |
| 05 | 62 | 36 | 49 | 0 | 37 | 45 | 16 | 0 | - | M | - | - | 0.00 | 30.19 | 30.26 | 9.1 | 24 | 10.0 | 24 | 23 | 20 | 23 | 05 |
| 06 | 64 | 50 | 57 | 8 | 35 | 47 | 8 | 0 | - | M | - | - | 0.00 | 30.00 | 30.07 | 11.0 | 30 | 12.7 | 37 | 31 | 28 | 29 | 06 |
| 07 | 50 | 36 | 43 | -6 | 24 | 36 | 22 | 0 | - | M | - | - | 0.00 | 30.04 | 30.12 | 12.2 | 34 | 12.9 | 30 | 30 | 25 | 31 | 07 |
| 08 | 44 | 30 | 37 | -11 | 24 | 32 | 28 | 0 | - | M | - | - | 0.00 | 30.13 | 30.21 | 5.4 | 33 | 6.2 | 22 | 32 | 18 | 30 | 08 |
| 09 | 60 | 37 | 49 | 1 | 42 | 47 | 16 | 0 | - | M | - | - | 0.00 | 29.99 | 30.07 | 8.5 | 23 | 9.0 | 20 | 23 | 17 | 22 | 09 |
| 10 | 67* | 56 | 62* | 14 | 54 | 57 | 3 | 0 | FG HZ | M | - | - | T | 29.75 | 29.81 | 10.6 | 25 | 10.7 | 23 | 23 | 20 | 24 | 10 |
| 11 | 62 | 35 | 49 | 2 | 28 | 39 | 16 | 0 | - | M | - | - | 0.00 | 30.16 | 30.24 | 10.1 | 3 | 10.9 | 25 | 1 | 21 | 1 | 11 |
| 12 | 51 | 32 | 42 | -5 | 30 | 37 | 23 | 0 | - | M | - | - | 0.00 | 30.28 | 30.34 | 2.6 | 14 | 9.8 | 21 | 23 | 17 | 22 | 12 |
| 13 | 57 | 41 | 49 | 2 | 40 | 45 | 16 | 0 | - | M | - | - | 0.00 | 30.00 | 30.06 | 2.8 | 31 | 6.9 | 22 | 24 | 17 | 23 | 13 |
| 14 | 57 | 37 | 47 | 1 | 43 | 47 | 18 | 0 | FG HZ | M | - | - | 0.00 | 29.64 | 29.83 | 5.8 | 27 | 9.3 | 36 | 31 | 26 | 32 | 14 |
| 15 | 46 | 36 | 41 | -5 | 24 | 35 | 24 | 0 | - | M | - | - | 0.00 | 29.54 | 29.73 | 15.5 | 32 | 16.1 | 36 | 30 | 29 | 30 | 15 |
| 16 | 43 | 30 | 37 | -9 | 20 | 31 | 28 | 0 | - | M | - | - | 0.00 | 29.46 | 31.39 | 16.9 | 31 | 17.0 | 37 | 32 | 30 | 30 | 16 |
| 17 | 44 | 28 | 36 | -9 | 18 | 30 | 29 | 0 | - | M | - | - | 0.00 | 29.91 | 29.99 | 8.7 | 33 | 9.8 | 30 | 32 | 25 | 32 | 17 |
| 18 | 49 | 31 | 40 | -5 | 29 | 36 | 25 | 0 | - | M | - | - | 0.00 | 30.23 | 30.30 | 6.4 | 25 | 7.2 | 20 | 23 | 16 | 23 | 18 |
| 19 | 58 | 41 | 50 | 6 | 44 | 47 | 15 | 0 | - | M | - | - | 0.00 | 30.29 | 30.36 | 6.4 | 21 | 6.8 | 15 | 19 | 13 | 20 | 19 |
| 20 | 61 | 42 | 52 | 8 | 52 | 53 | 13 | 0 | RA FG | M | - | - | 0.11 | 30.12 | 30.18 | 5.4 | 21 | 7.1 | 23 | 20 | 20 | 20 | 20 |
| 21 | 55 | 45 | 50 | 6 | 49 | 50 | 15 | 0 | FG+ FG | M | - | - | 0.01 | 30.16 | 30.22 | 1.1 | 8 | 2.3 | 11 | 3 | 10 | 3 | 21 |
| 23 | 56 | 52 | 54 | 11 | 53 | 53 | 11 | 0 | FG+ FG | M | - | - | 0.02 | 30.22 | 30.30 | 0.6 | 11 | 1.6 | 7 | 24 | 6 | 8 | 23 |
| 24 | 62 | 53 | 58 | 15 | 56 | 56 | 7 | 0 | RA FG+ FG | M | - | - | 0.03 | 30.11 | 30.18 | 3.4 | 20 | 5.5 | 18 | 19 | 15 | 19 | 24 |
| 25 | 58 | 46 | 52 | 10 | 48 | 49 | 13 | 0 | RA FG | M | - | - | 0.46 | 30.15 | 30.21 | 7.4 | 4 | 8.3 | 18 | 2 | 15 | 2 | 25 |
| 26 | 63 | 46 | 55 | 13 | 53 | 54 | 10 | 0 | RA FG+ FG | M | - | - | 0.57 | 29.95 | 30.02 | 7.2 | 12 | 12.6 | 26 | 21 | 21 | 21 | 26 |
| 27 | 62 | 46 | 54 | 13 | 48 | 51 | 11 | 0 | RA FG | M | - | - | 0.87 | 29.77 | 29.84 | 5.6 | 28 | 8.7 | 28 | 19 | 22 | 19 | 27 |
| 28 | 51 | 38 | 45 | 4 | 27 | 38 | 20 | 0 | - | M | - | - | 0.00 | 30.02 | 30.10 | 10.1 | 30 | 10.6 | 26 | 31 | 21 | 36 | 28 |
| 29 | 46 | 32 | 39 | -1 | 27 | 34 | 26 | 0 | - | M | - | - | T | 30.19 | 30.26 | 6.2 | 30 | 7.5 | 25 | 32 | 21 | 34 | 29 |
| 30 | 39 | 28 | 34* | -6 | 21 | 29 | 31 | 0 | - | M | - | - | T | 30.33 | 30.40 | 12.1 | 2 | 12.4 | 28 | 1 | 22 | 1 | 30 |
|  | 55.5 | 40.3 | 47.9 | -------- | 38.4 | 44.2 | 17.0 | .0 | <Monthly Averages | Totals> |  |  | 3.15 | 30.01 | 30.20 | 3.7 | 28.9 | 9.8 | <Monthly Average |  |  |  |  |
|  | 2.5 | 2.1 | 2.3 | -------- | <--------------------Departure From Normal-----------------------> |  |  |  |  |  |  |  | -.66 |  |  |  |  |  |  |  |  |  |  |

36 @160

**Degree Days** Monthly Season to Date

| | Total | Departure | Total | Departure |
|---|---|---|---|---|
| Heating: | 507 | -75 | | |
| Cooling: | 0 | 0 | | |

Greatest 24-hr Precipitation: 1.31date: 26-27
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.48 | 12 | 0843 |
| Minimum : | 29.46 | 16 | 1403 |

Number of Days with ----->

Max temp >= 90: 0
Max temp <= 32: 0
Thunderstorms : 0
Min temp <= 32: 7
Min temp <= 0 : 0
Heavy Fog : 4
Precipitation >= .01 inch: 0
Precipitation >= .10 inch : 0
Snowfall >= 1.0 inch : 0

47.9

9.8 / 289°

11/99

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 12/1999**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) | | | | | | Deg Days Base 65 Degrees | | Significant Weather | Snow/Ice on Gnd(In) | | Precipitation (In) | | Pressure (inches of Hg) | | Wind Speed=mph Dir=tens of degrees | | | | | | | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Heating | Cooling | | 0600 LST | 1200 LST | 2400 LST | 2400 LST | Avg. Station | Avg. Sea level | Resultant Speed | Res Dir | Avg. Speed | max 5-sec | | max 2-min | | |
| | | | | | | | | | | Depth | Water Equiv | Snow Fall | Water Equiv | | | | | | Speed | Dir | Speed | Dir | |
| 01 | 33 | 22 | 28 | -11 | 7 | 22 | 37 | 0 | - | M | - | - | 0.00 | 30.23 | 30.29 | 15.1 | 36 | 15.3 | 30 | 1 | 24 | 1 | 01 |
| 02 | 47 | 27 | 37 | -2 | 15 | 29 | 28 | 0 | - | M | - | - | 0.00 | 30.11 | 30.19 | 7.7 | 34 | 9.0 | 25 | 36 | 21 | 36 | 02 |
| 03 | 50 | 30 | 40 | 1 | 29 | 37 | 25 | 0 | - | M | - | - | 0.00 | 30.10 | 30.16 | 2.8 | 25 | 4.0 | 11 | 23 | 10 | 23 | 03 |
| 04 | 60* | 40 | 50 | 12 | 43 | 46 | 15 | 0 | RA FG | M | - | - | 0.06 | 30.03 | 30.10 | 4.5 | 28 | 6.3 | 24 | 30 | 21 | 30 | 04 |
| 05 | 59 | 36 | 48 | 10 | 45 | 47 | 17 | 0 | FG HZ | M | - | - | 0.00 | 30.03 | 30.11 | 2.6 | 20 | 3.7 | 20 | 20 | 15 | 20 | 05 |
| 06 | 55 | 46 | 51* | 14 | 51 | 51 | 14 | 0 | RA FG | M | - | - | 0.76 | 29.80 | 29.87 | 1.0 | 36 | 4.4 | 18 | 1 | 16 | 1 | 06 |
| 07 | 52 | 36 | 44 | 7 | 35 | 41 | 21 | 0 | FG | M | - | - | 0.16 | 29.91 | 29.98 | 13.6 | 35 | 14.1 | 37 | 33 | 26 | 32 | 07 |
| 08 | 48 | 33 | 41 | 4 | 30 | 36 | 24 | 0 | - | M | - | - | 0.00 | 30.23 | 30.30 | 4.9 | 29 | 7.2 | 22 | 31 | 20 | 31 | 08 |
| 09 | 46 | 32 | 39 | 3 | 33 | 36 | 26 | 0 | - | M | - | - | 0.00 | 30.26 | 30.32 | 0.5 | 28 | 2.2 | 8 | 5 | 7 | 4 | 09 |
| 10 | 54 | 33 | 44 | 8 | 43 | 44 | 21 | 0 | RA FG | M | - | - | 0.12 | 29.82 | 29.89 | 6.2 | 25 | 9.7 | 41 | 32 | 34 | 31 | 10 |
| 11 | 44 | 34 | 39 | 3 | 21 | 33 | 26 | 0 | - | M | - | - | 0.00 | 29.78 | 29.84 | 20.1 | 30 | 20.5 | 53 | 31 | 37 | 29 | 11 |
| 12 | 46 | 31 | 39 | 4 | 23 | 32 | 26 | 0 | - | M | - | - | 0.00 | 30.00 | 30.06 | 6.8 | 34 | 7.9 | 24 | 31 | 20 | 32 | 12 |
| 13 | 46 | 30 | 38 | 3 | 35 | 37 | 27 | 0 | RA FG | M | - | - | 0.17 | 30.03 | 30.10 | 6.2 | 5 | 6.7 | 14 | 1 | 11 | 1 | 13 |
| 14 | 43 | 37 | 40 | 5 | 37 | 39 | 25 | 0 | RA FG | M | - | - | 0.71 | 29.97 | 30.05 | 16.7 | 7 | 17.3 | 38 | 8 | 32 | 8 | 14 |
| 15 | 47 | 42 | 45 | 11 | 43 | 43 | 20 | 0 | RA FG | M | - | - | 0.15 | 29.98 | 30.06 | 11.7 | 7 | 12.7 | 28 | 10 | 23 | 10 | 15 |
| 16 | 51 | 37 | 44 | 10 | 35 | 41 | 21 | 0 | FG | M | - | - | 0.01 | 29.81 | 29.89 | 10.1 | 27 | 10.9 | 32 | 29 | 25 | 28 | 16 |
| 17 | 44 | 35 | 40 | 6 | 22 | 32 | 25 | 0 | - | M | - | - | 0.00 | 30.02 | 30.09 | 9.4 | 26 | 10.3 | 23 | 30 | 18 | 29 | 17 |
| 18 | 41 | 31 | 36 | 3 | 19 | 30 | 29 | 0 | - | M | - | - | 0.00 | 30.21 | 30.30 | 2.8 | 3 | 4.7 | 15 | 31 | 11 | 2 | 18 |
| 19 | 38 | 29 | 34 | 1 | 15 | 27 | 31 | 0 | - | M | - | - | 0.00 | 30.38 | 30.45 | 8.9 | 5 | 9.6 | 17 | 4 | 15 | 4 | 19 |
| 20 | 57 | 31 | 44 | 11 | 37 | 39 | 21 | 0 | RA FG | M | - | - | 0.24 | 30.13 | 30.21 | 9.7 | 8 | 14.0 | 30 | 18 | 24 | 16 | 20 |
| 21 | 55 | 37 | 46 | 14 | 33 | 40 | 19 | 0 | RA FG | M | - | - | 0.01 | 29.98 | 30.05 | 8.0 | 29 | 9.2 | 24 | 30 | 20 | 30 | 21 |
| 22 | 37 | 28 | 33 | 1 | 22 | 30 | 32 | 0 | - | M | - | - | T | 30.12 | 30.20 | 5.2 | 34 | 6.0 | 18 | 30 | 15 | 30 | 22 |
| 23 | 40 | 26 | 33 | 1 | 18 | 28 | 32 | 0 | FG | M | - | - | T | 30.10 | 30.16 | 6.8 | 27 | 8.9 | 25 | 31 | 22 | 32 | 23 |
| 24 | 29 | 20 | 25 | -7 | 7 | 20 | 40 | 0 | FG | M | - | - | T | 30.09 | 30.16 | 8.2 | 34 | 8.6 | 22 | 1 | 17 | 1 | 24 |
| 25 | 29 | 14 | 22* | -10 | 3 | 17 | 43 | 0 | - | M | - | - | 0.00 | 30.18 | 30.25 | 6.0 | 31 | 7.8 | 21 | 30 | 16 | 36 | 25 |
| 26 | 36 | 26 | 31 | 0 | 16 | 27 | 34 | 0 | - | M | - | - | 0.00 | 29.63 | 29.72 | 14.6 | 25 | 15.6 | 32 | 24 | 26 | 23 | 26 |
| 27 | 36 | 28 | 32 | 1 | 14 | 26 | 33 | 0 | - | M | - | - | T | 29.65 | 29.71 | 13.0 | 29 | 13.4 | 31 | 28 | 26 | 29 | 27 |
| 28 | 30 | 18 | 24 | -7 | 8 | 20 | 41 | 0 | - | M | - | - | 0.00 | 29.66 | 29.73 | 6.5 | 28 | 8.4 | 21 | 33 | 17 | 33 | 28 |
| 29 | 37 | 26 | 32 | 1 | 15 | 26 | 33 | 0 | - | M | - | - | 0.00 | 29.64 | 29.72 | 11.1 | 28 | 13.2 | 29 | 23 | 24 | 23 | 29 |
| 30 | 49 | 37 | 43 | 12 | 29 | 36 | 22 | 0 | - | M | - | - | 0.00 | 29.72 | 29.79 | 11.0 | 25 | 11.8 | 33 | 22 | 29 | 23 | 30 |
| 31 | 40 | 27 | 34 | 4 | 23 | 31 | 31 | 0 | HZ | M | - | - | T | 30.00 | 30.07 | 3.1 | 3 | 3.7 | 13 | 32 | 9 | 2 | 31 |
| | 44.5 | 30.9 | 37.7 | -------- | 26.0 | 33.7 | 27.1 | .0 | <Monthly Averages | Totals> | | | 2.39 | 29.99 | 30.06 | 4.2 | 31.6 | 9.6 | <Monthly Average | | | | |
| | 3.5 | 3.3 | 3.4 | -------- | <--------------------Departure From Normal----------------------> | | | | | | | | -1.11 | | | | | | | | | | |

37 @ 290°

| Degree Days | Monthly Total | Monthly Departure | Season to Date Total | Season to Date Departure |
|---|---|---|---|---|
| Heating: | 839 | -113 | | |
| Cooling: | 0 | 0 | | |

Greatest 24-hr Precipitation: 0.92date: 6-7
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.49 | 19 | 1051 |
| Minimum : | 29.55 | 29 | 0414 |

Number of Days with ----->
Max temp >= 90: 0
Max temp <= 32: 3
Thunderstorms : 0
Min temp <= 32: 18
Min temp <= 0 : 0
Heavy Fog : 0
Precipitation >= .01 inch: 0
Precipitation >= .10 inch : 0
Snowfall >= 1.0 inch : 0

37.7°F

9.6 /316°

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 01/2000**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) | | | | | | Deg Days Base 65 Degrees | | Significant Weather | Snow/Ice on Gnd(In) | | Precipitation (In) | | Pressure (inches of Hg) | | Wind Speed=mph Dir=tens of degrees | | | | | | | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Heating | Cooling | | 0600 LST Depth | 1200 LST Water Equiv | 2400 LST Snow Fall | 2400 LST Water Equiv | Avg. Station | Avg. Sea level | Resultant Speed | Res Dir | Avg. Speed | max 5-sec Speed | max 5-sec Dir | max 2-min Speed | max 2-min Dir | |
| 01 | 45 | 27 | 36 | 6 | 33 | 35 | 29 | 0 | FG+ FG FZFG HZ | M | - | - | 0.00 | 30.17 | 30.24 | 2.3 | 25 | 3.5 | 16 | 23 | 14 | 23 | 01 |
| 02 | 51 | 31 | 41 | 11 | 40 | 41 | 24 | 0 | FG+ FG HZ | M | - | - | T | 30.03 | 30.11 | 1.4 | 25 | 4.1 | 17 | 22 | 15 | 23 | 02 |
| 03 | 60* | 45 | 53* | 23 | 47 | 48 | 12 | 0 | RA FG+ FG HZ | M | - | - | 0.04 | 29.97 | 30.05 | 1.8 | 17 | 6.8 | 16 | 7 | 14 | 8 | 03 |
| 04 | 56 | 44 | 50 | 20 | 49 | 50 | 15 | 0 | RA FG+ FG | M | - | - | 0.75 | 29.68 | 29.76 | 8.2 | 20 | 13.5 | 33 | 21 | 26 | 20 | 04 |
| 05 | 48 | 27 | 38 | 8 | 19 | 30 | 27 | 0 | FG | M | - | - | 0.09 | 30.03 | 30.09 | 11.9 | 34 | 13.1 | 33 | 1 | 26 | 33 | 05 |
| 06 | 41 | 23 | 32 | 2 | 21 | 29 | 33 | 0 | - | M | - | - | 0.00 | 30.47 | 30.53 | 2.8 | 9 | 6.3 | 16 | 17 | 13 | 18 | 06 |
| 07 | 46 | 29 | 38 | 8 | 28 | 33 | 27 | 0 | FG | M | - | - | 0.00 | 30.10 | 30.18 | 6.3 | 29 | 7.3 | 33 | 30 | 29 | 31 | 07 |
| 08 | 39 | 28 | 34 | 5 | 18 | 29 | 31 | 0 | - | M | - | - | 0.00 | 30.20 | 30.27 | 8.5 | 26 | 9.4 | 21 | 23 | 17 | 23 | 08 |
| 09 | 48 | 37 | 43 | 14 | 32 | 38 | 22 | 0 | RA FG | M | - | - | 0.03 | 29.97 | 30.07 | 4.5 | 24 | 7.4 | 23 | 23 | 20 | 23 | 09 |
| 10 | 55 | 41 | 48 | 19 | 42 | 44 | 17 | 0 | RA FG | M | - | - | 0.39 | 29.63 | 30.94 | 6.3 | 12 | 14.6 | 34 | 21 | 29 | 21 | 10 |
| 11 | 53 | 40 | 47 | 18 | 32 | 40 | 18 | 0 | - | M | - | - | 0.00 | 29.50 | 30.31 | 11.7 | 26 | 13.1 | 36 | 29 | 28 | 29 | 11 |
| 12 | 46 | 31 | 39 | 10 | 20 | 33 | 26 | 0 | - | M | - | - | 0.00 | 29.92 | 30.00 | 15.1 | 30 | 15.9 | 39 | 31 | 31 | 31 | 12 |
| 13 | 35 | 17 | 26 | -3 | 19 | 26 | 39 | 0 | SN FG FZFG | M | - | - | 0.02 | 29.84 | 29.92 | 10.3 | 2 | 13.3 | 33 | 36 | 26 | 35 | 13 |
| 14 | 21 | 12 | 17 | -12 | -5 | 12 | 48 | 0 | - | M | - | - | 0.00 | 30.29 | 30.37 | 15.0 | 33 | 15.6 | 38 | 32 | 30 | 32 | 14 |
| 15 | 26 | 11 | 19 | -10 | 1 | 15 | 46 | 0 | - | M | - | - | T | 30.53 | 30.61 | 3.1 | 29 | 7.0 | 17 | 33 | 14 | 17 | 15 |
| 16 | 43 | 21 | 32 | 3 | 22 | 31 | 33 | 0 | - | M | - | - | T | 29.97 | 30.04 | 8.9 | 27 | 16.3 | 45 | 31 | 33 | 30 | 16 |
| 17 | 21 | 3 | 12 | -17 | 5 | 8 | 53 | 0 | - | M | - | - | 0.00 | 30.14 | 30.22 | 21.2 | 35 | 21.6 | 45 | 33 | 36 | 34 | 17 |
| 18 | 19 | 1 | 10* | -19 | -9 | 7 | 55 | 0 | - | M | - | - | 0.00 | 30.01 | 30.07 | 9.8 | 35 | 10.1 | 23 | 34 | 18 | 35 | 18 |
| 19 | M | M | M | M | - | 26 | M | M | - | M | - | - | 0.00 | 29.81 | 29.90 | 6.5 | 34 | 7.4 | 24 | 33 | 20 | 33 | 19 |
| 20 | 22 | 16 | 19 | -10 | 13 | 18 | 46 | 0 | SN FG | M | - | - | 0.03 | 29.58 | 30.27 | 10.1 | 3 | 10.8 | 23 | 1 | 18 | 36 | 20 |
| 21 | 23 | 8 | 16 | -12 | -2 | 12 | 49 | 0 | - | M | - | - | T | 29.56 | 30.26 | 17.3 | 32 | 18.0 | 43 | 32 | 33 | 31 | 21 |
| 22 | 19 | 4 | 12 | -16 | -7 | 9 | 53 | 0 | - | M | - | - | 0.00 | 30.01 | 30.09 | 9.9 | 31 | 11.0 | 28 | 29 | 22 | 30 | 22 |
| 23 | 26 | 10 | 18 | -10 | 8 | 17 | 47 | 0 | - | M | - | - | T | 30.15 | 30.22 | 6.5 | 7 | 8.0 | 17 | 10 | 14 | 7 | 23 |
| 24 | 33 | 24 | 29 | 1 | 18 | 25 | 36 | 0 | - | M | - | - | 0.00 | 30.01 | 30.08 | 3.9 | 4 | 5.6 | 17 | 3 | 14 | 2 | 24 |
| 25 | 32 | 24 | 28 | 0 | 24 | 28 | 37 | 0 | RA FZRA SN FG+ FG FZFG UP | M | - | - | 0.34 | 29.37 | 31.28 | 17.1 | 3 | 18.2 | 37 | 4 | 30 | 4 | 25 |
| 26 | 31 | 19 | 25 | -3 | 15 | 22 | 40 | 0 | SN FG UP HZ BLSN | M | - | - | T | 29.56 | 30.38 | 9.2 | 33 | 10.5 | 24 | 32 | 17 | 36 | 26 |
| 27 | 22 | 9 | 16 | -12 | 1 | 13 | 49 | 0 | - | M | - | - | 0.00 | 29.91 | 29.97 | 14.0 | 32 | 14.8 | 31 | 30 | 24 | 30 | 27 |
| 28 | 25 | 5 | 15 | -13 | -1 | 12 | 50 | 0 | - | M | - | - | 0.00 | 30.19 | 30.26 | 12.8 | 31 | 13.5 | 31 | 30 | 24 | 32 | 28 |
| 29 | 34 | 17 | 26 | -2 | -1 | 19 | 39 | 0 | - | M | - | - | T | 30.40 | 30.47 | 8.7 | 35 | 9.7 | 29 | 36 | 22 | 36 | 29 |
| 30 | 33 | 13 | 23 | -5 | 15 | 24 | 42 | 0 | RA SN FG | M | - | - | 0.20 | 30.23 | 30.30 | 1.5 | 8 | 4.8 | 23 | 8 | 21 | 8 | 30 |
| 31 | 38 | 30 | 34 | 5 | 26 | 31 | 31 | 0 | RA FG HZ | M | - | - | 0.23 | 29.63 | 29.71 | 8.3 | 29 | 14.7 | 30 | 29 | 24 | 28 | 31 |
| | 36.4 | 21.6 | 29.0 | -------- | 17.4 | 26.0 | 35.8 | .0 | <Monthly Averages | Totals> | | | 2.12 | 29.96 | 30.23 | 5.6 | 32.6 | 11.2 | <Monthly Average | | | | |
| | .4 | -.3 | .1 | -------- | <---------------------Departure From Normal-----------------------> | | | | | | | | -1.12 | | | | | | | | | | |

33 @ 310°

| Degree Days | Monthly Total | Monthly Departure | Season to Date Total | Season to Date Departure |
|---|---|---|---|---|
| Heating: | 1074 | -45 | | |
| Cooling: | 0 | 0 | | |

Greatest 24-hr Precipitation: 0.84date: 4-5
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.71 | 15 | 1025 |
| Minimum : | 29.14 | 25 | 2136 |

Number of Days with ----->
Max temp >= 90: M
Max temp <= 32: M
Thunderstorms : 0
Min temp <= 32: M
Min temp <= 0 : M
Heavy Fog : 5
Precipitation >= .01 inch: M
Precipitation >= .10 inch : M
Snowfall >= 1.0 inch : 0

29.0°F

11.2 / 326°

1/00

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 02/2000**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Deg Days Base 65 Degrees Heating | Cooling | Significant Weather | Snow/Ice on Gnd(In) 0600 LST Depth | 1200 LST Water Equiv | Precipitation (In) 2400 LST Snow Fall | 2400 LST Water Equiv | Pressure (inches of Hg) Avg. Station | Avg. Sea level | Wind Speed=mph Dir=tens of degrees Resultant Speed | Res Dir | Avg. Speed | max 5-sec Speed | Dir | max 2-min Speed | Dir | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 36 | 29 | 33 | 5 | 19 | 27 | 32 | 0 | - | M | - | - | 0.00 | 29.73 | 29.79 | 12.4 | 27 | 12.6 | 23 | 29 | 18 | 28 | 01 |
| 02 | M | M | M | M | - | 25 | M | M | - | M | - | - | 0.00 | 29.89 | 29.95 | 17.5 | 30 | 17.9 | 34 | 31 | 29 | 29 | 02 |
| 03 | 28 | 18 | 23 | -6 | 13 | 21 | 42 | 0 | SN FG | M | - | - | 0.04 | 29.91 | 29.97 | 1.5 | 34 | 6.7 | 17 | 30 | 14 | 30 | 03 |
| 04 | 30 | 25 | 28 | -1 | 24 | 27 | 37 | 0 | SN FG FZFG HZ | M | - | - | 0.02 | 29.78 | 29.86 | 1.7 | 1 | 5.7 | 14 | 4 | 11 | 5 | 04 |
| 05 | 34 | 23 | 29 | 0 | 17 | 25 | 36 | 0 | SN FG | M | - | - | T | 29.83 | 29.92 | 8.0 | 29 | 9.7 | 22 | 26 | 17 | 25 | 05 |
| 06 | 35 | 26 | 31 | 2 | 13 | 25 | 34 | 0 | - | M | - | - | 0.00 | 30.08 | 30.15 | 11.6 | 27 | 13.0 | 28 | 30 | 22 | 29 | 06 |
| 07 | 42 | 25 | 34 | 5 | 18 | 29 | 31 | 0 | - | M | - | - | 0.00 | 29.97 | 30.04 | 11.7 | 28 | 15.7 | 33 | 32 | 28 | 29 | 07 |
| 08 | 29 | 16 | 23* | -6 | 3 | 19 | 42 | 0 | - | M | - | - | T | 30.41 | 30.49 | 4.0 | 25 | 10.2 | 30 | 34 | 22 | 35 | 08 |
| 09 | 40 | 28 | 34 | 5 | 26 | 31 | 31 | 0 | FG | M | - | - | 0.00 | 30.07 | 30.15 | 10.3 | 24 | 10.4 | 23 | 24 | 20 | 24 | 09 |
| 10 | 44 | 28 | 36 | 7 | 31 | 34 | 29 | 0 | FG HZ | M | - | - | 0.00 | 29.95 | 30.02 | 3.6 | 10 | 5.8 | 14 | 2 | 13 | 2 | 10 |
| 11 | 46 | 29 | 38 | 9 | 33 | 35 | 27 | 0 | FG+ FG UP HZ | M | - | - | T | 29.73 | 29.81 | 3.8 | 3 | 9.2 | 33 | 32 | 24 | 34 | 11 |
| 12 | 32 | 22 | 27 | -3 | 8 | 22 | 38 | 0 | - | M | - | - | 0.00 | 30.17 | 30.25 | 2.7 | 35 | 6.6 | 22 | 36 | 16 | 1 | 12 |
| 13 | 36 | 19 | 28 | -2 | 21 | 27 | 37 | 0 | RA FG UP | M | - | - | 0.06 | 30.14 | 30.22 | 5.6 | 8 | 6.8 | 14 | 10 | 13 | 10 | 13 |
| 14 | 53 | 35 | 44 | 14 | 41 | 42 | 21 | 0 | TS TSRA RA SN FG+ FG UP | M | - | - | 0.59 | 29.57 | 29.91 | 4.8 | 22 | 10.7 | 51 | 19 | 41 | 21 | 14 |
| 15 | 44 | 27 | 36 | 6 | 20 | 31 | 29 | 0 | - | M | - | - | 0.00 | 29.95 | 30.02 | 9.9 | 33 | 11.3 | 28 | 32 | 21 | 32 | 15 |
| 16 | 45 | 27 | 36 | 6 | 30 | 34 | 29 | 0 | FG | M | - | - | 0.00 | 29.96 | 30.03 | 4.5 | 26 | 7.4 | 31 | 33 | 25 | 30 | 16 |
| 17 | 38 | 24 | 31 | 0 | 5 | 23 | 34 | 0 | - | M | - | - | 0.00 | 30.38 | 30.46 | 11.8 | 36 | 12.5 | 34 | 36 | 25 | 33 | 17 |
| 18 | 33 | 23 | 28 | -3 | 22 | 27 | 37 | 0 | RA FZRA SN FG+ FG FZFG | M | - | - | 0.97 | 30.23 | 30.31 | 12.3 | 6 | 13.4 | 38 | 8 | 32 | 8 | 18 |
| 19 | 32 | 27 | 30 | -1 | 29 | 30 | 35 | 0 | FZRA SN FG UP | 0.0 | - | - | 0.01 | 29.90 | 29.96 | 4.8 | 4 | 6.6 | 17 | 5 | 15 | 5 | 19 |
| 20 | 38 | 31 | 35 | 4 | 27 | 31 | 30 | 0 | FG | M | - | - | 0.01 | 30.08 | 30.15 | 7.7 | 29 | 8.2 | 24 | 30 | 20 | 29 | 20 |
| 21 | 40 | 23 | 32 | 1 | 25 | 30 | 33 | 0 | - | M | - | - | 0.00 | 30.32 | 30.39 | 5.5 | 25 | 6.6 | 14 | 22 | 13 | 22 | 21 |
| 22 | 44 | 24 | 34 | 2 | 28 | 32 | 31 | 0 | FG HZ | M | - | - | 0.00 | 30.46 | 30.54 | 2.5 | 20 | 3.5 | 15 | 20 | 13 | 20 | 22 |
| 23 | 48 | 28 | 38 | 6 | 35 | 37 | 27 | 0 | FG HZ | M | - | - | 0.00 | 30.40 | 30.47 | 2.2 | 23 | 4.0 | 18 | 21 | 15 | 20 | 23 |
| 24 | 57* | 35 | 46* | 14 | 39 | 42 | 19 | 0 | FG HZ | M | - | - | 0.00 | 30.17 | 30.27 | 2.4 | 24 | 4.1 | 14 | 24 | 11 | 23 | 24 |
| 25 | 44 | 38 | 41 | 8 | 40 | 41 | 24 | 0 | RA FG | M | - | - | 0.20 | 30.23 | 30.31 | 9.2 | 6 | 10.4 | 23 | 4 | 17 | 4 | 25 |
| 26 | 42 | 37 | 40 | 7 | 38 | 39 | 25 | 0 | FG | M | - | - | 0.00 | 30.38 | 30.45 | 10.9 | 4 | 11.1 | 22 | 5 | 17 | 6 | 26 |
| 27 | 50 | 39 | 45 | 12 | 42 | 42 | 20 | 0 | RA FG+ FG | M | - | - | 0.05 | 30.14 | 30.22 | 3.1 | 10 | 4.7 | 25 | 23 | 17 | 22 | 27 |
| 28 | 50 | 37 | 44 | 11 | 35 | 41 | 21 | 0 | RA FG | M | - | - | 0.18 | 29.88 | 29.95 | 10.6 | 30 | 13.3 | 37 | 31 | 31 | 30 | 28 |
| 29 | 53 | 35 | 44 | 11 | 20 | 35 | 21 | 0 | - | M | - | - | 0.00 | 30.01 | 30.08 | 11.6 | 34 | 12.5 | 34 | 32 | 29 | 32 | 29 |
| | 40.8 | 27.8 | 34.3 | -------- | 25.1 | 31.2 | 30.4 | .0 | <Monthly Averages | Totals> | | | 0.45 | 30.06 | 30.14 | 3.4 | 31.3 | 9.3 | <Monthly Average | | | | |
| | 3.2 | 4.6 | 3.9 | -------- | <----------------------Departure From Normal-----------------------> | | | | | | | | -2.56 | | | | | | | | | | |

41@210°

**Degree Days** Monthly Season to Date

| | Monthly Total | Monthly Departure | Season to Date Total | Season to Date Departure |
|---|---|---|---|---|
| Heating: | 852 | -117 | | |
| Cooling: | 0 | 0 | | |

Greatest 24-hr Precipitation: 0.22date: 27-28
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.63 | 17 | 2321 |
| Minimum : | 29.50 | 14 | 1044 |

Number of Days with ----->

Max temp >= 90: M
Max temp <= 32: M
Thunderstorms : 1

Min temp <= 32: M
Min temp <= 0 : M
Heavy Fog : 4

Precipitation >= .01 inch: M
Precipitation >= .10 inch : M
Snowfall >= 1.0 inch : 0

34,3°F

9,3/313°

2/00

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 03/2000**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) | | | | | | Deg Days Base 65 Degrees | | Significant Weather | Snow/Ice on Gnd(In) | | Precipitation (In) | | Pressure (inches of Hg) | | Wind Speed=mph Dir=tens of degrees | | | | | | | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Heating | Cooling | | 0600 LST | 1200 LST | 2400 LST | 2400 LST | Avg. Station | Avg. Sea level | Resultant Speed | Res Dir | Avg. Speed | max 5-sec | | max 2-min | | |
| | | | | | | | | | | Depth | Water Equiv | Snow Fall | Water Equiv | | | | | | Speed | Dir | Speed | Dir | |
| 01 | 44 | 30 | 37 | 3 | 29 | 35 | 28 | 0 | - | M | - | - | 0.00 | 29.91 | 29.98 | 3.2 | 10 | 4.7 | 11 | 10 | 10 | 10 | 01 |
| 02 | 49 | 34 | 42 | 8 | 26 | 35 | 23 | 0 | - | M | - | - | 0.00 | 29.61 | 29.69 | 14.0 | 30 | 14.6 | 36 | 29 | 31 | 31 | 02 |
| 03 | 47 | 32 | 40 | 5 | 18 | 32 | 25 | 0 | - | M | - | - | 0.00 | 29.64 | 29.71 | 14.1 | 33 | 14.4 | 36 | 35 | 28 | 34 | 03 |
| 04 | 51 | 32 | 42 | 7 | 13 | 32 | 23 | 0 | - | M | - | - | 0.00 | 29.67 | 29.73 | 8.3 | 31 | 9.7 | 26 | 32 | 20 | 36 | 04 |
| 05 | 52 | 36 | 44 | 9 | 26 | 37 | 21 | 0 | - | M | - | - | T | 29.67 | 29.76 | 10.1 | 32 | 11.3 | 33 | 32 | 26 | 31 | 05 |
| 06 | 53 | 36 | 45 | 10 | 18 | 35 | 20 | 0 | - | M | - | - | 0.00 | 30.00 | 30.06 | 10.2 | 34 | 11.8 | 34 | 33 | 26 | 36 | 06 |
| 07 | 55 | 31 | 43 | 7 | 29 | 38 | 22 | 0 | - | M | - | - | 0.01 | 30.05 | 30.12 | 6.4 | 24 | 7.5 | 21 | 23 | 17 | 24 | 07 |
| 08 | 48 | 37 | 43 | 7 | 37 | 40 | 22 | 0 | FG | M | - | - | 0.00 | 29.90 | 29.98 | 8.5 | 8 | 8.8 | 21 | 8 | 17 | 9 | 08 |
| 09 | 58 | 40 | 49 | 13 | 44 | 45 | 16 | 0 | TS TSRA FG+ FG HZ | M | - | - | 0.15 | 29.66 | 29.73 | 2.3 | 10 | 6.2 | 25 | 32 | 20 | 33 | 09 |
| 10 | 55 | 39 | 47 | 10 | 37 | 43 | 18 | 0 | FG+ FG | M | - | - | 0.00 | 29.94 | 30.01 | 3.2 | 35 | 9.7 | 25 | 2 | 22 | 2 | 10 |
| 11 | 40 | 37 | 39 | 2 | 36 | 37 | 26 | 0 | TS TSRA RA FG | M | - | - | 1.79 | 30.04 | 30.10 | 17.8 | 8 | 18.5 | 39 | 9 | 33 | 9 | 11 |
| 12 | 49 | 35 | 42 | 5 | 36 | 39 | 23 | 0 | RA FG | M | - | - | 0.53 | 29.61 | 29.68 | 8.4 | 35 | 11.5 | 32 | 1 | 25 | 35 | 12 |
| 13 | 47 | 31 | 39 | 1 | 15 | 31 | 26 | 0 | - | M | - | - | 0.00 | 30.17 | 30.24 | 6.7 | 32 | 8.2 | 26 | 31 | 21 | 31 | 13 |
| 14 | 50 | 32 | 41 | 3 | 29 | 36 | 24 | 0 | - | M | - | - | 0.00 | 30.23 | 30.29 | 5.2 | 22 | 7.9 | 23 | 21 | 18 | 20 | 14 |
| 15 | 56 | 32 | 44 | 6 | 35 | 40 | 21 | 0 | FG | M | - | - | 0.00 | 30.16 | 30.22 | 6.0 | 22 | 7.4 | 29 | 20 | 23 | 20 | 15 |
| 16 | 56 | 41 | 49 | 10 | 43 | 46 | 16 | 0 | RA FG | M | - | - | 0.34 | 29.94 | 30.01 | 4.0 | 23 | 6.1 | 16 | 19 | 13 | 19 | 16 |
| 17 | 49 | 27 | 38 | -1 | 25 | 32 | 27 | 0 | RA SN FG | M | - | - | 0.74 | 29.90 | 29.97 | 14.9 | 1 | 15.9 | 37 | 1 | 28 | 1 | 17 |
| 18 | 36 | 21 | 29* | -10 | 8 | 23 | 36 | 0 | - | M | - | - | 0.00 | 30.54 | 30.61 | 5.8 | 5 | 9.4 | 25 | 1 | 21 | 1 | 18 |
| 19 | 40 | 28 | 34 | -6 | 22 | 30 | 31 | 0 | - | M | - | - | 0.00 | 30.48 | 30.56 | 6.1 | 8 | 7.9 | 18 | 11 | 16 | 10 | 19 |
| 20 | 43 | 32 | 38 | -2 | 29 | 34 | 27 | 0 | HZ | M | - | - | 0.00 | 30.40 | 30.47 | 10.7 | 9 | 12.3 | 23 | 9 | 20 | 7 | 20 |
| 21 | 44 | 37 | 41 | 1 | 35 | 38 | 24 | 0 | FG HZ | M | - | - | 0.00 | 30.39 | 30.45 | 15.5 | 7 | 15.6 | 25 | 6 | 21 | 7 | 21 |
| 22 | 50 | 38 | 44 | 3 | 35 | 39 | 21 | 0 | - | M | - | - | 0.00 | 30.34 | 30.42 | 10.8 | 7 | 11.8 | 26 | 6 | 21 | 6 | 22 |
| 23 | 55 | 34 | 45 | 4 | 34 | 39 | 20 | 0 | FG HZ | M | - | - | 0.00 | 30.21 | 30.28 | 0.8 | 22 | 4.2 | 13 | 11 | 10 | 11 | 23 |
| 24 | 62 | 39 | 51 | 10 | 35 | 44 | 14 | 0 | FG | M | - | - | 0.00 | 30.07 | 30.15 | 0.7 | 11 | 6.3 | 20 | 18 | 16 | 19 | 24 |
| 25 | 57 | 38 | 48 | 7 | 39 | 43 | 17 | 0 | FG | M | - | - | 0.02 | 29.85 | 29.92 | 2.7 | 13 | 6.6 | 21 | 19 | 17 | 20 | 25 |
| 26 | 64* | 44 | 54* | 12 | 33 | 45 | 11 | 0 | RA FG | M | - | - | 0.09 | 29.58 | 29.66 | 8.0 | 31 | 9.8 | 28 | 31 | 22 | 29 | 26 |
| 27 | 54 | 34 | 44 | 2 | 36 | 42 | 21 | 0 | - | M | - | - | 0.00 | 29.61 | 29.92 | 6.1 | 10 | 8.1 | 20 | 14 | 16 | 7 | 27 |
| 28 | 56 | 47 | 52 | 10 | 43 | 47 | 13 | 0 | RA FG | M | - | - | 0.29 | 29.16 | 32.18 | 9.0 | 21 | 15.0 | 30 | 28 | 26 | 9 | 28 |
| 29 | 54 | 43 | 49 | 6 | 37 | 43 | 16 | 0 | RA FG | M | - | - | 0.06 | 29.52 | 30.46 | 12.2 | 26 | 13.0 | 36 | 25 | 28 | 28 | 29 |
| 30 | 55 | 41 | 48 | 5 | 33 | 41 | 17 | 0 | - | M | - | - | 0.00 | 29.82 | 29.90 | 6.1 | 25 | 9.2 | 20 | 1 | 17 | 22 | 30 |
| 31 | 56 | 33 | 45 | 2 | 28 | 38 | 20 | 0 | - | M | - | - | 0.00 | 29.98 | 30.05 | 4.5 | 32 | 7.7 | 22 | 2 | 17 | 1 | 31 |
| | 51.1 | 35.2 | 43.2 | -------- | 30.4 | 38.0 | 21.6 | .0 | <Monthly Averages | Totals> | | | 4.02 | 29.94 | 30.14 | 2.2 | 36 | 10.0 | <Monthly Average | | | | |
| | 4.9 | 4.3 | 4.6 | -------- | <--------------------Departure From Normal----------------------> | | | | | | | | 0.27 | | | | | | | | | | |

31 @ 310°

**Degree Days** Monthly Season to Date

| | Monthly Total | Monthly Departure | Season to Date Total | Season to Date Departure |
|---|---|---|---|---|
| Heating: | 669 | -149 | | |
| Cooling: | 0 | 0 | | |

Greatest 24-hr Precipitation: 2.22date: 11-12
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.68 | 18 | 1118 |
| Minimum : | 29.06 | 28 | 0839 |

Number of Days with ----->

Max temp >= 90: 0
Max temp <= 32: 0
Thunderstorms : 2

Min temp <= 32: 11
Min temp <= 0 : 0
Heavy Fog : 2

Precipitation >= .01 inch: 0
Precipitation >= .10 inch : 0
Snowfall >= 1.0 inch : 0

43.2° F

10.0 / 360°

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 04/2000**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Deg Days Base 65 Degrees Heating | Cooling | Significant Weather | Snow/Ice on Gnd(In) 0600 LST Depth | 1200 LST Water Equiv | Precipitation (In) 2400 LST Snow Fall | 2400 LST Water Equiv | Pressure (inches of Hg) Avg. Station | Avg. Sea level | Wind Speed=mph Dir=tens of degrees Resultant Speed | Res Dir | Avg. Speed | max 5-sec Speed | max 5-sec Dir | max 2-min Speed | max 2-min Dir | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 59 | 34 | 47 | 3 | 32 | 40 | 18 | 0 | - | M | - | - | 0.00 | 30.11 | 30.18 | 7.1 | 22 | 7.5 | 22 | 20 | 18 | 21 | 01 |
| 02 | 58 | 42 | 50 | 6 | 43 | 47 | 15 | 0 | - | M | - | - | 0.00 | 29.98 | 30.04 | 7.0 | 21 | 7.5 | 22 | 20 | 17 | 20 | 02 |
| 03 | 53 | 46 | 50 | 6 | 47 | 49 | 15 | 0 | FG+ FG | M | - | - | 0.00 | 29.82 | 29.88 | 5.6 | 9 | 6.6 | 15 | 8 | 13 | 8 | 03 |
| 04 | 57 | 46 | 52 | 8 | 49 | 51 | 13 | 0 | RA FG+ FG | M | - | - | 0.36 | 29.42 | 31.83 | 7.9 | 23 | 11.7 | 25 | 33 | 22 | 20 | 04 |
| 05 | 50 | 39 | 45 | 0 | 22 | 35 | 20 | 0 | - | M | - | - | 0.00 | 29.62 | 29.69 | 16.2 | 29 | 16.7 | 34 | 28 | 28 | 29 | 05 |
| 06 | 57 | 37 | 47 | 2 | 35 | 42 | 18 | 0 | - | M | - | - | 0.00 | 29.62 | 30.42 | 2.2 | 21 | 7.3 | 22 | 31 | 17 | 31 | 06 |
| 07 | 59 | 46 | 53 | 8 | 35 | 44 | 12 | 0 | - | M | - | - | 0.00 | 29.87 | 29.95 | 3.4 | 21 | 7.6 | 18 | 22 | 16 | 22 | 07 |
| 08 | 64 | 45 | 55 | 9 | 47 | 51 | 10 | 0 | RA FG | M | - | - | 0.01 | 29.59 | 30.02 | 9.3 | 18 | 12.4 | 31 | 20 | 24 | 20 | 08 |
| 09 | 52 | 32 | 42 | -4 | 30 | 36 | 23 | 0 | RA SN FG+ FG | M | - | - | 0.36 | 29.43 | 31.22 | 14.5 | 30 | 17.0 | 36 | 29 | 28 | 28 | 09 |
| 10 | 52 | 37 | 45 | -1 | 23 | 36 | 20 | 0 | - | M | - | - | 0.00 | 30.01 | 30.08 | 11.4 | 29 | 13.8 | 30 | 30 | 24 | 30 | 10 |
| 11 | 41 | 32 | 37* | -10 | 29 | 34 | 28 | 0 | SN FG HZ | M | - | - | 0.05 | 30.22 | 30.30 | 6.8 | 9 | 7.5 | 17 | 8 | 15 | 9 | 11 |
| 12 | 53 | 34 | 44 | -3 | 27 | 38 | 21 | 0 | RA FG | M | - | - | 0.01 | 30.14 | 30.21 | 10.4 | 33 | 11.5 | 31 | 33 | 25 | 30 | 12 |
| 13 | 49 | 30 | 40 | -7 | 21 | 33 | 25 | 0 | - | M | - | - | 0.00 | 30.43 | 30.49 | 6.5 | 22 | 9.4 | 22 | 21 | 18 | 21 | 13 |
| 14 | 52 | 33 | 43 | -5 | 30 | 39 | 22 | 0 | - | M | - | - | 0.00 | 30.34 | 30.39 | 4.4 | 19 | 6.2 | 18 | 21 | 16 | 21 | 14 |
| 15 | 53 | 43 | 48 | 0 | - | 44 | 17 | 0 | RA FG | M | - | - | 0.18 | 30.07 | 30.16 | 1.5 | 10 | 2.3 | 10 | 13 | 9 | 10 | 15 |
| 16 | 70* | 49 | 60* | 12 | 52 | 54 | 5 | 0 | RA FG+ FG BCFG HZ | M | - | - | 0.33 | 29.85 | 29.93 | 1.5 | 36 | 7.3 | 26 | 1 | 21 | 1 | 16 |
| 17 | 50 | 40 | 45 | -4 | 39 | 42 | 20 | 0 | RA FG | M | - | - | 0.27 | 30.09 | 30.17 | 13.7 | 9 | 14.8 | 32 | 9 | 26 | 10 | 17 |
| 18 | 49 | 38 | 44 | -5 | 34 | 39 | 21 | 0 | RA FG | M | - | - | 0.10 | 30.03 | 30.10 | 16.8 | 6 | 17.1 | 29 | 5 | 24 | 6 | 18 |
| 19 | 56 | 41 | 49 | 0 | 41 | 45 | 16 | 0 | RA FG | M | - | - | 0.02 | 29.96 | 30.03 | 13.7 | 4 | 13.9 | 28 | 5 | 22 | 2 | 19 |
| 20 | 59 | 45 | 52 | 2 | 44 | 47 | 13 | 0 | - | M | - | - | 0.00 | 29.95 | 30.04 | 2.1 | 15 | 6.0 | 14 | 16 | 13 | 23 | 20 |
| 21 | 48 | 44 | 46 | -4 | 45 | 45 | 19 | 0 | TS TSRA RA FG | M | - | - | 3.34 | 29.76 | 29.83 | 17.9 | 9 | 19.1 | 44 | 10 | 39 | 10 | 21 |
| 22 | 50 | 44 | 47 | -3 | 46 | 46 | 18 | 0 | RA FG | M | - | - | 0.13 | 29.48 | 30.29 | 13.5 | 3 | 13.9 | 31 | 5 | 23 | 6 | 22 |
| 23 | 49 | 42 | 46 | -5 | 41 | 44 | 19 | 0 | FG | M | - | - | 0.01 | 29.52 | 29.60 | 11.2 | 35 | 11.9 | 30 | 32 | 22 | 33 | 23 |
| 24 | 67 | 42 | 55 | 4 | 38 | 47 | 10 | 0 | - | M | - | - | 0.00 | 29.70 | 29.77 | 9.7 | 35 | 11.8 | 31 | 33 | 23 | 32 | 24 |
| 25 | 51 | 44 | 48 | -3 | 36 | 42 | 17 | 0 | - | M | - | - | 0.00 | 29.87 | 29.94 | 12.3 | 9 | 13.7 | 29 | 6 | 24 | 6 | 25 |
| 26 | 44 | 38 | 41 | -11 | 34 | 38 | 24 | 0 | - | M | - | - | 0.01 | 29.97 | 30.04 | 12.7 | 4 | 13.1 | 28 | 5 | 23 | 5 | 26 |
| 27 | 51 | 39 | 45 | -7 | 38 | 42 | 20 | 0 | - | M | - | - | 0.00 | 29.95 | 30.01 | 4.4 | 23 | 8.0 | 16 | 21 | 14 | 22 | 27 |
| 28 | 57 | 44 | 51 | -1 | 45 | 47 | 14 | 0 | FG HZ | M | - | - | T | 29.87 | 29.94 | 7.7 | 23 | 8.6 | 16 | 21 | 14 | 20 | 28 |
| 29 | 60 | 41 | 51 | -2 | 41 | 46 | 14 | 0 | FG | M | - | - | 0.00 | 29.83 | 29.90 | 1.0 | 16 | 8.0 | 20 | 10 | 16 | 10 | 29 |
| 30 | 63 | 49 | 56 | 3 | 28 | 44 | 9 | 0 | - | M | - | - | 0.00 | 29.91 | 29.98 | 12.1 | 35 | 13.8 | 37 | 31 | 32 | 31 | 30 |
| | 54.4 | 40.5 | 47.5 | -------- | 37.0 | 42.9 | 17.2 | .0 | <Monthly Averages | Totals> | | | 5.18 | 29.88 | 30.15 | 1.9 | 1.5 | 10.9 | <Monthly Average | | | | |
| | -2.2 | .7 | -.7 | -------- | <----------------------Departure From Normal-----------------------> | | | | | | | | 1.43 | | | | | | | | | | |

| Degree Days | Monthly Total | Monthly Departure | Season to Date Total | Season to Date Departure |
|---|---|---|---|---|
| Heating: | 516 | 12 | | |
| Cooling: | 0 | 0 | | |

Greatest 24-hr Precipitation: 3.47date: 21-22
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.57 | 13 | 0957 |
| Minimum : | 29.25 | 9 | 0720 |

Number of Days with ----->
Max temp >= 90: 0
Max temp <= 32: 0
Thunderstorms : 1
Min temp <= 32: 3
Min temp <= 0 : 0
Heavy Fog : 4
Precipitation >= .01 inch: 4
Precipitation >= .10 inch : 0
Snowfall >= 1.0 inch : 0

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 05/2000**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) | | | | | | Deg Days Base 65 Degrees | | Significant Weather | Snow/Ice on Gnd(In) | | Precipitation (In) | | Pressure (inches of Hg) | | Wind Speed=mph Dir=tens of degrees | | | | | | | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Heating | Cooling | | 0600 LST | 1200 LST | 2400 LST | 2400 LST | Avg. Station | Avg. Sea level | Resultant Speed | Res Dir | Avg. Speed | max 5-sec | | max 2-min | | |
| | | | | | | | | | | Depth | Water Equiv | Snow Fall | Water Equiv | | | | | | Speed | Dir | Speed | Dir | |
| 01 | 59 | 39 | 49 | -4 | 37 | 45 | 16 | 0 | FG | M | - | - | 0.05 | 29.94 | 30.02 | 6.6 | 22 | 8.1 | 24 | 20 | 20 | 21 | 01 |
| 02 | 65 | 51 | 58 | 4 | 45 | 51 | 7 | 0 | RA FG | M | - | - | 0.08 | 29.85 | 29.91 | 6.9 | 34 | 9.4 | 32 | 30 | 24 | 31 | 02 |
| 03 | 62 | 44 | 53 | -1 | 40 | 47 | 12 | 0 | - | M | - | - | 0.00 | 30.24 | 30.31 | 4.2 | 10 | 6.9 | 15 | 9 | 13 | 20 | 03 |
| 04 | 65 | 45 | 55 | 1 | 47 | 51 | 10 | 0 | FG | M | - | - | T | 30.22 | 30.29 | 7.7 | 21 | 8.0 | 23 | 20 | 18 | 21 | 04 |
| 05 | 83 | 53 | 68 | 13 | 57 | 60 | 0 | 3 | TS TSRA | M | - | - | 0.02 | 29.95 | 30.03 | 6.5 | 24 | 7.5 | 37 | 1 | 29 | 1 | 05 |
| 06 | 81 | 54 | 68 | 13 | 58 | 60 | 0 | 3 | FG HZ | M | - | - | 0.00 | 29.92 | 30.00 | 2.7 | 11 | 7.8 | 22 | 7 | 18 | 7 | 06 |
| 07 | 87 | 53 | 70 | 15 | 58 | 62 | 0 | 5 | FG HZ | M | - | - | 0.11 | 29.83 | 29.90 | 7.3 | 23 | 8.0 | 45 | 30 | 39 | 30 | 07 |
| 08 | 87* | 63 | 75* | 19 | 61 | 66 | 0 | 10 | TS FG | M | - | - | 0.02 | 29.76 | 29.81 | 5.9 | 23 | 6.7 | 21 | 20 | 17 | 20 | 08 |
| 09 | 84 | 61 | 73 | 17 | 61 | 65 | 0 | 8 | FG HZ | M | - | - | 0.00 | 29.57 | 29.66 | 8.9 | 23 | 10.2 | 26 | 34 | 22 | 20 | 09 |
| 10 | 72 | 49 | 61 | 4 | 50 | 51 | 4 | 0 | RA FG HZ | M | - | - | 0.36 | 29.71 | 29.78 | 15.3 | 10 | 17.8 | 39 | 10 | 30 | 10 | 10 |
| 11 | 73 | 50 | 62 | 5 | 48 | 54 | 3 | 0 | FG | M | - | - | 0.09 | 29.72 | 29.79 | 5.2 | 32 | 7.4 | 32 | 30 | 23 | 30 | 11 |
| 12 | 60 | 53 | 57 | 0 | 52 | 54 | 8 | 0 | TS TSRA RA FG | M | - | - | 0.25 | 29.77 | 29.85 | 6.5 | 9 | 7.2 | 15 | 8 | 14 | 7 | 12 |
| 13 | 58 | 52 | 55 | -3 | 53 | 54 | 10 | 0 | TS RA FG | M | - | - | 0.63 | 29.70 | 29.78 | 9.4 | 9 | 10.7 | 22 | 28 | 18 | 28 | 13 |
| 14 | 72 | 53 | 63 | 5 | 46 | 54 | 2 | 0 | - | M | - | - | 0.01 | 29.81 | 29.90 | 5.5 | 31 | 9.8 | 23 | 1 | 20 | 1 | 14 |
| 15 | 65 | 49 | 57 | -1 | 36 | 47 | 8 | 0 | - | M | - | - | 0.00 | 30.01 | 30.08 | 5.3 | 27 | 8.3 | 23 | 30 | 18 | 31 | 15 |
| 16 | 67 | 43 | 55 | -3 | 40 | 48 | 10 | 0 | - | M | - | - | 0.00 | 30.05 | 30.13 | 7.9 | 22 | 8.3 | 22 | 20 | 20 | 20 | 16 |
| 17 | 68 | 52 | 60 | 1 | 47 | 53 | 5 | 0 | - | M | - | - | 0.00 | 30.08 | 30.16 | 4.5 | 18 | 7.0 | 20 | 21 | 16 | 20 | 17 |
| 18 | 69 | 56 | 63 | 4 | 58 | 60 | 2 | 0 | TS TSRA RA FG HZ | 0.0 | - | - | T | 29.93 | 30.00 | 10.0 | 22 | 10.6 | 48 | 31 | 40 | 31 | 18 |
| 19 | 62 | 46 | 54 | -5 | 49 | 51 | 11 | 0 | RA FG | M | - | - | 0.45 | 30.01 | 30.08 | 10.7 | 5 | 11.6 | 30 | 6 | 22 | 6 | 19 |
| 20 | 51 | 45 | 48* | -12 | 44 | 47 | 17 | 0 | RA FG | M | - | - | 0.24 | 30.06 | 30.13 | 8.7 | 9 | 9.6 | 21 | 11 | 17 | 12 | 20 |
| 21 | 54 | 50 | 52 | -8 | 49 | 50 | 13 | 0 | FG | M | - | - | T | 29.99 | 30.05 | 6.6 | 11 | 6.9 | 15 | 10 | 13 | 10 | 21 |
| 22 | 56 | 51 | 54 | -6 | 50 | 51 | 11 | 0 | RA FG | M | - | - | 0.15 | 29.86 | 29.93 | 8.0 | 11 | 8.9 | 20 | 10 | 17 | 10 | 22 |
| 23 | 60 | 51 | 56 | -5 | 52 | 53 | 9 | 0 | RA FG HZ | M | - | - | 0.10 | 29.72 | 29.79 | 4.9 | 21 | 6.2 | 15 | 16 | 13 | 20 | 23 |
| 24 | 75 | 54 | 65 | 4 | 58 | 60 | 0 | 0 | RA FG HZ | M | - | - | 0.83 | 29.46 | 31.25 | 4.5 | 21 | 7.8 | 21 | 20 | 17 | 20 | 24 |
| 25 | 75 | 59 | 67 | 5 | 50 | 58 | 0 | 2 | HZ | M | - | - | T | 29.47 | 31.16 | 7.9 | 28 | 10.2 | 39 | 30 | 29 | 31 | 25 |
| 26 | 75 | 55 | 65 | 3 | 45 | 54 | 0 | 0 | - | M | - | - | 0.00 | 29.77 | 29.83 | 8.0 | 30 | 10.3 | 28 | 32 | 22 | 29 | 26 |
| 27 | 69 | 50 | 60 | -2 | 49 | 54 | 5 | 0 | - | M | - | - | 0.00 | 29.83 | 29.89 | 7.5 | 24 | 8.4 | 23 | 23 | 20 | 23 | 27 |
| 28 | 65 | 52 | 59 | -3 | 46 | 53 | 6 | 0 | - | M | - | - | 0.00 | 29.80 | 29.86 | 2.7 | 11 | 6.9 | 14 | 1 | 11 | 2 | 28 |
| 29 | 62 | 53 | 58 | -5 | 47 | 52 | 7 | 0 | - | M | - | - | 0.00 | 29.99 | 30.06 | 10.4 | 10 | 11.1 | 20 | 7 | 17 | 10 | 29 |
| 30 | 61 | 50 | 56 | -7 | 47 | 51 | 9 | 0 | - | 0.0 | - | - | 0.00 | 30.18 | 30.26 | 7.8 | 10 | 9.7 | 18 | 12 | 15 | 13 | 30 |
| 31 | 63 | 52 | 58 | -5 | 48 | 52 | 7 | 0 | - | M | - | - | 0.00 | 30.12 | 30.19 | 2.1 | 20 | 4.2 | 11 | 23 | 10 | 24 | 31 |
| | 67.9 | 51.2 | 59.6 | -------- | 49.3 | 53.8 | 6.2 | 1.0 | <Monthly Averages | Totals> | | | 0.00 | 29.88 | 30.06 | 1.6 | 17.2 | 8.8 | <Monthly Average | | | | |
| | 1.2 | 1.2 | 1.2 | -------- | <--------------------Departure From Normal-----------------------> | | | | | | | | -3.93 | | | | | | | | | | |

| Degree Days | Monthly Total | Monthly Departure | Season to Date Total | Season to Date Departure |
|---|---|---|---|---|
| Heating: | 192 | -27 | | |
| Cooling: | 31 | 16 | | |

Greatest 24-hr Precipitation: 0.00date:
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.37 | 3 | 1057 |
| Minimum : | 29.46 | 25 | 0812 |

Number of Days with ----->
Max temp >= 90: 0
Max temp <= 32: 0
Thunderstorms : 5
Min temp <= 32: 0
Min temp <= 0 : 0
Heavy Fog : 0
Precipitation >= .01 inch: M
Precipitation >= .10 inch : M
Snowfall >= 1.0 inch : 0

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 06/2000**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) | | | | | | Deg Days Base 65 Degrees | | Significant Weather | Snow/Ice on Gnd(In) | | Precipitation (In) | | Pressure (inches of Hg) | | Wind Speed=mph Dir=tens of degrees | | | | | | | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Heating | Cooling | | 0600 LST | 1200 LST | 2400 LST | 2400 LST | Avg. Station | Avg. Sea level | Resultant Speed | Res Dir | Avg. Speed | max 5-sec | | max 2-min | | |
| | | | | | | | | | | Depth | Water Equiv | Snow Fall | Water Equiv | | | | | | Speed | Dir | Speed | Dir | |
| 01 | 82 | 56 | 69 | 5 | 49 | 58 | 0 | 4 | FG HZ | 0.0 | - | - | 0.00 | 29.93 | 30.00 | 5.7 | 23 | 7.0 | 14 | 22 | 13 | 22 | 01 |
| 02 | 84 | 62 | 73 | 9 | 60 | 65 | 0 | 8 | TS TSRA FG HZ | M | - | - | 0.11 | 29.79 | 29.88 | 5.7 | 24 | 9.0 | 38 | 33 | 36 | 33 | 02 |
| 03 | 75 | 59 | 67 | 3 | 52 | 58 | 0 | 2 | FG | M | - | - | 0.00 | 29.96 | 30.01 | 5.5 | 35 | 9.2 | 31 | 1 | 24 | 1 | 03 |
| 04 | 72 | 56 | 64 | 0 | 52 | 57 | 1 | 0 | - | M | - | - | T | 30.07 | 30.13 | 5.1 | 20 | 6.2 | 15 | 19 | 11 | 19 | 04 |
| 05 | 64 | 59 | 62 | -3 | 51 | 56 | 3 | 0 | - | M | - | - | T | 30.06 | 30.13 | 12.3 | 9 | 12.7 | 25 | 9 | 20 | 9 | 05 |
| 06 | 59 | 50 | 55* | -11 | 51 | 53 | 10 | 0 | RA FG | M | - | - | 2.21 | 29.76 | 29.83 | 14.5 | 4 | 15.4 | 34 | 4 | 26 | 4 | 06 |
| 07 | 73 | 48 | 61 | -5 | 49 | 54 | 4 | 0 | RA FG | M | - | - | 0.33 | 29.91 | 29.99 | 8.5 | 36 | 9.3 | 26 | 32 | 21 | 32 | 07 |
| 08 | 72 | 52 | 62 | -4 | 54 | 58 | 3 | 0 | - | M | - | - | 0.00 | 29.99 | 30.06 | 5.6 | 21 | 6.2 | 22 | 20 | 18 | 20 | 08 |
| 09 | 88* | 63 | 76 | 10 | 62 | 66 | 0 | 11 | FG HZ | M | - | - | 0.00 | 29.89 | 29.96 | 9.2 | 24 | 9.5 | 25 | 30 | 22 | 30 | 09 |
| 10 | 87 | 64 | 76 | 10 | 64 | 68 | 0 | 11 | FG HZ | M | - | - | 0.00 | 29.91 | 29.98 | 8.7 | 24 | 9.0 | 21 | 23 | 17 | 23 | 10 |
| 11 | 86 | 61 | 74 | 8 | 66 | 69 | 0 | 9 | TS TSRA RA FG HZ . | M | - | - | 0.47 | 29.92 | 29.99 | 4.8 | 22 | 10.3 | 48 | 36 | 39 | 35 | 11 |
| 12 | 63 | 56 | 60 | -6 | 56 | 56 | 5 | 0 | RA FG | M | - | - | 0.04 | 30.07 | 30.13 | 11.7 | 9 | 11.8 | 20 | 10 | 18 | 9 | 12 |
| 13 | 60 | 54 | 57 | -10 | 50 | 53 | 8 | 0 | RA FG | M | - | - | 0.08 | 30.11 | 30.20 | 9.4 | 10 | 10.5 | 21 | 10 | 17 | 10 | 13 |
| 14 | 60 | 54 | 57 | -11 | 51 | 54 | 8 | 0 | - | M | - | - | 0.02 | 30.13 | 30.20 | 11.3 | 10 | 11.5 | 20 | 8 | 17 | 8 | 14 |
| 15 | 65 | 58 | 62 | -6 | 60 | 61 | 3 | 0 | RA FG | M | - | - | 0.01 | 29.92 | 30.00 | 6.3 | 9 | 7.1 | 14 | 11 | 11 | 10 | 15 |
| 16 | 82 | 63 | 73 | 5 | 67 | 68 | 0 | 8 | FG+ FG HZ | M | - | - | 0.00 | 29.86 | 29.93 | 6.6 | 21 | 8.2 | 23 | 19 | 18 | 20 | 16 |
| 17 | 85 | 68 | 77 | 9 | 69 | 71 | 0 | 12 | TS TSRA RA FG HZ | M | - | - | 0.38 | 29.88 | 29.96 | 6.3 | 26 | 8.4 | 39 | 33 | 31 | 34 | 17 |
| 18 | 71 | 63 | 67 | -1 | 60 | 63 | 0 | 2 | - | M | - | - | 0.03 | 30.01 | 30.07 | 4.4 | 8 | 5.3 | 15 | 9 | 13 | 7 | 18 |
| 19 | 71 | 61 | 66 | -3 | 60 | 62 | 0 | 1 | - | M | - | - | T | 30.04 | 30.11 | 2.6 | 36 | 6.0 | 14 | 1 | 13 | 2 | 19 |
| 20 | 81 | 56 | 69 | 0 | 56 | 62 | 0 | 4 | - | M | - | - | 0.00 | 30.03 | 30.11 | 2.6 | 33 | 5.1 | 20 | 30 | 16 | 31 | 20 |
| 21 | 79 | 62 | 71 | 2 | 62 | 65 | 0 | 6 | FG | M | - | - | T | 29.88 | 29.95 | 12.0 | 21 | 12.7 | 30 | 19 | 24 | 20 | 21 |
| 22 | 83 | 67 | 75 | 6 | 67 | 69 | 0 | 10 | RA FG HZ | M | - | - | 0.02 | 29.67 | 29.74 | 9.3 | 23 | 10.0 | 22 | 21 | 18 | 20 | 22 |
| 23 | 82 | 66 | 74 | 5 | 59 | 65 | 0 | 9 | - | M | - | - | 0.00 | 29.83 | 29.91 | 3.2 | 31 | 6.1 | 21 | 31 | 16 | 31 | 23 |
| 24 | 81 | 61 | 71 | 1 | 60 | 65 | 0 | 6 | - | M | - | - | 0.00 | 30.03 | 30.11 | 2.3 | 17 | 4.3 | 17 | 19 | 14 | 20 | 24 |
| 25 | 83 | 67 | 75 | 5 | 68 | 71 | 0 | 10 | FG HZ | M | - | - | 0.00 | 29.94 | 30.00 | 8.3 | 21 | 9.6 | 29 | 20 | 20 | 21 | 25 |
| 26 | 84 | 70 | 77 | 7 | 71 | 72 | 0 | 12 | TS TSRA RA FG HZ | M | - | - | 0.21 | 29.86 | 29.93 | 6.1 | 20 | 7.4 | 22 | 22 | 18 | 20 | 26 |
| 27 | 86 | 70 | 78* | 8 | 69 | 71 | 0 | 13 | RA FG HZ | M | - | - | 0.04 | 29.83 | 29.90 | 6.4 | 27 | 8.0 | 32 | 30 | 26 | 31 | 27 |
| 28 | 80 | 67 | 74 | 3 | 60 | 65 | 0 | 9 | - | M | - | - | 0.01 | 29.91 | 29.97 | 3.3 | 20 | 5.2 | 14 | 20 | 13 | 21 | 28 |
| 29 | 70 | 66 | 68 | -3 | 62 | 64 | 0 | 3 | RA FG | M | - | - | T | 29.76 | 29.83 | 1.7 | 16 | 3.8 | 9 | 13 | 8 | 19 | 29 |
| 30 | 79 | 62 | 71 | 0 | 58 | 63 | 0 | 6 | FG HZ | M | - | - | 0.00 | 29.80 | 29.87 | 2.5 | 30 | 6.1 | 20 | 22 | 17 | 22 | 30 |
| | 76.2 | 60.7 | 68.5 | -------- | 59.2 | 62.7 | 1.5 | 5.2 | <Monthly Averages | Totals> | | | 3.96 | 29.93 | 30.00 | 1.4 | 19.5 | 8.4 | <Monthly Average | | | | |
| | .2 | 1.6 | .9 | -------- | <--------------------Departure From Normal----------------------> | | | | | | | | 0.50 | | | | | | | | | | |

**Degree Days** Monthly Season to Date
Total DepartureTotal Departure
Heating: 45 27
Cooling: 156 60

Greatest 24-hr Precipitation: 2.51date: 6-7
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.25 | 14 | 1159 |
| Minimum : | 29.67 | 22 | 1844 |

Number of Days with ----->
Max temp >= 90: 0
Max temp <= 32: 0
Thunderstorms : 4
Min temp <= 32: 0
Min temp <= 0 : 0
Heavy Fog : 1
.Precipitation >= .01 inch: M
Precipitation >= .10 inch : M
Snowfall >= 1.0 inch : 0

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 07/2000**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) | | | | | | Deg Days Base 65 Degrees | | Significant Weather | Snow/Ice on Gnd(In) | | Precipitation (In) | | Pressure (inches of Hg) | | Wind Speed=mph Dir=tens of degrees | | | | | | | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Heating | Cooling | | 0600 LST | 1200 LST | 2400 LST | 2400 LST | Avg. Station | Avg. Sea level | Resultant Speed | Res Dir | Avg. Speed | max 5-sec | | max 2-min | | |
| | | | | | | | | | | Depth | Water Equiv | Snow Fall | Water Equiv | | | | | | Speed | Dir | Speed | Dir | |
| 01 | 80 | 60 | 70 | -1 | 58 | 63 | 0 | 5 | - | M | - | - | 0.00 | 29.95 | 30.01 | 3.6 | 24 | 6.9 | 17 | 23 | 15 | 22 | 01 |
| 02 | 84 | 62 | 73 | 1 | 59 | 62 | 0 | 8 | - | M | - | - | 0.00 | 29.97 | 30.03 | 4.8 | 21 | 5.8 | 21 | 21 | 16 | 21 | 02 |
| 03 | M | M | M | M | - | 52 | M | M | RA FG HZ | M | - | - | 0.07 | 29.92 | 30.00 | 4.4 | 22 | 6.0 | 22 | 29 | 17 | 30 | 03 |
| 04 | 80 | 69 | 75 | 3 | 69 | 71 | 0 | 10 | FG HZ | M | - | - | T | 29.77 | 29.86 | 5.3 | 24 | 6.0 | 14 | 24 | 13 | 23 | 04 |
| 05 | 87 | 67 | 77 | 5 | 56 | 64 | 0 | 12 | FG HZ | M | - | - | 0.00 | 29.73 | 29.81 | 7.3 | 36 | 8.7 | 23 | 31 | 18 | 31 | 05 |
| 06 | 75 | 60 | 68 | -5 | 51 | 59 | 0 | 3 | - | M | - | - | 0.00 | 29.80 | 29.90 | 3.6 | 5 | 7.9 | 16 | 2 | 14 | 2 | 06 |
| 07 | 77 | 61 | 69 | -4 | 49 | 58 | 0 | 4 | - | M | - | - | 0.00 | 29.90 | 29.96 | 10.0 | 36 | 10.4 | 25 | 2 | 18 | 1 | 07 |
| 08 | 79 | 56 | 68 | -5 | 50 | 58 | 0 | 3 | - | M | - | - | 0.00 | 30.00 | 30.07 | 7.9 | 34 | 9.6 | 26 | 33 | 21 | 33 | 08 |
| 09 | 80 | 59 | 70 | -3 | 60 | 64 | 0 | 5 | RA FG | M | - | - | 0.06 | 29.87 | 29.94 | 7.7 | 22 | 8.3 | 24 | 19 | 21 | 20 | 09 |
| 10 | 90* | 69 | 80* | 7 | 66 | 70 | 0 | 15 | RA FG HZ | M | - | - | 0.04 | 29.63 | 29.71 | 7.8 | 28 | 10.2 | 24 | 30 | 20 | 30 | 10 |
| 11 | 83 | 64 | 74 | 1 | 53 | 62 | 0 | 9 | - | M | - | - | 0.00 | 29.78 | 29.85 | 7.1 | 35 | 8.6 | 20 | 31 | 16 | 31 | 11 |
| 12 | 80 | 62 | 71 | -2 | 54 | 62 | 0 | 6 | - | M | - | - | 0.00 | 29.89 | 29.97 | 1.6 | 29 | 7.6 | 17 | 22 | 15 | 22 | 12 |
| 13 | 83 | 62 | 73 | -1 | 59 | 64 | 0 | 8 | - | M | - | - | 0.00 | 29.92 | 29.99 | 5.5 | 21 | 6.1 | 20 | 20 | 16 | 21 | 13 |
| 14 | 79 | 68 | 74 | 0 | 66 | 68 | 0 | 9 | - | M | - | - | T | 29.81 | 29.88 | 5.6 | 20 | 7.9 | 21 | 19 | 17 | 20 | 14 |
| 15 | 70 | 65 | 68 | -6 | 67 | 67 | 0 | 3 | TS TSRA RA FG | M | - | - | 1.57 | 29.71 | 29.77 | 11.3 | 14 | 11.7 | 30 | 14 | 23 | 15 | 15 |
| 16 | 77 | 65 | 71 | -3 | 67 | 69 | 0 | 6 | FG | M | - | - | T | 29.73 | 29.82 | 4.7 | 14 | 6.2 | 16 | 14 | 13 | 13 | 16 |
| 17 | 77 | 67 | 72 | -2 | 68 | 70 | 0 | 7 | FG HZ | M | - | - | 0.00 | 29.85 | 29.92 | 5.2 | 12 | 7.0 | 17 | 11 | 15 | 11 | 17 |
| 18 | 89 | 66 | 78 | 4 | 65 | 69 | 0 | 13 | FG HZ | M | - | - | 0.00 | 29.78 | 29.85 | 5.5 | 26 | 10.2 | 26 | 30 | 22 | 30 | 18 |
| 19 | 69 | 60 | 65* | -9 | 55 | 59 | 0 | 0 | - | M | - | - | 0.03 | 29.88 | 29.96 | 1.8 | 31 | 3.7 | 15 | 36 | 11 | 36 | 19 |
| 20 | 73 | 60 | 67 | -7 | 59 | 62 | 0 | 2 | - | M | - | - | 0.00 | 29.79 | 29.86 | 2.4 | 13 | 8.3 | 18 | 5 | 16 | 8 | 20 |
| 21 | 80 | 60 | 70 | -4 | 64 | 66 | 0 | 5 | FG HZ | M | - | - | T | 29.80 | 29.87 | 5.0 | 20 | 7.0 | 21 | 20 | 16 | 20 | 21 |
| 22 | 82 | 65 | 74 | 0 | 60 | 65 | 0 | 9 | FG HZ | M | - | - | T | 29.88 | 29.94 | 7.0 | 27 | 8.6 | 24 | 31 | 20 | 30 | 22 |
| 23 | 77 | 58 | 68 | -7 | 58 | 63 | 0 | 3 | - | M | - | - | 0.00 | 30.04 | 30.11 | 3.7 | 22 | 5.8 | 16 | 21 | 13 | 22 | 23 |
| 24 | 75 | 63 | 69 | -6 | 63 | 66 | 0 | 4 | - | M | - | - | 0.00 | 30.09 | 30.14 | 6.8 | 8 | 7.6 | 15 | 9 | 13 | 9 | 24 |
| 25 | 72 | 64 | 68 | -7 | 60 | 63 | 0 | 3 | FG | M | - | - | T | 30.16 | 30.21 | 8.5 | 8 | 9.6 | 18 | 9 | 16 | 8 | 25 |
| 26 | 68 | 63 | 66 | -9 | 65 | 65 | 0 | 1 | RA FG | M | - | - | 2.25 | 30.16 | 30.23 | 12.1 | 7 | 12.7 | 26 | 9 | 23 | 9 | 26 |
| 27 | 69 | 63 | 66 | -9 | 64 | 65 | 0 | 1 | RA FG | M | - | - | 0.33 | 30.01 | 30.10 | 9.8 | 5 | 10.0 | 20 | 5 | 15 | 5 | 27 |
| 28 | 72 | 63 | 68 | -7 | 63 | 65 | 0 | 3 | - | M | - | - | 0.00 | 30.00 | 30.06 | 2.0 | 3 | 5.4 | 13 | 2 | 10 | 2 | 28 |
| 29 | 72 | 66 | 69 | -6 | 66 | 67 | 0 | 4 | FG | M | - | - | 0.00 | 30.00 | 30.09 | 2.1 | 16 | 3.8 | 13 | 16 | 9 | 23 | 29 |
| 30 | 70 | 65 | 68 | -7 | 67 | 67 | 0 | 3 | RA FG | M | - | - | 0.51 | 30.07 | 30.13 | 7.3 | 9 | 7.4 | 15 | 8 | 14 | 9 | 30 |
| 31 | 69 | 65 | 67 | -8 | 67 | 67 | 0 | 2 | RA FG | M | - | - | 0.87 | 30.09 | 30.15 | 16.5 | 9 | 16.6 | 30 | 8 | 25 | 9 | 31 |
| | 77.3 | 63.2 | 70.3 | -------- | 60.9 | 64.3 | .0 | 5.5 | <Monthly Averages | Totals> | | | 5.73 | 29.90 | 29.97 | 0.8 | 9.4 | 8.1 | <Monthly Average | | | | |
| | -4.4 | -2.5 | -3.4 | -------- | <---------------------Departure From Normal----------------------> | | | | | | | | 1.95 | | | | | | | | | | |

| Degree Days | Monthly | | Season to Date | |
|---|---|---|---|---|
| | Total | Departure | Total | Departure |
| Heating: | 0 | 0 | | |
| Cooling: | 166 | -104 | | |

Greatest 24-hr Precipitation: 2.32date: 26-27
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| | Sea Level Pressure | Date | Time |
|---|---|---|---|
| Maximum: | 30.27 | 26 | 1129 |
| Minimum : | 29.66 | 10 | 1609 |

Number of Days with ----->
Max temp >= 90: M
Max temp <= 32: M
Thunderstorms : 1
Min temp <= 32: M
Min temp <= 0 : M
Heavy Fog : 0
Precipitation >= .01 inch: 0
Precipitation >= .10 inch : 0
Snowfall >= 1.0 inch : 0

UNEDITED LOCAL CLIMATOLOGICAL DATA
[NOAA, National Climatic Data Center] MONTH: 08/2000

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) | | | | | | Deg Days Base 65 Degrees | | Significant Weather | Snow/Ice on Gnd(In) | | Precipitation (In) | | Pressure (inches of Hg) | | Wind Speed=mph Dir=tens of degrees | | | | | | | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Heating | Cooling | | 0600 LST | 1200 LST | 2400 LST | 2400 LST | Avg. Station | Avg. Sea level | Resultant Speed | Res Dir | Avg. Speed | max 5-sec | | max 2-min | | |
| | | | | | | | | | | Depth | Water Equiv | Snow Fall | Water Equiv | | | | | | Speed | Dir | Speed | Dir | |
| 01 | 73 | 64 | 69 | -6 | 67 | 67 | 0 | 4 | RA FG | M | - | - | 0.43 | 29.98 | 30.06 | 5.9 | 8 | 7.0 | 21 | 9 | 17 | 9 | 01 |
| 02 | 80 | 69 | 75 | 0 | 72 | 72 | 0 | 10 | RA FG+ FG HZ | M | - | - | 0.02 | 29.90 | 29.97 | 2.8 | 17 | 5.9 | 15 | 23 | 11 | 21 | 02 |
| 03 | 79 | 68 | 74 | -1 | 72 | 72 | 0 | 9 | TS TSRA RA FG HZ | M | - | - | 0.88 | 29.89 | 29.96 | 7.1 | 22 | 8.2 | 23 | 32 | 20 | 31 | 03 |
| 04 | 78 | 69 | 74 | -1 | 63 | 67 | 0 | 9 | FG | M | - | - | 0.01 | 29.90 | 29.97 | 2.1 | 31 | 6.4 | 15 | 22 | 14 | 22 | 04 |
| 05 | 78 | 65 | 72 | -2 | 57 | 63 | 0 | 7 | - | M | - | - | 0.00 | 29.90 | 29.97 | 1.0 | 34 | 7.5 | 16 | 22 | 14 | 22 | 05 |
| 06 | 77 | 62 | 70 | -4 | 64 | 66 | 0 | 5 | FG | M | - | - | 0.07 | 29.93 | 30.00 | 6.5 | 21 | 8.1 | 29 | 21 | 23 | 20 | 06 |
| 07 | 88 | 72 | 80 | 6 | 72 | 74 | 0 | 15 | RA FG HZ | M | - | - | 0.15 | 29.80 | 29.88 | 10.1 | 24 | 10.4 | 20 | 24 | 17 | 24 | 07 |
| 08 | 88* | 72 | 80* | 6 | 69 | 72 | 0 | 15 | FG HZ | M | - | - | 0.00 | 29.81 | 29.91 | 7.3 | 24 | 7.7 | 20 | 28 | 16 | 23 | 08 |
| 09 | 85 | 73 | 79 | 5 | 71 | 73 | 0 | 14 | FG HZ | M | - | - | 0.01 | 29.76 | 29.85 | 6.7 | 23 | 7.2 | 22 | 25 | 15 | 24 | 09 |
| 10 | 83 | 69 | 76 | 2 | 68 | 71 | 0 | 11 | RA FG | M | - | - | 0.07 | 29.78 | 29.87 | 2.9 | 25 | 6.9 | 17 | 22 | 16 | 22 | 10 |
| 11 | 80 | 65 | 73 | -1 | 66 | 69 | 0 | 8 | TS TSRA RA FG | M | - | - | 3.99 | 29.81 | 29.90 | 5.9 | 7 | 7.7 | 30 | 36 | 24 | 36 | 11 |
| 12 | 73 | 64 | 69 | -5 | 61 | 64 | 0 | 4 | RA FG | M | - | - | 0.29 | 29.84 | 29.92 | 11.3 | 7 | 11.9 | 28 | 9 | 23 | 8 | 12 |
| 13 | M | M | M | M | - | - | M | M | - | M | - | - | 0.20 | 29.90 | 29.95 | 12.3 | 4 | 12.7 | 28 | 7 | 22 | 7 | 13 |
| 14 | M | M | M | M | - | - | M | M | TS TSRA RA FG HZ | M | - | - | 0.15 | 29.89 | 29.95 | 12.0 | 3 | 12.5 | 28 | 1 | 20 | 4 | 14 |
| 15 | 80 | 65 | 73 | 0 | 64 | 66 | 0 | 8 | FG | M | - | - | 0.00 | 29.92 | 29.99 | 4.9 | 4 | 7.0 | 20 | 2 | 15 | 3 | 15 |
| 16 | 85 | 64 | 75 | 2 | 60 | 66 | 0 | 10 | TS TSRA FG HZ | M | - | - | 0.07 | 29.78 | 29.85 | 8.1 | 28 | 9.7 | 28 | 29 | 23 | 29 | 16 |
| 17 | 76 | 59 | 68 | -5 | 53 | 59 | 0 | 3 | - | M | - | - | 0.00 | 29.90 | 29.98 | 4.2 | 32 | 6.4 | 21 | 29 | 16 | 29 | 17 |
| 18 | 68 | 59 | 64 | -9 | 58 | 60 | 1 | 0 | RA FG HZ | M | - | - | 0.05 | 29.86 | 29.95 | 4.1 | 5 | 6.8 | 16 | 21 | 13 | 20 | 18 |
| 19 | 77 | 59 | 68 | -5 | 54 | 60 | 0 | 3 | - | M | - | - | 0.00 | 29.92 | 30.01 | 9.1 | 36 | 9.5 | 21 | 1 | 16 | 1 | 19 |
| 20 | 72 | 57 | 65 | -8 | 46 | 55 | 0 | 0 | - | M | - | - | 0.00 | 30.10 | 30.18 | 7.8 | 35 | 8.4 | 25 | 1 | 20 | 1 | 20 |
| 21 | 75 | 53 | 64* | -9 | 49 | 56 | 1 | 0 | - | M | - | - | 0.00 | 30.20 | 30.27 | 5.0 | 36 | 6.6 | 18 | 30 | 15 | 31 | 21 |
| 22 | 75 | 56 | 66 | -6 | 54 | 59 | 0 | 1 | - | M | - | - | 0.00 | 30.21 | 30.28 | 4.0 | 20 | 6.1 | 15 | 24 | 13 | 23 | 22 |
| 23 | 74 | 65 | 70 | -2 | 62 | 65 | 0 | 5 | RA FG | M | - | - | 0.22 | 30.05 | 30.12 | 11.2 | 22 | 11.8 | 23 | 21 | 20 | 21 | 23 |
| 24 | 75 | 62 | 69 | -3 | 65 | 66 | 0 | 4 | FG+ FG HZ | M | - | - | 0.03 | 29.91 | 30.00 | 1.3 | 22 | 2.9 | 11 | 22 | 9 | 21 | 24 |
| 25 | 79 | 62 | 71 | -1 | 59 | 64 | 0 | 6 | - | M | - | - | 0.00 | 29.94 | 30.02 | 1.2 | 24 | 6.3 | 13 | 22 | 11 | 22 | 25 |
| 26 | 81 | 59 | 70 | -2 | 59 | 64 | 0 | 5 | - | M | - | - | 0.00 | 29.90 | 29.97 | 4.9 | 22 | 5.6 | 15 | 21 | 13 | 20 | 26 |
| 27 | 81 | 63 | 72 | 1 | 65 | 68 | 0 | 7 | FG HZ | M | - | - | 0.00 | 29.90 | 29.96 | 4.5 | 23 | 5.3 | 15 | 20 | 13 | 20 | 27 |
| 28 | 75 | 68 | 72 | 1 | 67 | 68 | 0 | 7 | FG+ FG HZ | M | - | - | 0.00 | 30.05 | 30.11 | 8.2 | 9 | 9.2 | 15 | 10 | 14 | 10 | 28 |
| 29 | 73 | 65 | 69 | -2 | - | - | 0 | 4 | - | M | - | - | 0.00 | 30.13 | 30.21 | 12.9 | 9 | 13.4 | 24 | 9 | 21 | 9 | 29 |
| 30 | 75 | 63 | 69 | -2 | 61 | 65 | 0 | 4 | - | M | - | - | 0.00 | 30.10 | 30.18 | 5.7 | 8 | 6.9 | 14 | 5 | 13 | 5 | 30 |
| 31 | 79 | 70 | 75 | 4 | 60 | 66 | 0 | 10 | FG+ FG HZ | M | - | - | 0.02 | 30.10 | 30.18 | 4.9 | 10 | 6.0 | 13 | 11 | 11 | 9 | 31 |
| | 78.0 | 64.2 | 71.1 | -------- | | | .1 | 6.5 | <Monthly Averages | Totals> | | | 6.66 | 29.94 | 30.01 | 0.6 | 3.7 | 8.0 | <Monthly Average | | | | |
| | -2.9 | -.9 | -2.0 | -------- | <---------------------Departure From Normal-----------------------> | | | | | | | | 3.41 | | | | | | | | | | |

**Degree Days** Monthly Season to Date

| | Monthly Total | Monthly Departure | Season to Date Total | Season to Date Departure |
|---|---|---|---|---|
| Heating: | 2 | 2 | | |
| Cooling: | 188 | -63 | | |

Greatest 24-hr Precipitation: 4.28date: 11-12
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: 0 date:

| Sea Level Pressure | | Date | Time |
|---|---|---|---|
| Maximum: | 30.33 | 22 | 0729 |
| Minimum : | 29.75 | 10 | 0237 |

Number of Days with ----->
Max temp >= 90: M
Max temp <= 32: M
Thunderstorms : 4
Min temp <= 32: M
Min temp <= 0 : M
Heavy Fog : 4
Precipitation >= .01 inch: 7
Precipitation >= .10 inch : 0
Snowfall >= 1.0 inch : 0

**UNEDITED LOCAL CLIMATOLOGICAL DATA**
**[NOAA, National Climatic Data Center] MONTH: 09/2000**

Station Location: BRIDGEPORT, CT (BDR)lat: 41° 10', lon: -73° 09'
Elev(Ground): 26 Feet Time Zone: WBAN: 94702

| date | Temperature (Fahrenheit) Max | Min | Avg. | Dep From Normal | Avg. Dew pt. | Avg Wet Bulb | Deg Days Base 65 Degrees Heating | Cooling | Significant Weather | Snow/Ice on Gnd(In) 0600 LST Depth | 1200 LST Water Equiv | Precipitation (In) 2400 LST Snow Fall | 2400 LST Water Equiv | Pressure (inches of Hg) Avg. Station | Avg. Sea level | Wind Speed=mph Dir=tens of degrees Resultant Speed | Res Dir | Avg. Speed | max 5-sec Speed | Dir | max 2-min Speed | Dir | date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 82 | 71 | 77* | 7 | 73 | 74 | 0 | 12 | RA FG+ FG | M | - | - | 0.05 | 30.05 | 30.11 | 2.1 | 18 | 3.8 | 11 | 21 | 9 | 23 | 01 |
| 02 | 81 | 71 | 76 | 6 | 74 | 74 | 0 | 11 | TS TSRA RA FG HZ | M | - | - | 0.45 | 29.90 | 29.98 | 3.3 | 22 | 4.6 | 17 | 2 | 15 | 2 | 02 |
| 03 | 75 | 71 | 73 | 3 | 73 | 73 | 0 | 8 | FG | M | - | - | 0.00 | 29.83 | 29.89 | 4.9 | 11 | 6.0 | 16 | 13 | 14 | 13 | 03 |
| 04 | 84 | 61 | 73 | 4 | 67 | 69 | 0 | 8 | RA FG HZ | M | - | - | T | 29.77 | 29.85 | 4.6 | 36 | 9.4 | 31 | 1 | 26 | 2 | 04 |
| 05 | 68 | 52 | 60 | -9 | 41 | 50 | 5 | 0 | - | M | - | - | 0.00 | 30.20 | 30.27 | 11.8 | 3 | 12.5 | 30 | 3 | 24 | 3 | 05 |
| 06 | 66 | 51 | 59* | -10 | 49 | 54 | 6 | 0 | - | M | - | - | 0.00 | 30.36 | 30.44 | 5.1 | 7 | 7.6 | 18 | 4 | 15 | 3 | 06 |
| 07 | 72 | 51 | 62 | -7 | 53 | 57 | 3 | 0 | - | M | - | - | 0.00 | 30.22 | 30.31 | 6.5 | 23 | 8.4 | 20 | 24 | 16 | 24 | 07 |
| 08 | 76 | 58 | 67 | -1 | 61 | 64 | 0 | 2 | - | M | - | - | 0.00 | 30.05 | 30.11 | 9.5 | 25 | 9.9 | 22 | 23 | 20 | 23 | 08 |
| 09 | 78 | 65 | 72 | 4 | 67 | 69 | 0 | 7 | FG HZ | M | - | - | T | 30.00 | 30.09 | 2.0 | 26 | 4.3 | 10 | 23 | 9 | 23 | 09 |
| 10 | 77 | 64 | 71 | 3 | 64 | 67 | 0 | 6 | FG | M | - | - | 0.00 | 30.10 | 30.17 | 4.8 | 9 | 6.9 | 14 | 9 | 11 | 9 | 10 |
| 11 | 75 | 64 | 70 | 3 | 65 | 67 | 0 | 5 | FG HZ | M | - | - | 0.00 | 30.08 | 30.16 | 3.8 | 13 | 5.8 | 16 | 16 | 13 | 17 | 11 |
| 12 | 81 | 69 | 75 | 8 | 69 | 71 | 0 | 10 | - | M | - | - | 0.00 | 29.92 | 29.99 | 9.3 | 21 | 9.8 | 23 | 22 | 20 | 22 | 12 |
| 13 | 79 | 62 | 71 | 4 | 63 | 66 | 0 | 6 | RA FG | M | - | - | 0.64 | 29.83 | 29.92 | 5.4 | 33 | 8.6 | 22 | 22 | 18 | 29 | 13 |
| 14 | 75 | 58 | 67 | 0 | 61 | 63 | 0 | 2 | - | M | - | - | 0.00 | 29.85 | 29.94 | 5.8 | 10 | 9.2 | 16 | 16 | 14 | 14 | 14 |
| 15 | 74 | 58 | 66 | -1 | 59 | 62 | 0 | 1 | TS TSRA RA FG | M | - | - | 0.92 | 29.56 | 29.64 | 5.9 | 28 | 9.2 | 22 | 16 | 18 | 30 | 15 |
| 16 | 68 | 53 | 61 | -5 | 46 | 52 | 4 | 0 | - | M | - | - | T | 29.77 | 29.84 | 7.9 | 31 | 9.1 | 23 | 30 | 20 | 30 | 16 |
| 17 | 70 | 49 | 60 | -5 | 48 | 54 | 5 | 0 | - | M | - | - | 0.00 | 29.93 | 30.00 | 10.4 | 26 | 11.2 | 28 | 23 | 24 | 23 | 17 |

-------- <Monthly Averages Totals> <Monthly Average

-------- <---------------------Departure From Normal----------------------->

**Degree Days** Monthly Season to Date
Total Departure Total Departure
Heating:
Cooling:

Greatest 24-hr Precipitation: date:
Greatest 24-hr Snowfall: date:
Greatest Snow Depth: date:

Sea Level Pressure Date Time
Maximum:
Minimum :

Number of Days with ----->
Max temp >= 90:
Max temp <= 32:
Thunderstorms : 2
Min temp <= 32:
Min temp <= 0 :
Heavy Fog : 1
Precipitation >= .01 inch:
Precipitation >= .10 inch :
Snowfall >= 1.0 inch : 0

Sept. 2000

**Harding Lawson Associates**
Engineering,
Environmental and
Construction Services

SHEET ______ OF ______
JOB NO. ______
DATE ______
PROJECT ______
COMPUTED BY ______
SUBJECT ______
CHECKED BY ______

Appendix

A.3 4.

'U.S. Coastal Pilot, Atlantic Coast ...'

(329) **Welches Point,** 0.8 mile westward of Pond Point, forms the east side of the entrance of The Gulf. A reef extends 0.3 mile southward from the point and is marked by a buoy.

(330) **The Gulf,** a bight between Welches Point and Charles Island, about 6.5 miles westward of New Haven Harbor entrance, affords anchorage in 6 to 15 feet and is sheltered in all but southerly and southeasterly winds. The entrance is clear. The shoaling is gradual, and soundings are the best guide on the northwest side of the bight; the western side of Welches Point and the reefs around Charles Island extending to the mainland should be approached with caution, as the shoaling is abrupt. The mean range of **tide** is about 6.6 feet.

(331) **Milford Harbor,** comprising the lower portion of the **Wepawaug River,** is entered at the mouth of the river between two jetties at the head of The Gulf. The westerly jetty extends southward from **Burns Point,** and the easterly jetty is marked by Milford Harbor Light 10. The harbor is used chiefly for recreational boating, and occasionally for the receipt of shellfish and fish. The National Marine Fisheries Service, U.S. Department of Commerce, maintains a laboratory and research vessel base on the west side of the harbor, about 0.2 mile northward of Burns Point.

(332) A dredged channel leads from The Gulf through the jettied entrance to a point about 400 feet above the town wharf, 0.6 mile above Burns Point. In November-December 1991, the controlling depths were 6½ feet (8 feet at midchannel) in the entrance channel and 8 feet in the anchorage basin along the west side of the channel except for lesser depths to 6 feet along the western edge. The channel is marked by a light and lighted and unlighted buoys.

(333) Milford Harbor has several small-craft facilities. (See the small-craft facilities tabulation on chart 12364 for services and supplies available.)

(334) A 5 mph **speed limit** is enforced in the harbor.

(335) **Charles Island,** on the southwest side at the entrance to The Gulf, is low and partly covered with trees. A white flagpole, barely visible over the trees, is on the island. The island is connected to the mainland by **The Bar,** a narrow neck about 0.5 mile long and surrounded by rocks awash and shoals. A buoy marks the end of a shoal that extends 250 yards east-northeastward from the island, and a lighted bell buoy marks the end of a rocky area that extends 0.4 mile southward from the island. Northward of Charles Island is a good anchorage in 10 to 16 feet, sheltered from southerly to southwesterly winds.

(336) Between Charles Island and **Stratford Point,** about 3 miles southwestward, several summer resorts are along the shore and the Housatonic River empties into Long Island Sound just above the point. The shoals which extend southward from Stratford Point toward Stratford Shoal Light (see chart 12354) consist of narrow ridges of hard sand with deeper water between, and have oyster beds marked with stakes. Depths of 12 feet or less extend 1 mile offshore.

(337) **Stratford Point Light** (41°09.1'N., 73°06.2'W.), 52 feet above the water, is shown from a white conical tower, with brown band midway of its height, from the southerly part of the point.

(338) **Chart 12370.–Housatonic River** rises in the Berkshire Hills of western Massachusetts and Connecticut, and empties into Long Island Sound about 10 miles southwestward of the New Haven Harbor entrance. The river is joined by the nonnavigable **Naugatuck River** in the vicinity of Derby, conn. Housatonic River is navigable to a point about 1 mile above Shelton, Conn., where it is closed by a power dam. The head of navigation for all practical purposes is at the towns of Derby and Shelton, 11.5 miles above the entrance. Small vessels can anchor in the river abreast of Stratford, where the channel has an available width of about 500 feet. The waterborne commerce on the river is principally in barge shipments of aggregate, fuel oil to the power plant at Devon, and seasonal commercial shellfishing. Navigation above Devon is limited to recreational boating.

(339) On the east side of the entrance to Housatonic River, a breakwater extends out from **Milford Point** across the bar and is marked at its south end by Housatonic River Breakwater Light 2A. The inner section of the breakwater is awash at high water.

(340) **Channels.–**A Federal project provides for an 18-foot dredged channel from Long Island Sound between the breakwater on the east and Stratford Point on the west upriver for about 4.3 miles to the lower end of Culver Bar. (See Notice to Mariners and the latest editions of the charts for controlling depths.) Above the lower end of Culver Bar, the river channel extends through several dredged sections across river bars to the towns of Derby and Shelton about 11.5 miles above the river entrance. In 1976-1978, the controlling depth was 5 feet (5½ feet at midchannel) to Camp Meeting Bar, 7.1 miles above the channel entrance, thence 2 feet to Twomile Island Bar, thence 1 foot (5½ feet at midchannel) across the bar, and thence 3 feet (5½ feet at midchannel) to Derby and Shelton. In September 1978, shoaling to 3 feet was reported in the channel across Mill Bar. The channel is marked to a point about 2.5 miles below Derby and Shelton.

(341) **Stratford** is a town on the west side of the river 2.3 miles above the entrance. The principal wharf has a depth of about 9 feet at its end. The **harbormaster** at Stratford controls anchorages and moorings, and has jurisdiction from the entrance of the river to the Shelton town line. Harbor regulations may be obtained from the harbormaster who may be contacted through the Stratford police or at the Town Hall.

(342) Stratford has several small-craft facilities. (See the small-craft facilities tabulation on chart 12364 for services and supplies available.)

(343) **Devon** is on the east side about 1 mile above Stratford. Local small craft anchor near the east bank of the river, just north of the highway bridge, in depths up to 10 feet. A 40-foot marine railway at a small–craft facility at Devon can haul out craft for engine and hull repairs; gasoline, water, ice, marine supplies, and storage are available. In July 1981, depths of 4 feet were reported alongside the facility.

(344) **Shelton,** a town on the west side of the river about 11.5 miles above the entrance is connected to **Derby** by two bridges; the town has several important factories. In 1971, the wharves at Derby and Shelton were in ruins and unsuitable for craft of any size.

(345) **Bridges.–**About 1 mile above Stratford is U.S. Route 1 highway bridge with a bascule span having a clearance of 32 feet. Two bridges cross the river about 0.3 mile farther up: the first, Interstate Route 95 fixed highway bridge, has a clearance of 65 feet, and the second, a railroad bridge with a bascule span, has a clearance of 19 feet. The bridgetenders of the U.S. Route 1 bridge and the railroad bridge monitor VHF-FM channel 13; call signs KXJ-695 and KU-6035, respectively. An overhead power cable with a clearance of 135 feet crosses at the railroad bridge. Other cables, near **Pecks Mill,** 1.5 miles above, have minimum clearance of 79 feet.

(346) The fixed highway bridge about 3.7 miles above Stratford has a clearance of 85 feet. At Shelton, two fixed highway bridges and a fixed railroad bridge have a least clearance of 17 feet. In April 1983, the railroad bridge suffered severe structural damage. The area should be avoided, but if transit is necessary, extreme caution should be exercised.

(347) **(See 117.1 through 117.59 and 117.207,** chapter 2, for drawbridge regulations.)

(348) **Tides.**–The mean range of tide is 5.5 feet at Stratford and 5 feet at Shelton. The time of the tide becomes later and the range diminishes in progressing up the river. At Stratford the tide is about 0.8 hour later than at the entrance whereas at Shelton high water is about 1.8 hours later and low water about 2.8 hours later than at the entrance. The river water is fresh about 6 miles above the entrance.

(349) **Currents.**–At the entrance near the end of the breakwater the flood has a strong westerly set. Between Milford Point and **Crimbo Point,** flood and ebb have a velocity of about 1.2 knots. The flood sets about 330° and the ebb 135°. Just north of the draw of the railroad bridge above Stratford, the velocity of flood is 1.1 knots and of ebb, 1.3 knots. In the openings of the bridge the flood current has some easterly set, but the ebb sets fair with the openings. Between that bridge and Shelton the tidal current has a velocity of about 1 knot. Because of the drainage flow of the river, the ebb is usually greater and the flood less than 1 knot. (Consult the Tidal Current Tables for current predictions and further details.)

(350) Spring **freshets** at Shelton rise 10 feet or more above mean high tide.

(351) **Ice** closes the river above Stratford during the winter and sometimes extends to the entrance.

(352) **Routes.**–The channel in Housatonic River is narrow and crooked, with little depth on either side, and across the bars in the channel are dredged cuts 100 feet wide. The tidal currents are strong, especially in the lower part of the river, and strangers are advised to take a pilot. Small craft, without a pilot, should proceed with caution and preferably on a rising tide.

(353) When entering the river during a flood current, care must be taken to avoid being set on the shoals on the west side by strong westerly currents. In the vicinity of Milford Point care should be exercised to avoid a shoal that reportedly extends from Milford Point to the eastern edge of the channel. Care should also be exercised off the extreme northern end of Nells Island as a shoal is reported to have encroached into the channel. By steering a midchannel course no difficulty should be encountered.

(354) **Pilots** and **tugs** can be obtained at New Haven.

(355) A 5 mph **speed limit** is enforced on the river near anchorage and mooring areas and near boat slips.

(356) **Chart 12354.–Stratford Shoal Middle Ground,** 5.4 miles south of Stratford Point and covered 4½ to 18 feet, is marked by **Stratford Shoal (Middle Ground) Light** (41°03.6′ N., 73°06.1′W.), 60 feet above the water and shown from a gray granite octagonal tower projecting from a house on a pier, and by buoys that mark the outer ends of shoal areas extending 1 mile north, 0.9 mile northeast, and 0.5 mile south of the light. A fog signal is at the light.

(357) **North Shore of Long Island.**–From Orient Point (41°09.6′N., 72°14.0′W.), for about 11 miles to Horton Point, the south shore of Long Island Sound is generally bluff and rocky. The 10-fathom curve is from 0.3 to 0.8 mile from shore, and the shoaling is generally abrupt. The outlying dangers are Orient Shoal and the rocky patch northward of Horton Point.

(358) The prominent features are Browns Hills, a tower at Rocky Point, a tank and television tower at Greenport, and Horton Point Light.

(359) Several rocky shoals, including **Orient Shoal** with a least depth of 7 feet, are offshore in the vicinity of **Rocky Point,** about 5 miles westward of Orient Point. The north end of Orient Shoal is marked by a buoy.

(360) **Horton Point Light** (41°05.1′ N., 72°26.8′W.), 103 feet above the water, is shown from a white square tower attached to a dwelling on the northwest part of the point. The former lighthouse tower is close by, southwestward of the present light.

(361) A rocky shoal with a least found depth of 26 feet is 1.6 miles northward of Horton Point. The shoal is a ridge having a northeast-southwest direction, with abrupt shoaling on its northwest and southeast sides.

(362) From Horton Point for about 32 miles to Old Field Point, the shore is fringed with shoals that extend off a greatest distance of 1.5 miles and rise abruptly from the deep water of Long Island Sound. Boulders are found near the shore on the shoals which extend off 0.5 mile in places. A sand shoal, about 0.5 mile in extent with a least depth of 26 feet, is about 1.1 miles northwestward of Duck Pond Point.

(363) The bluffs begin about 1 mile westward of Goldsmith Inlet and reach their greatest elevation just eastward of **Duck Pond Point.** A valley, formed by a break in the bluffs, is just westward of the point; a bathing pavilion is on the beach. Boulders that bare at low water are on the shoals that fringe the shore between Duck Pond Point and Mattituck Inlet.

(364) **Chart 12358.–Mattituck Inlet,** 6.7 miles southwestward of Horton Point Light, is entered between two short jetties. The inlet is marked by a long break in the bluffs, and numerous storage tanks inside the inlet are prominent. The outer end of the west jetty is marked by a light. A gong buoy about 1 mile north of the jetty light marks the entrance of the inlet. The sides of the channel are sandy, and, although shoaling is liable to occur at the entrance, strangers can enter the inlet without great danger. In September 1987, the controlling depth was 4 feet (6 feet at midchannel) from the entrance for about 1.8 miles to the turning basin at Mattituck with 7 feet available in the basin. The channel is marked by buoys and private markers. The overhead power cable about 1 mile above the entrance has a clearance of 78 feet.

(365) The **tidal currents** have an estimated velocity of about 3 knots in the narrow parts of the entrance of Mattituck Inlet. Slack waters occur possibly 1 hour after the time of high and low water. With northerly and westerly winds, the sea is rough in the entrance. The mean range of **tide** is 5.2 feet at the entrance. The inlet is sometimes closed by **ice** during portions of cold winters.

(366) Several marinas and a boatyard are inside the inlet. A 70-ton mobile hoist at the boatyard can haul out craft for engine, hull, and radio repairs. Marine supplies, gasoline, diesel fuel, water, and covered and wet storage can be obtained. A transient dock, operated by the Mattituck Park Commission, is at the head of the inlet; depths of about 6 feet are at the dock. A **dockmaster** is at the dock; water is available.

(367) **Mattituck** is a village on the railroad at the head of the inlet. Provisions can be obtained.

(368) **Jacobs Point** is about 11 miles southwestward of Horton Point Light. An aquaculture site, marked by private buoys, is about 1.4 miles west-northwest of Jacobs Point.

(369) **Offshore Terminal, Northville-Riverhead.**–An offshore platform for the delivery and receipt of petroleum products is in open roadstead, off Northville, NY (and Riverhead, NY), about 1.2 miles northward of Jacobs Point. It is owned and operated by Northville Industries Corporation, Riverhead, NY.

(370) A safety zone surrounds the offshore facility. (See **166.155,** chapter 2, for limits and regulations.

## CLIMATOLOGICAL TABLE

### BRIDGEPORT, CT (41° 10'N,073° 08'W) Elevation 26 feet (7.9 m)

| WEATHER ELEMENTS | JAN. | FEB. | MAR. | APR. | MAY | JUNE | JUL. | AUG. | SEP. | OCT. | NOV. | DEC. | YEAR | YEARS OF RECORD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SEA LEVEL PRESSURE | | | | | | | | | | | | | | |
| Mean (Millibars)........................... | 1018.0 | 1017.5 | 1016.0 | 1014.9 | 1016.0 | 1015.1 | 1015.8 | 1016.9 | 1018.9 | 1019.5 | 1018.1 | 1018.7 | 1017.1 | 40 |
| TEMPERATURE (DEGREES F) | | | | | | | | | | | | | | |
| Mean ..................................... | 30.1 | 31.3 | 38.7 | 48.9 | 58.8 | 68.2 | 74.2 | 73.0 | 65.9 | 55.7 | 45.6 | 34.6 | 52.2 | 47 |
| Mean Daily Maximum ........................ | 36.8 | 38.3 | 46.0 | 57.1 | 67.3 | 76.7 | 82.2 | 80.9 | 74.0 | 64.0 | 52.9 | 41.3 | 59.9 | 47 |
| Mean Daily Minimum......................... | 22.8 | 23.8 | 30.8 | 40.1 | 49.9 | 59.3 | 65.7 | 64.7 | 57.2 | 46.9 | 37.8 | 27.4 | 44.0 | 47 |
| Extreme Highest............................ | 65 | 67 | 84 | 91 | 92 | 96 | 103 | 100 | 99 | 85 | 78 | 65 | 103 | 47 |
| Extreme Lowest............................. | 7 | 5 | 4 | 18 | 31 | 41 | 49 | 44 | 36 | 26 | 16 | 4 | 7 | 47 |
| RELATIVE HUMIDITY | | | | | | | | | | | | | | |
| Average Percentage......................... | 55.3 | 50.0 | 34.5 | 24.4 | 35.2 | 26.4 | 33.4 | 43.8 | 63.5 | 69.9 | 55.8 | 62.4 | 46.5 | 47 |
| CLOUD COVER | | | | | | | | | | | | | | |
| Percent of time Clear...................... | 24.5 | 25.2 | 23.5 | 20.9 | 17.8 | 18.6 | 16.6 | 19.4 | 23.5 | 28.8 | 22.8 | 24.2 | 22.2 | 32 |
| Percent of time Scattered.................. | 14.8 | 15.5 | 15.2 | 15.5 | 17.3 | 20.6 | 22.7 | 23.9 | 20.2 | 19.2 | 17.3 | 15.3 | 18.1 | 32 |
| Percent of time Broken..................... | 13.4 | 13.0 | 14.3 | 16.3 | 17.8 | 19.8 | 22.5 | 20.6 | 17.2 | 15.8 | 14.3 | 12.8 | 16.5 | 32 |
| Percent of time Overcast................... | 43.2 | 42.0 | 42.9 | 41.7 | 41.2 | 34.7 | 31.8 | 29.8 | 33.4 | 31.4 | 40.7 | 43.6 | 38.0 | 32 |
| PRECIPITATION | | | | | | | | | | | | | | |
| Mean Amount (inches)....................... | 3.18 | 2.92 | 3.81 | 3.66 | 3.65 | 3.01 | 3.53 | 3.75 | 3.14 | 3.24 | 3.75 | 3.51 | 41.14 | 47 |
| Greatest Amount (inches)................... | 11.20 | 6.65 | 9.40 | 10.72 | 9.53 | 17.70 | 12.84 | 13.29 | 7.42 | 10.72 | 10.22 | 7.87 | 73.93 | 47 |
| Least Amount (inches)...................... | 0.40 | 0.43 | 0.69 | 0.69 | 0.41 | 0.07 | 0.47 | 0.72 | 0.43 | 0.33 | 0.36 | 0.33 | 23.01 | 47 |
| Maximum in 24 hrs. (inches)................ | 4.30 | 2.30 | 4.20 | 3.15 | 3.21 | 6.18 | 5.95 | 4.66 | 4.46 | 4.76 | 3.12 | 3.69 | 6.18 | 47 |
| Mean Number of Days with Precipitation..... | 17 | 16 | 17 | 17 | 17 | 15 | 14 | 14 | 13 | 13 | 16 | 17 | 186 | 39 |
| Mean Snowfall Amount (inches).............. | 7.4 | 7.7 | 4.8 | 0.4 | T | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 4.9 | 25.9 | 47 |
| Greatest Snowfall Amount (inches).......... | 26.2 | 27.9 | 21.8 | 6.0 | T | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 6.6 | 20.8 | 59.8 | 47 |
| Least Snowfall Amount (inches)............. | 0.5 | T | T | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T | 6.8 | 47 |
| Maximum Snowfall in 24 hrs. (inches)....... | 15.7 | 15.9 | 11.1 | 6.0 | T | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 6.2 | 15.0 | 15.9 | 47 |
| Mean Number of Days with Snow.............. | 11 | 10 | 8 | 2 | Miss | 0 | 0 | 0 | 0 | Miss | 2 | 9 | 42 | 39 |
| WIND | | | | | | | | | | | | | | |
| Percent of Observations with Gales (>34kts) | 0.21 | 0.21 | 0.15 | 0.09 | 0.02 | 0.02 | 0.00 | 0.04 | 0.06 | 0.12 | 0.16 | 0.13 | 0.15 | 40 |
| Mean Wind Speed (Knots).................... | 11.0 | 11.4 | 11.4 | 11.0 | 9.9 | 9.1 | 8.6 | 8.6 | 9.5 | 10.1 | 10.7 | 10.9 | 10.2 | 40 |
| Direction (percentage of Obs.) | | | | | | | | | | | | | | |
| North...................................... | 7.7 | 7.7 | 7.9 | 6.1 | 4.9 | 4.4 | 4.7 | 5.9 | 7.8 | 8.5 | 7.7 | 8.4 | 6.8 | 40 |
| North Northeast............................ | 5.1 | 5.2 | 4.7 | 4.0 | 3.6 | 3.3 | 3.3 | 5.0 | 7.0 | 6.6 | 5.9 | 5.6 | 4.9 | 40 |
| Northeast.................................. | 7.9 | 7.0 | 6.3 | 5.2 | 5.3 | 4.0 | 3.6 | 5.4 | 8.2 | 8.9 | 8.3 | 8.7 | 6.6 | 40 |
| East Northeast............................. | 5.6 | 6.4 | 6.9 | 6.5 | 6.8 | 4.3 | 3.3 | 3.7 | 4.7 | 4.7 | 4.5 | 5.3 | 5.2 | 40 |
| East....................................... | 2.9 | 4.5 | 6.8 | 7.1 | 9.0 | 6.6 | 4.6 | 4.3 | 4.3 | 4.0 | 3.2 | 2.4 | 4.9 | 40 |
| East Southeast............................. | 1.4 | 2.1 | 3.6 | 4.4 | 5.4 | 5.0 | 4.3 | 3.7 | 3.7 | 2.9 | 2.1 | 1.5 | 3.3 | 40 |
| Southeast.................................. | 0.9 | 1.5 | 2.1 | 2.8 | 3.4 | 3.9 | 3.4 | 3.4 | 3.1 | 2.4 | 1.8 | 1.2 | 2.5 | 40 |
| South Southeast............................ | 0.8 | 1.0 | 1.6 | 2.6 | 3.3 | 3.5 | 4.2 | 3.8 | 3.4 | 2.5 | 1.7 | 1.3 | 2.5 | 40 |
| South...................................... | 1.5 | 2.1 | 3.0 | 4.8 | 5.6 | 6.4 | 7.3 | 7.1 | 5.3 | 3.9 | 2.9 | 1.7 | 4.3 | 40 |
| South Southwest............................ | 2.0 | 2.4 | 3.9 | 5.6 | 7.5 | 8.8 | 10.6 | 9.1 | 6.6 | 4.2 | 3.3 | 2.0 | 5.5 | 40 |
| Southwest.................................. | 4.7 | 5.8 | 7.0 | 9.2 | 10.7 | 15.0 | 15.3 | 14.1 | 10.8 | 8.4 | 6.4 | 4.4 | 9.3 | 40 |
| West Southwest............................. | 8.4 | 8.3 | 6.6 | 8.6 | 10.4 | 13.4 | 13.6 | 11.1 | 8.2 | 8.6 | 8.7 | 7.7 | 9.5 | 40 |
| West....................................... | 12.3 | 9.3 | 6.8 | 6.6 | 5.6 | 6.3 | 6.6 | 6.2 | 5.9 | 8.7 | 10.8 | 11.9 | 8.1 | 40 |
| West Northwest............................. | 13.4 | 11.1 | 9.1 | 7.6 | 4.6 | 4.0 | 4.3 | 4.3 | 5.6 | 8.2 | 11.6 | 13.4 | 8.2 | 40 |
| Northwest.................................. | 13.4 | 12.9 | 11.4 | 8.6 | 5.9 | 4.7 | 4.6 | 5.1 | 6.4 | 7.9 | 10.2 | 11.5 | 8.6 | 40 |
| North Northwest............................ | 9.3 | 10.0 | 9.9 | 8.0 | 5.6 | 4.5 | 4.6 | 5.3 | 6.4 | 7.6 | 8.3 | 9.6 | 7.4 | 40 |
| Calm....................................... | 3.0 | 3.1 | 2.5 | 2.4 | 2.4 | 2.2 | 2.1 | 2.8 | 2.6 | 2.4 | 2.6 | 3.5 | 2.6 | 40 |
| Direction (Mean Speed, knots) | | | | | | | | | | | | | | |
| North...................................... | 9.9 | 10.5 | 11.2 | 10.8 | 9.7 | 9.1 | 7.7 | 7.5 | 8.4 | 9.2 | 8.8 | 9.5 | 9.4 | 40 |
| North Northeast............................ | 10.0 | 10.9 | 10.7 | 10.2 | 10.2 | 9.0 | 7.7 | 8.2 | 9.1 | 9.2 | 9.2 | 9.5 | 9.5 | 40 |
| Northeast.................................. | 10.8 | 11.3 | 11.1 | 11.1 | 10.2 | 9.5 | 8.1 | 8.7 | 9.9 | 10.4 | 10.3 | 10.9 | 10.3 | 40 |
| East Northeast............................. | 10.6 | 12.2 | 12.3 | 12.4 | 10.5 | 10.3 | 9.1 | 9.5 | 11.0 | 11.4 | 11.1 | 10.8 | 11.1 | 40 |
| East....................................... | 9.6 | 10.8 | 12.0 | 11.5 | 10.4 | 9.1 | 8.3 | 9.2 | 10.3 | 10.7 | 11.4 | 9.7 | 10.4 | 40 |
| East Southeast............................. | 8.9 | 9.7 | 9.9 | 10.6 | 9.1 | 9.1 | 8.5 | 9.4 | 10.1 | 10.6 | 11.1 | 11.2 | 9.7 | 40 |
| Southeast.................................. | 8.6 | 9.1 | 9.0 | 6.7 | 8.6 | 8.0 | 8.0 | 8.1 | 9.4 | 9.5 | 10.9 | 9.4 | 8.8 | 40 |
| South Southeast............................ | 8.2 | 9.8 | 9.4 | 8.9 | 8.3 | 7.7 | 7.7 | 7.8 | 8.9 | 9.1 | 10.1 | 10.3 | 8.6 | 40 |
| South...................................... | 8.5 | 8.9 | 9.0 | 9.3 | 9.2 | 8.6 | 8.4 | 8.0 | 8.8 | 8.7 | 9.3 | 9.2 | 8.7 | 40 |
| South Southwest............................ | 10.8 | 9.1 | 10.8 | 11.2 | 10.6 | 9.7 | 9.6 | 9.4 | 10.3 | 10.8 | 12.4 | 11.0 | 10.2 | 40 |
| Southwest.................................. | 10.7 | 10.6 | 10.5 | 10.8 | 10.2 | 9.4 | 9.3 | 9.4 | 10.6 | 11.3 | 11.9 | 11.8 | 10.3 | 40 |
| West Southwest............................. | 11.6 | 10.9 | 10.4 | 10.1 | 9.6 | 8.9 | 8.8 | 9.4 | 10.4 | 11.4 | 11.4 | 11.8 | 10.2 | 40 |
| West....................................... | 12.2 | 11.6 | 11.5 | 10.1 | 9.0 | 8.3 | 7.8 | 8.1 | 9.4 | 10.6 | 11.6 | 11.9 | 10.5 | 40 |
| West Northwest............................. | 12.6 | 13.6 | 14.0 | 11.4 | 11.4 | 10.4 | 9.2 | 8.9 | 9.6 | 10.8 | 12.0 | 12.5 | 12.0 | 40 |
| Northwest.................................. | 12.6 | 13.7 | 13.9 | 14.0 | 12.5 | 11.3 | 9.5 | 9.5 | 9.7 | 10.8 | 11.6 | 12.2 | 12.2 | 40 |
| North Northwest............................ | 11.6 | 12.4 | 12.7 | 12.5 | 11.2 | 10.5 | 9.3 | 8.8 | 9.3 | 10.1 | 10.8 | 11.4 | 11.1 | 40 |
| VISIBILITY | | | | | | | | | | | | | | |
| Mean Number of Days with Fog | 12 | 12 | 14 | 14 | 16 | 16 | 16 | 17 | 15 | 14 | 13 | 13 | 172 | 39 |
| Percent Obs with Visibility <= 1/2 mile.... | 2.16 | 2.55 | 2.30 | 1.81 | 2.66 | 1.88 | 0.86 | 0.35 | 0.38 | 0.86 | 0.93 | 1.87 | 1.54 | 40 |

$\sigma_{15}$ = specific gravity @ 59°F

$19 = (\rho_{15} - 1)1000$

$\therefore \rho_{15} = 1.019$

D = 62.4 pcf × 1.019 = 63.6 pcf

∴ use $\boxed{64 \text{ pcf}}$ for engineering analysis/design

### MEAN SURFACE WATER TEMPERATURES (T) AND DENSITIES (D)

| Stations | Years | Jan | | Feb | | Mar | | Apr | | May | | June | | July | | Aug | | Sept | | Oct | | Nov | | Dec | | Mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (T) °C | (D) $\sigma_{15}$ | (T) °C | (D) $\sigma_{15}$ | (T) °C | (D) $\sigma_{15}$ | (T) °C | (D) $\sigma_{15}$ | (T) °C | (D) $\sigma_{15}$ | (T) °C | (D) $\sigma_{15}$ | (T) °C | (D) $\sigma_{15}$ | (T) °C | (D) $\sigma_{15}$ | (T) °C | (D) $\sigma_{15}$ | (T) °C | (D) $\sigma_{15}$ | (T) °C | (D) $\sigma_{15}$ | (T) °C | (D) $\sigma_{15}$ | (T) °C | (D) $\sigma_{15}$ |
| Cape Cod Canal (E. ent.), Mass. (41°46'N., 70°30'W.) | 16 | 1.1 | 23.5 | 0.4 | 23.5 | 1.8 | 23.4 | 5.3 | 23.3 | 9.4 | 23.1 | 12.8 | 23.2 | 14.7 | 23.4 | 16.2 | 23.4 | 15.9 | 23.4 | 13.3 | 23.5 | 9.4 | 23.4 | 4.7 | 23.5 | 8.8 | 23.4 |
| Cape Cod Canal (W. ent.), Mass. (41°44'N., 70°37'W.) | 15 | 0.8 | 23.2 | 0.4 | 23.2 | 2.2 | 23.1 | 6.1 | 22.9 | 10.4 | 22.9 | 15.0 | 23.0 | 17.6 | 23.2 | 18.7 | 23.3 | 17.4 | 23.3 | 13.9 | 23.3 | 9.6 | 23.2 | 4.3 | 23.2 | 9.7 | 23.2 |
| Woods Hole, Mass. (41°31'N., 70°40'W.) | 27 | 1.2 | 23.2 | 0.5 | 23.2 | 2.4 | 23.1 | 6.8 | 23.2 | 11.8 | 23.3 | 17.0 | 23.5 | 20.9 | 23.6 | 21.6 | 23.5 | 19.7 | 23.6 | 15.6 | 23.6 | 10.5 | 23.5 | 4.9 | 23.3 | 11.1 | 23.4 |
| Newport, R.I. (41°30'N., 71°20'W.) | 16 | 2.3 | 22.7 | 1.6 | 22.5 | 3.1 | 22.5 | 6.3 | 22.3 | 10.9 | 22.8 | 16.3 | 23.1 | 19.8 | 23.5 | 20.6 | 23.4 | 18.6 | 23.5 | 15.3 | 23.4 | 11.3 | 23.1 | 5.8 | 22.9 | 11.0 | 23.0 |
| New London, Conn. (41°22'N., 70°06'W.) | 24 | 2.8 | 13.6 | 2.4 | 12.4 | 4.3 | 10.1 | 9.3 | 9.2 | 14.3 | 10.4 | 19.2 | 13.9 | 22.1 | 17.4 | 22.5 | 18.7 | 20.3 | 19.2 | 16.2 | 18.7 | 10.9 | 16.2 | 5.5 | 14.1 | 12.5 | 14.5 |
| Bridgeport, Conn. (41°10'N., 73°11'W.) | 7 | 3.9 | 19.5 | 3.6 | 18.4 | 5.8 | 18.1 | 10.1 | 17.7 | 15.7 | 17.6 | 21.7 | 18.0 | 24.8 | 19.1 | 26.3 | 19.8 | 24.4 | 19.9 | 19.6 | 20.1 | 13.9 | 20.0 | 8.0 | 19.7 | 14.8 | 19.0 |
| Plum Island (L.I. Sound), N.Y. (41°10'N., 72°12'W.) | 10 | 2.9 | 21.6 | 1.3 | 21.6 | 2.4 | 21.4 | 5.6 | 20.9 | 9.7 | 20.8 | 14.6 | 21.3 | 18.8 | 21.8 | 20.3 | 22.2 | 19.3 | 24.7 | 15.8 | 22.4 | 11.5 | 22.0 | 6.4 | 21.8 | 10.7 | 21.9 |
| Montauk (Fort Pond Bay), N.Y. (41°03'N., 71°58'W.) | 23 | 2.2 | 22.5 | 1.5 | 22.4 | 3.1 | 22.3 | 6.6 | 21.7 | 10.8 | 21.8 | 16.1 | 22.2 | 20.1 | 22.6 | 21.1 | 22.8 | 19.6 | 23.1 | 15.9 | 23.1 | 11.0 | 22.9 | 5.7 | 22.6 | 11.1 | 22.5 |
| Willets Point (E. River), N.Y. (40°48'N., 73°47'W.) | 39 | 1.9 | 18.8 | 1.0 | 18.5 | 2.8 | 18.3 | 7.0 | 17.7 | 12.2 | 17.7 | 17.1 | 18.1 | 20.3 | 18.6 | 22.1 | 19.1 | 21.2 | 19.2 | 16.8 | 19.0 | 11.1 | 19.0 | 5.1 | 18.8 | 11.6 | 18.6 |
| New York (The Battery), N.Y. (40°42'N., 74°01'W.) | 44 | 2.8 | 15.5 | 2.0 | 15.4 | 3.7 | 13.6 | 7.6 | 12.1 | 12.9 | 13.7 | 18.3 | 15.7 | 21.9 | 17.0 | 22.9 | 17.5 | 21.4 | 17.5 | 16.8 | 17.3 | 11.4 | 16.2 | 6.0 | 15.3 | 12.3 | 15.6 |
| Bear Mountain (Hudson R.), N.Y. (41°19'N., 73°59'W.) | 5 | 0.7 | −0.6 | 0.4 | −0.8 | 1.8 | −0.7 | 7.6 | −0.8 | 14.1 | −0.9 | 20.6 | −0.8 | 24.2 | −0.4 | 25.2 | −0.2 | 23.8 | 0.2 | 17.8 | 0.0 | 10.8 | −0.5 | 3.8 | −0.5 | 12.6 | −0.5 |
| New York (Fort Hamilton), N.Y. (40°37'N., 74°02'W.) | 12 | 2.1 | 16.6 | 1.2 | 17.3 | 2.4 | 14.8 | 8.5 | 12.5 | 11.8 | 15.2 | 17.0 | 17.0 | 20.8 | 18.1 | 21.8 | 19.0 | 19.8 | 18.7 | 15.3 | 17.9 | 9.8 | 16.8 | 4.9 | 16.5 | 11.1 | 16.7 |
| Sandy Hook, N.J. (40°28'N., 74°01'W.) | 33 | 1.4 | 17.0 | 1.4 | 16.9 | 4.1 | 15.9 | 9.1 | 14.9 | 14.6 | 16.2 | 20.2 | 17.7 | 23.4 | 19.0 | 23.5 | 19.1 | 20.8 | 19.2 | 15.1 | 19.1 | 9.4 | 18.4 | 3.8 | 17.5 | 12.2 | 17.6 |

F (Fahrenheit) = 1.8C (Celsius) + 32

Density as used in this table is the specific gravity of the sea water or the ratio between the weight of a sea-water sample and the weight of an equal volume of distilled water at 15°C (59°F). These figures representing density at 15°C ( $\rho_{15}$ ) are expressed in terms of sigma-t ( $\sigma_t$ ) where t = 15°C and $\sigma_{15}$ = ( $\rho_{15}$ − 1) 1000. Thus, for $\rho_{15}$ = 1.0238, $\sigma_{15}$ = 23.8.

**Harding Lawson Associates**
Engineering,
Environmental and
Construction Services

PROJECT Stratford Causeway
SUBJECT
SHEET OF
JOB NO.
DATE
COMPUTED BY
CHECKED BY

Appendix
A3 5. & 6.
(hard copy not included)

SHEET ______ OF ______

JOB NO. ______

DATE ______

PROJECT ______

SUBJECT ______

COMPUTED BY ______

CHECKED BY ______

Appendix

A.3 7.

"Downloaded Benchmark Publication..."

CONNECTICUT 846 7150

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

# TIDAL BENCH MARKS

## BRIDGEPORT, BRIDGEPORT HARBOR

LATITUDE: 41ø 10.4' N LONGITUDE: 73ø 10.9' W
NOAA CHART: 12369 USGS QUAD: BRIDGEPORT

To reach the tidal bench marks from eastbound Interstate 95, take the east Main Street exit, proceed south on east Main Street for 0.1 mile (0.2 km), proceed left onto Stratford Avenue for 0.1 mile (0.2 km), and right on Pembroke Street to Pauls Diesel Repair. The bench marks are located within a 1 mile (1.6 km) radius of the tide station. The tide house is at the end of the pier.

..................................................................................

### BENCH MARK STAMPING: 14 1942

MONUMENTATION: Survey Disk VM#: 250
AGENCY: PID#: LX0852
SETTING CLASSIFICATION: Granite Step

The bench mark is set in the granite step at the United Illuminating Company main entrance at 1115 Broad Street, 61 feet (19 m) north of the centerline of Cannon Street, 39.0 feet (11.9 m) north of the SE corner of the United Illuminating Company building, and 30.2 feet (9.2 m) WSW of the centerline of Broad Street. The bench mark is 0.5 foot (0.2 m) above the sidewalk.

### BENCH MARK STAMPING: A31 1963

MONUMENTATION: Survey Disk VM#: 251
AGENCY: PID#: LX0861
SETTING CLASSIFICATION: Concrete Wall

The bench mark is located at the Stratford Avenue underpass beneath the Connecticut Turnpike, 87.0 feet (26.6 m) SE of light pole #9058, 37.9 feet (11.6 m) east of the centerline of Stratford Avenue, and 1.0 feet (0.3 m) east of the west corner of the south abutment of the underpass wall. The bench mark is 2.5 feet (0.8 m) above ground level, and is set vertically in the SE corner of the east headwall.

### BENCH MARK STAMPING: CHD D1310 BASELINE

MONUMENTATION: Survey Disk VM#: 256
AGENCY: PID#: LX2343
SETTING CLASSIFICATION: Concrete Sidewalk

The bench mark is set in a concrete sidewalk located directly under the eastbound lane of Interstate 95 along Stratford Avenue just east of the Pequonnock River bridge, 26.6 feet (8.1 m) west of light pole #528, 8.3 feet (2.6 m) north of a chain link fence, and 2.0 feet (0.6 m) south of the curb.

□

CONNECTICUT 846 7150

BRIDGEPORT, BRIDGEPORT HARBOR

BENCH MARK STAMPING: CITY OF BRIDGEPORT

MONUMENTATION: Survey Disk VM#: 255
AGENCY: PID#: LX0859
SETTING CLASSIFICATION: Concrete Sidewalk

The bench mark is set in concrete sidewalk located on the NE corner of the intersection of Stratford Avenue and Hough Avenue, 26.3 feet (8.0 m) north of the traffic island on Stratford Avenue, 22.9 feet (7.0 m) east of the centerline of Hough Avenue, and 7.0 feet (2.1 m) east of the east line of the curb of Hough and Stratford Avenues, and 2.4 feet (0.7 m) north of the north curb of Hough and Stratford Avenues.

BENCH MARK STAMPING: NO 15 1964

MONUMENTATION: Survey Disk VM#: 252
AGENCY: PID#: LX0857
SETTING CLASSIFICATION: Concrete Foundation

The bench mark is set flush in the concrete floor located inside the Hitchcocks Gas Engine Companys machine shop, 46.2 feet (14.1 m) SE of the most NE corner of Hitchcocks Gas Engine Company, 11 feet (3 m) SE of a stairway leading to the office, 8.8 feet (2.7 m) SW of the NE corner of the machine shop, and 4.5 feet (1.4 m) west of the interior face of the east wall of the building.

BENCH MARK STAMPING: NO 16 1973

MONUMENTATION: Survey Disk VM#: 253
AGENCY: PID#: LX2345
SETTING CLASSIFICATION: Concrete Headwall

The bench mark is set in the marine railway concrete headwall, located on the west side of the Hitchcock Marina building, 22.4 feet (6.8 m) east of the east door leading to the engine shop, 16.0 feet (4.9 m) east of the east rail of the railway, and 0.9 foot (0.3 m) north of the south end of the railway.

BENCH MARK STAMPING: NO 17 1973

MONUMENTATION: Survey Disk VM#: 254
AGENCY: PID#: LX2344
SETTING CLASSIFICATION: Concrete Footing

The bench mark is set in a concrete footing for a wire fence located on the east edge of the Hitchcock Gas Engine Company property, 45.7 feet (13.9 m) SE of the east corner of the two-story brick machine shop, 39.1 feet (11.9 m) south of a metal gate post in the yard, 23.6 feet (7.2 m) NE of the NE corner of the engine shop, 18 feet (5 m) south of the south end of an asphalt drive leading to the marina, and 5 feet (2 m) north of a fire hydrant. The bench mark is 0.7 foot (0.2 m) above ground level.

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BRIDGEPORT, BRIDGEPORT HARBOR

BENCH MARK STAMPING: T2 1922 ELEV. 16.772 FT

MONUMENTATION: Survey Disk VM#: 249
AGENCY: PID#: LX0855

NO NGVD 29
for this B.M.

SETTING CLASSIFICATION: Granite Foundation

The bench mark is located at the SE corner of the intersection of State Street and Main Street in the NW corner of the Connecticut National Bank granite foundation, 41.8 feet (12.7 m) ESE of the centerline of Main Street, 27 feet (8.2 m) south of the centerline of State Street, and 6.2 feet (1.9 m) east of the NW corner of the bank building. The bench mark is set 1.6 feet (0.5 m) above the sidewalk.

BENCH MARK STAMPING: TIDAL 12 ELEV. 15.321 FT

MONUMENTATION: Survey Disk — VM#: 248
AGENCY: — PID#: LX0856
SETTING CLASSIFICATION: Concrete Foundation

The bench mark is located in the front foundation wall at 445 Stratford Avenue, 128 feet (39.0 m) east of the centerline of Pembroke Street, 34.2 feet (10.4 m) NW of the centerline of Stratford Avenue, and 1 foot (0.3 m) east of the SW corner of the building. The bench mark is set vertically 0.5 foot (0.2 m) above ground level.

BENCH MARK STAMPING: V2 20.49

MONUMENTATION: Survey Disk — VM#: 257
AGENCY: — PID#: LX0864
SETTING CLASSIFICATION: Stone Step

The bench mark is set in the south end of the bottom step, located on Hollister Street at the southernmost entrance to McKinley School, 54.0 feet (16.5 m) east of the centerline of Hollister Street, 35.2 feet (10.7 m) north of the SW corner of the brickwork at the basement level, 12 feet (4 m) north of the south end of the building, and 7.6 feet (2.3 m) south of the north edge of the southerly entrance way on the west face of the building. The bench mark is 0.3 foot (0.1 m) above ground level.

□
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BRIDGEPORT, BRIDGEPORT HARBOR

Tidal datums at BRIDGEPORT, BRIDGEPORT HARBOR are based on the following:

LENGTH OF SERIES = 18 YEARS
TIME PERIOD = 1967-1984
TIDAL EPOCH = 1960-1978 (19yrs)
CONTROL TIDE STATION = THE BATTERY, NY (851 8750)

Elevations of tidal datums referred to mean lower low water (MLLW) are as follows:

HIGHEST OBSERVED WATER LEVEL (09/21/1938) = 12.44 FEET
MEAN HIGHER HIGH WATER (MHHW) = 7.33 FEET
MEAN HIGH WATER (MHW) = 6.99 FEET
MEAN TIDE LEVEL (MTL) = 3.62 FEET ←
*NATIONAL GEODETIC VERTICAL DATUM-1929 (NGVD) = 2.92 FEET
MEAN LOW WATER (MLW) = 0.25 FEET
MEAN LOWER LOW WATER (MLLW) = 0.00 FEET ← Derived datum
LOWEST OBSERVED WATER LEVEL (02/02/1976) = -4.41 FEET

*NGVD reference based on adjustment of 1967 and NOS levels of 1967-1984.

Bench mark elevation information:

Landside datum

| BENCH MARK STAMP/DESIGNATION | ELEVATION IN FEET ABOVE: MLLW | MHW |
|---|---|---|
| 14 1942 | 21.31 | 14.32 |
| A31 1963 | 23.37 | 16.38 |
| CHD D1310 BASELINE | 11.54 | 4.55 |
| CITY OF BRIDGEPORT | 16.08 ← | 9.09 |
| NO 15 1964 | 13.36 ← | 6.37 |
| NO 16 1973 | 9.37 | 2.38 |
| NO 17 1973 | 13.07 | 6.08 |
| T2 1922 ELEV. 16.772 FT | 19.69 | 12.70 |
| TIDAL 12 ELEV. 15.321 FT | 18.24 | 11.25 |
| V2 20.49 | 23.34 | 16.35 |

☐

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CONNECTICUT 846 7150

BRIDGEPORT, BRIDGEPORT HARBOR

Mean Sea Level (MSL) is a tidal datum determined over a 19-year National Tidal Datum Epoch. It pertains to local mean sea level and should not be confused with the fixed datums of North American Vertical Datum of 1988 (NAVD 88).

NGVD 29 is a fixed datum adopted as a national standard geodetic reference for heights but is now considered superseded. NGVD 29 is sometimes referred to as Sea Level Datum of 1929 or as Mean Sea Level on some early issues of Geological Survey Topographic Quads. NGVD 29 was originally derived from a general adjustment of the first-order leveling networks of the U.S. and Canada after holding mean sea level observed at 26 long term tide stations as fixed. Numerous local and wide-spread adjustments have been made since establishment in 1929. Bench mark elevations relative to NGVD 29 are available from the National Geodetic Survey (NGS) data base via the World Wide Web at www.ngs.noaa.gov.

NAVD 88 is a fixed datum derived from a simultaneous, least squares, minimum constraint adjustment of Canadian/Mexican/United States leveling observations. Local mean sea level observed at Father Point/Rimouski, Canada was held fixed as the single initial constraint. NAVD 88 replaces NGVD 29 as the national standard geodetic reference for heights. Bench mark elevations relative to NAVD 88 are available from NGS through the World Wide Web at www.ngs.noaa.gov

NGVD 29 and NAVD 88 are fixed geodetic datums whose elevation relationships to local MSL and other tidal datums may not be consistent from one location to another.

The Vertical Mark Number (VM#) and PID# shown on the bench mark sheet are unique identifiers for bench marks in the tidal and geodetic databases, respectively. Each bench mark in either database has a single, unique VM# and/or PID# assigned. Where both VM# and PID# are indicated, both tidal and geodetic elevations are available for the bench mark listed.

The NAVD 88 elevation is shown on the Elevations of Tidal Datums Table Referred to MLLW only when two or more of the bench marks listed have NAVD 88 elevations. The NAVD 88 elevation relationship shown in the table is derived from an average of several bench mark elevations relative to tide station datum. As a result of this averaging, NAVD 88 bench mark elevations computed indirectly from the tidal datums elevation table may differ slightly from NAVD 88 elevations listed for each bench mark in the NGS database.

CONNECTICUT 846 6791

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

## TIDAL BENCH MARKS

## SNIFFENS POINT, HOUSATONIC RIVER

LATITUDE: 41ø 11.2' N LONGITUDE: 73ø 6.8' W
NOAA CHART: 12370 USGS QUAD: MILFORD

To reach the tidal bench marks from the intersection of U.S. Highway 1 and Main Street (State Highway 113) in Stratford, proceed south on Main Street for 3.7 km (2.3 mi) to the TEXTRON LYCOMING plant, then turn left on Sniffens Lane and continue east for 1.0 km (0.6 mi) to the Breakwater Key Condominiums at Sniffens Point. The bench marks are located along Sniffens Lane and the tide gage and staff were located on the west side of the Breakwater Key marina.

……

BENCH MARK STAMPING: 6791 A 1993
DESIGNATION: 846 6791 A

LATITUDE: 41ø 11.2' N LONGITUDE: 73ø 6.8' W

MONUMENTATION: Tidal Station disk VM#: 12455
AGENCY: National Ocean Service (NOS) PID#:
SETTING CLASSIFICATION: Concrete catch basin

The bench mark is a disk set in the SE end of a concrete catch basin at the SE end of the westernmost row of condominiums at Breakwater Key development, 15.33 m (50.3 ft) SSE of the SW corner of condo Number 220, 15.09 m (49.5 ft) SW of the west edge of the marina bulkhead, 3.96 m (13.0 ft) NE of the centerline of the driveway, and 0.18 m (0.6 ft) above the pavement.

BENCH MARK STAMPING: 6791 B 1993
DESIGNATION: 846 6791 B

{"used for USACE soundings"}

LATITUDE: 41ø 11.2' N LONGITUDE: 73ø 6.8' W

MONUMENTATION: Tidal Station disk VM#: 12456
AGENCY: National Ocean Service (NOS) PID#:
SETTING CLASSIFICATION: Concrete pad

13.14' Above MLLW, see

The primary bench mark is a disk set in the NW corner of a 1.62 m x 1.31 m (5.3 ft x 4.3 ft) concrete pad west of Breakwater Key Condominiums, 27.52 m (90.3 ft) west of a fire hydrant, 6.22 m (20.4 ft) south of the centerline of Sniffens Lane, 1.98 m (6.5 ft) ESE of power pole Number 3828, and at ground level.

□

BENCH MARK STAMPING: 6791 C 1993
DESIGNATION: 846 6791 C

LATITUDE: 41ø 11.2' N LONGITUDE: 73ø 6.8' W

MONUMENTATION: Tidal Station disk VM#: 12457
AGENCY: National Ocean Service (NOS) PID#:
SETTING CLASSIFICATION: Concrete foundation

The bench mark is a disk set in the SW corner of a 2.29 m (7.5 ft) square concrete foundation for a sewer access, 13.14 m (43.1 ft) east of power pole Number 6071, 11.92 m (39.1 ft) WSW of the employee's entrance at Number 360 Sniffens Lane (Industrial Heating Company), 11.46 m (37.6 ft) north of the centerline of Sniffens Lane, and 0.09 m (0.3 ft) below ground level.

BENCH MARK STAMPING: 6791 D 1993
DESIGNATION: 846 6791 D

LATITUDE: 41ø 11.2' N LONGITUDE: 73ø 6.8' W

MONUMENTATION: Tidal Station disk VM#: 12458
AGENCY: National Ocean Service (NOS) PID#:
SETTING CLASSIFICATION: Concrete footing

The bench mark is a disk set in the east end of a concrete footing for a crossover pipeline near the contractor's entrance to the TEXTRON plant, 16.79 m (55.1 ft) SW of the SW corner of a large stone and aluminum building, 9.33 m (30.6 ft) NNW of the centerline of Sniffens Lane, 6.22 m (20.4 ft) ENE of the SE corner of the guard shack, and 0.88 m (2.9 ft) above the pavement.

BENCH MARK STAMPING: 6791 E 1993
DESIGNATION: 846 6791 E

LATITUDE: 41ø 11.2' N LONGITUDE: 73ø 6.8' W

MONUMENTATION: Tidal Station disk VM#: 12459
AGENCY: National Ocean Service (NOS) PID#:
SETTING CLASSIFICATION: Concrete pad

The bench mark is a disk set in the NE corner of a 3 m x 2 m (11 ft x 6 ft) concrete pad in front of the Engineering Technologies Laboratory (Building 6) at the TEXTRON plant, 19 m (62 ft) west of the centerline of the front entrance driveway, 14.72 m (48.3 ft) north of the north wall of the building, 14.05 m (46.1 ft) south of the centerline of Sniffens Lane, and 0.37 m (1.2 ft) above ground level.

PUBLICATION DATE: 05/10/2000 Page 3

CONNECTICUT 846 6791

SNIFFENS POINT, HOUSATONIC RIVER

BENCH MARK STAMPING: F 31 1965
DESIGNATION: F 31

LATITUDE: 41ø 10.1' N LONGITUDE: 73ø 7.5' W

MONUMENTATION: Bench Mark disk VM#: 12460
AGENCY: US Coast and Geodetic Survey (USC&GS) PID#: LX0871
SETTING CLASSIFICATION: Brick wall

The bench mark is a disk set vertically in the west brick face and in the center of a high brick wall which is 3 m (10 ft) wide and 12 m (40 ft) high, directly beween hangers 1 and 2 at AVCO Flight Services on the east side of Igor Sikorsky Memorial Airport, and 0.73 m (2.4 ft) above the pavement.

CONNECTICUT 846 6791

SNIFFENS POINT, HOUSATONIC RIVER

Tidal datums at SNIFFENS POINT, HOUSATONIC RIVER are based on the following:

| | | |
|---|---|---|
| LENGTH OF SERIES | = | 3 MONTHS |
| →TIME PERIOD | = | June 1993 - August 1993 |
| TIDAL EPOCH | = | 1960-1978 |
| CONTROL TIDE STATION | = | BRIDGEPORT, BRIDGEPORT HARBOR (846 7150) |

-208'/A

Elevations of tidal datums referred to mean lower low water (MLLW) are as follows:

| | | | |
|---|---|---|---|
| MEAN HIGHER HIGH WATER (MHHW) | = | 2.136 METERS | 7.008' |
| MEAN HIGH WATER (MHW) | = | 2.032 METERS | 6.667' |
| MEAN TIDE LEVEL (MTL) | = | 1.052 METERS | 3.451' |
| MEAN SEA LEVEL (MSL) | = | 1.036 METERS | 3.399' |
| MEAN LOW WATER (MLW) | = | 0.073 METERS | 0.239' |
| MEAN LOWER LOW WATER (MLLW) | = | 0.000 METERS | 0.00' |

Bench mark elevation information:

| | ELEVATION IN METERS ABOVE: | | | |
|---|---|---|---|---|
| BENCH MARK STAMP/DESIGNATION | MLLW | | MHW | |
| 6791 A 1993 | 3.942 | | 1.910 | (see USACE soundings) |
| 6791 B 1993 | 4.005 | (13.14) | 1.973 | |
| 6791 C 1993 | 4.433 | | 2.401 | |
| 6791 D 1993 | 4.048 | | 2.016 | |
| 6791 E 1993 | 3.486 | | 1.454 | |
| F 31 1965 | 3.935 | (12.91) | 1.903 | |

CONNECTICUT 846 6791

SNIFFENS POINT, HOUSATONIC RIVER

Mean Sea Level (MSL) is a tidal datum determined over a 19-year National Tidal Datum Epoch. It pertains to local mean sea level and should not be confused with the fixed datums of North American Vertical Datum of 1988 (NAVD 88).

NGVD 29 is a fixed datum adopted as a national standard geodetic reference for heights but is now considered superseded. NGVD 29 is sometimes referred to as Sea Level Datum of 1929 or as Mean Sea Level on some early issues of Geological Survey Topographic Quads. NGVD 29 was originally derived from a general adjustment of the first-order leveling networks of the U.S. and Canada after holding mean sea level observed at 26 long term tide stations as fixed. Numerous local and wide-spread adjustments have been made since establishment in 1929. Bench mark elevations relative to NGVD 29 are available from the National Geodetic Survey (NGS) data base via the World Wide Web at www.ngs.noaa.gov.

NAVD 88 is a fixed datum derived from a simultaneous, least squares, minimum constraint adjustment of Canadian/Mexican/United States leveling observations. Local mean sea level held fixed at Father Point/Rimouski, Canada was held fixed as the single initial constraint. NAVD 88 replaces NGVD 29 as the national standard geodetic reference for heights. Bench mark elevations relative to NAVD 88 are available from NGS through the World Wide Web at www.ngs.noaa.gov

NGVD 29 and NAVD 88 are fixed geodetic datums whose elevation relationships to local MSL and other tidal datums may not be consistent from one location to another.

The Vertical Mark Number (VM#) and PID# shown on the bench mark sheet are unique identifiers for bench marks in the tidal and geodetic databases, respectively. Each bench mark in either database has a single, unique VM# and/or PID# assigned. Where both VM# and PID# are indicated, both tidal and geodetic elevations are available for the bench mark listed.

The NAVD 88 elevation is shown on the Elevations of Tidal Datums Table Referred to MLLW only when two or more of the bench marks listed have NAVD 88 elevations. The NAVD 88 elevation relationship shown in the table is derived from an average of several bench mark elevations relative to tide station datum. As a result of this averaging, NAVD 88 bench mark elevations computed indirectly from the tidal datums elevation table may differ slightly from NAVD 88 elevations listed for each bench mark in the NGS database.

# The NGS Data Sheet

```
DATABASE = Sybase ,PROGRAM = datasheet, VERSION = 6.27
Starting Datasheet Retrieval...
1        National Geodetic Survey,   Retrieval Date = OCTOBER 17, 2000
 LX0871 ***********************************************************************
 LX0871  TIDAL BM      -  This is a Tidal Bench Mark.
 LX0871  DESIGNATION -  F 31
 LX0871  PID         -  LX0871
 LX0871  STATE/COUNTY-  CT/FAIRFIELD
 LX0871  USGS QUAD   -  BRIDGEPORT (1984)
 LX0871
 LX0871                         *CURRENT SURVEY CONTROL
 LX0871  ___________________________________________________________________
 LX0871* NAD 83(1986)-  41 10 04.     (N)    073 07 29.     (W)     SCALED
 LX0871* NAVD 88     -         2.779  (meters)        9.12  (feet)  ADJUSTED
 LX0871  ___________________________________________________________________
 LX0871  GEOID HEIGHT-        -29.89  (meters)                      GEOID99
 LX0871  DYNAMIC HT  -          2.778 (meters)        9.11  (feet)  COMP
 LX0871  MODELED GRAV-     980,303.4  (mgal)                        NAVD 88
 LX0871
 LX0871  VERT ORDER  -  FIRST     CLASS I
 LX0871
 LX0871.This mark is at Igor I Sikorsky Mem Airport (BDR)
 LX0871
 LX0871.The horizontal coordinates were scaled from a topographic map and have
 LX0871.an estimated accuracy of +/- 6 seconds.
 LX0871
 LX0871.The orthometric height was determined by differential leveling
 LX0871.and adjusted by the National Geodetic Survey in June 1991.
 LX0871
 LX0871.This Tidal Bench Mark is designated as VM 12460
 LX0871.by the Center for Operational Oceanographic Products and Services.
 LX0871
 LX0871.The geoid height was determined by GEOID99.
 LX0871
 LX0871.The dynamic height is computed by dividing the NAVD 88
 LX0871.geopotential number by the normal gravity value computed on the
 LX0871.Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
 LX0871.degrees latitude (g = 980.6199 gals.).
 LX0871
 LX0871.The modeled gravity was interpolated from observed gravity values.
 LX0871
 LX0871;                    North         East     Units  Estimated Accuracy
 LX0871;SPC CT       -    189,610.      273,350.     MT   (+/- 180 meters Scaled)
 LX0871
 LX0871                         SUPERSEDED SURVEY CONTROL
 LX0871
 LX0871  NGVD 29     -          3.107  (m)           10.19   (f) ADJ UNCH    1 1
 LX0871
 LX0871.Superseded values are not recommended for survey control.
 LX0871.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
 LX0871.See file dsdata.txt to determine how the superseded data were derived.
 LX0871
 LX0871_MARKER: DB = BENCH MARK DISK
 LX0871_SETTING: 30 = WALL
 LX0871_STAMPING: F 31 1963
 LX0871_STABILITY: D = MARK OF QUESTIONABLE OR UNKNOWN STABILITY
 LX0871
 LX0871  HISTORY     - Date     Condition          Recov. By
 LX0871  HISTORY     - 1963     MONUMENTED         CGS
 LX0871  HISTORY     - 1965     GOOD               NGS
 LX0871  HISTORY     - 1982     MARK NOT FOUND     NGS
 LX0871  HISTORY     - 1985     GOOD               USPSQD
 LX0871
 LX0871                         STATION DESCRIPTION
```

```
LX0871
LX0871'DESCRIBED BY NATIONAL GEODETIC SURVEY 1965
LX0871'AT BRIDGEPORT AIRPORT.
LX0871'AT THE BRIDGEPORT MUNICIPAL AIRPORT, 0.4 MILE NORTHEAST OF THE
LX0871'ADMINISTRATION BUILDING, SET VERTICALLY IN THE WEST BRICK FACE
LX0871'AND IN THE CENTER OF A HIGH BRICK WALL, 10 FEET WIDE AND 40 FEET
LX0871'HIGH, DIRECTLY BETWEEN HANGARS 1 AND 2, 2.4 FEET ABOVE THE
LX0871'LEVEL OF THE GROUND.
LX0871
LX0871                          STATION RECOVERY (1982)
LX0871
LX0871'RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 1982
LX0871'MARK NOT FOUND.
LX0871
LX0871                          STATION RECOVERY (1985)
LX0871
LX0871'RECOVERY NOTE BY US POWER SQUADRON 1985
LX0871'EXCEPT THAT AIRPORT IS NOW CALLED 'IGOR SIKORSKY MEMORIAL AIRPORT'.
LX0871'BENCH MARK IS LOCATED IN BRICK WALL OF HANGAR USED BY AVCO FLIGHT
LX0871'SERVICES. WALL AND BENCH MARK HAVE BEEN PAINTED RED. BENCH MARK IS
LX0871'STILL VISIBLE TROUGH PAINT.

*** retrieval complete.
Elapsed Time = 00:00:02
```

**Harding Lawson Associates**
Engineering,
Environmental and
Construction Services

SHEET ______ OF ______
JOB NO. ______
DATE ______
PROJECT ______
COMPUTED BY ______
SUBJECT ______
CHECKED BY ______

Appendix

A3 8.

"http://tidesonline.nos.noaa.gov ....."

- Elevation Data Graphics
  of Bench Marks

- Tidal Fluctuation - Sampling

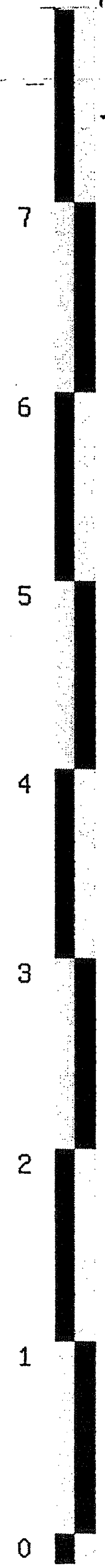
Sniffen's Point

Date created
Fri Mar 9 14:30:17 EST 2001

Elevation Information for PID = LX0871, VM = 12460
Station_ID --- 8466791

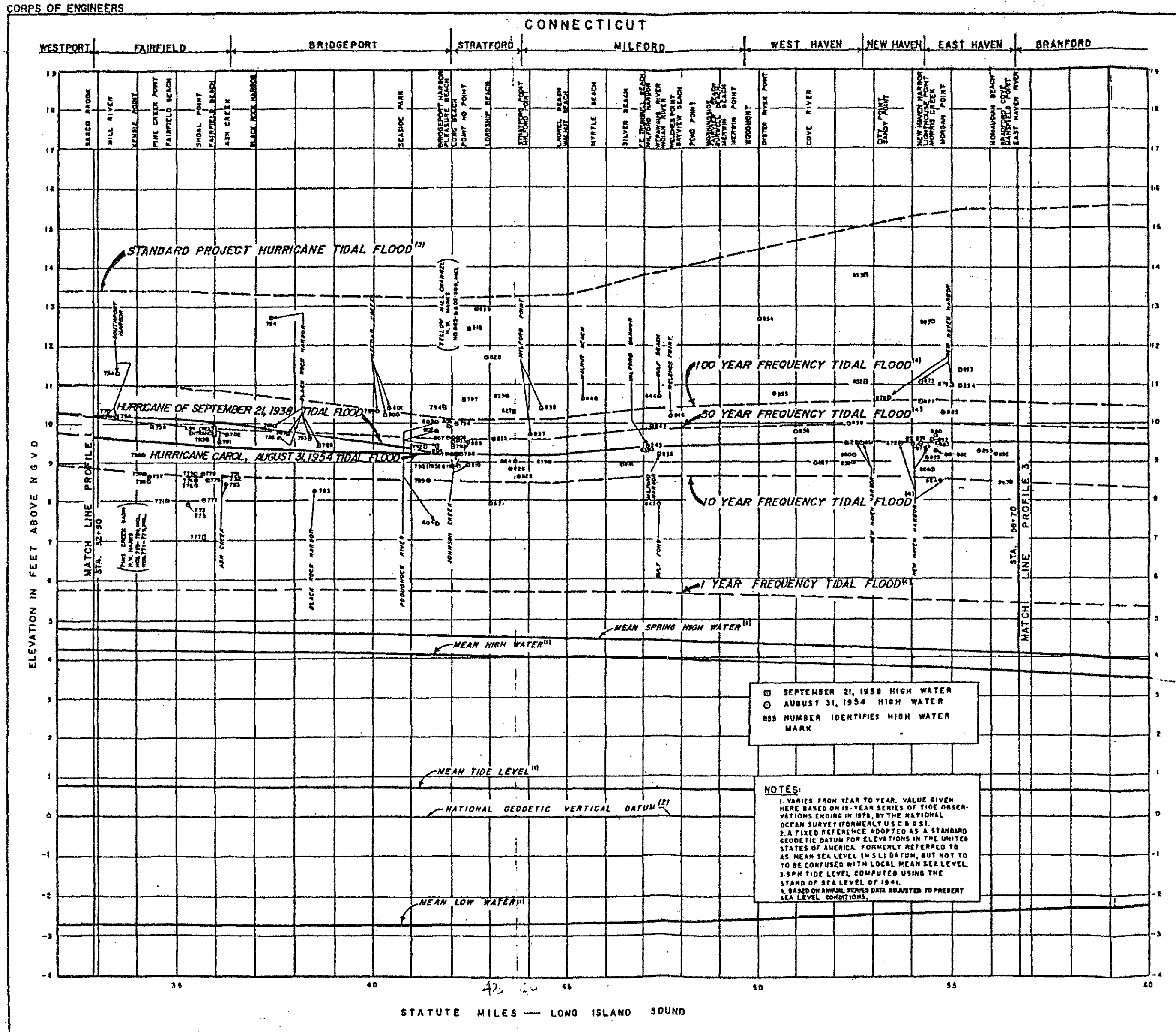
| | | |
|---|---|---|
| Std Prjt Hurricane Tidal Flood | 16.00 | 13.28 |
| 100yr Freq. Tidal Flood | 12.83 | 10.11 |
| 50yr " " " | 12.31 | 9.59 |
| Hurricane Carol | 11.27 | 8.55 |
| 10yr " " " | 8.31 | 5.59 |
| --- MHHW | = 7.01 feet | 4.29 |
| --- MHW | = 6.67 feet | 3.95 |
| --- NAVD88 | = 3.8 feet | 1.08 |
| --- MTL | = 3.45 feet | 0.73 |
| MSL | = 3.40 feet | 0.68 |
| --- NGVD29 | = 2.72 feet | **0.00** |
| --- MLW | = 0.24 feet | -2.40 |
| --- MLLW | = 0.00 feet | -2.72 |

From Ref. 13



reduced

CORPS OF ENGINEERS U. S. ARMY



NOTES:

1. VARIES FROM YEAR TO YEAR. VALUE GIVEN HERE BASED ON 19-YEAR SERIES OF TIDE OBSERVATIONS ENDING IN 1978, BY THE NATIONAL OCEAN SURVEY (FORMERLY U S C & G S).
2. A FIXED REFERENCE ADOPTED AS A STANDARD GEODETIC DATUM FOR ELEVATIONS IN THE UNITED STATES OF AMERICA. FORMERLY REFERRED TO AS MEAN SEA LEVEL (M S L) DATUM, BUT NOT TO TO BE CONFUSED WITH LOCAL MEAN SEA LEVEL.
3. SPH TIDE LEVEL COMPUTED USING THE STAND OF SEA LEVEL OF 1941.
4. BASED ON ANNUAL SERIES DATA ADJUSTED TO PRESENT SEA LEVEL CONDITIONS.

13.28'

10.11'
9.59'
8.55'

5.59'

4.06' MHW

0.62
0.00

-2.59

NGVD 29

From Ref. 13

NEW ENGLAND COASTLINE
TIDAL FLOOD SURVEY

## TIDAL FLOOD PROFILE NO. 2
FAIRFIELD, CONN., TO
EAST HAVEN, CONN.

DEP [illegible] NT OF THE ARMY
NEW ENGL [illegible] ON, CORPS OF ENGINEERS
[illegible] M, MASS.
[illegible] BER 1988

PLATE C-5

Date created
Fri Oct 20 15:32:05 EDT 2000

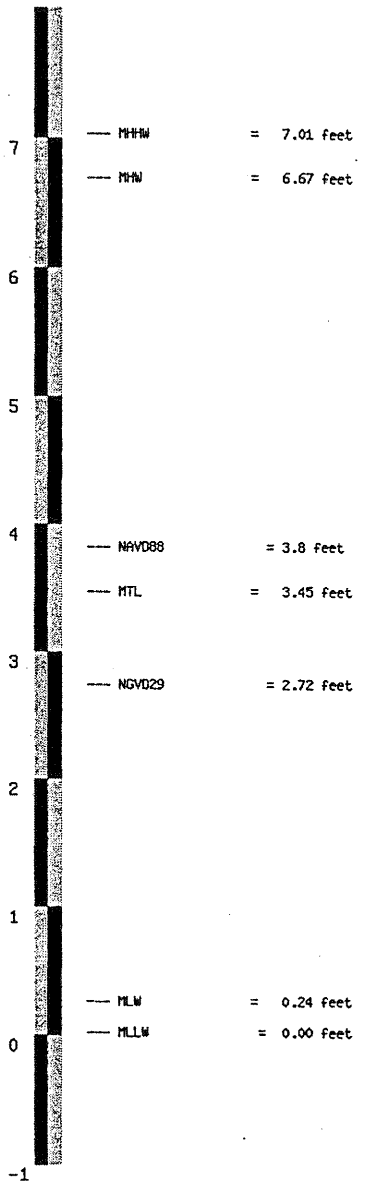
Elevation Information for PID = LX0871, VM = 12460
Station_ID --- 8466791

Snittens Pt

Stamping: F31 1965

Tidal info:
3 months: June 1993 → August 199

Benchmark @ 13.14' above MLLW



The NAVD 88 and the NGVD 29 elevations related to MLLW were computed from Bench Mark, F 31, at the station.

Benchmark @ 13.14' above MLW

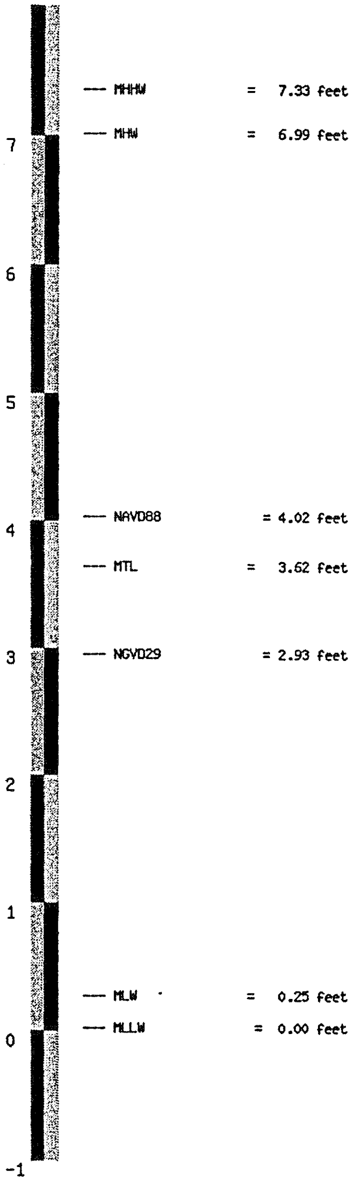
Displayed tidal datums are Mean Higher High Water(MHHW),
Mean High Water (MHW), Mean Tide Level(MTL), Mean Low Water(MLW),
and Mean Lower Low Water(MLLW)

http://www.nos.noaa.gov/ [illegible]

Date created
Fri Oct 20 15:43:14 EDT 2000

Elevation Information for PID = LX0861, VM = 251
Station_ID --- 8467150

Bridgeport
Bench Mark Stamping
A31 1963

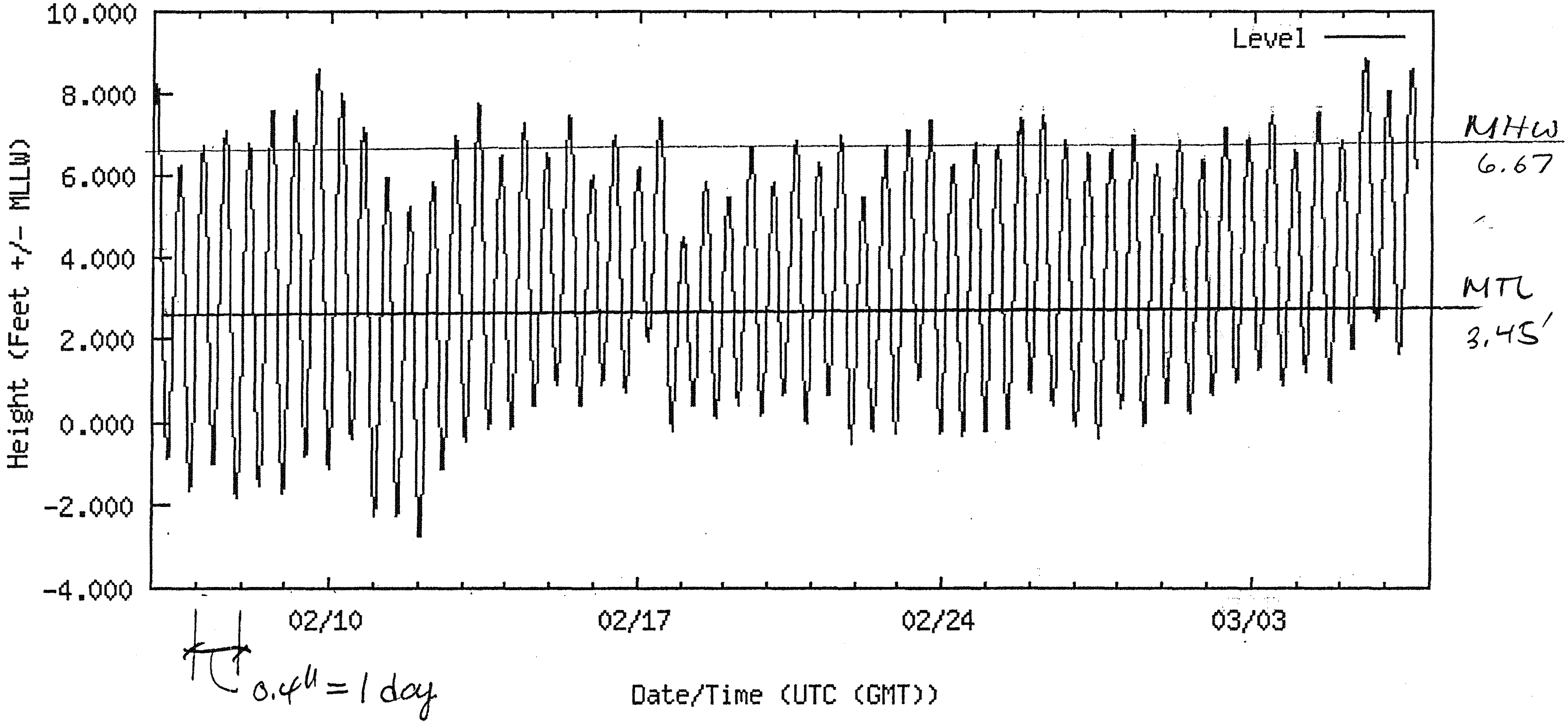


The NAVD 88 and the NGVD 29 elevations related to MLLW were computed from Bench Mark, A 31, at the station.

Benchmark @ 23.37' above MLLW

Displayed tidal datums are Mean Higher High Water(MHHW), Mean High Water (MHW), Mean Tide Level(MTL), Mean Low Water(MLW), and Mean Lower Low Water(MLLW)

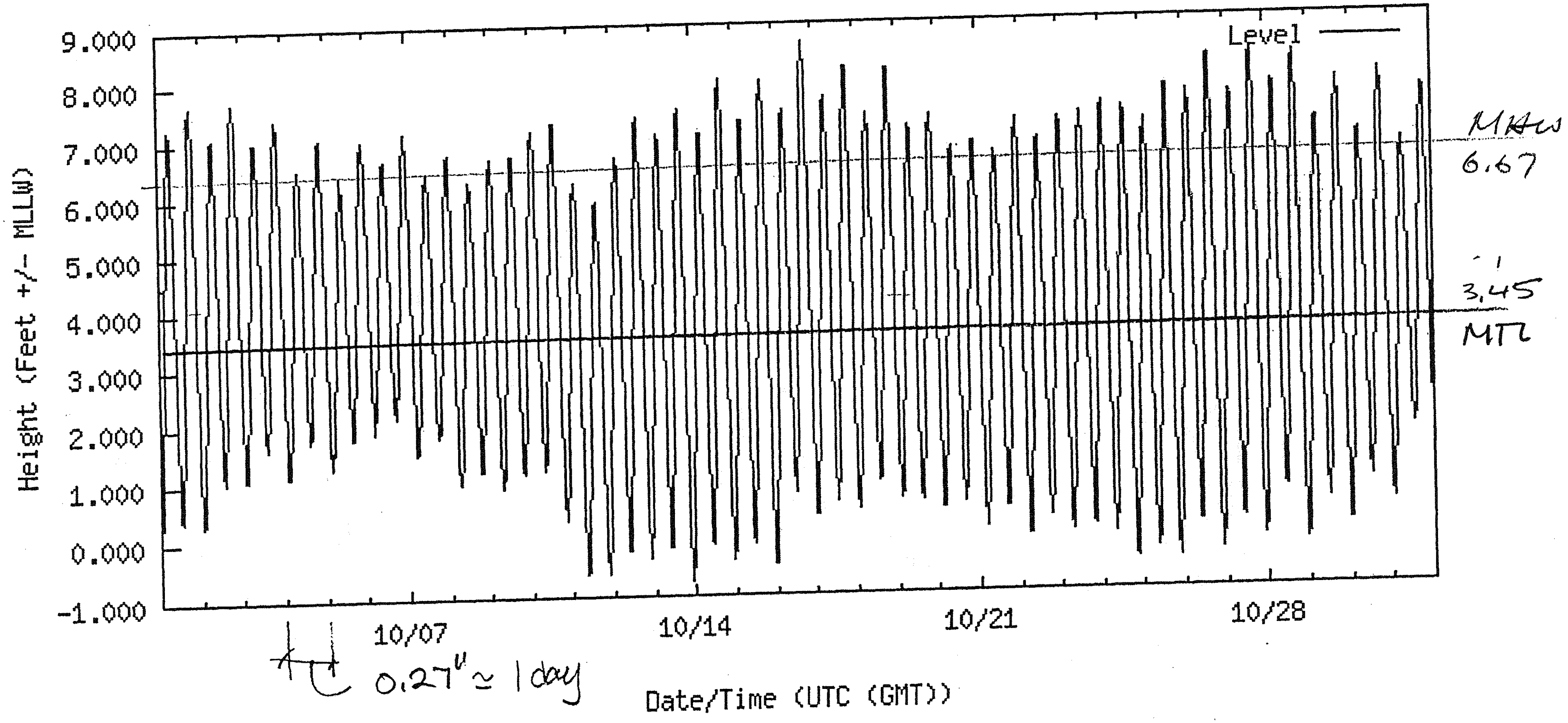
NOAA/NOS/CO-OPS
Preliminary 6 Minute Water Level (A1) Plot
8467150 Bridgeport , CT
from 02/06/2001 - 03/06/2001



Ref. 8

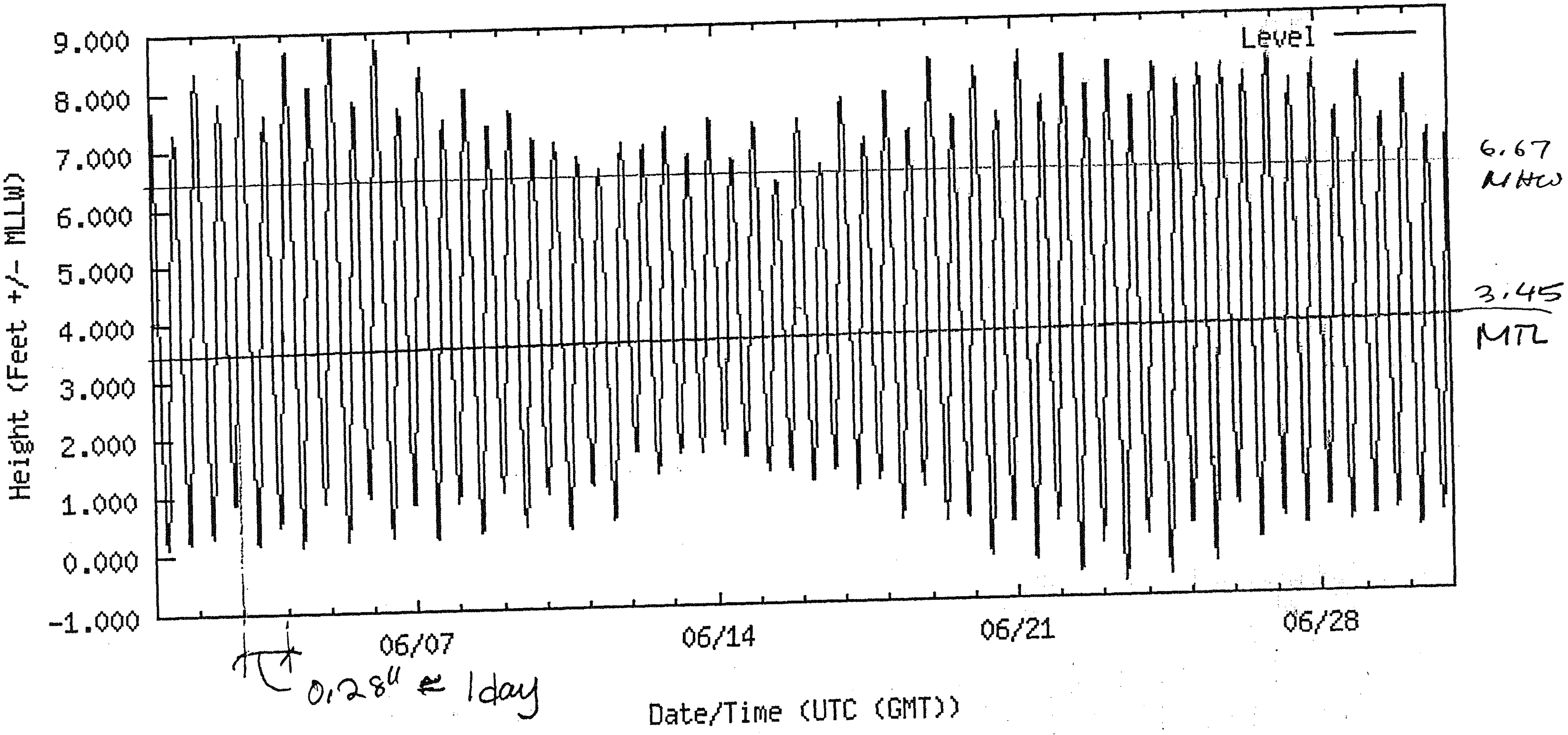
Average time of submergance @ MTL: $\frac{0.08}{0.40} \times 1$ day = 0.20 day ⇒ 4.8 hrs

NOAA/NOS/CO-OPS
Preliminary 6 Minute Water Level (A1) Plot
8467150 Bridgeport , CT
from 10/01/2000 - 10/31/2000



Avg. time of submergance : $\approx \left(\frac{0.07''}{0.27''}\right) \times 1\text{day} = .26\text{day} \Rightarrow \underline{6.2 \text{ hours}}$
@ MTL

NOAA/NOS/CO-OPS
Preliminary 6 Minute Water Level (A1) Plot
8467150 Bridgeport , CT
from 06/01/1997 - 06/30/1997



avg. time of submergence: @ MTL

$\frac{0.07''}{0.28''} \times 1$ day ≈ 6 hours

**Harding Lawson Associates**
Engineering,
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Construction Services

SHEET ____ OF ____

JOB NO. ____

DATE 01/23/01

PROJECT Stratford Causeway

SUBJECT ____

COMPUTED BY ____

CHECKED BY ____

Appendix

A.3 9.

"Tidal Differences and Other in"

NOAA/NOS CO-OPS

How to apply differences (+ , -) and ratios (*)

# Tidal Differences and Other Constants

## CONNECTICUT, Long Island Sound

| Station | Time Diff. |  | Hgt. Diff. |  | Ref. Station |
|---|---|---|---|---|---|
|  | High | Low | High | Low |  |
| Stonington, Fishers Island Sound | -0 32 | -0 41 | *1.05 | *1.05 | New London |
| Noank, Mystic River entrance | -0 22 | -0 08 | *0.89 | *0.90 | New London |
| West Harbor, Fishers Island, N.Y. | 0 00 | -0 06 | *0.97 | *0.97 | New London |
| Silver Eel Pond, Fishers Island, N.Y. | -0 16 | -0 04 | *0.89 | *0.89 | New London |
| **Thames River** |  |  |  |  |  |
| NEW LONDON, State Pier | Daily Predictions |  |  |  | New London |
| Smith Cove entrance | 0 00 | +0 10 | *0.97 | *0.95 | New London |
| Norwich | +0 13 | +0 25 | *1.16 | *1.15 | New London |
| Millstone Point | +0 09 | +0 01 | *1.05 | *1.05 | New London |
| **Connecticut River** |  |  |  |  |  |
| Saybrook Jetty | +1 11 | +0 45 | *1.36 | *1.35 | New London |
| Saybrook Point | +1 11 | +0 53 | *1.24 | *1.25 | New London |
| Lyme, highway bridge | +1 25 | +1 10 | *1.20 | *1.20 | New London |
| Essex | +1 39 | +1 38 | *1.16 | *1.15 | New London |
| **Connecticut River** |  |  |  |  |  |
| Hadlyme #7 | +2 19 | +2 23 | *1.05 | *1.05 | New London |
| East Haddam | +2 42 | +2 53 | *1.12 | *1.10 | New London |
| Haddam #7 | +2 48 | +3 08 | *0.97 | *0.95 | New London |
| Higganum Creek | +2 55 | +3 25 | *1.01 | *1.00 | New London |
| Portland #7 | +3 51 | +4 28 | *0.85 | *0.85 | New London |
| Rocky Hill #7 | +4 44 | +5 44 | *0.78 | *0.80 | New London |
| Hartford #7 | +5 30 | +6 52 | *0.74 | *0.75 | New London |
| Westbrook, Duck Island Roads | -0 24 | -0 32 | *0.61 | *0.60 | Bridgeport |
| Duck Island | -0 26 | -0 35 | *0.67 | *0.68 | Bridgeport |
| Madison | -0 21 | -0 30 | *0.73 | *0.72 | Bridgeport |
| Falkner Island | -0 14 | -0 25 | *0.80 | *0.80 | Bridgeport |
| Sachem Head | -0 11 | -0 15 | *0.80 | *0.80 | Bridgeport |
| Money Island | -0 12 | -0 23 | *0.83 | *0.84 | Bridgeport |
| Branford Harbor | -0 08 | -0 18 | *0.88 | *0.88 | Bridgeport |
| New Haven Harbor entrance | -0 09 | -0 14 | *0.92 | *0.92 | Bridgeport |
| New Haven (city dock) | +0 01 | -0 01 | *0.89 | *0.88 | Bridgeport |
| Milford Harbor | -0 08 | -0 10 | *0.98 | *0.96 | Bridgeport |
| Stratford, Housatonic River | +0 26 | +1 01 | *0.82 | *0.80 | Bridgeport |
| Shelton, Housatonic River | +1 35 | +2 44 | *0.74 | *0.72 | Bridgeport |
| BRIDGEPORT | Daily Predictions |  |  |  | Bridgeport |
| Black Rock Harbor entrance | -0 04 | -0 03 | *1.02 | *1.04 | Bridgeport |
| Saugatuck River entrance | -0 02 | +0 01 | *1.04 | *1.04 | Bridgeport |
| South Norwalk | +0 09 | +0 15 | *1.05 | *1.04 | Bridgeport |
| Greens Ledge | -0 02 | -0 01 | *1.07 | *1.08 | Bridgeport |
| Stamford | +0 03 | +0 08 | *1.07 | *1.08 | Bridgeport |
| Cos Cob Harbor | +0 05 | +0 11 | *1.07 | *1.08 | Bridgeport |
| Greenwich | +0 01 | +0 01 | *1.10 | *1.08 | Bridgeport |
| Great Captain Island | 0 00 | +0 01 | *1.08 | *1.08 | Bridgeport |

## NEW YORK

### Long Island Sound, north side

| Station | Time Diff. |  | Hgt. Diff. |  | Ref. Station |
|---|---|---|---|---|---|
|  | High | Low | High | Low |  |
| ort Chester | -0 03 | -0 14 | *1.01 | *1.01 | Willets Point |
| ye Beach | -0 22 | -0 31 | *1.01 | *1.01 | Willets Point |
| Mamaroneck | -0 02 | -0 13 | *1.02 | *1.04 | Willets Point |
| New Rochelle | -0 18 | -0 21 | *1.02 | *1.04 | Willets Point |
| Davids Island | +0 04 | -0 09 | *1.01 | *1.00 | Willets Point |
| City Island | +0 03 | -0 05 | *1.01 | *1.00 | Willets Point |
| Throgs Neck | +0 08 | +0 12 | *0.98 | *0.98 | Willets Point |

NOAA/NOS CO-OPS

## Secondary Station Adjustments Instructions

The publication of full daily tide predictions is necessarily limited to a comparatively small number of stations. These stations are referred to as "reference stations". Tide predictions for more than 3000 other locations can be obtained by applying certain differences to the daily tide predictions for the reference stations.

These pages provide a listing of the more than 3000 "subordinate stations" for which such predictions can be made, the differences or ratios to be used, and a link to the appropriate reference station. The stations in the listing are arranged in geographical order to make it possible to find stations which are available for an area you are interested in.

**Caution:** The time and height differences and ratios are derived from a comparison of simultaneous tide observations at the subordinate station and it reference station. Because these figures are constant, they may not always provide for the daily variations of the actual tide, especially if the subordinate station is some distance from the reference station. Therefore, although the application of time and height differences will generally provide reasonably accurate approximations, they cannot result in predictions as accurate as those listed for the reference stations which are based on much larger periods of analysis.

**Time Differences:** To determine the time of high and low tide at any station listed in this table there is given the columns headed "Time Differences"in which the hours and minutes to be added or subtracted from the time of high or low tide of the reference stations. A plus sign (+) indicates that the tide at the subordinate station occurs later than at the reference station and the difference should be added; a minus sign (-) indicates that it is earlier and should be subtracted.

To obtain the tide at a subordinate station on any date, apply the difference to the tide at the reference station for that same date. In some cases, however, to obtain an AM tide it may be necessary to use the preceding day's PM tide at the reference station or to obtain a PM tide it may be necessary to use the following day's AM tide. For example, if a high tide at a reference station occurs at 0200 on July 17, and the tide at the subordinate station occurs 5 hours earlier, the high tide at the subordinate station will occur at 900 PM on July 16. For the second case, if the high water at a reference station occurs at 1000 PM, and the tide at the subordinate station occurs 3 hours later, then high tide will occur at 100 AM on July 3 at the subordinate station.

The results obtained by application of the time differences will be in local time for the subordinate station. The necessary allowances for the change in date when crossing the international date line, or for different time zones have been included in the time differences listed.

**Height Differences:** The height of the tide, referred to the datum of nautical charts, is obtained by means of the height difference or ratios. A plus sign (+) indicates that the difference should be added to the height at the reference station, and a minus sign (-) indicates that it should be subtracted. For most stations, use of a predicted height difference would give unsatisfactory predictions. In such cases they have been omitted and one or two ratios, indicated by an asterisk (*), are given. To obtain the height of tide at the subordinate station in these cases, multiply the height of tide at the reference station by the ratio listed. The result is normally rounded to the nearest .1 foot.

For some subordinate stations there is given, in parentheses, a ratio as well as a correction. In those instances, each predicted high and low water at the reference station should be first multiplied by the ratio and then the correction is added or subtracted from each product.

**Example Tide Calculations**

For Atlantic City, New Jersey, the time and height adjustments listed in the tables are:

```
-0 27    -0 35    *0.88    *0.88
```

and the reference station is Sandy Hook, New Jersey. If the times in column 1 are the tides for a day at Sandy Hook, column 2 are the time corrections and column 3 are the height corrections, column 4 will be the predicted tides at Atlantic City.

| (1) | (2) | (3) | (4) |
|---|---|---|---|
| 446am 0.3ft | -0 35 | *0.88 | 411am 0.3ft |
| 1052am 4.2ft | -0 27 | *0.88 | 1025am 3.7ft |
| 502pm 0.2ft | -0 35 | *0.88 | 427pm 0.2ft |
| 1127pm 4.3ft | -0 27 | *0.88 | 1100pm 3.8ft |

For Monterey California, the time and height adjustments listed in the tables are:

```
-1 08    -0 47    -0.5   0.0
```

and the reference station is San Francisco, California. If the times in column 1 are the tides for a day at San Francisco, column 2 are the time corrections and column 3 are the height corrections, column 4 will be the edicted tides at Monterey.

| (1) | (2) | (3) | (4) |
|---|---|---|---|
| 237am 5.1ft | -1 08 | -0.5 | 129am 4.6ft |
| 828am 1.9ft | -0 47 | 0.0 | 741am 1.9ft |
| 231pm 4.2ft | -1 08 | -0.5 | 323pm 3.7ft |
| 820pm 1.6ft | -0 47 | 0.0 | 733pm 1.6ft |

NOAA/NOS CO-OPS

# Tide Prediction Accuracy Table

| Station Name | Year | 90% Distribution Level | | | | Standard Deviation of Differences | | | | Average Differences | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | High Water (Hour) | Low Water (Hour) | High Water (Feet) | Low Water (Feet) | High Water (Hour) | Low Water (Hour) | High Water (Feet) | Low Water (Feet) | High Water (Hour) | Low Water (Hour) | High Water (Feet) | Low Wate (Feet |
| Eastport, ME | 1995 | 0.2 | 0.2 | 0.7 | 0.6 | 0.08 | 0.09 | 0.39 | 0.41 | 0.00 | -0.01 | 0.19 | -0.0 |
| Portland, ME | 1995 | 0.2 | 0.2 | 0.6 | 0.6 | 0.15 | 0.13 | 0.41 | 0.42 | 0.05 | 0.07 | 0.06 | 0.0 |
| Boston, MA | 1995 | 0.2 | 0.2 | 0.6 | 0.6 | 0.14 | 0.14 | 0.40 | 0.43 | 0.05 | 0.03 | 0.08 | -0.0 |
| Newport, RI | 1995 | 0.3 | 0.7 | 0.6 | 0.7 | 0.24 | 0.46 | 0.42 | 0.44 | 0.00 | 0.05 | 0.05 | -0.0 |
| New London, CT | 1995 | 0.5 | 0.4 | 0.6 | 0.6 | 0.36 | 0.33 | 0.44 | 0.43 | -0.04 | -0.01 | -0.02 | 0.0 |
| Bridgeport, CT | 1995 | 0.2 | 0.3 | 0.8 | 0.8 | 0.14 | 0.18 | 0.60 | 0.53 | -0.07 | -0.12 | 0.06 | -0.0 |
| Willets Point, NY | 1995 | 1.0 | 1.0 | 0.9 | 0.8 | 0.69 | 0.56 | 0.63 | 0.61 | -0.09 | -0.33 | 0.09 | -0.0 |
| The Battery, NY | 1995 | 0.5 | 0.4 | 0.7 | 0.8 | 0.35 | 0.31 | 0.52 | 0.53 | -0.07 | -0.06 | 0.00 | 0.0 |
| Albany, NY <1> | 1986 | 1.0 | 0.8 | >1.0 | >1.0 | 0.40 | 0.52 | 0.91 | 1.16 | 0.62 | 0.00 | -0.50 | -0.1 |
| Sandy Hook, NJ | 1995 | 0.4 | 0.3 | 0.7 | 0.8 | 0.26 | 0.27 | 0.51 | 0.52 | 0.02 | 0.03 | 0.02 | 0.0 |
| Philadelphia, PA | 1989 | 0.5 | 0.6 | 1.0 | 1.0 | 0.30 | 0.36 | 0.72 | 0.65 | 0.14 | 0.11 | -0.12 | 0.2 |
| Reedy Point, DE | 1995 | 0.3 | 0.5 | 0.9 | 0.9 | 0.23 | 0.26 | 0.61 | 0.61 | 0.05 | -0.13 | 0.13 | -0.0 |
| Breakwater Harbor, DE | 1995 | 0.3 | 0.3 | 0.8 | 0.9 | 0.23 | 0.22 | 0.52 | 0.55 | -0.05 | 0.02 | 0.06 | -0.0 |
| Baltimore, MD <2> | 1995 | 1.0 | >1.0 | 0.9 | 0.9 | 0.57 | 0.83 | 0.58 | 0.58 | 0.29 | -0.01 | -0.04 | 0.0 |
| Washington, D.C. | 1995 | 0.6 | 0.6 | 1.0 | 0.9 | 0.35 | 0.40 | 0.64 | 0.59 | -0.16 | -0.19 | -0.01 | 0.0 |
| Hampton Roads, VA | 1995 | 0.4 | 0.4 | 0.8 | 0.9 | 0.27 | 0.25 | 0.51 | 0.56 | 0.07 | 0.05 | 0.03 | -0.0 |
| Wilmington, NC | 1995 | 0.5 | 0.4 | 0.5 | 0.7 | 0.36 | 0.27 | 0.32 | 0.46 | -0.06 | -0.08 | 0.08 | 0.0 |
| Charleston, SC | 1995 | 0.4 | 0.3 | 0.7 | 0.8 | 0.27 | 0.24 | 0.44 | 0.50 | 0.05 | 0.04 | 0.06 | 0.0 |
| Savannah, GA <1> | 1980 | 0.4 | 0.4 | 0.7 | 0.9 | 0.28 | 0.23 | 0.45 | 0.60 | -0.02 | -0.06 | -0.09 | -0.0 |
| Savannah River Ent., GA | 1995 | 0.3 | 0.3 | 0.7 | 0.9 | 0.21 | 0.19 | 0.47 | 0.58 | -0.01 | -0.07 | 0.05 | 0.0 |
| Fernandina Beach, FL | 1995 | 0.2 | 0.3 | 0.9 | 0.9 | 0.15 | 0.19 | 0.48 | 0.56 | -0.02 | 0.06 | 0.33 | 0.3 |
| Mayport, FL | 1995 | 0.3 | 0.4 | 0.6 | 0.8 | 0.20 | 0.27 | 0.40 | 0.48 | 0.09 | 0.10 | 0.12 | 0.1 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Miami Harbor Ent, FL <1> | 1980 | 0.3 | 0.3 | 0.4 | 0.4 | 0.17 | 0.17 | 0.26 | 0.26 | -0.04 | -0.02 | 0.04 | 0.0 |
| Key West, FL | 1995 | 0.8 | 0.6 | 0.4 | 0.4 | 0.39 | 0.34 | 0.25 | 0.27 | -0.30 | -0.17 | 0.01 | 0.0 |
| St. Petersburg, FL | 1995 | 0.7 | 0.7 | 0.7 | 0.7 | 0.45 | 0.51 | 0.47 | 0.46 | 0.13 | -0.03 | -0.07 | 0.0 |
| Pensacola, FL <2> | 1995 | >1.0 | >1.0 | 0.6 | 0.9 | 2.61 | 2.72 | 0.48 | 0.41 | 0.04 | 0.10 | -0.04 | 0.0 |
| Mobile, AL <1><2> | 1984 | >1.0 | >1.0 | 0.8 | 0.7 | 2.56 | 2.49 | 0.48 | 0.45 | 0.05 | -0.09 | -0.05 | 0.0 |
| Galveston, TX <2> | 1995 | >1.0 | >1.0 | 0.7 | 0.8 | 1.29 | 1.25 | 0.50 | 0.54 | -0.15 | -0.12 | -0.03 | 0.0 |
| Honolulu, HI | 1995 | 0.6 | 0.5 | 0.3 | 0.3 | 0.39 | 0.37 | 0.21 | 0.20 | 0.01 | 0.03 | -0.03 | 0.0 |
| San Diego, CA | 1995 | 0.4 | 0.3 | 0.3 | 0.3 | 0.17 | 0.17 | 0.17 | 0.18 | 0.20 | 0.16 | 0.06 | -0.0 |
| Los Angeles, CA | 1995 | 0.3 | 0.3 | 0.2 | 0.2 | 0.23 | 0.22 | 0.17 | 0.18 | 0.04 | 0.02 | -0.03 | 0.0 |
| San Francisco, CA | 1995 | 0.3 | 0.4 | 0.4 | 0.6 | 0.18 | 0.25 | 0.31 | 0.39 | -0.12 | -0.03 | 0.03 | -0.0 |
| Humboldt Bay, CA | 1995 | 0.2 | 0.3 | 0.4 | 0.6 | 0.13 | 0.15 | 0.42 | 0.47 | 0.07 | 0.15 | 0.03 | -0.0 |
| Crescent City, CA | 1995 | 0.2 | 0.2 | 0.6 | 0.6 | 0.12 | 0.12 | 0.41 | 0.44 | 0.04 | 0.05 | 0.01 | 0.0 |
| Astoria, OR | 1995 | 0.2 | 0.3 | 0.7 | 0.9 | 0.11 | 0.17 | 0.48 | 0.55 | -0.02 | 0.04 | -0.04 | 0.0 |
| Aberdeen, WA <1> | 1982 | 0.4 | 0.7 | 1.0 | >1.0 | 0.26 | 0.31 | 0.58 | 0.76 | 0.04 | 0.34 | -0.29 | -0.1 |
| Port Townsend, WA | 1995 | 0.4 | 0.4 | 0.8 | 0.8 | 0.24 | 0.23 | 0.49 | 0.49 | -0.01 | 0.09 | 0.05 | 0.0 |
| Seattle, WA | 1995 | 0.2 | 0.2 | 0.7 | 0.7 | 0.16 | 0.14 | 0.46 | 0.50 | 0.00 | -0.02 | 0.03 | -0.0 |
| Ketchikan, AK | 1995 | 0.1 | 0.1 | 0.8 | 0.7 | 0.08 | 0.08 | 0.48 | 0.47 | 0.02 | 0.01 | -0.03 | 0.0 |
| Sitka, AK | 1995 | 0.1 | 0.1 | 0.7 | 0.7 | 0.09 | 0.09 | 0.45 | 0.44 | 0.01 | 0.01 | 0.04 | -0.0 |
| Juneau, AK | 1995 | 0.1 | 0.1 | 0.8 | 0.8 | 0.10 | 0.11 | 0.50 | 0.49 | 0.01 | 0.00 | 0.16 | -0.1 |
| Cordova, AK | 1995 | 0.2 | 0.2 | 0.8 | 0.8 | 0.15 | 0.14 | 0.52 | 0.51 | 0.06 | 0.03 | -0.03 | 0.0 |
| Valdez, AK | 1995 | 0.2 | 0.2 | 0.8 | 0.8 | 0.14 | 0.11 | 0.52 | 0.52 | 0.02 | -0.04 | -0.07 | 0.0 |
| Seldovia, AK | 1995 | 0.1 | 0.1 | 0.8 | 0.9 | 0.08 | 0.09 | 0.52 | 0.56 | -0.01 | 0.03 | -0.04 | 0.0 |
| Nikiski, AK <3> | 1995 | 0.2 | 0.2 | >1.0 | >1.0 | 0.13 | 0.16 | 0.38 | 0.37 | -0.07 | -0.06 | -1.47 | -1.6 |
| Anchorage, AK <3> | 1995 | 0.2 | 0.2 | >1.0 | >1.0 | 0.12 | 0.12 | 0.70 | 0.78 | 0.08 | 0.02 | 0.06 | 0.2 |
| Kodiak, AK | 1983 | 0.2 | 0.2 | 0.9 | 0.9 | 0.16 | 0.15 | 0.55 | 0.55 | 0.01 | 0.04 | -0.09 | -0.2 |
| Sweeper Cove, AK | 1995 | 0.4 | 0.3 | 0.7 | 0.8 | 0.33 | 0.23 | 0.47 | 0.48 | 0.09 | 0.07 | -0.02 | 0.0 |
| Unalaska, AK | 1995 | 0.4 | 0.4 | 0.8 | 0.8 | 0.30 | 0.22 | 0.47 | 0.47 | 0.12 | 0.13 | -0.01 | 0.0 |

1. These stations are no longer active, no recent data is available to conduct analysis.
2. These stations have strong non-tidal influences normally caused by short-term meteorological events. Such areas are difficult to predict accurately.
3. These stations have tidal ranges in excess of 20 feet. Although differences between predictions and observations may be greater than 1 foot, this difference represents less than 5% of the total range of the station.

**Harding Lawson Associates**
Engineering,
Environmental and
Construction Services

PROJECT Stratford Causeway

SUBJECT

SHEET ____ OF ____

JOB NO.

DATE

COMPUTED BY

CHECKED BY

Appendix

A.3 10.

'Retrieve Verified / Historic (Tides)...'

**Monthly Means (W5)**

Station -- Unique seven character identifier for the station
Year -- Year of data
Mo -- Month of data
MHW -- Mean High Water
MLW -- Mean Low Water
MSL -- Mean Sea Level
MN -- Difference between MHW and MLW
MTL -- Mean of MHW and MLW
MHHW -- Mean Higher-High Water
MLLW -- Mean Lower-Low Water
DHQ -- Difference between MHHW and MHW
DLQ -- Difference between MLW and MLLW
GT -- Difference between MHHW and MLLW
DTL -- Mean of MHHW and MLLW
HWI -- Greenwich Mean High Water Interval in Hours
LWI -- Greenwich Mean Low Water Interval in Hours

**Data are in Feet above MLLW**
**Times are on UTC (GMT)**

**8467150 BRIDGEPORT, BRIDGEPORT HARBOR, CT from 19790101 to 20000801**

---

| Station | Year | Mo | MHW | MLW | MSL | MN | MTL | MHHW | MLLW |
|---|---|---|---|---|---|---|---|---|---|
| 8467150 | 1979 | 1 | 7.07 | 0.19 | 3.63 | 6.88 | 3.63 | 7.48 | -0.18 |
| 8467150 | 1979 | 2 | [ 6.54] | [ -0.16] | [ 3.19] | [ 6.70] | [ 3.19] | [ 6.87] | [ -0.46] [ |
| 8467150 | 1979 | 3 | 6.84 | -0.11 | 3.36 | 6.95 | 3.36 | 7.10 | -0.35 |
| 8467150 | 1979 | 4 | 7.05 | 0.19 | 3.62 | 6.87 | 3.62 | 7.38 | -0.09 |
| 467150 | 1979 | 5 | 7.06 | 0.20 | 3.63 | 6.86 | 3.63 | 7.32 | -0.04 |
| 8467150 | 1979 | 6 | 7.17 | 0.23 | 3.71 | 6.94 | 3.70 | 7.48 | -0.03 |
| 8467150 | 1979 | 7 | 7.19 | 0.27 | 3.74 | 6.91 | 3.73 | 7.48 | 0.07 |
| 8467150 | 1979 | 8 | 7.28 | 0.32 | 3.82 | 6.96 | 3.80 | 7.57 | 0.14 |
| 8467150 | 1979 | 9 | 7.26 | 0.24 | 3.76 | 7.01 | 3.75 | 7.56 | 0.06 |
| 8467150 | 1979 | 10 | 7.22 | 0.21 | 3.73 | 7.01 | 3.72 | 7.49 | 0.02 |
| 8467150 | 1979 | 11 | 6.96 | 0.01 | 3.50 | 6.94 | 3.49 | 7.24 | -0.19 |
| 8467150 | 1979 | 12 | 6.67 | -0.19 | 3.25 | 6.85 | 3.24 | 7.03 | -0.45 |
| 8467150 | 1980 | 1 | 6.67 | -0.05 | [ 3.32] | 6.71 | 3.31 | 7.07 | -0.32 |
| 8467150 | 1980 | 2 | 6.75 | 0.07 | 3.43 | 6.68 | 3.41 | 7.08 | -0.13 |
| 8467150 | 1980 | 3 | 6.81 | 0.08 | 3.42 | 6.73 | 3.44 | 7.14 | -0.19 |
| 8467150 | 1980 | 4 | 7.10 | 0.33 | 3.72 | 6.77 | 3.72 | 7.34 | 0.13 |
| 8467150 | 1980 | 5 | 7.27 | 0.32 | 3.80 | 6.95 | 3.80 | 7.56 | 0.10 |
| 8467150 | 1980 | 6 | 7.17 | 0.17 | 3.68 | 7.00 | 3.67 | 7.48 | -0.11 |
| 8467150 | 1980 | 7 | 7.23 | 0.16 | 3.70 | 7.07 | 3.70 | 7.51 | -0.05 |
| 8467150 | 1980 | 8 | 7.34 | 0.26 | 3.80 | 7.08 | 3.80 | 7.58 | 0.10 |
| 8467150 | 1980 | 9 | 7.17 | 0.19 | 3.69 | 6.98 | 3.68 | 7.42 | 0.04 |
| 8467150 | 1980 | 10 | 6.97 | 0.21 | 3.60 | 6.77 | 3.59 | 7.30 | 0.01 |
| 8467150 | 1980 | 11 | 6.77 | 0.02 | 3.41 | 6.75 | 3.40 | 7.14 | -0.31 |
| 8467150 | 1980 | 12 | 6.39 | -0.20 | 3.11 | 6.59 | 3.10 | 6.75 | -0.51 |
| 8467150 | 1981 | 1 | 6.30 | -0.26 | 3.03 | 6.56 | 3.02 | 6.68 | -0.45 |
| 8467150 | 1981 | 2 | 6.59 | -0.12 | 3.24 | 6.71 | 3.24 | 6.96 | -0.31 |
| 8467150 | 1981 | 3 | 6.82 | 0.14 | 3.49 | 6.69 | 3.48 | 7.09 | -0.12 |
| 8467150 | 1981 | 4 | 6.71 | -0.14 | 3.29 | 6.85 | 3.29 | 6.94 | -0.41 |
| 8467150 | 1981 | 5 | 7.27 | 0.26 | 3.78 | 7.01 | 3.77 | 7.58 | 0.00 |
| 8467150 | 1981 | 6 | 7.27 | 0.21 | 3.74 | 7.06 | 3.74 | 7.61 | -0.04 |
| 467150 | 1981 | 7 | 7.30 | 0.25 | 3.77 | 7.05 | 3.77 | 7.62 | 0.02 |
| 467150 | 1981 | 8 | 7.33 | 0.36 | 3.85 | 6.97 | 3.85 | 7.61 | 0.16 |
| 8467150 | 1981 | 9 | 7.32 | 0.50 | 3.92 | 6.82 | 3.91 | 7.58 | 0.35 |
| 8467150 | 1981 | 10 | 6.97 | 0.27 | 3.62 | 6.69 | 3.62 | 7.32 | 0.06 |
| 8467150 | 1981 | 11 | 7.05 | 0.41 | 3.73 | 6.64 | 3.73 | 7.36 | 0.17 |
| 8467150 | 1981 | 12 | 6.80 | 0.22 | 3.52 | 6.58 | 3.51 | 7.20 | -0.05 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 8467150 | 1982 | 1 | 6.48 | -0.14 | 3.17 | 6.62 | 3.17 | 6.90 | -0.43 |
| 8467150 | 1982 | 2 | 6.68 | -0.02 | 3.34 | 6.69 | 3.33 | 7.01 | -0.26 |
| 8467150 | 1982 | 3 | 6.75 | 0.00 | 3.38 | 6.75 | 3.37 | 6.99 | -0.25 |
| 3467150 | 1982 | 4 | 6.57 | -0.20 | 3.19 | 6.77 | 3.19 | 6.93 | -0.56 |
| 8467150 | 1982 | 5 | 7.15 | 0.24 | 3.70 | 6.91 | 3.69 | 7.41 | 0.01 |
| 8467150 | 1982 | 6 | 7.57 | 0.65 | 4.11 | 6.92 | 4.11 | 7.91 | 0.36 |
| 8467150 | 1982 | 7 | 7.13 | 0.30 | 3.73 | 6.83 | 3.72 | 7.46 | 0.07 |
| 8467150 | 1982 | 8 | 7.12 | 0.33 | 3.73 | 6.79 | 3.72 | 7.41 | 0.10 |
| 8467150 | 1982 | 9 | 7.21 | 0.42 | 3.82 | 6.80 | 3.81 | 7.45 | 0.22 |
| 8467150 | 1982 | 10 | 7.33 | 0.62 | 3.99 | 6.70 | 3.98 | 7.56 | 0.42 |
| 8467150 | 1982 | 11 | 6.81 | 0.13 | 3.48 | 6.69 | 3.47 | 7.15 | -0.12 |
| 8467150 | 1982 | 12 | 7.02 | 0.25 | 3.63 | 6.77 | 3.63 | 7.45 | -0.01 |
| 8467150 | 1983 | 1 | 6.91 | 0.23 | 3.57 | 6.68 | 3.57 | 7.32 | -0.01 |
| 8467150 | 1983 | 2 | 7.12 | 0.58 | 3.86 | 6.54 | 3.85 | 7.51 | 0.30 |
| 8467150 | 1983 | 3 | 7.32 | 0.63 | 3.96 | 6.69 | 3.97 | 7.59 | 0.37 |
| 8467150 | 1983 | 4 | 7.41 | 0.74 | 4.07 | 6.67 | 4.07 | 7.70 | 0.48 |
| 8467150 | 1983 | 5 | 7.20 | 0.48 | 3.83 | 6.72 | 3.84 | 7.52 | 0.20 |
| 8467150 | 1983 | 6 | 7.25 | 0.48 | 3.86 | 6.77 | 3.86 | 7.60 | 0.18 |
| 8467150 | 1983 | 7 | 7.32 | 0.52 | 3.93 | 6.80 | 3.92 | 7.68 | 0.28 |
| 8467150 | 1983 | 8 | 7.41 | 0.56 | 3.99 | 6.85 | 3.98 | 7.74 | 0.36 |
| 8467150 | 1983 | 9 | 7.38 | 0.51 | 3.96 | 6.86 | 3.95 | 7.69 | 0.35 |
| 8467150 | 1983 | 10 | 7.42 | 0.69 | 4.06 | 6.73 | 4.05 | 7.74 | 0.46 |
| 8467150 | 1983 | 11 | 7.40 | 0.69 | 4.04 | 6.71 | 4.04 | 7.80 | 0.36 |
| 8467150 | 1983 | 12 | 6.92 | 0.32 | 3.63 | 6.60 | 3.62 | 7.30 | -0.02 |
| 8467150 | 1984 | 1 | 6.79 | 0.26 | 3.53 | 6.53 | 3.53 | 7.20 | 0.02 |
| 8467150 | 1984 | 2 | 6.85 | 0.28 | 3.57 | 6.57 | 3.57 | 7.29 | 0.06 |
| 8467150 | 1984 | 3 | 7.08 | 0.50 | 3.79 | 6.58 | 3.79 | 7.35 | 0.29 |
| 8467150 | 1984 | 4 | 7.48 | 0.79 | 4.14 | 6.69 | 4.13 | 7.74 | 0.59 |
| 8467150 | 1984 | 5 | 7.16 | 0.39 | 3.76 | 6.77 | 3.77 | 7.50 | 0.14 |
| 8467150 | 1984 | 6 | 7.31 | 0.49 | 3.91 | 6.83 | 3.90 | 7.67 | 0.21 |
| 3467150 | 1984 | 7 | 7.27 | 0.35 | 3.80 | 6.92 | 3.81 | 7.60 | 0.10 |
| 8467150 | 1984 | 8 | 7.51 | 0.50 | 4.00 | 7.01 | 4.00 | 7.79 | 0.33 |
| 8467150 | 1984 | 9 | 7.27 | 0.39 | 3.84 | 6.88 | 3.83 | 7.55 | 0.23 |
| 8467150 | 1984 | 10 | 7.32 | 0.62 | 3.99 | 6.70 | 3.97 | 7.61 | 0.44 |
| 8467150 | 1984 | 11 | 7.12 | 0.53 | 3.83 | 6.59 | 3.82 | 7.52 | 0.26 |
| 8467150 | 1984 | 12 | 6.77 | 0.26 | 3.53 | 6.51 | 3.51 | 7.18 | 0.03 |
| 8467150 | 1985 | 1 | 6.53 | 0.19 | 3.37 | 6.35 | 3.36 | 6.95 | -0.16 |
| 8467150 | 1985 | 2 | 6.74 | 0.18 | 3.44 | 6.56 | 3.46 | 7.08 | -0.06 |
| 8467150 | 1985 | 3 | 6.64 | 0.15 | 3.42 | 6.49 | 3.39 | 6.91 | -0.04 |
| 8467150 | 1985 | 4 | 6.87 | 0.26 | 3.56 | 6.60 | 3.56 | 7.14 | -0.01 |
| 8467150 | 1985 | 5 | 7.18 | 0.41 | 3.80 | 6.77 | 3.79 | 7.52 | 0.15 |
| 8467150 | 1985 | 6 | 7.17 | 0.37 | 3.78 | 6.81 | 3.77 | 7.52 | 0.06 |
| 8467150 | 1985 | 7 | 7.21 | 0.41 | 3.81 | 6.80 | 3.81 | 7.55 | 0.11 |
| 8467150 | 1985 | 8 | 7.23 | 0.50 | 3.88 | 6.73 | 3.87 | 7.52 | 0.30 |
| 8467150 | 1985 | 9 | 7.18 | 0.58 | 3.89 | 6.60 | 3.88 | 7.57 | 0.39 |
| 8467150 | 1985 | 10 | 7.04 | 0.44 | 3.74 | 6.60 | 3.74 | 7.41 | 0.28 |
| 8467150 | 1985 | 11 | 7.33 | 0.82 | 4.07 | 6.50 | 4.07 | 7.66 | 0.50 |
| 8467150 | 1985 | 12 | 6.81 | 0.31 | 3.57 | 6.51 | 3.56 | 7.29 | -0.02 |
| 8467150 | 1986 | 1 | 6.47 | -0.03 | 3.24 | 6.50 | 3.22 | 6.90 | -0.37 |
| 8467150 | 1986 | 2 | 6.91 | 0.39 | 3.65 | 6.52 | 3.65 | 7.19 | 0.15 |
| 8467150 | 1986 | 3 | 6.62 | 0.06 | 3.34 | 6.56 | 3.34 | 6.98 | -0.18 |
| 8467150 | 1986 | 4 | 7.37 | 0.67 | 4.02 | 6.71 | 4.02 | 7.68 | 0.44 |
| 8467150 | 1986 | 5 | 7.24 | 0.54 | 3.91 | 6.70 | 3.89 | 7.58 | 0.24 |
| 8467150 | 1986 | 6 | 7.12 | 0.41 | 3.77 | 6.70 | 3.76 | 7.47 | 0.13 |
| 8467150 | 1986 | 7 | 7.29 | 0.68 | 3.99 | 6.61 | 3.99 | 7.63 | 0.39 |
| 8467150 | 1986 | 8 | 7.08 | 0.60 | 3.84 | 6.48 | 3.84 | 7.40 | 0.41 |
| 8467150 | 1986 | 9 | 7.02 | 0.45 | 3.74 | 6.57 | 3.73 | 7.33 | 0.27 |
| 3467150 | 1986 | 10 | 7.14 | 0.66 | 4.00 | 6.48 | 3.90 | 7.43 | 0.44 |
| 8467150 | 1986 | 11 | 6.87 | 0.41 | 3.68 | 6.46 | 3.64 | 7.35 | 0.03 |
| 8467150 | 1986 | 12 | 6.93 | 0.33 | 3.63 | 6.60 | 3.63 | 7.42 | -0.04 |
| 8467150 | 1987 | 1 | 6.90 | 0.45 | 3.68 | 6.45 | 3.68 | 7.39 | 0.03 |
| 8467150 | 1987 | 2 | 6.54 | 0.15 | 3.35 | 6.39 | 3.34 | 6.84 | -0.05 |

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8467150 1987  3     7.16      0.64      3.91      6.52      3.90      7.40      0.41
8467150 1987  4     7.24      0.74      3.98      6.50      3.99      7.58      0.50
8467150 1987  5     6.99      0.47      3.73      6.53      3.73      7.36      0.18
8467150 1987  6     7.19      0.54      3.87      6.65      3.86      7.57      0.18
 467150 1987  7     7.28      0.60      3.95      6.67      3.94      7.66      0.23
8467150 1987  8     7.26      0.58      3.93      6.68      3.92      7.62      0.34
8467150 1987  9     7.23      0.58      3.91      6.65      3.90      7.58      0.38
8467150 1987 10     7.04      0.43      3.75      6.61      3.74      7.39      0.36
8467150 1987 11     6.85      0.35      3.61      6.50      3.60      7.23      0.17
8467150 1987 12     6.95      0.51      3.74      6.43      3.73      7.45      0.10
8467150 1988  1     6.41      0.09      3.26      6.32      3.25      6.89      0.21
8467150 1988  2     6.67      0.32      3.50      6.35      3.50      7.15     -0.16
8467150 1988  3     6.54      0.14      3.35      6.40      3.34      6.80      0.05
8467150 1988  4     7.24      0.67      3.96      6.57      3.95      7.60     -0.05
8467150 1988  5 [   7.09] [   0.47] [   3.79] [   6.62] [   3.78] [   7.48] [   0.45
8467150 1988  6     7.13      0.49      3.81      6.64      3.81      7.53      0.21] [
8467150 1988  7     7.09      0.30      3.70      6.79      3.69      7.43      0.18
8467150 1988  8     7.21      0.37      3.79      6.84      3.79      7.48      0.08
8467150 1988  9     7.07      0.36      3.72      6.71      3.72      7.38      0.18
8467150 1988 10     6.97      0.54      3.77      6.43      3.75      7.33      0.20
8467150 1988 11     6.71      0.30      3.52      6.42      3.51      7.16      0.25
8467150 1988 12     6.52      0.20      3.37      6.32      3.36      6.89      0.01
8467150 1989  1     6.53      0.19      3.38      6.34      3.36      6.92     -0.05
8467150 1989  2     6.57      0.13      3.34      6.44      3.35      6.95     -0.02
8467150 1989  3     6.60      0.24      3.44      6.36      3.42      6.86     -0.11
8467150 1989  4     6.72      0.16      3.44      6.55      3.44      6.99      0.03
8467150 1989  5     7.11      0.37      3.74      6.74      3.74      7.49     -0.12
8467150 1989  6     7.28      0.44      3.86      6.84      3.86      7.65      0.08
8467150 1989  7     7.15      0.42      3.79      6.73      3.78      7.51      0.11
8467150 1989  8     7.29      0.57      3.93      6.72      3.93      7.57      0.15
 467150 1989  9     7.19      0.55      3.88      6.64      3.87      7.47      0.36
8467150 1989 10     7.13      0.52      3.83      6.61      3.83      7.44      0.36
8467150 1989 11     6.82      0.30      3.56      6.52      3.56      7.33      0.29
8467150 1989 12     6.44     -0.04      3.22      6.48      3.20      6.89     -0.04
8467150 1990  1     6.62      0.04      3.34      6.59      3.33      7.05     -0.32
8467150 1990  2     6.66      0.16      3.42      6.50      3.41      7.01     -0.24
8467150 1990  3     6.61     -0.01      3.31      6.62      3.30      6.92     -0.13
8467150 1990  4     6.67      0.16      3.44      6.51      3.42      6.98     -0.24
8467150 1990  5     7.17      0.51      3.87      6.66      3.84      7.52     -0.04
8467150 1990  6     7.14      0.42      3.79      6.72      3.78      7.51      0.24
8467150 1990  7     7.14      0.53      3.85      6.61      3.83      7.48      0.16
8467150 1990  8 [   7.25] [   0.79] [   4.03] [   6.46] [   4.02] [   7.58] [   0.30
8467150 1990  9     7.20      0.57      3.90      6.63      3.89      7.46      0.61] [
8467150 1990 10     7.17      0.48      3.82      6.69      3.82      7.50      0.42
8467150 1990 11     6.99      0.38      3.71      6.60      3.69      7.48      0.28
8467150 1990 12     6.82      0.13      3.49      6.69      3.47      7.27      0.04
8467150 1991  1     6.93      0.24      3.58      6.69      3.58      7.32     -0.17
8467150 1991  2     6.72      0.19      3.48      6.53      3.46      7.04     -0.05
8467150 1991  3     7.24      0.59      3.91      6.65      3.91      7.51     -0.02
8467150 1991  4     7.04      0.34      3.70      6.69      3.69      7.38      0.39
8467150 1991  5     7.11      0.40      3.76      6.71      3.76      7.51      0.08
8467150 1991  6     7.30      0.55      3.93      6.75      3.92      7.67      0.11
8467150 1991  7     7.33      0.52      3.93      6.81      3.93      7.67      0.25
8467150 1991  8     7.28      0.43      3.85      6.85      3.85      7.60      0.31
8467150 1991  9     7.23      0.40      3.82      6.83      3.81      7.50      0.22
8467150 1991 10     7.40      0.62      4.04      6.78      4.01      7.81      0.23
8467150 1991 11     7.09      0.57      3.84      6.52      3.83      7.43      0.43
 467150 1991 12     6.87      0.31      3.60      6.56      3.59      7.41      0.31
8467150 1992  1     6.83      0.42      3.62      6.41      3.62      7.32      0.03
8467150 1992  2     6.96      0.44      3.70      6.52      3.70      7.30      0.16
8467150 1992  3     6.93      0.39      3.66      6.54      3.66      7.28      0.21
8467150 1992  4     7.13      0.46      3.79      6.67      3.79      7.45      0.15
```

| | | | MHW | MLW | MSL | MN | MTL | MHHW | MLLW |
|---|---|---|---|---|---|---|---|---|---|
| 8467150 | 1992 | 5 | 7.24 | 0.44 | 3.84 | 6.80 | 3.84 | 7.63 | 0.22 |
| 8467150 | 1992 | 6 | 7.41 | 0.55 | 3.98 | 6.86 | 3.98 | 7.76 | 0.30 |
| 8467150 | 1992 | 7 | 7.54 | 0.52 | 4.04 | 7.02 | 4.03 | 7.86 | 0.33 |
| 8467150 | 1992 | 8 | 7.40 | 0.36 | 3.88 | 7.04 | 3.88 | 7.66 | 0.24 |
| 8467150 | 1992 | 9 | 7.31 | 0.40 | 3.85 | 6.90 | 3.85 | 7.56 | 0.25 |
| 8467150 | 1992 | 10 | 7.18 | 0.48 | 3.84 | 6.70 | 3.83 | 7.44 | 0.31 |
| 8467150 | 1992 | 11 | 7.11 | 0.47 | 3.80 | 6.64 | 3.79 | 7.41 | 0.23 |
| 8467150 | 1992 | 12 | 7.05 | 0.55 | 3.81 | 6.50 | 3.80 | 7.50 | 0.24 |
| 8467150 | 1993 | 1 | 6.79 | 0.31 | 3.56 | 6.48 | 3.55 | 7.20 | 0.04 |
| 8467150 | 1993 | 2 | 7.10 | 0.43 | 3.77 | 6.67 | 3.77 | 7.40 | 0.20 |
| 8467150 | 1993 | 3 | 6.85 | 0.32 | 3.61 | 6.53 | 3.59 | 7.16 | 0.02 |
| 8467150 | 1993 | 4 | 7.51 | 0.66 | 4.10 | 6.85 | 4.08 | 7.75 | 0.44 |
| 8467150 | 1993 | 5 | 7.39 | 0.46 | 3.93 | 6.93 | 3.93 | 7.73 | 0.19 |
| 8467150 | 1993 | 6 | 7.32 | 0.37 | 3.85 | 6.95 | 3.85 | 7.64 | 0.10 |
| 8467150 | 1993 | 7 | 7.45 | 0.51 | 3.98 | 6.94 | 3.98 | 7.76 | 0.27 |
| 8467150 | 1993 | 8 | 7.41 | 0.56 | 4.00 | 6.85 | 3.99 | 7.63 | 0.41 |
| 8467150 | 1993 | 9 | 7.37 | 0.51 | 3.94 | 6.86 | 3.94 | 7.60 | 0.35 |
| 8467150 | 1993 | 10 | 7.27 | 0.48 | 3.87 | 6.79 | 3.87 | 7.61 | 0.25 |
| 8467150 | 1993 | 11 | 6.91 | 0.26 | 3.60 | 6.65 | 3.59 | 7.29 | 0.03 |
| 8467150 | 1993 | 12 | 7.16 | 0.48 | 3.82 | 6.68 | 3.82 | 7.65 | 0.14 |
| 8467150 | 1994 | 1 | 6.52 | -0.08 | 3.23 | 6.60 | 3.22 | 6.95 | -0.44 |
| 8467150 | 1994 | 2 | 6.67 | 0.20 | 3.47 | 6.47 | 3.44 | 7.00 | -0.09 |
| 8467150 | 1994 | 3 | 7.07 | 0.18 | 3.63 | 6.88 | 3.63 | 7.36 | -0.05 |
| 8467150 | 1994 | 4 | 6.93 | -0.04 | 3.45 | 6.98 | 3.44 | 7.22 | -0.29 |
| 8467150 | 1994 | 5 | 7.34 | 0.38 | 3.87 | 6.96 | 3.86 | 7.65 | 0.14 |
| 8467150 | 1994 | 6 | 7.21 | 0.24 | 3.73 | 6.97 | 3.73 | 7.54 | 0.02 |
| 8467150 | 1994 | 7 | 7.24 | 0.40 | 3.83 | 6.84 | 3.82 | 7.53 | 0.21 |
| 8467150 | 1994 | 8 | 7.20 | 0.41 | 3.82 | 6.79 | 3.81 | 7.44 | 0.29 |
| 8467150 | 1994 | 9 | 7.36 | 0.51 | 3.93 | 6.85 | 3.94 | 7.55 | 0.38 |
| 8467150 | 1994 | 10 | 7.30 | 0.43 | 3.88 | 6.87 | 3.86 | 7.52 | 0.27 |
| 8467150 | 1994 | 11 | 6.90 | 0.04 | 3.48 | 6.86 | 3.47 | 7.33 | -0.24 |
| 8467150 | 1994 | 12 | 7.12 | 0.25 | 3.70 | 6.86 | 3.68 | 7.56 | -0.05 |
| 8467150 | 1995 | 1 | 6.90 | 0.07 | 3.50 | 6.83 | 3.48 | 7.25 | -0.18 |
| 8467150 | 1995 | 2 | 6.60 | -0.09 | 3.27 | 6.69 | 3.25 | 6.95 | -0.27 |
| 8467150 | 1995 | 3 | 7.09 | 0.18 | 3.64 | 6.91 | 3.63 | 7.30 | 0.04 |
| 8467150 | 1995 | 4 | 6.96 | 0.10 | 3.54 | 6.86 | 3.53 | 7.26 | -0.14 |
| 8467150 | 1995 | 5 | 7.36 | 0.48 | 3.94 | 6.89 | 3.92 | 7.71 | 0.18 |
| 8467150 | 1995 | 6 | 7.18 | 0.28 | 3.74 | 6.90 | 3.73 | 7.48 | 0.03 |
| 8467150 | 1995 | 7 | 7.32 | 0.33 | 3.85 | 6.99 | 3.83 | 7.60 | 0.15 |
| 8467150 | 1995 | 8 | 7.55 | 0.57 | 4.08 | 6.98 | 4.06 | 7.85 | 0.44 |
| 8467150 | 1995 | 9 | 7.46 | 0.53 | 4.01 | 6.94 | 4.00 | 7.74 | 0.41 |
| 8467150 | 1995 | 10 | 7.34 | 0.46 | 3.90 | 6.88 | 3.90 | 7.65 | 0.23 |
| 8467150 | 1995 | 11 | 7.37 | 0.52 | 3.95 | 6.85 | 3.94 | 7.73 | 0.20 |
| 8467150 | 1995 | 12 | 7.04 | 0.26 | 3.65 | 6.78 | 3.65 | 7.42 | 0.00 |
| 8467150 | 1996 | 1 | 7.16 | 0.64 | 3.90 | 6.52 | 3.90 | 7.63 | 0.23 |
| 8467150 | 1996 | 2 | 6.95 | 0.17 | 3.57 | 6.78 | 3.56 | 7.24 | 0.01 |
| 8467150 | 1996 | 3 | 6.88 | 0.20 | 3.55 | 6.68 | 3.54 | 7.10 | -0.05 |
| 8467150 | 1996 | 4 | 7.32 | 0.51 | 3.92 | 6.81 | 3.91 | 7.64 | 0.26 |
| 8467150 | 1996 | 5 | 7.34 | 0.34 | 3.84 | 7.00 | 3.84 | 7.65 | 0.12 |
| 8467150 | 1996 | 6 | 7.48 | 0.35 | 3.92 | 7.14 | 3.92 | 7.79 | 0.14 |
| 8467150 | 1996 | 7 | 7.61 | 0.36 | 4.00 | 7.25 | 3.98 | 7.90 | 0.12 |
| 8467150 | 1996 | 8 | 7.63 | 0.34 | 4.00 | 7.30 | 3.98 | 7.84 | 0.19 |
| 8467150 | 1996 | 9 | 7.95 | 0.88 | 4.42 | 7.06 | 4.42 | 8.18 | 0.72 |
| 8467150 | 1996 | 10 | 7.68 | 0.82 | 4.25 | 6.86 | 4.25 | 7.98 | 0.60 |
| 8467150 | 1996 | 11 | 7.40 | 0.59 | 4.00 | 6.80 | 3.99 | 7.67 | 0.34 |
| 8467150 | 1996 | 12 | 7.48 | 0.76 | 4.13 | 6.72 | 4.12 | 7.89 | 0.41 |
| 8467150 | 1997 | 1 | 7.03 | 0.24 | 3.64 | 6.78 | 3.63 | 7.46 | -0.11 |
| 8467150 | 1997 | 2 | 7.16 | 0.21 | 3.70 | 6.95 | 3.68 | 7.40 | -0.02 |
| 8467150 | 1997 | 3 | 7.20 | 0.33 | 3.76 | 6.87 | 3.76 | 7.49 | 0.06 |
| 8467150 | 1997 | 4 | 7.67 | 0.62 | 4.14 | 7.04 | 4.14 | 7.87 | 0.35 |
| 8467150 | 1997 | 5 | 7.34 | 0.26 | 3.80 | 7.09 | 3.80 | 7.62 | -0.01 |
| 8467150 | 1997 | 6 | 7.65 | 0.54 | 4.10 | 7.12 | 4.09 | 8.00 | 0.27 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 8467150 | 1997 | 7 | 7.44 | 0.37 | 3.91 | 7.07 | 3.90 | 7.76 | 0.15 |
| 8467150 | 1997 | 8 | 7.56 | 0.52 | 4.05 | 7.04 | 4.04 | 7.84 | 0.33 |
| 8467150 | 1997 | 9 | 7.50 | 0.52 | 4.02 | 6.99 | 4.01 | 7.77 | 0.36 |
| 8467150 | 1997 | 10 | 7.49 | 0.60 | 4.06 | 6.89 | 4.04 | 7.82 | 0.37 |
| 467150 | 1997 | 11 | 7.44 | 0.68 | 4.07 | 6.76 | 4.06 | 7.86 | 0.37 |
| 8467150 | 1997 | 12 | 7.14 | 0.36 | 3.78 | 6.78 | 3.75 | 7.54 | 0.00 |
| 8467150 | 1998 | 1 | 7.49 | 0.64 | 4.07 | 6.85 | 4.07 | 7.82 | 0.39 |
| 8467150 | 1998 | 2 | 7.70 | 0.96 | 4.35 | 6.74 | 4.33 | 8.00 | 0.67 |
| 8467150 | 1998 | 3 | 7.35 | 0.39 | 3.88 | 6.96 | 3.87 | 7.66 | 0.15 |
| 8467150 | 1998 | 4 | 7.63 | 0.58 | 4.11 | 7.04 | 4.10 | 7.95 | 0.36 |
| 8467150 | 1998 | 5 | 7.77 | 0.75 | 4.27 | 7.02 | 4.26 | 8.09 | 0.54 |
| 8467150 | 1998 | 6 | 7.63 | 0.60 | 4.13 | 7.03 | 4.12 | 7.92 | 0.39 |
| 8467150 | 1998 | 7 | 7.55 | 0.61 | 4.08 | 6.94 | 4.08 | 7.84 | 0.43 |
| 8467150 | 1998 | 8 | 7.46 | 0.59 | 4.03 | 6.88 | 4.02 | 7.73 | 0.46 |
| 8467150 | 1998 | 9 | 7.57 | 0.65 | 4.11 | 6.92 | 4.11 | 7.83 | 0.54 |
| 8467150 | 1998 | 10 | 7.30 | 0.39 | 3.85 | 6.91 | 3.84 | 7.54 | 0.19 |
| 8467150 | 1998 | 11 | 7.20 | 0.27 | 3.74 | 6.93 | 3.73 | 7.54 | 0.06 |
| 8467150 | 1998 | 12 | 7.08 | 0.17 | 3.63 | 6.91 | 3.62 | 7.45 | -0.15 |
| 8467150 | 1999 | 1 | 6.91 | 0.16 | 3.54 | 6.76 | 3.53 | 7.29 | -0.11 |
| 8467150 | 1999 | 2 | 7.29 | 0.58 | 3.93 | 6.71 | 3.93 | 7.54 | 0.38 |
| 8467150 | 1999 | 3 | 7.06 | 0.27 | 3.67 | 6.79 | 3.66 | 7.35 | 0.00 |
| 8467150 | 1999 | 4 | 7.37 | 0.48 | 3.92 | 6.89 | 3.92 | 7.65 | 0.24 |
| 8467150 | 1999 | 5 | 7.39 | 0.50 | 3.95 | 6.89 | 3.95 | 7.70 | 0.29 |
| 8467150 | 1999 | 6 | 7.32 | 0.42 | 3.87 | 6.89 | 3.87 | 7.62 | 0.19 |
| 8467150 | 1999 | 7 | 7.49 | 0.48 | 4.00 | 7.01 | 3.99 | 7.77 | 0.26 |
| 8467150 | 1999 | 8 | 7.64 | 0.59 | 4.13 | 7.05 | 4.12 | 7.91 | 0.42 |
| 8467150 | 1999 | 9 | 7.53 | 0.59 | 4.06 | 6.95 | 4.06 | 7.81 | 0.41 |
| 8467150 | 1999 | 10 | 7.34 | 0.38 | 3.86 | 6.96 | 3.86 | 7.59 | 0.19 |
| 8467150 | 1999 | 11 | 7.11 | 0.17 | 3.64 | 6.94 | 3.64 | 7.43 | -0.07 |
| 8467150 | 1999 | 12 | 7.01 | 0.23 | 3.62 | 6.78 | 3.62 | 7.37 | -0.08 |
| 467150 | 2000 | 1 | 6.67 | -0.03 | 3.34 | 6.70 | 3.32 | 7.19 | -0.44 |
| 8467150 | 2000 | 2 | 6.58 | -0.08 | 3.25 | 6.66 | 3.25 | 6.86 | -0.28 |
| 8467150 | 2000 | 3 | 7.10 | 0.45 | 3.78 | 6.65 | 3.78 | 7.34 | 0.21 |
| 8467150 | 2000 | 4 | 7.22 | 0.44 | 3.83 | 6.78 | 3.83 | 7.47 | 0.20 |
| 8467150 | 2000 | 5 | 7.49 | 0.49 | 3.99 | 7.00 | 3.99 | 7.75 | 0.25 |
| 8467150 | 2000 | 6 | 7.47 | 0.38 | 3.93 | 7.09 | 3.92 | 7.79 | 0.11 |
| 8467150 | 2000 | 7 | 7.70 | 0.51 | 4.12 | 7.19 | 4.10 | 8.01 | 0.27 |
| 8467150 | 2000 | 8 | 7.62 | 0.47 | 4.07 | 7.15 | 4.05 | 7.87 | 0.31 |

1979 MONTHLY WATER LEVEL DATA
National Ocean Service (NOAA)

Station: 8467150
Name: BRIDGEPORT, BRIDGEPORT HARBOR
Note: [] Denotes Inferred Water Level Value

| 1979 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Se |
|---|---|---|---|---|---|---|---|---|---|
| MHW | 8.88 | [ 8.35] | 8.65 | 8.86 | 8.87 | 8.98 | 9.00 | 9.09 | 9.0 |
| MLW | 2.00 | [ 1.65] | 1.70 | 2.00 | 2.01 | 2.04 | 2.08 | 2.13 | 2.0 |
| MSL | 5.44 | [ 5.00] | 5.17 | 5.43 | 5.44 | 5.52 | 5.55 | 5.63 | 5.5 |
| MN | 6.88 | [ 6.70] | 6.95 | 6.87 | 6.86 | 6.94 | 6.91 | 6.96 | 7.0 |
| MTL | 5.44 | [ 5.00] | 5.17 | 5.43 | 5.44 | 5.51 | 5.54 | 5.61 | 5.5 |
| MHHW | 9.29 | [ 8.68] | 8.91 | 9.19 | 9.13 | 9.29 | 9.29 | 9.38 | 9.3 |
| MLLW | 1.63 | [ 1.35] | 1.46 | 1.72 | 1.77 | 1.78 | 1.88 | 1.95 | 1.8 |
| DHQ | 0.41 | [ 0.33] | 0.26 | 0.33 | 0.26 | 0.31 | 0.29 | 0.30 | 0.3 |
| DLQ | 0.37 | [ 0.30] | 0.24 | 0.28 | 0.24 | 0.25 | 0.20 | 0.17 | 0.1 |
| GT | 7.66 | [ 7.33] | 7.45 | 7.47 | 7.37 | 7.50 | 7.40 | 7.43 | 7.5 |
| DTL | 5.46 | [ 5.02] | 5.18 | 5.46 | 5.45 | 5.54 | 5.59 | 5.67 | 5.6 |
| HWI | 3.73 |  | 3.79 | 3.89 | 3.84 | 3.92 | 3.91 | 3.80 | 3.8 |
| LWI | 10.09 |  | 10.12 | 10.18 | 10.14 | 10.23 | 10.22 | 10.14 | 10.1 |

□

1980 MONTHLY WATER LEVEL DATA
National Ocean Service (NOAA)

Station: 8467150
Name: BRIDGEPORT, BRIDGEPORT HARBOR
Note: [] Denotes Inferred Water Level Value

| 1980 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Se |
|---|---|---|---|---|---|---|---|---|---|
| MHW | 8.48 | 8.56 | 8.62 | 8.91 | 9.08 | 8.98 | 9.04 | 9.15 | 8.9 |
| MLW | 1.76 | 1.88 | 1.89 | 2.14 | 2.13 | 1.98 | 1.97 | 2.07 | 2.0 |
| MSL | [ 5.13] | 5.24 | 5.23 | 5.53 | 5.61 | 5.49 | 5.51 | 5.61 | 5.5 |
| MN | 6.71 | 6.68 | 6.73 | 6.77 | 6.95 | 7.00 | 7.07 | 7.08 | 6.9 |
| MTL | 5.12 | 5.22 | 5.25 | 5.53 | 5.61 | 5.48 | 5.51 | 5.61 | 5.4 |
| MHHW | 8.88 | 8.89 | 8.95 | 9.15 | 9.37 | 9.29 | 9.32 | 9.39 | 9.2 |
| MLLW | 1.49 | 1.68 | 1.62 | 1.94 | 1.91 | 1.70 | 1.76 | 1.91 | 1.8 |
| DHQ | 0.40 | 0.32 | 0.33 | 0.24 | 0.29 | 0.31 | 0.28 | 0.24 | 0.2 |
| DLQ | 0.27 | 0.20 | 0.26 | 0.20 | 0.22 | 0.28 | 0.22 | 0.16 | 0.1 |
| GT | 7.38 | 7.20 | 7.32 | 7.22 | 7.46 | 7.59 | 7.57 | 7.48 | 7.3 |
| DTL | 5.18 | 5.29 | 5.29 | 5.55 | 5.64 | 5.49 | 5.54 | 5.65 | 5.5 |
| HWI | 3.70 | 3.74 | 3.73 | 3.80 | 3.85 | 3.83 | 3.80 | 3.74 | 3.7 |
| LWI | 10.05 | 10.07 | 10.06 | 10.13 | 10.15 | 10.14 | 10.14 | 10.08 | 10.1 |

□

1981 MONTHLY WATER LEVEL DATA
National Ocean Service (NOAA)

Station: 8467150
Name: BRIDGEPORT, BRIDGEPORT HARBOR
Note: [] Denotes Inferred Water Level Value

| 1981 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Se |
|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| MHW | 8.11 | 8.40 | 8.63 | 8.52 | 9.08 | 9.08 | 9.11 | 9.14 | 9.1 |
| MLW | 1.55 | 1.69 | 1.95 | 1.67 | 2.07 | 2.02 | 2.06 | 2.17 | 2.3 |
| MSL | 4.84 | 5.05 | 5.30 | 5.10 | 5.59 | 5.55 | 5.58 | 5.66 | 5.7 |
| MN | 6.56 | 6.71 | 6.69 | 6.85 | 7.01 | 7.06 | 7.05 | 6.97 | 6.8 |
| MTL | 4.83 | 5.05 | 5.29 | 5.10 | 5.58 | 5.55 | 5.58 | 5.66 | 5.7 |
| MHHW | 8.49 | 8.77 | 8.90 | 8.75 | 9.39 | 9.42 | 9.43 | 9.42 | 9.3 |
| MLLW | 1.36 | 1.50 | 1.69 | 1.40 | 1.81 | 1.77 | 1.83 | 1.97 | 2.1 |
| DHQ | 0.38 | 0.38 | 0.26 | 0.23 | 0.31 | 0.34 | 0.32 | 0.28 | 0.2 |
| DLQ | 0.18 | 0.19 | 0.26 | 0.27 | 0.26 | 0.25 | 0.22 | 0.21 | 0.1 |
| GT | 7.12 | 7.27 | 7.21 | 7.34 | 7.58 | 7.65 | 7.60 | 7.46 | 7.2 |
| DTL | 4.93 | 5.14 | 5.29 | 5.08 | 5.60 | 5.59 | 5.63 | 5.69 | 5.7 |
| HWI | 3.75 | 3.67 | 3.76 | 3.71 | 3.70 | 3.76 | 3.83 | 3.79 | 3.8 |
| LWI | 10.09 | 10.00 | 10.07 | 10.06 | 10.03 | 10.08 | 10.15 | 10.12 | 10.1 |

□

1982 MONTHLY WATER LEVEL DATA
National Ocean Service (NOAA)

Station: 8467150
Name: BRIDGEPORT, BRIDGEPORT HARBOR
Note: [] Denotes Inferred Water Level Value

| 1982 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Se |
|---|---|---|---|---|---|---|---|---|---|
| MHW | 8.29 | 8.49 | 8.56 | 8.38 | 8.96 | 9.38 | 8.94 | 8.93 | 9.0 |
| MLW | 1.67 | 1.79 | 1.81 | 1.61 | 2.05 | 2.46 | 2.11 | 2.14 | 2.2 |
| MSL | 4.98 | 5.15 | 5.19 | 5.00 | 5.51 | 5.92 | 5.54 | 5.54 | 5.6 |
| MN | 6.62 | 6.69 | 6.75 | 6.77 | 6.91 | 6.92 | 6.83 | 6.79 | 6.8 |
| MTL | 4.98 | 5.14 | 5.18 | 5.00 | 5.50 | 5.92 | 5.53 | 5.53 | 5.6 |
| MHHW | 8.71 | 8.82 | 8.80 | 8.74 | 9.22 | 9.72 | 9.27 | 9.22 | 9.2 |
| MLLW | 1.38 | 1.55 | 1.56 | 1.25 | 1.82 | 2.17 | 1.88 | 1.91 | 2.0 |
| DHQ | 0.42 | 0.33 | 0.25 | 0.36 | 0.26 | 0.35 | 0.33 | 0.29 | 0.2 |
| DLQ | 0.29 | 0.25 | 0.25 | 0.37 | 0.23 | 0.28 | 0.23 | 0.23 | 0.1 |
| GT | 7.33 | 7.27 | 7.24 | 7.49 | 7.40 | 7.55 | 7.39 | 7.31 | 7.2 |
| DTL | 5.05 | 5.18 | 5.18 | 4.99 | 5.52 | 5.95 | 5.58 | 5.57 | 5.6 |
| HWI | 3.77 | 3.77 | 3.73 | 3.76 | 3.79 | 3.82 | 3.88 | 3.85 | 3.9 |
| LWI | 10.13 | 10.11 | 10.08 | 10.11 | 10.14 | 10.16 | 10.19 | 10.15 | 10.2 |

□

1983 MONTHLY WATER LEVEL DATA
National Ocean Service (NOAA)

Station: 8467150
Name: BRIDGEPORT, BRIDGEPORT HARBOR
Note: [] Denotes Inferred Water Level Value

| 1983 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Se |
|---|---|---|---|---|---|---|---|---|---|
| MHW | 8.72 | 8.93 | 9.13 | 9.22 | 9.01 | 9.06 | 9.13 | 9.22 | 9.1 |
| MLW | 2.04 | 2.39 | 2.44 | 2.55 | 2.29 | 2.29 | 2.33 | 2.37 | 2.3 |
| MSL | 5.38 | 5.67 | 5.77 | 5.88 | 5.64 | 5.67 | 5.74 | 5.80 | 5.7 |
| MN | 6.68 | 6.54 | 6.69 | 6.67 | 6.72 | 6.77 | 6.80 | 6.85 | 6.8 |
| MTL | 5.38 | 5.66 | 5.78 | 5.88 | 5.65 | 5.67 | 5.73 | 5.79 | 5.7 |
| MHHW | 9.13 | 9.32 | 9.40 | 9.51 | 9.33 | 9.41 | 9.49 | 9.55 | 9.5 |
| MLLW | 1.80 | 2.11 | 2.18 | 2.29 | 2.01 | 1.99 | 2.09 | 2.17 | 2.1 |
| DHQ | 0.40 | 0.39 | 0.27 | 0.29 | 0.32 | 0.36 | 0.36 | 0.33 | 0.3 |
| DLQ | 0.25 | 0.28 | 0.26 | 0.26 | 0.28 | 0.30 | 0.24 | 0.19 | 0.1 |
| GT | 7.33 | 7.21 | 7.22 | 7.22 | 7.32 | 7.43 | 7.40 | 7.38 | 7.3 |
| DTL | 5.46 | 5.71 | 5.79 | 5.90 | 5.67 | 5.70 | 5.79 | 5.86 | 5.8 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| HWI | 3.71 | 3.77 | 3.76 | 3.76 | 3.81 | 3.86 | 3.85 | 3.81 | 3.8 |
| LWI | 10.03 | 10.12 | 10.10 | 10.10 | 10.11 | 10.17 | 10.15 | 10.16 | 10.1 |

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## 1984 MONTHLY WATER LEVEL DATA
National Ocean Service (NOAA)

Station: 8467150
Name: BRIDGEPORT, BRIDGEPORT HARBOR
Note: [] Denotes Inferred Water Level Value

| 1984 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Se |
|---|---|---|---|---|---|---|---|---|---|
| MHW | 8.60 | 8.66 | 8.89 | 9.29 | 8.97 | 9.12 | 9.08 | 9.32 | 9.0 |
| MLW | 2.07 | 2.09 | 2.31 | 2.60 | 2.20 | 2.30 | 2.16 | 2.31 | 2.2 |
| MSL | 5.34 | 5.38 | 5.60 | 5.95 | 5.57 | 5.72 | 5.61 | 5.81 | 5.6 |
| MN | 6.53 | 6.57 | 6.58 | 6.69 | 6.77 | 6.83 | 6.92 | 7.01 | 6.8 |
| MTL | 5.34 | 5.38 | 5.60 | 5.94 | 5.58 | 5.71 | 5.62 | 5.81 | 5.6 |
| MHHW | 9.01 | 9.10 | 9.16 | 9.55 | 9.31 | 9.48 | 9.41 | 9.60 | 9.3 |
| MLLW | 1.83 | 1.87 | 2.10 | 2.40 | 1.95 | 2.02 | 1.91 | 2.14 | 2.0 |
| DHQ | 0.41 | 0.44 | 0.27 | 0.26 | 0.34 | 0.35 | 0.34 | 0.29 | 0.2 |
| DLQ | 0.25 | 0.22 | 0.21 | 0.21 | 0.25 | 0.28 | 0.24 | 0.17 | 0.1 |
| GT | 7.18 | 7.24 | 7.06 | 7.15 | 7.36 | 7.46 | 7.50 | 7.46 | 7.3 |
| DTL | 5.42 | 5.49 | 5.63 | 5.97 | 5.63 | 5.75 | 5.66 | 5.87 | 5.7 |
| HWI | 3.77 | 3.75 | 3.76 | 3.74 | 3.77 | 3.77 | 3.81 | 3.80 | 3.8 |
| LWI | 10.11 | 10.08 | 10.07 | 10.06 | 10.06 | 10.07 | 10.10 | 10.12 | 10.1 |

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## 1985 MONTHLY WATER LEVEL DATA
National Ocean Service (NOAA)

Station: 8467150
Name: BRIDGEPORT, BRIDGEPORT HARBOR
Note: [] Denotes Inferred Water Level Value

| 1985 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Se |
|---|---|---|---|---|---|---|---|---|---|
| MHW | 8.34 | 8.55 | 8.45 | 8.68 | 8.99 | 8.98 | 9.02 | 9.04 | 8.9 |
| MLW | 2.00 | 1.99 | 1.96 | 2.07 | 2.22 | 2.18 | 2.22 | 2.31 | 2.3 |
| MSL | 5.18 | 5.25 | 5.23 | 5.37 | 5.61 | 5.59 | 5.62 | 5.69 | 5.7 |
| MN | 6.35 | 6.56 | 6.49 | 6.60 | 6.77 | 6.81 | 6.80 | 6.73 | 6.6 |
| MTL | 5.17 | 5.27 | 5.20 | 5.37 | 5.60 | 5.58 | 5.62 | 5.68 | 5.6 |
| MHHW | 8.76 | 8.89 | 8.72 | 8.95 | 9.33 | 9.33 | 9.36 | 9.33 | 9.3 |
| MLLW | 1.65 | 1.75 | 1.77 | 1.80 | 1.96 | 1.87 | 1.92 | 2.11 | 2.2 |
| DHQ | 0.41 | 0.35 | 0.27 | 0.28 | 0.34 | 0.35 | 0.34 | 0.29 | 0.3 |
| DLQ | 0.35 | 0.24 | 0.18 | 0.27 | 0.25 | 0.30 | 0.30 | 0.21 | 0.1 |
| GT | 7.10 | 7.14 | 6.95 | 7.15 | 7.37 | 7.46 | 7.44 | 7.23 | 7.1 |
| DTL | 5.20 | 5.32 | 5.25 | 5.38 | 5.65 | 5.60 | 5.64 | 5.72 | 5.7 |
| HWI | 3.77 | 3.71 | 3.72 | 3.71 | 3.79 | 3.86 | 3.86 | 3.84 | 3.8 |
| LWI | 10.12 | 10.04 | 10.05 | 10.04 | 10.11 | 10.18 | 10.18 | 10.14 | 10.1 |

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## 1986 MONTHLY WATER LEVEL DATA
National Ocean Service (NOAA)

Station: 8467150
Name: BRIDGEPORT, BRIDGEPORT HARBOR
Note: [] Denotes Inferred Water Level Value

| 1986 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Se |
|---|---|---|---|---|---|---|---|---|---|
| MHW | 8.28 | 8.72 | 8.43 | 9.18 | 9.05 | 8.93 | 9.10 | 8.89 | 8.8 |
| MLW | 1.78 | 2.20 | 1.87 | 2.48 | 2.35 | 2.22 | 2.49 | 2.41 | 2.2 |
| MSL | 5.05 | 5.46 | 5.15 | 5.83 | 5.72 | 5.58 | 5.80 | 5.65 | 5.5 |
| MN | 6.50 | 6.52 | 6.56 | 6.71 | 6.70 | 6.70 | 6.61 | 6.48 | 6.5 |
| MTL | 5.03 | 5.46 | 5.15 | 5.83 | 5.70 | 5.57 | 5.80 | 5.65 | 5.5 |
| MHHW | 8.71 | 9.00 | 8.79 | 9.49 | 9.39 | 9.28 | 9.44 | 9.21 | 9.1 |
| MLLW | 1.44 | 1.96 | 1.63 | 2.25 | 2.05 | 1.94 | 2.20 | 2.22 | 2.0 |
| DHQ | 0.43 | 0.29 | 0.36 | 0.30 | 0.34 | 0.35 | 0.34 | 0.33 | 0.3 |
| DLQ | 0.34 | 0.23 | 0.24 | 0.22 | 0.30 | 0.28 | 0.29 | 0.19 | 0.1 |
| GT | 7.26 | 7.04 | 7.16 | 7.23 | 7.33 | 7.33 | 7.25 | 7.00 | 7.0 |
| DTL | 5.08 | 5.48 | 5.21 | 5.87 | 5.72 | 5.61 | 5.82 | 5.72 | 5.6 |
| HWI | 3.72 | 3.75 | 3.72 | 3.71 | 3.77 | 3.85 | 3.89 | 3.84 | 3.8 |
| LWI | 10.08 | 10.07 | 10.04 | 10.04 | 10.09 | 10.16 | 10.18 | 10.15 | 10.1 |

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1987 MONTHLY WATER LEVEL DATA
National Ocean Service (NOAA)

Station: 8467150
Name: BRIDGEPORT, BRIDGEPORT HARBOR
Note: [] Denotes Inferred Water Level Value

| 1987 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Se |
|---|---|---|---|---|---|---|---|---|---|
| MHW | 8.71 | 8.35 | 8.97 | 9.05 | 8.80 | 9.00 | 9.09 | 9.07 | 9.0 |
| MLW | 2.26 | 1.96 | 2.45 | 2.55 | 2.28 | 2.35 | 2.41 | 2.39 | 2.3 |
| MSL | 5.49 | 5.16 | 5.72 | 5.79 | 5.54 | 5.68 | 5.76 | 5.74 | 5.7 |
| MN | 6.45 | 6.39 | 6.52 | 6.50 | 6.53 | 6.65 | 6.67 | 6.68 | 6.6 |
| MTL | 5.49 | 5.15 | 5.71 | 5.80 | 5.54 | 5.67 | 5.75 | 5.73 | 5.7 |
| MHHW | 9.20 | 8.65 | 9.21 | 9.39 | 9.17 | 9.38 | 9.47 | 9.43 | 9.3 |
| MLLW | 1.84 | 1.76 | 2.22 | 2.31 | 1.99 | 2.04 | 2.15 | 2.19 | 2.1 |
| DHQ | 0.48 | 0.30 | 0.24 | 0.34 | 0.37 | 0.38 | 0.38 | 0.36 | 0.3 |
| DLQ | 0.42 | 0.20 | 0.22 | 0.24 | 0.29 | 0.32 | 0.27 | 0.20 | 0.2 |
| GT | 7.36 | 6.88 | 6.99 | 7.07 | 7.18 | 7.34 | 7.32 | 7.24 | 7.2 |
| DTL | 5.52 | 5.20 | 5.72 | 5.85 | 5.58 | 5.71 | 5.81 | 5.81 | 5.7 |
| HWI | 3.66 | 3.75 | 3.77 | 3.78 | 3.79 | 3.83 | 3.84 | 3.83 | 3.8 |
| LWI | 10.00 | 10.08 | 10.11 | 10.11 | 10.07 | 10.16 | 10.14 | 10.15 | 10.1 |

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1988 MONTHLY WATER LEVEL DATA
National Ocean Service (NOAA)

Station: 8467150
Name: BRIDGEPORT, BRIDGEPORT HARBOR
Note: [] Denotes Inferred Water Level Value

| 1988 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Se |
|---|---|---|---|---|---|---|---|---|---|
| MHW | 8.22 | 8.48 | 8.35 | 9.05 | [ 8.90] | 8.94 | 8.90 | 9.02 | 8.8 |
| MLW | 1.90 | 2.13 | 1.95 | 2.48 | [ 2.28] | 2.30 | 2.11 | 2.18 | 2.1 |
| MSL | 5.07 | 5.31 | 5.16 | 5.77 | [ 5.60] | 5.62 | 5.51 | 5.60 | 5.5 |
| MN | 6.32 | 6.35 | 6.40 | 6.57 | [ 6.62] | 6.64 | 6.79 | 6.84 | 6.7 |
| MTL | 5.06 | 5.31 | 5.15 | 5.76 | [ 5.59] | 5.62 | 5.50 | 5.60 | 5.5 |
| MHHW | 8.70 | 8.96 | 8.61 | 9.41 | [ 9.29] | 9.34 | 9.24 | 9.29 | 9.1 |
| MLLW | 1.65 | 1.86 | 1.76 | 2.26 | [ 2.02] | 1.99 | 1.89 | 1.99 | 2.0 |
| DHQ | 0.48 | 0.47 | 0.26 | 0.36 | [ 0.39] | 0.40 | 0.34 | 0.27 | 0.3 |
| DLQ | 0.25 | 0.27 | 0.19 | 0.22 | [ 0.27] | 0.31 | 0.22 | 0.18 | 0.1 |
| GT | 7.06 | 7.10 | 6.85 | 7.15 | [ 7.27] | 7.35 | 7.34 | 7.29 | 7.1 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| DTL | 5.18 | 5.41 | 5.19 | 5.83 | [ 5.65] | 5.66 | 5.56 | 5.64 | 5.6 |
| HWI | 3.77 | 3.76 | 3.78 | 3.79 | | 3.85 | 3.83 | 3.81 | 3.8 |
| LWI | 10.11 | 10.06 | 10.08 | 10.12 | | 10.13 | 10.13 | 10.14 | 10.1 |

1989 MONTHLY WATER LEVEL DATA
National Ocean Service (NOAA)

Station: 8467150
Name: BRIDGEPORT, BRIDGEPORT HARBOR
Note: [] Denotes Inferred Water Level Value

| 1989 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Se |
|---|---|---|---|---|---|---|---|---|---|
| MHW | 8.34 | 8.38 | 8.41 | 8.53 | 8.92 | 9.09 | 8.96 | 9.10 | 9.0 |
| MLW | 2.00 | 1.94 | 2.05 | 1.97 | 2.18 | 2.25 | 2.23 | 2.38 | 2.3 |
| MSL | 5.19 | 5.15 | 5.25 | 5.25 | 5.55 | 5.67 | 5.60 | 5.74 | 5.6 |
| MN | 6.34 | 6.44 | 6.36 | 6.55 | 6.74 | 6.84 | 6.73 | 6.72 | 6.6 |
| MTL | 5.17 | 5.16 | 5.23 | 5.25 | 5.55 | 5.67 | 5.59 | 5.74 | 5.6 |
| MHHW | 8.73 | 8.76 | 8.67 | 8.80 | 9.30 | 9.46 | 9.32 | 9.38 | 9.2 |
| MLLW | 1.79 | 1.70 | 1.84 | 1.69 | 1.89 | 1.92 | 1.96 | 2.17 | 2.1 |
| DHQ | 0.40 | 0.38 | 0.26 | 0.28 | 0.39 | 0.37 | 0.35 | 0.29 | 0.2 |
| DLQ | 0.21 | 0.24 | 0.21 | 0.28 | 0.29 | 0.33 | 0.27 | 0.21 | 0.1 |
| GT | 6.94 | 7.06 | 6.83 | 7.11 | 7.42 | 7.54 | 7.36 | 7.21 | 7.1 |
| DTL | 5.26 | 5.23 | 5.26 | 5.25 | 5.59 | 5.69 | 5.64 | 5.78 | 5.7 |
| HWI | 3.77 | 3.76 | 3.73 | 3.78 | 3.82 | 3.88 | 3.89 | 3.82 | 3.8 |
| LWI | 10.09 | 10.09 | 10.06 | 10.09 | 10.16 | 10.20 | 10.16 | 10.14 | 10.1 |

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1990 MONTHLY WATER LEVEL DATA
National Ocean Service (NOAA)

Station: 8467150
Name: BRIDGEPORT, BRIDGEPORT HARBOR
Note: [] Denotes Inferred Water Level Value

| 1990 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Se |
|---|---|---|---|---|---|---|---|---|---|
| MHW | 8.43 | 8.47 | 8.42 | 8.48 | 8.98 | 8.95 | 8.95 | [ 9.06] | 9.0 |
| MLW | 1.85 | 1.97 | 1.80 | 1.97 | 2.32 | 2.23 | 2.34 | [ 2.60] | 2.3 |
| MSL | 5.15 | 5.23 | 5.12 | 5.25 | 5.68 | 5.60 | 5.66 | [ 5.84] | 5.7 |
| MN | 6.59 | 6.50 | 6.62 | 6.51 | 6.66 | 6.72 | 6.61 | [ 6.46] | 6.6 |
| MTL | 5.14 | 5.22 | 5.11 | 5.23 | 5.65 | 5.59 | 5.64 | [ 5.83] | 5.7 |
| MHHW | 8.86 | 8.82 | 8.73 | 8.79 | 9.33 | 9.32 | 9.29 | [ 9.39] | 9.2 |
| MLLW | 1.57 | 1.68 | 1.57 | 1.77 | 2.05 | 1.97 | 2.11 | [ 2.42] | 2.2 |
| DHQ | 0.42 | 0.35 | 0.31 | 0.31 | 0.35 | 0.37 | 0.35 | [ 0.33] | 0.2 |
| DLQ | 0.27 | 0.29 | 0.23 | 0.20 | 0.27 | 0.26 | 0.23 | [ 0.18] | 0.1 |
| GT | 7.28 | 7.14 | 7.16 | 7.02 | 7.28 | 7.35 | 7.19 | [ 6.97] | 7.0 |
| DTL | 5.21 | 5.25 | 5.15 | 5.28 | 5.69 | 5.64 | 5.70 | [ 5.90] | 5.7 |
| HWI | 3.79 | 3.75 | 3.72 | 3.67 | 3.84 | 3.90 | 3.95 | | 3.8 |
| LWI | 10.11 | 10.09 | 10.08 | 10.00 | 10.22 | 10.20 | 10.27 | | 10.2 |

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1991 MONTHLY WATER LEVEL DATA
National Ocean Service (NOAA)

Station: 8467150
Name: BRIDGEPORT, BRIDGEPORT HARBOR
Note: [] Denotes Inferred Water Level Value

| 1991 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Se |
|---|---|---|---|---|---|---|---|---|---|
| MHW | 8.74 | 8.53 | 9.05 | 8.85 | 8.92 | 9.11 | 9.14 | 9.09 | 9.0 |
| MLW | 2.05 | 2.00 | 2.40 | 2.15 | 2.21 | 2.36 | 2.33 | 2.24 | 2.2 |
| MSL | 5.39 | 5.29 | 5.72 | 5.51 | 5.57 | 5.74 | 5.74 | 5.66 | 5.6 |
| MN | 6.69 | 6.53 | 6.65 | 6.69 | 6.71 | 6.75 | 6.81 | 6.85 | 6.8 |
| MTL | 5.39 | 5.27 | 5.72 | 5.50 | 5.57 | 5.73 | 5.74 | 5.66 | 5.6 |
| MHHW | 9.13 | 8.85 | 9.32 | 9.19 | 9.32 | 9.48 | 9.48 | 9.41 | 9.3 |
| MLLW | 1.76 | 1.79 | 2.20 | 1.89 | 1.92 | 2.06 | 2.12 | 2.03 | 2.0 |
| DHQ | 0.39 | 0.32 | 0.27 | 0.34 | 0.39 | 0.38 | 0.34 | 0.32 | 0.2 |
| DLQ | 0.29 | 0.22 | 0.20 | 0.26 | 0.29 | 0.30 | 0.21 | 0.21 | 0.1 |
| GT | 7.37 | 7.06 | 7.12 | 7.29 | 7.40 | 7.42 | 7.36 | 7.38 | 7.2 |
| DTL | 5.44 | 5.32 | 5.76 | 5.54 | 5.62 | 5.77 | 5.80 | 5.72 | 5.6 |
| HWI | 3.77 | 3.77 | 3.78 | 3.80 | 3.80 | 3.86 | 3.82 | 3.73 | 3.7 |
| LWI | 10.08 | 10.09 | 10.11 | 10.10 | 10.13 | 10.19 | 10.13 | 10.08 | 10.1 |

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1992 MONTHLY WATER LEVEL DATA
National Ocean Service (NOAA)

Station: 8467150
Name: BRIDGEPORT, BRIDGEPORT HARBOR
Note: [] Denotes Inferred Water Level Value

| 1992 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Se |
|---|---|---|---|---|---|---|---|---|---|
| MHW | 8.64 | 8.77 | 8.74 | 8.94 | 9.05 | 9.22 | 9.35 | 9.21 | 9.1 |
| MLW | 2.23 | 2.25 | 2.20 | 2.27 | 2.25 | 2.36 | 2.33 | 2.17 | 2.2 |
| MSL | 5.43 | 5.51 | 5.47 | 5.60 | 5.65 | 5.79 | 5.85 | 5.69 | 5.6 |
| MN | 6.41 | 6.52 | 6.54 | 6.67 | 6.80 | 6.86 | 7.02 | 7.04 | 6.9 |
| MTL | 5.43 | 5.51 | 5.47 | 5.60 | 5.65 | 5.79 | 5.84 | 5.69 | 5.6 |
| MHHW | 9.13 | 9.11 | 9.09 | 9.26 | 9.44 | 9.57 | 9.67 | 9.47 | 9.3 |
| MLLW | 1.97 | 2.02 | 1.96 | 2.05 | 2.03 | 2.11 | 2.14 | 2.05 | 2.0 |
| DHQ | 0.49 | 0.34 | 0.35 | 0.33 | 0.38 | 0.35 | 0.32 | 0.27 | 0.2 |
| DLQ | 0.26 | 0.23 | 0.24 | 0.22 | 0.22 | 0.25 | 0.19 | 0.12 | 0.1 |
| GT | 7.16 | 7.09 | 7.13 | 7.21 | 7.41 | 7.46 | 7.53 | 7.42 | 7.3 |
| DTL | 5.55 | 5.57 | 5.52 | 5.66 | 5.73 | 5.84 | 5.90 | 5.76 | 5.7 |
| HWI | 3.76 | 3.68 | 3.72 | 3.70 | 3.84 | 3.87 | 3.83 | 3.83 | 3.8 |
| LWI | 10.09 | 10.02 | 10.03 | 10.04 | 10.20 | 10.19 | 10.13 | 10.16 | 10.1 |

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1993 MONTHLY WATER LEVEL DATA
National Ocean Service (NOAA)

Station: 8467150
Name: BRIDGEPORT, BRIDGEPORT HARBOR
Note: [] Denotes Inferred Water Level Value

| 1993 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Se |
|---|---|---|---|---|---|---|---|---|---|
| MHW | 8.60 | 8.91 | 8.66 | 9.32 | 9.20 | 9.13 | 9.26 | 9.22 | 9.1 |
| MLW | 2.12 | 2.24 | 2.13 | 2.47 | 2.27 | 2.18 | 2.32 | 2.37 | 2.3 |
| MSL | 5.37 | 5.58 | 5.42 | 5.91 | 5.74 | 5.66 | 5.79 | 5.81 | 5.7 |
| MN | 6.48 | 6.67 | 6.53 | 6.85 | 6.93 | 6.95 | 6.94 | 6.85 | 6.8 |
| MTL | 5.36 | 5.58 | 5.40 | 5.89 | 5.74 | 5.66 | 5.79 | 5.80 | 5.7 |
| MHHW | 9.01 | 9.21 | 8.97 | 9.56 | 9.54 | 9.45 | 9.57 | 9.44 | 9.4 |
| MLLW | 1.85 | 2.01 | 1.83 | 2.25 | 2.00 | 1.91 | 2.08 | 2.22 | 2.1 |
| DHQ | 0.41 | 0.30 | 0.30 | 0.24 | 0.34 | 0.32 | 0.30 | 0.22 | 0.2 |
| DLQ | 0.27 | 0.24 | 0.30 | 0.22 | 0.28 | 0.27 | 0.24 | 0.15 | 0.1 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| GT | 7.16 | 7.20 | 7.14 | 7.31 | 7.55 | 7.54 | 7.48 | 7.22 | 7.2 |
| DTL | 5.43 | 5.61 | 5.40 | 5.90 | 5.77 | 5.68 | 5.83 | 5.83 | 5.7 |
| HWI | 3.76 | 3.74 | 3.75 | 3.75 | 3.82 | 3.85 | 3.86 | 3.87 | 3.8 |
| LWI | 10.07 | 10.04 | 10.08 | 10.06 | 10.14 | 10.16 | 10.16 | 10.20 | 10.1 |

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1994 MONTHLY WATER LEVEL DATA
National Ocean Service (NOAA)

Station: 8467150
Name: BRIDGEPORT, BRIDGEPORT HARBOR
Note: [] Denotes Inferred Water Level Value

| 1994 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Se |
|---|---|---|---|---|---|---|---|---|---|
| MHW | 8.33 | 8.48 | 8.88 | 8.74 | 9.15 | 9.02 | 9.05 | 9.01 | 9.1 |
| MLW | 1.73 | 2.01 | 1.99 | 1.77 | 2.19 | 2.05 | 2.21 | 2.22 | 2.3 |
| MSL | 5.04 | 5.28 | 5.44 | 5.26 | 5.68 | 5.54 | 5.64 | 5.63 | 5.7 |
| MN | 6.60 | 6.47 | 6.88 | 6.98 | 6.96 | 6.97 | 6.84 | 6.79 | 6.8 |
| MTL | 5.03 | 5.25 | 5.44 | 5.25 | 5.67 | 5.54 | 5.63 | 5.62 | 5.7 |
| MHHW | 8.76 | 8.81 | 9.17 | 9.03 | 9.46 | 9.35 | 9.34 | 9.25 | 9.3 |
| MLLW | 1.37 | 1.72 | 1.76 | 1.52 | 1.95 | 1.83 | 2.02 | 2.10 | 2.1 |
| DHQ | 0.43 | 0.33 | 0.30 | 0.29 | 0.31 | 0.33 | 0.29 | 0.24 | 0.1 |
| DLQ | 0.36 | 0.29 | 0.24 | 0.24 | 0.24 | 0.22 | 0.18 | 0.13 | 0.1 |
| GT | 7.39 | 7.09 | 7.41 | 7.51 | 7.51 | 7.52 | 7.32 | 7.16 | 7.1 |
| DTL | 5.05 | 5.26 | 5.47 | 5.28 | 5.71 | 5.59 | 5.68 | 5.67 | 5.7 |
| HWI | 3.69 | 3.65 | 3.71 | 3.75 | 3.79 | 3.87 | 3.86 | 3.83 | 3.7 |
| LWI | 10.04 | 10.07 | 10.03 | 10.07 | 10.07 | 10.17 | 10.18 | 10.11 | 10.1 |

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1995 MONTHLY WATER LEVEL DATA
National Ocean Service (NOAA)

Station: 8467150
Name: BRIDGEPORT, BRIDGEPORT HARBOR
Note: [] Denotes Inferred Water Level Value

| 1995 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Se |
|---|---|---|---|---|---|---|---|---|---|
| MHW | 8.71 | 8.41 | 8.90 | 8.77 | 9.17 | 8.99 | 9.13 | 9.36 | 9.2 |
| MLW | 1.88 | 1.72 | 1.99 | 1.91 | 2.29 | 2.09 | 2.14 | 2.38 | 2.3 |
| MSL | 5.31 | 5.08 | 5.45 | 5.35 | 5.75 | 5.55 | 5.66 | 5.89 | 5.8 |
| MN | 6.83 | 6.69 | 6.91 | 6.86 | 6.89 | 6.90 | 6.99 | 6.98 | 6.9 |
| MTL | 5.29 | 5.06 | 5.44 | 5.34 | 5.73 | 5.54 | 5.64 | 5.87 | 5.8 |
| MHHW | 9.06 | 8.76 | 9.11 | 9.07 | 9.52 | 9.29 | 9.41 | 9.66 | 9.5 |
| MLLW | 1.63 | 1.54 | 1.85 | 1.67 | 1.99 | 1.84 | 1.96 | 2.25 | 2.2 |
| DHQ | 0.36 | 0.35 | 0.21 | 0.30 | 0.35 | 0.31 | 0.28 | 0.30 | 0.2 |
| DLQ | 0.25 | 0.18 | 0.14 | 0.24 | 0.29 | 0.25 | 0.17 | 0.13 | 0.1 |
| GT | 7.44 | 7.22 | 7.26 | 7.40 | 7.53 | 7.45 | 7.45 | 7.40 | 7.3 |
| DTL | 5.35 | 5.15 | 5.48 | 5.38 | 5.76 | 5.57 | 5.70 | 5.96 | 5.8 |
| HWI | 3.77 | 3.77 | 3.77 | 3.79 | 3.79 | 3.85 | 3.82 | 3.77 | 3.7 |
| LWI | 10.09 | 10.10 | 10.09 | 10.14 | 10.13 | 10.15 | 10.14 | 10.08 | 10.0 |

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1996 MONTHLY WATER LEVEL DATA
National Ocean Service (NOAA)

Station: 8467150
Name: BRIDGEPORT, BRIDGEPORT HARBOR
Note: [] Denotes Inferred Water Level Value

| 1996 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Se |
|---|---|---|---|---|---|---|---|---|---|
| HW | 8.97 | 8.76 | 8.69 | 9.13 | 9.15 | 9.29 | 9.42 | 9.44 | 9.7 |
| MLW | 2.45 | 1.98 | 2.01 | 2.32 | 2.15 | 2.16 | 2.17 | 2.15 | 2.6 |
| MSL | 5.71 | 5.38 | 5.36 | 5.73 | 5.65 | 5.73 | 5.81 | 5.81 | 6.2 |
| MN | 6.52 | 6.78 | 6.68 | 6.81 | 7.00 | 7.14 | 7.25 | 7.30 | 7.0 |
| MTL | 5.71 | 5.37 | 5.35 | 5.72 | 5.65 | 5.73 | 5.79 | 5.79 | 6.2 |
| MHHW | 9.44 | 9.05 | 8.91 | 9.45 | 9.46 | 9.60 | 9.71 | 9.65 | 9.9 |
| MLLW | 2.04 | 1.82 | 1.76 | 2.07 | 1.93 | 1.95 | 1.93 | 2.00 | 2.5 |
| DHQ | 0.47 | 0.29 | 0.22 | 0.32 | 0.31 | 0.31 | 0.29 | 0.20 | 0.2 |
| DLQ | 0.41 | 0.16 | 0.25 | 0.24 | 0.22 | 0.21 | 0.23 | 0.14 | 0.1 |
| GT | 7.40 | 7.22 | 7.15 | 7.38 | 7.53 | 7.65 | 7.78 | 7.64 | 7.4 |
| DTL | 5.74 | 5.44 | 5.34 | 5.76 | 5.70 | 5.77 | 5.82 | 5.83 | 6.2 |
| HWI | 3.78 | 3.78 | 3.82 | 3.84 | 3.88 | 3.92 | 3.90 | 3.91 | 3.8 |
| LWI | 10.11 | 10.08 | 10.10 | 10.18 | 10.21 | 10.24 | 10.21 | 10.24 | 10.2 |

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1997 MONTHLY WATER LEVEL DATA
National Ocean Service (NOAA)

Station: 8467150
Name: BRIDGEPORT, BRIDGEPORT HARBOR
Note: [] Denotes Inferred Water Level Value

| 1997 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Se |
|---|---|---|---|---|---|---|---|---|---|
| MHW | 8.84 | 8.97 | 9.01 | 9.48 | 9.15 | 9.46 | 9.25 | 9.37 | 9.3 |
| LW | 2.05 | 2.02 | 2.14 | 2.43 | 2.07 | 2.35 | 2.18 | 2.33 | 2.3 |
| MSL | 5.45 | 5.51 | 5.57 | 5.95 | 5.61 | 5.91 | 5.72 | 5.86 | 5.8 |
| MN | 6.78 | 6.95 | 6.87 | 7.04 | 7.09 | 7.12 | 7.07 | 7.04 | 6.9 |
| MTL | 5.44 | 5.49 | 5.57 | 5.95 | 5.61 | 5.90 | 5.71 | 5.85 | 5.8 |
| MHHW | 9.27 | 9.21 | 9.30 | 9.68 | 9.43 | 9.81 | 9.57 | 9.65 | 9.5 |
| MLLW | 1.70 | 1.79 | 1.87 | 2.16 | 1.80 | 2.08 | 1.96 | 2.14 | 2.1 |
| DHQ | 0.44 | 0.25 | 0.30 | 0.21 | 0.28 | 0.35 | 0.32 | 0.28 | 0.2 |
| DLQ | 0.36 | 0.22 | 0.27 | 0.28 | 0.27 | 0.26 | 0.21 | 0.19 | 0.1 |
| GT | 7.58 | 7.42 | 7.43 | 7.53 | 7.63 | 7.73 | 7.60 | 7.52 | 7.4 |
| DTL | 5.48 | 5.50 | 5.59 | 5.92 | 5.62 | 5.95 | 5.76 | 5.89 | 5.8 |
| HWI | 3.85 | 3.87 | 3.84 | 3.83 | 3.89 | 3.92 | 3.94 | 3.94 | 3.9 |
| LWI | 10.19 | 10.18 | 10.14 | 10.20 | 10.21 | 10.23 | 10.26 | 10.26 | 10.2 |

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1998 MONTHLY WATER LEVEL DATA
National Ocean Service (NOAA)

Station: 8467150
Name: BRIDGEPORT, BRIDGEPORT HARBOR
Note: [] Denotes Inferred Water Level Value

| 1998 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Se |
|---|---|---|---|---|---|---|---|---|---|
| MHW | 9.30 | 9.51 | 9.16 | 9.44 | 9.58 | 9.44 | 9.36 | 9.27 | 9.3 |
| MLW | 2.45 | 2.77 | 2.20 | 2.39 | 2.56 | 2.41 | 2.42 | 2.40 | 2.4 |
| MSL | 5.88 | 6.16 | 5.69 | 5.92 | 6.08 | 5.94 | 5.89 | 5.84 | 5.9 |
| MN | 6.85 | 6.74 | 6.96 | 7.04 | 7.02 | 7.03 | 6.94 | 6.88 | 6.9 |
| MTL | 5.88 | 6.14 | 5.68 | 5.91 | 6.07 | 5.93 | 5.89 | 5.83 | 5.9 |
| MHHW | 9.63 | 9.81 | 9.47 | 9.76 | 9.90 | 9.73 | 9.65 | 9.54 | 9.6 |
| MLLW | 2.20 | 2.48 | 1.96 | 2.17 | 2.35 | 2.20 | 2.24 | 2.27 | 2.3 |
| DHQ | 0.32 | 0.30 | 0.31 | 0.32 | 0.31 | 0.29 | 0.29 | 0.27 | 0.2 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| DLQ | 0.25 | 0.29 | 0.24 | 0.22 | 0.21 | 0.21 | 0.17 | 0.12 | 0.1 |
| GT | 7.42 | 7.33 | 7.51 | 7.59 | 7.54 | 7.52 | 7.40 | 7.27 | 7.2 |
| DTL | 5.92 | 6.14 | 5.72 | 5.96 | 6.12 | 5.97 | 5.95 | 5.91 | 5.9 |
| WI | 3.78 | 3.80 | 3.78 | 3.83 | 3.89 | 3.96 | 3.95 | 3.92 | 3.9 |
| LWI | 10.14 | 10.17 | 10.13 | 10.18 | 10.21 | 10.27 | 10.24 | 10.24 | 10.2 |

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1999 MONTHLY WATER LEVEL DATA
National Ocean Service (NOAA)

Station: 8467150
Name: BRIDGEPORT, BRIDGEPORT HARBOR
Note: [] Denotes Inferred Water Level Value

| 1999 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Se |
|---|---|---|---|---|---|---|---|---|---|
| MHW | 8.72 | 9.10 | 8.87 | 9.18 | 9.20 | 9.13 | 9.30 | 9.45 | 9.3 |
| MLW | 1.97 | 2.39 | 2.08 | 2.29 | 2.31 | 2.23 | 2.29 | 2.40 | 2.4 |
| MSL | 5.35 | 5.74 | 5.48 | 5.73 | 5.76 | 5.68 | 5.81 | 5.94 | 5.8 |
| MN | 6.76 | 6.71 | 6.79 | 6.89 | 6.89 | 6.89 | 7.01 | 7.05 | 6.9 |
| MTL | 5.34 | 5.74 | 5.47 | 5.73 | 5.76 | 5.68 | 5.80 | 5.93 | 5.8 |
| MHHW | 9.10 | 9.35 | 9.16 | 9.46 | 9.51 | 9.43 | 9.58 | 9.72 | 9.6 |
| MLLW | 1.70 | 2.19 | 1.81 | 2.05 | 2.10 | 2.00 | 2.07 | 2.23 | 2.2 |
| DHQ | 0.38 | 0.25 | 0.29 | 0.28 | 0.31 | 0.30 | 0.28 | 0.27 | 0.2 |
| DLQ | 0.26 | 0.20 | 0.26 | 0.24 | 0.21 | 0.23 | 0.22 | 0.17 | 0.1 |
| GT | 7.40 | 7.16 | 7.35 | 7.41 | 7.41 | 7.42 | 7.51 | 7.49 | 7.4 |
| DTL | 5.40 | 5.77 | 5.49 | 5.75 | 5.80 | 5.71 | 5.83 | 5.97 | 5.9 |
| HWI | 3.82 | 3.84 | 3.82 | 3.88 | 3.93 | 3.94 | 3.92 | 3.90 | 3.8 |
| LWI | 10.18 | 10.20 | 10.19 | 10.18 | 10.24 | 10.25 | 10.23 | 10.21 | 10.1 |

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2000 MONTHLY WATER LEVEL DATA
National Ocean Service (NOAA)

Station: 8467150
Name: BRIDGEPORT, BRIDGEPORT HARBOR
Note: [] Denotes Inferred Water Level Value

| 2000 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Se |
|---|---|---|---|---|---|---|---|---|---|
| MHW | 8.48 | 8.39 | 8.91 | 9.03 | 9.30 | 9.28 | 9.51 | 9.43 | 9.3 |
| MLW | 1.78 | 1.73 | 2.26 | 2.25 | 2.30 | 2.19 | 2.32 | 2.28 | 2.3 |
| MSL | 5.15 | 5.06 | 5.59 | 5.64 | 5.80 | 5.74 | 5.93 | 5.88 | 5.8 |
| MN | 6.70 | 6.66 | 6.65 | 6.78 | 7.00 | 7.09 | 7.19 | 7.15 | 6.9 |
| MTL | 5.13 | 5.06 | 5.59 | 5.64 | 5.80 | 5.73 | 5.91 | 5.86 | 5.8 |
| MHHW | 9.00 | 8.67 | 9.15 | 9.28 | 9.56 | 9.60 | 9.82 | 9.68 | 9.5 |
| MLLW | 1.37 | 1.53 | 2.02 | 2.01 | 2.06 | 1.92 | 2.08 | 2.12 | 2.2 |
| DHQ | 0.52 | 0.29 | 0.24 | 0.25 | 0.27 | 0.32 | 0.31 | 0.25 | 0.2 |
| DLQ | 0.41 | 0.19 | 0.24 | 0.24 | 0.24 | 0.27 | 0.24 | 0.16 | 0.1 |
| GT | 7.63 | 7.14 | 7.12 | 7.27 | 7.51 | 7.68 | 7.74 | 7.56 | 7.3 |
| DTL | 5.19 | 5.10 | 5.59 | 5.64 | 5.81 | 5.76 | 5.95 | 5.90 | 5.8 |
| HWI | 3.90 | 3.82 | 3.88 | 3.86 | 3.89 | 3.91 | 3.92 | 3.91 | 3.9 |
| LWI | 10.22 | 10.13 | 10.20 | 10.18 | 10.21 | 10.23 | 10.25 | 10.24 | 10.2 |

**Harding Lawson Associates**
Engineering,
Environmental and
Construction Services

SHEET ______ OF ______
JOB NO. ______
DATE ______
COMPUTED BY ______
CHECKED BY ______

PROJECT Stratford Causeway
SUBJECT ______

Appendix

A.3 11.

' Tidal Current Tables .... '

**CENTER FOR OPERATIONAL OCEANOGRAPHIC PRODUCTS & SERVICES**
**PRODUCTS AND SERVICES DIVISION**
**NATIONAL OCEAN SERVICE**

DEPARTMENT OF COMMERCE · UNITED STATES OF AMERICA

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NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION · U.S. DEPARTMENT OF COMMERCE

# Facsimile Transmittal

October 20, 2000
Number of Pages:

To: Jeff Hillson
Fax#: 303-293-6031

From: Todd Ehret
Physical Oceanographer
Tide and Tidal Current Predictions

Attached:

- Copy of Table 2 page from Atlantic Coast Current Tables which covers the Housatonic River.

# TABLE 2 – CURRENT DIFFERENCES AND OTHER CONSTANTS

| No. | PLACE | Meter Depth | POSITION | | TIME DIFFERENCES | | | | SPEED RATIOS | | AVERAGE SPEEDS AND DIRECTIONS | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Latitude | Longitude | Min. before Flood | Flood | Min. before Ebb | Ebb | Flood | Ebb | Minimum before Flood | | Maximum Flood | | Minimum before Ebb | | Maximum Ebb | |
| | | ft | North | West | h m | h m | h m | h m | | | knots | Dir. | knots | Dir. | knots | Dir. | knots | Dir. |
| | LONG ISLAND SOUND–cont.<br>Time meridian, 75° W | | | | on The Race, p.24 | | | | | | | | | | | | | |
| | *Connecticut River–cont.* | | | | | | | | | | | | | | | | | |
| 2861 | Eustasia Island, 0.6 mile ESE of | | 41° 23.30' | 72° 24.23' | +2 14 | +1 59 | +1 32 | +1 15 | 0.4 | 0.5 | 0.0 | -- | 1.1 | 290° | 0.0 | -- | 1.4 | 070° |
| 2866 | Eddy Rock Shoal, west of | 15 | 41° 26.57' | 72° 27.78' | +2 02 | +2 37 | +2 10 | +1 09 | 0.3 | 0.2 | 0.0 | -- | 0.8 | 350° | 0.0 | -- | 0.6 | 155° |
| 2871 | Higganum Creek, 0.5 mile ESE of | | 41° 30.02' | 72° 32.62' | +3 27 | +3 13 | +2 44 | +2 50 | 0.3 | 0.3 | 0.0 | -- | 0.8 | 270° | 0.0 | -- | 1.0 | 080° |
| 2876 | Wilcox Island Park, east of | | 41° 34.33' | 72° 38.88' | +4 27 | +3 57 | +3 16 | +3 24 | 0.3 | 0.3 | 0.0 | -- | 0.9 | 355° | 0.0 | -- | 1.0 | 160° |
| 2881 | Rocky Hill | 9 | 41° 39.82' | 72° 37.73' | +5 02 | +3 58 | +3 30 | +3 19 | 0.2 | 0.3 | 0.0 | -- | 0.6 | 335° | 0.0 | -- | 0.8 | 135° |
| 2886 | Hartford Jetty <42> | 9 | 41° 45.07' | 72° 39.02' | +6 06 | +5 00 | +3 31 | +4 18 | 0.0 | 0.2 | 0.0 | -- | 0.1 | 290° | 0.0 | -- | 0.7 | 095° |
| 2891 | Saybrook Breakwater, 1.5 miles SE of | | 41° 14.78' | 72° 19.05' | –1 09 | –0 50 | –0 46 | –2 08 | 0.7 | 0.7 | 0.0 | -- | 1.9 | 260° | 0.0 | -- | 2.0 | 070° |
| 2896 | Mulford Point, 3.1 miles northwest of | 15 | 41° 12.00' | 72° 19.08' | +0 15 | –0 44 | +0 04 | –0 35 | 0.7 | 0.8 | 0.0 | -- | 1.9 | 269° | 0.0 | -- | 2.3 | 066° |
| 2901 | Orient Point, 1 mile WNW of | | 41° 10.02' | 72° 15.11' | –0 48 | –1 41 | –0 24 | –1 26 | 0.5 | 1.0 | 0.0 | -- | 1.4 | 245° | 0.0 | -- | 3.1 | 055° |
| | | | | | | –0 38 | | | 0.3 | | | | 0.8 | 255° | | | | |
| | | | | | | +0 12 | | | 0.8 | | | | 2.1 | 245° | | | | |
| 2906 | Rocky Point, 0.3 mile north of | 15 | 41° 08.63' | 72° 21.42' | –0 06 | –0 41 | –0 52 | –0 39 | 0.7 | 0.7 | 0.0 | -- | 1.8 | 279° | 0.0 | -- | 2.1 | 041° |
| 2911 | Cornfield Point, 2.8 n mi. SE of | 15d | 41° 13.95' | 72° 20.33' | –1 14 | –0 36 | –0 33 | –1 43 | 0.7 | 0.5 | 0.1 | 170° | 1.9 | 249° | 0.0 | -- | 1.4 | 085° |
| 2916 | Cornfield Point, 3 miles south of | 7 | 41° 12.9' | 72° 22.4' | –0 45 | +0 01 | –0 08 | –0 34 | 0.7 | 0.6 | 0.0 | -- | 2.0 | 256° | 0.0 | -- | 1.7 | 094° |
| 2921 | Cornfield Point, 1.1 miles south of | 15 | 41° 14.65' | 72° 23.40' | –0 40 | –1 13 | –0 53 | –2 14 | 0.5 | 0.5 | 0.0 | -- | 1.4 | 293° | 0.0 | -- | 1.6 | 108° |
| 2926 | Cornfield Point, 1.9 n.mi. SW of | 15d | 41° 14.48' | 72° 25.30' | –0 56 | –1 14 | –1 25 | –1 22 | 0.5 | 0.5 | 0.1 | 174° | 1.3 | 272° | 0.1 | 358° | 1.5 | 091° |
| 2931 | Kelsey Point, 2.1 miles southeast of | | 41° 14.10' | 72° 27.93' | –0 14 | –0 41 | –0 45 | –1 11 | 0.6 | 0.6 | 0.0 | -- | 1.5 | 260° | 0.0 | -- | 1.8 | 070° |
| 2936 | Six Mile Reef, 1.5 miles north of | | 41° 12.66' | 72° 28.87' | +0 04 | +0 09 | –0 14 | –0 52 | 0.4 | 0.4 | 0.0 | -- | 1.0 | 290° | 0.0 | -- | 1.3 | 095° |
| 2941 | Six Mile Reef, 2 miles east of | | 41° 10.83' | 72° 26.90' | –0 15 | +0 09 | +0 02 | –0 46 | 0.6 | 0.7 | 0.0 | -- | 1.6 | 235° | 0.0 | -- | 2.1 | 040° |
| 2946 | Horton Point, 1.4 miles NNW of | | 41° 06.30' | 72° 27.40' | +0 25 | +0 29 | +0 06 | –0 29 | 0.5 | 0.7 | 0.0 | -- | 1.4 | 260° | 0.0 | -- | 2.0 | 040° |
| 2951 | Kelsey Point, 1 mile south of | | 41° 14' | 72° 30' | –1 21 | –0 42 | –1 08 | –2 05 | 0.7 | 0.5 | 0.0 | -- | 2.0 | 249° | 0.0 | -- | 1.5 | 118° |
| 2956 | Hammonasset Point, 1.2 miles SW of | 15 | 41° 14.22' | 72° 34.00' | –0 38 | –0 54 | –0 35 | –1 42 | 0.4 | 0.3 | 0.0 | -- | 1.0 | 287° | 0.0 | -- | 1.0 | 106° |
| 2961 | Hammonasset Point, 5 miles south of | 15 | 41° 09.80' | 72° 34.17' | +0 18 | +0 18 | –0 15 | –0 17 | 0.5 | 0.5 | 0.0 | -- | 1.4 | 284° | 0.0 | -- | 1.5 | 090° |
| 2966 | Duck Pond Point, 3.2 n.mi. NW of | 15d | 41° 04.73' | 72° 33.91' | –0 12 | +0 12 | –0 07 | –0 14 | 0.5 | 0.4 | 0.2 | 161° | 1.2 | 253° | 0.1 | 343° | 1.2 | 071° |
| 2971 | Mattituck Inlet, 1 mile northwest of | 15 | 41° 01.68' | 72° 34.22' | 0 00 | +0 06 | +0 01 | –0 37 | 0.4 | 0.3 | 0.0 | -- | 0.9 | 241° | 0.0 | -- | 1.0 | 053° |
| 2976 | Sachem Head, 1 mile SSE of | | 41° 13.65' | 72° 42.30' | –0 17 | –0 15 | –0 26 | –1 13 | 0.4 | 0.3 | 0.0 | -- | 1.1 | 255° | 0.0 | -- | 1.0 | 065° |
| 2981 | Sachem Head 6.2 miles south of | 15 | 41° 08.73' | 72° 42.30' | +0 50 | +0 45 | –0 03 | –0 15 | 0.2 | 0.3 | 0.0 | -- | 0.6 | 260° | 0.0 | -- | 0.9 | 065° |
| 2986 | Roanoke Point, 5.6 miles north of | 15 | 41° 04.37' | 72° 42.53' | +0 19 | +0 19 | –0 06 | –0 35 | 0.3 | 0.3 | 0.0 | -- | 0.7 | 255° | 0.0 | -- | 0.9 | 050° |
| 2991 | Roanoke Point, 2.3 miles NNW of | | 41° 00.92' | 72° 42.97' | –0 58 | –0 01 | –0 01 | –0 40 | 0.3 | 0.2 | 0.0 | -- | 0.9 | 270° | 0.0 | -- | 0.7 | 070° |
| 2996 | Sachem Head, 1 mile south of | | 41° 14' | 72° 43' | –0 35 | +0 21 | –0 38 | –0 52 | 0.3 | 0.4 | 0.0 | -- | 0.9 | 278° | 0.0 | -- | 1.2 | 084° |
| 3001 | Herod Point, 2.8 miles north of | 15 | 41° 00.97' | 72° 49.93' | –0 08 | +0 04 | –0 18 | –0 17 | 0.2 | 0.2 | 0.1 | 020° | 0.4 | 290° | 0.1 | 020° | 0.6 | 090° |
| 3006 | Herod Point, 6.5 miles north of | 15 | 41° 04.65' | 72° 49.80' | –0 06 | +0 27 | +0 21 | –0 18 | 0.3 | 0.2 | 0.0 | -- | 0.9 | 254° | 0.0 | -- | 0.7 | 070° |
| 3011 | Herod Point, 5.0 n.mi. NW of | 15d | 41° 01.64' | 72° 54.73' | +0 04 | +0 04 | –0 28 | 0 00 | 0.2 | 0.2 | 0.1 | 179° | 0.6 | 271° | 0.0 | -- | 0.7 | 089° |
| 3016 | New Haven Harbor entrance <12> | | 41° 14' | 72° 55' | –1 00 | –1 16 | –0 42 | –1 29 | 0.5 | 0.3 | 0.0 | -- | 1.4 | 319° | 0.0 | -- | 0.9 | 152° |
| 3021 | City Point, 1.3 miles northeast of | | 41° 17.83' | 72° 54.42' | +0 32 | +0 51 | +0 42 | –0 03 | 0.1 | 0.1 | 0.0 | -- | 0.3 | 015° | 0.0 | -- | 0.4 | 215° |
| 3026 | Oyster River Pt., 1.3 miles SSE of <1> | | 41° 12.87' | 72° 58.00' | --- | +0 06 | --- | –0 58 | 0.1 | 0.1 | 0.0 | -- | 0.3 | 255° | 0.0 | -- | 0.3 | 060° |
| 3031 | Pond Point, 4.2 miles SSE of | | 41° 08.60' | 72° 58.08' | +0 01 | +0 25 | +0 05 | –0 25 | 0.2 | 0.2 | 0.0 | -- | 0.6 | 265° | 0.0 | -- | 0.6 | 065° |
| 3036 | Stratford Shoal, 6 miles east of | | 41° 04.52' | 72° 58.43' | +0 22 | +0 19 | +0 02 | –0 20 | 0.2 | 0.2 | 0.0 | -- | 0.6 | 265° | 0.0 | -- | 0.6 | 060° |
| 3041 | Sound Beach, 2.2 miles north of | | 41° 00.33' | 72° 58.45' | +0 18 | +0 15 | –0 06 | –0 36 | 0.3 | 0.3 | 0.0 | -- | 0.9 | 270° | 0.0 | -- | 0.9 | 075° |
| 3046 | Charles Island, 0.8 mile SSE of | | 41° 10.77' | 73° 02.63' | –0 30 | –0 15 | –0 21 | –1 05 | 0.2 | 0.1 | 0.0 | -- | 0.4 | 250° | 0.0 | -- | 0.4 | 070° |
| | *Housatonic River* | | | | | | | | | | | | | | | | | |
| 3051 | Milford Point, 0.2 mile west of | 10 | 41° 10.35' | 73° 06.82' | +0 15 | +0 22 | +0 24 | –1 06 | 0.4 | 0.4 | 0.0 | -- | 1.2 | 330° | 0.0 | -- | 1.2 | 135° |
| 3056 | Railroad drawbridge, above | 5 | 41° 12.53' | 73° 06.67' | +0 55 | +0 34 | +0 38 | –1 06 | 0.4 | 0.4 | 0.0 | -- | 1.1 | 350° | 0.0 | -- | 1.3 | 185° |
| 3061 | Fowler Island, 0.1 mile NNW of | 5 | 41° 14.40' | 73° 06.23' | +1 09 | +0 31 | +0 39 | +0 37 | 0.4 | 0.4 | 0.0 | -- | 1.1 | 040° | 0.0 | -- | 1.1 | 270° |
| 3066 | Wooster Island, 0.1 mile southwest of | 5 | 41° 16.67' | 73° 05.20' | +1 40 | +0 54 | +0 29 | +0 11 | 0.2 | 0.2 | 0.0 | -- | 0.6 | 020° | 0.0 | -- | 0.7 | 220° |
| 3071 | Derby–Shelton Bridge, below <13> | | 41° 18.73' | 73° 04.78' | --- | --- | --- | –0 17 | -- | 0.1 | 0.0 | -- | -- | -- | 0.0 | -- | 0.4 | 095° |
| 3076 | Point No Point, 2.1 miles south of | 15 | 41° 06.75' | 73° 07.13' | –0 09 | +0 15 | +0 01 | –0 12 | 0.5 | 0.4 | 0.0 | -- | 1.3 | 251° | 0.0 | -- | 1.2 | 074° |
| 3081 | Old Field Point, 1 mile east of | 15 | 40° 58.47' | 73° 05.80' | +3 47 | +2 52 | +2 34 | +1 45 | 0.1 | 0.2 | 0.0 | -- | 0.2 | 105° | 0.0 | -- | 0.6 | 308° |
| | . . . do. | 22 | 40° 58.47' | 73° 05.80' | +2 51 | +2 15 | +2 26 | +1 33 | 0.1 | 0.2 | 0.0 | -- | 0.2 | 110° | 0.0 | -- | 0.5 | 297° |
| 3086 | Old Field Point, 2.9 n.mi. NNW of | 15d | 41° 01.32' | 73° 08.37' | +0 40 | +0 10 | –0 36 | –0 14 | 0.2 | 0.2 | 0.0 | -- | 0.5 | 254° | 0.1 | 338° | 0.6 | 076° |
| 3091 | Old Field Point, 2 miles northeast of | 15 | 41° 00.23' | 73° 05.70' | +0 54 | +0 34 | –0 02 | +0 47 | 0.4 | 0.4 | 0.0 | -- | 1.0 | 266° | 0.0 | -- | 1.1 | 092° |
| | . . . do. | 40 | 41° 00.23' | 73° 05.70' | +0 43 | +0 29 | –0 03 | +0 30 | 0.2 | 0.2 | 0.0 | -- | 0.5 | 236° | 0.0 | -- | 0.6 | 081° |

Endnotes can be found at the end of table 2.

**Harding Lawson Associates**
Engineering, Environmental
and Construction Services

SHEET______ OF ______
JOB NO.______
DATE ______
COMPUTED BY ______
CHECKED BY ______

PROJECT______
SUBJECT______

Convert millibars to inches of mercury

$$\frac{1\text{ millibar}}{100\text{ Pa}} = \frac{1017.1\text{ millibar.}}{X\text{ Pa}}$$

$$X = 101{,}710\text{ Pa}$$

$$\frac{1''\text{ mercury}}{3{,}386.39\text{ Pa}} = \frac{x''\text{ mercury}}{101{,}710\text{ Pa}}$$

$$X = \underline{\underline{30.04}}\text{ '' mercury.}$$

**Harding Lawson Associates**
Engineering,
Environmental and
Construction Services

SHEET ____ OF ____
JOB NO. ____
DATE ____
COMPUTED BY ____
CHECKED BY ____

PROJECT Stratford Causeway
SUBJECT ____

Appendix

A.3 12.

(hard copy not included)

**A3.13**

Coastal Div 114-5

# TIDAL FLOOD PROFILES
# NEW ENGLAND COASTLINE

PREPARED BY THE
HYDRAULICS AND WATER QUALITY SECTION
NEW ENGLAND DIVISION
U.S. ARMY CORPS OF ENGINEERS

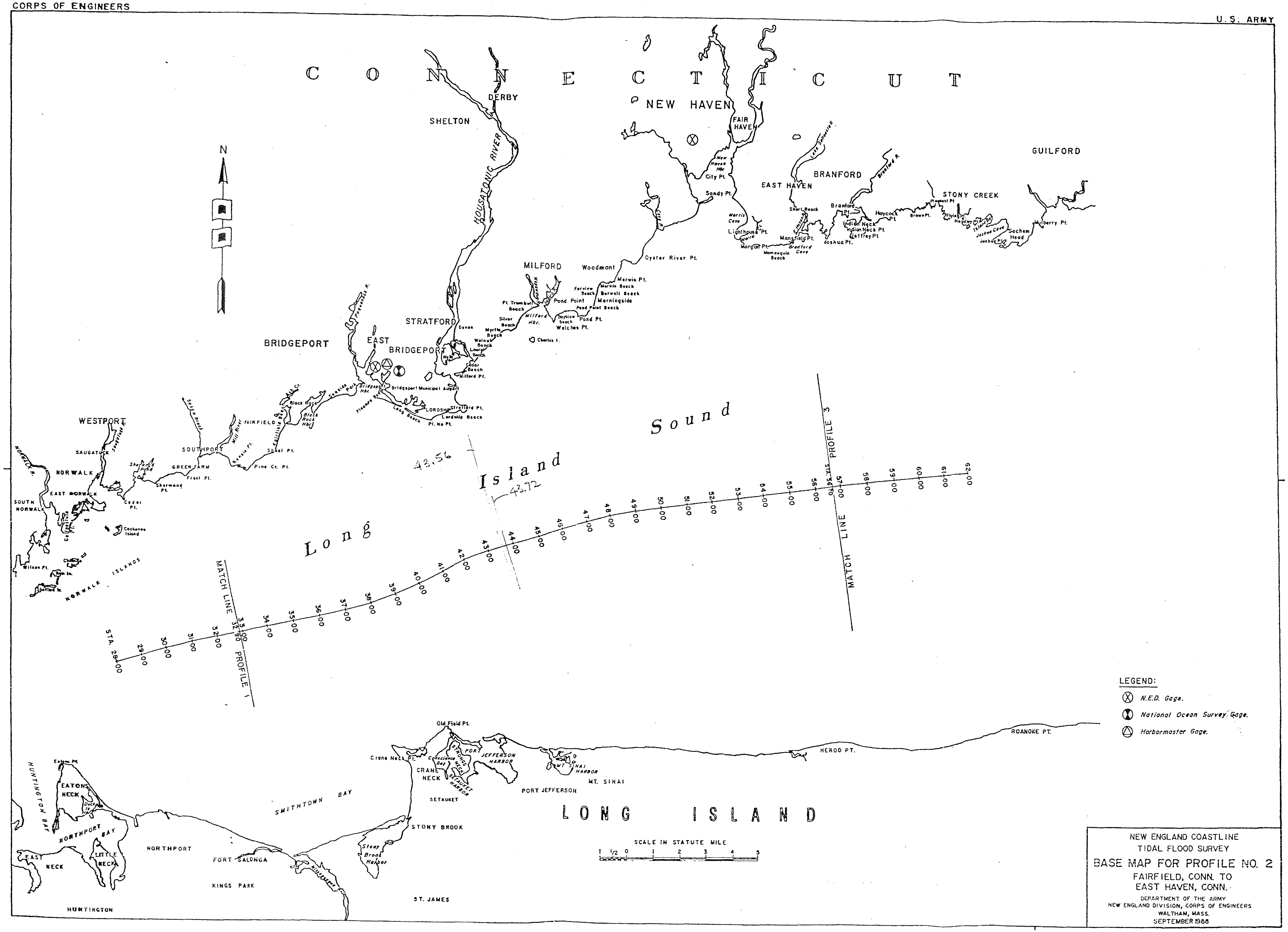
SEPTEMBER 1988

Ref. No 13

Enclosure 1

CORPS OF ENGINEERS

U.S. ARMY



NEW ENGLAND COASTLINE
TIDAL FLOOD SURVEY

BASE MAP FOR PROFILE NO. 2

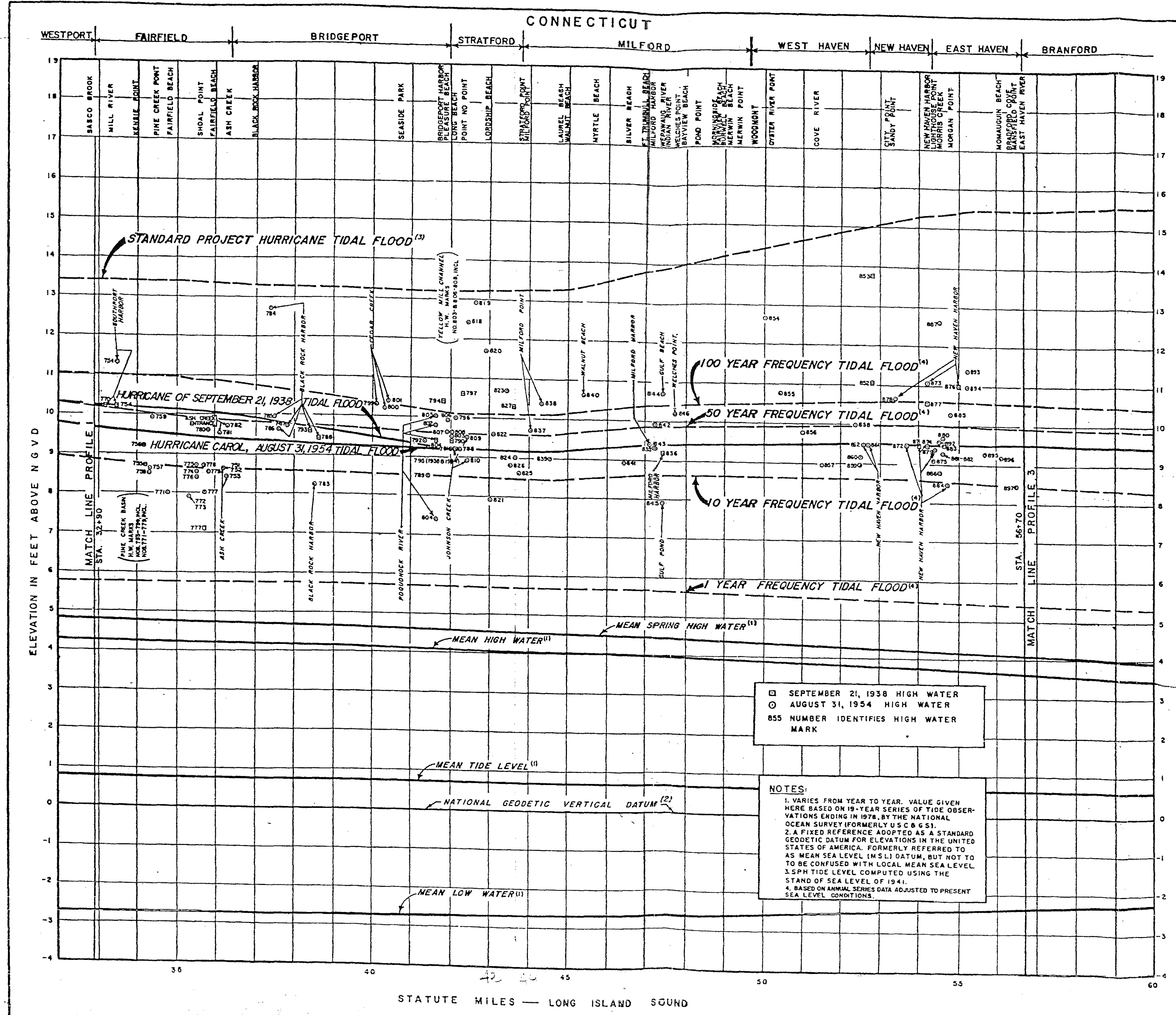
FAIRFIELD, CONN. TO
EAST HAVEN, CONN.

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.
SEPTEMBER 1988

PLATE C-4

CORPS OF ENGINEERS

U. S. ARMY



⊡ SEPTEMBER 21, 1938 HIGH WATER
⊙ AUGUST 31, 1954 HIGH WATER
855 NUMBER IDENTIFIES HIGH WATER MARK

NOTES:
1. VARIES FROM YEAR TO YEAR. VALUE GIVEN HERE BASED ON 19-YEAR SERIES OF TIDE OBSERVATIONS ENDING IN 1978, BY THE NATIONAL OCEAN SURVEY (FORMERLY U S C & G S).
2. A FIXED REFERENCE ADOPTED AS A STANDARD GEODETIC DATUM FOR ELEVATIONS IN THE UNITED STATES OF AMERICA. FORMERLY REFERRED TO AS MEAN SEA LEVEL (M S L) DATUM, BUT NOT TO TO BE CONFUSED WITH LOCAL MEAN SEA LEVEL.
3. SPH TIDE LEVEL COMPUTED USING THE STAND OF SEA LEVEL OF 1941.
4. BASED ON ANNUAL SERIES DATA ADJUSTED TO PRESENT SEA LEVEL CONDITIONS.

13.28'

10.11'

9.59'

8.55'

5.59'

4.06' MHW

0.62

0.00

-2.59

NGVD 29

NEW ENGLAND COASTLINE
TIDAL FLOOD SURVEY

TIDAL FLOOD PROFILE NO. 2

FAIRFIELD, CONN. TO
EAST HAVEN, CONN.

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.
SEPTEMBER 1988

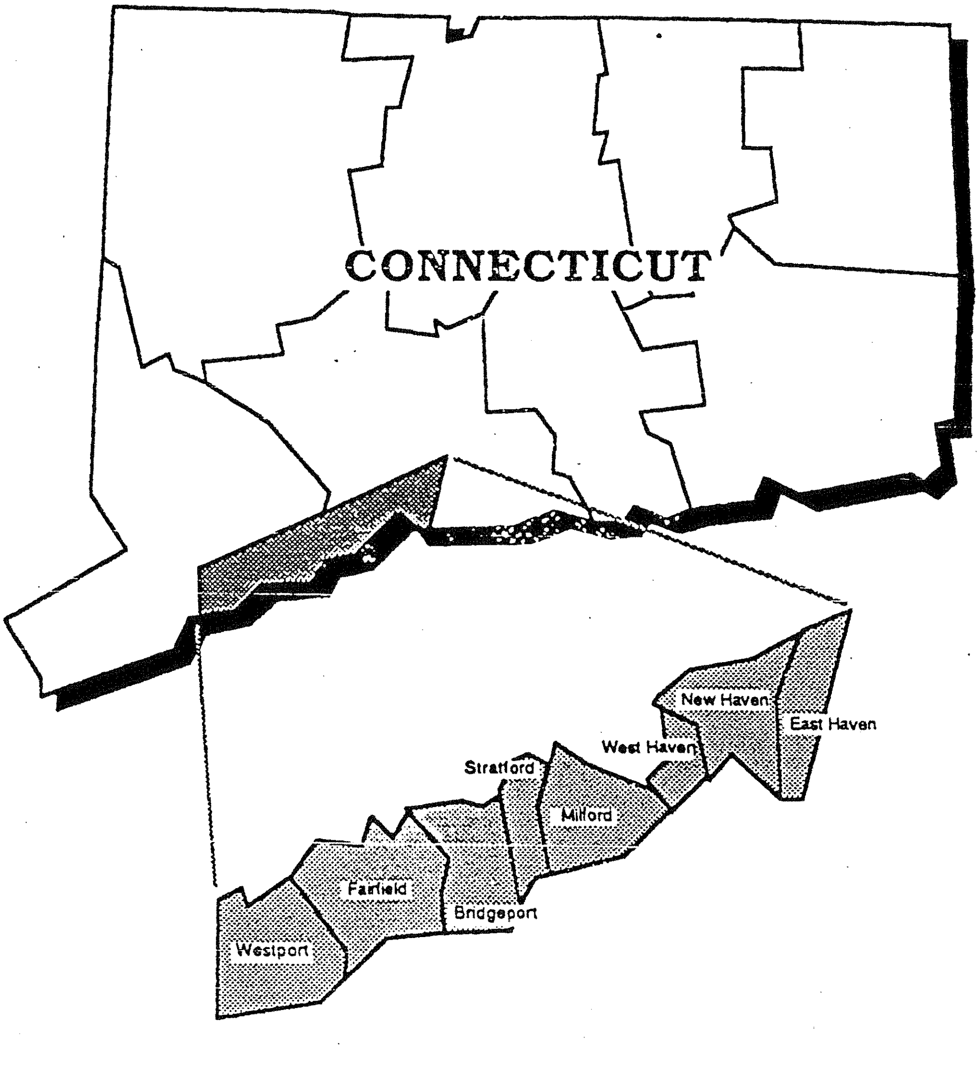
PLATE C-5

**A3.14**

Reconnaissance Report

Water Resources Study
Long Island Sound

# Tidal-Flood Management West Central Connecticut



US Army Corps
of Engineers
New England Division
June 1988

Ref. No. 14

Enclosure 2

# WEST CENTRAL CONNECTICUT
# TIDAL FLOOD MANAGEMENT STUDY

## Tidal Hydrology
## Appendix

Hydraulics and Water Quality Section
Water Control Branch
Engineering Division

New England Division
Corps of Engineers
02254-9149

September 1987

the Sound, extreme hurricane winds generally coming from between the SW and SE. Locally generated waves were not part of the WES study. Therefore, wave height and period for these waves must be estimated based on wind speed, duration and fetch distance.

(2) Wind Data for Estimating Locally Generated Waves

An estimate of wind speed is one of the essential ingredients in any wave hindcasting effort. The most accurate estimate of winds at sea, which generate waves and propel them landward, is obtained by utilizing isobars of barometric pressure recorded during a given storm. However, actual recorded wind speed and direction data observed at a land based coastal meteorological station can serve as a useful guide when more locally generated waves and currents are of interest. The disadvantage with using land based wind records is that they may not be totally indicative of wind velocities at the sea-air interface where the waves are generated. However, often they are the only available source of information and adjustments must be made to develop overwater estimates from the land based records.

The National Weather Service (NWS) recorded 13 complete years of hourly one-minute average wind speed and direction data at Bridgeport Municipal Airport in Stratford, Connecticut from 1949 through 1974. Bridgeport is the closest location to the study area for which relatively complete, systematically recorded, wind data are available. These wind speed data were then adjusted to a standard 33-foot observation height, and one-minute average wind speeds were converted to one-hour average wind speeds. Since Bridgeport Municipal Airport is almost directly adjacent to the ocean, no land-sea conversion was applied. However, a wind stability correction was made except between W and NW where fetches of interest are less than 10 miles. All adjustments were made in accordance with ETL 1110-2-305 on the subject of determining wave characteristics on sheltered waters. Utilizing these one-hour average wind data, the percent occurrence of wind direction and wind speed range has been computed. Since only on-shore winds are of interest, the wind directions utilized in this analysis have been limited to those between east-northeast (ENE) and northwest (NW). This analysis, the results of which are shown in Table 7, indicates that the principal onshore wind direction for wind speeds ≤5 mph is from the NW and, for wind speeds >5 and ≤15 mph it is from the SW. Winds >15 mph and ≤30 mph generally come from the NW to WNW. Winds exceeding 30 mph seem to come from the E and W to NW. The maximum average wind speed (10.2 mph) is from the WNW and the greatest maximum speed was 47.5 mph from the E. Overall average speed is 9.3 mph. The greatest percentage of wind speeds is shown to be >10 and ≤15 mph.

Utilizing the above mentioned height adjusted data base, average wind speeds and resultant directions were computed over various durations with the other previously mentioned adjustments being made subsequently.

## TABLE 7

## STRATFORD, CONNECTICUT
## ADJUSTED HOURLY WIND OBSERVATIONS BETWEEN "ENE" AND "NW"
(One-Hour Average Values)

### Percent of Onshore Windspeed and Direction Observations (X 10)

| | Windspeed Range (MPH) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Direction | 0-5 | 5-10 | 10-15 | 15-20 | 20-25 | 25-30 | Over 30 | All Inclusive | Average Speed | Maximum Speed |
| ENE | 10 | 18 | 27 | 10 | 5 | 2 | 0 | 73 | 9.5 | 41.9 |
| E | 10 | 19 | 28 | 9 | 5 | 2 | 1 | 74 | 9.6 | 47.5 |
| ESE | 7 | 15 | 16 | 4 | 2 | 0 | 0 | 45 | 9.3 | 36.9 |
| SE | 8 | 14 | 11 | 2 | 0 | 0 | 0 | 36 | 7.9 | 38.9 |
| SSE | 8 | 14 | 10 | 2 | 0 | 0 | 0 | 34 | 7.7 | 26.6 |
| S | 12 | 23 | 22 | 5 | 2 | 1 | 0 | 65 | 8.8 | 38.9 |
| SSW | 9 | 21 | 28 | 8 | 3 | 0 | 0 | 70 | 9.7 | 37.9 |
| SW | 16 | 39 | 55 | 12 | 4 | 1 | 0 | 126 | 9.3 | 32.8 |
| WSW | 13 | 39 | 49 | 13 | 5 | 1 | 0 | 120 | 9.7 | 44.1 |
| W | 14 | 36 | 46 | 14 | 8 | 2 | 1 | 120 | 9.4 | 36.3 |
| WNW | 13 | 27 | 44 | 17 | 11 | 4 | 1 | 117 | 10.2 | 36.3 |
| NW | 19 | 26 | 41 | 19 | 12 | 3 | 1 | 121 | 10.0 | 34.5 |
| ENE-NW | 139 | 291 | 377 | 115 | 57 | 16 | 4 | 1,000 | 9.3 | 47.5 |

NOTE: Windspeed ranges indicated include values greater than the lower limit and less than or equal to the higher limit

Annual maximum values were then determined for each onshore direction. The frequency of these annual values has been determined using a Pearson Type III distribution function with expected probability adjustment. The systematic record alone was used for all analyses. In some cases severe extratropical storm winds were identified as high outliers in a statistical test and sometimes high skews were observed. These cause some inconsistency in the estimates which can best be accommodated by a graphical smoothing of the tabular data. All results are summarized in Table 8. It should be noted that frequency estimates are generally quite accurate for return periods up to twice the period of record, 26 years in this case. To obtain estimates of wind speed-duration relationships for a particular return period and direction, it is recommended that a graphical curve fitting analysis employing engineering judgment be conducted using the tabularized values. Figure 8 is an example of this technique for the WSW direction which may be a critical wave generation direction in the study area. Analysis of other directions is left to a potential user.

Additionally, wind speed persistence was determined on a directional basis. The resulting wind speed persistence data, shown on Table 9, for directions east-northeast through northwest, indicate the maximum number of consecutive hourly wind speed observations that occurred at or above a given speed from a particular direction. Data on Table 9 indicate an occurrence of winds in excess of 25 mph for five consecutive hours from the south. Three consecutive hourly values greater than 30 mph and five consecutive hourly values greater than 25 mph from the west-southwest are shown. The highest average wind speed listed is 47 mph from the E. Winds greater than 30 mph from the west for three consecutive hours are presented in the table. All this information demonstrates that high onshore winds can occur for extended periods of time in the study area. Lower speed winds seem to come mainly from the SSE with an increasingly westerly or easterly trend as the speed class increases.

TABLE 8

FREQUENCY OF ADJUSTED ANNUAL MAXIMUM WIND SPEEDS (MPH)
STRATFORD, CONNECTICUT
(Based on 13 Years of Hourly Observations, 1949-1974)

Direction: ENE

| Duration (hours) | Expected Return Period (Years) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 |
| 1 min | 24 | 33 | 41 | 46 | 52 | 58 | 64 |
| 1 | 19 | 27 | 33 | 37 | 42 | 47 | 52 |
| 3 | 18 | 24 | 27 | 29 | 32 | 35 | 37 |
| 8 | 16 | 22 | 24 | 25 | 26 | 27 | 28 |

## Direction: E

| Duration (hours) | Expected Return Period (Years) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 |
| 1 min | 25 | 36 | 46 | 52 | 60 | 67 | 74 |
| 1 | 20 | 29 | 37 | 42 | 48 | 54 | 60 |
| 3 | 17 | 26 | 33 | 38 | 45 | 50 | 55 |
| 8 | 15 | 22 | 29 | 33 | 40 | 46 | 52 |

## Direction: ESE

| Duration (hours) | Expected Return Period (Years) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 |
| 1 min | 22 | 31 | 36 | 41 | 46 | 51 | 56 |
| 1 | 18 | 25 | 29 | 33 | 37 | 41 | 45 |
| 3 | 13 | 21 | 24 | 26 | 27 | 28 | 29 |
| 8 | 13 | 19 | 22 | 24 | 27 | 29 | 31 |

## Direction: SE

| Duration (hours) | Expected Return Period (Years) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 |
| 1 min | 19 | 27 | 36 | 41 | 48 | 55 | 62 |
| 1 | 15 | 22 | 29 | 33 | 39 | 44 | 50 |
| 3 | 12 | 18 | 21 | 22 | 23 | 24 | 25 |
| 8 | 7 | 15 | 18 | 19 | 20 | 20 | 21 |

## Direction: SSE

| Duration (hours) | Expected Return Period (Years) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 |
| 1 min | 18 | 30 | 32 | 33 | 34 | 35 | 35 |
| 1 | 15 | 24 | 26 | 27 | 28 | 28 | 28 |
| 3 | 14 | 20 | 23 | 26 | 29 | 31 | 34 |
| 8 | 7 | 16 | 18 | 20 | 22 | 23 | 24 |

## Direction: S

| Duration (hours) | Expected Return Period (Years) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 |
| 1 min | 23 | 35 | 40 | 44 | 48 | 51 | 54 |
| 1 | 19 | 28 | 33 | 35 | 39 | 41 | 44 |
| 3 | 18 | 25 | 28 | 30 | 32 | 34 | 36 |
| 8 | 5 | 20 | 24 | 26 | 28 | 29 | 30 |

### Direction: SSW

| Duration (hours) | Expected Return Period (Years) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 |
| 1 min | 24 | 34 | 40 | 44 | 48 | 52 | 55 |
| 1 | 19 | 28 | 32 | 35 | 39 | 42 | 45 |
| 3 | 18 | 23 | 25 | 27 | 29 | 30 | 32 |
| 8 | 15 | 19 | 23 | 27 | 32 | 36 | 40 |

### Direction: SW

| Duration (hours) | Expected Return Period (Years) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 |
| 1 min | 22 | 32 | 37 | 39 | 42 | 45 | 47 |
| 1 | 18 | 26 | 30 | 32 | 34 | 36 | 38 |
| 3 | 18 | 22 | 26 | 30 | 35 | 39 | 43 |
| 8 | 13 | 20 | 23 | 24 | 26 | 27 | 29 |

### Direction: WSW

| Duration (hours) | Expected Return Period (Years) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 |
| 1 min | 17 | 35 | 45 | 51 | 59 | 65 | 71 |
| 1 | 14 | 29 | 36 | 41 | 47 | 52 | 57 |
| 3 | 15 | 24 | 30 | 34 | 40 | 44 | 48 |
| 8 | 13 | 22 | 27 | 29 | 33 | 36 | 38 |

### Direction: W

| Duration (hours) | Expected Return Period (Years) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 |
| 1 min | 19 | 35 | 41 | 44 | 47 | 49 | 52 |
| 1 | 15 | 29 | 33 | 35 | 38 | 40 | 42 |
| 3 | 12 | 26 | 30 | 31 | 33 | 34 | 35 |
| 8 | 10 | 22 | 25 | 27 | 28 | 29 | 30 |

### Direction: WNW

| Duration (hours) | Expected Return Period (Years) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 |
| 1 min | 24 | 36 | 41 | 43 | 46 | 49 | 51 |
| 1 | 19 | 29 | 33 | 35 | 38 | 39 | 41 |
| 3 | 17 | 26 | 29 | 30 | 32 | 33 | 34 |
| 8 | 15 | 22 | 25 | 27 | 29 | 30 | 31 |

Direction: NW

| Duration (hours) | Expected Return Period (Years) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 |
| 1 min | 22 | 35 | 40 | 42 | 45 | 47 | 50 |
| 1 | 18 | 28 | 32 | 34 | 37 | 38 | 40 |
| 3 | 16 | 24 | 27 | 29 | 31 | 33 | 35 |
| 8 | 16 | 21 | 24 | 26 | 28 | 30 | 32 |

Waves generated during coastal storms are particularly potent as an erosive and flooding force. Therefore, it is useful to examine wind conditions occurring during past storms when estimating the severity of wave conditions. Table 10 presents available National Weather Service wind observations recorded between 1947 and 1975 at Bridgeport Airport during days of storm-induced tidal flooding. It can be seen that the strongest winds recorded on these dates generally occurred between north and east. The highest speed listed, 64.5 mph from the east, was recorded on 25 November 1950.

The most reliable data on experienced hurricane wind velocities in New England begin with the September 1938 hurricane. The maximum velocity in New England during this storm was a recorded gust of 186 mph at the Blue Hills observatory in Milton, Massachusetts, where a sustained 5-minute wind of 121 mph was also recorded. At other locations in southern New England, sustained 5-minute velocities ranging from 38 to 87 mph were experienced.

During the hurricane of 14 September 1944, a maximum gust of 109 mph was registered at Hartford, Connecticut. Sustained 5-minute velocities ranging from 33 to an estimated 85 mph were recorded at a number of locations between New York City and Block Island, Rhode Island, during this same hurricane.

## TABLE 9

## WINDSPEED PERSISTENCE
## STRATFORD, CONNECTICUT

Maximum Duration, Hours and (Average Windspeed, MPH)

| Direction | Windspeed Class, MPH | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | >5 | >10 | >15 | >20 | > 25 | >30 | >35 | >40 | >45 |
| ENE | 24 (18) | 24 (18) | 23 (23) | 13 (22) | 3 (29) | 2 (35) | 1 (39) | 1 (42) | - |
| E | 24 ( 9) | 23 (12) | 18 (27) | 14 (26) | 10 (37) | 9 (39) | 7 (40) | 2 (43) | 1 (47) |
| ESE | 12 (19) | 12 (19) | 12 (25) | 12 (25) | 4 (26) | 1 (34) | 1 (37) | - | - |
| SE | 13 (12) | 7 (14) | 7 (17) | 2 (24) | 2 (28) | 1 (39) | 1 (39) | - | - |
| SSE | 14 (16) | 14 (16) | 6 (18) | 3 (23) | 1 (26) | - | - | - | - |
| S | 13 (11) | 12 (13) | 7 (19) | 6 (24) | 5 (32) | 2 (31) | 1 (38) | - | - |
| SSW | 17 (16) | 16 (17) | 10 (21) | 5 (26) | 3 (27) | 2 (35) | 1 (38) | - | - |
| SW | 21 (14) | 21 (14) | 15 (26) | 15 (26) | 4 (27) | 1 (33) | - | - | - |
| WSW | 17 (11) | 14 (21) | 14 (21) | 9 (24) | 5 (26) | 3 (34) | 1 (40) | 1 (43) | - |
| W | 24 (16) | 24 (17) | 14 (23) | 12 (26) | 6 (26) | 3 (33) | 1 (36) | - | - |
| WNW | 22 (15) | 22 (19) | 16 (20) | 7 (24) | 3 (30) | 2 (35) | 1 (36) | - | - |
| NW | 24 (17) | 24 (17) | 14 (19) | 8 (28) | 8 (28) | 2 (32) | - | - | - |

NOTE: Based on 13 years of hourly observation, 1949-1974

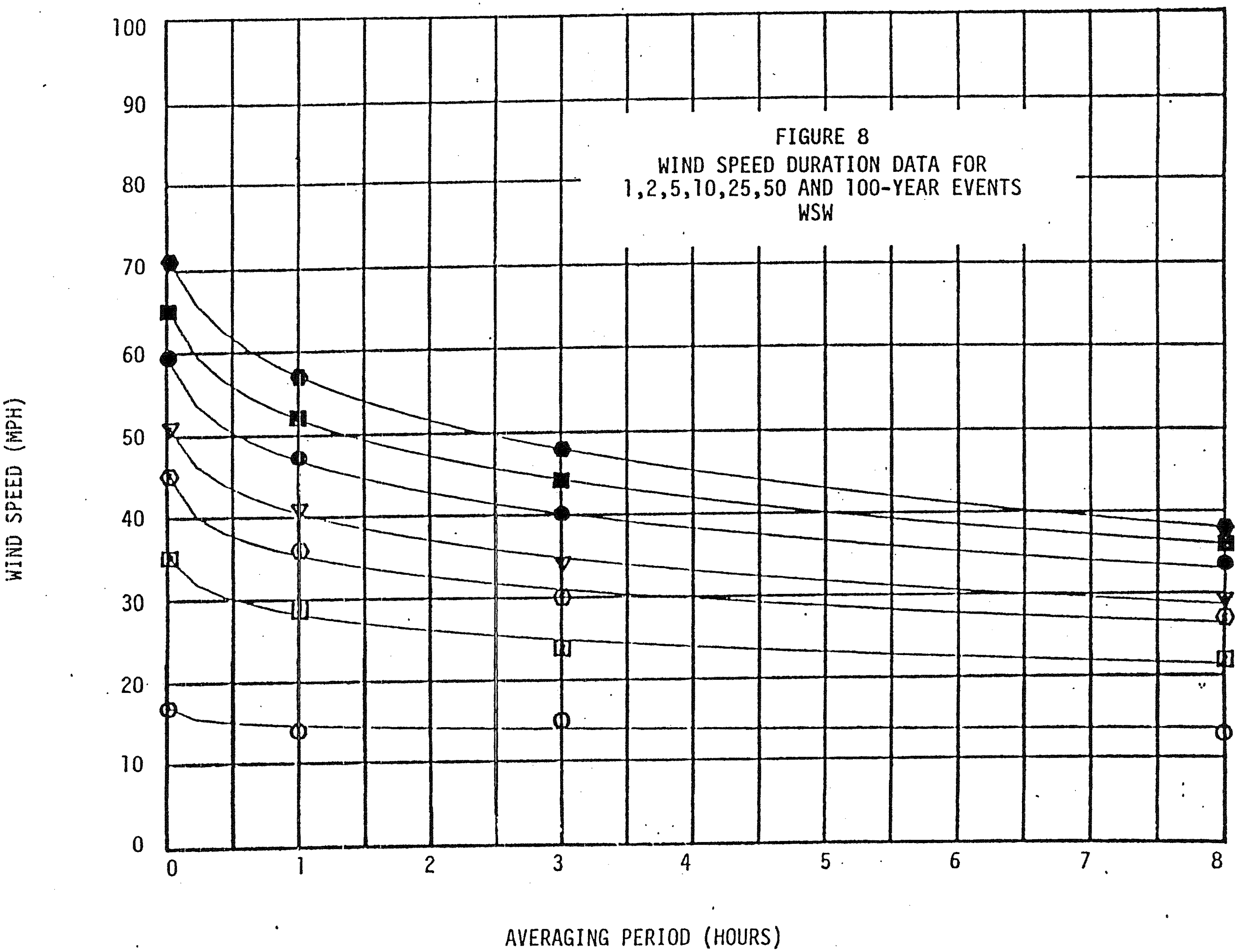


FIGURE 8
WIND SPEED DURATION DATA FOR
1,2,5,10,25,50 AND 100-YEAR EVENTS
WSW

## TABLE 10

### BRIDGEPORT, CONNECTICUT
### NATIONAL WEATHER SERVICE
### MAXIMUM ONE-MINUTE AVERAGE WIND OBSERVATIONS
### DAYS OF MAXIMUM TIDAL FLOODS
### (1947-1975)

| Date | Maximum Speed (mph) | Direction |
|---|---|---|
| 21 Sep 1938 (Hurricane) | * | * |
| 31 Aug 1954 (Hurricane-Carol) | 41.7 | NNE |
| 14 Sep 1944 (Hurricane) | * | * |
| 25 Nov 1950 | 64.5 | E |
| 6 Feb 1978 | * | * |
| 7 Nov 1953 | 35.4 | SSE & NE |
| 12 Sep 1960 (Hurricane-Donna) | 41.7 | NE |
| 25 Oct 1980 | * | * |
| 14 Oct 1955 | 48.1 | NE & ENE |
| 19 Feb 1960 | * | * |
| 29 Mar 1984 | * | * |
| 12 Nov 1968 | 41.7 | ENE |
| 27 Sep 1985 (Hurricane-Gloria) | * | * |
| 13 Apr 1961 | 55.7 | E |
| 6 Mar 1962 | 41.7 | ENE |
| 25 Dec 1978 | * | * |
| 30 Nov 1944 | * | * |
| 4 Apr 1973 | 41.7 | E |
| 9 Jan 1978 | * | * |
| 16 Feb 1958 | 41.7 | E |
| 20 Mar 1958 | * | * |
| 21 Sep 1961 | * | * |
| 10 Nov 1962 | * | * |
| 26 Dec 1969 | 35.7 | ENE |
| 19 Feb 1972 | 40.5 | NE |
| 2 Dec 1974 | 32.9 | ENE |
| 14 Oct 1977 | * | * |
| 31 Oct 1947 | 39.2 | NNE |
| 12 Mar 1959 | 36.7 | E |
| 14 Feb 1960 | * | * |
| 9 Mar 1961 | * | * |
| 16 Sep 1971 | 12.7 | NNE |

*Wind Data Not Available

(Events are listed in order of decreasing stillwater tidal level to conform with Table 12)

In southern New England, during Hurricane Carol (31 August 1954) gusts of 125 and 135 mph were experienced at Blue Hill, Massachusetts, and Block Island, respectively. Sustained 1-minute velocities ranging from 38 to 98 mph were registered.

Recorded wind velocities at a number of locations in southern New England and New York City, for the three great hurricanes of 1938, 1944, and 1954, are given in Table 11. More recent hurricanes, "Donna" (12 September 1960) and "Gloria" (27 September 1985), did not pack as much punch as the great hurricanes.

The wind data in Table 11 are for historical hurricanes that passed to the east of Stratford and caused high surges to enter the east entrance of Long Island Sound. The winds at Stratford in these three hurricanes were, in general, from the northern sector. This tended to decrease wave action in the study area. Hurricanes passing to the west of the area by a distance of 50 miles or so would produce critical winds from the southern sector. These winds would cause greater wave action.

### c. Effects of Storms On Water Levels

Three distinct processes may produce an increased water level near the coast during storms.

#### (1) The Inverted Barometer Effect

In the deep sea, a reduction in atmospheric pressure is accompanied by a rise in the sea surface which will lead toward a constant pressure level at some distance below the water surface. Although for equilibrium to be achieved the water would have to rise about 13.25 inches for a pressure drop of one inch of mercury, the approximation of a one-foot rise in water level for one-inch fall in atmospheric pressure is often used. Nearshore boundary conditions at the bottom or sides may alter the response of the sea to pressure changes so that the actual rise is generally less than that indicated above, but it can be greater. This tendency for the water level to rise under low atmospheric pressure is often called the "inverted barometer effect."

#### (2) Wind Setup

Friction between the wind and the water surface generates a current, which is initially parallel with the wind, but which, because of the rotation of the earth, rotates toward the right with increasing time and increasing depth so that the water transport due to a steady wind on very deep water is about $90^{\circ}$ to the right of the wind. In shallow water, far from the shore, the direction of the current differs little from the direction of the wind. Near the shore the current is constrained to flow parallel to the shore but, because of the earth's rotation, the mean free

TABLE 11

## WIND VELOCITIES

### New England Hurricanes of 1938, 1944, and 1954

Velocity in Miles Per Hour

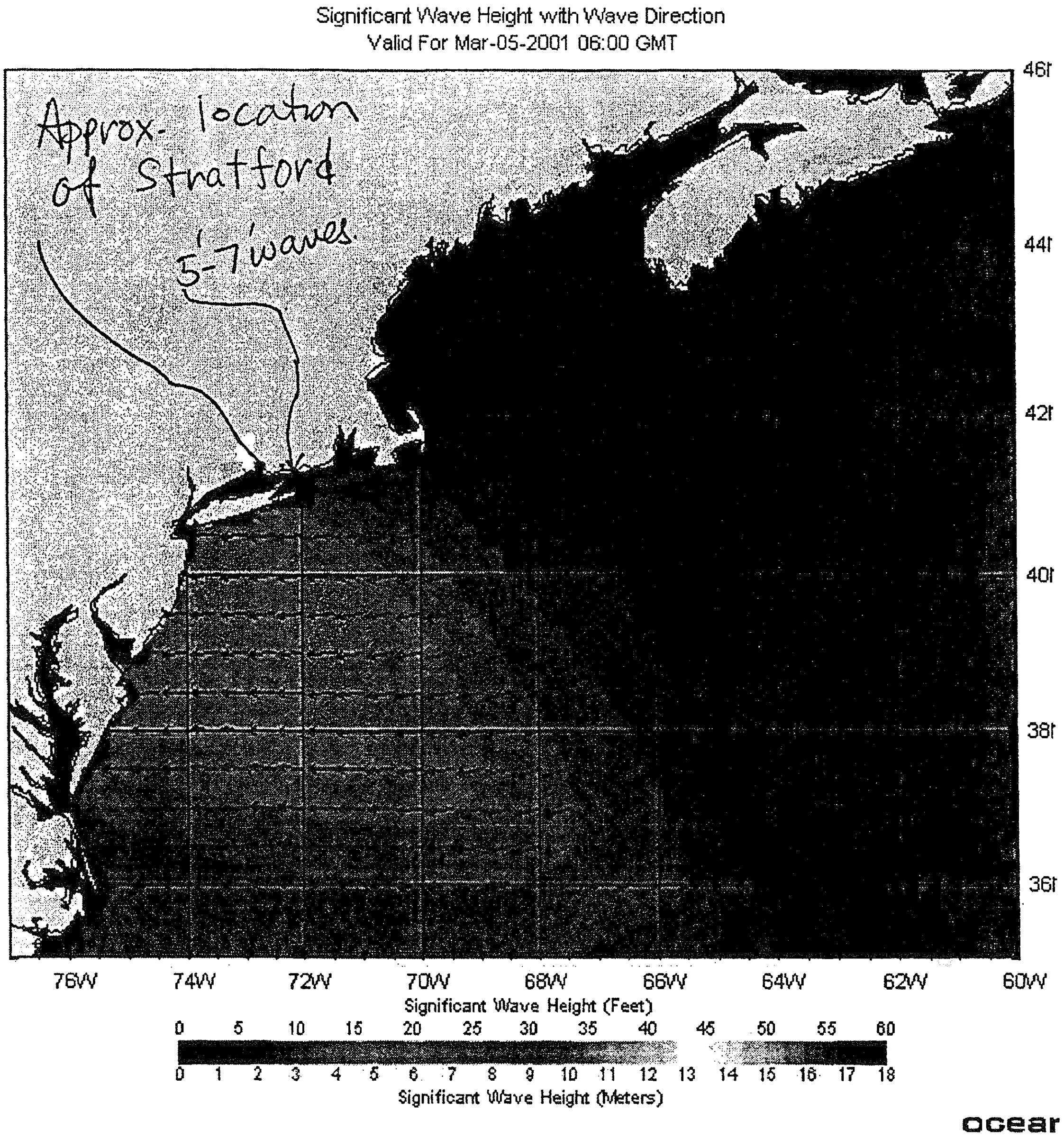
| Location | Sustained 5-Min. | Sustained 1-Min. | Maximum Gusts | Direction |
|---|---|---|---|---|
| Hurricane of 21 September 1938 | | | | |
| New York, N.Y. | 70 | - | 80 | NW |
| New Haven, Conn. | 38 | - | 46 | NE |
| Hartford, Conn. | 46 | - | 59 | NE |
| Block Island, R.I. | 82 | - | 91 | SE |
| Providence, R.I. | 87 | 95 | 125* | SW |
| Milton, Mass. (Blue Hill Observatory) | 121 | - | 186 | S |
| Hurricane of 14 September 1944 | | | | |
| New York, N.Y. | 81 | 99 | - | N |
| New Haven, Conn. | 33 | 38 | 65 | N & NE |
| Hartford, Conn. | 50 | 62 | 109** | N |
| Point Judith, R.I. | 85* | 90* | - | SSE |
| Block Island, R.I. | 82 | 88 | 100 | SE |
| Providence, R.I. | 43 | 49 | 90 | SE |
| Milton, Mass. (Blue Hill Observatory) | 67 | 77 | - | - |
| Hurricane of 31 August 1954 | | | | |
| New York, N.Y. | - | - | 61 | NW |
| Bridgeport, Conn. | - | - | 60 | - |
| Hartford, Conn. | - | 56 | 64 | NE |
| New Haven, Conn. | - | 38 | 65 | N |
| Block Island, R.I. | - | 98 | 135 | SE |
| Providence, R.I. | - | 90 | 105 | ESE |
| Milton, Mass. (Blue Hill Observatory) | - | 93 | 125 | SE |

* Estimated
** Taken from indicator; clocked for 4 seconds

# A3.15

# Northeast US Analysis Wave Map

**oceanweather inc.**
*Marine forecasts/hindcasts Research at the air-sea interface*



Approx. location of Stratford

5'-7' waves

*This image shows the wave model output from* *__Oceanweather's EC2000 Regional Forecast__* *as contours of significant wave height (in meters) with vectors representing vector mean direction (to which the waves are traveling). The valid time is given in GMT - Greenwich Mean Time.*

*The winds driving Oceanweather's Ocean Wave Models are derived from an assimulation of real-time buoys, ships, CMAN stations, altimeter, and scatterometer measurements along with a background wind field provided from NCEP's Aviation model. The wind observations are incorporated interactively by a skilled marine-meteorologist using Oceanweather's Wind WorkStation. Tropical systems are added to the final wind fields using Oceanweather's Tropical Boundary Layer Model.*

---

Return to Oceanweather's Current Data Page

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- CAR RENTALS in White Plains
- GUIDE Travel Information

# Search results

Port Chester, New York

Project location

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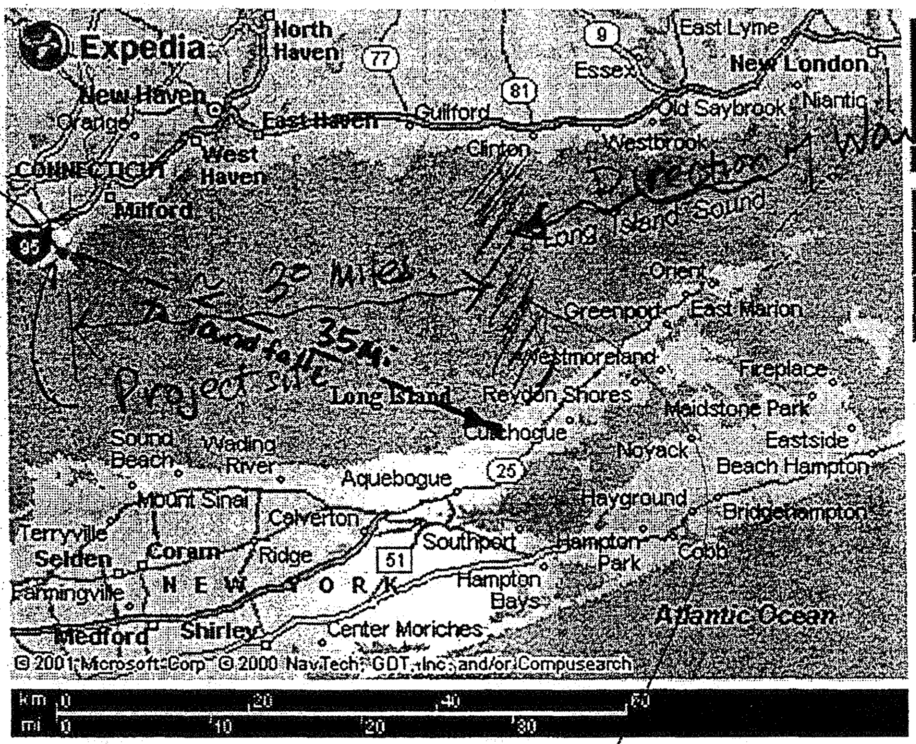

Hide label

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## Other options

- Get driving directions to this location
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- Search for a new map

Approx. limit of 5' wave, see previous page

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# APPENDIX B

**Harding Lawson Associates**
Engineering,
Environmental and
Construction Services

PROJECT Stratford Causeway
SUBJECT

SHEET OF
JOB NO.
DATE
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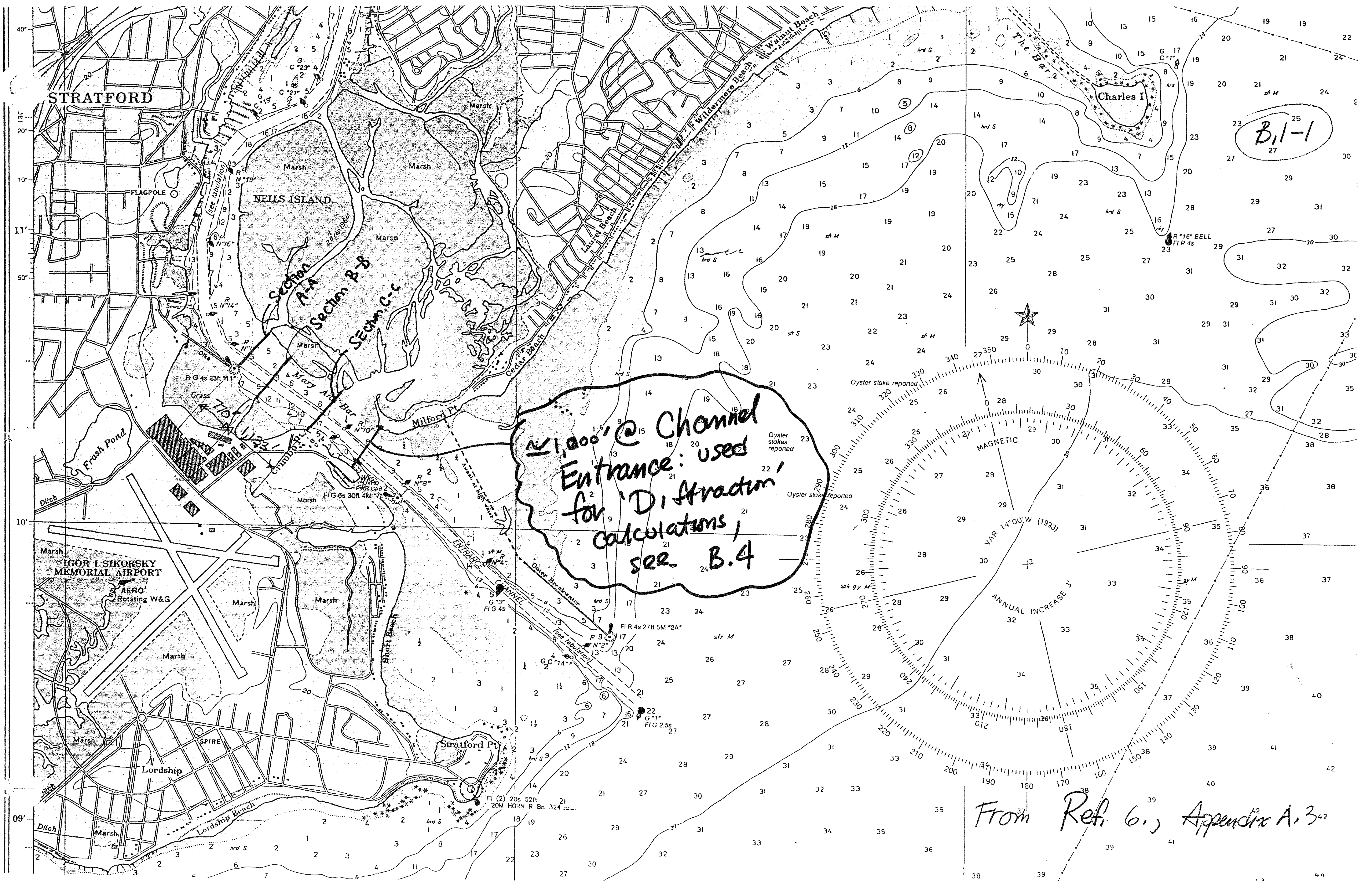
# Appendix

# B.1

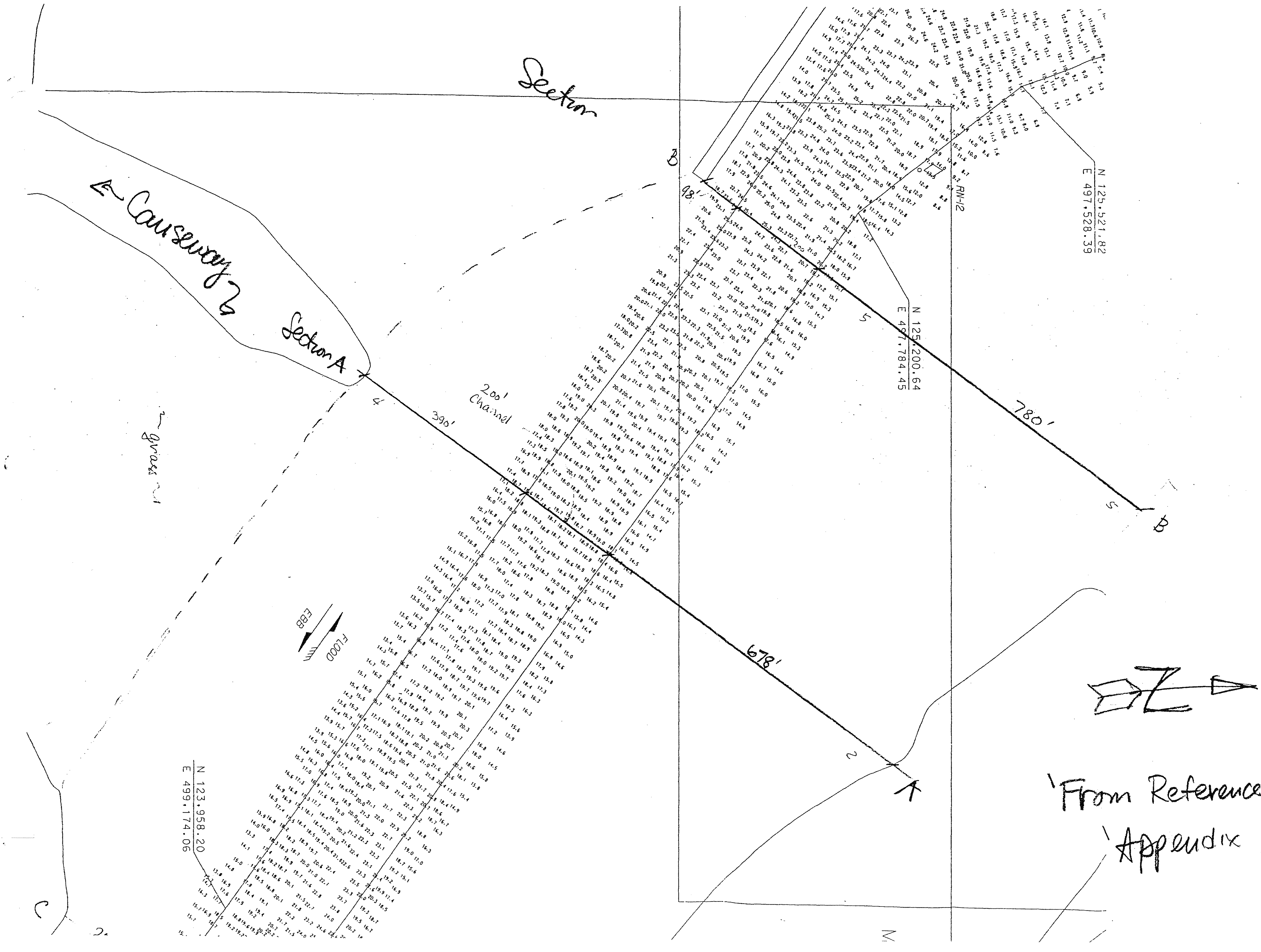
"Determination of Channel Section and Near-shore Geometry, Water Depths and Fetch Lengths"



~1,000' @ Channel Entrance: used for 'Diffraction' calculations, see B.4

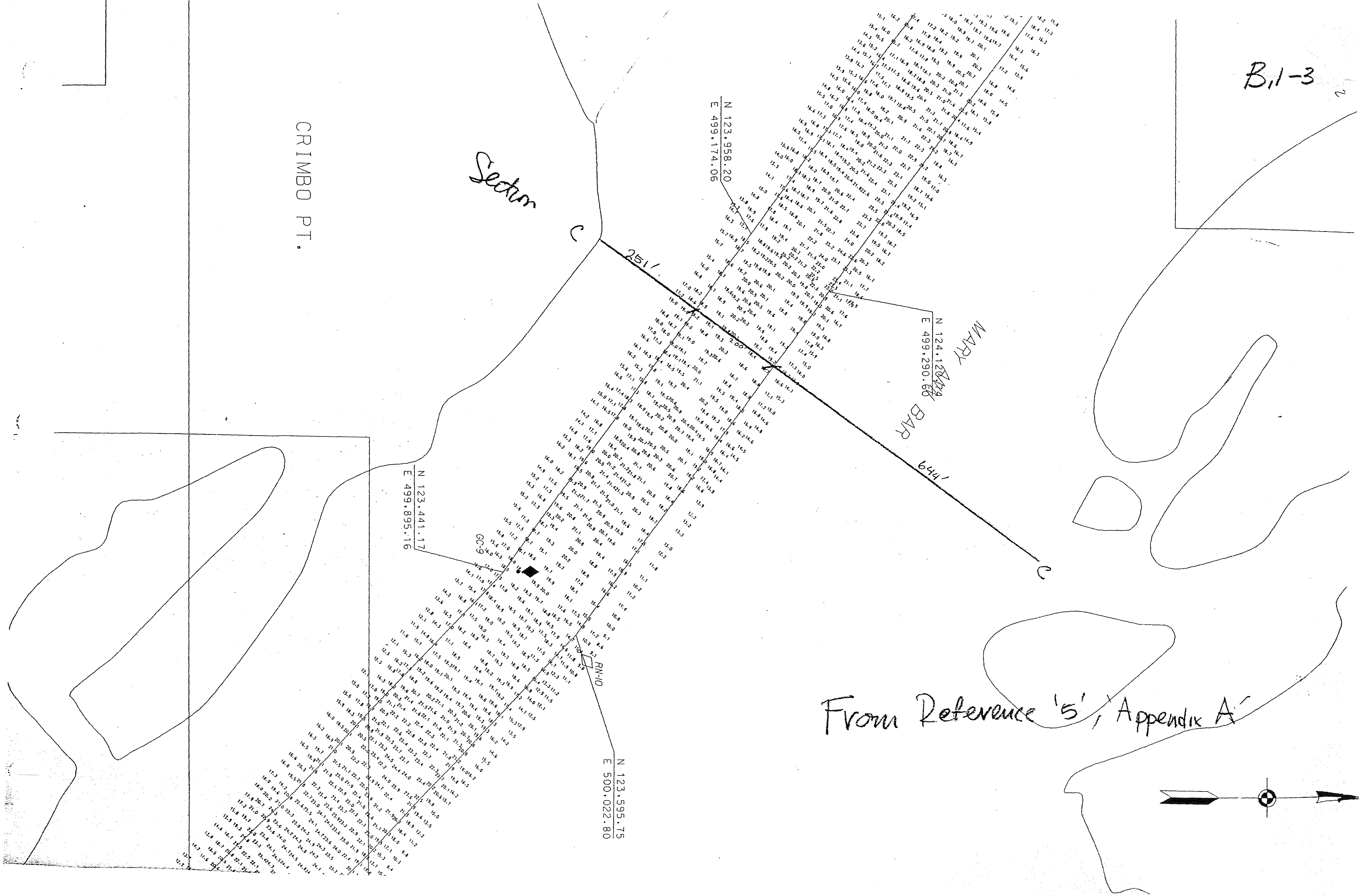
From Ref. 6., Appendix A.3

B.1-2



'From Reference '5'
'Appendix A'

B.1-3



From Reference '5', Appendix A

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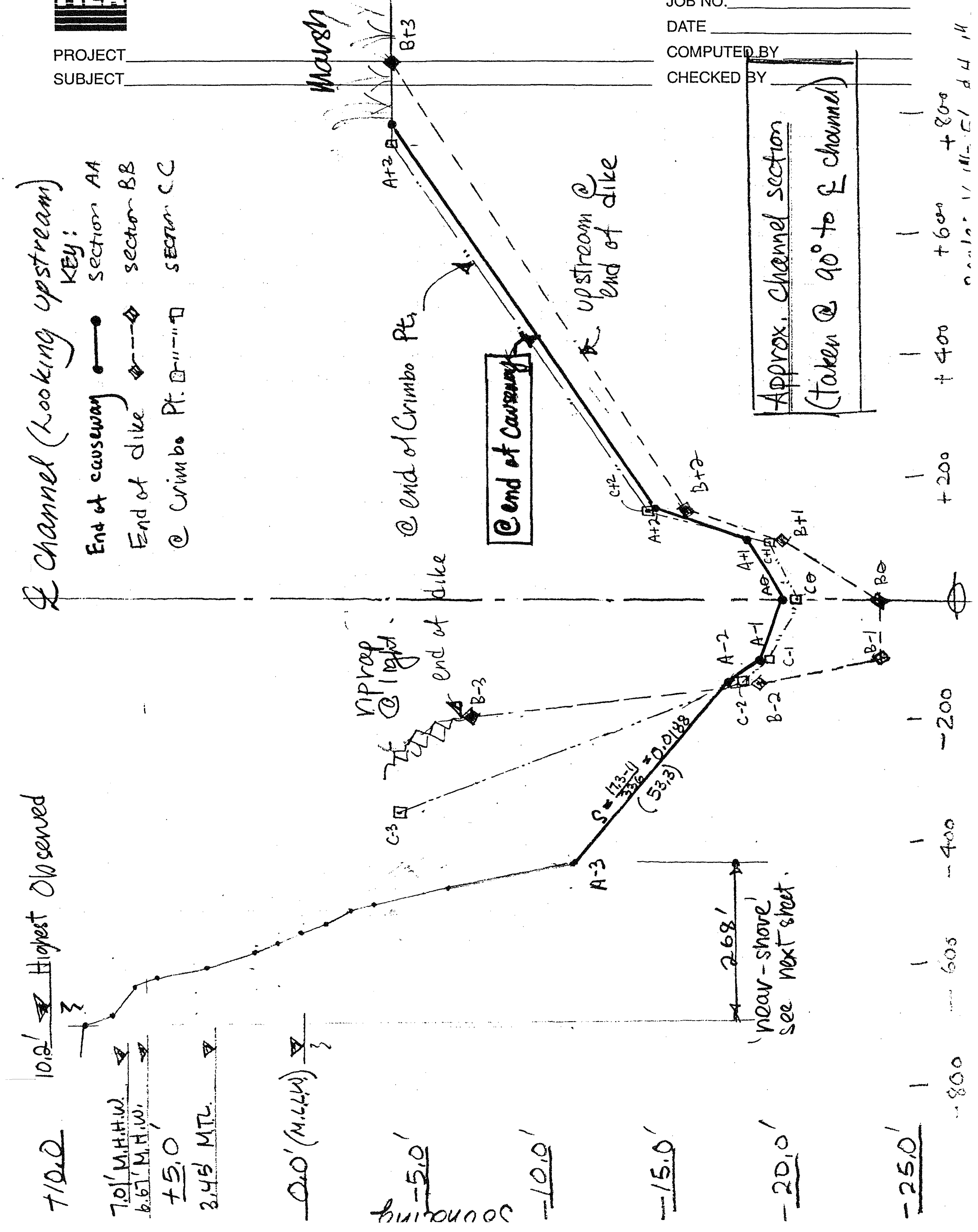

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SHEET B.1-5 OF
JOB NO.
DATE 10/00
COMPUTED BY
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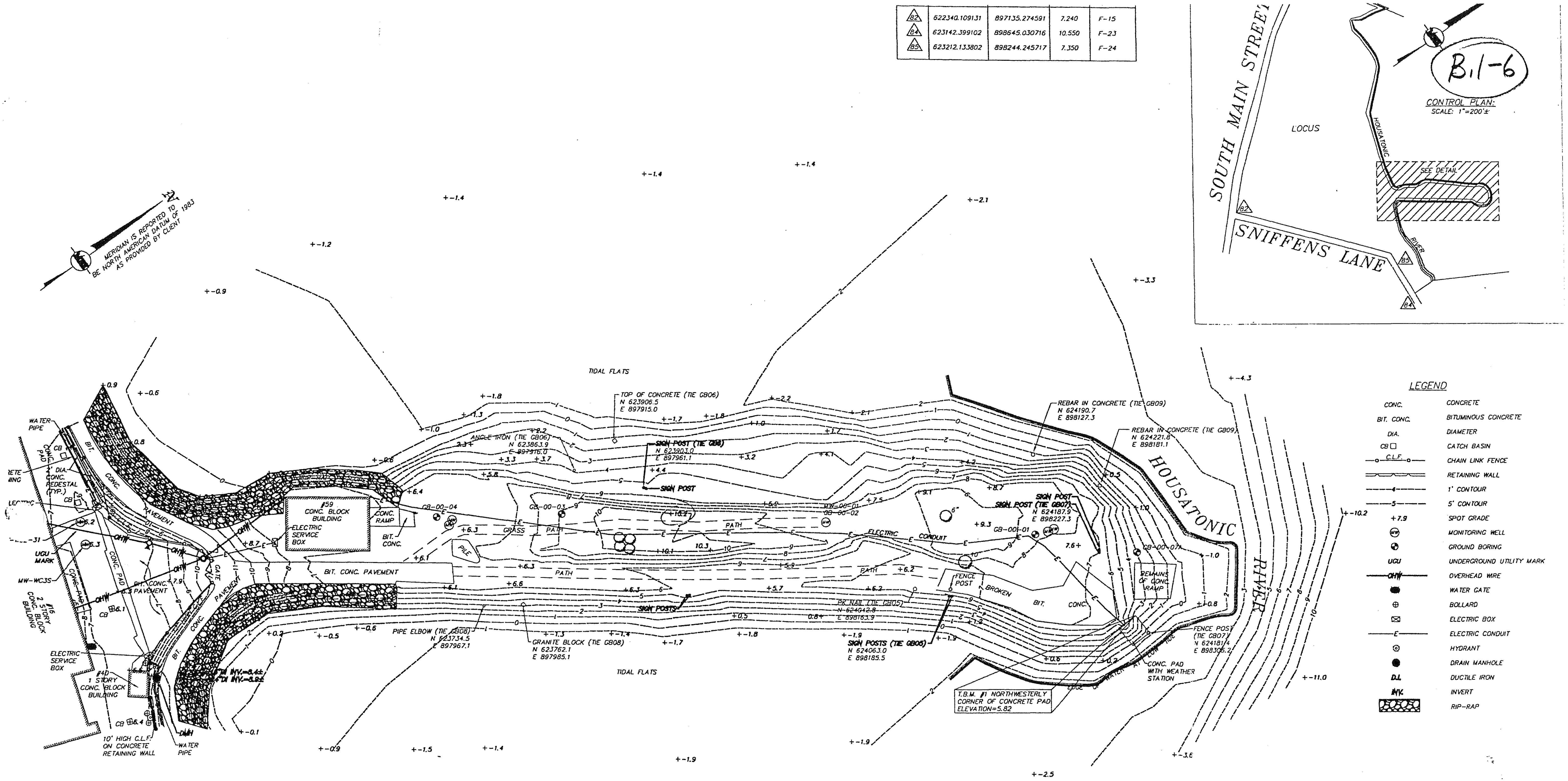
PROJECT Stratford Causeway
SUBJECT Channel Section Coord.

| Section AA | | Section BB | | Section CC | |
|---|---|---|---|---|---|
| A+3 | 778, -4 (est) | B+3 | 880, -4 (est) | C+3 | 744, -4(es |
| A+2 | 150, -14.6 | B+2 | 150, -15.8 | C+2 | 150, -14.3 AV |
| A+1 | 100, -18.1 | B+1 | 100, -19.8 | C+1 | 100, -19.1 |
| A0 | 0, -19.8 | B0 | 0, -23.5 | C0 | 0, -20.1 |
| A-1 | -100, -18.6 | B-1 | -100, -23.5 (Avg) | C-1 | -100, -19.1 |
| A-2 | -150. -17.3 | B-2 | -150, -18.7 | C-2 | -150 -18 (Avg |
| A-3 | -436, -11.0 | B-3 | -298, -7 | C-3 | -351, -4 |

~~A +476, -4.0~~

B.1-6

| | | | | |
|---|---|---|---|---|
| 82 | 622340.109131 | 897135.274591 | 7.240 | F-15 |
| 84 | 623142.399102 | 898645.030716 | 10.550 | F-23 |
| 85 | 623212.133802 | 898244.245717 | 7.350 | F-24 |



| | |
|---|---|
| CONC. | CONCRETE |
| BIT. CONC. | BITUMINOUS CONCRETE |
| DIA. | DIAMETER |
| CB □ | CATCH BASIN |
| —o—C.L.F.—o— | CHAIN LINK FENCE |
| ═══ | RETAINING WALL |
| ——4—— | 1' CONTOUR |
| ——5—— | 5' CONTOUR |
| +7.9 | SPOT GRADE |
| MW | MONITORING WELL |
| ⊕ | GROUND BORING |
| UGU | UNDERGROUND UTILITY MARK |
| —OHW— | OVERHEAD WIRE |
| ● | WATER GATE |
| ⊕ | BOLLARD |
| ⊠ | ELECTRIC BOX |
| ——E—— | ELECTRIC CONDUIT |
| ◎ | HYDRANT |
| ● | DRAIN MANHOLE |
| D.I. | DUCTILE IRON |
| INV. | INVERT |
| ▨ | RIP-RAP |

NOTES:

1. THE SOLE PURPOSE OF THIS PLAN IS TO DEPICT THE TOPOCRAHY SITE DETAIL AND LOCATIONS OF WELLS, BORINGS FROM A PARTIAL FIELD SURVEY CONDUCTED BETWEEN OCTOBER 16 & 17, 2000.

2. THE LOCATIONS OF THE POINTS DEPICTED HEREON ARE FOR PICTORAL PURPOSES ONLY. FOR POINT COORDINATE INFORMATION AND ELEVATION SEE ACCESS FILE PRODUCED BY MERIDIAN ENGINEERING, INC.

3. HORIZONTAL AND VERTICAL CONTROL POINTS WERE PROVIDED BY MICHAEL G. WILMES, L.S. OF URS GREINER WOODWARD CLYDE. THE DATUMS WERE REPORTED TO BE ON THE NORTH AMERICAN DATUM OF 1983 AND NATIONAL GEODETIC VERTICAL DATUM OF 1929.

4. NO UTILITIES ARE DEPICTED ON THIS PLAN EXCEPT THE ELECTRIC CONDUIT LOCATED WITHIN THE PENINSULA.

PROPERTY LINES ARE NOT DEPICTED ON THIS PLAN. MERIDIAN ENGINEERING INC. DOES NOT OFFER ANY OPINION AS TO THE LOCATION OF THE PROPERTY LINES.

6. THIS PLAN IS A TOPOGRAPHIC SURVEY IN ACCORDANCE WITH THE MOST RECENT CONNECTICUT ASSOCIATION OF LAND SURVEYORS, RECOMMENDED STANDARDS FOR SURVEY AND MAPS IN THE STATE OF CONNECTICUT. THIS MAP CONFORMS WITH A CLASS V2 VERTICAL ACCURACY AND CLASS T-1 TOPOGRAPHIC SURVEY ACCURACY.

TO THE BEST OF MY KNOWLEDGE AND BELIEF, THIS MAP IS SUBSTANTIALLY CORRECT AS NOTED HEREON.

FOR MERIDIAN ENGINEERING, INC. 10/31/00

GRAPHIC SCALE
SCALE: 1"=40'
FEET 40 0 20 40 80 160
METERS 0 10 20 40 60

REVISIONS

| NO. | DATE | DESCRIPTION | BY | CHK'D |
|---|---|---|---|---|
| | | | | |
| | | | | |

DWG. No. 3420RECPENINSULA
BK. #318, PG. #24

STRATFORD ARMY ENGINE PLANT

RECORD CONDITIONS PLAN OF LAND
LOCATED IN
STRATFORD, CONNECTICUT
(FAIRFIELD COUNTY)

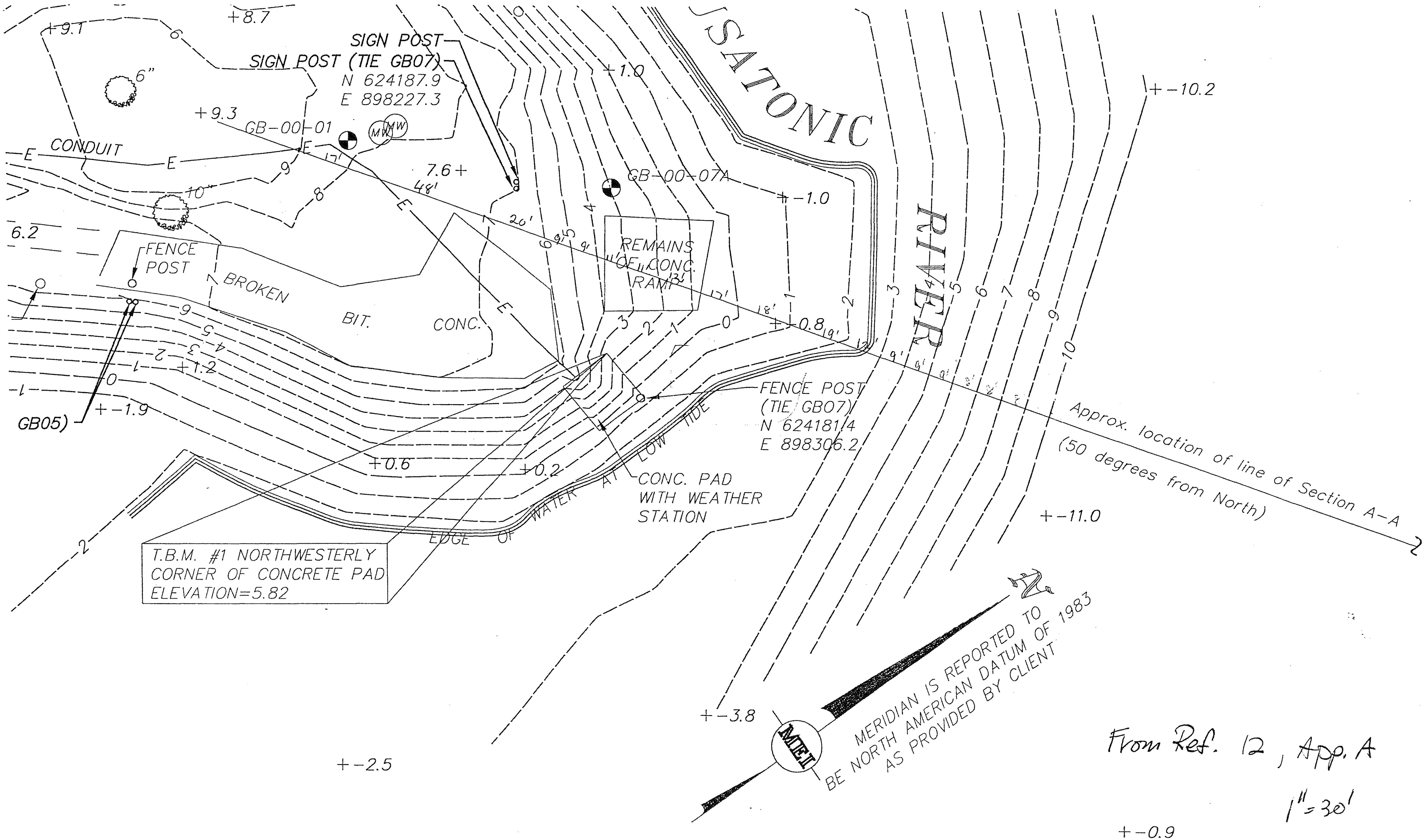
PREPARED FOR
FOSTER WHEELER ENVIRONMENTAL CORPORATION
SCALE: 1"= 40' DATE: OCTOBER 25, 200

MERIDIAN
ENGINEERING, INC.
98 HIGH STREET
DANVERS, MASSACHUSETTS 01923
TELEPHONE: (978) 739-9130

SHEET No. 1 OF 1 PROJECT No. 3420

Ref 12, App. A

B.1-4



From Ref. 12, App. A

1" = 30'

**Harding Lawson Associates**
Engineering, Environmental
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SHEET B.1-8 OF
JOB NO.
DATE 10/00
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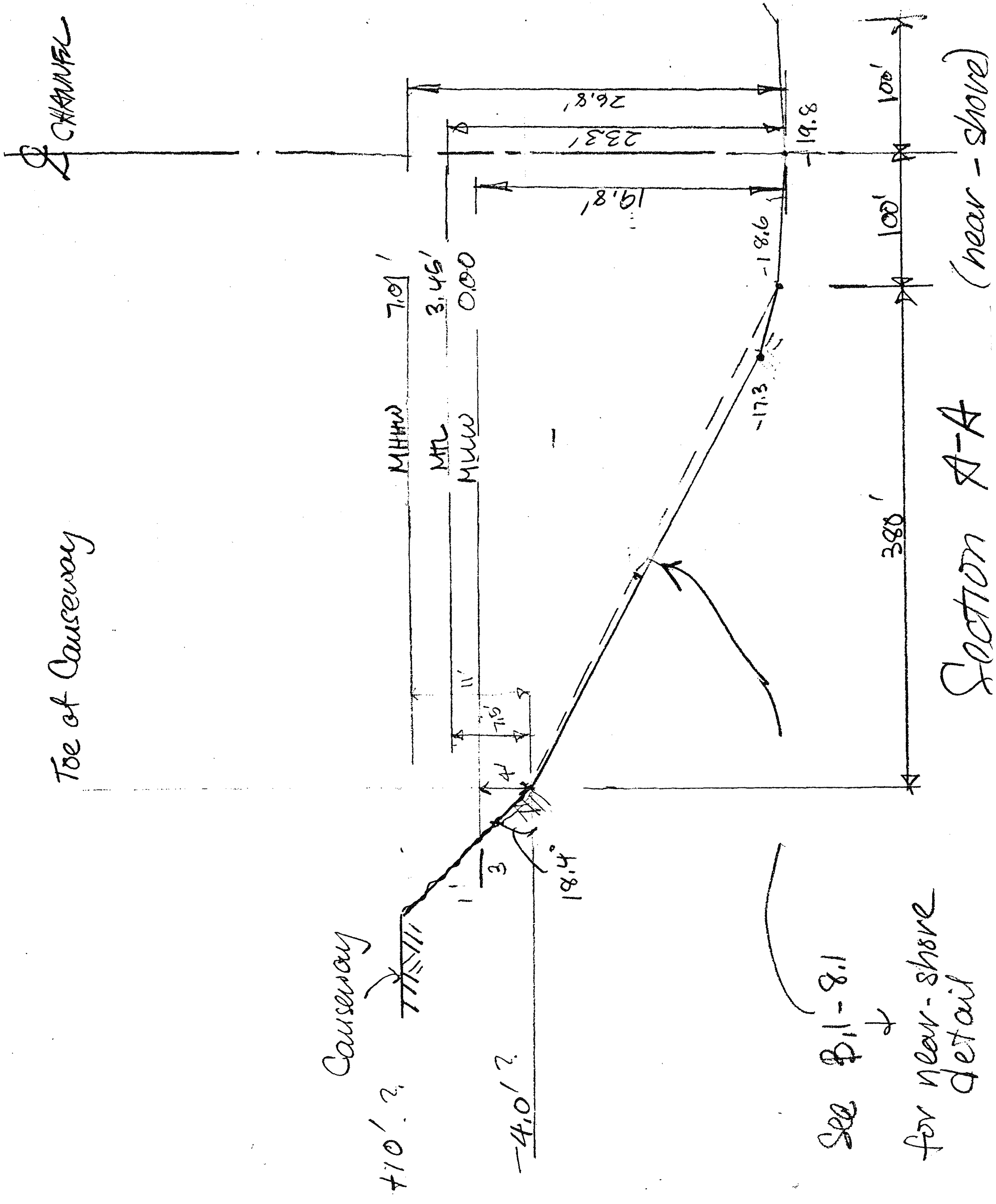
PROJECT Stratford Causeway Revetment
SUBJECT



SHEET B.1-8.1 OF

JOB NO.

DATE 11/02

COMPUTED BY

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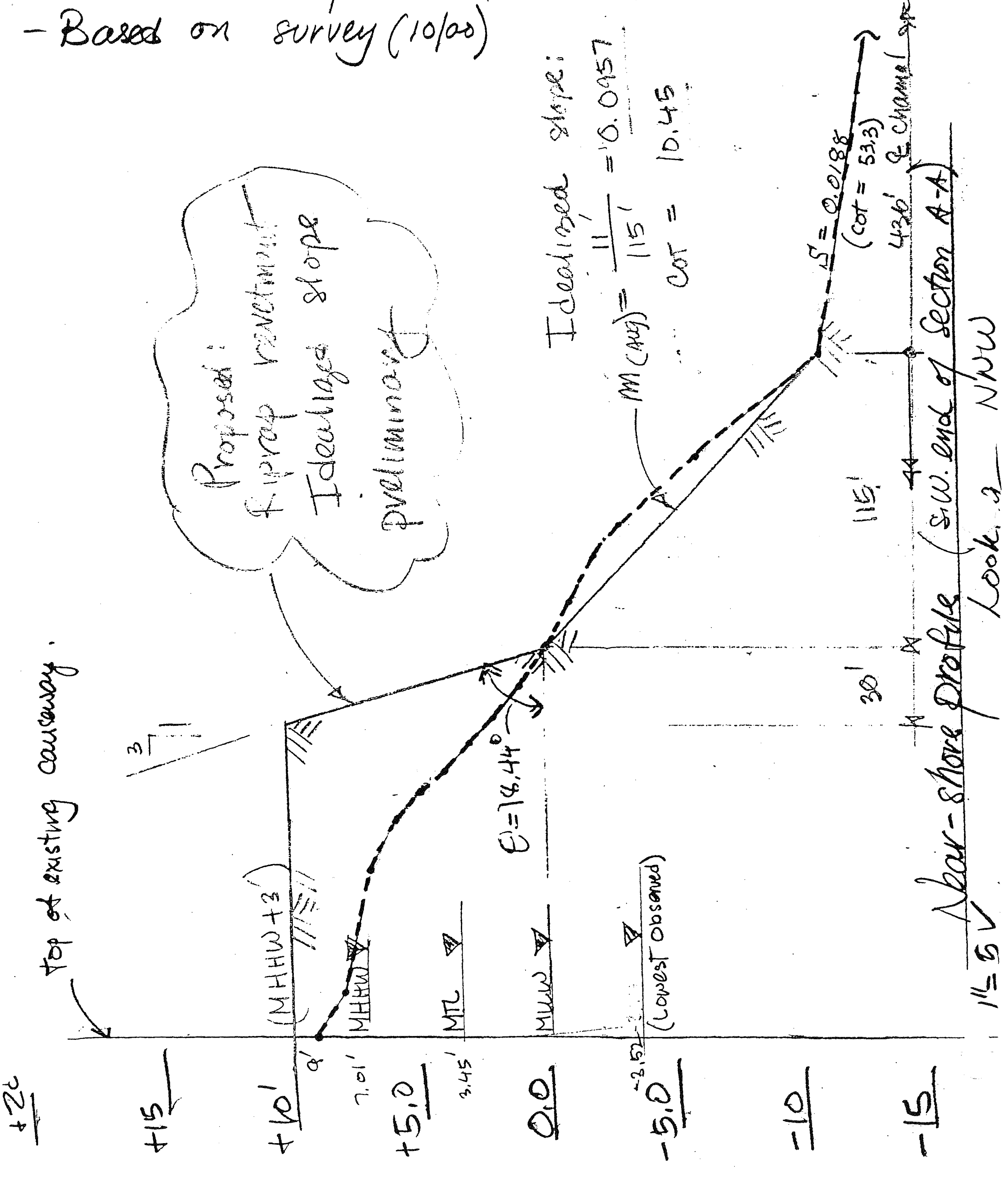
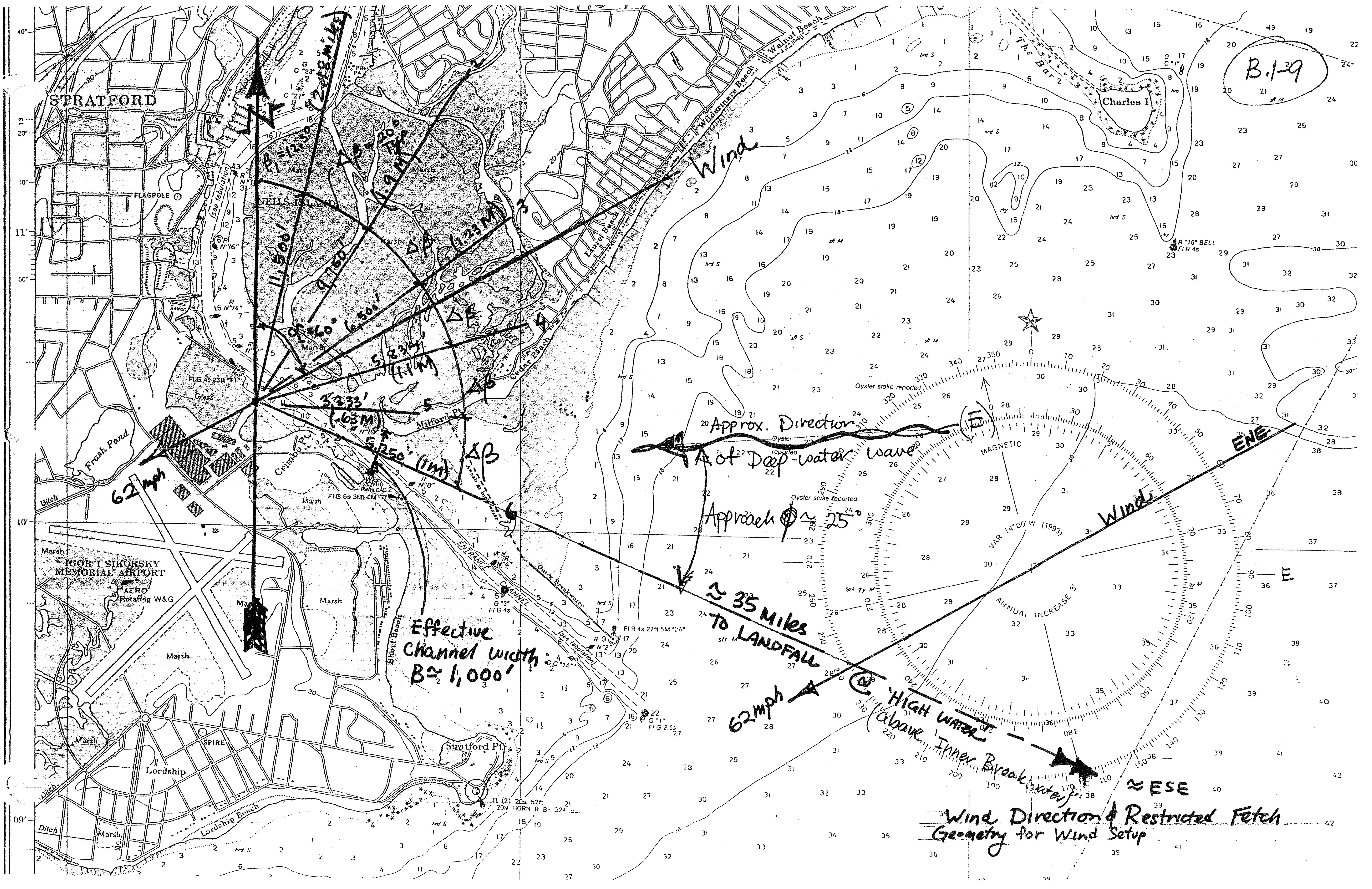
PROJECT Stratford Causeway

SUBJECT Near-shore profile (Section A-A)

- Based on survey (10/00)



B.1-9



Wind Direction & Restricted Fetch Geometry for Wind Setup

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PROJECT Stratford
SUBJECT

SHEET B.1-10 OF
JOB NO.
DATE
COMPUTED BY
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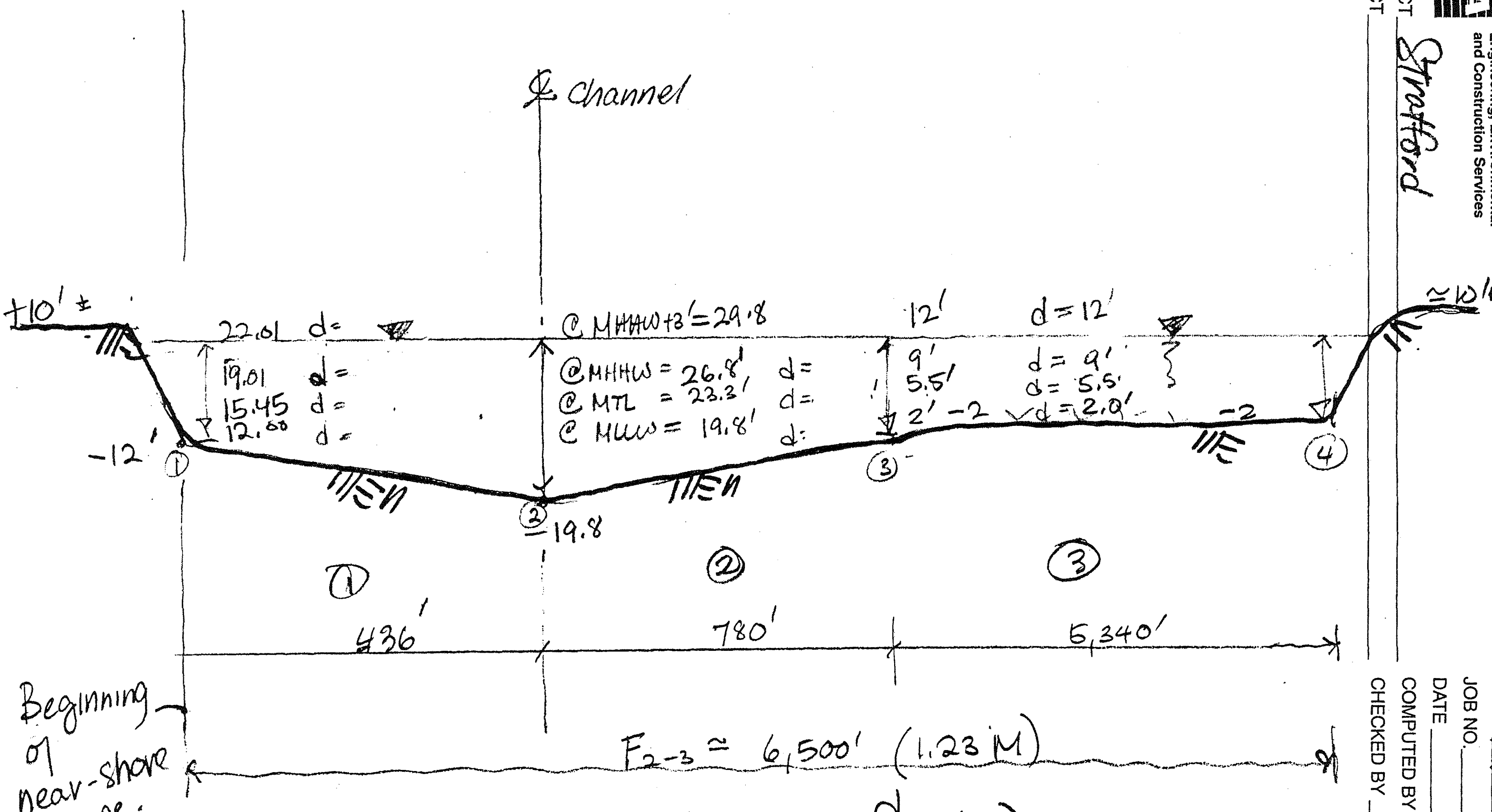

| | $d_{1-3}$ (Avg) |
|---|---|
| @ (MHHW +3') | 11.98' |
| @ MHHW | 9.50' |
| @ MTL | 6.84' |
| @ MLLW | 5.15' |

## Section A-A (entire fetch $\simeq \beta_{2-3}$)

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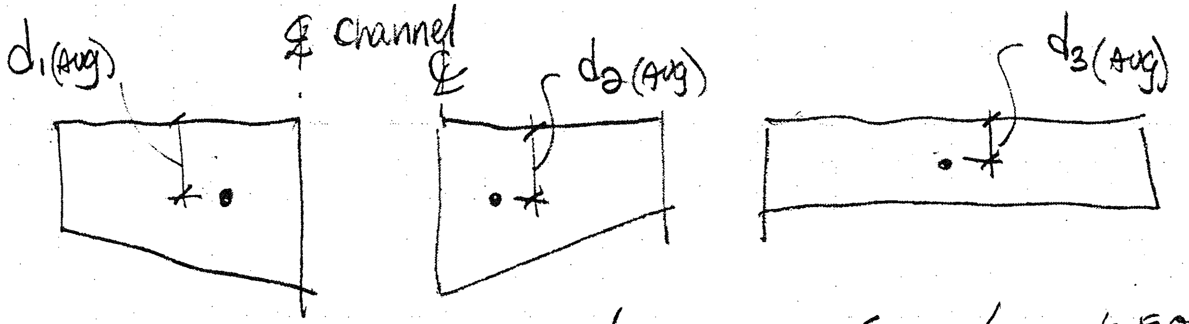
SHEET B.1-11 OF
JOB NO.
DATE 10/00
COMPUTED BY

PROJECT Stratford Causeway
SUBJECT Calculate average fetch depth

@ (MHHW +3), MHHW, MTL & MLW



380' + 780' + 5,340' = $\frac{6,500'}{5,280}$ = 1.23 mi

|  | ① $A_1$ / $d_{1(Avg)}$ | ② $A_2$ / $d_{2(Avg)}$ | ③ $A_3$ / $d_{3(Avg)}$ | Fetch Average $A_{1-3}$ / $d_{1-3}$ |
|---|---|---|---|---|
| (MHHW +3) | 11,290 ft² / 13.1' | 16,300 ft² / 11.1' | 64,080 ft² / 12' | 91,670 / 11.02 |
| MHHW | 9,987 / 11.6' | 13,960 / 9.7' | 48,060 / 9' | 72,007 / 9.50 |
| MTL | 8,448 / 9.8' | 11,230 / 8.1' | 29,370 / 5.5 | 49,048 / 6.84 |
| MLW | 6,932 / 8.1' | 8,502 / 6.7' | 10,680 / 2 | 26,114 / 5.15' |

SHEET B.2-0 OF

JOB NO.

DATE

COMPUTED BY

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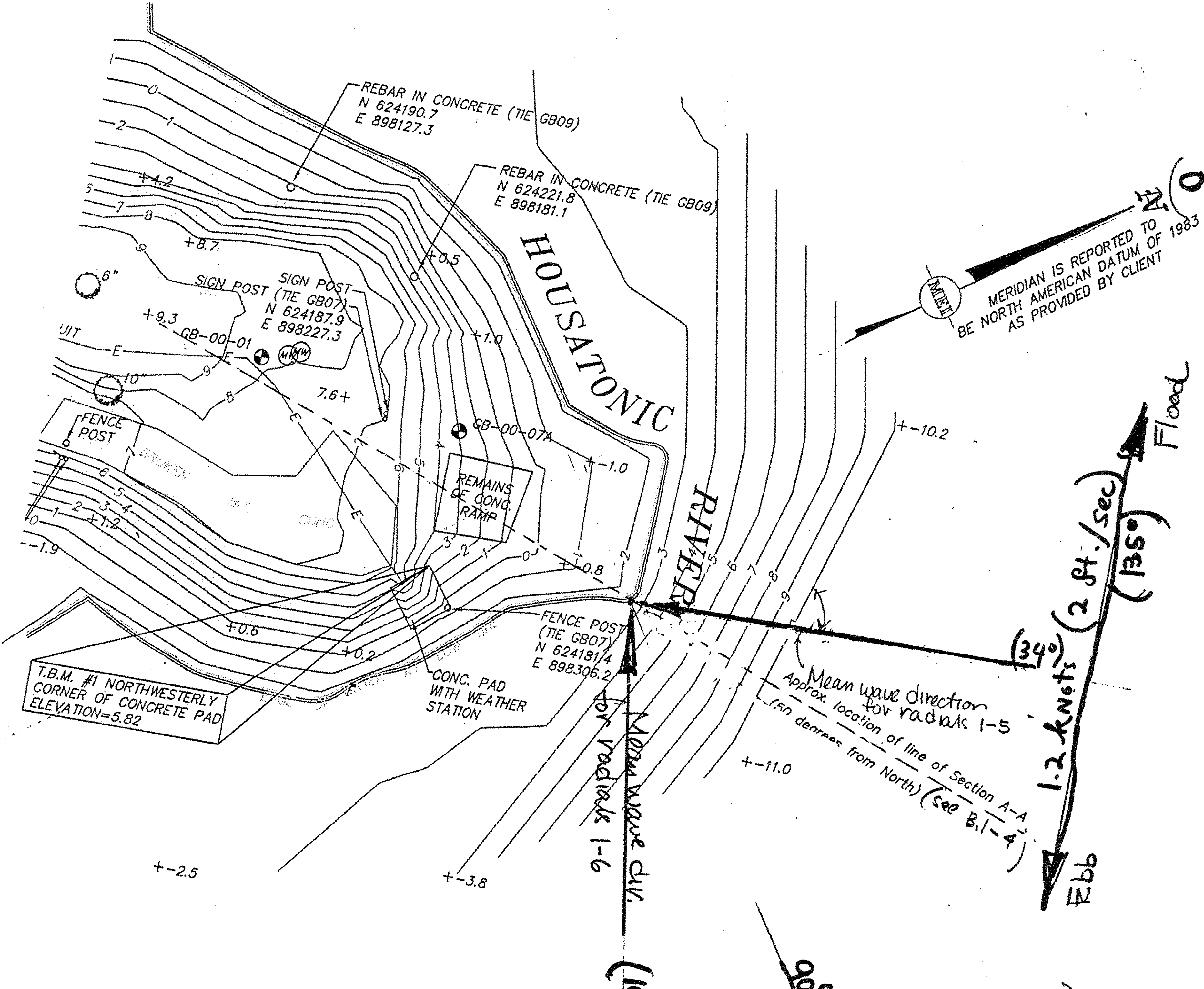
PROJECT Stratford Causeway

SUBJECT

# Appendix

## B.2

'Wind Adjustment and Wave-Growth Results'


REBAR IN CONCRETE (TIE GB09)
N 624190.7
E 898127.3
REBAR IN CONCRETE (TIE GB09)
N 624221.8
E 898181.1
HOUSATONIC
RIVER
SIGN POST
SIGN POST (TIE GB07)
N 624187.9
E 898227.3
GB-00-01
GB-00-07A
6"
10"
+4.2
+8.7
+9.3
7.6+
+0.5
+1.0
+1.2
+0.6
+0.2
+0.8
+-1.9
+-1.0
+-10.2
+-11.0
+-2.5
+-3.8
FENCE POST
REMAINS OF CONC. RAMP
BROKEN
CONC
FENCE POST (TIE GB07)
N 624181.4
E 898306.2
CONC. PAD WITH WEATHER STATION
T.B.M. #1 NORTHWESTERLY CORNER OF CONCRETE PAD ELEVATION=5.82
MERIDIAN IS REPORTED TO BE NORTH AMERICAN DATUM OF 1983 AS PROVIDED BY CLIENT
MEI
N
Mean wave direction for radials 1-5
(34°)
Approx. location of line of Section A-A (50 degrees from North) (see B.1-4)
Mean wave dir. for radials 1-6
1.2 knots (2 ft./sec) (135°)
Flood
Ebb

SHEET B.2-~~0~~.2 OF
JOB NO.
DATE 3/01
COMPUTED BY
CHECKED BY

PROJECT Stratford
SUBJECT

# Comparison of Wind Direction/Duration (speed/duration)

| (Direction) Case No, | $H_{mo}$ | * 30% Design<br>ŧ 90% Design | From Ref. 14, Table 8 (100 year return) |
|---|---|---|---|
| (ENE) | | | — |
| 1b | 3.31 | * 81 mph/8 min. | 64 mph/1 min |
| 1a | 2.39 | * 62 mph/1 hour | 52 mph/1 hour |
| 1c.1 | 2.97 | ŧ 37 mph/3 hour | 37 mph/3 hours |
| 1f1 | 2.48 | ŧ 28 mph/8 hours. | 28 mph/8 hours. |
| (E) | ŧ | fetch & duration, limited | 74 mph/1 min |
| 1e.1 | 4.72 | ŧ 60 mph/1 hour | 60 mph/1 hour. |
| 1e.2 | 4.50 | ŧ 55 mph/3 hours | 55 mph/3 hours |
| 1e.3 | 4.36 | ŧ 52 mph/8 hours | 52 mph/8 hours |

As shown in 'B.4' open-water waves will be reduced by diffraction @ Channel Entrance

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Infrastructure, Inc.

Engineering, Planning, and Construction Services

SHEET B.2-0.3 OF
JOB NO.
DATE 3/01
COMPUTED BY JH
PROJECT Stratford
SUBJECT Diffraction @ Channel Entrance
CHECKED BY

Conclusion:

From Case 1e.1 $H_{mo} = \underline{4.72}$

$T_p = \underline{5.05}$ sec

From Ref. 15: Deep-water wave

$H_s$ 'significant wave height' ≃ $\underline{5'}$ ← Use
($H_s \simeq H_{mo}$ @ deepwater) (& $T_p \simeq 4.5$ sec)
Fig. 3-24, Ref G

Use to determine effect of diffraction thru Channel Entrance

see calc section B.4

SHEET B.2-1 OF
JOB NO.
DATE 11/00
COMPUTED BY JH
CHECKED BY

PROJECT Stratford Causeway
SUBJECT Summary of Wind Adjustment & Wave Growth Results

"unmodified for 'near-shore' effects"

| SWL | Case # | $d_{(avg)}$ | $H_{mo}$ | $H_{1/3}$ | $H_{1/10}$ |
|---|---|---|---|---|---|
| MHHW+3' | 1a | 11.98' | 2.39' | 2.38 | 3.04 |
| | 1a.1 | ↓ | 2.43 | 2.42 | 3.09 |
| | 1b | | 3.31 | 3.29 | 4.21 |
| | 1b.1 | | 3.31 | | |
| MHHW | 2a | 9.50' | 2.28 | 2.27 | 2.90 |
| | 2a.1 | ↓ | 2.32 | 2.31 | 2.95 |
| | 2a.2 | | 2.34 | 2.33 | 2.97 |
| | 2b | | 3.11 | 3.10 | 3.95 |
| | 2b.1 | | 3.11 | | |
| MTL | 3a | 6.84' | 2.07 | 2.06 | 2.63 |
| | 3a.1 | ↓ | 2.11 | | |
| | 3b | | 2.76 | 2.75 | 3.51 |
| | 3b.1 | | 2.76 | | |
| MLW | 4a | 5.15 | 1.86 | 1.85 | 2.36 |
| | 4a.1 | ↓ | 1.89 | | |
| | 4a.2 | | 1.92 | 1.91 | 2.44 |

(over)

**Harding Lawson Associates**
Engineering and
Environmental Services

SHEET B.2-2 OF
JOB NO.
DATE 11/00
COMPUTED BY JLT
CHECKED BY

PROJECT Stratford Causeway
SUBJECT Summary (Cont)

| SWL | Case # | d(avg) | $H_{mo}$ | $H_{1/3}$ | $H_{1/10}$ |
|---|---|---|---|---|---|
| MLLW | 4b | 5.15 | 2.41 | 2.41 | 3.08 |
| | 4b.1 | | 2.41 | | |
| | 4b.2 | | 2.41 | 2.40 | 3.06 |

"unmodified for 'near-shore' effects"

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Engineering,
Environmental and
Construction Services

SHEET B.2-3 OF ____
JOB NO. ____
DATE 11/00
COMPUTED BY JA
CHECKED BY ____

PROJECT Stratford Causeway
SUBJECT Summary

Non-breaking wave adjusted for refraction and shoaling ($K_r K_s$) for water depth > 3.70'

From page B.3-8 $K_R K_s \approx \underline{0.92}$

| ∴ | Case # | $H_{1/3}$ (ft) | $H_{1/10}$ (ft) |
|---|---|---|---|
| MHHW +3' | – | 3.03 | 3.87 |
| MHHW | – | 2.85 | 3.63 |
| MTL | – | 2.53 | 3.23 |
| MLLW | – | 2.22 | 2.83 |

Case 1a

```
Elevation of Observed Wind    Zobs:      30.00  ft        Wind Observation Type
Observed Wind Speed           Uobs:      62.00  mph       ---------------------
Air-Sea Temp. Difference      delT:      -6.40  deg F          Inland
Duration of Observed Wind     DurO:       0.10  hr
   ration of Final Wind       DurF:       1.00  hr
    itude of Observation       LAT:      41.16  deg
Average Depth of Fetch           d:      11.98  ft
Length of Wind Fetch             F:       1.83  mi        Wave Growth Equations
Equiv. Neutral Wind Speed       Ue:      52.25  mph       ---------------------
Adjusted Wind Speed             Ua:      79.50  mph       Restricted Fetch
Wave Height                    Hm0:       2.39  ft        Shallow-water
Wave Period                     Tp:       2.81  sec       Fetch-limited
Wind Direction                Wdir:      60.00  deg
Mean Wave Direction          Theta:      34.00  deg
```

---

WIND ADJUSTMENT and WAVE GROWTH

```
Elevation of Observed Wind    Zobs:      30.00  ft        Wind Observation Type
Observed Wind Speed           Uobs:      62.00  mph       ---------------------
Air-Sea Temp. Difference      delT:      -6.40  deg F          Inland
Duration of Observed Wind     DurO:       0.10  hr
Duration of Final Wind        DurF:       1.00  hr
Latitude of Observation        LAT:      41.16  deg
Average Depth of Fetch           d:      11.98  ft
Length of Wind Fetch             F:       1.83  mi        Wave Growth Equations
Equiv. Neutral Wind Speed       Ue:      52.25  mph       ---------------------
Adjusted Wind Speed             Ua:      79.50  mph       Restricted Fetch
Wave Height                    Hm0:       2.39  ft        Shallow-water
   ve Period                    Tp:       2.81  sec       Fetch-limited
  ind Direction               Wdir:      60.00  deg
Mean Wave Direction          Theta:      34.00  deg
```

$$L = 2.81\,s\sqrt{g \times 11.98} = 55.2' \Rightarrow H/L = 0.04$$

$$\frac{1}{25} < d/L = \frac{11.98}{55.2} = 0.22 < 1/2$$

$\therefore$ transitional water

$$d < L/2$$

$$C = \frac{55.2'}{2.81\,sec} = 19.64\,ft/s$$

For average fetch of 1.83 miles (9,662')

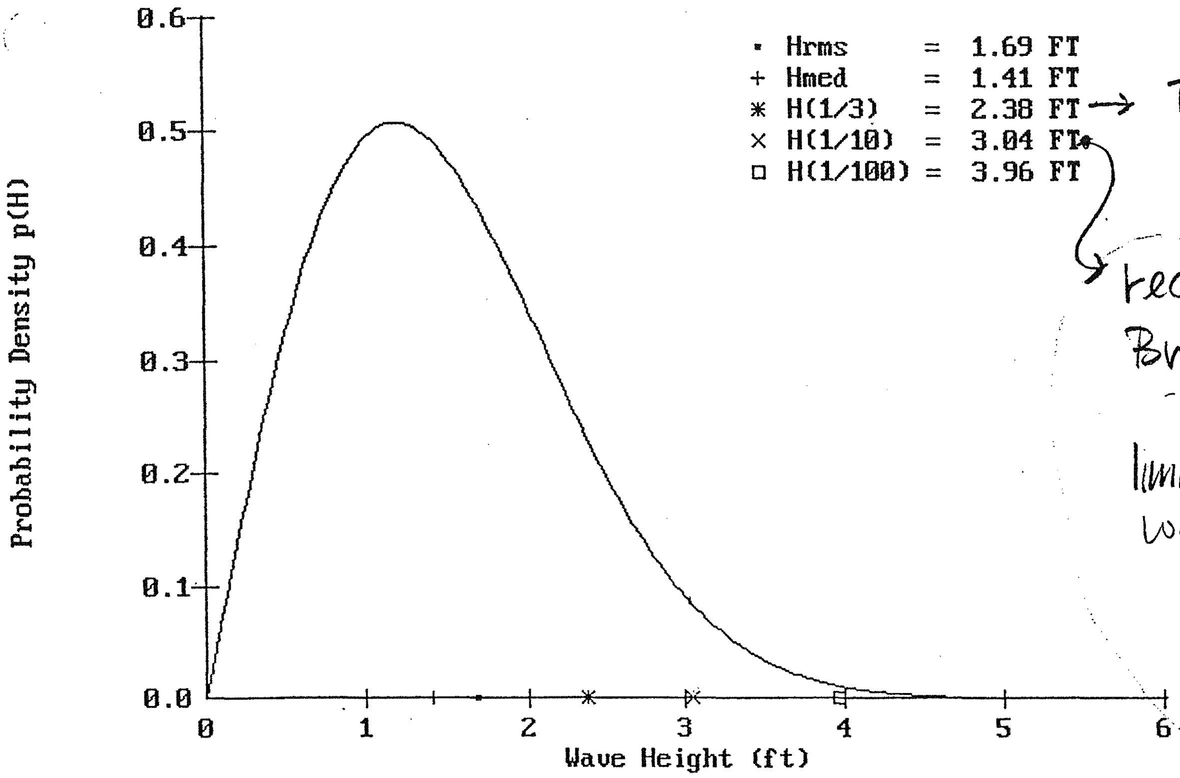
$t_f = 492\,s \simeq 8$ minutes

Case 1a

EM 111-2-1614 (pg 2-4)

for $T_s/T_p = 0.88$

RAYLEIGH DISTRIBUTION
INPUT CONDITIONS Hmo = 2.39f Tp = 2.81S h = 11.98f



$T_s \simeq 0.88 \times 2.81 = \underline{2.47s}$

recommended by Brodenck & limit for shallow-water prediction Ref. A, pg C-26 para. b.

$d = 11.98 > \frac{H(1/3)}{2} = 1.19'$ (Ref. C, 2-7(3a))

Case 1a.1

```
                         WIND ADJUSTMENT and WAVE GROWTH

Elevation of Observed Wind   Zobs:      30.00  ft        Wind Observation Type
  served Wind Speed          Uobs:      62.00  mph       ---------------------
  -Sea Temp. Difference      delT:      -6.40  deg F          Inland
Duration of Observed Wind    DurO:       8.00  min ←
Duration of Final Wind       DurF:      60.00  min
Latitude of Observation       LAT:      41.17  deg
Average Depth of Fetch          d:      11.98  ft
Length of Wind Fetch            F:       1.83  mi        Wave Growth Equations
Equiv. Neutral Wind Speed      Ue:      53.08  mph       ---------------------
Adjusted Wind Speed            Ua:      81.20  mph       Restricted Fetch
Wave Height                   Hm0:       2.43  ft        Shallow-water
Wave Period                    Tp:       2.83  sec       Fetch-limited
Wind Direction               Wdir:      60.00  deg
Mean Wave Direction         Theta:      34.00  deg
```

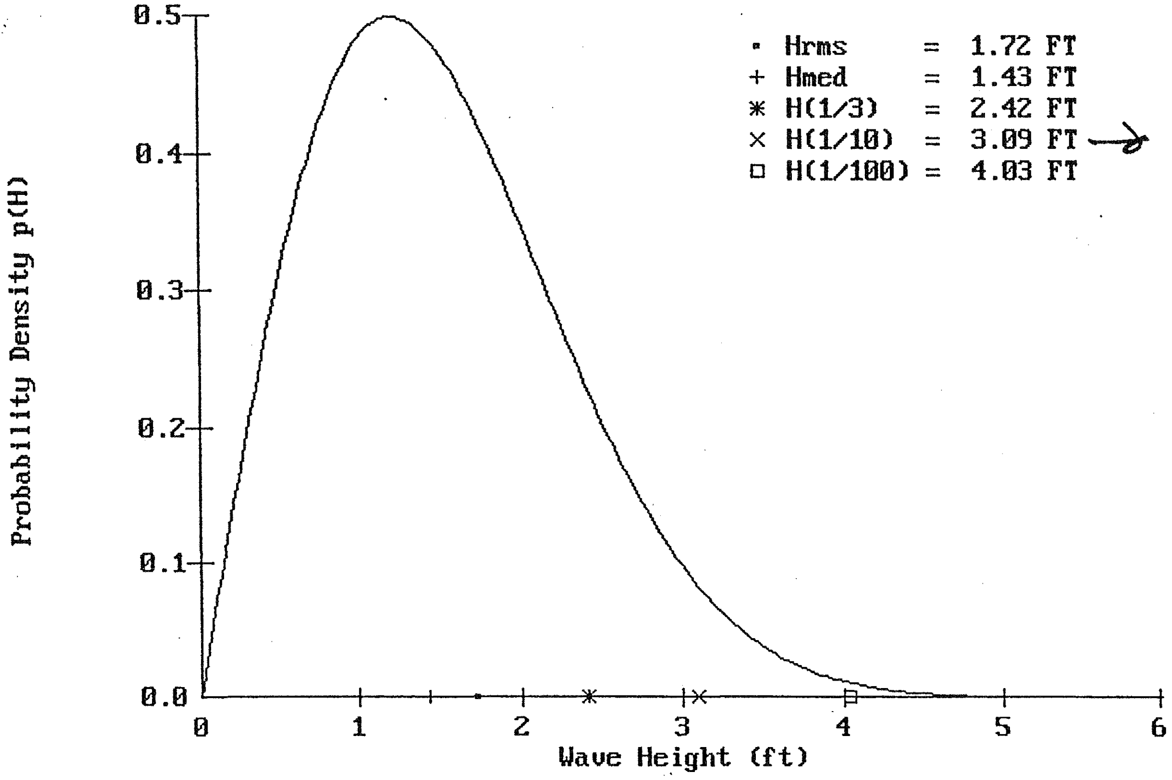
$$L = 2.83\sqrt{32.2 \times 11.98} = 55.6'$$

$$C = \frac{55.6'}{2.83\ s} = 19.64\ ft/s \quad (13.4\ mph)$$

Case 1a.1

## RAYLEIGH DISTRIBUTION

INPUT CONDITIONS Hmo = 2.43f Tp = 2.83S h = 11.98f



Case 1b

```
                    WIND ADJUSTMENT and WAVE GROWTH

Elevation of Observed Wind     Zobs:      30.00   ft       Wind Observation Type
  erved Wind Speed             Uobs:      81.00   mph      ---------------------
   -Sea Temp. Difference       delT:      -6.40   deg F          Inland
Duration of Observed Wind      DurO:       0.10   hr
Duration of Final Wind         DurF:       0.10   hr
Latitude of Observation         LAT:      41.16   deg
Average Depth of Fetch            d:      11.98   ft
Length of Wind Fetch              F:       1.83   mi       Wave Growth Equations
Equiv. Neutral Wind Speed        Ue:      69.24   mph      ---------------------
Adjusted Wind Speed              Ua:     116.35   mph      Restricted Fetch
Wave Height                     Hm0:       3.31   ft       Shallow-water
Wave Period                      Tp:       3.28   sec      Fetch-limited
Wind Direction                 Wdir:      60.00   deg
Mean Wave Direction           Theta:      34.00   deg
```

```
                    WIND ADJUSTMENT and WAVE GROWTH

Elevation of Observed Wind     Zobs:      30.00   ft       Wind Observation Type
Observed Wind Speed            Uobs:      81.00   mph      ---------------------
Air-Sea Temp. Difference       delT:      -6.40   deg F          Inland
Duration of Observed Wind      DurO:       0.10   hr
Duration of Final Wind         DurF:       0.10   hr
Latitude of Observation         LAT:      41.16   deg
Average Depth of Fetch            d:      11.98   ft
Length of Wind Fetch              F:       1.83   mi       Wave Growth Equations
  iv. Neutral Wind Speed         Ue:      69.24   mph      ---------------------
Adjusted Wind Speed              Ua:     116.35   mph      Restricted Fetch
Wave Height                     Hm0:       3.31   ft       Shallow-water
Wave Period                      Tp:       3.28   sec      Fetch-limited
Wind Direction                 Wdir:      60.00   deg
Mean Wave Direction           Theta:      34.00   deg
```

$$L = 3.28\sqrt{32.2 \times 11.98} = 64.4'$$

$$d < L/2$$

∴ still transitional

$$C = \frac{64.4'}{3.28\text{ sec}} = 19.64\text{ ft/s}$$

For fetch of 1.83 mi (9,662')

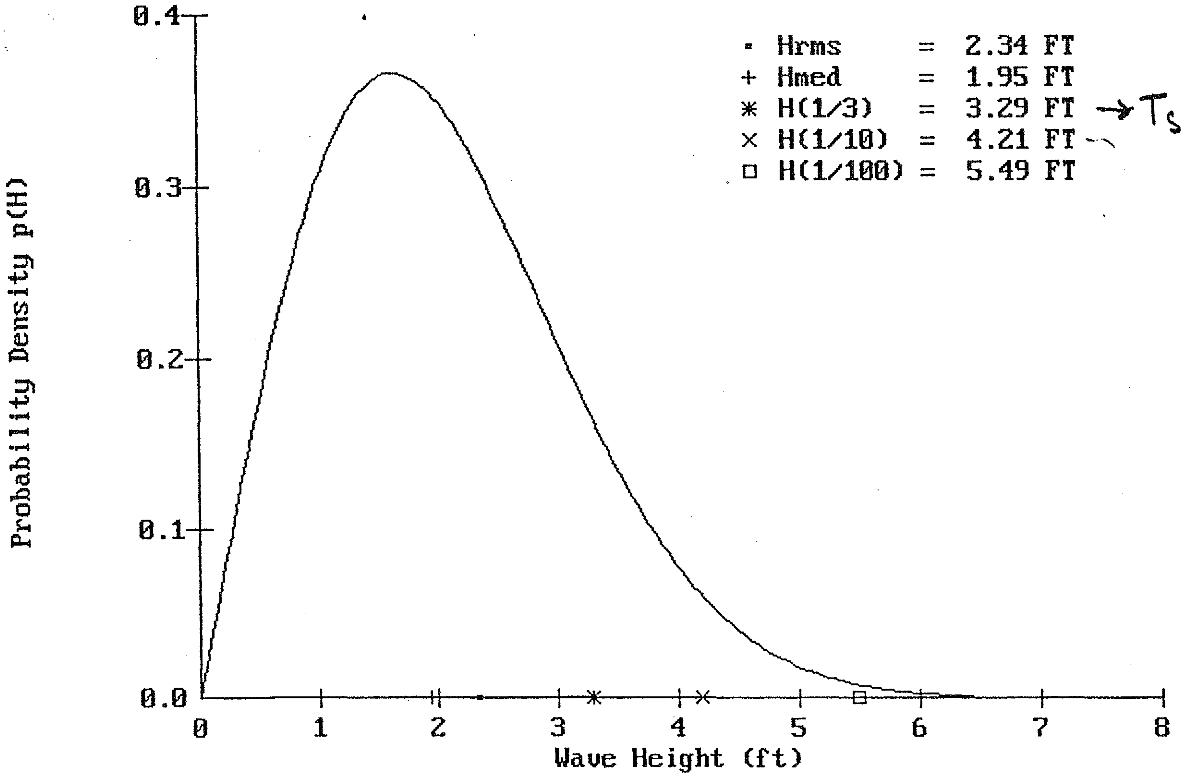
$$t_f = 8.2\text{ min} \quad (0.14\text{ hrs})$$

∴ use 0.14 hours

Case 1b

## RAYLEIGH DISTRIBUTION

INPUT CONDITIONS Hmo = 3.31f Tp = 3.28S h = 11.98f > $\frac{H(1/3)}{2} = 1.15'$ (Ref C, 2-7(30))



→ $T_s = 0.88 \times 3.28 = \underline{2.89\,s}$

Case 1b.1

```
Elevation of Observed Wind     Zobs:      30.00   ft        Wind Observation Type
Observed Wind Speed            Uobs:      81.00   mph       ---------------------
Air-Sea Temp. Difference       delT:      -6.40   deg F          Inland
Duration of Observed Wind      DurO:       8.00   min ←
 ration of Final Wind          DurF:       8.00   min ←
   itude of Observation         LAT:      41.17   deg
Average Depth of Fetch            d:      11.98   ft
Length of Wind Fetch              F:       1.83   mi        Wave Growth Equations
Equiv. Neutral Wind Speed        Ue:      69.24   mph       ---------------------
Adjusted Wind Speed              Ua:     116.35   mph       Restricted Fetch
Wave Height                     Hm0:       3.31   ft        Shallow-water
Wave Period                      Tp:       3.28   sec       Fetch-limited
Wind Direction                 Wdir:      60.00   deg
Mean Wave Direction           Theta:      34.00   deg
```

---

```
                      WIND ADJUSTMENT and WAVE GROWTH

Elevation of Observed Wind     Zobs:      30.00   ft        Wind Observation Type
Observed Wind Speed            Uobs:      81.00   mph       ---------------------
Air-Sea Temp. Difference       delT:      -6.40   deg F          Inland
Duration of Observed Wind      DurO:       8.00   min
Duration of Final Wind         DurF:       8.00   min
Latitude of Observation         LAT:      41.17   deg
Average Depth of Fetch            d:      11.98   ft
Length of Wind Fetch              F:       1.83   mi        Wave Growth Equations
Equiv. Neutral Wind Speed        Ue:      69.24   mph       ---------------------
Adjusted Wind Speed              Ua:     116.35   mph       Restricted Fetch
Wave Height                     Hm0:       3.31   ft        Shallow-water
  e Period                       Tp:       3.28   sec       Fetch-limited
 ind Direction                 Wdir:      60.00   deg
Mean Wave Direction           Theta:      34.00   deg
```

no change from case '1b'

1c.1 (Fetch, Radial 6- 35 miles)

```
                    WIND ADJUSTMENT and WAVE GROWTH

Elevation of Observed Wind   Zobs:      30.00  ft     Wind Observation Type
  served Wind Speed          Uobs:      37.00  mph    ---------------------
  -Sea Temp. Difference      delT:      -6.40  deg F       Inland
Duration of Observed Wind    DurO:       3.00  hr
Duration of Final Wind       DurF:       3.00  hr
Latitude of Observation       LAT:      41.16  deg
Average Depth of Fetch          d:      11.98  ft
Length of Wind Fetch            F:      23.77  mi     Wave Growth Equations
Equiv. Neutral Wind Speed      Ue:      41.79  mph    ---------------------
Adjusted Wind Speed            Ua:      59.12  mph    Restricted Fetch
Wave Height                   Hm0:       2.97  ft     Shallow-water
Wave Period                    Tp:       3.74  sec    Fetch-limited
Wind Direction               Wdir:      60.00  deg
Mean Wave Direction         Theta:     106.00  deg
```

Assumes No diffraction effect @ channel entrance.

Assumes no breakwater effective @ channel entrance during MHHW +3'

STOP

1e.1 Fetch Radial 6 - [illegible] miles
Wind @ 90° (E)

```
                     WIND ADJUSTMENT and WAVE GROWTH

Elevation of Observed Wind    Zobs:      30.00  ft        Wind Observation Type
 served Wind Speed            Uobs:      60.00  mph       ---------------------
  -Sea Temp. Difference       delT:      -6.40  deg F         Inland
Duration of Observed Wind     DurO:       1.00  hr
Duration of Final Wind        DurF:       1.00  hr
Latitude of Observation        LAT:      41.16  deg
Average Depth of Fetch           d:      11.98  ft
Length of Wind Fetch             F:      23.77  mi        Wave Growth Equations
Equiv. Neutral Wind Speed       Ue:      61.03  mph       ---------------------
Adjusted Wind Speed             Ua:      97.99  mph       Restricted Fetch
Wave Height                    Hm0:       4.72  ft        Shallow-water
Wave Period                     Tp:       5.05  sec       Fetch-limited
Wind Direction                Wdir:      90.00  deg
Mean Wave Direction          Theta:     106.00  deg
```

16.2

Fetch Radial 6 @ 55 miles
Wind @ 90° (E)

```
                         WIND ADJUSTMENT and WAVE GROWTH

Elevation of Observed Wind     Zobs:       30.00   ft         Wind Observation Type
  served Wind Speed            Uobs:       55.00   mph        --------------------
  r-Sea Temp. Difference       delT:       -6.40   deg F           Inland
Duration of Observed Wind      DurO:        3.00   hr
Duration of Final Wind         DurF:        3.00   hr
Latitude of Observation         LAT:       41.16   deg
Average Depth of Fetch            d:       11.98   ft
Length of Wind Fetch              F:       23.77   mi         Wave Growth Equations
Equiv. Neutral Wind Speed        Ue:       57.03   mph        ---------------------
Adjusted Wind Speed              Ua:       89.41   mph        Restricted Fetch
Wave Height                     Hm0:        4.50   ft         Shallow-water
Wave Period                      Tp:        4.89   sec        Fetch-limited
Wind Direction                 Wdir:       90.00   deg
Mean Wave Direction           Theta:      106.00   deg
```

1e, 3

FETCH RADIAL @ – MILES
WIND @ 90° (E)

```
                        WIND ADJUSTMENT and WAVE GROWTH

Elevation of Observed Wind    Zobs:      30.00   ft       Wind Observation Type
erved Wind Speed              Uobs:      52.00   mph      ---------------------
-Sea Temp. Difference         delT:      -6.40   deg F         Inland
Duration of Observed Wind     DurO:       8.00   hr
Duration of Final Wind        DurF:       8.00   hr
Latitude of Observation        LAT:      41.16   deg
Average Depth of Fetch           d:      11.98   ft
Length of Wind Fetch             F:      23.77   mi       Wave Growth Equations
Equiv. Neutral Wind Speed       Ue:      54.59   mph      ---------------------
Adjusted Wind Speed             Ua:      84.30   mph      Restricted Fetch
Wave Height                    Hm0:       4.36   ft       Shallow-water
Wave Period                     Tp:       4.79   sec      Fetch-limited
Wind Direction                Wdir:      90.00   deg
Mean Wave Direction          Theta:     106.00   deg
```

14.1 Fetch Radial 6 @ 35mi.

```
                     WIND ADJUSTMENT and WAVE GROWTH

Elevation of Observed Wind    Zobs:      30.00  ft      Wind Observation Type
  served Wind Speed           Uobs:      28.00  mph     ---------------------
  r-Sea Temp. Difference      delT:      -6.40  deg F        Inland
Duration of Observed Wind     DurO:       8.00  hr
Duration of Final Wind        DurF:       8.00  hr
Latitude of Observation        LAT:      41.16  deg
Average Depth of Fetch           d:      11.98  ft
Length of Wind Fetch             F:      23.77  mi      Wave Growth Equations
Equiv. Neutral Wind Speed       Ue:      33.54  mph     ---------------------
Adjusted Wind Speed             Ua:      44.43  mph     Restricted Fetch
Wave Height                    Hm0:       2.48  ft      Shallow-water
Wave Period                     Tp:       3.34  sec     Fetch-limited
Wind Direction                Wdir:      60.00  deg
Mean Wave Direction          Theta:     106.00  deg
```

does not govern.

Case 2a

```
                         WIND ADJUSTMENT and WAVE GROWTH

Elevation of Observed Wind   Zobs:       30.00  ft       Wind Observation Type
  served Wind Speed          Uobs:       62.00  mph      ----------------------
   -Sea Temp. Difference     delT:       -6.40  deg F         Inland
Duration of Observed Wind    DurO:        0.10  hr
Duration of Final Wind       DurF:        1.00  hr
Latitude of Observation       LAT:       41.16  deg
Average Depth of Fetch          d:        9.50  ft
Length of Wind Fetch            F:        1.83  mi       Wave Growth Equations
Equiv. Neutral Wind Speed      Ue:       52.25  mph      ----------------------
Adjusted Wind Speed            Ua:       79.50  mph      Restricted Fetch
Wave Height                   Hm0:        2.28  ft       Shallow-water
Wave Period                    Tp:        2.77  sec      Fetch-limited
Wind Direction               Wdir:       60.00  deg
Mean Wave Direction         Theta:       34.00  deg
```

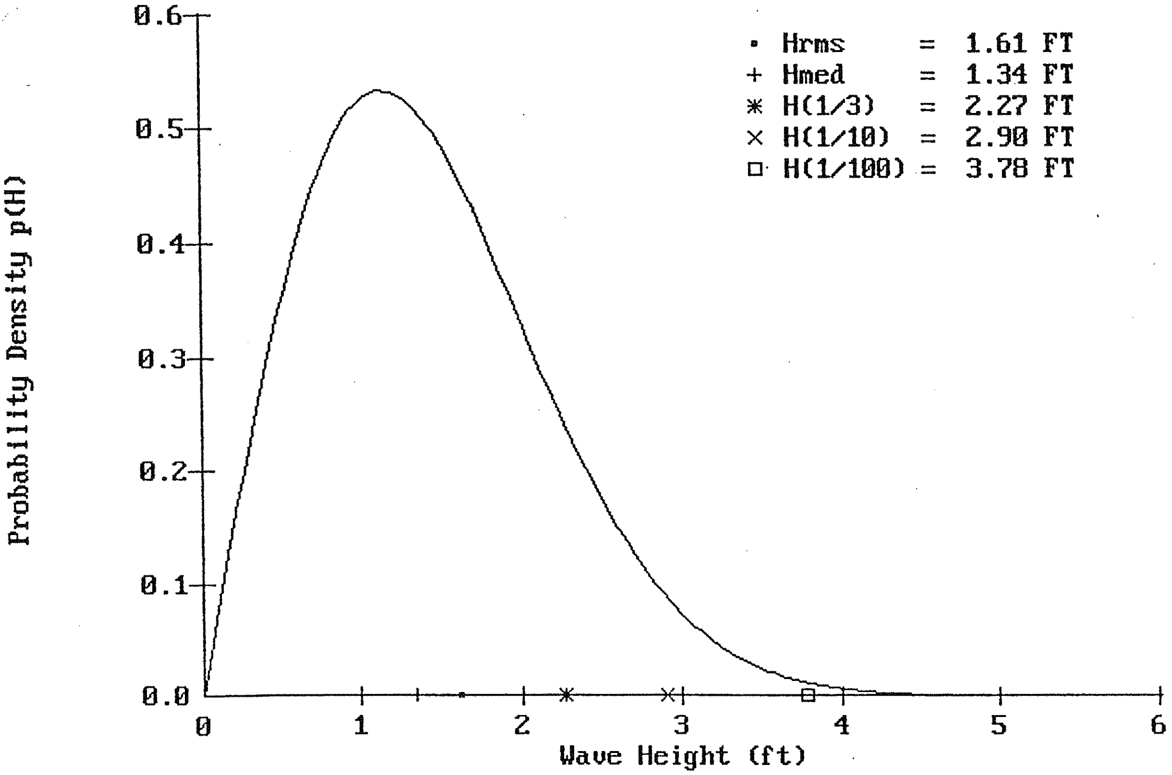
$$L = 2.77\sqrt{32.2 \times 9.5} = 48.5'$$

$$C = \frac{48.5'}{2.77\,s} = 17.49\ s$$

Case 2a

RAYLEIGH DISTRIBUTION

INPUT CONDITIONS Hmo = 2.28f Tp = 2.77S h = 9.50f



2a.1

```
                            WIND ADJUSTMENT and WAVE GROWTH

Elevation of Observed Wind    Zobs:      30.00  ft       Wind Observation Type
   erved Wind Speed           Uobs:      62.00  mph      ----------------------
  -Sea Temp. Difference       delT:      -6.40  deg F         Inland
Duration of Observed Wind     DurO:       8.00  min  ←
Duration of Final Wind        DurF:      60.00  min
Latitude of Observation        LAT:      41.17  deg
Average Depth of Fetch           d:       9.50  ft
Length of Wind Fetch             F:       1.83  mi       Wave Growth Equations
Equiv. Neutral Wind Speed       Ue:      53.08  mph      ----------------------
Adjusted Wind Speed             Ua:      81.20  mph      Restricted Fetch
Wave Height                    Hm0:       2.32  ft       Shallow-water
Wave Period                     Tp:       2.79  sec      Fetch-limited
Wind Direction                Wdir:      60.00  deg
Mean Wave Direction          Theta:      34.00  deg
```

$$L = 2.79\sqrt{32.2 \times 9.5} = 48.8'$$

$$C = \frac{48.8'}{2.79\,s} = 17.49\ ft/s$$

$$t_f = \frac{9{,}662'}{17.49} \times \frac{1}{60} = 9.2\ min$$

↓

$$d/L = \frac{9.5}{48.8} = .195$$

transitional

shallow-water

Increase DurO to

↓

9.2 min

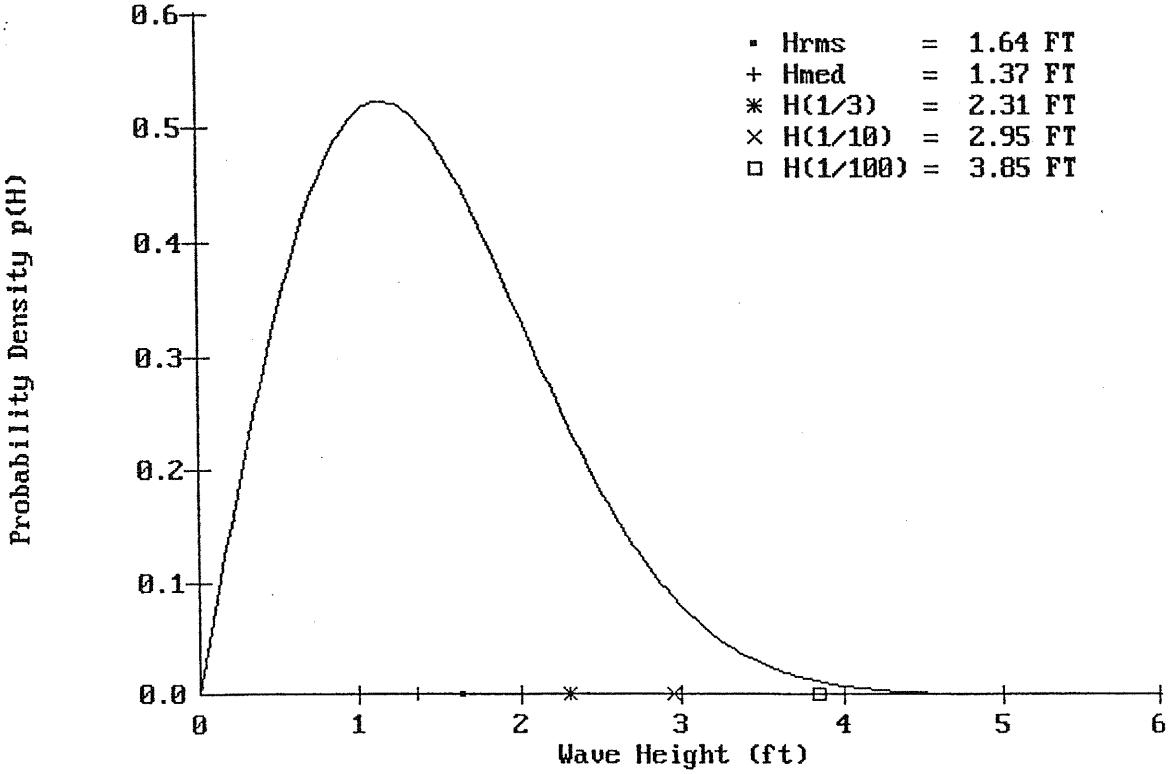
↓

Case 2a.2

Case 2a.1

RAYLEIGH DISTRIBUTION

INPUT CONDITIONS Hmo = 2.32f Tp = 2.79S h = 9.50f



Case 2a.2

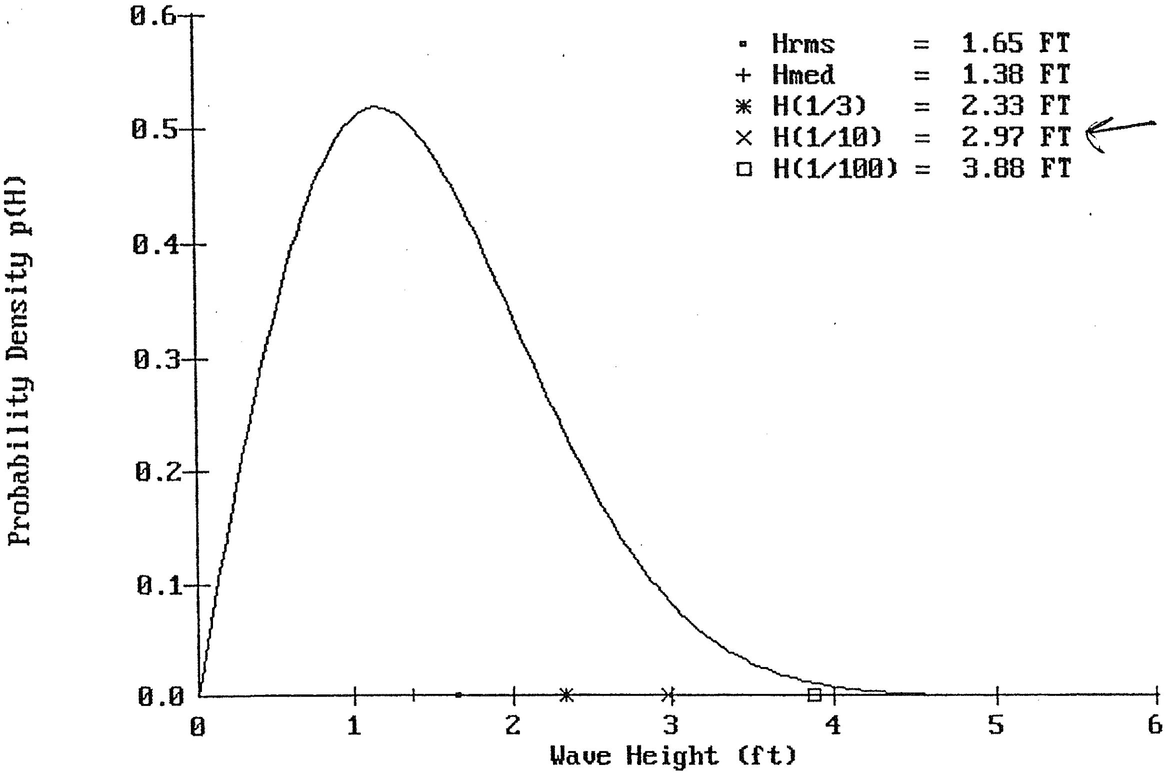
from case 2a.1

```
                         WIND ADJUSTMENT and WAVE GROWTH

Elevation of Observed Wind    Zobs:       30.00  ft        Wind Observation Type
  served Wind Speed           Uobs:       62.00  mph       ---------------------
   -Sea Temp. Difference      delT:       -6.40  deg F          Inland
Duration of Observed Wind     DurO:        9.20  min
Duration of Final Wind        DurF:       60.00  min
Latitude of Observation        LAT:       41.17  deg
Average Depth of Fetch           d:        9.50  ft
Length of Wind Fetch             F:        1.83  mi        Wave Growth Equations
Equiv. Neutral Wind Speed       Ue:       53.45  mph       ---------------------
Adjusted Wind Speed             Ua:       81.96  mph       Restricted Fetch
Wave Height                    Hm0:        2.34  ft   ✓    Shallow-water
Wave Period                     Tp:        2.80  sec  ✓    Fetch-limited
Wind Direction                Wdir:       60.00  deg
Mean Wave Direction          Theta:       34.00  deg
```

Case 2a.2

RAYLEIGH DISTRIBUTION
INPUT CONDITIONS Hmo = 2.34f Tp = 2.80S h = 9.50f



Case 2b

```
                      WIND ADJUSTMENT and WAVE GROWTH

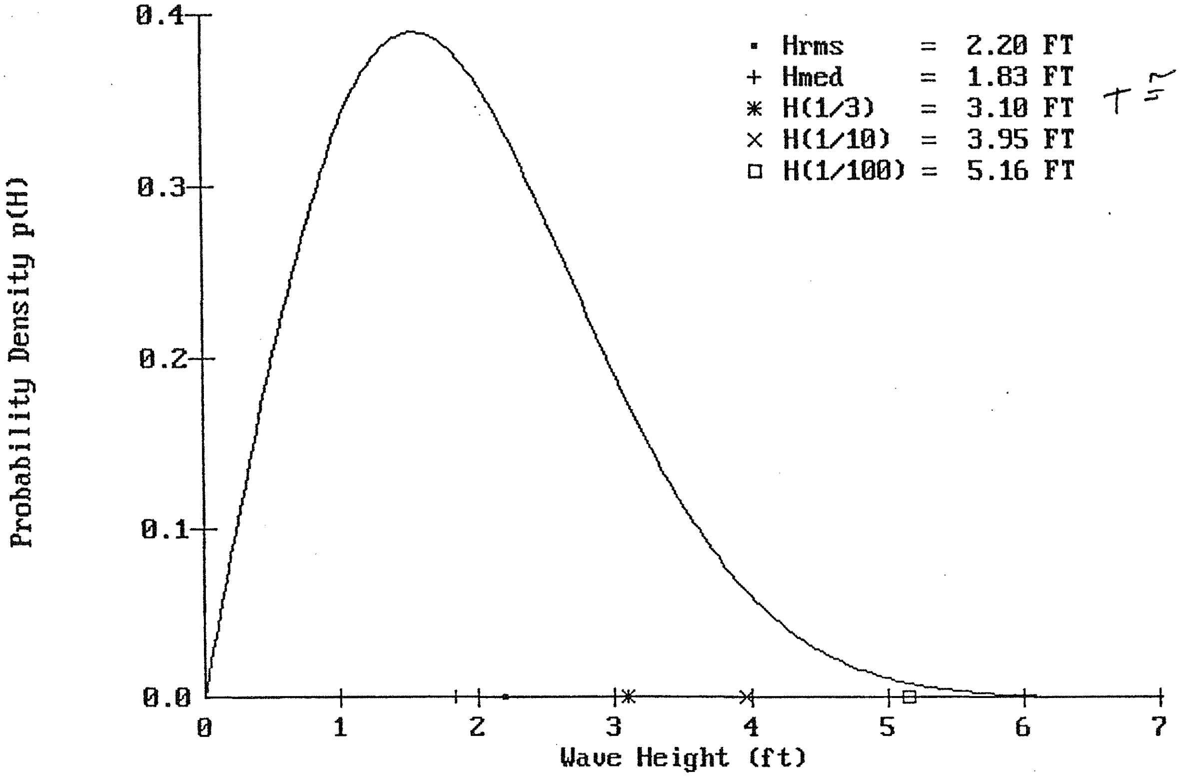
Elevation of Observed Wind   Zobs:      30.00  ft       Wind Observation Type
   served Wind Speed         Uobs:      81.00  mph      ---------------------
  -Sea Temp. Difference      delT:      -6.40  deg F          Inland
Duration of Observed Wind    DurO:       0.10  hr
Duration of Final Wind       DurF:       0.10  hr
Latitude of Observation       LAT:      41.16  deg
Average Depth of Fetch          d:       9.50  ft
Length of Wind Fetch            F:       1.83  mi       Wave Growth Equations
Equiv. Neutral Wind Speed      Ue:      69.24  mph      ---------------------
Adjusted Wind Speed            Ua:     116.35  mph      Restricted Fetch
Wave Height                   Hm0:       3.11  ft       Shallow-water
Wave Period                    Tp:       3.23  sec      Fetch-limited
Wind Direction               Wdir:      60.00  deg
Mean Wave Direction         Theta:      34.00  deg
```

```
                      WIND ADJUSTMENT and WAVE GROWTH

Elevation of Observed Wind   Zobs:      30.00  ft       Wind Observation Type
Observed Wind Speed          Uobs:      81.00  mph      ---------------------
Air-Sea Temp. Difference     delT:      -6.40  deg F          Inland
Duration of Observed Wind    DurO:       0.10  hr
Duration of Final Wind       DurF:       0.10  hr
Latitude of Observation       LAT:      41.16  deg
Average Depth of Fetch          d:       9.50  ft
Length of Wind Fetch            F:       1.83  mi       Wave Growth Equations
   iv. Neutral Wind Speed      Ue:      69.24  mph      ---------------------
Adjusted Wind Speed            Ua:     116.35  mph      Restricted Fetch
Wave Height                   Hm0:       3.11  ft       Shallow-water
Wave Period                    Tp:       3.23  sec      Fetch-limited
Wind Direction               Wdir:      60.00  deg
Mean Wave Direction         Theta:      34.00  deg
```

Case 2b

RAYLEIGH DISTRIBUTION
INPUT CONDITIONS Hmo = 3.11f Tp = 3.23S h = 9.50f



T ≃ 0,88 x 3.23 s = 2.8

Case 2b,1

```
                         WIND ADJUSTMENT and WAVE GROWTH

Elevation of Observed Wind     Zobs:       30.00   ft       Wind Observation Type
   erved Wind Speed            Uobs:       81.00   mph      ---------------------
  -Sea Temp. Difference        delT:       -6.40   deg F         Inland
Duration of Observed Wind      DurO:        8.00   min
Duration of Final Wind         DurF:        8.00   min
Latitude of Observation         LAT:       41.17   deg
Average Depth of Fetch            d:        9.50   ft
Length of Wind Fetch              F:        1.83   mi       Wave Growth Equations
Equiv. Neutral Wind Speed        Ue:       69.24   mph      ---------------------
Adjusted Wind Speed              Ua:      116.35   mph      Restricted Fetch
Wave Height                     Hm0:        3.11   ft       Shallow-water
Wave Period                      Tp:        3.23   sec      Fetch-limited
Wind Direction                 Wdir:       60.00   deg
Mean Wave Direction           Theta:       34.00   deg
```

```
                         WIND ADJUSTMENT and WAVE GROWTH

Elevation of Observed Wind     Zobs:       30.00   ft       Wind Observation Type
Observed Wind Speed            Uobs:       81.00   mph      ---------------------
Air-Sea Temp. Difference       delT:       -6.40   deg F         Inland
Duration of Observed Wind      DurO:        8.00   min
Duration of Final Wind         DurF:        8.00   min
Latitude of Observation         LAT:       41.17   deg
Average Depth of Fetch            d:        9.50   ft
   gth of Wind Fetch              F:        1.83   mi       Wave Growth Equations
   iiv. Neutral Wind Speed       Ue:       69.24   mph      ---------------------
 ajusted Wind Speed              Ua:      116.35   mph      Restricted Fetch
Wave Height                     Hm0:        3.11   ft       Shallow-water
Wave Period                      Tp:        3.23   sec      Fetch-limited
Wind Direction                 Wdir:       60.00   deg
Mean Wave Direction           Theta:       34.00   deg
```

No change.

22.1 WIND @ 90°(E)

~~Average Depth of Fetch d: 9.50 ft~~
~~Length of Wind Fetch F: 23.77 mi~~ ~~Wave Growth Equations~~
~~Equiv. Neutral Wind Speed Ue: 54.59 mph~~ ~~---------------------~~
~~Adjusted Wind Speed Ua: 84.30 mph~~ ~~Restricted Fetch~~
~~ve Height Hm0: 3.70 ft~~ ~~Shallow-water~~
~~ve Period Tp: 4.58 sec~~ ~~Fetch-limited~~
~~Wind Direction Wdir: 90.00 deg~~
~~Mean Wave Direction Theta: 106.00 deg~~

---

```
                     WIND ADJUSTMENT and WAVE GROWTH

Elevation of Observed Wind    Zobs:     30.00  ft      Wind Observation Type
Observed Wind Speed           Uobs:     52.00  mph     ---------------------
Air-Sea Temp. Difference      delT:     -6.40  deg F         Inland
Duration of Observed Wind     DurO:      8.00  hr
Duration of Final Wind        DurF:      8.00  hr
Latitude of Observation        LAT:     41.16  deg
Average Depth of Fetch           d:      9.50  ft
Length of Wind Fetch             F:     23.77  mi      Wave Growth Equations
Equiv. Neutral Wind Speed       Ue:     54.59  mph     ---------------------
Adjusted Wind Speed             Ua:     84.30  mph     Restricted Fetch
Wave Height                    Hm0:      3.70  ft      Shallow-water
Wave Period                     Tp:      4.58  sec     Fetch-limited
Wind Direction                Wdir:     90.00  deg
Mean Wave Direction          Theta:    106.00  deg
```

STOP.

Fetch Radial 6 = 35 miles

Below this depth, fetch '6' can reduce to 1 mile, see B.1-9

Case 3a

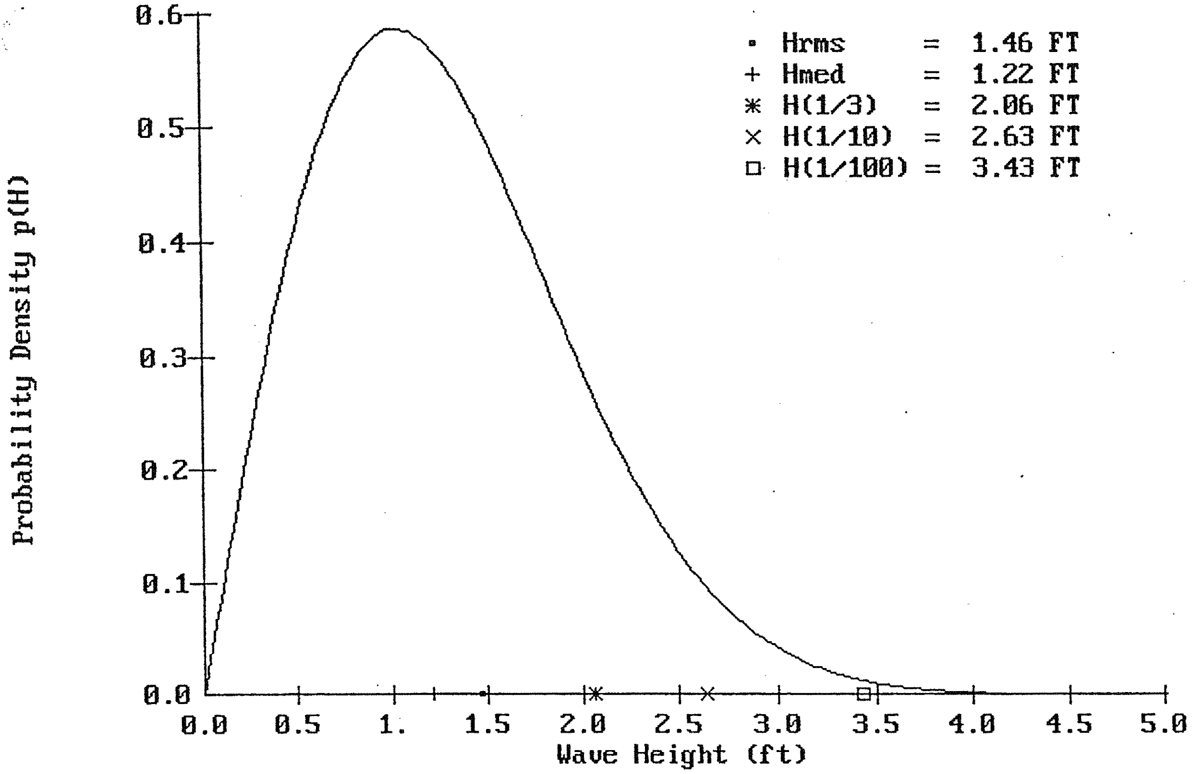
```
                      WIND ADJUSTMENT and WAVE GROWTH

Elevation of Observed Wind    Zobs:      30.00  ft        Wind Observation Type
   served Wind Speed          Uobs:      62.00  mph       ---------------------
    -Sea Temp. Difference     delT:      -6.40  deg F          Inland
Duration of Observed Wind     DurO:       0.10  hr
Duration of Final Wind        DurF:       1.00  hr
Latitude of Observation        LAT:      41.16  deg
Average Depth of Fetch           d:       6.84  ft ←
Length of Wind Fetch             F:       1.83  mi        Wave Growth Equations
Equiv. Neutral Wind Speed       Ue:      52.25  mph       ---------------------
Adjusted Wind Speed             Ua:      79.50  mph       Restricted Fetch
Wave Height                    Hm0:       2.07  ft        Shallow-water
Wave Period                     Tp:       2.69  sec       Fetch-limited
Wind Direction                Wdir:      60.00  deg
Mean Wave Direction          Theta:      34.00  deg
```

Case 3a

## RAYLEIGH DISTRIBUTION

INPUT CONDITIONS Hmo = 2.07f Tp = 2.69S h = 6.84f



Case 3a.1

```
                         WIND ADJUSTMENT and WAVE GROWTH

Elevation of Observed Wind   Zobs:       30.00  ft       Wind Observation Type
    erved Wind Speed          Uobs:       62.00  mph      ----------------------
  -Sea Temp. Difference       delT:       -6.40  deg F         Inland
Duration of Observed Wind    DurO:        8.00  min
Duration of Final Wind       DurF:       60.00  min
Latitude of Observation       LAT:       41.17  deg
Average Depth of Fetch          d:        6.84  ft
Length of Wind Fetch            F:        1.83  mi       Wave Growth Equations
Equiv. Neutral Wind Speed      Ue:       53.08  mph      ----------------------
Adjusted Wind Speed            Ua:       81.20  mph      Restricted Fetch
Wave Height                   Hm0:        2.11  ft       Shallow-water
Wave Period                    Tp:        2.72  sec      Fetch-limited
Wind Direction               Wdir:       60.00  deg
Mean Wave Direction         Theta:       34.00  deg
```

only slight change.

Case 3b

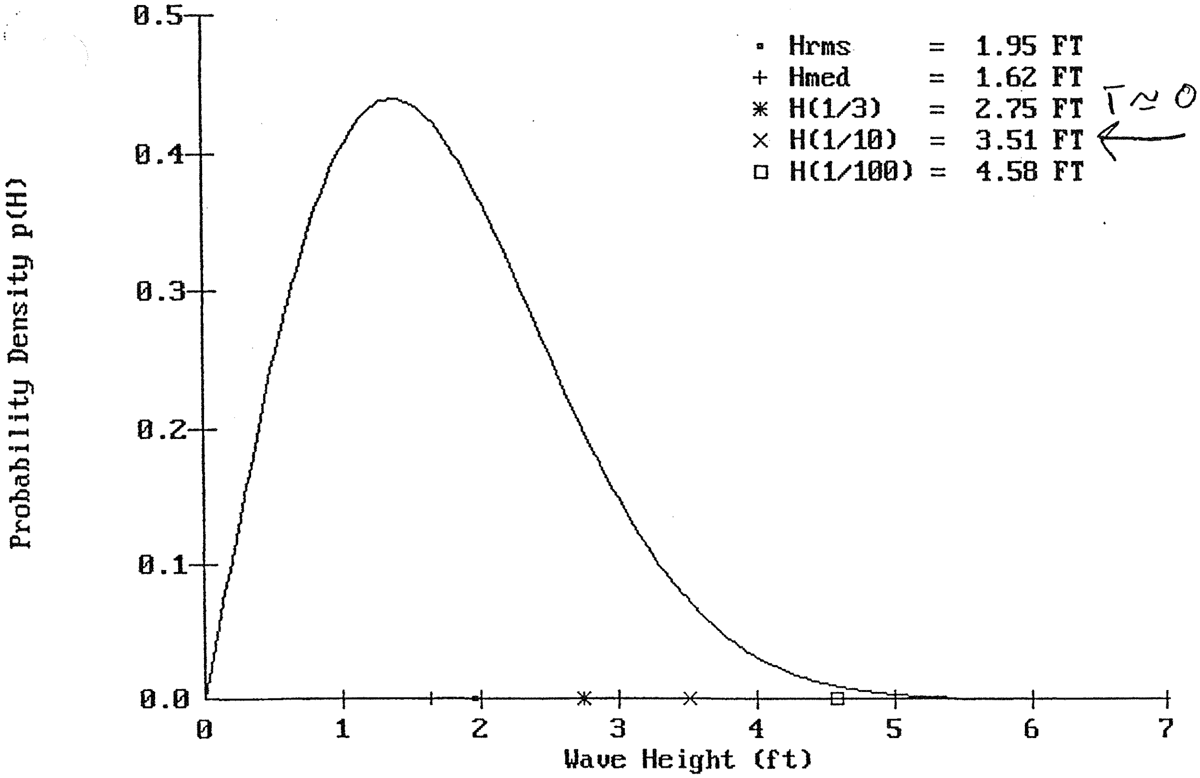
```
                         WIND ADJUSTMENT and WAVE GROWTH

Elevation of Observed Wind     Zobs:       30.00  ft        Wind Observation Type
  served Wind Speed            Uobs:       81.00  mph       ---------------------
  -Sea Temp. Difference        delT:       -6.40  deg F          Inland
Duration of Observed Wind      DurO:        0.10  hr
Duration of Final Wind         DurF:        0.10  hr
Latitude of Observation         LAT:       41.16  deg
Average Depth of Fetch            d:        6.84  ft
Length of Wind Fetch              F:        1.83  mi        Wave Growth Equations
Equiv. Neutral Wind Speed        Ue:       69.24  mph       ---------------------
Adjusted Wind Speed              Ua:      116.35  mph       Restricted Fetch
Wave Height                     Hm0:        2.76  ft        Shallow-water
Wave Period                      Tp:        3.13  sec       Fetch-limited
Wind Direction                 Wdir:       60.00  deg
Mean Wave Direction           Theta:       34.00  deg
```

Case 3b

RAYLEIGH DISTRIBUTION

INPUT CONDITIONS Hmo = 2.76f Tp = 3.13S h = 6.84f



T ≃ 0.88 × 3.13 = 2.75

Case 36.1

```
                    WIND ADJUSTMENT and WAVE GROWTH

Elevation of Observed Wind    Zobs:      30.00  ft       Wind Observation Type
 served Wind Speed            Uobs:      81.00  mph      --------------------
 r-Sea Temp. Difference       delT:      -6.40  deg F         Inland
Duration of Observed Wind     DurO:       8.00  min
Duration of Final Wind        DurF:       8.00  min
Latitude of Observation        LAT:      41.17  deg
Average Depth of Fetch           d:       6.84  ft
Length of Wind Fetch             F:       1.83  mi       Wave Growth Equations
Equiv. Neutral Wind Speed       Ue:      69.24  mph      ---------------------
Adjusted Wind Speed             Ua:     116.35  mph      Restricted Fetch
Wave Height                    Hm0:       2.76  ft       Shallow-water
Wave Period                     Tp:       3.13  sec      Fetch-limited
Wind Direction                Wdir:      60.00  deg
Mean Wave Direction          Theta:      34.00  deg
```

unchanged.

Case 4a

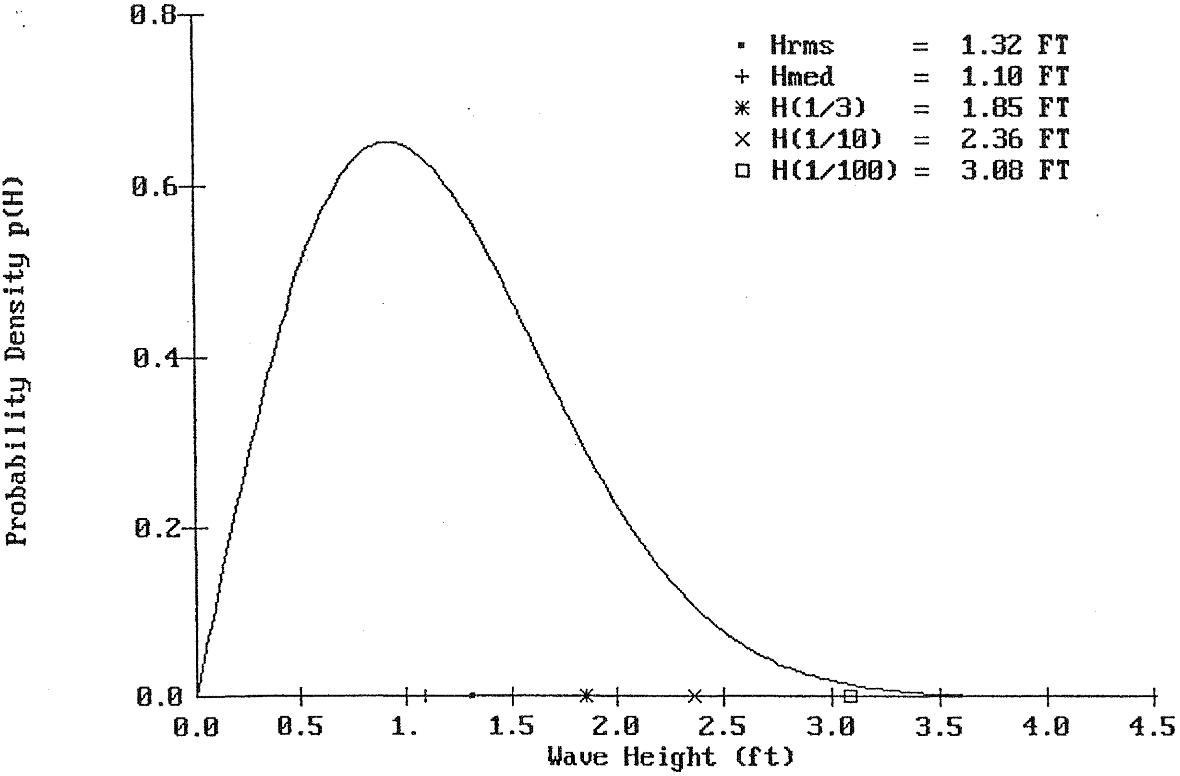
```
                    WIND ADJUSTMENT and WAVE GROWTH

Elevation of Observed Wind    Zobs:      30.00  ft        Wind Observation Type
  erved Wind Speed            Uobs:      62.00  mph       ---------------------
   -Sea Temp. Difference      delT:      -6.40  deg F          Inland
Duration of Observed Wind     DurO:       0.10  hr
Duration of Final Wind        DurF:       1.00  hr
Latitude of Observation        LAT:      41.16  deg
Average Depth of Fetch           d:       5.15  ft
Length of Wind Fetch             F:       1.83  mi        Wave Growth Equations
Equiv. Neutral Wind Speed       Ue:      52.25  mph       ---------------------
Adjusted Wind Speed             Ua:      79.50  mph       Restricted Fetch
Wave Height                    Hm0:       1.86  ft        Shallow-water
Wave Period                     Tp:       2.62  sec       Fetch-limited
Wind Direction                Wdir:      60.00  deg
Mean Wave Direction          Theta:      34.00  deg
```

Case 4a

RAYLEIGH DISTRIBUTION

INPUT CONDITIONS Hmo = 1.86f Tp = 2.62S h = 5.15f



Case 4a.1

## WIND ADJUSTMENT and WAVE GROWTH

```
Elevation of Observed Wind     Zobs:      30.00  ft        Wind Observation Type
 erved Wind Speed              Uobs:      62.00  mph       ---------------------
 -Sea Temp. Difference         delT:      -6.40  deg F          Inland
Duration of Observed Wind      DurO:       8.00  min
Duration of Final Wind         DurF:      60.00  min
Latitude of Observation         LAT:      41.17  deg
Average Depth of Fetch            d:       5.15  ft
Length of Wind Fetch              F:       1.83  mi        Wave Growth Equations
Equiv. Neutral Wind Speed        Ue:      53.08  mph       ---------------------
Adjusted Wind Speed              Ua:      81.20  mph       Restricted Fetch
Wave Height                     Hm0:       1.89  ft        Shallow-water
Wave Period                      Tp:       2.64  sec       Fetch-limited
Wind Direction                 Wdir:      60.00  deg
Mean Wave Direction           Theta:      34.00  deg
```

$$L = 2.64\sqrt{32.2 \times 5.15} = 34.0'$$

$$C = \frac{34.0'}{2.64\,s} = 12.88\ ft/s$$

$$t_f = \frac{9{,}660'}{12.88} * \frac{1}{60} = \underline{12.5\ min}$$

Increase Dur O
for 62 mph

Case 4a.2

Case 4a.2

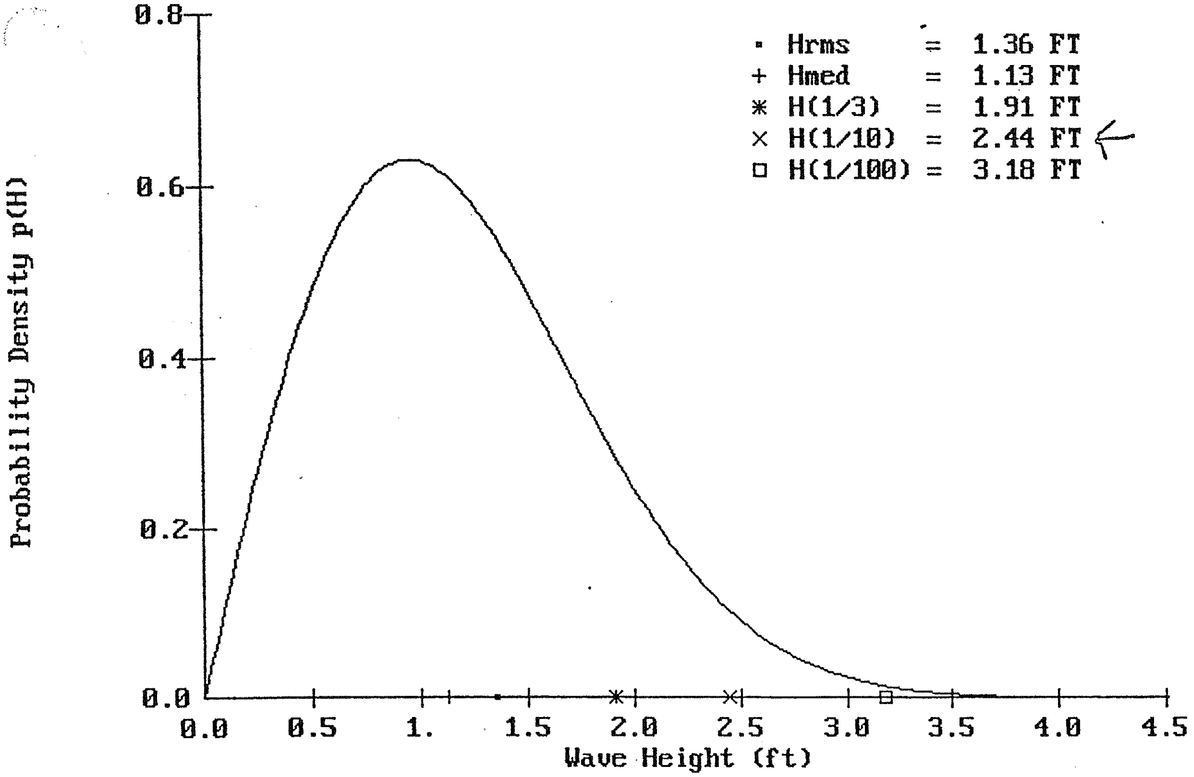
```
                    WIND ADJUSTMENT and WAVE GROWTH

Elevation of Observed Wind   Zobs:      30.00  ft      Wind Observation Type
  served Wind Speed          Uobs:      62.00  mph     ---------------------
  r-Sea Temp. Difference     delT:      -6.40  deg F        Inland
Duration of Observed Wind    DurO:      12.50  min ←
Duration of Final Wind       DurF:      60.00  min
Latitude of Observation       LAT:      41.67  deg
Average Depth of Fetch          d:       5.15  ft
Length of Wind Fetch            F:       1.83  mi      Wave Growth Equations
Equiv. Neutral Wind Speed      Ue:      54.18  mph     ---------------------
Adjusted Wind Speed            Ua:      83.45  mph     Restricted Fetch
Wave Height                   Hm0:       1.92  ft      Shallow-water
Wave Period                    Tp:       2.67  sec     Fetch-limited
Wind Direction               Wdir:      60.00  deg
Mean Wave Direction         Theta:      34.00  deg
```

Case 4a.2

RAYLEIGH DISTRIBUTION

INPUT CONDITIONS Hmo = 1.92f Tp = 2.67S h = 5.15f



```
= "MSJOB 22"
@PJL USTATUS JOB = ON
     USTATUS PAGE = OFF
@PJL USTATUS DEVICE = ON
@PJL USTATUS TIMED = 0
B
```

Case 4b

```
Elevation of Observed Wind     Zobs:      30.00  ft        Wind Observation Type
Observed Wind Speed            Uobs:      81.00  mph       ---------------------
Air-Sea Temp. Difference       delT:      -6.40  deg F          Inland
Duration of Observed Wind      DurO:       0.10  hr
  ration of Final Wind         DurF:       0.10  hr
  itude of Observation          LAT:      41.16  deg
Average Depth of Fetch            d:       5.15  ft
Length of Wind Fetch              F:       1.83  mi        Wave Growth Equations
Equiv. Neutral Wind Speed        Ue:      69.24  mph       ---------------------
Adjusted Wind Speed              Ua:     116.35  mph       Restricted Fetch
Wave Height                     Hm0:       2.41  ft        Shallow-water
Wave Period                      Tp:       3.04  sec       Fetch-limited
Wind Direction                 Wdir:      60.00  deg
Mean Wave Direction           Theta:      34.00  deg
```

WIND ADJUSTMENT and WAVE GROWTH

```
Elevation of Observed Wind     Zobs:      30.00  ft        Wind Observation Type
Observed Wind Speed            Uobs:      81.00  mph       ---------------------
Air-Sea Temp. Difference       delT:      -6.40  deg F          Inland
Duration of Observed Wind      DurO:       0.10  hr
Duration of Final Wind         DurF:       0.10  hr
Latitude of Observation         LAT:      41.16  deg
Average Depth of Fetch            d:       5.15  ft
Length of Wind Fetch              F:       1.83  mi        Wave Growth Equations
Equiv. Neutral Wind Speed        Ue:      69.24  mph       ---------------------
Adjusted Wind Speed              Ua:     116.35  mph       Restricted Fetch
Wave Height                     Hm0:       2.41  ft        Shallow-water
  ve Period                      Tp:       3.04  sec       Fetch-limited
Wind Direction                 Wdir:      60.00  deg
Mean Wave Direction           Theta:      34.00  deg
```

$$L = 3.04\sqrt{32.2 \times 5.15} = 39.2'$$

$$C = 39.2/3.04 = 12.89\,\text{ft/s} \Rightarrow t_f = 12.5\,\text{min}$$

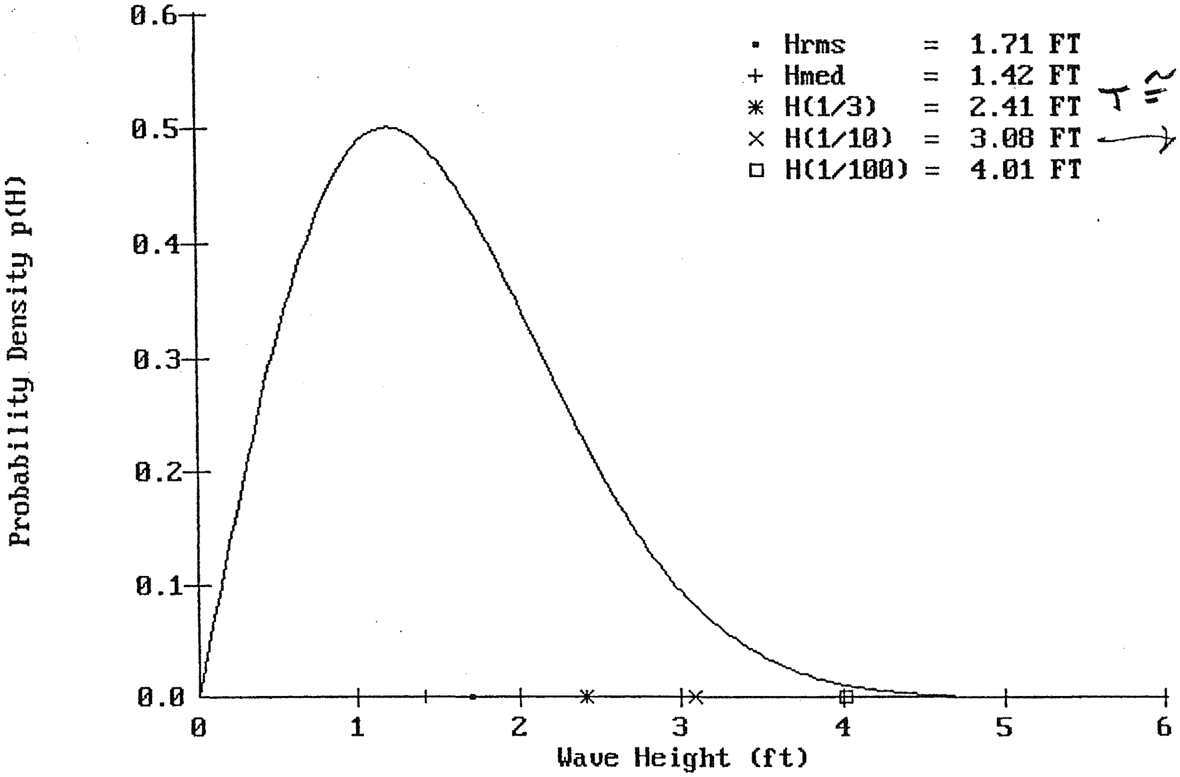
$$\frac{1}{25} < d/L = \frac{5.15}{39.2} = 0.14 < 1/2$$

$$\frac{d}{L} = \frac{5.15}{39.2} = 0.131$$

Look @ Cnoidal wave
Theory (2 sheets over)

Case 4b

RAYLEIGH DISTRIBUTION
INPUT CONDITIONS Hmo = 2.42f Tp = 3.04S h = 5.15f



T ≅ 0.88 × 2.64 = 2.32

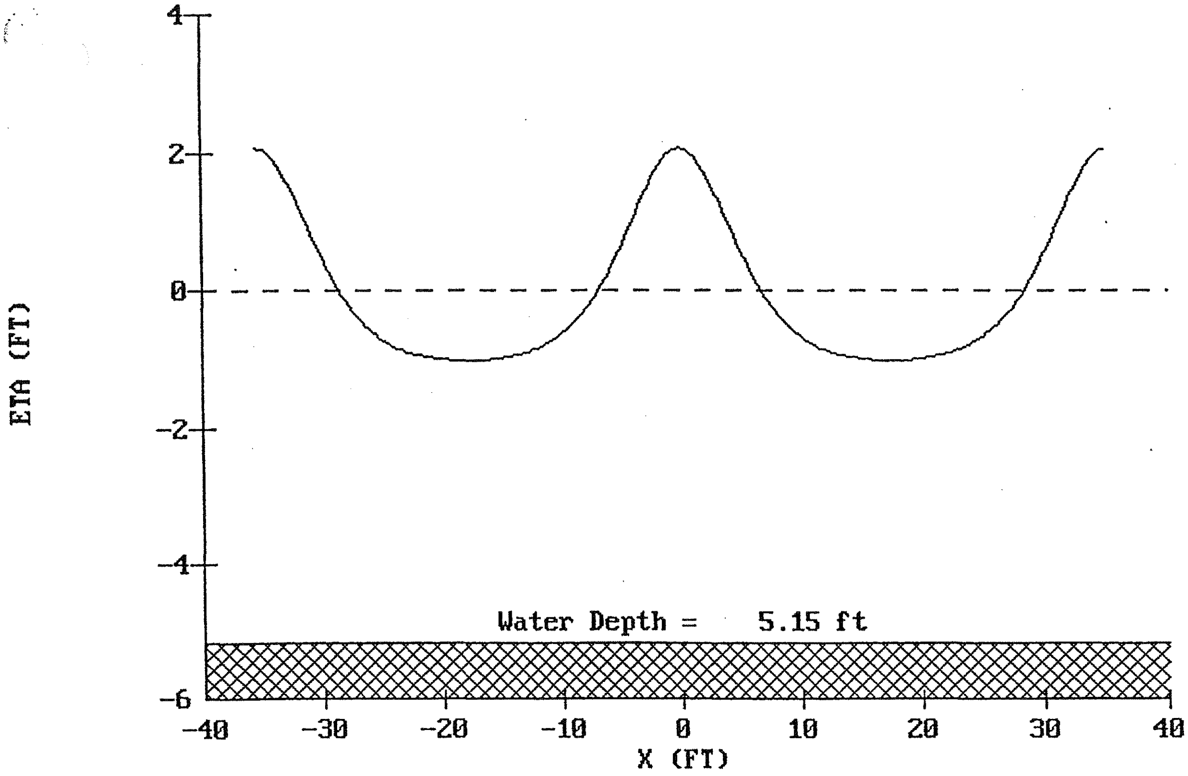
Case 4b

```
                              Cnoidal Wave Theory
  Wave     Wave     Water     Wave    Wave     Energy       Energy      Ursell   Order
   Ht     Period    Depth    Length   Celer    Density       Flux        No.
   ft      sec       ft        ft    ft/sec  ft-lb/ft^2  ft-lb/s-ft
   .080   3.040     5.150   35.352  11.629     71.557      546.916      28.180

  Vert Coord:     -2.000   ft
Wavelen Frac:      0.250                                  Horiz      Vertical
  Water Surf:     -0.461   ft                Velocity:    -1.190     1.518 ft/sec
    Pressure:    117.857   lb/ft^2            Acceler:     5.530     1.798 ft/s^2
```

Case 4b

CNOIDAL WAVE THEORY
Water Surface Elevation



L = 35.35'

T = 3.04 sec

Case 4b.1

```
                         WIND ADJUSTMENT and WAVE GROWTH

Elevation of Observed Wind    Zobs:      30.00  ft       Wind Observation Type
  served Wind Speed           Uobs:      81.00  mph      ---------------------
  r-Sea Temp. Difference      delT:      -6.40  deg F         Inland
Duration of Observed Wind     DurO:       8.00  min
Duration of Final Wind        DurF:       8.00  min
Latitude of Observation        LAT:      41.17  deg
Average Depth of Fetch           d:       5.15  ft
Length of Wind Fetch             F:       1.83  mi       Wave Growth Equations
Equiv. Neutral Wind Speed       Ue:      69.24  mph      ---------------------
Adjusted Wind Speed             Ua:     116.35  mph      Restricted Fetch
Wave Height                    Hm0:       2.41  ft       Shallow-water
Wave Period                     Tp:       3.04  sec      Fetch-limited
Wind Direction                Wdir:      60.00  deg
Mean Wave Direction          Theta:      34.00  deg
```

No change.

Case 4b.2

W/ DurO = 12.5 min.

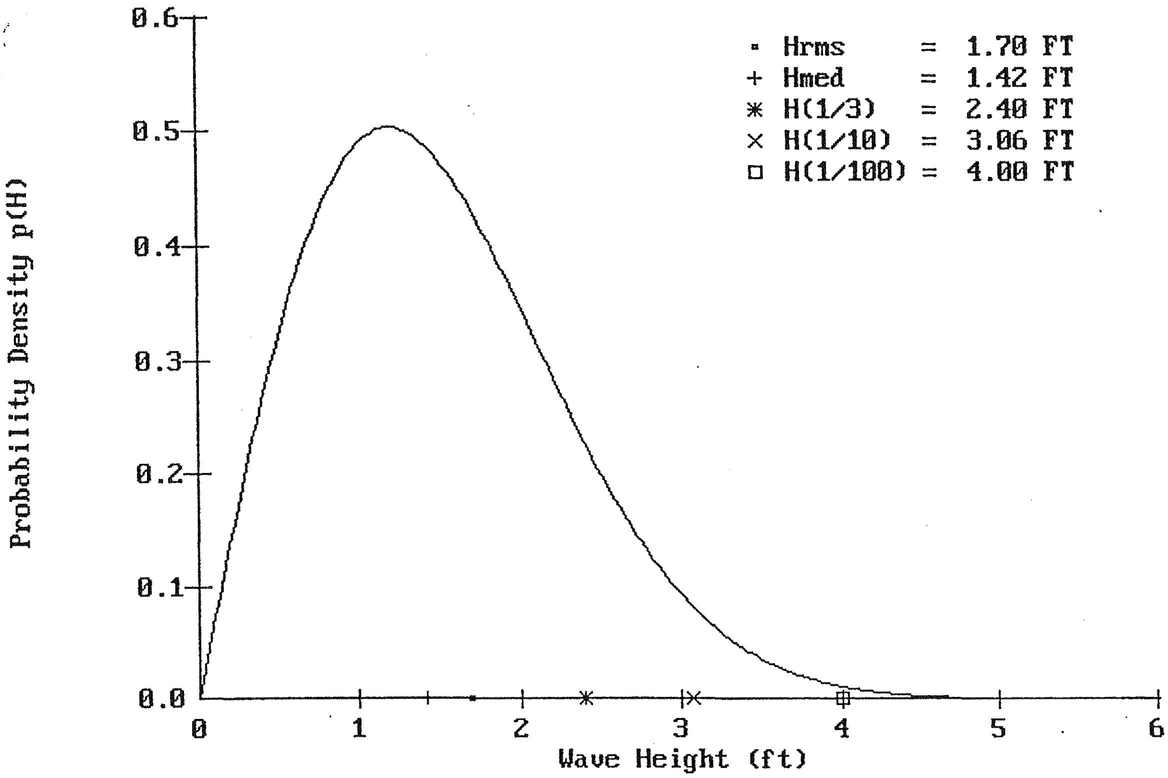
Case 46.2

```
                          WIND ADJUSTMENT and WAVE GROWTH

Elevation of Observed Wind     Zobs:      30.00   ft        Wind Observation Type
   erved Wind Speed            Uobs:      81.00   mph       ---------------------
    -Sea Temp. Difference      delT:      -6.40   deg F          Inland
Duration of Observed Wind      DurO:      12.50   min
Duration of Final Wind         DurF:      12.50   min
Latitude of Observation         LAT:      41.67   deg
Average Depth of Fetch            d:       5.15   ft
Length of Wind Fetch              F:       1.83   mi        Wave Growth Equations
Equiv. Neutral Wind Speed        Ue:      69.25   mph       ---------------------
Adjusted Wind Speed              Ua:     116.38   mph       Restricted Fetch
Wave Height                     Hm0:       2.41   ft        Shallow-water
Wave Period                      Tp:       3.04   sec       Fetch-limited
Wind Direction                 Wdir:      60.00   deg
Mean Wave Direction           Theta:      34.00   deg
```

Case 4b.2

RAYLEIGH DISTRIBUTION
INPUT CONDITIONS Hmo = 2.41f Tp = 3.04S h = 5.15f



SHEET B.3-0 OF

JOB NO.

DATE 11/00

PROJECT Stratford Causeway

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SUBJECT

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# Appendix

# B.3

'Near-shore' affects:
Limit of non-breaking condition,
refraction and shoaling
Factors'

**Harding Lawson Associates**
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SHEET B.3-1 OF
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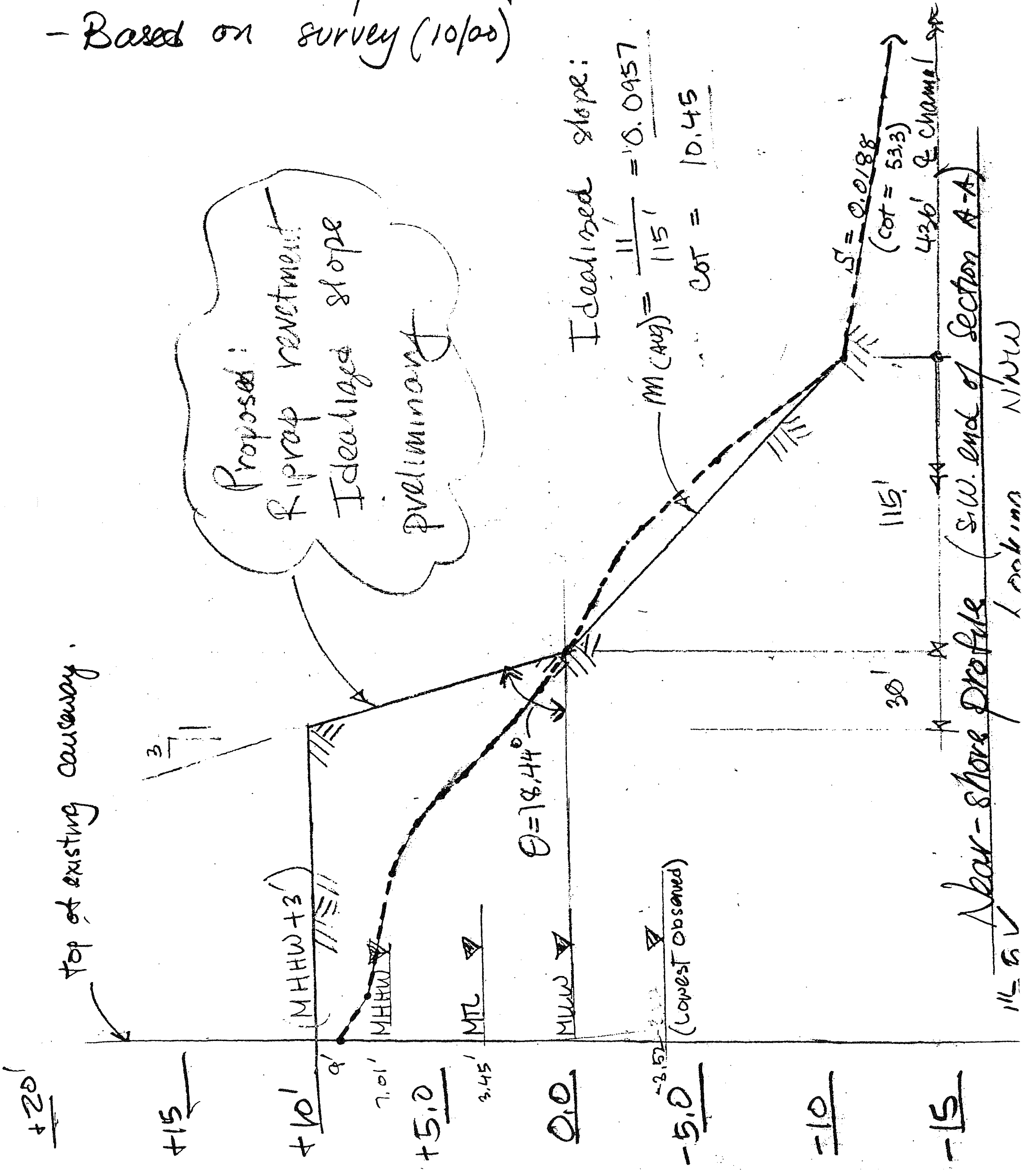
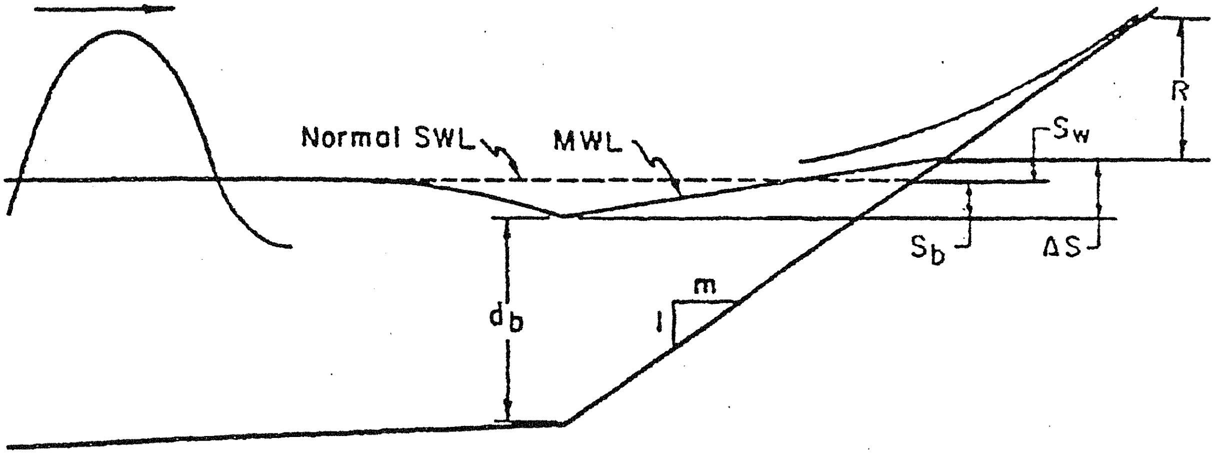
PROJECT Stratford Causeway
SUBJECT Near-shore profile (Section A-A)

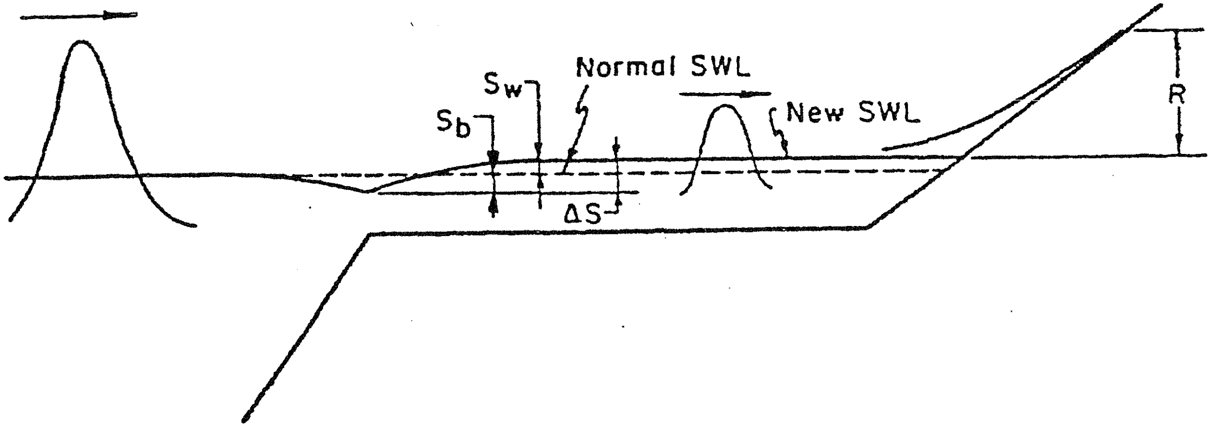
- Based on survey (10/00)



B.3-2
~~26~~



a. On a beach



b. On a berm or reef

Figure 3-2. Definition sketch of wave setup

| Case | (over fetch) d (Avg) | $H_{1/3}$ | T | $\frac{1}{gT^2}$ | abs. $\frac{d}{gT^2}$ | Ord. $H/gT^2$ |
|---|---|---|---|---|---|---|
| 1 MHHW+3' | 11.98' | 3.29 | 2.89 | 0.00372 | 0.04455 | 0.01223 |
| 2 MHHW | 9.5' | 3.10 | 2.84 | 0.00385 | 0.0366 | 0.01194 |
| 3 MTL | 6.84' | 2.75 | 2.75 | 0.00411 | 0.0281 | 0.01129 |
| 4 MLLW | 5.15' | 2.41 | 2.32 | 0.00575 | 0.0297 | 0.0139 |

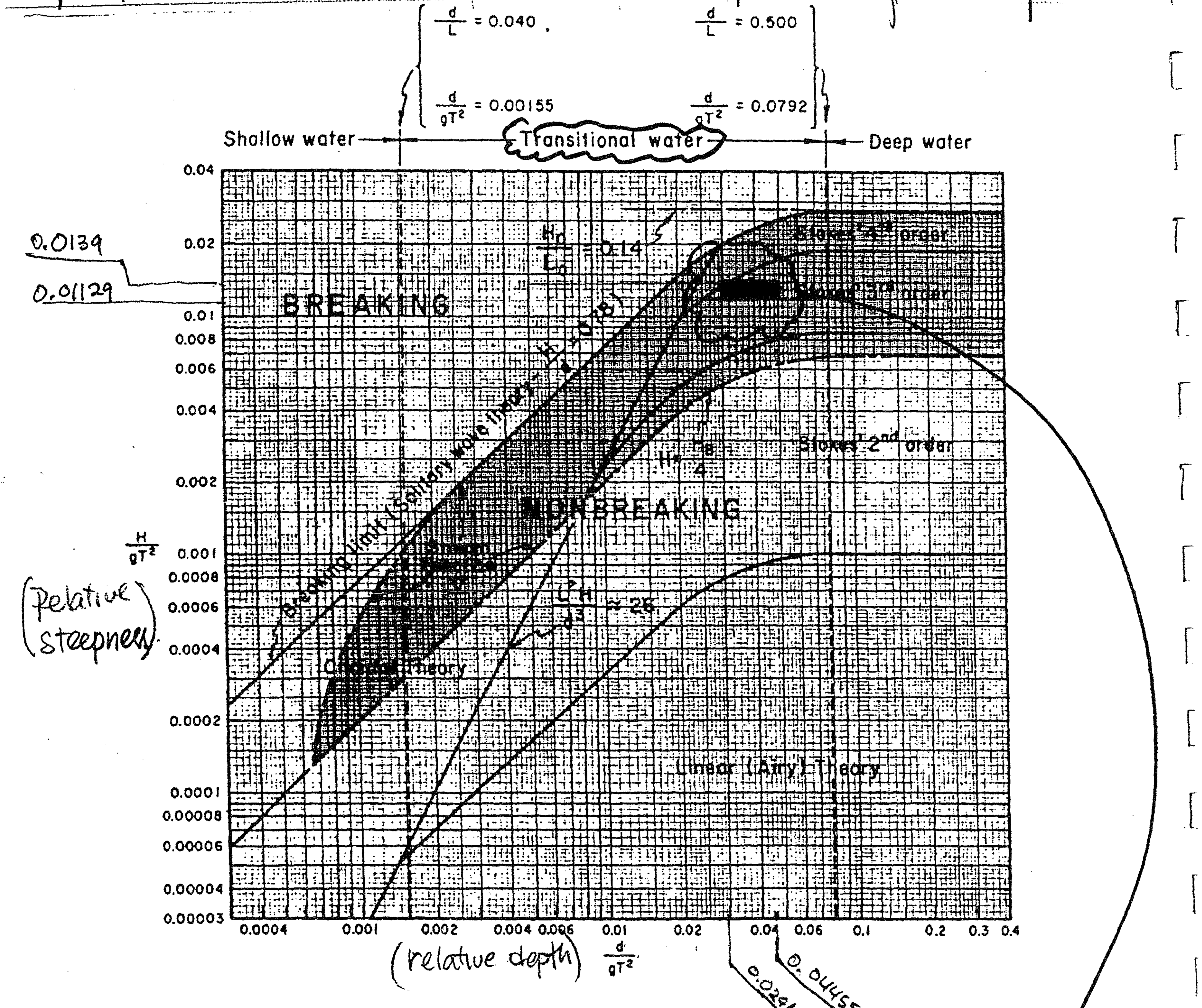


Figure 5-3. Regions of validity for various wave theories (after item 85)

" Range of shoaling non-refracting wave
in Non-Breaking condition

B.3-3

$\frac{H}{H_b} \cong 1.0$

over

Case 1 MHHW +3'

```
                              LINEAR WAVE THEORY / SNELLS LAW
                 Units          Known Wave          Subject Wave        Deepwater Wave
Wave Height      ft               H1:     3.290      H2:     3.096        H0:     3.385
Wave Period      sec               T:     3.280
Water Depth      ft               d1:    21.000      d2:    10.000
Crest Angle      deg          Alpha1:     0.000  Alpha2:     0.000    Alpha0:     0.000
Wave Length      ft               L1:    54.242      L2:    47.705        L0:    55.083
Celerity         ft/sec           C1:    16.537      C2:    14.544        C0:    16.794
Group Veloc      ft/sec          Cg1:     8.889     Cg2:    10.036       Cg0:     8.397
Energy Dens      ft-lb/ft^2       E1:    86.574      E2:    76.677        E0:    91.649
Energy Flux      ft-lb/s-ft       P1:   769.563      P2:   769.563        P0:   769.563
Ursell Param                      U1:     1.045      U2:     7.046     H0/L0:     0.061
COTAN NS Slope:    10.450       Breaker  Hb:     3.676  db:     3.814 ft
```

$$\frac{3.096}{3.29} = 0.94 \simeq K_{ps} \approx 0.92.$$

find $T_2$:

$$T_2 = \frac{L_2}{C_2} = \frac{47.71}{14.55} = \underline{3.28\,s}.$$

{approx to T in Plate C-3, Ref G}

Case 2 MHHW

```
                          LINEAR WAVE THEORY / SNELLS LAW
                   Units          Known Wave           Subject Wave      Deepwater Wave
Wave Height      ft              H1:      3.100       H2:      2.959       H0:      3.228
Wave Period      sec              T:      3.230
Water Depth      ft              d1:     18.000       d2:      7.010
Crest Angle      deg         Alpha1:      0.000   Alpha2:      0.000   Alpha0:      0.000
Wave Length      ft              L1:     52.052       L2:     41.825       L0:     53.417
Celerity         ft/sec          C1:     16.115       C2:     12.949       C0:     16.538
Group Veloc      ft/sec         Cg1:      8.966      Cg2:      9.844      Cg0:      8.269
Energy Dens      ft-lb/ft^2      E1:     76.863       E2:     70.009       E0:     83.341
Energy Flux      ft-lb/s-ft      P1:    689.133       P2:    689.133       P0:    689.133
Ursell Param                     U1:      1.440       U2:     15.024    H0/L0:      0.060
COTAN NS Slope:    10.450      Breaker  Hb:     3.520    db:     3.634 ft
```

$$\frac{H_2}{H_1} = \frac{2.96}{3.10} = 0.95$$

$$T_2 = \frac{41.83'}{12.95\ \text{ft/s}} = 3.23\ \text{s}$$ {good approx w/ Plate C-3, Ref. 9}

Case 3 MTL +0.25'

```
                        LINEAR WAVE THEORY / SNELLS LAW
                Units            Known Wave          Subject Wave      Deepwater Wave
Wave Height    ft               H1:     2.750      H2:     2.807      H0:     2.910
Wave Period    sec               T:     3.130
Water Depth    ft               d1:    14.450      d2:     3.700
Crest Angle    deg          Alpha1:     0.000  Alpha2:     0.000  Alpha0:     0.000
Wave Length    ft               L1:    47.941      L2:    31.499      L0:    50.160
Celerity       ft/sec           C1:    15.317      C2:    10.064      C0:    16.026
Group Veloc    ft/sec          Cg1:     8.973     Cg2:     8.614     Cg0:     8.013
Energy Dens    ft-lb/ft^2       E1:    60.487      E2:    63.011      E0:    67.735
Energy Flux    ft-lb/s-ft       P1:   542.746      P2:   542.746      P0:   542.746
Ursell Param                    U1:     2.095      U2:    54.979   H0/L0:     0.058
COTAN NS Slope:    10.450      Breaker  Hb:     3.207  db:     3.271 ft
```

lower limit of $d_2$ (@ toe) for non-breaking wave.

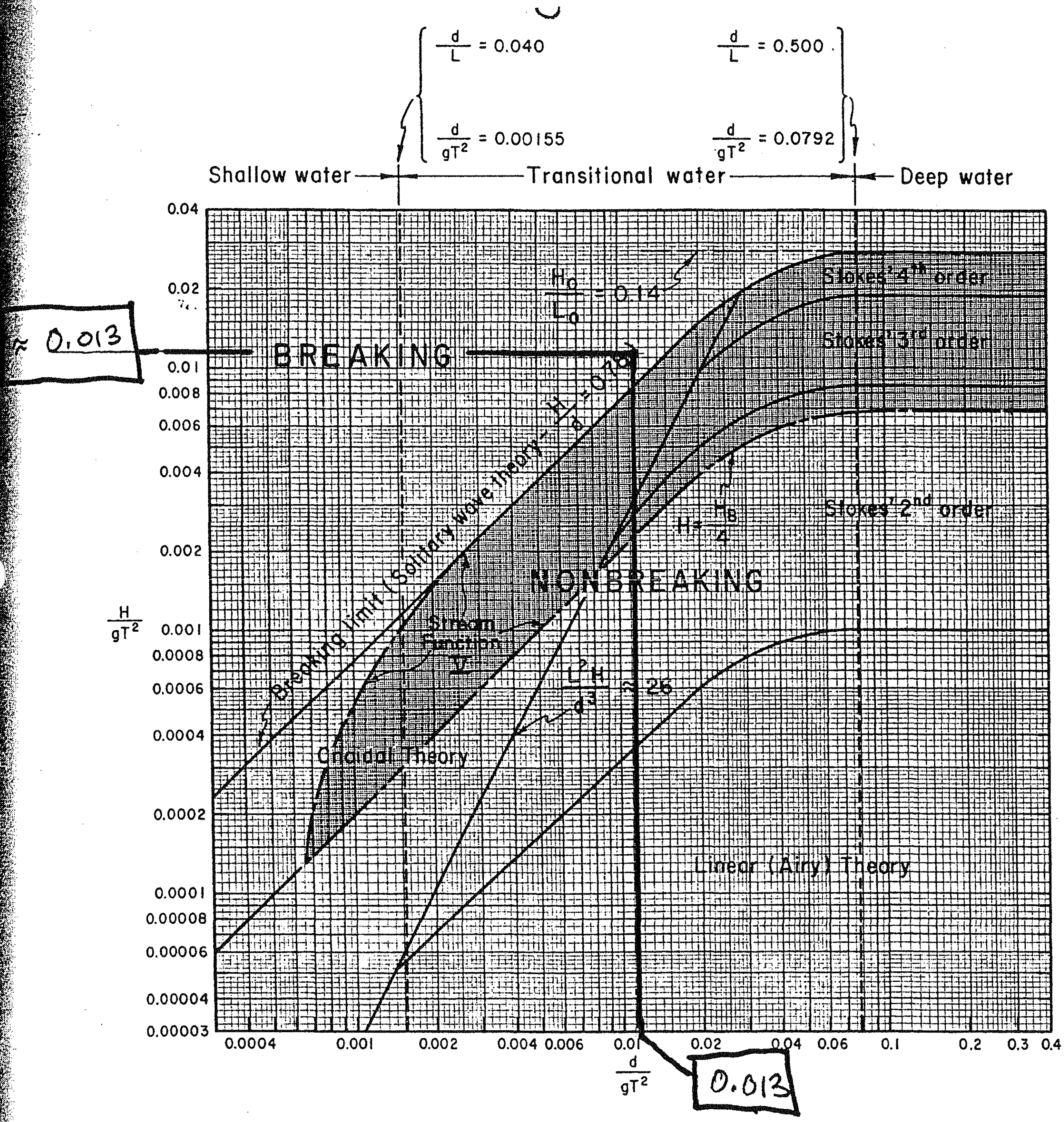
$$\frac{H_2}{H_1} = \frac{2.81}{2.75} = 1.02$$

$$T_2 = \frac{31.5'}{10.06} = 3.13 \text{ sec}$$

{Good approx w/ C-3, Ref G}

(B.3-

ACES: 'Linear Wave Theory / Snell's Law
Structures' determined that d ≅ 3.70'
is lower depth threshold for
non-breaking wave.



(after Le Mehaute, 1969)

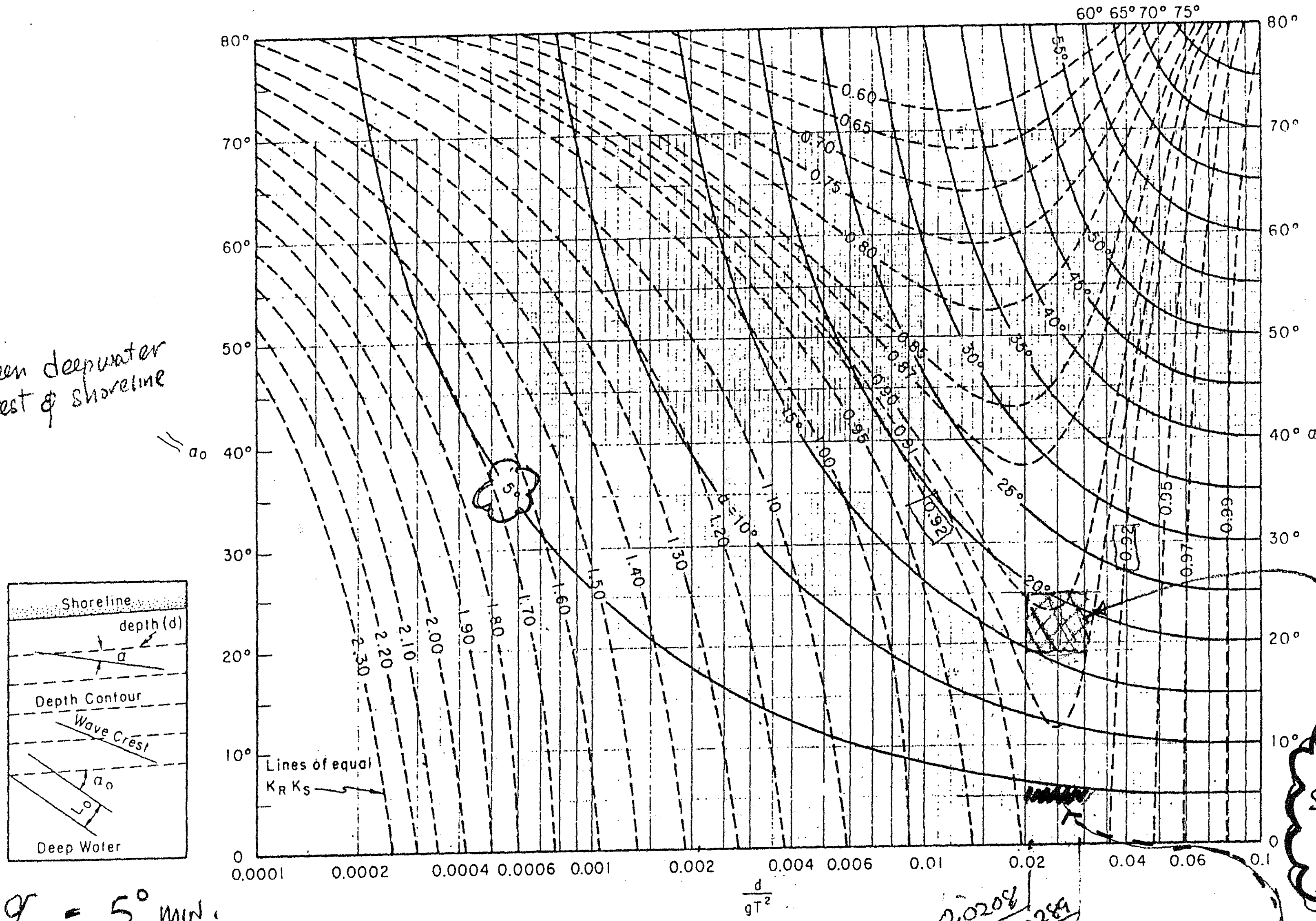
Figure 2-7. Regions of validity for various wave theories.

from Ref. 9

Ref 'G'

∡ between deepwater wave crest & shoreline = $a_0$

∡ between wave crest & shore = $\alpha$



$\alpha = \alpha_0 = 5°$ MIN.

Plate C-6. Change in wave direction and height due to refraction on slopes with straight, parallel depth contours including shoaling.

Adjustment for refraction / shoaling

Due to slight shift in $\alpha$ & $\alpha_0$ see B.5-2

$K_{RS} \simeq \boxed{0.92}$

$\left(d/gT^2\right)_i = (0.0289)_1, \; (0.0208)_2$

Non breaking ⟷ Breaking

(10.229). (7.[illegible].23) | (3.50, 3.13) (0, 3.04).

B.3-8

# B4

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SUBJECT Diffraction @ Channel Entrance

Ref.

# Input

Deepwater.

- $H_S = 5'$
  $T = 4.5\,s$ $\Big\}\ \lambda = \dfrac{32.2(4.5)^2}{2\pi} = 104'$

B, pg 5-

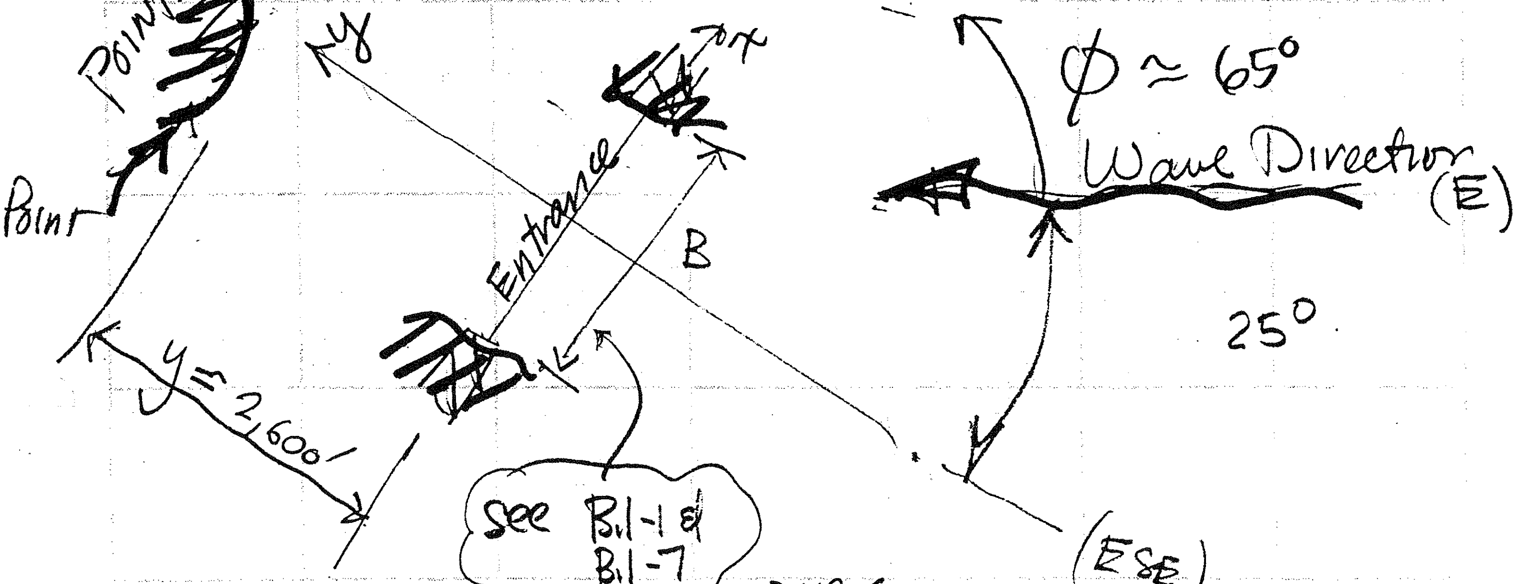
Avg Waterdepth ≅ 13'  avg. @ MHHW +3'
(see $A_1$ & $A_2$, pg B.1-11),

Breakwater Gap @ Channel Entrance:

~~WIDTH~~ B ≃ 1,000' ≈ 8λ > 5λ

Find $K' = \dfrac{\text{Diffracted Wave Height}}{\text{Incident Wave Height}}$

G, pg 2-



over

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SUBJECT Diffraction thru Channel Entrance

Ref G

If $B > 5\lambda$, then

for $\frac{y}{L} = \frac{2,600}{104} = 25$ ; $x/L = 0$

$\phi = 90° - 25° = \underline{65°}$, Figure 2-55 pg 2-10

↑ for chart

↓

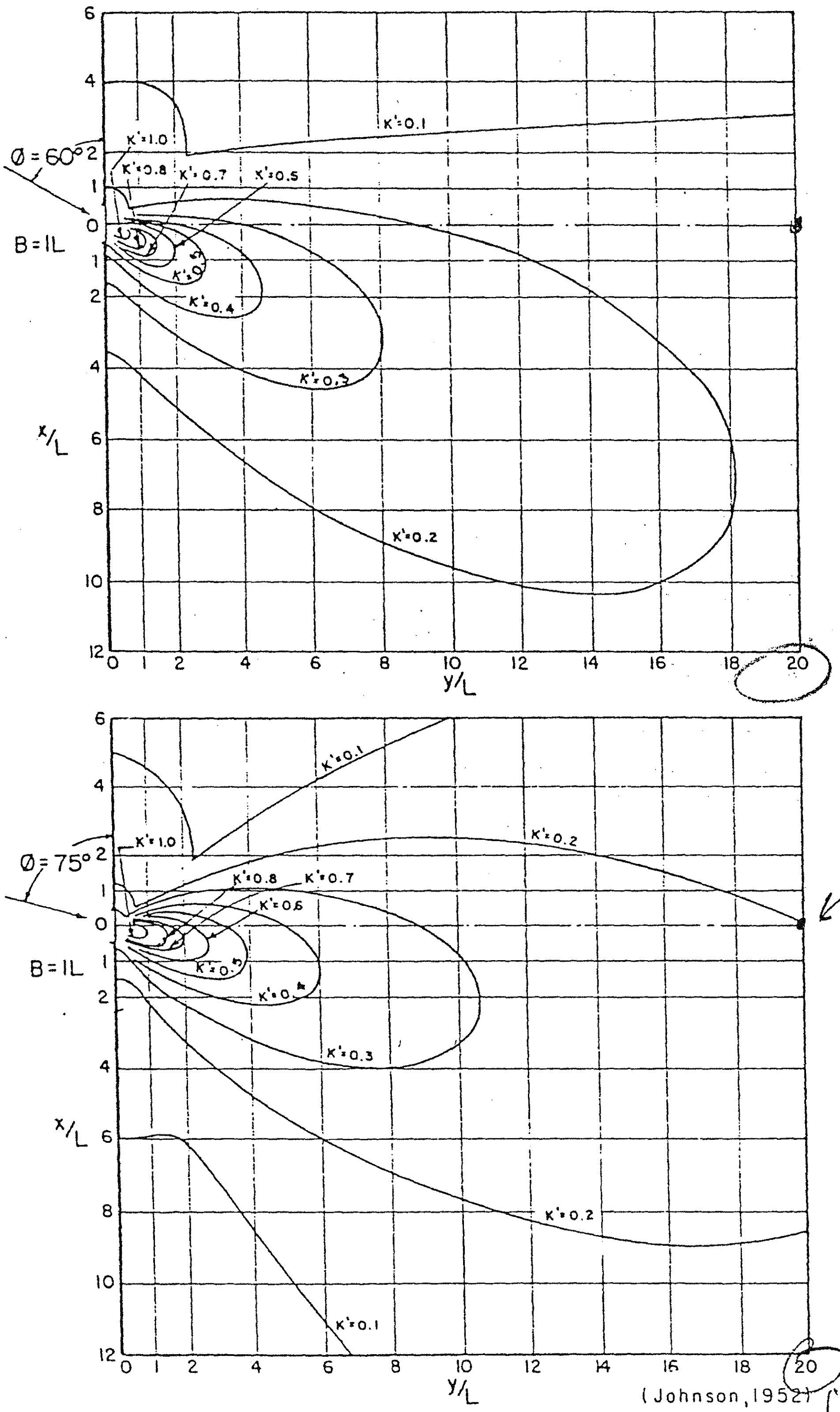
(see next page)

∴ Diffracted Wave Height $\simeq 0.2 \times 5' \cong \underline{1.0'}$

retraction/shoaling will further reduce height

∴ $H_{1/10} = \underline{3.87'}$ for design throughout

B.4-3



(Johnson, 1952)

K' ≈ 0.15

K' = 0.2

$y/L = \frac{2600}{104, 100, 83} = 25, 26, 31$

Figure 2-57. Diffraction for a breakwater gap of one wavelength width where $\phi = 60^\circ$ and $75^\circ$.

From Ref. 9

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SUBJECT Diffraction Thru Channel Entrance

Ref.

Review 'Flood' velocity effects on wave diffraction;

Tidal current (flood) = 2.00 ft/sec (1.2 knots) 4

Hypothesis

- tidal current will increase wave celerity & consequently shortening wave length.

→ transitional water

Fig. 5

$$C' = \text{tidal current} + \left[\frac{gT}{2\pi}\tanh\left(\frac{2\pi d}{L}\right)\right]$$

(over)

**From linear (Airy) wave theory, Reference B, Fig. 5-2:**

Wave celerity 'C' for linear wave in deep water:

$$\left(32.2 \cdot \frac{4.5}{2 \cdot \pi}\right) = 23.062$$

Wave celerity 'C' for linear wave in transitional water:

$$\left[\left(\tanh\left(2 \cdot \pi \cdot \frac{30}{133}\right)\right) \cdot \left(32.2 \cdot \frac{4.50}{2 \cdot \pi}\right)\right] = 20.502$$

Wave celerity 'C' for linear wave combined with tidal current (flood) at 2 feet/sec in transitional water:

$$C := \left[\left(\tanh\left(2 \cdot \pi \cdot \frac{30}{133}\right)\right) \cdot \left(32.2 \cdot \frac{4.50}{2 \cdot \pi}\right) + 2\right]$$

$$C = 22.502$$

Therefore, modified wavelength in transitional water, based on C :

$$L := C \cdot 4.5$$

$L = 101.26$ ft.

Wave celerity 'C' for linear wave combined with tidal current at 2 feet/sec (ebb) in transitional water:

$$C := \left[\tanh\left(2 \cdot \pi \cdot \frac{30}{133}\right) \cdot \left(32.2 \cdot \frac{4.50}{2 \cdot \pi}\right)\right] - 2$$

$$C = 18.502$$

Therefore, ebb current modified wavelength in transitional water, based on C :

$$L := C \cdot 4.5$$

$L = 83.26$ ft.

SHEET B.4-6 OF
JOB NO.
DATE 3/01
COMPUTED BY
PROJECT Stratford
SUBJECT Diffraction Thru Channel Entrance
CHECKED BY

Conclusion:

From a mean wave direction of 106° (through channel entrance), diffracted wave height $\simeq$ 1.0'. This is significantly less than the $H_{1/10}$ = 3.87' being currently used for design.

**B5**

B.5-1

### Ebb-Flood Velocity Effect on the design wave period in the near-shore region

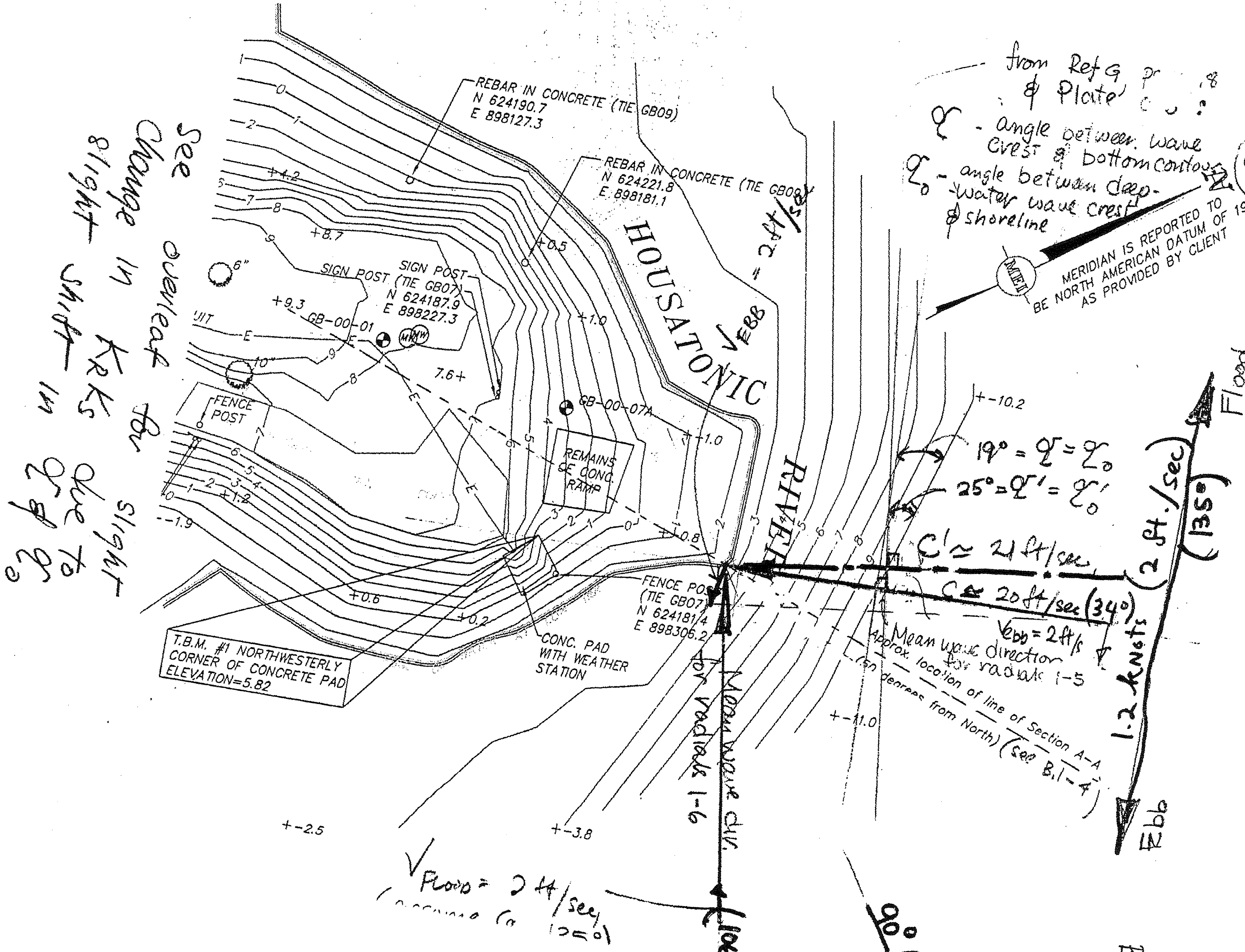
For radials 1-5, calculated mean wave direction is 34 degrees (from north). By 'adding' $V_{flood/ebb}$=2 ft/sec (center of Channel) to the $H_{1/10}$ wave celerity C=20 ft/sec is approxmately equal to C' = 21 ft/sec results in an approxmate 10% reduction in period 'T' (period shift) and a corresponding change in the angle between wavecrest and shoreline (=bottom contour).

From Plate C-6, Ref. G., calc sheet B.5-2, shows that a slight angular shift of $\alpha$ and $\alpha_0$ only changes the refraction/shoaling coefficient '$K_rK_s$' from approxmately 0.92 to 0.90.
A 10% reduction in period, changes $d/g(1.10T)^2$ (abscissa) by 20%, but $K_rK_s$ still remains approximately 0.92.

This is conservative because ebb/flood current velocity is likely to be even smaller near shore of the Causeway Point (boundary layer).

Therefore, effect of ebb current on the design wave height can be neglected.

(over)


REBAR IN CONCRETE (TIE GB09)
N 624190.7
E 898127.3
REBAR IN CONCRETE (TIE GB08)
N 624221.8
E 898181.1
SIGN POST
SIGN POST (TIE GB07)
N 624187.9
E 898227.3
GB-00-01
GB-00-07A
FENCE POST
REMAINS OF CONC RAMP
CONC. PAD WITH WEATHER STATION
FENCE POST (TIE GB07)
N 624181.4
E 898306.2
T.B.M. #1 NORTHWESTERLY CORNER OF CONCRETE PAD ELEVATION=5.82
HOUSATONIC RIVER
MERIDIAN IS REPORTED TO BE NORTH AMERICAN DATUM OF 19
AS PROVIDED BY CLIENT
MEI
Approx. location of line of Section A-A (50 degrees from North) (see B.1-4)
+4.2
+8.7
+9.3
7.6+
+0.5
+1.0
+-1.0
+0.8
+0.6
+0.2
+1.2
+-1.9
+-10.2
+-11.0
+-2.5
+-3.8
6"
10"
from Ref 9 & Plate
α - angle between wave crest & bottom contours
α₀ - angle between deep-water wave crest & shoreline
19° = α = α₀
25° = α′ = α₀′
C′ ≈ 21 ft/sec
C ≈ 20 ft/sec (340)
V_EBB = 2 ft/sec
V_EBB
V_ebb = 2 ft/s
Mean wave direction for radials 1-5
Mean wave dir. for radials 1-6
V_FLOOD = 2 ft/sec
2 ft./sec (135°)
1.2 Knots
Flood
Ebb
90°
See overleaf for change in K_R K_S due to slight shift in α₀ of 6°

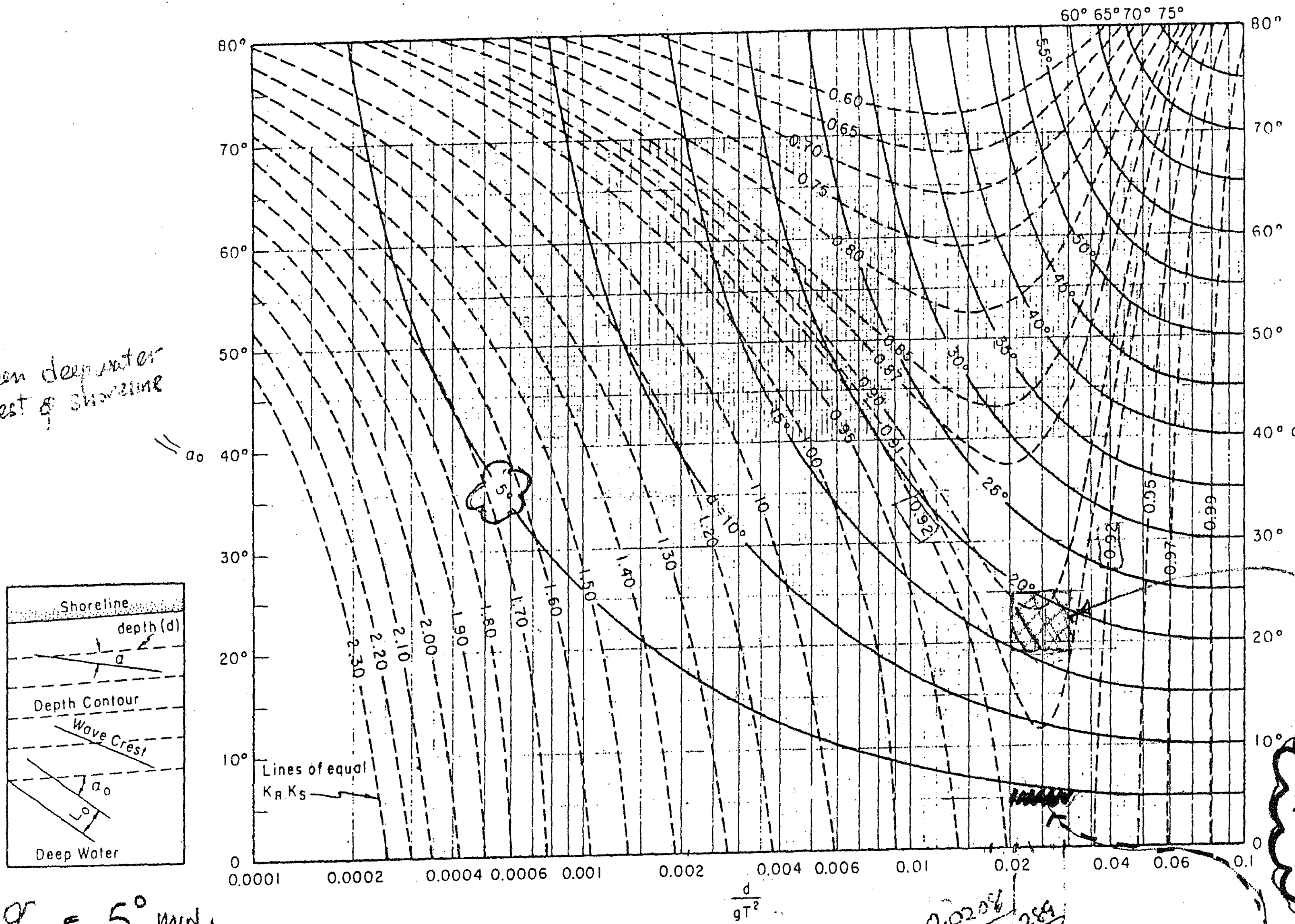
Ref 'G'

C-35

Adjustment for refraction / shoaling

∡ between deepwater wave crest & shoreline = $a_0$

∡ between wave crest & shore =



0.0208

0.0289

Due to slight shift in α & $α_0$ see B.5-2

$α = α_0 = 5°$ MIN.

Plate C-6. Change in wave direction and height due to refraction on slopes with straight, parallel depth contours including shoaling.

$K_{RS} \simeq \boxed{0.92}$

$\left(\frac{d}{gT^2}\right)_i = (0.0289)_1, \quad (0.0208)_2$

Non-breaking ⟷ Breaking

(10, 3.28), (7.01, 3.23)$_2$ | (3.70, 3.13)$_2$ (0, 3.04)

B.5-3

B6

**Harding Lawson Associates**
Infrastructure, Inc.
HLA
Engineering, Planning, and Construction Services

SHEET B.6-1 OF
JOB NO.
DATE 2/01
COMPUTED BY
PROJECT Stratford
SUBJECT Results of Runup Calculations
CHECKED BY

Over-Topping Rate (ft³/s-ft)

|  | Slope of 'Trilock Brick' |  |  |  |
|---|---|---|---|---|
|  | 1:3 | 1:4 |  | 1:9 |
| Smooth Slope | 0.28 | 0.064 |  | 0 |
| Rough Slope | 0.013 | — |  | — |

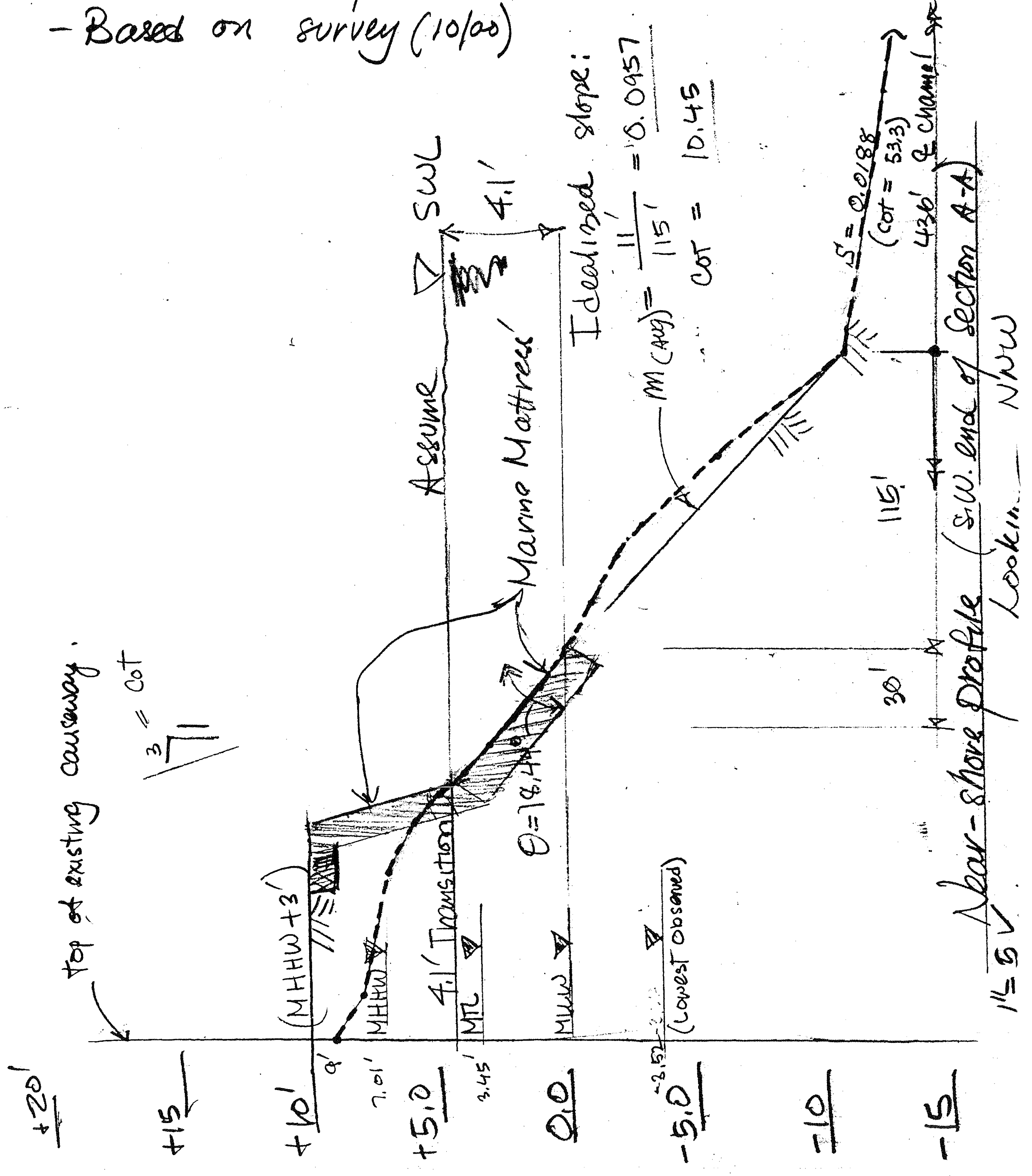
actual slope

calculated to check sensitivity of Q to slope.

SHEET B.6-2 OF
JOB NO.
DATE 11/02
COMPUTED BY
CHECKED BY

PROJECT Stratford Causeway
SUBJECT Near-shore profile (Section A-A)

- Based on survey (10/00)



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Engineering, Planning, and Construction Services

SHEET B.6-3 OF

JOB NO.

DATE 3/01

COMPUTED BY

CHECKED BY

PROJECT Stratford

SUBJECT Runup @ Causeway Point

Ana
Ref
F

~~ACES~~: "Wave Runup on Impermeable Struct."

Non-breaking

Irregular Wave $= H_{1/10}$

(adjusted for '$K_r K_s$'; see B.3)

$T \simeq 3$ sec

To find over-topping coefficients

G
pg:

$\alpha$ & $Q_0^*$

from Fig 7-28, plot the following

$d_s = (7.01, 4.1)$

$H_0' = (3.87, 3.23)$ {modified for $K_R K_s$}

∴ abscissa:

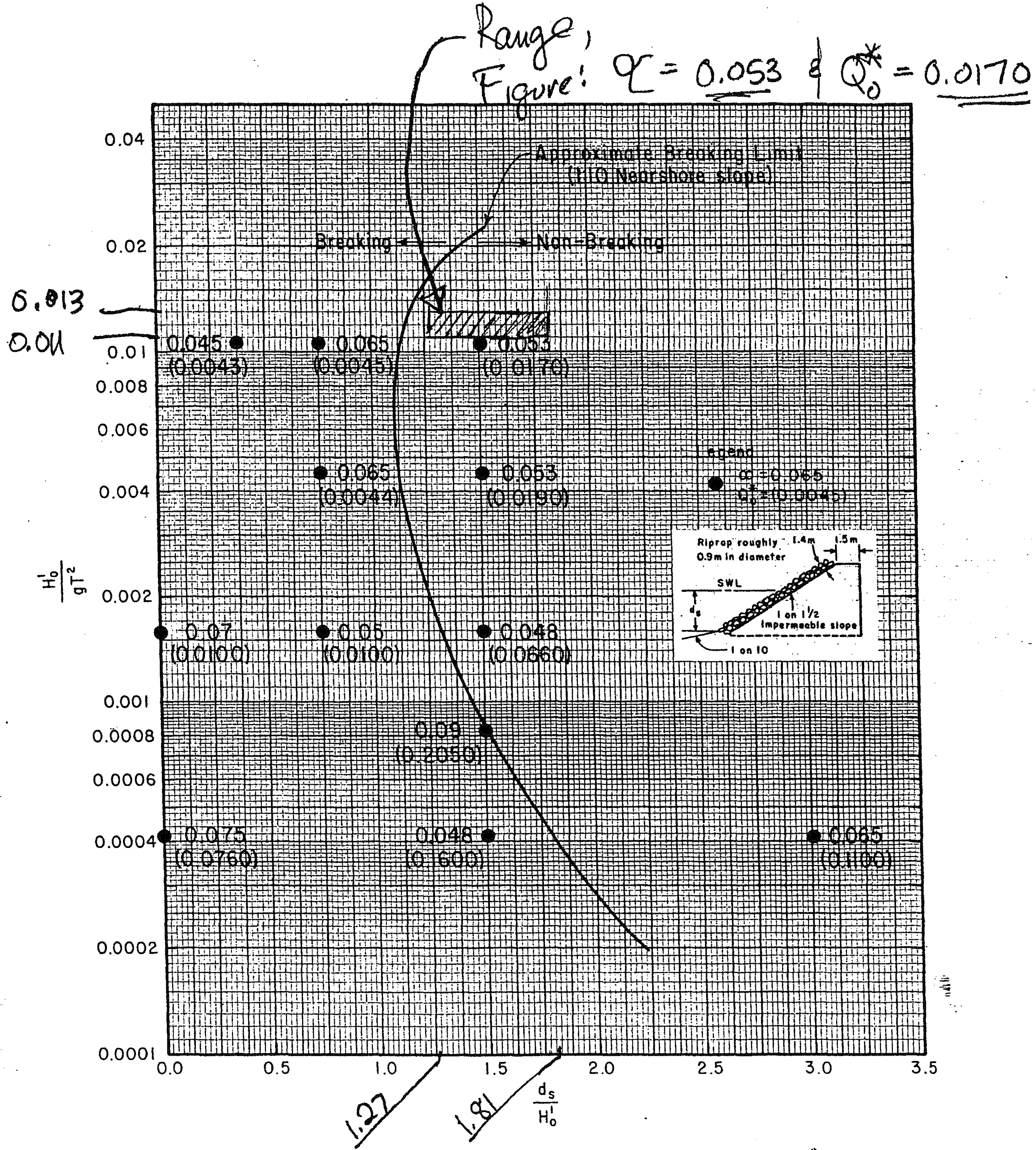
$$\left(\frac{d_s}{H_0'}\right) = (1.81, 1.27)$$

ordinate:

$$\left(\frac{H_0'}{gT^2}\right) = (0.013, 0.011)$$

$T \approx 3$ sec

over.



Range, Figure: α = 0.053 & $Q_0^*$ = 0.0170

0.013

0.011

1.27

1.81

Figure 7-28. Overtopping parameters α and $Q_o^*$ (riprapped 1:1.5 structure slope on a 1:10 nearshore slope).

Range; use α = 0.08 & $Q_o^* = 0.011$

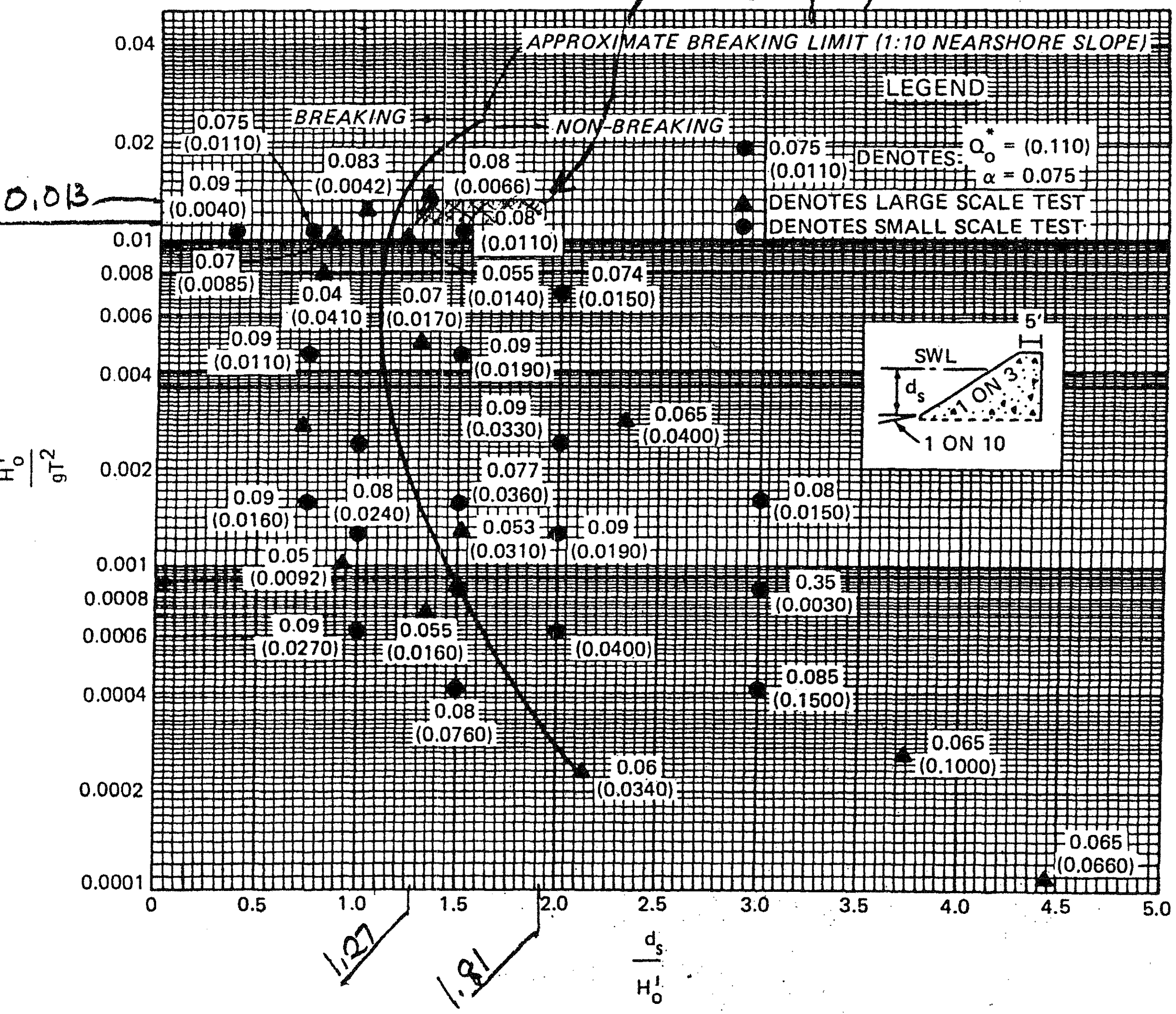


Figure 7-26. Overtopping parameters α and $Q_o^*$ (smooth 1:3 structure slope on a 1:10 nearshore slope).

B.6-5

$\cot\theta = 3$ B.6-7

```
                 Wave Runup and Overtopping on Impermeable Structures
                    Item                         Unit         Value
   Sig. Wave Height at Toe          Hs:      ft                 3.870        Irregular
    eak Wave Period                  T:      sec                3.000           Wave
    OTAN of Nearshore Slope                                    10.450        Rough Slope
   Water Depth at Toe               ds:      ft                 7.010        Overtopping
   COTAN of Structure Slope                                     3.000
   Structure Height Above Toe       hs:      ft                10.000
   Rough Slope Coefficient           a:                         0.956
   Rough Slope Coefficient           b:                         0.398
   Deepwater Sig. Wave Height      Hs0:      ft                 4.238
   Relative Height             (ds/Hs0):                        1.654
   Wave Steepness            (Hs0/gT^2):                        0.146E-01
   Wave Runup for Sig. Wave         Rs:      ft                 2.919
   Onshore Wind Velocity             U:      ft/sec            90.933
   Overtopping Coefficient       Alpha:                         0.530E-01    0.053
   Overtopping Coefficient      Qstar0:                         0.170E-01    0.017
   Overtopping Rate                  Q:      ft^3/s-ft          0.013
```

Cot θ = 3   B.6-8

```
              Wave Runup and Overtopping on Impermeable Structures
                Item                         Unit          Value
 Sig. Wave Height at Toe          Hs:    ft                3.870        Irregular
   ak Wave Period                  T:    sec               3.000           Wave
   TAN of Nearshore Slope                                 10.450     →Smooth Slope←
 Water Depth at Toe               ds:    ft                7.010       Overtopping
 COTAN of Structure Slope                                  3.000
 Structure Height Above Toe       hs:    ft               10.000
 Deepwater Sig. Wave Height      Hs0:    ft                4.238
 Relative Height            (ds/Hs0):                      1.654
 Wave Steepness          (Hs0/gT^2):                       0.146E-01
 Wave Runup for Sig. Wave         Rs:    ft                4.460
 Onshore Wind Velocity             U:    ft/sec           90.933
 Overtopping Coefficient       Alpha:                      0.800E-01 } see pg —
 Overtopping Coefficient     Qstar0:                       0.110E-01 }
 Overtopping Rate                  Q:    ft^3/s-ft         0.277
```

```
              WAVE TRANSMISSION ON IMPERMEABLE STRUCTURES
                Item                       Unit         Value
Incident Wave Height             Hi:        ft            3.870       Smooth Slope
 ave Period                       T:        sec           3.000        Runup and
 OTAN of Nearshore Slope                                 10.380       Transmissio
Water Depth                      ds:        ft            7.010
COTAN of Structrue Slope                                  3.000
Structure Height Above Toe       hs:        ft           10.000
Structure Crest Width             B:        ft          100.000
Wave Runup                        R:        ft            4.460
Transmission Rate                HT:        ft            0.000
```

B.6-10

For other values of θ on smooth slope

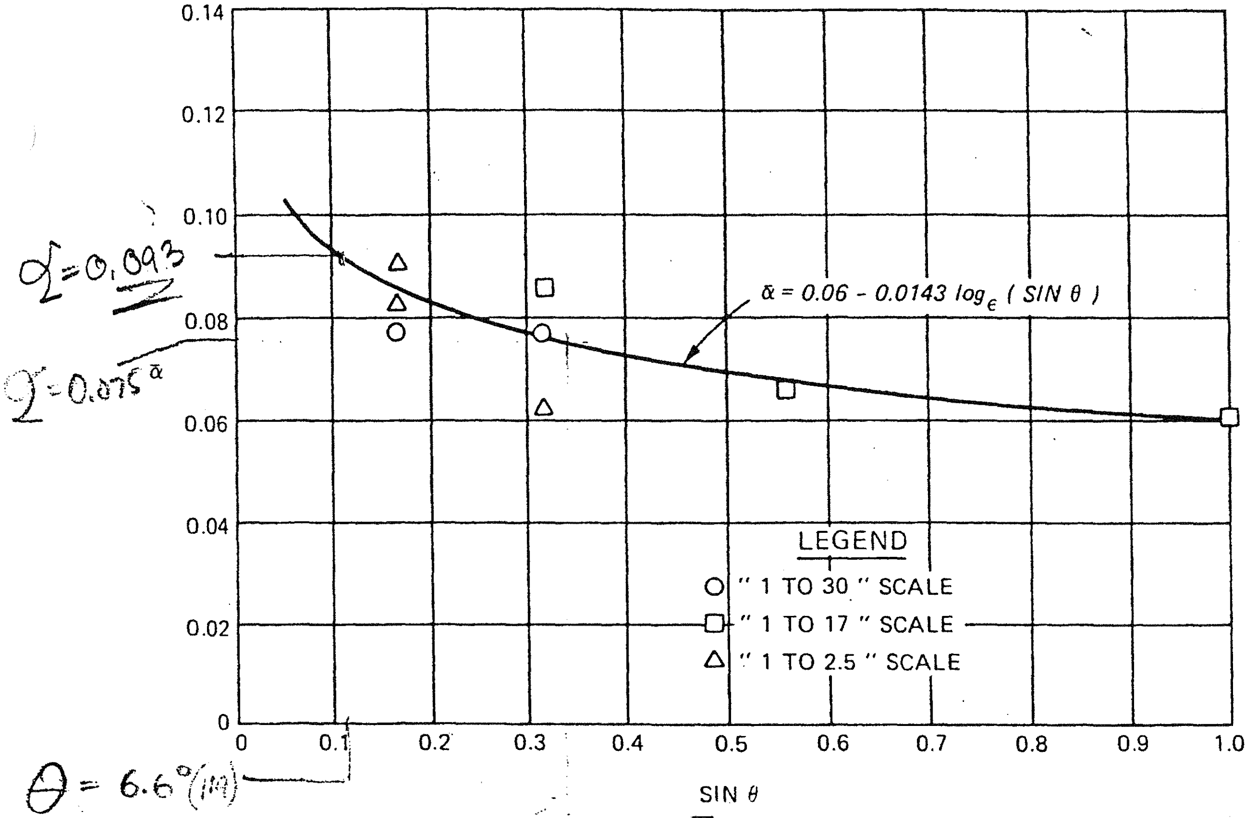


Figure 7-33. Variation of $\overline{\alpha}$ with structure slope Θ .

slopes only), based on this analysis is given by equation (7-13)

$$\overline{\alpha} = 0.06 - 0.0143 \ln (\sin \Theta) \tag{7-13}$$

where Θ is the structure slope angle from the horizontal.

The variation of $Q_o^*$ between waves conforming to linear theory and to cnoidal theory was also investigated by Weggel (1976). The findings of this investigation are illustrated in Figure 7-34. $Q_o^*$ is shown as a function of depth at the structure $d_s$ , estimated deepwater wave height $H_o'$ , and period T , for both linear and cnoidal theory.

Calculation of wave overtopping rates is illustrated by the following example.

* * * * * * * * * * * * * * * * EXAMPLE PROBLEM 7 * * * * * * * * * * * * * * *

GIVEN: An impermeable structure with a smooth slope of 1 on 2.5 is subjected to waves having a deepwater height $H_o'$ = 1.5 m (4.9 ft) and a period T = 8 s . The depth at the structure toe is $d_s$ = 3.0 m (9.8 ft) ; crest elevation is 1.5 m (4.8 ft) above SWL. Onshore winds of 35 knots are assumed.

FIND: Estimate the overtopping rate for the given wave.

Cot θ = 4 8.6-11

```
          Wave Runup and Overtopping on Impermeable Structures
             Item                        Unit         Value
 Sig. Wave Height at Toe        Hs:    ft             3.870       Irregular
  eak Wave Period                T:    sec            3.000         Wave
  OTAN of Nearshore Slope                            10.450      Smooth Slop
 Water Depth at Toe             ds:    ft             7.010      Overtopping
 COTAN of Structure Slope                             4.000
 Structure Height Above Toe     hs:    ft            10.000
 Deepwater Sig. Wave Height    Hs0:    ft             4.238
 Relative Height          (ds/Hs0):                   1.654
 Wave Steepness         (Hs0/gT^2):                   0.146E-01
 Wave Runup for Sig. Wave       Rs:    ft             3.345
 Onshore Wind Velocity           U:    ft/sec        90.933
 Overtopping Coefficient    Alpha:                    0.750E-01
 Overtopping Coefficient   Qstar0:                    0.110E-01
 Overtopping Rate                Q:    ft^3/s-ft      0.064
```

$\cot \theta = 9$

```
          Wave Runup and Overtopping on Impermeable Structures
             Item                         Unit         Value
 Sig. Wave Height at Toe         Hs:     ft              3.870       Irregular
  eak Wave Period                 T:     sec             3.000          Wave
 OTAN of Nearshore Slope                                10.450       Smooth Slope
 water Depth at Toe              ds:     ft              7.010       Overtopping
 COTAN of Structure Slope                                9.000
 Structure Height Above Toe      hs:     ft             10.000
 Deepwater Sig. Wave Height     Hs0:     ft              4.238
 Relative Height            (ds/Hs0):                    1.654
 Wave Steepness           (Hs0/gT^2):                    0.146E-01
 Wave Runup for Sig. Wave        Rs:     ft              1.487
 Onshore Wind Velocity            U:     ft/sec         90.933
 Overtopping Coefficient      Alpha:                     0.920E-01
 Overtopping Coefficient     Qstar0:                     0.110E-01
 Overtopping Rate                 Q:     ft^3/s-ft       0.000
```

No overtopping

# APPENDIX F

## CONTAMINATED SOIL VOLUME ESTIMATES

## ATTACHMENT A - ADDENDUM TO FINAL CAUSEWAY AND DIKE PRE-DESIGN INVESTIGATION REPORT

# APPENDIX F
# TECHNICAL MEMORANDUM
# DELINEATION OF CONTAMINATED SOILS ON THE CAUSEWAY REQUIRING EXCAVATION
## STRATFORD ARMY ENGINE PLANT
## STRATFORD, CT

The objective of this technical memorandum is to support the design of a permeable erosion control cover system on the Causeway property of the Stratford Army Engine Plant in Stratford, Connecticut. This technical memorandum contains:

1) a chronology and summary of soil sampling programs and analytical results from Causeway soils investigations conducted between September 1999 and September 2000,
2) an interpreted delineation of contaminated soil areas requiring excavation prior to the placement of a permeable cover system on the Causeway.

## 1.0 CHRONOLOGY AND SUMMARY OF SOIL SAMPLING PROGRAMS

Three separate soil sampling programs were conducted on the Causeway in September 1999, May 2000, and September 2000. These investigations and corresponding analytical results are presented in the following subsections.

### 1.1 PRE-DESIGN INVESTIGATION SAMPLING AND RESULTS (SEPTEMBER 1999)

Results of Causeway field investigation activities, conducted by Foster Wheeler Environmental Corporation (Foster Wheeler) and Harding Lawson Associates (HLA) during the summer and fall of 1999, are presented in the Final Causeway and Dike Non-Time Critical Removal Action (NCRA) Pre-Design Investigation Report (Foster Wheeler/HLA, 2000a). Specific to the Causeway, a number of soil samples collected and analyzed during the September 1999 field investigations indicated concentrations of volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and vanadium exceeding criteria presented in the Connecticut Department of Environmental Protection (CTDEP) Remediation Standard Regulations (RSRs). The following paragraphs present a summary of the soils contamination.

Environmental contamination was detected in the soils at concentrations above CTDEP residential Direct Exposure Criteria (DEC) and Pollutant Mobility Criteria for a GB-classified aquifer (GB PMC). VOCs were detected at boring locations CB-99-01, CB-99-02, CB-99-03, CB-99-04, CB-99-08, CB-99-11, and CB-99-13 (see Figure F-1). Other locations with VOC exceedances include TP-99-06, TP-99-10, TP-DEP-11, and TP-DEP-12. VOC exceedances were mostly confined to explorations located in southern and northern portions of the Causeway.

The distribution of SVOC DEC and GB PMC exceedances indicates that contamination by these compounds is concentrated in the northern one-third of the Causeway. SVOCs were detected in eight explorations, with only two explorations (CB-99-02 and CB-99-09) being located near Building 59 toward the southern end of the Causeway. The remaining exceedances are found in explorations CB-99-11, CB-99-12, CB-99-14, CB-99-15, TP-99-10, and TP-DEP-11 (see Figure F-1). Detections occurred generally at shallower depths (1-3 feet bgs); however, the fuel-related compounds were also found at deeper depths nearer the water table. This is evident at CB-99-09 (10-12 feet bgs), CB-99-12 (8-10 feet bgs), and in CB-99-15 (7-9 feet bgs). Polychlorinated biphenyl (PCB) exceedances were detected at CB-99-02, TP-99-10, and TP-DEP-11.

The extent of inorganic contamination above CTDEP criteria is limited primarily to the northern one-third of the Causeway. These are mostly for the willow soils and are residential DEC exceedances. The only inorganic exceedance away from the outer end of the Causeway was detected in CB-99-03, this being a GB PMC exceedance for vanadium at 4-6 feet below ground surface (bgs).

Discussions with the CTDEP identified the need for synthetic precipitate leaching procedure (SPLP) analysis of soils on the Causeway which exceed the GB PMC.

### 1.2 SPLP SAMPLING AND RESULTS (MAY 3, 2000)

A Supplemental Work Plan (Foster Wheeler/HLA, 2000b) was prepared to address the SPLP data needs. Specifically, the CTDEP indicated that if it could be demonstrated that soils with GB PMC exceedances from previous sampling did not exceed 10 times (x 10) the Groundwater Protection Criteria using SPLP results, then the CTDEP RSRs would allow installation of a permeable soil cover on the Causeway, rather than an engineered barrier to prevent infiltration.

In addition the CTDEP requested that SPLP results be compared to the USEPA Freshwater Acute Aquatic Water Quality Criteria (AWQC) as an additional screening value to indicate the need for remediation/excavation of contaminated soils on the Causeway. CTDEP's Comment #7 on the Causeway Engineering Evaluation/Cost Analysis (EE/CA), dated July 31, 2000, regarding the use of the AWQC was as follows:

> "DEP understands that groundwater quality will be addressed in a separate operational unit. RCSA section 22a 133k 3(b)(2) mandates that groundwater discharging to the tidal flat conform with surface water quality criteria. Note that these values are lower than the Remediation Standard Regulation Appendix D Surface Water Protection Criteria, which incorporate a default attenuation factor. To ensure the interim remedy is consistent with the final remedy, DEP recommends that the proposed spot removal of soils with mobile pollutants also consider potential impacts of leachable pollutants on surface water. This would limit the risk for further action in a final remedy to address soil as a pollutant source if groundwater exceeds evaluation criteria. The degree of concern depends on the difference between a pollutant's GB Pollutant Mobility Criterion (the target interim removal criterion) and its Aquatic Water Quality Benchmark value, and also on the potential for attenuation between the soil location and the receptor tidal flat. For example, DEP recommends a value of 280 μg/l for vanadium acute toxicity in water, as compared to a GB Pollutant Mobility Criterion of 500 μg/l. A removal criterion of 280 μg/l, as opposed to 500, would ensure that, even without any attenuation on the transport path from soil to surface water, there would be no possibility of acute toxicity……"

Therefore, the Causeway SPLP soils data is compared to AWQC values within this document as a criteria for determining the extent of contaminated soil requiring excavation.

The field investigation and results of the May 3, 2000 SPLP sampling event are presented in an Addendum to the Final Pre-Design Investigation Report for the Causeway and Dike, which is included as Attachment A of this Appendix. The following paragraphs summarize the findings of this Addendum.

As indicated in Section 1.1, results of soil sampling and analyses conducted on the Causeway in September 1999 identified a number of samples with concentrations that exceed the GB PMC (Foster Wheeler/HLA, 2000a). Of these samples, only the soils at, or above, 4.5-feet bgs (the approximate water table at high tide) were re-sampled for SPLP analyses, and only for those parameters already found to exceed the GB PMC criteria.

Ten (10) previously sampled exploration locations were re-sampled on the Causeway to collect additional subsurface soil samples for SPLP analyses. For these samples, SPLP analyses were requested for those parameters that were previously detected at concentrations above the GB PMC. Exploration locations and sample analyses are listed on Figure F-1 and Table 1 of Attachment A, respectively. All re-sampled exploration locations were completed on May 3, 2000 using a backhoe and test-pitting techniques. Soil sample descriptions and sampling information were written on test pits logs, included in Attachment A.

Detected analytes from SPLP soil analyses are presented in Table F-1, indicated by the sampling date of May 3, 2000. The CTDEP Groundwater Protection Criteria values multiplied by a factor of 10 are also presented on Table F-1. For contaminated soils in a GB area, or an area encompassing a non-potable groundwater aquifer, the CTDEP RSRs state, "A substance other than total petroleum hydrocarbons in soil above the seasonal high water table in a GB area may be remediated to a level at which the results of a TCLP or SPLP analysis of such soil does not exceed the ground-water protection criterion for any such substance multiplied by 10.... "

Of the eight locations sampled for VOCs, only one location, TP-DEP-12, exhibited concentrations above the CTDEP Groundwater Protection Criteria x 10 for VOCs. Vinyl chloride was detected at a concentration of 35 micrograms per liter (µg/L) versus a criterion of 20 µg/L, and trichloroethene (TCE) was detected at a concentration of 160 µg/L versus a criterion of 50 µg/L (see Table F-1).

A total of five locations were sampled for SVOCs (see Attachment A, Table 1). Of these, only two locations (CB-99-15 and TP-99-10) indicated exceedances above the CTDEP Groundwater Protection Criteria x 10 (see Table F-1).

At the two locations that were re-sampled for vanadium, TP-DEP-11 and TP-DEP-12, SPLP results were both below the CTDEP Groundwater Protection Criteria x 10 of 500 µg/L (see Table F-1 and Attachment A). However, the vanadium concentration of 415 µg/L at TP-DEP-12 exceeds the AWQC of 280 µg/L.

In summary, the results of the SPLP sampling and analyses conducted in May 2000 to address the locations with contaminant concentrations exceeding the CTDEP GB PMC indicated the following:

- one location (TP- DEP-12) exhibited VOC concentrations exceeding the CTDEP Groundwater Protection Criteria x 10,

- two locations (CB-99-15 and TP-99-10) exhibited SVOC concentrations exceeding the CTDEP Groundwater Protection Criteria x 10, and
- one location the vanadium concentration of 415 µg/L at TP-DEP-12 exceeds the AWQC of 280 µg/L.

### 1.3 SPLP SAMPLING AND RESULTS (SEPTEMBER 14, 2000)

As a result of the criteria exceedances in May 2000 samples, additional SPLP sampling and analyses was performed in September 2000 to delineate the extent of contaminants at these locations exceeding the CTDEP Groundwater Protection Criteria x 10 and AWQC. Table F-2 presents a summary of the samples collected for SPLP analyses. The sample locations are presented on Figure F-1.

In the Pre-Design Investigation Report (Foster Wheeler/HLA, 2000), groundwater elevations on the Causeway are known from measurements in the two willow wells MWCD-99-01A and MWCD-99-02A. Based on groundwater elevations in these two wells, the average depth to water bgs for the Causeway is approximately 4.5-feet bgs (4.27-feet bgs at MWCD-99-01A and 4.65-feet bgs at MWCD-99-02A). For contaminated soils in a GB area, all soils at or above the seasonal high water table are to be considered for remediation based upon results of the SPLP analysis.

Two locations, TP-DEP-11 and TP-DEP-12, which previously contained vanadium concentrations exceeding CTDEP Groundwater Protection Criteria x 10 or AWQC, were re-sampled. These locations are in areas where Honeywell removed radiologically contaminated soil in March 2000. These areas were re-sampled to assess whether vanadium levels in soils still exceed the GB PMC after the excavation was completed.

Four samples were collected for VOC analyses from North, South, East, and West locations 10 feet out from TP-DEP-12 original location (see Figure F-1). Four samples were collected for SVOC analyses from North, South, East, and West locations 10 feet out from CB-99-15 original location (see Figure F-1). Three samples were collected for SVOC analyses from North, South, and East locations 10 feet out from TP-99-10 original location. The West location would have been in the tidal zone, and was therefore not collected. Additional samples were collected 15 feet out from original sample locations; however, these were not analyzed, as results from the samples collected 10 feet from the original explorations indicated that the contaminant concentrations exceeding screening criteria had been delineated.

Samples were sent to the Pittsburgh, Pennsylvania Severn-Trent Laboratories lab for analysis. Split samples were also sent to the USACE laboratory (AMRO).

Results of the SPLP analyses indicate that VOC, SVOC, and vanadium concentrations are all below CTDEP Groundwater Protection Criteria x 10. However, vanadium concentrations at locations TP-DEP-11 (338 µg/L in the duplicate sample) and TP-DEP-12 (391 µg/L) exceed the AWQC of 280 µg/L (see Table F-1).

## 2.0 DELINEATION OF CONTAMINATED CAUSEWAY SOILS REQUIRING EXCAVATION

Based on the results presented in Section 1.0, six contaminated areas of soil (EA-1 through EA-6) on the Causeway require excavation prior to the placement of an erosion control cover system. The locations, and rationale for excavation are provided below. Note that the table describes a 5-ft excavation radius and a 2-ft. depth for developing cleanup volumes. Confirmation sampling will be performed on 4 sidewalls and the bottom of the excavation for each of these initial 5-ft radius areas and additional excavation would be performed if the initial sampling showed that contamination above the cleanup criteria are exceeded.

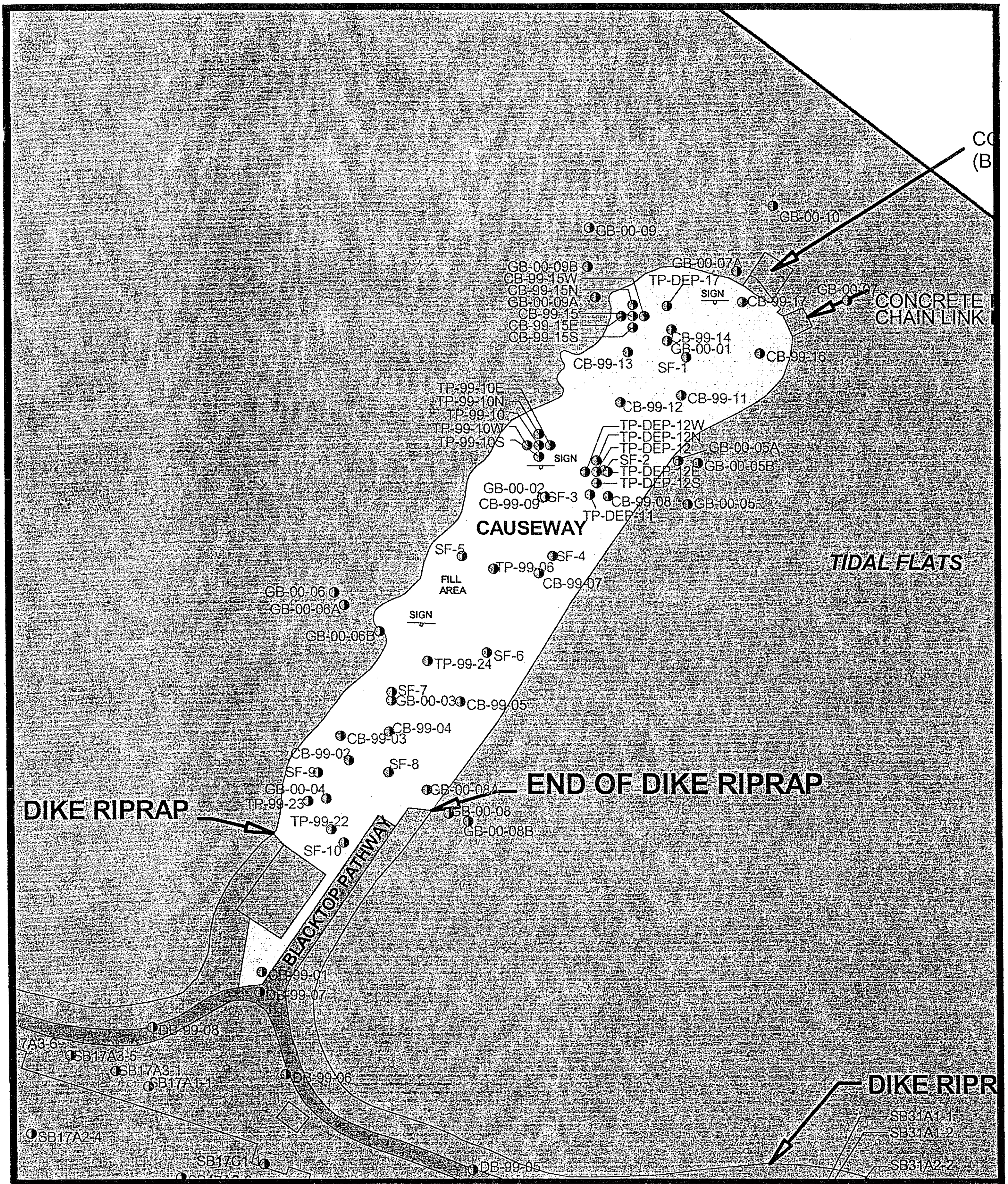
In addition to the six excavation areas indicated above, the CTDEP requested in comments (dated August 2, 2001) on the 90% Design that soils with PCB concentrations greater than 1 ppm also be excavated. There are six locations on the Causeway where PCB concentrations in soil exceed 1 ppm: TP-DEP-11, TP-99-06, TP-99-10, TP-99-22, TP-99-23, and CB-99-02 (see Figure 1, attached). Total PCB concentrations in soils at these locations range from 1.6 to 11 ppm. Two of the locations (TP-DEP-11 and TP-99-10) where PCBs in soil exceed 1 ppm, are co-located with proposed excavation areas (EA-3 and EA-5) previously identified in the Causeway Design. The remaining four locations where PCB concentrations exceed 1 ppm will be added to areas requiring excavation in the Design, and will be designated as follows:

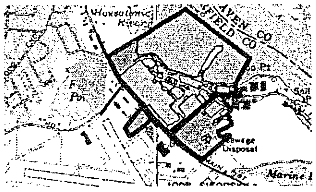
EA-7, centered on TP-99-06 (minimum excavation depth 8 feet)
EA-8, centered on TP-99-22 (minimum excavation depth 3 feet)
EA-9, centered on TP-99-23 (minimum excavation depth 3 feet)
EA-10, centered on CB-99-02 (minimum excavation depth 2 feet)

The locations of these excavation areas (EA-7 through EA-10), and the estimated volume of soil to be removed, are provided below. Confirmation sampling will be performed on 4 sidewalls and the bottom of the excavation for each of these initial 5-ft radius areas and additional excavation would be performed if the initial sampling showed that contamination above the cleanup criteria are exceeded.

| Excavation Area | Associated Exploration | Contaminants | Criteria Exceeded | Radius of Excav. | Excavation Depth | Excavation Volume |
|---|---|---|---|---|---|---|
| EA-1 | CB-99-01 | Zinc | AWQC | 5 feet | 2 feet | 5.8 cu yds |
| EA-2 | CB-99-03 | Vanadium | GB PMC<br>GW Prot.x10<br>AWQC | 5 feet | 2 feet | 5.8 cu yds |
| EA-3 | TP-DEP-11 | Vanadium<br>PCBs | AWQC | 5 feet | 2 feet | 5.8 cu yds |
| EA-4 | TP-DEP-12 | Vanadium<br>TCE<br>Vinyl Chloride | AWQC<br>GW Prot.x10<br>GW Prot.x10 | 5 feet | 2 feet | 5.8 cu yds |
| EA-5 | TP-99-10 | SVOCs | AWQC | 5 feet | 2 feet | 5.8 cu yds |

| Excavation Area | Associated Exploration | Contaminants | Criteria Exceeded | Radius of Excav. | Excavation Depth | Excavation Volume |
|---|---|---|---|---|---|---|
| | | PCBs | | | | |
| EA-6 | CB-99-15 | SVOCs | AWQC | 5 feet | 2 feet | 5.8 cu yds |
| EA-7 | TP-99-06 | PCBs | CTDEP RSRs | 5 feet | 8 feet | 23.3 cu yds |
| EA-8 | TP-99-22 | PCBs | CTDEP RSRs | 5 feet | 3 feet | 8.7 cu yds |
| EA-9 | TP-99-23 | PCBs | CTDEP RSRs | 5 feet | 3 feet | 8.7 cu yds |
| EA-10 | CB-99-02 | PCBs | CTDEP RSRs | 5 feet | 2 feet | 5.8 cu yds |




Site Map

Legend

◑ Soil Samples

FIGURE F-1
Causeway
Sample Locations

Stratford Army Engine Plant
Stratford, Connecticut
Harding Lawson Associates

# TABLE F-1
# DETECTED ANALYTES - SPLP SAMPLING AND ANLYSES
# CAUSEWAY SOILS

## STRATFORD ARMY ENGINE PLANT
## STRATFORD, CONNECTICUT

| LOCATION ID | SAMPLE ID | START DEPTH (FT BGS) | END DEPTH (FT BGS) | SAMPLE TYPE | SAMPLE DATE | ANALYTICAL METHOD | ANALYTICAL METHODOLOGY | PARAMETER | RESULT | QUAL-IFIER | CTDEP GB PMC | 10x CTDEP GW PROTECTION CRITERIA | AWQC (FW-ACUTE) | UNITS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CB-99-01 | CB9901002XX | 0 | 2 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Barium | 48.7 |  | 10000 | 10000 | 110 | UG/L |
| CB-99-01 | CB9901002XX | 0 | 2 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Copper | 2.4 |  | 13000 | 13000 | 18 | UG/L |
| CB-99-01 | CB9901002XX | 0 | 2 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Lead | 2.8 |  | 150 | 150 | 82 | UG/L |
| CB-99-01 | CB9901002XX | 0 | 2 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Nickel | 6.1 |  | 1000 | 1000 | 1400 | UG/L |
| CB-99-01 | CB9901002XX | 0 | 2 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Zinc | 293 | J | 50000 | 50000 | 120 | UG/L |
| CB-99-03 | CB9903004XX | 2 | 4 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Arsenic | 3.9 |  | 500 | 500 | 66 | UG/L |
| CB-99-03 | CB9903006XX | 4 | 6 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Arsenic | 5.7 |  | 500 | 500 | 66 | UG/L |
| CB-99-03 | CB9903006XX | 4 | 6 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Barium | 22.4 |  | 10000 | 10000 | 110 | UG/L |
| CB-99-03 | CB9903004XX | 2 | 4 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Copper | 3.2 |  | 13000 | 13000 | 18 | UG/L |
| CB-99-03 | CB9903006XX | 4 | 6 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Copper | 8.9 |  | 13000 | 13000 | 18 | UG/L |
| CB-99-03 | CB9903006XX | 4 | 6 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Lead | 15.4 |  | 150 | 150 | 82 | UG/L |
| CB-99-03 | CB9903006XX | 4 | 6 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Nickel | 85 |  | 1000 | 1000 | 1400 | UG/L |
| CB-99-03 | CB9903004XX | 2 | 4 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Vanadium | 10 |  | 500 | 500 | 280 | UG/L |
| CB-99-03 | CB9903006XX | 4 | 6 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Vanadium | 5920 |  | 500 | 500 | 280 | UG/L |
| CB-99-15 | CB9915003XX | 1 | 3 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Barium | 8.2 |  | 10000 | 10000 | 110 | UG/L |
| CB-99-15 | CB9915003XX | 1 | 3 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Vanadium | 3.5 |  | 500 | 500 | 280 | UG/L |
| TP-99-10 | TP9910005XX | 3 | 5 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Barium | 21.3 |  | 10000 | 10000 | 110 | UG/L |
| TP-99-10 | TP9910005XX | 3 | 5 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Copper | 1.2 |  | 13000 | 13000 | 18 | UG/L |
| TP-99-10 | TP9910005XX | 3 | 5 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Vanadium | 11.7 |  | 500 | 500 | 280 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Antimony | 17 |  | 60 | 60 | 180 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Arsenic | 3.6 |  | 500 | 500 | 66 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Barium | 30.5 |  | 10000 | 10000 | 110 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Cadmium | 0.54 |  | 50 | 50 | 3.9 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Chromium | 2.9 |  | 500 | 500 | 16 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Copper | 14.9 |  | 13000 | 13000 | 18 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Lead | 25 |  | 150 | 150 | 82 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Nickel | 19.6 |  | 1000 | 1000 | 1400 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Silver | 1.2 |  | 360 | 360 | 4.1 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Vanadium | 807 |  | 500 | 500 | 280 | UG/L |
| TP-DEP-12 | TPDEP12003XX | 1 | 3 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Barium | 76.5 |  | 10000 | 10000 | 110 | UG/L |
| TP-DEP-12 | TPDEP12003XX | 1 | 3 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Copper | 3 |  | 13000 | 13000 | 18 | UG/L |
| TP-DEP-12 | TPDEP12003XX | 1 | 3 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Nickel | 94.7 |  | 1000 | 1000 | 1400 | UG/L |
| TP-DEP-12 | TPDEP12003XX | 1 | 3 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Vanadium | 1070 |  | 500 | 500 | 280 | UG/L |
| CB-99-01 | CB9901002XX | 0 | 1 | SA | May 3, 2000 | SW8260B | SPLP VOA | Acetone | 9 | J | N/A | 7000 | - | UG/L |
| CB-99-01 | CB9901002XX | 0 | 1 | SA | May 3, 2000 | SW8260B | SPLP VOA | Dichloromethane | 1 | J | N/A | 50 | - | UG/L |
| CB-99-03 | CB9903003XX | 0 | 3 | SA | May 3, 2000 | SW8260B | SPLP VOA | Acetone | 16 |  | N/A | 7000 | - | UG/L |
| CB-99-03 | CB9903003XX | 0 | 3 | SA | May 3, 2000 | SW8260B | SPLP VOA | Dichloromethane | 10 |  | N/A | 50 | - | UG/L |
| CB-99-03 | CB9903003XX | 0 | 3 | SA | May 3, 2000 | SW8260B | SPLP VOA | Tetrachloroethene | 1 | J | N/A | 50 | 5280 | UG/L |
| TP-99-10 | TP9910003XX | 0 | 3.5 | SA | May 3, 2000 | SW8260B | SPLP VOA | Acetone | 13 |  | N/A | 7000 | - | UG/L |
| TP-99-10 | TP9910003XX | 0 | 3.5 | SA | May 3, 2000 | SW8260B | SPLP VOA | Dichloromethane | 4 | J | N/A | 50 | - | UG/L |
| TP-99-10 | TP9910003XX | 0 | 3.5 | SA | May 3, 2000 | SW8260B | SPLP VOA | Trichloroethene | 1 | J | N/A | 50 | 45000 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | May 3, 2000 | SW8260B | SPLP VOA | Acetone | 13 |  | N/A | 7000 | - | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | May 3, 2000 | SW8260B | SPLP VOA | cis-1,2-Dichloroethene | 1 | J | N/A | 700 | - | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | May 3, 2000 | SW8260B | SPLP VOA | Dichloromethane | 30 |  | N/A | 50 | - | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | May 3, 2000 | SW8260B | SPLP VOA | Tetrachloroethene | 1 | J | N/A | 50 | 5280 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | May 3, 2000 | SW8260B | SPLP VOA | Trichloroethene | 7 |  | N/A | 50 | 45000 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1.5 | SA | May 3, 2000 | 6010A | SPLP Inorganics | Vanadium | 164 |  | 500 | 500 | 280 | UG/L |
| TP-DEP-12 | TPDEP12002XX | 0 | 1.5 | SA | May 3, 2000 | SW8260B | SPLP VOA | 2-Butanone | 4 | J | N/A | 4000 | - | UG/L |
| TP-DEP-12 | TPDEP12002XX | 0 | 1.5 | SA | May 3, 2000 | SW8260B | SPLP VOA | Acetone | 11 |  | N/A | 7000 | - | UG/L |
| TP-DEP-12 | TPDEP12002XX | 0 | 1.5 | SA | May 3, 2000 | SW8260B | SPLP VOA | cis-1,2-Dichloroethene | 70 |  | N/A | 700 | - | UG/L |
| TP-DEP-12 | TPDEP12002XX | 0 | 1.5 | SA | May 3, 2000 | SW8260B | SPLP VOA | Dichloromethane | 8 |  | N/A | 50 | - | UG/L |
| TP-DEP-12 | TPDEP12002XX | 0 | 1.5 | SA | May 3, 2000 | SW8260B | SPLP VOA | Tetrachloroethene | 2 | J | N/A | 50 | 5280 | UG/L |
| TP-DEP-12 | TPDEP12002XX | 0 | 1.5 | SA | May 3, 2000 | SW8260B | SPLP VOA | Toluene | 1 | J | N/A | 10000 | 17500 | UG/L |
| TP-DEP-12 | TPDEP12002XX | 0 | 1.5 | SA | May 3, 2000 | SW8260B | SPLP VOA | trans-1,2-Dichloroethene | 2 | J | N/A | 1000 | - | UG/L |
| TP-DEP-12 | TPDEP12002XX | 0 | 1.5 | SA | May 3, 2000 | SW8260B | SPLP VOA | Trichloroethene | 160 |  | N/A | 50 | 45000 | UG/L |
| TP-DEP-12 | TPDEP12002XX | 0 | 1.5 | SA | May 3, 2000 | SW8260B | SPLP VOA | Vinyl Chloride | 35 |  | N/A | 20 | - | UG/L |

# TABLE F-1
# DETECTED ANALYTES - SPLP SAMPLING AND ANLYSES
# CAUSEWAY SOILS

## STRATFORD ARMY ENGINE PLANT
## STRATFORD, CONNECTICUT

| LOCATION ID | SAMPLE ID | START DEPTH (FT,BGS) | END DEPTH (FT,BGS) | SAMPLE TYPE | SAMPLE DATE | ANALYTICAL METHOD | ANALYTICAL METHODOLOGY | PARAMETER | RESULT | QUAL-IFIER | CTDEP GB PMC | 10x CTDEP GW PROTECTION CRITERIA | AWQC (FW-ACUTE) | UNITS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CB-99-15E | CB991502EXX | 0 | 2 | SA | September 14, 2000 | SW8270C | SPLP SVOA | Anthracene | 0.03 | J | N/A | 20000 | - | UG/L |
| CB-99-15S | CB991502SXX | 0 | 2 | SA | September 14, 2000 | SW8270C | SPLP SVOA | Carbazole | 0.052 | J | N/A | - | - | UG/L |
| CB-99-15S | CB991502SXX | 0 | 2 | SA | September 14, 2000 | SW8270C | SPLP SVOA | Naphthalene | 0.051 | J | N/A | 2800 | 2300 | UG/L |
| CB-99-15S | CB991502SXX | 0 | 2 | SA | September 14, 2000 | SW8270C | SPLP SVOA | Phenanthrene | 0.046 | J | N/A | 2000 | 30 | UG/L |
| TP-99-10E | TP991002EXX | 0 | 2 | SA | September 14, 2000 | SW8270C | SPLP SVOA | Fluoranthene | 0.043 | J | N/A | 2800 | 3980 | UG/L |
| TP-99-10E | TP991002EXX | 0 | 2 | SA | September 14, 2000 | SW8270C | SPLP SVOA | Phenanthrene | 0.061 | J | N/A | 2000 | 30 | UG/L |
| TP-99-10N | TP991002NXX | 0 | 2 | SA | September 14, 2000 | SW8270C | SPLP SVOA | Fluoranthene | 0.03 | J | N/A | 2800 | 3980 | UG/L |
| TP-99-10N | TP991002NXX | 0 | 2 | SA | September 14, 2000 | SW8270C | SPLP SVOA | Phenanthrene | 0.037 | J | N/A | 2000 | 30 | UG/L |
| TP-99-10S | TP991001SXX | 0 | 1 | SA | September 14, 2000 | SW8270C | SPLP SVOA | Benzo[a]anthracene | 0.026 | J | N/A | 0.6 | - | UG/L |
| TP-99-10S | TP991001SXX | 0 | 1 | SA | September 14, 2000 | SW8270C | SPLP SVOA | Carbazole | 0.041 | J | N/A | - | - | UG/L |
| TP-99-10S | TP991001SXX | 0 | 1 | SA | September 14, 2000 | SW8270C | SPLP SVOA | Fluoranthene | 0.062 | J | N/A | 2800 | 3980 | UG/L |
| TP-99-10S | TP991001SXX | 0 | 1 | SA | September 14, 2000 | SW8270C | SPLP SVOA | Phenanthrene | 0.095 | J | N/A | 2000 | 30 | UG/L |
| TP-99-10S | TP991001SXX | 0 | 1 | SA | September 14, 2000 | SW8270C | SPLP SVOA | Pyrene | 0.041 | J | N/A | 2000 | - | UG/L |
| TP-DEP-11 | TPDEP11012D | 10 | 12 | DU | September 14, 2000 | SW6010B | SPLP Inorganics | Vanadium | 338 |  | 500 | 500 | 280 | UG/L |
| TP-DEP-11 | TPDEP11012X | 10 | 12 | SA | September 14, 2000 | SW6010B | SPLP Inorganics | Vanadium | 223 |  | 500 | 500 | 280 | UG/L |
| TP-DEP-12 | TPDEP12022X | 0 | 2 | SA | September 14, 2000 | SW6010B | SPLP Inorganics | Vanadium | 391 |  | 500 | 500 | 280 | UG/L |
| TP-DEP-12E | TPDEP12022E | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | 2-Butanone | 4.4 | J B | N/A | 4000 | - | UG/L |
| TP-DEP-12E | TPDEP12022E | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | Tetrachloroethene | 2.4 | J | N/A | 50 | 5280 | UG/L |
| TP-DEP-12E | TPDEP12022E | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | Trichloroethene | 14 |  | N/A | 50 | 45000 | UG/L |
| TP-DEP-12N | TPDEP12022N | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | 1,2-Dichloroethylenes (cis and trans) | 3.2 | J | N/A | 700 | 11600 | UG/L |
| TP-DEP-12N | TPDEP12022N | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | 2-Butanone | 4.5 | J B | N/A | 4000 | - | UG/L |
| TP-DEP-12N | TPDEP12022N | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | Acetone | 3.9 | J B | N/A | 7000 | - | UG/L |
| TP-DEP-12N | TPDEP12022N | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | Tetrachloroethene | 3.2 | J | N/A | 50 | 5280 | UG/L |
| TP-DEP-12N | TPDEP12022N | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | Trichloroethene | 16 |  | N/A | 50 | 45000 | UG/L |
| TP-DEP-12S | TPDEP12022S | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | 2-Butanone | 4.8 | J B | N/A | 4000 | - | UG/L |
| TP-DEP-12S | TPDEP12022S | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | Acetone | 4.5 | J B | N/A | 7000 | - | UG/L |
| TP-DEP-12W | TPDEP12022W | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | 2-Butanone | 4.2 | J B | N/A | 4000 | - | UG/L |
| TP-DEP-12W | TPDEP1202WD | 0 | 2 | DU | September 14, 2000 | SW8260B | SPLP VOA | 2-Butanone | 4.5 | J B | N/A | 4000 | - | UG/L |
| TP-DEP-12W | TPDEP12022W | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | Acetone | 3.7 | J B | N/A | 7000 | - | UG/L |
| TP-DEP-12W | TPDEP1202WD | 0 | 2 | DU | September 14, 2000 | SW8260B | SPLP VOA | Acetone | 4.3 | J B | N/A | 7000 | - | UG/L |
| TP-DEP-12W | TPDEP12022W | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | Tetrachloroethene | 15 |  | N/A | 50 | 5280 | UG/L |
| TP-DEP-12W | TPDEP1202WD | 0 | 2 | DU | September 14, 2000 | SW8260B | SPLP VOA | Tetrachloroethene | 15 |  | N/A | 50 | 5280 | UG/L |
| TP-DEP-12W | TPDEP12022W | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | Trichloroethene | 2.2 | J | N/A | 50 | 45000 | UG/L |
| TP-DEP-12W | TPDEP1202WD | 0 | 2 | DU | September 14, 2000 | SW8260B | SPLP VOA | Trichloroethene | 2.5 | J | N/A | 50 | 45000 | UG/L |

NOTES: Shaded values indicate exceedances of: 1) the CTDEP Pollutant Mobility Criteria (PMC) for a GB aquifer, 2) 10 x the CTDEP Groundwater Protection Criteria, or 3) the USEPA Ambient Water Quality Criteria (AWQC) - Freshwater, Acute values

- = no published AWQC value
AWQC = USEPA Ambient Water Quality Criteria
B = parameter detected in laboratory method blank
CTDEP = Connecticut Department of Environmental Protection
DU = duplicate sample result
FT,BGS = feet below ground surface
GB PMC = CTDEP Pollutant Mobility Criteria for a GB-classified (industrial/commercial) aquifer
GW = groundwater
J = estimated value
N/A = not applicable (CTDEP GB PMC criteria for VOA and SVOA parameters must be compared against results for mass/mass analyses)
SA = original sample result
SPLP = synthetic precipitate leaching procedure
SVOA = semivolatile organic analysis
VOA = volatile organic analysis

# TABLE F-1
# DETECTED ANALYTES - SPLP SAMPLING AND ANLYSES
# CAUSEWAY SOILS

## STRATFORD ARMY ENGINE PLANT
## STRATFORD, CONNECTICUT

| LOCATION ID | SAMPLE ID | START DEPTH (FT BGS) | END DEPTH (FT BGS) | SAMPLE TYPE | SAMPLE DATE | ANALYTICAL METHOD | ANALYTICAL METHODOLOGY | PARAMETER | RESULT | QUAL-IFIER | HIT | CTDEP GB PMC | 10x CTDEP GW PROTECTION CRITERIA | AWQC (FW-ACUTE) | UNITS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CB-99-01 | CB9901002XX | 0 | 2 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Barium | 48.7 |  | 1 | 10000 | 10000 | 110 | UG/L |
| CB-99-01 | CB9901002XX | 0 | 2 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Copper | 2.4 |  | 1 | 13000 | 13000 | 18 | UG/L |
| CB-99-01 | CB9901002XX | 0 | 2 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Lead | 2.8 |  | 1 | 150 | 150 | 82 | UG/L |
| CB-99-01 | CB9901002XX | 0 | 2 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Nickel | 6.1 |  | 1 | 1000 | 1000 | 1400 | UG/L |
| CB-99-01 | CB9901002XX | 0 | 2 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Zinc | 293 | J | 1 | 50000 | 50000 | 120 | UG/L |
| CB-99-03 | CB9903004XX | 2 | 4 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Arsenic | 3.9 |  | 1 | 500 | 500 | 66 | UG/L |
| CB-99-03 | CB9903006XX | 4 | 6 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Arsenic | 5.7 |  | 1 | 500 | 500 | 66 | UG/L |
| CB-99-03 | CB9903006XX | 4 | 6 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Barium | 22.4 |  | 1 | 10000 | 10000 | 110 | UG/L |
| CB-99-03 | CB9903004XX | 2 | 4 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Copper | 3.2 |  | 1 | 13000 | 13000 | 18 | UG/L |
| CB-99-03 | CB9903006XX | 4 | 6 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Copper | 8.9 |  | 1 | 13000 | 13000 | 18 | UG/L |
| CB-99-03 | CB9903006XX | 4 | 6 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Lead | 15.4 |  | 1 | 150 | 150 | 82 | UG/L |
| CB-99-03 | CB9903006XX | 4 | 6 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Nickel | 85 |  | 1 | 1000 | 1000 | 1400 | UG/L |
| CB-99-03 | CB9903004XX | 2 | 4 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Vanadium | 10 |  | 1 | 500 | 500 | 280 | UG/L |
| CB-99-03 | CB9903006XX | 4 | 6 | SA | September 20, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Vanadium | 5920 |  | 1 | 500 | 500 | 280 | UG/L |
| CB-99-15 | CB9915003XX | 1 | 3 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Barium | 8.2 |  | 1 | 10000 | 10000 | 110 | UG/L |
| CB-99-15 | CB9915003XX | 1 | 3 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Vanadium | 3.5 |  | 1 | 500 | 500 | 280 | UG/L |
| TP-99-10 | TP9910005XX | 3 | 5 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Barium | 21.3 |  | 1 | 10000 | 10000 | 110 | UG/L |
| TP-99-10 | TP9910005XX | 3 | 5 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Copper | 1.2 |  | 1 | 13000 | 13000 | 18 | UG/L |
| TP-99-10 | TP9910005XX | 3 | 5 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Vanadium | 11.7 |  | 1 | 500 | 500 | 280 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Antimony | 17 |  | 1 | 60 | 60 | 180 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Arsenic | 3.6 |  | 1 | 500 | 500 | 66 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Barium | 30.5 |  | 1 | 10000 | 10000 | 110 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Cadmium | 0.54 |  | 1 | 50 | 50 | 3.9 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Chromium | 2.9 |  | 1 | 500 | 500 | 16 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Copper | 14.9 |  | 1 | 13000 | 13000 | 18 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Lead | 25 |  | 1 | 150 | 150 | 82 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Nickel | 19.6 |  | 1 | 1000 | 1000 | 1400 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Silver | 1.2 |  | 1 | 360 | 360 | 4.1 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Vanadium | 807 |  | 1 | 500 | 500 | 280 | UG/L |
| TP-DEP-12 | TPDEP12003XX | 1 | 3 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Barium | 76.5 |  | 1 | 10000 | 10000 | 110 | UG/L |
| TP-DEP-12 | TPDEP12003XX | 1 | 3 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Copper | 3 |  | 1 | 13000 | 13000 | 18 | UG/L |
| TP-DEP-12 | TPDEP12003XX | 1 | 3 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Nickel | 94.7 |  | 1 | 1000 | 1000 | 1400 | UG/L |
| TP-DEP-12 | TPDEP12003XX | 1 | 3 | SA | September 21, 1999 | EPA 1312/SW846 6010B | SPLP Inorganics | Vanadium | 1070 |  | 1 | 500 | 500 | 280 | UG/L |
| CB-99-01 | CB9901002XX | 0 | 1 | SA | May 3, 2000 | SW8260B | SPLP VOA | Acetone | 9 | J | 1 | N/A | 7000 | - | UG/L |
| CB-99-01 | CB9901002XX | 0 | 1 | SA | May 3, 2000 | 8260B | SPLP VOA | Bromofluorobenzene | 50 |  | 1 | N/A | - | - | UG/L |
| CB-99-01 | CB9901002XX | 0 | 1 | SA | May 3, 2000 | SW8260B | SPLP VOA | Dichloromethane | 1 | J | 1 | N/A | 50 | - | UG/L |
| CB-99-03 | CB9903003XX | 0 | 3 | SA | May 3, 2000 | SW8260B | SPLP VOA | Acetone | 16 |  | 1 | N/A | 7000 | - | UG/L |
| CB-99-03 | CB9903003XX | 0 | 3 | SA | May 3, 2000 | 8260B | SPLP VOA | Bromofluorobenzene | 51 |  | 1 | N/A | - | - | UG/L |
| CB-99-03 | CB9903003XX | 0 | 3 | SA | May 3, 2000 | SW8260B | SPLP VOA | Dichloromethane | 10 |  | 1 | N/A | 50 | - | UG/L |
| CB-99-03 | CB9903003XX | 0 | 3 | SA | May 3, 2000 | SW8260B | SPLP VOA | Tetrachloroethene | 1 | J | 1 | N/A | 50 | 5280 | UG/L |
| CB-99-15 | CB9915002XX -RE1 | 0 | 2 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | 2-Methylnaphthalene | 0.66 | J | 1 | N/A | - | - | UG/L |
| CB-99-15 | CB9915002XX -RE1 | 0 | 2 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Acenaphthene | 3.6 | J | 1 | N/A | - | 80 | UG/L |
| CB-99-15 | CB9915002XX -RE1 | 0 | 2 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Acenaphthylene | 0.18 | J | 1 | N/A | 4200 | - | UG/L |
| CB-99-15 | CB9915002XX -RE1 | 0 | 2 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Anthracene | 6.6 |  | 1 | N/A | 20000 | - | UG/L |
| CB-99-15 | CB9915002XX -RE1 | 0 | 2 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Benzo (a) anthracene | 8.4 |  | 1 | N/A | 0.6 | - | UG/L |
| CB-99-15 | CB9915002XX -RE1 | 0 | 2 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Benzo (a) pyrene | 6.9 |  | 1 | N/A | 2 | 0.24 | UG/L |
| CB-99-15 | CB9915002XX -RE1 | 0 | 2 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Benzo (b) flouranthene | 7 |  | 1 | N/A | 0.8 | - | UG/L |
| CB-99-15 | CB9915002XX -RE1 | 0 | 2 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Benzo (ghi) perylene | 4.8 |  | 1 | N/A | - | - | UG/L |
| CB-99-15 | CB9915002XX -RE1 | 0 | 2 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Benzo (k) flouranthene | 5.1 |  | 1 | N/A | 5 | - | UG/L |
| CB-99-15 | CB9915002XX -RE1 | 0 | 2 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Carbazole | 8.1 |  | 1 | N/A | - | - | UG/L |
| CB-99-15 | CB9915002XX -RE1 | 0 | 2 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Chrysene | 8.4 |  | 1 | N/A | - | - | UG/L |
| CB-99-15 | CB9915002XX -RE1 | 0 | 2 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Dibenzo (a,h) anthracene | 1.9 |  | 1 | N/A | - | - | UG/L |
| CB-99-15 | CB9915002XX -RE1 | 0 | 2 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Fluoranthene | 29 |  | 1 | N/A | 2800 | 33.6 | UG/L |
| CB-99-15 | CB9915002XX -RE1 | 0 | 2 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Fluorene | 5 |  | 1 | N/A | 2800 | 70 | UG/L |
| CB-99-15 | CB9915002XX -RE1 | 0 | 2 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Indeno (1,2,3-cd) pyrene | 4.5 |  | 1 | N/A | - | - | UG/L |

# TABLE F-1
# DETECTED ANALYTES - SPLP SAMPLING AND ANLYSES
# CAUSEWAY SOILS

## STRATFORD ARMY ENGINE PLANT
## STRATFORD, CONNECTICUT

| LOCATION ID | SAMPLE ID | START DEPTH (FT,BGS) | END DEPTH (FT,BGS) | SAMPLE TYPE | SAMPLE DATE | ANALYTICAL METHOD | ANALYTICAL METHODOLOGY | PARAMETER | RESULT | QUALIFIER | HIT | CTDEP GB PMC | 10x CTDEP GW PROTECTION CRITERIA | AWQC (FW-ACUTE) | UNITS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CB-99-15 | CB9915002XX -RE1 | 0 | 2 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Naphthalene | 1.3 | J | 1 | N/A | 2800 | 2300 | UG/L |
| CB-99-15 | CB9915002XX -RE1 | 0 | 2 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Phenanthrene | 24 |  | 1 | N/A | 2000 | 30 | UG/L |
| CB-99-15 | CB9915002XX -RE1 | 0 | 2 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Pyrene | 19 |  | 1 | N/A | 2000 | - | UG/L |
| TP-99-10 | TP9910003XX | 3 | 3.5 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | 2-Methylnaphthalene | 1.2 |  | 1 | N/A | - | - | UG/L |
| TP-99-10 | TP9910003XX | 3 | 3.5 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Acenaphthene | 0.46 | J | 1 | N/A | - | 80 | UG/L |
| TP-99-10 | TP9910003XX | 3 | 3.5 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Acenaphthylene | 1.6 |  | 1 | N/A | 4200 | - | UG/L |
| TP-99-10 | TP9910003XX | 0 | 3.5 | SA | May 3, 2000 | SW8260B | SPLP VOA | Acetone | 13 |  | 1 | N/A | 7000 | - | UG/L |
| TP-99-10 | TP9910003XX | 3 | 3.5 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Anthracene | 1.6 |  | 1 | N/A | 20000 | - | UG/L |
| TP-99-10 | TP9910003XX | 3 | 3.5 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Benzo (a) anthracene | 3.1 |  | 1 | N/A | 0.6 | - | UG/L |
| TP-99-10 | TP9910003XX | 3 | 3.5 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Benzo (a) pyrene | 3.1 |  | 1 | N/A | 2 | 0.24 | UG/L |
| TP-99-10 | TP9910003XX | 3 | 3.5 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Benzo (b) flouranthene | 2.7 |  | 1 | N/A | 0.8 | - | UG/L |
| TP-99-10 | TP9910003XX | 3 | 3.5 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Benzo (ghi) perylene | 2.6 |  | 1 | N/A | - | - | UG/L |
| TP-99-10 | TP9910003XX | 3 | 3.5 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Benzo (k) flouranthene | 2.3 |  | 1 | N/A | 5 | - | UG/L |
| TP-99-10 | TP9910003XX | 3 | 3.5 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Carbazole | 1.4 |  | 1 | N/A | - | - | UG/L |
| TP-99-10 | TP9910003XX | 3 | 3.5 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Chrysene | 3.2 |  | 1 | N/A | - | - | UG/L |
| TP-99-10 | TP9910003XX | 3 | 3.5 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Dibenzo (a,h) anthracene | 0.71 |  | 1 | N/A | - | - | UG/L |
| TP-99-10 | TP9910003XX | 0 | 3.5 | SA | May 3, 2000 | SW8260B | SPLP VOA | Dichloromethane | 4 | J | 1 | N/A | 50 | - | UG/L |
| TP-99-10 | TP9910003XX | 3 | 3.5 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Fluoranthene | 9.2 |  | 1 | N/A | 2800 | 33.6 | UG/L |
| TP-99-10 | TP9910003XX | 3 | 3.5 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Fluorene | 1.6 |  | 1 | N/A | 2800 | 70 | UG/L |
| TP-99-10 | TP9910003XX | 3 | 3.5 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Indeno (1,2,3-cd) pyrene | 2.1 |  | 1 | N/A | - | - | UG/L |
| TP-99-10 | TP9910003XX | 3 | 3.5 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Naphthalene | 6.8 |  | 1 | N/A | 2800 | 2300 | UG/L |
| TP-99-10 | TP9910003XX | 3 | 3.5 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Phenanthrene | 7.7 |  | 1 | N/A | 2000 | 30 | UG/L |
| TP-99-10 | TP9910003XX | 3 | 3.5 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Pyrene | 7.1 |  | 1 | N/A | 2000 | - | UG/L |
| TP-99-10 | TP9910003XX | 0 | 3.5 | SA | May 3, 2000 | SW8260B | SPLP VOA | Trichloroethene | 1 | J | 1 | N/A | 50 | 45000 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0.5 | 1 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | 2-Methylnaphthalene | 0.08 | J | 1 | N/A | - | - | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0.5 | 1 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Acenaphthene | 0.063 | J | 1 | N/A | - | 80 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | May 3, 2000 | SW8260B | SPLP VOA | Acetone | 13 |  | 1 | N/A | 7000 | - | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0.5 | 1 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Anthracene | 0.089 | 1 | 1 | N/A | 20000 | - | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0.5 | 1 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Benzo (a) anthracene | 0.072 | J | 1 | N/A | 0.6 | - | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0.5 | 1 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Benzo (a) pyrene | 0.054 | J | 1 | N/A | 2 | 0.24 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0.5 | 1 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Benzo (b) flouranthene | 0.06 | J | 1 | N/A | 0.8 | - | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0.5 | 1 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Benzo (ghi) perylene | 0.048 | J | 1 | N/A | - | - | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0.5 | 1 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Benzo (k) flouranthene | 0.052 | J | 1 | N/A | 5 | - | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | May 3, 2000 | 8260B | SPLP VOA | Bromofluorobenzene | 53 |  | 1 | N/A | - | - | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0.5 | 1 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Carbazole | 0.11 | J | 1 | N/A | - | - | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0.5 | 1 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Chrysene | 0.072 | J | 1 | N/A | - | - | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | May 3, 2000 | SW8260B | SPLP VOA | cis-1,2-Dichloroethene | 1 | J | 1 | N/A | 700 | - | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | May 3, 2000 | SW8260B | SPLP VOA | Dichloromethane | 30 |  | 1 | N/A | 50 | - | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0.5 | 1 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Fluoranthene | 0.31 |  | 1 | N/A | 2800 | 33.6 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0.5 | 1 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Fluorene | 0.075 | J | 1 | N/A | 2800 | 70 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0.5 | 1 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Indeno (1,2,3-cd) pyrene | 0.04 | J | 1 | N/A | - | - | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0.5 | 1 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Naphthalene | 0.11 | J | 1 | N/A | 2800 | 2300 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0.5 | 1 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Phenanthrene | 0.42 |  | 1 | N/A | 2000 | 30 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0.5 | 1 | SA | May 3, 2000 | SW-846 8270C | SPLP SVOA | Pyrene | 0.2 |  | 1 | N/A | 2000 | - | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | May 3, 2000 | SW8260B | SPLP VOA | Tetrachloroethene | 1 | J | 1 | N/A | 50 | 5280 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1 | SA | May 3, 2000 | SW8260B | SPLP VOA | Trichloroethene | 7 |  | 1 | N/A | 50 | 45000 | UG/L |
| TP-DEP-11 | TPDEP11001XX | 0 | 1.5 | SA | May 3, 2000 | 6010A | SPLP Inorganics | Vanadium | 164 |  | 1 | 500 | 500 | 280 | UG/L |
| TP-DEP-12 | TPDEP12002XX | 0 | 1.5 | SA | May 3, 2000 | SW8260B | SPLP VOA | 2-Butanone | 4 | J | 1 | N/A | 4000 | - | UG/L |
| TP-DEP-12 | TPDEP12002XX | 0 | 1.5 | SA | May 3, 2000 | SW8260B | SPLP VOA | Acetone | 11 |  | 1 | N/A | 7000 | - | UG/L |
| TP-DEP-12 | TPDEP12002XX | 0 | 1.5 | SA | May 3, 2000 | 8260B | SPLP VOA | Bromofluorobenzene | 57 |  | 1 | N/A | - | - | UG/L |
| TP-DEP-12 | TPDEP12002XX | 0 | 1.5 | SA | May 3, 2000 | SW8260B | SPLP VOA | cis-1,2-Dichloroethene | 70 |  | 1 | N/A | 700 | - | UG/L |
| TP-DEP-12 | TPDEP12002XX | 0 | 1.5 | SA | May 3, 2000 | SW8260B | SPLP VOA | Dichloromethane | 8 |  | 1 | N/A | 50 | - | UG/L |
| TP-DEP-12 | TPDEP12002XX | 0 | 1.5 | SA | May 3, 2000 | SW8260B | SPLP VOA | Tetrachloroethene | 2 | J | 1 | N/A | 50 | 5280 | UG/L |
| TP-DEP-12 | TPDEP12002XX | 0 | 1.5 | SA | May 3, 2000 | SW8260B | SPLP VOA | Toluene | 1 | J | 1 | N/A | 10000 | 17500 | UG/L |
| TP-DEP-12 | TPDE[illegible]002XX | 0 | 1.5 | SA | May 3, 2000 | SW8260B | SPLP VOA | trans-1,2-Dichloroethene | 2 | J | 1 | N/A | 1000 | - | UG/L |

# T. E F-1
# DETECTED ANALYTES - SPLP SAMPLING AND ANLYSES
# CAUSEWAY SOILS

## STRATFORD ARMY ENGINE PLANT
## STRATFORD, CONNECTICUT

| LOCATION ID | SAMPLE ID | START DEPTH (FT,BGS) | END DEPTH (FT,BGS) | SAMPLE TYPE | SAMPLE DATE | ANALYTICAL METHOD | ANALYTICAL METHODOLOGY | PARAMETER | RESULT | QUAL-IFIER | HIT | CTDEP GB PMC | 10x CTDEP GW PROTECTION CRITERIA | AWQC (FW-ACUTE) | UNITS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TP-DEP-12 | TPDEP12002XX | 0 | 1.5 | SA | May 3, 2000 | SW8260B | SPLP VOA | Trichloroethene | 160 | | 1 | N/A | 50 | 45000 | UG/L |
| TP-DEP-12 | TPDEP12002XX | 1.5 | 2 | SA | May 3, 2000 | 6010A | SPLP Inorganics | Vanadium | 415 | | 1 | 500 | 500 | 280 | UG/L |
| TP-DEP-12 | TPDEP12002XX | 0 | 1.5 | SA | May 3, 2000 | SW8260B | SPLP VOA | Vinyl Chloride | 35 | | 1 | N/A | 20 | - | UG/L |
| CB-99-15E | CB991502EXX | 0 | 2 | SA | September 14, 2000 | SW8270C | SPLP SVOA | Anthracene | 0.03 | J | 1 | N/A | 20000 | - | UG/L |
| CB-99-15S | CB991502SXX | 0 | 2 | SA | September 14, 2000 | SW8270C | SPLP SVOA | Carbazole | 0.052 | J | 1 | N/A | - | - | UG/L |
| CB-99-15S | CB991502SXX | 0 | 2 | SA | September 14, 2000 | SW8270C | SPLP SVOA | Naphthalene | 0.051 | J | 1 | N/A | 2800 | 2300 | UG/L |
| CB-99-15S | CB991502SXX | 0 | 2 | SA | September 14, 2000 | SW8270C | SPLP SVOA | Phenanthrene | 0.046 | J | 1 | N/A | 2000 | 30 | UG/L |
| TP-99-10E | TP991002EXX | 0 | 2 | SA | September 14, 2000 | SW8270C | SPLP SVOA | Fluoranthene | 0.043 | J | 1 | N/A | 2800 | 33.6 | UG/L |
| TP-99-10E | TP991002EXX | 0 | 2 | SA | September 14, 2000 | SW8270C | SPLP SVOA | Phenanthrene | 0.061 | J | 1 | N/A | 2000 | 30 | UG/L |
| TP-99-10N | TP991002NXX | 0 | 2 | SA | September 14, 2000 | SW8270C | SPLP SVOA | Fluoranthene | 0.03 | J | 1 | N/A | 2800 | 33.6 | UG/L |
| TP-99-10N | TP991002NXX | 0 | 2 | SA | September 14, 2000 | SW8270C | SPLP SVOA | Phenanthrene | 0.037 | J | 1 | N/A | 2000 | 30 | UG/L |
| TP-99-10S | TP991001SXX | 0 | 1 | SA | September 14, 2000 | SW8270C | SPLP SVOA | Benzo (a) anthracene | 0.026 | J | 1 | N/A | 6 | - | UG/L |
| TP-99-10S | TP991001SXX | 0 | 1 | SA | September 14, 2000 | SW8270C | SPLP SVOA | Carbazole | 0.041 | J | 1 | N/A | - | - | UG/L |
| TP-99-10S | TP991001SXX | 0 | 1 | SA | September 14, 2000 | SW8270C | SPLP SVOA | Fluoranthene | 0.062 | J | 1 | N/A | 2800 | 33.6 | UG/L |
| TP-99-10S | TP991001SXX | 0 | 1 | SA | September 14, 2000 | SW8270C | SPLP SVOA | Phenanthrene | 0.095 | J | 1 | N/A | 2000 | 30 | UG/L |
| TP-99-10S | TP991001SXX | 0 | 1 | SA | September 14, 2000 | SW8270C | SPLP SVOA | Pyrene | 0.041 | J | 1 | N/A | 2000 | - | UG/L |
| TP-DEP-11 | TPDEP11012X | 10 | 12 | SA | September 14, 2000 | SW6010B | SPLP Inorganics | Vanadium | 223 | | 1 | 500 | 500 | 280 | UG/L |
| TP-DEP-11 | TPDEP11012D | 10 | 12 | DU | September 14, 2000 | SW6010B | SPLP Inorganics | Vanadium | 338 | | 1 | 500 | 500 | 280 | UG/L |
| TP-DEP-12 | TPDEP12022X | 0 | 2 | SA | September 14, 2000 | SW6010B | SPLP Inorganics | Vanadium | 391 | | 1 | 500 | 500 | 280 | UG/L |
| TP-DEP-12E | TPDEP12022E | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | 2-Butanone | 4.4 | J B | 1 | N/A | 4000 | - | UG/L |
| TP-DEP-12E | TPDEP12022E | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | Tetrachloroethene | 2.4 | J | 1 | N/A | 50 | 5280 | UG/L |
| TP-DEP-12E | TPDEP12022E | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | Trichloroethene | 14 | | 1 | N/A | 50 | 45000 | UG/L |
| TP-DEP-12N | TPDEP12022N | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | 1,2-Dichloroethylenes (cis | 3.2 | J | 1 | N/A | 700 | 11600 | UG/L |
| TP-DEP-12N | TPDEP12022N | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | 2-Butanone | 4.5 | J B | 1 | N/A | 4000 | - | UG/L |
| TP-DEP-12N | TPDEP12022N | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | Acetone | 3.9 | J B | 1 | N/A | 7000 | - | UG/L |
| TP-DEP-12N | TPDEP12022N | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | Tetrachloroethene | 3.2 | J | 1 | N/A | 50 | 5280 | UG/L |
| TP-DEP-12N | TPDEP12022N | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | Trichloroethene | 16 | | 1 | N/A | 50 | 45000 | UG/L |
| TP-DEP-12S | TPDEP12022S | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | 2-Butanone | 4.8 | J B | 1 | N/A | 4000 | - | UG/L |
| TP-DEP-12S | TPDEP12022S | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | Acetone | 4.5 | J B | 1 | N/A | 7000 | - | UG/L |
| TP-DEP-12W | TPDEP12022W | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | 2-Butanone | 4.2 | J B | 1 | N/A | 4000 | - | UG/L |
| TP-DEP-12W | TPDEP1202WD | 0 | 2 | DU | September 14, 2000 | SW8260B | SPLP VOA | 2-Butanone | 4.5 | J B | 1 | N/A | 4000 | - | UG/L |
| TP-DEP-12W | TPDEP12022W | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | Acetone | 3.7 | J B | 1 | N/A | 7000 | - | UG/L |
| TP-DEP-12W | TPDEP1202WD | 0 | 2 | DU | September 14, 2000 | SW8260B | SPLP VOA | Acetone | 4.3 | J B | 1 | N/A | 7000 | - | UG/L |
| TP-DEP-12W | TPDEP12022W | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | Tetrachloroethene | 15 | | 1 | N/A | 50 | 5280 | UG/L |
| TP-DEP-12W | TPDEP1202WD | 0 | 2 | DU | September 14, 2000 | SW8260B | SPLP VOA | Tetrachloroethene | 15 | | 1 | N/A | 50 | 5280 | UG/L |
| TP-DEP-12W | TPDEP12022W | 0 | 2 | SA | September 14, 2000 | SW8260B | SPLP VOA | Trichloroethene | 2.2 | J | 1 | N/A | 50 | 45000 | UG/L |
| TP-DEP-12W | TPDEP1202WD | 0 | 2 | DU | September 14, 2000 | SW8260B | SPLP VOA | Trichloroethene | 2.5 | J | 1 | N/A | 50 | 45000 | UG/L |

**NOTES:** Shaded values indicate exceedances of: 1) the CTDEP Pollutant Mobility Criteria (PMC) for a GB aquifer, 2) 10 x the CTDEP Groundwater Protection Criteria, or 3) the USEPA Ambient Water Quality Criteria (AWQC) - Freshwater, Acute values

- = no published AWQC value
AWQC = USEPA Ambient Water Quality Criteria
B = parameter detected in laboratory method blank
CTDEP = Connecticut Department of Environmental Protection
DU = duplicate sample result
FT,BGS = feet below ground surface
GB PMC = CTDEP Pollutant Mobility Criteria for a GB-classified (industrial/commercial) aquifer
GW = groundwater
J = estimated value
N/A = not applicable (CTDEP GB PMC criteria for VOA and SVOA parameters must be compared against results for mass/mass analyses)
SA = original sample result
SPLP = synthetic precipitate leaching procedure
SVOA = semivolatile organic analysis
VOA = volatile organic analysis

## TABLE F-2
## OFF-SITE ANALYTICAL SPLP SAMPLING
## SEPTEMBER 14, 2000

## CAUSEWAY AND DIKE NON-TIME CRITICAL REMOVAL ACTION
## STRATFORD ARMY ENGINE PLANT
## STRATFORD, CONNECTICUT

| EXPLORATION LOCATION | SAMPLE DEPTH (feet bgs) | ANALYTICAL PARAMETER AND METHOD |
|---|---|---|
| CB-99-15N (10' north of CB-99-15) | 1' – 3' | SPLP for SVOCs by 1312/Modified8270 SIM |
| CB-99-15E (10' east of CB-99-15) | 1' – 3' | SPLP for SVOCs by 1312/Modified8270 SIM |
| CB-99-15S (10' south of CB-99-15) | 1' – 3' | SPLP for SVOCs by 1312/Modified8270 SIM |
| CB-99-15W (10' west of CB-99-15) | 1' – 3' | SPLP for SVOCs by 1312/Modified8270 SIM |
| TP-99-10N (10' north of TP-99-10) | 3' – 4.5' | SPLP for SVOCs by 1312/Modified 8270 SIM |
| TP-99-10E (10' east of TP-99-10) | 3' – 4.5' | SPLP for SVOCs by 1312/Modified 8270 SIM |
| TP-99-10S (10' south of TP-99-10) | 3' – 4.5' | SPLP for SVOCs by 1312/Modified 8270 SIM |
| TP-DEP-11 | 0' – 1' | SPLP for Vanadium by 1312/6010B |
| TP-DEP-12N (10' north of TP-DEP-12) | 1' – 3' | SPLP for VOCs by 1312/8260B<br>SPLP for Vanadium by 1312/6010B |
| TP-DEP-12E (10' east of TP-DEP-12) | 1' – 3' | SPLP for VOCs by 1312/8260B<br>SPLP for Vanadium by 1312/6010B |
| TP-DEP-12S (10' south of TP-DEP-12) | 1' – 3' | SPLP for VOCs by 1312/8260B<br>SPLP for Vanadium by 1312/6010B |
| TP-DEP-12W (10' west of TP-DEP-12) | 1' – 3' | SPLP for VOCs by 1312/8260B<br>SPLP for Vanadium by 1312/6010B |

Notes:

SIM = Selective Ion Monitoring
SPLP = Synthetic Precipitation Leaching Procedure
SVOC = Semivolatile Organic Compounds
VOC = Volatile Organic Compounds

Analytical methods are from USEPA SW0846 "Test Methods for Evaluating Solid Waste Chemical/Physical Methods", SW-846, Final Update III, revised 1993, or more recent edition unless otherwise indicated.

# ATTACHMENT A

# ADDENDUM TO FINAL CAUSEWAY AND DIKE PRE-DESIGN INVESTIGATION REPORT

**Harding Lawson Associates**

HLA

May 26, 2000

Ms. Michelle Brock
U.S. Army Corps of Engineers
New England District
696 Virginia Road
Concord, MA 01742-2751

**Subject:** **USACE CONTRACT NO. DACW33-94-D-0002**
**TASK ORDER NO. 020**
**TOTAL ENVIRONMENTAL RESTORATION CONTRACT**
**ADDENDUM TO FINAL CAUSEWAY AND DIKE PRE-DESIGN INVESTIGATION REPORT**
**STRATFORD ARMY ENGINE PLANT**

Dear Ms. Brock,

Enclosed for your review is the Addendum to the Causeway and Dike Pre-Design Investigation Report that discusses the results of the SPLP sampling recently conducted on the Causeway. Please review and provide comments by June 1, 2000. Comments will be incorporated into an Addendum for USEPA and CTDEP review.

Please feel free to call me at (207) 775-5401 x3637 if you have any questions.

Sincerely,

**HARDING LAWSON ASSOCIATES**

D. Roderick Pendleton

for Nelson Walter, P.E.
Project Manager

cc: J. Burleson - SAEP/TACOM
J. Borkland - Foster Wheeler
T. Corley - USACE – NYD

Engineering and
Environmental Services

511 Congress Street, P.O. Box 7050, Portland, ME 04112-7050 207/775-5401 Fax: 207/772-4762

# ADDENDUM TO FINAL PRE-DESIGN INVESTIGATION REPORT
# CAUSEWAY AND DIKE NCRA
# STRATFORD ARMY ENGINE PLANT
## Stratford, Connecticut

## 1.0 Introduction

Foster Wheeler Environmental Corporation (Foster Wheeler) and Harding Lawson Associates (HLA) have been contracted through the U.S. Army Corps of Engineers – New England District (USACE) to complete a Non-time Critical Removal Action (NCRA) for the Causeway and Dike Area at the Stratford Army Engine Plant (SAEP) under Task Order No. 020 of Contract No. DACW33-94-D-0002. The objectives of this task are to: 1) complete additional field activities necessary to characterize physical and chemical subsurface conditions on the Causeway and Dike, 2) summarize the results of field activities in a report, and 3) document the decision process for selection of a removal action for the Causeway and Dike area in an Engineering Evaluation/Cost Analysis (EE/CA) and a Removal Action Memorandum (RAM).

Results of field investigation activities intended to address items 1 and 2 listed above, conducted by Foster Wheeler and HLA during the summer and fall of 1999, are presented in the Final Causeway and Dike NCRA Pre-Design Investigation Report (Foster Wheeler/HLA, 2000a). Specific to the Causeway, a number of soil samples collected and analyzed during the field investigations indicated concentrations of volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and vanadium exceeding criteria presented in the Connecticut Department of Environmental Protection (CTDEP) Remediation Standard Regulations (RSRs). The criteria exceeded include Direct Exposure Criteria (DEC) for soil (residential scenario), and GB Pollutant Mobility Criteria (PMC) for subsurface soil from above the water table. Discussions with the CTDEP identified data needs relative to SPLP analysis of soils exceeding the PMC. A Supplemental Work Plan (Foster Wheeler/HLA, 2000b) was prepared to address those additional data needs. Specifically, if it could be demonstrated that areas with PMC exceedances be reevaluated to demonstrate that SPLP results were less than 10 times the CTDEP Groundwater Protection Criteria, then the CTDEP RSRs would allow installation of a permeable soil cover on the Causeway, rather than an engineered barrier to prevent infiltration.

This Addendum to the Pre-Design Investigation Report (Foster Wheeler/HLA, 2000a) describes the fieldwork, and presents the results of additional sampling conducted on the Causeway during May 2000.

## 2.0 Field Program

Results of soil sampling and analyses conducted on the Causeway identified a number of samples with concentrations that exceed the CTDEP PMC (Foster Wheeler/HLA, 2000a). Of these, only the soils at or above 4.5-feet bgs (the approximate water table at high tide) were resampled, and only for those parameters already found to exceed the CTDEP PMC criteria.

Ten (10) previously sampled exploration locations were resampled on the Causeway to collect additional subsurface soil samples. For these samples, SPLP analyses were requested for those parameters that were previously detected at concentrations above the PMC. Exploration locations are listed on Table 1, and are shown on Figure 1. All resampled exploration locations were completed on May 3, 2000 using a backhoe, and employed test-pitting techniques. Soil sample descriptions and sampling information were written on test pits logs, included in Appendix A.

Soil samples were collected using stainless steel spatulas and spoons. VOC samples were collected in 4-ounce soil jars with airtight silicon septa, and completely filled to minimize headspace in the jar. SVOC and vanadium samples were homogenized and placed into 8-ounce soil jars. All samples were delivered to the off-site laboratory on the day they were collected, and SPLP extractions were performed within 48 hours of sample collection. Table 2 lists the CTDEP SPLP PMCs, and the minimum required reporting limits for the SPLP analyses. Additionally, USACE quality assurance (QA) split samples were collected for the analyses, as shown on Table 1. These were shipped to the USACE laboratory, AMRO Environmental Laboratories in Merrimack, New Hampshire, on the day they were collected.

## 3.0 Results

SPLP soil analytical data with concentrations exceeding the CTDEP RSR PMC are shown on Figure 2. Complete analytical data are presented in Appendix B. For polluted soils in a GB area, or an area encompassing a non-potable groundwater aquifer, the CTDEP RSRs state, "A substance other than total petroleum hydrocarbons in soil above the seasonal high water table in a GB area may be remediated to a level at which the results of a TCLP or SPLP analysis of such soil does not exceed the ground-water protection criterion for any such substance multiplied by 10…. " These criteria are also shown on Figure 2 for each analyte exceedance.

Of the eight locations sampled for VOCs, only one location, TP-DEP-12, exhibited concentrations above the SPLP PMC for VOCs. Vinyl chloride was detected at a concentration of 35 µg/L, and trichloroethene (TCE) was detected at a concentration of 160 µg/L (see Figure 1).

At the two locations that were resampled for vanadium, TP-DEP-11 and TP-DEP-12, SPLP results were both below the PMC of 500 µg/L (see Appendix B).

A total of five locations were sampled for SVOCs. Of these, only two locations (TP-99-10 and CB-99-15) recorded exceedances above the RSR SPLP PMC. These are shown on Figure 2.

## Summary and Conclusions

- Excavation and removal of soil is likely required at the locations where laboratory results indicate exceedances of the SPLP PMC.
- The Causeway EE/CA will present proposed removal actions, and a plan for confirmation sampling following any removal actions.

## References

Foster Wheeler Environmental Corporation/Harding Lawson Associates (Foster Wheeler/HLA), 2000. Final Pre-Design Investigation Report for the Non-Time Critical Removal Action for the Causeway and Dike. Prepared for the U.S. Army Corps of Engineers, April 2000.

## TABLE 1
## SUMMARY OF OFF-SITE ANALYTICAL SAMPLING

## ADDENDUM TO THE PRE-DESIGN INVESTIGATION REPORT CAUSEWAY AND DIKE NON-TIME CRITICAL REMOVAL ACTION
## STRATFORD ARMY ENGINE PLANT
## STRATFORD, CONNECTICUT

| EXPLORATION LOCATION | SAMPLE DEPTH (feet bgs) | ANALYTICAL PARAMETER AND METHOD | QA SPLIT SAMPLES |
|---|---|---|---|
| CB-99-01 | 1' | SPLP for VOCs by 1312/8260B | |
| CB-99-03 | 3' | SPLP for VOCs by 1312/8260B | |
| CB-99-04 | 2' | SPLP for VOCs by 1312/8260B | |
| CB-99-08 | 2' | SPLP for VOCs by 1312/8260B | |
| CB-99-11 | 2' | SPLP for VOCs by 1312/8260B<br>SPLP for SVOCs by 1312/ Modified 8270 SIM | |
| CB-99-14 | 2' | SPLP for SVOCs by 1312/Modified 8270 SIM | |
| CB-99-15 | 2' | SPLP for SVOCs by 1312/Modified8270 SIM | SVOCs |
| TP-99-10 | 3.5' | SPLP for VOCs by 1312/8260B<br>SPLP for SVOCs by 1312/Modified 8270 SIM | |
| TP-DEP-11 | 1' | SPLP for VOCs by 1312/8260B<br>SPLP for SVOCs by 1312/Modified 8270 SIM<br>SPLP for Vanadium by 1312/6010B | VOCs<br>SVOCs<br>Vanadium |
| TP-DEP-12 | 1.5' | SPLP for VOCs by 1312/8260B<br>SPLP for Vanadium by 1312/6010B | |

Notes:

QA = Quality Assurance Split Samples sent to USACE Laboratory
SIM = Selective Ion Monitoring
SPLP = Synthetic Precipitation Leaching Procedure
SVOC = Semivolatile Organic Compounds
VOC = Volatile Organic Compounds

## E 2
## SPLP ANALYSES MINIMUM REQUIRED REPORTING LIMITS

## ADDENDUM TO PRE-DESIGN INVESTIGATION REPORT CAUSEWAY AND DIKE NON-TIME CRITICAL REMOVAL ACTION
## STRATFORD ARMY ENGINER PLANT
## STRATFORD, CONNECTICUT

| | CTDEP Groundwater Protection Criteria (ug/l) | SPLP Pollutant Mobility Criteria (Groundwater Protection Criteria x10 (µg/l) | Required Reporting Limit for SPLP Analyses (µg/l) |
|---|---|---|---|
| **VOCs** | | | |
| Acetone | 700 | 7000 | 3500 |
| Acrylonitrile | 0.5 | 5 | 2.5 |
| Benzene | 1 | 10 | 5 |
| Bromform | 4 | 40 | 20 |
| 2-Butanon (MEK) | 400 | 4000 | 2000 |
| Carbon Tetrachloride | 5 | 50 | 25 |
| Chlorobenzene | 100 | 1000 | 500 |
| Chloroform | 6 | 60 | 30 |
| Dibromochloromethane | 0.5 | 5 | 2.5 |
| 1,2-Dichlorobenzene | 600 | 6000 | 3000 |
| 1,3-Dichlorobenzene | 600 | 6000 | 3000 |
| 1,4-Dichlorobenzene | 75 | 750 | 375 |
| 1,1-Dichloroethane | 70 | 700 | 350 |
| 1,2-Dichloroethane | 1 | 10 | 5 |
| 1,1-Dichloroethylene | 7 | 70 | 35 |
| Cis-1,2-Dichloroethylene | 70 | 700 | 350 |
| Trans-1,2-Dichloroethylene | 100 | 1000 | 500 |
| 1,2-Dichloropropane | 5 | 50 | 25 |
| 1,3-Dichloropropene | 0.5 | 5 | 2.5 |
| Ethylbenzene | 700 | 7000 | 3500 |
| Methyl-Tert-Butyl-Ether | 100 | 1000 | 500 |
| Methyl Isobutyl Ketone | 350 | 3500 | 1750 |
| Methylene Chloride | 5 | 50 | 25 |
| Styrene | 100 | 1000 | 500 |
| 1,1,1,2-Tetrachloroethane | 1 | 10 | 5 |
| 1,1,2,2-Tetrachloroethane | 0.5 | 5 | 2.5 |
| Tetrachloroethylene | 5 | 50 | 25 |
| Toluene | 1000 | 10000 | 5000 |
| 1,1,1-Trichloroethane | 200 | 2000 | 1000 |
| 1,1,2-Trichloroethane | 5 | 50 | 25 |
| Trichloroethylene | 5 | 50 | 25 |
| Vinyl Chloride | 2 | 20 | 10 |
| Xylenes | 530 | 5300 | 2650 |

# T. E 2
# SPLP ANALYSES MINIMUM ._QUIRED REPORTING LIMITS

## ADDENDUM TO PRE-DESIGN INVESTIGATION REPORT CAUSEWAY AND DIKE NON-TIME CRITICAL REMOVAL ACTION
## STRATFORD ARMY ENGINER PLANT
## STRATFORD, CONNECTICUT

| | CTDEP Groundwater Protection Criteria (ug/l) | SPLP Pollutant Mobility Criteria (Groundwater Protection Criteria x10 (µg/l) | Required Reporting Limit for SPLP Analyses (µg/l) |
|---|---|---|---|
| **SVOCs** | | | |
| Acenaphthylene | 420 | 4200 | 2100 |
| Anthracene | 2000 | 20000 | 10000 |
| Benzo(A)Anthracene | 0.06 | 0.6 | 0.3 |
| Benzo(B)Fluoranthene | 0.08 | 0.8 | 0.4 |
| Benzo(K)Fluoranthene | 0.5 | 5 | 2.5 |
| Benzo(A)Pyrene | 0.2 | 2 | 1 |
| Fluoranthene | 280 | 2800 | 140 |
| Fluorene | 280 | 2800 | 1400 |
| Naphthalene | 280 | 2800 | 1400 |
| Phenanthrene | 200 | 2000 | 1000 |
| Pyrene | 200 | 2000 | 1000 |

| | | CTDEP GB Pollutant Mobility Criteria (µg/l) | Required Reporting Limit for SPLP Analyses (µg/L) |
|---|---|---|---|
| Vanadium | | 500 | 500 |

Notes:

CTDEP = Connecticut Departmetn of Environmental Protection
VOCs = volatile organic compounds
SVOCs = semivolatile organic compounds
µg/L = micrograms per liter
SPLP = Synthetic Precipitate Leaching Procedures

# TEST PIT LOGS

# TEST PIT RECORD

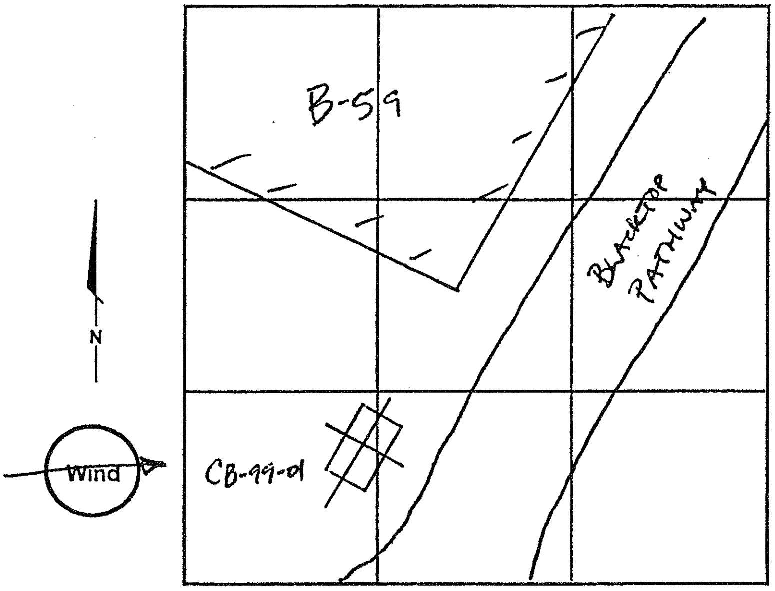
1 of 21

Site: Stratford Army Engine Plant - Causeway

Project No.: 47254-21054 - ADDENDUM TO PDIR Date: 5-3-00

Test Pit ID: CB-99-01

**Sketch Map of Test Pit Site:**



Scale: 1"=________ft.
NOT TO SCALE

**Crew Members:**

1. TOM LONGLEY - HLA
2. STEFAN SMITH - NFE
3. JOHN FLEMING - WE MANAGE
4.
5.
6.

**Monitor Equipment:**

| | |
|---|---|
| PI Meter | [✓ Y] N |
| Explosive Gas | Y N |
| Avail. Oxygen | Y N |
| OVA | Y N |

Other:
LUDLUM PANCAKE PROBE
(GEIGER-MUELLER)

**Notes:**

RESAMPLING EXPLORATIONS FOR SPLP ANALYSES

EXCAVATED TO 1.5' SAMPLE COLLECTED
@ 1' bgs ON N. SIDE OF PREVIOUS
EXCAVATION
Soil is GRAVELLY SAND - NO PID readings.
PANCAKE Probe = 50-TO-80 counts
per minute (CPM)
DRY
COLLECTED VOC SAMPLE

# TEST PIT RECORD

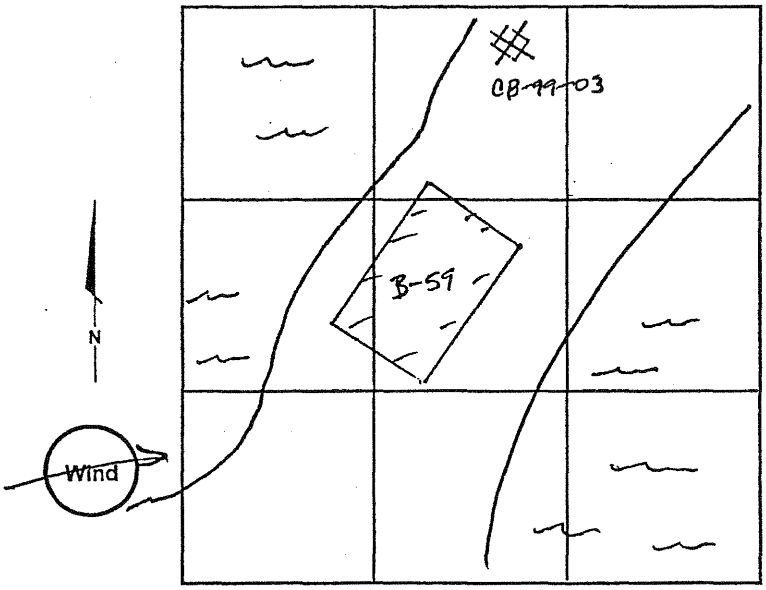
1 of ~~2~~ 1

Site: Stratford Army Engine Plant - Causeway

Project No.: 47254-21054 - ADDENDUM TO PDIR Date: 5-3-00

Test Pit ID: CB-99-03

Sketch Map of Test Pit Site:



Scale: 1"=_________ft.
NOT TO SCALE

**Crew Members:**

1. TOM LONGLEY - HLA
2. STEFAN SMITH - NFE
3. JOHN FLEMING - WE MANAGE
4.
5.
6.

**Monitor Equipment:**

PI Meter [✓ Y] N
Explosive Gas Y N
Avail. Oxygen Y N
OVA Y N
Other: LUDLUM PANCAKE PROBE (GEIGER-MUELLER)

**Notes:**

RESAMPLING EXPLORATIONS FOR SPLP ANALYSES

EXCAVATED TO 4'
AT 3', COUNTS = 40-TO-60 CPM PID=0 ppm
SAMPLE AT 3' FROM AN AREA JUST SW OF ORIGINAL CB-99-03 boring.
TAN, WELL-SORTED, LOOSE FINE SAND, DRY & CLEAN LOOKING
Collected VOC Sample

# TEST PIT RECORD

1 of ~~2~~1

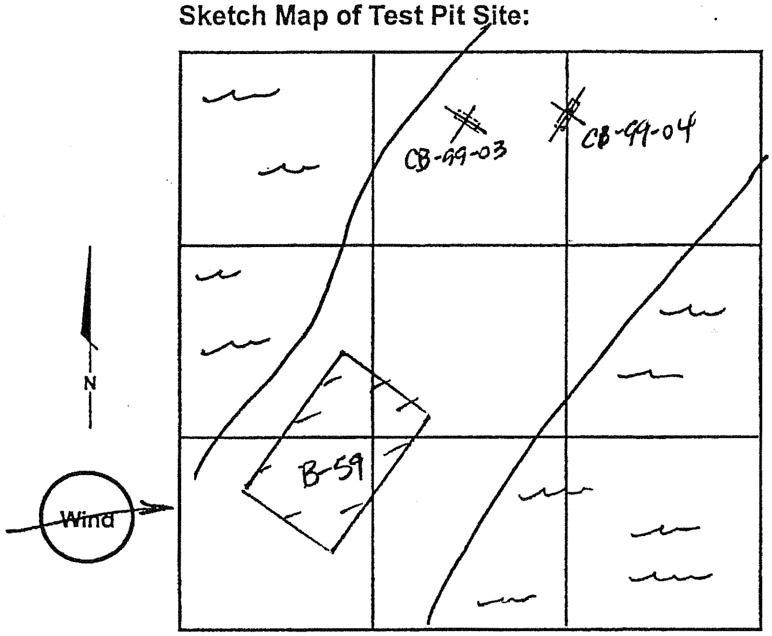
Site: Stratford Army Engine Plant - Causeway

Project No.: 47254-21054 - ADDENDUM TO PDIR

Date: 5-3-00

Test Pit ID: CB-99-04

**Sketch Map of Test Pit Site:**



**Scale: 1"=** ______ **ft.**

NOT TO SCALE

**Crew Members:**

1. TOM LONGLEY - HLA
2. STEFAN SMITH - NFE
3. JOHN FLEMING - WE MANAGE
4.
5.
6.

**Monitor Equipment:**

PI Meter [✓ Y] N
Explosive Gas Y N
Avail. Oxygen Y N
OVA Y N
Other: LUDLUM PANCAKE PROBE (GEIGER-MUELLER)

**Notes:**

RESAMPLING EXPLORATIONS FOR SPLP ANALYSES

LOCATION IS JUST SOUTH OF ORIGINAL CB-99-04 EXPLORATION

PANCAKE PROBE @ 2" = 70-TO-90 cpm (Background = ~60 cpm)

PID = 0 ppm

SAMPLE AT 2' bgs. GRAVELLY SAND, TAN, LOOSE-TO-FIRM, MOSTLY CLEAN BUT W/ SOME brick pieces & Cobbles - ROOTS TO 12"

Collected VOC Sample

# TEST PIT RECORD

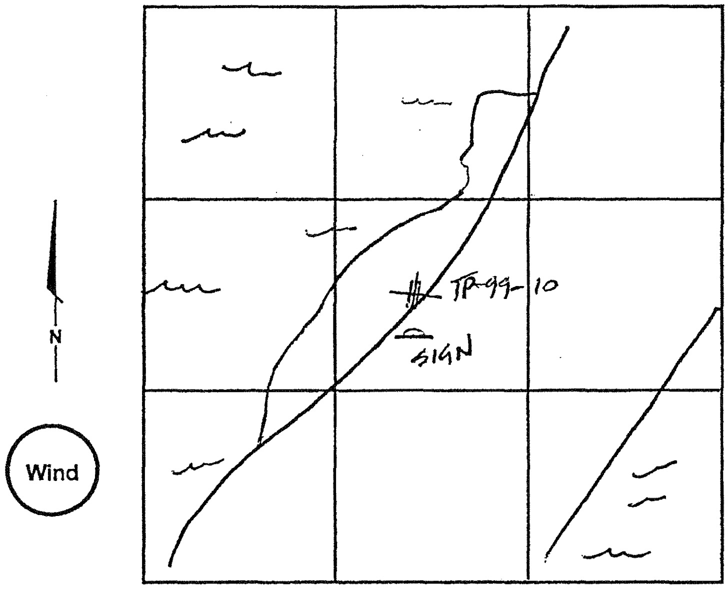
1 of 21

Site: Stratford Army Engine Plant - Causeway

Project No.: 47254-21054 - ADDENDUM TO PDIR Date: 5-3-00

Test Pit ID: TP-99-10

Sketch Map of Test Pit Site:



Scale: 1"=________ft.
NOT TO SCALE

**Crew Members:**

1. TOM LONGLEY - HLA
2. STEFAN SMITH - NFE
3. JOHN FLEMING - WE MANAGE
4. 
5. 
6.

**Monitor Equipment:**

PI Meter [✓ Y] N
Explosive Gas Y N
Avail. Oxygen Y N
OVA Y N
Other: LUDLUM PANCAKE PROBE (GEIGER-MUELLER)

**Notes:**

RESAMPLING EXPLORATIONS FOR SPLP ANALYSES
EXCAVATED TO ~ 4' bgs.
PANCAKE Probe @ 3' = 110-to-150 cpm
Background = 20-to-30 cpm
NEAR LARGE CONCRETE Blocks w/ higher
READINGS NOTED AT These. PID=0
BROWN FILL OF CONCRETE, TAR, BRICKS, GRAVEL,
SAND - NO ODORS - ~~Dry~~ to DAMP, Roots to 2.5'
SAMPLE AT 3.5' just South of original
Sample Location - SOME CRUDE LAYERING OF
FILL w/ SLIGHT COLOR CHANGES NOTED -
also some slag.

COLLECTED VOC & SVOC

# TEST PIT RECORD

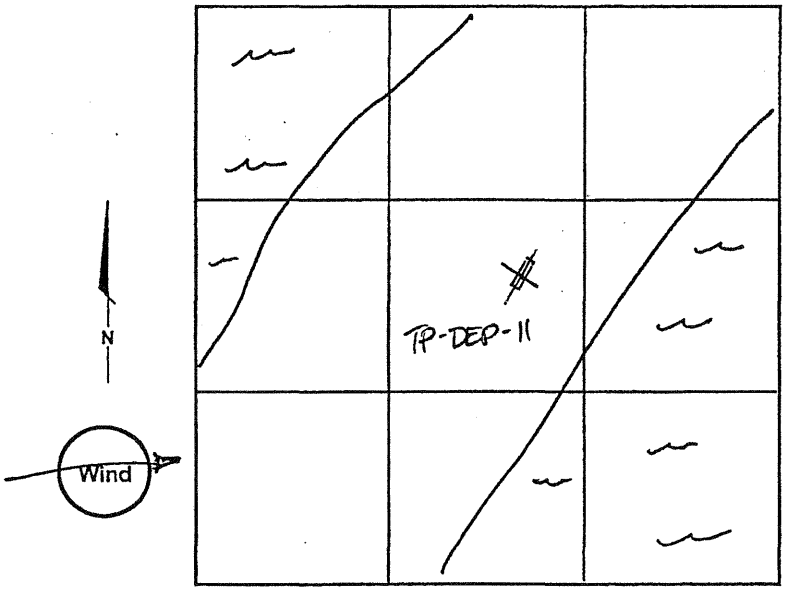
1 of ~~2~~ 1

Site: Stratford Army Engine Plant - Causeway

Project No.: 47254-21054 - ADDENDUM TO PDIR Date: 5-3-00

Test Pit ID: TP-DEP-11

**Sketch Map of Test Pit Site:**



Scale: 1"=________ft.

NOT TO SCALE

**Crew Members:**

1. TOM LONGLEY - HLA
2. STEFAN SMITH - NFE
3. JOHN FLEMING - WE MANAGE
4. 
5. 
6.

**Monitor Equipment:**

PI Meter [✓ Y] N
Explosive Gas Y N
Avail. Oxygen Y N
OVA Y N
Other: LUDLUM PANCAKE PROBE (GEIGER-MUELLER)

**Notes:**

RESAMPLING EXPLORATIONS FOR SPLP ANALYSES
PANCAKE PROBE = 100 cpm w/ bgk. = 40-50 cpm
PID = 0 ppm
NOSE ODOR OF FUELS & hydrocarBONS
BLack- to: Very Dark BROWN w/
Rusty zone of GRAVEL, SLAG, CONCRETE
Debris, SAND, etc. - DAmp-to- DRY
Lot of ~~B~~ Rubble here
SAMPLED @ 1' bgs - just South of REMOVAL AREA
Collected VOC, SVOC, VANADIUM
ALSO COLLECTED VOC, SVOC, VANADIUM
for USACE SPLIT SAmples.

# TEST PIT RECORD

1 of 21

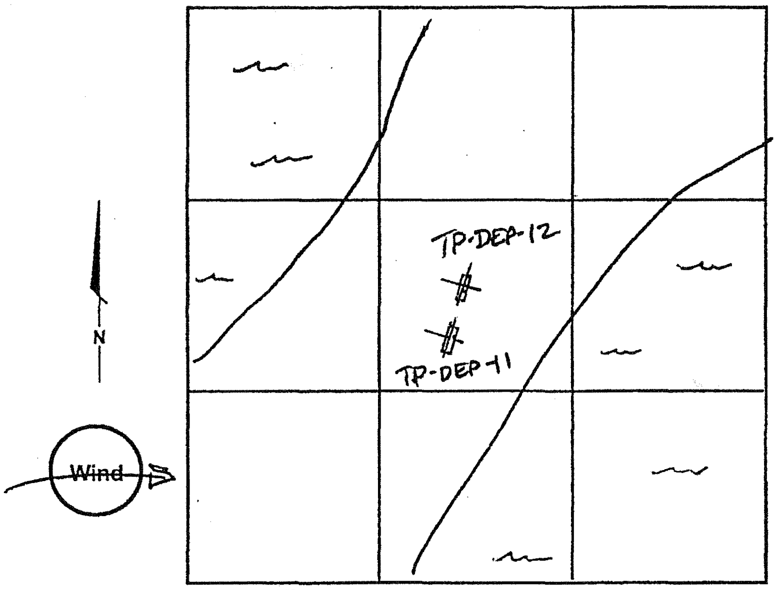
Site: Stratford Army Engine Plant - Causeway

Project No.: 47254-21054 - ADDENDUM TO PDIR

Date: 5-3-00

Test Pit ID: TP-DEP-12

**Sketch Map of Test Pit Site:**



Scale: 1"=________ft.
NOT TO SCALE

**Crew Members:**

1. TOM LONGLEY - HLA
2. STEFAN SMITH - NFE
3. JOHN FLEMING - WE MANAGE
4.
5.
6.

**Monitor Equipment:**

| | |
|---|---|
| PI Meter | [✓ Y] N |
| Explosive Gas | Y N |
| Avail. Oxygen | Y N |
| OVA | Y N |

Other: LUDLUM PANCAKE PROBE (GEIGER-MUELLER)

**Notes:**

RESAMPLING EXPLORATIONS FOR SPLP ANALYSES

Probe = 100 cpm
PID = 0 ppm
Sample @ 1.5' bgs

BRICKS, CONCRETE, CINDERS, gravel, SAND, MOIST-TO-DRY
ALL RUBBLE w/ little SAND

COLLECTED VOC & VANADIUM

# TEST PIT RECORD

1 of ~~2~~ 1

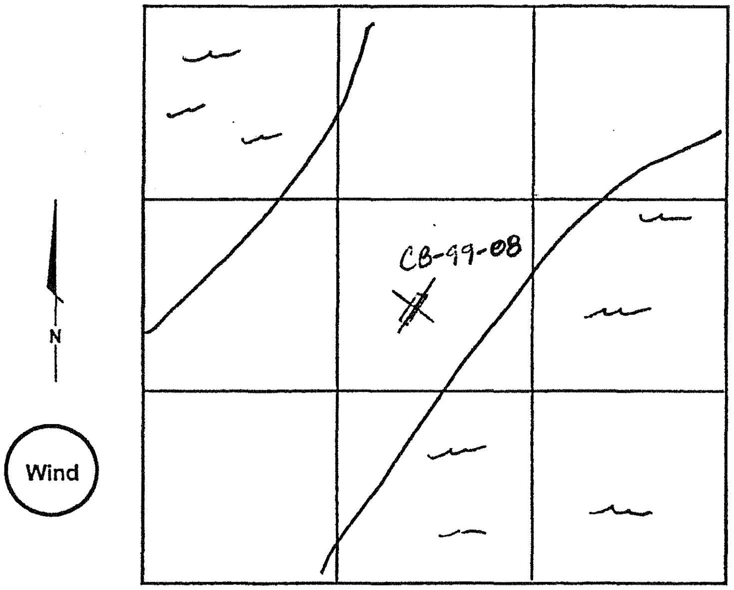
Site: Stratford Army Engine Plant - Causeway

Project No.: 47254-21054 - ADDENDUM TO PDIR

Date: 5-3-00

Test Pit ID: CB-99-08

**Sketch Map of Test Pit Site:**



Scale: 1"=_________ft.
NOT TO SCALE

**Crew Members:**

1. TOM LONGLEY - HLA
2. STEFAN SMITH - NFE
3. JOHN FLEMING - WE MANAGE
4.
5.
6.

**Monitor Equipment:**

PI Meter [✓ Y] N
Explosive Gas Y N
Avail. Oxygen Y N
OVA Y N
Other: LUDLUM PANCAKE PROBE (GEIGER-MUELLER)

**Notes:**

RESAMPLING EXPLORATIONS FOR SPLP ANALYSES
LOCATION IS just OFF OF TP-DEP-11/12 AREA. HAS BACKTOP ROADWAY UNDER ≈ 6" OF FILL.

PROBE = 40-60 CPM @ 2' bgs, PID=0
NOT much SOIL HERE - CEMENTED MASS OF Bricks, TAR & CINDERS/ASH MATERIAL
BACKhoe has DIFFICULTY EXCAVATING This MATERIAL.
COLLECTED SAMPLE just EAST OF ORIGINAL EXPLORATION LOCATION - SAMPLE IS OF PULVERIZED MATERIAL

COLLECTED VOC

# TEST PIT RECORD

1 of 21

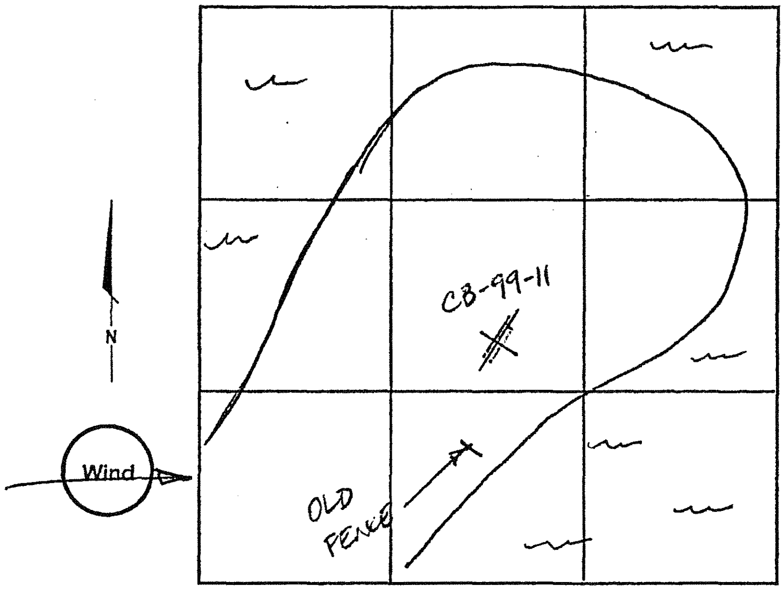
Site: Stratford Army Engine Plant - Causeway

Project No.: 47254-21054 - ADDENDUM TO PDIR

Date: 5-3-00

Test Pit ID: CB-99-11

Sketch Map of Test Pit Site:



Scale: 1"=__________ft.
NOT TO SCALE

Crew Members:

1. TOM LONGLEY - HLA
2. STEFAN SMITH - NFE
3. JOHN FLEMING - WE MANAGE
4. 
5. 
6.

Monitor Equipment:

| | |
|---|---|
| PI Meter | [✓ Y] N |
| Explosive Gas | Y N |
| Avail. Oxygen | Y N |
| OVA | Y N |

Other: LUDLUM PANCAKE PROBE (GEIGER-MUELLER)

Notes:

RESAMPLING EXPLORATIONS FOR SPLP ANALYSES

PROBE = 5 cpm @ 2' bgs

PID = 0 ppm

SAMPLE @ 2' below tarred roadway, in CEMENTED BLACK ASH/SLAG.

VERY HARD & CEMENTED (as in CB-99-08)

Whitish when pulverized, But BLACK otherwise

COLLECTED VOC & SVOC

W9912003

Harding Lawson Associates

# TEST PIT RECORD

1 of ~~2~~ 1

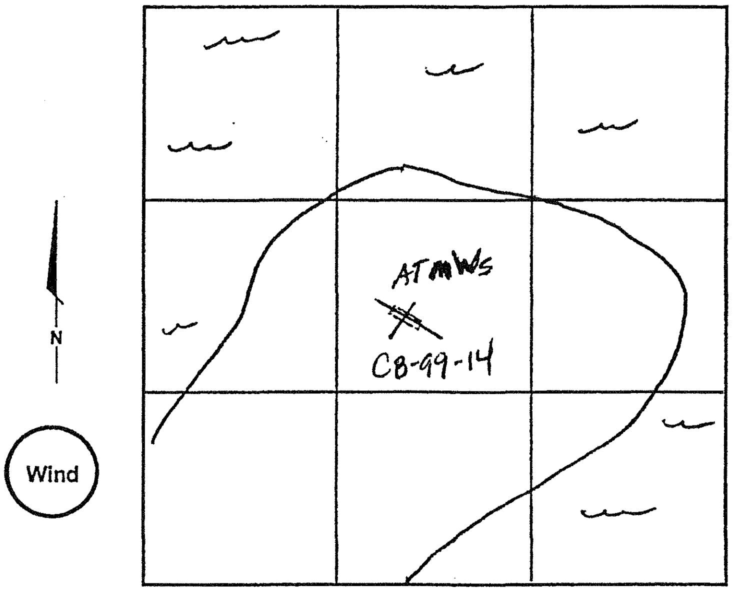
Site: Stratford Army Engine Plant - Causeway

Project No.: 47254-21054 - ADDENDUM TO PDIR

Date: 5-3-00

Test Pit ID: CB-99-14

**Sketch Map of Test Pit Site:**



Scale: 1"=_________ft.
NOT TO SCALE

**Crew Members:**

1. TOM LONGLEY - HLA
2. STEFAN SMITH - NFE
3. JOHN FLEMING - WE MANAGE
4. 
5. 
6.

**Monitor Equipment:**

PI Meter [✓ Y] N
Explosive Gas Y N
Avail. Oxygen Y N
OVA Y N
Other:
LUDLUM PANCAKE PROBE
(GEIGER-MUELLER)

**Notes:**

RESAMPLING EXPLORATIONS FOR SPLP ANALYSES
Dug just South of The Monitoring
Wells (MWCD-99-02A,B)

BRIGHT Yellow brown, SAND, CLEAN
FILL, DRY, LOOSE-TO-FIRM
COLLECTED SVOC
Probe = 5-to-9 CPM
PID = 0 ppm
Sample @ 2'

# TEST PIT RECORD

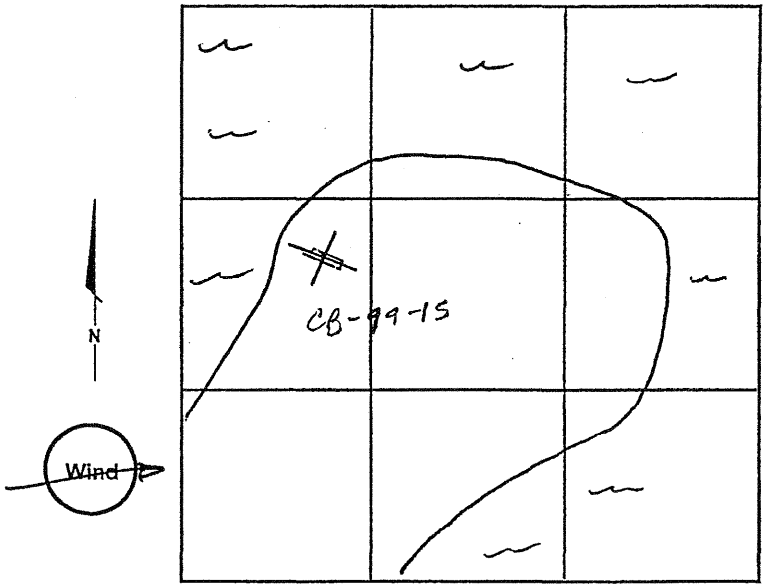
1 of 21

Site: Stratford Army Engine Plant - Causeway

Project No.: 47254-21054 - ADDENDUM TO PDIR Date: 5-3-00

Test Pit ID: CB-99-15

Sketch Map of Test Pit Site:



Scale: 1"=________ft.

NOT TO SCALE

Crew Members:

1. TOM LONGLEY - HLA
2. STEFAN SMITH - NFE
3. JOHN FLEMING - WE MANAGE
4. 
5. 
6.

Monitor Equipment:

| | |
|---|---|
| PI Meter | [✓ Y] N |
| Explosive Gas | Y N |
| Avail. Oxygen | Y N |
| OVA | Y N |

Other: LUDLUM PANCAKE PROBE (GEIGER-MUELLER)

Notes:

RESAMPLING EXPLORATIONS FOR SPLP ANALYSES

PROBE = 40-TO-50 cpm

PID = 0 ppm

DARK BROWN GRAVELLY, BLOCKY, SANDY, LOOSE, DRY - FILL w/ ASPHALT pieces, etc.

Collect Sample @ 2' for SVOC

ALSO COLLECTED USACE SPLIT SVOC

W9912003

Harding Lawson Associates

# OFF-SITE ANALYTICAL RESULTS

Committed To *Your* Success

**Severn Trent Laboratories**
128 Long Hill Cross Road
Shelton CT 06484
Tel: (203) 929-8140
Fax: (203) 929-8142
www.stl-inc.com

May 17, 2000

Mr. Chris Ricardi
FOSTER WHEELER ENVIRONMENTAL
C/O Harding Lawson Associates
511 Congress St.  Po Box 7050
Portland, ME 04112

Dear Mr. Ricardi :

Please find enclosed the analytical results of 10 sample(s) received at our laboratory on May 3, 2000. This report contains sections addressing the following information at a minimum:

- sample summary
- analytical methodology
- state certifications
- definition of data qualifiers and terminology
- analytical results
- chain-of-custody

| STL Report #7000-0859A | Purchase Order #004602.0007 |
|---|---|
| Project ID: STRATFORD ARMY ENGINE PLAN | |

Copies of this analytical report and supporting data are maintained in our files for a minimum of five years unless special arrangements have been made. Unless specifically indicated, all analytical testing was performed at this laboratory location and no portion of the testing was subcontracted.

We appreciate your selection of our services and welcome any questions or suggestions you may have relative to this report. Please contact your customer service representative at (203) 929-8140 for any additional information. Thank you for utilizing our services; we hope you will consider us for your future analytical needs.

I have reviewed and approved the enclosed data for final release.

Very truly yours,

Jeffrey C. Curran
Laboratory Manager

JCC

## 7000-0859A
## FOSTER WHEELER ENVIRONMENTAL

### Case Narrative

**Sample Receipt** – All samples were received in good condition.

The following analyses were subcontracted out to the indicated laboratories:

**SPLP-PAH's** sent to STL – Pittsburgh (PA), 450 William Pitt Way, Building 6, Pittsburgh, PA 15238. Refer to Subcontracted SPLP PAH Data Package for results.

**Classical Chemistry** - Listed below are the wet chemistry analyte methods and references for all samples analyzed in this SDG. No analytical problems were encountered and all holding times were met.

| Analyte | Method | Reference |
|---|---|---|
| SPLP-PREP | 1312 | 1 |

References:

1. Test Methods for the Evaluation of Solid Waste, SW846, 3rd edition, 1986.

**Volatile Organics** – Volatile organics were determined by purge and trap GC/MS using guidance provided in Method 5030B/8260B. The instrumentation used was a Tekmar Model 2000/2016 Concentrator interfaced with a Hewlett Packard Model 5970A GC/MS/DS.

The following percent recoveries were outside the criteria limits in the 020PPB_QCS sample:
1,2-dichloroethane, 1,1,1-trichloroethane, carbon tetrachloride, bromodichloromethane and dibromochloromethane.

No problems were encountered.

**Metals** – ICAP metals were determined using a JA61E trace ICAP following guidance provided in SW846 according to methods 3010A/6010B.

No problems occurred during analysis. All appropriate protocols were employed. All data appears to be consistent.

Aqueo

# TABLE VO-1.0
7000-0859A
FOSTER WHEELER ENVIRONMENTAL
VOLATILE ORGANICS (SPLP)

All values are ug/L.

| Client Sample I.D.<br>Lab Sample I.D.<br>Method Blank I.D.<br>Quant. Factor | Method Blank<br>VBLKKE<br>VBLKKE<br>1.00 | CB9904002XX<br>000859A-01<br>VBLKKE<br>1.00 | CB9901002XX<br>000859A-02<br>VBLKKE<br>1.00 | Quant. Limits with n Diluti |
|---|---|---|---|---|
| Chloromethane | U | U | U | 10 |
| Bromomethane | U | U | U | 10 |
| Vinyl Chloride | U | U | U | 10 |
| Chloroethane | U | U | U | 10 |
| Methylene Chloride | U | 3J | 1J | 5.0 |
| Acetone | U | U | 9J | 10 |
| Carbon Disulfide | U | U | U | 5.0 |
| Vinyl Acetate | U | U | U | 10 |
| 1,1-Dichloroethene | U | U | U | 5.0 |
| 1,1-Dichloroethane | U | U | U | 5.0 |
| cis-1,2-Dichloroethene | U | U | U | 5.0 |
| trans-1,2-Dichloroethene | U | U | U | 5.0 |
| Chloroform | U | U | U | 5.0 |
| 1,2-Dichloroethane | U | U | U | 5.0 |
| 2-Butanone | U | U | U | 10 |
| 1,1,1-Trichloroethane | U | U | U | 5.0 |
| Carbon Tetrachloride | U | U | U | 5.0 |
| Bromodichloromethane | U | U | U | 5.0 |
| 1,2-Dichloropropane | U | U | U | 5.0 |
| cis-1,3-Dichloropropene | U | U | U | 5.0 |
| Trichloroethene | U | .7J | U | 5.0 |
| Dibromochloromethane | U | U | U | 5.0 |
| 1,1,2-Trichloroethane | U | U | U | 5.0 |
| Benzene | U | U | U | 5.0 |
| trans-1,3-Dichloropropene | U | U | U | 5.0 |
| Bromoform | U | U | U | 5.0 |
| 4-Methyl-2-Pentanone | U | U | U | 10 |
| 2-Hexanone | U | U | U | 10 |
| Tetrachloroethene | U | .6J | U | 5.0 |
| Toluene | U | U | U | 5.0 |
| 1,1,2,2-Tetrachloroethane | U | U | U | 5.0 |
| Chlorobenzene | U | U | U | 5.0 |
| Ethylbenzene | U | U | U | 5.0 |
| Styrene | U | U | U | 5.0 |
| Xylene (total) | U | U | U | 5.0 |
| Date Received<br>Date Extracted<br>Date Analyzed | <br>N/A<br>05/09/00 | 05/03/00<br>N/A<br>05/09/00 | 05/03/00<br>N/A<br>05/09/00 | |

See Appendix for qualifier definitions
Note: Compound detection limit = quantitation limit x quantitation factor
Quant. Factor = a numerical value which takes into account any variation in sample weight/volume, % moisture and sample dilution.

Aqueous

# TABLE VO-1.1
7000-0859A
FOSTER WHEELER ENVIRONMENTAL
VOLATILE ORGANICS (SPLP)

All values are ug/L.

| Client Sample I.D. | CB9908002XX | CB9908002XX FMS | CB9903003XX | Quant. Limits with no Dilution |
|---|---|---|---|---|
| Lab Sample I.D. | 000859A-03 | 000859A-03 FMS | 000859A-04 | |
| Method Blank I.D. | VBLKKE | VBLKKE | VBLKKE | |
| Quant. Factor | 1.00 | 1.00 | 1.00 | |
| Chloromethane | U | 40X | U | 10 |
| Bromomethane | U | 45X | U | 10 |
| Vinyl Chloride | U | 45X | U | 10 |
| Chloroethane | U | 45X | U | 10 |
| Methylene Chloride | 3J | 51X | 10 | 5.0 |
| Acetone | 11 | 64X | 16 | 10 |
| Carbon Disulfide | U | 41X | U | 5.0 |
| Vinyl Acetate | U | 2JX | U | 10 |
| 1,1-Dichloroethene | U | 47X | U | 5.0 |
| 1,1-Dichloroethane | U | 54X | U | 5.0 |
| cis-1,2-Dichloroethene | 1J | 46 | U | 5.0 |
| trans-1,2-Dichloroethene | U | 44 | U | 5.0 |
| Chloroform | U | 54X | U | 5.0 |
| 1,2-Dichloroethane | U | 62X | U | 5.0 |
| 2-Butanone | U | 67X | U | 10 |
| 1,1,1-Trichloroethane | U | 57X | U | 5.0 |
| Carbon Tetrachloride | U | 61X | U | 5.0 |
| Bromodichloromethane | U | 61X | U | 5.0 |
| 1,2-Dichloropropane | U | 56X | U | 5.0 |
| cis-1,3-Dichloropropene | U | 56X | U | 5.0 |
| Trichloroethene | 7 | 81X | U | 5.0 |
| Dibromochloromethane | U | 62X | U | 5.0 |
| 1,1,2-Trichloroethane | U | 57X | U | 5.0 |
| Benzene | U | 54X | U | 5.0 |
| trans-1,3-Dichloropropene | U | 58X | U | 5.0 |
| Bromoform | U | 65X | U | 5.0 |
| 4-Methyl-2-Pentanone | U | 80X | U | 10 |
| 2-Hexanone | U | 83X | U | 10 |
| Tetrachloroethene | 1J | 52X | 1J | 5.0 |
| Toluene | U | 51X | U | 5.0 |
| 1,1,2,2-Tetrachloroethane | U | 30X | U | 5.0 |
| Chlorobenzene | U | 48X | U | 5.0 |
| Ethylbenzene | U | 56X | U | 5.0 |
| Styrene | U | 56X | U | 5.0 |
| Xylene (total) | U | 160X | U | 5.0 |
| Date Received | 05/03/00 | 05/03/00 | 05/03/00 | |
| Date Extracted | N/A | N/A | N/A | |
| Date Analyzed | 05/09/00 | 05/09/00 | 05/09/00 | |

See Appendix for qualifier definitions
Note: Compound detection limit = quantitation limit x quantitation factor
Quant. Factor = a numerical value which takes into account any variation in sample weight/volume, % moisture and sample dilution.

Aqueou

# TABLE VO-1.2
7000-0859A
FOSTER WHEELER ENVIRONMENTAL
VOLATILE ORGANICS (SPLP)

All values are ug/L.

| Client Sample I.D. | TP9910003XX | CB9911002XX | TPDEP12002XX | Quant. Limits with no Dilutio |
|---|---|---|---|---|
| Lab Sample I.D. | 000859A-06 | 000859A-08 | 000859A-09 | |
| Method Blank I.D. | VBLKKE | VBLKKE | VBLKKE | |
| Quant. Factor | 1.00 | 1.00 | 1.00 | |
| Chloromethane | U | U | U | 10 |
| Bromomethane | U | U | U | 10 |
| Vinyl Chloride | U | U | 35 | 10 |
| Chloroethane | U | U | U | 10 |
| Methylene Chloride | 4J | 14 | 8 | 5.0 |
| Acetone | 13 | 16 | 11 | 10 |
| Carbon Disulfide | U | U | U | 5.0 |
| Vinyl Acetate | U | U | U | 10 |
| 1,1-Dichloroethene | U | U | U | 5.0 |
| 1,1-Dichloroethane | U | U | U | 5.0 |
| cis-1,2-Dichloroethene | U | U | 70 | 5.0 |
| trans-1,2-Dichloroethene | U | U | 2J | 5.0 |
| Chloroform | U | U | U | 5.0 |
| 1,2-Dichloroethane | U | U | U | 5.0 |
| 2-Butanone | U | 5J | 4J | 10 |
| 1,1,1-Trichloroethane | U | U | U | 5.0 |
| Carbon Tetrachloride | U | U | U | 5.0 |
| Bromodichloromethane | U | U | U | 5.0 |
| 1,2-Dichloropropane | U | U | U | 5.0 |
| cis-1,3-Dichloropropene | U | U | U | 5.0 |
| Trichloroethene | 1J | 1J | 160 | 5.0 |
| Dibromochloromethane | U | U | U | 5.0 |
| 1,1,2-Trichloroethane | U | U | U | 5.0 |
| Benzene | U | U | U | 5.0 |
| trans-1,3-Dichloropropene | U | U | U | 5.0 |
| Bromoform | U | U | U | 5.0 |
| 4-Methyl-2-Pentanone | U | U | U | 10 |
| 2-Hexanone | U | U | U | 10 |
| Tetrachloroethene | U | 1J | 2J | 5.0 |
| Toluene | U | U | 1J | 5.0 |
| 1,1,2,2-Tetrachloroethane | U | U | U | 5.0 |
| Chlorobenzene | U | U | U | 5.0 |
| Ethylbenzene | U | U | U | 5.0 |
| Styrene | U | U | U | 5.0 |
| Xylene (total) | U | U | U | 5.0 |
| Date Received | 05/03/00 | 05/03/00 | 05/03/00 | |
| Date Extracted | N/A | N/A | N/A | |
| Date Analyzed | 05/09/00 | 05/09/00 | 05/09/00 | |

See Appendix for qualifier definitions
Note: Compound detection limit = quantitation limit x quantitation factor
Quant. Factor = a numerical value which takes into account any variation in sample weight/volume, % moisture and sample dilution.

TABLE VO-1.3
7000-0859A
FOSTER WHEELER ENVIRONMENTAL
VOLATILE ORGANICS (SPLP)

Aqueou

All values are ug/L.

| Client Sample I.D. | TPDEP11001XX | | | Quant. Limits with no Dilutio |
|---|---|---|---|---|
| Lab Sample I.D. | 000859A-10 | | | |
| Method Blank I.D. | VBLKKE | | | |
| Quant. Factor | 1.00 | | | |
| Chloromethane | U | | | 10 |
| Bromomethane | U | | | 10 |
| Vinyl Chloride | U | | | 10 |
| Chloroethane | U | | | 10 |
| Methylene Chloride | 30 | | | 5.0 |
| Acetone | 13 | | | 10 |
| Carbon Disulfide | U | | | 5.0 |
| Vinyl Acetate | U | | | 10 |
| 1,1-Dichloroethene | U | | | 5.0 |
| 1,1-Dichloroethane | U | | | 5.0 |
| cis-1,2-Dichloroethene | 1J | | | 5.0 |
| trans-1,2-Dichloroethene | U | | | 5.0 |
| Chloroform | U | | | 5.0 |
| 1,2-Dichloroethane | U | | | 5.0 |
| 2-Butanone | U | | | 10 |
| 1,1,1-Trichloroethane | U | | | 5.0 |
| Carbon Tetrachloride | U | | | 5.0 |
| Bromodichloromethane | U | | | 5. |
| 1,2-Dichloropropane | U | | | 5.0 |
| cis-1,3-Dichloropropene | U | | | 5.0 |
| Trichloroethene | 7 | | | 5.0 |
| Dibromochloromethane | U | | | 5.0 |
| 1,1,2-Trichloroethane | U | | | 5.0 |
| Benzene | U | | | 5.0 |
| trans-1,3-Dichloropropene | U | | | 5.0 |
| Bromoform | U | | | 5.0 |
| 4-Methyl-2-Pentanone | U | | | 10 |
| 2-Hexanone | U | | | 10 |
| Tetrachloroethene | 1J | | | 5.0 |
| Toluene | U | | | 5.0 |
| 1,1,2,2-Tetrachloroethane | U | | | 5.0 |
| Chlorobenzene | U | | | 5.0 |
| Ethylbenzene | U | | | 5.0 |
| Styrene | U | | | 5.0 |
| Xylene (total) | U | | | 5.0 |
| Date Received | 05/03/00 | | | |
| Date Extracted | N/A | | | |
| Date Analyzed | 05/09/00 | | | |

See Appendix for qualifier definitions

Note: Compound detection limit = quantitation limit x quantitation factor
Quant. Factor = a numerical value which takes into account any variation in sample weight/volume, % moisture and sample dilution.

Aqueous

# TABLE AS-1.0
7000-0859A
FOSTER WHEELER ENVIRONMENTAL
MISCELLANEOUS ATOMIC SPECTROSCOPY (SPLP)

All values are ug/L.

| Client Sample I.D. | TPDEP12002XX | TPDEP11001XX | | |
|---|---|---|---|---|
| Lab Sample I.D. | 000859A-09 | 000859A-10 | | |
| Vanadium | 415. | 164. | | |

See Appendix for qualifier definitions

# ORGANICS APPENDIX

U - Indicates that the compound was analyzed for but not detected.

J - Indicates that the compound was analyzed for and determined to be present in the sample. The mass spectrum of the compound meets the identification criteria of the method. The concentration listed is an estimated value, which is less than the specified minimum detection limit but is greater than zero.

B - This flag is used when the analyte is found in the blanks as well as the sample. It indicates possible sample contamination and warns the data user to use caution when applying the results of this analyte.

N - Indicates that the compound was analyzed for but not requested as an analyte. Value will not be listed on tabular result sheet.

S - Estimated due to surrogate outliers.

X - Matrix spike compound.

(1) - Cannot be separated.

(2) - Decomposes to azobenzene. Measured and calibrated as azobenzene.

A - This flag indicates that a TIC is a suspected aldol condensation product.

E - Indicates that it exceeds calibration curve range.

D - This flag identifies all compounds identified in an analysis at a secondary dilution factor.

C - Confirmed by GC/MS.

T - Compound present in TCLP blank.

P - This flag is used for a pesticide/aroclor target analyte when there is a greater than 25 percent difference for detected concentrations between the two GC columns (see Form X).

# INORGANICS APPENDIX

## C - Concentration qualifiers

U - Indicates analyte was not detected at method reporting limit.

B - Indicates analyte result between IDL and contract required detection limit (CRDL)

## Q - QC qualifiers

E - Reported value is estimated because of the presence of interference

M - Duplicate injection precision not met

N - Spiked sample recovery not within control limits

S - The reported value was determined by the method of standard additions (MSA)
W - Post-digest spike recovery furnace analysis was out of 85-115 percent control limit, while sample absorbance was less than 50 percent of spike absorbance

* - Duplicate analysis not within control limit

+ - Correlation coefficient for MSA is less than 0.995

## M - Method codes

P - ICP

A - Flame AA

F - Furnace AA

CV - Cold vapor AA (manual)

C - Cyanide

NR - Not Required

NC - Not Calculated as per protocols

# STATE CERTIFICATIONS

In some instances it may be necessary for environmental data to be reported to a regulatory authority with reference to a certified laboratory. For your convenience, the laboratory identification numbers for the STL-Connecticut laboratory are provided in the following table. Many states certify laboratories for specific parameters or tests within a category (i.e. method 325.2 for wastewater). The information in the following table indicates the lab is certified in a general category of testing such as drinking water or wastewater analysis. The laboratory should be contacted directly if parameter-specific certification information is required.

## STL-Connecticut
## Certification Summary (as of April 2000)

| State | Responsible Agency | Certification [illegible] | Lab Number |
|---|---|---|---|
| Connecticut | Department of Health Services | Drinking Water, Wastewater | PH-0497 |
| Maine | Department of Health and Environmental Services | Drinking Water, Wastewater/Solid, Hazardous Waste | CT023 |
| Massachusetts | Department of Environmental Protection | Potable/Non-Potable Water | CT023 |
| New Hampshire | Department of Environmental Services | Drinking Water, Wastewater | 2528 |
| New Jersey | Department of Environmental Protection | Drinking Water, Wastewater | 46410 |
| New York | Department of Health | CLP, Drinking Water, Wastewater, Solid/ Hazardous Waste | 10602 |
| North Carolina | Division of Environmental Management | Wastewater | 388 |
| Rhode Island | Department of Health | Chemistry...Non-Potable Water and Wastewater | A43 |
| Washington | Department of Ecology | Wastewater/Hazardous Waste | C231 |
| Wisconsin | Department of Natural Resources | Wastewater | 998355710 |

# 7000-0859A
# FOSTER WHEELER ENVIRONMENTAL
# SAMPLE SUMMARY

| CLIENT ID | LAB ID | MATRIX | DATE COLLECTED | DATE RECEIVED |
|---|---|---|---|---|
| CB9904002XX | 000859A-01 | SOIL | 05/03/00 | 05/03/00 |
| CB9901002XX | 000859A-02 | SOIL | 05/03/00 | 05/03/00 |
| CB9908002XX | 000859A-03 | SOIL | 05/03/00 | 05/03/00 |
| CB9903003XX | 000859A-04 | SOIL | 05/03/00 | 05/03/00 |
| CB9914002XX | 000859A-05 | LEACHATE | 05/03/00 | 05/03/00 |
| TP9910003XX | 000859A-06 | LEACHATE | 05/03/00 | 05/03/00 |
| CB9915002XX | 000859A-07 | LEACHATE | 05/03/00 | 05/03/00 |
| CB9911002XX | 000859A-08 | LEACHATE | 05/03/00 | 05/03/00 |
| TPDEP12002XX | 000859A-09 | SOIL | 05/03/00 | 05/03/00 |
| TPDEP11001XX | 000859A-10 | LEACHATE | 05/03/00 | 05/03/00 |

# IEA-CT ANALYTICAL SUMMARY

**Client ID:** CB9901002XX, CB9903003XX, CB9904002XX, CB9908002XX, CB9911002XX, CB9914002XX, CB9915002XX, TP9910003XX, TPDEP11001XX, TPDEP12002XX

**Job Number:** 7000-0859A

Date: 5/18/100

| Qty | Matrix | Analysis | Description |
|---|---|---|---|
| 5 | LEACHATE | BN-L8270C-MISC | Miscellaneous Base-N |
| 2 | LEACHATE | V-LSW846 | Vanadium (TCLP) |
| 8 | LEACHATE | VOA-L8260B-TCL | Volatile Organics (T |
| 1 | None | DISK | Diskette Prep. |
| 5 | SOIL | BNA-1312-PREP | SPLP BNA Leach |
| 2 | SOIL | MET-1312-PREP | SPLP Metals Leach |
| 8 | SOIL | VOA-1312-PREP | SPLP Volatiles Leach |

# GC/MS SEMIVOLATILE SUMMARY

Lab Name: Severn Trent Laboratories, Inc.
SDG Number:

Matrix: (soil/water) WATER
Method: SW846 SW846 8270C SIM 8270C (SIM)
Lab Sample ID: C0E060119 001

Sample WT/Vol: 1000 / mL
Work Order: DCVF6101
Dilution factor: 1
Moisture %: NA
Date Received: 05/06/00
Date Extracted: 05/08/00
Date Analyzed: 05/10/00

QC Batch: 0130111

Client Sample Id: CB9914002XX

| CAS NO. | COMPOUND | CONCENTRATION UNITS: (ug/L or ug/kg) ug/L | Q | |
|---|---|---|---|---|
| 83-32-9 | Acenaphthene | 1.0 | U | |
| 208-96-8 | Acenaphthylene | 0.080 | J | |
| 120-12-7 | Anthracene | 0.29 | | |
| 56-55-3 | Benzo(a)anthracene | 0.083 | J | |
| 205-99-2 | Benzo(b)fluoranthene | 0.042 | J | |
| 207-08-9 | Benzo(k)fluoranthene | 0.034 | J | |
| 191-24-2 | Benzo(ghi)perylene | 0.20 | U | |
| 50-32-8 | Benzo(a)pyrene | 0.033 | J | |
| 218-01-9 | Chrysene | 0.082 | J | |
| 206-44-0 | Fluoranthene | 0.85 | | |
| 86-73-7 | Fluorene | 0.46 | | |
| 193-39-5 | Indeno(1,2,3-cd)pyrene | 0.20 | U | |
| 91-57-6 | 2-Methylnaphthalene | 0.046 | J | |
| 91-20-3 | Naphthalene | ~~1.0~~ 0.0032 | J ~~U~~ | DWS 5/16/00 |
| 85-01-8 | Phenanthrene | 1.9 | | |
| 129-00-0 | Pyrene | 0.45 | | |
| 53-70-3 | Dibenzo(a,h)anthracene | 0.20 | U | |
| 86-74-8 | Carbazole | 0.21 | J | |

FORM I

Lab Name: Severn Trent Laboratories, Inc. SDG Number:

Matrix: (soil/water) WATER
Method: SW846 SW846 8270C SIM
8270C (SIM)

Lab Sample ID: C0E060119 002

Sample WT/Vol: 1000 / mL
Work Order: DCVF8101
Dilution factor: 1
Moisture %: NA

Date Received: 05/06/00
Date Extracted: 05/08/00
Date Analyzed: 05/10/00

QC Batch: 0130111

Client Sample Id: TP9910003XX

| CAS NO. | COMPOUND | CONCENTRATION UNITS: (ug/L or ug/kg) ug/L | Q |
|---|---|---|---|
| 83-32-9 | Acenaphthene | 0.46 | J |
| 208-96-8 | Acenaphthylene | 1.6 | |
| 120-12-7 | Anthracene | 1.6 | |
| 56-55-3 | Benzo(a)anthracene | 3.1 | |
| 205-99-2 | Benzo(b)fluoranthene | 2.7 | |
| 207-08-9 | Benzo(k)fluoranthene | 2.3 | |
| 191-24-2 | Benzo(ghi)perylene | 2.6 | |
| 50-32-8 | Benzo(a)pyrene | 3.1 | |
| 218-01-9 | Chrysene | 3.2 | |
| 206-44-0 | Fluoranthene | 9.2 | |
| 86-73-7 | Fluorene | 1.6 | |
| 193-39-5 | Indeno(1,2,3-cd)pyrene | 2.1 | |
| 91-57-6 | 2-Methylnaphthalene | 1.2 | |
| 91-20-3 | Naphthalene | 6.8 | |
| 85-01-8 | Phenanthrene | 7.7 | |
| 129-00-0 | Pyrene | 7.1 | |
| 53-70-3 | Dibenzo(a,h)anthracene | 0.71 | |
| 86-74-8 | Carbazole | 1.4 | |

FORM I

Lab Name:Severn Trent Laboratories, Inc. SDG Number:

Matrix: (soil/water) WATER Lab Sample ID:C0E060119 003
Method: SW846 SW846 8270C SIM
8270C (SIM)

Sample WT/Vol: 1000 / mL Date Received: 05/06/00
Work Order: DCVF9101 Date Extracted:05/08/00
Dilution factor: 1 Date Analyzed: 05/10/00
Moisture %:NA

QC Batch: 0130111

Client Sample Id: CB9911002XX

| CAS NO. | COMPOUND | CONCENTRATION UNITS: (ug/L or ug/kg) ug/L | Q |
|---|---|---|---|
| 83-32-9 | Acenaphthene | 1.0 | U |
| 208-96-8 | Acenaphthylene | 1.0 | U |
| 120-12-7 | Anthracene | 0.032 | J |
| 56-55-3 | Benzo(a)anthracene | 0.042 | J |
| 205-99-2 | Benzo(b)fluoranthene | 0.20 | U |
| 207-08-9 | Benzo(k)fluoranthene | 0.20 | U |
| 191-24-2 | Benzo(ghi)perylene | 0.20 | U |
| 50-32-8 | Benzo(a)pyrene | 0.20 | U |
| 218-01-9 | Chrysene | 0.035 | J |
| 206-44-0 | Fluoranthene | 0.21 | |
| 86-73-7 | Fluorene | 0.037 | J |
| 193-39-5 | Indeno(1,2,3-cd)pyrene | 0.20 | U |
| 91-57-6 | 2-Methylnaphthalene | 0.060 | J |
| 91-20-3 | Naphthalene | 0.27 | J |
| 85-01-8 | Phenanthrene | 0.22 | |
| 129-00-0 | Pyrene | 0.20 | |
| 53-70-3 | Dibenzo(a,h)anthracene | 0.20 | U |
| 86-74-8 | Carbazole | 1.0 | U |

Lab Name:Severn Trent Laboratories, Inc.      SDG Number:

Matrix:  (soil/water) WATER      Lab Sample ID:C0E060119 004
Method:  SW846 SW846 8270C SIM
         8270C (SIM)

Sample WT/Vol: 1000 / mL      Date Received: 05/06/00
Work Order:  DCVFA101      Date Extracted:05/08/00
Dilution factor:  1      Date Analyzed: 05/10/00
Moisture %:NA

QC Batch: 0130111

Client Sample Id: CB9915002XX

| CAS NO. | COMPOUND | CONCENTRATION UNITS: (ug/L or ug/kg) ug/L | Q |
|---|---|---|---|
| 83-32-9 | Acenaphthene | 4.3 | |
| 208-96-8 | Acenaphthylene | 0.21 | J |
| 120-12-7 | Anthracene | 7.8 | |
| 56-55-3 | Benzo(a)anthracene | 9.7 | |
| 205-99-2 | Benzo(b)fluoranthene | 7.2 | |
| 207-08-9 | Benzo(k)fluoranthene | 6.7 | |
| 191-24-2 | Benzo(ghi)perylene | 5.6 | |
| 50-32-8 | Benzo(a)pyrene | 8.0 | |
| 218-01-9 | Chrysene | 9.4 | |
| 206-44-0 | Fluoranthene | 31 | E |
| 86-73-7 | Fluorene | 6.1 | |
| 193-39-5 | Indeno(1,2,3-cd)pyrene | 5.5 | |
| 91-57-6 | 2-Methylnaphthalene | 0.76 | J |
| 91-20-3 | Naphthalene | 1.4 | |
| 85-01-8 | Phenanthrene | 27 | E |
| 129-00-0 | Pyrene | 21 | E |
| 53-70-3 | Dibenzo(a,h)anthracene | 2.3 | |
| 86-74-8 | Carbazole | 9.6 | |

FORM I

Lab Name:Severn Trent Laboratories, Inc.
SDG Number:

Matrix: (soil/water) WATER
Method: SW846 SW846 8270C SIM
8270C (SIM)
Lab Sample ID:C0E060119 004

Sample WT/Vol: 1000 / mL
Work Order: DCVFA201
Dilution factor: 4
Moisture %:NA

Date Received: 05/06/00
Date Extracted:05/08/00
Date Analyzed: 05/10/00

QC Batch: 0130111

Client Sample Id: CB9915002XX -RE 1

| CAS NO. | COMPOUND | CONCENTRATION UNITS: (ug/L or ug/kg) ug/L | Q |
|---|---|---|---|
| 83-32-9 | Acenaphthene | 3.6 | J |
| 208-96-8 | Acenaphthylene | 0.18 | J |
| 120-12-7 | Anthracene | 6.6 | |
| 56-55-3 | Benzo(a)anthracene | 8.4 | |
| 205-99-2 | Benzo(b)fluoranthene | 7.0 | |
| 207-08-9 | Benzo(k)fluoranthene | 5.1 | |
| 191-24-2 | Benzo(ghi)perylene | 4.8 | |
| 50-32-8 | Benzo(a)pyrene | 6.9 | |
| 218-01-9 | Chrysene | 8.4 | |
| 206-44-0 | Fluoranthene | 29 | |
| 86-73-7 | Fluorene | 5.0 | |
| 193-39-5 | Indeno(1,2,3-cd)pyrene | 4.5 | |
| 91-57-6 | 2-Methylnaphthalene | 0.66 | J |
| 91-20-3 | Naphthalene | 1.3 | J |
| 85-01-8 | Phenanthrene | 24 | |
| 129-00-0 | Pyrene | 19 | |
| 53-70-3 | Dibenzo(a,h)anthracene | 1.9 | |
| 86-74-8 | Carbazole | 8.1 | |

Lab Name:Severn Trent Laboratories, Inc. SDG Number:

Matrix: (soil/water) WATER
Method: SW846 SW846 8270C SIM
8270C (SIM)

Lab Sample ID:C0E060119 005

Sample WT/Vol: 1000 / mL
Work Order: DCVFC101
Dilution factor: 1
Moisture %:NA

Date Received: 05/06/00
Date Extracted:05/08/00
Date Analyzed: 05/10/00

QC Batch: 0130111

Client Sample Id: TPDEP11001XX

| CAS NO. | COMPOUND | CONCENTRATION UNITS: (ug/L or ug/kg) ug/L | Q |
|---|---|---|---|
| 83-32-9 | Acenaphthene | 0.063 | J |
| 208-96-8 | Acenaphthylene | 1.0 | U |
| 120-12-7 | Anthracene | 0.089 | J |
| 56-55-3 | Benzo(a)anthracene | 0.072 | J |
| 205-99-2 | Benzo(b)fluoranthene | 0.060 | J |
| 207-08-9 | Benzo(k)fluoranthene | 0.052 | J |
| 191-24-2 | Benzo(ghi)perylene | 0.048 | J |
| 50-32-8 | Benzo(a)pyrene | 0.054 | J |
| 218-01-9 | Chrysene | 0.072 | J |
| 206-44-0 | Fluoranthene | 0.31 | |
| 86-73-7 | Fluorene | 0.075 | J |
| 193-39-5 | Indeno(1,2,3-cd)pyrene | 0.040 | J |
| 91-57-6 | 2-Methylnaphthalene | 0.080 | J |
| 91-20-3 | Naphthalene | 0.11 | J |
| 85-01-8 | Phenanthrene | 0.42 | |
| 129-00-0 | Pyrene | 0.20 | |
| 53-70-3 | Dibenzo(a,h)anthracene | 0.20 | U |
| 86-74-8 | Carbazole | 0.11 | J |

FORM I

STL Monroe
CHECK SAMPLE COMPOUNDS

Lab Name:Severn Trent Laboratories, Inc.      SDG Number:

Matrix: (soil/water) WATER      Lab Sample ID:C0E090000 111
Method: SW846 SW846 8270C SIM
8270C (SIM)

Sample WT/Vol: 1000 / mL      Date Received: 05/06/00
Work Order: DCWWV102      Date Extracted:05/08/00
Dilution factor: 1      Date Analyzed: 05/10/00
Moisture %:NA

QC Batch: 0130111

Client Sample Id: CHECK SAMPLE

| CAS NO. | COMPOUND | CONCENTRATION UNITS: (ug/L or ug/kg) ug/L | Q |
|---|---|---|---|
| 83-32-9 | Acenaphthene | 3.49 | |
| 208-96-8 | Acenaphthylene | 3.40 | |
| 120-12-7 | Anthracene | 3.99 | |
| 56-55-3 | Benzo(a)anthracene | 4.04 | |
| 205-99-2 | Benzo(b)fluoranthene | 3.91 | |
| 207-08-9 | Benzo(k)fluoranthene | 3.71 | |
| 191-24-2 | Benzo(ghi)perylene | 3.54 | |
| 50-32-8 | Benzo(a)pyrene | 3.39 | |
| 218-01-9 | Chrysene | 3.98 | |
| 53-70-3 | Dibenzo(a,h)anthracene | 3.47 | |
| 206-44-0 | Fluoranthene | 4.44 | |
| 86-73-7 | Fluorene | 3.69 | |
| 193-39-5 | Indeno(1,2,3-cd)pyrene | 3.47 | |
| 91-57-6 | 2-Methylnaphthalene | 3.52 | |
| 91-20-3 | Naphthalene | 3.56 | |
| 85-01-8 | Phenanthrene | 3.99 | |
| 129-00-0 | Pyrene | 4.10 | |
| 86-74-8 | Carbazole | 4.28 | |

FORM I

STL Monroe
CHECK SAMPLE DUPLICATE COMPOUNDS

Lab Name:Severn Trent Laboratories, Inc. SDG Number:

Matrix: (soil/water) WATER
Method: SW846 SW846 8270C SIM
8270C (SIM)

Lab Sample ID:C0E090000 111

Sample WT/Vol: 1000 / mL
Work Order: DCWWV103
Dilution factor: 1
Moisture %:NA

Date Received: 05/06/00
Date Extracted:05/08/00
Date Analyzed: 05/10/00

QC Batch: 0130111

Client Sample Id: DUPLICATE CHECK

| CAS NO. | COMPOUND | CONCENTRATION UNITS: (ug/L or ug/kg) ug/L | Q |
|---|---|---|---|
| 83-32-9 | Acenaphthene | 3.54 | |
| 208-96-8 | Acenaphthylene | 3.44 | |
| 120-12-7 | Anthracene | 3.99 | |
| 56-55-3 | Benzo(a)anthracene | 4.02 | |
| 205-99-2 | Benzo(b)fluoranthene | 4.15 | |
| 207-08-9 | Benzo(k)fluoranthene | 3.57 | |
| 191-24-2 | Benzo(ghi)perylene | 3.50 | |
| 50-32-8 | Benzo(a)pyrene | 3.38 | |
| 218-01-9 | Chrysene | 3.96 | |
| 206-44-0 | Fluoranthene | 4.53 | |
| 86-73-7 | Fluorene | 3.75 | |
| 193-39-5 | Indeno(1,2,3-cd)pyrene | 3.44 | |
| 91-57-6 | 2-Methylnaphthalene | 3.52 | |
| 91-20-3 | Naphthalene | 3.58 | |
| 85-01-8 | Phenanthrene | 4.04 | |
| 129-00-0 | Pyrene | 4.11 | |
| 53-70-3 | Dibenzo(a,h)anthracene | 3.45 | |
| 86-74-8 | Carbazole | 4.34 | |

# APPENDIX G

# 100% DESIGN COST ESTIMATE

# APPENDIX G
# 100% ENGINEERING DESIGN COST ESTIMATE
# CAUSEWAY NON-TIME CRITICAL REMOVAL ACTION
# STRATFORD ARMY ENGINE PLANT

The following report contains estimated costs associated with construction of the erosion control cover system on the Causeway at the Stratford Army Engine Plant (SAEP). The report is a printout of the 30% engineering design cost estimate prepared using MCACES software. Three phases of the costs are presented in the estimate, including project direct costs, project indirect costs, and project owner costs.

Project direct costs (listed on summary pages 11 through 16) provide a summary of the direct costs associated with construction of the alternative, including labor, equipment, and material costs. Project indirect costs (listed on summary pages 6 through 10) include the project direct costs, contractor overhead, home office costs, profit, and bond costs. Project owner costs (listed on summary pages 1 through 5) include project indirect costs, escalation costs, contingency costs, and USACE project administration costs (i.e., SIOH).

The final pages of the following report (settings pages 1 through 4) summarize the percentages used in the cost estimate for various contractors that may be used during construction of the alternative.

Stratford Army Engine Plant
Stratford, Connecticut

Designed By: Harding, ESE - Portland, Maine
Estimated By: Harding, ESE - Portland, Maine

Prepared By: Harding, ESE - Reno, Nevada

Preparation Date: 01/24/01
Effective Date of Pricing: 01/24/01
Est Construction Time: 150 Days

Sales Tax: 6.0%

MCACES for Windows

Release 1.2

Currency in DOLLARS

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The Stratford Army Engine Plant Causeway Non-time Critical Removal Action (NCRA) consists of limited soil removal and construction of an erosion control cover system on the existing Causeway to prevent direct contact with contaminated soil. The design is consistent with the Causeway Decision Document. The project has been divided into two phases to facilitate completion of the project.

Phase I of the project includes preliminary activities conducted to clear the Causeway of structures and materials that would impede the construction of an erosion control cover system. These activities include:

1 - Pre-construction activities, including Work Plan, SSHP, and Environment Protection Plan development 2 - Mobilization of equipment and personnel 3 - Abandonment of designated existing monitoring wells 4 - Installation and maintenance of erosion and sediment control measures 5 - Clearing of trees and brush from the Causeway 6 - Removal of the containment berm around the Building 34 former AST farm and removal of associated protective posts and tank supports to existing ground surface, followed by paving of the area to improve access to the Causeway 7 - Demolition and off-site dipsosal of Building 5, including existing utility disconnection, to improve access to the Causeway 8 - Excavation and off-site disposal of soil in six locations that contains contamination in exceedance of specific CTDEP or federal criteria 9 - Demolition and off-site disposal of Building 59 and the Causeway weather station, including existing utlity removal 10 - Removal and off-site disposal of oversized surface debris measureing greater than two feet in any dimension 11 - Topographic survey of the Causeway and development of a Phase I Completion Report

Incidental work shall include decontamination of personnel and equipment, on-site treatment and disposal of decontamination fluids, personnel health and safety, contract meetings, and project documentation.

It is anticipated that Phase I activities shall take approximately 9 weeks to complete. With the exception of clearing and grubbing, weather station demolition, and removal of oversized debris below the primary silt fence, Phase I activities can be completed during the "closed" period from April 1 to September 30.

Demolition and off-site disposal of Building 59 and Building 5 comprise a significant portion of the cost for Phase I of this removal action. Building 59 is a one-story, 1,300 square-foot, unoccupied concrete building located on the Causeway. It is surrounded by 1-1/2-foot thick, heavily reinforced, perimeter concrete blast walls (230 linear feet), and is divided into 4 separate rooms. The roof of the building is flat and covered with tar and gravel. Building 59 will be removed to 2 feet below existing grade.

Building 5 is a former fuel system testing facility. It is a one-story, 5,300 square-foot, concrete block building with a flat roof. The roof of the facility and water pipe insulation have been determined to contain asbestos (estimated 10 cy). The existing exterior and interior walls of the building will be removed to existing grade - the slab will remain in place.

Phase II work shall consist of construction of the cover system (lower and upper) and finishing work. Activities for Phase II include:

1 - Maintenance of erosion and sediment control measures placed during Phase I of work on the Causeway. 2 - Excavation of soil located on the Causeway sideslopes, placement of satisfactory excavated material on the top of the Causeway, and grading of the Causeway to the elevations indicated on the drawings. 3 - Off-site transport and disposal of unsatisfactory excavated material. 4 - Removal and off-site disposal of oversized debris identified during Phase I activities and encountered during sideslope excavation. 5 - Placement of the lower cover system, consisting of a rock-filled toe (at the end of the Causeway), a rock-filled crest drainage layer, a woven geotextile, and polymeric marine mattress baskets, on the excavated sideslopes of the Causeway. 6 - Placement of the upper cover system, consisting, from bottom to top, of Sand Bedding, a woven geotextile, interlocking concrete blocks, interstitial gravel, and gravel over the concrete blocks. 7 - Placement a Rip Rap transition connecting the lower cover system to the upper cover system. 8 - Placement of a vegetative support layer, including vegetative support soil, suitable grass cover, and an erosion control mat. 9 - Monitoring well grade adjustments on four existing monitoring wells. 10 - Completion of site surveys during and following the completion of Phase II construction activities. 11 - Demobilization activities, including removal of temporary facilities and final site cleanup.

Incidental work shall include decontamination of personnel and equipment, on-site treatment and disposal of decontamination fluids, personnel health and safety, contract meetings, and project documentation.

It is anticipated that Phase II activities shall take approximately 12 weeks to complete. In addition, it is assumed that Phase II activities can NOT be completed during the "closed" period from April 1 to September 30.

Installation, maintenance, and removal of the floating silt curtain, including materials, anchors, and installation labor have been deleted from this cost estimate, based on comments from the CTDEP-OLISP.

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SUMMARY REPORTS SUMMARY PAGE

No Detailed Estimate...

No Backup Reports...

* * * END TABLE OF CONTENTS * * *

** PROJECT OWNER SUMMARY - System **

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                                               QUANTITY UOM  CONTRACT    ESCALATN     CONTINGN        SIOH TOTAL CST UNIT COST
-----------------------------------------------------------------------------------------------------------------------


 G  Phase I and II

 G. A  Phase I

 G. A.01  Mobilization                                      12,201         195        1,889       1,000    15,285
 G. A.05  Pre-construction and Oversite          1.00 EA   126,690       2,027       19,616      10,383   158,716 158716.36
 G. A.10  Site Preparation                                  14,885         238        2,305       1,220    18,647
 G. A.15  Excavation and Demolition                        143,515       2,296       22,222      11,762   179,796
 G. A.20  Confirmation Sampling & Analysis       1.00 EA    24,969         400        3,866       2,046    31,281  31281.12
 G. A.25  Decontamination Equipment              1.00 EA    44,460         711        6,884       3,644    55,700  55699.54
 G. A.31  Debris Transportation & Offhaul                  312,853       5,006       48,442      25,641   391,942
 G. A.35  Phase I Closeout                                   2,016          32          312         165     2,526
                                                         --------- ----------- ----------- ----------- ---------
    TOTAL Phase I                                1.00 EA   681,589      10,905      105,536      55,862   853,893 853892.96


 G. B  Phase II

 G. B.01  Mobilization                                       1,933          31          299         158     2,421
 G. B.04  Pre-construction and Oversite          1.00 EA   129,744       2,076       20,089      10,634   162,543 162542.55
 G. B.10  Site Preparation                                   3,735          60          578         306     4,679
    B.15  Soil Excavation and Causeway Gra                  74,349       1,190       11,512       6,094    93,144
    B.25  Placement of Lower Cover System                1,364,445      21,831      211,269     111,828 1,709,373
 G. B.30  Placement of UpperCover System                   351,919       5,631       54,491      28,843   440,883
 G. B.35  Placement of Rip-rap Transition                   12,405         198        1,921       1,017    15,541
 G. B.45  Placement of Grass Cover                         138,354       2,214       21,423      11,339   173,330
 G. B.50  Off-Site Transport & Disposal                     81,048       1,297       12,549       6,643   101,537
 G. B.55  Sample and Anaylsis                    1.00 EA    19,622         314        3,038       1,608    24,582  24582.26
 G. B.70  Site Survey                            1.00 EA    29,857         478        4,623       2,447    37,404  37404.43
 G. B.80  Demobilization/Project Closeout                   19,248         308        2,980       1,578    24,114
                                                         --------- ----------- ----------- ----------- ---------
    TOTAL Phase II                               1.00 EA 2,226,658      35,627      344,772     182,494 2,789,551   2789551
                                                         --------- ----------- ----------- ----------- ---------
    TOTAL Phase I and II                         1.00 EA 2,908,248      46,532      450,308     238,356 3,643,444   3643444
                                                         --------- ----------- ----------- ----------- ---------
    TOTAL Stratford Army Engine Plant                    2,908,248      46,532      450,308     238,356 3,643,444
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                                                 QUANTITY UOM  CONTRACT    ESCALATN     CONTINGN        SIOH TOTAL CST UNIT COST
------------------------------------------------------------------------------------------------------------------------------


 G  Phase I and II

 G. A  Phase I

 G. A.01  Mobilization

 G. A.01.30  Equipment Mobilization                             12,201         195        1,889       1,000    15,285
                                                             --------- ----------- ----------- ----------- ---------
       TOTAL Mobilization                                       12,201         195        1,889       1,000    15,285


 G. A.05  Pre-construction and Oversite

 G. A.05.01  PPC/PPE                                            35,175         563        5,446       2,883    44,067
 G. A.05.08  Home Office                                        11,615         186        1,798         952    14,552
 G. A.05.13  Site Office                                        65,041       1,041       10,071       5,331    81,483
 G. A.05.18  Preconstruction Meeting                             1,032          17          160          85     1,293
 G. A.05.23  Work Plan                                           3,844          62          595         315     4,816
 G. A.05.28  Health and Safety Plan                              3,844          62          595         315     4,816
 G. A.05.33  Environmental Protection Plan                       3,844          62          595         315     4,816
 G. A.05.38  Project Scheduling                                  2,294          37          355         188     2,874
                                                             --------- ----------- ----------- ----------- ---------
       TOTAL Pre-construction and Oversite          1.00 EA    126,690       2,027       19,616      10,383   158,716 15871


 G. A.10  Site Preparation

 G. A.10.03  Equipment Decon Pad                                 4,305          69          667         353     5,394
 G. A.10.07  Remove Existing Utilities                           2,041          33          316         167     2,557
 G. A.10.15  Clear and Grub                                        895          14          139          73     1,121
 G. A.10.31  Vertical  Displacement Monument                     3,121          50          483         256     3,910
 G. A.10.36  Build Stockpile Areas                               3,421          55          530         280     4,286
 G. A.10.41  Abandon MWCD-00-01                                  1,101          18          170          90     1,379
                                                             --------- ----------- ----------- ----------- ---------
       TOTAL Site Preparation                                   14,885         238        2,305       1,220    18,647


 G. A.15  Excavation and Demolition

 G. A.15.03  Erosion and Sedimentation Contro                   16,346         262        2,531       1,340    20,478
 G. A.15.06  Other Debris on Causeway                           22,059         353        3,416       1,808    27,636
 G. A.15.11  Demolition - Bldg 59                   1.00        43,179         691        6,686       3,539    54,095  54095.10
 G. A.15.16  Demolition Building 5                              37,184         595        5,758       3,048    46,584
 G. A.15.21  Demolition Weather Station                          9,623         154        1,490         789    12,056
 G. A.15.26  Remove Causeway Hot Spots                           8,242         132        1,276         675    10,325
 G. A.15.36  Building 34 Berm  Demolition                        6,882         110        1,066         564     8,621
                                                             --------- ----------- ----------- ----------- ---------
       TOTAL Excavation and Demolition                         143,515       2,296       22,222      11,762   179,796
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                                                   QUANTITY UOM  CONTRACT    ESCALATN    CONTINGN        SIOH TOTAL CST UNIT COST
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 G. A.20  Confirmation Sampling & Analysis

 G. A.20. 5  Sample and Anaylsis                        1.00 EA    24,969         400       3,866       2,046    31,281  31281.12
                                                                ---------  ----------  ----------  ----------  ---------
      TOTAL Confirmation Sampling & Analysis            1.00 EA    24,969         400       3,866       2,046    31,281  31281.12


 G. A.25  Decontamination Equipment

 G. A.25. 5  Decontamination Equipment                  1.00 EA    15,236         244       2,359       1,249    19,087  19087.49
 G. A.25.10  Decontamination Crew                       1.00 EA    29,224         468       4,525       2,395    36,612  36612.05
                                                                ---------  ----------  ----------  ----------  ---------
      TOTAL Decontamination Equipment                   1.00 EA    44,460         711       6,884       3,644    55,700  55699.54


 G. A.31  Debris Transportation & Offhaul

 G. A.31.30  Debris Transportation & Offhaul                      312,853       5,006      48,442      25,641   391,942
                                                                ---------  ----------  ----------  ----------  ---------
      TOTAL Debris Transportation & Offhaul                       312,853       5,006      48,442      25,641   391,942


    A.35  Phase I Closeout

 G. A.35.46  Topographic Survey                                     1,153          18         179          95     1,445
 G. A.35.51  Phase I Completion Report                                863          14         134          71     1,081
                                                                ---------  ----------  ----------  ----------  ---------
      TOTAL Phase I Closeout                                        2,016          32         312         165     2,526
                                                                ---------  ----------  ----------  ----------  ---------
      TOTAL Phase I                                     1.00 EA   681,589      10,905     105,536      55,862   853,893 853892.96


 G. B  Phase II

 G. B.01  Mobilization

 G. B.01.30  Equipment Mobilization                                 1,933          31         299         158     2,421
                                                                ---------  ----------  ----------  ----------  ---------
      TOTAL Mobilization                                            1,933          31         299         158     2,421


 G. B.04  Pre-construction and Oversite

 G. B.04.01  PPC/PPE                                               28,179         451       4,363       2,310    35,303
 G. B.04.13  Site Office                                           86,721       1,388      13,428       7,108   108,644
 G. B.04.18  Preconstruction Meeting                                1,032          17         160          85     1,293
 G. B.04.23  Work Plan                                              3,844          62         595         315     4,816
 G. B.04.28  Health and Safety Plan Addendum                        1,915          31         296         157     2,399
 G. B.04.33  Environmental Protect. Plan Adde                       1,915          31         296         157     2,399
    B.04.38  Project Scheduling                                     2,294          37         355         188     2,874
```

| | | QUANTITY | UOM | CONTRACT | ESCALATN | CONTINGN | SIOH | TOTAL CST | UNIT COST |
|---|---|---|---|---|---|---|---|---|---|
| G. B.04.43 | Contractor Quality Control Plan | | | 3,844 | 62 | 595 | 315 | 4,816 | |
| | TOTAL Pre-construction and Oversite | 1.00 | EA | 129,744 | 2,076 | 20,089 | 10,634 | 162,543 | 162542.55 |
| G. B.10 | Site Preparation | | | | | | | | |
| G. B.10.03 | Maintain Stockpile/Decon Area | | | 800 | 13 | 124 | 66 | 1,002 | |
| G. B.10.46 | Maintain Erosion Control Measure | | | 2,935 | 47 | 454 | 241 | 3,677 | |
| | TOTAL Site Preparation | | | 3,735 | 60 | 578 | 306 | 4,679 | |
| G. B.15 | Soil Excavation and Causeway Gra | | | | | | | | |
| G. B.15.06 | Side Slope Soil Excavation | | | 65,500 | 1,048 | 10,142 | 5,368 | 82,059 | |
| G. B.15.10 | Grading | | | 8,849 | 142 | 1,370 | 725 | 11,085 | |
| | TOTAL Soil Excavation and Causeway Gra | | | 74,349 | 1,190 | 11,512 | 6,094 | 93,144 | |
| G. B.25 | Placement of Lower Cover System | | | | | | | | |
| G. B.25.02 | Rock Fill Material | | | 36,193 | 579 | 5,604 | 2,966 | 45,343 | |
| G. B.25.04 | Geotexiles | | | 188,644 | 3,018 | 29,209 | 15,461 | 236,332 | |
| G. B.25.10 | QC Soil Testing | 1.00 | EA | 1,047 | 17 | 162 | 86 | 1,312 | 1311.66 |
| G. B.25.27 | Import and Place Gravel | 1.00 | EA | 2,780 | 44 | 430 | 228 | 3,483 | 3483.08 |
| G. B.25.30 | Compact Gravel | 1.00 | EA | 247 | 4 | 38 | 20 | 310 | 309.87 |
| G. B.25.40 | Placing Polymeric Marine Mattres | 1.00 | EA | 1,135,534 | 18,169 | 175,824 | 93,067 | 1,422,593 | 1422593 |
| | TOTAL Placement of Lower Cover System | | | 1,364,445 | 21,831 | 211,269 | 111,828 | 1,709,373 | |
| G. B.30 | Placement of UpperCover System | | | | | | | | |
| G. B.30.10 | Import and Place Sand | 1.00 | EA | 35,253 | 564 | 5,458 | 2,889 | 44,164 | 44164.49 |
| G. B.30.20 | Compact Sand | 1.00 | EA | 2,597 | 42 | 402 | 213 | 3,254 | 3253.61 |
| G. B.30.40 | Placement of 4" Interlocking Blo | 1.00 | EA | 304,420 | 4,871 | 47,136 | 24,950 | 381,376 | 381376.10 |
| G. B.30.50 | Import and Place Gravel | 1.00 | EA | 4,865 | 78 | 753 | 399 | 6,095 | 6095.40 |
| G. B.30.70 | QC Soil Testing | 1.00 | EA | 4,784 | 77 | 741 | 392 | 5,994 | 5993.51 |
| | TOTAL Placement of UpperCover System | | | 351,919 | 5,631 | 54,491 | 28,843 | 440,883 | |
| G. B.35 | Placement of Rip-rap Transition | | | | | | | | |
| G. B.35.15 | Rip-rap Transition | 1.00 | EA | 12,405 | 198 | 1,921 | 1,017 | 15,541 | 15540.75 |
| | TOTAL Placement of Rip-rap Transition | | | 12,405 | 198 | 1,921 | 1,017 | 15,541 | |

| | | QUANTITY | UOM | CONTRACT | ESCALATN | CONTINGN | SIOH | TOTAL CST | UNIT COST |
|---|---|---|---|---|---|---|---|---|---|
| G. B.45 | Placement of Grass Cover | | | | | | | | |
| G. B.45.08 | Placement of Grass Cover | | | 138,354 | 2,214 | 21,423 | 11,339 | 173,330 | |
| | TOTAL Placement of Grass Cover | | | 138,354 | 2,214 | 21,423 | 11,339 | 173,330 | |
| G. B.50 | Off-Site Transport & Disposal | | | | | | | | |
| G. B.50.01 | Steam Clean and Dispose of Debri | | | 81,048 | 1,297 | 12,549 | 6,643 | 101,537 | |
| | TOTAL Off-Site Transport & Disposal | | | 81,048 | 1,297 | 12,549 | 6,643 | 101,537 | |
| G. B.55 | Sample and Anaylsis | | | | | | | | |
| G. B.55. 5 | Sample and Anaylsis | 1.00 | EA | 19,622 | 314 | 3,038 | 1,608 | 24,582 | 24582.26 |
| | TOTAL Sample and Anaylsis | 1.00 | EA | 19,622 | 314 | 3,038 | 1,608 | 24,582 | 24582.26 |
| G. B.70 | Site Survey | | | | | | | | |
| .70.46 | Topographic Survey | | | 28,429 | 455 | 4,402 | 2,330 | 35,616 | |
| G. B.70.51 | Final Report Generation | | | 1,428 | 23 | 221 | 117 | 1,788 | |
| | TOTAL Site Survey | 1.00 | EA | 29,857 | 478 | 4,623 | 2,447 | 37,404 | 37404.43 |
| G. B.80 | Demobilization/Project Closeout | | | | | | | | |
| G. B.80.30 | Equipment Demobilization | | | 14,134 | 226 | 2,188 | 1,158 | 17,707 | |
| G. B.80.51 | Phase II Completion Report | | | 863 | 14 | 134 | 71 | 1,081 | |
| G. B.80.56 | Removal of Erosion Control | | | 751 | 12 | 116 | 62 | 941 | |
| G. B.80.61 | Site Clean-up | | | 1,338 | 21 | 207 | 110 | 1,677 | |
| G. B.80.66 | Environ. Land-use Restrictions | | | 2,162 | 35 | 335 | 177 | 2,708 | |
| | TOTAL Demobilization/Project Closeout | | | 19,248 | 308 | 2,980 | 1,578 | 24,114 | |
| | TOTAL Phase II | 1.00 | EA | 2,226,658 | 35,627 | 344,772 | 182,494 | 2,789,551 | 2789551 |
| | TOTAL Phase I and II | 1.00 | EA | 2,908,248 | 46,532 | 450,308 | 238,356 | 3,643,444 | 3643444 |
| | TOTAL Stratford Army Engine Plant | | | 2,908,248 | 46,532 | 450,308 | 238,356 | 3,643,444 | |

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                               ** PROJECT INDIRECT SUMMARY - System **

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                                  QUANTITY UOM    DIRECT    OVERHEAD    HOME OFC      PROFIT        BOND TOTAL CST UNIT COST
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 G  Phase I and II

 G. A  Phase I

 G. A.01  Mobilization                              10,100         789         381         786         145    12,201
 G. A.05  Pre-construction and Over      1.00 EA   104,874       8,193       3,957       8,162       1,502   126,690 126689.60
 G. A.10  Site Preparation                          12,322         963         465         959         176    14,885
 G. A.15  Excavation and Demolition                118,803       9,281       4,483       9,247       1,702   143,515
 G. A.20  Confirmation Sampling & A      1.00 EA    20,669       1,615         780       1,609         296    24,969  24969.02
 G. A.25  Decontamination Equipment      1.00 EA    36,804       2,875       1,389       2,865         527    44,460  44460.15
 G. A.31  Debris Transportation & O                258,982      20,233       9,773      20,157       3,710   312,853
 G. A.35  Phase I Closeout                           1,669         130          63         130          24     2,016
                                                 --------- ----------- ----------- ----------- ----------- ---------
    TOTAL Phase I                        1.00 EA   564,223      44,080      21,291      43,914       8,082   681,589 681589.20


 G. B  Phase II

 G. B.01  Mobilization                               1,600         125          60         125          23     1,933
 G. B.04  Pre-construction and Over      1.00 EA   107,402       8,391       4,053       8,359       1,538   129,744 129743.72
 G. B.10  Site Preparation                           3,092         242         117         241          44     3,735
 G. B.15  Soil Excavation and Cause                 61,546       4,808       2,322       4,790         882    74,349
 G. B.25  Placement of Lower Cover               1,129,494      88,242      42,621      87,910      16,179 1,364,445
 G. B.30  Placement of UpperCover S                291,320      22,759      10,993      22,674       4,173   351,919
 G. B.35  Placement of Rip-rap Tran                 10,269         802         387         799         147    12,405
 G. B.45  Placement of Grass Cover                 114,530       8,948       4,322       8,914       1,641   138,354
 G. B.50  Off-Site Transport & Disp                 67,092       5,242       2,532       5,222         961    81,048
 G. B.55  Sample and Anaylsis            1.00 EA    16,243       1,269         613       1,264         233    19,622  19621.90
 G. B.70  Site Survey                    1.00 EA    24,716       1,931         933       1,924         354    29,857  29856.74
 G. B.80  Demobilization/Project Cl                 15,934       1,245         601       1,240         228    19,248
                                                 --------- ----------- ----------- ----------- ----------- ---------
    TOTAL Phase II                       1.00 EA 1,843,238     144,003      69,553     143,461      26,403 2,226,658   2226658
                                                 --------- ----------- ----------- ----------- ----------- ---------
    TOTAL Phase I and II                 1.00 EA 2,407,461     188,082      90,844     187,375      34,485 2,908,248   2908248
                                                 --------- ----------- ----------- ----------- ----------- ---------
    TOTAL Stratford Army Engine Pla              2,407,461     188,082      90,844     187,375      34,485 2,908,248

  Escalation                                                                                                 46,532
                                                                                                          ---------
    SUBTOTAL                                                                                              2,954,780
  Contingency                                                                                               450,308
                                                                                                          ---------
    SUBTOTAL                                                                                              3,405,088
  Supervision, Inspection, and Overhead                                                                     238,356
                                                                                                          ---------
    TOTAL INCL OWNER COSTS                                                                                3,643,444
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| | QUANTITY | UOM | DIRECT | OVERHEAD | HOME OFC | PROFIT | BOND | TOTAL CST | UNIT COST |
|---|---|---|---|---|---|---|---|---|---|
| G Phase I and II | | | | | | | | | |
| G. A Phase I | | | | | | | | | |
| G. A.01 Mobilization | | | | | | | | | |
| G. A.01.30 Equipment Mobilization | | | 10,100 | 789 | 381 | 786 | 145 | 12,201 | |
| TOTAL Mobilization | | | 10,100 | 789 | 381 | 786 | 145 | 12,201 | |
| G. A.05 Pre-construction and Over | | | | | | | | | |
| G. A.05.01 PPC/PPE | | | 29,118 | 2,275 | 1,099 | 2,266 | 417 | 35,175 | |
| G. A.05.08 Home Office | | | 9,615 | 751 | 363 | 748 | 138 | 11,615 | |
| G. A.05.13 Site Office | | | 53,841 | 4,206 | 2,032 | 4,191 | 771 | 65,041 | |
| G. A.05.18 Preconstruction Meetin | | | 854 | 67 | 32 | 66 | 12 | 1,032 | |
| G. A.05.23 Work Plan | | | 3,182 | 249 | 120 | 248 | 46 | 3,844 | |
| G. A.05.28 Health and Safety Plan | | | 3,182 | 249 | 120 | 248 | 46 | 3,844 | |
| G. A.05.33 Environmental Protecti | | | 3,182 | 249 | 120 | 248 | 46 | 3,844 | |
| G. A.05.38 Project Scheduling | | | 1,899 | 148 | 72 | 148 | 27 | 2,294 | |
| TOTAL Pre-construction and O | 1.00 | EA | 104,874 | 8,193 | 3,957 | 8,162 | 1,502 | 126,690 | 126689.60 |
| G. A.10 Site Preparation | | | | | | | | | |
| G. A.10.03 Equipment Decon Pad | | | 3,564 | 278 | 134 | 277 | 51 | 4,305 | |
| G. A.10.07 Remove Existing Utilit | | | 1,690 | 132 | 64 | 132 | 24 | 2,041 | |
| G. A.10.15 Clear and Grub | | | 741 | 58 | 28 | 58 | 11 | 895 | |
| G. A.10.31 Vertical Displacement | | | 2,584 | 202 | 97 | 201 | 37 | 3,121 | |
| G. A.10.36 Build Stockpile Areas | | | 2,832 | 221 | 107 | 220 | 41 | 3,421 | |
| G. A.10.41 Abandon MWCD-00-01 | | | 911 | 71 | 34 | 71 | 13 | 1,101 | |
| TOTAL Site Preparation | | | 12,322 | 963 | 465 | 959 | 176 | 14,885 | |
| G. A.15 Excavation and Demolition | | | | | | | | | |
| G. A.15.03 Erosion and Sedimentat | | | 13,531 | 1,057 | 511 | 1,053 | 194 | 16,346 | |
| G. A.15.06 Other Debris on Causew | | | 18,261 | 1,427 | 689 | 1,421 | 262 | 22,059 | |
| G. A.15.11 Demolition - Bldg 59 | 1.00 | | 35,744 | 2,793 | 1,349 | 2,782 | 512 | 43,179 | 43179.46 |
| G. A.15.16 Demolition Building 5 | | | 30,781 | 2,405 | 1,162 | 2,396 | 441 | 37,184 | |
| G. A.15.21 Demolition Weather Sta | | | 7,966 | 622 | 301 | 620 | 114 | 9,623 | |
| G. A.15.26 Remove Causeway Hot Sp | | | 6,823 | 533 | 257 | 531 | 98 | 8,242 | |
| G. A.15.36 Building 34 Berm Demo | | | 5,697 | 445 | 215 | 443 | 82 | 6,882 | |
| TOTAL Excavation and Demolit | | | 118,803 | 9,281 | 4,483 | 9,247 | 1,702 | 143,515 | |

** PROJECT INDIRECT SUMMARY - SubSystm **

| | QUANTITY | UOM | DIRECT | OVERHEAD | HOME OFC | PROFIT | BOND | TOTAL CST | UNIT COST |
|---|---|---|---|---|---|---|---|---|---|
| G. A.20 Confirmation Sampling & A | | | | | | | | | |
| G. A.20. 5 Sample and Anaylsis | 1.00 | EA | 20,669 | 1,615 | 780 | 1,609 | 296 | 24,969 | 24969.02 |
| TOTAL Confirmation Sampling | 1.00 | EA | 20,669 | 1,615 | 780 | 1,609 | 296 | 24,969 | 24969.02 |
| G. A.25 Decontamination Equipment | | | | | | | | | |
| G. A.25. 5 Decontamination Equipm | 1.00 | EA | 12,612 | 985 | 476 | 982 | 181 | 15,236 | 15235.90 |
| G. A.25.10 Decontamination Crew | 1.00 | EA | 24,192 | 1,890 | 913 | 1,883 | 347 | 29,224 | 29224.25 |
| TOTAL Decontamination Equipm | 1.00 | EA | 36,804 | 2,875 | 1,389 | 2,865 | 527 | 44,460 | 44460.15 |
| G. A.31 Debris Transportation & O | | | | | | | | | |
| G. A.31.30 Debris Transportation | | | 258,982 | 20,233 | 9,773 | 20,157 | 3,710 | 312,853 | |
| TOTAL Debris Transportation | | | 258,982 | 20,233 | 9,773 | 20,157 | 3,710 | 312,853 | |
| G. A.35 Phase I Closeout | | | | | | | | | |
| G. A.35.46 Topographic Survey | | | 955 | 75 | 36 | 74 | 14 | 1,153 | |
| G. A.35.51 Phase I Completion Rep | | | 714 | 56 | 27 | 56 | 10 | 863 | |
| TOTAL Phase I Closeout | | | 1,669 | 130 | 63 | 130 | 24 | 2,016 | |
| TOTAL Phase I | 1.00 | EA | 564,223 | 44,080 | 21,291 | 43,914 | 8,082 | 681,589 | 681589.20 |
| G. B Phase II | | | | | | | | | |
| G. B.01 Mobilization | | | | | | | | | |
| G. B.01.30 Equipment Mobilization | | | 1,600 | 125 | 60 | 125 | 23 | 1,933 | |
| TOTAL Mobilization | | | 1,600 | 125 | 60 | 125 | 23 | 1,933 | |
| G. B.04 Pre-construction and Over | | | | | | | | | |
| G. B.04.01 PPC/PPE | | | 23,327 | 1,822 | 880 | 1,816 | 334 | 28,179 | |
| G. B.04.13 Site Office | | | 71,788 | 5,608 | 2,709 | 5,587 | 1,028 | 86,721 | |
| G. B.04.18 Preconstruction Meetin | | | 854 | 67 | 32 | 66 | 12 | 1,032 | |
| G. B.04.23 Work Plan | | | 3,182 | 249 | 120 | 248 | 46 | 3,844 | |
| G. B.04.28 Health and Safety Plan | | | 1,585 | 124 | 60 | 123 | 23 | 1,915 | |
| G. B.04.33 Environmental Protect. | | | 1,585 | 124 | 60 | 123 | 23 | 1,915 | |
| G. B.04.38 Project Scheduling | | | 1,899 | 148 | 72 | 148 | 27 | 2,294 | |

** PROJECT INDIRECT SUMMARY - SubSystm **

| | | QUANTITY | UOM | DIRECT | OVERHEAD | HOME OFC | PROFIT | BOND | TOTAL CST | UNIT COST |
|---|---|---|---|---|---|---|---|---|---|---|
| G. B.04.43 | Contractor Quality Con | | | 3,182 | 249 | 120 | 248 | 46 | 3,844 | |
| | TOTAL Pre-construction and O | 1.00 | EA | 107,402 | 8,391 | 4,053 | 8,359 | 1,538 | 129,744 | 129743.72 |
| G. B.10 | Site Preparation | | | | | | | | | |
| G. B.10.03 | Maintain Stockpile/Dec | | | 662 | 52 | 25 | 52 | 9 | 800 | |
| G. B.10.46 | Maintain Erosion Contr | | | 2,430 | 190 | 92 | 189 | 35 | 2,935 | |
| | TOTAL Site Preparation | | | 3,092 | 242 | 117 | 241 | 44 | 3,735 | |
| G. B.15 | Soil Excavation and Cause | | | | | | | | | |
| G. B.15.06 | Side Slope Soil Excava | | | 54,222 | 4,236 | 2,046 | 4,220 | 777 | 65,500 | |
| G. B.15.10 | Grading | | | 7,325 | 572 | 276 | 570 | 105 | 8,849 | |
| | TOTAL Soil Excavation and Ca | | | 61,546 | 4,808 | 2,322 | 4,790 | 882 | 74,349 | |
| G. B.25 | Placement of Lower Cover | | | | | | | | | |
| 3.25.02 | Rock Fill Material | | | 29,961 | 2,341 | 1,131 | 2,332 | 429 | 36,193 | |
| G. B.25.04 | Geotexiles | | | 156,160 | 12,200 | 5,893 | 12,154 | 2,237 | 188,644 | |
| G. B.25.10 | QC Soil Testing | 1.00 | EA | 867 | 68 | 33 | 67 | 12 | 1,047 | 1046.99 |
| G. B.25.27 | Import and Place Grave | 1.00 | EA | 2,302 | 180 | 87 | 179 | 33 | 2,780 | 2780.25 |
| G. B.25.30 | Compact Gravel | 1.00 | EA | 205 | 16 | 8 | 16 | 3 | 247 | 247.34 |
| G. B.25.40 | Placing Polymeric Mari | 1.00 | EA | 940,000 | 73,437 | 35,470 | 73,161 | 13,465 | 1,135,534 | 1135534 |
| | TOTAL Placement of Lower Cov | | | 1,129,494 | 88,242 | 42,621 | 87,910 | 16,179 | 1,364,445 | |
| G. B.30 | Placement of UpperCover S | | | | | | | | | |
| G. B.30.10 | Import and Place Sand | 1.00 | EA | 29,182 | 2,280 | 1,101 | 2,271 | 418 | 35,253 | 35252.71 |
| G. B.30.20 | Compact Sand | 1.00 | EA | 2,150 | 168 | 81 | 167 | 31 | 2,597 | 2597.08 |
| G. B.30.40 | Placement of 4" Interl | 1.00 | EA | 252,000 | 19,687 | 9,509 | 19,613 | 3,610 | 304,420 | 304419.69 |
| G. B.30.50 | Import and Place Grave | 1.00 | EA | 4,028 | 315 | 152 | 313 | 58 | 4,865 | 4865.43 |
| G. B.30.70 | QC Soil Testing | 1.00 | EA | 3,960 | 309 | 149 | 308 | 57 | 4,784 | 4784.10 |
| | TOTAL Placement of UpperCove | | | 291,320 | 22,759 | 10,993 | 22,674 | 4,173 | 351,919 | |
| G. B.35 | Placement of Rip-rap Tran | | | | | | | | | |
| G. B.35.15 | Rip-rap Transition | 1.00 | EA | 10,269 | 802 | 387 | 799 | 147 | 12,405 | 12404.84 |
| | TOTAL Placement of Rip-rap T | | | 10,269 | 802 | 387 | 799 | 147 | 12,405 | |

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                              ** PROJECT INDIRECT SUMMARY - SubSystm **

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                                        QUANTITY UOM    DIRECT    OVERHEAD    HOME OFC      PROFIT        BOND TOTAL CST UNIT COST
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 G. B.45  Placement of Grass Cover

 G. B.45.08  Placement of Grass Cov                114,530       8,948       4,322       8,914       1,641   138,354
                                                 --------- ----------- ----------- ----------- ----------- ---------
       TOTAL Placement of Grass Cov                114,530       8,948       4,322       8,914       1,641   138,354


 G. B.50  Off-Site Transport & Disp

 G. B.50.01  Steam Clean and Dispos                 67,092       5,242       2,532       5,222         961    81,048
                                                 --------- ----------- ----------- ----------- ----------- ---------
       TOTAL Off-Site Transport & D                 67,092       5,242       2,532       5,222         961    81,048


 G. B.55  Sample and Anaylsis

 G. B.55. 5  Sample and Anaylsis          1.00 EA   16,243       1,269         613       1,264         233    19,622  19621.90
                                                 --------- ----------- ----------- ----------- ----------- ---------
       TOTAL Sample and Anaylsis          1.00 EA   16,243       1,269         613       1,264         233    19,622  19621.90


 G. B.70  Site Survey

 G. B.70.46  Topographic Survey                     23,534       1,839         888       1,832         337    28,429
 G. B.70.51  Final Report Generatio                  1,182          92          45          92          17     1,428
                                                 --------- ----------- ----------- ----------- ----------- ---------
       TOTAL Site Survey                  1.00 EA   24,716       1,931         933       1,924         354    29,857  29856.74


 G. B.80  Demobilization/Project Cl

 G. B.80.30  Equipment Demobilizati                 11,700         914         441         911         168    14,134
 G. B.80.51  Phase II Completion Re                    714          56          27          56          10       863
 G. B.80.56  Removal of Erosion Con                    622          49          23          48           9       751
 G. B.80.61  Site Clean-up                           1,108          87          42          86          16     1,338
 G. B.80.66  Environ. Land-use Rest                  1,789         140          68         139          26     2,162
                                                 --------- ----------- ----------- ----------- ----------- ---------
       TOTAL Demobilization/Project                 15,934       1,245         601       1,240         228    19,248
                                                 --------- ----------- ----------- ----------- ----------- ---------
       TOTAL Phase II                     1.00 EA 1,843,238     144,003      69,553     143,461      26,403 2,226,658   2226658
                                                 --------- ----------- ----------- ----------- ----------- ---------
       TOTAL Phase I and II               1.00 EA 2,407,461     188,082      90,844     187,375      34,485 2,908,248   2908248
                                                 --------- ----------- ----------- ----------- ----------- ---------
       TOTAL Stratford Army Engine                2,407,461     188,082      90,844     187,375      34,485 2,908,248

  Escalation                                                                                                  46,532
                                                                                                           ---------
    SUBTOTAL                                                                                               2,954,780
  Contingency                                                                                                450,308
                                                                                                           ---------
    SUBTOTAL                                                                                               3,405,088
```

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                                      QUANTITY UOM     DIRECT    OVERHEAD    HOME OFC      PROFIT        BOND TOTAL CST UNIT COST
----------------------------------------------------------------------------------------------------------------------------


  Supervision, Inspection, and Overhead                                                                      238,356
                                                                                                           ---------
    TOTAL INCL OWNER COSTS                                                                                 3,643,444
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** PROJECT DIRECT SUMMARY - System **

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                                              QUANTITY UOM  MANHRS     LABOR  EQUIPMNT  MATERIAL     OTHER TOTAL CST UNIT COST
------------------------------------------------------------------------------------------------------------------


G  Phase I and II

G. A  Phase I

G. A.01  Mobilization                                            0         0         0         0    10,100    10,100
G. A.05  Pre-construction and Oversite            1.00 EA    2,237    61,791    14,053    29,030         0   104,874 104874.23
G. A.10  Site Preparation                                      271     7,252     2,137       433     2,500    12,322
G. A.15  Excavation and Demolition                           2,290    60,938    49,491     8,374         0   118,803
G. A.20  Confirmation Sampling & Analysis         1.00 EA        0         0         0         0    20,669    20,669  20669.47
G. A.25  Decontamination Equipment                1.00 EA    1,080    24,192    12,612         0         0    36,804  36804.31
G. A.31  Debris Transportation & Offhaul                       174     5,963     7,569         0   245,450   258,982
G. A.35  Phase I Closeout                                       60     1,329       340         0         0     1,669
                                                           ------- --------- --------- --------- --------- ---------
   TOTAL Phase I                                  1.00 EA    6,112   161,465    86,201    37,837   278,719   564,223 564222.63


G. B  Phase II

G. B.01  Mobilization                                            0         0         0         0     1,600     1,600
G. B.04  Pre-construction and Oversite            1.00 EA    2,401    64,911    18,719    23,772         0   107,402 107402.44
G. B.10  Site Preparation                                      100     3,092         0         0         0     3,092
G. B.15  Soil Excavation and Causeway Gra                      775    27,946    33,600         0         0    61,546
G. B.25  Placement of Lower Cover System                       523    17,716     2,809   168,102   940,867 1,129,494
G. B.30  Placement of UpperCover System                        150     5,409     2,405    22,529   260,977   291,320
G. B.35  Placement of Rip-rap Transition                       163     5,191     1,923     3,155         0    10,269
G. B.45  Placement of Grass Cover                            1,907    57,976       136    49,395     7,023   114,530
G. B.50  Off-Site Transport & Disposal                         298     9,144     9,298         0    48,650    67,092
G. B.55  Sample and Anaylsis                      1.00 EA        0         0         0         0    16,243    16,243  16243.10
G. B.70  Site Survey                              1.00 EA    1,000    19,611     5,104         0         0    24,716  24715.54
G. B.80  Demobilization/Project Closeout                       146     4,234         0         0    11,700    15,934
                                                           ------- --------- --------- --------- --------- ---------
   TOTAL Phase II                                 1.00 EA    7,463   215,231    73,994   266,953 1,287,060 1,843,238   1843238
                                                           ------- --------- --------- --------- --------- ---------
   TOTAL Phase I and II                           1.00 EA   13,574   376,696   160,196   304,790 1,565,779 2,407,461   2407461
                                                           ------- --------- --------- --------- --------- ---------
   TOTAL Stratford Army Engine Plant                        13,574   376,696   160,196   304,790 1,565,779 2,407,461

 Prime Contractor's Field Overhead                                                                           188,082
                                                                                                           ---------
   SUBTOTAL                                                                                                2,595,543
 Prime's Home Office Expense                                                                                  90,844
                                                                                                           ---------
   SUBTOTAL                                                                                                2,686,387
 Prime Contractor's Profit                                                                                   187,375
                                                                                                           ---------
   SUBTOTAL                                                                                                2,873,762
 Prime Contractor's Bond                                                                                      34,485
                                                                                                           ---------
   TOTAL INCL INDIRECTS                                                                                    2,908,248
 Escalation                                                                                                   46,532
```

| | QUANTITY | UOM | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL CST | UNIT COST |
|---|---|---|---|---|---|---|---|---|---|
| SUBTOTAL | | | | | | | | 2,954,780 | |
| Contingency | | | | | | | | 450,308 | |
| SUBTOTAL | | | | | | | | 3,405,088 | |
| Supervision, Inspection, and Overhead | | | | | | | | 238,356 | |
| TOTAL INCL OWNER COSTS | | | | | | | | 3,643,444 | |

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                                               QUANTITY UOM MANHRS     LABOR EQUIPMNT MATERIAL     OTHER TOTAL CST UNIT COST
-------------------------------------------------------------------------------------------------------------------------------


 G  Phase I and II

 G. A  Phase I

 G. A.01  Mobilization

 G. A.01.30  Equipment Mobilization                               0         0         0         0    10,100    10,100
                                                            ------- --------- --------- --------- --------- ---------
       TOTAL Mobilization                                         0         0         0         0    10,100    10,100


 G. A.05  Pre-construction and Oversite

 G. A.05.01  PPC/PPE                                             46     1,633        52    27,432         0    29,118
 G. A.05.08  Home Office                                        315     9,615         0         0         0     9,615
 G. A.05.13  Site Office                                      1,440    38,243    14,000     1,598         0    53,841
 G. A.05.18  Preconstruction Meeting                             24       854         0         0         0       854
 G. A.05.23  Work Plan                                          113     3,182         0         0         0     3,182
 G. A.05.28  Health and Safety Plan                             113     3,182         0         0         0     3,182
 G. A.05.33  Environmental Protection Plan                      113     3,182         0         0         0     3,182
 G. A.05.38  Project Scheduling                                  73     1,899         0         0         0     1,899
                                                            ------- --------- --------- --------- --------- ---------
       TOTAL Pre-construction and Oversite         1.00 EA    2,237    61,791    14,053    29,030         0   104,874 1048


 G. A.10  Site Preparation

 G. A.10.03  Equipment Decon Pad                                 30       934       130         0     2,500     3,564
 G. A.10.07  Remove Existing Utilities                           64     1,350       340         0         0     1,690
 G. A.10.15  Clear and Grub                                      10       306       435         0         0       741
 G. A.10.31  Vertical  Displacement Monument                    109     2,465        15       104         0     2,584
 G. A.10.36  Build Stockpile Areas                               43     1,600     1,073       159         0     2,832
 G. A.10.41  Abandon MWCD-00-01                                  16       598       144       169         0       911
                                                            ------- --------- --------- --------- --------- ---------
       TOTAL Site Preparation                                   271     7,252     2,137       433     2,500    12,322


 G. A.15  Excavation and Demolition

 G. A.15.03  Erosion and Sedimentation Contro                   175     5,253       519     7,759         0    13,531
 G. A.15.06  Other Debris on Causeway                           340     8,944     9,317         0         0    18,261
 G. A.15.11  Demolition - Bldg 59                  1.00         700    20,096    15,648         0         0    35,744  35744.15
 G. A.15.16  Demolition Building 5                              730    16,840    13,941         0         0    30,781
 G. A.15.21  Demolition Weather Station                         176     4,240     3,727         0         0     7,966
 G. A.15.26  Remove Causeway Hot Spots                          113     3,617     2,590       615         0     6,823
 G. A.15.36  Building 34 Berm  Demolition                        56     1,948     3,749         0         0     5,697
                                                            ------- --------- --------- --------- --------- ---------
       TOTAL Excavation and Demolition                        2,290    60,938    49,491     8,374         0   118,803
```

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                                            QUANTITY UOM  MANHRS     LABOR  EQUIPMNT  MATERIAL     OTHER TOTAL CST UNIT COST
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 G. A.20  Confirmation Sampling & Analysis

 G. A.20. 5  Sample and Anaylsis                  1.00 EA       0         0         0         0    20,669    20,669  20669.47
                                                          ------- --------- --------- --------- --------- ---------
      TOTAL Confirmation Sampling & Analysis      1.00 EA       0         0         0         0    20,669    20,669  20669.47


 G. A.25  Decontamination Equipment

 G. A.25. 5  Decontamination Equipment            1.00 EA       0         0    12,612         0         0    12,612  12612.35
 G. A.25.10  Decontamination Crew                 1.00 EA   1,080    24,192         0         0         0    24,192  24191.96
                                                          ------- --------- --------- --------- --------- ---------
      TOTAL Decontamination Equipment             1.00 EA   1,080    24,192    12,612         0         0    36,804  36804.31


 G. A.31  Debris Transportation & Offhaul

 G. A.31.30  Debris Transportation & Offhaul                  174     5,963     7,569         0   245,450   258,982
                                                          ------- --------- --------- --------- --------- ---------
      TOTAL Debris Transportation & Offhaul                   174     5,963     7,569         0   245,450   258,982


    A.35  Phase I Closeout

 G. A.35.46  Topographic Survey                                32       614       340         0         0       955
 G. A.35.51  Phase I Completion Report                         28       714         0         0         0       714
                                                          ------- --------- --------- --------- --------- ---------
      TOTAL Phase I Closeout                                   60     1,329       340         0         0     1,669
                                                          ------- --------- --------- --------- --------- ---------
      TOTAL Phase I                               1.00 EA   6,112   161,465    86,201    37,837   278,719   564,223 564222.63


 G. B  Phase II

 G. B.01  Mobilization

 G. B.01.30  Equipment Mobilization                             0         0         0         0     1,600     1,600
                                                          ------- --------- --------- --------- --------- ---------
      TOTAL Mobilization                                        0         0         0         0     1,600     1,600


 G. B.04  Pre-construction and Oversite

 G. B.04.01  PPC/PPE                                           46     1,633        52    21,641         0    23,327
 G. B.04.13  Site Office                                    1,920    50,990    18,667     2,131         0    71,788
 G. B.04.18  Preconstruction Meeting                           24       854         0         0         0       854
 G. B.04.23  Work Plan                                        113     3,182         0         0         0     3,182
 G. B.04.28  Health and Safety Plan Addendum                   56     1,585         0         0         0     1,585
 G. B.04.33  Environmental Protect. Plan Adde                  56     1,585         0         0         0     1,585
    '.04.38  Project Scheduling                                73     1,899         0         0         0     1,899
```

| | | QUANTITY | UOM | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL CST | UNIT COST |
|---|---|---|---|---|---|---|---|---|---|---|
| G. B.04.43 | Contractor Quality Control Plan | | | 113 | 3,182 | 0 | 0 | 0 | 3,182 | |
| | TOTAL Pre-construction and Oversite | 1.00 | EA | 2,401 | 64,911 | 18,719 | 23,772 | 0 | 107,402 | 107402.44 |
| G. B.10 | Site Preparation | | | | | | | | | |
| G. B.10.03 | Maintain Stockpile/Decon Area | | | 20 | 662 | 0 | 0 | 0 | 662 | |
| G. B.10.46 | Maintain Erosion Control Measure | | | 80 | 2,430 | 0 | 0 | 0 | 2,430 | |
| | TOTAL Site Preparation | | | 100 | 3,092 | 0 | 0 | 0 | 3,092 | |
| G. B.15 | Soil Excavation and Causeway Gra | | | | | | | | | |
| G. B.15.06 | Side Slope Soil Excavation | | | 625 | 22,752 | 31,469 | 0 | 0 | 54,222 | |
| G. B.15.10 | Grading | | | 150 | 5,194 | 2,131 | 0 | 0 | 7,325 | |
| | TOTAL Soil Excavation and Causeway Gra | | | 775 | 27,946 | 33,600 | 0 | 0 | 61,546 | |
| G. B.25 | Placement of Lower Cover System | | | | | | | | | |
| G. B.25.02 | Rock Fill Material | | | 177 | 5,254 | 2,604 | 22,103 | 0 | 29,961 | |
| G. B.25.04 | Geotexiles | | | 334 | 12,000 | 0 | 144,160 | 0 | 156,160 | |
| G. B.25.10 | QC Soil Testing | 1.00 | EA | 0 | 0 | 0 | 0 | 867 | 867 | 866.70 |
| G. B.25.27 | Import and Place Gravel | 1.00 | EA | 9 | 318 | 144 | 1,839 | 0 | 2,302 | 2301.50 |
| G. B.25.30 | Compact Gravel | 1.00 | EA | 4 | 144 | 61 | 0 | 0 | 205 | 204.75 |
| G. B.25.40 | Placing Polymeric Marine Mattres | 1.00 | EA | 0 | 0 | 0 | 0 | 940,000 | 940,000 | 940000.00 |
| | TOTAL Placement of Lower Cover System | | | 523 | 17,716 | 2,809 | 168,102 | 940,867 | 1,129,494 | |
| G. B.30 | Placement of UpperCover System | | | | | | | | | |
| G. B.30.10 | Import and Place Sand | 1.00 | EA | 93 | 3,339 | 1,516 | 19,311 | 5,017 | 29,182 | 29182.35 |
| G. B.30.20 | Compact Sand | 1.00 | EA | 42 | 1,514 | 636 | 0 | 0 | 2,150 | 2149.88 |
| G. B.30.40 | Placement of 4" Interlocking Blo | 1.00 | EA | 0 | 0 | 0 | 0 | 252,000 | 252,000 | 252000.00 |
| G. B.30.50 | Import and Place Gravel | 1.00 | EA | 15 | 557 | 253 | 3,218 | 0 | 4,028 | 4027.63 |
| G. B.30.70 | QC Soil Testing | 1.00 | EA | 0 | 0 | 0 | 0 | 3,960 | 3,960 | 3960.30 |
| | TOTAL Placement of UpperCover System | | | 150 | 5,409 | 2,405 | 22,529 | 260,977 | 291,320 | |
| G. B.35 | Placement of Rip-rap Transition | | | | | | | | | |
| G. B.35.15 | Rip-rap Transition | 1.00 | EA | 163 | 5,191 | 1,923 | 3,155 | 0 | 10,269 | 10268.78 |
| | TOTAL Placement of Rip-rap Transition | | | 163 | 5,191 | 1,923 | 3,155 | 0 | 10,269 | |

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                                              QUANTITY UOM  MANHRS     LABOR  EQUIPMNT  MATERIAL     OTHER TOTAL CST UNIT COST
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 G. B.45  Placement of Grass Cover

 G. B.45.08  Placement of Grass Cover                          1,907    57,976       136    49,395     7,023   114,530
                                                             ------- --------- --------- --------- --------- ---------
       TOTAL Placement of Grass Cover                          1,907    57,976       136    49,395     7,023   114,530


 G. B.50  Off-Site Transport & Disposal

 G. B.50.01  Steam Clean and Dispose of Debri                    298     9,144     9,298         0    48,650    67,092
                                                             ------- --------- --------- --------- --------- ---------
       TOTAL Off-Site Transport & Disposal                       298     9,144     9,298         0    48,650    67,092


 G. B.55  Sample and Anaylsis

 G. B.55. 5  Sample and Anaylsis                  1.00 EA          0         0         0         0    16,243    16,243  16243.10
                                                             ------- --------- --------- --------- --------- ---------
       TOTAL Sample and Anaylsis                  1.00 EA          0         0         0         0    16,243    16,243  16243.10


 G. B.70  Site Survey

    B.70.46  Topographic Survey                                  960    18,430     5,104         0         0    23,534
 G. B.70.51  Final Report Generation                              40     1,182         0         0         0     1,182
                                                             ------- --------- --------- --------- --------- ---------
       TOTAL Site Survey                          1.00 EA      1,000    19,611     5,104         0         0    24,716  24715.54


 G. B.80  Demobilization/Project Closeout

 G. B.80.30  Equipment Demobilization                              0         0         0         0    11,700    11,700
 G. B.80.51  Phase II Completion Report                           28       714         0         0         0       714
 G. B.80.56  Removal of Erosion Control                           21       622         0         0         0       622
 G. B.80.61  Site Clean-up                                        37     1,108         0         0         0     1,108
 G. B.80.66  Environ. Land-use Restrictions                       60     1,789         0         0         0     1,789
                                                             ------- --------- --------- --------- --------- ---------
       TOTAL Demobilization/Project Closeout                     146     4,234         0         0    11,700    15,934
                                                             ------- --------- --------- --------- --------- ---------
       TOTAL Phase II                             1.00 EA      7,463   215,231    73,994   266,953 1,287,060 1,843,238   1843238
                                                             ------- --------- --------- --------- --------- ---------
       TOTAL Phase I and II                       1.00 EA     13,574   376,696   160,196   304,790 1,565,779 2,407,461   2407461
                                                             ------- --------- --------- --------- --------- ---------
       TOTAL Stratford Army Engine Plant                      13,574   376,696   160,196   304,790 1,565,779 2,407,461

  Prime Contractor's Field Overhead                                                                         188,082
                                                                                                          ---------
    SUBTOTAL                                                                                              2,595,543
  Prime's Home Office Expense                                                                                90,844
                                                                                                          ---------
    SUBTOTAL                                                                                              2,686,387
```

| | QUANTITY | UOM | MANHRS | LABOR | EQUIPMNT | MATERIAL | OTHER | TOTAL CST | UNIT COST |
|---|---|---|---|---|---|---|---|---|---|
| Prime Contractor's Profit | | | | | | | | 187,375 | |
| SUBTOTAL | | | | | | | | 2,873,762 | |
| Prime Contractor's Bond | | | | | | | | 34,485 | |
| TOTAL INCL INDIRECTS | | | | | | | | 2,908,248 | |
| Escalation | | | | | | | | 46,532 | |
| SUBTOTAL | | | | | | | | 2,954,780 | |
| Contingency | | | | | | | | 450,308 | |
| SUBTOTAL | | | | | | | | 3,405,088 | |
| Supervision, Inspection, and Overhead | | | | | | | | 238,356 | |
| TOTAL INCL OWNER COSTS | | | | | | | | 3,643,444 | |

```
                                                       ** CONTRACTOR SETTINGS **
     ------------------------------------------------------------------------------------------------------------------------------
                                                   AMOUNT    PCT  PCT S    RISK    DIFF    SIZE  PERIOD  INVEST  ASSIST  SUBCON
-------------------------------------------------------------------------------------------------------------------------------


AA Prime Contractor

   Prime Contractor's Field Overhead         C
   Prime's Home Office Expense               P              3.50
   Prime Contractor's Profit                 C              6.98          0.080   0.090   0.080   0.080   0.075   0.100   0.030
   Prime Contractor's Bond                   P              1.20

AT Acustic Treatment Contractor

   Prime Contractor's Field Overhead         P             12.00
   Prime's Home Office Expense               P              8.00
   Prime Contractor's Profit                 P              8.00
   Prime Contractor's Bond                   P              1.00

CA Carpeting Contractor

   Prime Contractor's Field Overhead         P             12.00
   Prime's Home Office Expense               P              8.00
   Prime Contractor's Profit                 P              8.00
   Prime Contractor's Bond                   P              1.00

EL Electrical Contractor

   Prime Contractor's Field Overhead         P             12.00
   Prime's Home Office Expense               P              8.00
   Prime Contractor's Profit                 P              8.00
   Prime Contractor's Bond                   P              1.00

FP Fire Protection Contractor

   Prime Contractor's Field Overhead         P             12.00
   Prime's Home Office Expense               P              8.00
   Prime Contractor's Profit                 P              8.00
   Prime Contractor's Bond                   P              1.00

GW Gypsum Wallboard Contractor

   Prime Contractor's Field Overhead         P             12.00
   Prime's Home Office Expense               P              8.00
   Prime Contractor's Profit                 P              8.00
   Prime Contractor's Bond                   P              1.00

HV HVAC Contractor

   Prime Contractor's Field Overhead         P             12.00
   Prime's Home Office Expense               P              8.00
   Prime Contractor's Profit                 P              8.00
   Prime Contractor's Bond                   P              1.00
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                                                   ** CONTRACTOR SETTINGS **
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                                                   AMOUNT    PCT  PCT S    RISK    DIFF    SIZE  PERIOD  INVEST  ASSIST  SUBCON
--------------------------------------------------------------------------------------------------------------------------------


LP Lath, Plaster, Stucco Contractor

   Prime Contractor's Field Overhead          P            12.00
   Prime's Home Office Expense                P             8.00
   Prime Contractor's Profit                  P             8.00
   Prime Contractor's Bond                    P             1.00

MA Masonry Contractor

   Prime Contractor's Field Overhead          P            12.00
   Prime's Home Office Expense                P             8.00
   Prime Contractor's Profit                  P             8.00
   Prime Contractor's Bond                    P             1.00

MC Controls Contractor

   Prime Contractor's Field Overhead          P            12.00
   Prime's Home Office Expense                P             8.00
   Prime Contractor's Profit                  P             8.00
   Prime Contractor's Bond                    P             1.00

ME Mechanical Contrator

   Prime Contractor's Field Overhead          P            12.00
   Prime's Home Office Expense                P             8.00
   Prime Contractor's Profit                  P             8.00
   Prime Contractor's Bond                    P             1.00

MR Membrane Roofing Contractor

   Prime Contractor's Field Overhead          P            12.00
   Prime's Home Office Expense                P             8.00
   Prime Contractor's Profit                  P             8.00
   Prime Contractor's Bond                    P             1.00

PL Plumbing Contractor

   Prime Contractor's Field Overhead          P            12.00
   Prime's Home Office Expense                P             8.00
   Prime Contractor's Profit                  P             8.00
   Prime Contractor's Bond                    P             1.00

PS Painting and Sealants Contractor

   Prime Contractor's Field Overhead          P            12.00
   Prime's Home Office Expense                P             8.00
   Prime Contractor's Profit                  P             8.00
   Prime Contractor's Bond                    P             1.00
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                                                      ** CONTRACTOR SETTINGS **
        ------------------------------------------------------------------------------------------------------------
                                                      AMOUNT    PCT  PCT S    RISK    DIFF    SIZE  PERIOD  INVEST  ASSIST  SUBCON
---------------------------------------------------------------------------------------------------------------------


RF Resilient Flooring Contractor

   Prime Contractor's Field Overhead       P              12.00
   Prime's Home Office Expense             P               8.00
   Prime Contractor's Profit               P               8.00
   Prime Contractor's Bond                 P               1.00

SM Sheetmetal Contractor

   Prime Contractor's Field Overhead       P              12.00
   Prime's Home Office Expense             P               8.00
   Prime Contractor's Profit               P               8.00
   Prime Contractor's Bond                 P               1.00

SR Shingles, Roofing Tiles Contract

   Prime Contractor's Field Overhead       P              12.00
   Prime's Home Office Expense             P               8.00
   Prime Contractor's Profit               P               8.00
   Prime Contractor's Bond                 P               1.00

SS Structural Steel Contractor

   Prime Contractor's Field Overhead       P              12.00
   Prime's Home Office Expense             P               8.00
   Prime Contractor's Profit               P               8.00
   Prime Contractor's Bond                 P               1.00

SW Sitework Contractor

   Prime Contractor's Field Overhead       P              12.00
   Prime's Home Office Expense             P               8.00
   Prime Contractor's Profit               P               8.00
   Prime Contractor's Bond                 P               1.00

TI Tile Contractor

   Prime Contractor's Field Overhead       P              12.00
   Prime's Home Office Expense             P               8.00
   Prime Contractor's Profit               P               8.00
   Prime Contractor's Bond                 P               1.00

WC Wall Covering Contractor

   Prime Contractor's Field Overhead       P              12.00
   Prime's Home Office Expense             P               8.00
   Prime Contractor's Profit               P               8.00
   Prime Contractor's Bond                 P               1.00
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                                                   ** CONTRACTOR SETTINGS **
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                                                   AMOUNT     PCT  PCT S     RISK     DIFF     SIZE  PERIOD  INVEST  ASSIST  SUBCON
-------------------------------------------------------------------------------------------------------------------------------


CT Ceramic Tile Contractor

   Prime Contractor's Field Overhead         P             12.00
   Prime's Home Office Expense               P              8.00
   Prime Contractor's Profit                 P              8.00
   Prime Contractor's Bond                   P              1.00

AB Work Not In Construction Contrac

   Prime Contractor's Field Overhead         P              0.00
   Prime's Home Office Expense               P              0.00
   Prime Contractor's Profit                 P              0.00
   Prime Contractor's Bond                   P              0.00
```

# APPENDIX H

## SUPPLEMENTAL INFORMATION

ATTACHMENT A – Photographs of Oversized Materials on the Causeway (February 2001)
ATTACHMENT B – Well Installation Details (Boring No. MWCD-00-01)
ATTACHMENT C – Building 59 Plans and Photographs (February 2001)
ATTACHMENT D – Building 5 Plans and Photographs (February 2001)
ATTACHMENT E – Berm Near Building 34
ATTACHMENT F – Building 59 Characterization Sampling Results

# Attachment A – Photographs of Oversized Materials on the Causeway (February 2001)

PHOTO 1

PHOTO 2

PHOTO 3

PHOTO 4

PHOTO 5

PHOTO 6

PHOTO 7

PHOTO 8

PHOTO 9

PHOTO 10

PHOTO 11

PHOTO 12

PHOTO 12

PHOTO 13

PHOTO 14

PHOTO 15

PHOTO 16

PHOTO 17

PHOTO 18

PHOTO 19

PHOTO 20

PHOTO 21

PHOTO 22

PHOTO 23

PHOTO 24

PHOTO 25

PHOTO 26

PHOTO 27

PHOTO 28

PHOTO 29

PHOTO 30

PHOTO 31

PHOTO 32

PHOTO 1-33

PHOTO 34

PHOTO 35

PHOTO 36

PHOTO 37

PHOTO 38

PHOTO 39

PHOTO 40

PHOTO 41

PHOTO 42

PHOTO 43

PHOTO 44

PHOTO 45

PHOTO 46

PHOTO 47

PHOTO 48

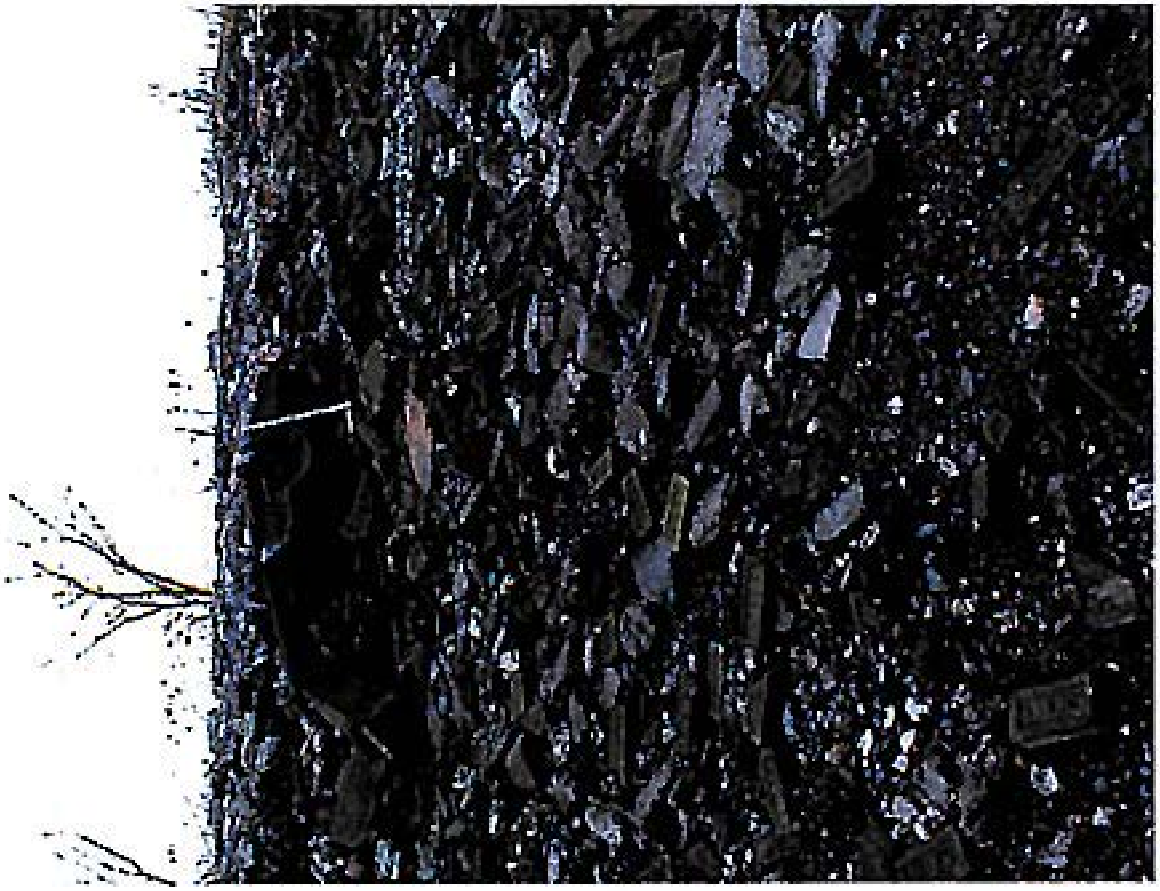


PHOTO 49

PHOTO 50

PHOTO 51

PHOTO 52

PHOTO 53

**PHOTO 54**

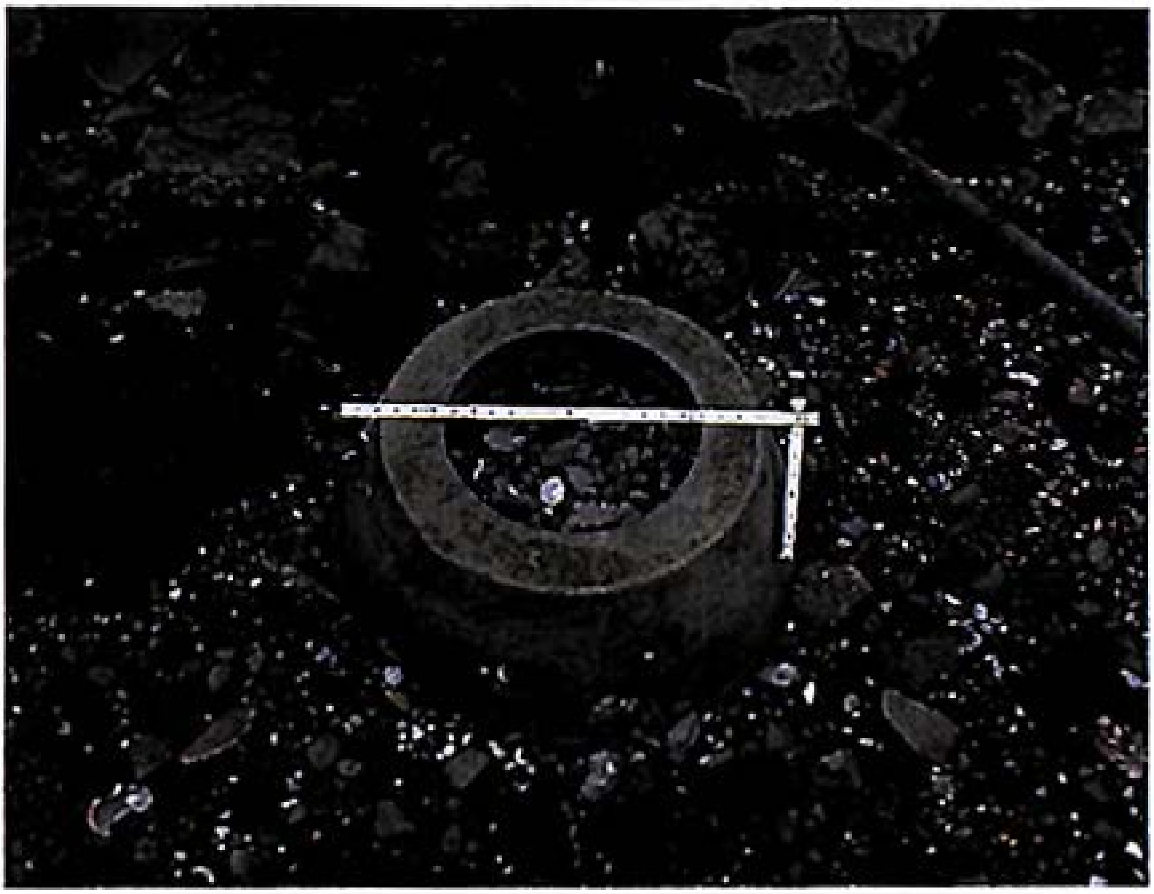


**PHOTO 55**

PHOTO 56

PHOTO 57

PHOTO 58

PHOTO 59

PHOTO 60

PHOTO 61

PHOTO 62

PHOTO 63

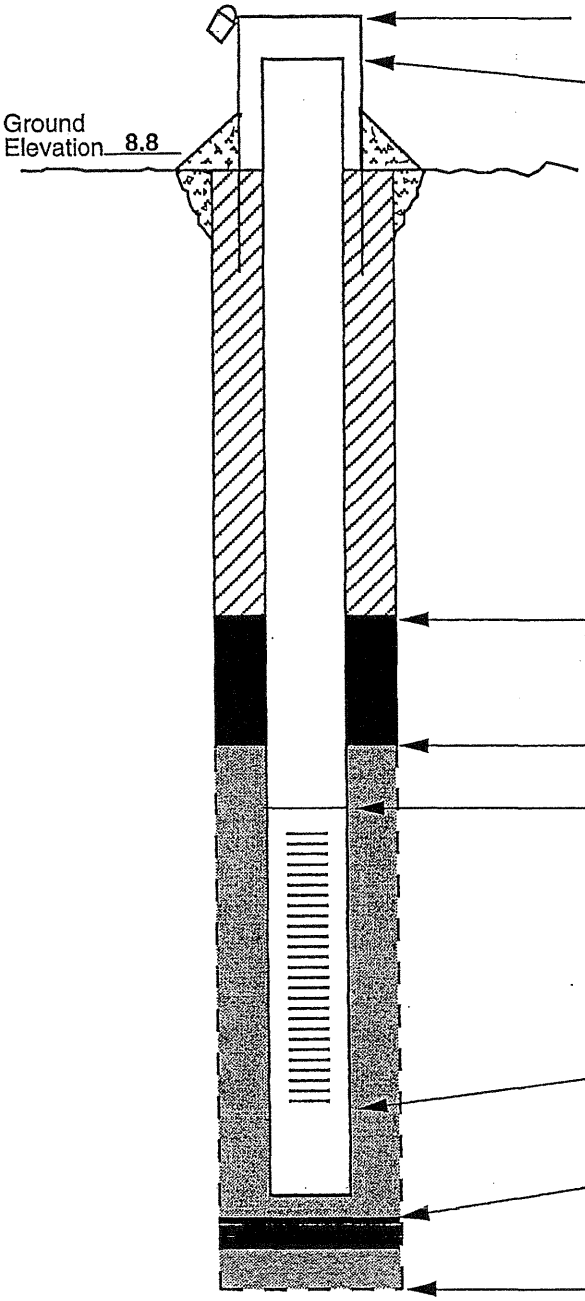
PHOTO 64

PHOTO 65

# Attachment B – Well Installation Details (Boring No. MWCD-00-01)

# MONITORING WELL CONSTRUCTION DIAGRAM

Project **SAEP**
Study Area **Causeway**
Driller **Earth Exploration, Inc.**
Project No. **50796/1032**
Boring No. **MWCD-00-01**
Drilling Method **Drive & Wash**
Date Installed **9-26-00**
Development Method **Pump & Surge**
Field Geologist **T. Longley**



Ground Elevation **8.8**

Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface:
Elevation of Top of Riser Pipe:
Type of Surface Seal: **Concrete**
Type of Surface Casing: **Steel**

ID of Surface Casing: **4"**

Diameter of Borehole: **4"**

Riser Pipe ID: **2"**
Type of Riser Pipe: **Sch 40 PVC**

Type of Backfill: **Bentonite/Cement**

Elevation of Top of Seal: **-3.2'**
Depth of Top of Seal: **12'**
Type of Seal: **Benonite Pellets**

Elevation of Top of Sand: **-5.2'**
Depth of Top of Sand: **14'**

Elevation of Top of Screen: **-7.2'**
Depth of Top of Screen: **16'**

Type of Screen: **Sch 40 PVC**
Slot Size x Length: **0.010" x 10'**
ID of Screen: **2"**

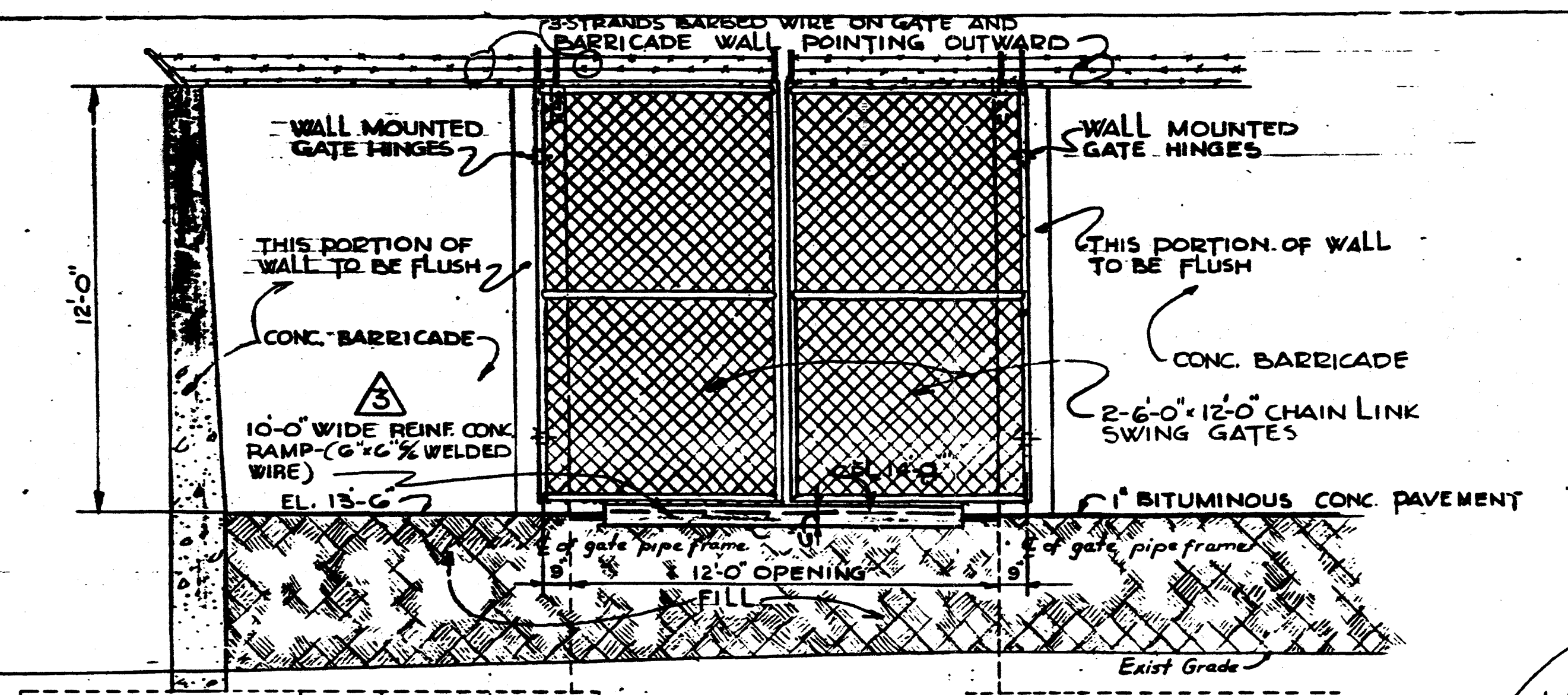
Type of Sandpack: **Silica Well Sand**

Elevation of Bottom of Screen: **-17.2'**
Depth of Bottom of Screen: **26'**
Depth of Sediment Sump with Plug: **26'**

Elevation of Top of Seal: **-18.2'**
Depth of Top of Seal: **27'**
Type of Seal: **Bentonite Pellets (3' thick)**

Elevation of Bottom of Borehole: **-61.2'**
Depth of Bottom of Borehole: **70'**

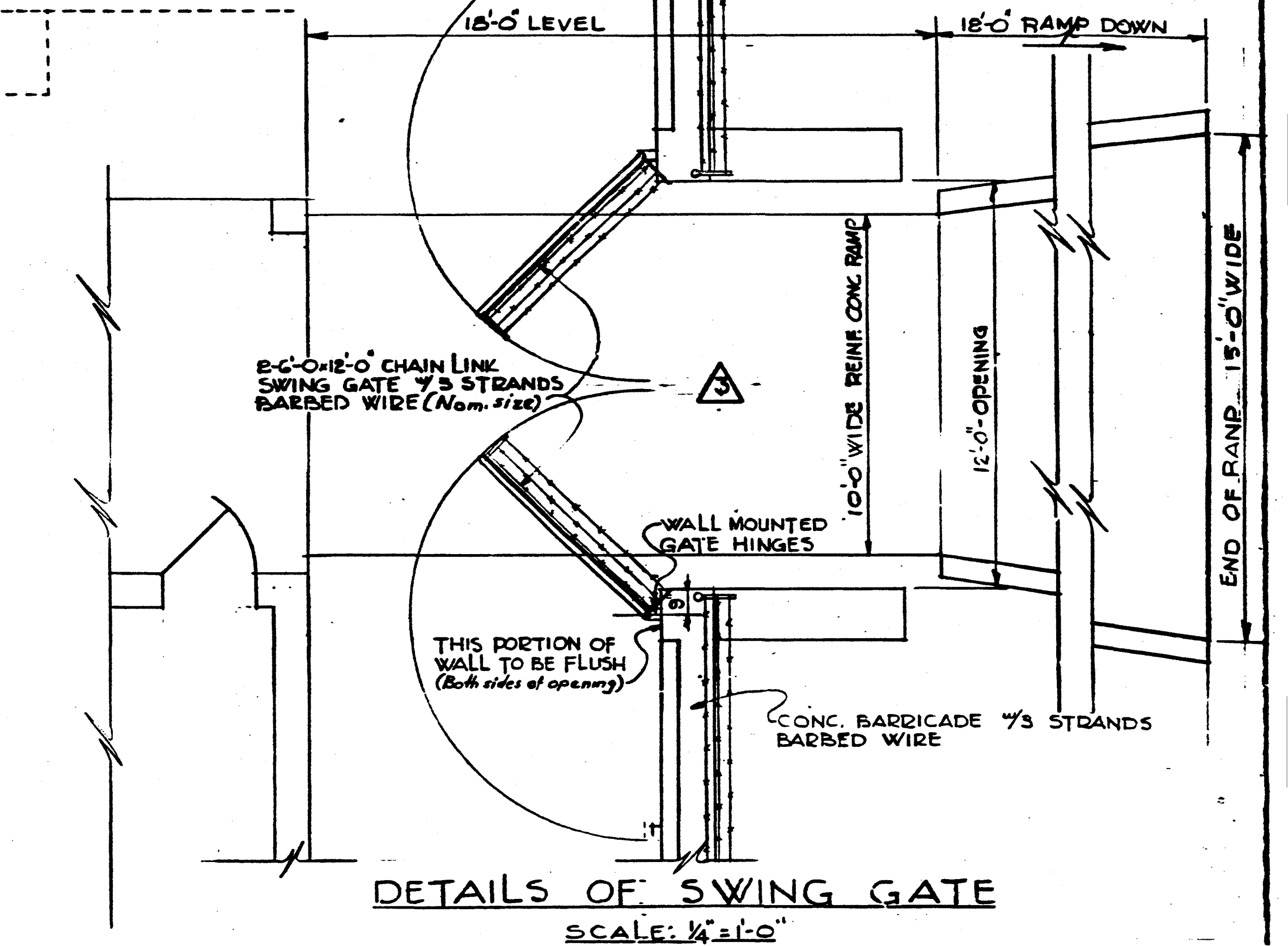
# Attachment C – Building 59 Plans and Photographs (February 2001)



## ELEVATION

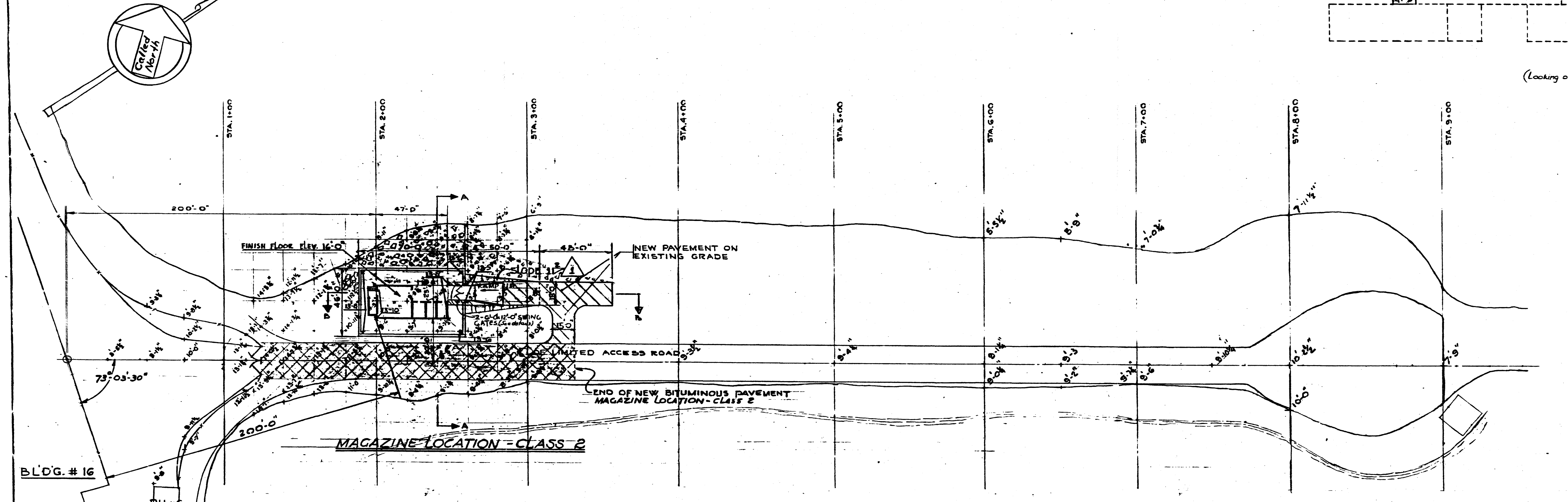
(Looking out, thru gate, in an easterly direction)

SCALE: ¼"=1'-0"



## DETAILS OF SWING GATE

SCALE: ¼"=1'-0"



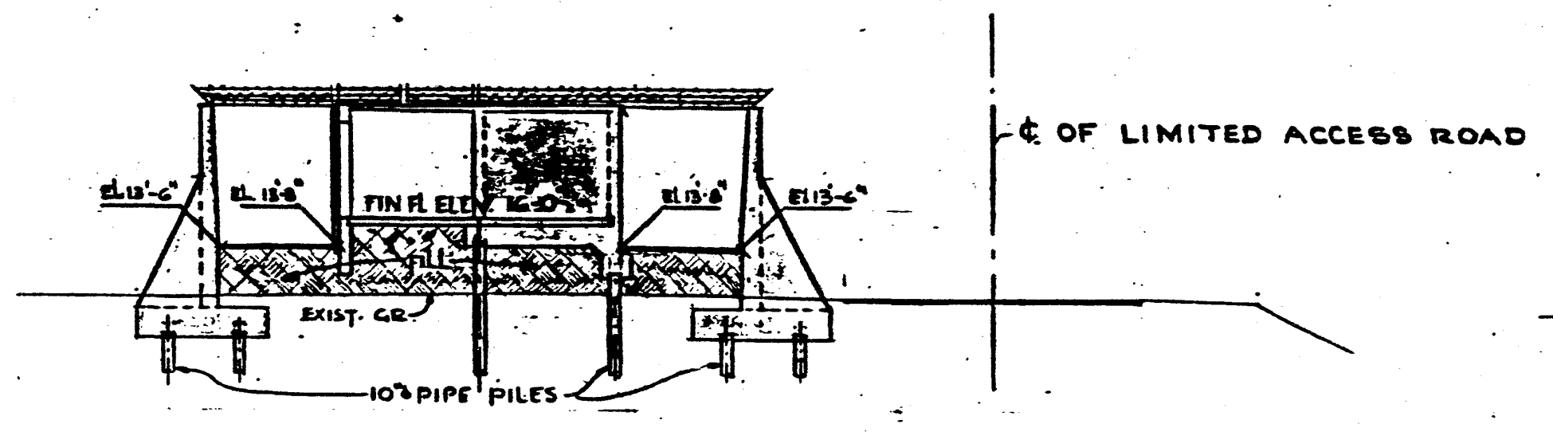
## SITE PLAN

SCALE: 1"=40'-0"

△3

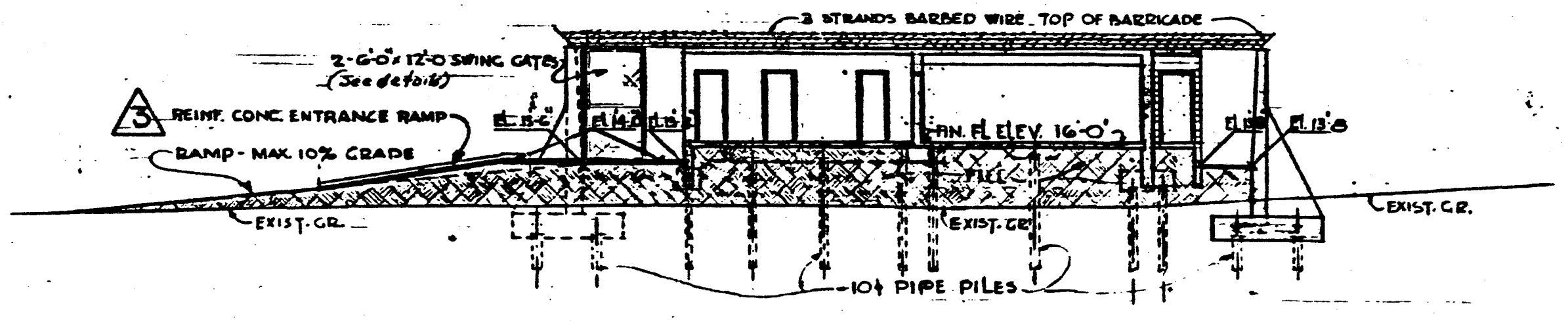
## LEGEND

| | |
|---|---|
| 9'-5½" | DENOTES EXISTING ELEVATION |
| + | DENOTES APPROXIMATE LOCATION OF ELEVATION |
| 12'-6" | DENOTES NEW ELEVATION |
| × | DENOTES APPROXIMATE LOCATION OF ELEVATION |
| ▒ | DENOTES NEW 1" BITUMINOUS CONCRETE PAVEMENT |
| ▨ | DENOTES NEW 2" BITUMINOUS CONCRETE PAVEMENT |
| ▩ | DENOTES 1" BITUMINOUS CONCRETE PAVEMENT ON EXISTING BITUMINOUS CONCRETE PAVEMENT |
| ⁂ | DENOTES CRUSHED TRAP ROCK LARGE SIZE 5"×10", MIN. 1'-0" DEEP △3 |



## PROFILE "A-A"

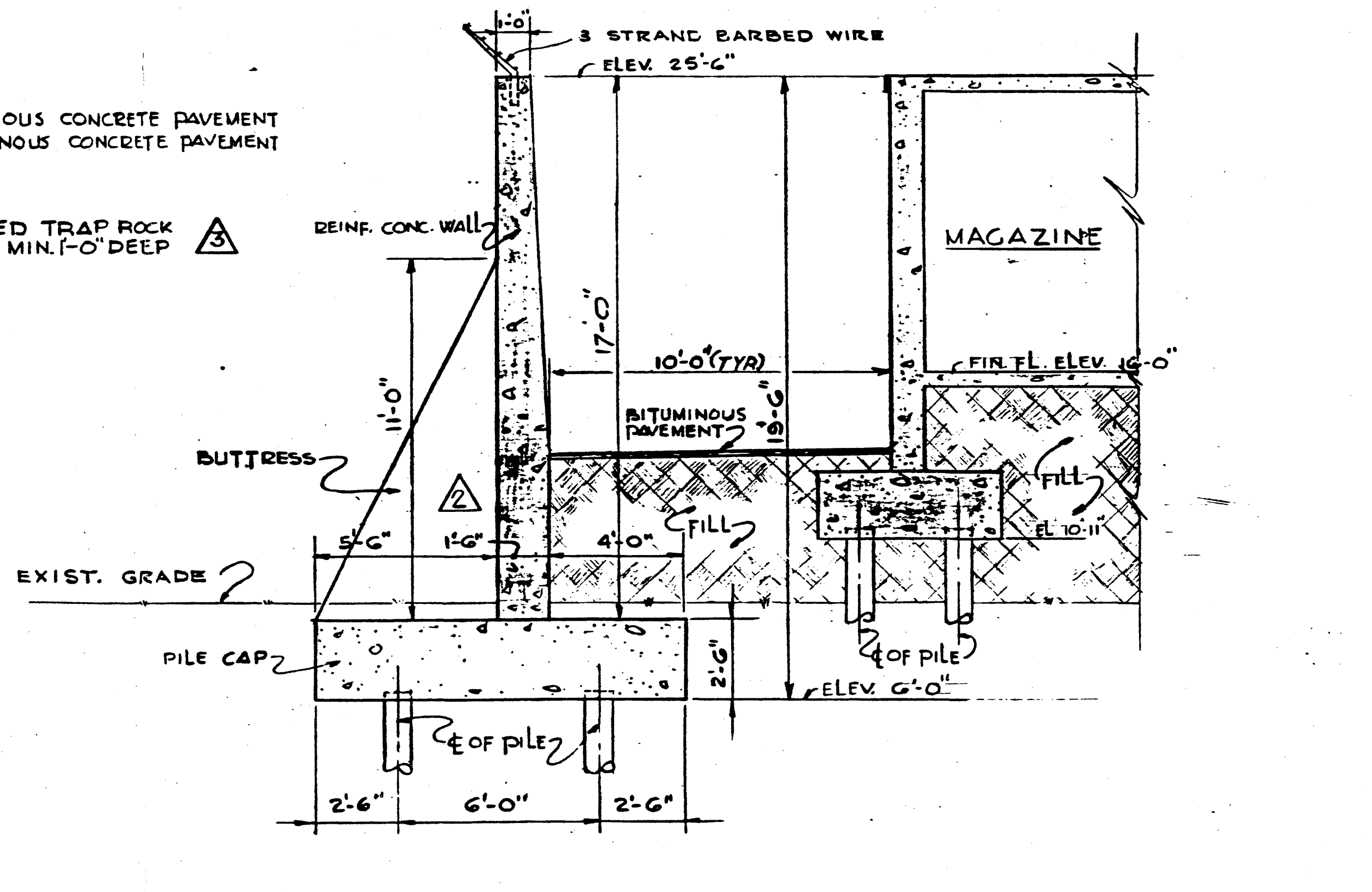
SCALE: 1/16"=1'-0"



## PROFILE "B-B"

SCALE: 1/16"=1'-0"

△3



## DETAIL OF BARRICADE

SCALE: ¼"=1'-0"

| Rev. | Date | Description |
|---|---|---|
| △3 | 5/21/68 | Construction of reinf. conc. entrance ramp, elev. in bldg. yard, crushed rock rip rap on river shore. |
| △2 | 3/21/68 | Deleted weep holes in barricade wall to conform to field installation. |
| △1 | 3/18/67 | Ramp, slope, and ramp slope to be paved, 1". |

| | | |
|---|---|---|
| SAFETY APPROVAL | PREPARED BY | John Bayuk<br>DIRECTOR OF PLANT ENGINEERING - AVCO LYCOMING DIVISION |
| AVCO<br>Kenneth L. Stebbins | RECOMMENDED BY | VICE-PRESIDENT - AVCO LYCOMING DIVISION |
| USAF/AFPRO/AVCO<br>A A Saunders | RECOMMENDED BY | |
| | APPROVED BY | |
| | APPROVED BY | |

JOB TITLE
PEN AIDS FACILITIES BLDG. Nº 59

DWG. TITLE
SITE PLAN, PROFILES, & DETAIL

SHT. SIZE 28"×40" SCALE AS NOTED DATE NOV. 8, 1966

DRAWN R.A PARKER

CHECKED B.F. MURPHY

DIRECTOR PLANT ENG'G. John Bayuk

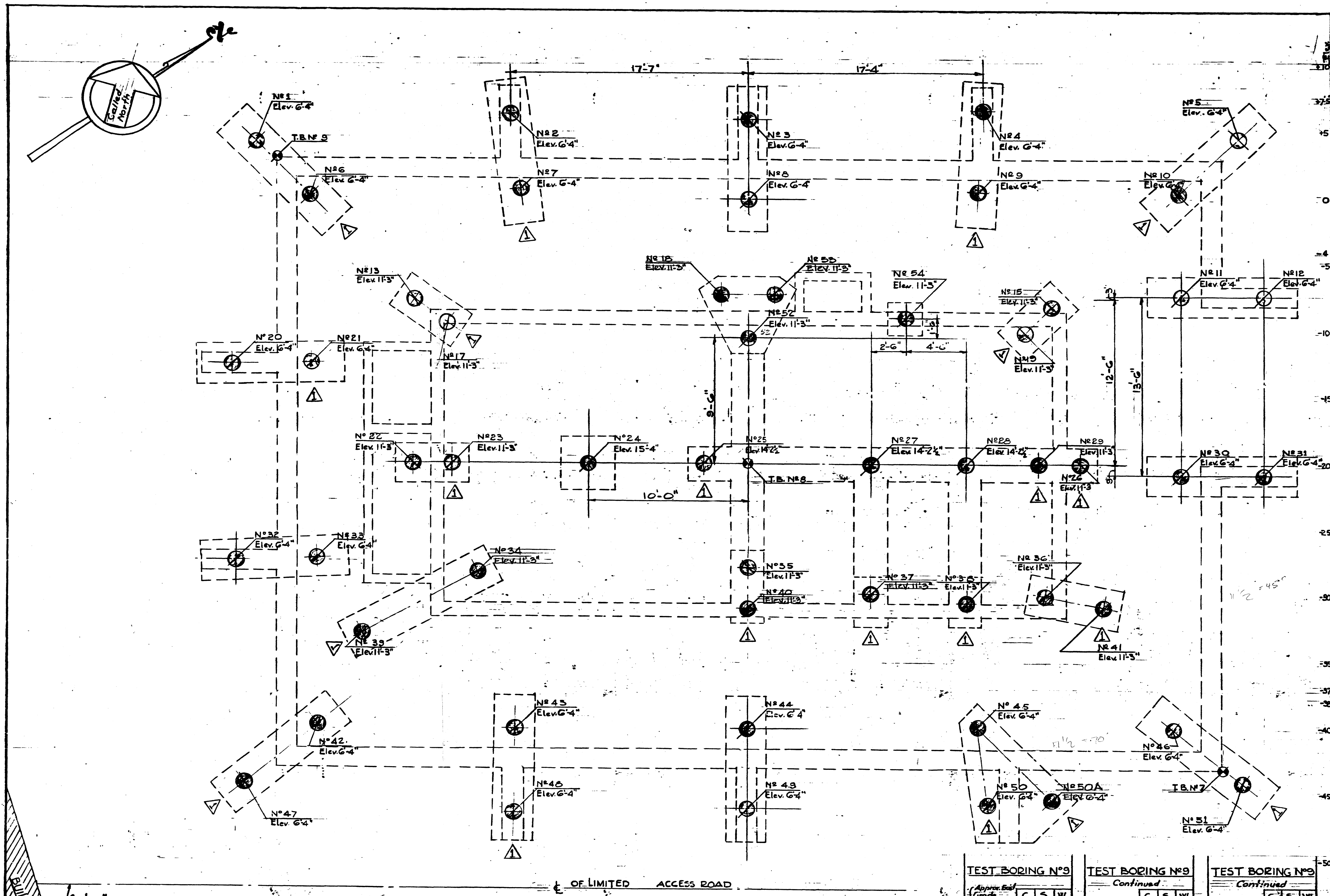
AVCO LYCOMING DIVISION
STRATFORD • CONNECTICUT

PLANT ENGINEERING

SHEET 24 OF 33 SHEETS

DWG. NO. B59-300-1Z

| APPROVED | DATE | APPROVED | DATE |
|---|---|---|---|
| K L Stebbins | 11/3/66 | | 11/8/66 |
| | 11/29/66 | | 3/24/67 |



## PILE PLAN

*Scale ¼" = 1'-0"*

### LEGEND

Nº 25 — DENOTES PILE NUMBER
Elev. 13'-9" — DENOTES ELEVATION OF PILE CUT-OFF.
LOCATION OF PILE
T.B. Nº 9 DENOTES TEST BORING NUMBER
LOCATION TEST BORING

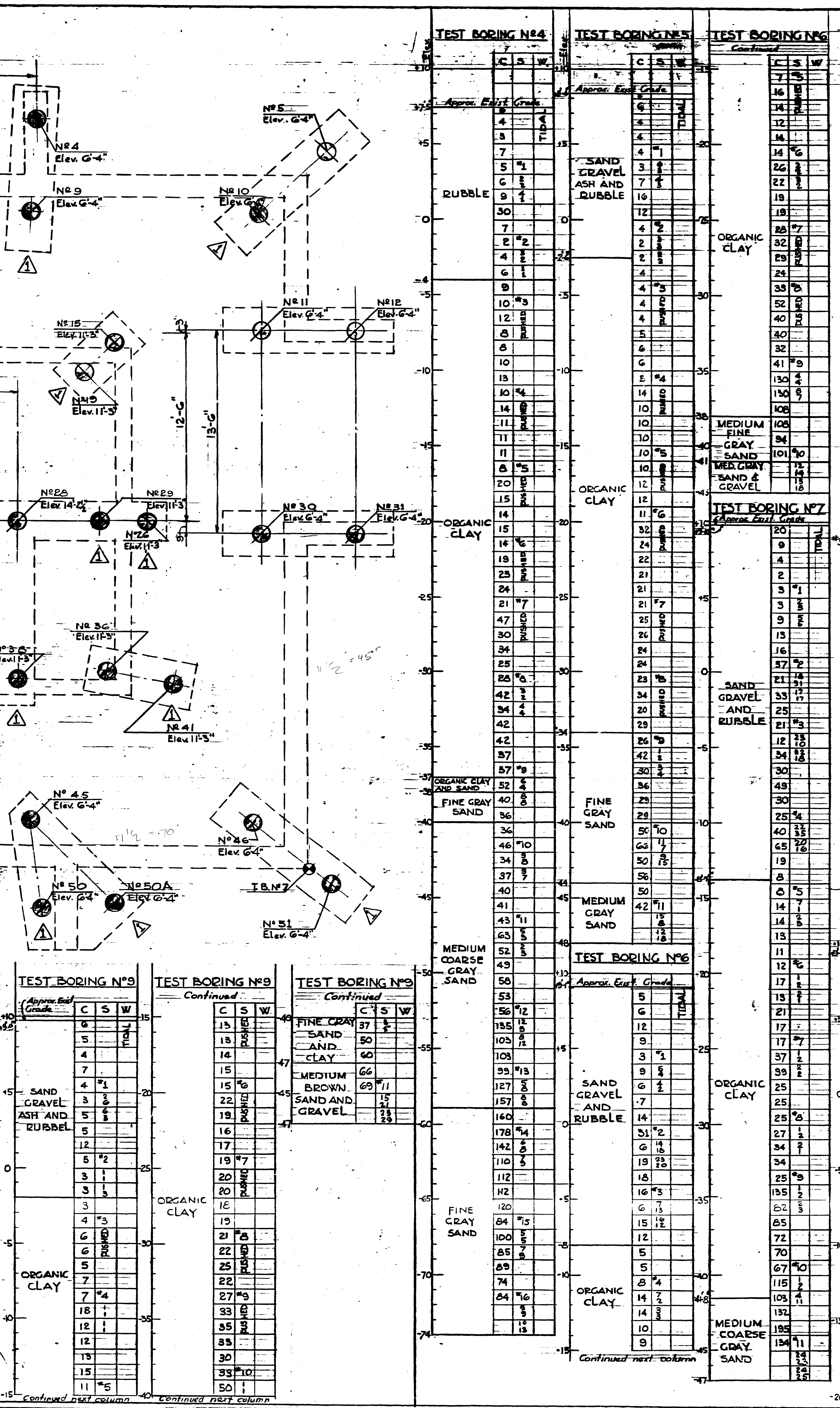
230 LF of Blast Wall 15' high

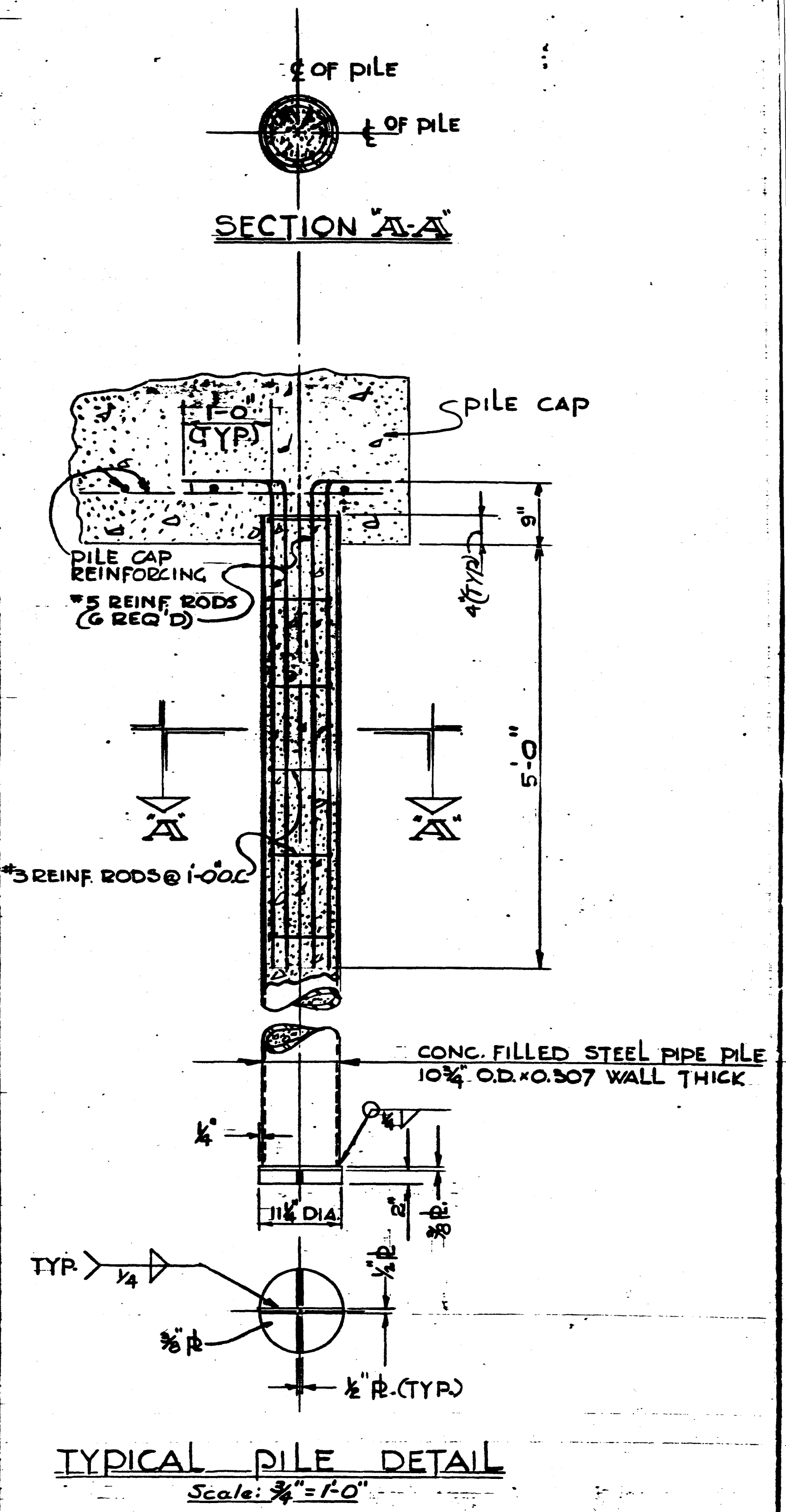
### TEST BORING LEGEND

C – Indicates number of blows to drive 2½" casing 1'-0", 300 lb. wt., 2'-0" fall.

S – Indicates number of blows to drive 2" spoon 0'-6", 140 lb. wt., 2'-6" fall.

W – Indicates water level after completion of hole.





TYPICAL PILE DETAIL

*Scale: ¾" = 1'-0"*

| | | | |
|---|---|---|---|
| △1 | CHANGED PILES TO CONFORM TO FIELD INSTALLATION | B.F.M. | MAR 18/68 |
| NO. | DESCRIPTION | BY | DATE |

REVISIONS

SAFETY APPROVAL

AVCO
Kenneth L. Stebbins

USAF/AFPRO/AVCO
A.A. Saunders

PREPARED BY John Bayuk
DIRECTOR OF PLANT ENGINEERING - AVCO LYCOMING DIVISION

RECOMMENDED BY
VICE-PRESIDENT - AVCO LYCOMING DIVISION

RECOMMENDED BY

APPROVED BY

APPROVED BY

No. 4302
REGISTERED PROFESSIONAL ENGINEER

JOB TITLE
PEN-AIDS FACILITIES BUILDING Nº 59

DWG. TITLE
PILE PLAN AND TEST BORINGS

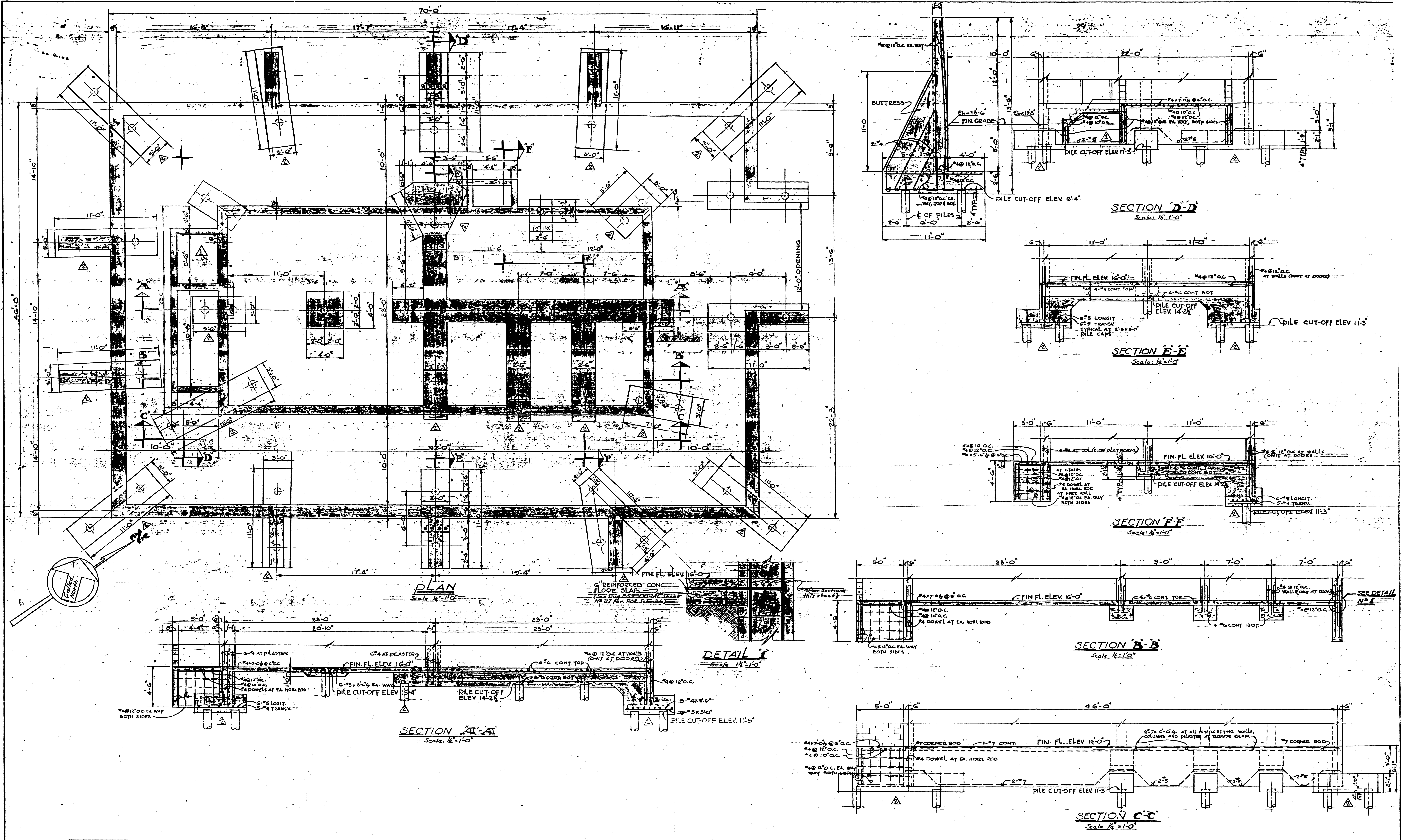
SHT. SIZE 28×40" SCALE As shown DATE FEB. 14, 1967

DRAWN GUINTA
CHECKED N. SANSONE
DIRECTOR PLANT ENG'G John Bayuk

AVCO LYCOMING DIVISION
STRATFORD • CONNECTICUT
PLANT ENGINEERING

SHEET 25 OF 33 SHEETS
DWG. NO. B59-300-1AA
B58-300-1AA

| APPROVED | DATE | APPROVED |
|---|---|---|
| | | |



| | | | |
|---|---|---|---|
| △ | CHANGED PILES & FOOTINGS TO CONFORM TO FIELD INSTALLATION | B.F.M. | MAR 12/68 |
| △ | CHANGED STEPS & PLATFORM AT SECT. "D"-"D" & ITS PLAN | B.F.M. | MAR 16/67 |
| REV. NO. | DESCRIPTION | BY | DATE |

REVISIONS

SAFETY APPROVAL

AVCO Kenneth L. Stebbins

USAF/AFPRO/AVCO A.W. Saunders

| | |
|---|---|
| PREPARED BY | John Bay[illegible]<br>DIRECTOR OF PLANT ENGINEERING, AVCO LYCOMING DIVISION |
| RECOMMENDED BY | S. Webster Cr[illegible]<br>VICE-PRESIDENT - AVCO LYCOMING DIVISION |
| RECOMMENDED BY | |
| APPROVED BY | |
| APPROVED BY | |

REGISTERED PROFESSIONAL ENGINEER No. 4203

JOB TITLE PEN-AIDS FACILITIES BUILDING No 59

DWG. TITLE FOUNDATION PLAN AND SECTIONS

SHT. SIZE 28"x40" SCALE As shown DATE FEB. 14, 1967

DRAWN GUINTA

CHECKED N. SANSONE

DIRECTOR PLANT ENG'G. John Bay[illegible]

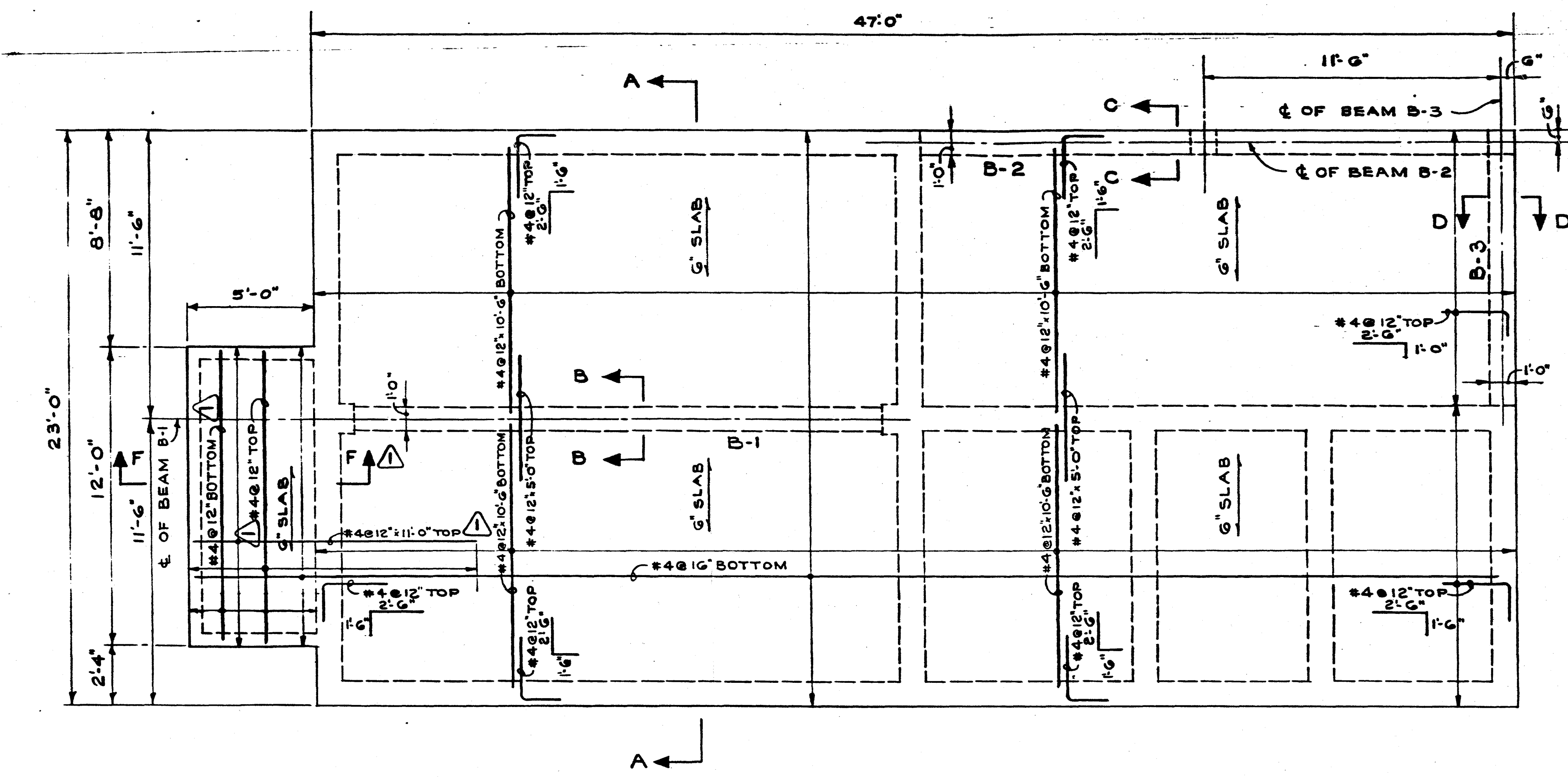
AVCO LYCOMING DIVISION
STRATFORD CONNECTICUT

PLANT ENGINEERING

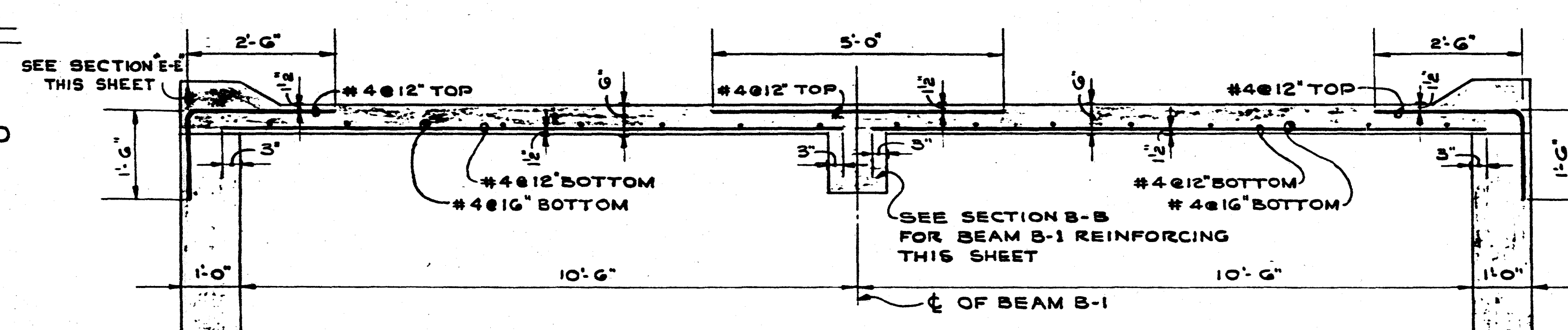
SHEET 26 OF 33 SHEETS

DWG. NO. B59-300-1AB
B58-300-1AB

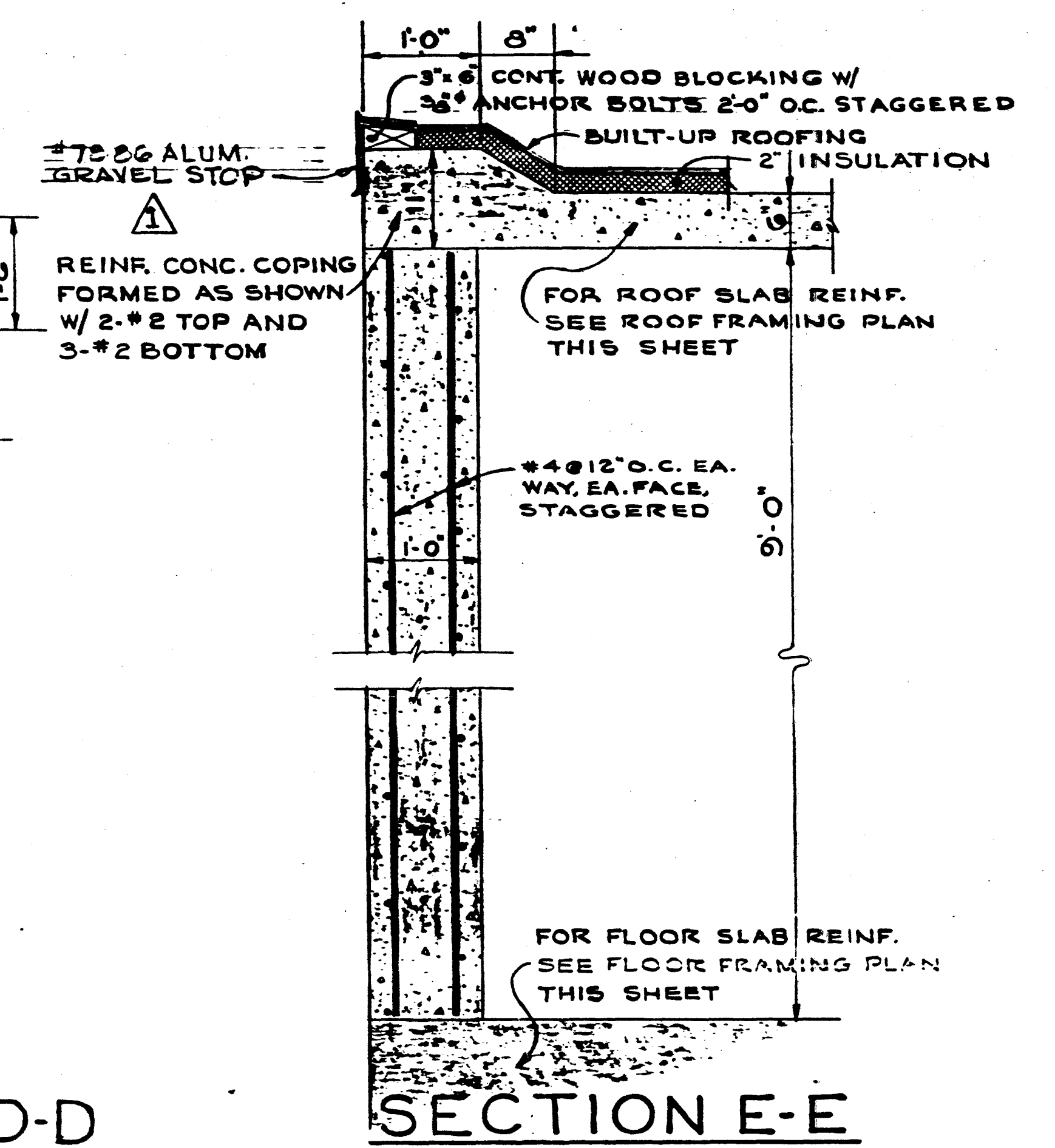
| APPROVED | DATE | APPROVED | |
|---|---|---|---|

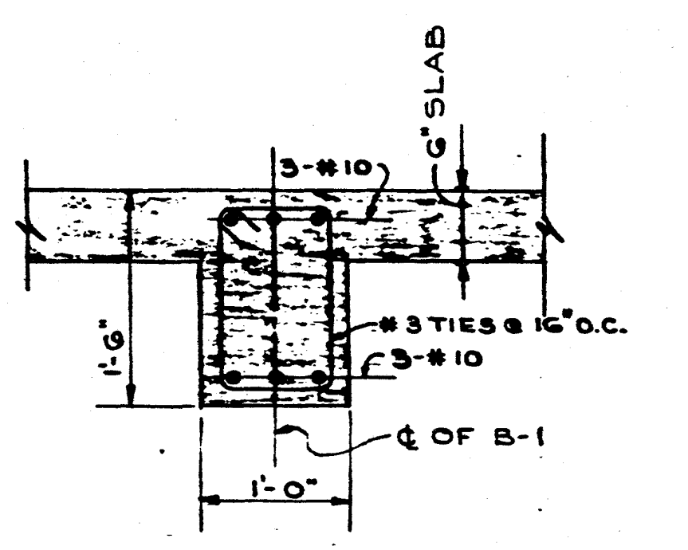


ROOF FRAMING PLAN
SCALE: ¼"=1'-0"

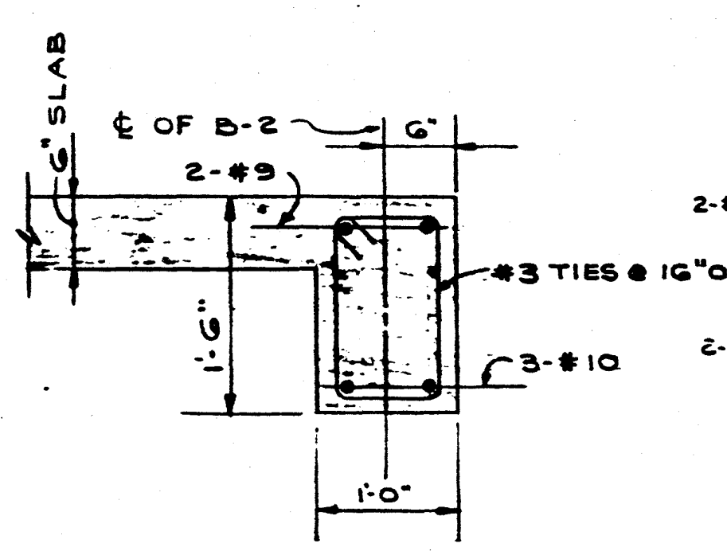


SECTION A-A
SCALE: ½"=1'-0"

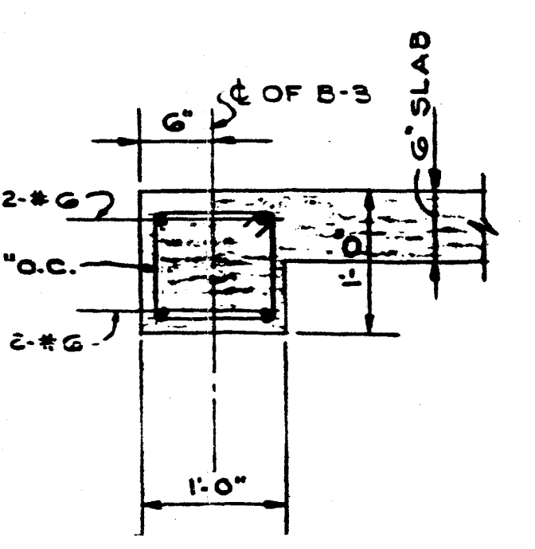




SECTION B-B
DET. OF BEAM B-1
SCALE: ¾"=1'-0"

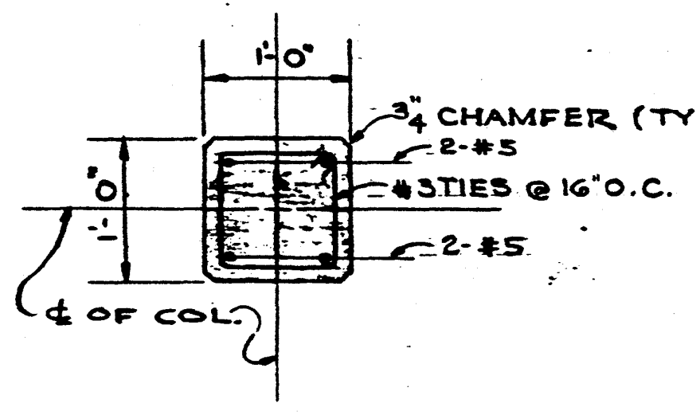


SECTION C-C
DET. OF BEAM B-2
SCALE: ¾"=1'-0"

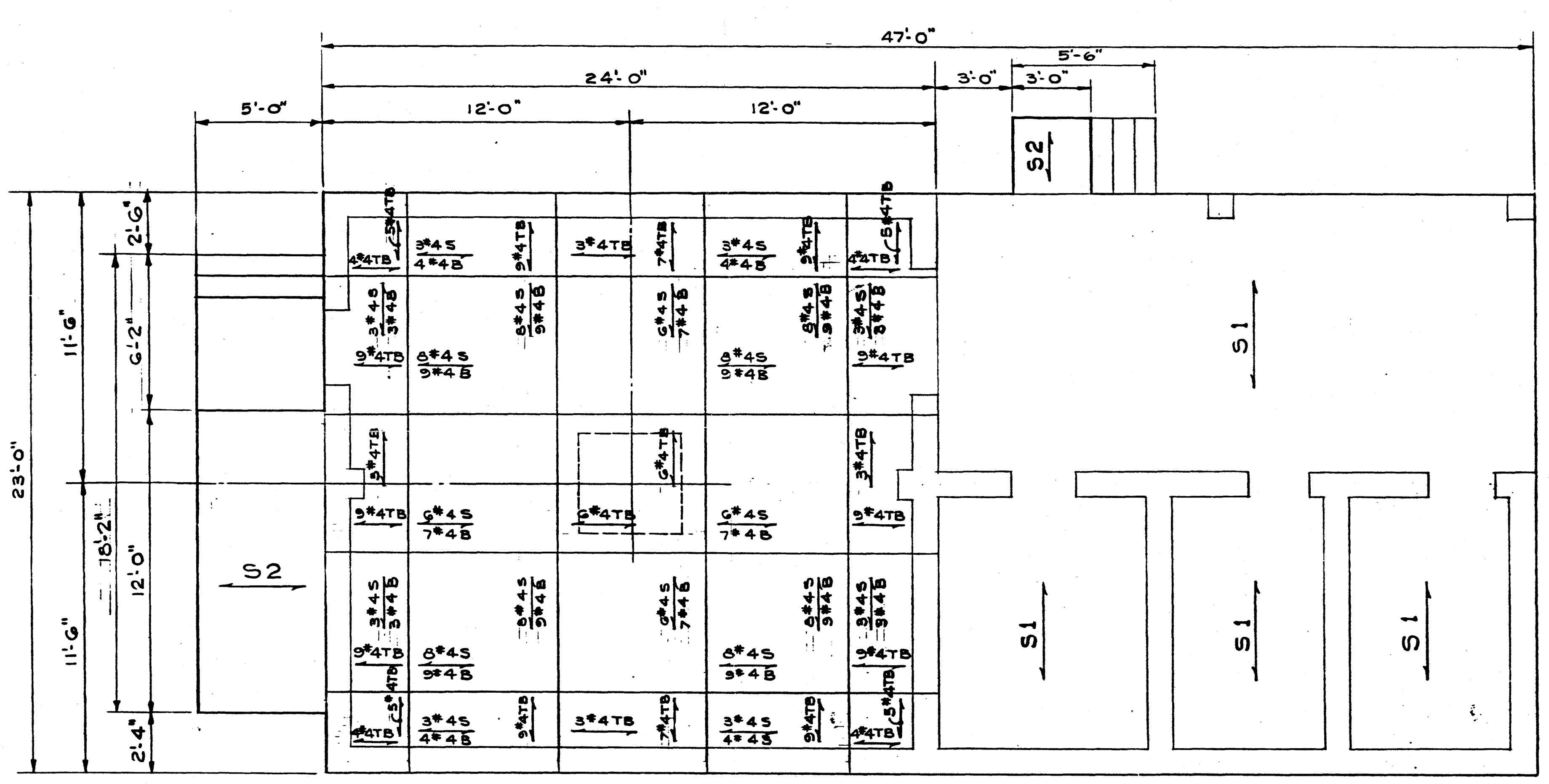


SECTION D-D
DET. OF BEAM B-3
SCALE: ¾"=1'-0"

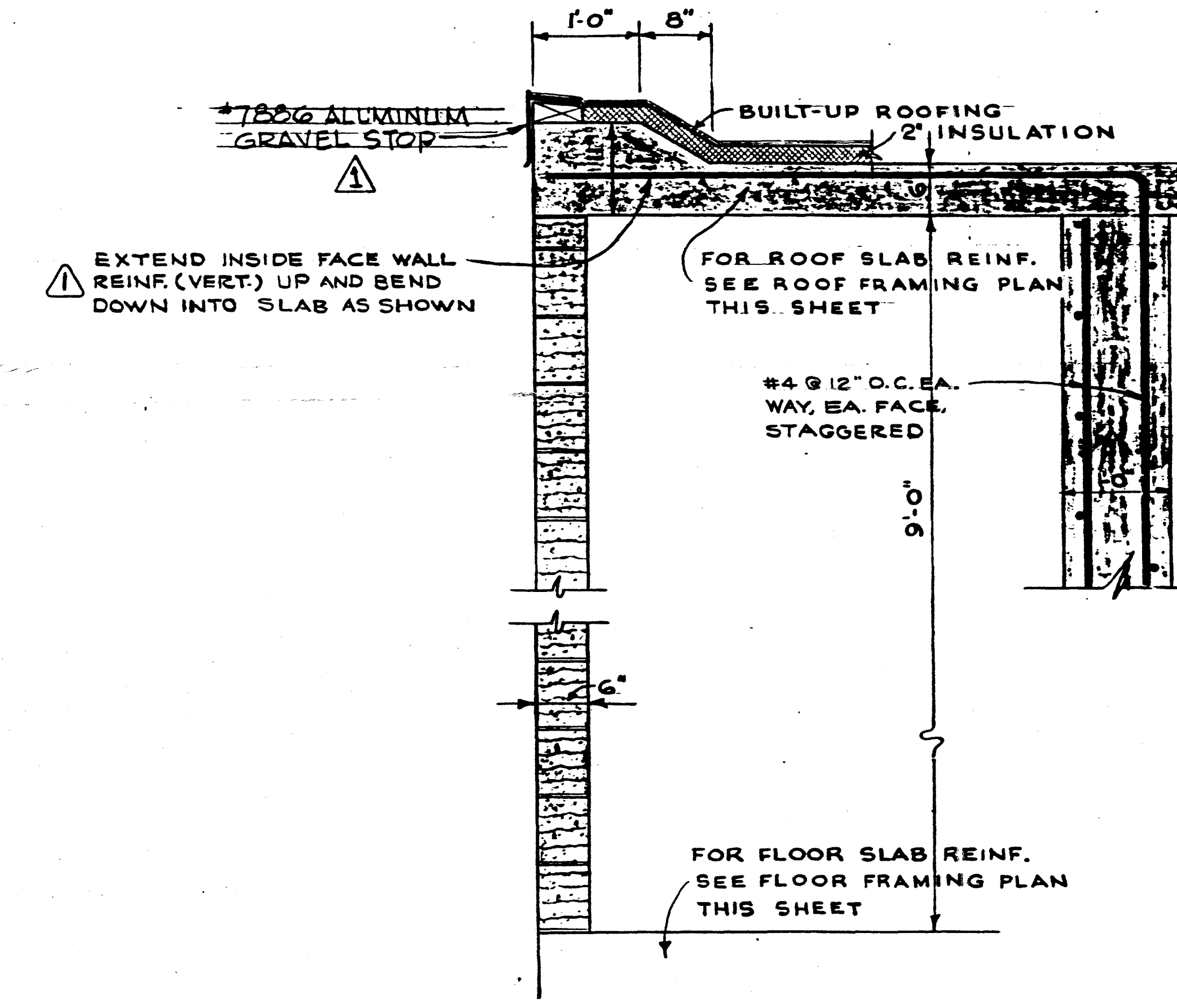
SECTION E-E
TYP. DET. OF WALL
SCALE: ¾"=1'-0"



TYP. DET. OF COL.
SCALE: ¾"=1'-0"



FLOOR FRAMING PLAN
SCALE: ¼"=1'-0"



SECTION F-F
TYP. DET. OF WALL
SCALE: ¾"=1'-0"

CONCRETE SLAB SCHEDULE BL'D'G. #59

| SLAB MARK | DEPTH | MAIN REINFORCING BARS | | | TEMP. STEEL. | REMARKS |
|---|---|---|---|---|---|---|
| | | STR. | BENT | TOP | | |
| S1 | 6" | #5@11" | #5@11" | #5@11" | #3@12" | TOP BARS OVER SUPPORT |
| S2 | 6" | #4@10" | | #4@12" | #4@6" | |
| | | | | | | |

| REV. NO. | DESCRIPTION | BY | DATE |
|---|---|---|---|
| 1 | ADDED REINF. IN ELECTRICAL EQUIP. RM. ROOF SLAB-CHANGED GRAVEL [illegible] | R.A.P. | 3-16-67 |

REVISIONS

SAFETY APPROVAL

AVCO
Kenneth L. Stibbins

USAF/AFPRO/AVCO
A. A. Saunders

PREPARED BY John Bayuk
DIRECTOR OF PLANT ENGINEERING - AVCO LYCOMING DIVISION

RECOMMENDED BY
VICE-PRESIDENT - AVCO LYCOMING DIVISION

RECOMMENDED BY

APPROVED BY

APPROVED BY

JOHN BAYUK
No. 4903

JOB TITLE
PEN-AIDS FACILITIES - BUILDING Nº 59

DWG. TITLE
STRUCTURAL PLANS & DETAILS

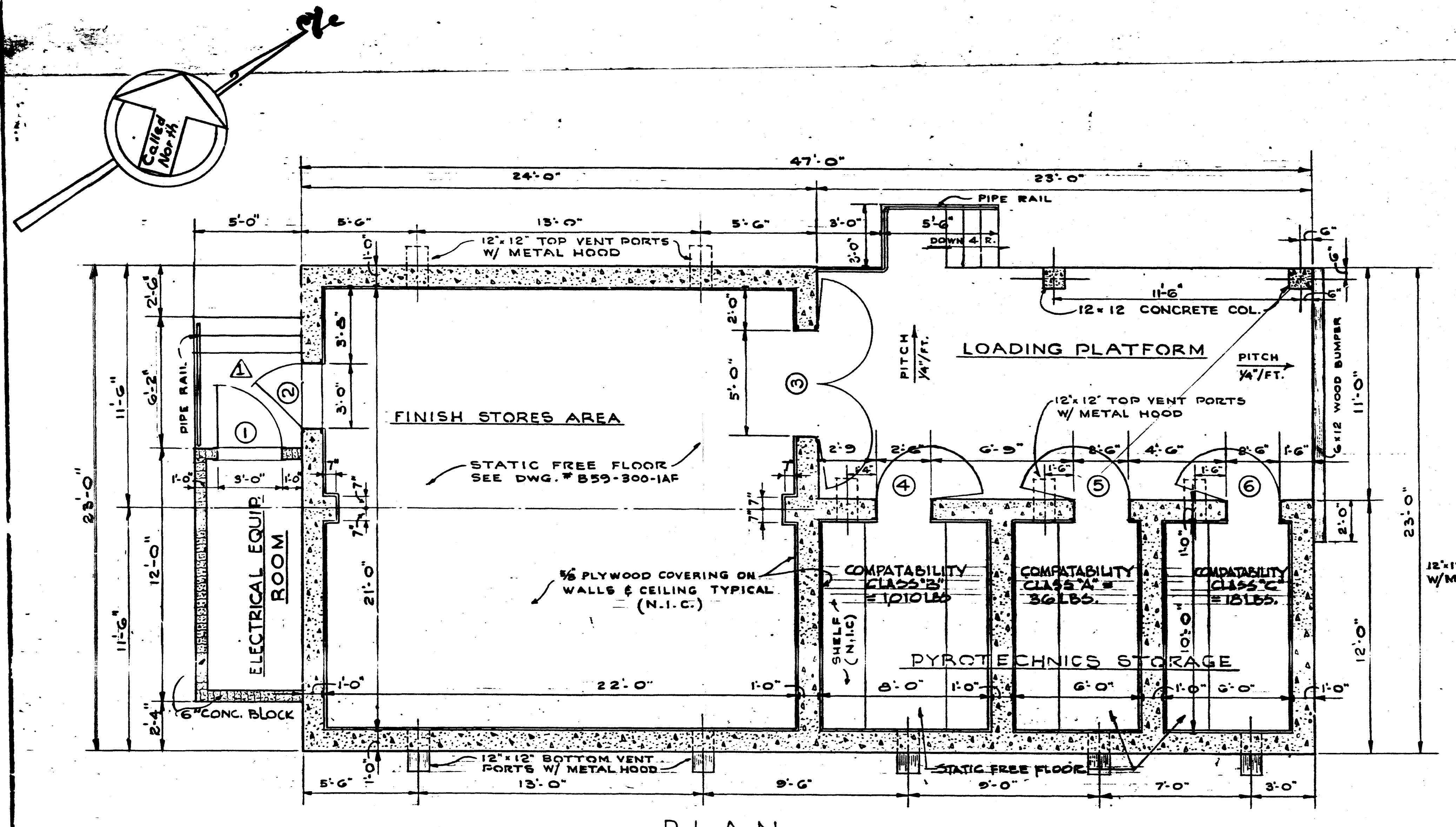
SHT. SIZE 28x40 SCALE AS NOTED DATE FEB. 14, 1967

DRAWN R.A. PARKER
CHECKED N. SANSONE
DIRECTOR PLANT ENG'G. John Bayuk

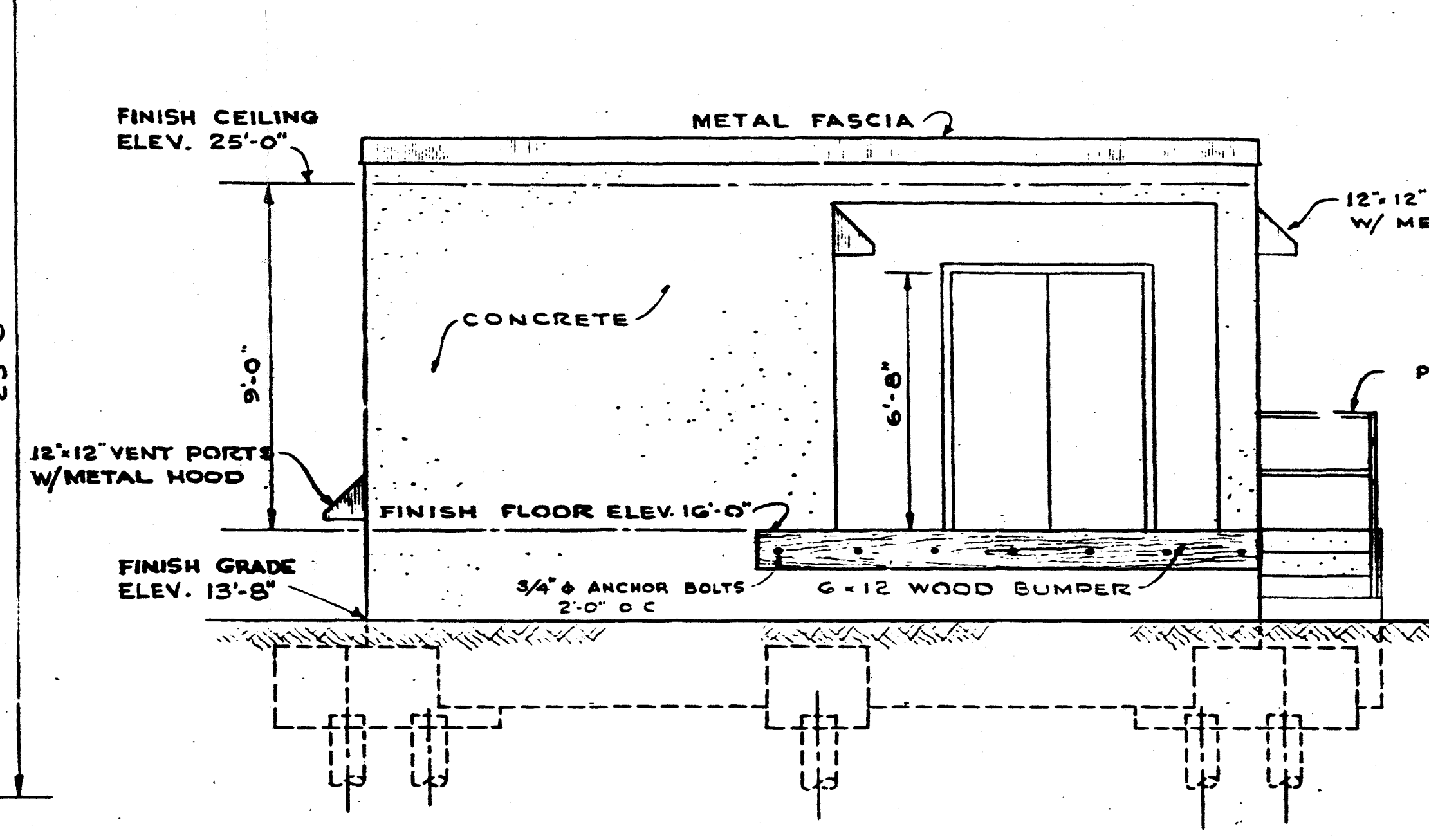
AVCO LYCOMING DIVISION
STRATFORD • CONNECTICUT
PLANT ENGINEERING

SHEET 27 OF 33 SHEETS
DWG. NO.
B59-300-1AC
B5X-300-1AC

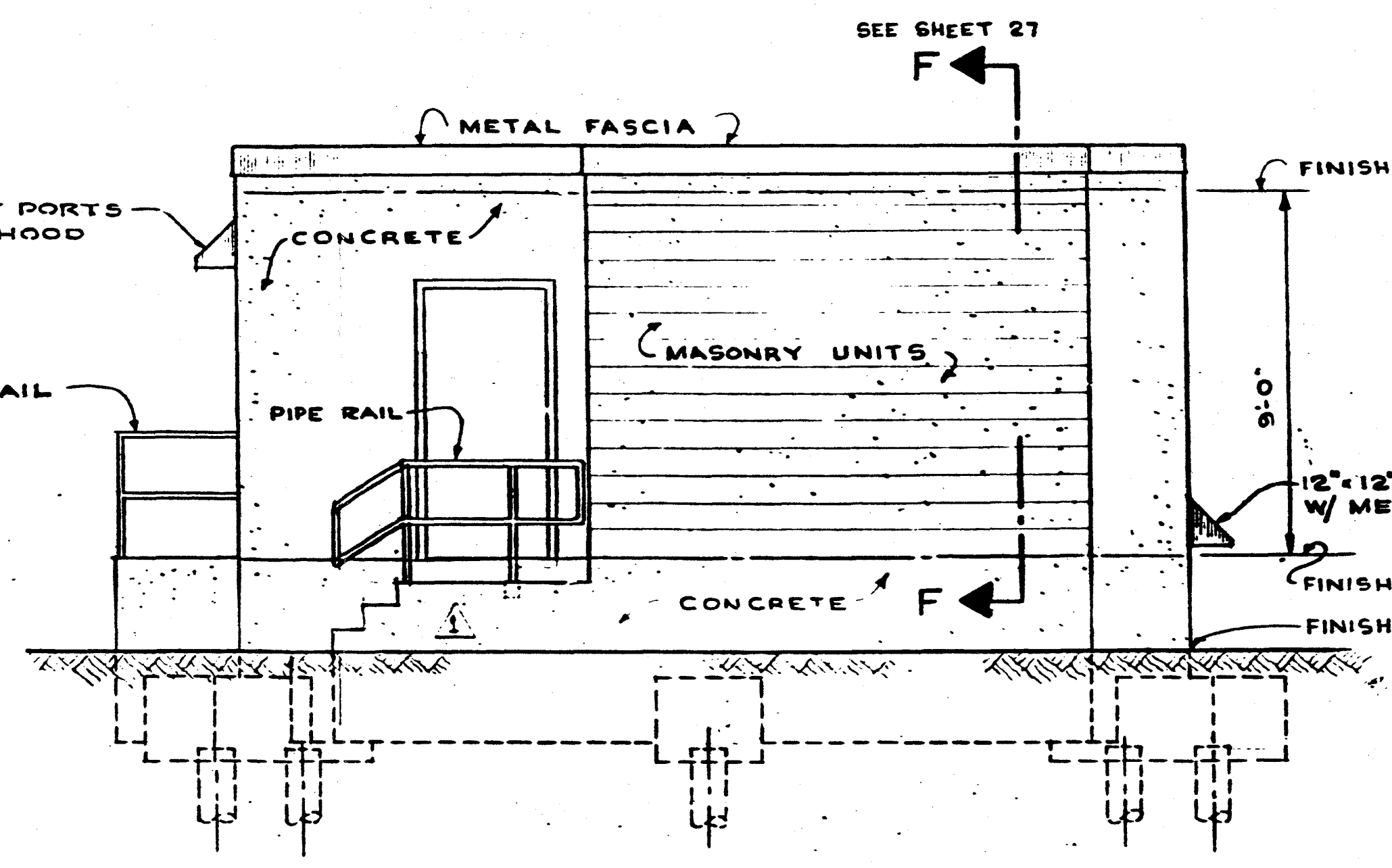
| APPROVED | DATE | APPROVED |
|---|---|---|
| | | |



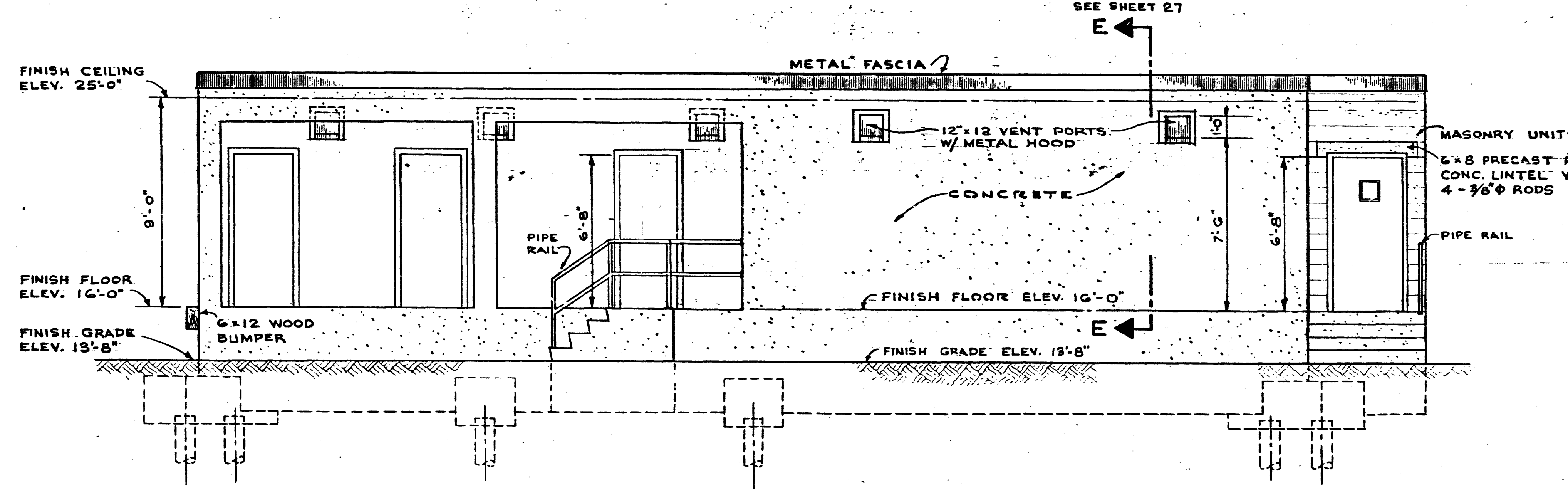
PLAN
SCALE: 1/4"=1'-0"
CLASS 2 EXPLOSIVES
~~MAX. ALLOWABLE TRANSIENT WORKERS = 4.~~



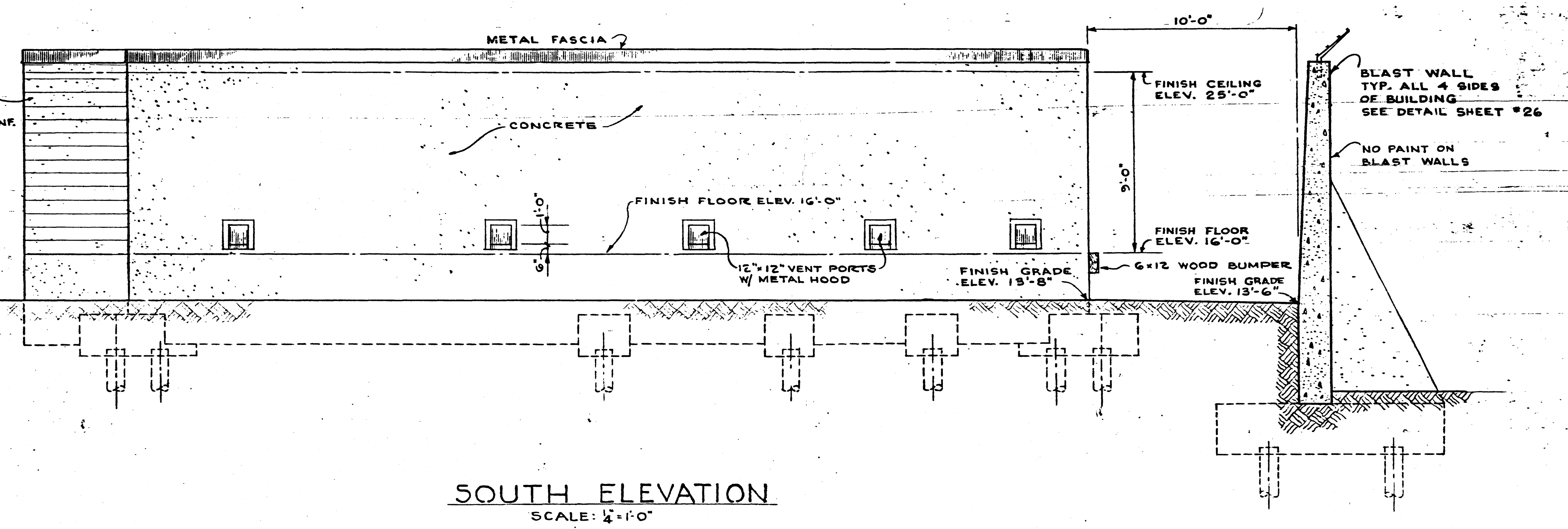
EAST ELEVATION
SCALE: 1/4"=1'-0"



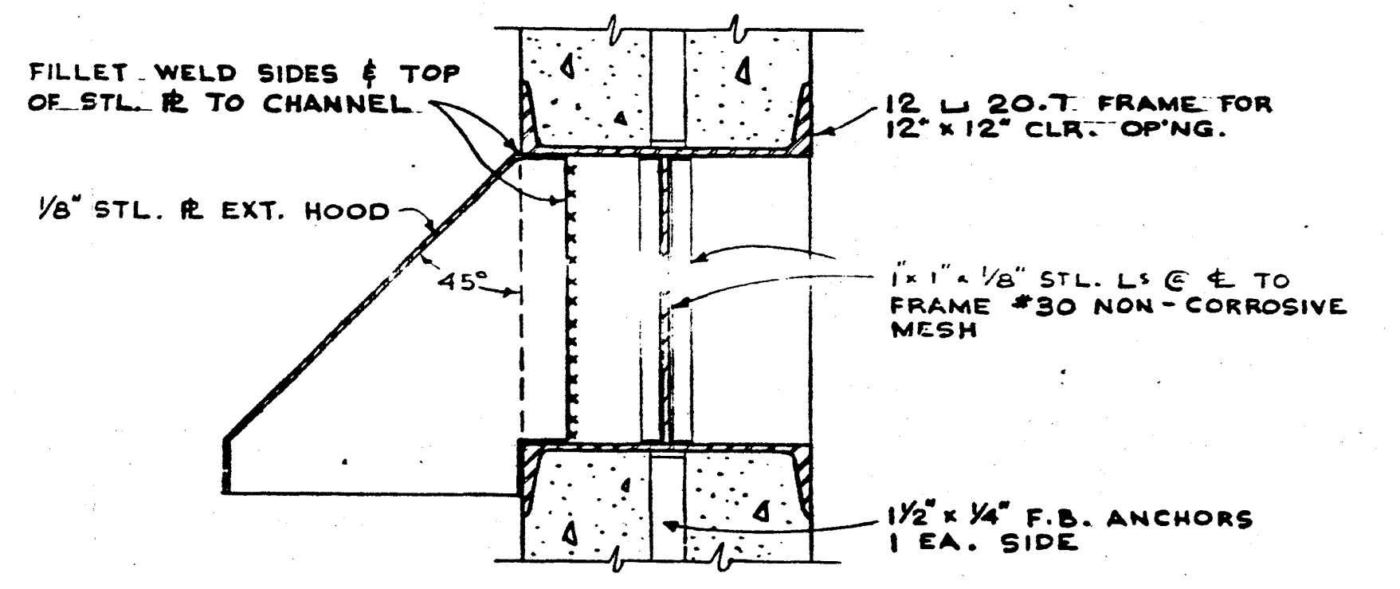
WEST ELEVATION
SCALE: 1/4"=1'-0"



NORTH ELEVATION
SCALE: 1/4"=1'-0"



SOUTH ELEVATION
SCALE: 1/4"=1'-0"



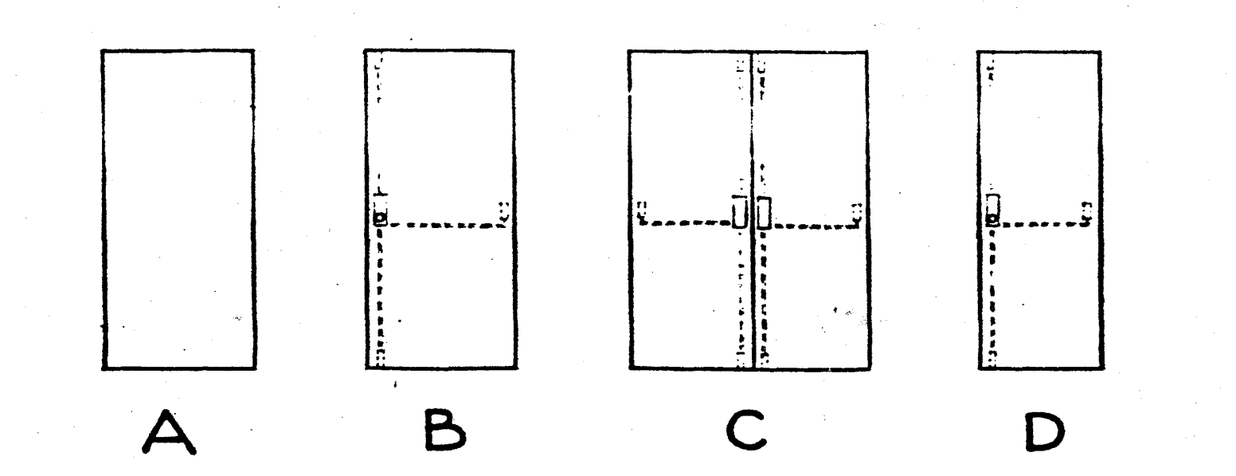
TYP. SECT. THRU VENT
SCALE: 1 1/2" = 1'-0"

NOTE:
1. TOP VENTS LOCATE TOP OF OP'NG. 6" DOWN FROM CEILING. BOTTOM VENTS LOCATE BOT. OF OP'NG. 6" OFF FLOOR. SEE PLAN FOR LOCATIONS (TOTAL 10 - REQ'D)
2. ALL INTERIOR WALL & CEILING SURFACES SHALL HAVE A FIRE RESISTANT GLAZED COATING - SEE REVISED SPECIFICATION. △1
3. ALL EXTERIOR CONC. & CONC. BLOCK SURFACES SHALL HAVE A WATER REPELLENT COATING - SEE REVISED SPECS. △1

## DOOR SCHEDULE

| Nº | KEYED FROM | KEYED TO | DOOR SWING | DOOR SIZE | DOOR TYPE | FRAME | SADDLE | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 1. | EXTERIOR | ELEC. EQUIP. RM. | RHRB | 3'-0"×1 3/4"×6'-8" | A | A | A | △1 |
| 2. | EXTERIOR | FIN. STOR. AREA | RHRB | 3'-0"×1 3/4"×6'-8" | B | B | A | CLOSER (BRASS) & PANIC HDWR. (BRASS) |
| 3. | EXTERIOR | FIN. STOR. AREA | LHRB ACT. | PR 2'-6"×1 3/4"×6'-8" | C | B | — | CLOSER (180°-(BRASS) & PANIC HDWR. (BRASS) |
| 4. | EXTERIOR | CLASS "B" STOR. | LHRB | 2'-6"×1 3/4"×6'-8" | D | B | — | CLOSER (180° - BRASS) & PANIC HDWR. (BRASS) |
| 5. | EXTERIOR | CLASS "A" STOR. | RHRB | 2'-6"×1 3/4"×6'-8" | D | B | — | CLOSER (180° - BRASS) & PANIC HDWR. (BRASS) |
| 6. | EXTERIOR | CLASS "C" STOR. | RHRB | 2'-6"×1 3/4"×6'-8" | D | B | — | CLOSER (180° - BRASS) & PANIC HDWR (BRASS) |

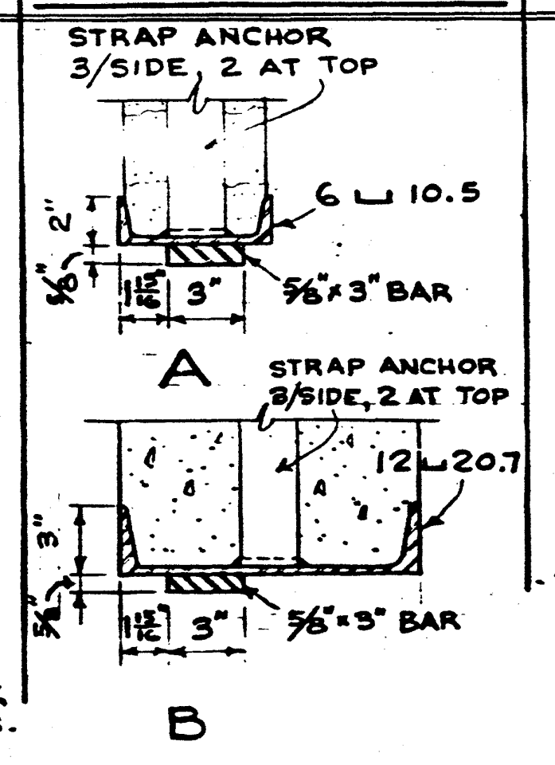
## HOLLOW METAL DOOR TYPES



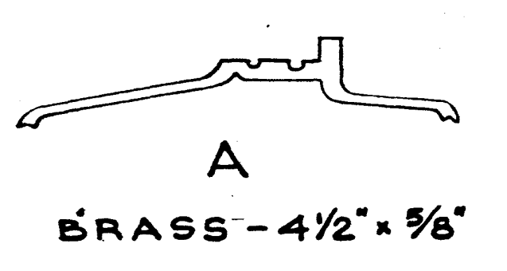
ALL DOORS EXCEPT Nº1 TO BE EQUIVALENT TO CLASS "A" LABEL RATING
~~DOOR Nº1~~ SHALL BE FULL FLUSH STANDARD STEEL DOOR

NOTE: △1
ALL DOORS EXCEPT Nº1 DOORS SHALL HAVE CALCIUM SILICATE BLOCK CORE SURROUNDED BY 18 GA. STEEL CHANNEL FULLY WELDED AT CORNERS. THE CALCIUM SILICATE BLOCK SHALL BE FURNISHED IN 20# DENSITY WITH COMPRESSIVE STRENGTH OF 500#/SQ. IN., AND FLEXURAL STRENGTH OF 175#/SQ. IN.

## FRAME TYPES



## SADDLES



GENERAL NOTES.
1. Contractor to verify all dimensions in field.
2. Contractor to furnish all labor and materials for a complete installation.
3. Reinforcing steel to be of deformed bar.
4. Concrete to be transit plant mixed and to attain compressive strength of 3000 P.S.I. in 28 days.
5. Contractor to protect all property, personnel etc. from damage, injury, dust, etc.
6. Work to be done during normal working hours.
7. All debris, excess and reused fill to be dumped in designated areas.
8. Area to be cleaned periodically and at completion of job.
9. Backfill to be thoroughly puddled.
10. All work to be completely formed and steel trowelled.
11. All concrete to be mechanically vibrated.
12. All reinforcing steel to be tied or welded.
13. Contractor to establish all elevations as noted.
14. Owner to furnish air-water and power. Contractor to provide all connections and hose.
15. All structural steel to receive one shop and one field coat of industrial paint color by owner.

| REV. NO. | DESCRIPTION | BY | DATE |
|---|---|---|---|
| △1 | REVISED PLATFORM & DOOR Nº1. ADDED FINISHES | B.F.M. | MAR 15/67 |

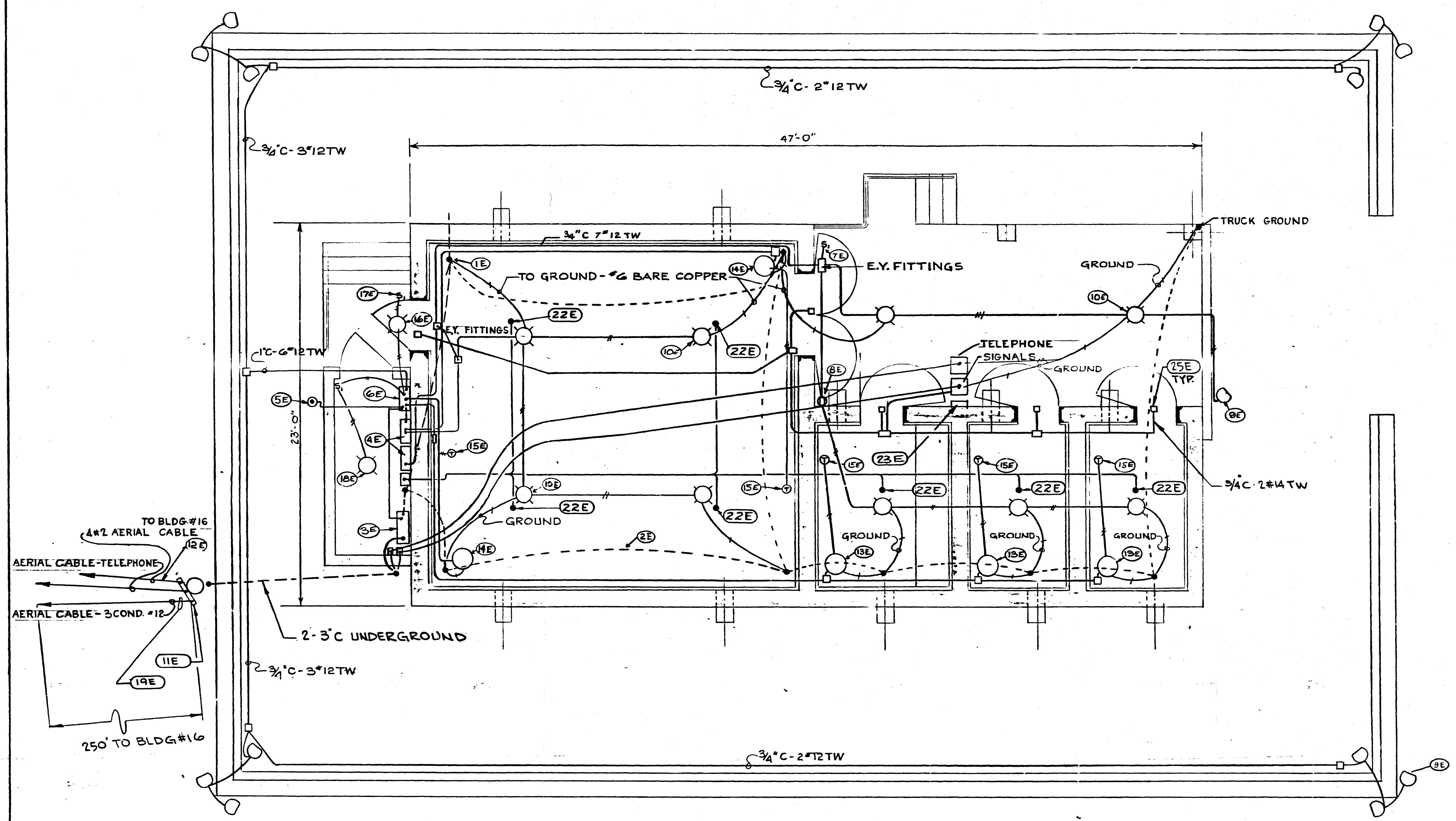
REVISIONS

SAFETY APPROVAL
AVCO Kenneth L. Stebbins
USAF/AFPRO/AVCO A. A. Saunders

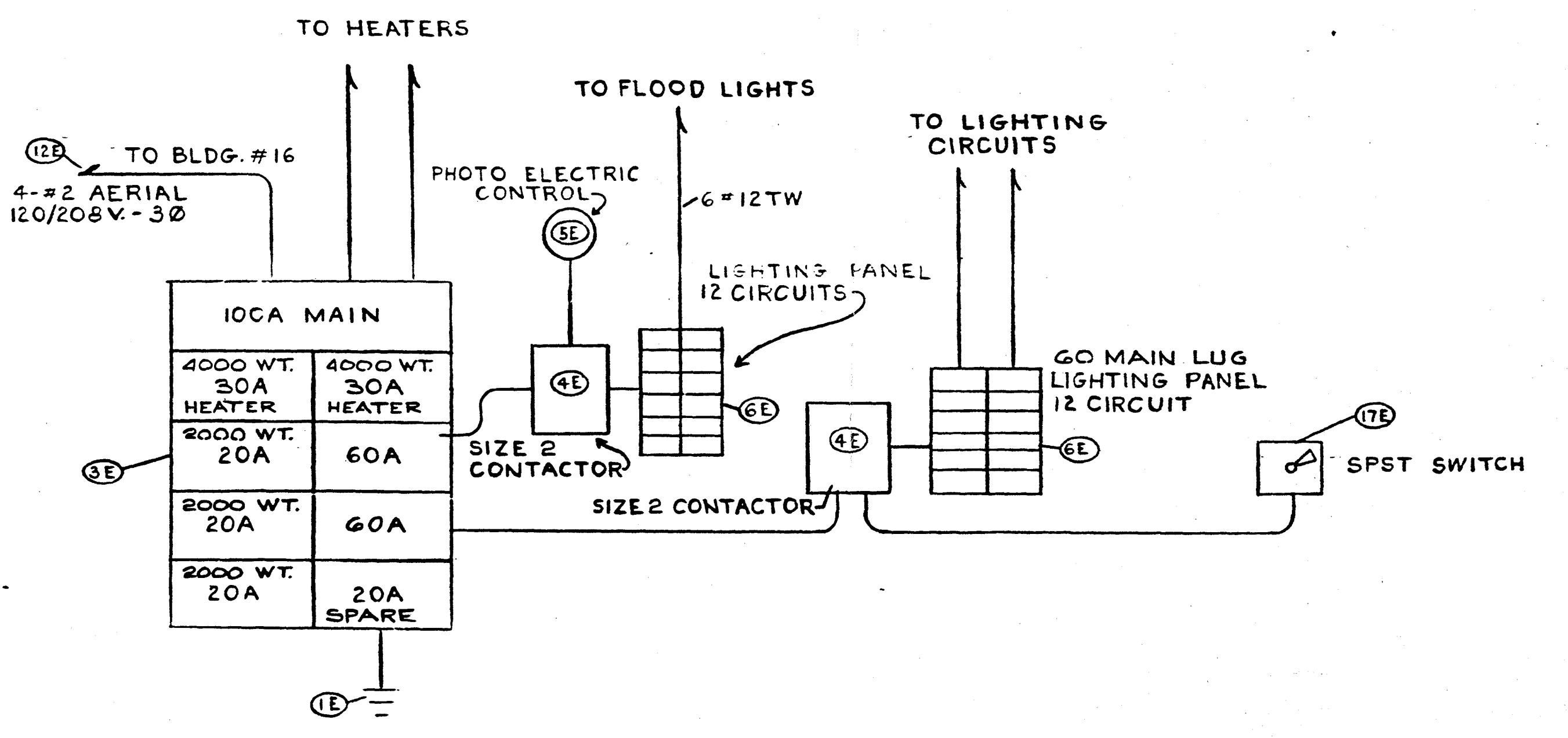
PREPARED BY John Bayuk
DIRECTOR OF PLANT ENGINEERING - AVCO LYCOMING DIVISION
RECOMMENDED BY
VICE-PRESIDENT - AVCO LYCOMING DIVISION
RECOMMENDED BY
C.M.R.P.P. U.S. AIR FORCE
APPROVED BY
APPROVED BY

JOB TITLE PEN-AIDS FACILITIES BLDG. Nº 59
DWG. TITLE PLAN, ELEVATIONS & DETAILS
SHT. SIZE 28"×40" SCALE AS NOTED DATE FEB. 14, 1967
AVCO LYCOMING DIVISION
STRATFORD • CONNECTICUT
PLANT ENGINEERING
DRAWN R. A. PARKER A. A. TOMAIUOLO
CHECKED B. F. MURPHY
DIRECTOR PLANT ENG'G. John Bayuk
SHEET 28 OF 33
DWG. NO. B59-300-1A
B58-300-1A

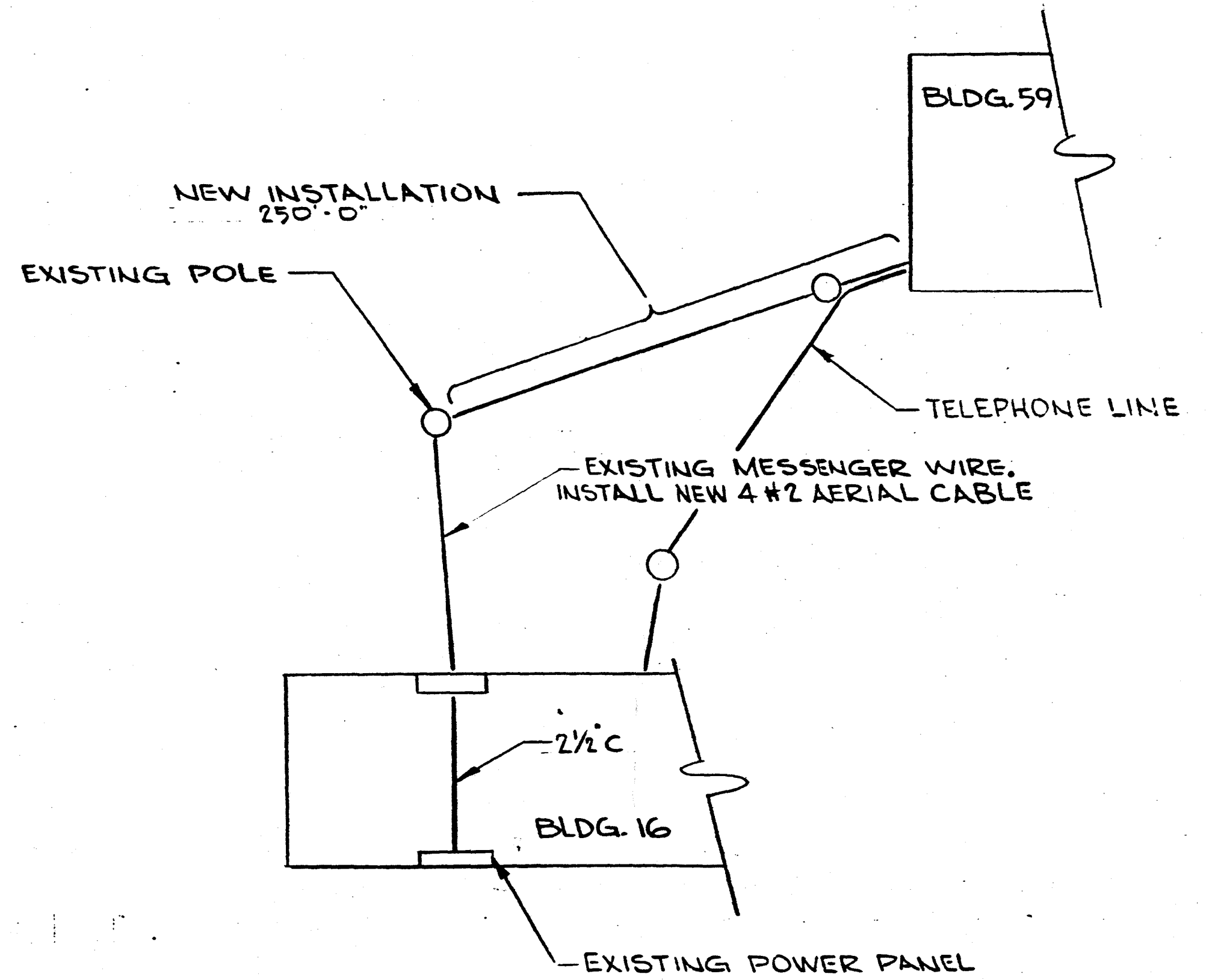
| APPROVED | DATE | APPROVED | |
|---|---|---|---|
| K. L. Stebbins | 11/7/66 | L. Landry | 11/9/66 |
| | 11/20/66 | | |



PLAN
SCALE: ¼"=1'-0"



RISER DIAGRAM
NO SCALE

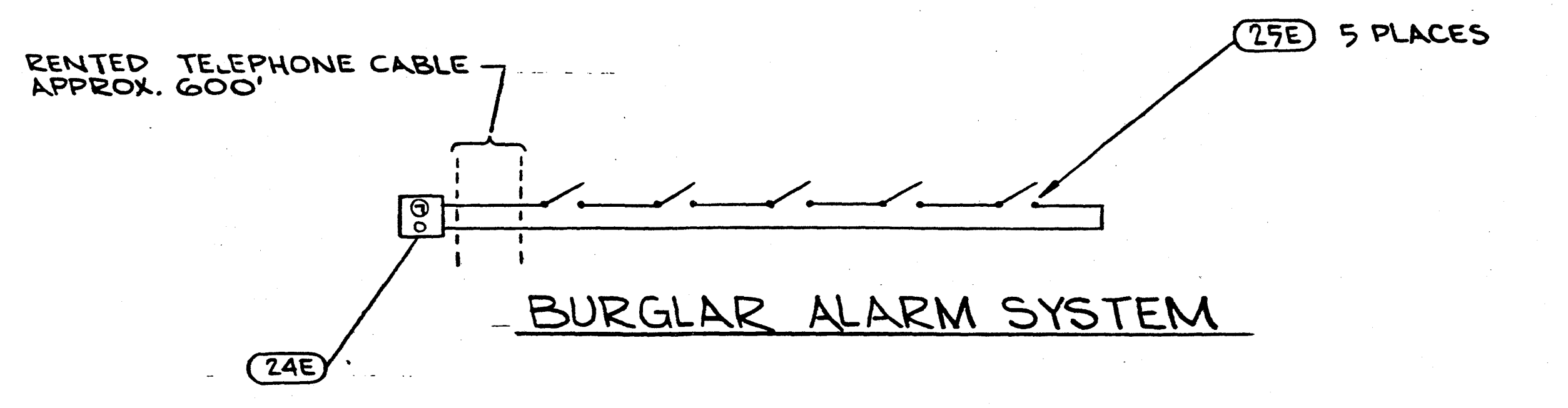


AERIAL POWER FEED
N.T.S.
SEE NOTE 2

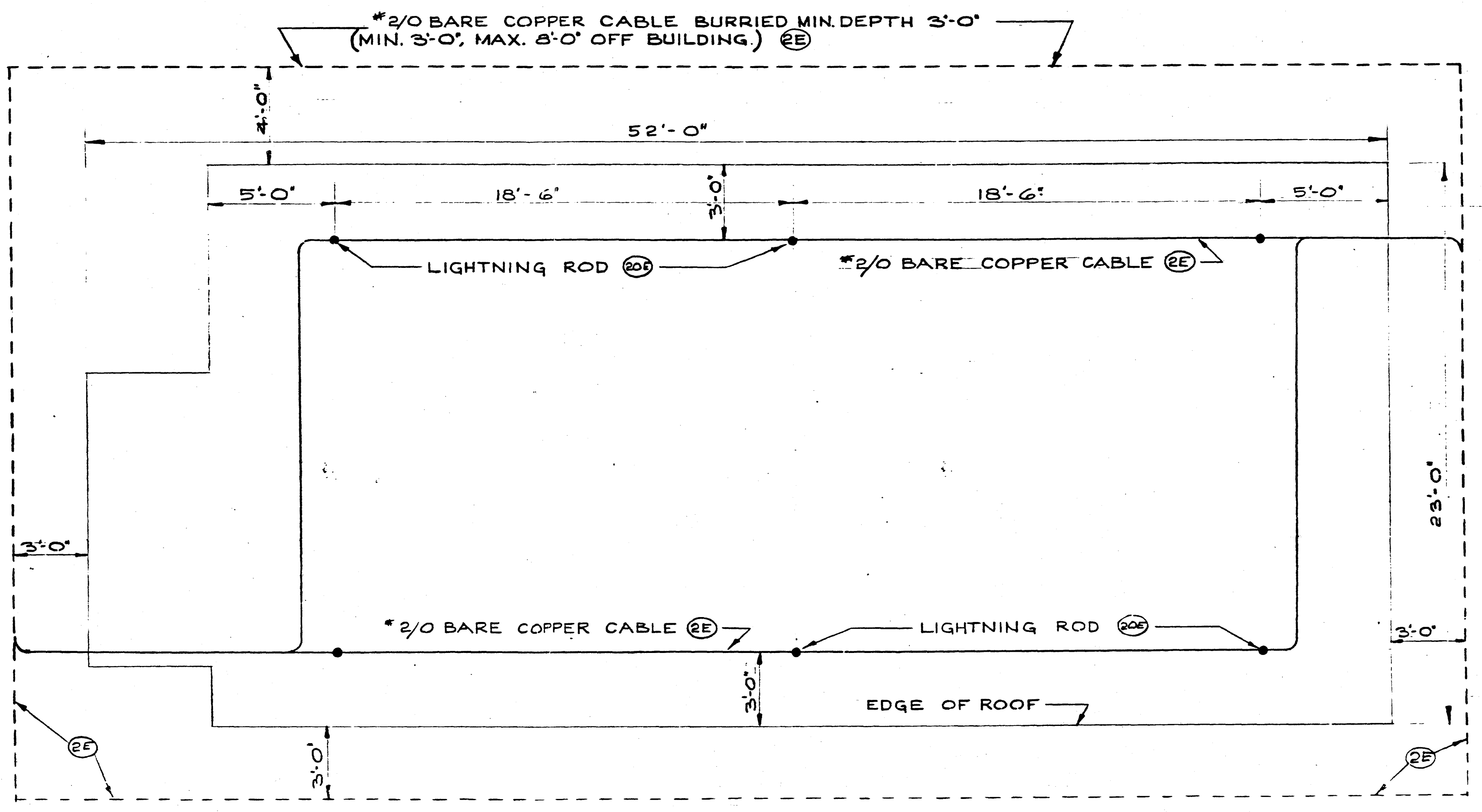
## BILL OF MATERIALS

| ITEM NO. | DESCRIPTION | QUANTITY | SUPPLIED BY | INSTALLED BY |
|---|---|---|---|---|
| 1 E | GROUND RODS ¾"X10' COPPERWELD | 9 | ELEC. CONTR. | ELEC. CONTR. |
| 2 E | #2/0 BARE COPPER CABLE | AS REQ'D | " | " |
| 3 E | POWER PANEL-100A. MAIN C.B., 2-60A, 2-30A, 4-20A. CB, 3Ø-4W | 1 | " | " |
| 4 E | SIZE 2-CONTACTOR-MAGNETIC-3P.-250V. | 2 | " | " |
| 5 E | PHOTO ELECTRIC CONTROL | 1 | " | " |
| 6 E | LIGHTING PANEL-12-1P-20A. C.B., 60A. M.LUG, 3Ø-4W | 2 | " | " |
| 7 E | SPST SWITCH CL 1 GPD-15A-C.H. #EFS1129 OR EQUAL | 1 | " | " |
| 8 E | RECEPTACLE & PLUG, CL 1-GPD, 110V-CH #CPS w/CPP PLUG OR EQUAL | 1 | " | " |
| 9 E | FLOOD LIGHT- 200 W., BRYANT-C1100 W/LAMP OR EQUAL | 13 | " | " |
| 10 E | INCANDESCENT FIXTURE-200W.-CL1GPD-CH #EVCX 215 OR EQUAL | 9 | " | " |
| 11 E | WOOD POLE CLASS II - 30' W/CROSSARM | 1 | " | " |
| 12 E | AERIAL CABLE- 4#2 WIRE WITH MESSENGER | AS REQ'D | " | " |
| 13 E | 2000 W. HEATER-CL 1-GPD, ELECTROMODE 6200K OR EQUAL | 3 | " | " |
| 14 E | 4000 W. HEATER-CL 1-GPD, ELECTROMODE 6200 L OR EQUAL | 2 | " | " |
| 15 E | THERMOSTAT-CL 1-GPD-ELECTROMODE 7164 W/ADALET-XJLGC-CL1GPD-OR EQ. | 5 | " | " |
| 16 E | LIGHT FIXTURE-HOLOPHANE 420 | 1 | " | " |
| 17 E | SPST SWITCH-WEATHER PROOF-15A, 110V. | 2 | " | " |
| 18 E | FIXTURE- 100 W, AL3140, ALABAX WHITE PORCELIAN FIXTURE OR EQUAL | 1 | " | " |
| 19 E | AERIAL CABLE-3 COND. #12 TW WITH GEOPRENE JACKET | 1 | " | " |
| 20 E | LIGHTNING ROD - AIR TERMINAL | 6 | " | " |
| 21 E | STATIC FREE FLOOR COVERING SYSTEM | AS REQ'D. | " | " |
| 22 E | FIRE DETECTOR HEAD GAMEWELL N/C-200°F #47391#27414 | 7 | " | " |
| 23 E | FIRE BOX #523 | 1 | " | " |
| 24E | ADEMCO MODEL 'A' BURGLAR ALARM CONT. IN PLANT PROTEC. HDQTRS | 1 | EXISTING ELEC. | EXISTING ELEC. |
| 25E | LIMIT SWITCH-OIL TIGHT CUTLER HAMMER #10316H211 w/ROLLER LEVER | 5 | EXISTING ELEC. | EXISTING ELEC. |

NOTE
1. ALL LAMPS WILL BE SUPPLIED BY ELECTRICAL CONTRACTOR
2. AERIAL POWER FEED (480V) WILL BE RUN THRU D-1 CONTROL ROOM IN BLDG #16 TO AN EXISTING POWER PANEL. APPROX DISTANCE 250'



BURGLAR ALARM SYSTEM



LIGHTNING PROTECTION PLAN
SCALE: ¼"=1'-0"

|  |  |  |  |
|---|---|---|---|
| 1 | ADDED ITEM 23E<br>ADDED TELEPHONE LINE & POLE<br>ITEM 22E WAS EDWARDS SYSTEM | FER | 5-8-68 |
| No. | DESCRIPTION | By | Date |

REVISIONS

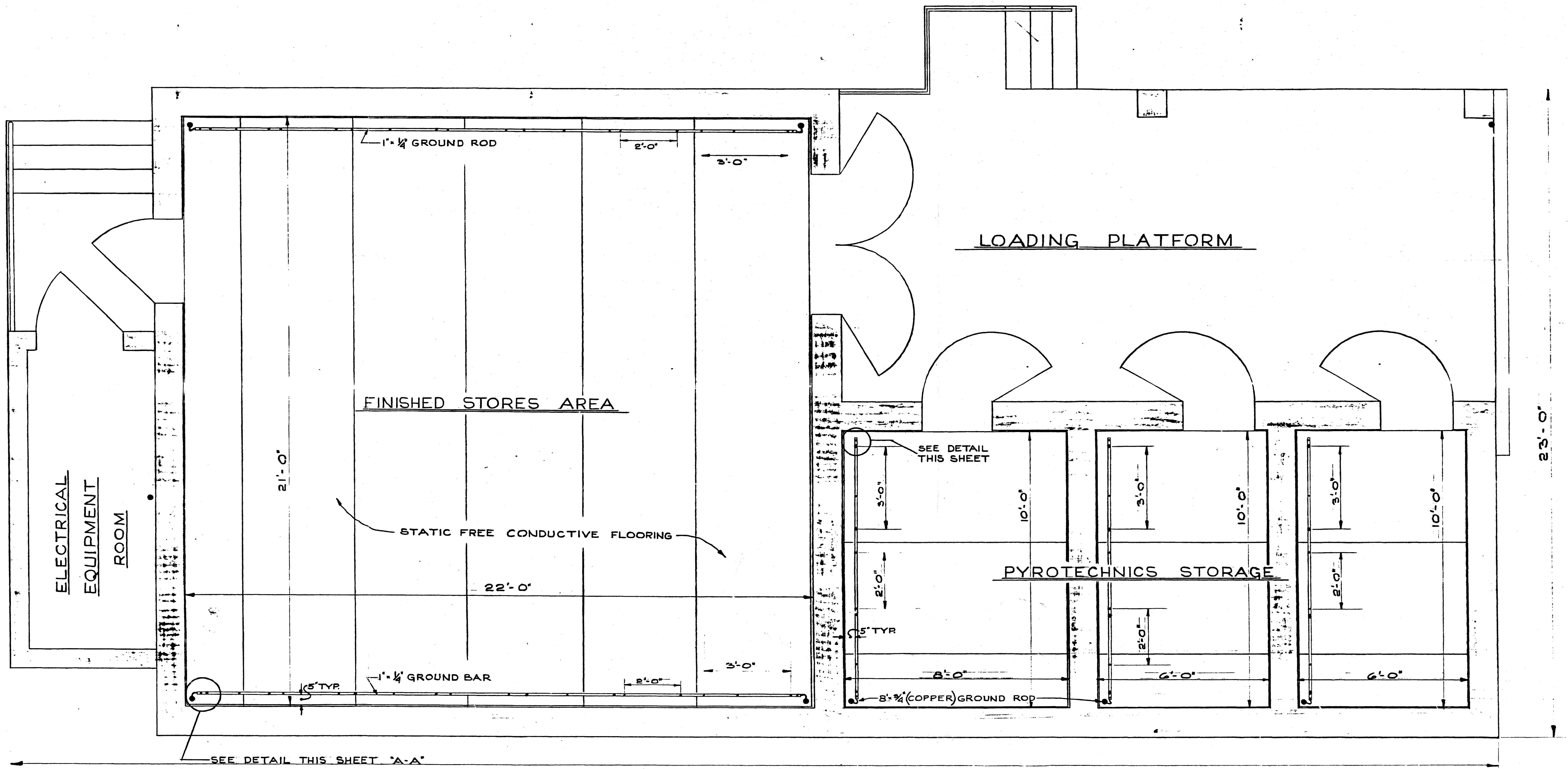
| SAFETY APPROVAL | | |
|---|---|---|
| AVCO<br>Kenneth L. Stebbins | PREPARED BY | John Bayuk<br>DIRECTOR OF PLANT ENGINEERING - AVCO LYCOMING DIVISION |
| USAF/AFPRO/AVCO<br>A.A. Saunders | RECOMMENDED BY | VICE-PRESIDENT - AVCO LYCOMING DIVISION |
| | RECOMMENDED BY | |
| | APPROVED BY | |
| | APPROVED BY | |

JOB TITLE
PEN-AIDS FACILITIES - BUILDING Nº59
DWG. TITLE ELECTRICAL, POWER, LIGHTING, LIGHTNING, GROUNDING & HEATING
SHT. SIZE 28"X 40" SCALE AS SHOWN DATE FEB 14, 1967
DRAWN M. HACKET
CHECKED
DIRECTOR PLANT ENG'G. John Bayuk

AVCO LYCOMING DIVISION
STRATFORD • CONNECTICUT
PLANT ENGINEERING

SHEET 29 OF 33 SHEE
DWG. NO. B59-300-1AE

| APPROVED | DATE | APPROVED | |
|---|---|---|---|



PLAN
SCALE: ½"=1'-0"

| ROOM SIZE REQUIREMENTS | |
|---|---|
| LOCATION | SIZE |
| FINISHED STORES AREA | 21'-0"×22'-0" |
| | |
| PYROTECHNICS STORAGE | 8'-0"×10'-0" |
| " " | 6'-0"×10'-0" |
| " " | 6'-0"×10'-0" |

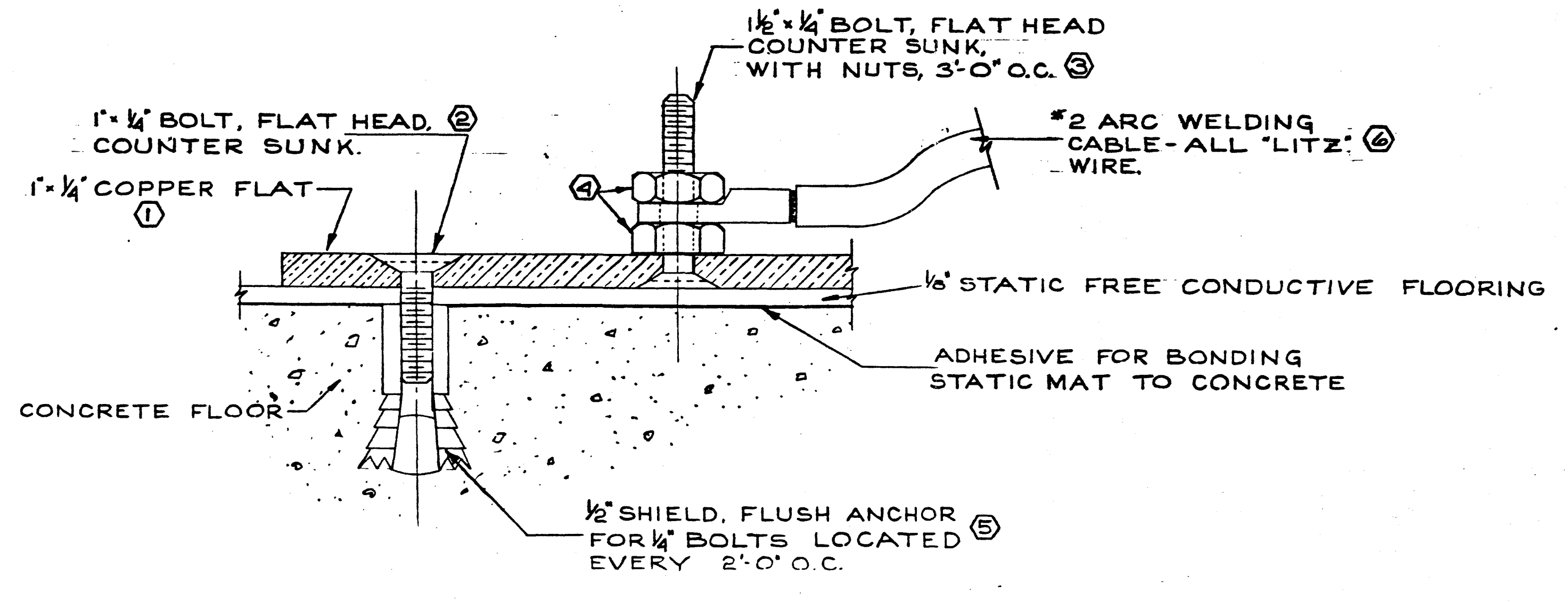
⚠1

LIST OF MATERIALS

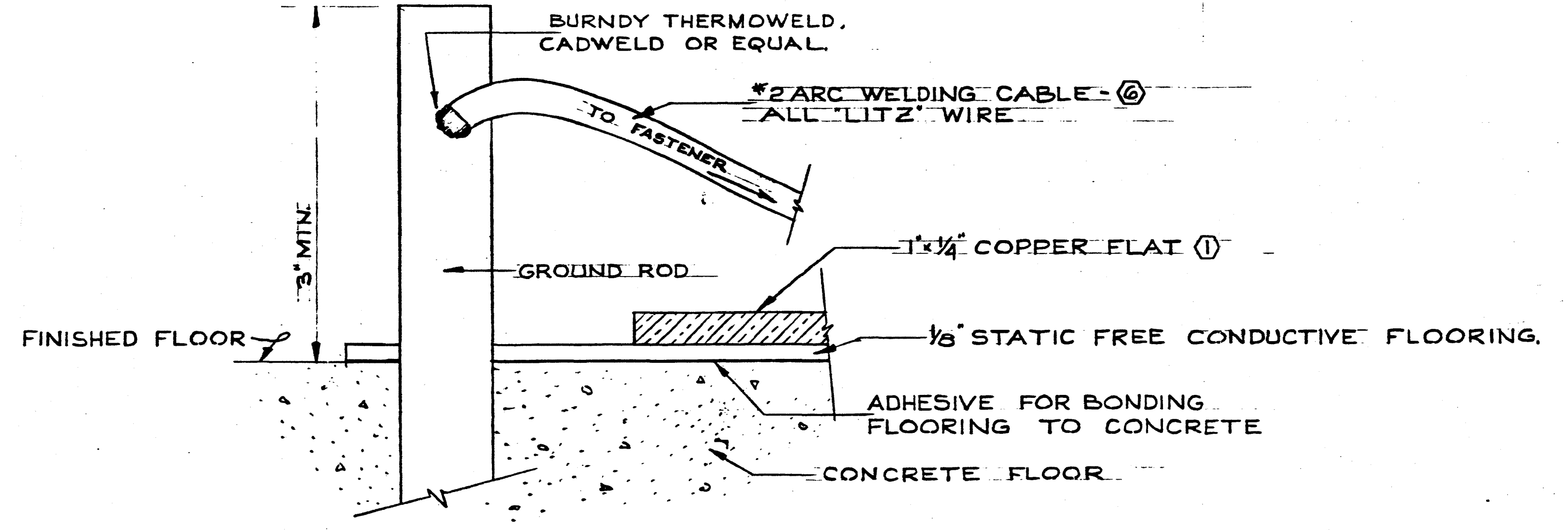
| Nº | DESCRIPTION | | Q'NTY | SUPPLIED BY | INSTALLED BY |
|---|---|---|---|---|---|
| ① | 1"×¼" GROUND BAR (COPPER) | APPROX | 355 FT. | EL.CONT. | EL.CONT. |
| ② | 1"×¼" BOLT, FLAT HEAD, (BRASS) | " | 195 | " | " |
| ③ | 1½"×¼" BOLT, FLAT HEAD, (BRASS) | " | 130 | " | " |
| ④ | HEX NUTS FOR ABOVE BOLT (BRASS) | " | 260 | " | " |
| ⑤ | ½" SHIELDS - FLUSH ANCHOR | " | 195 | " | " |
| ⑥ | #2 ARC WELDING CABLE - ALL "LITZ" WIRE | | AS REQ'D | " | " |

⚠1 NOTE:

THE LIST OF MATERIALS INCLUDE APPROXIMATE QUANTITIES FOR BOTH BUILDING #58 AND BUILDING #59.



DETAIL - MAT, GROUND BAR & FASTENER
SCALE: FULL SIZE



⚠1 DETAIL - "A-A"
SCALE: FULL SIZE

| NO | DESCRIPTION | BY | DATE |
|---|---|---|---|
| ⚠1 | DETAILS & MATERIALS | J.F.A. | 3-13-67 |

REVISIONS

SAFETY APPROVAL
AVCO
USAF/AFPRO/AVCO
A.P. Saunders

PREPARED BY John Bayuk
DIRECTOR OF PLANT ENGINEERING - AVCO LYCOMING DIVISION

RECOMMENDED BY
VICE-PRESIDENT - AVCO LYCOMING DIVISION

RECOMMENDED BY

APPROVED BY

APPROVED BY

JOB TITLE
PEN-AIDS FACILITIES - BUILDING #59

DWG. TITLE
ELECTRICAL LAYOUT - CONDUCTIVE FLOORING

SHT. SIZE 28" × 40" SCALE AS NOTED DATE FEB. 14, 1967

DRAWN J.F. ADAMS
CHECKED M.S. Oppel
DIRECTOR PLANT ENG'G. John Bayuk

AVCO LYCOMING DIVISION
STRATFORD • CONNECTICUT

PLANT ENGINEERING

SHEET 30 OF 33 SHEET

DWG. NO.
B59-300-1AF
B58-300 - 1AF⚠1

APPROVED DATE APPROVED

PHOTO H-C-1

PHOTO H-C-2

PHOTO H-C-3

PHOTO H-C-4

PHOTO H-C-5

PHOTO H-C-6

PHOTO H-C-7

PHOTO H-C-8

PHOTO H-C-9

PHOTO H-C-10

PHOTO H-C-11

PHOTO H-C-12

PHOTO H-C-13

PHOTO H-C-14

PHOTO H-C-15

PHOTO H-C-16

PHOTO H-C-17

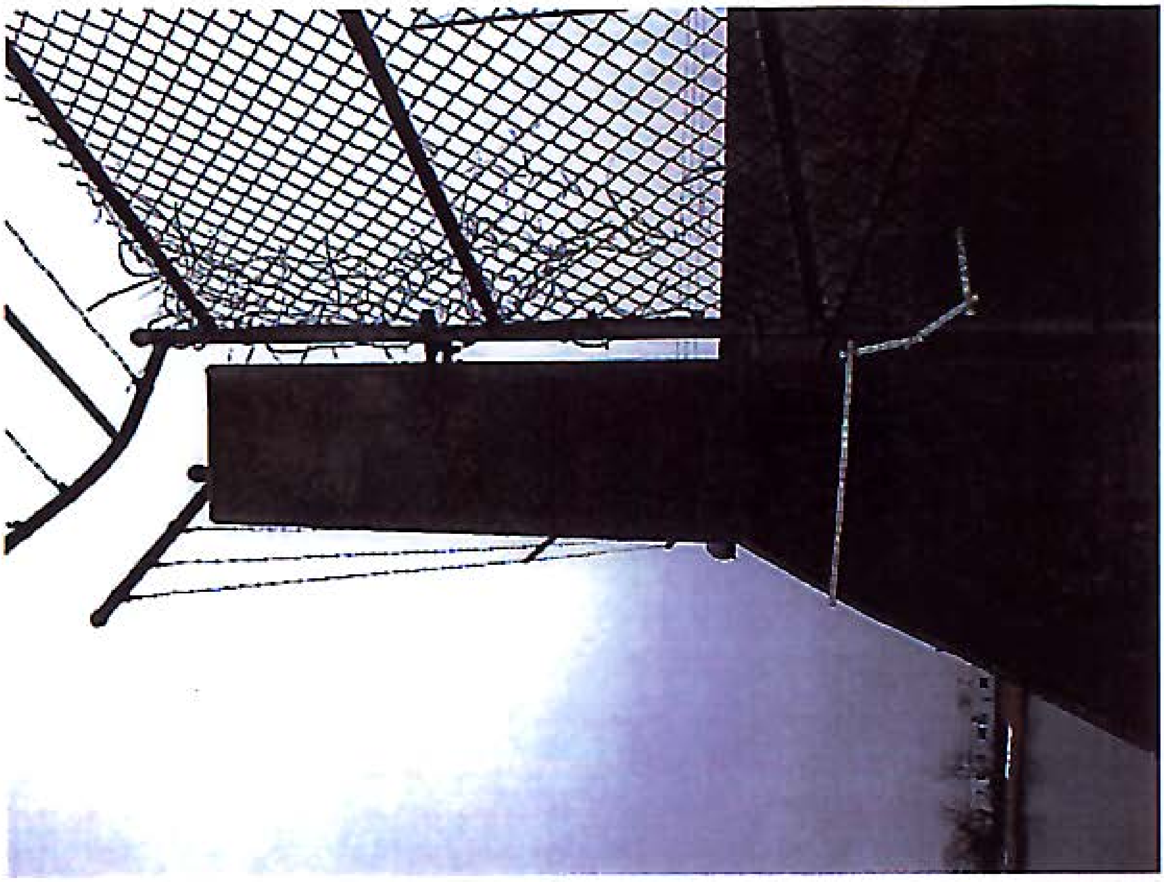
PHOTO H-C-18

PHOTO H-C-19

PHOTO H-C-20

PHOTO H-C-21

PHOTO H-C-22



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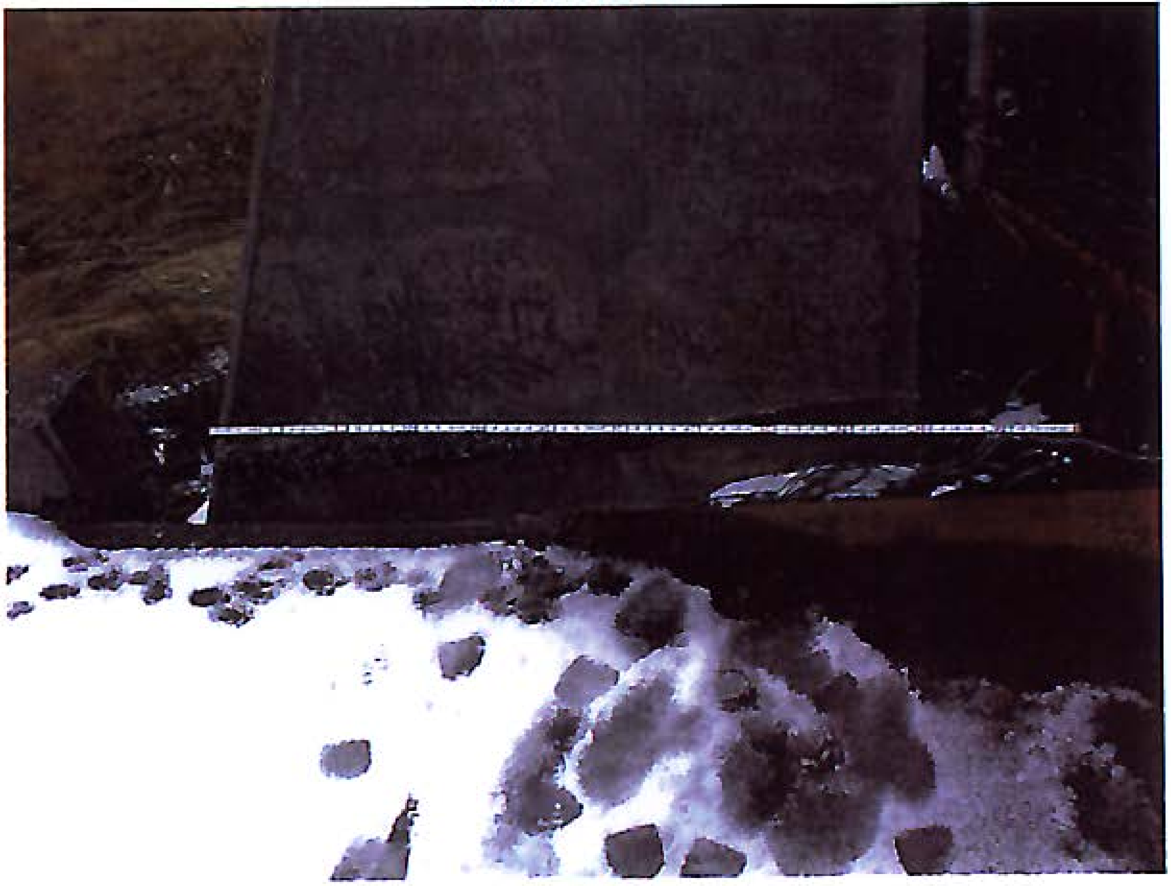


PHOTO H-C-24

PHOTO H-C-25

PHOTO H-C-26

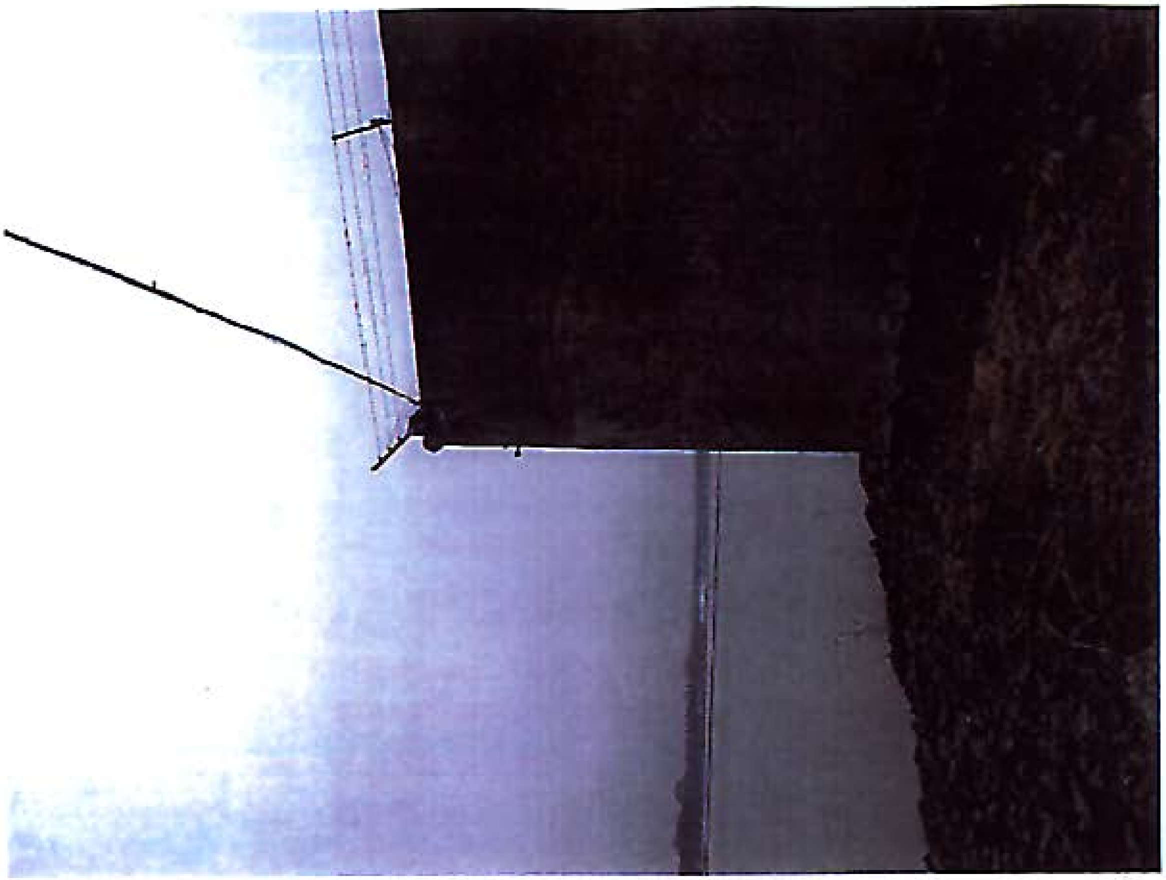


**PHOTO H-C-27**

**PHOTO H-C-28**

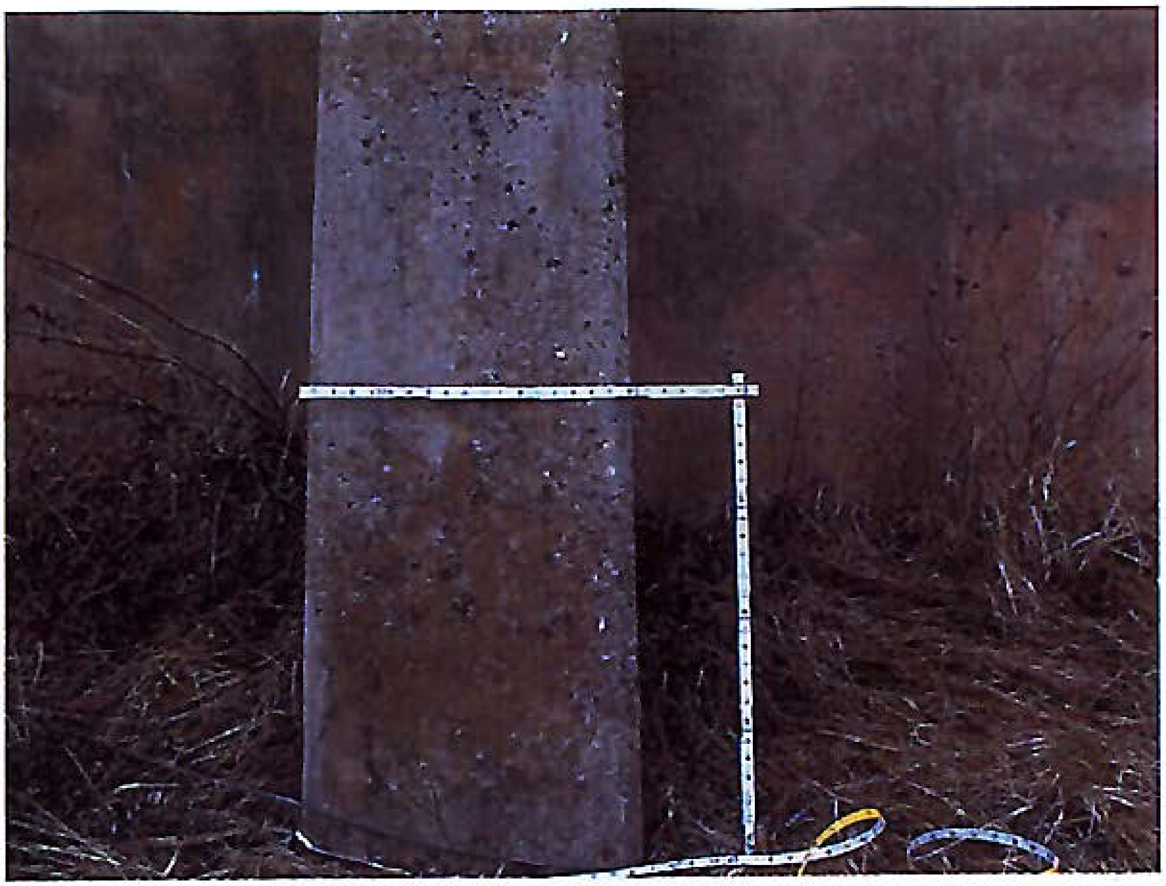


PHOTO H-C-29

PHOTO H-C-30

PHOTO H-C-31

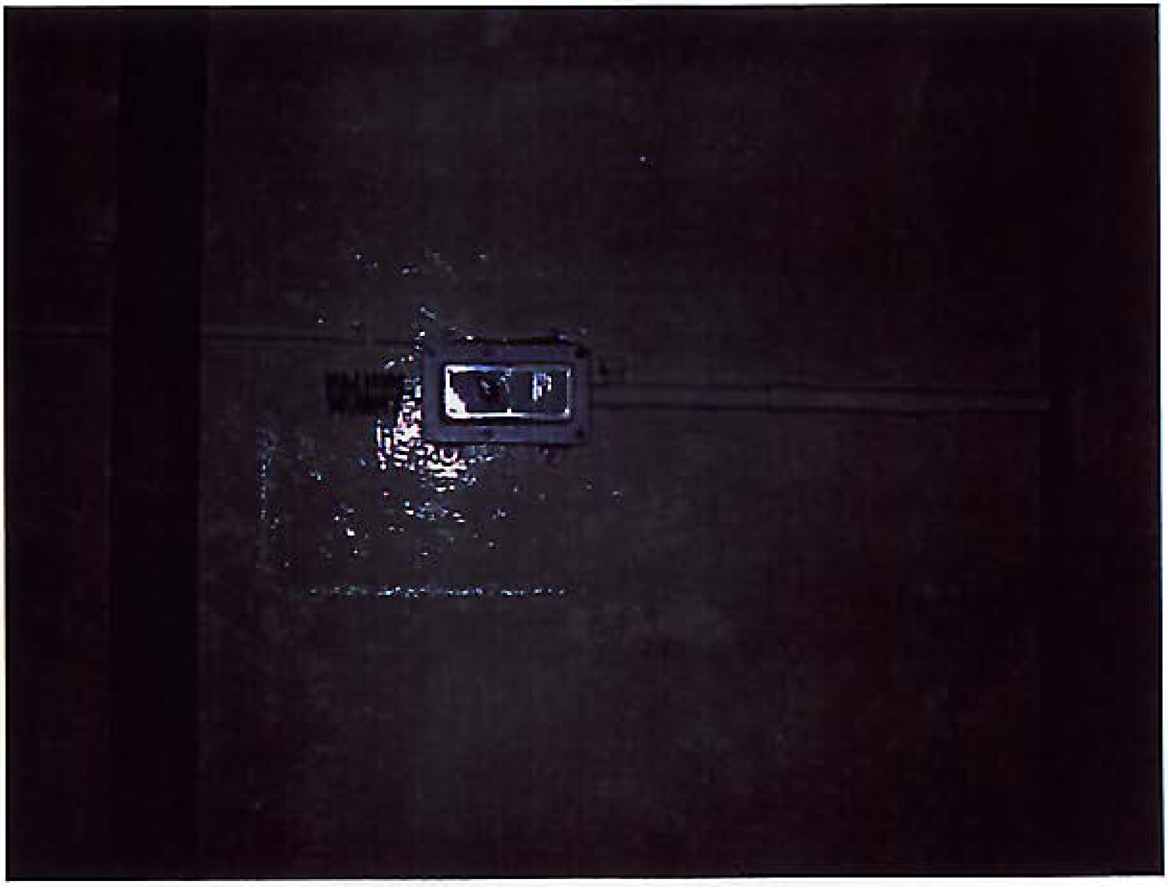


PHOTO H-C-32

PHOTO H-C-33

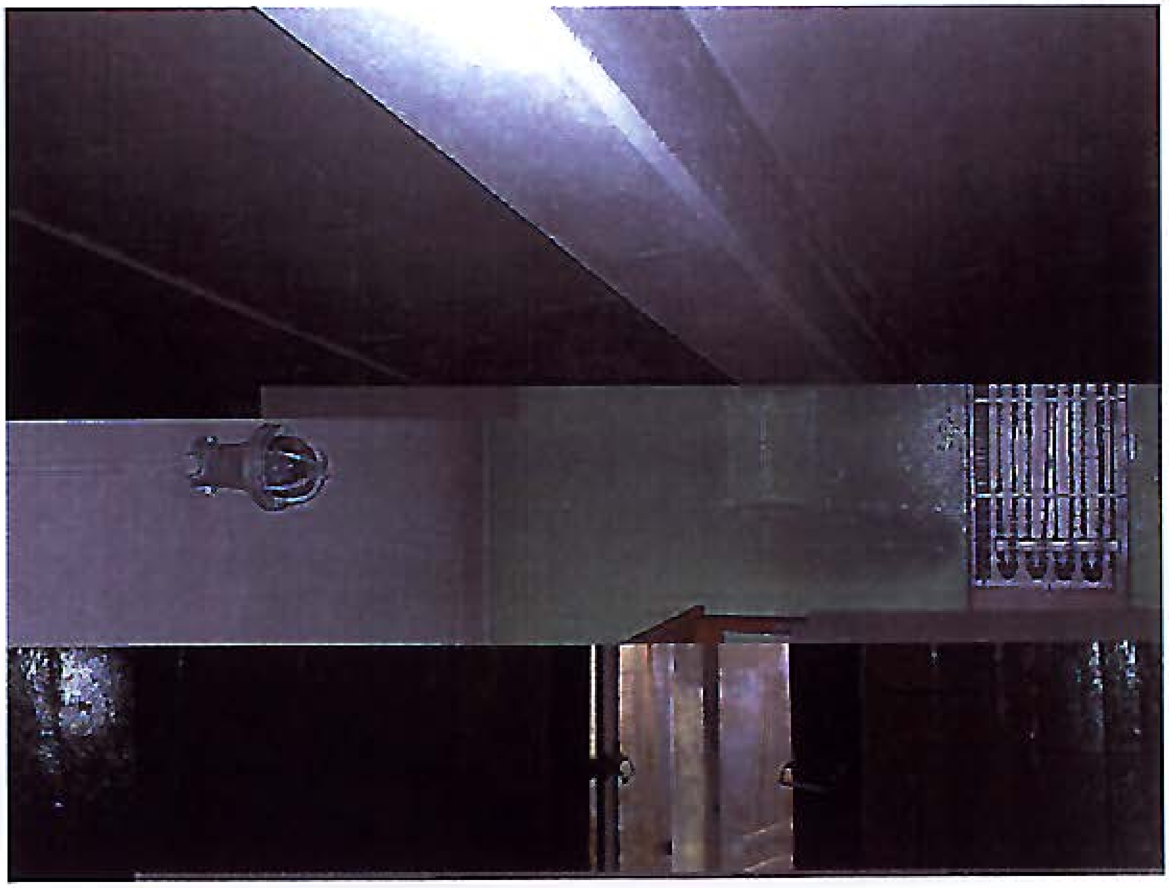


PHOTO H-C-34

PHOTO H-C-35

PHOTO H-C-36

PHOTO H-C-37

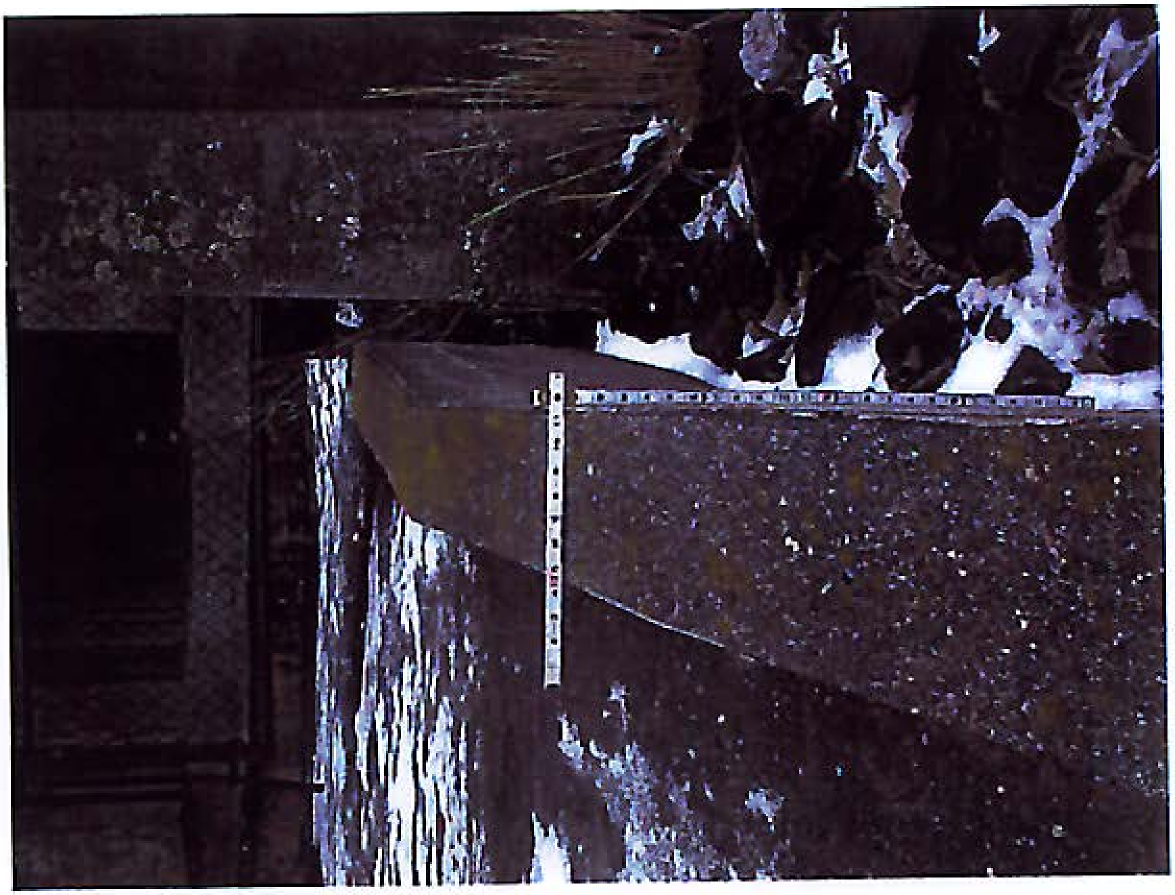


PHOTO H-C-38

PHOTO H-C-39

PHOTO H-C-40

PHOTO H-3-41

PHOTO H-C-42

PHOTO H-C-43

PHOTO H-C-44

PHOTO H-C-45

PHOTO H-C-46

PHOTO H-C-47

# H-D-1 Asbestos Survey Information

# TABLE 3.6.1
# TOTAL ESTIMATED QUANTITIES OF ASBESTOS CONTAINING MATERIALS
# BUILDING 5

## TOTAL ESTIMATED QUANTITIES OF ASBESTOS CONTAINING MATERIALS

| Item # | Material Description | Quantity | Units |
|---|---|---|---|
| 1 | Pipe insulation and associated fittings, magnesium block, 3-6" O.D. | 878 | LF |
| 10 | Fabric strapping | 6 | LF |
| 18 | Pipe insulation, Aircell, 2-6" O.D. | 3 | LF |
| 53 | Vibration joints, white fabric | 2 | EA |
| 136 | Pipe insulation and associated fittings, magnesium block, 8" O.D. | 12 | LF |
| FD | Fire Doors | 6 | EA |
| Roof | Roofing Material | 5,363 | SF |
| WC | Window Caulking | 350 | LF |

Key:
LF = Linear Feet; SF = Square Feet; EA = Each; O.D. = Outer Diameter

# TABLE 3.6.3
# SUMMARY OF ANALYTICAL RESULTS
# BUILDING 5

| Lab Sample No. | Field Sample No. | Description | % Asb [1] |
|---|---|---|---|
| 060297- 319 | - 05 - ROOF - | Built-up roofing material - Building 5 | 0.0 |
| 060297- 320 | - 05 - FLASH - | Roof flashing - Building 5 | 17.2 |
| 110497- 985 | 110397 - 05 - 279 - 01 | Grey Cementitious Caulking around door, both sides(CK5-1 from exterior) | 4.0 |
| 110497- 986 | 110397 - 05 - 282 - 01 | Dark grey chewy caulking between window and wall (CK5-2) | 0.0 |
| 110497- 987 | 110397 - 05 - 281 - 01 | Plaster-like yellowish white window caulking on interior of steel panes (CK5-3) | 2.3 |
| 110497- 988 | 110397 - 05 - 281 - 02 | Plaster-like yellowing white window caulking on interior newer windows (CK5-4) | 0.0 |
| 110497- 989 | 110397 - 05 - 285 - 01 | Light grey flexible caulking - around door w/ glass panels on either side, caulking on both interior and exterior (CK5-5) | 0.0 |
| 111397- 1046 | 110697 - 05 - 53 - 01 | Vibration joint, white fabric | 58.4 |

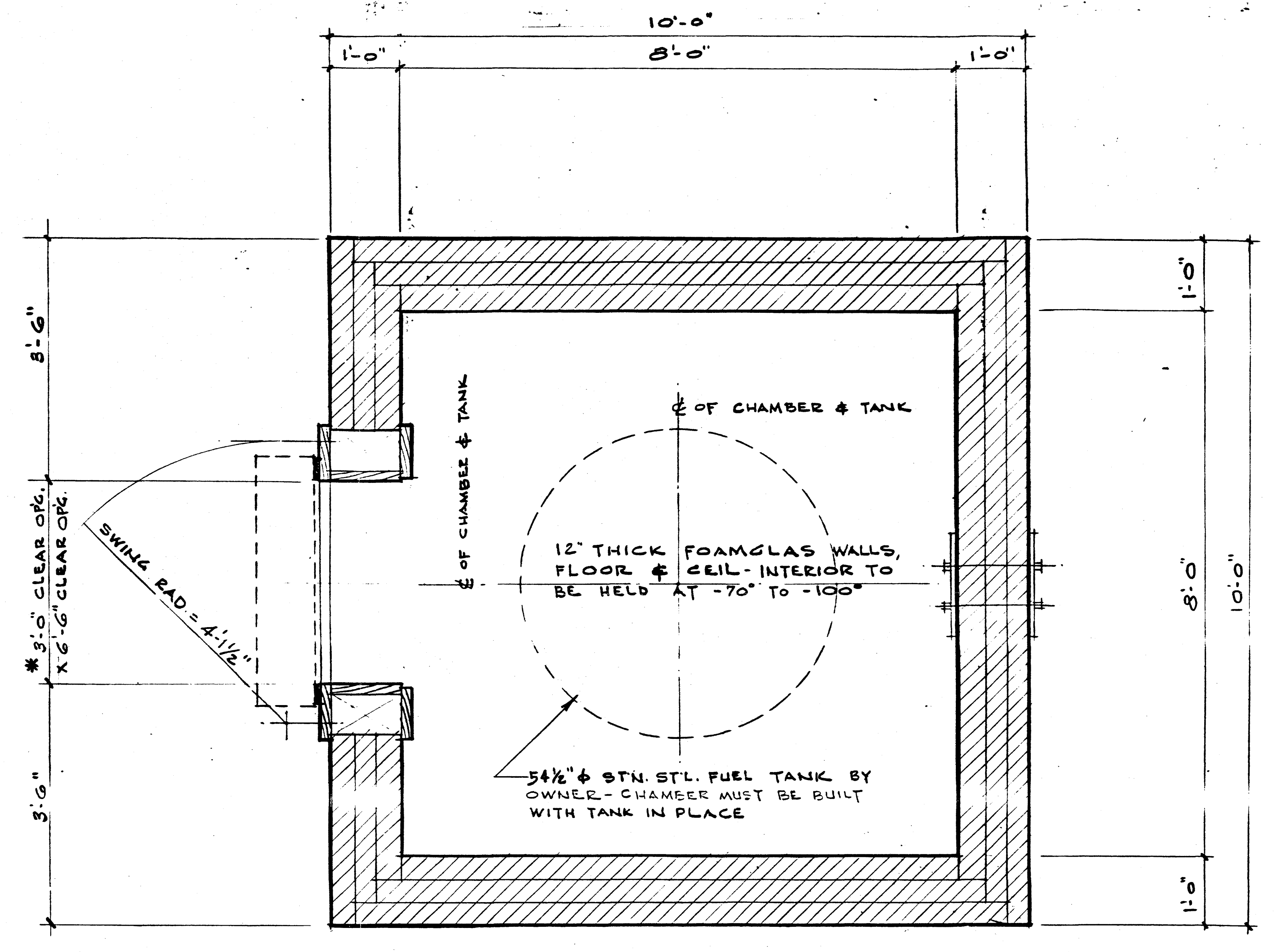
Notes:

(1) Results are based upon Polarized Light Microscopy (PLM) analysis.

# Attachment D – Building 5 Plans and Photographs (February 2001)

# BUILDING 5 - FUEL SYSTEM TEST

Building 5 is a one-story, 5,363 square foot building constructed of concrete floors, steel supports, and masonry exterior walls. Roofing consists of tar and felt built-up roofing material.

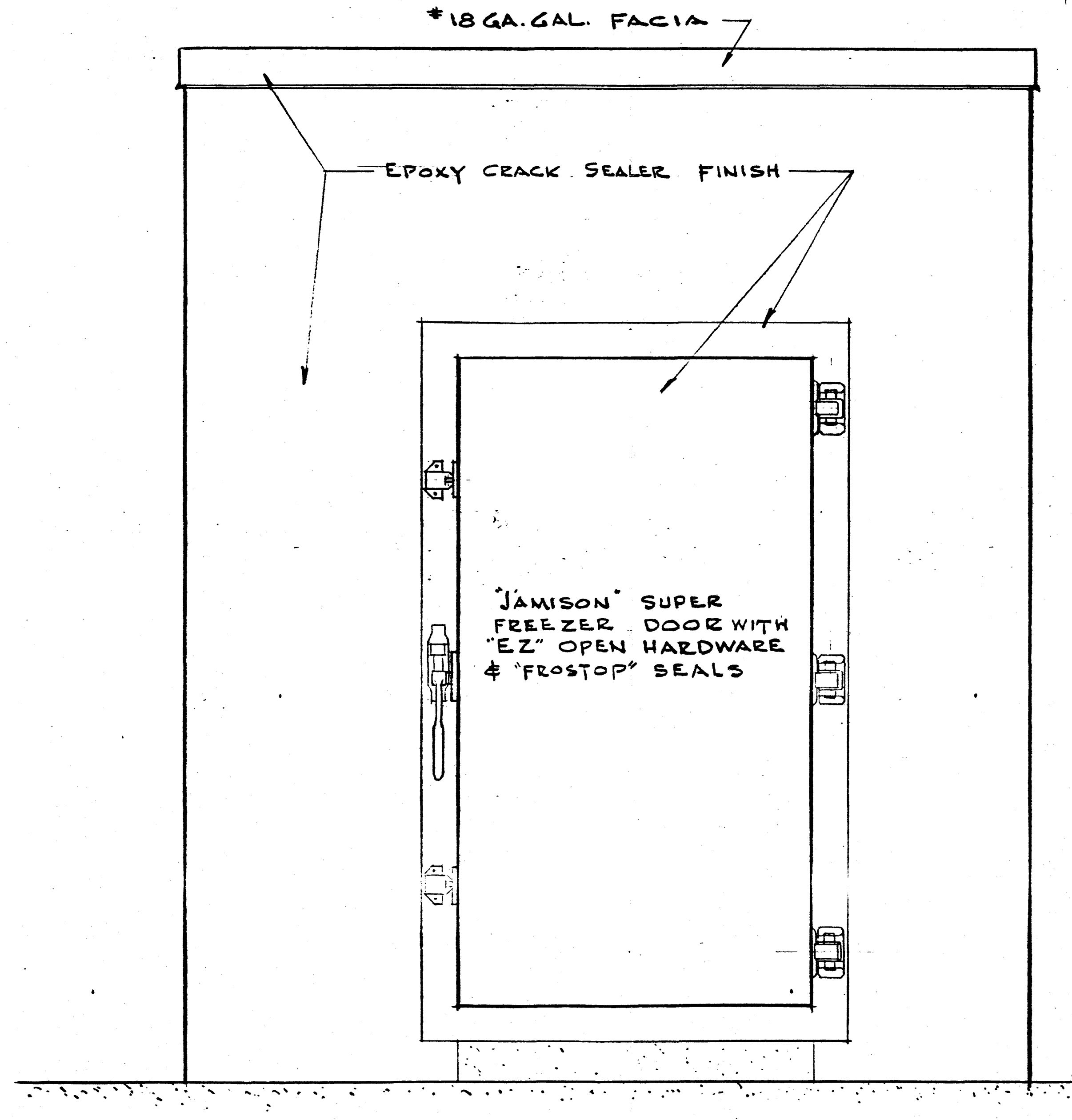


## PLAN

SCALE: ¾" = 1'-0"

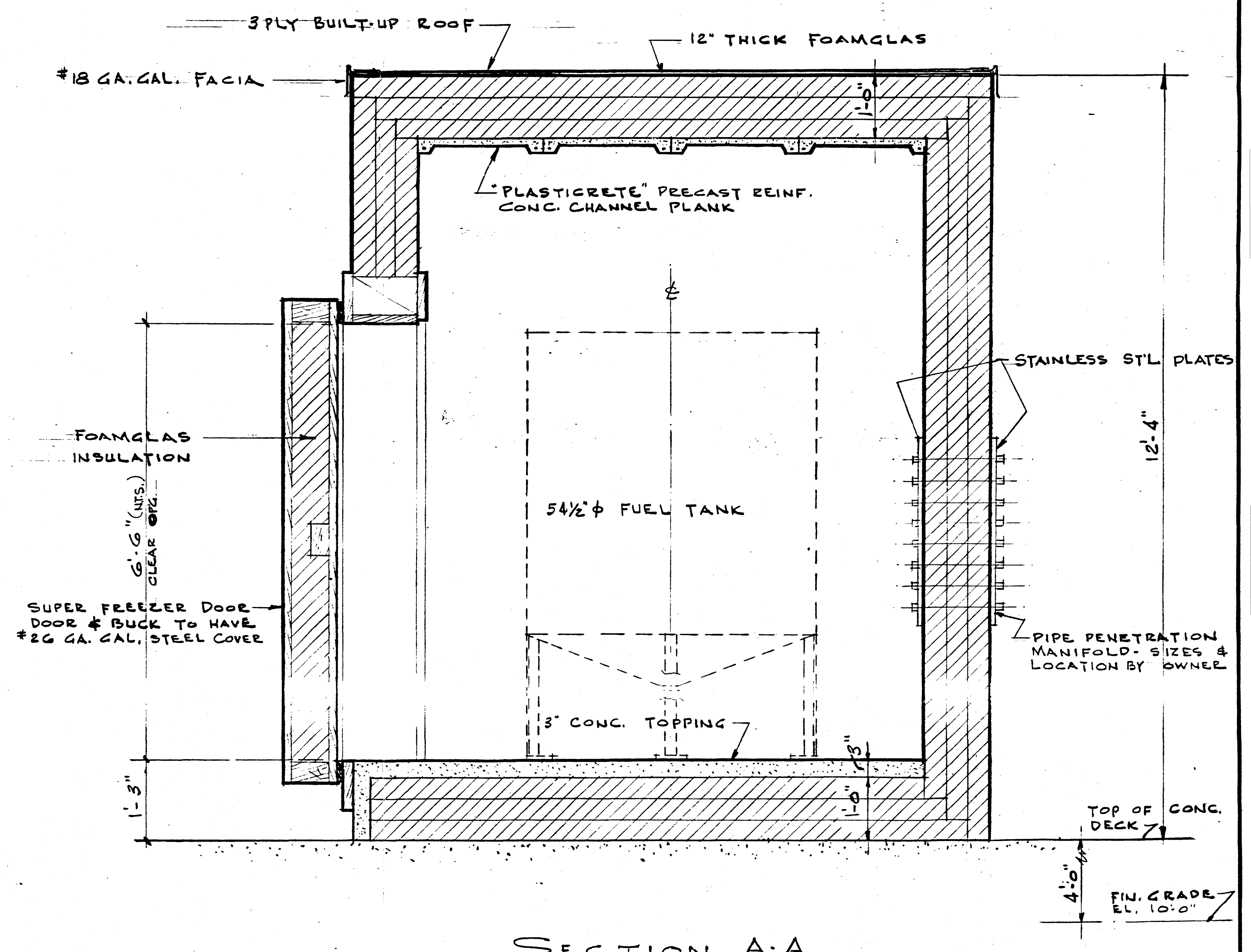
✱ ALTERNATE #1

SUPPLY 5'-0" X 7'-0" CLEAR OPENING DOOR IN PLACE OF 3'-0" X 6'-6".



## FRONT ELEVATION

SCALE: ¾" = 1'-0"



## SECTION A·A

SCALE: ¾" = 1'-0"

## SPECIFICATION NOTES

1. ALL EXPOSED SURFACES OF INTERIOR & EXTERIOR TO BE COATED WITH EPOXY CRACK SEALER
2. DOOR TO BE EQUIPED WITH "JAMISON" FROSTOP SEALS
3. CONTRACTOR TO SUPPLY SHOP DRAWINGS FOR APPROVAL BEFORE AWARD OF CONTRACT.

JOHN BAYUK
No. 4303

NOTE - CONTRACTOR MUST VISIT SITE AND VERIFY ALL CONDITIONS AND DIMENSIONS.

U. S. A. F. MINOR PROJECT
No. ....................................

| | |
|---|---|
| Prepared by Lycoming Div., Avco | John Bayuk<br>Plant Engineer |
| Recommended for Approval by Lycoming Div., Avco | J R Klein<br>President |
| Approved by N. Y. A. P. D. | |

JOB TITLE FUEL ICING TEST RIG - BUILDING #5

DWG. TITLE COOLING CHAMBER, PLAN- SECTION & DETAILS

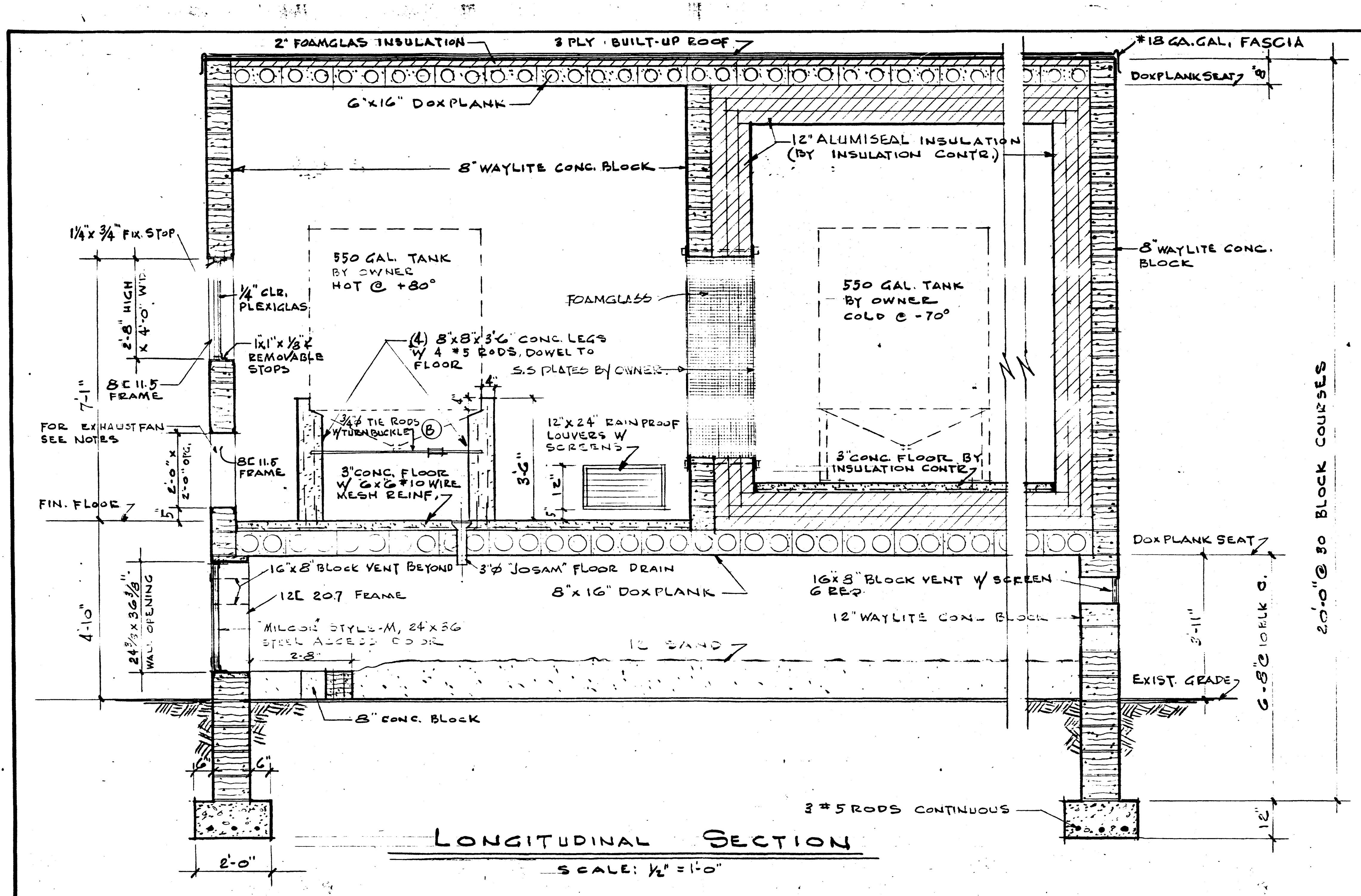
SHT. SIZE: 30" x 42" SCALE: AS NOTED DATE: MAY 31, 1961

**Lycoming**
DIVISION **Avco** CORPORATION
STRATFORD • CONNECTICUT

PLANT ENGINEERING

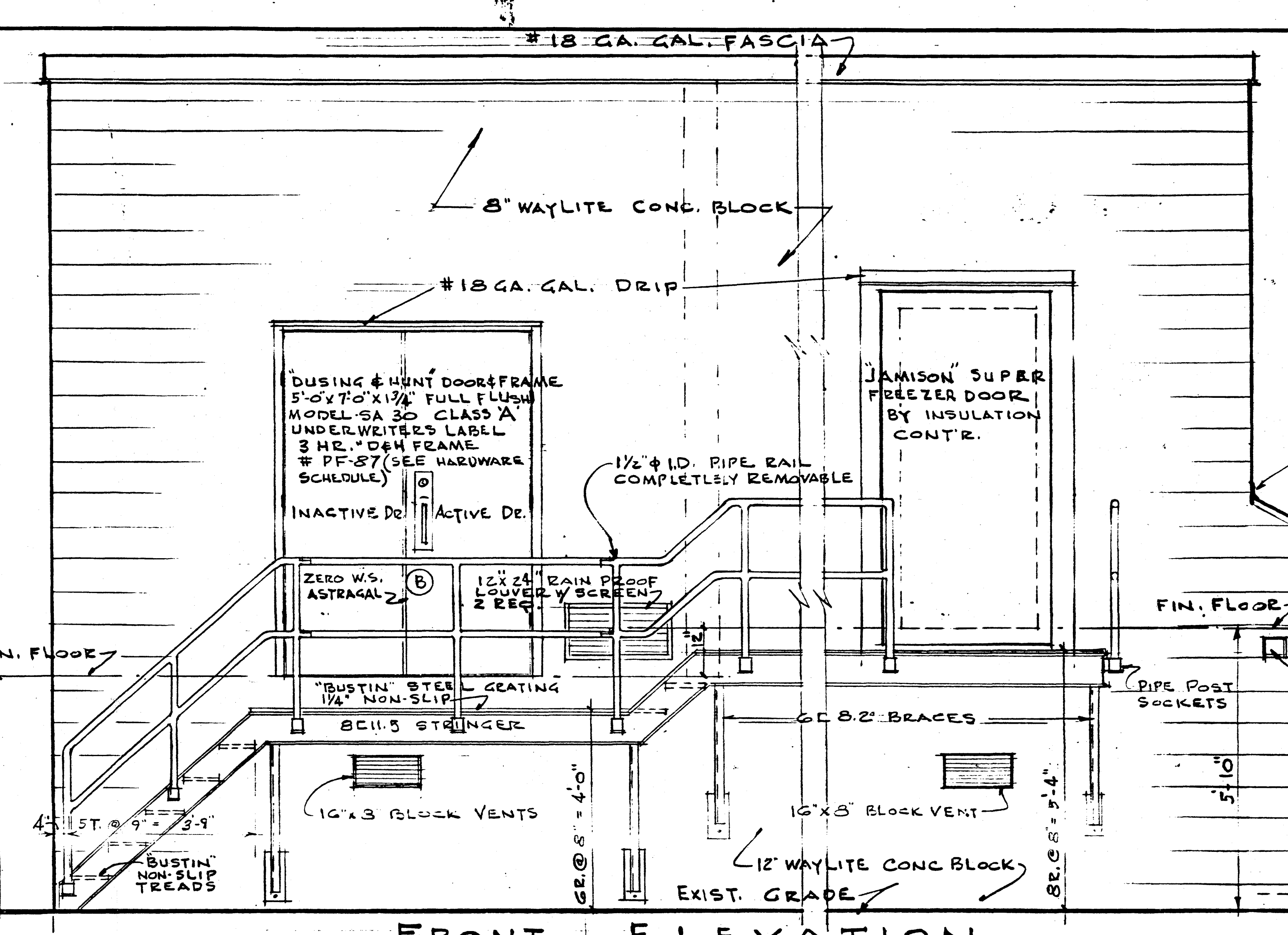
S. Litterman 8/25/61
APPROVED DATE APPROVED

DRAWN WEST
CHECKED SANSONE
PLANT ENG. John Bayuk
SHEET 3 OF 6 SHEETS
DWG. NO. B5-208-10C



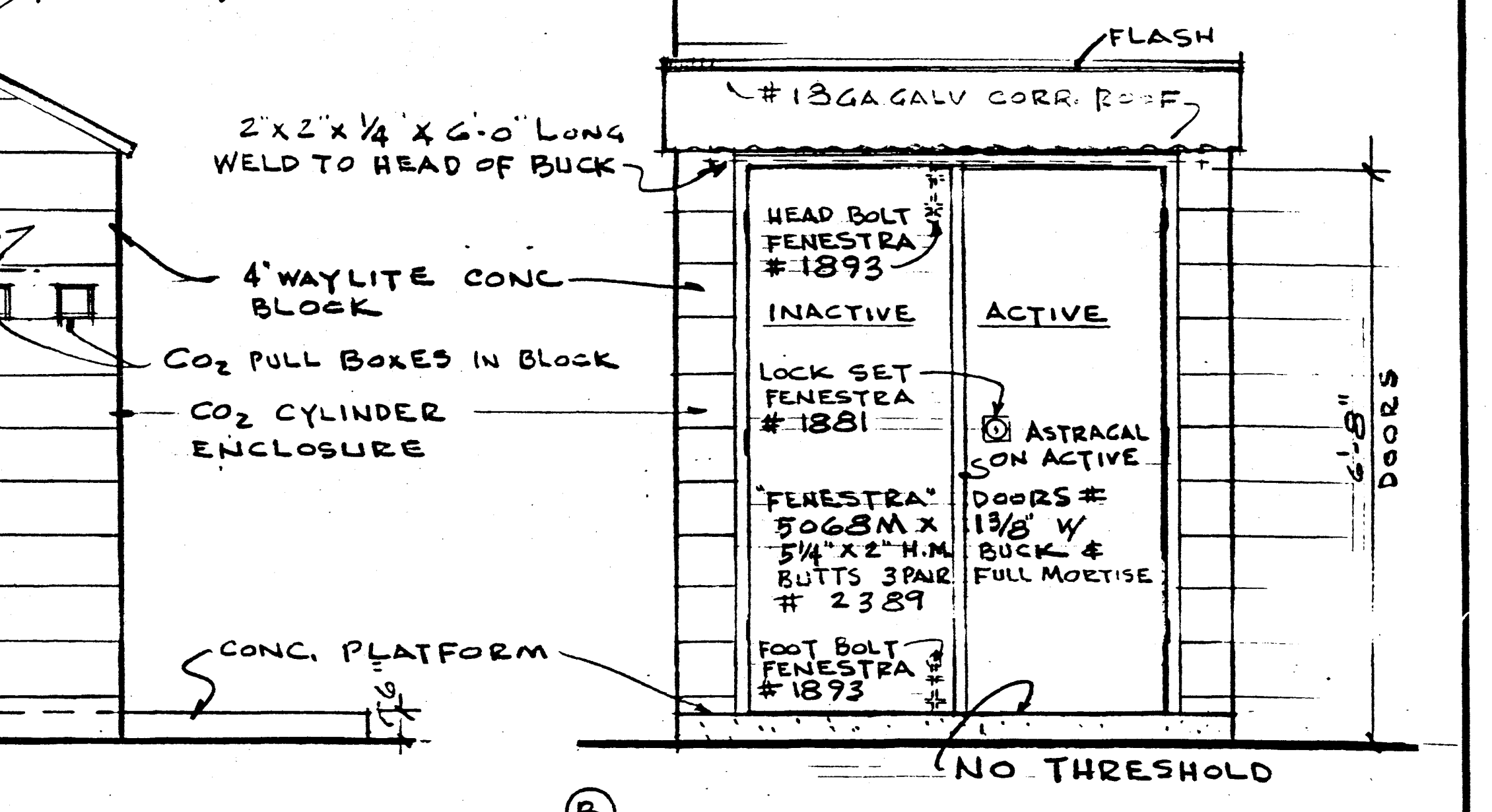
LONGITUDINAL SECTION

SCALE: ½" = 1'-0"



FRONT ELEVATION

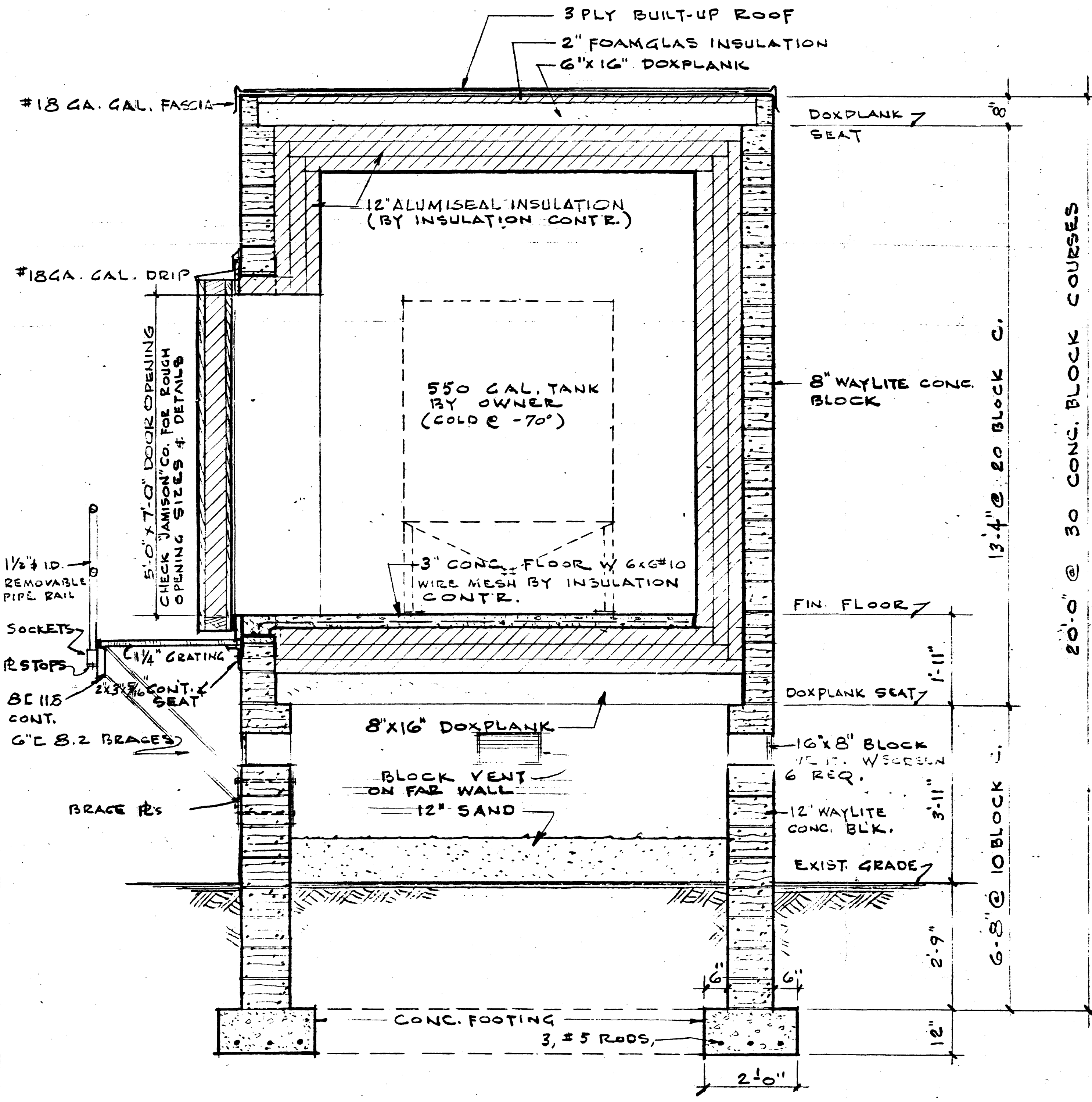
SCALE: ½" = 1'-0"



B

CO₂ CYLINDER ENCLOSURE DETAILS

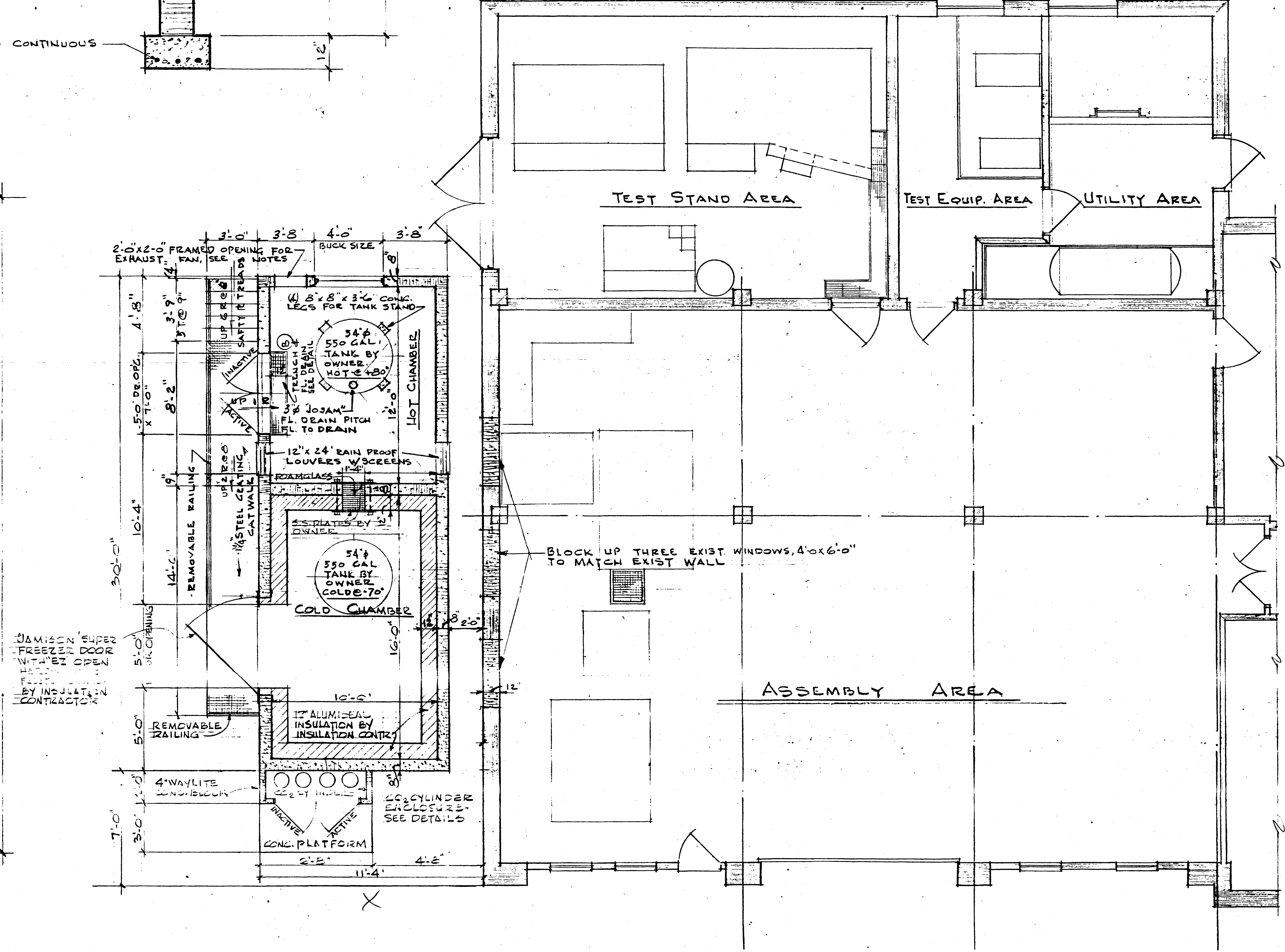
SCALE: ½" = 1'-0"



CROSS SECTION

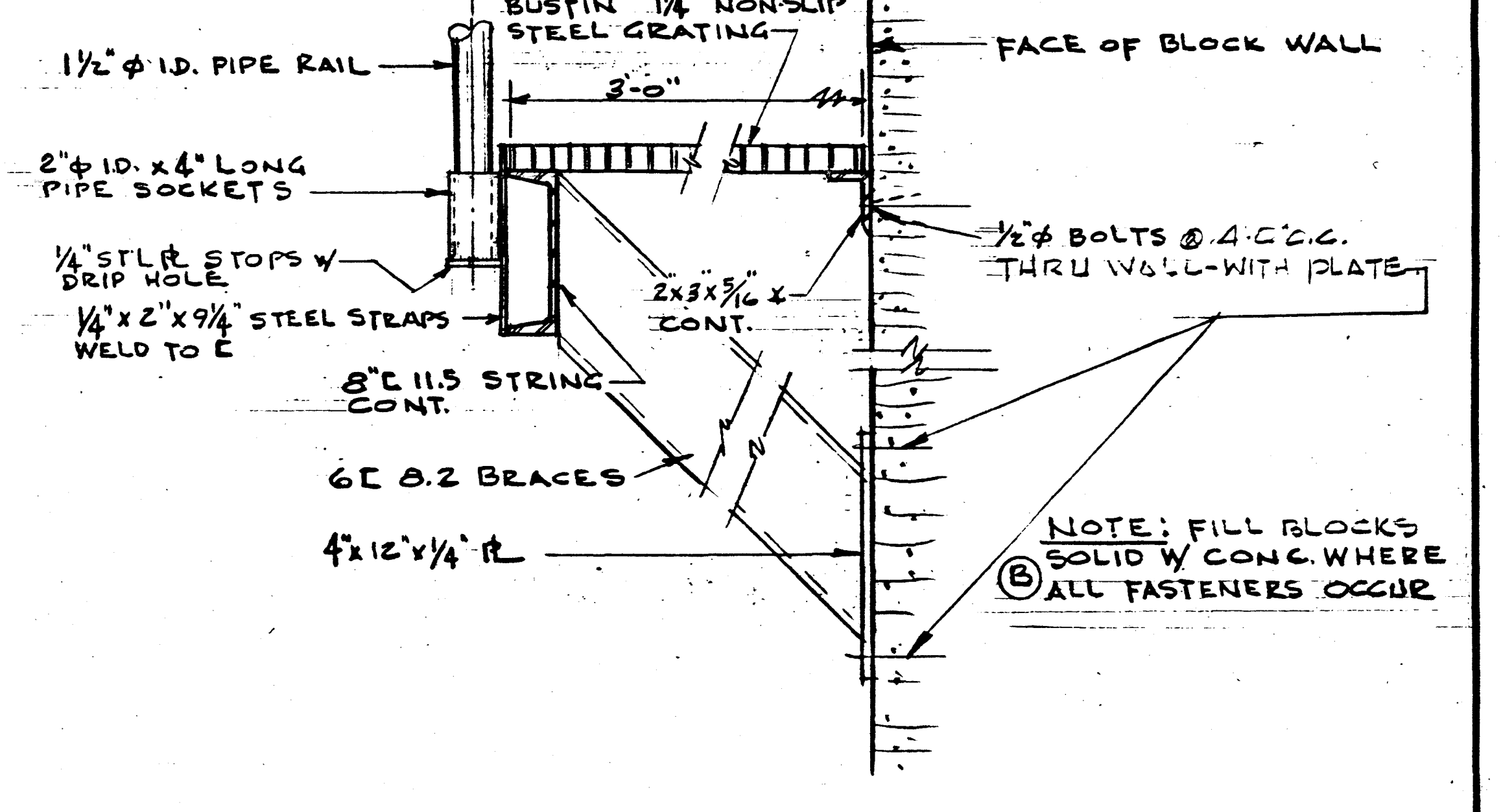
THRU COLD CHAMBER

SCALE: ½" = 1'-0"



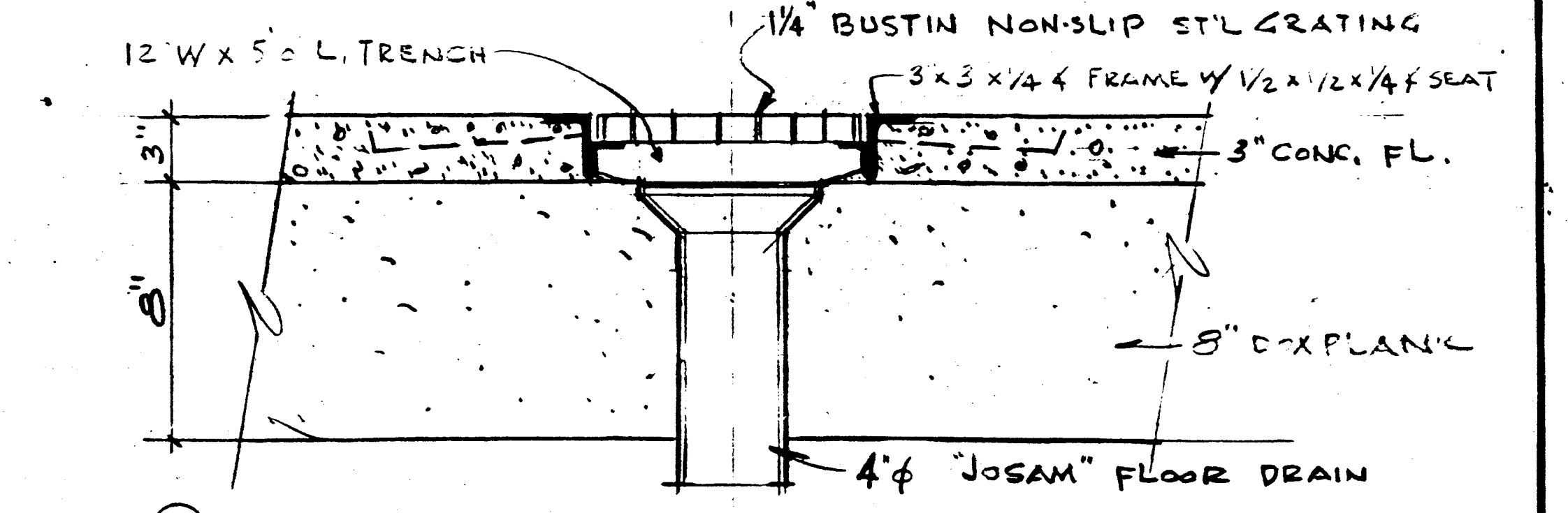
CHAMBER PLAN & PART PLAN OF BUILDING #5

SCALE: ¼" = 1'-0"



TYPICAL CAT WALK DETAIL

SCALE: 1½" = 1'-0"



B

DOOR TRENCH DETAIL FOR HOT CHAMBER

SCALE: 1½" = 1'-0"

## HARDWARE SCHEDULE FOR HOT CHAMBER DOORS

BUTTS: "DUSING & HUNT" # SH-501 - 1½ PAIR PER DOOR, FULL MORTISED 4½ x 4½

Ⓑ CLOSERS: INACTIVE DOOR; "DUSING & HUNT" # SC 4359 W/ SOFFIT BRACKET (AUTO. SELF CLOSING)
ACTIVE DOOR; "DUSING & HUNT" # SC 4359 W/ FUSIBLE LINK ARM & SOFFIT BRACKET

HARDWARE: "RUSSWIN", INACTIVE DOOR; # 52 VERTICAL EXIT BOLT RIM TYPE.
ACTIVE DOOR; #58 VERTICAL EXIT BOLT RIM TYPE W/ LEVER HANDLE & PULL HANDLE ON EXTERIOR (CYLINDER LOCK MUST BE KEYED TO LYCOMING'S MASTER KEY SYSTEM)

Ⓑ THRESHOLD: "ZERO WEATHERSTRIP CO" # 15 ALUM. W/ # 25 ALUM. ANGLE ON DOORS

Ⓑ WEATHERSTRIPPING: "ZERO W.S. CO" # 139A AT HEAD & JAMBS & # 55M TYPE A SURFACE ASTRAGAL.

ALTERNATE #1: SUBMIT PRICE FOR "FENESTRA" INC. EQUAL HARDWARE TO ABOVE LIST.

## SPECIFICATION NOTES

1. CONTRACTOR TO SUPPLY & INSTALL DUR-O-WAL REINFORCING IN EVERY BLOCK COURSE
2. PAINT - ALL EXTERIOR SURFACES TO BE PAINTED ONE COAT - THOROSEAL & ONE COAT THOROSHEEN - COLOR, CONC. GRAY. INTERIOR OF HOT CHAMBER TO BE COMPLETELY COVERED WITH "EPOXY" SURFACE COAT BY SIKA CORP. - COLOR, GRAY. THIS INCLUDES, WALLS, CEIL., FLOOR, CONC. LEGS, DOORS & FRAMES AND ALL OTHER EXPOSED SURFACES EXCEPT TANK & OTHER MECHANICAL EQUIPMENT, ONE COAT.
3. #18 GA. GALV. FACIA TO HAVE ALL SOLDERED JOINTS.
4. EXHAUST FAN SHALL BE "AMERICAN BLOWER" CAT. No. 1G18 - 23¾" x 23¾"; 1/12 H.P. 440V, 3φ 2 SPEED EXPLOSION PROOF MOTOR - 2065 TO 2530 CFM.

Ⓑ 5. CONTRACTOR TO SUBMIT SHOP DRAWINGS FOR APPROVAL ON INSTALLATION OF "DUSING & HUNT" DOOR & BUCK & ON STEEL CAT WALK. SHOP DRAWINGS MUST BE SUBMITTED BEFORE AWARD OF CONTRACT.

Ⓑ 6. CONTRACTOR SHALL PATCH ALL EXIST. PAVING REMOVED BY HIM. PAVING TO MATCH EXIST. & SHALL PITCH AWAY FROM NEW BUILDING.

JOHN BAYUK
No. 4303

NOTE - CONTRACTOR MUST VISIT SITE AND VERIFY ALL CONDITIONS AND DIMENSIONS.

U. S. A. F. MINOR PROJECT
No. ....................

| | |
|---|---|
| Prepared by Lycoming Div., Avco | John Bayuk<br>Plant Engineer |
| Recommended for Approval by Lycoming Div., Avco | President |
| Approved by N. Y. A. P. D. | |

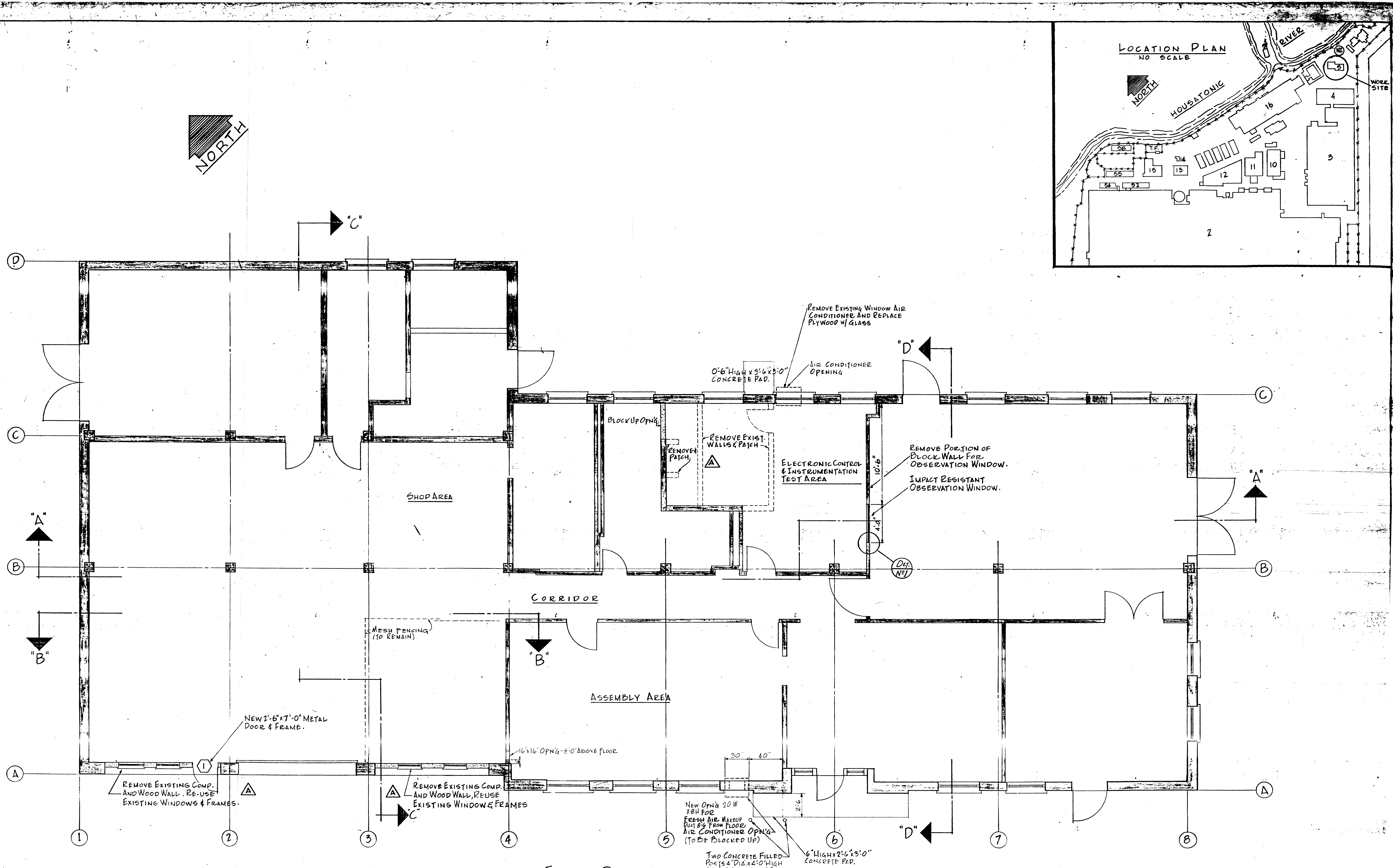
REVISION Ⓑ ADDITIONAL INFORMATION DATE: 6/23/61

JOB TITLE: FUEL ICING TEST RIG - BUILDING #5
DWG. TITLE: PLAN, SECTIONS & DETAILS
SHT. SIZE: 30" x 42" SCALE: AS SHOWN DATE: JUNE 9, 1961
DRAWN: A WEST
CHECKED: SANSONE
PLANT ENG.:

Lycoming
DIVISION Avco CORPORATION
STRATFORD CONNECTICUT

PLANT ENGINEERING
SHEET 2 OF 6 SHEETS
DWG. NO. [illegible]

S Littman 6/23/61
APPROVED DATE APPROVED



FLOOR PLAN
SCALE 1/4" = 1'-0"

GENERAL NOTES.

1. Contractor to verify all dimensions in field.
2. Contractor to furnish all labor and materials for a complete installation.
3. Reinforcing steel to be of deformed bar.
4. Concrete to be transit plant mixed and to attain compressive strength of 3000 P.S.I. in 28 days.
5. Contractor to protect all property, personnel etc. from damage, injury, dust, etc.
6. Work to be done during normal working hours.
7. All debris, excess and reused fill to be dumped in designated areas.
8. Area to be cleaned periodically and at completion of job.
9. Backfill to be thoroughly puddled.
10. All work to be completely formed and steel trowelled.
11. All concrete to be mechanically vibrated.
12. All reinforcing steel to be tied or welded.
13. Contractor to establish all elevations as noted.
14. Owner to furnish air water and power. Contractor to provide all connections [illegible]

NOTE:
ALL NEW WORK SHALL RECEIVE
TWO (2) COATS OF PAINT. COLOR
CHOICE BY AVCO.

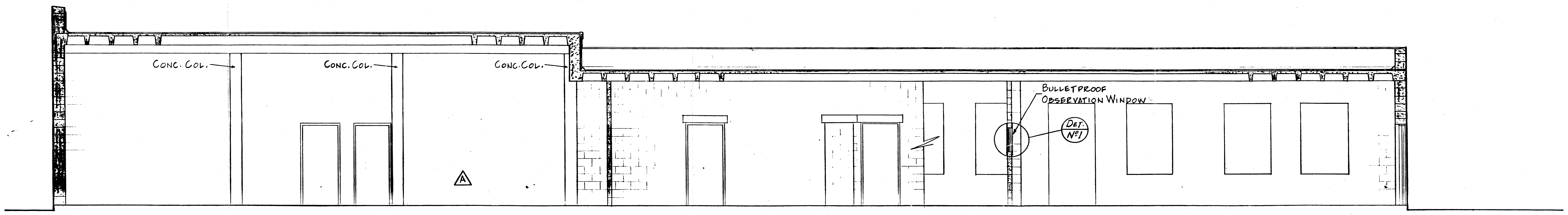
| No. | Description | By | Date |
|---|---|---|---|
| A | GENERAL REV'S. | P.H. | 5-11-70 |

REVISIONS

NOTE - CONTRACTOR MUST VISIT SITE AND VERIFY ALL CONDITIONS AND DIMENSIONS

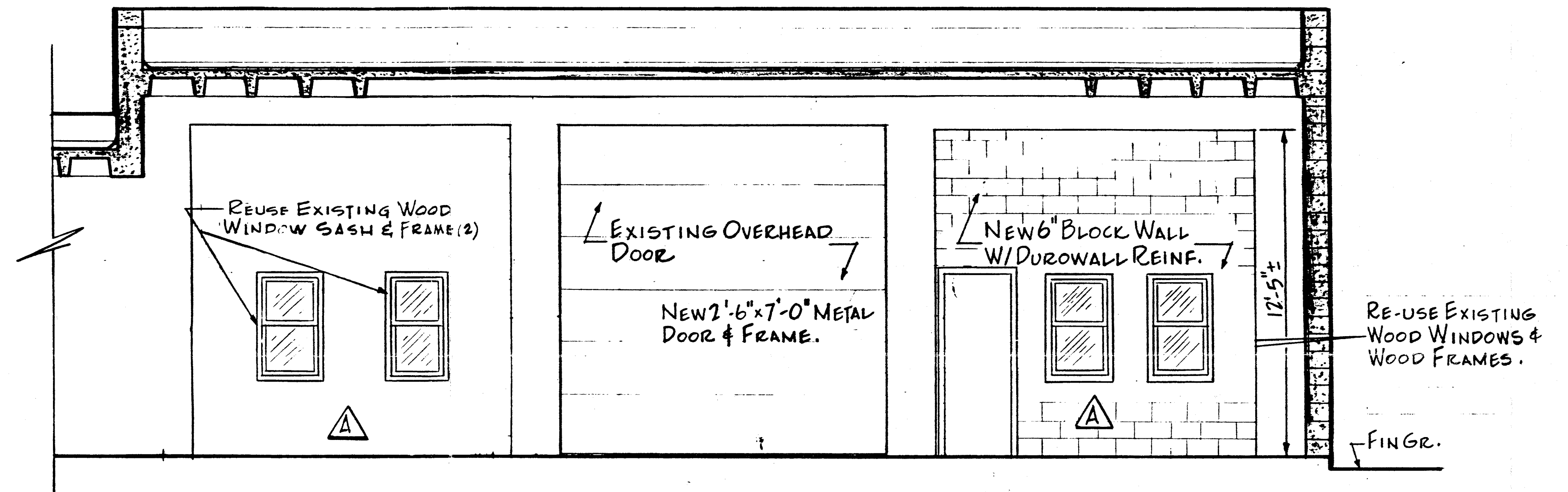
STATE OF CONNECTICUT
JOHN BAYUK
No. 4303
REGISTERED PROFESSIONAL ENGINEER

JOB TITLE REARRANGEMENT OF FUEL CONTROL LAB - BLDG. No 5
DWG. TITLE FLOOR PLAN
SHT. SIZE 28" x 42"  SCALE 1/4" = 1'-0"  DATE 3 19-70
DRAWN PATTI HAYNA
JOSEPH R. GAMBINO
CHECKED
DIRECTOR PLANT ENG'G.
AVCO LYCOMING DIVISION
STRATFORD • CONNECTICUT
PLANT ENGINEERING
SHEET 1 OF 5
Neal Hanson 3/19/70
APPROVED DATE APPROVED
DWG. NO.



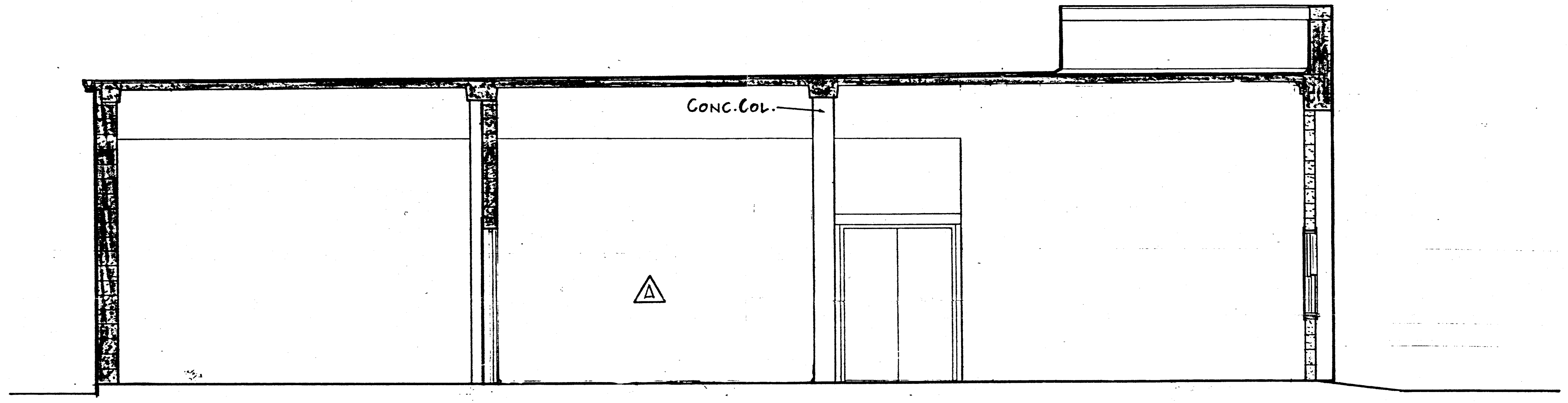
## Section "A-A"

Scale 1/4"=1'-0"



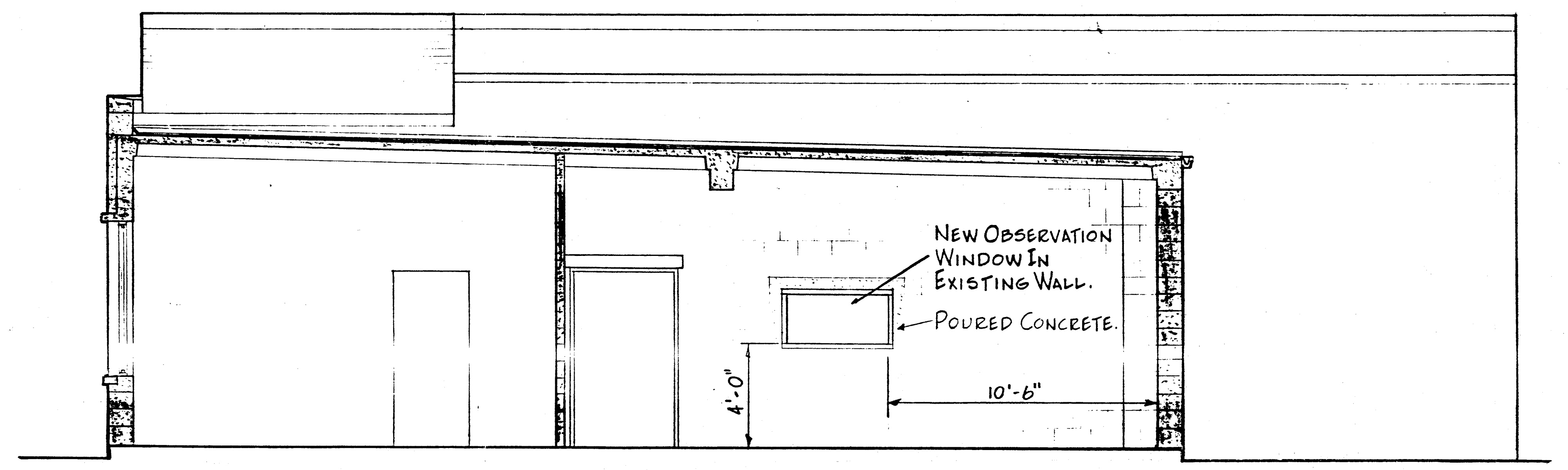
## Section "B-B"

Scale 1/4"=1'-0"



## Section "C-C"

Scale 1/4"=1'-0"



## Section "D-D"

Scale-1/4"=1'-0"

**GENERAL NOTES.**

1. Contractor to verify all dimensions in field.
2. Contractor to furnish all labor and materials for a complete installation.
3. Reinforcing steel to be of deformed bar.
4. Concrete to be transit plant mixed and to attain compressive strength of 3000 P.S.I. in 28 days.
5. Contractor to protect all property, personnel etc. from damage, injury, dust, etc.
6. Work to be done during normal working hours.
7. All debris, excess and reused fill to be dumped in designated areas.
8. Area to be cleaned periodically and at completion of job.
9. Backfill to be thoroughly puddled.
10. All work to be completely formed and steel trowelled.
11. All concrete to be mechanically vibrated.
12. All reinforcing steel to be tied or welded.
13. Contractor to establish all elevations as noted.
14. Owner to furnish air-water and power. Contractor to provide all connections and hose.
15. All structural steel to receive one shop and one field coat of industrial paint color by owner.

| No. | Description | By | Date |
|---|---|---|---|
| A | GENERAL REV'S. | P.H. | 5-11-70 |

REVISION

NOTE - CONTRACTOR MUST VISIT SITE AND VERIFY ALL CONDITIONS AND DIMENSIONS.

JOB TITLE Rearrangement of Fuel Control Lab - Bldg. Nº5

DWG. TITLE Sections Through Building

SHT. SIZE 28"x42" SCALE 1/4"=1'-0" DATE 3-19-70

DRAWN JOSEPH R. GAMBINO

CHECKED

DIRECTOR PLANT ENG'G. John Bayuk

AVCO LYCOMING DIVISION
STRATFORD • CONNECTICUT

PLANT ENGINEERING

SHEET 2 OF 5 SHEETS

Neal 3/19/70

APPROVED DATE APPROVED

DWG. NO. B5-300-4B

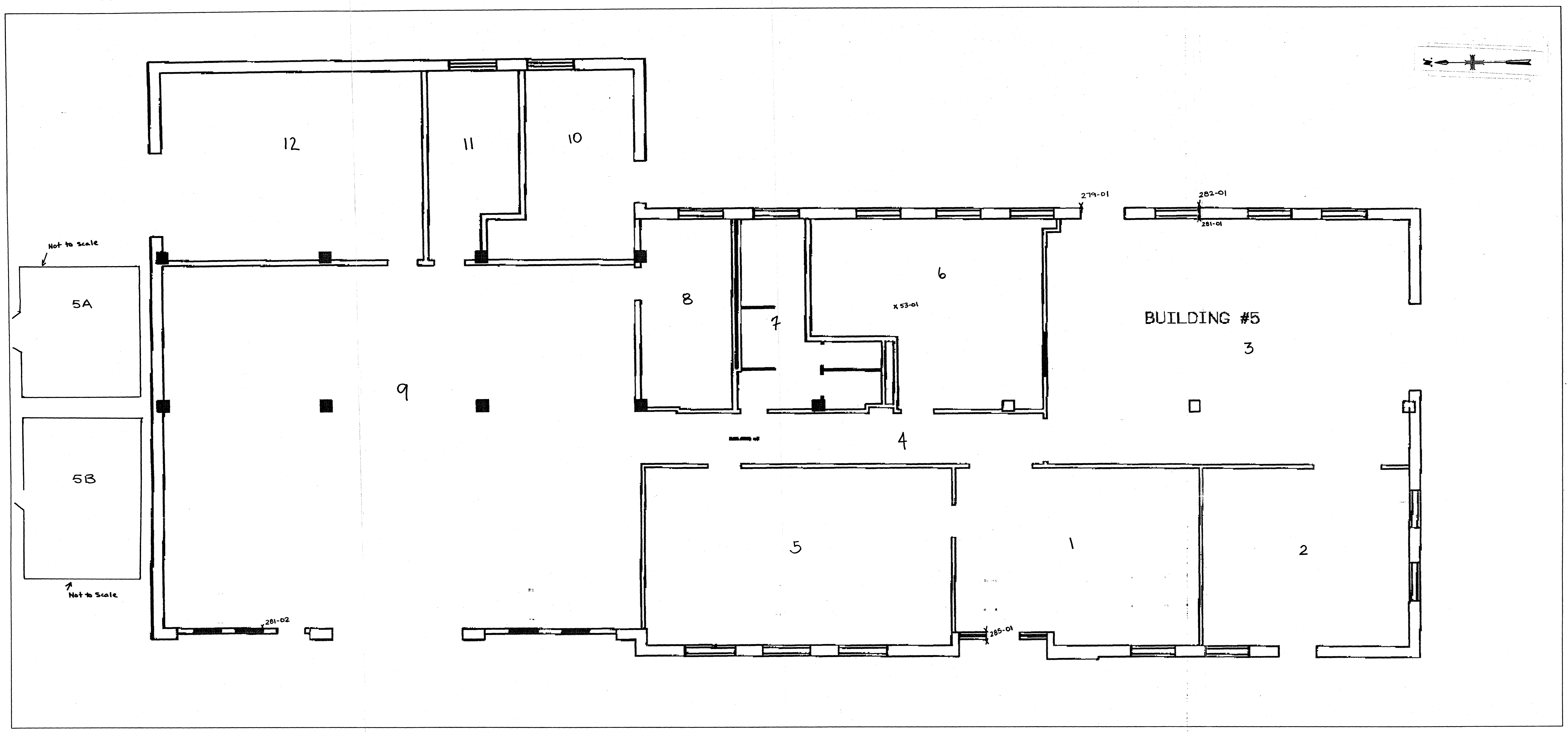
Note: Utility Line Locations are Approximate

| Itemref | Quantity | Title/Name, designation, material, dimension etc | Article No./Reference |
|---|---|---|---|

| Designed by | Checked by | Approved by - date | Filename | Date | Scale<br>1" = 8'-0" |
|---|---|---|---|---|---|

**Bldg. No. 5 & Utilities**

Edition | Sheet

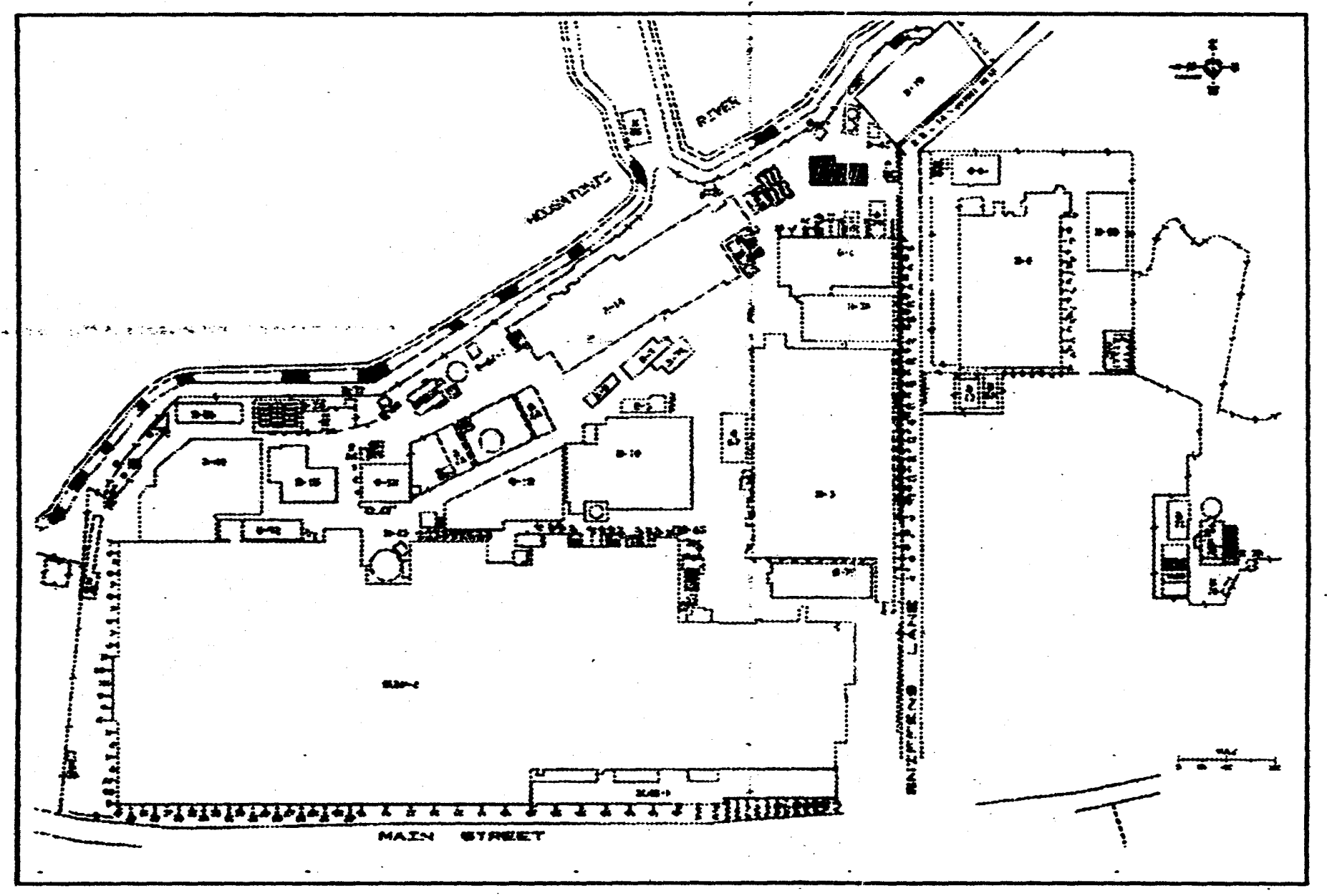


**KEY:**

**x 26-01** = Sample Location

**102** = Area ID

0 4' 8' 12'
SCALE IN FEET
1/4"=1'-0"
(APPROXIMATE)



BUILDING LOCATION MAP

SOURCE: ALLIEDSIGNAL INC.
STRATFORD, CT.

| REV | DATE | DESCRIPTION | BY |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

US Army Corps of Engineers

U.S. ARMY ENGINEER DISTRICT, NEW YORK
CORPS OF ENGINEERS
NEW YORK, NEW YORK

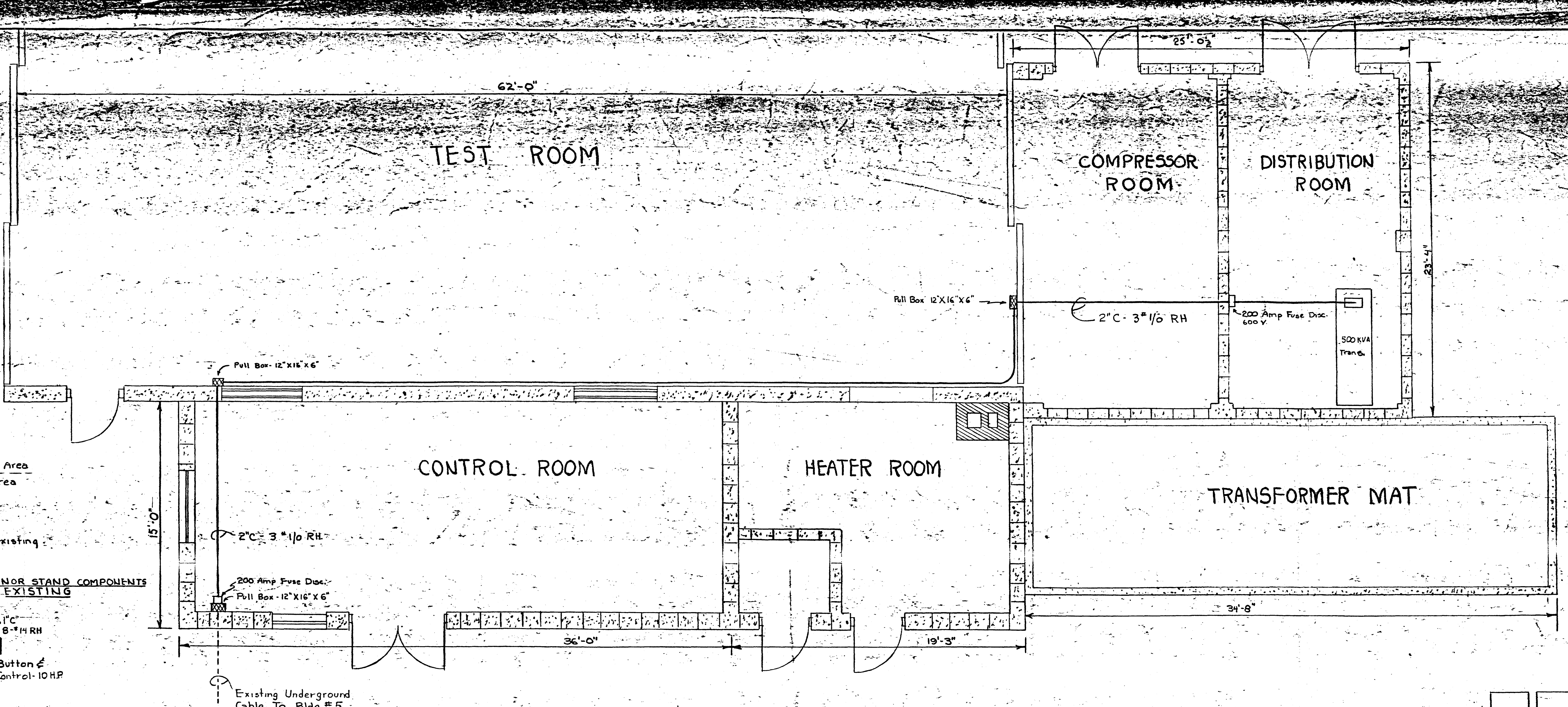
STRATFORD ARMY ENGINE PLANT STRATFORD, CT
ASBESTOS SURVEY REPORT

# BUILDING 5
## SAMPLE AND AREA LOCATIONS

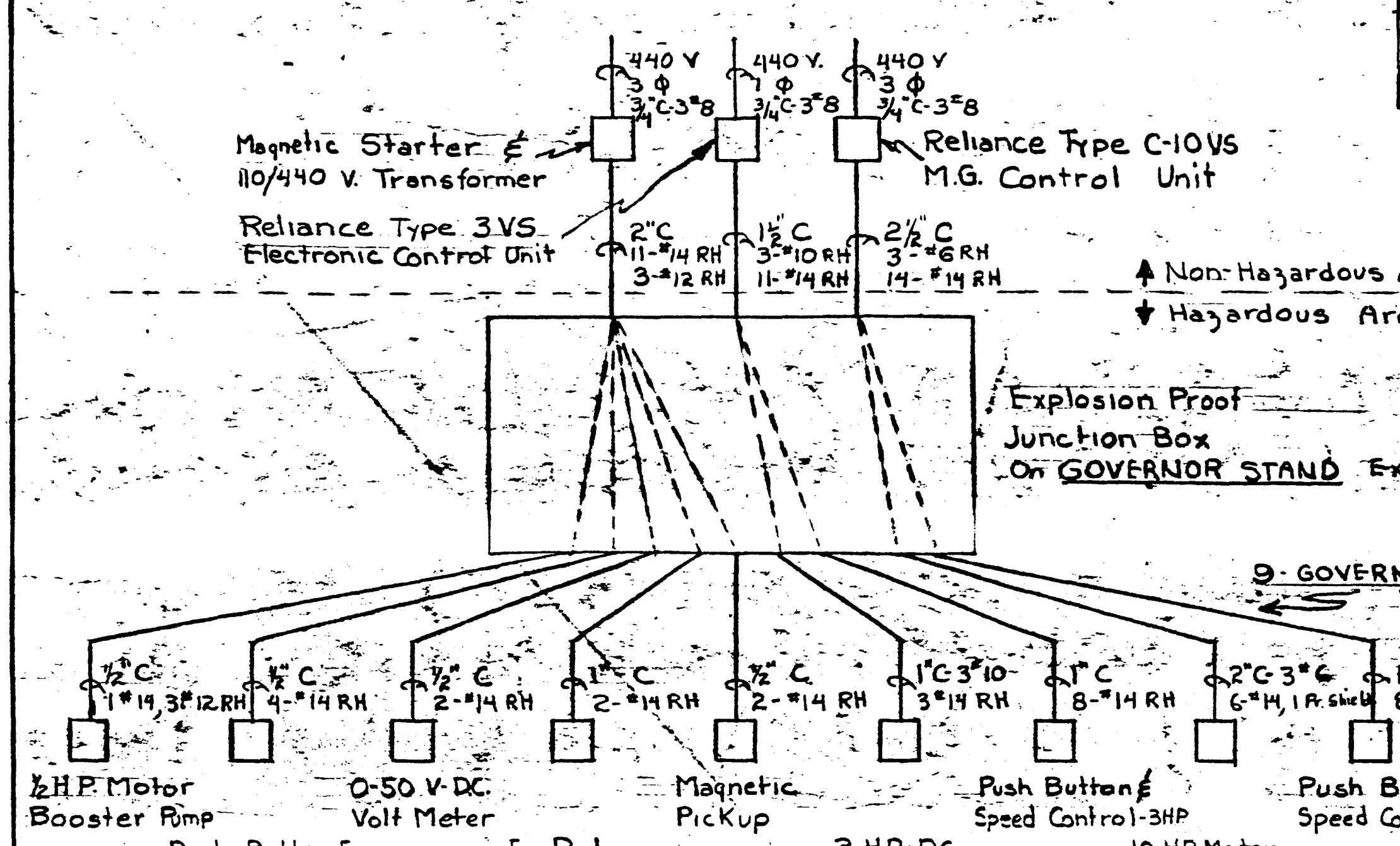
MALCOLM PIRNIE

FIGURE 3.6.1

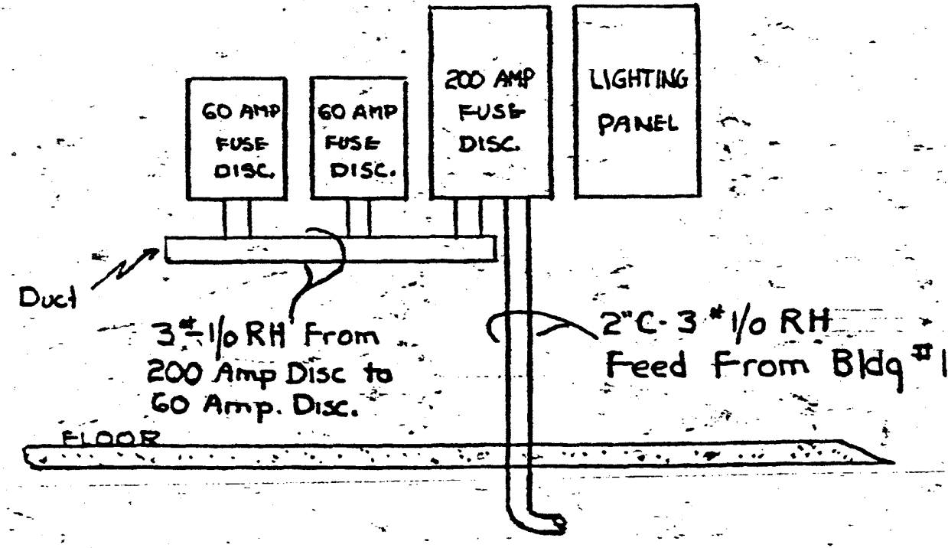
SCALE: AS NOTED | DATE:DEC. 1997 | SHEET



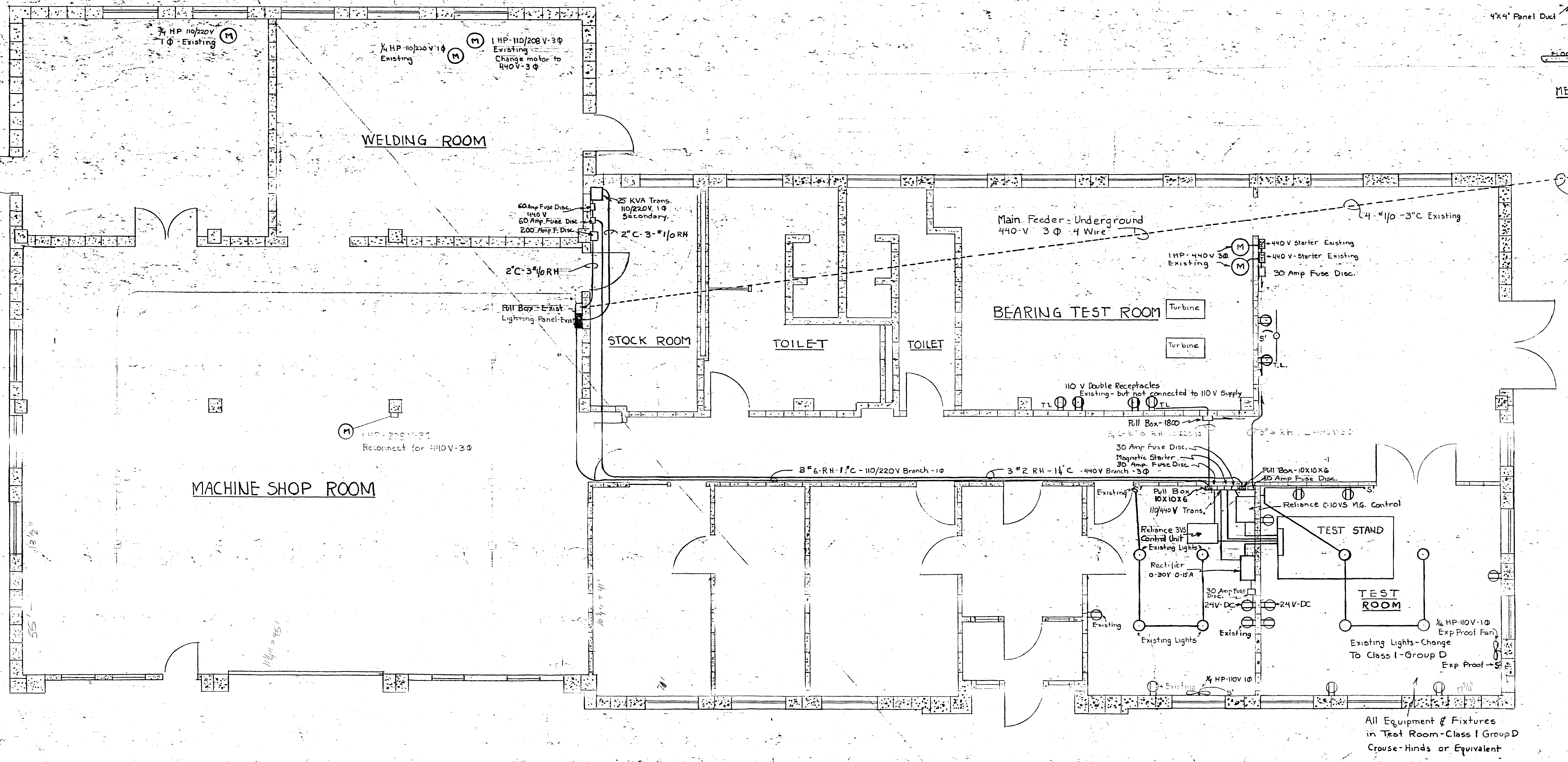
FIRST FLOOR PLAN - BLDG. NO. 19
SCALE - 1/4" = 1'-0"



CONNECTION DIAGRAM - GOVERNOR STAND
NO SCALE



METHOD OF INSTALLING DISCONNECTS
NO SCALE



FIRST FLOOR PLAN - BLDG. 5
SCALE - 1/4" = 1'-0"

| ELECTRICAL SYMBOLS | |
|---|---|
| SYMBOL | DESCRIPTION |
| ■ | LIGHTING PANEL |
| ▨ | POWER PANEL |
| MC | MOTOR CONTROLLER |
| ▩ | PULL BOX |
| ▣ | PUSH BUTTON - TEST CELL CALL SYSTEM |
| ▭ | BUZZER - TEST CELL CALL SYSTEM |
| ⊖ | DOUBLE RECEPTACLE - 110 V. |
| ⊖TL | RECEPTACLE - TWIST LOCK |
| (M) | MOTOR |
| —○— | TWO LAMP FLOURESCENT FIXTURE - 4' LUMINAIRE |
| ∞ | FAN MOTOR |
| □ | FUSED DISCONNECT SWITCH |
| | |

## NOTE

ELECTRICAL WORK TO BE PERFORMED INCLUDES ALL WIRING SHOWN IN BLDG #19 AND WIRING SHOWN INSIDE ENCLOSURE IN BLDG. #5.

DC RECEPTACLES TO BE PROTECTED BY 30 AMP FUSE DISCONNECT.

| APPROVALS | DATE |
|---|---|
| | 5-24-54 |
| | 5/27/54 |

| REV. | BY | DATE |
|---|---|---|
| #1 | HEO | 12-10-54 |

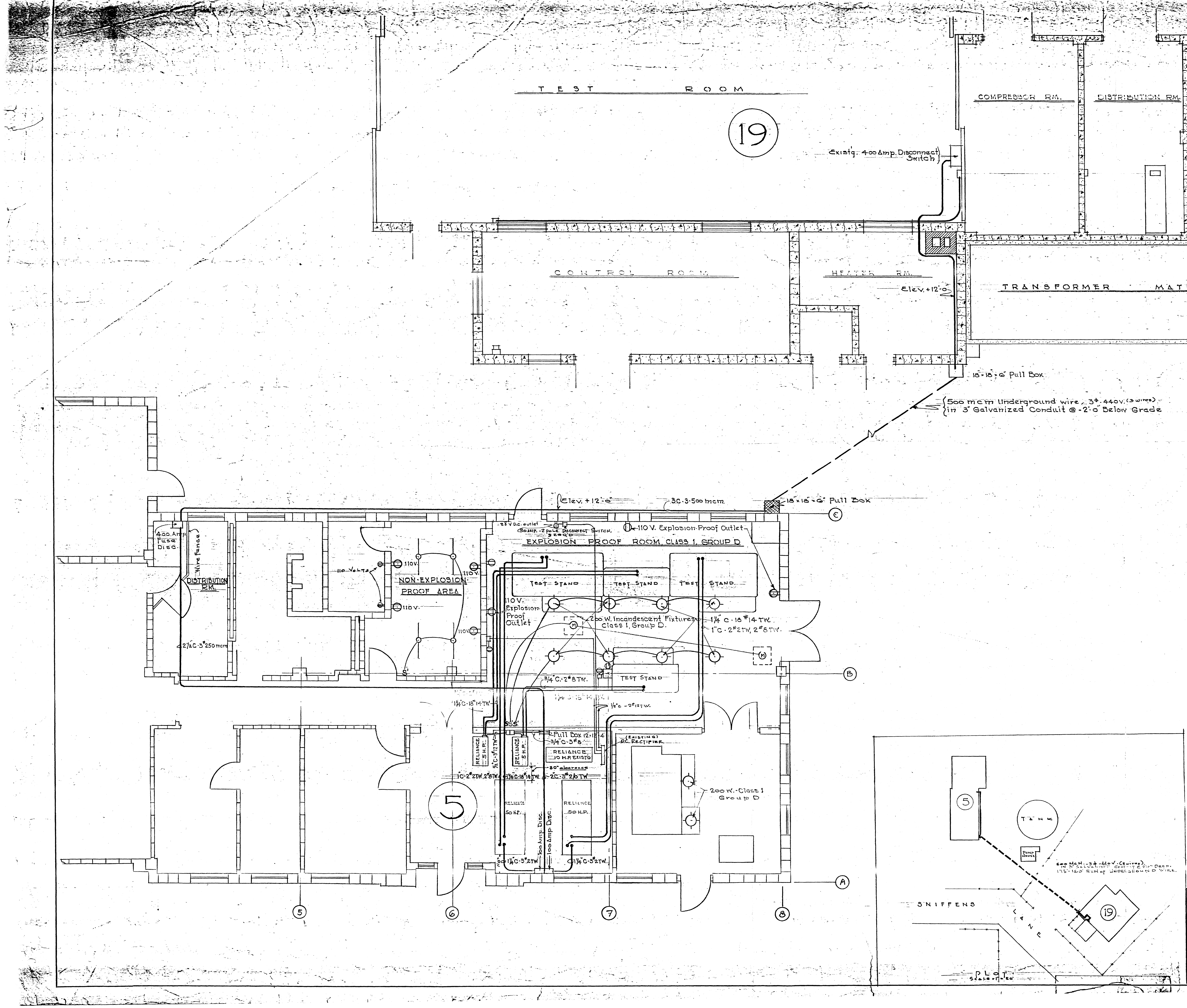
# ELECTRICAL LAYOUT
ADDITIONS TO BLDG #5 & #19

| IN PLACE OF | SCALE | DWG. SIZE | DATE |
|---|---|---|---|
| DATE | 1/4" = 1'-0" | 30" X 44" | 5-20-54 |

MADE BY: OPPEL
CHECKED BY A.N.B.
APP. BY
SHEET 1 OF 1 SHEETS

PLANT ENGINEERING
[redacted] LYCOMING
DIVISION AVCO MANUFACTURING CORPORATION
STRATFORD, CONN.

B5-206-1



| | | | |
|---|---|---|---|
| 7-12-56 | | | |
| 7/10/56 | | | |
| 7/10/56 | | | |
| APPROVALS | DATE | | |
| REV. | BY | DATE | |

PRIMARY ELECTRICAL SERVICES
FROM BLDG. Nº 19 TO BLDG. Nº 5

ELECTRICAL INSTALLATION FOR FUEL PUMP TEST STANDS
GAS TURBINE TESTING

| IN PLACE OF | SCALE | DWG. SIZE | DATE | MADE BY H. OPPEL & G.E.G. |
|---|---|---|---|---|
| DATE | 1/4" = 1'-0" | 30" × 42" | 7-10-56 | CHECKED BY A.N.B. & H.S. |

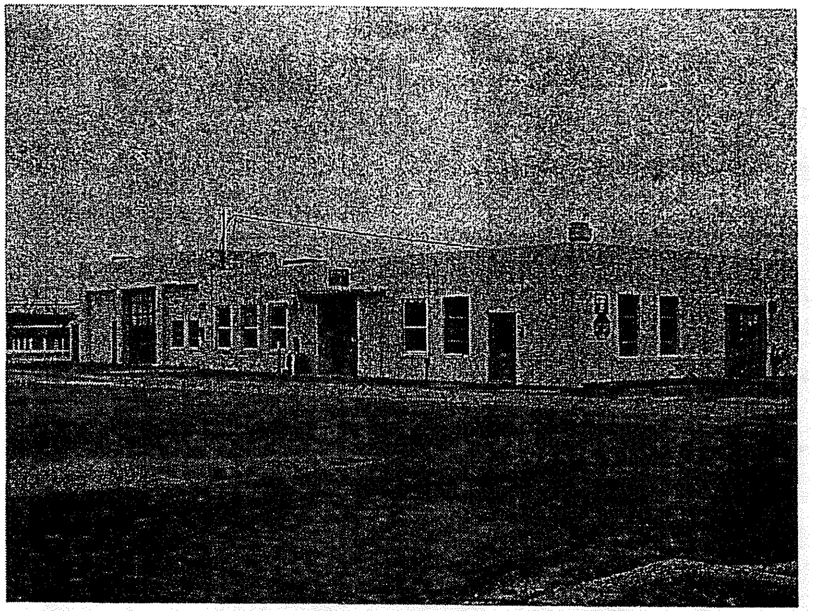
PLANT ENGINEERING
~~BRIDGEPORT~~ LYCOMING
DIVISION AVCO MANUFACTURING CORPORATION
STRATFORD, CONN.

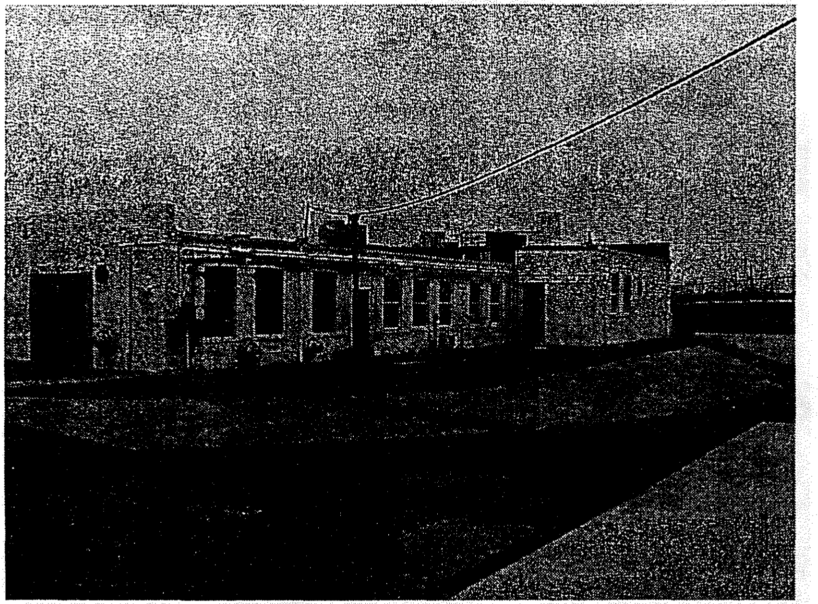
APP. BY John
SHEET 1 OF 1 SHEETS
B5-208-2

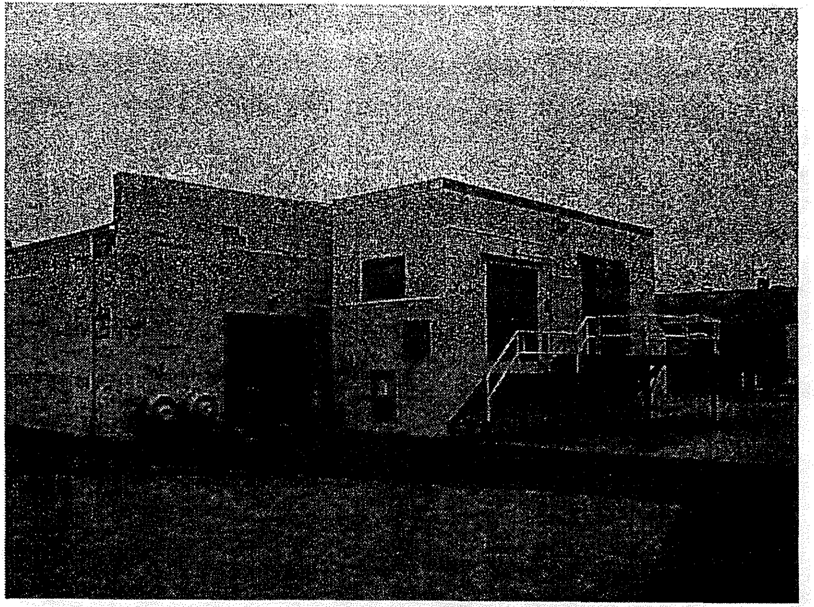
# Attachment E – Berm Near Building 34

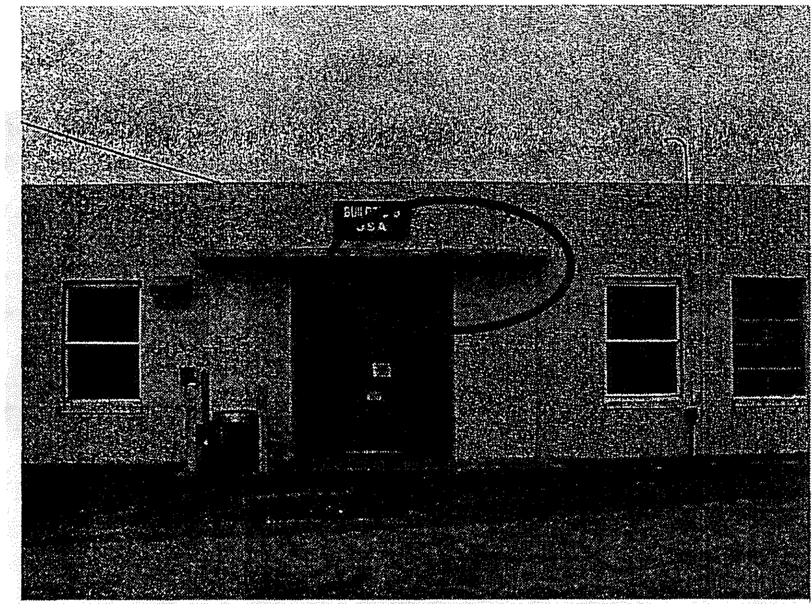
# H-D-2 Building 5 Photos


Overview of building from Northwest

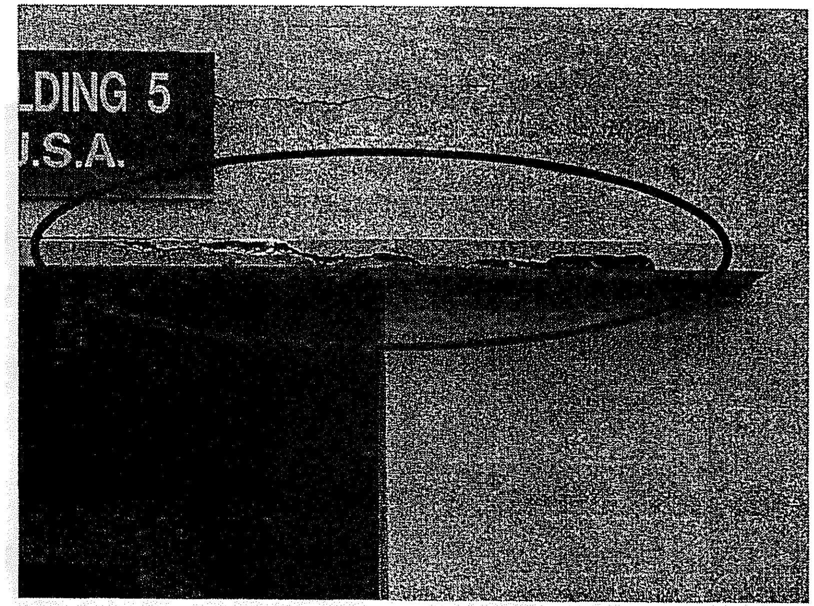

Overview of building from Southwest


Overview of building from Southeast

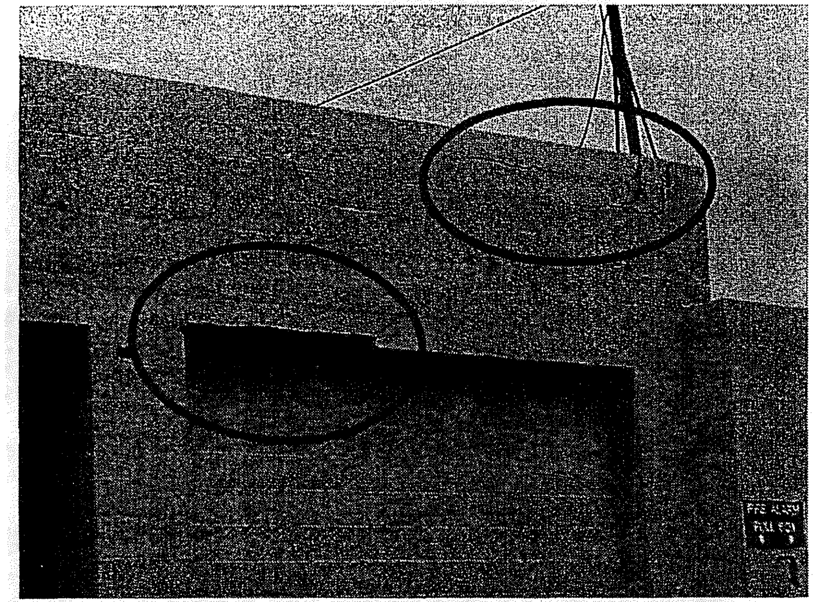

Overview of building from Northeast



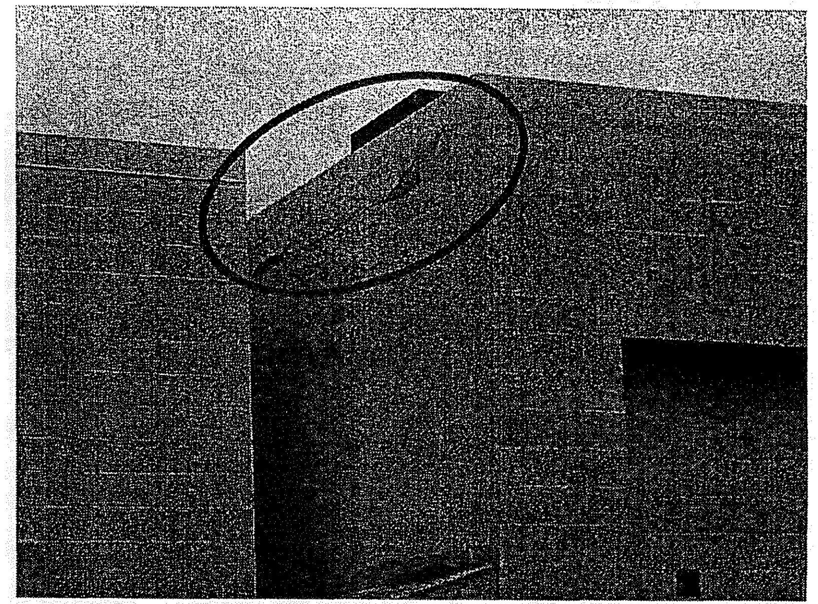
Front View Deterioration



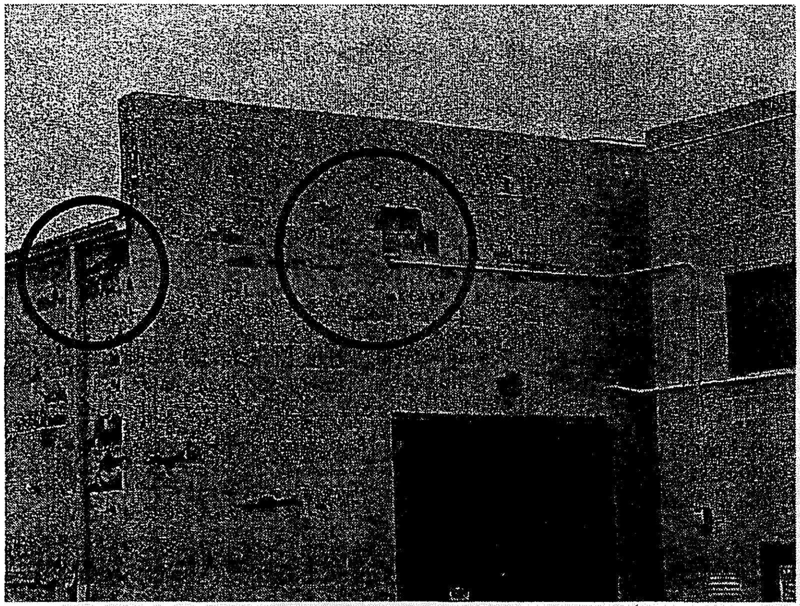
Front Entrance Overhang Deterioration



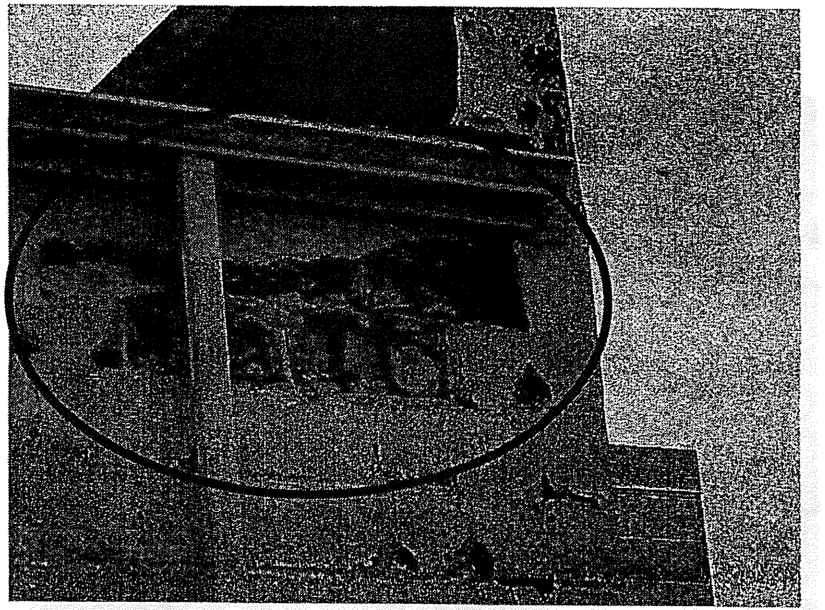
Lintel & Wall Deterioration



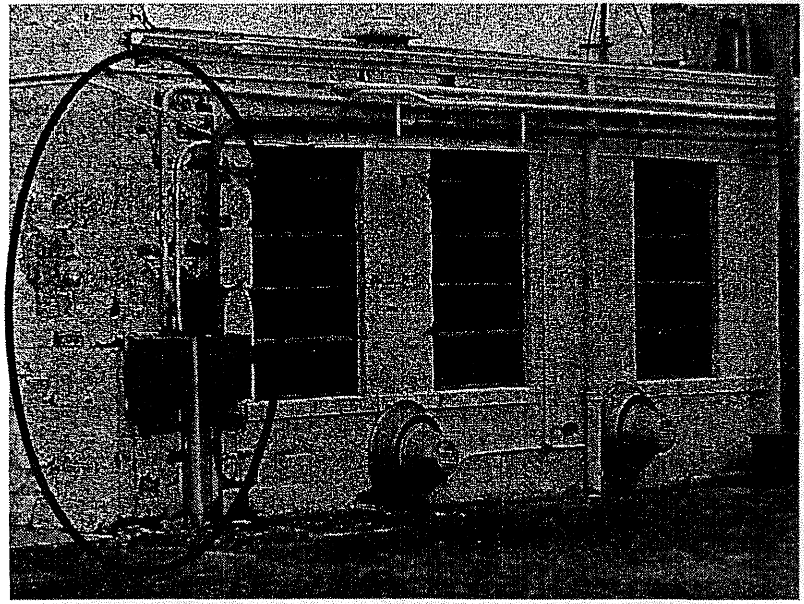
Wall Deterioration



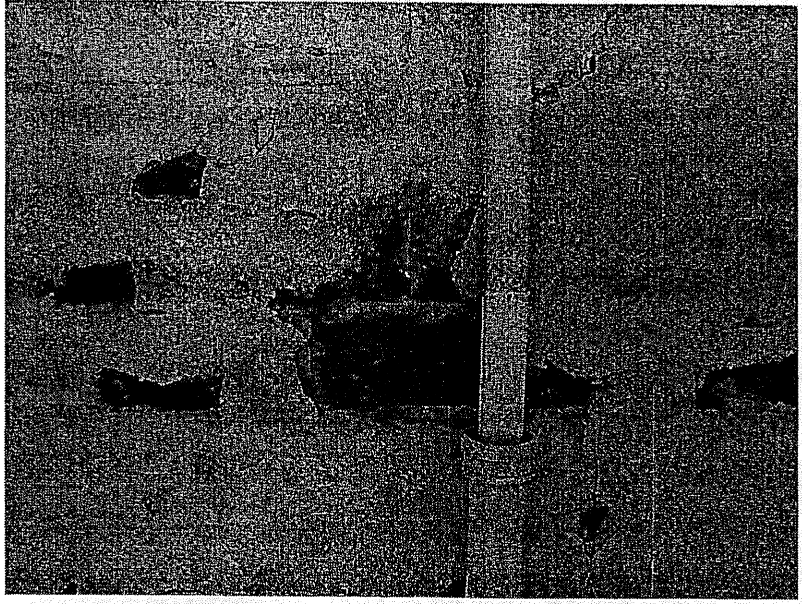
Severe Deterioration Northeast Corner



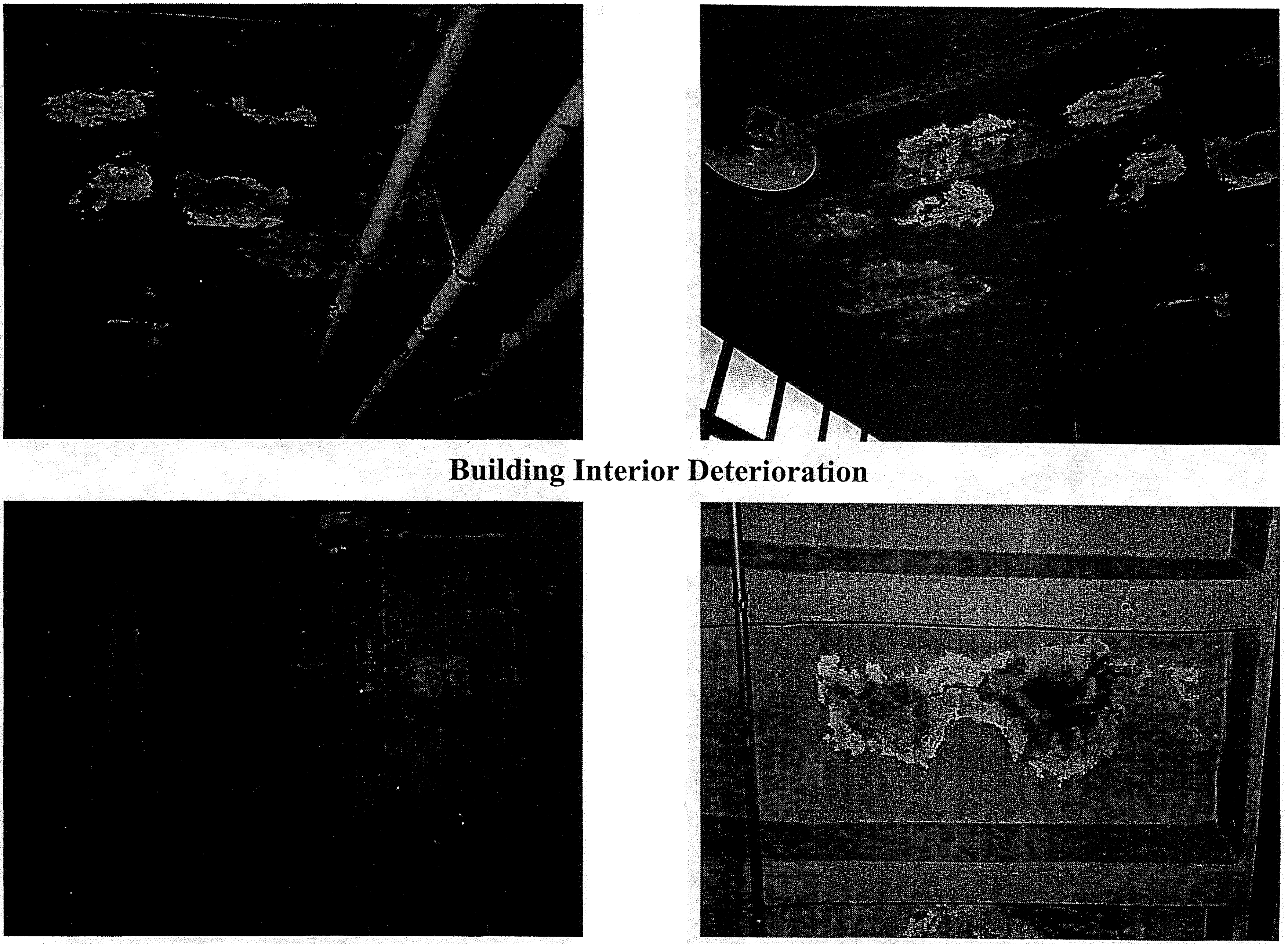
Detail of Deterioration Northeast Corner



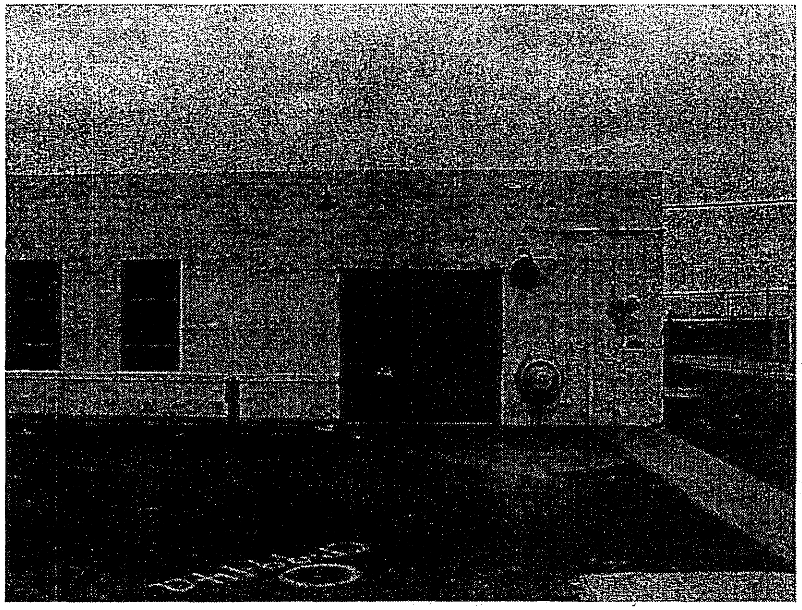
Deterioration Southeast Corner

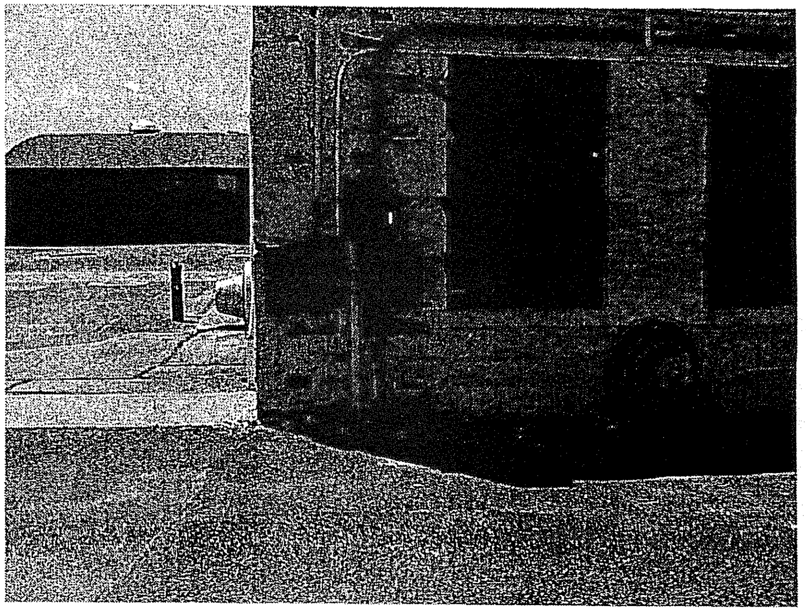


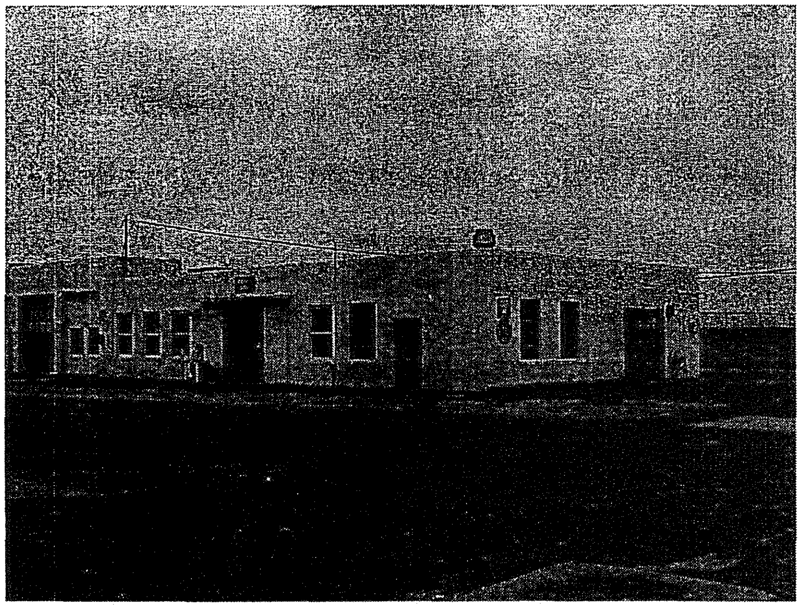
Deterioration East Wall

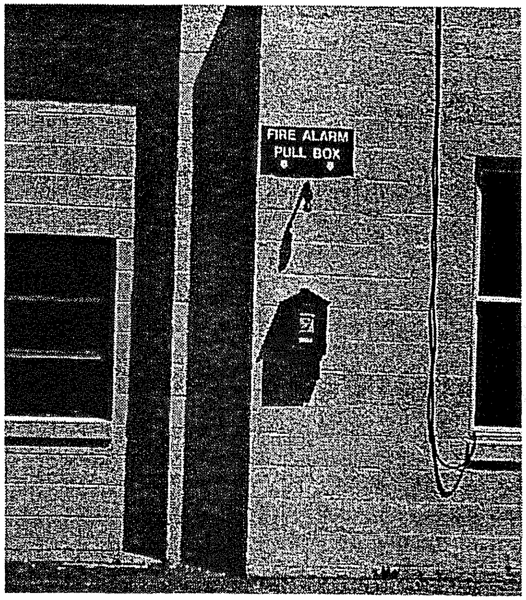


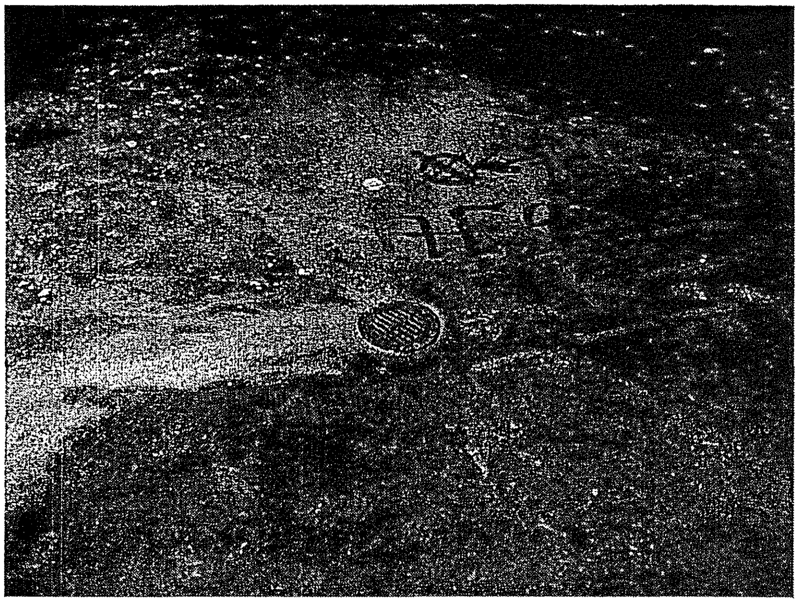
Building Interior Deterioration

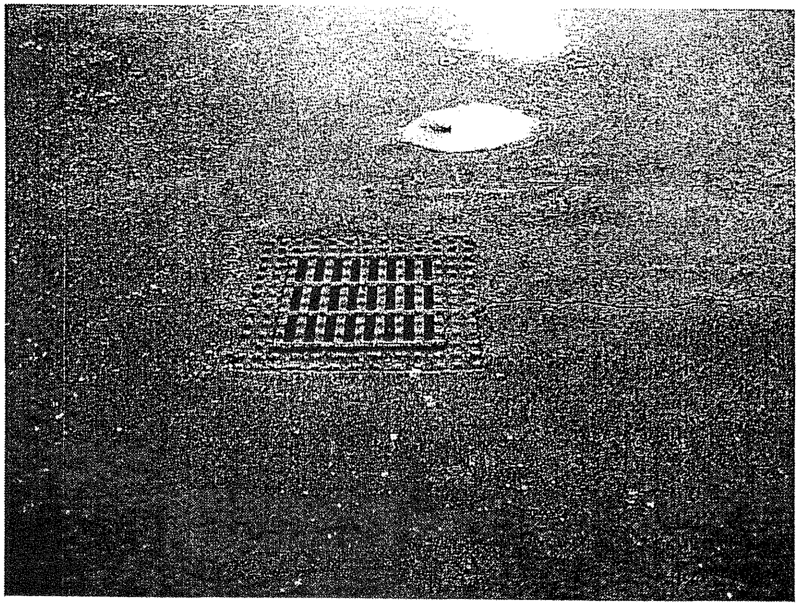


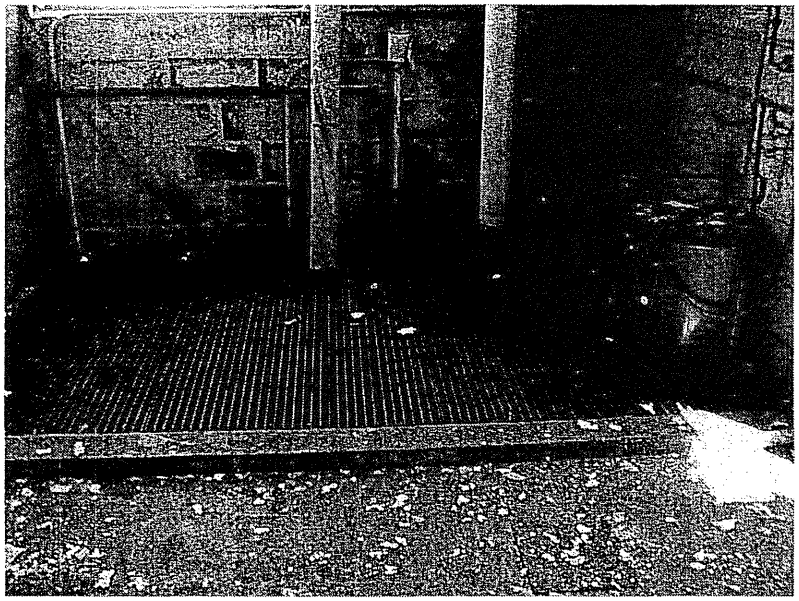


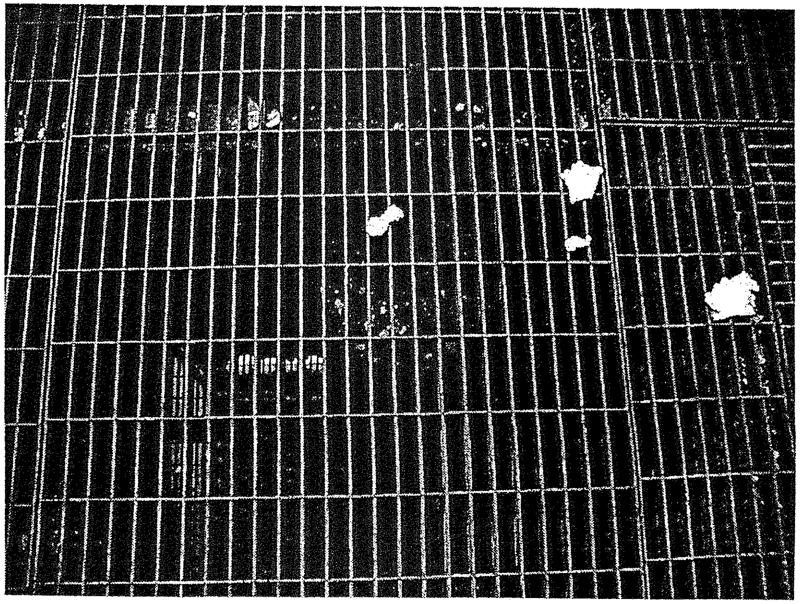


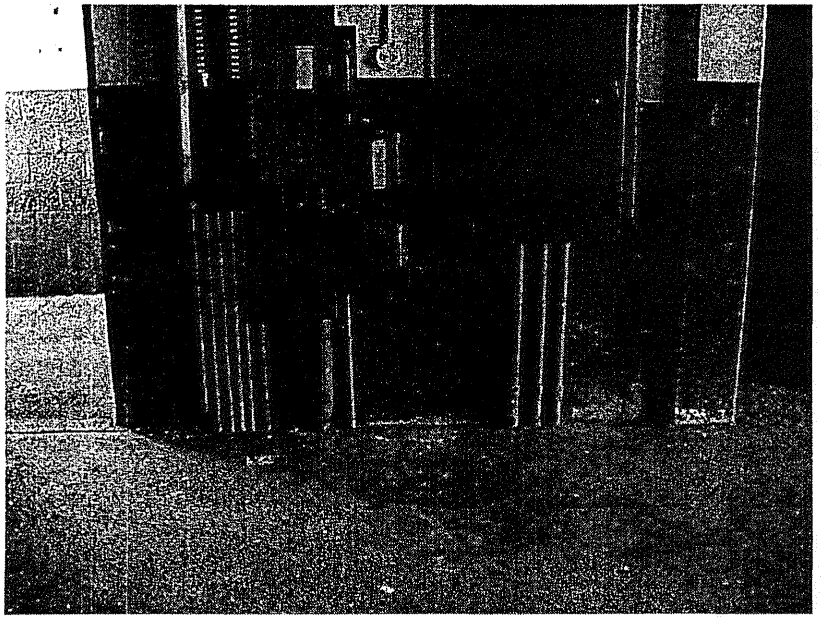

FIRE ALARM
PULL BOX

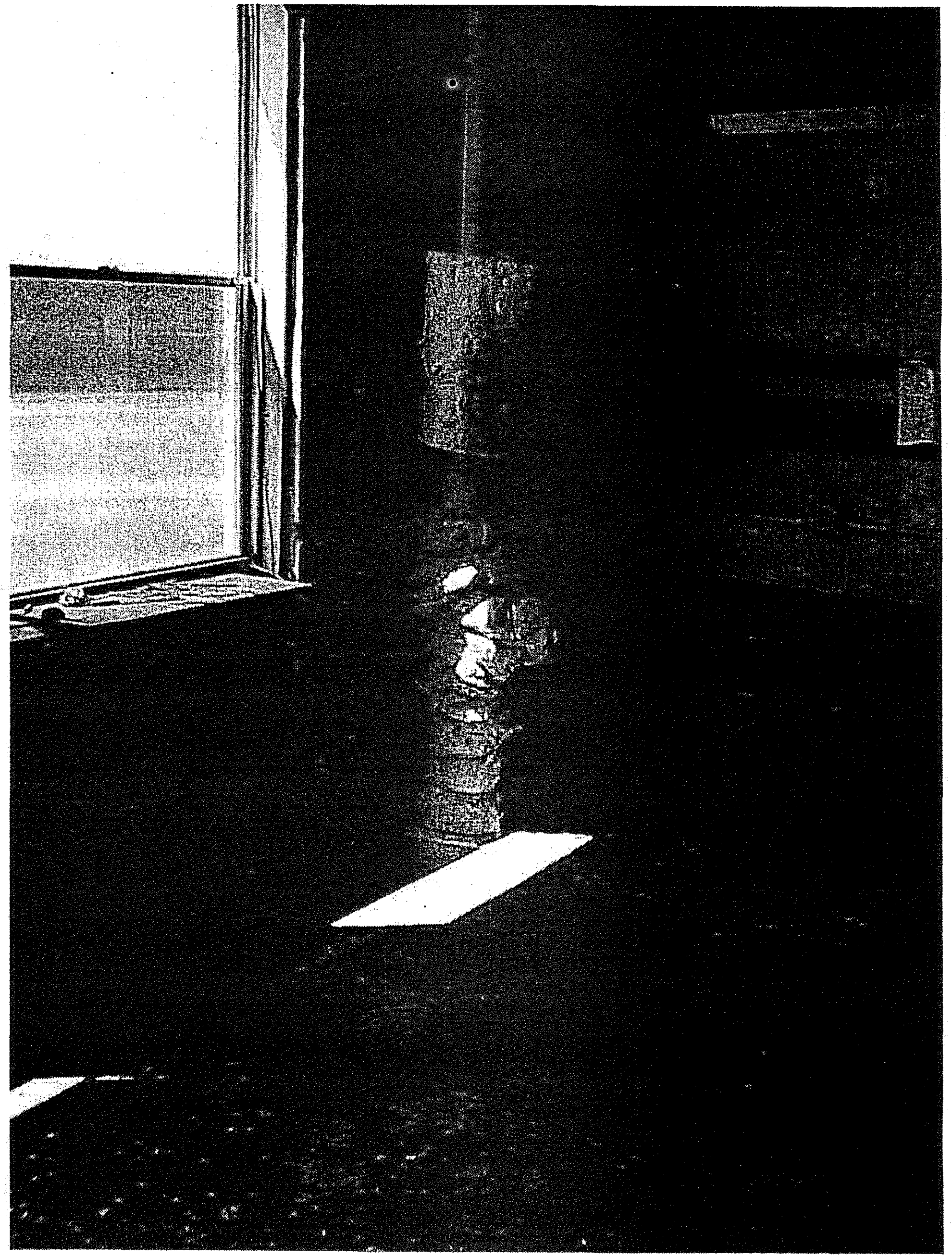


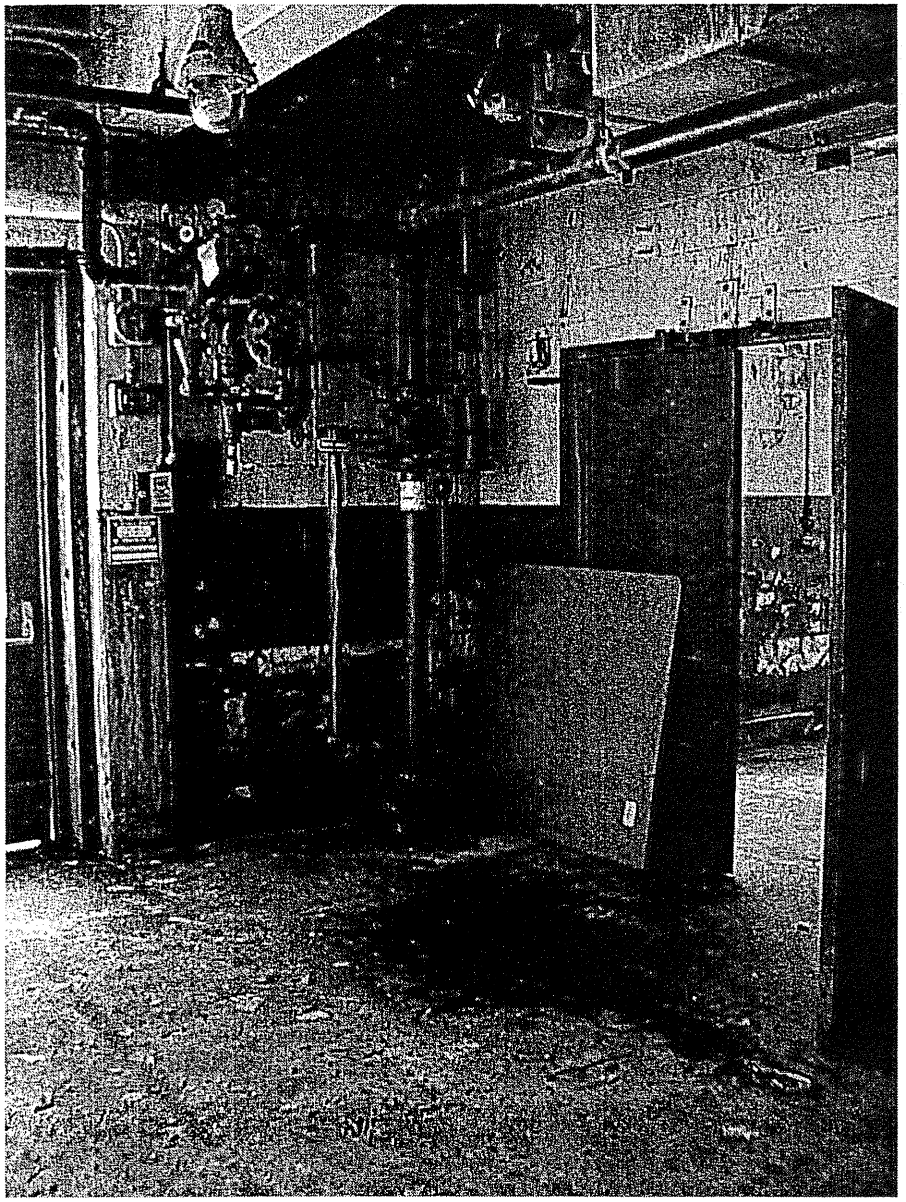


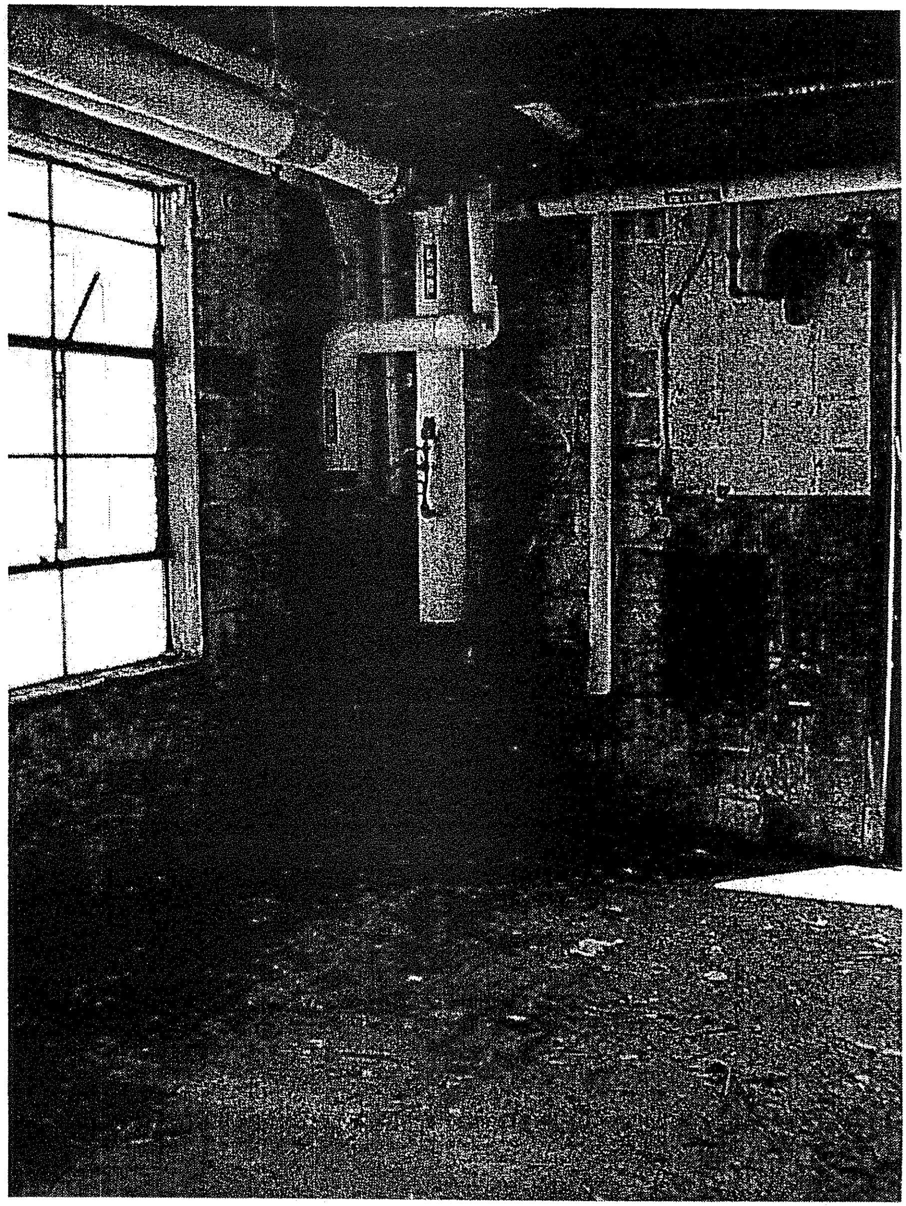


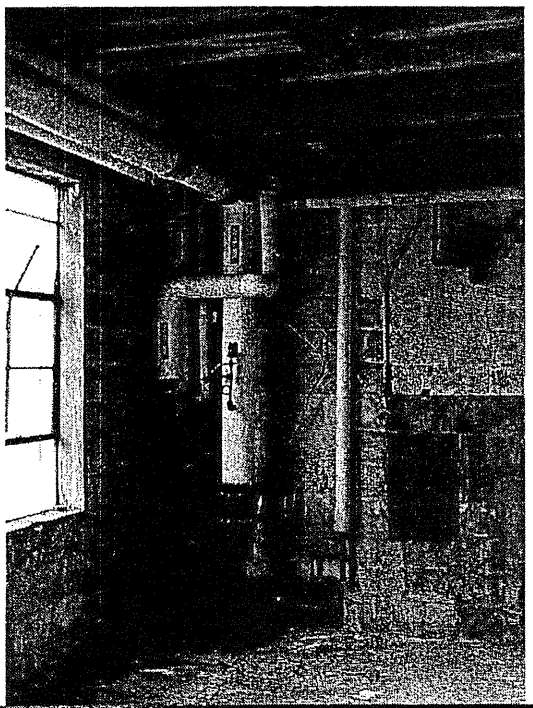


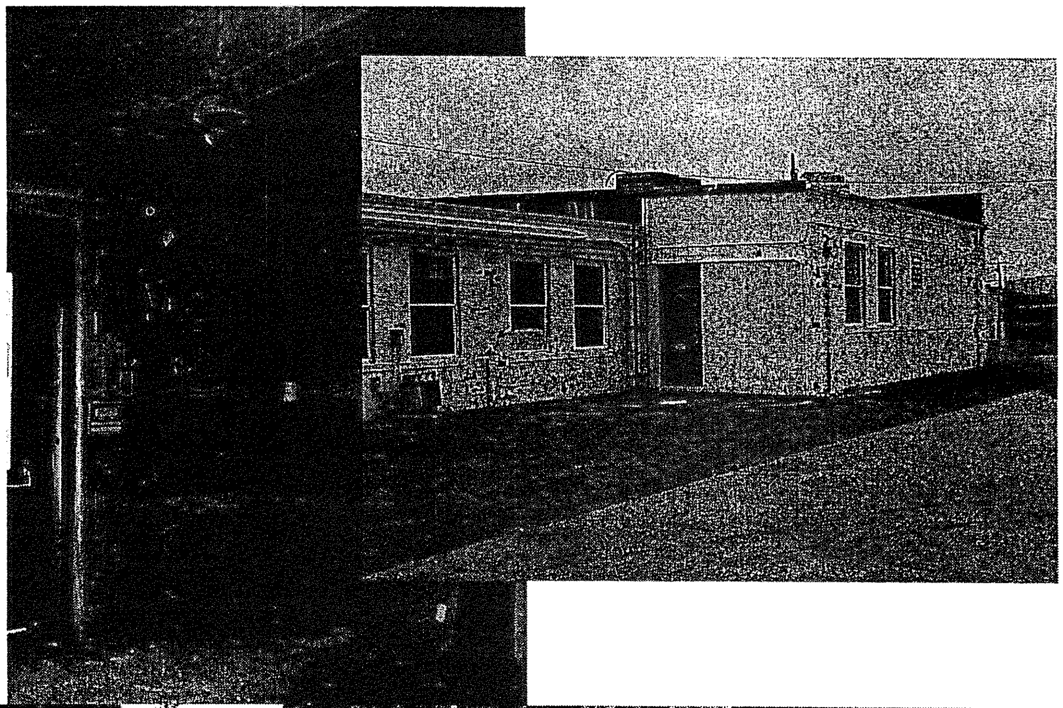


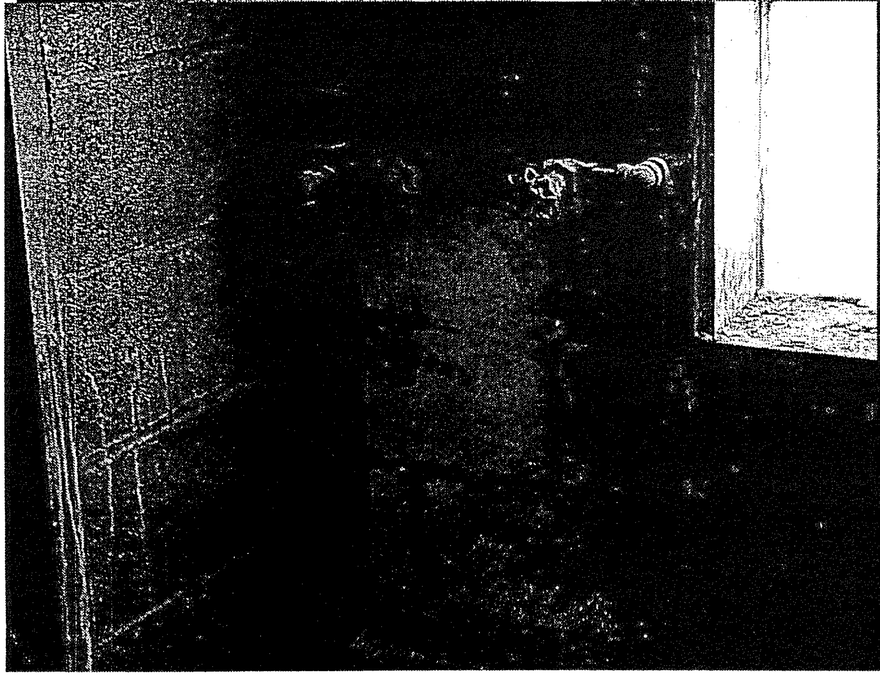


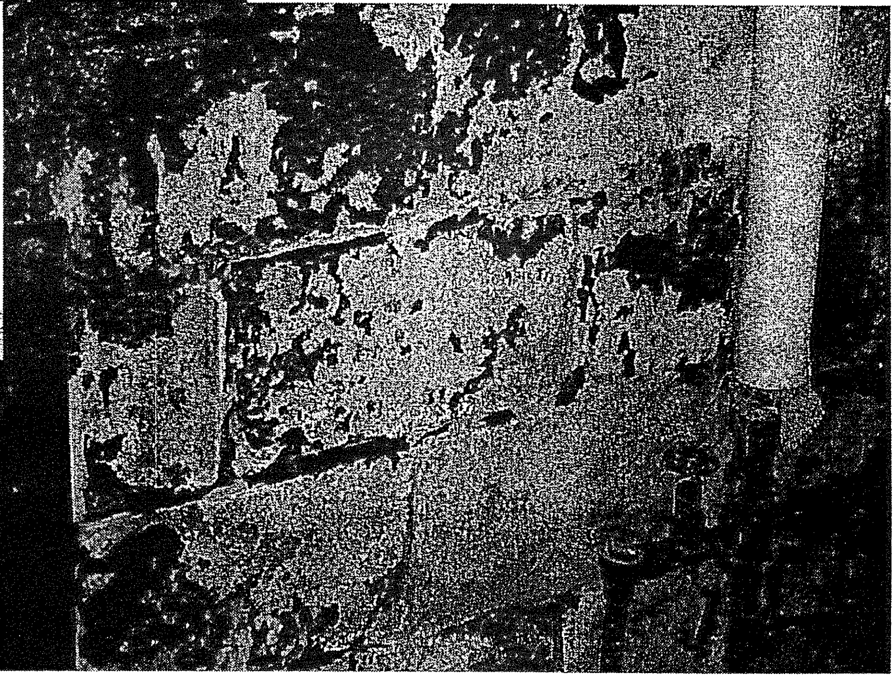


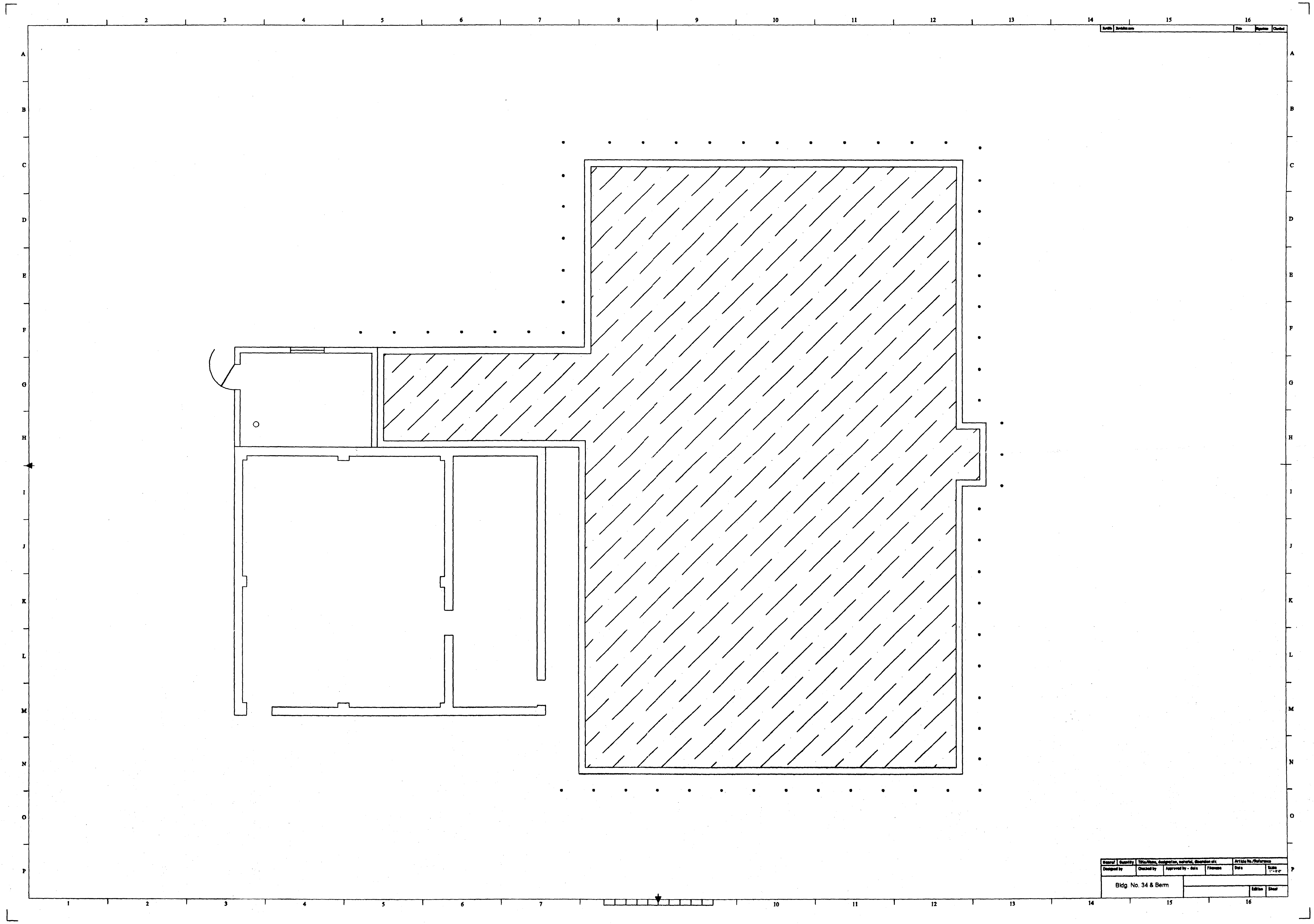










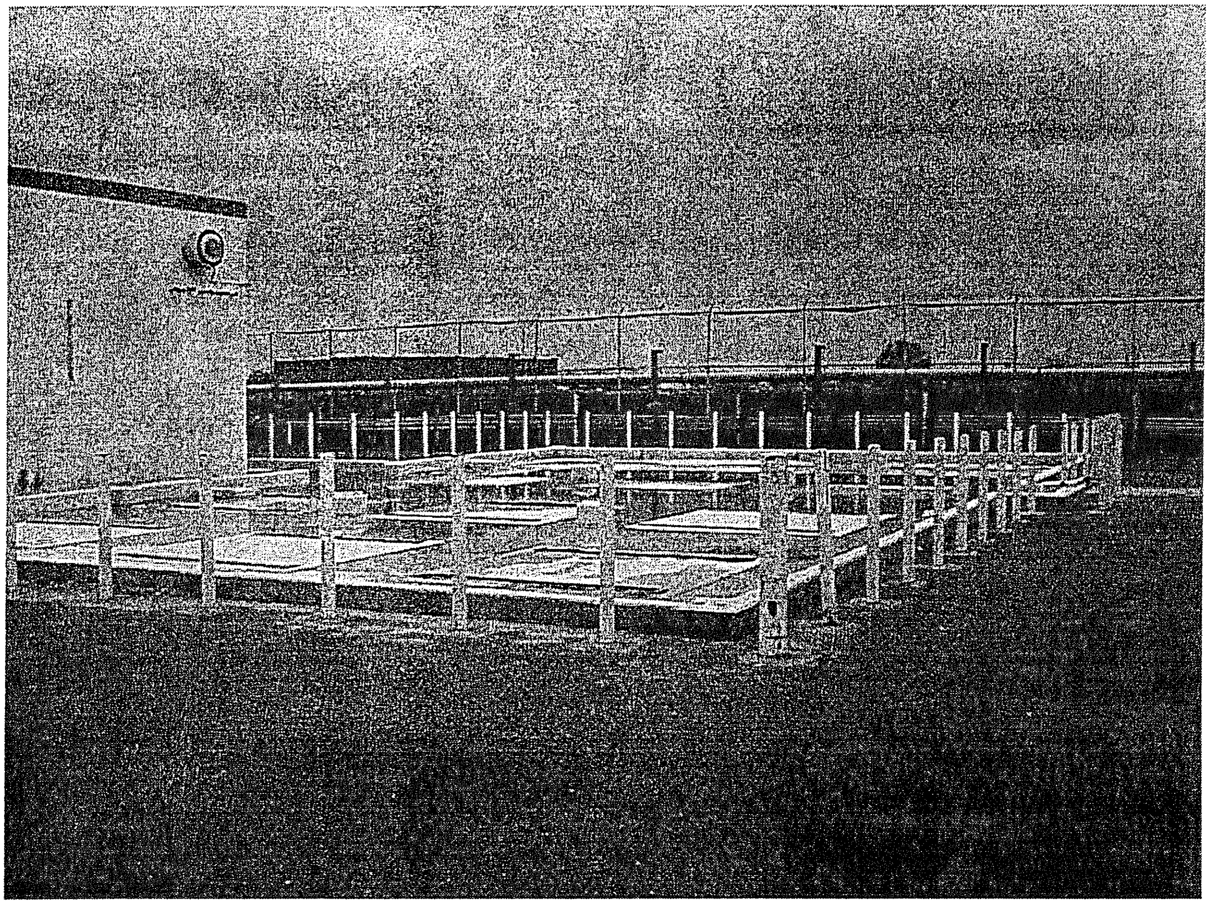


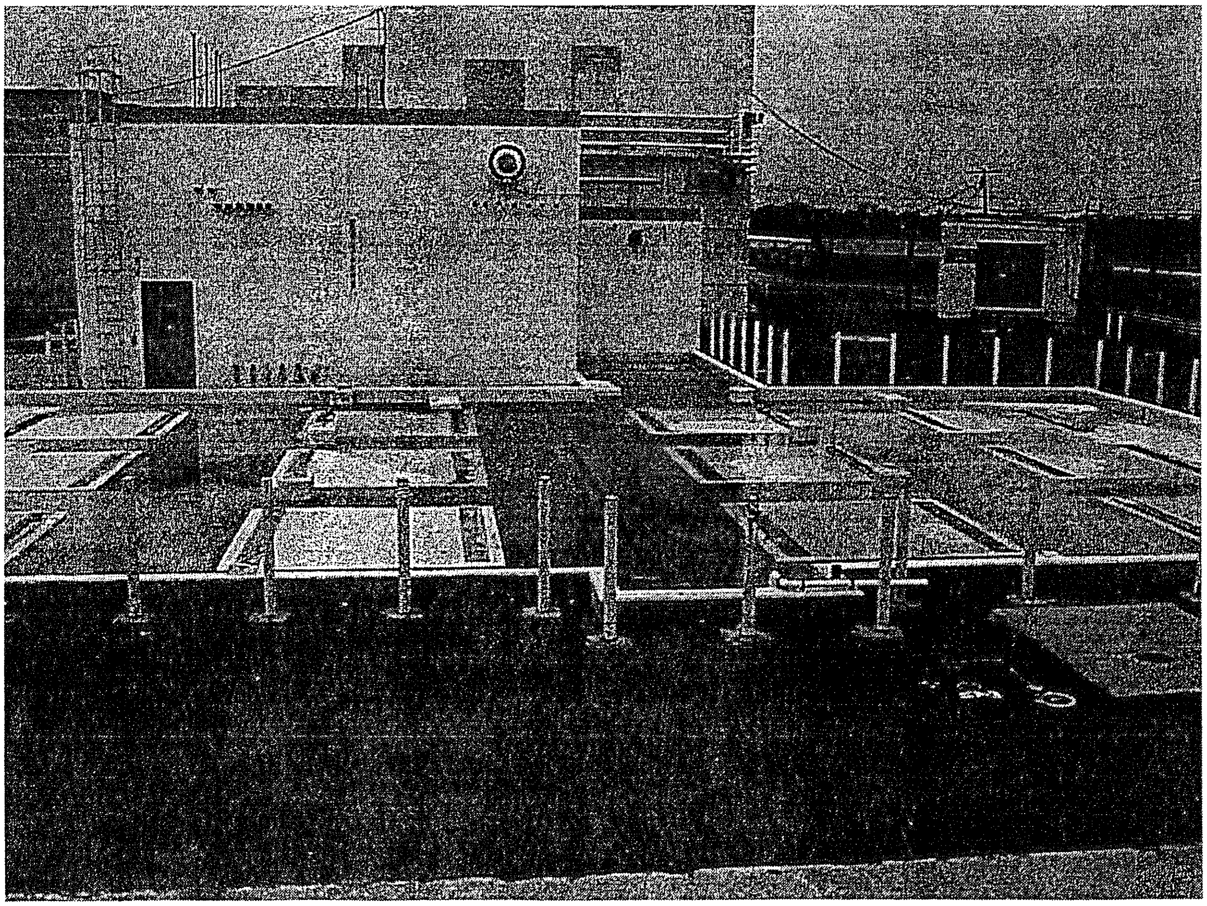
| Revidis | Revision note | Date | Signature | Checked |
|---|---|---|---|---|

| Item ref | Quantity | Title/Name, designation, material, dimension etc | | | Article No./Reference | |
|---|---|---|---|---|---|---|
| Designed by | | Checked by | Approved by - date | Filename | Date | Scale 1" = 8'-0" |

Bldg. No. 34 & Berm

| Edition | Sheet |
|---|---|





# ATTACHMENT F

# BUILDING 59 CHARACTERIZATION SAMPLING RESULTS

## ATTACHMENT F
## APPENDIX H

# CAUSEWAY DESIGN
# BUILDING B-59 CONCRETE CHARACTERIZATION SAMPLING
# STATFORD ARMY ENGINE PLANT

Harding ESE collected concrete chip and powder samples from the floors and walls of different areas of Building B-59 on June 27, 2001. The purpose of the sampling was to characterize the potential nature of the contamination in the concrete construction material of the building. The Construction Contractor will use the chemical data in the determination of concrete disposal options following demolition.

Building B-59 is located on the southwestern portion of the Causeway at the Stratford Army Engine Plant in Stratford, Connecticut. Explosives were stored in Building B-59 during the late 1960's and 1970's, for use in the manufacturing of re-entry vehicles for the Titan and Minuteman Intercontinental Ballistic Missile (ICBM) systems. The explosives used at SAEP were reportedly for explosive bolts or explosive materials used in the guidance systems of the ICBMs, packed inside cylindrical containers.

Building B-59 is constructed primarily of concrete, and consists of 4 cells, or rooms, with cell #1 being the largest room measuring approximately 21' x 22' (see Figure 1). The other three rooms measure either 6' x 10' or 8' x 10', and all ceilings are approximately 9' high. A loading dock measures approximately 11' x 23', and is located on the outside of these four rooms. A concrete ramp leads up to the loading dock for access from the Causeway and passes through an opening in a 16' high concrete wall that completely surrounds the building. This surrounding wall measures approximately 46' x 70'. Figure 1 schematically depicts the relationships of these features at Building B-59.

A total of ten samples were collected from the following locations at Building B-59:

- the floors of each of the four cells were sampled in a minimum four locations, and the samples were composited into a single sample (4 samples total); these samples are designated as CELL2F0101(the "2" denotes the number 2 cell room, etc., and the "F" denotes a sample from the floor; 0101 designates this being the first sampling round in the year 2001)

- the walls of each of the four rooms were sampled in a minimum four locations, and the samples were composited into a single sample (4 samples total); these samples are designated as CELL3W0101 (the "W" denotes a wall sample, this sample being from the number 3 cell room)

- the concrete ramp leading into Building B-59 was sampled in four locations, and then composited into a single sample (1 sample total); this is identified as RAMP0101

- the loading dock was sampled in four locations, and the then composited into a single sample (1 sample total); this is identified as LD0101

Figure 1 shows the areas where the samples were collected. Each sample was collected using a hand-held air hammer drill to chip away enough sample volume for collection. For each sample, all of the collected material was composited in a stainless steel mixing bowl before being placed into sample jars. Except for the concrete ramp sample, samples were collected from randomly selected locations of the walls or floors. The ramp sample was collected from a low channel-like depression that leads away from the loading dock. All samples were placed into two 8-oz. jars (one jar for metals analysis, one for all other analyses). The samples were preserved with ice, and were then sent via overnight delivery to CompuChem laboratory in Cary, NC for analysis.

The analytical tests performed were for TCLP metals (Methods 1311/6010/7470), PCBs (Method 8082), explosive compounds (Method 8330), and reactivity (Method SW846-Section 8.3). Analytical data received from the laboratory underwent a chemist review for quality assurance, but have not undergone USEPA validation procedures (CHECK THIS W/ CHRIS). Analytical results for detected analytes are presented in Table 1. Complete analytical results are presented in Table 2.

# TABLE 1
# BUILDING B-59 CONCRETE CHARACTERIZATION SAMPLES - HITS ONLY

## PHASE I AND II 90% DESIGN
## STRATFORD ARMY ENGINE PLANT
## STRATFORD, CONNECTICUT

| | Sample ID<br>Sample Date<br>Lab ID | CELL1F0101<br>06/27/01<br>Q2122-2 | CELL1W0101<br>06/27/01<br>Q2122-9 | CELL2F0101<br>06/27/01<br>Q2122-3 | CELL2W0101<br>06/27/01<br>Q2122-8 | CELL3F0101<br>06/27/01<br>Q2122-4 | CELL3W0101<br>06/27/01<br>Q2122-7 | CELL4F0101<br>06/27/01<br>Q2122-5 |
|---|---|---|---|---|---|---|---|---|
| Method | Parameter | | | | | | | |
| TCLP Metals (µg/L) | | | | | | | | |
| SW6010B | BARIUM | 448 J | 601 J | 267 J | 654 J | 377 J | 519 J | 160 J |
| | CADMIUM | 4 J | - | - | - | - | - | - |
| | CHROMIUM | 86.8 J | 25.3 J | 63.6 J | 28.1 J | 28.8 J | 4.4 J | 24.3 J |
| | LEAD | - | - | - | - | - | - | 18.1 J |
| | MERCURY | - | - | - | - | 0.2 J | 0.15 J | - |
| | SELENIUM | 11.2 J | 11.7 J | 10.3 J | 11.3 J | 10.5 J | 13.4 J | 9.2 J |
| PCB (µg/kg) | | | | | | | | |
| SW8082 | PCB-1248 | - | - | 48 J | - | - | - | - |
| | PCB-1254 | 36 | - | - | - | - | - | - |
| | PCB-1260 | 20 J | 120 P | 26 J | 67 | - | 57 J | - |

**Notes:**

| | |
|---|---|
| J = | Estimated value |
| - = | not detected |
| µg/L = | micrograms per liter |
| µg/kg = | micrograms per kilogram |
| TCLP = | Toxicity Characteristic Leaching Procedure |
| PCB = | Polychlorinated biphenyls |

Explosive Compounds and Reactivity Analyses did not have positive detections.

# TABLE 1
# BUILDING B-59 CONCRETE CHARACTERIZATION SAMPLES - HITS ONLY

## PHASE I AND II 90% DESIGN
## STRATFORD ARMY ENGINE PLANT
## STRATFORD, CONNECTICUT

| | Sample ID | CELL4W0101 | LD0101 | RAMP0101 |
|---|---|---|---|---|
| | Sample Date | 06/27/01 | 06/27/01 | 06/27/01 |
| | Lab ID | Q2122-6 | Q2122-1 | Q2122-10 |
| Method | Parameter | | | |
| TCLP Metals (µg/L) | | | | |
| SW6010B | BARIUM | 289 J | 402 J | 198 J |
| | CADMIUM | - | - | 24.4 J |
| | CHROMIUM | 38 J | 11.3 J | 297 J |
| | LEAD | - | - | - |
| | MERCURY | 0.16 J | - | - |
| | SELENIUM | 8.8 J | 13.2 J | 11.6 J |
| PCB (µg/kg) | | | | |
| SW8082 | PCB-1248 | - | - | - |
| | PCB-1254 | - | - | - |
| | PCB-1260 | 170 J | - | - |

**Notes:**

J = Estimated value

\- = not detected

µg/L = micrograms per liter

µg/kg = micrograms per kilogram

TCLP = Toxicity Characteristic Leaching Procedure

PCB = Polychlorinated biphenyls

Explosive Compounds and Reactivity Analyses did not have positive detections.

Chemist Review:

A project chemist review was completed on construction material samples collected at the SAEP Causeway. Samples were collected on June 27, 2001 and analyzed by CompuChem Laboratory in Cary, North Carolina. Analyses included TCLP Inorganics by Method 1311/6010B, PCBs by Method 8082, explosives by Method 8330C, and reactivity. Results from the following sample analyses were reviewed:

| **Sample ID** | **Lab Sample ID** |
|---|---|
| CELL1F0101 | Q2122-2 |
| CELL1W0101 | Q2122-9 |
| CELL2F0101 | Q2122-3 |
| CELL2W0101 | Q2122-8 |
| CELL3F0101 | Q2122-4 |
| CELL3W0101 | Q2122-7 |
| CELL4F0101 | Q2122-5 |
| CELL4W0101 | Q2122-6 |
| LD0101 | Q2122-1 |
| RAMP0101 | Q2122-10 |

A review of the laboratory data was completed by the Harding ESE project chemist to provide a general evaluation of data quality of the reported results, and to determine if there were data usability considerations that should be identified. The chemist review included a review of the laboratory case narratives, data set completeness, holding time compliance, data accuracy (lab control samples and matrix spike data), and quality control blank data. If necessary, results were qualified in accordance with USEPA data validation guidelines (USEPA, 1994). A summary of the chemist review and explanations of data qualification actions is presented below.

Inorganics:

- A subset of results were qualified B by the laboratory indicating the detected concentrations were less than the sample quantitation limits (SQLs) established for the method. These results have been qualified as estimated J during the chemist review.

- Low concentrations of lead, cadmium, and arsenic reported in samples were qualified non-detect U due to similar concentrations reported in laboratory QC blanks. The QC blank data indicated that low concentration contamination was possible.

PCBs:

- A subset of results for aroclor 1248, and aroclor 1260 were qualified P by the laboratory indicating variability between concentration in the confirmation column analysis. These results were qualified estimate J in the final data.

Explosives:

- Results for 1,3,5-trinitrobenzene in all samples were qualified estimated J due to low recoveries in the associated matrix spike sample RAMP0101. Recovery ranged from 41% to 44% indicating a possible low bias.

- Results for 2,4,6-trinitrotoluene, 2-amino-4,6-dinitrotoluene, 4-amino-2,6-dinitrotoluene, tetryl, and 3-nitrotoluene were qualified rejected R due to low recovery in the matrix spikes. Good recoveries were reported in the lab control samples (blank spikes). However; recovery of 0% in the spiked sample matrix indicates that the sample matrix was incompatible with these compounds.

References:

U.S. Environmental Protection Agency (USEPA), 1994. "USEPA Contract Laboratory Program National Functional Guidelines for Organic (Inorganic) Data Review"; Office of Solid Waste and Emergency Response; EPA-540/R-94/012; February 1994.

## TABLE 2
## BUILDING 59 CONCRETE CHARACTERIZATION SAMPLES - COMPLETE ANALYTICAL RESULTS
## PHASE I AND II 90% DESIGN
## STRATFORD ARMY ENGINE PLANT
## STRATFORD, CONNECTICUT

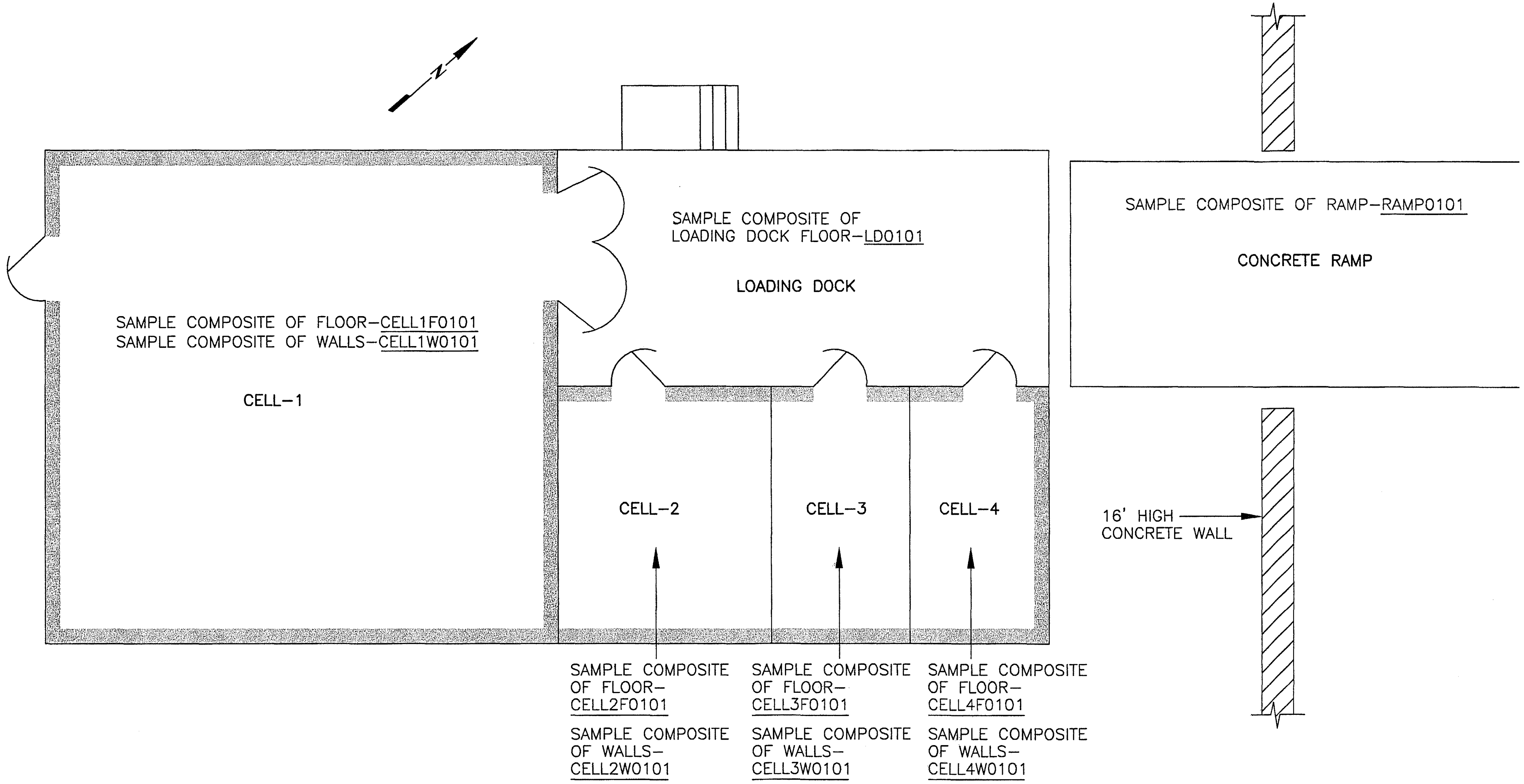
| | Sample ID | | CELL1F0101 | CELL1W0101 | CELL2F0101 | CELL2W0101 | CELL3F0101 | CELL3W0101 | CELL4F0101 | CELL4W0101 | LD0101 | RAMP0101 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sample date | | 06/27/01 | 06/27/01 | 06/27/01 | 06/27/01 | 06/27/01 | 06/27/01 | 06/27/01 | 06/27/01 | 06/27/01 | 06/27/01 |
| | Lab ID | | Q2122-2 | Q2122-9 | Q2122-3 | Q2122-8 | Q2122-4 | Q2122-7 | Q2122-5 | Q2122-6 | Q2122-1 | Q2122-10 |
| Method | Parameter | | | | | | | | | | | |
| TCLP Metals | | | | | | | | | | | | |
| SW6010B | ARSENIC | µg/L | 2.3 U | 2.1 U | 2.1 U | 2.1 U | 2.9 U | 2.7 U | 3.2 U | 6.6 U | 5.8 U | 2.1 U |
| | BARIUM | µg/L | 448 J | 601 J | 267 J | 654 J | 377 J | 519 J | 160 J | 289 J | 402 J | 198 J |
| | CADMIUM | µg/L | 4 J | 0.3 U | 0.3 U | 0.3 U | 0.3 U | 0.3 U | 0.48 U | 0.3 U | 0.3 U | 24.4 J |
| | CHROMIUM | µg/L | 86.8 J | 25.3 J | 63.6 J | 28.1 J | 28.8 J | 4.4 J | 24.3 J | 38 J | 11.3 J | 297 J |
| | LEAD | µg/L | 2.4 U | 7 U | 3 U | 2.4 U | 3.2 U | 1.7 U | 18.1 J | 1.7 U | 2.4 U | 1.1 U |
| | MERCURY | µg/L | 0.1 U | 0.1 U | 0.1 U | 0.1 U | 0.2 J | 0.15 J | 0.1 U | 0.16 J | 0.1 U | 0.1 U |
| | SELENIUM | µg/L | 11.2 J | 11.7 J | 10.3 J | 11.3 J | 10.5 J | 13.4 J | 9.2 J | 8.8 J | 13.2 J | 11.6 J |
| | SILVER | µg/L | 0.7 U | 0.7 U | 0.7 U | 0.7 U | 0.7 U | 0.7 U | 0.7 U | 0.7 U | 0.7 U | 0.7 U |
| PCBs | | | | | | | | | | | | |
| SW8082 | PCB-1016 | µg/kg | 34 U | 33 U | 35 U | 33 U | 34 U | 33 U | 34 U | 33 U | 34 U | 33 U |
| | PCB-1221 | µg/kg | 44 U | 43 U | 46 U | 43 U | 44 U | 43 U | 44 U | 43 U | 44 U | 43 U |
| | PCB-1232 | µg/kg | 34 U | 33 U | 35 U | 33 U | 34 U | 33 U | 34 U | 33 U | 34 U | 33 U |
| | PCB-1242 | µg/kg | 23 U | 23 U | 24 U | 23 U | 23 U | 23 U | 23 U | 23 U | 23 U | 23 U |
| | PCB-1248 | µg/kg | 23 U | 23 U | 48 J | 23 U | 23 U | 23 U | 23 U | 23 U | 23 U | 23 U |
| | PCB-1254 | µg/kg | 36 | 23 U | 24 U | 23 U | 23 U | 23 U | 23 U | 23 U | 23 U | 23 U |
| | PCB-1260 | µg/kg | 20 J | 120 | 26 J | 67 | 34 U | 57 J | 34 U | 170 J | 34 U | 33 U |
| Explosive Compounds | | | | | | | | | | | | |
| SW8330C | 1,3,5-TRINITROBENZENE | mg/kg | 0.26 UJ | 0.26 UJ | 0.27 UJ | 0.26 UJ | 0.26 UJ | 0.26 UJ | 0.26 UJ | 0.26 UJ | 0.26 UJ | 0.26 UJ |
| | 1,3-DINITROBENZENE | mg/kg | 0.26 U | 0.26 U | 0.27 U | 0.26 U | 0.26 U | 0.26 U | 0.26 U | 0.26 U | 0.26 U | 0.26 U |
| | 2,4,6-TNT | mg/kg | R | R | R | R | R | R | R | R | R | R |
| | 2,4-DINITROTOLUENE | mg/kg | 0.26 U | 0.26 U | 0.27 U | 0.26 U | 0.26 U | 0.26 U | 0.26 U | 0.26 U | 0.26 U | 0.26 U |
| | 2,6-DINITROTOLUENE | mg/kg | 0.52 U | 0.51 U | 0.54 U | 0.51 U | 0.52 U | 0.51 U | 0.52 U | 0.51 U | 0.52 U | 0.51 U |
| | 2-NT | mg/kg | 0.52 U | 0.51 U | 0.54 U | 0.51 U | 0.52 U | 0.51 U | 0.52 U | 0.51 U | 0.52 U | 0.51 U |
| | 2A,4,6-DNT | mg/kg | R | R | R | R | R | R | R | R | R | R |
| | 3-NT | mg/kg | R | R | R | R | R | R | R | R | R | R |
| | 4-NT | mg/kg | 0.52 U | 0.51 U | 0.54 U | 0.51 U | 0.52 U | 0.51 U | 0.52 U | 0.51 U | 0.52 U | 0.51 U |
| | 4A,2,6-DNT | mg/kg | R | R | R | R | R | R | R | R | R | R |
| | HMX | mg/kg | 0.26 U | 0.26 U | 0.27 U | 0.26 U | 0.26 U | 0.26 U | 0.26 U | 0.26 U | 0.26 U | 0.26 U |
| | NITROBENZENE | mg/kg | 0.26 U | 0.26 U | 0.27 U | 0.26 U | 0.26 U | 0.26 U | 0.26 U | 0.26 U | 0.26 U | 0.26 U |
| | RDX | mg/kg | 0.26 U | 0.26 U | 0.27 U | 0.26 U | 0.26 U | 0.26 U | 0.26 U | 0.26 U | 0.26 U | 0.26 U |
| | TETRYL | mg/kg | R | R | R | R | R | R | R | R | R | R |

# TABLE 2
# BUILDING 59 CONCRETE CHARACTERIZATION SAMPLES - COMPLETE ANALYTICAL RESULTS
## PHASE I AND II 90% DESIGN
## STRATFORD ARMY ENGINE PLANT
## STRATFORD, CONNECTICUT

| | Sample ID | | CELL1F0101 | CELL1W0101 | CELL2F0101 | CELL2W0101 | CELL3F0101 | CELL3W0101 | CELL4F0101 | CELL4W0101 | LD0101 | RAMP0101 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sample date | | 06/27/01 | 06/27/01 | 06/27/01 | 06/27/01 | 06/27/01 | 06/27/01 | 06/27/01 | 06/27/01 | 06/27/01 | 06/27/01 |
| | Lab ID | | Q2122-2 | Q2122-9 | Q2122-3 | Q2122-8 | Q2122-4 | Q2122-7 | Q2122-5 | Q2122-6 | Q2122-1 | Q2122-10 |
| Reactivity | | | | | | | | | | | | |
| WETCHEM | REACTIVE CYANIDE | mg/kg | 260 U | 254 U | 268 U | 254 U | 260 U | 254 U | 261 U | 255 U | 259 U | 255 U |
| | REACTIVE SULFIDE | mg/kg | 260 U | 254 U | 268 U | 254 U | 260 U | 254 U | 261 U | 255 U | 259 U | 255 U |

Notes:

µg/L = micrograms per liter
µg/kg = micrograms per kilogram
mg/kg = milligrams per kilogram
U = not detected; the associated value represents the detection limit
J = estimated value
R = rejected



BUILDING 59

SCHEMATIC PLAN

SCALE: 1"=5'

**FIGURE 1**
**CONCRETE SAMPLE LOCATIONS**
**BUILDING 59**
**STRATFORD ARMY ENGINE PLANT**
**STRATFORD, CONNECTICUT**

Harding ESE
A MACTEC COMPANY

P:\CAD\Data2\50796\C50796101.dwg Tue, 14 Aug 2001 – 2:44pm RDCYR

# APPENDIX I

## EROSION AND SEDIMENT CONTROL

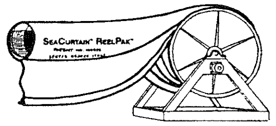
Attachment A – Floating Silt Curtain

# Attachment A – Floating Silt Curtain

KEPNER PLASTICS
FABRICATORS, INC.

3131 Lomita Boulevard, Torrance, California USA 90505-5158
TEL: (310) 325-3162 FAX: (310) 326-8560

- MANUFACTURER...Custom or Production, All Materials, Fast Service
- COVERS & LINERS...Industrial, Equipment, Tanks, Ponds, etc.
- SPECIALTIES...R&D, Technical, Inflatable, Vacuum, etc.
- GUARANTEED WORKMANSHIP..."We Do Good Work"



**SeaCurtain***
**Pollution Control Products**

- ReelPak*, FireGard*, Compactible*, Inland, Harbor & Offshore Booms
- SeaVac* Skimmers & Separators
- SeaContainer* Tanks & Bladders

HARDING ESE
A Mactec Company
Portland, ME

23, March 2001

Subject: Introduction to Kepner Plastics Fabricators, Inc.
Sample projects for Silt Barriers

Gentlemen,

We are pleased to provide you with information on Kepner Plastics' oil spill pollution control products, engineering and manufacturing capabilities. Kepner Plastics manufactures a large variety of oil spill emergency response systems, custom boom design work and accessories, including:

SeaCurtain™ Containment Booms
ReelPak™
**SeaCurtain™ Silt Barriers**
Harbor and Offshore SeaVac™ Skimmers
SeaContainer™ Towable and Flexible Tanks
KepBerm™ Secondary Containment Systems - FireGard™

Since 1961, major oil companies, governmental agencies, cleanup co-ops and contractors have proved our pollution control systems' reliability and effectiveness through repeated use worldwide.

We pride ourselves in continuous enhancements and innovations to our systems and in our commitment to designing and manufacturing the best systems for each customer's specific needs. Most of our oil spill related products are our own design and are patented.

In addition to oil spill containment and recovery equipment, Kepner Plastics custom designs and fabricates a wide variety of specialty products, including environmental covers and liners, collapsible tanks, inflatable lift bags and relocatable shelters.

Thirty plus years of experience have made us experts in manufacturing products made of coated fabrics, films, extrusions and/or foam materials in conjunction with mechanical devices, hardware and/or fasteners.

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* Trademark

1.) We have attached copies of some colored pictures numbered (1-14), these are actual photos taken of the dredging operation in Long Beach Harbor by Manson Construction. This project was the beginning phase to rebuild the harbor to assist in the new Ocean Container Terminals that needed to be constructed after the U.S. Navy shut down and moved from Long Beach, California.

One of the problems we at Kepner Plastics encountered was that the end user and the local government officials were forcing the contractor to use a system that was too much for the job. We at Kepner Plastics can only supply the buyer or end users with information and then manufacture the product based on what they want to order in the end.
The Manson Construction project was a good example of to many, too much and not taking any good advise, which cost Manson the contractor more money in the end. This was not Manson's doing in any way but the cost was incurred onto them because of the situation.

We were asked to manufacture a much longer skirt than needed with the Geo-Membrane Black woven fabric. Pictures # 1 and # 2 show how the product looked when packaged and ready to ship. Pictures 3, 4, & 7 show the product on the floor of our facility while being manufactured. Notice the length of the skirt and how long it is as of the time we manufactured it the first time.

Pictures # 8, 9, & 10 are showing the damaged areas due to anchoring, drift and current problems due to the long skirted area. Another problem is that the marine growth was evident after only one week; this created a drag effect and eventually caused the boom to come apart in certain areas.

Look very carefully and you will see the entire skirted area (Black) floating to the surface, this is the sail effect we mentioned to Brian and Tom and basically the product became useless at this point. The stress and drag were so great from the current (which was less than 1.25 knots) that is tore, ripped and damaged the barrier to where a new plan had to be set up very quickly by the end user.

Picture # 11 is the total length shot of the entire Silt Curtain at the time of deployment. The main dredging was to the right, as you can see the color difference in the water.

Picture # 12 is just an example of what you see from the surface; looking down, notice the skirt section creating the sail effect.

Now look at Pictures 13, and 14: This was the final Silt Barrier for the project that not only worked but had the final approval from all agencies involved. Notice the solid skirt section and length of the skirt compared to the first barrier ordered. This project is a good example for your company to examine and as a manufacturer this was that 30 year plus learning curve we experience from time to time.

Please keep in mind that Silt Barrier projects vary a great deal from project to project, there is no exact science but there are experienced people in the industry that can help.

2.) Attached also is a project booklet on an overseas product that Kepner Plastics manufactured. The Jebel Ali Gas Turbine "G" Station was created to assist in the control of debris and other objects that were being pulled into the water turbine system. This system assisted in controlling the situation.


①
SEACURTAIN
SEACURTAIN
SEACURTAIN
KEPNER PLASTICS-TORRANCE, CALIF


②
MANSON CONSTRUCTION

③

④

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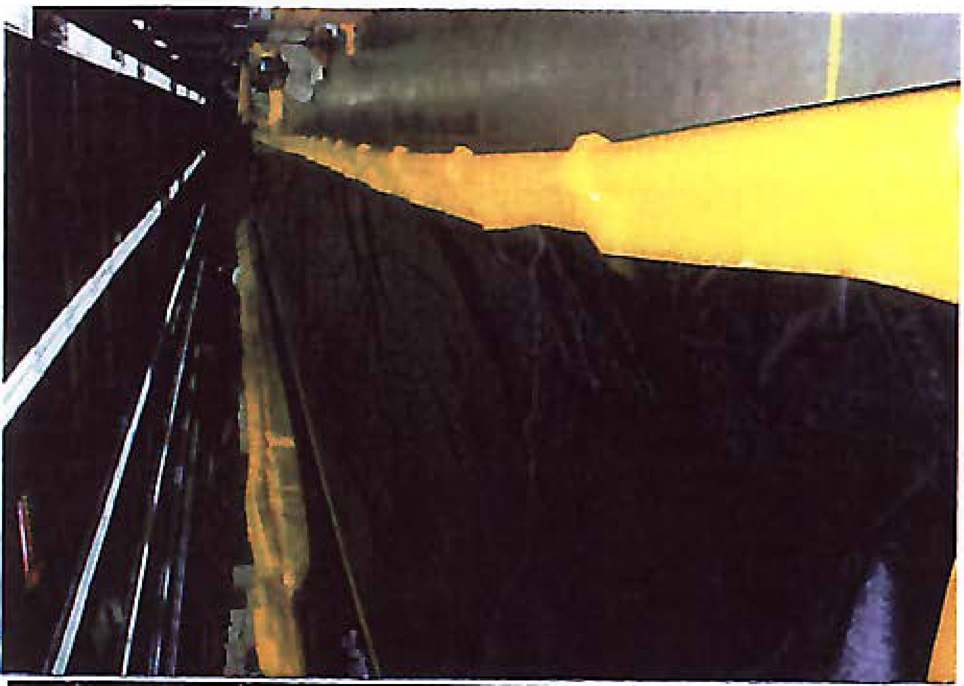
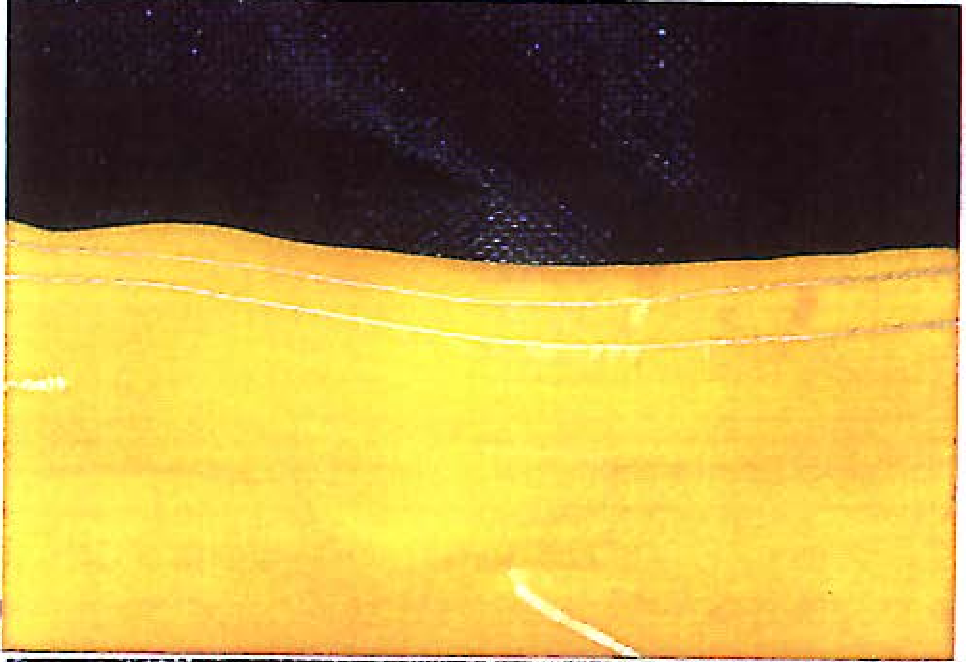


(9)



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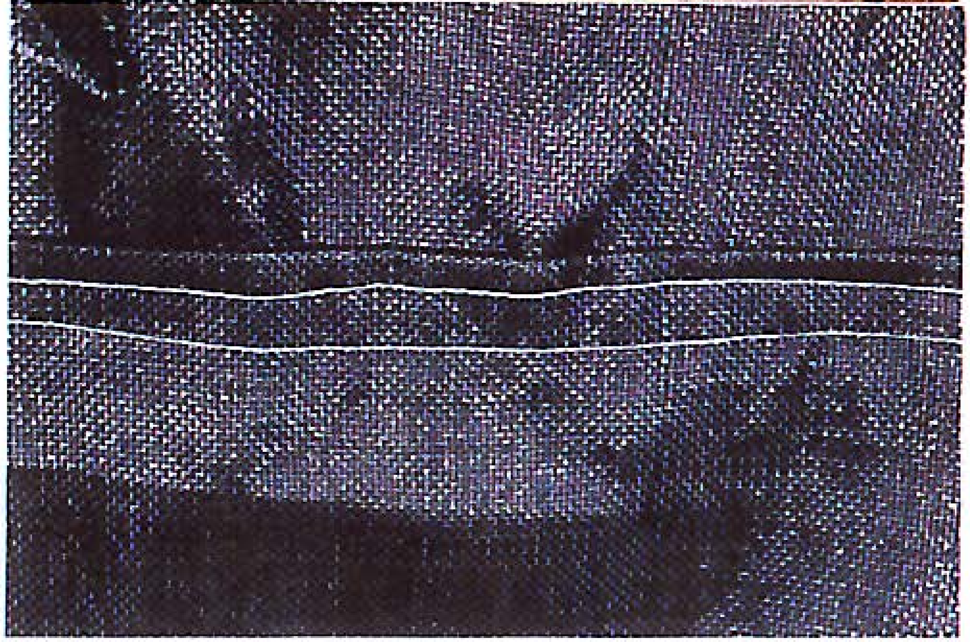

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13

14

Various Government agencies we deal with on a regular basis:

U.S Air Force
Royal Danish Air Force
U.S. Army Corps of Engineers
U.S. Navy
NAVFACCOM
U.S. Marine Corps
U.S.C.G.
Indian Coast Guard
Swedish Coast Guard
NASA
Orbital Science Group
Sandia National Laboratories

Samples of International and U.S. recognition for publications and accomplishments as a Corporation:

Mariners Annual
The International Oil Spill Control Directory and Counsel
Pollution Equipment Buyer Guide
)ffshore Technology Member
OHMSAT Testing Facility
NAVFACCOM ( Port Hueneme, Ca.) Naval Engineering Facilities Command Testing Facility

Please feel free to contact us regarding any questions or additional information.

Sincerely,

KEPNER PLASTICS FABRICATORS, INC.

David R. Parrow
Sales Associate

# SEACURTAIN™ OIL SPILL CONTAINMENT BOOM

# COMMISSIONING REPORT

## JEBEL ALI GAS TURBINE "G" STATION

Customer: COSTAIN DUBAI COMPANY
LPO 47739
KPF W.O. #5414

KEPNER PLASTICS FABRICATORS, INC.
3131 Lomita Boulevard
Torrance, California 90505-5158 U.S.A.
TEL: (310) 325-3162

# Table of Contents

Appendix:

# Commissioning of the KEPNER SEACURTAIN™ Oil Exclusion Boom System for the Seawater Intake at the Jebel Ali "G" Power Plant, Dubai, United Arab Emirates

## Introduction

This report details findings and recommendations made pursuant to a commissioning agreement between KEPNER PLASTICS FABRICATORS, INC. and COSTAIN DUBAI COMPANY.

The agreement specifies technical services to be provided relating to the installation and commissioning of a KEPNER SEACURTAIN™ oil exclusion boom system to protect a water intake serving the Jebel Ali "G" power plant and desalination facility in Dubai, United Arab Emirates.

Photographs illustrating and supplementing the text are included in Appendix A to this report.

## Meetings and Relations with Customer

### Preliminary Tour of Facilities

On Sunday, 12 December 1933, Peter Fisher, of COSTAIN DUBAI COMPANY (hereafter designated CDC), picked up Mr. Rik Shafer (hereinafter designated KPF REP) up at the Chicago Beach Hotel in Dubai and drove to the Jebel Ali "G" power plant site to meet George Kingsbury, Project Superintendent with COSTAIN DUBAI. The following facilities were viewed:

- ***The boat ramp where the exclusion boom system is to be launched and retrieved.*** The facility appeared to be essentially complete except for approach roads.
- ***The boathouse where the boom, tow boat, and associated equipment are to be stored.*** The facility is under construction, but completion is expected in a few weeks.
- ***A yard where the boom containers and the tow boat were stored.*** One boom container had been partially opened for inspection, but contents appeared intact at this point.

During this initial inspection tour KPF REP observed only moderate wave action in the waters just offshore of the boat ramp. (See Photo 1.) The existing temporary jetties, which were evidently built to protect the boat ramp and water outfall during construction, in the existing wind conditions may make launching and retrieval of the boom with an inexperienced crew difficult. If sea conditions were much worse than observed, it would be risky trying to bring a boat through the nearshore surf zone.

### Initial Meeting

At 10:15 AM, Sunday, 12 December 1993, Peter Fisher, George Kingsbury, and KPF REP met with Iain Bell, Engineering Manager with Dutco Balfour Beatty (Pvt.) Ltd., for the Jebel Ali 'G' Power Station project (hereinafter designated "DBB"). Activities were reviewed as planned to occur over the next few days, as listed in the following schedule:

*SUNDAY, 12 DEC 93:*

1) ***Open the boom shipping containers. Inspect and inventory their contents.***
2) ***Insure that ground surfaces adjacent to the boat ramp and boathouse are graded and compacted.***

*MONDAY, 13 DEC 93:*

1) ***Assemble the components of the exclusion boom system on a site near the boat ramp*** There were no paved surfaces available for this activity, however sufficient men were to be

assigned to be able to lift reasonable-sized portions of the boom into position for assembly, and get it to the launch point on the boat ramp without dragging it across the ground or rough concrete.

Monday afternoon, tides were to become too low for safe recovery of the boom late in the day, given the present sea state.

2) ***Launch the boat and tie it up at a nearby pier.***
3) ***Complete the work of attaching the anchor buoys to existing anchors at the water intake site.***

*TUESDAY, 14 DEC 93:*

1) ***Launch the assembled boom into the water***
2) ***Tow the boom to the water intake site.***
3) ***Attach the boom to the anchoring system.***
4) ***Lower the skirt.***
5) ***Evaluate boom performance.***
6) ***Raise the skirt and securely wrap hanging portions with the loose ends of the skirt control lines..***
7) ***Disconnect the boom from the anchoring system.***
8) ***Tow the boom to the boat ramp.***
9) ***Retrieve the boom and stack it on the boat ramp.*** Depending on sea state and wind conditions, boom retrieval may not be possible to do this safely with only one boat, because wind may drive the trailing end of the boom onto the rocks of the nearby jetties.

***WEDNESDAY, 15 DEC 93:***

1) ***Demonstrate launching and recovery for the client*** (assuming all went well during Tuesday's practice).

## *Contacts with Peter Fisher, Area Quantity Surveyor, Costain Dubai Company [CDC]*

KPF REP had direct contact with Peter Fisher only during the initial and final meetings, but spoke with him by phone or left him messages almost daily to keep him advised of his progress of the work.

## *Contacts with George Kingsbury, Project Superintendent, Costain Abu Dhabi Company/Costain Dubai Company*

George Kingsbury provided direct supervision of boom deployment and recovery operations during the period as in Dubai.

## *Contacts with Iain Bell, Engineering Manager, Jebel Ali 'G' Power Station Project, Dutco Balfour Beatty (Pvt) Ltd.[DBB]*

Dutco Balfour Beatty is responsible for overall project management and Mr. Iain Bell is Engineering Manager.

Some of the factors affecting the boom deployment and recovery, under control of DBB, included: a) configuration of the boat ramp and water outfall, b) completion of the boathouse with its winch installation, c) procurement of the boat, and d) assignment of the boat operator.

## *Contacts with Mike Degan, Foreman, Jebel Ali 'G' Power Station Project, Dutco Balfour Beatty (Pvt) Ltd.*

George Kingsbury and the KPF REP had daily contact with Mike Degan who was instrumental in coordinating DBB support for some of the work.

## *Closing Meeting*

On Saturday, 18 December 1993, the KPF REP met with Peter Fisher (CDC), George Kingsbury (CDC), Iain Bell (DBB) and Mike Degan (DBB Foreman) to review the status of actions and future plans. Principal action items include the following:

- ***Mooring Buoys in approachway to boat ramp:*** In addition to mooring points already placed on either side of the foot of the boat ramp, DBB is to fabricate and place two steel plate anchors, and CDC will use them to secure two mooring buoys in the approachway to the boat ramp. The buoys are to be placed along a line extending out to sea from the foot of the boat ramp. The first buoy is to be placed approximately at the mouth of the approachway, and the second approximately 200 m farther out into the Gulf and beyond the surf zone.

The operational plan for return of the boom to the boathouse is now is as follows:

1. The boat crew tows the forward end of the boom loop to the outermost buoy and temporarily secures it there.
2. The boat crew then picks up the trailing end of the boom loop and takes it to the innermost buoy where it is attached to a line from shore that has been secured there earlier.
3. The boat and crew then return to the outermost buoy and reattach the end of the boom to the boat using the towing adapter and bridle assembly.
4. The boat is then operated to maintain light tension on the boom and guide it away from the rocks while the boom is pulled onto the boat ramp using the winch which is to be installed at the boathouse.
5. The boat ramp does not line up exactly with the seaward approach, so some method is needed to redirect the tension and keep the boom away from a concrete seawall next to the ramp. The KPF Rep suggested securing a KEPNER BOOMVEYOR™ near the foot of the ramp as one option they might consider. A vertical-axis roller mounted in the same location would be another possibility.

- ***Skirt lifting system:*** As discussed elsewhere in this report, CDC's crew experienced some difficulty lifting the boom skirt by hand. The KPF Rep described, for the group, a proposed system using a winch on the foredeck of the boat to assist in lifting the boom skirt and in binding it in place to secure it for towing. (See Figure 1.)

- ***Anchor buoy attachment system:*** The KPF Rep also described a proposed system using the same winch mentioned above to facilitate pulling the anchor buoys and boom anchor points together when hooking up the boom at the water intake site. (See Figure 2.)

- ***Training:*** The KPF REP was advised that his services were not be needed to train the plant operators at this time.

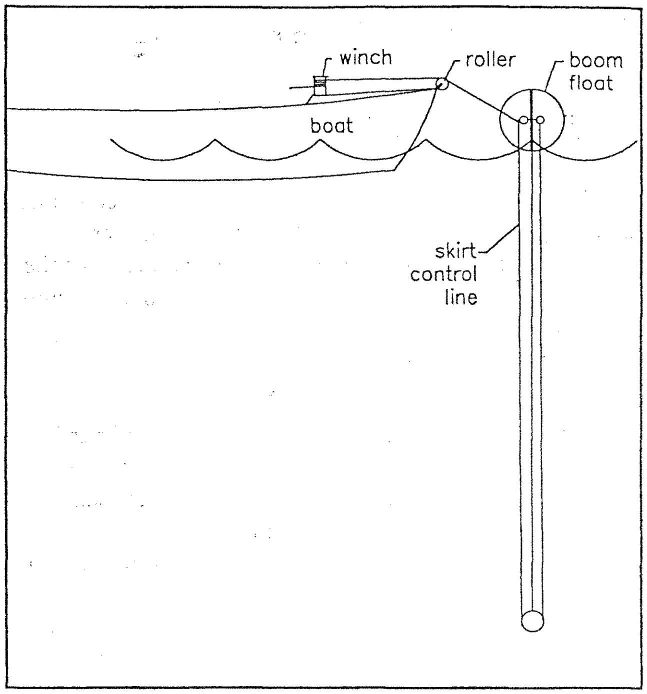

***Figure 1.*** *A winch mounted on the foredeck of the boat could be used for pulling up on the skirt control lines during the initial raising of the skirt, and also for assisting in tightening the line while it is being wrapped around loose segments of the skirt to bind them in place.*

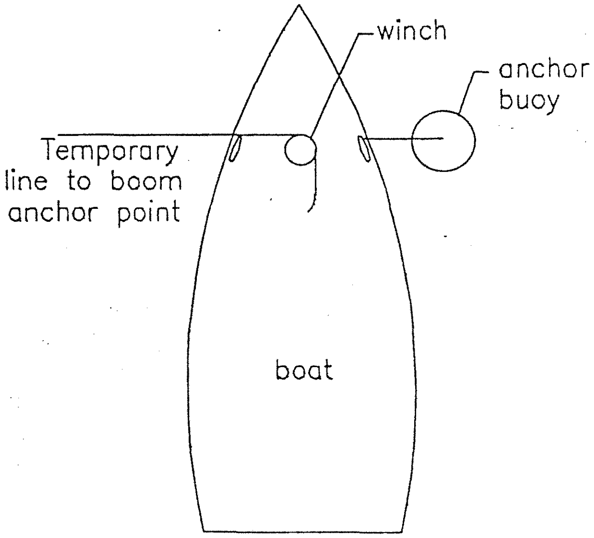

***Figure 2.*** *The same winch mounted on the foredeck of the boat would facilitate pulling the boom anchor points and the anchor buoys together.*

# Observed Operations

## *Opening of Containers and Inspection of Boom System*

On Sunday, 12 December 1993. The boom containers were moved to a site near the boat ramp and a crew of 5 men was assigned to open the containers and remove their contents for examination and inventory. Photo 2 shows the boom system containers immediately after opening.

## *Assemble Boom System*

Monday, 13 December 1993, was devoted primarily to assembling the boom system. The boom went together well but progress seemed slow. Because of the language barrier and the workers' lack of experience with oil containment boom and its functions, the workers required considerable time to comprehend some procedures. Once they understood and recognized a pattern in their tasks, the work went more quickly. Assembly of the boom system was complete by Tuesday morning, 14 December 1993, and the assembled boom was lined up on the boat ramp for launch. (See Photos 3, 4 and 5).

## *Launch Boom System*

The boom system was launched on Wednesday morning, 15 December 1993, and towed to the site. The process went reasonably well considering it was the first run with an inexperienced crew.

The boat operator encountered some difficulty while approaching the boat ramp. He had never operated a boat this large before, nor one with twin engines, so his response was slow and not always appropriate. His limited understanding of English contributed to the problem.

The boat ramp area presents some challenges because it shares the site of a large water outfall from the power plant, as shown in Photo 6, and consequently the approach to the boat ramp is full of eddies. Large jagged rocks on either side of the channel increase the risk. As discussed elsewhere, DBB is installing some mooring devices in the approaches to the boat ramp to make it easier for the boat operator to hold position while the towing bridle is hooked up.

Future plans for the site involve removal of the jetties and substantial increases in the outfall discharge rates.

## *Deployment of the Boom System to the Water Intake Site*

Once the boat and boom were under way there was no further problem maneuvering, and the boom was quickly relocated to the water intake site offshore, as shown in Photos 7 and 8.

## *Attachment of the Boom to the Anchoring System*

Attaching the boom to the mooring buoys at the water intake site presented some difficulty, but with modification of some of the equipment as discussed elsewhere, this should go more quickly next time. Photos 9 and 10 respectively show positioning of the boom and the boom in place around the water intakes.

Prior to launch George Kingsbury had marked the anchor points where he intended to attach the boom to the anchor buoys. This proved to be a very good idea. Also, it was discovered that once the first one or two attachments are made it is usually easier to move the mooring buoys to the boom than try to move the boom to the buoys. In a stronger wind or current situation the operators may have had great difficulty completing some of the hookups. A plan for facilitating this process is discussed elsewhere in this report.

## *Lowering the Skirt*

There was some difficulty getting the skirt down. Prior to launch the boom handling crew had sprially wrapped the free end of the skirt lifting ropes around the boom and in the process the boom handlers tied some knots that proved difficult to undo in the water. This would be easily corrected on shore before the next launch.

Secondly, it was elected to leave the small temporary tie lines around the boom until it was in position at the water intake site. This may have been a mistake, as they would have been easier to remove while the boom was on shore. Cutting the ties had to be done very carefully to avoid puncturing the boom fabric. Again, this should be corrected before another launch is undertaken .

Only about one section of the boom skirt was actually lowered during this operation because of the difficulties experienced in lowering it and the anticipated difficulty in raising it.

The crew found lowering the boom to be much easier to do if one or two people in the water. This was not a problem for CDC because they had a diving crew on site. It may be a problem for the plant operators, however.

## Inspection and Evaluation of Boom Performance

Once the boom was in place observations and photographs were made of its performance. The CDC tugboat made one complete circuit of the boom site at full throttle to observe roll and heave response characteristics in the tug's wake. The boom appeared to perform quite well. (See Photos 11–13.)

## Raising the Skirt

Late in the day Wednesday, CDC's crew raised the previously-lowered portions of the skirt by lifting the skirt control lines. This proved to be quite difficult for two men. They were, however, able to start securing the intermediate sections of the skirt between anchor points before the end of the day. On Thursday morning the CDC diving crew finished securing the raised skirt of the boom and proceeded to bring it back in at about noon. (See Photos 14 and 15.)

A proposed system to facilitate raising the skirt is described elsewhere in this report.

## Towing the Boom to Shore

As shown in Photo 16 the trip to shore was uneventful, except it was noted that the *shamal* (strong wind) that had been predicted to arrive at noon was right on schedule.

## Landing the Boom

By the time the boat arrived at the boat ramp with the boom in tow the *shamal* was blowing briskly from the northwest and was starting to pile up some seas.

The crew had originally planned to tow the forward end of the boom to the entrance of the boat ramp/water outfall facility and pass a tow line to men on shore who could take the line to the boat ramp and pull the boom in. The boat was then to pick up the rear of the boom and apply enough tension to keep it off the rocks. However, as the boat was getting into position, the rear bight of the boom was being blown east past the jetty and onto an adjacent beach. (See Photos 17 and 18.)

From there Mother Nature had her own plans for bringing the boom ashore, and the entire boom soon was spread out along the beach as shown in Photo 19.

The CDC people quickly rounded up a small army of workers who managed to lift the boom up onto the upper beach, away from the water. (See Photos 20 and 21.) A bulldozer working nearby was borrowed to help smooth the upper beach and remove debris.

The boom was arranged in a zigzag formation to facilitate moving it west along the upper beach by hand. By the end of the day progress was being made in walking the boom off the beach.

The transfer of the beached boom to the boat ramp was completed on Friday morning, 17 December 1993.

## Cleaning and Inspection of the Boom

On Friday, 17 December 1993 the boom was washed and drained, and the skirt was secured with additional wrappings. (See Photo 22.) A careful inspection of the boom by George Kingsbury and his workmen confirmed that the boom received no damage. Mr. Kingsbury commented that this reflects well on the durability of the SEACURTAIN™ boom system.

# Training Provided

## *Review of Steps for Deployment and Recovery of the Boom System*

During the opening meeting the KPF REP acquainted those present with techniques commonly employed for combating oil spills in the marine environment, and described the steps that would be involved in deploying and recovery of the SeaCurtain™ exclusion boom system.

## *Boom Handling on Shore*

After removal of the boom from its shipping containers it was necessary to relocate the boom to the boat ramp where it could be assembled and launched. The KPF REP instructed the shore crew in how to first arrange the boom in a zigzag formation to facilitate orderly and systematic movement. The language problem slowed this instruction, but by breaking the tasks down into small increments, providing methodical demonstrations, and carefully monitoring progress they were successful in accomplishing the objectives.

## *Skirt Lacing*

One man was selected who communicated well in English, and he was instructed on skirt lacing procedures, using the Kepner Plastics training aid provided. (See Photos 23 and 24.) That man then instructed others, using their own language.

## *Preparation of a Training Manual*

To facilitate classroom instruction for the operators who will be assigned to deploy and recover the SeaCurtain™ exclusion boom system, the KPF REP proceeded to write some text for a training manual. Late during his stay at Dubai it was decided that he would not be required to instruct the operator's crew. (The assignments to the crew have not yet been designated.) For future use CDC and DBB requested a copy of what was prepared. In the time available the KPF REP was not able to complete a stand-alone document, but the draft text should provide a good starting point for future development of a training manual and is included as Appendix B of this report.

# Recommendations Provided to Operating Crew

## *Towing Adapter*

Iain Bell had some papers from Kepner describing a suitable towing adapter. He sent copies to the DBB shop to fabricate. The item the shop produced was nothing like the pictures, and in fact would not work properly if we tried to use it. Mr. Bell sent it back with instructions about following the drawing more closely.

Meanwhile, because of time constraints, George Kingsbury had a towing adapter fabricated in the CDC shop. What they produced had galvanized rather than stainless steel parts, but it would have worked fine. In the end a hybrid of parts from each shop was used. (See Photo 25.)

At the connection chosen for the towing bridle the connector plates were turned for both adjacent sections to the outside of the loop, as shown in Photo 32. A special pair of shackles were fabricated for the purpose.

## *Bridle*

The KPF REP discussed the options of using a tow post on the boat or a bridle. The bridle was easier to rig so that is what was selected for initial operations. The bridle DBB and CDC had intended to use was to have a fixed apex. The KPF REP pointed out that during a turn, the inside leg of such a bridle would go slack, placing all the tension load on side of the boat facing the outside of the turn and making it difficult to steer. In a sharp turn the slack line might even get down into the propellers. Some bridle rigs actually use a sheave at the apex of the bridle to make the tow line move along the bridle line more easily.

For long term use the KPF REP recommended they consider installing a tow post on the centerline of the boat just forward of the engines. He pointed out that bridles generally don't work as well as tow posts; they tend to twist up and bind, and/or get caught in the propellers.

# Specific Project Problems and Recommendations for Rectification

## *Language Problems*

Few of the workers knew more than a few words in English, and in fact the workers spoke a variety of dialects, so there was no common language among them. This effectively precluded verbally explaining a process to them. One would need several interpreters all shouting the same thing in different languages! Complex tasks had to be demonstrated in small incremental steps.

There is no easy solution to this problem, but planning must take it into account and allocate plenty of time to the low end of the learning curve.

## *Wind and Sea State*

From late Sunday, 12 December 1993 through Monday, 13 December 1993 the weather remained essentially unchanged, with troublesome winds and waves in the approaches to the boat ramp that could swamp the boat if the crew tried to launch the boom or return it to the ramp. From Thursday noon on similar wind and sea conditions prevented boom deployment and recovery.

Suggested actions to alleviate these problems include:

- Extend one or both jetties into deeper water to prevent breaking waves from forming in the approachway. Advice of a competent coastal engineer should sought. (DBB indicated this could not be considered.)
- Place mooring points within the boat approach as discussed in the closing meeting described earlier in this report. (This action is being taken by DBB.)
- Complete the boat house and install the winch as planned. (This action is in progress.)
- Provide a boom retrieval device, such as the BOOMVEYOR™ manufactured by KEPNER, to assist in pulling the boom up on the ramp. (See Appendix C.) As discussed earlier, a roller might also be used to redirect forces on the boom.
- Under high surf conditions which would prevent the boat from approaching the boat ramp, a diver might deliver a boom tow line to the outermost channel buoy or directly to the boat operating beyond the surf line.

The KPF REP suggested that boom launching and recovery operations not be attempted until at least the second and third items above are accomplished.

## *Anchor Buoy Installation Delays*

Early in the week the wave action offshore produced essentially zero underwater visibility. Divers were unable to safely work so near the active water intakes until Wednesday morning, 15 December 1993, when they were able to quickly complete the installation. As it turned out this did not delay the project because the boom could not be brought to the site until the boat operator showed up. However, had other work gone more quickly, lack of the anchor buoys may have been of concern. In any case, the buoys *are* permanently installed at this time so no further action is needed.

## *Boat Operator Deficiencies*

CDC representatives advised that under present contract arrangements DBB was responsible for providing a boat operator. A boat operator should have been made available on Tuesday, 14 December 1993, but none appeared until Wednesday. About 6 hours of weather window were lost because of this. In retrospect, had the boat operator been available earlier, the beaching of the boom might have been avoided. (But the lessons from the beaching experience would then not have been learned.)

## *Anchoring dimensions*

Because of the vagaries of tides and chain catenaries, the boom will not be precisely where the plan shows as shown on the "Plan on Oil Containment Booms" detail on Dutco Balfour Beatty 'G' Drawing No. 10090-HA-S-12242 revision D. Additionally, the lengths specified for the polygon sides are not quite in agreement with the distance between anchor points on the boom (about 7.8 meters).

As part of the commissioning, it may be desirable to leave the boom in place through several tidal cycles and watch how it performs, how near it gets to the water intakes, and such.

## *Attachment of Boom to Anchor Buoys*

As discussed in the account of the closing meeting, attachment of the boom to the anchor buoys can be expedited with a winch and a pair of snubbers or cleats on the boat. (See Figure 2.) The winch should be mounted on the foredeck perhaps 0.5 m aft of the bow and on the centerline. The snubbers or cleats should be mounted on each gunwale directly abeam (port and starboard) of the winch.

To use this system a 25-m (approximate) line should be prepared with a snap hook at its end. The hook is attached to the boom anchor point and the other end retained on board the boat. The boat is then moved to the targeted anchor buoy and the anchor buoy connecting line attached. The other end of the connecting line is pulled in and temporarily attached to the closest snubber or cleat. The line connected to the boom is then passed around the winch head with the appropriate number of loops, and the winch is activated until the anchor buoy line is close enough to attach to the boom anchor point, whereupon the 5-m line can be retrieved and the boat cast off.

### *Skirt manipulation*

The winch discussed in the previous paragraph can also be used to help draw tight the boom skirt control lines. To raise the skirt, the boat bow is nosed over near an anchor point and the free end of the skirt control line is passed through the sheave on the boat's bow. Appropriate turns are taken around the winch and it is activated to raise the skirt, as shown in Figure 1.

It would also be useful to attach snubbers to each of the boom hinge points, then this same system can be used to help tighten the helical windings of the skirt control line to secure the skirt in a raised position.

### *Storage*

The KPF REP recommended that for the immediate future the boom be stacked near the boathouse and covered with a tarp. It should be moved indoors when the boathouse is completed—which is supposed to be in a few weeks.

## Other Pertinent Information and Observations

- This operation would have been much easier if it could have been done after the boathouse is completed. For that matter, without the boathouse the planned demonstration deployment cannot truly represent operations as they are ultimately intended to be conducted.
- The power plant operators should be made aware of the need for training and frequent exercises in deployment and recovery.
- Peter Fisher, CDC, had originally hoped to be able to demonstrate boom deployment and retrieval for his clients on Wednesday, 15 December 1993, but this became impossible because of wind and sea conditions, and difficulty getting the boat and boom safely through the surf zone. As it turned out, weather and facility configurations also precluded demonstrations later in the week.

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# DRAFT

# The Jebel Ali "G" Seawater Intake SEACURTAIN™ Oil Exclusion Boom System: Draft Training Manual

*The following manual is provided as a courtesy and was not required by the contract.*

## Jebel Ali "G" Seawater Intake SeaCurtain™ Oil Exclusion Boom System

This section describes special procedures for the assembly, deployment, and recovery of the Jebel Ali "G" Seawater Intake SEACURTAIN™ Oil Exclusion Boom System.

These procedures were designed specifically for a special deep-skirt boom manufactured by KEPNER PLASTICS FABRICATORS, INC, of Torrance, California, U.S.A., for protection of a water intake structure at the Jebel Ali "G" site near Dubai, United Arab Emirates. Much of what is discussed here will not be applicable for other oil containment boom installations.

### Background on Oil Spill Response Boom

Spill response frequently involves use of oil spill response boom, also called containment boom. Spill containment boom is a floating barrier device that functions to prevent or constrain the movement of spilled oil. Figure 1 shows a typical cross-section view of an oil spill containment boom.

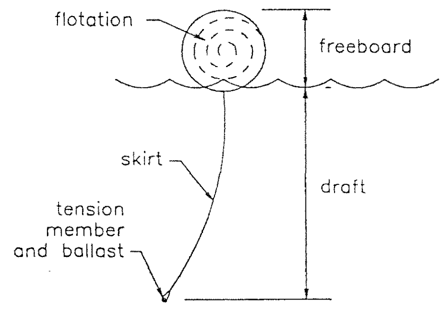

*Figure 1: Cross-section of a typical oil spill response boom showing its component parts.*

The following are definitions which apply specifically to oil spill response boom and boom handling:

$^1$**aft** (${}^2$ft) *adv*: behind, from behind, near the stern of a vessel

$^2$**aft, after** (${}^2$ft"...r) *adj*: rearward

**anchor point** *n*: a point on a boom designed for the attachment of an anchor or mooring line.

**ballast** *n*: heavy material attached to the SKIRT which helps the BOOM resist overturning and float more or less vertically in the water.

**bridle** *n*: a device for distributing the tensile load between a boom and a boat or mooring attachment.

**boom** *n*: floating barrier which prevents or constrains the movement of spilled oil

**cleat** *n*: a metal or plastic fitting, usually made with two projecting horns around which a rope may be fastened

**draft** *n*: the vertical dimension of the portion of a BOOM that extends below the waterline

**end connector** *n*: device attached to each end of a boom SECTION that is used for connecting adjacent sections together

**flotation** *n*: part of the boom containing air or light-weight material which provides buoyancy to support the boom in the water

**freeboard** *n*: the vertical dimension of the portion of a BOOM that extends above the waterline

**handhold** *n*: a device or location on a boom where it can be grasped by hand

**hinge** *n*: location where a boom is constructed so it can be folded back upon itself to facilitate storage.

**lifting point** *n*: an attachment or location designed for lifting, as with a crane.

**membrane** *n*: impermeable material which acts as a barrier to the movement of floating oil [see SKIRT]

**section** *n*: a portion of boom with an END CONNECTOR on each end

**segment** *n*: repetitive, identical portion of a boom section

**skirt** *n*: the portion of the MEMBRANE below the waterline

**stiffener** *n*: a component which provides support to the membrane to resist folding or bending

**tension member** *n*: part of a BOOM that provide axial tensile strength {Tension members are commonly made of stainless steel cable or galvanized chain.}

**towing adapter** *n*: device for connecting a towing line to a boom

## Training

As with any complex procedure involving cooperative actions by many individuals, teams must be well trained and drilled before they can conduct operations safely and efficiently. It is recommended that designated individuals employed by the operator have relatively long-term assignments (e.g. several years) on the exclusion boom team, and that training and unannounced exercises in boom deployment and recovery be conducted at least semiannually under different weather and sea conditions. If team performance is judged weak in some areas, additional practice should be considered.

## Description of boom

The Jebel Ali "G" Seawater Intake SEACURTAIN™ Oil Exclusion Boom System is made up of six sections of boom which can be connected into a continuous loop.

Each section has a total length of approximately 62.8 meters. Sections are divided into 24 segments of approximately equal size.

Each segment is provided with a cylindrical float approximately 356 mm in diameter and 2.4 m long, covered with yellow polyurethane coated fabric. Floats are separated by short hinge pieces where the boom can be readily folded back upon itself. An anchor attachment point is provided in every third hinge.

Beneath the bottom of the floatation units is a continuous skirt consisting of (from top to bottom) approximately 914 mm of polyurethane coated fabric, 7620 mm of ½-in × ½-in mesh, and 610 mm of polyurethane coated fabric.

A galvanized steel chain is sewn into a continuous pocket in the bottom of the skirt to serve as ballast and to provide additional tensile strength.

The ends of sections are joined near the waterline by bolts which pass through aluminum bars sewn into pockets in the boom. The skirts beneath are joined by lacing with a 3/8-inch nylon lacing lines which pass through brass grommets set in the boom fabric.

When the boom is moored in place, the skirt can be raised and lowered using 3/8-inch nylon skirt control lines.

## Assembly

Assembly of the boom involves the following steps:

1) Open the shipping containers.
2) Inspect and inventory the contents of the shipping containers, noting any missing or defective items.
3) Arrange the boom sections in the launch area.
4) Bolt the section end connectors together and incorporate the towing adapter in the assembly of one pair of sections.
5) Lace the skirts of adjacent sections together.
6) Using the free ends of the skirt control lines, wrap the boom helically to provide support for intermediate portions of the skirt while the boom is being moved to the site. While the boom is still on land, remove any temporary ties placed by the manufacturer to hold up the skirt.
7) Chains at the bottom of the skirt sections are connected using the shackles provided.

## Deployment

The procedure described here is based on the assumption that the boom system is permanently assembled in a loop and stored in the boat storage building adjacent to the boat ramp.

Recommended team composition for the deployment procedure are shown on the below list. It is expected that personnel assigned to these spill emergency positions will have a regular position somewhere in the plant from which they can be quickly reassigned in the event of a threatening spill or during training and drills. The suggested manning level shown is in parentheses is provisional. Experience gained during drills may indicate need for adjustment of these numbers either up or down.

- **Boom Deployment and Recovery Supervisor** (1).
- **Boat Operator** (1).
- **Boat Crew Members** (2).
- **Boom Handling Team Leader** (1)
- **Boom Handling Team Members** (8)

Specific procedures to be followed include the following steps:

1) The boat crew launches the boat with the assistance of the boom handling team. The boat should have the following items on board:
    - all mooring lines
    - appropriate spares
    - boat hook
    - radio suitable for solid communication with the team leader on shore
    - personal flotation device for each person on board
    - food and water for the crew
    - fuel for the boat
2) The boat and crew proceeds to a location where it can safely stand by.
3) The boom handling team secures tarpaulins, polyvinyl sheeting or similar material on the surface of the ground and boat ramp to protect the boom from abrasion.
4) The boom handling team slides the towing end of the boom loop (where the towing adapter has been attached) down the boat ramp to a position close to the water's edge. Each side of the boom loop is then brought down its respective side of the boat ramp and placed with boom segments laid in a zigzag pattern.
5) The boat crew brings the boat near shore and with the assistance of the boom handling team
6) attaches the towing bridle between the boat and the boom towing adapter.
7) The boat crew tows the boom away from the boat ramp while the boom handling team guides it to prevent damage. Once the boom is free from shore the boom handling team can be released to their normal duties until they are called upon to assist in recovery and storage of the boom system.
8) The boat crew tows the boom system to the water intake structure site, approaching the site from down current.
9) The boat crew attaches one of the boom mooring lines to the nearest boom mooring eye and makes it fast to the boat. The towing bridle assembly is then disconnected from the boom and from the boat and brought on board, taking care that the boat's propellers are not fouled in the process.
10) The end of the boom mooring line not attached to the boom is brought to the nearby anchor boom and attached. The free end of the boom assembly is then temporarily allowed to drift with the current.
11) The boat crew then moves to successive anchor buoys along the seaward side of the water intake. At each such anchor buoy the closest anchor eye is attached to the buoy using one of the prepared mooring lines. The attachment sequence shown can be modified to accommodate different current conditions. If assistance is required to pull the boom anchor point and the anchor buoy close enough to hook up.
12) The boat crew then repeats the procedure described in the last step for all anchor buoys along the shoreward side of the water intake structure.

## Dropping the skirt

1) Beginning at any convenient point along the boom loop, the boat unwraps the end of the skirt control line which had been used to bind up the skirt.
2) The boat crew then pays out the skirt control line allowing the skirt to lower.
3) The boat crew repeats this process at successive segments around the boom until the entire skirt has been lowered.

4) The boat crew then takes the boat to an appropriate mooring site near shore, whereupon the boat crew can be released to return to their regular assignments until called to assist in boom recovery operations.
5) The condition of the boom should be monitored at least twice daily while it is in use. If problems are noted, appropriate corrective steps should be taken.

## Recovery

Procedures for recovery of the deployed boom system are included in the below-listed steps. If wind and sea conditions are poor, consideration should be given to leaving the boom in place until conditions improve.

1) **Raising the Skirt.** The boat and boat crew work successively around the anchored boom raising the skirt by manipulation of the skirt control lines. Assistance in raising the skirt can be provided with a winch on the bow of the boat.
2) **Securing the Skirt.** The boat and boat crew make a second circuit of the boom. For each span of boom between skirt lifting points the free end of the skirt control line is wrapped helically around the boom and skirt, and brought up snugly to support intermediate portions of the skirt. Assistance in synching up the line can be provided by the same winch described previously. The free end is then tied off to the next skirt lifting point
3) **Casting off the Boom.** The boat and crew next remove and retain on board all mooring lines *except the mooring line farthest up current.* The boom is temporarily allowed to trail from the remaining mooring line.
4) **Attachment of Towing Bridle.** The boat and crew next proceed to the end connectors where the towing adapter is attached. There the crew assembles the towing bridle attaching the boom to the boat.
5) **Towing to Shore.** The boom is then towed to shore, taking care to keep well clear of obstacles.
6) **Landing the Boom.** The boat crew brings the forward end of the boom to the outermost buoy and temporarily secures it there.
7) The boat crew then picks up the trailing end of the boom and takes it to the innermost buoy where it is attached to a line from shore which has been secured there earlier.
8) The boat and crew then returns to the outermost buoy and attaches to the end of the boom using the towing adapter and bridle assembly.
9) The boat is then operated to maintain light tension on the boom and to guide it away from the rocks while the boom is pulled onto the boat ramp using a winch at the boathouse.
10) The boom handling crew places it in a zigzag pattern.
11) Once the seaward end of the boom is out of danger of being damaged, the boat casts off.

## Cleaning and inspection

While on the boat ramp the boom should be carefully washed with fresh water and inspected for damage.

## Maintenance and repair

Any tears in the fabric should be repaired following the manufacturers recommended procedures. Damaged or missing hardware should be replaced.

## Storage

After the boom has drained it should be stored in an orderly fashion in the boathouse. It is recommended that the boom be stored on pallets rather than directly on the floor to allow for any final drainage and for free air circulation to prevent mildew formation.

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Photo 1: Jebel Ali "G" Boat Ramp

Photo 2: SeaCurtain Boom System in Containers

Photo 3: Moving Boom to Launch Site

Photo 4: Positioning Boom on Boat Ramp for launch

Photo 5: SeaCurtain Boom Ready for launch

Photo 6: Jebel Ali "G" water outfall

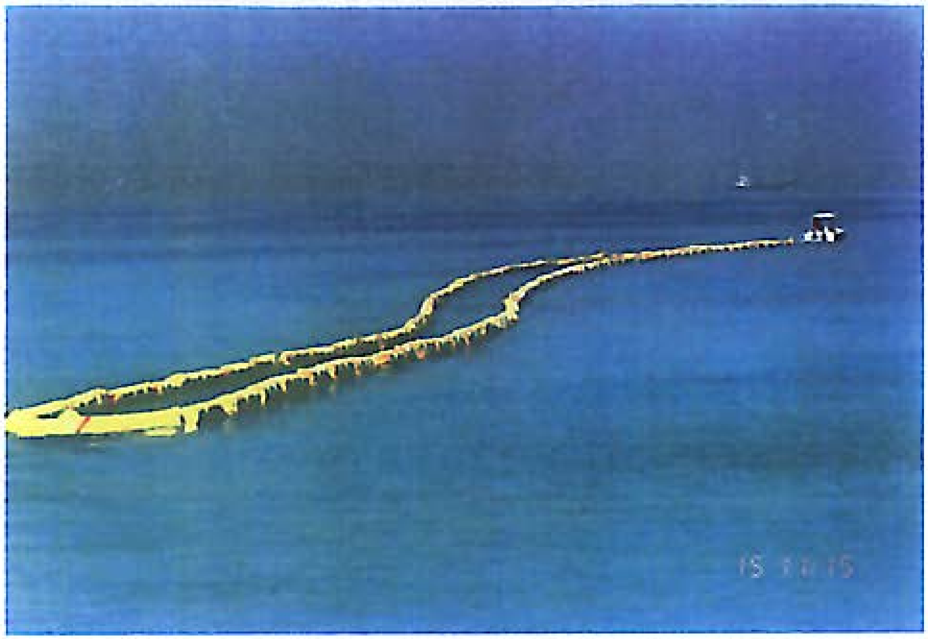


Photo 7: Towing SeaCurtain Boom to Seawater Intake site

Photo 8: Positioning Boom around Seawater Intakes

Photo 9: SeaCurtain Boom positioning around Seawater intakes

Photo 10: SeaCurtain Boom in Position around Jebel Ali "G" Seawater Intakes

Photo 11: SeaCurtain Boom heave and roll response demonstration

Photo 12: SeaCurtain Boom heave and roll response demonstration

Photo 13: SeaCurtain Boom heave and roll response demonstration

Photo 14: Raising the skirt on the SeaCurtain Boom

Photo 15: Towing SeaCurtain Boom towards shore for recovery

Photo 16: Preparing to recover SeaCurtain Boom

Photo 17: *Shamal* blowing SeaCurtain Boom ashore during recovery

Photo 18: SeaCurtain Boom blowing ashore during recovery

Photo 19: SeaCurtain Boom piled up on shore

Photo 20: Removing SeaCurtain Boom from surfline

Photo 21: Positioning SeaCurtain Boom to move to launch area

Photo 22: Inspecting, cleaning and preparing SeaCurtain Boom for next deployment

Photo 23: SeaCurtain Boom Skirt Lacing Training Aid

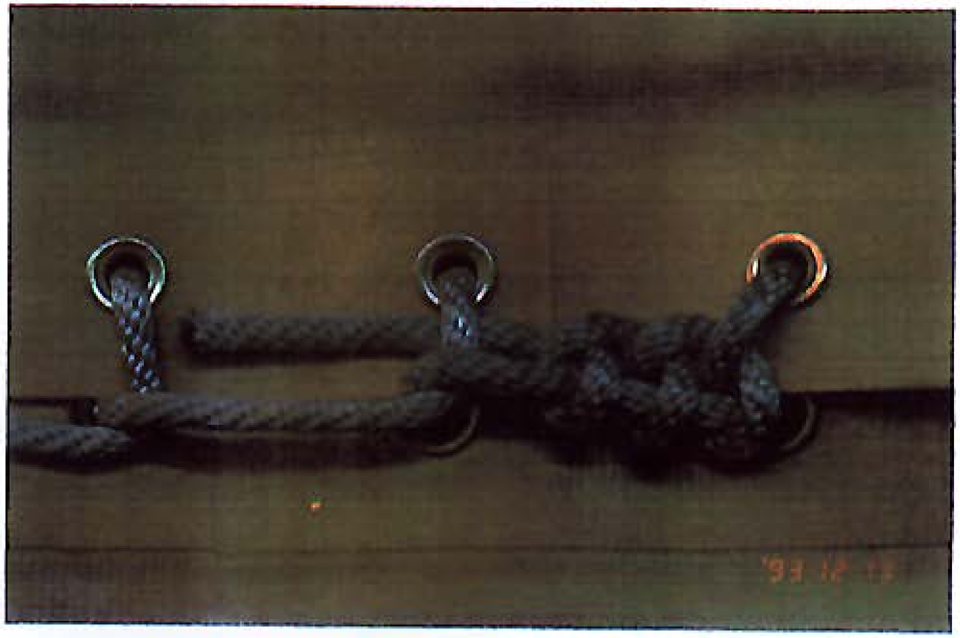


Photo 24: SeaCurtain Boom Skirt Lacing Training Aid

Photo 25: Towing Adapter attached to SeaCurtain Boom

# APPENDIX J

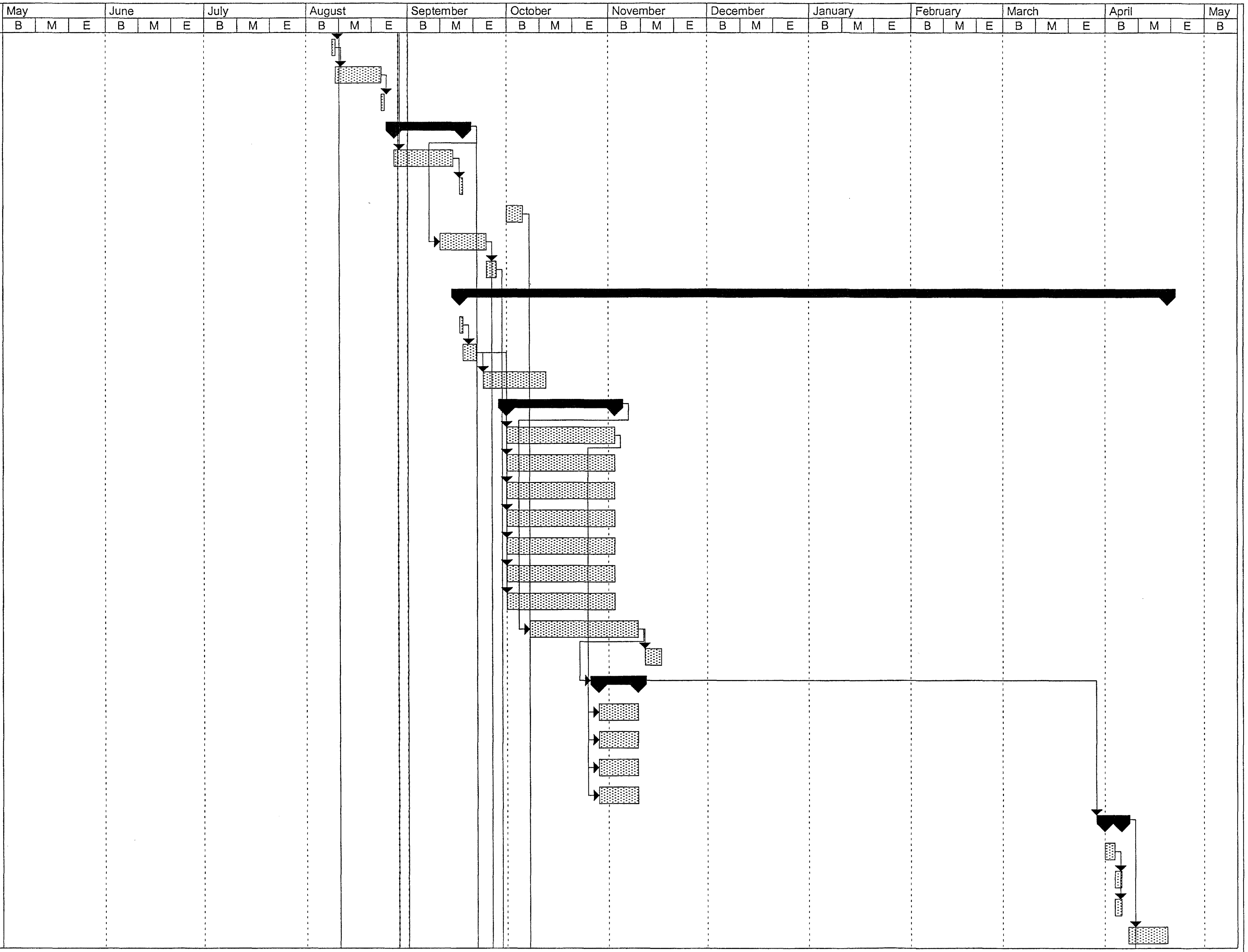
# SCHEDULE

| ID | Task | Task Name | Duration | Start |
|---|---|---|---|---|
| 1 | **100** | **Finalize Design** | **41 days** | **Wed 5/9/01** |
| 2 | 101 | Submit 90% Phase II for Re | 1 day | Wed 5/9/01 |
| 3 | 102 | Review Phase I and II (Army | 10 days | Thu 5/10/01 |
| 4 | 103 | 90% Issue for Bidding to Arr | 10 days | Thu 5/24/01 |
| 5 | 104 | Review (USEPA & CTDEP) | 10 days | Thu 6/7/01 |
| 6 | 105 | Finalize Phase I and II Desi | 10 days | Thu 6/21/01 |
| 7 | **200** | **Procure Contractor** | **35 days** | **Thu 6/7/01** |
| 8 | 201 | Prepare Bid Documents | 5 days | Thu 6/7/01 |
| 9 | 202 | Issue Bid | 0 days | Wed 6/13/01 |
| 10 | 203 | Bidding by Contractors | 15 days | Thu 6/14/01 |
| 11 | 204 | Contract Award | 15 days | Thu 7/5/01 |
| 12 | **300** | **Phase I Construction** | **87 days** | **Thu 6/7/01** |
| 13 | **301** | **Mobilization** | **5 days** | **Thu 7/26/01** |
| 14 | 302 | Site Office Constructior | 5 days | Thu 7/26/01 |
| 15 | 303 | Decontamination Facilit | 3 days | Thu 7/26/01 |
| 16 | 304 | Heave Platform Install a | 1 day | Thu 7/26/01 |
| 17 | **310** | **Containment Berm @ Bld** | **5 days** | **Tue 7/31/01** |
| 18 | 311 | Remove Berm and Pos | 3 days | Tue 7/31/01 |
| 19 | 312 | Pavement | 2 days | Fri 8/3/01 |
| 20 | **320** | **Sediment and Erosion Co** | **50 days** | **Thu 6/7/01** |
| 21 | 321 | Procurement lead time | 40 days | Thu 6/7/01 |
| 22 | 322 | Install Primary Silt Curt | 2 days | Thu 8/2/01 |
| 23 | 323 | Install Anchors for Silt | 8 days | Mon 8/6/01 |
| 24 | 324 | Install Silt Curtain | 8 days | Mon 8/6/01 |
| 25 | **330** | **Building 5 Demolition** | **15 days** | **Tue 8/7/01** |
| 26 | 332 | Utility Disconnect | 3 days | Tue 8/7/01 |
| 27 | 333 | Asbestos Removal | 5 days | Fri 8/10/01 |
| 28 | 334 | Building Demolition | 5 days | Fri 8/17/01 |
| 29 | 335 | Pavement | 2 days | Fri 8/24/01 |
| 30 | **340** | **Abandon Monitoring Wells** | **1 day** | **Tue 8/21/01** |
| 31 | **350** | **Clear and Grub Causeway** | **2 days** | **Mon 10/1/01** |
| 32 | **360** | **Hotspot Excavation (requi** | **14 days** | **Tue 8/7/01** |
| 33 | 361 | Excavation | 2 days | Tue 8/7/01 |

Project: SAEP Causeway Design
Date: Wed 8/29/01

| | | | | | |
|---|---|---|---|---|---|
| Task | ▨ | Milestone | ◆ | Rolled Up Task | ▨ |
| Progress | ▬ | Summary | ▬ | Rolled Up Milestone | ◇ |
| Rolled Up Progress | ▬ | External Tasks | ▨ | | |
| Split | ........ | Project Summary | ▬ | | |

| ID | Task | Task Name | Duration | Start |
|---|---|---|---|---|
| 34 | 362 | Confirmatory Sampling | 1 day | Thu 8/9/01 |
| 35 | 363 | Laboratory Testing | 10 days | Fri 8/10/01 |
| 36 | 364 | Notice of Acceptance | 1 day | Fri 8/24/01 |
| 37 | **370** | **Building 59 Demolition** | **15 days** | **Tue 8/28/01** |
| 38 | 372 | Building and Foundatio | 14 days | Tue 8/28/01 |
| 39 | 373 | Grade | 1 day | Mon 9/17/01 |
| 40 | **380** | **Weather Station Demolitio** | **5 days** | **Mon 10/1/01** |
| 41 | **385** | **Removal of Oversized Mat** | **10 days** | **Tue 9/11/01** |
| 42 | **390** | **Topographic Survey** | **3 days** | **Tue 9/25/01** |
| 43 | **400** | **Phase II Construction** | **155 days** | **Mon 9/17/01** |
| 44 | 401 | Mobilization | 1 day | Mon 9/17/01 |
| 45 | 404 | Receive Cover Materials at I | 4 days | Tue 9/18/01 |
| 46 | 405 | Fabricate Marine Mattresse | 15 days | Mon 9/24/01 |
| 47 | **410** | **Construct Lower Cover Sy** | **25 days** | **Mon 10/1/01** |
| 48 | 411 | Excavate Soils From Si | 25 days | Mon 10/1/01 |
| 49 | 412 | Place Bedding Gravel ( | 25 days | Mon 10/1/01 |
| 50 | 413 | Place Perimeter Geogri | 25 days | Mon 10/1/01 |
| 51 | 414 | Place Woven Geotextil | 25 days | Mon 10/1/01 |
| 52 | 415 | Place Polymeric Marine | 25 days | Mon 10/1/01 |
| 53 | 416 | Place Rock Fill Toe | 25 days | Mon 10/1/01 |
| 54 | 417 | Place Rock Fill Crest | 25 days | Mon 10/1/01 |
| 55 | **420** | **Grade Causeway** | **25 days** | **Mon 10/8/01** |
| 56 | **430** | **Construct Rip Rap Transit** | **5 days** | **Mon 11/12/01** |
| 57 | **440** | **Construct Upper Cover Sy** | **10 days** | **Mon 10/29/01** |
| 58 | 441 | Place Bedding Sand, C | 10 days | Mon 10/29/01 |
| 59 | 442 | Place Non-Woven Geo | 10 days | Mon 10/29/01 |
| 60 | 443 | Place Interlocking Bloc | 10 days | Mon 10/29/01 |
| 61 | 444 | Place Gravel | 10 days | Mon 10/29/01 |
| 62 | **450** | **Place Vegetative Support I** | **5 days** | **Mon 4/1/02** |
| 63 | 451 | Vegetative Support Soil | 3 days | Mon 4/1/02 |
| 64 | 452 | Seed and Fertilizer | 2 days | Thu 4/4/02 |
| 65 | 453 | Erosion Control Mat | 2 days | Thu 4/4/02 |
| 66 | **460** | **Demobilization** | **10 days** | **Mon 4/8/02** |



Project: SAEP Causeway Design
Date: Wed 8/29/01

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Task | ▨ | Milestone | ◆ | Rolled Up Task | ▨ | Rolled Up Progress | ▬ | External Tasks | ▨ |
| Progress | ▬ | Summary | ▬ | Rolled Up Milestone | ◇ | Split | ⋯⋯ | Project Summary | ▬ |

| ID | Task | Task Name | Duration | Start |
|---|---|---|---|---|
| 67 | **500** | **Waste Management (up to tran** | **54 days** | **Tue 8/7/01** |
| 68 | 501 | Bldg. 34 Berm and Posts | 10 days | Tue 8/7/01 |
| 69 | 502 | Building 5 | 10 days | Tue 8/28/01 |
| 70 | 506 | Causeway Hotspots | 10 days | Mon 8/27/01 |
| 71 | 503 | Building 59 | 10 days | Tue 9/18/01 |
| 72 | 504 | Weather Station | 10 days | Mon 10/8/01 |
| 73 | 505 | Oversized Debris | 10 days | Tue 9/25/01 |
| 74 | **600** | **Project Closeout** | **151 days** | **Fri 9/28/01** |
| 75 | 601 | Final Survey | 1 day | Mon 4/8/02 |
| 76 | 602 | Phase I Completion Report | 15 days | Fri 9/28/01 |
| 77 | 603 | Phase II Completion Report | 15 days | Mon 4/8/02 |