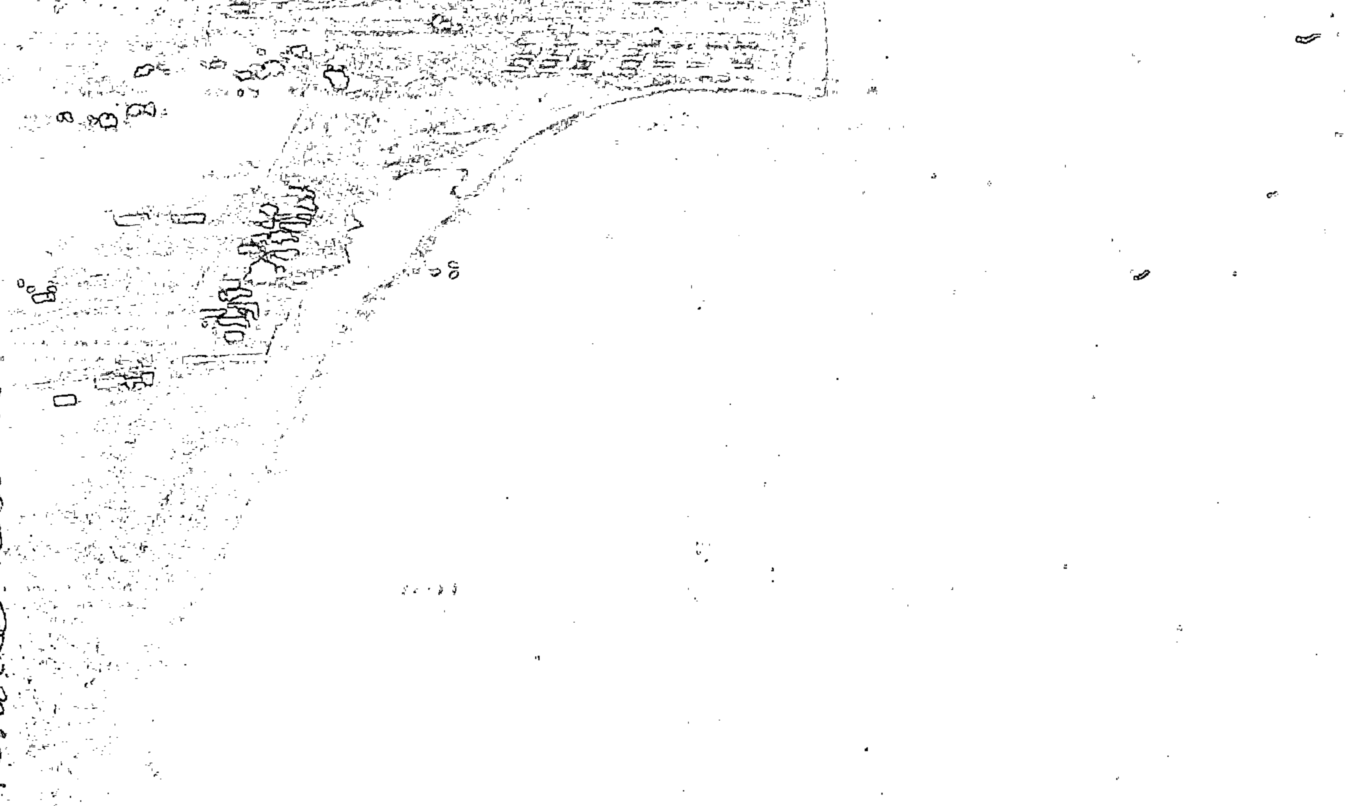
FINAL REPORT

PRELIMINARY ENGINEERING DAVISVILLE PORT EXPANSION

JANUARY, 1981



prepared for

RHODE ISLAND PORT AUTHORITY AND ECONOMIC DEVELOPMENT CORPORATION

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DAVISVILLE PORT EXPANSION
PRELIMINARY ENGINEERING REPORT

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SUMMARY

This preliminary engineering report has been prepared by CE Maguire under contract to the Rhode Island Port Authority and Economic Development Corporation. Its purpose is to develop criteria for design of expanded port facilities at Davisville, Rhode Island to accommodate increased demand for port services resulting from exploratory and production drilling on the North Atlantic Outer Continental Shelf. The study evaluated technical and economic suitability of various selected alternate site configurations, for various projected marine related port users including methods of construction and materials. As a companion to this report an environmental assessment of expansion of the port facilities at Davisville was performed by the Coastal Resources Center of the University of Rhode Island.

The preliminary engineering report investigated the following five major aspects regarding expansion of port facilities:

1. Project Requirements

   Analysis to estimate project requirements included: current and projected trends in modes of commercial cargo handling, shipping routes, vessel sizes and land use requirements; potential users associated with oil and gas development on the Outer Continental Shelf (OCS), their requirements and projected volume; an inventory of current U.S. Navy Amphibious and Cargo Fleets; current and projected fishing vessel sizes and fishing port requirements. The recommended development will provide facilities for OCS supply base operations or domestic shipping as the need arises.

2. Site Surveys

Field surveys were performed to provide base data on existing site conditions. The work included: precise fathometer surveys, subsurface and subaqueous soil borings, laboratory testing of soil samples and oceanographic analysis of the site including wind, waves, tides, and currents.

3. Alternate Site Development Configurations

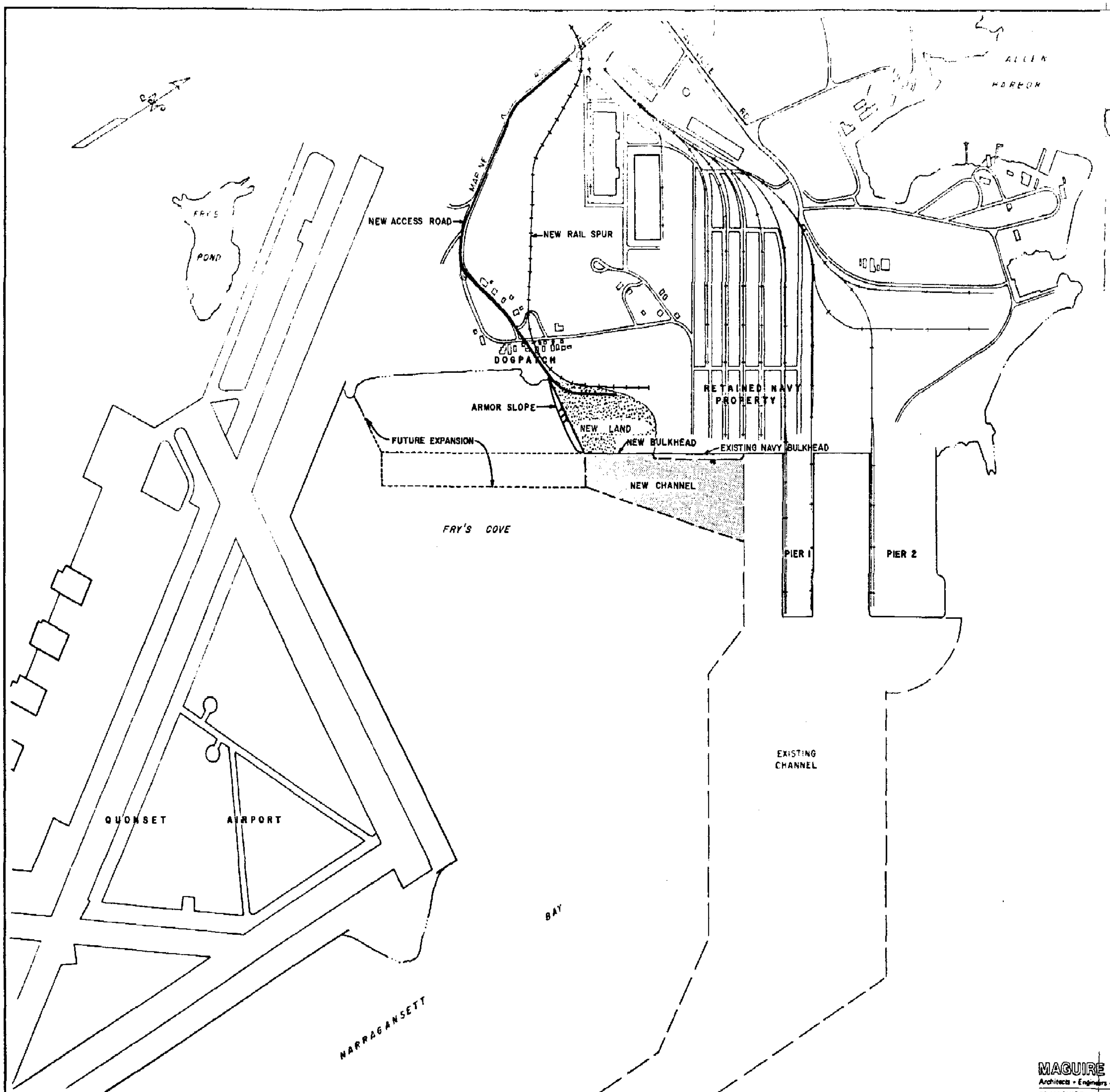
Six primary configurations were analyzed taking into account current land use; oceanographic considerations; geotechnical parameters; environmental factors; dredging and landfilling requirements; budget costs and degree to which the proposed alternate would satisfy operational need. The six configurations investigated: expansion along Dogpatch Beach in one phase and incrementally; filling essentially all of Fry's Cove; expansion north of the existing piers; rehabilitation of the existing Navy bulkhead; and construction of a new pier either pile supported or earth-filled.

4. Alternate Construction Methods

Various waterfront structural systems for providing expanded port facilities were evaluated for the conditions existing at the locations of the configuration alternates. Construction costs were developed for each waterfront construction system to determine the most cost effective development.

5. Recommended Development and Implementation

A program cost estimate and time schedule for implementation of the recommended development was prepared. The recommended expansion of the port, as shown in Figure S-1, will involve the construction of 675 linear feet of new steel sheetpile bulkhead with a dredge depth of Elevation -25 MLW. Approximately 350,000 cubic yards of dredging is required. Of this total 160,000 cubic yards are excess and will be stockpiled on site for future development use. The remaining 190,000 cubic yards will be used to fill a total of 18 acres, 10 acres of which is currently at or below Elev. 0 MLW. The new land will be at Elevation +10 immediately adjacent to the berth sloping up to Elevation +17 at the westward limit of filling. A stone armored slope 700 feet in length will be required to contain the fill. A new access road, railroad spur and utility lines will be constructed to service the expanded port area. Estimated cost of construction for the initial phase is $ 6,071,000, based upon projected September, 1982 prices. Total estimated project cost, including engineering and technical services is $6,513,000. The facilities will be constructed to allow for future expansion of the port. The total expanded port will include 2,400 linear feet of new berthing space. The expansion will involve an additional 550,000 cubic yards of dredging. This quantity along with the 160,000 cubic yards of previously stockpiled material will be used to create an additional 28 acres of land.



AREA: 18 acres of new useable land

DREDGE: 13 acres — 160,000c.y. dredge and stockpile
190,000c.y. dredge and fill

BULKHEAD: 775 l.f. — 675 l.f. useable for berthing

STONE ARMORED SLOPE: 800 l.f.

ROAD:
new 2,300 l.f.
upgrade 2,300 l.f.

RAIL: 4,000 l.f.

WATER: 1,250 l.f.

SEWER: 1,300 l.f.

GRAPHIC SCALE

0 400' 800'

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DAVISVILLE PORT EXPANSION
NORTH KINGSTON, RHODE ISLAND

PROPOSED PORT EXPANSION

SCALE: 1" = 800' | FIGURE NO.: S-1

I

I. INTRODUCTION

A. Requirements for Planning

In 1976, the Department of Economic Development and the Coastal Resources Management Council sponsored a three-day seminar on Rhode Island and Offshore Oil. At that seminar, W.D.C. Lyddou, Chief Planning Officer for the Scottish Development Department, delivered a presentation entitled, Planning Aspects of Oil Related Development. The presentation focused on three distinct points:

- that the atmosphere of uncertainty surrounding oil and gas development demands more, not less planning;
- that such planning should be comprehensive, not just limited to impact analysis;
- that the mystique surrounding oil and gas development hides the fact that what is required is simply good industrial planning, both long-range and near term as well as area wide and site-specific.

The significance of these facts becomes more apparent when the Scottish experience in support of offshore oil exploration and production is reviewed, particularly in view of the similarities in the geographic characteristics between the Scottish coast along the North Sea and New England coast along the North Atlantic.

Had Scotland not anticipated, planned for, and prepared for this influx of economic activity, the outside development forces would have controlled land use planning and the direction of growth.

In anticipation of the growth associated with oil and gas development on the North Atlantic Outer Continental Shelf (OCS), the Rhode Island Port Authority and Economic Development Corporation has authorized CE Maguire to determine the facilities required to expand the port at Davisville and to begin the design of these new structures. The construction of modern, effecient and adequate port facilities at Davisville will enable the Port Authority to control, direct influence and shape the development which offshore support industries will undoubtedly bring. As part of the comprehensive planning being performed by the Rhode Island Port Authority and Economic Development Corporation and its consultants, including CE Maguire, the uncertainty of OCS development has been dealt with as a very real consideration. However, the full scope of the facilities required is difficult to project owing to the uncertainities surrounding the quantities of recoverable oil and gas in Baltimore Canyon and Georges Bank.

B. <u>NERBC-RALI Report</u>

In 1976, a report was prepared by the New England River Basins Commission (NERBC) for project development and application of a methodology for siting on-shore facilities associated with exploration and development of OCS petroleum resources. The report was prepared with the Resources and Land Investigations (RALI) Program of the United States Department of the Interior's Geological Survey. The NERBC-RALI report was prepared to aid New England states and coastal states throughout the nation in planning for the major issues associated with the on-shore industrial development associated with accelerated off-shore oil and gas exploration and production. The New England states, through NERBC, were selected for this national study because, for many years the New England states have shown an extraordinary interest in OCS development. A series of detailed Tech Updates was prepared to accompany the NERBC-RALI report investigating specific aspects of OCS development in-depth.

The NERBC-RALI report presented three primary scenarios dealing in detail with the impact of OCS development on Georges Bank. These scenarios; High Find, Medium Find, and No Find; assumed the following quantities of commercially exploitable hydrocarbons:

High Find Scenario
2.4 billion barrels of oil
12.5 trillion cubic feet of gas

Medium Find Scenario
0.9 billion barrels of oil
4.2 trillion cubic feet of gas

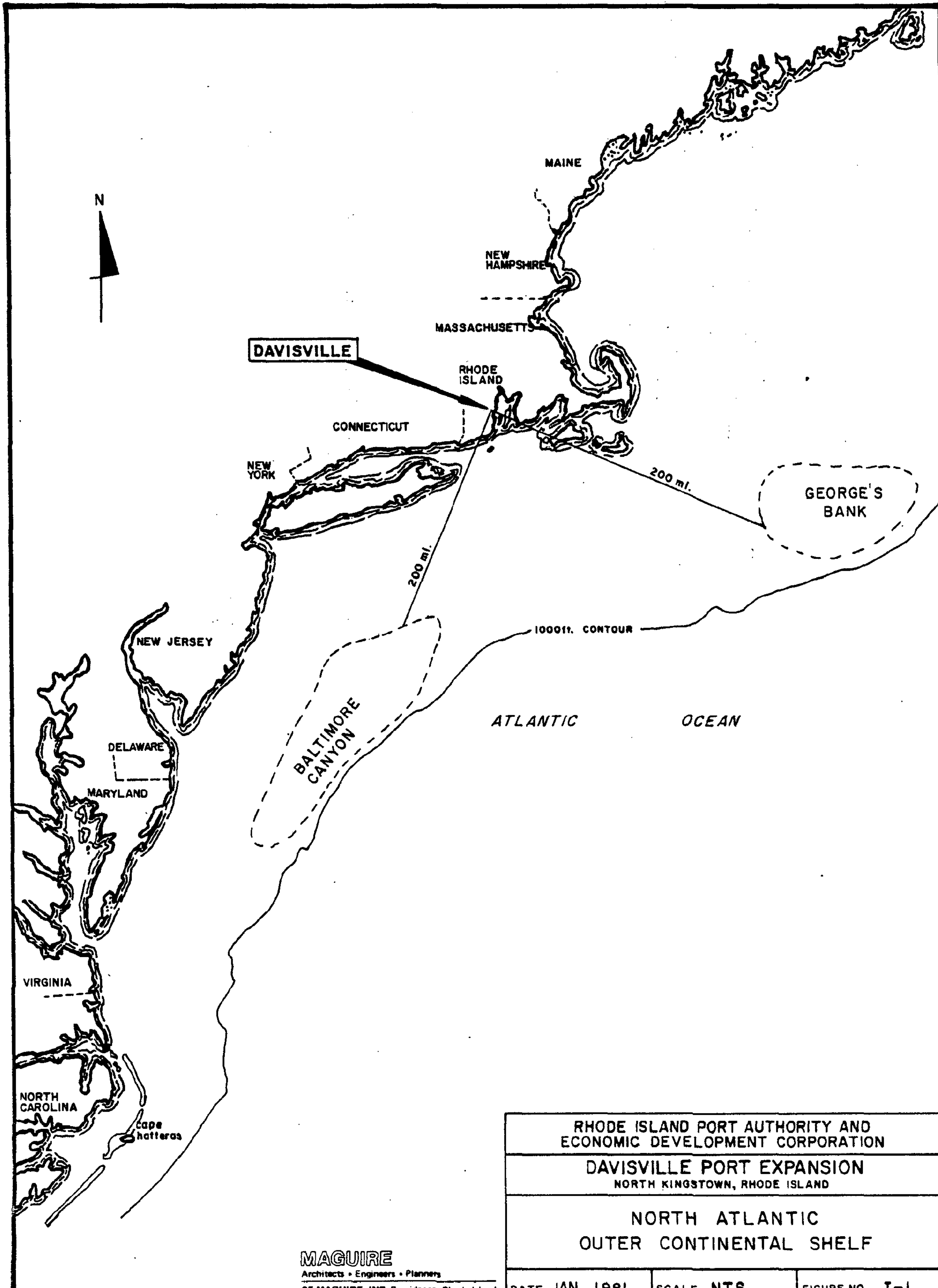
No Find Scenario
No commercially developable quantities are discovered.

These scenarios are based upon statistical studies by the United States Geological Survey. This report has been based upon demands associated with the Medium Find Scenario. Additional information for this report was provided by the Booz-Allen Progress Briefing of June 25, 1980, on Management Alternatives for the Port of Davisville, Rhode Island; the Keyes Associates, March 1977, Quonset Point Technical Park Facilities Study; and the University of Rhode Island, Coastal Resources Center, Marine Technical Report #55, 1977, The Redevelopment of Quonset/Davisville: An Environmental Assessment. These sources were supplemented by site specific requirements obtained from interviews with current and potential users of Davisville including oil companies, platform fabricators, service boat operators, drilling fluid companies, and speciality contractors.

CE Maguire has been charged with the task of evaluating OCS development to establish parameters for the design of port facilities. Given the uncertainties associated with OCS dvelopment these facilities should provide maximum operational flexibility to serve a variety of potential industrial and commercial users including OCS commercial cargo, commercial fishing, and possible use by the U.S. Navy. The major thrust of the early stages of the study was to identify what similarities and differences exist among the various potential users. In the following sections of this report, the various potential users and their requirements are presented. The appendices contain more detailed studies of the current status and future trends of the OCS, commercial cargo and fishing industries.

One common requirement of all ports, regardless of users, is that for a port to remain competitive, it must efficiently and economically service its users. Davisville, Rhode Island, is well located geographically with respect to both Georges Bank and Baltimore Canyon exploration sites being approximately 200 miles from both areas. As shown in Figure I-1, there are no major ports significantly closer. This means that with respect to travel time and distance to and from the drilling sites, Davisville is highly competitive with other port area where service basis could be established.

The ability of supporting intermodal transportation networks to efficiently move products to and from a port is a major factor in its successful operation. Davisville occupies an excellent position in this regard. Davisville is located close to the Interstate Highway System with good connecting routes (Figure I-2). It is also served by rail lines, as shown in Figure I-3, connecting directly to the north-south Mainline tracks in West Davisville. Rail spurs extend to the two existing piers which is a rarity for OCS service basis, but a feature that makes for very efficient loading



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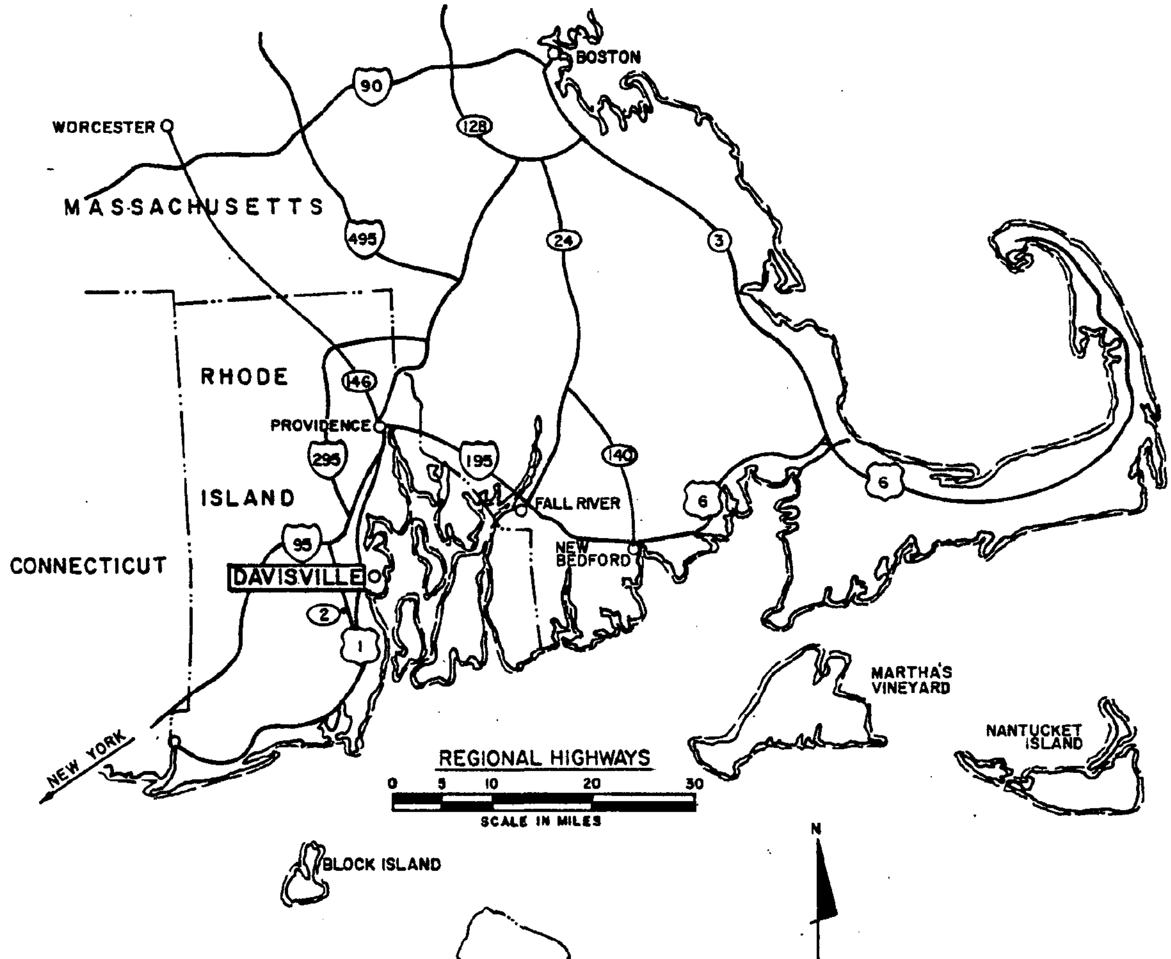
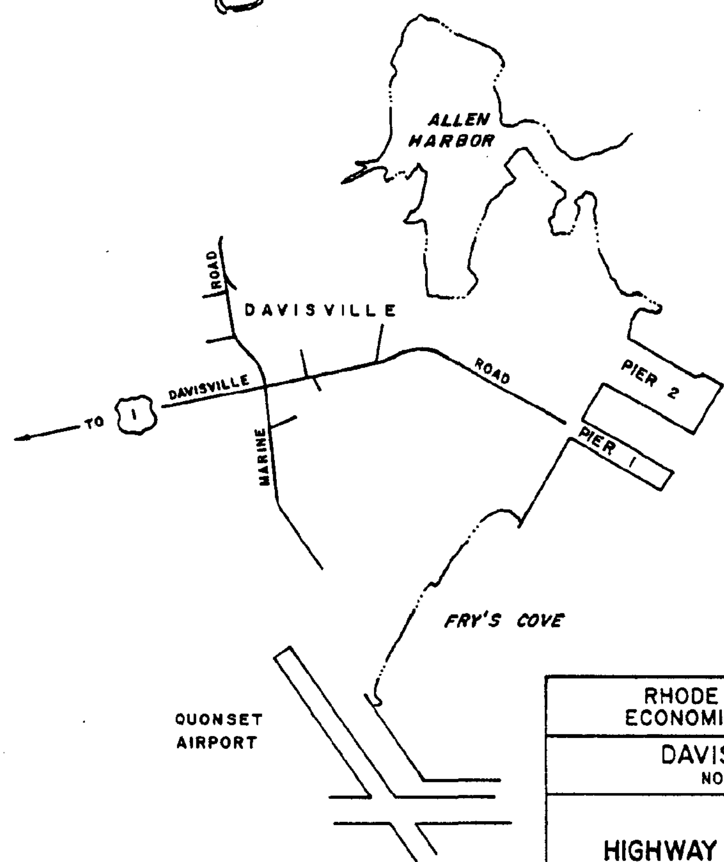
DAVISVILLE PORT EXPANSION
NORTH KINGSTOWN, RHODE ISLAND

NORTH ATLANTIC
OUTER CONTINENTAL SHELF

DATE JAN., 1981	SCALE N.T.S.	FIGURE NO. I-1





LOCAL ROADS
N.T.S.

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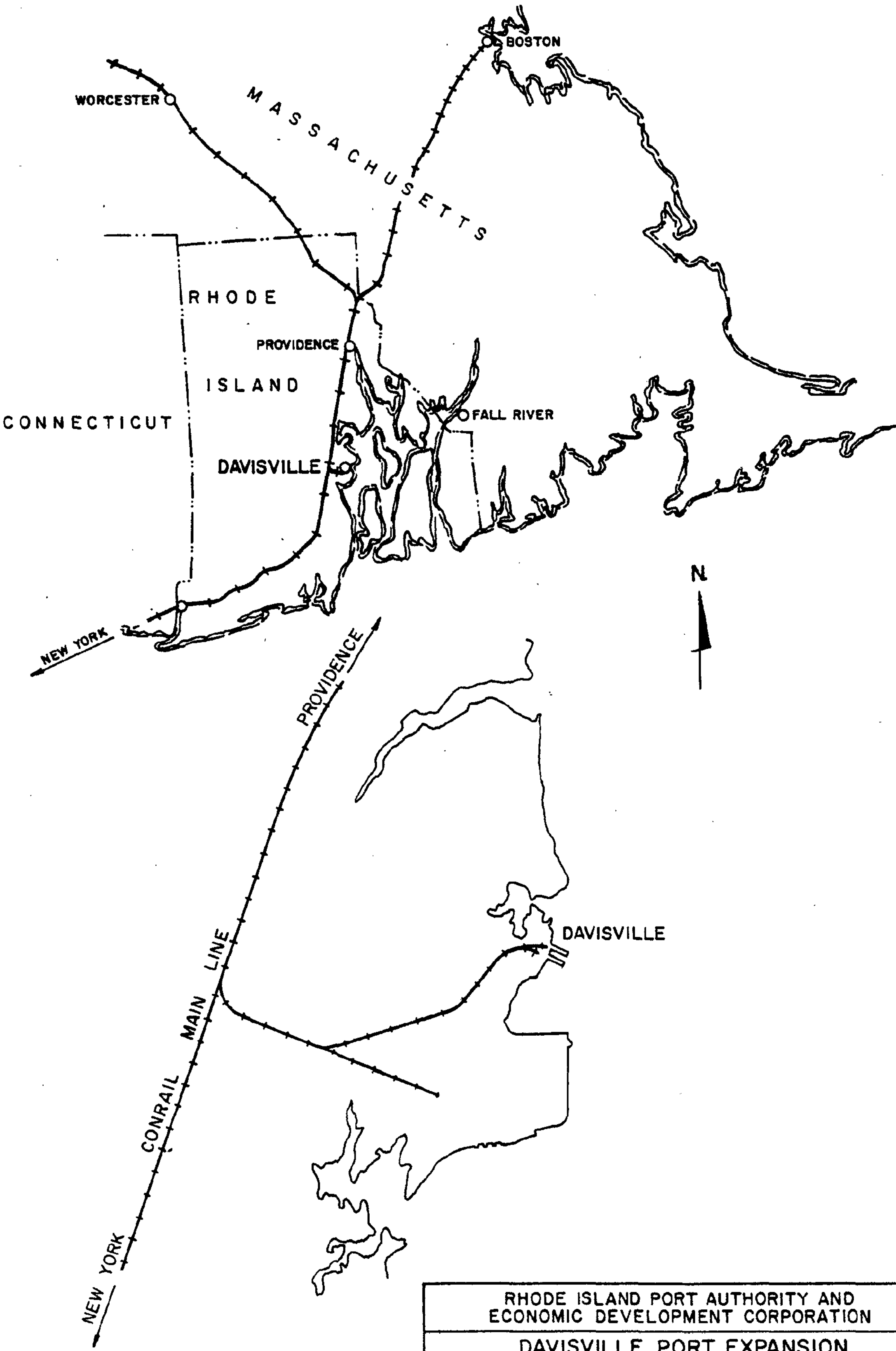
HIGHWAY TRANSPORTATION SYSTEM

DATE JAN., 1981	SCALE N.T.S.	FIGURE NO. I-2



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RAILROAD TRANSPORTATION SYSTEM

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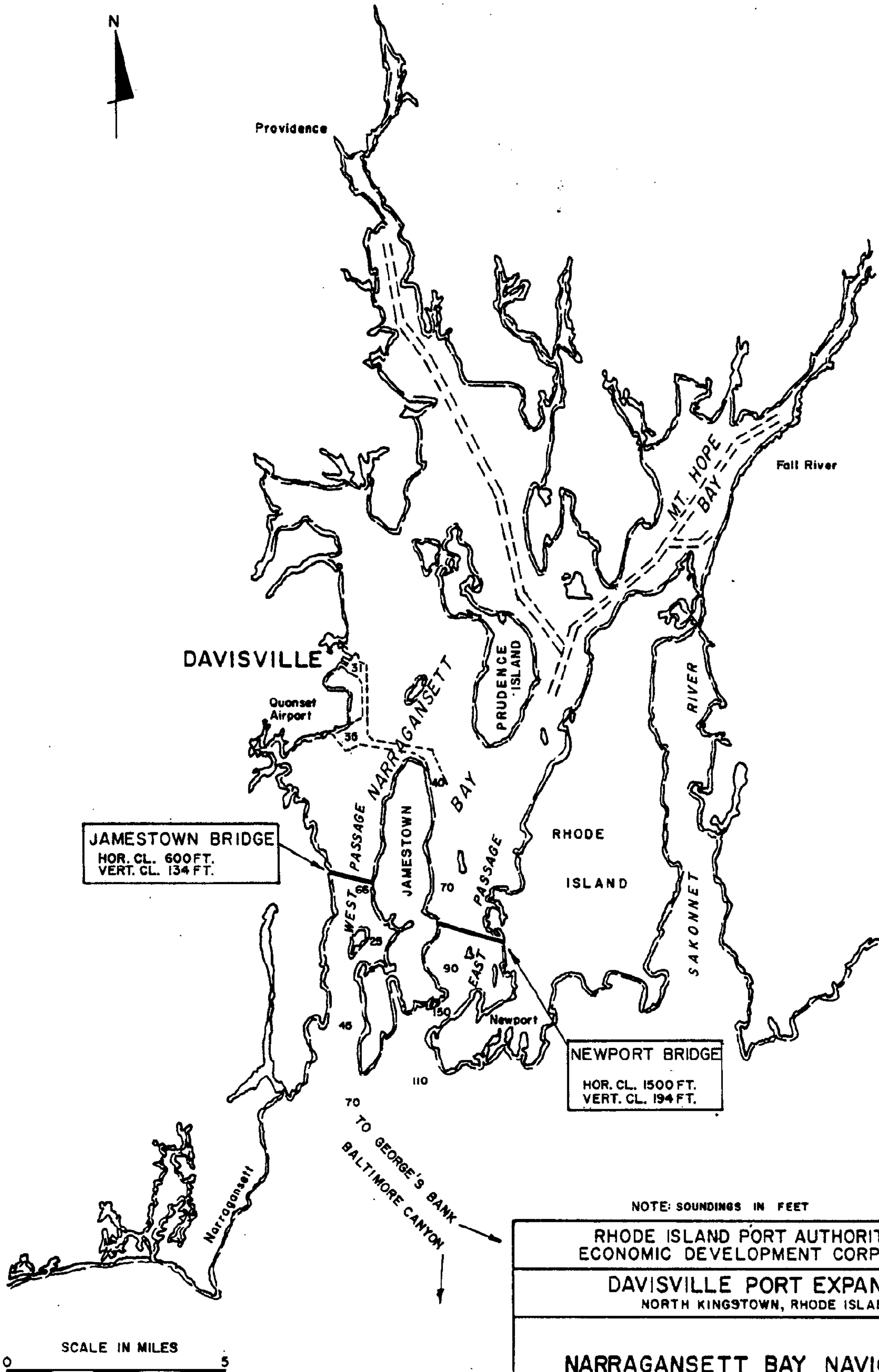
DATE JAN., 1981	SCALE N.T.S.	FIGURE NO. I-3

and unloading. These reasons - excellent facilities, geographic location and leasing rates - account for Davisville's current utilization for as the primary service base for support of exploratory operations in the Mid-Atlantic.

Service bases for offshore drilling have developed in several manners. Initial production drilling in the Gulf of Mexico was frequently near to shore. Travel time to platforms could be kept to a minimum by having several small bases serving a few platforms. The quieter sea conditions in the Gulf of Mexico permitted the use of vessels that are still generally much smaller than those currently utilized off New England and New Jersey. These larger vessels have larger cargo capacities making efficient port operation a significant factor in vessel turnaround time. In the past few years (with the increased requirement for new oil and gas resources and the development of technology to support drilling on the outer continental shelf) the distance to oil fields has increased making it possible for one base to service several platforms over a larger geographic area without significantly affecting travel time. OCS service boats have become larger making it possible for more equipment and supplies to be transported on each trip. All of these factors support the decision for a large OCS base supporting several exploratory and production units.

The entire oil support operation can be made even more efficient by locating supporting businesses adjacent to the service bases allowing for quick response, minimum haul distances and ready access to the waterfront. A large, all-encompassing service base complex would be an attractive facility to the petroleum industry. The development of a large OCS base will require considerable areas and berthing space. In this regard, Davisville occupies a favorable status in Narragansett Bay (see Figure I-4) if not the entire Northeast as one of the few ports remaining where expansion of crowded harbor facilities can be accomplished without displacing current port users or neighboring industry.

Most ports in the northeastern United States are faced with shortages of upland area for storage and berthing space. Many of the larger ports are making long-term commitments of land and financial resources to develop port facilities that can handle new modes of cargo handling, in particular containerization. Construction of berthing space and land area in these ports is comparitively costly. Many of the older medium-sized ports are bordered by metropolitan, commercial and industrial areas that make economic expansion of land area costly, if not altogether unfeasible. The large areas of adjacent, essentially unused land surrounding Davisville allow for efficient expansion of existing port facilities providing space for needed upland support areas.



NOTE: SOUNDINGS IN FEET

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NARRAGANSETT BAY NAVIGATION

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DATE JAN., 1981	SCALE AS SHOWN	FIGURE NO. I-4

Disposal of dredge material is another problem facing many ports. Land disposal has become a virtual necessity at present because there are no ocean dumping sites currently open for disposal. With the space shortage around most ports, land disposal of dredge material is usually not feasible nor uneconomical. In addition, dredging in most port areas involves significant proportions of soft organic silt. This material presents a very real disposal problem because of large amounts of contained water, turbidity of effluent, odor and long-term settlement problems. At Davisville, the projected quantity of organic sediments represents a relatively small proportion of the dredge material and can be readily handled on site.

Davisville occupies a rare and favorable position with regard to most ports in that it has land area available for dredge material disposal immediately adjacent to the waterfront and any surplus material can be stockpiled near the areas of construction to allow economical material handling. The material being dredged is essentially all non-organic sand which can be used for engineered fills. Disposal of dredge material can be accomplished by creation of land which provides additional acreage along the waterfront. Therefore, Davisville can expand into a large port complex with ample upland area to service OCS activities as well as commercial cargo operations.

Rhode Island has a long history of maritime trade. There currently exists in Narragansett Bay an excellent infrastructure that is available to service an influx of OCS supply boats or expanded cargo services. There are well developed businesses to service and maintain vessels including their hulls engines and equipment. There are firms specializing in repair and maintenance of hydraulic, electrical and pneumatic equipment and marine electronics. Because its history is so closely linked to the sea, Rhode Island has a socio-economic philosophy favorable to maritime service. This creates an environment generally conducive to the marine industry.

II

II. PROJECT REQUIREMENTS

A. Major Criteria

The primary intended user for the new facilities will be for support of mid and north Atlantic OCS oil and gas related operations. Admittedly, there is a significant margin of uncertainty associated with predicting the level of demand for support bases over the next 20 to 30 years. To assure that the cost of new facilities can be ammortized, the facilities should be attractive to the maximum number of potential users. In developing the design criteria for the port facilities, consideration was given to three potential users in addition to OCS support. These are commercial cargo, commercial fishing and the United States Navy. Essential design elements have been developed for all four users and are presented in the following sections. Detailed analyses of each are presented in the Appendices.

The major factors affecting the design are:

Marine Requirements:	vessel draft, beam & length; wind, waves, tides, & currents
Land Requirements:	contiguous acreage, apron loadings, pavement, & covered storage
Utility Requirements:	water, sewer, storm drainage, electrical, telephone & fire alarm system
Transportation:	highway and railroad

Vessel dimensions establish channel width, dredge depth, berth length, turning radii for vessel maneuvering and elevation of wharf apron. Land requirements depend heavily upon the user's operations. Large amounts of contiguous land area are required and remote marshalling areas may also be necessary. Loadings on the wharf apron are also very dependent upon usage. Cargo, OCS and Naval operations may develop loads up to 1,000 pounds per square feet or higher on the wharf apron while commercial fishing produces relatively light apron loads. The need for large paved areas or covered storage is usually associated with cargo operations, but the amounts are very dependent upon actual cargo being handled.

Utility demands are functions of the number of employers, materials processing and operation equipment as well as actual services required by vessels. Transportation needs are dependent upon source and destination or types and quantities of products, materials and goods being handled.

The various criteria for each potential user are developed in detail in the following paragraphs.

B. <u>OCS Supply Boat Service Bases</u>

The harsh nature of the Atlantic ocean off the northeast coast of the United States necessitates larger supply boats than are customarily utilized in the quieter waters of the

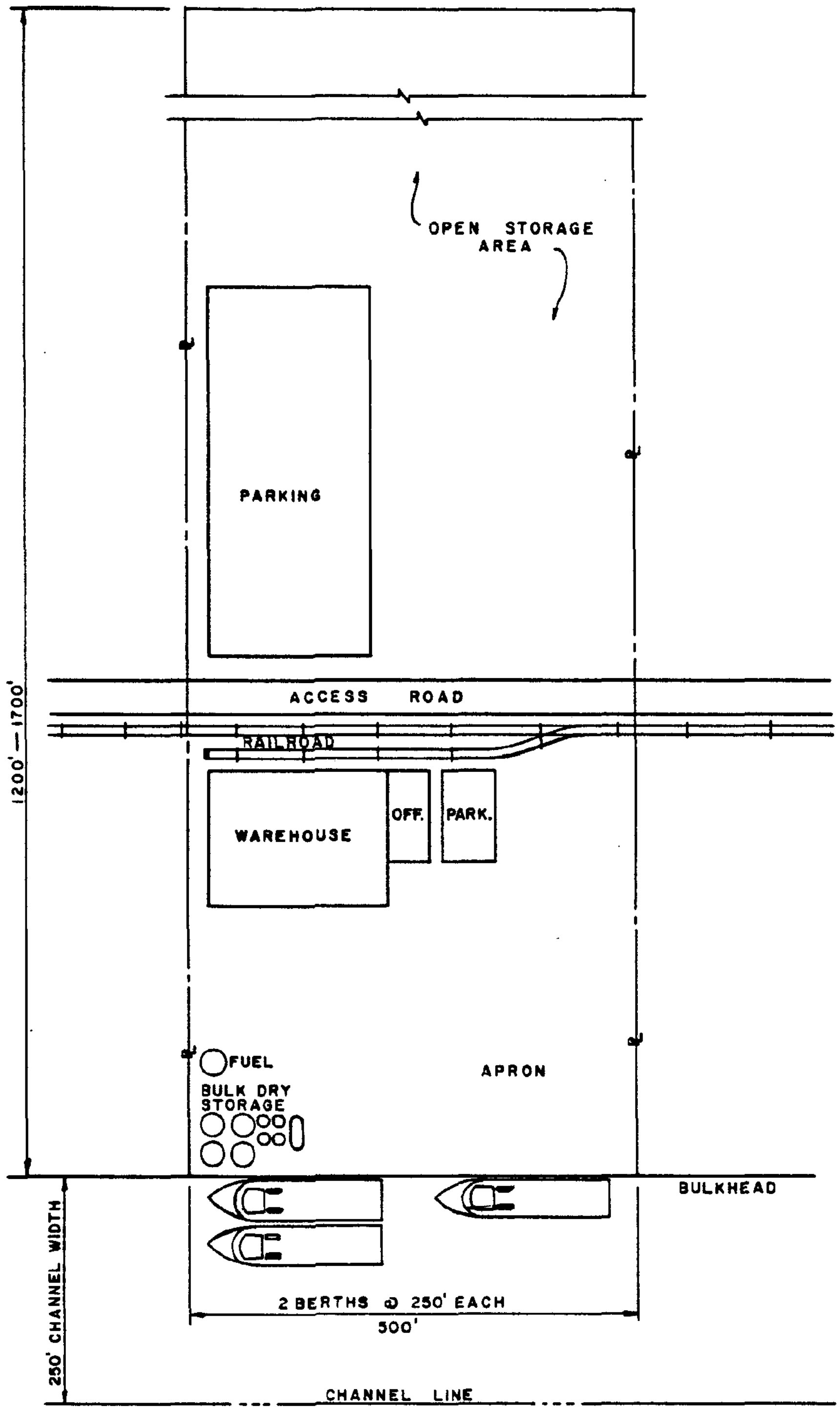
Gulf of Mexico. The boats presently in use off New Jersey are typically the largest boats of the American fleet. These characteristics vessels have the following dimensions:

Draft	12 to 19 feet
Length	150 to 210 feet
Beam	30 to 45 feet

These figures are based upon interviews with current users and an inventory of several United States boat operators. This data is presented in more detail in Appendix A.

Sea conditions in the Western North Atlantic are off New England and New Jersey no less severe than in the North Sea. Boats recently constructed for service in the North Sea are as large as 300 feet in length. If large scale production drilling becomes a reality, it can be expected that even larger vessels will be constructed to service the Baltimore Canyon and Georges Bank areas. Service boats of up to 250 feet in length, with a draft of 20 feet and a beam of 45 should be anticipated for the facilities of Davisville.

To better describe the port requirements of an OCS service base, Figure II-1 shows the conceptual layout of an idealized OCS service base. It must be remembered that the actual configuration of any port facility is dependent upon the preferences of the specific user as well as the con-



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IDEALIZED OCS SERVICE BASE

DATE JAN. 1981	SCALE N.T.S.	FIGURE NO. II-1

straints applied by channel and land configurations. Road rail and utility acces will also affect layout. The layout presented in Figure II-1 is not meant to present the appearance of any existing service bases nor predict the appearance of Davisville in a few years. This and other idealized port configurations presented in this report have been prepared to assist the reader in interpretting the text. The data used in preparing this layout was obtained from research by CE Maguire and information regarding typical facilities as presented in the Booz-Allen Hamilton Progress Briefing of June 25, 1980 on Management Alternatives for the Port of Davisville, Rhode Island.

This idealized service base is a facility capable of supplying three to four offshore exploration or production units providing two berths of 250 feet in length with 8 to 10 acres of land supporting each berth for a total of 16 to 20 acres. Approximately 20,000 to 30,000 square feet of covered warehouse storage space would be needed and 2,000 to 3,000 square feet of office space. A large parking area is required for service boat and drill rig personnel. Silos and tanks will be constructed for bulk storage of dry drilling fluids and tanks for diesel fuel. The remainder of the area will be utilized for open storage of equipment for drilling operations, such as tools, pipes, rods, anchors, chains, cables, lines, tanks, and other assorted materials.

There are numerous bases servicing offshore drilling and productive units that provide fewer facilities than are being proposed for Davisville. Most of these bases are either evolutionary - having started small, growing to meet a demand and finding ways to operate within the limitations - or they are in regions where all of the desired parameters can not be met. Bases with limited space can be tolerated but result in many port inefficiencies.

Strong competition exists in New England ports for conventional port users. The promise of new revenues associated with OCS oil related services is already producing a spirited competition to attract OCS businesses. Ports from Virginia to Newfoundland are competing for OCS oil dollars. To attract and hold tenants, the Rhode Island Port Authority must provide a complete and efficient port complex with an active marketing and management philosophy. The proposed development program therefore has been prepared to provide a complete, efficient and economical port complex at Davisville.

Other support operations such as suppliers of speciality tools, diving services, drilling tools, well-head equipment, and several other service and equipment suppliers will also desire facilities near the service bases, but it is not essential that they be immediately adjacent to the waterfront.

The largest utility demand associated with an OCS service base is for fresh water. One well requires a total of about one million gallons of water. The remaining utility demands are associated primarily with the office and warehouse operations and wharf lighting. There are additional electrical requirements for blower and pump motors on the bulk dry storage system.

Rail service directly to dockside is very desirable (but not mandatory) for movement of bulk materials thereby eliminating the need for double handling of goods. If rail service is not provided directly to the base, sidings must be available nearby. Highway access is essential to the operation of an OCS service base.

In November 1976, Tech Update II was issued to the NERBC report presenting revised impact estimates for New England. At this time under the medium find scenario, assumed commercially recoverable quantities of oil and gas were estimated at 900 million barrels of oil and 4.2 trillion cubic feet of natural gas. A total of 25 production platforms will be installed to produce this oil. In addition, as many as 12 exploratory rigs will be in operation ay any one time.

In November 1979, the United States Geological Survey issued a summary report on Outer Continental Shelf Oil and Gas Activities in the Mid-Atlantic and Their Onshore Impacts.

This report presented estimates of recoverable quantities of oil and gas in the region surrounding the Baltimore Canyon. For a probability similar to the NERBC Medium Find Scenario, it was estimated that 530 million barrels of oil and 4.1 trillion cubic feet of gas can be produced in the Mid-Atlantic. Using the same production rates utilized in the NERBC report, seventeen platforms would be required to recover these quantities. This is essentially two-thirds of the current predictions for Georges Bank. While development of the two regions will not commence at the same time, service base support will be required for over twenty years. With the maximum assistance required for either reqion for the five to six years, immediately after, production drilling begins in that area.

In evaluating the effects OCS development, estimates of berthing requirements have been based upon average levels of support of two service boats per exploratory rig and three service boats per production platform. These are conservative levels as compared to the NERBC-RALI numbers (for locations more than 150 miles from shore) of three boats per exploratory rig and four per production platform. Therefore, based on exploration and development rates predicted by NERBC in the first twenty years after lease sales supply boat demands will range from 6 to 51 boats at any one time, with an average demand of 22 boats. Similarly, estimates could be made for the Mid-Atlantic of 4 to 35 boats with the average at 15.

Generally, it can be anticipated that two boats will operate out of one berth. If all OCS support was performed out of one service base, berths would be required for an average of 37 boats with peak volume at 65 to 85 berths. This translates to an average of 19 berths with peak demand at 33 to 43 berths. Acknowledging that some addition rafting could be tolerated during peak periods, as many as three ships could be assumed to work out of one berth. Based upon this assumption at peak activity, 22 to 28 berths would be needed. The present facilities at Davisville can provide 19 berths for OCS vessels. If all of the berths at Davisville were to be used for OCS support, the port of Davisville could service without further expansion essentially all of the activity in the Georges Bank and Baltimore Canyon tracts under the USGS medium Find Scenario.

C. Pile Jacket Fabrication

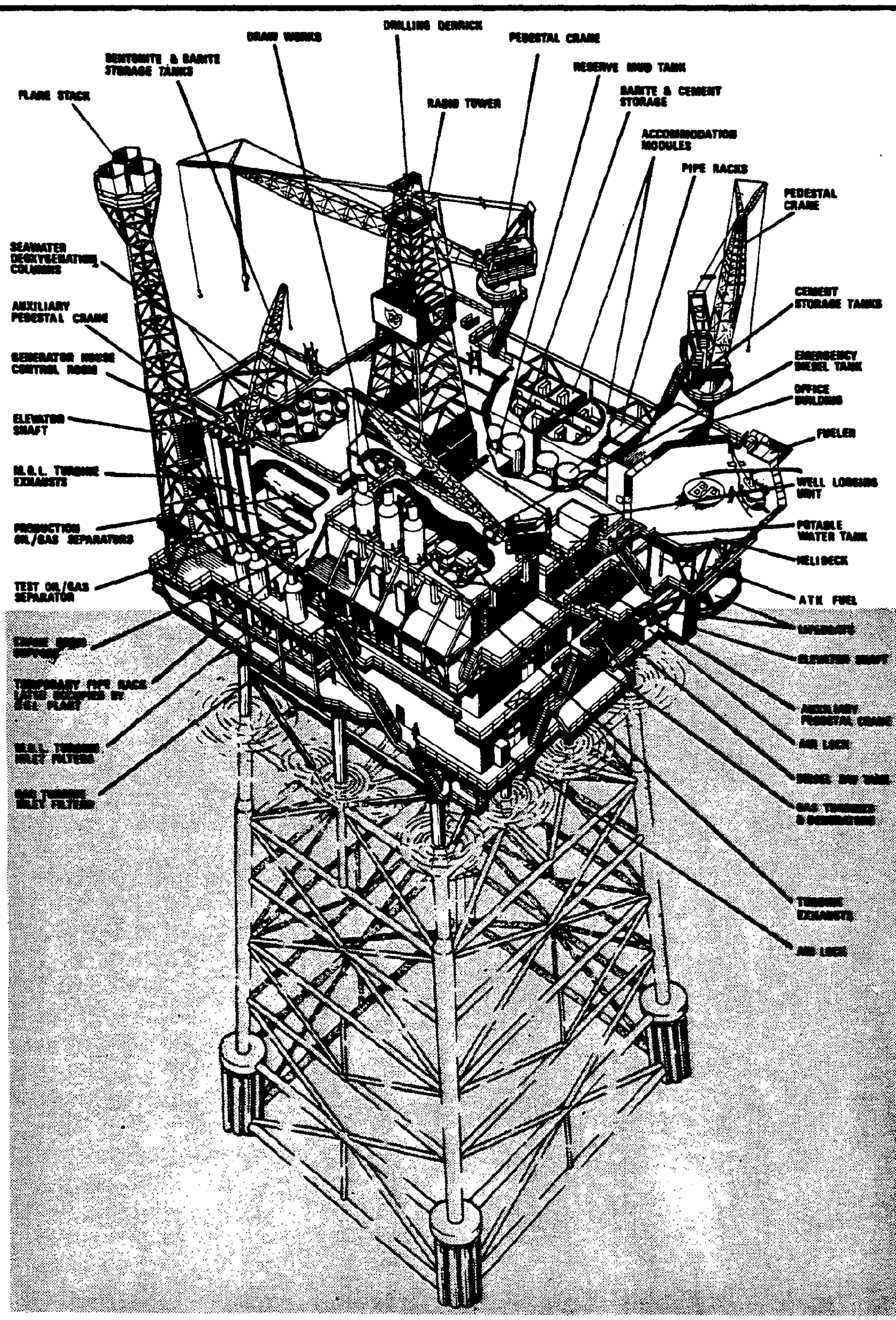
Associated with development of oil wells on the outer continental shelf in the Baltimore Canyon and Georges Bank areas will be the need for pile jackets (legs) for support of production drilling platforms. The number of pile jackets required depends upon the extent of the oil finds. The oil companies must weigh the cost of each pile jacket and platform against quantities of gas and oil that can be produced. The size of the pile jacket depends upon the depth of water; wave tide and currents; storm conditions; and facilities to be provided. Water depths in the Georges

Bank area range from less than 100 up to 1000 feet but most interest has been in areas with less than 500 feet of water (although at present it has been reported that interest is shifting to deeper water areas). Water depths in Mid-Atlantic tracts are generally similar to the Georges Bank tracts although water tend to be somewhat greater in depth.

Based upon current designs, the sizes of "typical" production platforms projected for North Atlantic OCS will have decks that are in the vicinity of 180 by 220 feet in plan area. The actual size depends upon the quality of the oil and gas being produced and the number of wells installed. The pile jacket supporting the platform are typically rectangular in plan measuring about 75 by 180 feet. The legs of the pile jacket are battered outward at 1 horizontal to 8 vertical to 1 to 12. Figure II-2 shows a typical OCS production platform supported on a tubular steel pile jacket.

Based upon these parameters, a pile jacket 400 feet in height would measure about 150 by 260 at the base and a 600 foot high pile jacket would be about 200 by 300 at the base.

The size of pile jackets that could be fabricated at Davisville are potentially limited by several factors. Exit from Narragansett Bay is controled by the Newport Bridge which has a vertical clearance of 194 feet and a horizontal clearance of 1,500 feet. This bridge clearance would restrict



SOURCE: OCEAN INDUSTRY, FEBRUARY, 1975

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TYPICAL OFFSHORE PLATFORM

DATE JAN., 1981	SCALE N.T.S.	FIGURE NO. II-2

pile jackets to a maximum of about 175 feet or less, in their smallest dimension. The channel leading out of Davisville has a width of 500 feet and a project depth of 34 feet. Soundings taken in June, 1980, as part of this report crossed the channel in the Davisville area three times and did not encounter depths less than 29 feet at mean low water. This depth is further substantiated by soundings performed in 1980 by R. McMaster of the University of Rhode Island. This should be adequate for towing of pile jackets and should not cause difficulties.

Vertical restrictions for the Quonset Point Airport landing patterns require that obstructions be kept below Elevation 169 throughout the Davisville area. Allowing for the height of barge and skids above the water surface, this effectively limits the maximum size of any platform to about 150 feet in its smallest dimension provided that permission was obtained from airport authorities for frequent encroachment of cranes above Elevation 169. Platforms of only 150 feet in their least dimension are smaller than the majority of platforms that will be required. However, a substantial portion of the tracts that are potentially productive are in water less than 400 feet in depth. It may be practical to fabricate pile jackets in Narragansett Bay for these well in accordance with current design methods. While platforms can and are fabricated in more than one section, this typically is only done when it is impractical to construct, load out, transport, and launch a pile jacket in single unit because of limitations of available launching equipment, yard limitations or structural design considerations. The construction of pile jackets in more than one section is extremely expensive. Therefore it is normally used only as a last resort. State-of-the-art technology is such that pile jackets up to about 1000 in height have been launched. Based upon current design practices, it therefore appears impractical for all pile jackets to be fabricated at Davisville or anywhere in Narragansett Bay because of airport height limitations and bridge clearances.

A second possibility is the use of guyed towers rather than conventional pile jackets. The state-of-the-art offshore for platform technology is on the threshold of practical guyed tower design. These structures will not have battered legs but rather will be vertical with a relatively constant cross-sectional area. The towers will probably be of about the same dimension as the top of present pile jackets, that being about 75 feet by 180 feet. It therefore may be practical to construct towers of this type in Davisville for virtually any water depths off of the Northeast coast. The effective utilization of Davisville as a fabrication yard hinges on the magnitude of the oil and gas finds as well as future developments in offshore technology.

In the event that fabrication of pile jackets or towers was to occur at Davisville, the amount of area required would depend upon the size, complexity and number of units being assembled at any one time. For a single pile jacket yard, a waterfront area ranging from 50 to 200 acres of waterfront is needed for fabrication, and load out, depending upon the entire fabrication operation. In addition to waterfront land, additional contiguous or nearby land capable of of from 50 to 200 acres is needed for storage of tubular stocks. A total facility fabricating three or four platforms may require upwards of 1,000 acres.

D. Commercial Cargo Port

Commercial shipping is another major market area which should be considered for potential marine-related industrial development at the Quonset-Davisville facilities. Rapidly rising fuel costs coupled with diminishing fuel supply is gradually bringing waterborne transport of goods to the forefront as a cost-effective and energy-efficient mode of transport. For this reason, an analysis was conducted which considered present and future trends in the commercial shipping industry and their applicability to the Davisville pier expansion project. A summary discussion of shipping trends is presented in Appendix B of this report.

The appendix illustrates three types of merchant shipping services to be considered:

1. Liner Service - Scheduled sailings to designated ports of call;
2. Charter Service - Ships generally hired to carry a single commodity from one port to another;
3. Specialized Industrial Carriers - Commonly referred to as Bulk and Neo-Bulk shipping and generally associated with shore support processing and/or trans-shipment and distribution facilities.

In addition to the types of service, Appendix B presents seven primary methods of commercial cargo handling and shipping. These are:

1. General (Break Bulk) Cargo
2. Containerization
3. Lighter-Aboard-Ship (LASH)
4. Bulk Carriers
5. Coastal Barges
6. Roll-On/Roll-Off (RO/RO)
7. Palletization

In evaluating the applicability of these and waterborne transport modes and service methods to Davisville, the advantages and disadvantages of the port must be considered. The advantages are: proximity to Block Island Sound and the open Atlantic Ocean, adequate rail, road and utility networks, ample land, and a Port Authority and State Government committed to industrial development.

Major disadvantages include: attractive existing deep-water (40-foot draft) port facilities at the ports of Providence, Fall River, and Melville, and an approach channel depth limitation of approximately 30 feet to the Davisville port. While the long-range potential of deepening the approach channel should not be ruled out pending detailed engineering and environmental studies, design of near-term construction must consider marine transport modes which require shallower draft ships.

Engineering designs should, however, provide the flexibility to expand the port to deeper draft capabilities in the future, should the demand become evident.

Because of the relatively shallow 30-foot deep channel serving Davisville, it appears that trans-ocean shipping, which tends towards deeper draft vessels, with drafts in excess of 35 feet would be precluded from the new facility in the foreseeable future. There are, of course, some exceptions such as auto carriers, which due to their large volume to weight ratio typically have drafts of 30 feet or less and therefore do not require the deepwater ports. The remaining potential market while somewhat limited appears to be in the coastal shipping and feeder type service.

As pointed out in the 1980 National Port Assessment by the United States Department of Commerce, coastal shipping operations appear to be increasing, primarily due to the rising costs of fuel and the energy efficiency afforded by waterborne transport. The container-barge operations at the Port of Providence, and the RO/RO container operations from Halifax to Portland and to Fall River are examples of this expanding shipping mode. While, admittedly, these vanguard operations have met with minimal success, it is anticipated that the lessons learned from their shortcomings (most notably large vessels that were too large and the lack of return cargo) can be put to good advantage by future users.

As fuel costs continue to rise, it is anticipated that coastal shipping, predominantly by containers, will also rise. Conceivably, with the increasing congestion of the road system through the Washington - New York - Boston megalopolis, with no major new road systems planned, north-south RO/RO services will replace trucking of non-perishable goods. Even perishable goods are feasible in refrigerated containers. The trend towards this type of shipping was recognized in the 1979 U.S. Department of Commerce, Maritime Administration study of Mid-America ports which predicted that traffic on the Mississippi River system would double by the year 2000. The upsurge of the unit-train is another example of a trend towards an energy efficient mode of transportation, with direct applicability to Davisville with its existing rail network. A unit-train is a train made up of 1,000 cars or more carrying a single commodity such as coal or grain between a single source and a single user. In the past year, definite interest has been expressed by the bulk grain and coal shippers, (e.g. Italgrani or New England Power) concerning location of terminals in Narragansett Bay.

Coastal shipping is a major market to be considered in planning for the port at Davisville. Infrastructure requirements of a coastal shipping facility are very similar to those required by OCS service vessels. Both industries require a small-scale port facility; in the case of OCS service, to trans-ship to a drilling platform two or three hundred miles at sea; in the case of coastal shipping, to trans-ship to (and receive from) a port several hundred miles along the coast.

Of the seven transportation modes described in Appendix B, three should be actively considered for Davisville:

1. Containerization
2. Coastal Barges
3. Roll-On/Roll-Off (RO/RO)

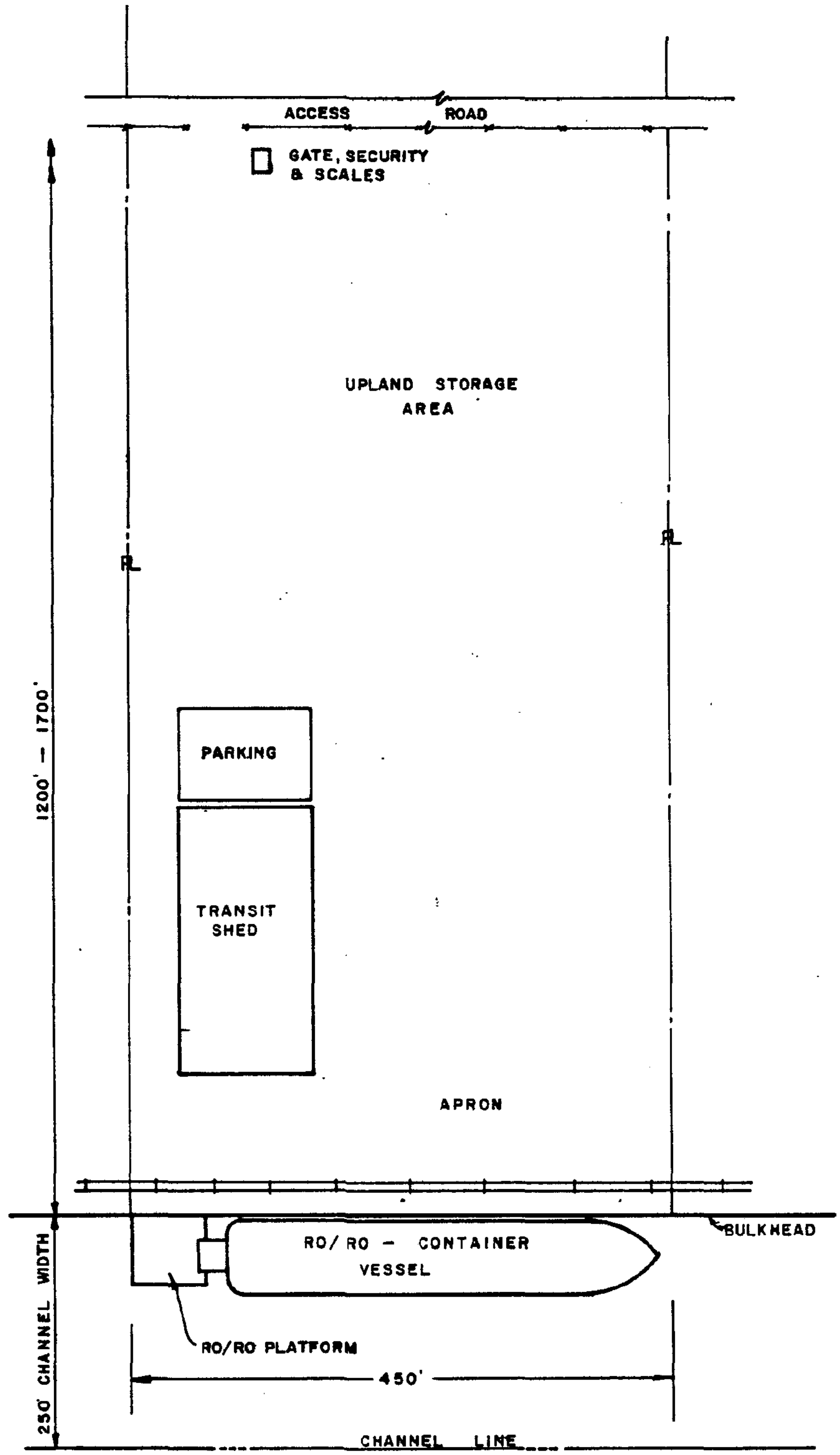
General (break bulk) cargo can be ruled out since it is rapidly being taken over by containers and RO/RO operations. Bulk carriers are generally deep draft vessels which are prohibited from using Davisville by the existing 30 foot channel. With the advent of the unit train, there is some potential for coastal distribution of bulk commodities, for example coal; however, this would present a specialized opportunity which should be addressed if such a proposal is received. LASH and palletization are more prominent in European ports, but have not appeared significantly in US Maritime Commerce. It is anticipated that facilities designed for coastal shipping and/or barging could easily be adapted to these modes if necessary in the future.

Potential markets could include scheduled Liner Service as is the case in Fall River and Portland. These existing operations deal with regional shipping. With the potential for coastal shipping increasing in response to rising highway transportation costs, it is predicted that interregional shipping will expand. Goods being shipped will include some of the more conventional materials such as petroleum to products that will be relatively new to coastal barge shipping such as consumable commodities, textiles and lumber.

Even more advantageous would be specialized Neo-bulk carriers including cars, lumber, steel, chemicals, and petroleum products. These last two products can be significant to Rhode Island in view of the industrial land available Davisville for processing and distribution facilities. Based upon past experience the existence of a pier facility would be a major advantage in attracting commercial shipping and associated industries since most industries would prefer to have the port facilities provided to them on an exclusive or scheduled basis for which they would pay appropriate wharfage, dockage, and demurrage fees.

The actual configuration of any port facility is dependent upon numerous factors including: specific users, vessels, cargo, channel, utilities, and land configuration. Figure II-3 has been prepared to present the general concept of the physical layout of a facility to serve coastal shipping. The basic infrastructure required would be provided by the Port Authority while more detailed development would be adapted to the specific requirements of the user by the tenant.

The berth should have the capability of accommodating a barge, small container ship or RO/RO ship. Most probably, the ship would be a combination RO/RO, lift-on/lift-off container carrier with a capacity of about 100 containers. This vessel is based on previous similar proposals under consideration at several New England ports including Eastport and Portland, Maine; Portsmouth, New Hampshire; and New Bedford and Fall River, Massachusetts. A typical ship of this capacity would have the following characteristics:



RHODE ISLAND PORT AUTHORITY AND ECONOMIC DEVELOPMENT CORPORATION

DAVISVILLE PORT EXPANSION
NORTH KINGSTOWN, RHODE ISLAND

IDEALIZED DOMESTIC SHIPPING PORT

MAGUIRE
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CE MAGUIRE, INC. Providence, Rhode Island

DATE JAN., 1981	SCALE N.T.S.	FIGURE NO. II-3

Length:	300 feet
Beam:	48 feet
Draft:	18 feet

The apron area should provide a minimum clear width of 80 feet between the wharf face and transit sheds to allow for turning of large trucks and the use of mobile dock side cranes, front-end loaders, etc. The apron should have the capability for future installation of a gantry crane, should this become a user preference to provide for a future gantry crane, a minimum apron width of 120 feet should be provided. This typical transshipment operation would require approximately twelve acres of contiguous or easily accessibly marshalling area for each berth. It would also most probably require a secure area with a restricted access entrance with an inspection station and scales. Any associated processing, distribution, or stripping/stuffing operations would require additional area. Railroad spurs should be provided to the transit shed and/or wharf face. Utility services should include water for fire protection and to fill ships tanks; sewage for dock workers and possibly ship pump-out; power to service refrigerated containers and lighting for night operations; and communications.

The port should include RO/RO platform for bow and stern ramps. The platform should be of adequate size for a minimum two lane ramp and to allow turning of the trucks. The platform should be able to accommodate the ship in a loaded or empty position over the normal tide range. The platform can be either fixed or floating; however, recognizing the small-tide range at Davisville, it is anticipated that a fixed platform will be adequate and require less maintenance. It should be noted that the existing ramp adjacent to the northern pier at Davisville could be readily adapted to accommodate RO/RO vessels at minimal expected costs.

The ramp may be fixed in-place at the most desirable location and height in light of the specific site conditions. Facilities at Montreal, Canada, and Port Elizabeth, New Jersey utilize this concept. The ramp should be set at a height to minimize the influence of wave action, but low enough to allow utilization of the ramp during the entire range of the tide cycle. Factors establish the design critiera are the height of the vessel's ramp above the water line, both loaded and unloaded, the size of the vessel's ramp, the maximum acceptable grade of the extended ramp while loading and unloading, and the tide range.

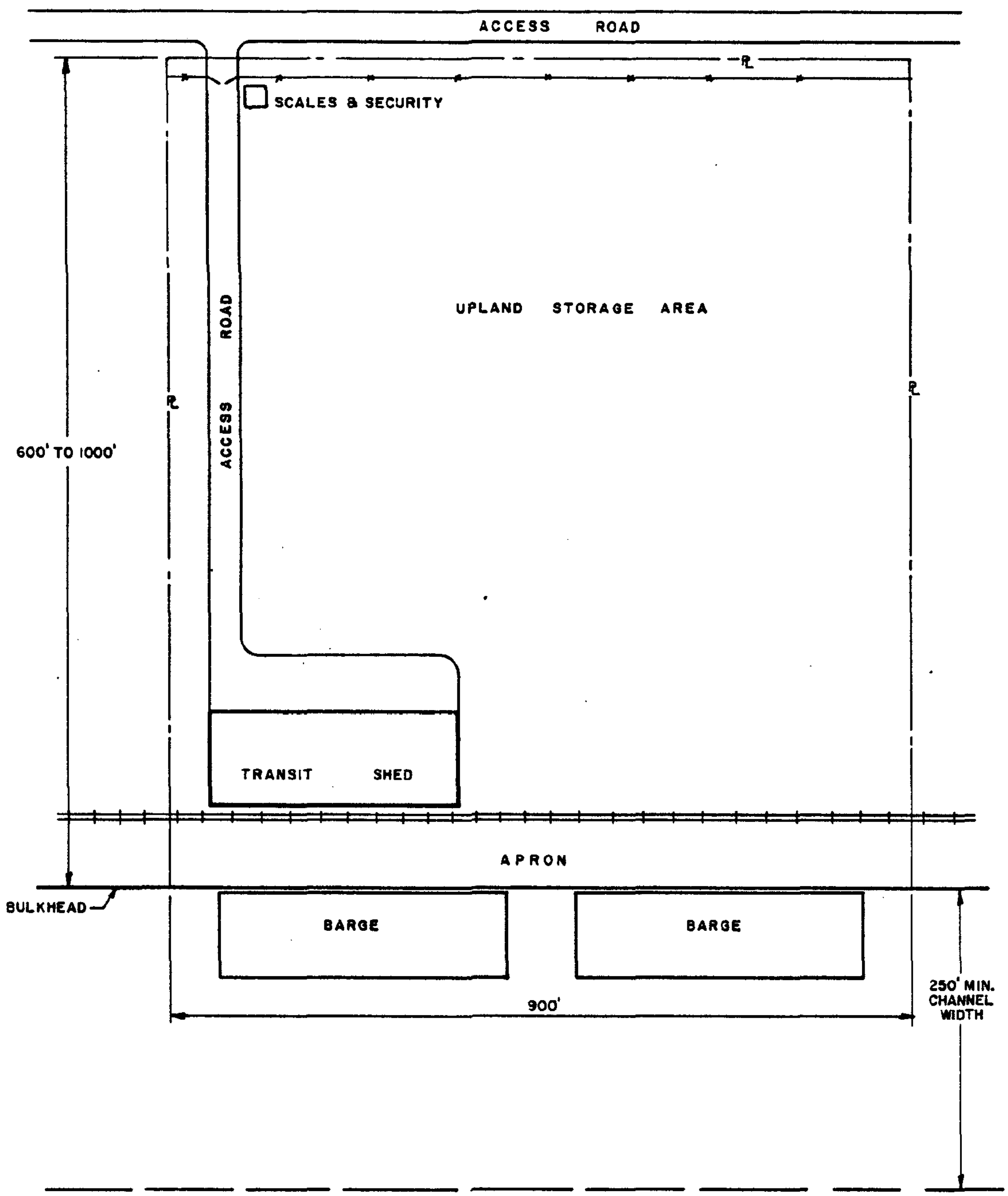
The design vessel outlined earlier would require a berth which is a minimum of 110 feet wide and 500 feet in length excluding approach and fairway requirements. Any peculiar berthing manuevers required due to the location and orientation of the berth could require additional area. The loaded draft of the design vessel is approximately 18 feet.

The extreme low water is -3.0 MLW and allowing some tolerance for squat, water density variation, and under keel clearance a minimum dredged depth of 25 feet below Mean Low Water is recommended.

If coastal barge service was initiated in lieu of self propelled vessels, the basic port requirements remain essentially unchanges. These being a 12 to 20 acre parcel with a 120 foot wide apron. A 450 foot long berth is needed for a facility to service one 300 foot long barge. To accommodate two barges, a berth length of approximately 800 feet is necessary. Draft of these barges would be from 12 to 18 feet requiring a dredge depth of 25 feet. Figure II-4 has been prepared to show the conceptual layout of an idealized coastal barge port capable of accommodating two barges or a barge and coastal RO/RO-container vessel at one time.

E. Commercial Fishing Port

The establishment of the 200-mile fishing limit has resulted in the largest expansion of the New England fishing industry in over a century. Foreign fishing efforts on Georges Bank are being controlled and significantly reduced, and once-depleted fisheries are recovering. Under-utilized species such as mackerel, squid, silver hake, and herring offer potential for supporting commercial fishery operations. Markets, both domestic and foreign, previously dominated by foreign vessels operating on the U.S. continental shelf have



RHODE ISLAND PORT AUTHORITY AND
ECONOMIC DEVELOPMENT CORPORATION

DAVISVILLE PORT EXPANSION
NORTH KINGSTOWN, RHODE ISLAND

IDEALIZED COASTAL BARGE PORT

MAGUIRE
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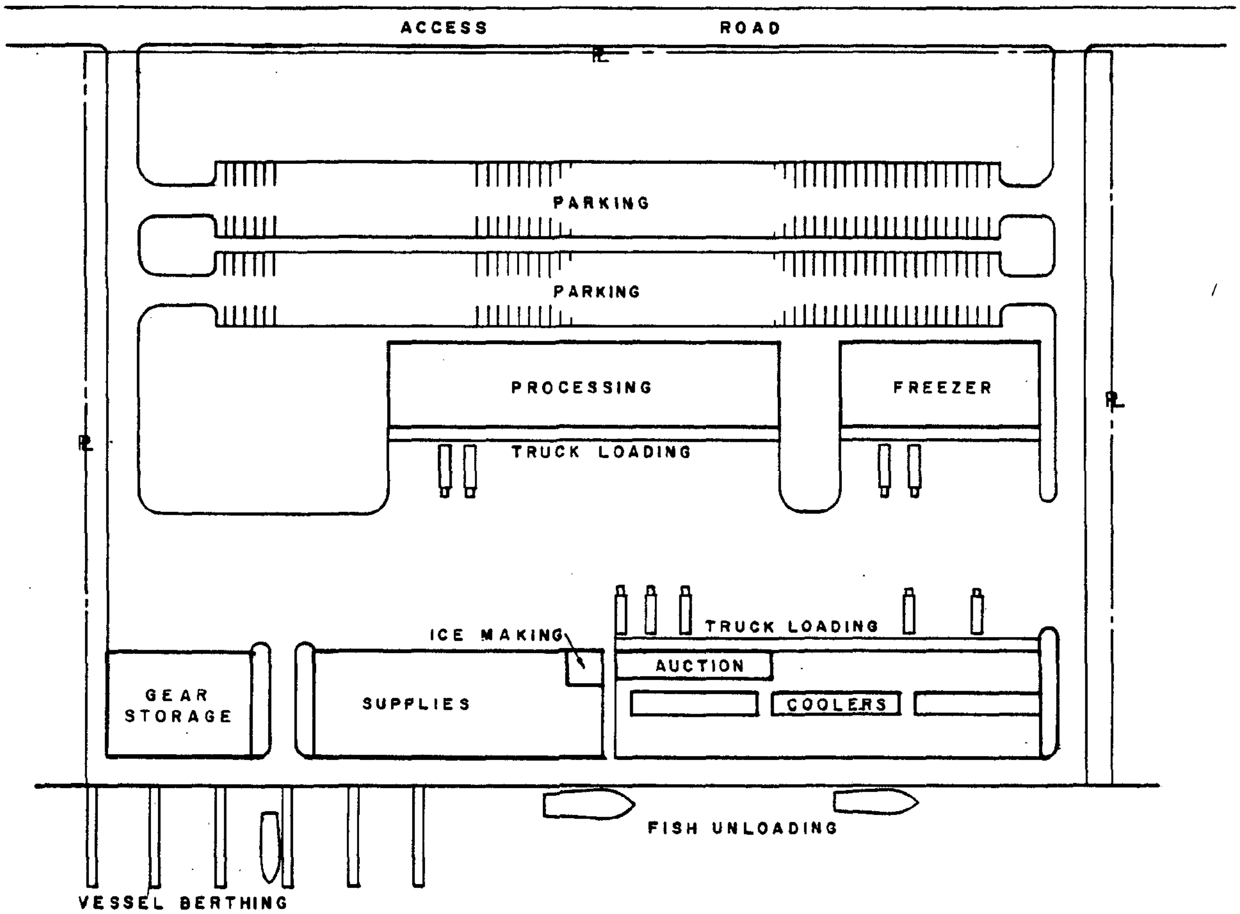
CE MAGUIRE, INC. Providence, Rhode Island

DATE JAN., 1981 | SCALE N.T.S. | FIGURE NO. II-4 had to seek other sources of supply. As a result of the potential for capturing these markets, new vessels are entering the New England fishing fleet and numerous coastal communities are exploring the possibility of establishing fishing industries.

A study presently being prepared by the University of Rhode Island Coastal Research Center on Commercial Fishing Facility Needs in Rhode Island for the Rhode Island Coastal Management Program conservatively estimates that 45 to 200 additional fishing vessels will be in demand in New England within the next 10 years, with 11 to 60 of these based in Rhode Island if adequate facilities are available. This represents an increase of about 25 percent over the present fishing fleet of 125 vessels. In addition, significant numbers of vessels from other areas of the East Coast could relocate to Rhode Island should berth space become available. However, traditional Rhode Island fishing ports such as Newport and Galilee have been expanded to their practical limits or are occupied at near capacity levels, and significant expansion in either area would encounter significant political, economic and social resistance. It has been estimated by the University of Rhode Island Coastal Resources Center that the surplus US Navy land in Melville can accommodate up to 30 vessels. Should the prediction of 60 vessels prove accurate, facilities for 30 vessels would be lacking. With significant development, Melville could accommodate up to 40 vessels, but there would still be a need for berth space for 20 to 25 additional vessels. These vessels would range from 45 to 95 feet in length, with a few possibly as big as 125 feet, and would have drafts of 6 to 18 feet. Based on the distance from Narragansett Bay to Georges Bank (approximately 200 miles), most of the vessels operating out of Rhode Island ports would probably be in the 75 to 95 foot range. This would result in a need for approximately 1500 to 2000 feet of additional berthing space in Narragansett Bay and approximately 8 to 20 acres of back-up space if sorting, processing, packing, and sales operations are located adjacent to the berths. If the catch is off-loaded onto trucks for processing elsewhere, approximately 5 acres of land adjacent to the berthing area would be required for gear storage parking, fuel, pump-out facilities, ice-making, and supply services. Given the limited number of potential sites in Rhode Island, it appears that unless existing facilities can be expanded or new sites developed, additions to the New England fishing fleet will locate elsewhere. Figure II-5 shows an idealized configuration for the type of facility that could be provided at Davisville. The actual configuration will be dependent upon the size of the fleet, species being caught and configuration of the available land area and channel. Depth alongside the wharf should be deep enough to accommodate vessels at all tide levels. The maximum draft that can be expected is 18 feet thereby requiring a 23 to 25 foot channel depth.



RHODE ISLAND PORT AUTHORITY AND ECONOMIC DEVELOPMENT CORPORATION

DAVISVILLE PORT EXPANSION
NORTH KINGSTOWN, RHODE ISLAND

IDEALIZED COOPERATIVE FISHING PORT

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DATE JAN., 1981	SCALE N.T.S.	FIGURE NO. II-5

Channel widths should be a minimum of 150 feet with 200 to 250 feet being preferred as this would allow rafting. Even wider dredged channels are needed if finger piers were to be constructed out into the navigable waterway.

Davisville has a number of advantages in considering the potential location of a fishing industry there. The existence of berthing space and shore support infrastructure minimizes development requirements. There is also adequate water depth available alongside the wharf, another considerable advantage since dredging and disposal of dredge spoils is in itself costly and can involve a lengthy and expensive permit process. Davisville is also well served by road and rail, and has back-up land available adjacent to the berthing area. Since the port area of Davisville is isolated from nearby commercial/residential areas and is and has been primarily industrial, environmental concern over establishment of a fishing industry would not be as great as in other Narragansett Bay sites. These factors appear to indicate that there will be a future demand for fishing industry berthing and support facilities in Rhode Island. This offers a potential developmental opportunity for Davisville. The impact of the fishing industry on Davisville would be minor if limited to offloading and support facilities or it could be extensive if establishment of an integrated fish plant or a fishing cooperative, was to take place. This is dependent upon the level and type of development desired by the Rhode Island Port Authority and the space to be provided.

There is a significant opportunity for development of the Rhode Island fishing industry and a well planned, joint public/private sector effort is necessary for its successful expansion. Aggressive marketing techniques and commitment of capital for vessels, shore support facilities, and fish handling and processing equipment is needed to prevent the preemption of this opportunity by other New England states.

F. US Navy

The design of facilities for the U.S. Navy is beyond the scope of this study. Similarly, it would not be appropriate for a state agency, such as the Rhode Island Port Authority, to undertake the construction of facilities solely for use by the U.S. Navy. However, it must be kept in mind that the Navy and the Port Authority are neighbors and in many regards have similar waterfront demands. These being, the need for efficient port facilities with ample berthing space and contiguous land area for marshalling of cargo. For the Davisville Construction Battalion Center to fulfill its wartime mission, it must be capable of handling and loading large volumes of materials and equipment. The agreement between the U.S. Navy and the State of Rhode Island allows for occasional use of Davisville and Quonset piers. During peacetime, this need for berthing appears to be quite limited, but in a wartime situation, the berthing requirement could be substnatial.

Acknowledging the close working relationship that must exist between the Navy and the State of Rhode Island, the Port Authority at the request of the U.S. Navy included as part of this report a brief analysis of U.S. Navy port requirements and what effect proposed expansion would have on the ability of the Navy to utilize facilities at Davisville.

The primary thrust of this analysis was in compilation and review of available Navy vessels that might use the facilities at Davisville. This included the Navy's amphibious vessels and vessels listed in the Military Sealift Command register as of July, 1980.

All of the 72 sea-going amphibious Navy vessels have drafts of less than 30 feet and, therefore, should be able to utilize the existing piers as Davisville. Because of the 30 foot channel depth (MLW) the 22 vessels with drafts in excess of 25 feet precautions such as entering or leaving Davisville during high tide would be necessary when fully loaded. The remaining 50 vessels have drafts that range from 15 to 23 feet and lengths from 445 to 570 feet. All of these ships could make use of the proposed port expansion provided that the 14 vessels with drafts in excess of 20 feet took precautions when maneuvering at low tide.

The Military Sealift Command lists 289 U.S. Flag cargo vessels that could be drawn upon to move military supplies and equipment from the Construction Battalion Center at Davisville. Of a total of 298 ships, 102 or 34 percent have drafts of 30 feet or less which is considered the maximum draft vessel that should enter Davisville during high tide stages. None of these 102 ships have drafts of less than 26 feet which would effectively rule out their use of the proposed port expansion. However, the two existing piers could be utilized for military cargo operations.

In summary, the proposed port expansion will not restrict the use by the Navy of the existing piers at Davisville and 69 percent of the Navy's amphibious fleet could make limited to full use of the proposed expansion.

III

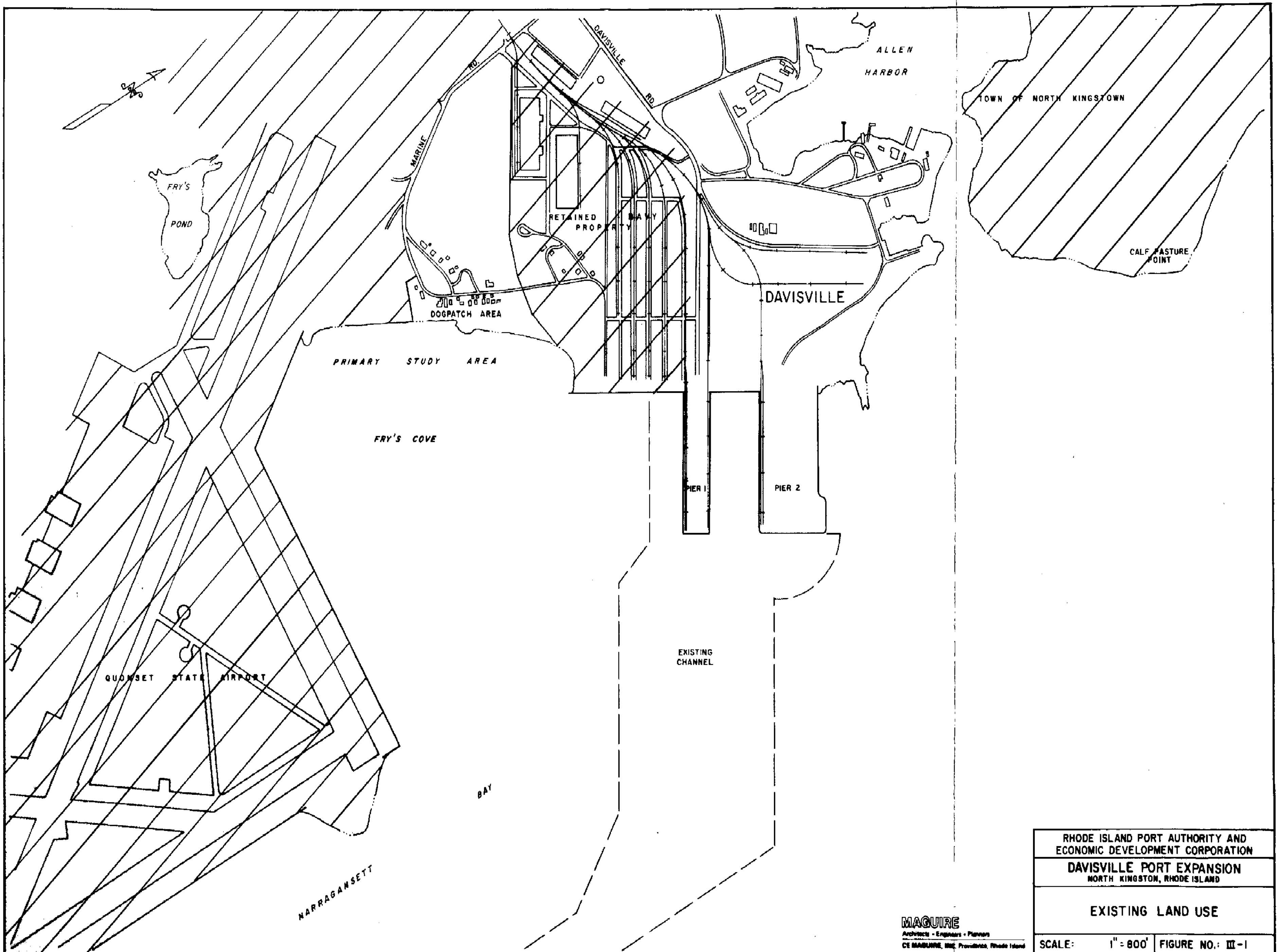
III. SITE DEVELOPMENT CONSIDERATIONS

A. Existing Land Uses

The planning of expanded port facilities at Davisville as performed by CE Maguire for this Preliminary Engineering Report has been controlled by several diverse factors. Current land use and ownership is the most significant restriction. This aspect was dealt with in some detail in the "Quonset Point Technical Park Facilities Study", March, 1977 and in "The Redevelopment of Quonset/Davisville An Environmental Assessment, 1977".

The primary area of this study is known as the Dogpatch Beach area and the adjacent area called Fry's Cove as indicated in Figure III-1. To the south and west is the Quonset State Airport complex occupying some 650 acres. In addition to the physical boundary created by the presence of a airport property there are also numerous clear zones and height restrictions as shown in Figure III-2. The airport therefore imposes specifies controls on development at Davisville. The allowable height of structures is quite low near the southwestern end of the proposed bulkhead creating a significant restraint on potential users.

There is approximately 95 acres of land immediately north of the 35-acre Dogpatch area retained as part of the Navy Permanent Mission including a small area of military housing. This parcel separates the Dogpatch area from the 100-acre tract adjoining Piers 1 and 2. This separation signifi-

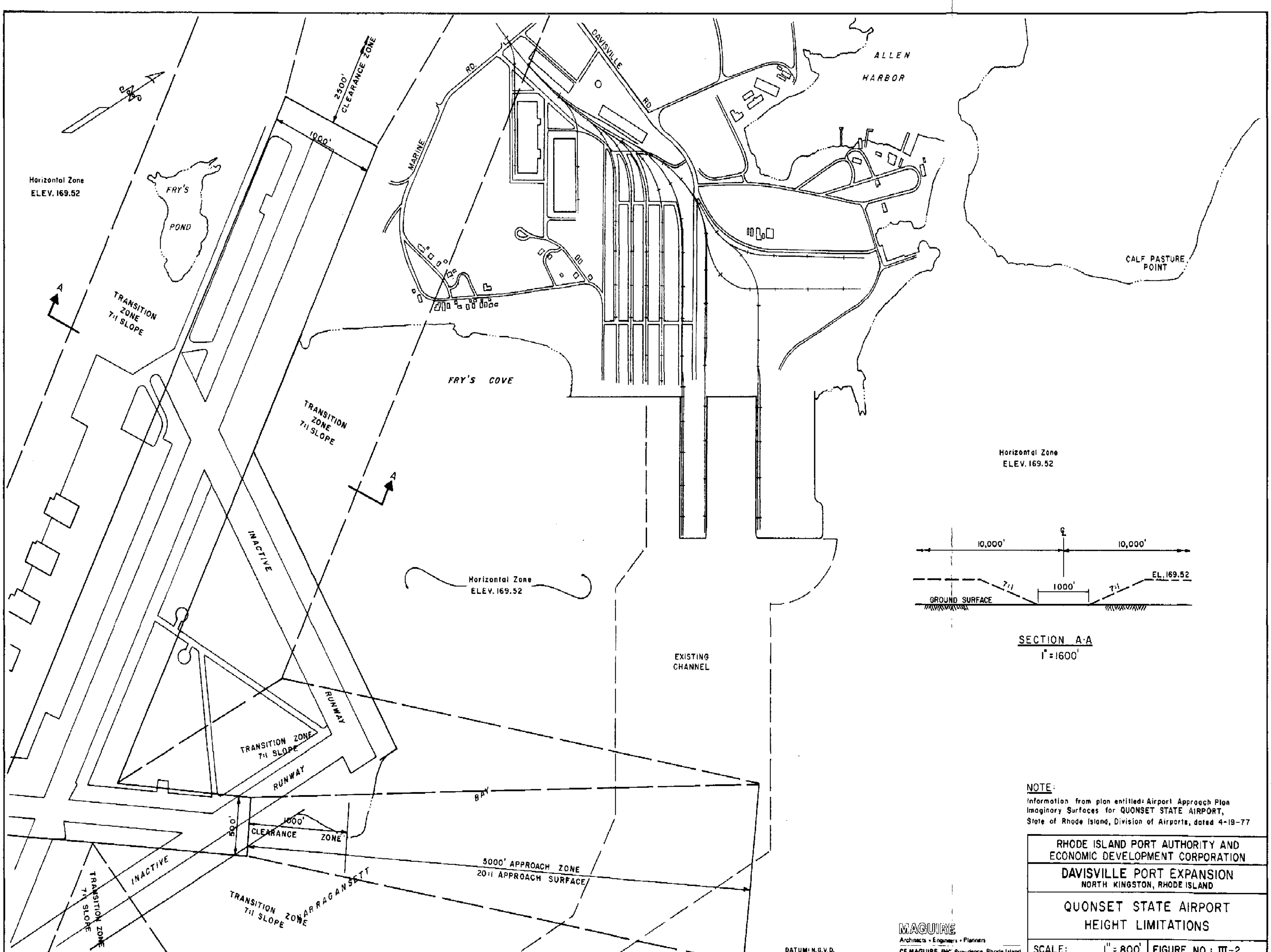


RHODE ISLAND PORT AUTHORITY AND ECONOMIC DEVELOPMENT CORPORATION

DAVISVILLE PORT EXPANSION
NORTH KINGSTON, RHODE ISLAND

EXISTING LAND USE

SCALE: 1" = 800' FIGURE NO.: III-1



NOTE:
Information from plan entitled: Airport Approach Plan Imaginary Surfaces for QUONSET STATE AIRPORT, State of Rhode Island, Division of Airports, dated 4-19-77

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NORTH KINGSTON, RHODE ISLAND

QUONSET STATE AIRPORT
HEIGHT LIMITATIONS

SCALE: 1" = 800' | FIGURE NO.: III-2

cantly affects the manner in which the Port at Davisville can be developed, by dividing the port into two separate areas.

North of Davisville is Allen Harbor and Calf Pasture Point. These areas have been designated for potential recreational development. The impact of expanded port activities at Davisville on these recreational uses must also be considered.

In developing the alternate configurations discussed in the following section, it was assumed that the 95-acre parcel immediately south of Pier 2 will remain under the control of the Navy. Therefore, instead of having a single 260-acre port complex, two areas are created, one being 95 acres and the other being 60 acres in size separated by 100 acres of retained Navy property. While this separation can be accommodated in the site design, it does result in increased development costs and decreased flexibility. Some cost reductions can be realized if transportation and utility corridors can be provided through retained Navy property. An even more beneficial arrangement would be the lease of all or a substantial portion of the retained 95 acres of Navy land. This could result in as much as 260 acres of waterfront industrial land with over 8,000 linear feet of berthing space making the facility attractive to more potential users.

B. Environmental Factors

In conjunction with CE Maguire's preliminary engineering of expanded port facilities at Davisville, an environmental assessment of the project was made by the Coastal Resources Center of the University of Rhode Island, Graduate School of Oceanography. This detailed assessment, its findings and recommendation, are presented in the CRC report.

C. Geotechnical Considerations

Geotechnical analysis of expanded port facilities at Davisville were based primarily upon data obtained from a boring program consisting of 18 bore holes. All borings were located in the water and were patterned so as to yield geological and geotechnical information on the overburden and bedrock structural regimes throughout the site. Standard and undisturbed laboratory strength analysis of sediment samples were performed. A comprehensive literature search coupled with varied project experience in port and harbor design throughout Narragansett Bay, New England, and much of the world were drawn upon during formulation of design alternatives at Davisville. Additional data was provided by work performed by the Coastal Resources Center of the University of Rhode Island Graduate School of Oceanography as part of their environmental assessment of this project. This work included geologic and oceanographic studies conducted within and adjacent to the study area.

Generally, the geologic strata of the study area are that of a glacial outwash plane with bedrock elevations ranging from 45 to 100 feet below mean low water. In the near shore area, it appears that most of the port expansion construction would be undertaken in areas where water depths average 5 feet or less. The most prominent geologic feature observed is a 700-foot wide drowned river valley running parallel, and approximately 800 feet off shore and north of the east-west airport runway at Davisville. This feature extends some 3,000 to 4,000 feet into Fry's Cove and averages 19 feet, but does not exceed 25 feet in depth.

Surficially, the sediment overburden is blanketed with a stratum of extremely loose and compressible organic silt from 1 to 10 feet in thickness. In the drowned valley, the organic silt was sampled to a depth of 25 feet. Underneath this in the Fry's Cove Area is a deposit of medium dense, fine to medium sand which is locally varved with silt from 15 to 45 feet thick. This overlies a thin (5 to 15 feet-thick), but ubiquetous layer of very dense glacial till. The final stratum encountered was bedrock, consisting of shale, both graphitic and nongraphitic in composition.

In the area north of Pier 2, sediment overburden thickness, and bedrock depths appear to be deeper than in the Fry's Cove study area south of Pier 2 by approximately 25 percent. Sediments north of Pier 2 generally are of a finer grained nature, reflecting their deposition under less turbulent outwash conditions.

The significance of the various study area strata as engineering materials can be discussed relative to the location of the design alternates. As previously discussed, existing Pier 2 demarkes the boundary between the more northerly, finer-grained (silty) sediments and the more coarse-grained (predominently fine to medium sand with little silt) southerly strata.

Fill material for the various alternates considered will be obtained from dredging of the access channels. In the areas of minimal surficial organics, homoginization of sediments during the dredging and placement processes, will render insignificant any detrimental characteristics that the organics may impart to the gross fill properties. Areas of organic deposits over 5 feet in thickness, as in the drowned valley, may require some selective segregation and stockpiling. It is the medium-dense fine to medium sand, intermediate sediment stratum that will provide the majority of the necessary fill. This granular material will be competent enough to permit conventional steel bulkhead construction in all of Fry's Cove exclusive of the drowned valley area.

In those areas of thick, loose, silty sediments, or soft organic silt sediments, (e.g. the drowned river valley in Fry's Cove and in the area north of pier 2), it is anticipated that loads applied by the sediment will exceed the structural limitations of standard available sheet piling sections for systems utilizing a single tie back.

Other construction methods, which could be utilized to provide a bulkhead, include removal of these weak soils and replacement with competent material, or installation of a double tie back system. Both of these options would be cost prohibitive. Other design alternatives studied included relieving platforms, cellular cofferdam, pile-supported reinforced concrete pier, and slurry wall construction.

Stone armored slopes, where required, were designed with a multi-stage stone filtering system to prevent migration of fines from the foundation soils.

In the new pier installation (Alternate 6), two methods of construction are proposed: steel sheet piling perimeter anchored by a tie back system filled with dredged material or a reinforced concrete deck supported by concrete piles founded on bedrock.

D. <u>Ocean Engineering Parameters</u>

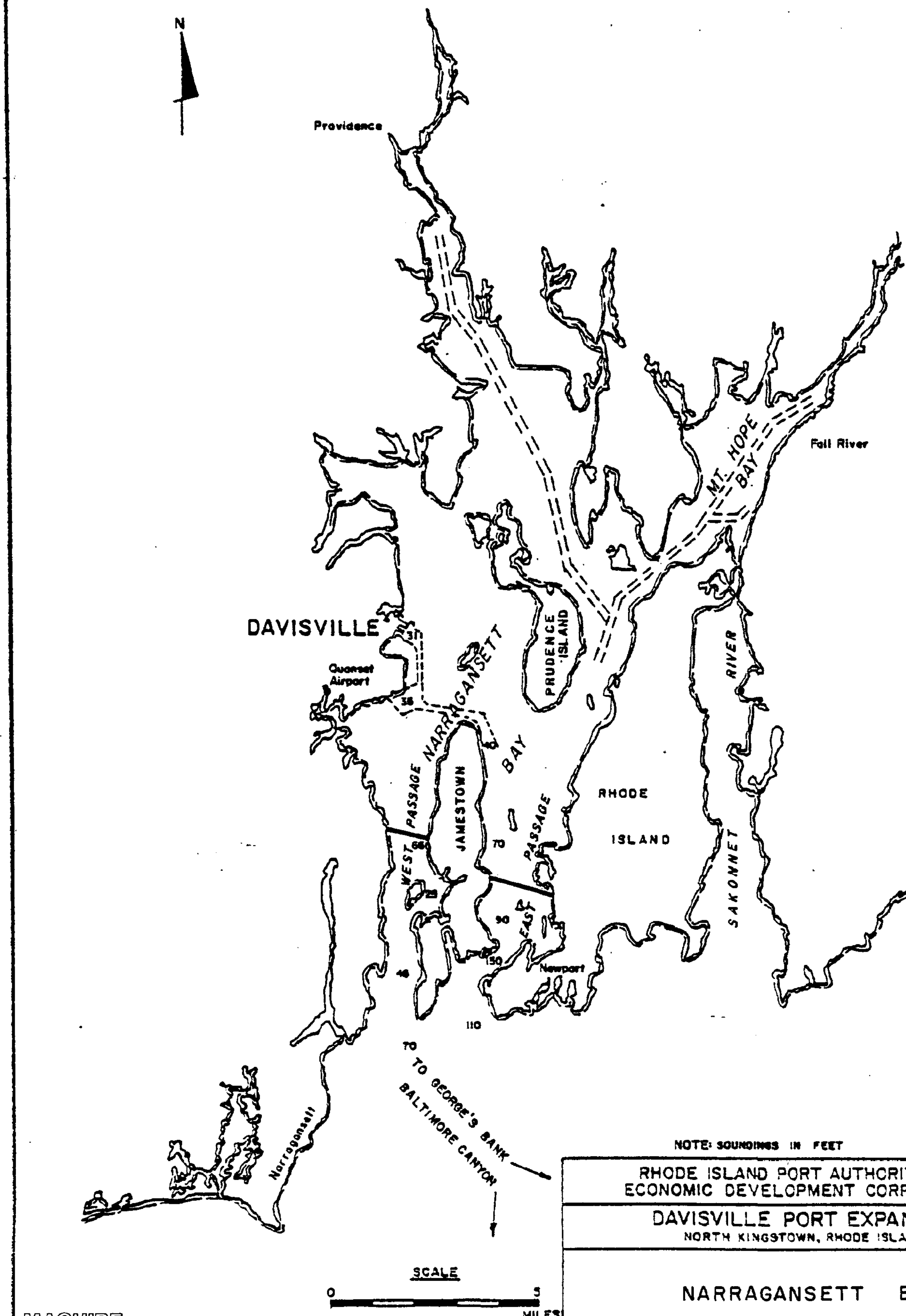
Oceanographic conditions at Davisville are compatible with the construction of port facilities. Wind conditions are generally mild, with the average annual wind speed approximately 10 mph. This is well below velocities that could become troublesome to vessels during berthing operations. The wind direction varies seasonably with winds from the northwest in winter months and from the southwest during the summer months.

Hurricanes in this region generally occur in the latter part of the summer - August and September - and have caused major damage within the bay several times during this past century. The damage is caused principally by winds of up to 125 mph and the surge in tides that accompany hurricanes.

These tides are well above normal elevations. The most severe hurricane on record to hit the Rhode Island coast and Narragansett Bay occured in September 1938.

Normal tidal range at Davisville is about midway between that of Newport and Providence with a mean range of 3.8 feet. Mean high water is 4.0 feet above MLW. The spring tide range for Davisville area is 4.7 feet. The maximum spring tide is 5.4 feet above MLW, and the minimum low water is 2.2 feet below MLW. During hurricanes, storm surges have risen 10 to 15 feet above NGVD. Based on a frequency analysis of tidal flooding from hurricanes and storms at Providence, Rhode Island by the U.S. Army Corps of Engineers - New England Division (December 1956) the 10-year event produces a storm surge of 12.3 feet above MLW; the 20-year event produces a surge of 14.0 feet above MLW; and the 50-year event produces a surge of 16.2 feet above MLW. The hurricane of September 1938 corresponds to the 100-year event and produced a surge of 17.7 feet above MLW. Elevations above NGVD are slightly lower at Davisville. The higher levels at Providence are caused by the configuration of Narragansett Bay (Figure III-3) which narrows the northern end constricting the storm surge and causing higher flood levels at Providence. The US Department of Housing and Urban Development, Federal Insurance Administration Flood Hazard Boundary Maps show the 100-year Base Flood as Elevation +15 MLW (+13 NGVD) in the project area.

Waves are generally less than two feet in this region of the bay, reduced in height from the open ocean by refraction and shoaling effects. This low energy type of environment should not interfere with port activities except in severe weather. High wave levels will cause port operations to be suspended because of excessive vessel motions. It is anticipated that "downtime" in the Davisville area will not be more than two percent due to adverse wind and wave conditions. Based on the Corps hurricane survey, it is conceivable that waves of 7.5 feet could occur in the middle



RHODE ISLAND PORT AUTHORITY AND ECONOMIC DEVELOPMENT CORPORATION

DAVISVILLE PORT EXPANSION
NORTH KINGSTOWN, RHODE ISLAND

NARRAGANSETT BAY

DATE JAN., 1981	SCALE AS SHOWN	FIGURE NO. III–3

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section of the West Passage under hurricane conditions. Utilizing solitary wave theory coupled with analysis of bay geomorphology and prevailing wind conditions, a wave height of 5 feet was used to determine effects of wave run-up and overtopping of the proposed bulkhead, and selection of stone armor size for encompassing fill material in the project area. This wave height would correspond approximately to that of a 10-year event.

Currents in the port area are weak, generally 0.3 knots or less, and will not interfere in any way with berthing maneuvers and docking activities.

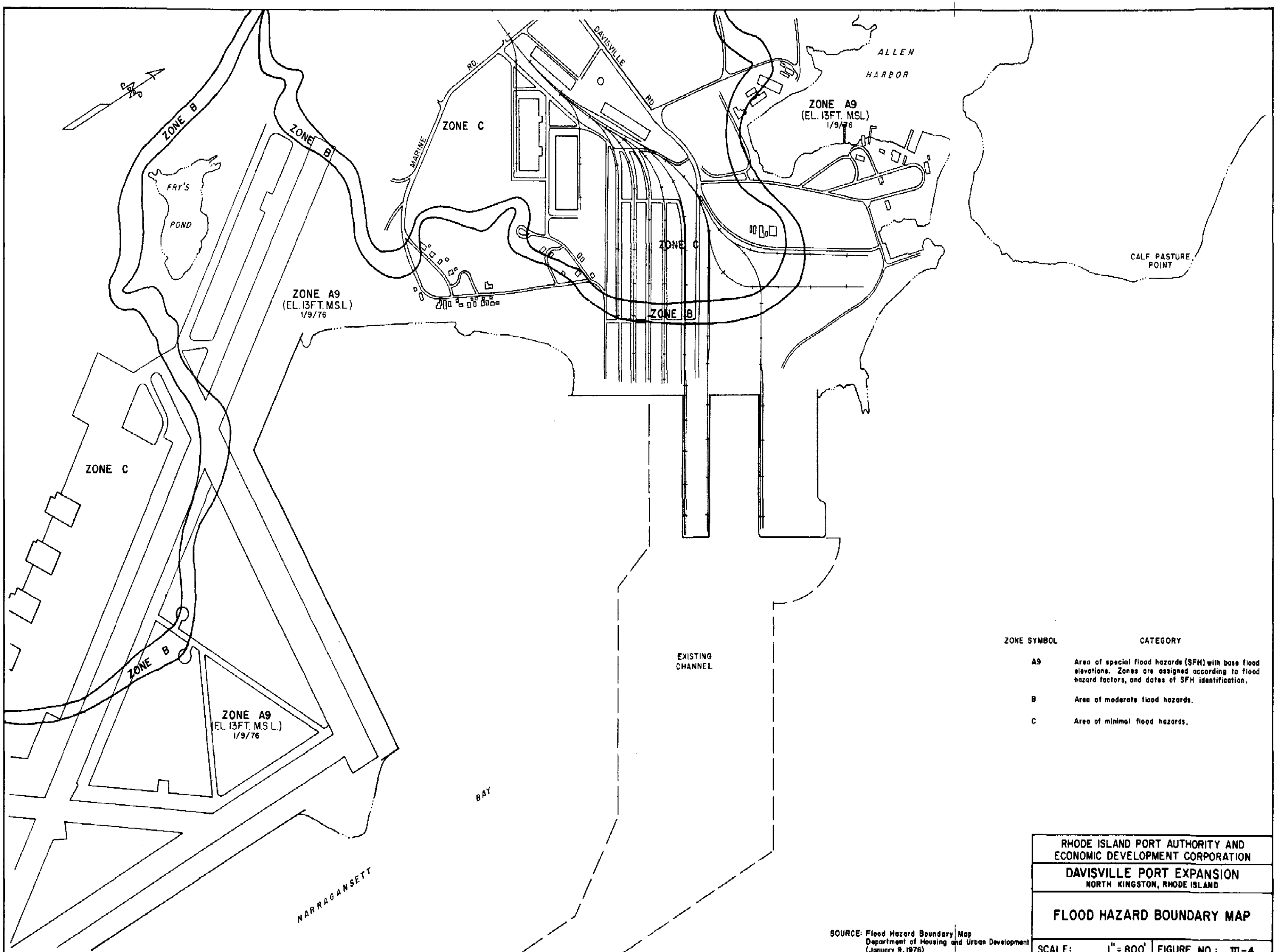
For any of the proposed alternates, the normal oceanographic and meteorological conditions will not adversely affect port operations, in fact, the area is sheltered from waves developing from prevailing northwest and southwest winds. The fetch is relatively limited precluding, under normal conditions, the development of large waves.

The alignment of proposed alternates 3 and 4 are most directly exposed to the northeast and, as such, could experience increased wave heights and wind intensity during northeast storms. None of the proposed alignments are directly exposed to the southeast storm although are exposed to storms developing from the easterly directions. The potential for wave run-up and overtopping of the bulkhead exists with any of the proposed alternates under severe storm conditions.

E. Flood Plain

Ports by nature of the role they plan in waterbourne commerce have to be located in or at least on the margin of flood plains. The majority of the existing port facilities at Davisville are below Elevation +13 MSL (approximately +15 MLW) which is the FIA (FEMA) 100-year flood level of the area. Most of the created land fill will fall below Elevation +13 MSL and will therefore fall within 100-year coastal flood plain. (See Figure III-4)

Land based facilities will have to constructed in accordance with FEMA criteria. Sewer manholes will require watertight covers and electrical substations will be located above flood levels. The bulkhead and stone armored slopes will be designed for wave overtopping and have passages to allow receding waters to flow back into Narragansett Bay.



ZONE SYMBOL	CATEGORY
A9	Area of special flood hazards (SFH) with base flood elevations. Zones are assigned according to flood hazard factors, and dates of SFH identification.
B	Area of moderate flood hazards.
C	Area of minimal flood hazards.

SOURCE: Flood Hazard Boundary Map
Department of Housing and Urban Development
(January 9, 1976)

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FLOOD HAZARD BOUNDARY MAP

SCALE: 1" = 800' | FIGURE NO.: III-4

IV

IV. CONFIGURATION ALTERNATES

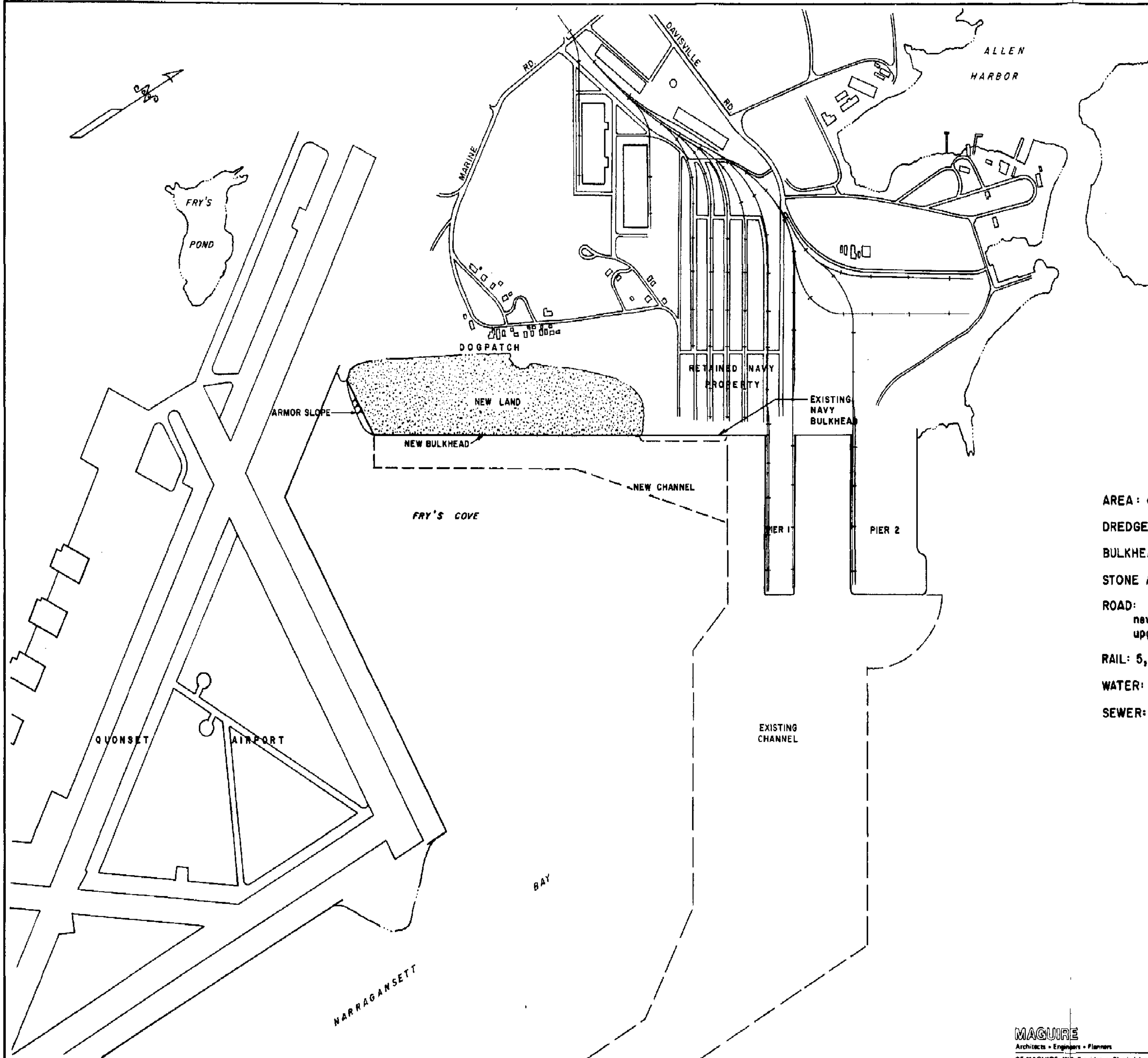
A. General

There are an infinite number of alternate alignments and configurations that could be considered for construction of facilities at Davisville making the evaluation of all possible configurations an impossibility. A set of six primary alternates was established and evaluated as part of the preliminary engineering for this project. The evaluation of these alternate is presented in detail in the following sections of this chapter.

During the early conceptual stages of this project, the Rhode Island Port Authority identified the extension of the Navy bulkhead towards the south (in the Dogpatch Beach area) as an apparently advantageous method of expansion of the port facilities at Davisville. This configuration was therefore one of six alternates that were analyzed in some detail. The five other alternates that were investigated included: incremental extension in the Dogpatch Beach area, maximizing land creation in Fry's Cove, expansion of Davisville north of Pier 1 and Pier 2, rehabilitation of the Navy bulkhead and construction of a new pier. These six alternates are discussed in the following sections.

B. Alternate 1

As shown in Figure IV-1, Alternate 1 presents the original concept as presented in the 1977 Quonset Point Technical



AREA: 46 acres of new useable land

DREDGE: 28 acres — 900,000 c.y.

BULKHEAD: 2,400 l.f.

STONE ARMORED SLOPE: 500 l.f.

ROAD:
new 3,700 l.f.
upgrade 2,200 l.f.

RAIL: 5,500 l.f.

WATER: 2,650 l.f.

SEWER: 2,700 l.f.

GRAPHIC SCALE
0 400' 800'

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ALTERNATE I

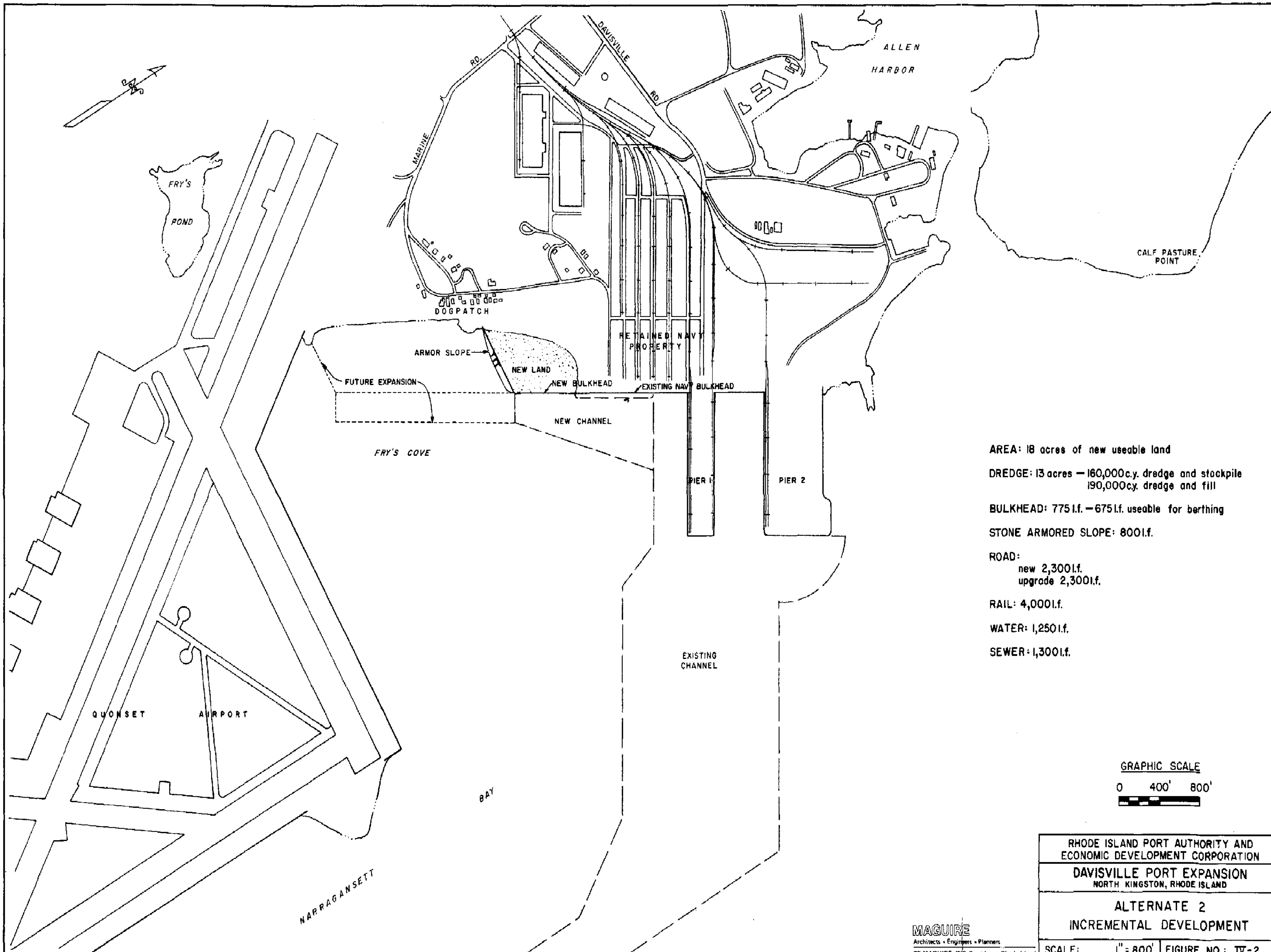
SCALE: 1" = 800' FIGURE NO.: IV-1

Park Facilities Study with some refinements due to site conditions as discussed in the previous chapter. Alignment of this alternate is such that future replacement of the Navy bulkhead can be readily accomplished should this be desired. Approximately 2,400 l.f. of new bulkhead and 500 l.f. of stone armored slope would be constructed. Some 30 acres of new usable land would be created by filling with 900,000 c.y. of material from 28 acres of new channel dredging. Four acres of area between mean high water and mean low water would be filled. All dredged materials will be utilized on site. Finish site grades will be adjusted such that fill quantities will equal dredge quantities thereby eliminating the need for stockpiling of excess dredge materials.

Rail and highway access will be provided through State property. Marine Road will be upgraded to accommodate the increased volume and weight of traffic with a new road being constructed through the Dogpatch housing area and onto the new land area. A new rail spur will generally parallel the access road, however, more stringent horizontal curve requirements will necessitate that it be constructed nearer the retained Navy Property. Consideration was given to providing rail and street access through retained Navy property. This would result in a reduction in developmental costs of approximately $300,000. However, this would necessitate long-term agreements with the U.S. Navy. Water would be provided by tying into the existing 16-inch watermain in the Dogpatch housing area. Sewer service will be provided by connecting into a new sewer which is proposed to pass through the retained Navy property. It should be noted that a portion of the northern limit of the Dogpatch development will take place on Navy property. Additional work on Navy property will be required for utilities and for connecting the new bulkhead to the existing bulkhead. It has been assumed that easements with mutually benificial terms can be negotiated for the use of this property. At present much of this area is below the mean high water level and the remainder is undeveloped low lying areas not now useable by the Navy. Development can occur in the Dogpatch area without doing work on Navy property, however there would be a reduction in both berth length and new land area without a corresponding reduction in price. This would result in costs for development in the Dogpatch area higher than those for Alternate 1.

C. Alternate 2

Considerations was given to configurations that allow for initial developments of reduced scope with future expansion potential. An incremental approach can be applied to pier construction, as well as bulkhead structures. Alternate 2, as shown in Figure IV-2, presents the phasing of Alternate 1 by construction of 775 l.f. of new bulkhead. Of this length, approximately 675 l.f. would be usable for berthing. The remaining length would be used to tie the bulkhead



AREA: 18 acres of new useable land

DREDGE: 13 acres — 160,000c.y. dredge and stockpile
190,000c.y. dredge and fill

BULKHEAD: 775 l.f. — 675 l.f. useable for berthing

STONE ARMORED SLOPE: 800 l.f.

ROAD:
new 2,300 l.f.
upgrade 2,300 l.f.

RAIL: 4,000 l.f.

WATER: 1,250 l.f.

SEWER: 1,300 l.f.

GRAPHIC SCALE
0 400' 800'

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ALTERNATE 2
INCREMENTAL DEVELOPMENT

SCALE: 1" = 800' FIGURE NO.: IV-2

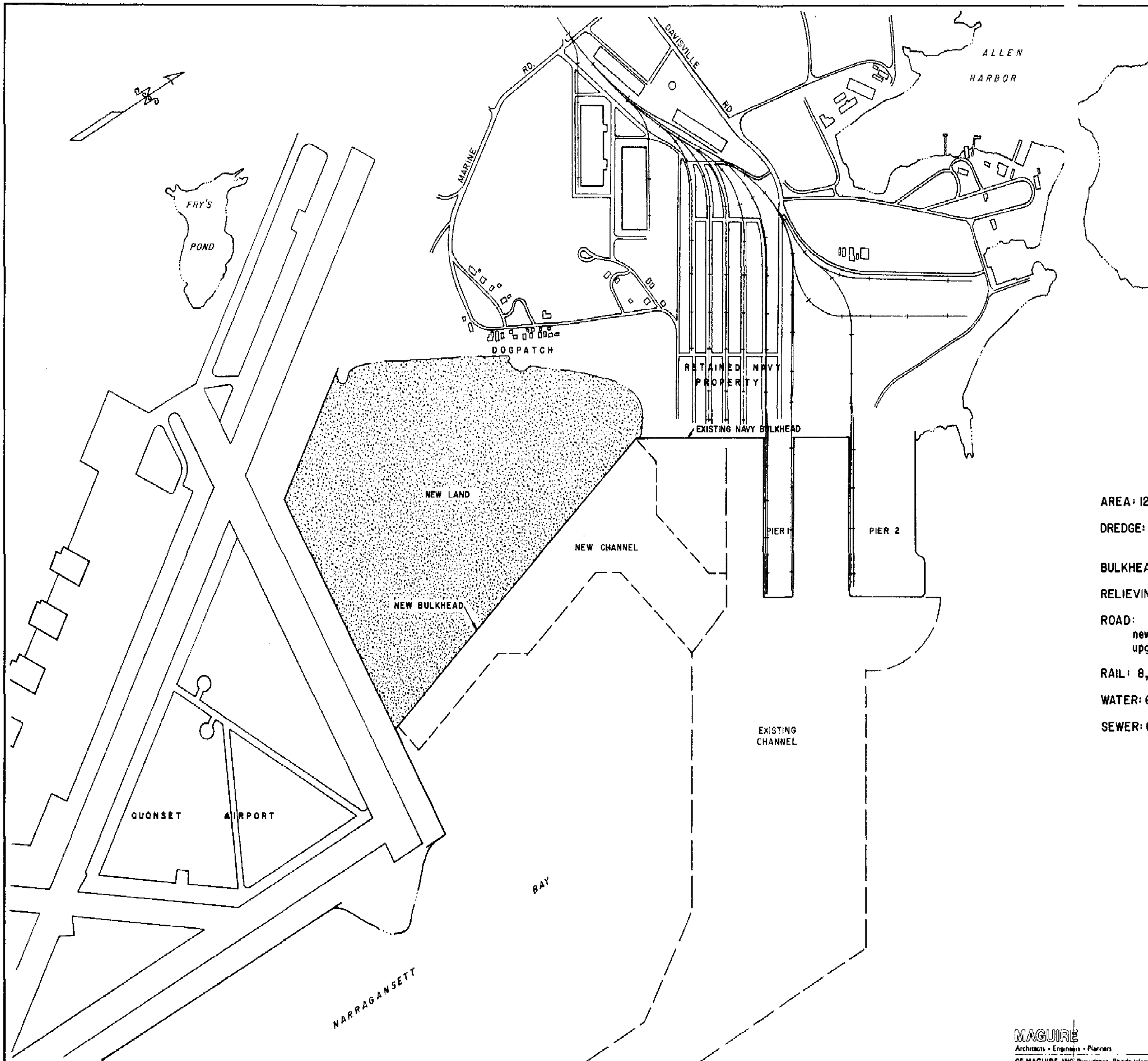
system into the stone armored slope and into the existing Navy bulkhead. To retain the filled land, 800 l.f. of stone armored slope will be constructed to produce 18 acres of new usable area. The new channel would require that about 13 acres be dredged of 350,000 cubic yards of material.

Unlike Alternate 1 this proposed incremental development will require the stockpiling of 160,000 c.y. of surplus granular dredge material which can be used for fill in future developments. The distance from the new channel to the stockpile area should be kept to a minimum to reduce haul distance thereby reducing the cost of initial construction as well as future expansion. The area west of Dogpatch beach is the most favorable as it is close to both initial and future construction sites. This open land between the main north-south runway and Marine Road is presently part of the State Airport Complex. This stockpiling should not adversly affect the airport as construction will consist of low earth dikes constructed with earth moving equipment. Road, rail, water and sewer services will be constructed along the same routes as in Alternate 1 with provisions made for the future expansion. As discussed in Alternate 1 the northern limit of the Dogpatch development will take place to some extent on Navy property. This will require agreements between the State and the Navy.

D. Alternate 3

The previous two alternates have dealt with development along Dogpatch Beach generally following the lines of the 1977 Facilities Study. These alternates produce a strip of land approximately 700 feet in width (measured perpendicular to the wharf face). This is equivalent to 14.5 acres for a berth 900 feet in length. For selected port users, such as a containerized cargo port, far more acreage per berth is required. Alternate 3 was developed to investigate the feasibility of maximizing the developable land as would be needed for a major containerized port facility. The configuration investigated as shown in Figure IV-3 would create about 120 acres of land behind a new bulkhead 3,200 feet in length with approximately 34 acres per 900 foot berth. The bulkhead would extend from the southern end of the Navy bulkhead to a point about 900 feet from the eastern corner of the Airport bulkhead. There are considerable environmental problems associated with the filling of over 100 acres of Fry's Cove and dredging of an additional 40 acres which results in the elimination of virtually all of Fry's Cove.

There are also several technical difficulties associated with this alternate. The proposed dredging will produce 1,200,000 cubic yards of material that can be used for filling, however, an additional 2,900,000 cubic yards of



AREA: 120 acres of new useable land

DREDGE: 40 acres — 1,200,000 c.y. dredge
2,900,000 c.y. of additional fill needed

BULKHEAD: 1,800 l.f.

RELIEVING PLATFORM: 1,300 l.f.

ROAD:
new 8,100 l.f.
upgrade 2,200 l.f.

RAIL: 8,900 l.f.

WATER: 6,800 l.f.

SEWER: 6,700 l.f.

GRAPHIC SCALE
0 400' 800'

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ALTERNATE 3

SCALE: 1" = 800' | FIGURE NO.: IV-3

fill would be required to complete the land creation. One possible source of material would be to utilize the area as a disposal site for other dredging projects in Narragansett Bay. Several dredging projects in the bay are being held in abeyance pending opening of an acceptable disposal site.

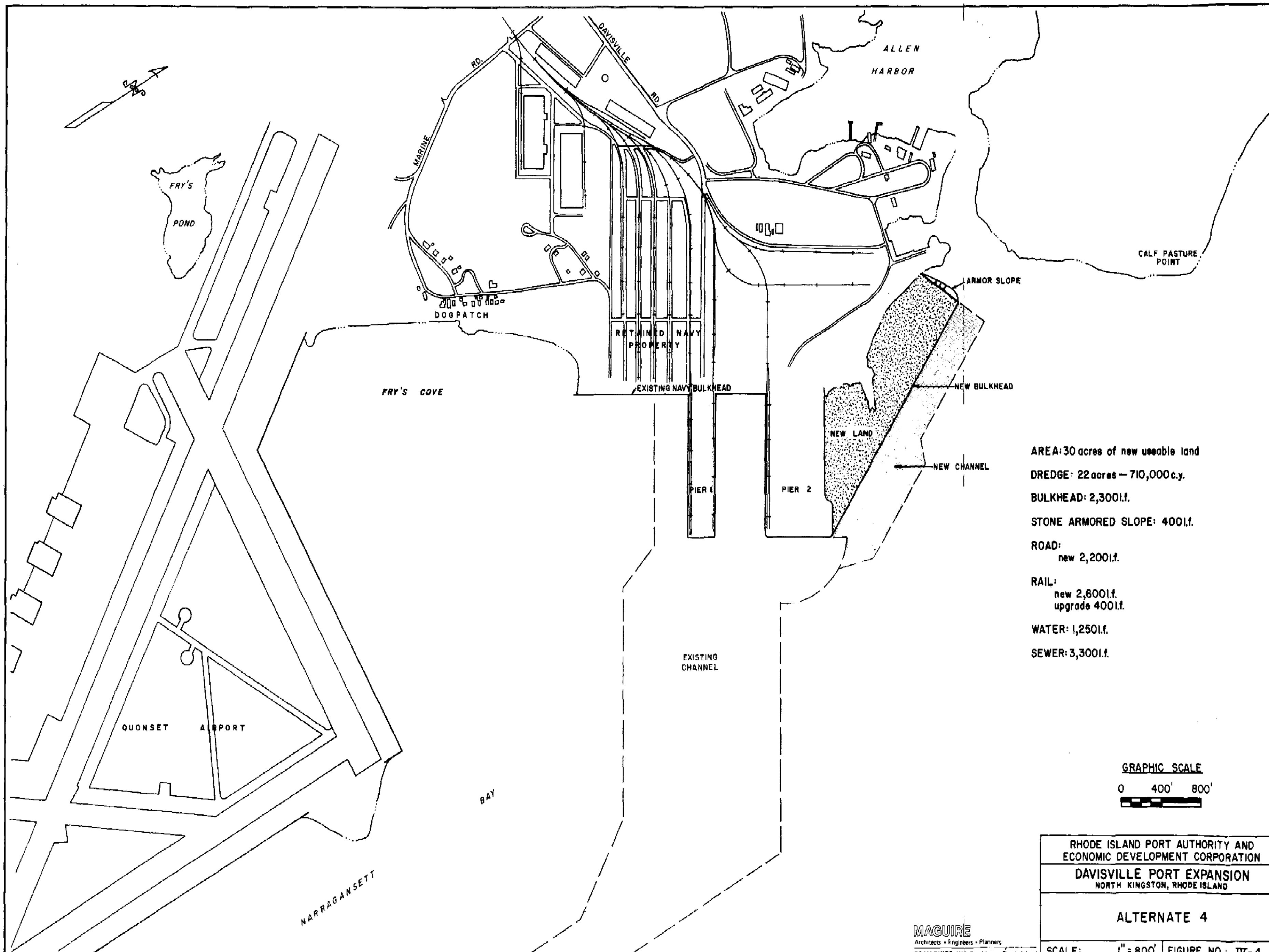
However, there are significant technical problems associated with the transferring of dredge spoil into the proposed fill area in environmentally acceptable manner. If there was a significant time span between construction of this and other dredging projects in Narragansett Bay, the resulting stagnation in the impounded area would be a serious environmental consideration. In most cases the material being imported would consist primarily of organic silt. As discussed in the previous chapter, the presence of buried organic silt greatly decreases the flexibility of a site. There are very few developmental options that could make affective use of this type of filled land without the associated high cost of special foundation preparation. Therefore, even though it might appear economically attractive to use the area for dredge disposal, the resulting land area would be of minimal value to most users.

In addition to the cost of handling the fill and the decreased value of the land associated with the presence of silt, there are two additional factors significantly affecting the cost of this estimate. The first is the need to extend the existing culvert from Fry's Pond for a distance of 2,200 feet. A more costly problem is the presence of the deep channel containing organic silt near the existing airport bulkhead. As discussed in the following chapter, the presence of soft soil deposits at depth significantly affects the loads on the waterfront structural system resulting in more costly construction.

One financial benefit that would result from this alternate is the elimination of the need for the future replacement of some 3,200 feet of deteriorated steel bulkhead along the airport perimeter. This bulkhead is presently in very poor condition with some localized structural failures. The steel sheets and wale have been perforated by corrosion in numerous locations. Loss of retained fill material is occurring over much of the length of the bulkhead with resulting exposure of tie rods. The filling of Fry's Cove would eliminate the need for this bulkhead and the need for its eventual replacement.

E. Alternate 4

In addition to development in the Fry's Cove/Dogpatch area, Alternate 4 was prepared to investigate development in the area north of the existing Davisville piers. The proposed construction as shown in Figure IV-4 would extend from the northeast corner of Pier 2 northwestward for 2,300 feet terminating adjacent to the Allen Harbor entrance channel.



AREA: 30 acres of new useable land

DREDGE: 22 acres — 710,000 c.y.

BULKHEAD: 2,300 l.f.

STONE ARMORED SLOPE: 400 l.f.

ROAD:
new 2,200 l.f.

RAIL:
new 2,600 l.f.
upgrade 400 l.f.

WATER: 1,250 l.f.

SEWER: 3,300 l.f.

GRAPHIC SCALE
0 400' 800'

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ALTERNATE 4

SCALE: 1" = 800' | FIGURE NO.: IV-4

All of the 710,000 cubic yards of material from 22 acres of dredging will be utilized for landfilling to create approximately 30 acres of new usable land. Road, rail and water services would be provided by tying into services existing adjacent to Pier 2. New sewer lines will tie directly to the new sewage pumping station.

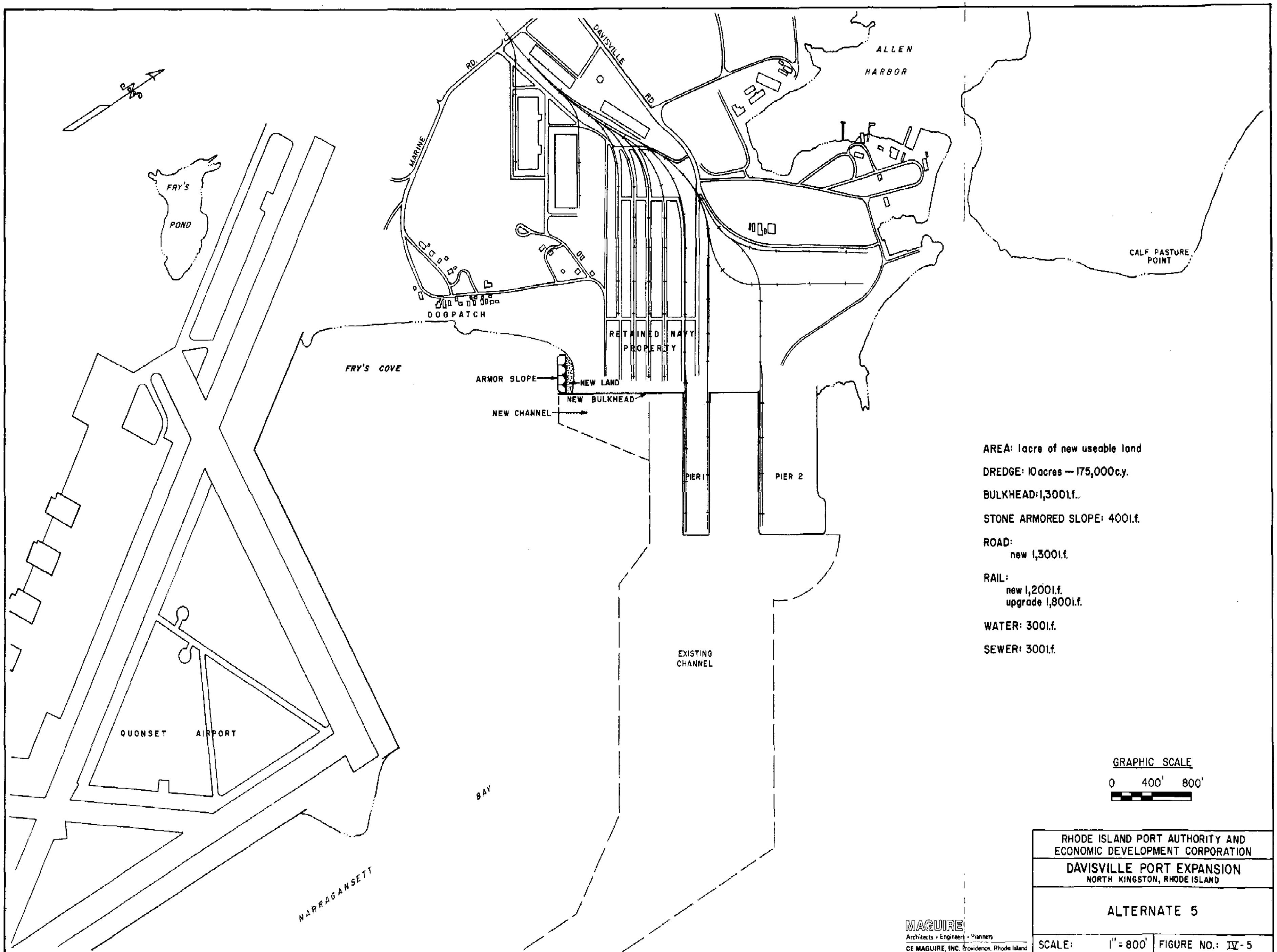
For many port operations the 30 acres created by landfilling would be inadequate to support 2300 l.f. of berth. The additional support area would have to be provided from the 100 acres already supporting Piers 1 and 2. This would result in increased congestion of this tract and could be undesirable under some instances. Development in the Dogpatch area could take advantage of the currently unutilized 35 acres of land to provide additional supporting land independent of the 100 acres at Piers 1 and 2. This operational factor in addition to the economic advantage of the Dogpatch area make Alternate 1 and 2 more attractive than Alternate 4.

F. Alternate 5

In an attempt to minimize the environmental impact of the proposed expansion of the port complex at Davisville, consideration was given to configurations that essentially do not create any new land. There are essentially two methods in which this can be accomplished. The first is to provide berthing along the existing Navy bulkhead. This development is presented in Figure IV-5 as Alternate 5. The second is the construction of a pile-supported deck similar to Pier 1. This proposed construction is discussed as Alternate 6 in the following section.

Approximately 175,000 cubic yards of material would be dredged from some 10 acres to provide access to the bulkhead. As almost no new land would be created, virtually all of this material will have to be stockpiled at least a half mile from the construction area. The existing timber bulkhead is in very deteriorated condition and was not designed for a 25-foot dredge depth. The replacement of this bulkhead is essential to utilization of this area as part of the port facilities. A new anchored steel sheetpile bulkhead 1,300 feet in length would be constructed approximately 5 feet seaward of the existing timber bulkhead. Stone armor would be installed along the shoreline starting at the southern end of the existing bulkhead extending for about 400 feet towards Dogpatch Beach.

A major assumption of this alternate is that long-term agreements could be negotiated with the Navy for the use of the bulkhead and adjoining land. The need for upland storage and marshalling area contiguous to the berths is discussed in Chapter II of this report.



AREA: 1acre of new useable land

DREDGE: 10acres — 175,000c.y.

BULKHEAD:1,300l.f.

STONE ARMORED SLOPE: 400l.f.

ROAD:
new 1,300l.f.

RAIL:
new 1,200l.f.
upgrade 1,800l.f.

WATER: 300l.f.

SEWER: 300l.f.

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ALTERNATE 5

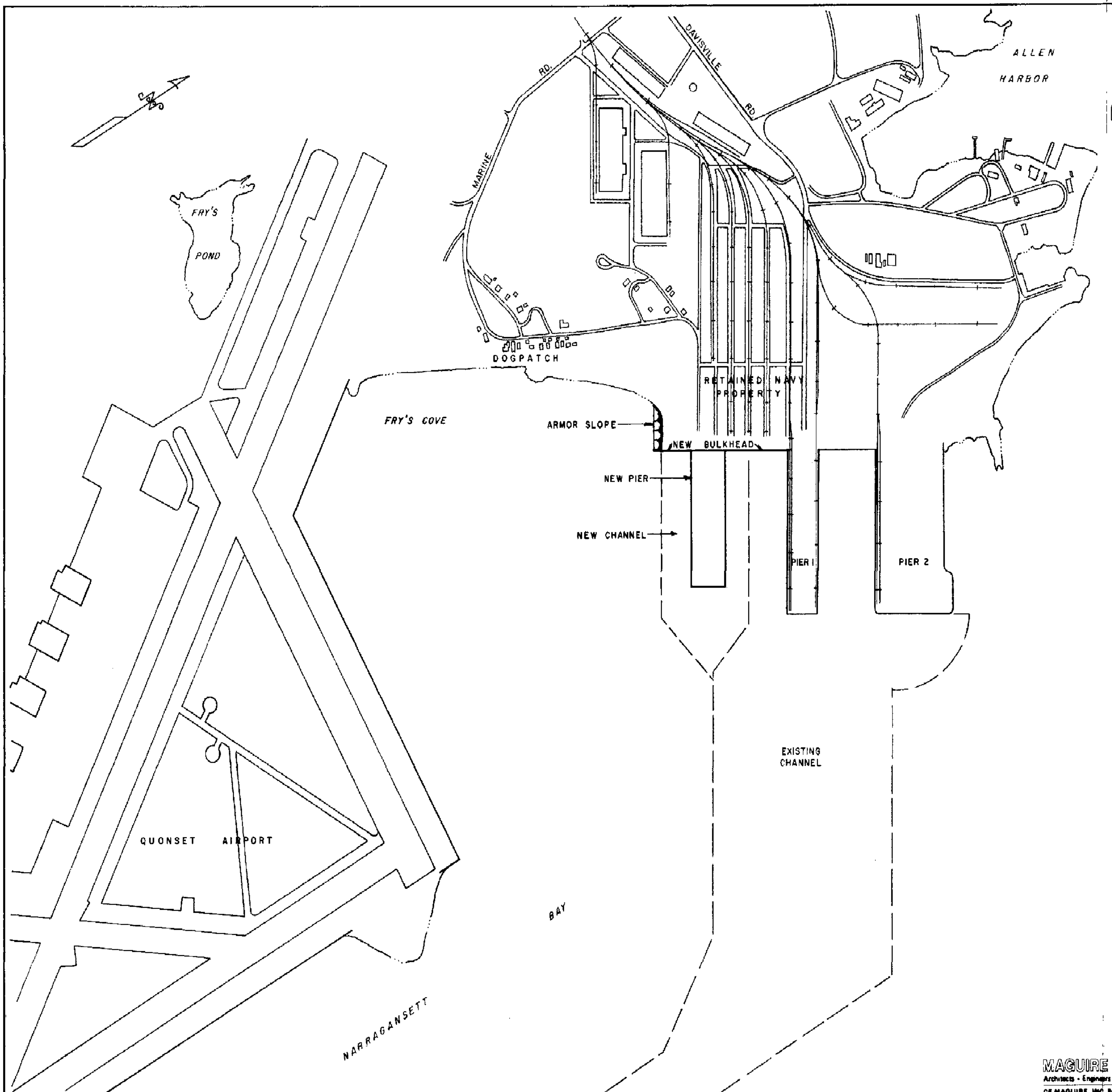
SCALE: 1" = 800' | FIGURE NO.: IV-5

G. <u>Alternate 6</u>

All of the five alternates previously presented have been concerned primarily with construction of bulkheads and other earth-containment waterfront structures. The alignment of these alternates has been generally parallel to the shore. The other type of structure considered was a pier (either pile-supported or earth-filled) which would be constructed perpendicular to the shoreline. Pile-supported piers reduce environmental impacts by eliminating filling. There are still the negative impacts associated with channel dredging and disposal of surplus material. With earth-filled piers there is a ready-made disposal area. With a pile-supported pier all of the dredge material is surplus and must be disposed of.

The major attraction of piers is that vessels can berth on both sides. In some regard, it can be considered that two berths are created for the price of one. However, the analysis is not that simple. For a pile-supported pier, this is essentially true. All sides of earth-filled pier must have containment structures and therefore, may not be particularly economical. As presented in Appendix F, a pile-supported pier is a very expensive waterfront structure being several times the price of most other waterfront structures. Earth-filled piers or wharves tend to be more cost effective alternates for the uses provided site conditions allow for their construction. Pile-supported piers are attractive when a narrow pier width is acceptable as is frequently the case for dry and liquid bulk cargos (oil, coal, ores, grain, etc.). For neo-bulk, break bulk, RO/RO, containerization, barging, OCS and similar port operations relatively large storage and marshalling areas are required adjacent to the berth. These port users require from a few to several hundred feet of combined apron and storage area contiguous to the berth.

Figure IV-6 presents a pier extending from the existing Navy bulkhead and is similar to the piers proposed for a high-find scenario in the 1977 Facilities Study. This configuration was selected because it minimizes dredging requirements. Other possible configurations that were considered were the lengthening of either Pier 1 or Pier 2. These alternates were rejected because of the increased congestion that would occur at the shoreward end of these expanded piers. During periods of active pier utilization, the high volume of incoming and outgoing cargos would result in congestion and greatly decreased port efficiency. The need to move cargo to and from the more outboard berths means that the inner berths would have very little apron width available for the temporary stockpiling of cargo prior to, during and following loading and unloading. Cargos would have to be moved to and from the apron rapidly to avoid blocking access to more outboard berths. Coupled with the difficulties of coordinating the cargo operation would be



PILE SUPPORTED DECK

AREA: 7 acres of new useable area

DREDGE & FILL: 370,000c.y. (stockpiled)

PIER: 300' x 100'

BULKHEAD: 600l.f. (rehabilitate)

RAIL:
new 1,700l.f.
upgrade 1,800l.f.

WATER: 2,400l.f.

SEWER: 1,000l.f.

EARTH FILLED PIER

AREA: 7 acres of new useable land

DREDGE & STOCKPILE: 170,000c.y.

DREDGE & FILL: 200,000c.y.

BULKHEAD: 800l.f.

REHABILITATE NAVY BULKHEAD: 600l.f.

RELIEVING PLATFORM: 600l.f.

CELLULAR COFFERDAM: 900l.f.

RAIL:
new 1,700l.f.
upgrade 1,800l.f.

WATER: 2,400l.f.

SEWER: 1,000l.f.

GRAPHIC SCALE
0 400' 800'

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ALTERNATE 6

SCALE: 1" = 800' FIGURE NO.: IV-6

the fact that marshalling and upland storage areas could well be from one-quarter to one-half mile distant from the actual berth.

The construction of a relatively wide new pier of limited length was determined to be the only viable approach to expansion of the Davisville port by pier construction. The selected pier dimensions were 300 feet wide by 1,000 feet long. This would allow an apron of from 100 to 125 feet in width which is considered as the absolute minimum for an OCS or commercial cargo operation. Nine OCS berths or four to five commercial cargo berths would be provided by this pier. The pier would require use of the adjacent Navy Land to provide storage and marshalling area within a practical travel distance. Utilities, road and rail access would all be provided through the retained Navy property. Estimates were prepared for both pile-supported and earth-filled piers.

V

V. CONSTRUCTION ALTERNATES

A. General

Numerous waterfront construction systems for providing land area and berthing space were considered for use at Davisville. In this preliminary design phase, factors such as service life structural loadings, foundation stability, operational considerations, maintenance and corrosion protection were evaluated to determine those construction alternates best suited to site specific constraints and design requirements at the Davisville port.

One of the important considerations in this project is the choice between open (e.g. pile-supported construction) and closed construction (e.g. bulkhead). In many ports this choice has considerable impact on wave reflection, currents, sediment transport and cost. In Davisville, which is a "low-energy" site with generally small waves, small tidal range and low current velocities, cost is the primary consideration. Geotechnical as well as oceanographic conditions have direct impact on the system selection. Areas of high bedrock generally favored gravity type structures, although gravity structures may prove economical in other foundation conditions as well. Soft layers of sediment often dictate the use of deep foundation systems such as piles. Our preliminary analysis included conventional systems such as steel sheetpiling as well as traditional gravity structures including granite block and cofferdam structures. Newer construction systems considered include cylindrical concrete pile walls and precast concrete block walls.

All the systems described briefly below have been evaluated for their cost-effectiveness, expected life span, maintenance requirements, site constraints and suitability for the design requirements needed at the Davisville port facility.

Bulkhead Construction - Anchored and Cantilever

- Precast Reinforced Concrete Sheetpile
- Steel Sheetpile
- Aluminum Sheetpile
- Timber Sheetpile
- Soldier Piles

Gravity-Type Construction

- Cut Stone Walls
- Precast Concrete Block Units
- Precast Reinforced Concrete Box Caissons
- Steel Sheetpile Cellular Cofferdams

Pile-Supported Structures

- Pile-Supported Reinforced Concrete Deck
- Pile-Supported Relieving Platform

In any bulkhead design, the system can be fixed by simple cantilever action or anchored by a tie rod and deadman system. For the Davisville Port, the cantilever system was quickly eliminated because of the high bending momemts involved due to design dredge depths and excessive embedment lengths required. For all bulkheads utilized for vessel berthing anchorage, systems will be required. Cantilever bulkheads may be feasible for short distances where dredge depths are becoming shallower and in transition areas to tie into other containment structures sucg as armored slopes.

1. Precast Reinforced Concrete Sheetpiling

Precast concrete has been used extensively in sheet-piling work. It generally performs better than either steel or wood under the adverse environmental conditions of a marine installation and can be constructed in sections that are better able to withstand bending stresses. As a construction material reinforced concrete is durable and presents a clean, attractive appearance. Concrete sheetpiling can be constructed so as to provide greater bending capacity and thereby withstand greater dredge depths than convetional steel sheeting. On an initial cost basis, in New England, concrete sheetpiling is seldom competitive with steel. Sheetpiling must work in both positive and negative bending requiring reinforcing steel on both faces. This results in relatively high costs. However, a major advantage of concrete, is that when properly designed and constructed it requires relatively little maintenance.

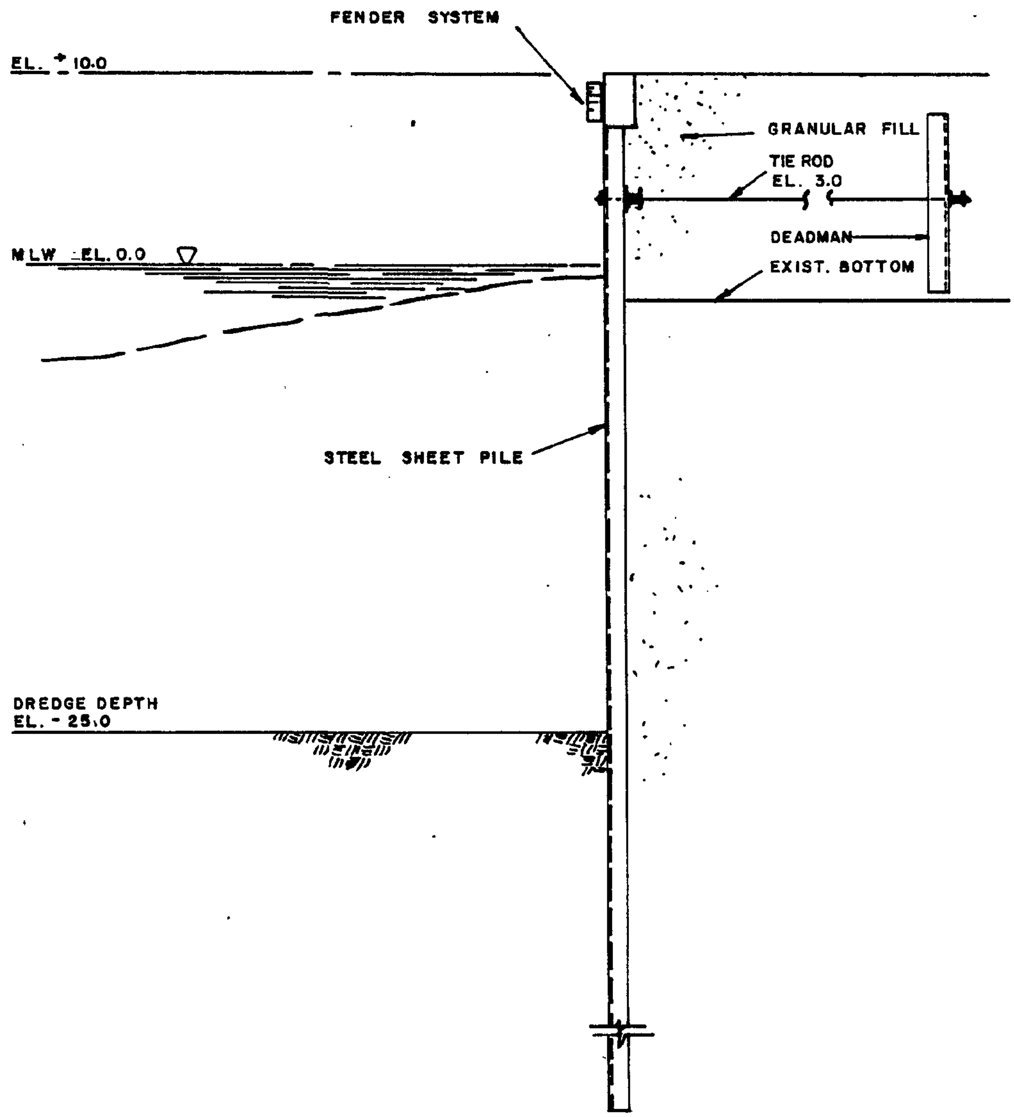
A major construction difficulty with precast concrete sheetpiling is in driving the material. Occasionally, the tongue or the edges of the groove break off during the driving process or the sheets may walk sideways due to lack of positive interlock. This requires costly cast-in-place fillers which must be fabricated to maintain structural integrity. Steel sheetpiles have a positive interlocking connection that maintains continuity. Precast concrete sheetpiling does not perform well in very soft soils nor in very dense soils as cracking or other damage to the sheets often occurs during driving. A further concern in the use of concrete sheetpiling is that when a sheet meets an obstruction and driving is stopped prior to design embedment depth, cutting of the sheet is difficult and costly. Subsurface explorations at Davisville encountered dense glacial till near the anticipated tip elevation. The distinct possibility of hard driving therefore exists. When additional measures such as pre-augering may be employed to make driving of the precast concrete sheetpiles easier, however, this additional work results in concrete sheetpiling being uneconomical as compared to other alternates.

2. Steel Sheetpile Bulkhead

Analyses of anchored steel sheetpile bulkheads (Figure V-1) were conducted for this preliminary engineering design. The advantages of normal sections of steel sheetpiling are that the interlock is completely soil tight and essentially watertight under normal conditions. The interlock also provides wall continuity connecting one pile to another. The pile cross-section shape is designed to provide the maximum resistance to bending moment with a minimum amount of material. The material itself is a significant advantage. For a given bending moment the necessary steel sheet is lighter in weight than either timber or concrete, the transport of the sheetpiles and the maneuvering into driving position is easier and less expensive, and generally a smaller driving hammer can be used to achieve the same rate of penetration.

Anchored steel sheetpile bulkheads can be adopted to numerous existing conditions. Figure V-2 readily shows the design that is proposed to be used for replacement of the existing deteriorated timber bulkhead along the retained Navy property (discussed as configuration Alternate 5).

The most important factor governing the cost of the steel sheetpile wall is the section of piling selec-



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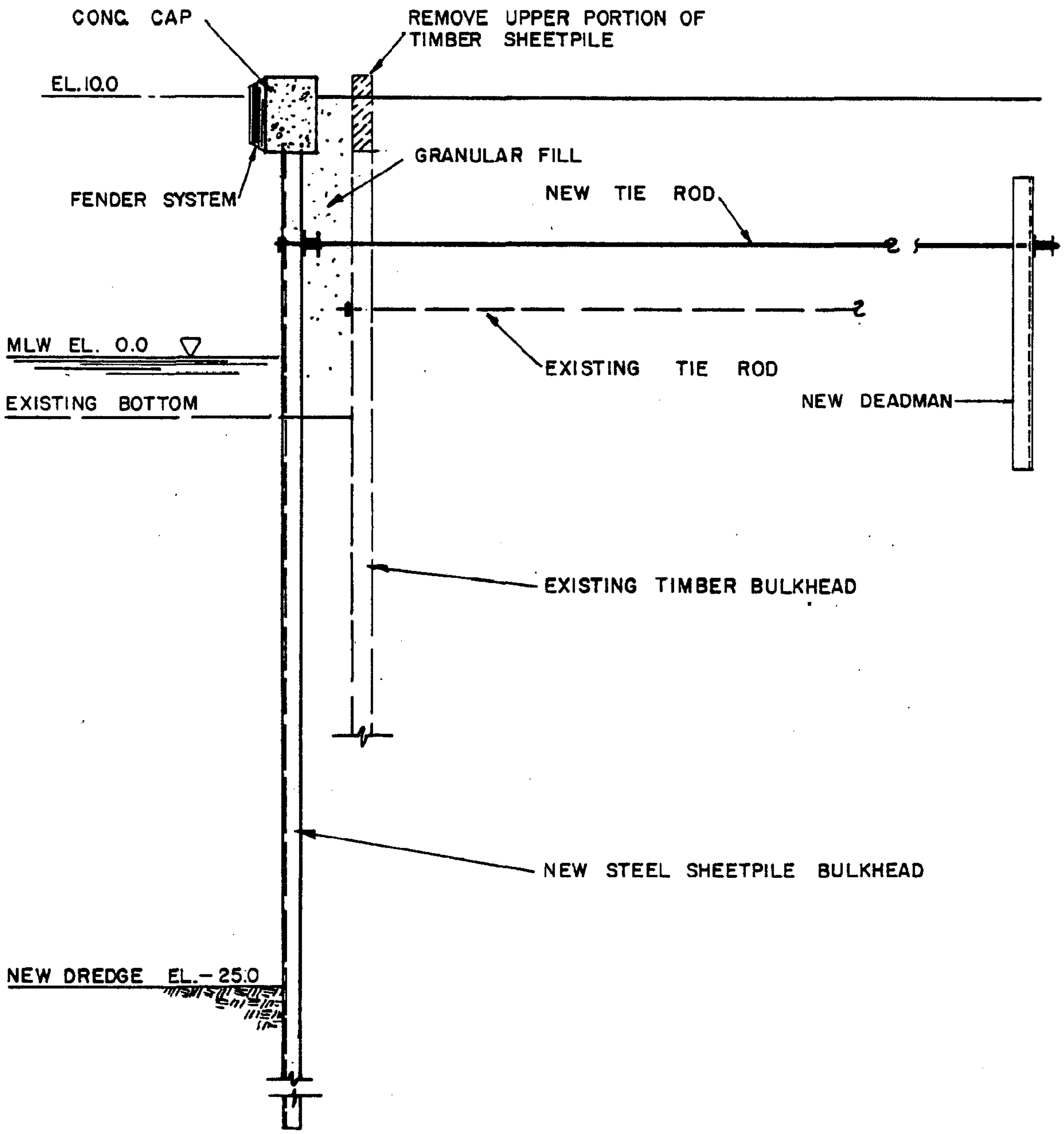
ANCHORED BULKHEAD

DATE JAN., 1981	SCALE N.T.S.	FIGURE NO. V-1



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REPLACEMENT OF
NAVY BULKHEAD

DATE JAN., 1981	SCALE N.T.S.	FIGURE NO. V-2

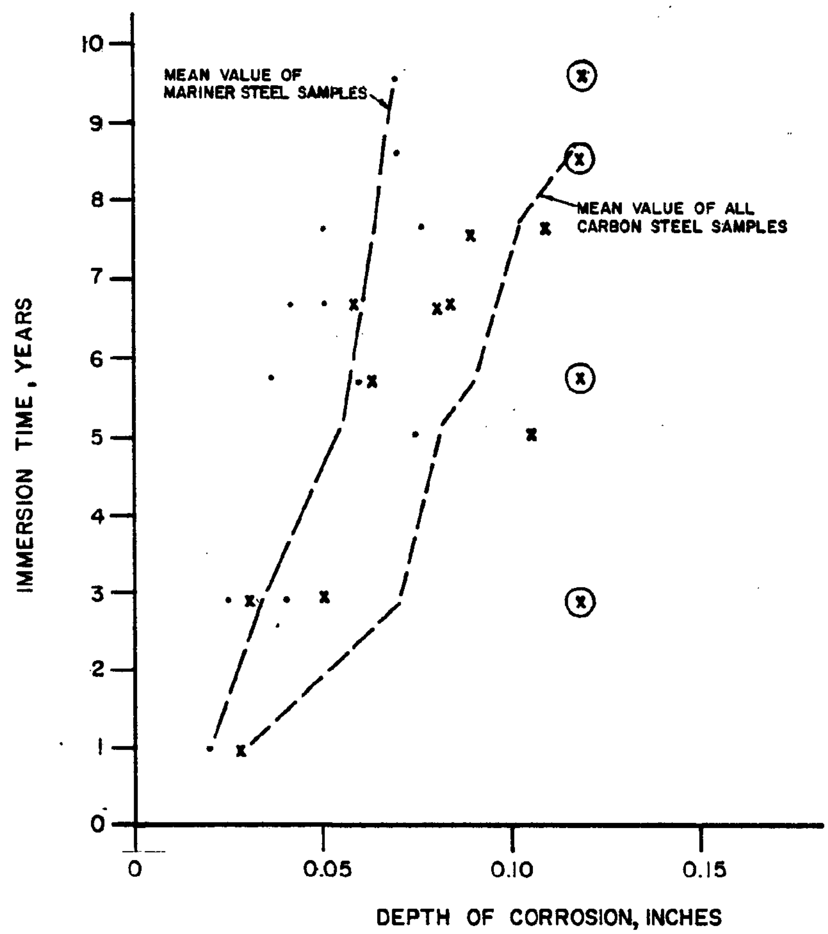
ted-the greater the per foot weight, the greater the cost. This in turn is governed by driving conditions, soil pressures, differential hydro-static pressures, surcharge loading from port operations, dredge depth and anchor location. In performing the design analyses, most of the parameters are controlled by site conditions and proposed port/cargo operations. The remaining parameters that could be varied (specifically anchor location and soil properties above the existing bottom) were manipulated to determine the most economical design.

The next design consideration for steel sheetpiling is the form of corrosion protection to be used. The question is not whether to use corrosion protection, but what type to choose: corrosion resistant steel, protective coatings (such as coal tar epoxies) or a cathodic protection system. Several studies have shown the importance of protecting steel against corrosion, particular in the "splash zone" - the area between high and low tides.

As the steel corrodes, the loss of steel reduces the load-carrying capacity of the wall and can ultimately lead to failure. In some instances, the material can corrode to such an extent as to allow perforation of the steel. The resulting holes allow the fill behind the wall to wash through. The resulting settlement behind the wall can be disastrous to wharf utilities, pavement and rail. Much of the steel sheetpiling along the airport perimeter has been perforated by corrosion in the splash zone with a resulting loss of backfill.

Corrosion is due to galvanic action with the seawater acting as the electrolyte and nonuniformities and non-ferrous impurities in the steel behaving as the dissimilar metals. Under these conditions, a flow of current is established from the steel (the anode) through the seawater to the dissimilar metal (the cathode). As the current flows, iron atoms are exchanged with hydrogen ions, leaving a formation of rust behind on the steel. This process results in a gradual loss of steel cross which will eventially lead to reduction of the cross-section and weakening of the structure.

The type of steel itself has a great influence on the rate of corrosion. Corrosion studies by United States Steel show the loss due to corrosion of carbon steel to be approximately two times greater than corrosion resistant Mariner steel. Figure V-3 graphically presents the results of studies by United States Steel.



LEGEND

• MARINER STEEL

x REGULAR CARBON STEEL

(x) TEST STRIP PERFORATED BY CORROSION

SOURCE: U.S. STEEL STUDY ON CORROSION

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STEEL CORROSION		
DATE JAN., 1981	SCALE AS SHOWN	FIGURE NO. V-3

In our analysis of the steel sheetpile alternate, we have investigated the several systems of corrosion protection. The first system - cathodic protection - can be one of two methods: an external-impressed current method, or a sacrificial galvanic anode method. The external impressed current method utilizes a soluble metal, such as iron, or an insoluble metal, such as graphite, to act as the anode. External impressed-current cathodic protection requires constant electrical consumption resulting in high operating costs. Furthermore, cathodic protection is marginally affective to wholly unaffective in the splash zone. The sacrifical anode method requires periodic replacement of anodes. This procedure is frequently neglected in maintenance programs making the system inoperable. Even when conscientious maintenance is employed, cathodic protection is only completely effective below the low water level. In the intertidal and splash zones cathodic protection is of little or no value.

The selection of cathodic protection is not judged as being economically nor appropriate, for the Davisville facility. The optimum bulkhead solution would be the use of a corrosion resistant steel such as Mariner steel with a protective coating of coal tar epoxy to extend the service life.

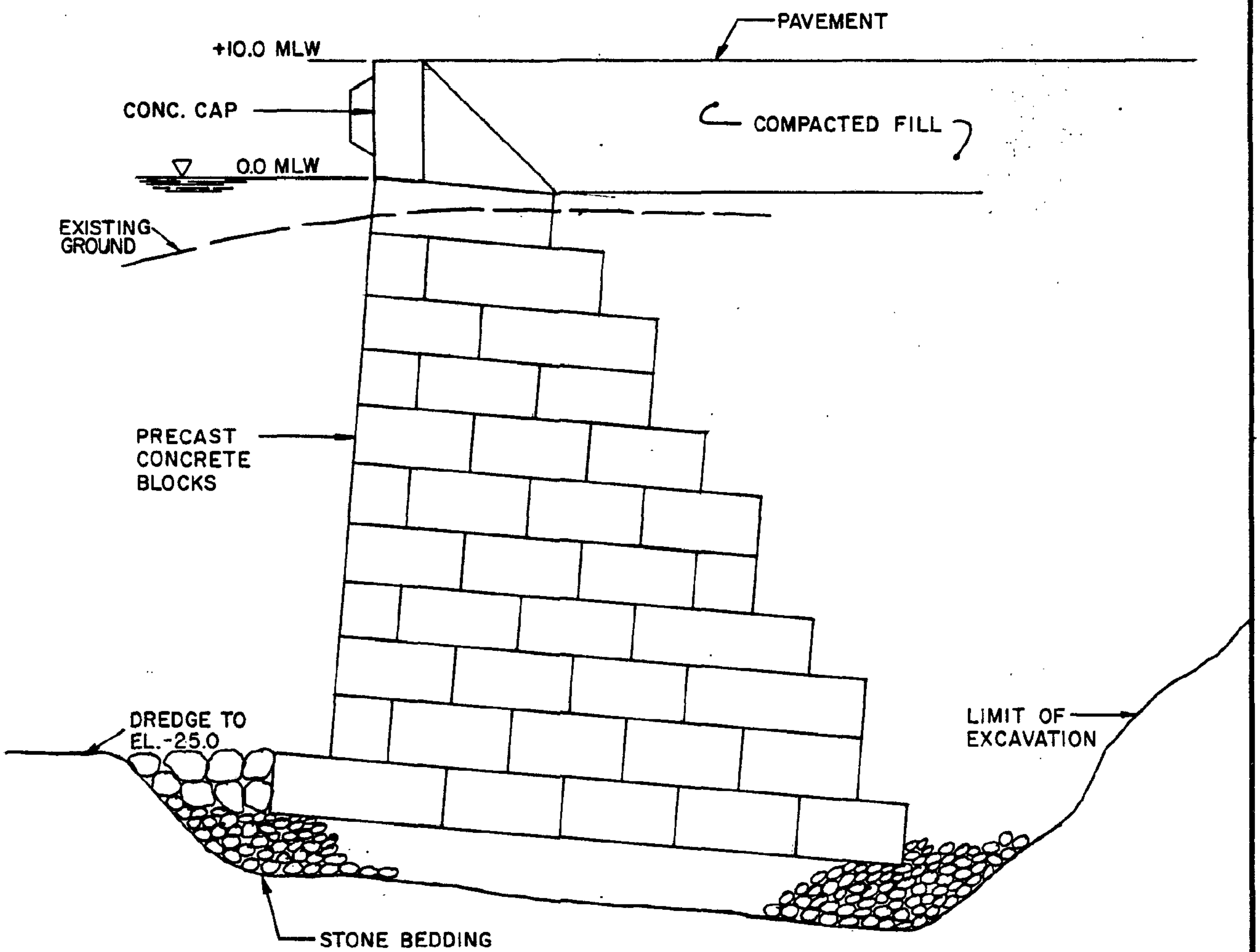
3. Soldier Piles

Soldier piles, either prestressed reinforced concrete, steel-H or pipe piles, have been used effectively in situations where underlying foundation materials are too dense to allow driving of sheetpiles and of sufficient strength to provide high lateral resistance to the pile tip. This is the case when bedrock is present essentially at the dredge depth. For this type of installation, the piles are at fixed intervals into pre-drilled holes in the rock and grouted in-place creating a picket fence appearance. Precast or cast-in-place panels would be used to close the space between them. The pile also support a cast-in-place or precast concrete deck or cap. A conventional tie-rod and deadman system or high strength rock anchor system can be utilized to provide lateral support near the top of the piles if the applied pressure exceeds the cantilever capacity of the system. The subsurface exploration program indicates that bedrock is too deep for this system to be structurally adequate at Davisville.

B. Gravity-Type Construction

1. Cut Stone Walls

Granite block wharves (Figure V-4) are a traditional form of construction in the harbors of New England. The chief advantage of a cut stone wall is its excellent resistance to lateral and vertical loads. It also



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CUT STONE GRAVITY WALL		
DATE JAN., 1981	SCALE N.T.S.	FIGURE NO. V-4

requires little to no maintenance. While rock quarries abound in New England, recently the price of cut stone has steadily increased as has the cost of labor required for construction of the wall. This type of traditional gravity structural is usually not competitive for the dredge depths that are required in modern port facilities. In recent years the concept has proved economical only in areas where high bedrock is present. This is not the case at Davisville. Massive gravity walls require a very strong founding stratum such as glacial till or bedrock. Therefore, a cut stone seawall is not appropriate for the foundation conditions at Davisville nor is it an economical solution.

2. <u>Precast Concrete Block Units</u>

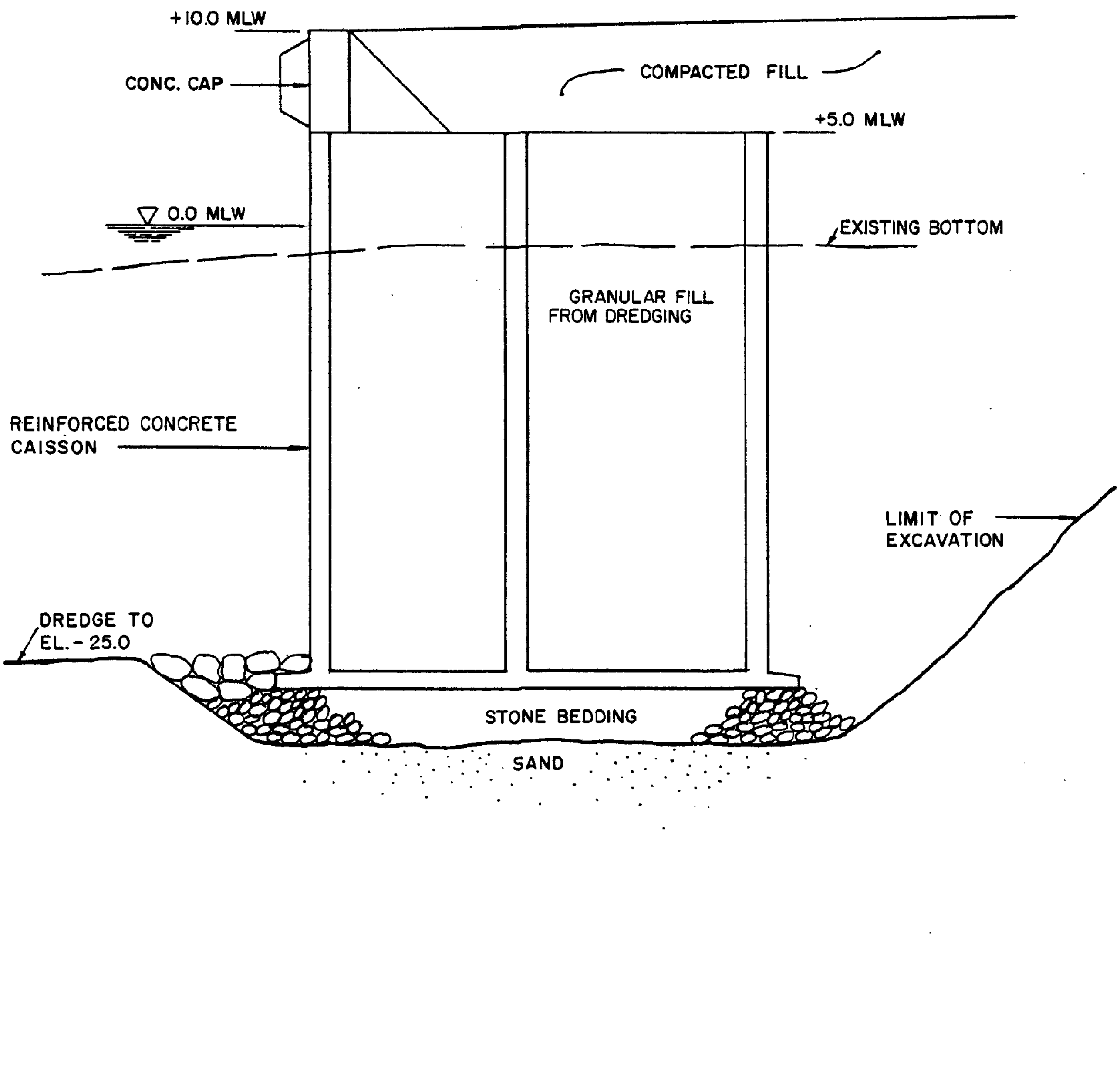
One alternative to cut stone is the use of large, solid concrete blocks. This type of wall is constructed in the same manner as cut stone. It is the cost of erection that makes cut stone walls uneconomical more so than the cost of materials. The use of concrete as opposed to stone still does not make this an economical solution. Furthermore, the foundation conditions are no more appropriate to this type of massive gravity wall then for a cut stone wall.

An alternative to cut stone blocks or solid concrete blocks is a retaining wall system that consists of precast, interlocking reinforced concrete block units. Once in-place the units would be backfilled with either free-draining material such as crushed rock or for added mass the units could be filled with tremie concrete. However, the alternate was not considered appropriate for Davisville due to the cost of placing and filling units below water level and the foundation conditions.

3. Precast Reinforced Concrete Box Caissons

Large prefabricated reinforced concrete structures are common in many European ports, notably the 7,500-foot quay in Southampton, England. They can be constructed offsite, launched, and floated into position where they are ballasted and sunk into place. Since ballast material can consist of the material dredged on-site, this alternative could provide an efficient use of the most readily available construction material, that is dredge spoil. Figure V-5 presents a sketch of a concrete caisson.

The caissons can be constructed in numerous modular lengths, multiples of which equal the desired total wharf length. Obviously, the larger the caissons, the fewer the number of sinkings necessary and the fewer



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REINFORCED CONCRETE CAISSON

DATE JAN., 1981	SCALE N.T.S.	FIGURE NO. V-5

the number of connections. The savings of decreased connections must be balanced against the cost of fabricating very large units.

Caissons are typically closed at the bottom, where they are placed onto a crushed stone leveling course. The height of the precast caisson crest is typically set at a level somewhat above high water so as to allow for a cast-in-place concrete cap and deck system to be constructed to true alignment and grade. In this manner, provisions are easily made for attachment of fender systems, installation of crane rails, utilities, and other waterfront items.

4. Steel Sheetpile Cellular Cofferdams

The previous gravity wall systems including caisson installation require excavation of large volume of soil, beyond the berthing limits to allow for construction. Most of this material can eventually be used for backfill of the wall or for filling of caissons. This results in increased excavation, backfill and disposal costs and tends to increase the environmental impacts of the project. The alternative is to use a gravity structure that can be erected in-place without pre-excavation such as cellular cofferdams.

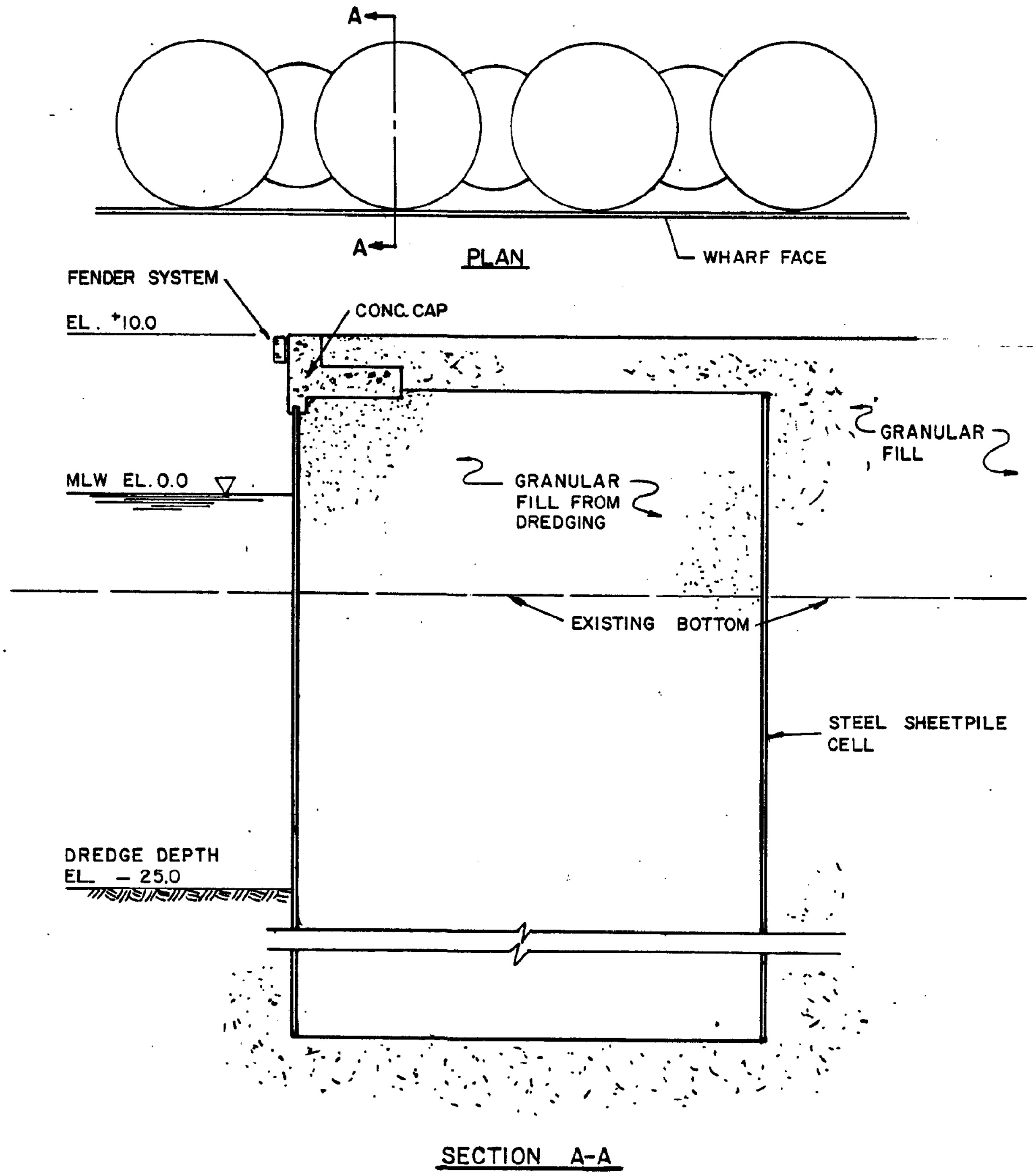
Cellular cofferdams are earth-filled structures that can be of a variety of shapes: circular, semi-circular, elliptical, or diaphragm. Figure V-6 shows a circular configuration. The walls of the cells are constructed of flat or shallow arch steel sheetpiling. Each piling is interlocked to the adjacent unit and acts in tension to retain the fill inside the cell, in much the same way as the hoops and staves of a barrel. The resulting structure is able to resist overturning and sliding at the base by gravity. The sheetpile cells are best used where bottom conditions permit adequate embedment of the sheets which is the case in most areas of Davisville.

The recent development of sheetpiling with an interlock strength of 28 kips per inch allows for the use of greater cell heights and diameters. A cofferdam structure for the port at Davisville would need sheets about 50 feet long, and would be costly, relative to the steel sheetpile alternate presented below, requiring more than twice the quantity of steel to accomplish essentially the same service.

C. Pile Supported Structures

1. Pile-Supported Relieving Platforms

Relieving platforms (Figure V-7) historically have been used when high retaining walls were needed, and sheet-



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CELLULAR COFFERDAM

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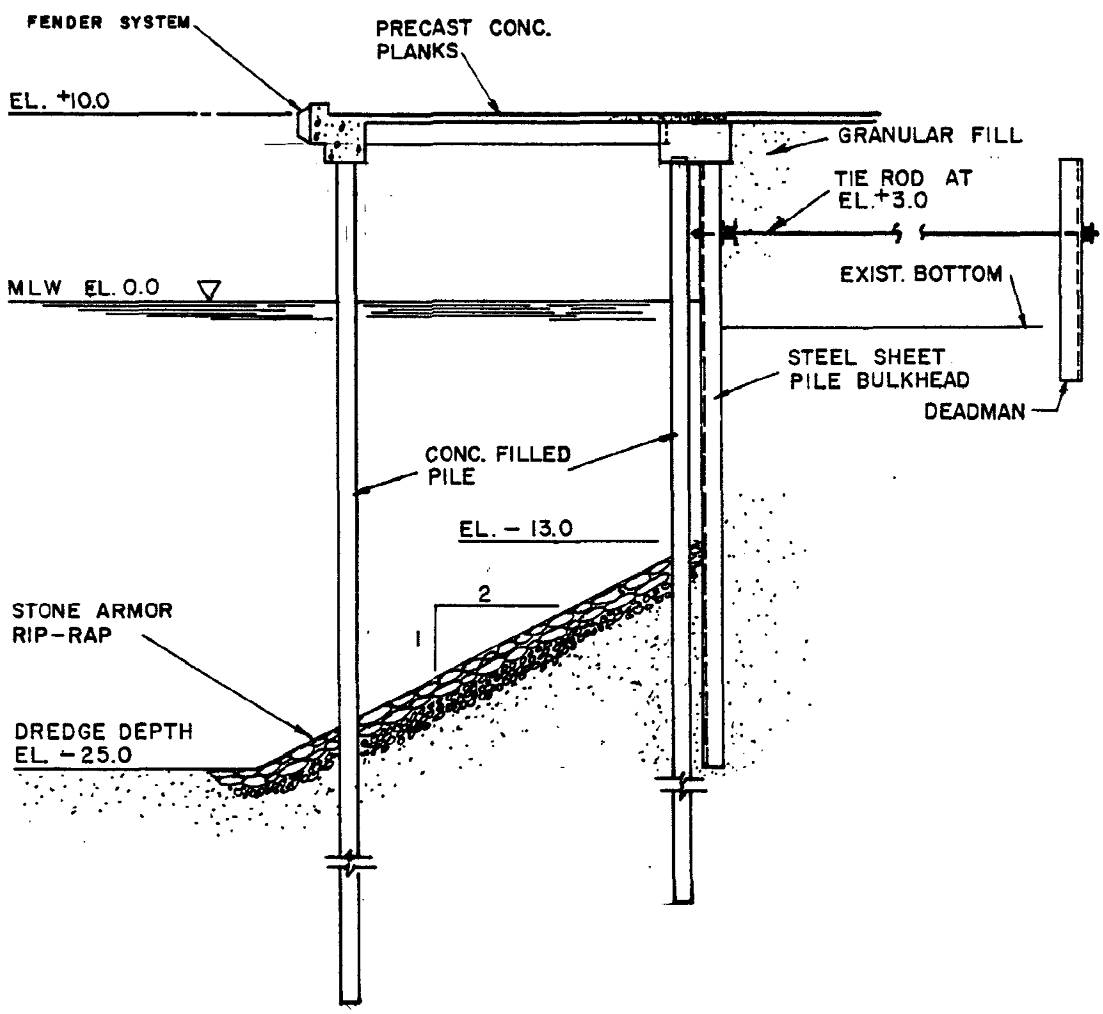
DATE JAN., 1981 | SCALE N.T.S. | FIGURE NO. V-6



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DAVISVILLE PORT EXPANSION

NORTH KINGSTOWN, RHODE ISLAND

RELIEVING PLATFORM

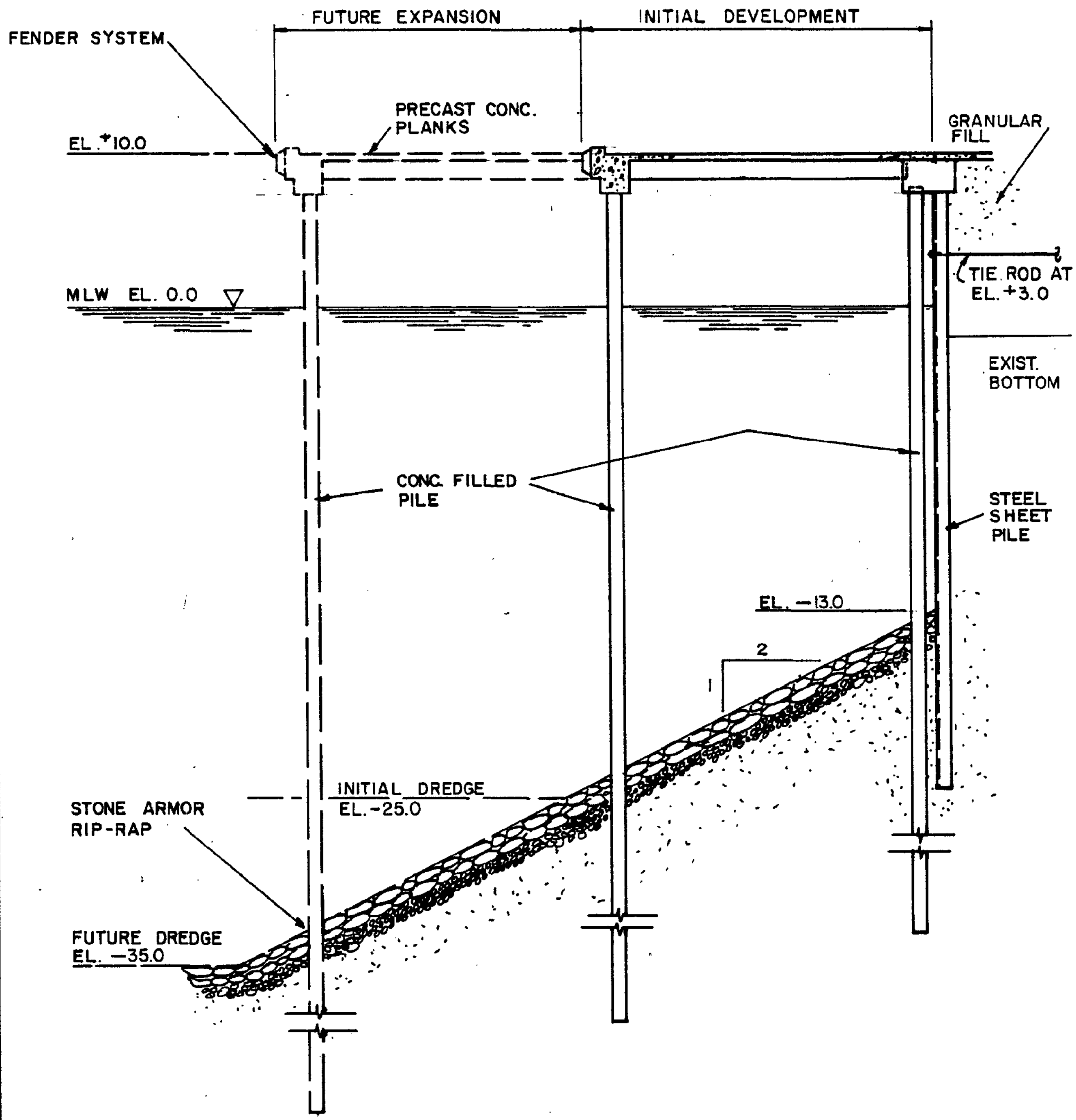
DATE JAN., 1981	SCALE N.T.S.	FIGURE NO. V-7

piling with an adequate section modulus could not be obtained to resist large bending moments. The reinforced concrete relieving platform is a deck located seaward of a sheetpile bulkhead. The deck may serve to anchor the sheetpiling and also reduce the bending moment on the sheetpiling. Use of a relieving platform generally is used when the conventional sheetpile wall will not work such as:

- when there is insufficient space to the landward for tie rods and anchorages or
- when the use of conventional anchorages is difficult due to unsuitable foundation conditions.
- when there are to be very large loads directly on the wharf due to rail or crane tracks which would require pile support

In lieu of tiebacks and deadman, batter piles frequently have been used to resist the lateral loads induced by soil pressures on the bulkhead. High vertical loads are required to develop this lateral resistance. This vertical load has been historically provided by several feet of soil supported on a reinforced concrete deck. The piling and deck system must be structurally adequate to resist the soil plus the customary cargo and berthing loads. This results in a system which is considerably more expensive than using a conventional deadman and tierod system. Where adequate area exists shoreward of the platform, a conventional tierod and deadman system is frequently the more economical than solution. With this system, the bottom slopes upward from the dredge depth towards the shore with a conventional bulkhead at the junction of the deck and shore. The sheetpiling is subjected to a much shallower effective dredge depth, thereby reducing the required sheetpile section: This slope is typically armored with stone riprap to prevent erosion from prop wash and wave action.

In the Dogpatch Beach area analysis has shown that a conventional anchored bulk can withstand the imposed loads. In the area north of Piers 1 and 2, where less favorable soil conditions exist a conventional anchored sheetpile system will not function while a pile supported relieving platform will. This pile supported platform, as shown in Figure V-8, is the most economical solution for the northern area where conventional anchored systems can not be permitted. Relieving platforms lend themselves to incremental expansion of port facilities where future dredge depths will be deeper than initial depths. The berth depth can be deepened in the manner shown in Figure V-8. A slope of 2 on 1 would be maintained on the shoreward side of the berth. The relieving platform deck would be extended



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DAVISVILLE PORT EXPANSION
NORTH KINGSTOWN, RHODE ISLAND

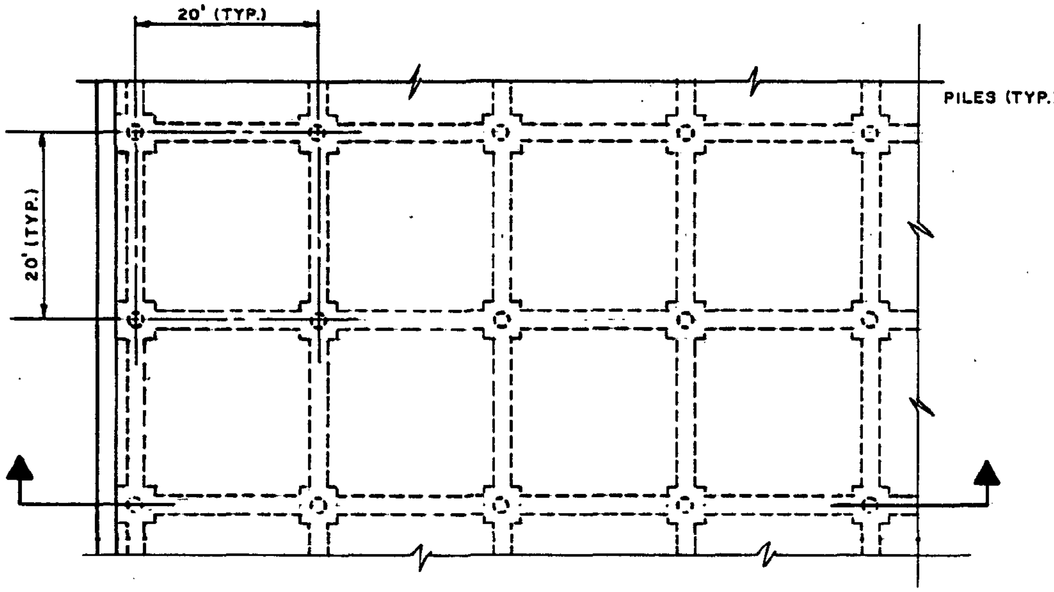
INCREMENTAL DEVELOPMENT
RELIEVING PLATFORM

DATE JAN., 1981	SCALE N.T.S.	FIGURE NO. V-8

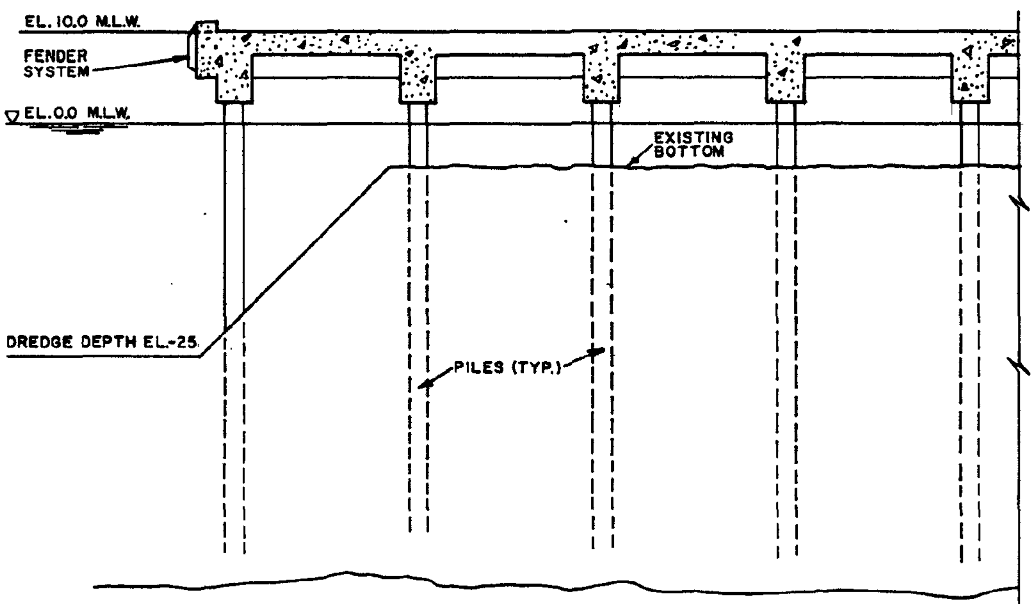
out onto a new line of piles to the point where the 2 on 1 slope reached the desired dredge depth. Figure V-8 shows the expansion adding onto an existing relieving platform. This method can also be utilized to deepen the draft at an existing bulkhead with the final configuration being essentially that shown in Figure V-7.

2. Pile Support Deck

The pile supported pier is a common method of construction in harbors throughout the world. Historically, timber piles and timber decks have been used. With the trend to deck loads of 1,000 pounds per square foot and higher, recent pile supported decks have been constructed of cast-in-place and precast reinforced concrete. In addition to the high load carrying concrete structures, concrete provides a low maintenance system when proper design procedures are followed. To provide for economical deck systems, high capacity piles are customarily utilized with concrete decks. Concrete is often used in high capacity piles because it is a very economical material for resisting comprehensive loads. Types of piling that can be used include: precast concrete, cast-in-place concrete, concrete-filled shell and pipe piles, and steel-H piles. Figure V-9 shows a typical pile supported deck as could be used for constructing a third pier at Davisville.



Plan



Section

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PILE SUPPORTED REINFORCED CONCRETE PIER

DATE JAN., 1981	SCALE N.T.S.	FIGURE NO. V-9

In addition to their excellent load carrying capabilities, another primary advantage of reinforced concrete, pile-supported decks is their adaptability to poor soil conditions. Foundation piles can extend through overlying poor soils such as soft marine sediments to obtain support in underlying firm strata. A primary disadvantage of pile-supported decks is their cost. Because of their high cost decks are seldom used to produce large areas. Only when other more economical methods prove unfeasible are large decked areas created. As a result, pile-supported piers often are used as finger piers which only support loading and unloading facilities and provide for berthing but do not provide large areas for handling and marshalling cargo. Pile-supported systems are often used for wet and dry bulk cargo piers where relatively little pier area is needed provided shore based storage facilties are available.

D. Other Alternates

Several other systems were initially considered for this project and, for various reasons, were found to be unacceptable. Among those considered were aluminum sheetpiling. This is an attractive material for use in the marine environment because it is extruded from a corrosion-resistant alloy of the same type used in ship-hull and underwater construction. Under most normal site conditions, including use in the splash zone, aluminum sheetpiling requires no protective coating. This material has been successfully used in groins, retaining walls, and bulkheads. The chief disadvantage is the low load-carrying capacity of aluminum as compared to steel. Aluminum sheetpiling has insufficient strength to resist the heavy crane, rail, cargo and soil loads inherent in modern port wharf designs. For the same reasons, timber sheetpiling was quickly eliminated from analysis. In addition to timber's inadequate strength critiera, there is also the added initial cost, (and maintenance as well) of protecting the wood from marine borer activity with a preservative.

Also considered for the Davisville site was an anchored tremie concrete wall which would consist of a composite steel-concrete member fixed at the toe in an excavated trench and also at the top by means of a horizontal tie rod to a deadman system located inboard. This concrete wall would be cast-in-place in a narrow trench excavated in the soil for the full height of the wall. This type of construction system has been utilized in cities and other areas that are too congested to allow open cuts or in acreas where vibrations from driving sheetpiles would be hazardous to adjoining structures and utilities. At Davisville where adequate area exists for tie-rods and deadman and vibrations are not a problem, the cost of a system such as this is not warranted.

VI

VI. RECOMMENDED DEVELOPMENT AND IMPLEMENTATION

The studies performed as part of the preparation of this report have concentrated on selection of the optimum method of expanding the port facilities at Davisville. In performing these analyses certain assumptions were necessary. First, the primary intended user of current and expanded facilities at Davisville will be industries associated with exploratory and production drilling for oil and gas in the North Atlantic. Secondary users included commercial cargo operations and commercial fisheries operations. This report identified potential commercial cargo markets in coastal barging or coastal container-RO/RO vessels for both feeder service to the primary regional ports of Boston and New York and for long distance coastal transport. A narrower but more conventional market in neo-bulk transoceanic cargo (specifically automobile importers) was also identified. Other cargo users would require deepening of the existing approach channel (extending from east passage off the northern tip of Jamestown to the site) from 30 to 35 feet or more. This is considered a major development factor which was beyond the scope of this study.

The probable expansion of the Rhode Island fishing fleet over the next few years was documented with a deficiency in Narragansett Bay of berths for as many as 35 fishing vessels. This estimate is from a study entitled Commercial Fishing Facility Needs in Rhode Island prepared by the University of Rhode Island Coastal Resources Center for the Rhode Island Coastal Management Program.

Six alternate configurations were examined for expanding the Port of Davisville. Each of these alternates are discussed in greater detail in Section IV of this report. A series of meetings were held with the Quonset Point/Davisville Task Force concerning choosing the best alternative for expanding the Davisville port facilities. Topics discussed at these meeting included:

1. Need - The NERBC/RALI On-Shore Facilities Related to Off-Shore Oil and Gas Development and U.S.G.S. estimated the potential quantities of oil and gas in the North Atlantic. Based upon these estimates a potential need for land support area and berthing spaces were determined. Using this data CE Maguire has estimated that to support OCS activity in the Baltimore Canyon and Georges Bank areas there will be an average need for 19 berths with a maximum demand for as many as 43 berths. The existing piers at Davisville can provide 19 OCS berths averaging between 250 and 300 feet in length. Therefore, there will be need for additional berthing facilities at Davisville if the following conditions occur:

    a. If the commercially recoverable quantities of oil and gas in the Georges Bank and Baltimore Canyon tracts are equal to or greater than those of the U.S.G.S. medium-fine scenario; that development of Georges Bank and Baltimore Canyon commences within about 8 years of each other; and if Davisville attracts substantially all of the OCS supply boat service base activity;

b. Other OCS industries such as platform fabrication were to locate at Daviville.

In addition to OCS support, other ocean related industries such as commercial cargo and fishing could also locate at Davisville. If these industries decide to use Davisville in conjunction with estimated level of OCS activity, a demand will be created for new berthing space.

Since there is only a potential need for additional berthing space at Davisville expansion of the port facilities does not appear warranted at the present time. The Task Force decided that bulkhead expansion should wait until exploratory drilling reveals a clearer picture of the recoverable quantities of oil and gas. With these oil and gas reserves better defined, the Port Authority will have a clearer idea of the needs of the OCS industry. The Port Authority could then plan on expanding the port facilities with a higher level of confidence.

Alternate 2, the development of 675 feet of berth in the Dogpatch area and Alternate 5, rehabilitation of the existing Navy Bulkhead, appear to be the best choices in terms of satisfying an uncertain need. These alternates provide the Port Authority with a maximum flexibility in design by permitting the Port Authority to construct facilities with the capability of future expansion. The cost effective rehabilitation of the Navy bulkhead assumes long term agreements can be made between the State and the Navy for use of the retained Navy property.

2. Environmental Concerns - In a separate document entitled Environmental Assessment, Davisville Port Expansion prepared by the Coastal Resources Center of the University of Rhode Island, the environmental impacts associated with the expansion of the port facilities at Davisville were examined. The report concluded that Alternate 2 and Alternate 5 would have the least impact on the environment in comparison with the other alternates.

3. Economic Analysis - In Appendix G of this report, CE Maguire has estimated the cost for each of the six alternates. The results of this cost comparison indicated that in terms of cost per-foot-of-berth the least expensive alternate for expanding the port facilities would be rehabilitation of the Navy bulkhead (Alternate 5). The next most economical method of expansion of berth space would be the development of 2,400 feet of berth in the Dogpatch area (Alternate 1).

In terms of these three factors outlined above; Need, Environmental Impact, and Economic Analysis, it appears that the rehabilitation of the Navy bulkhead would be the best alternative for expanding berthing facilities at Davisville. However, it would probably not be prudent for the Port Authority to make a major investment on property in which it does not have exclusive control. For the purpose of this study, it has been assumed that the Navy intends to retain the property.

It therefore appears that the best alternative for the Port Authority would be the incremental approach as shown in Figure VI-1. Development of 675 feet of berth in the Dogpatch area and the creation of 18 acres of new support land along with the existing 35 acres of Dogpatch will provide new port facilities at Davisville. The opportunity for future expansion provides the necessary flexibility for Port Authority planning.

If the Port Authority wishes to implement Alternate 2, it should advance the engineering to the 70 percent design level. Included in the scope of work would be:

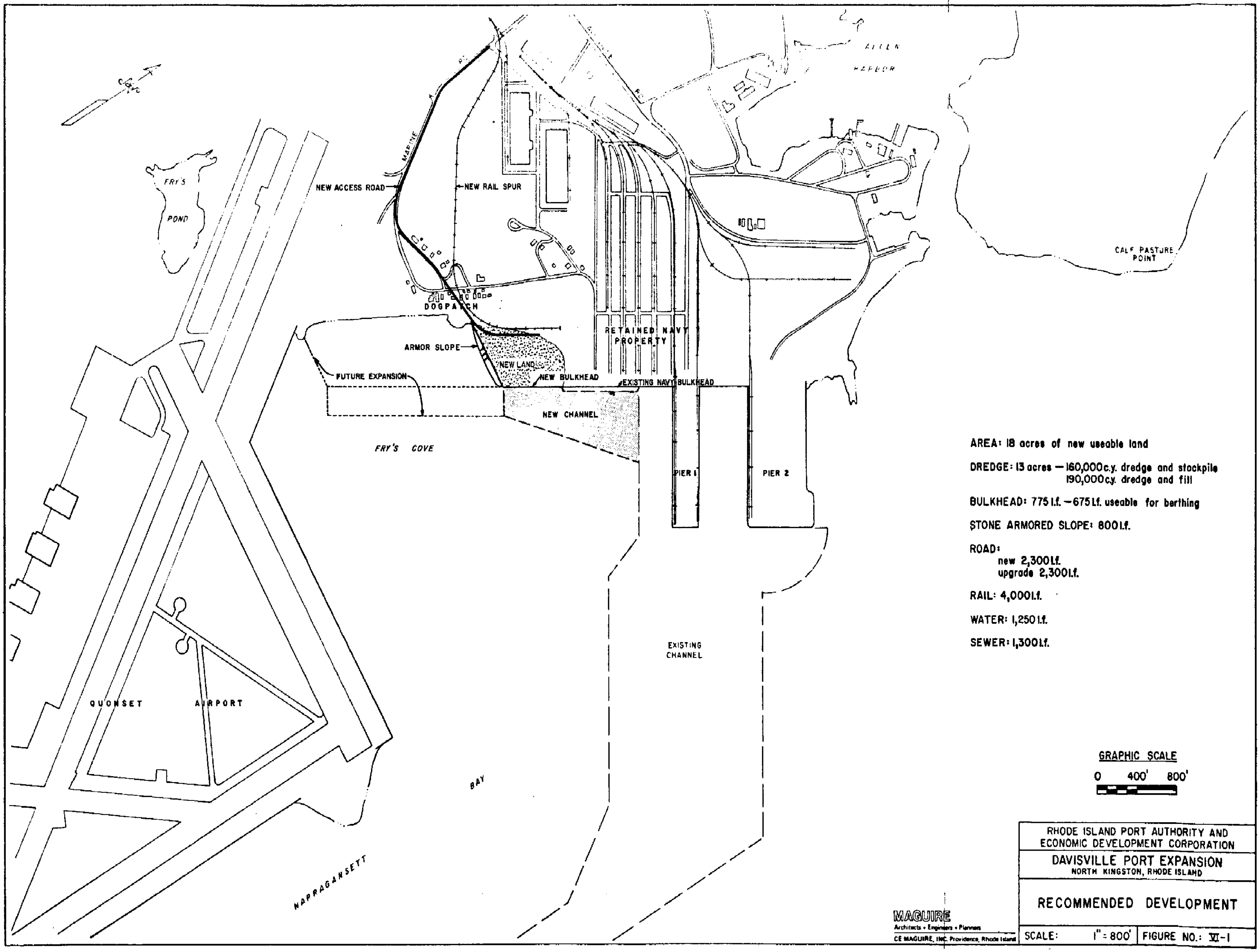
1. Finalize design of primary project elements and perform preliminary design of structural and site details.

2. Continue development of project specifications from current outline level to draft specifications.

3. Prepare tentative construction schedules including time to perform final design.

4. Update regulatory permits for the Port Authority.

5. Assist the Port Authority in obtaining agreements with other State and Federal agencies for work that will be required on Navy and airport property.


FRY'S POND
NEW ACCESS ROAD
NEW RAIL SPUR
MARINE RD.
ALLEN HARBOR
CALF PASTURE POINT
DOGPATCH
RETAINED NAVY PROPERTY
ARMOR SLOPE
NEW LAND
FUTURE EXPANSION
NEW BULKHEAD
EXISTING NAVY BULKHEAD
NEW CHANNEL
FRY'S COVE
PIER 1
PIER 2
EXISTING CHANNEL
QUONSET AIRPORT
BAY
NARRAGANSETT
AREA: 18 acres of new useable land
DREDGE: 13 acres — 160,000c.y. dredge and stockpile
190,000c.y. dredge and fill
BULKHEAD: 775 l.f. — 675 l.f. useable for berthing
STONE ARMORED SLOPE: 800 l.f.
ROAD:
new 2,300 l.f.
upgrade 2,300 l.f.
RAIL: 4,000 l.f.
WATER: 1,250 l.f.
SEWER: 1,300 l.f.
GRAPHIC SCALE
0 400' 800'
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NORTH KINGSTON, RHODE ISLAND
RECOMMENDED DEVELOPMENT
SCALE: 1" = 800'
FIGURE NO.: VI-1

While user committments appear to be a prerequisite to the proposed expansion, it should be noted that such a committment will be difficult to obtain without the port facilities in-place. Herein lies a "chicken-and-egg" dilemma which must be addressed. While prudence dictates that such a large capitol investment should not be made without a firm committment by a user, most users (particularly in the OCS service and marine transport industries) cannot afford to wait the one to two years which will be necessary to implement the port expansion of Davisville.

Therefore the Port Authority must follow closely updated estimates of potential oil and gas reserves in the North Atlantic so as to have adequate lead time to plan for and construct the required port expansion at Davisville.

Timing to anticipate future use will be critical: when to proceed with the constructing of the pier so that the Port Authority's investment will be economically worthwhile, yet to proceed far enough in advance so that the Port Authority will be able to meet the demand from OCS and for other marine users.

A

APPENDIX A

OCS USER REQUIREMENTS

A. General

The NERBC-RALI report identified the various onshore impacts of OCS oil and gas development. These shore based activities can be classified into the following major categories: services bases, maintenance yards, platform fabrication yards, pipe coating yards, transportation facilities, partial processing facilities, refineries, petrochemical plants and ancillary industries. Of all of these operations, those that will be most suited to development in the Quonset-Davisville area are those that require direct waterfront access, contiguous marshalling and storage area and good land transportation networks, as these are Davisville's most marketable features. Service bases and platform fabrication yards are the two OCS related uses that are considered to be the most appropriate users of Davisville. These users require both direct waterfront access, contiguous land area and good transportation systems and can function with the limitation of a 30 foot deep channel.

B. Service Bases

1. Supply Boat Operators

Service bases are established as transshipment points to move materials and supplies to and from drilling and production platforms that are located a few hundred miles at sea. The NERBC report presented the following data for primary materials used per 15,000-foot exploratory well:

Fresh Water: 1.19 million gallons (4,960 tons)

Drilling Fluid (Mud): 642 tons

Diesel Fuel: 3,318 bbls. (557 tons)

Steel Tubulars: 455 tons

Cement: 315 tons

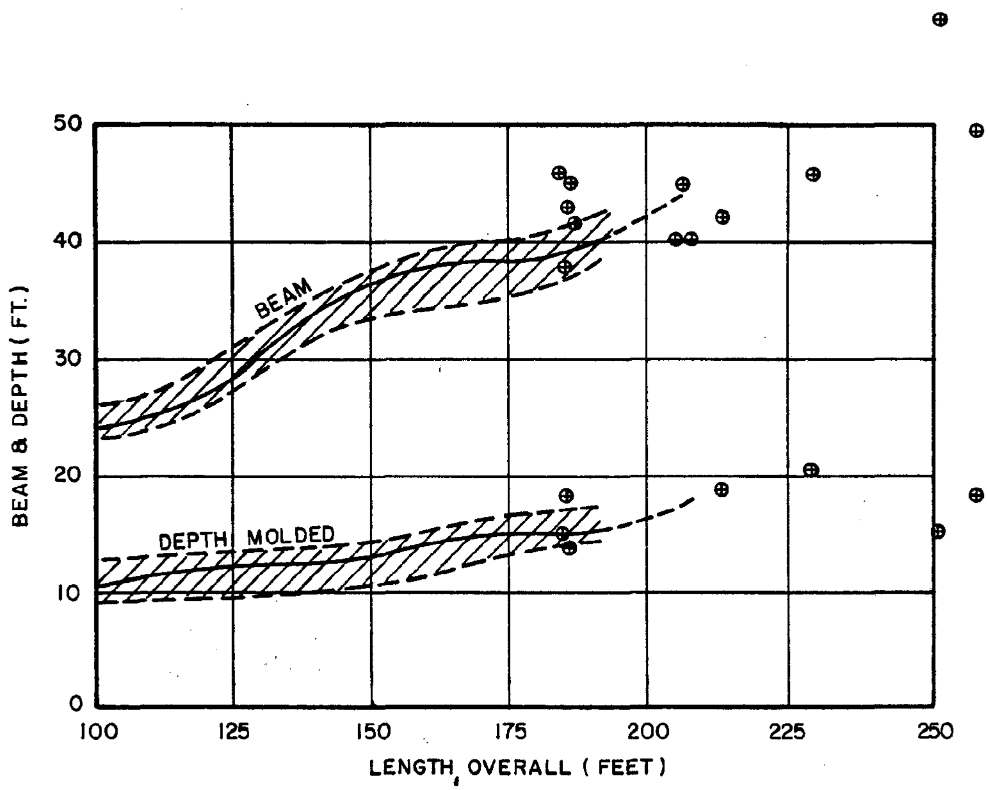
Smaller tonnages associated with food, tools, bits and miscellaneous supplies and equipment are also shipped. All commodities (with the exception of personnel which are customarily flown to the rigs by helicopter) are moved by supply boats.

Five OCS service boat operators representing over 200 U.S. vessels were contacted to obtain information on boats that are available at present and over the next few years. At present, vessels range in length from about 100 to 220 feet with most in the 180 foot range. Vessel drafts range from 12 to 19 feet with most vessels drawing 15 feet or more. Beams of vessels studied ranged from 26 to 45 feet with the majority at 38 feet or more. There are a few boats designed for specific uses such as anchor handling and pipe carrying that typically have larger beams, drafts and/or lengths.

Figure A-1, A-2 and A-3 present data from a paper presented at the 1979 Offshore Technology Conference entitled "Trends in Offshore Towing and Supply Vessel Designs." These figures illustrate typical dimensions, break horsepower and cargo capacity of OCS service vessels. Supplemental data to include vessels as of June 1980 points have been added to Figure A-1 based upon the interviews and research conducted by CE Maguire. It can be seen that there is a continuing trend towards longer and wider vessels, however, the draft of vessels is not increasing as rapidly. It also appears that the maximum vessel draft is remaining relatively constant at about 20 feet. Probably due to channel limitations for existing OCS service bases rather than more scientific factors such as hull hydrodynamics.

A design draft of 20 to 21 feet is predicted as being the maximum required by OCS supply boats during the life of these facilities. Vessel beam and length are somewhat harder to define. For design purposes, a typical length of 180 feet should be assumed provided facilities can accommodate boats up to 250 feet in length. Channel, berth, and fairways should be based upon a typical beam of 42 feet with a provision for a maximum of 55 feet.

The recommended minimum channel width adjacent to the wharf is 250 feet. This allows sufficient space for two OCS vessels to be berthed side by side (rafted) with clearance



ALL VESSELS TWIN SCREW

BEAM AND DEPTH vs LENGTH OVERALL

LEGEND

- – – UPPER & LOWER LIMIT
- —— MEAN
- ⊕ DATA POINTS FROM FLEET INVENTORY CONDUCTED BY C.E. MAGUIRE AND SUPPLEMENTAL TO WORK BY RAJ AND WHITE.

SOURCE : TRENDS IN OFFSHORE TOWING AND SUPPLY VESSEL DESIGNS BY A. RAJ AND N. WHITE, 1979 OFFSHORE TECHNOLOGY CONFERENCE.

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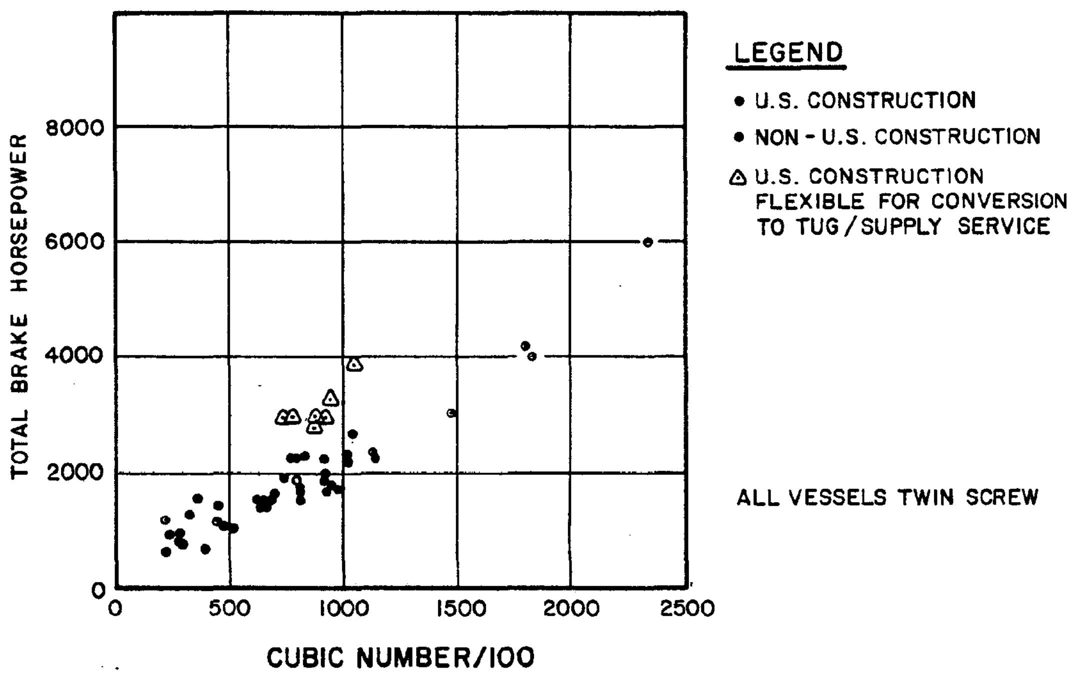
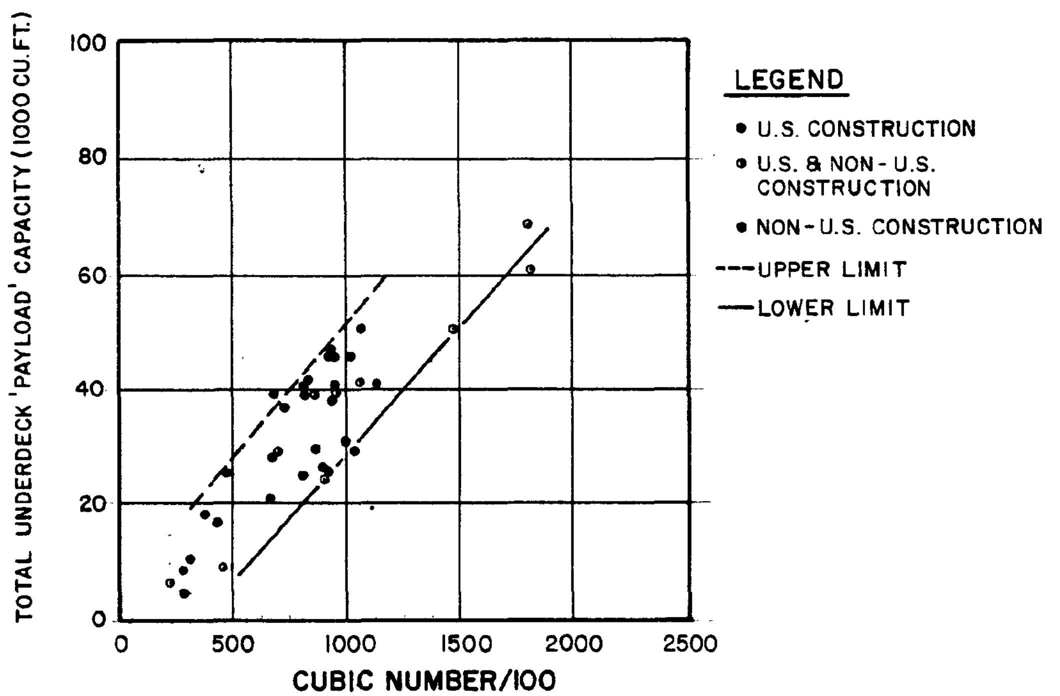
OCS SERVICE VESSEL DIMENSIONS		
DATE JAN., 1981	SCALE AS SHOWN	FIGURE NO. A-1





CUBIC NO. = LENGTH x BEAM x DEPTH

SOURCE: TRENDS IN OFFSHORE TOWING AND SUPPLY VESSEL DESIGNS BY A. RAJ AND N. WHITE, 1979 OFFSHORE TECHNOLOGY CONFERENCE.

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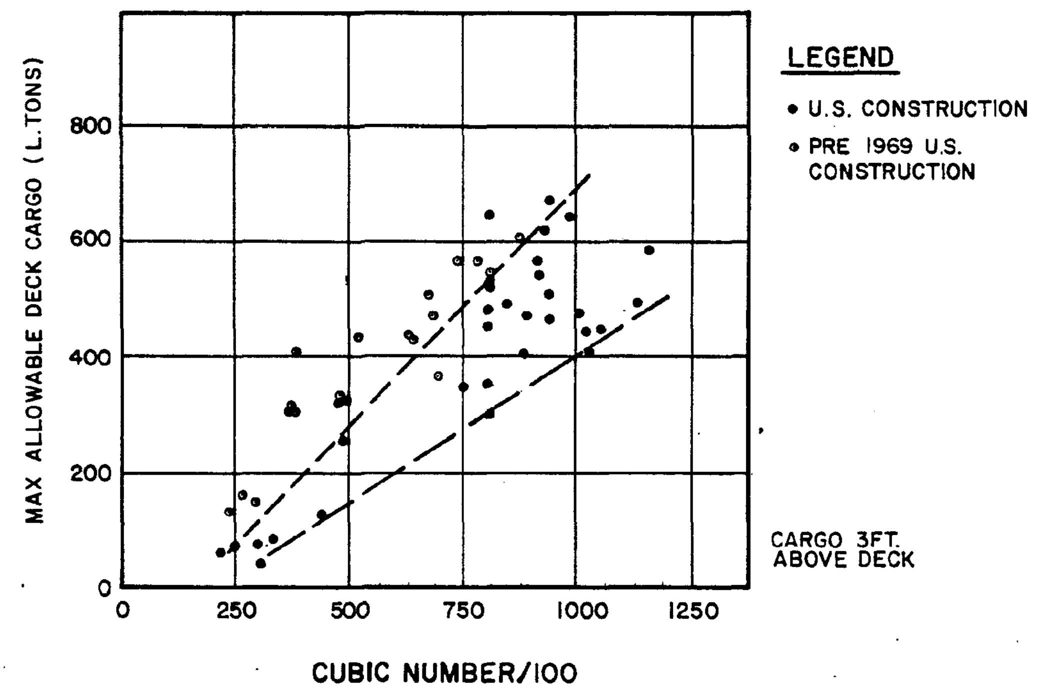
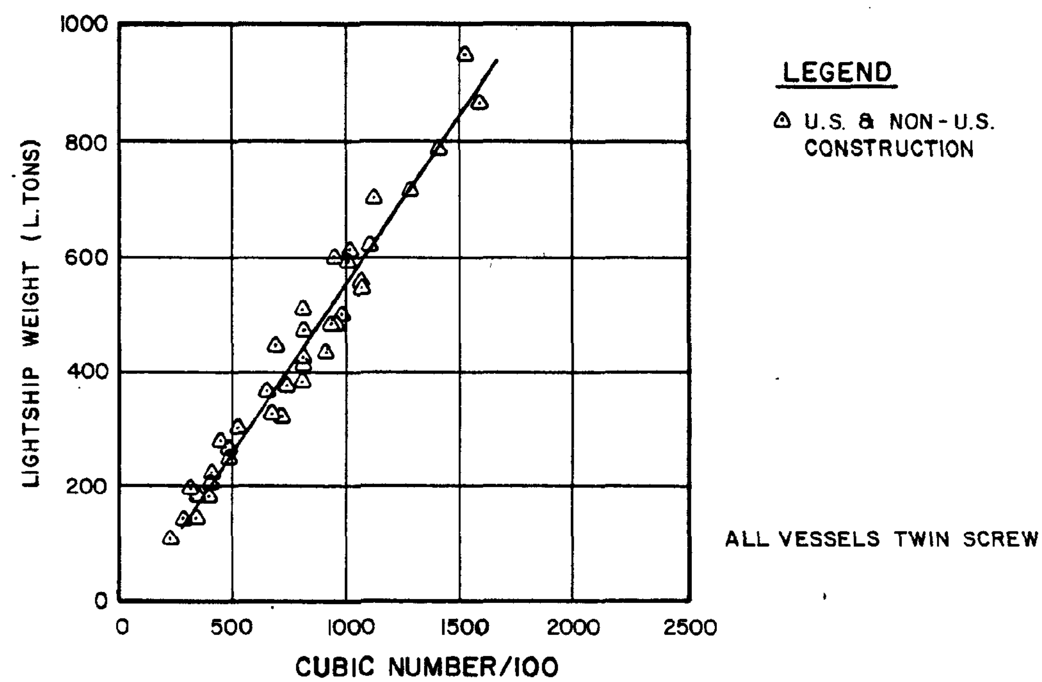
DAVISVILLE PORT EXPANSION
NORTH KINGSTOWN, RHODE ISLAND

OCS SERVICE VESSELS
BHP & UNDER DECK PAYLOAD

DATE JAN., 1981	SCALE AS SHOWN	FIGURE NO. A-2





CUBIC NO. = LENGTH x BEAM x DEPTH

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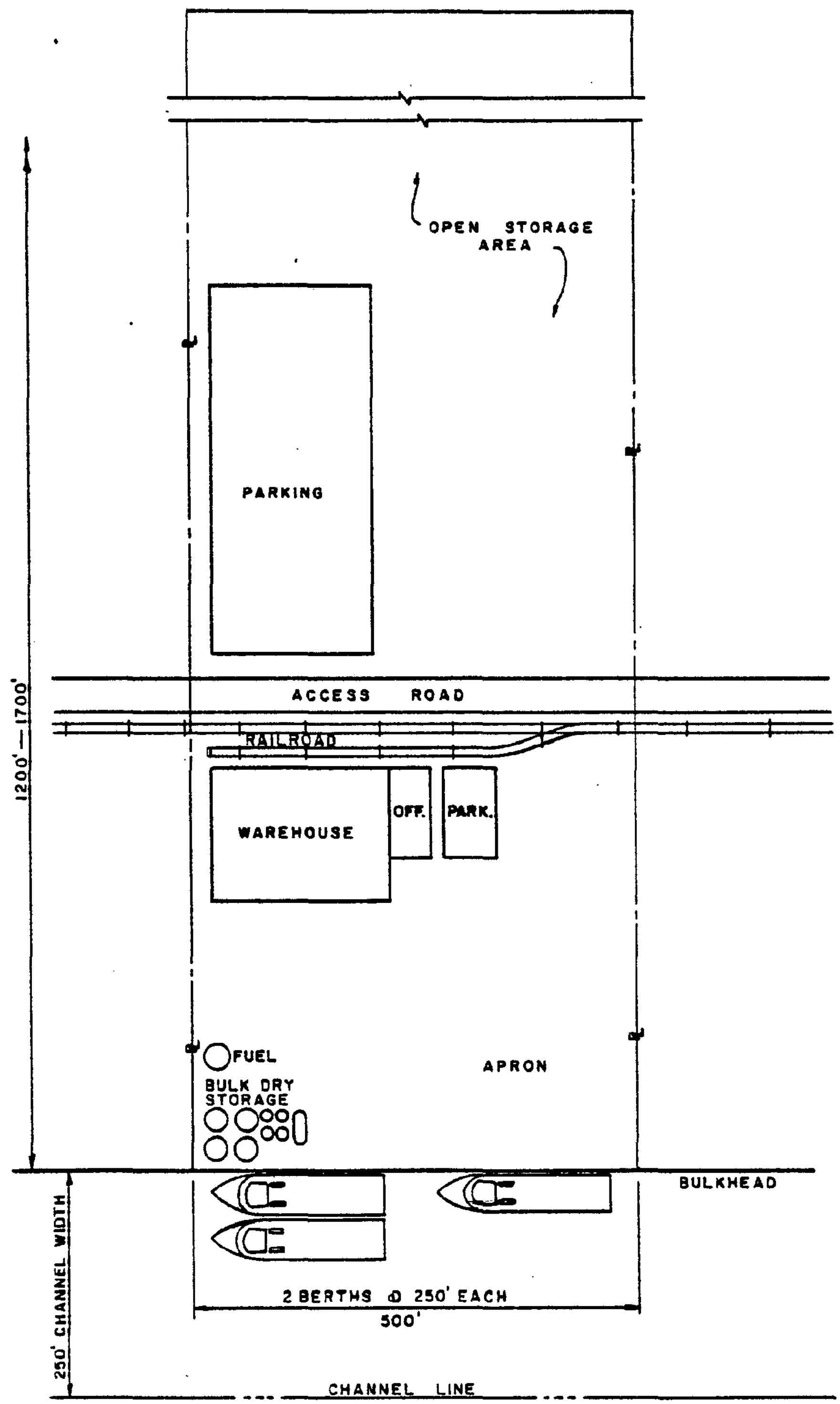
OCS SERVICE VESSELS LIGHTSHIP WEIGHT & DECK CARGO		
DATE JAN., 1981	SCALE AS SHOWN	FIGURE NO. A-3

for a third to pass. Owing to their extreme maneuverability, the majority of the OCS service boats (200 feet or less in length) will be able to turn at their mooring within the confines of the 250 foot wide channel. Because all but a few boats will be able to turn in the channel there is no need for a separate turning basin. Only a small number of vessels would be required to back into or out of their berths. Larger cargo vessels will most likely reqire tug assistance. The 250 foot channel will also be adequate for tug assisted maneuvering of larger vessels.

Based upon CE Maguire's research, the NERBC report and work by Booz-Allen, it has been determined that the optimum area required to support each 300 foot long OCS berth is approximately 8 to 10 acres. Figure A-4 presents the layout of an idealized OCS service base. As shown in Table A-1, there are several OCS service bases that have much less acreage per berth, but these are in regions where berthing and port space are at extreme premiums. Most note worthy is the base in Kenai, Alaska which only has 10 acres of contiguous supporting area for five berths. An idealized OCS service base for servicing one or two drilling or production units, 200 to 300 miles at sea, would include a 16 to 20-acre site with a minimum of two 250-foot berths. Depending upon the number of offshore units being serviced by the base, additional berthing space and land area could be required. The actual tenant would depend upon the oil companies involved. Ideally, the base would be leased and operated by an oil



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DAVISVILLE PORT EXPANSION NORTH KINGSTOWN, RHODE ISLAND
IDEALIZED OCS SERVICE BASE

DATE JAN., 1981	SCALE N.T.S.	FIGURE NO. A-4

TABLE A-1

COMPARISON OF OCS SUPPORT BASES

BASE	OFFSHORE UNITS	TOTAL ACRES	BERTHS			STORAGE		FACILITIES						SERVICES			
			Number	Frontage Feet	Depth Feet	Open Acres	Covered Sq. Feet	Mud	Cement	Water	Fuel	Power	Rail	Labor	Shop	Logistics	Schedule
SHELL	15	42	7	1,300	20	35	14K			*	*		Near	*		*	*
CAMERON	25	65	11	2,400	35	40	20K	Direct Sale	Near	Free	*			*		*	*
SABINE	16	25	9	1,800	18	18	60K	*	*	*	*			*		*	*
KENAI	15	10	5[3]	1,000	16	7	30K	*	*	*	*			*		*	*
SEABASE ST. JOHN'S	N/A	16	3	640	30	15	34K	*	*	*	*			*	*	*	*
SEAFORTH ABERDEEN	20	41	3	656	20	40	N/A	*	*	*	*			*	*	*	*
ASCo PETERHEAD	15	23	7	1,500	24	15	150K	*	*	*	*			*	*	*	*
NORSEA STAYANGER	30	150	12	3,000	N/A	110	500K	*	*	*	*			*	*	*	*
DAVISVILLE	2	110	19	5,000	28	90+	150K+	*	*	*	*	*	*				

1 - Remote storage
2 - Add'l. 100 acres remote storage
3 - Only 3 berths at all stages of tide

Source: Progress Briefing, June 25, 1980, Management Alternatives for the Port of Davisville, Rhode Island, Booz-Allen Hamilton company with all goods being moved through the base to the vessel. This eliminates the need for the boat to dock at one berth for drilling supplies and water, another for mud and drilling fluids, a third for fuel and so on. These are major factors affecting the overall efficiency of a port operation and therefore its attractiveness to propsective tenants.

2. <u>Mud Companies</u>

In addition to users located directly on the waterfront (e.g. the oil companies and service boat operators), OCS development will attract numerous ancillary industries. These firms provide special equipment materials and services to support the drilling and production operations. It can be expected that many of these industries will locate adjacent to the service base. Of the actual material provided, the largest volume to be supplied (after fresh water and fuel oil) is for bulk drilling fluids. The dry, bulk material is mixed with water and additives to make a drilling fluid commonly called "mud". The mud is used for lubricating, cooling and cleaning the well as drilling progresses. Much of the pier space at Davisville is currently being leased by mud companies. This method appears to be working adequately at this time as it allows transfer from bulk storage tanks located on the piers directly to the supply boat. On the other hand the boat has to go to separate berths for fuel and in a full production situation could reguire moving to a third berth for equipment and tools . At some service bases this problem is alleviated by having other outgoing supplies brought to the mud companies yard. The boat, therefore, takes on virtually all of its cargo at one stop. Fuel also may be taken on at this time or the supply boat may move to a separate fueling berth.

If full production drilling is undertaken, berthing space and supporting land should be in such demand at Davisville that optimum utilization may not allow mud companies to have their own berths. The berths would be leased by the primary users, the oil companies, or their drilling contractor. With this arrangement, all cargoes would be taken on at this primary berth. Drilling mud will either be brought to the wharf from the mud companies yard by truck or it may be bought in large quantities and brought in by rail and stored at dockside in bulk silos.

Regardless of whether the mud companies locate directly on the waterfront or in contiguous support areas, direct rail access will be required. As much as 90 percent of the material handled by larger mud companies is moved by rail, usually in bulk tank cars. Special small volume additives are frequently shipped by truck. The smaller mud companies frequently move most of their product by truck, therefore, rail access is less of a priority. Other utilities that are required by mud companies are normal services required by a light industrial firm, these being, water, sewer, and electricity. Office requirements would be approximately 2,000 square feet with 10,000 to 20,000 square feet of covered warehouse and 2 to 4 acres of open storage. Actual space requirements are highly dependent upon the number of wells being serviced. The numbers presented are considered adequate for facilities servicing 5 to 10 wells.

3. Ancillary Industries

As the drilling of a well progresses, successively smaller diameter casing is utilized. The annular space between casings of different sizes and the space between the casing and drilled hole in rock is cemented to seal the well. Seperate firms usually locate near the service base to supply cement. Cement companies requirements are similar to those of mud companies, except that virtually no open storage is needed and that rail is not essential. The majority of the product is transported by truck and stored in warehouses or bulk silos making the need for rail access and open storage less critical. However, cement companies do prefer rail to highway transport and will desire facilities directly on a rail spur.

The next group of supporting industires are suppliers of down-hole equipment including piping, drilling tools, fishing tools and other speciality tool firms. These companies customarily rent their equipment and hire out technical services and personnel to the oil companies for use on the drill rig on an as-needed basis. Shore facilities for these firms are usually located nearby or adjacent to the service base for rapid response time. Requirements vary, but generally a total of 5,000 to 20,000 square feet of building area is typical for office and warehouse space. Additional space would be necessary if maintenance and repair facilities are established. A limited amount of outside storage space is required for larger equipment.

There are several other categories of firms which typically have requirements similar to one another. Logging, perforating, and well-head firms require 5,000 to 20,000 square feet of combined office and storage space on a 1 to 2-acre parcel. These companies typically only require good highway access and close proximity to the service base.

Diving service companies provide labor and equipment for underwater operations such as construction, inspection and repairs. Diving services may be provided by firms already doing business in the region or by large, world-wide companies which may set up satellite facilities in the vicinity of the service base. Location directly on the waterfront is desirable, but not critical. Diving companies will require a 1 to 4-acre parcel with 2,000 to 15,000 square feet of combined office, warehouse and repair facilities.

A large land area of up to 20 acres is required by companies that specialize in well completion, stimulation, work-over and production services. Proximity to the wharf is not essential, but would be advantageous. The primary requirement of these firms is good highway and rail access to move large equipment to and from the service base. Usually a relatively large building is constructed for warehouseing, office and maintenance operations.

There are numerous other services required by various participants in the entire oil exploration and production program that are similar to industrial firms in general. These include: catering, trucking, fabrication, welding, machine shops, and tool supplies. Rhode Island firms, because of its well-established industrial base, can provide most of the required supplies and services through existing firms either with existing operations or by expansion. Some new facilities will undoubtedly be established near the service base.

Helicopter service is essential to offshore operations. Because of the specialized nature of the maintenance requirements, helicopter operations will most probably be carried out from an existing airport rather than from a newly constructed helicopter support facility. Therefore, there is an extremely low probability that a helicopter service base would be established at Davisville. A far more probable development is the establishment of a helicopter service base being established at the Quonset Airport.

B

APPENDIX B

COMMERCIAL CARGO

The marine cargo industry utilizes many different types of merchant service and modes of cargo handling depending on the type of cargo and the port facilities. To better understand the shipping industry, a brief summary of the most widely used shipping services and cargo handling modes currently utilized by the market is presented below.

MERCHANT SHIPPING SERVICE - Liner versus Charter

In discussing marine cargo movement, a differentiation must be made between two major categories of merchant shipping offered to customers: liner service and charter service. Liner service consists of repeated sailings at regular intervals between the same designated ports, with a frequency dictated by the volume of business offered by shippers on the route. Charter (tramp) shipping is a term used to define a vessel whose services are contracted, usually to carry full shiploads of a single commodity from one port to another. Each trip is scheduled individually, subject to the requirements of the cargo to be carried and the particular route to be followed.

It stands to reason that a scheduled liner service will be established and continue to operate only at those ports along those routes where sufficient cargo is generated on a repetitive basis. Industries will deliver the cargo to a port known for its reliable scheduled service to the intended destination. It is on this premise that the larger ports such as New York and Boston have evolved with a large concentration of scheduled liner services, and an established, seemingly immovable position in the system of world-wide ports.

Charter shipping, on the other hand, services any port capable of accommodating the vessel, where cargo is available in quantities sufficient to justify the economics of the charter. Consequently, charter services are used by industries, or groups of industries, which generate sufficient cargo in shipload lots bound for the same destination.

Of course, there are variations to the two basic categories as necessary to service unique shipping requirements. An example is the time charter, where a vessel is chartered for a specific period of time to provide services and visit ports as dictated by the leasee.

MODES OF CARGO SHIPPING

The basic function of a marine terminal is to provide the meeting place and area where cargo is exchanged between land and water transportation carriers. The degree of efficiency attained in the transfer of cargo from one mode to another directly effect the all-important turn-around time and resultant expenses of ship in port. The need for minimal in-port time has inspired the advent of many changes in port operations in the past two decades. Most notably, containerization and its off-shoots, LASH (Lighter Aboard Ship), and RO/RO (Roll/On Roll/Off), have gradually replaced general cargo, and liner, operations. Also charter shipping has evolved into specialized industrial carriers, both company-owned and on a charter basis. The result has been a decline in general cargo movement and a correspondingly growing prominence of the more innovative forms of marine transport. Table B-1 presents a summary of the vessel dimensions and port requirements for the various shipping modes as discussed in the following paragraphs.

Specialized Industrial (Neo Bulk Carriers) Cargo Handling Modes

Within the world merchant marine fleet are many vessles which, because of very specialized design, belong to a category of Special Carriers. These vessels may be owned by the industrial organization itself, or by steamship companies which provide charter service to the industry. These vessels serve as a link in the process of manufacturer and/or distribution of materials used by or produced by an industrial organization.

This list of specialized carriers is endless; among the many different types are: refrigerated fruit and meats, grains, mineral ores, bulk cement, coal, oil, liquified natural gas, industrial salt, locomotives and railroad rolling stock, wire in bulk, wood pulp and lumber. Similarly, just as the use of a specialized carrier proved beneficial for certain material, specialized terminals must also be considered to enhance the efficiency of these carriers.

In many cases, the terminal requirement may be as simple as adequate marshalling area and apron width as in the case of lumber and auto

TABLE B-1

SUMMARY OF CARGO VESSEL AND PORT FACILITY REQUIREMENTS

General Break Bulk/Palletization	
Length	600'
Beam	80'
Draft	32'
Apron Width	100'
Covered Transit Shed	50,000 to 120,000 s.f.
Upland Transit Area	12 acres minimum
RO/RO (Roll On/Roll Off) - Transoceanic	
Length	700'
Beam	100'
Draft	30'
Apron Width	80'
Covered Transit Shed	10,000 to 50,000 s.f.
Upland Transit Area	12 acres minimum
RO/RO (Roll On/Roll Off) - Coastal	
Length	300'
Beam	48'
Draft	18'
Apron Width	80'
Covered Transit Shed	10,000 to 50,000 s.f.
Upland Transit Area	8 acres minimum
LASH (Lighter Aboard Ship)	
Length	850'
Beam	100'
Draft	35'
Apron Width	120'
Covered Transit Shed	50,000 to 120,000 s.f.
Upland Transit Area	12 acres minimum
Coastal Barges	
Length	300'
Beam	50'
Draft	15'
Apron Width	80'
Covered Transit Shed	10,000 to 50,000 s.f.
Upland Transit Area	8 acres minimum

TABLE B-1

SUMMARY OF CARGO VESSEL AND PORT FACILITY REQUIREMENTS

(Continued)

Containerization

Length	800'
Beam	100'
Draft	35'
Apron Width	1,200'
Covered Transit Shed	150,000 s.f.
Upland Transit Area	30 acres

Neo Bulk Carriers and Deep Draft Bulk Carriers

Requirements are highly dependent upon vessels and cargos. In all but a few isolated cases, such as car carriers, drafts are in excess of 35 feet (ranging up to 190 feet) and are nor appropriate for consideratopm as potential users of the Davisville facilities.

Car Carriers

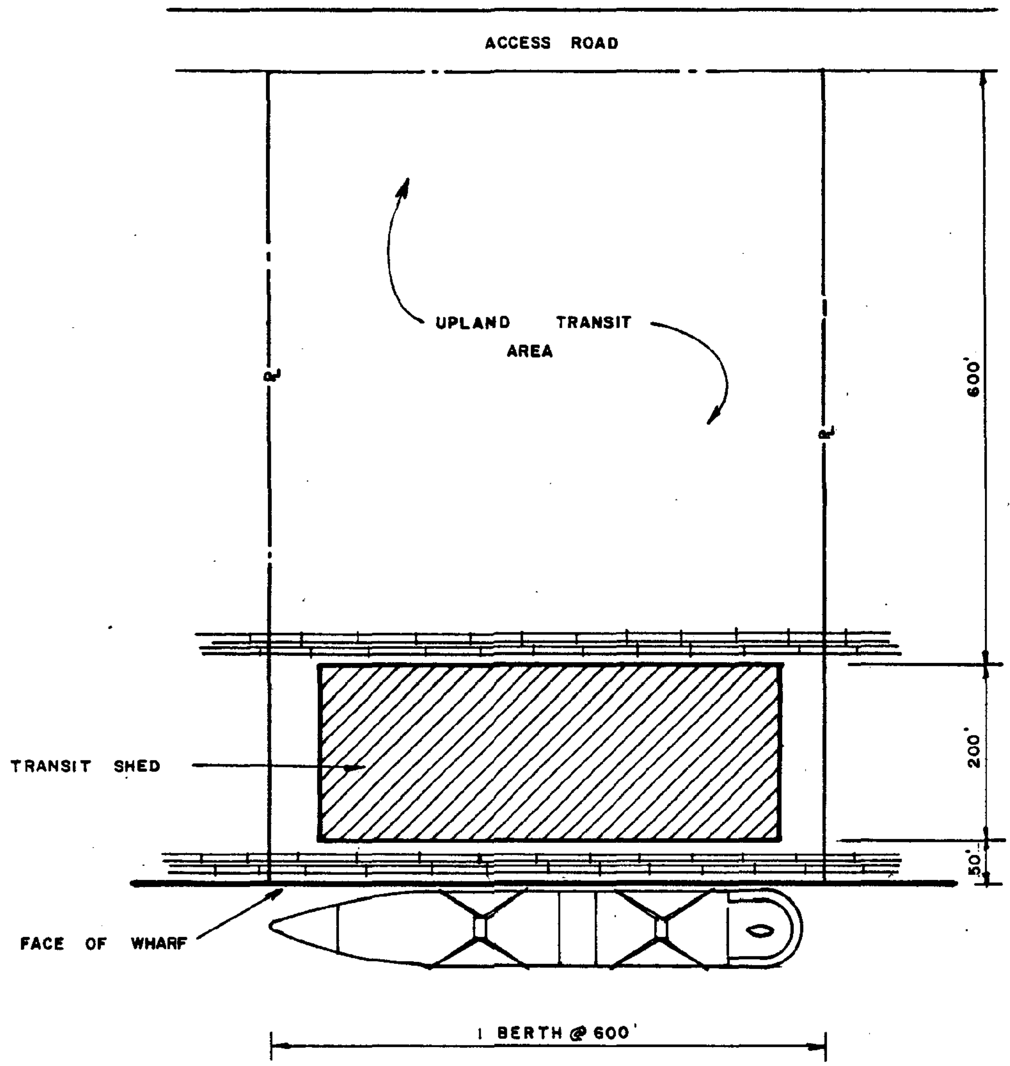
Length	700'
Beam	120'
Draft	29'
Apron Width	50'
Covered Transit Shed	Offices only
Upland Transit Area	20 acres

carriers; while in other cases, specialized materials handling equipment, refrigerated storage, silos, may be essential. To attempt to quantify terminal requirements for individual special carriers would be a monumental task and the results would be speculative at best, since many other factors such as local tax structures, proximity to distribution markets, potential for processing installations, are jsut as influential in attracting the market.

General (Break Bulk) Cargo

General Cargo, as the name implies, consists of miscellaneous cargoes of varying quantities and sizes which are compiled at the terminal for subsequent shipment to a common port or regional destination. Basic terminal facilities to tranship general cargo consists of a pier or wharf, an adjacent apron, for transfer of the cargo to and from the vessel, a marshalling area, a covered transit shed where the cargo is accumulated or stored for subsequent shipment to its destination, and adequate rail and roadway access. A conceptual layout of an idealized general cargo terminal is illustrated in Figure B-1.

The choice of configuration for a general cargo terminal can take many forms, depending on numerous factors ranging from the type of cargo most frequently transhipped to local climatic and oceanographic conditions. In general, however, a typical facility for ocean-going vessels would have berths capable of accommodating vessels up to 600 feet in length and a draft of at least 35 feet. Apron widths must be sufficient to allow crane access to the vessel and for yard equipment to remove the cargo from the wharf. An apron width of 50 feet is



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NORTH KINGSTOWN, RHODE ISLAND

GENERAL CARGO PORT

DATE JAN., 1981	SCALE N.T.S.	FIGURE NO. B-1

generally considered adequate. A typical transit shed area for a small port with small lots and infrequent cargo movement is approximately 50,000 square feet. Larger port transit sheds could be as large as 120,000 square feet per berth. Rail sidings should be adjacent to the wharf face to allow rail-to-keel transfer. Truck cargoes are generally served by truck-height platforms at the rear of the transit shed.

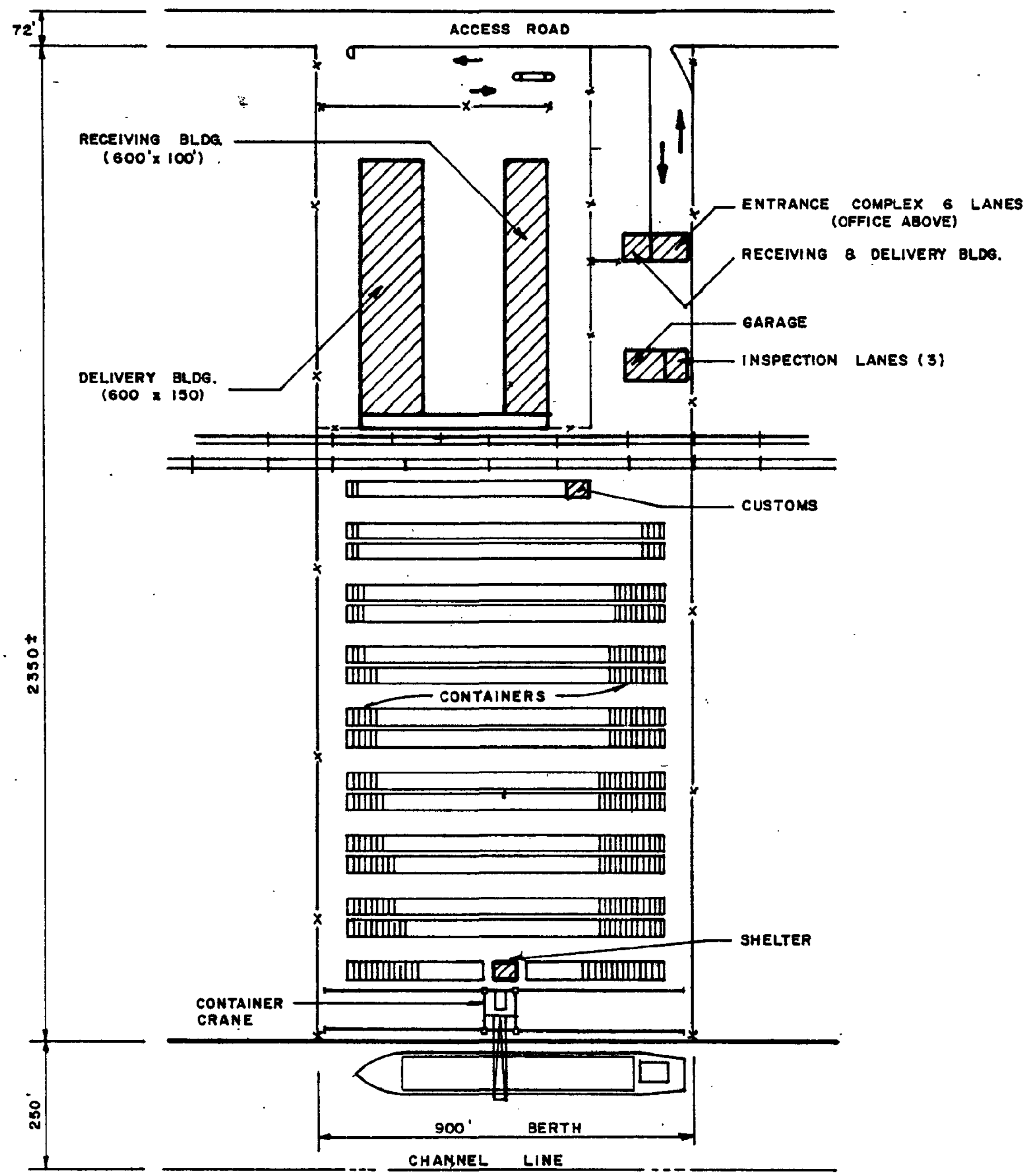
Containerization

One of the most significant advances in modern shipping, particularly as related to terminal efficiency and vessel turn-around time, is the advent of containerized cargoes. Containerization can briefly be described as the placing of cargo inside of vans, boxes or containers for transport by ship, truck, railroad, aircraft or other means. The basic container is a closed metal box with fixtures for stacking, lifting, handling, and attachment to truck beds, railroad flat cars, ships and each other. Variations include: refrigerated units (reefers) and special types for the transportation of bulk cargo, automotive equipment, livestock, liquids, etc. Cargo carried by containers can include practically everything. The exceptions are dry or liquid bulk products which are shipped in large quantities, (such as coal, ore, or petroleum) or commodities which cannot generally be containerized economically because of their nature, size and weight.

A problem does exist with respect to the use of containers for one-way traffic where there is no cargo available for the return route. The shipper must then pay the return freight for an empty container. In cases where charges are levied on the basis of volume, the shipper pays as much for transport of the empty return as for the loaded trip. The inbalance between marine import and export commodities in the New England area has been a significant factor inhibiting the growth of containerports in the region.

Container terminal requirements vary from those of general cargo terminals primarily in on-shore and equipment needs. For a large international container terminal, the minimum water depth should be 35 feet, and berths should be planned in lengths up to 900 feet. Smaller coastal or feeder ports would, of course, require much smaller berths as dictated by the size of the ship or barge.

The back-up area needed to serve a container terminal is generally larger than that required for a general cargo operation. Terminal space requirements will vary somewhat according to the sizes of ships calling, throughput time of cargo, cargo handling equipment, method of storing, etc. A terminal space of 35 acres per berth is not excessive for an ocean terminal. A conceptual layout of an idealized one-berth container terminal is shown on Figure B-2. Most of the space requirements are for container storage or parking and marshalling operations. Some container terminals may also involve consolidation and stuffing operations which will add to the space requirements. Parking area requirements can be reduced by vertically stacking containers three of four high, or by the use of multi-level container parking structures. It is essential that a container port be located close to major highway and railroad networks.



RHODE ISLAND PORT AUTHORITY AND ECONOMIC DEVELOPMENT CORPORATION

DAVISVILLE PORT EXPANSION
NORTH KINGSTOWN, RHODE ISLAND

CONTAINERIZED CARGO PORT

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DATE JAN., 1981	SCALE N.T.S.	FIGURE NO. B-2

Terminal equipment generally includes a wharf mounted gantry crane of 30 to 50-ton capacity to handle the standard size containers. Additional gantry cranes, rail or rubber-tire mounted, or other specialized handling equipment is needed to transport the containers from the dockside to the back-up area for marshalling, consolidation, stacking and retrieval. Warehouses, transit shed and consolidation sheds may be required, depending on the type of operation. If container packing is to be done at the terminal or if refrigerated cargo is handled, special facilities would be required. Container ports require large volumes of goods to justify the large volume of the ships and rapid turnaround time. Cargo movements should be essentially balanced to avoid the cost of returning empty containers.

Port labor requirements in container handling differ considerably from those of general cargo handling. Containership operations are approximately four times as productive on a man-hour basis as conventional general cargo operations. An ordinary general cargo ship with five hatches requires about 85 longshoremen to load and unload, and may require several days. A containership requires about 35 men and two cranes and can generally be turned around within 24 hours.

Lighter-Abroad-Ship (LASH)

In this concept, a high speed vessel is specially designed to carry a fleet of specially fitted barges. The cargo is prepacked inside the barges, and, in effect, the barge is the container or packing case for the cargo. The concept eliminates the need for the mother ship to penetrate into ports or to visit numerous regional ports. The central component of the LASH concept is an integrated, high capacity shipboard crane. With this crane, the vessel takes-on and off-loads its own barges. The handling of cargo within the barges is a separate operation, divorced from the vessel itself. Barge cargo is loaded or unloaded at shore-based terminals or destinations usually somewhere within the geographical area served by the principal port of call. As long as a fully loaded complement of barges is available for loading upon the vessel's arrival and the port has room to accept off-loaded barges without delay, the vessel need not be concerned with barge operations pertaining to cargo stowage and discharge. It follows, then, that the barges and not the vessel become subject to the often cumbersome tasks of cargo loading, stowage and unloading. The concept very effectively liberates the vessel from the time-consuming routines of handling cargo in port. It needs only to concern itself with the barges -- getting them off and getting a new group on board for the return voyage. Table B-2 presents vessel characteristics of LASH vessels from four shipping lines specializing in this mode of shipping

Being a large, fast, vessel capable of rapid turn-around performance, an efficient LASH-type operation requires a heavy concentration of cargo. These heavy concentrations are generally found in the larger ports of the world. Consequently, LASH carriers concentrate on larger ports. For maximum efficiency, the vessel should run between only two major terminals ports, each containing facilities for the pre-loading and marshalling of barges on the export cycle and for their unloading

TABLE B-2

SELECTED "LASH" CARRIERS

Central Gulf Lines

2 vessels holding 73 barges each
820' x 102' x 27'

3 vessels holding 80 barges each
851' x 95' x 35'

2 vessels holding 18 barges each
600' x 101' x 22'

3 non-propelled units holding 8 barges each
256' x 76' (Draft Not Available)

900 barges
59' x 30' x 8'

Delta Lines

4 vessels holding 85 barges each
852' x 95' (Draft Not Available)

572 barges - size not available

Lykes Lines

3 vessels Seabee class carries holding 38 barges each
834' x 102' x 37'

249 barges
93' x 33' (Draft Not Available)

Farrell

3 vessels holding 50 barges each
788' x 95' x 33'

Barge size not available

Note: Vessel dimensions -- Length overall x Beam x Draft in feet

Source: Jane's Freight Containers, 1979

on the import cycle. This arrangement permits the vessel to off-load a full compelment of barges and to take on a full complement for a turn-around voyage in something less than 36 hours.

The configuration of lighter terminals will vary considerable, depending on the regional distribution system, the tonnage and configuration of cargo, stuffing and stripping operations, and climatic and oceanographic conditions. However, since the terminal essentially serves as a barge loading port, its needs are very similar to a general cargo terminal on a smaller scale. On-shore facilities consist of a truck docking area, transit shed and apron. Mechanized loading equipment and covered apron and berth areas are desirable features; however, their installation is dictated by the type and volume of cargo and the need for speed and all-weather operations. Unlike containerization terminals, the marshalling area of a LASH operation is waterbourne, thus eliminating the need for comparatively large waterfront acreage. Berth space should be adequate for one or two barges of about 100 feet in length.

It must be noted that, like the container operation, a balanced trade of import and export commodities is needed to eliminate the costly return tow of empty barges to the LASH terminal.

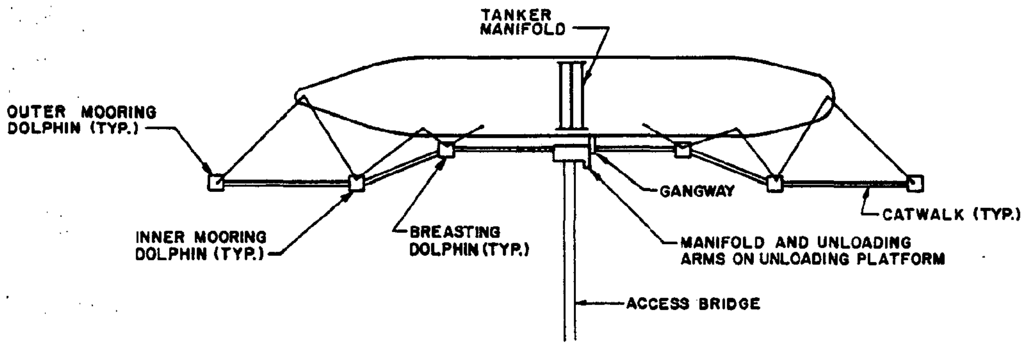
Deep-Draft Bulk Carriers

In the context of new innovations in marine transport, vessels which have drafts in excess of 60 feet and require water depths of 70 to 100 feet must be discussed. These represent the new generation of super-deep draft vessels. The deep-draft category, includes many of the newer dry and, liquid bulk carriers. Tankers of 500,000 DWT and dry-bulk carriers of 250,000 DWT are already in operation. The vessels draw so much water, that their concept begins with the proposition that only special terminals at limited locations in the world will be usable. The depth of water required by these carriers usually require reaching out to deeper open water to construct an offshore type of berthing and unloading arrangement. Petroleum tankers lend themselves to these technological applications somewhat more easily than do dry bulk carriers, the chief difference being that the tanker needs only hose connections and pipes to load or unload at the berth, whereas a bulk carrier generally requires unloading or loading equipment plus conveyor transporting or storage equipment. The offshore dry-bulk terminal thus typically represents a more complex undertaking.

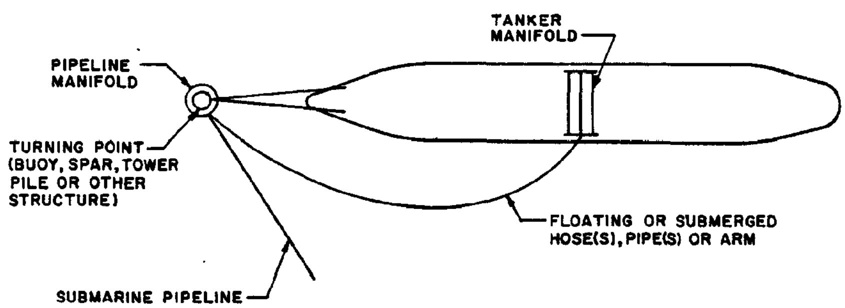
Regarding the so-called tanker-glut which exists in the world, this surplus is a result of supply and demand for petroleum tankers brought on by substantial orders for new vessels stimulated by high shipping prices. The increase in total tanker capacity occurred as a result of new vessels. This increased capacity was coupled with reductions in petroleum consumption resulting from embargos and high petroleum prices. The net result was in a significant reduction in tanker capacity demand. This surplus, however, does not negate the need for a deepwater terminal, since the larger class vessels are more efficient.

Offshore terminals fall into two categories, single point moorings and sea islands as shown in Figure B-3. The monomoorings or single point moorings (SPM) are generally defined as moorings which employ a single mooring point. This type of mooring generally consists of a mooring buoy anchored to the sea bottom and allows the tanker to naturally align itself so as to give least resistance to wind, waves and currents in a weathervane effect. Pipelines are generally located on the sea bottom with floating hoses connected to the ship manifold which is generally located midship. There are currently no SPM's installed in the United States, although in excess of 100 installations are located throughout the world.

A hybird variation of the offshore terminal concept sometimes arises in a deep-cove or deep-bay situation application. Sea islands are generally isolated offshore berthing structures suitable for use in naturally protected areas. A typical sea island generally consists of an unloading platform which supports the manifold piping and unloading areas and serves as a base platform for off-loading or on-loading operations. A series of mooring dolphins, generally six if a wide range of vessel sizes is anticipated) are located symmetrically about the berth midpoint. The dolphins are usually interconnected by causeway or walkways. Sea islands can be one-sided or double-sided berths depending on available maneuvering space and adequate water depth. Berthing is usually aided by tugs.



LAYOUT OF ONE-SIDED SEA ISLAND



LAYOUT OF SINGLE-POINT MOORING (S.P.M.)

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SEA ISLAND AND SINGLE-POINT MOORING

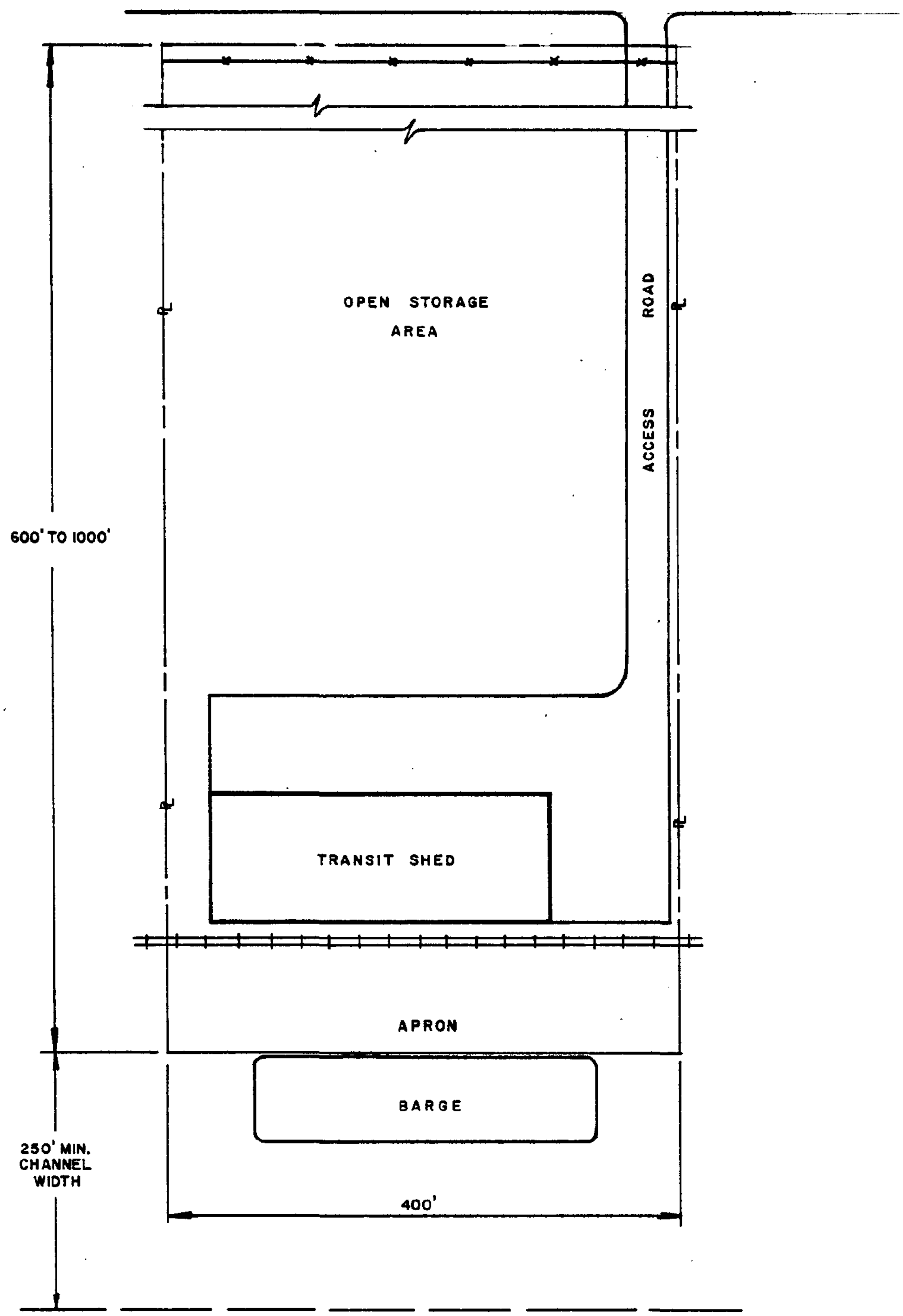
DATE JAN., 1981	SCALE N.T.S.	FIGURE NO. B-3

Coastal Barge Operations

Until recent years, cargo movement by barge was confined to relatively short haul and inland waterway traffic. Similar to the development of supertankers, super bulk carriers and containerships, the barge is now developing as an economic and competitive means of transporting dry and liquid bulk cargo containers and general cargo in coastal routes and in some cases, ocean shipping. Inland waterborne traffic will, undoubtedly, continue to use conventional barge transport for certain traffic since water depths restrict operations of very large barges and cargo vessels. The recent trend for using barges on coastal routes is a result of the relatively high costs of labor, fuel, and equipment for the conventional cargo vessels and similar high cost of land transportation of goods by truck. The unmanned barge tug concept has the economic advantage primarily in inland waterway and relatively short-haul coastal operations. Port requirements for barge operations are essentially the same as for a general cargo port only on a much smaller scale as shown in Figure B-4 which shows an idealized coastal large port for accommodating one barge. Table B-3 presents vessel statics for four lines that specialize in this mode of shipping.

Roll On/Roll Off (RO/RO)

Roll on/roll off, RO/RO, ships are vessels that specialize in the transport of wheeled equipment, vehicles, or wheeled containers. Cargo is rolled on and off the vessel through bow, stern or side ramps similar to that shown in Figure B-5. Combination container ships are being used with features that permit the transport of wheeled vehicles concurrently with unwheeled containers. Many of the special carriers



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IDEALIZED COASTAL BARGE PORT

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DATE JAN., 1981 | SCALE N.T.S. | FIGURE NO. B-4

TABLE B-3

SELECTED BARGE CARRIERS

Foss Alaska Line

Three Units:	
Length:	270' to 330'
Beam:	72'
Draft:	16' to 17'

Trailer Marine Transport

Seven Units:	
Length:	381' to 595'
Beam:	95' to 108'
Draft:	11' to 18'

Euro Arab Sea Trailer

Two Units:	
Length:	397'
Beam:	100'
Draft:	14'

Coordinated Carribbean Transport

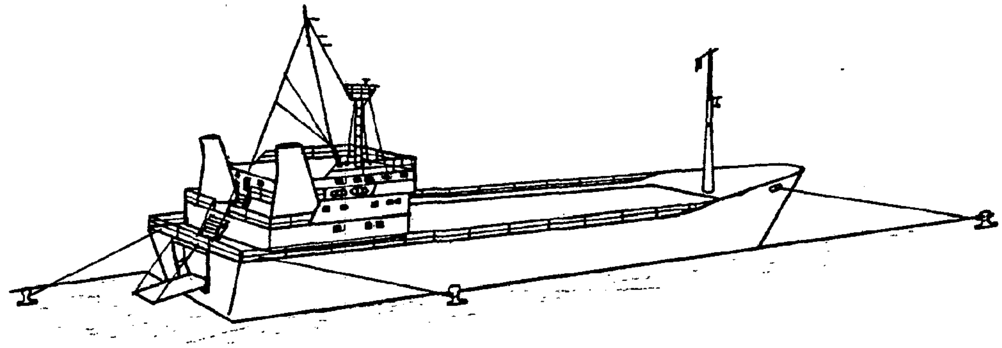
Three Units:	
Length:	400' to 605'
Beam:	56' to 82'
Draft:	13' to 16'

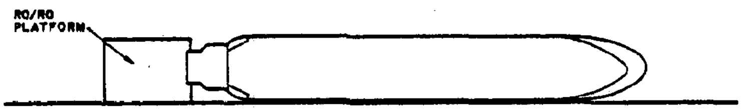
Source: Jane's Freight Containers, 1979

previously discussed, specifically auto carriers and some railroad rolling stock carriers, utilize the RO/RO principle. By strict definition, a ferry service can also be considered a RO/RO system. A typical RO/RO vessels for coastal or transoceanic shipping are shown in Figure B-5.

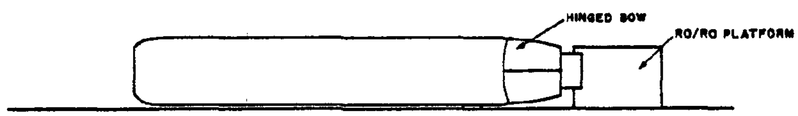
The basic concept of the RO/RO vessel is the increased efficiency of the materials handling phase of cargo offloading since costly crane equipment is not used. An inherent disadvantage in the system is the reduced cargo density by virtue of the internal ramps and elevators required and by the loss in volume taken up by chassis equipment. The RO/RO system is consequently ideally suited for shorter sea and coastal routes where fast turn-around time overshadows the reduced cargo density. The system is also ideally suited for auto carriers where the chassis equipment is an integral part of the cargo.

The design of berth and port layout for RO/RO service is, in most cases, inextricably tied in with the design of the vessel. In general, however, vessels are loaded via side ports and ramps in which case sufficient apron width is necessary to accommodate vehicular lanes and turning radii. Bow and stern ramps are also in common use, particularly in regions where tide ranges require a more substantial adjustment between wharf and vessel. These various RO/RO ramp configurations are presented in Figure B-6.

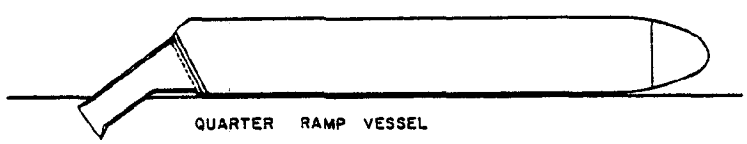




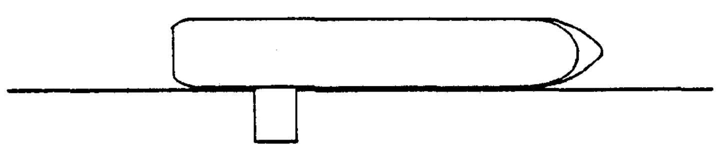
STERN RAMP VESSEL



BOW RAMP VESSEL



QUARTER RAMP VESSEL



SIDE RAMP VESSEL

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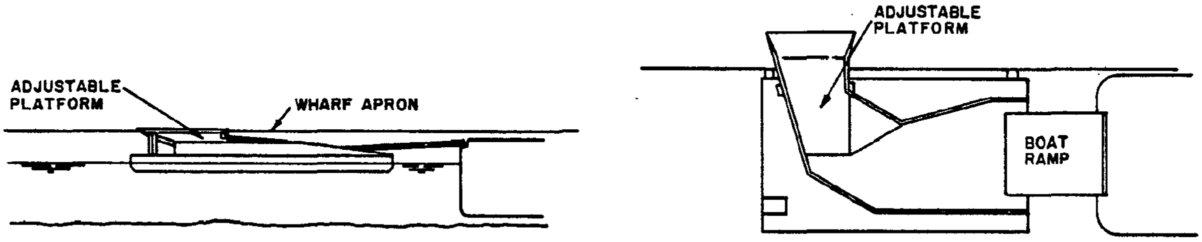
TYPICAL RO/RO VESSELS

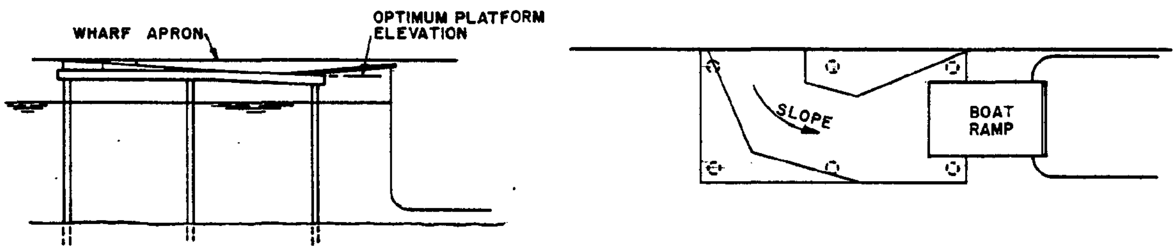
DATE JAN., 1981	SCALE N.T.S.	FIGURE NO. B-5



Elevation

Plan

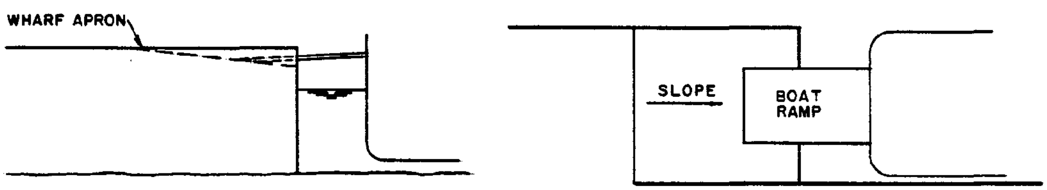
FLOATING PLATFORM



Elevation

Plan

FIXED PLATFORM



Elevation

Plan

OFFSET WHARF

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TYPICAL RO/RO PLATFORMS		
DATE JAN., 1981	SCALE N.T.S.	FIGURE NO. B-6

The future of RO/RO service appears bright in view of the many vessels and berths proposed and constructed throughout the world. The system appears ideally suited, especially as a feeder service from main container transhipment ports and for short sea and coastal routes.

Palletization

Like the RO/RO vessels, pallet ships have some advantages on short haul coastal or inland transport where trade volumes are comparatively small. Essentially, the pallet system is a simplified form of unitized, containerized, cargo transport. The most efficient method of handling palletized cargoes is by fork lifts through side ports. A fork lift located within the vessel brings the pallets to the side hatch where a second fork lift located on the wharf transfers the cargo to the transit shed. Tidal variations as well as variations in vessel draft as cargo is on or off-loaded can be accommodated by vertical travel of the fork, or, in larger vessels, by internal, between-deck elevators. A series of fork lifts operating in at several side ports located along the length of the vessel result in efficient offloading of the vessel and subsequent reduced vessel turnaround time compared to conventional cargo handling techniques.

One of the most prominent advantages of the pallet system is the reduced capitalization cost. Conventional cargo vessels can be converted to palletization at little cost, if in fact conversion is necessary, i.e., pallets could be loaded by cranes if the reduced loading efficiency can be tolerated. In addition, the cost of pallets themselves are significantly less than steel containers and stacked volume of empty pallets is much less than empty containers, which is a significant factor when unbalanced import/export tonnage is encountered.

The palletization concept shows much promise for shorter sea routes and combined RO/RO-Pallet-LASH vessels are conceivable in situations where flexibility is desirable due to mix in tonnage.

C

APPENDIX C

COMMERCIAL FISHING PORT TRENDS

A. General

The establishment of the 200-mile limit has resulted in the largest expansion of the New England fishing industry in over a century. Foreign fishing efforts on Georges Bank are being controlled and significantly reduced, and once-depleted stocks are recovering. Under-utilized species such as mackerel, squid, silver lake, and herring offer potential for supporting commercial fishery operations. Markets, both domestic and foreign, previously dominated by foreign vessels operating on the U.S. continental shelf have been left without a source of supply as a result of the 200-mile fishing limit. As a result of the potential for capturing these markets, new vessels are entering the New England fishing fleet and numerous coastal communities are exploring the possibility of establishing fishing industries.

B. Fishing Industry Characteristics

Fishing ports can be divided into four broad categories, based on vessel and shore support facility characteristics.

1. A simple landing place with minimal facilities is customarily used by fishermen operating on a daily basis a short distance from shore. These may be recreational or subsistence fishing operations. Support requirements include a berthing area, fuel, and vessel maintenance and repair

facilities. Establishments of this type dot the perimeter of Narragansett Bay. No support facilities for the catch, with the possible exception of an ice machine, are located at the landing place since little, if any, of the catch is marketed commercially.

2. Vessels making one or two day trips in coastal water have more sophisticated equipment, are larger than vessels using a simple landing place, and require a greater degree of protection and more extensive support facilities. These vessels generally range from 50 to 75 feet in length. Many of the harbors in and around Narragansett Bay are typical of this type of port. Support facilities at dockside may be limited to ice making, a truck access ramp for offloading and the same type of vessel-support discussed above, or may be more sophisticated, including equipment and service suppliers and a cooler for storage of the catch.

3. Traditional New England fishing ports such as Galilee and New Bedford are typical of the third type of establishment. These ports support vessels of 75 to 125 feet that can make trips of up to two weeks and cover several hundred miles. These vessels require a well developed shore support infrastructure to service their sophisticated electronic, hydraulic, pneumatic and mechanical equipment. As with the type of establishment discussed above, dockside catch-support facilities may be limited to a cooler and off load-

ing area, or may include processing, packing and an area for auction sales of the catch. Fishing cooperatives are becoming increasingly popular with this type of establishment and often provide a complete range of services for the vessel and the catch.

4. "Factory" fishing vessels often stay at sea for months at a time, operating thousands of miles from home port and returning only for major overhauls or resupply. These ships, generally Russian, Japanese, West German, can make calls only at ports with specialized facilities. Processing facilities for this type of fishing establishment are generally sophisticated and include complete, often mechanized, handling equipment. Some processing operations may occur at sea. Often a factory ship will be accompanied by several smaller fishing boats.

C. Industry Trends

Most of the traditional New England fishing ports are in the third category and are evolutionary, in that they developed from the first or second category. The market potential created by the establishment of the 200-mile limit, however, has created new opportunities and has highlighted a potential obstacle in the form of inadequate and inefficient onshore fish handling and processing facilities. Expansion of existing facilities is often difficult due to physical restrictions. In order to take advantage of the opportunities created by the 200-mile limit, there have been several developments in the fishing industry. In some cases, establishment of an integrated fishing operation with a complete range of support and automated handling and processing facilities adjacent to the berthing area has been achieved in a previously undeveloped area. In other cases, cooperatives have been established in traditional fishing ports, offering improvements in catch handling, processing and selling procedures, due to sophisticated technologies and economies of scale. The establishment of a cooperative, however, is contingent on the cooperation of local fishermen, who are often strongly opposed to any real or imposed restrictions on their traditional and highly valued independence.

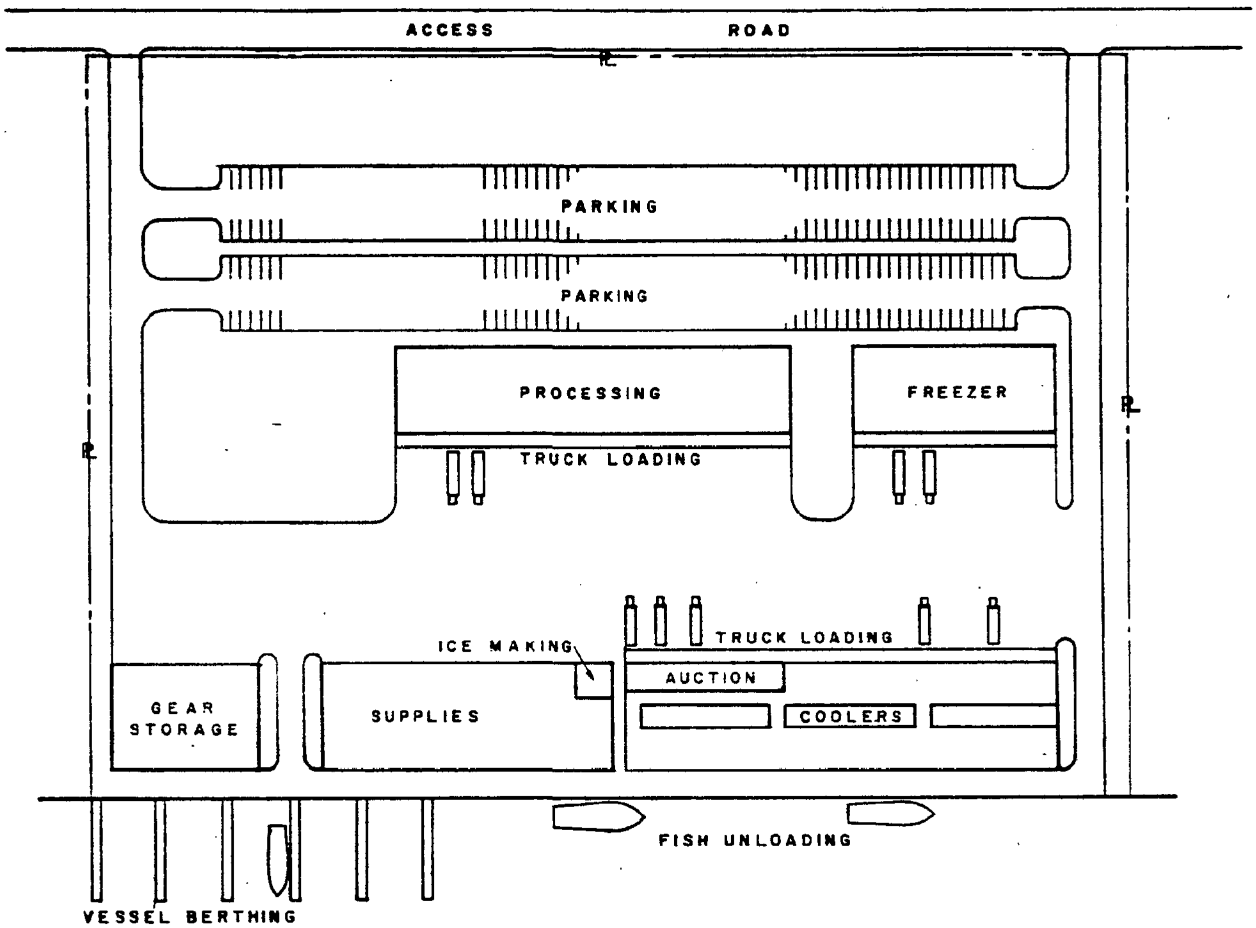
Until recently, the trend in the fishing industry has been to larger vessels, due mainly to "trading up" within the fishing fleet, with most of the sold vessels remaining in operation. Large vessels allow increased range and longer fishing time per trip, but the rapid increases in fuel prices since 1973 have begun to limit the cost-effectiveness of larger boats. It now appears that the optimal vessel size is 75 to 95 feet, due to economics and the availability of adequate shore support facilities. As discussed previously, this size vessel is more likely to be involved in a fishing cooperative or an integrated fishing port than a smaller vessel.

D. The Rhode Island Fishing Industry and Davisville

A number of recent studies have pointed out the potential opportunities for entrepeneurs and communities in the expansion of the New England fishing industry. Resources and markets are both readily available, and technical and operational improvements have been identified that will facilitate optimization of delivery of the resource to the market.

A study presently being prepared by the University of Rhode Island Coastal Research Center on Commercial Fishing Facility Needs in Rhode Island for the Rhode Island Coastal Management Program conservatively estimates that 45 to 200 additional fishing vessels will be in demand in New England within the next 10 years, with 11 to 60 of these based in Rhode Island if adequate facilities are available. This represents an increase of about 25 percent over the present fishing fleet of 125 vessels. However, traditional Rhode Island fishing ports such as Newport and Galilee are at or near capacity, and significant expansion in either area would face significant political economic and social problems. It has been estimated by the University of Rhode Island Coastal Resources Center that the surplus US Navy land in Melville can accommodate up to 30 vessels. Should the prediction of 60 vessels prove accurate, facilities for 30 vessels would be lacking. With significant development, Melville could accommodate up to 40 vessels, but there would still be a need for berth space for 20 additional vessels. These vessels would range from 45 to 95 feet in length, with a few possibly as big as 125 feet, and would have drafts of 6 to 18 feet. Based on the distance from Narragansett Bay to Georges Bank (approximately 200 miles), most of the Rhode Island - based vessels would probably be in the 75 to 95 foot range. This would result in a need for approximately 1500 to 2000 feet of additional berthing space in Narragansett Bay and approximately 6 to 8 acres of back-up space if sorting, processing, packing, and sales operations are located adjacent to the berths. (The conceptual layout of an idealized cooperative fishing port if this type is presented in Figure C-1.) If the catch is off-loaded unto trucks for processing elsewhere, approximately 2 acres of land adjacent to the berthing area would be required for gear storage parking, fuel, pump-out facilities, ice-making, and supply services. Given the limited number of potential sites in Rhode Island, it appears that unless existing facilities can be expanded or new sites developed, additions to the New England fishing fleet will locate elsewhere. Depth alongside the wharf should be about 23 to 25 feet (MLW) to accommodate vessels at all tide levels for the maximum anticipated draft of 18 feet.

The prime consideration in development of new port facilities or expansion of an existing port is cost, with the major cost item being construction of berth space. Construction of berthing space can range from approximately $500 to $5,000 per linear foot, depending on type of construction and local conditions. In New England, construction is further complicated by the fact that most waterfront areas suitable for development have already been



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IDEALIZED COOPERATIVE FISHING PORT

DATE JAN., 1981	SCALE N.T.S.	FIGURE NO. C-1

developed. The site conditions in many undeveloped areas are such that development would be prohibitively expensive, particularly where development requires construction of at least some marginal wharf rather than piers, as is the case with the offloading area of a fishing port.

Davisville, with its existing berths, does not face this problem in considering the potential location of a fishing industry there. There is also adequate water depth available alongside the wharf, another considerable advantage since dredging and disposal of dredge spoils is in itself costly and can involve a lengthy and expensive permit process. Davisville is also well served by road and rail, and has back-up land available adjacent to the berthing area. Since the port area of Davisville is isolated from nearby commercial/ residential areas and is and has been primarily industrial, environmental concern over establishment of a fishing industry would not be as great as in may other Narragansett Bay sites. These factors appear to indicate that there will be a future demand for fishing industry berthing and support facilities in Rhode Island. This offers a potential developmental opportunity for Davisville, The impact of the fishing industry on Davisville would be minor if limited to offloading and support facilities or it could be extensive if establishment of an integrated fish plant or a fishing cooperative was to take place. This is dependent on the level and type of development desired by the Rhode Island Port Authority and the space available.

There is a significant opportunity for development of the Rhode Island fishing industry. There are also significant potential problems, however, and a well planned, joint public/private sector effort is necessary to overcome these obstacles. Aggressive marketing techniques and commitment of capital for vessels, shore support facilities, and fish handling and processing equipment is needed to prevent the preemption of this opportunity by other New England states.

D

APPENDIX D

US NAVY AMPHIBIOUS AND CARGO FLEETS

In fulfilling its mission, the Construction Battalion Center at Davisville must be able to assemble and load materials and equipment onto cargo vessels. Based upon discussions with Lt. Cmdr. Reese of the Military Traffic Management Command (MTMC), Transportation Engineering Agency, the primary method of transportation would be by U.S. Flag cargo ships as listed in the Military Sealift Command ships register. The secondary method of transportation would be on actual U.S. Navy amphibious ships. Data concerning the amphibious fleet and the cargo ships have been summarized and are presented in Tables D-1 and D-2, respectively.

As listed in the 1979 issue of Jane's Fighting Ships, there are 72 oceangoing vessels in the U.S. Navy's amphibious forces. These as well as actual landing craft are listed in Table D-1. All of the vessels have drafts of less than 30 feet and therefore would be able to utilize the existing piers at Davisville. Of the 72 total vessels, 36 have drafts that range from 15 to 20 and would be able to utilize the proposed port expansion with its 25-foot dredge depth. Another 14 vessels with drafts of 22 and 23 feet could use the new facilities provided caution was exercised in moving the vessel at periods of moderate to low tide levels. The remaining 22 vessels have drafts of from 26 to 29 feet and would be unable to berth at the proposed bulkhead but could use the existing piers. All of these larger vessels will have to proceed up the Davisville entrance channel at slow speed, particularly if fully-loaded and then only during daily high tides,

TABLE D-1

SUMMARY OF U.S. NAVY AMPHIBIOUS FORCES

From Jane's Fighting Ships

Class	Number Of Vessels	Length Overall feet	Beam feet	Draft feet	Displacement (tons)
LCC	2	620	82	29	17,100
LHA	5	778	106	26	39,300
LPH	7	592	84	26	17,500 to 18,300
LPD (Austin)	12	570	100	23	13,900 to 17,000
LPD (Raleigh)	2	522	100	22	13,600
LSD (Anchorage)	5	553	84	20	13,600
LSD (Thomaston)	8	510	84	19	11,270
LST (Newport)	20	522	70	15	8,450
LST (DeSoto County)	3	445	62	18	7,100
LKA (Charleston)	5	57@	62	26	18,600
LKA (Tulare)	1	564	80	28	17,500
LPA	2	564	76	27	16,838
LCU (1,610)	60	135	29	6	375
LCU (1,466)	24	119	34	6	360
LCU (501)	21	105	33	5	309 to 320
LCM (8)	*	76	21	5	115
LCVP	*	36	10	4	14
LWT	*	93	23	7	12

*Quantity not listed.

TABLE D-2

SUMMARY OF DRY CARGO SHIPS

MILITARY SEALIFT COMMAND

Number Of Vessels	Draft feet	Length (Overall) feet	Beam feet	Capacity L. Tons X 1,000
4	26	659	72	14.1
10	27	499 - 560	64 - 78	6.9 - 9.4
14	28	492 - 791	73 - 105	7.8 - 12.6
22	29	455 - 695	62 - 92	6.0 - 13.0
52	30	494 - 695	68 - 78	8.4 - 14.7
50	31	493 - 664	70 - 82	6.9 - 13.5
74	32	540 - 701	72 - 102	8.2 - 26.0
28	33	523 - 876	72 - 106	9.9 - 21.8
11	34	601 - 721	90 - 95	11.2 - 21.7
20	35	605 - 947	82 - 105	17.9 - 24.1
9	38	893	100	32.0
4	41	820	100	24.1

SOURCE: Military Traffic Management Command, Transport Engineering Agency, Transportability Analysis Summary of US Flag Dry Cargo Ships, July 1980.

because depths of only 30 feet were recorded in both the channel and turning basin and even shallower depths were measured adjacent to the piers.

The Military Sealift Command lists 289 US Flag cargo vessels that could be drawn upon to move military supplies and equipment from a Construction Battalion Center such as Davisville. Of a total of 298 ships, 102, or 34 percent, have drafts of 30 feet or less, which is considered the maximum draft vessel that should enter Davisville during high tide stages. None of these 102 ships have drafts of less than 26 feet which would effectively rule out their use of the proposed port expansion. However, the two existing piers could be utilized for military cargo operations. Because of the 26 to 30-foot draft of the 102 cargo vessels, they would have to utilize caution when navigating in the Davisville approach channel, turning basin and berthing areas.

E

APPENDIX E

GEOTECHNICAL ENGINEERING ANALYSIS

I. GEOTECHNICAL SITE INVESTIGATION

An exploration program consisting of 18 borings taken in the Narragansett Bay area immediately adjoining the Quonset State Airport and port facility at Davisville was performed by Guild Drilling Company of East Providence, Rhode Island between March and April, 1980 under the full-time observation of a representative of CE Maguire. The program was undertaken in order to assess soil conditions for the six alternate port expansion configurations. A program of laboratory tests were performed on a series of 3-inch undisturbed piston samples taken in an area where design problems were anticipated due to large quantities of soft compressible material. An extensive literature search was conducted to supplement the field and laboratory data.

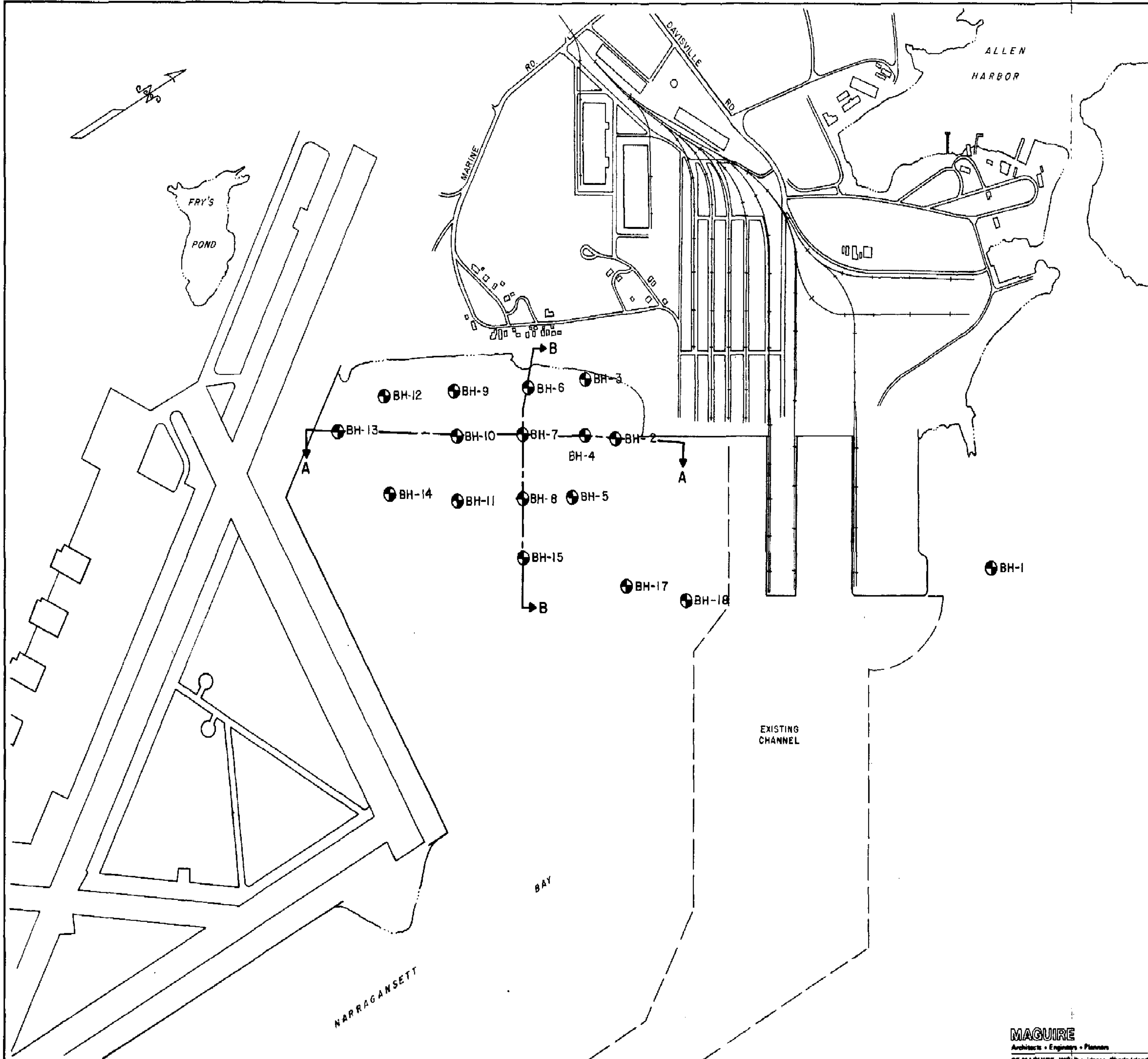
The geology of the Narragansett Bay bottom in the vicinity of Quonset/Davisville presents relatively few constraints to development of the area. The existing dredged channel to the pier area has a minimum depth of 30 feet. Outside the channel are shallow areas which will require dredging for vessel access. Depths to bedrock in the immediate area are sufficient for dredging to the proposed depth of Elevation -25 MLW.

A seismic survey of the vicinity performed by the Coastal Resources Center of the Universiry of Rhode Island for their environmental assessment of the project showed no evidence of local faulting, and there have been no earthquake epicenters recorded in the immediate area. Results of magnetic surveys suggest possible north-south and northeast-southwest trending faults to the east of Quonset/Davisville that have controlled the location of bedrock channels.

Surface sediments adjacent to Quonset/Davisville reflect the area's hydrographic conditions, with silt in dredged channels and more sandy sediments on the undredged bottom.

Surficial U.S.G.S. mapping of the Quonset/Davisville site indicates substantial landfill primarily in the airport complex and the Davisville port areas. This land reclamation was undertaken in the early 1940's at the time the Naval Base was constructed. Hydraulic fill material was obtained by channel dredging to berthing areas.

Borings BH-2 through BH-15 (Figure E-1) were undertaken in the Fry's Cove area of proposed landfill, bulkhead installation, and dredged channel extension; it is note-worthy that relatively little surficial organic silt was observed with the exception of borings BH-13 and BH-14 which were taken within the drowned stream valley complex adjacent and north of the airport bulkhead line. Boring BH-1 was located north of the existing piers.



LEGEND

BH-1	BORING NUMBER AND LOCATION
A - - A	SOIL PROFILE SECTION
NOTE	BH-16 WAS NOT PERFORMED

GRAPHIC SCALE

0 400' 800'

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BORING LOCATION PLAN

SCALE: 1" = 800' FIGURE NO.: E-1

The water depth within The Drowned Valley area was observed, by the recent fathometer survey, to be more than twice as deep as the adjoining cove, averaging approximately 12 to 15 feet in the near shore and 19 feet in the above eastern areas. Borings here suggest that organic siltation has taken place to thicknesses of 25 feet or more. The drowned valley is approximately 700 feet in width, and is aligned generally parallel to and some 800 feet offshore and north of the East - West airport runway at Davisville.

The relatively thin surficial organic silt deposits observed in the majority of borings and local geologic surveys would indicate that prior to the airfield construction, unobstructed tidal currents were sufficient to prohibit sedimentation of the finer particles. Borings indicate that below the organic, silt a stratum of typically glacial sand and silt outwash which has an average thickness of about 45 feet in the near shore Fry's Cove Area. There is a continuous layer of very dense boulderous, sand and gravel, non-cemented till averaging about 10 feet in thickness overlying weathered bedrock.

Bedrock drilling was accomplished in the borings through a grid pattern ending borings with refusal on the rock surface or with a 5-foot rock core thereby providing representative sampling at minimal expense.

Borings BH-17 and BH-18 were performed in a more off-shore area to provide data for possible pier construction and in the channel area to serve as an offshore reference. Generally, aside from a greater water depth in these two borings, a similar geologic profile and depth to bedrock was observed. The only unusual feature sited in these borings was in BH-18, which was taken in the vicinity of the existing dredged access channel to the present Davisville Docking Facility, which shows an organic silt stratum at a sediment depth of 6 to 12 feet. It is surmised that this layer was originally surficial, with 6 feet of material deposited locally during the channel dredging.

BH-1 was done to the north of the existing Davisville Port Facility in the tidal flats leading into Allen Harbor. Generally, a greater thickness of surficial organic silt and a finer as well as thicker glacial outwash strata is seen in this area.

II. REGIONAL GEOLOGY

A. Preglacial and Glacial Geology

The Quonset/Davisville complex is at the western limits of the Narragansett Structural Bedrock Basin. The Narragansett Basin is composed of a complex northerly synclinal rock mass containing several thousand feet of clastic, nonmarine sedimentary rock deposits dating to the Pennsylvanian Period. The basin extends north from the mouth of the Narragansett Bay through Providence and Pawtucket, and then northeast into Massachusetts.

A rise in sea level and a subsidence of the land in recent geologic time has inundated the lowest areas forming Narragansett Bay in which islands are former hills. Greenwich Bay and Wickford Harbor are examples of submerged basin lowlands. The erosion and deposition in glacial and post glacial times further modified the topography.

Bedrock cores in the study and adjacent areas indicate a predominance of gray metamorphosed granite gneiss, whose major constituents are potassium feldspar, quartz, and chlorite. Shale, graphitic and non graphitic, also underlies part of this area, and there is also evidence of a slightly metamorphaosed sandstone. It is numerously documented that in the bedrock formations underlying Narragansett Bay, metomorphism increases as one moves southerly down the bay. Local shales and sandstones consist of fine white mica and chlorite, thought to be derived from the original sedimented rocks prior to metamorphism. Beds of high and meta-anthracite (locally carbonaceous, coaly or graphitic rocks of the Narragansett Basin) in various forms occur through the basin, graphitic shale being an example.

In all cases of rock drilling in the study area, bedrock proved surfically weathered, fractured, and seamy. Geologic studies in the area have noted that the bedrock of the Narraganset Basin is strikingly softer and therefore more erosion prone than the older (Precambrian and Paleozoic

Eras) more crystaline, igneous and metamorphic formations directly beneath and adjoining the basin. Several cycles of uplift and erosion, previous to the glacial advance and retreat of the Pleistocene, eroded these softer Pennsylvanian rocks to form the structural basin.

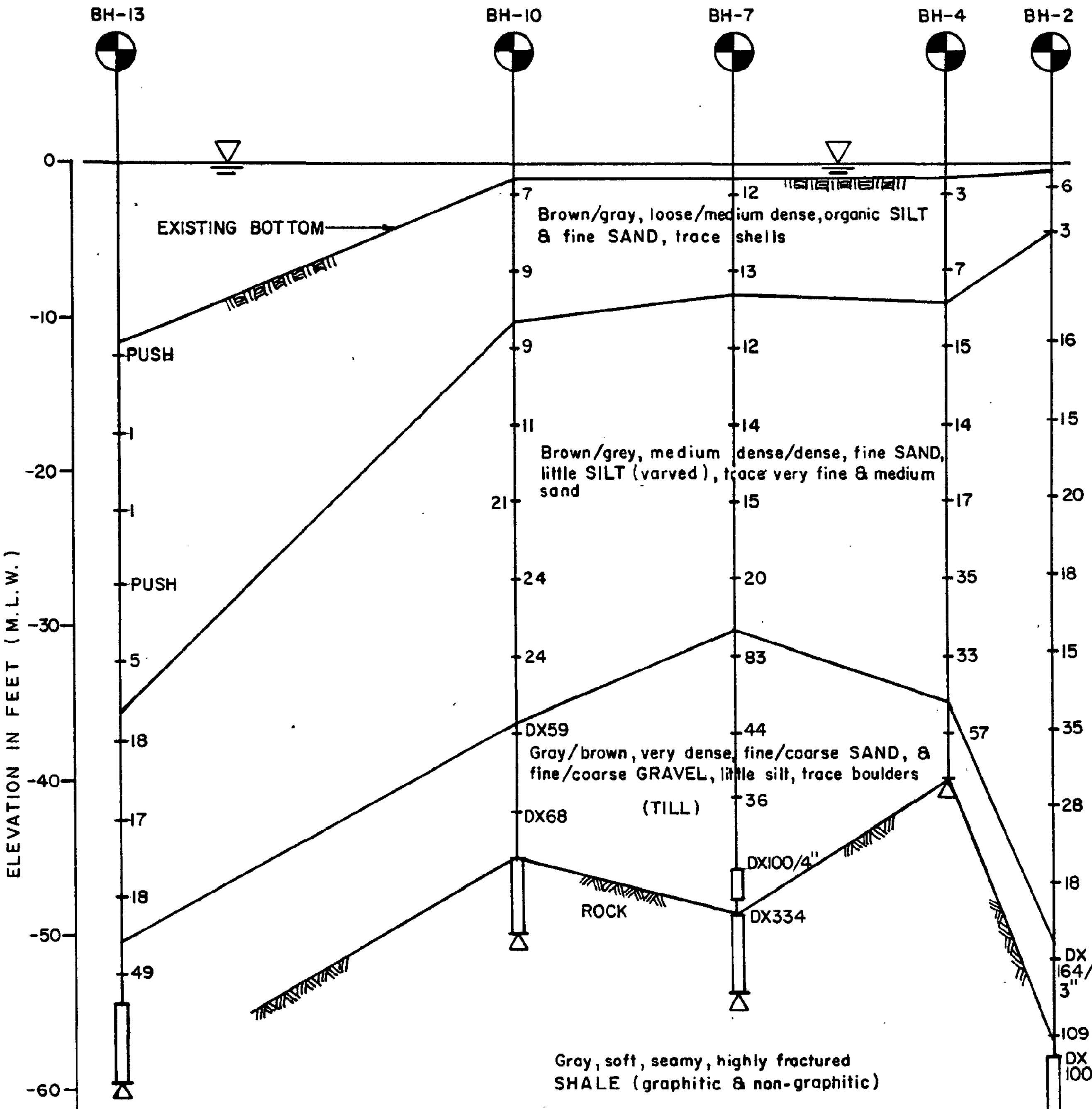
A fairly thin, ubiquetous strata of very dense weathered rock fragments reworked with glacial till covers bedrock in the study area, attesting to the bedrock's highly weathered condition.

Sediments in Narragansett Bay generally show a trend toward coarser textured material as one moves southerly down the Bay. This observation of sediment distribution is related to tidal induced turbulance which progressively reduces the amount of suspended sediment allowed to reach bottom.

Bedrock in the study area is from the Pennsylvanian Period, which was entirely nonmarine and deposited in an area of great relief. Rapid deposition took place, as evidenced by the presence of unweathered feldspars and rock fragments. High energy erosion of surrounding highlands led to clastic sediment deposition in intermountain lowlands. Evidence that Pennsylvanian sediments of the Narragansett Basin were from a distant source, probably from the northeast tend to support this theory. Swampy lowland areas escaped sedimentation temporarily by way of their distance from sediment laden streams. Vegetation flourished in the mild climate of this period. This vegetation later became the coal and graphitic strata of the Narragansett Basin. Pennsylvanian sedimentation terminated when the area was subject to vigorous tectonic action. It was during this time that the Narragansett Basin sediments were folded, faulted, and metamorphosed into their present rock structure.

Water wells drilled into bedrock just west of the study area have discovered buried preglacial channels formed when sea level stood considerably lower. In these areas, as much as 200 feet of glacial deposits overly the bedrock. This is part of the concept that Narragansett Bay results from the submergence of a stream cut valley after glaciation.

Sand and gravel interbedded with homogeneous and varved strata of sands and silts overly bedrock suggesting that the study area was glaciated at least once, and possibly several times during the Pleistocene. There is considerable evidence that Long Island has been glaciated several times as well as Block Island, Martha's Vineyard, Nantucket, Elizabeth Island, and Cape Cod. The Wickford Quadrangle, which includes the study area, is only 40-65 miles north of these islands and most certainly underwent a similar glacial history. The geologic sections of the study area (Figures E-2 and E-3) do not show multiple glaciations, although the stratigraphy is rather complex. Possibly, earlier glacial



LEGEND

BH-11 Boring location and number

Water elevation (M.L.W.)

Rock core

Bottom of boring

24 Standard penetration resistance in blows/foot

DX 300lb. hammer

Rock elevation

FOR NOTES SEE FIGURE NO. E-3

SCALES:

VERT. 1" = 10'

HORZ. 1" = 400'

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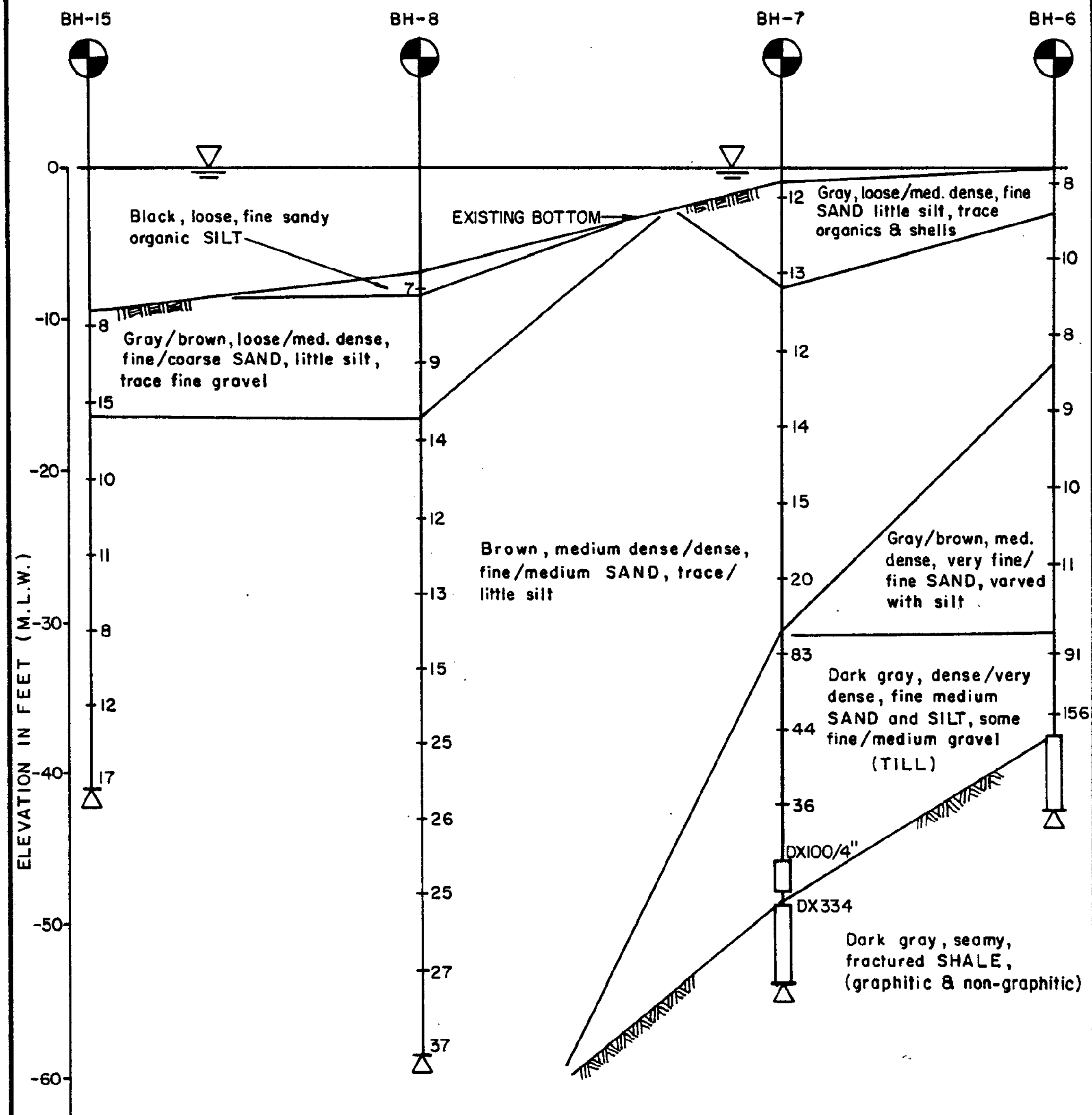
NORTH KINGSTOWN, RHODE ISLAND

SOIL PROFILE SECTION A—A

DATE JAN., 1981	SCALE AS SHOWN	FIGURE NO. E-2



SCALES:

VERT. 1" = 10'
HORZ. 1" = 200'

NOTES

1. For location of profile see FIGURE NO. E-1
2. For additional information see Boring Logs.
3. Soil Profiles were prepared as an aid in presenting subsurface conditions. Variations in conditions must be anticipated.
4. For LEGEND see FIGURE NO. E-2

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SOIL PROFILE SECTION B — B

DATE JAN., 1981	SCALE AS SHOWN	FIGURE NO. E-3

depositions were removed by more recent ice cover, or are indistinguishable from later glaciation.

Till and decomposed rock, overlying the weathered Pennsylvanian bedrock, is generally dark gray with cobbles and boulders. The rock portions derived from the parent bedrock are angular and easily fractured. This decomposed material is set in a matrix of unsorted glacial material, and probably was deposited directly by the ice with little water present. During glacial retreat, successive strata of outwash, sorted and stratified silt, sand and gravel were deposited directly over the till by meltwater streams. The study area is part of a regional outwash plain extending from Providence to southern Rhode Island which slopes gently southward.

The demarkation of pre- and post-glacial time in the study area can be inferred to occur at the interface between the loose, gray, surficial, organic silt, and the uppermost layer of angular to subangular fine to medium sand, and silt. On adjacent easterly ridges, this surficial material is ground moraine. Lesser amounts of weathering of this material may indicate that it is of late Pleistocent Age.

The laminated or varved layering occuring in the uppermost strata probably developed when ponding or ice daming occurred on the outwash plain. Finer material was carried into these stagnant waters and deposited in varves. Coarser material, fine sands, were deposited during the warm summer runoff season when currents were more active. The finer materials, clays and silts, were deposited during the winter season when melt water runoff was a minimum. Varving results from this cyclical depositional condition, with each varve believed to constitute a single summer-winter cycle. The transition from coarse to fine lamination being rather abrupt owing to the rapid influx of melt waters and sediment accompanying the spring runoff. Grain-size distribution and thickness of individual varves are functions of the duration of the runoff period, the distance from the source, and the local topography. Pleistocene geology of the Wickford Quadrangle has been described by various authors, and some of the main points of their discussions as they relate to the study area are as follows:

Glacial ice advancing over the area eroded most or all of the preglacial soil, weathered rock surface, and even solid bedrock to an extent. Glacial action did not carry this material far. Grooves, and friction cracks in local bedrock outcroppings indicate a generally southerly advance of ice, deviating only in cases of local topographic irregularities.

Material picked up during ice movement was redeposited on bedrock as ground moraine. In valley areas, this layer was later washed away by melt waters. This was not the case in the study area.

Locally, no large accumulations of till discernable as end moraine occurs. The nearest known end moraine is the Charlestown moraine some 10 to 15 miles south of the study area.

Geologists who have studied this area agree that the ice sheet receded by downwasting and stagnation, because of the abundance of knolls, ridges, undrained depressions, and ice channels deposits. Accordingly, the ice became thinner until no forward movement was possible. Along the perimeter of the ice sheet, ice masses broke off from the main body during thinning. Melt water flowing in between these stagnant ice masses carried and deposited much sand, gravel, and fines to form the various glacial formations. Most of these outwash deposits grade into or intrude upon each other forming an integrated system such as seen in the geologic profiles, Figures E-2 and E-3.

Generally, in the Wickford Quadrangle a uniform layer of windblown silt or sandy silt overlies the glacial material. The rock portions within this layer show evidence of being cut and polished by wind action, indicating that wind conditions during deglaciation were more intense than at present. Sparce vegetation during these times promoted this deposition.

In the period just after deglaciation, deep frost action, in some areas, has mixed underlying glacial material with the windblown deposits to form an unstructured matrix similar to till.

This condition of post glacial windblown fine material deposited over late glacial, angular outwash is observed in the study area profile.

B. Post Glacial

During deglaciation, when wind conditions were less severe and vegetation was at a minimum, much of the fine glacially ground material which became exposed was transported by wind and redeposited over nearby areas.

A similar pattern is evident in the Hudson River Valley and New York City Harbor area, Housatonic, Quinnipiac, Connecticut, and Thames River Valleys of Connecticut, Taunton-Sakonnet, and Charles River Valleys of Massachusetts, and the Kennebel, Presumpscot, and Penobscot River Valleys of Maine.

Adjacent to the study area, uplands are covered with windblown silt which is readily distinguished from the coarse outwash immediately beneath. Bay sediments reflect these same conditions fine glacial material making its way to flowing melt waters, and finally being deposited in shallow water estuaries as the sea invaded low-lying land still depressed by ice loading.

Soft surficial layers of highly compressible organic silts and clays are common in New England estuaries as encountered by CE Maguire in local geotechnical investigation for coastal structures in Providence and Quonset, Rhode Island; Stratford, New Haven, and New London, Connecticut; and Boston, Massachusetts.

Bemben and Richardson in a 1973 publication for Woods Hole Oceanographic Institute also indicate several instances of design and dredge work with estuarine organic silts along the coast of New England. Sites where these materials have been studied include Stratford, Stamford, and New London, Connecticut; Fox Point and Narragansett Bay, Rhode Island; and Plymouth Harbor, Charles River (Boston), and Fall River, Massachusetts.

The Army Corps of Engineers in their 1957 hurricane barrier survey of Narragansett Bay showed several soil profiles which include a surficial strata of organic silt from the south street section of the Providence River south to south of the Jamestown Bridge. In the profiles, organic silt layers of 25 feet or more in thickness are not uncommon.

Representative samplings of local surficial organic silt when examined minteralogically revealed constituents quartz, feldspar, mica (illite) chlorite, and kaolinite, with quartz and feldspar particles showing considerable angularity owing to their glacial origin. Similarly, the major components of the bedrock encountered in the study, and adjacent watershed, areas include; granite gneiss (potassium feldspar, quartz, chlorite) and sandstone (mica and chlorite) which comprise the inorganic components of the surficial silts with the exception of kaolinite and illite (hyprous mica) which are pseudomorphous to feldspar and mica respectively. In this fashion, parent bedrock material can be traced to surficial sediments.

During the rise of sea level in post glacial times, which exceeded the crustal rebound after ice unloading, the outwash area of Narragansett Bay, along with virtually all coastal lowlands in New England, become inundated. This process occurred over a period of several thousands of years, and the drowned vegetation was broken down and incorporated into the silt laden sediments which were being deposited. Sediment laden melt waters, reaching newly formed estuaries underwent reduced current velocities and mixing with more saline organic rich waters. Both these factors induce sedimentation, the increased salinity would be sufficient to induce flocculation of fine suspended particles and their incorporation with the organics. This process was postulated to account for the onset of organic siltation in the New York area of the Hudson River. Similar geologic profiles in the Providence River, New Haven Harbor, Boston Harbor, and throughout the buried river valleys of New England suggest that the onset of organic siltation, some 11,000 years ago, occurs in a similar fashion throughout the region.

III. LOCAL AND SITE GEOLOGY

A specific surficial Geological Investigation by R. L. McMaster and S. M. Greenlee (1980) was conducted on the beaches and adjacent near shore bottom in the general area defined by Calf Pasture Point and the Quonset State Airport bulkhead. This data is included in the report entitled, "Environmental Assessment Davisville Port Expansion, 1980."

IV. LABORATORY ANALYSIS

A. Organic Silt, Boring 14A, Sediment Depth 6 to 10 Feet

Two 3-inch undisturbed piston samples were taken in Boring BH-14A at depths 6 to 8 feet and 8.5 to 10 feet. Boring BH-14A was located within the drowned valley immediately north of the airport bulkhead where appreciable organic silt deposits were observed. The results of these tests are enclosed at the end of this appendix.

1. Index Properties

Some insight into the engineering behavior of the organic silt may be obtained through investigation of its index properties. The value of these type tests are in their economy of both time and trained personnel, while providing data which is reproducible and indicative of probable stress-strain soil behavior obtained only in more sophisticated and costly analysis.

Laboratory testing indicates that approximately 17 percent of the organic silt has grain sizes in the clay range, i.e. less than 2 microns. This minor fraction of fine material coupled with an organic content in the range of 4 percent (by the dry combustion method) would impart the properties of high plasticity and compressibility, along with a very soft consistency to the mineral silt particles. Natural water content and Atterburg limit values are observed to be well into the clay range, with an average water content and plasticity index of 80 and 31, respectively. Placement on the plasticity chart is slightly below the A-line in the highly elastic organic range of OH, similar to other organic silts of New England.

Natural water content is an indirect measurement of unit weight for a saturated soil, with increases in water content reflecting a decrease in unit weight. An open mineral-organic structural configuration and a high natural water content yield an average total unit weight of 91.8 pounds per cubic foot, and an effective in-situ bouyant unit weight of approximately 28 pounds per cubic foot.

The natural water content, grain size, and Atterburg limit value appear fairly consistent. Natural water contents are greater than the liquid limit indicating a sensitive soil. The term sensitivity implies a strength loss between the undisturbed and remolded states. From experience with this material, a sensitivity of approximately 4 is typical. This magnitude of sensitivity implies that the soil loses 75 percent of its strength upon disturbance or remolding.

Sensitivity may be related to liquidity index, since the greatest loss in strength during remolding should occur in a soil whose natural water content is greater than its liquid limit. With a liquidity index of 1.5, the organic silt would place in the highly sensitive category.

3. <u>Compressibility</u>

The organic silt in oedometer testing proved to be highly compressible, as one would surmise from the previous index property analysis. High natural water contents and high initial void ratios attest to a loose, open particle structural arrangement owed largely to the incorporation of organics with the mineral silt particles.

Plots of the coefficient of consolidation, C_v, which is an indicator of the time rate of compression versus pressure, would indicate that consolidation is most rapid at pressures just below past maximum pressure, and again in an area well into the virgin loading range. This later observation could be due to high effective stress causing particle structure collapse and/or crushing where as the former could be due to an initial particle restructuring. This restructuring or "internal consolidation" stabilizes the silt-organic matrix until an effective stress is reached that is equivalent to that previously experienced. Both the logarithum and square root of time curve fitting techniques for computing C_v were employed and graphs are included in the test results. Typically, one might expect a relationship between these two methods. Thus: $C_v(\sqrt{t}) = (2 \pm 0.5)\ C_v(\log t)$, owing to the emphasis placed on different time segments of the consolidation process by each method. Examination of the incremental deformation versus time plots show considerable secondary consolidation occuring (by definition: continued consolidation after the dissipation of excess pore pressures). This is typical and directly attributable to the nature of the organic fraction in soils of this type. In soils, where appreciable secondary consolidation is evident, it is more representative when examining Cv to favor the log curve fitting technique as this method emphasizes the latter stages of consolidation where this behavior is more easily seen.

Examination of the compression index (C_c) and the strain normalized compression ratio ($C_R = C_c/1 + e_o$) would substantiate the highly compressive nature of the organic silt. A rough correlation between the classical Terzaghi and Peck relationship: [C_c = 0.009 (liquid limit minus 10)] for clay soils, and the organic silt tested can be drawn. This is seen as the influence that organic matter has on the engineering behavior of a silt. Rebound loading is seen as typically flat, in the strain versus log pressure plot, until the virgin effective stress increment is reached, then characteristic consolidation ensues.

Interpretting the results of the oedometer testing, and selecting values of the past maximum pressure ($\bar{P}_c$, Casagrande method) in comparison to the calculated effective overburden pressure ($\bar{P}_o$) one observes that the organic silt is approximately normally consolidated, i.e. $\bar{P}_c/\bar{P}_o \cong 1.0$.

3. Shear Strength

Soil strength properties are of major interest because it directly relates to bearing capacity and stability of a deposit, and thus to its potential value as an engineering material.

Shear strength, which generally decreases with increasing water content for a saturated soil, is uniquely related to density. Surficial samples having high water contents and low densities typically exhibit low shear strengths.

As discussed previously, the organic silt is soft, weak, highly compressible, and occurs in a loose but elastic organic structural framework. Torvane results, which show an increased resistance to shear with depth, reflect a strength gain with increasing effective stress, derived from overburden pressures. The classical observation that the shear strength of a homogeneous deposit of normally consolidated soil increases linearly with depth, gives rise to the correlary that the ratio of undrained shear strength to verticle effective stress ($Su/\bar{P}_o$) is a constant. There has been some evidence that with an increasing plasticity index, this ratio also tends to increase. In $\overline{CIU}$ (triaxial consolidated isotropically undrained with pore pressure measurements) testing, the shear strengths must be normalized against the laboratory consolidation pressure ($Su/\bar{P}_c$) since the consolidation pressures typically exceed insitu conditions by a factor of 2 to 3 to negate the effects of sample disturbance. The ($Su/\bar{P}_c$) ratios obtained in this study have a normalized average of 0.48, which is a high value for correlation with inorganic silts and clays sited in literature, but compares well with work done with New England organic silts. These seemingly high strength ratios have been attributed to some degree of interparticle cementation by the organic material at elevated effective stresses. Although higher than anticipated strengths were obtained in the $\overline{CIU}$ testing, the organic silt is still classified "very soft" based on 'push' blow count values obtained during sampling.

Due to the nature of the testing, and expecially the rates of strain employed, the torvane and $\overline{CIU}$ shear strength values can only be correlated in the most general way.

Typically for soils with some degree of cohesion, failure modes in triaxial testing might include classical single shear, cone shear, and failure by bulging of the central portion of the sample. For the organic silt tested, only bulging failures were observed. It is apparent that samples compressed considerable before failure.

$\overline{\text{CIU}}$ tests were carried to 20 percent strain. It is note-worthy that the average values of the maximum deviator stress and the effective principle stress ratio occurred at 10 percent strain or better, and was fairly constant over the 10 to 20 percent strain range. It is well known that when larger strain values (in excess of 5 to 10 percent) are reached, test data is questionable since stress conditions are not uniform due to end effects and sample bulging.

The $\overline{\text{CIU}}$ stress-strain curves show extremely elastic, ductile behavior, with a rapid rise at low strains (below 2 percent) which is followed by a reduced but steadily increasing slope whose peak value is reached at strains greater than 10 percent with this peak value generally maintained until the strain limit of testing. As a reference, in conventional geotechnical problems dealing with settlement criteria, soil strains in the range of 2 to 4 percent could be considered failure.

The maintenance of peak shearing resistance over such a wide strain range can be attributed to particle-organic elastic structural contraction and fractional factors predominating at higher strains. The bulging type shear failure typically seen in ductle clays is produced by the elastic nature of the silt-organic sediment fabric.

Generally, the change in pore pressure-strain curves mirror the stress-strain curves showing a rapid rise to 2 percent strain after which a maximum value is reached at approximately 10 percent strain and maintenance until test termination. Similarly, the A factor-strain curves show near maximum values attained at 10 percent strain with the maximum maintained or slightly increased to the strain limits of the test. This suggests again that the silt-organic structure is extremely elastic making a peak strength value difficult to define regardless of criteria employed.

It is well known that normally consolidated and over consolidated clays having the same void ratio will exhibit different strengths due to their different stress histories. The reason for this lies partly in the pore pressures developed during shearing. The magnitude of the excess pore pressure is almost singularly regulated by the overconsolidation ratio. The A factor which is also highly dependent upon stress history is roughly defined as a soils tendency toward volume change upon stress application, with positive values indicating structural contraction and negative values dilation.

From the oedometer tests, the organic silt behaved as if it were normally consolidated. The average A factor at failure (A_f) was 1.67, which is indicative of a very sensitive soft soil. Generally, A_f increases with sensitivity or liquidity index.

Regarding the two classical failure criteria in triaxial testing , if at the point of maximum deviator stress ($\bar{\sigma}_1 - \bar{\sigma}_3$) max, the pore pressure attains a maximum value, then the two failure criteria coincide. If the deviator stress is constant or decreases slightly with strain after peaking, then the maximum principal stress ratio ($\frac{\bar{\sigma}_1}{\bar{\sigma}_3}$) max will occur after the point of maximum deviator stress. In the $\overline{\text{CIU}}$ testing for this study, the maximum pore pressure reached its peak at an average value of 11 percent strain, and maintined peak until 20 percent strain. The average strain values for ($\bar{\sigma}_1/\bar{\sigma}_3$) max and ($\bar{\sigma}_1 - \bar{\sigma}_3$) max was approximately 16 percent and 9.5 percent respectively. The near constant change in pore pressure ($\Delta\mu$)-strain curve over the 10 to 20 percent strain range would indicate no distinct point of structural collapse which might favor one of the two classical failure criteria. This prolonged level of high shearing resistance after the point of maximum pore pressure might be explained by the soil undergoing an internal structural rearrangement in the failure zone, thus on further strain, the deviator stress and the principle effective stress ratio could increase slightly, maintain current levels. Possibly this behavior is merely the result of the elastic deformation of the organic framework. Since a more distinct peak is observed in the ($\bar{\sigma}_1 - \bar{\sigma}_3$) versus strain curves in the range of the $\Delta\mu$ max strain, it is the logical choice for failure criteria. In this study, the average effective fraction angle ($\bar{\phi}$) attained from the ($\bar{\sigma}_1 - \bar{\sigma}_3$) max. criteria was 30°. This value is unconservative for use in design calculations as presented in the previous discussion.

Attempts have been made to account for the influence of clay size fraction and plasticity on the effective friction angles for normally consolidated terrestrial soils. Considerable scatter is observed in this data owing to the many parameters that affect strength, but generally the ultimate effective friction angles from triaxial testing on normally consolidated soils tend to decrease with an increase in clay-size fraction. It has been shown that stress history or over consolidation ratio has little effect on the magnitude of the effective friction angle. The data from this study suggests that the organic silt has a higher effective friction angle than normally consolidated terrestrial soils of similar clay-size fraction. These high friction angles could be the result of interlocking of angular glacially derived particles, and the clustering or aggregation of smaller particles into larger units by the organics.

In summary, the origins of the mineral constituents of local surficial organic silts is glacially derived and fluvially deposited from the bedrock in the immediate and adjacent northeast areas of New England.

The aggregating influence of suspended organic matter in Narragansett Bay results in their sedimentation and eventual structural incorporation with fine mineral particles, i.e. organic silt.

The effects of a small percentage of organics on engineering properties of a soil is largely detrimental. The organics impart the adverse behavior traits of high water content, compressibility (particularly secondary compression), and sensitivity, along with low density, permeability, and shear strength. The magnitude of these adverse qualities is generally proportional to the organic content, with greater organic fractions amplifying those mentioned traits.

The geotechnical properties of the organic silt studied correlates well with that of other New England organic silts, and organic silts from the Great Lakes region, and behaves similarly to highly elastic organic and non-organic clays. This is attributed to the organic matter. Some structural cohesion and cementation appear to be attributable to the association of organics.

Cementation, at elevated effective stress, is proposed to account for the higher than anticipated $Su/\bar{P}_c$ ratios derived from triaxial $\overline{CIU}$ testing. Cohesion and structural elasticity directly attributed to the organics made sampling of good quality possible, as evidenced by the strain versus log pressure consolidation curves and the B-Factor (pore pressure response) values attained in triaxial testing. Oedometer tests indicate that the organic silt studied exhibits normal consolidation behavior. High effective friction angles are exhibited in all organic silts of New England cited in literature, this study inclusive. The mechanism responsible is probably aggregation of particles by the organics and angular particle interlocking. It is particularly an engineering judgement when considering the use of this friction angle in design calculations. Owing to the conclusions of this study, the organic silt under consideration is particularly trecherous when being dealt with from an engineering viewpoint. Furthermore, environmental restrictions may be encountered if dredging of this material is undertaken because of the excessive organic fraction.

B. Analysis of Granular Outwash of Materials

In the Fry's Cove area, laboratory analysis of outwash sediments substantiate the field observations. Within the working sediment depths of 0 to 40 feet, the sediment is uniformly characterized as medium-dense, fine to medium sands and silts. Gravel observed within these depths is confined to minor sediment fractions occuring in thin, shallow lenses. Component granular particles tend to be angular to subangular in texture, and composed of durable relatively unweathered mineral types, attributable to their glacial orgins. These characteristics along with a substantial degree of in-situ density contribute to inherent sediment strengths sufficient to sustain conventional sheet pile bulkheading for a 25-foot dredge depth throughout Fry's Cove, exclusive of the drowned valley area. A conspicuous absence of cobbles, boulders, or excessively dense gravel stratum within the working sediment depths would facilitate installation of sheet piling, or any other mode of support structure.

The stratum to be dredged and reused as hydraulic and engineered fill material is estimated to have sufficient permeability to prevent excessive hydrostatic pressure build-up against proposed sheet pile berthing structures. The silt contents observed in these fill materials would classify them as not of prime quality, but through judicious use they may serve their designed intent.

Field and laboratory examination of sediment in the tidal flats area north of pier 2 (BH-1) revealed excessive loose silt containing 20 to 50 percent very fine sand. The combination of loose, structural packing and predominent silt particle-size render these strata unacceptable for support of conventional sheet pile bulkheading for a 25-foot dredge depth. Other proposed construction alternates employing deep pile support, would be feasible in this area. The high silt content of this soil would make control of suspended sediment from dredge spoils a significant construction consideration. In addition these soils when dredged and used for fill will have poor engineering properties similar to the soil in its in-situ state.

C. Geotechnical Design Consideartions

For design alternates involving construction in Fry's Cove near Dogpatch Beach, bulkheads will retain approximately 22 feet of existing sediments, over which will be placed (on the average) eight feet of hydraulical fill and five feet of controlled compacted fill. These soils will cause active earth pressures against the proposed bulkhead. Hydraulic and engineered fill materials will be derived principly from on-site dredging which will be composed primarily of silty fine sand (SM) with a trace of fine gravel yielding in place properties after surcharging:

$\bar{\gamma}_{SAT} = 121$ PCF, $\bar{\gamma}_{WET} = 108$ PCF, $\bar{\gamma} = 59$ PCF, $\bar{\phi} = 30°$, $\delta_{STEEL} = 13°$ AND $K_A = 0.33$

The retained 22 feet of existing sediment in this area is predominantly medium dense silty fine sand with a trace of fine to medium gravel (SM) having essentially the same properties as the in-place hydraulic fill after surcharging.

Passive resistance mobilized by the proposed sheet piling will be developed at existing sediment depths of between 25 to 40 feet. The resisting force will be derived from two distinct stratum at those depths. The upper two-thirds is composed of a layer of medium-dense fine sand with 20 to 50 percent silt (SM) having anticipated properties: $\bar{\gamma}_b = 63\text{PCF}$, $\bar{\phi} = 33^\circ$, $K_p = 5.33$, $\delta_{STEEL} = 12^\circ$.

The lower one-third of this passive zone is made up of a very dense, fine to medium sand and fine to medium gravel, with 5 to 20 percent silt (GM) with resulting properties:
$\bar{\gamma}_b = 80\text{ PCF}$, $\bar{\phi} = 40^\circ$, $K_p = 9.46$, $\delta_{STEEL} = 17^\circ$

These derived parameters are averaged strata properties for the Fry's Cove design alternates. At this stage, there is insufficient data to fine tune the soil parameters to the individual design alternates. Due to the nature of the envisioned dredging process, surficial organic sediments less than five feet in thickness can be sufficiently homogenized to nullify any detrimental quantities that this material may impart to the overall fill properties. Should these organic sediments be found to exist in thickness exceeding five feet, selective stockpiling should be employed.

North of pier 2, the sediment overburden is characterized by loose, fine-grained material extending some 77 feet to glacial till and finally bedrock. This is deeper than in the Fry's Cove area. The predominant sediment grain size is silt and/or very fine outwash sand (see grain-size analysis). Uniform surficial deposits of organic silt are estimated to be at least six feet in depth. Generally, due to the less dense and finer grained sediment conditions in this area, conventional steel sheet piling would prove structurally inadequate for a dredge depth of 25 feet. Deep pile foundation will be required to some extent in this area.

Armored slopes are recommended in all but one of the proposed design alternates (alternate 3). Typical to all of the armored slopes proposed is a coarse seaward layer of 300 pound nominal stone beneath which is a multi-stage stone, gravel and sand filtering system. Gradation curves for the filtering systems particular to the various design alternates were derived from an averaging of design armor stone and in-situ boundary constraints in accordance with current filter design procedure and are presented at the end of this Appendix. The finer in-situ material anticipated in alternates 1 and 4 required an additional filtering stage over the sand and gravel containment dike. The finest layer of bedding filter material may be eliminated if appropriately engineered filter fabric is employed.

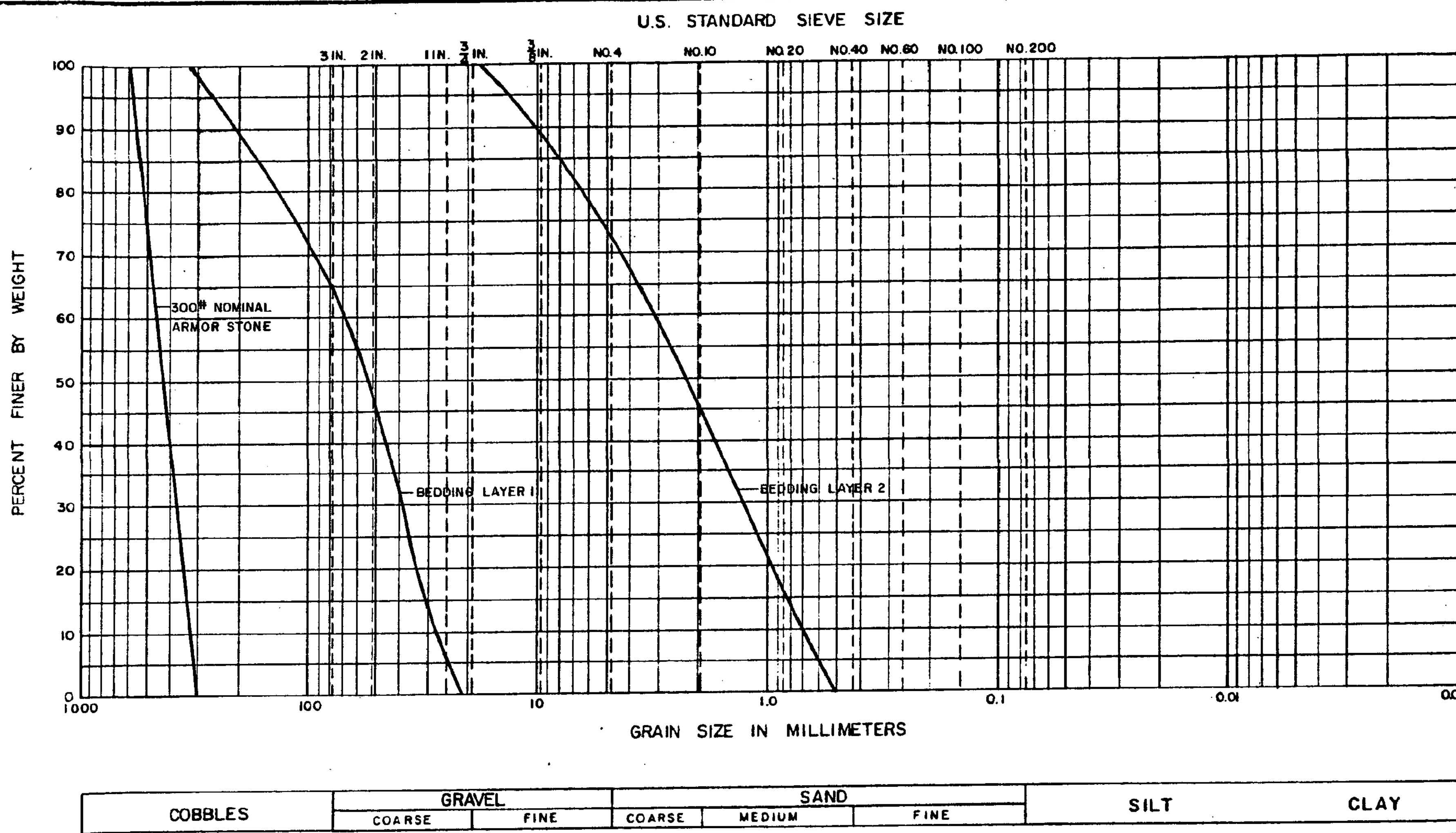
A critical area from a geotechnical viewpoint is the surficially loose, highly compressible organic silt stratum observed to extend to depths of 25 feet within the drowned valley area. If substantial organic removal is not anticipated along the proposed bulkhead line in the drowned valley area, and in that area north of the existing Davisville Piers (alternate 4), laboratory analysis suggests that after surcharging; (1) down drag frictional forces on bulkhead or other berthing structures would be in the range of 135 psf on organic silt-structural contact surfaces, (2) as much as 2.5 feet of settlement within a relatively short period after surcharge loading, neglecting the effects of considerable secondary settlement known to occur in this type material, would have to be designed for, (3) with initially low organic and loose inorganic silt sediment shear strengths, and an anticipated 75 percent strength loss upon disturbance, stability of any structure involving load transfer with these deposits must be viewed with caution, (4) the structural capability of standard available steel sheet piling employing a single tie back system for a 25-foot dredge depth would be exceeded due to excessive loose, low strength sediment in both the Dogpatch drowned valley and north of the existing pier area.

Addressing the problem of proposed new pier construction, both steel sheet pile bulkheads anchored by an in-board line of sheeting, (deadman) filled with hydraulically placed and controlled compacted material, and pile-supported reinforced concrete pier constructions were studied. In the area of proposed pier construction, bedrock lies some 60 to 100 feet below mean low water. Using a pile support system of anticipated capacity 200 tons, conventional piling materials and installation techniques may be employed to derive desired pile capacities from both frictional and end bearing components. It may not be necessary to found such a pile support system on bedrock. A more intensive study based upon final design borings will be necessary. A driven sheet-piling, earth-filled pier is equally feasible from a construction stand point no obstructions to sheet driving are anticipated and the existing sediments are competent for a 25-foot dredge depth based on existing data. Economics will dictate which technique will be employed if this alternate is constructed.

As recommended in this report, the prime area for development of Davisville is in the Dogpatch beach area of Fry's Cove. No major geotechnical problems are anticipated in this area with respect to trenching for buried utility lines. Twelve inches of compacted gravel bedding should placed beneath said lines. All organic material will have to be removed from the marsh area adjacent to Dogpatch Beach, and replaced with clean granular or hydraulic fill material. Balast for railroad construction and subbase for access roadways may be installed on existing soils or compacted fills.

Along the proposed bulkhead line, driven steel sheet piling should not encounter obstruction such as boulders or cobbles within foreseeable driving depths.

Recommendations for additional subsurface exploration prior to final design in this area include: (1) Along the proposed bulkhead line, borings should be taken at 100-foot intervals in a pattern of alternating bedrock refusal, and estimated extent of sheet piling depth termination, (2) Borings for sewer or other deep buried utility should be done at 300-foot intervals unless encountering an area of substantial fill or known poor soils (3) Railroad, roadway, or shallow buried utility lines, such as water or electrical, will require shallow borings and/or test pits at 300-foot intervals, (4) In those areas where containment dikes are proposed, borings should be taken along the major dike axis at 100-foot centers to depths where applied stress levels become less than 10 percent of the existing soil stress (5) Several additional borings will be necessary in the proposed access channel area east of the existing Navy bulkhead.



Sample No.	Elev or Depth	Classification	Nat WC	LL	PL	PI	

C E MAGUIRE, INC.

PROJECT DAVISVILLE PORT EXPANSION

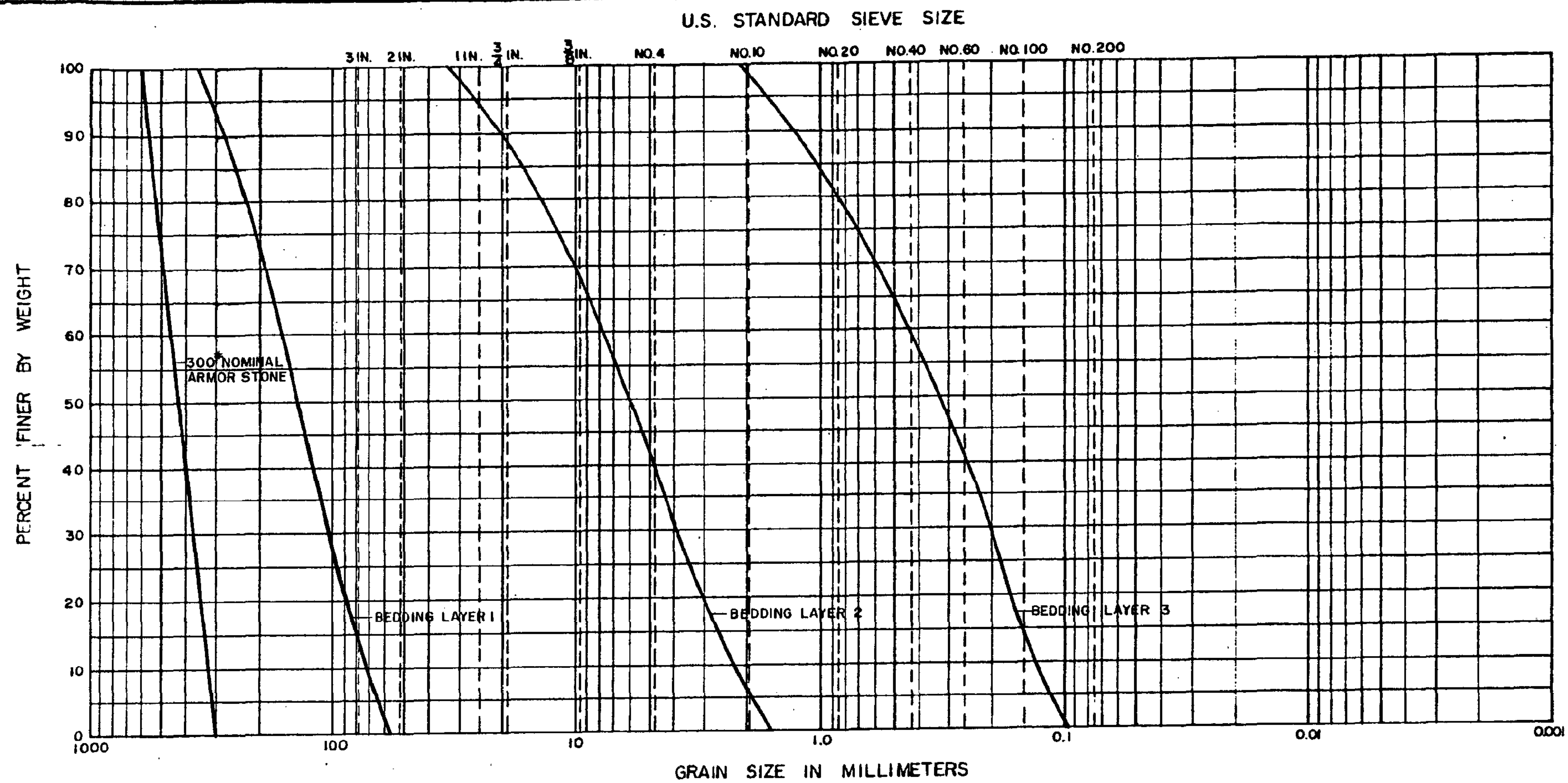
AREA DAVISVILLE, R.I.

BORING NO.

DATE

GRADATION CURVES

ALTERNATE (2,5 & 6) FILTER MATERIAL



COBBLES	GRAVEL		SAND			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

Sample No.	Elev or Depth	Classification	NatWC	LL	PL	PI	

C E MAGUIRE, INC.

PROJECT DAVISVILLE PORT EXPANSION

AREA DAVISVILLE, R.I.

BORING NO.

DATE

GRADATION CURVES

ALTERNATE (1&4) FILTER MATERIAL

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 1 OF 3
DATE
HOLE NO. BH-1
LINE & STA.
OFFSET
SURF. ELEV.

TO C. E. Maguire, Inc. ADDRESS Providence, R.I.
PROJECT NAME Davisville Bulkhead LOCATION Quonset Point, R.I.
REPORT SENT TO above PROJ. NO. 3603
SAMPLES SENT TO " OUR JOB NO. 80-256

WATER OBSERVATIONS			CASING	SAMPLER	CORE BAR.
At ____ after ____ Hours		Rods-"AW" Type	BW	S/S	
Tide 0.0	12'9"	Size I.D.	2½"	1 3/8"	
At ____ after ____ Hours		Hammer Wt.	300#	140#	BIT
		Hammer Fall	24"	30"	

	Date	Time
START	4/3/80	a.m. p.m.
COMPLETE	4/3/80	a.m. p.m.
TOTAL HRS.		

BORING FOREMAN E. Peterson
INSPECTOR D. Calvi
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From – To	Type of Sample	Blows per 6" on Sampler 0-6	6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
	1	0'-1'6"	D	1	2	2	Wet		Dark Gray sandy Organic	1	18"	18"
	3						soft		SILT, trace of shells			
	5											
	6											
	10						Wet/m					
	12	5'-6'6"	D	2	3	3	stiff	6'	Dark Gray Organic SILT	2	18"	18"
	20											
	22											
	25											
	30						Wet		Gray Brown very fine			
	12	10'-11'6"	D	8	9	14	medium		SAND, little silt	3	18"	18"
	16						dense		(layered)			
	22											
	27											
	35											
	24	15'-16'6"	D	3	4	5	Wet			4	18"	18"
	30						loose					
	26											
	28											
	28						Wet					
	25	20'-21'6"	D	5	8	10	medium			5	18"	18"
	35						dense					
	39							23'				
	46											
	50											
	26	25'-26'6"	D	5	3	3	Wet		Gray Brown silty very	6	18"	18"
	42						loose		fine SAND (layered)			
	52											
	55											
	56											
		30'-31'6"	D	2	3	3	"			7	18"	18"
								35'				
		35'-36'6"	D	1	3	5	Wet		Dark Gray SILT, trace of	8	18"	18"
							stiff		very fine sand			

GROUND SURFACE TO ____ USED ____ "CASING: THEN ____

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used	
trace	0 to 10%
little	10 to 20%
some	20 to 35%
and	35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency			
0-10	Loose	0-4	Soft	30 +	Hard
10-30	Med. Dense	4-8	M/Stiff		
30-50	Dense	8-15	Stiff		
50 +	Very Dense	15-30	V-Stiff		

SUMMARY:
Earth Boring 84'
Rock Coring
Samples 18

HOLE NO. BH-1

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 2 OF 3
DATE
HOLE NO. BH-1
LINE & STA.
OFFSET
SURF. ELEV.

TO | ADDRESS
PROJECT NAME | LOCATION
REPORT SENT TO | PROJ. NO.
SAMPLES SENT TO | OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS		CASING	SAMPLER	CORE BAR.
At after Hours	Type			
	Size I.D.			
At after Hours	Hammer Wt.			BIT
	Hammer Fall			

	Date	Time
START		a.m. p.m.
COMPLETE		a.m. p.m.
TOTAL HRS.		
BORING FOREMAN		
INSPECTOR		
SOILS ENGR.		

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler From 0-6	To 6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
		40'-41'6"	D	1	2	3	Wet medium stiff		Dark Gray SILT varved with little very fine sand layers (compact)	9	18'	18"
		45'-46'6"	D	1	2	3	"			10	18'	18"
		50'-51'6"	D	3	1	2	Wet soft	55'		11	18'	18"
		55'-56'6"	D	2	3	2	Wet medium stiff	60'	Dark Gray fine sandy SILT, trace of fine gravel	12	18'	18"
		60'-61'6"	D	2	2	3	"		Gray SILT varved with trace of very fine sand layers	13	18'	18"
		65'-66'6"	D	3	3	4	"			14	18'	18"
		70'-71'6"	D	3	4	3	"	75'		15	18'	18"
		75'-76'6"	D	3	4	4	"	77'6"	Gray fine sandy SILT	16	18'	12"

GROUND SURFACE TO USED "CASING: THEN

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used	
trace	0 to 10%
little	10 to 20%
some	20 to 35%
and	35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency	
0-10	Loose	0-4	Soft
10-30	Med. Dense	4-8	M/Stiff
30-50	Dense	8-15	Stiff
50 +	Very Dense	15-30	V-Stiff
		30 +	Hard

SUMMARY:
Earth Boring
Rock Coring
Samples

HOLE NO. BH-1

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 3 OF 3
DATE
HOLE NO. BH-1
LINE & STA.
OFFSET
SURF. ELEV.

TO
ADDRESS
PROJECT NAME
LOCATION
REPORT SENT TO
PROJ. NO.
SAMPLES SENT TO
OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS

At after Hours

At after Hours

	CASING	SAMPLER	CORE BAR.
Type			
Size I.D.			
Hammer Wt.			BIT
Hammer Fall			

	Date	Time
START		a.m. p.m.
COMPLETE		a.m. p.m.
TOTAL HRS.		

BORING FOREMAN
INSPECTOR
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler From 0-6	To 6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
		80'-81'6"	D	15	16	18	Wet		Dark Gray F-M SAND, Silt	17	18"	12"
							dense	82'	w/little F-M gravel, cobbles			
									Dark Gray fine SAND, Silt			
		83'-84'	D	18	22		"	84'	with little fine gravel	18	12"	12"
		@ 84'	D	50/0"					Refusal at 84'			

GROUND SURFACE TO USED "CASING: THEN

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used	
trace	0 to 10%
little	10 to 20%
some	20 to 35%
and	35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency			
0-10	Loose	0-4	Soft	30 +	Hard
10-30	Med. Dense	4-8	M/Stiff		
30-50	Dense	8-15	Stiff		
50 +	Very Dense	15-30	V-Stiff		

SUMMARY:
Earth Boring
Rock Coring
Samples

HOLE NO. BH-1

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 1 OF 2
DATE
HOLE NO. BH-2
LINE & STA.
OFFSET
SURF. ELEV. -2.0 MSL

TO C. E. Maguire, Inc. ADDRESS Providence, R.I.
PROJECT NAME Davisville Bulkhead LOCATION Quonset Point, R.I.
REPORT SENT TO above PROJ. NO. 3603
SAMPLES SENT TO " OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS		CASING	SAMPLER	CORE BAR.
At 5' of Water 10:10 AM after Hours	Rods-"AW" Type	BW	S/S	AXD3
2.75 Tide Board 10:30 AM	Size I.D.	2½"	1 3/8"	
At 4.75 Water after Hours	Hammer Wt.	300#	140#	BIT
	Hammer Fall	24"	30"	Dia.

	Date	Time
START	3/4/80	a.m. p.m.
COMPLETE	3/6/80	a.m. p.m.
TOTAL HRS.		
BORING FOREMAN	P. Brescia	
INSPECTOR	D. Erickson	
SOILS ENGR.		

LOCATION OF BORING: On the Water

DEPTH	Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler 0-6	6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
	6	0'-1'6"	D	4	2	4	Wet loose		Gray Brown fine SAND, trace of fine to coarse gravel, trace of silt & shells	1	18"	14"
	9											
	14											
	17							4'6"				
	19											
	5	4'6"-6'	D	2	1 =	12"	"		Gray fine SAND, trace of silt	2	18"	9"
	4							7'6"				
	1								Gray SILT (change in wash)			
	3							9'6"				
	4											
	6	10'-11'6"	D	4	8	8	Wet medium dense		Gray fine to medium SAND, trace of silt & fine to coarse gravel	3	18"	6"
	12											
	16							13'6"				
	17											
	15											
	8	15'-16'6"	D	5	7	8	"		Brown Gray fine SAND, trace of silt	4	18"	18"
	15											
	18											
	20											
	28							20'				
	18	20'-21'6"	D	4	9	11	"		Brown Gray fine SAND, trace of silt & medium sand	5	18"	18"
	29											
	34											
	39							24'				
	45											
	40	25'-26'6"	D	7	9	9	"		Gray Brown fine SAND, little silt layers varved, tr. fine gravel	6	18"	18"
	39							27'				
	36											
	47											
	56											
	71	30'-31'6"	D	4	6	9	"		Gray fine SAND, little silt	7	18"	18"
	52											
	60											
	63											
	61							35'				
	6	35'-36'6"	D	9	18	17	Moist dense		Brown Gray fine SAND, little silt (compact)	8	18"	16"
	71											
	52											
	60											
	63							40'				

GROUND SURFACE TO 57' USED BW "CASING: THEN Cored

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used
trace 0 to 10%
little 10 to 20%
some 20 to 35%
and 35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency		
0-10	Loose	0-4	Soft	30 + Hard
10-30	Med. Dense	4-8	M/Stiff	
30-50	Dense	8-15	Stiff	
50 +	Very Dense	15-30	V-Stiff	

SUMMARY:
Earth Boring 57'
Rock Coring 5'
Samples 12

HOLE NO. BH-2

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 2 OF 2
DATE
HOLE NO. BH-2
LINE & STA.
OFFSET
SURF. ELEV.

TO | ADDRESS
PROJECT NAME | LOCATION
REPORT SENT TO | PROJ. NO.
SAMPLES SENT TO | OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS
At ______ after ______ Hours
At ______ after ______ Hours

	CASING	SAMPLER	CORE BAR.
Type			
Size I.D.			
Hammer Wt.			BIT
Hammer Fall			

	Date	Time
START		a.m. p.m.
COMPLETE		a.m. p.m.
TOTAL HRS.		

BORING FOREMAN
INSPECTOR
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler From 0-6	To 6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
	17	40'-41'6"	D	5	11	17	Wet medium dense		Gray fine (running) SAND, trace of silt	9	18"	18"
	30											
	46											
	51											
	59											
	37	45'-46'6"	D	4	7	11	"			10	18"	18"
	47											
	60											
	66											
	58							50'6"				
	36	50'-51'3"	D	10	113	51/3" (300#)	Wet very dense		Gray silty fine to medium SAND & fine to coarse Gravel, trace of coarse sand, weathered rock	11	15"	12"
	126											
	57											
	75											
	98											
	136	55'-56'6"	D	31	41	68	"			12	18"	12"
	175	@ 57'	DXX	100/0"				57'	Top of Rock			
		57'-62'	C						Dark Gray Graphitic SHALE with Silt Layers, seamy, soft & fractured	C	60"	13"
								62'				
									Bottom of Boring 62'			
									DXX open and AW rod 300#-30"			

GROUND SURFACE TO ______ USED ______ "CASING: THEN ______

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used
trace 0 to 10%
little 10 to 20%
some 20 to 35%
and 35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency		
0-10	Loose	0-4	Soft	30 + Hard
10-30	Med. Dense	4-8	M/Stiff	
30-50	Dense	8-15	Stiff	
50 +	Very Dense	15-30	V-Stiff	

SUMMARY:
Earth Boring
Rock Coring
Samples

HOLE NO. BH-2

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 1 OF 1
DATE
HOLE NO. BH-3
LINE & STA.
OFFSET
SURF. ELEV.

TO C. E. Maguire, Inc. ADDRESS Providence, R.I.
PROJECT NAME Davisville Bulkhead LOCATION Quonset Point, R.I.
REPORT SENT TO above PROJ. NO. 3603
SAMPLES SENT TO " OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS
At 3'6" after 8:50 AM Hours
At ______ after ______ Hours

Rods-"AW"	CASING	SAMPLER	CORE BAR.
Type	BW	S/S	
Size I.D.	2½"	1 3/8"	
Hammer Wt.	300#	140#	BIT
Hammer Fall	24"	30"	

	Date	Time
START	4/1/80	a.m. p.m.
COMPLETE	4/1/80	a.m. p.m.
TOTAL HRS.		

BORING FOREMAN P. Brescia
INSPECTOR D. Calvi
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler From 0-6	6-12	To 12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
	4	0'-1'6"	D	4	3	5	Wet loose		Gray Black fine SAND & Organic Silt (layered)	1	18"	14"
	5											
	16											
	20							4'				
	82											
	110	5'-6'6"	D	35	50	36	Wet very dense		Yellow Brown & Gray fine to medium SAND, Silt & fine to coarse Gravel (fractured Granite)	2	18"	12"
	190											
	200											
								10'				
		10'-11'2"	DXX	65	100	50/2"	D/v/d	11'2"	Br. Gray weathered SCHIST	3	14"	-
									Refusal at 11'2"			
									Hole called by Inspector			
									DXX open end AW rod 300#-30"			

GROUND SURFACE TO 8' USED BW "CASING: THEN O. E. Rod to 11'2"

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used
trace 0 to 10%
little 10 to 20%
some 20 to 35%
and 35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency		
0-10	Loose	0-4	Soft	30 + Hard
10-30	Med. Dense	4-8	M/Stiff	
30-50	Dense	8-15	Stiff	
50 +	Very Dense	15-30	V-Stiff	

SUMMARY:
Earth Boring 11'2"
Rock Coring
Samples 3

HOLE NO. BH-3

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

TO	C. E. Maguire, Inc.	ADDRESS	Providence, R.I.
PROJECT NAME	Davisville Bulkhead	LOCATION	Quonset Point, R.I.
REPORT SENT TO	above	PROJ. NO.	3603
SAMPLES SENT TO	"	OUR JOB NO.	80-256

SHEET 1 OF 1
DATE
HOLE NO. BH-4
LINE & STA.
OFFSET
SURF. ELEV.

GROUND WATER OBSERVATIONS

At ______ after ______ Hours
Water 1'6" MLT
At ______ after ______ Hours

Rods-"AW"	CASING	SAMPLER	CORE BAR.
Type	BW	S/S	
Size I.D.	2½"	1 3/8"	
Hammer Wt.	300#	140#	BIT
Hammer Fall	24"	30"	

	Date	Time
START	3/26/80	a.m. p.m.
COMPLETE	3/28/80	a.m. p.m.
TOTAL HRS.		
BORING FOREMAN	A. D'Aiello	
INSPECTOR	D. Calvi	
SOILS ENGR.		

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler 0-6	6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
	2	0'-1'6"	D	1	2	1	Wet soft		Gray Organic SILT, trace of fine sand	1	18"	10"
	3											
	4											
	4											
	6											
	8	5'-6'6"	D	3	3	4	Wet medium stiff			2	18"	11"
	11											
	12							8'				
	14											
	12											
	16	10'-11'6"	D	6	9	7	Wet medium dense		Brown fine SAND, little silt, trace of fine gravel	3	18"	11"
	20											
	28											
	25											
	33							15'				
	12	15'-16'6"	D	5	6	8	"		Brown fine SAND, trace of silt & medium sand	4	18"	11"
	14											
	16											
	18											
	21											
	21	20'-21'6"	D	9	8	9	"			5	18"	10"
	36											
	48							23'				
	51											
	73											
	52	25'-26'6"	D	9	15	20	Wet dense		Brown fine SAND, some silt (layered)	6	18"	11"
	67											
	52							28'				
	65											
	71											
	15	30'-31'6"	D	12	13	20	Wet Hard		Gray Brown very fine sandy SILT (compact)	7	18"	11"
	31											
	42											
	48							34'				
	82											
		35'-36'6"	D	19	26	31	Wet very dense		Dark Gray fine to medium SAND, Silt & fine Gravel (Till)	8	18"	10"
		DXX open end	AW rod	300#-30"								
		@ 38'7"	DXX	120/0"				38'7"				
									Refusal at 38'7"			

GROUND SURFACE TO 35' USED BW "CASING: THEN S/S & O.E. Rod to 38'7"

Sample Type	Proportions Used	140 lb Wt. x 30" fall on 2" O.D. Sampler Cohesionless Density	Cohesive Consistency	SUMMARY:
D=Dry C=Cored W=Washed	trace 0 to 10%	0-10 Loose	0-4 Soft 30 + Hard	Earth Boring 38'7"
UP=Undisturbed Piston	little 10 to 20%	10-30 Med. Dense	4-8 M/Stiff	Rock Coring
TP=Test Pit A=Auger V=Vane Test	some 20 to 35%	30-50 Dense	8-15 Stiff	Samples 8
UT=Undisturbed Thinwall	and 35 to 50%	50 + Very Dense	15-30 V-Stiff	HOLE NO. BH-4

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 1 OF 2
DATE
HOLE NO. BH-5
LINE & STA.
OFFSET
SURF. ELEV.

TO C. E. Maguire, Inc. ADDRESS Providence, R.I.
PROJECT NAME Davisville Bulkhead LOCATION Quonset Point, R.I.
REPORT SENT TO above PROJ. NO. 3603
SAMPLES SENT TO " OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS
At 11'6" after 3/19/80 Hours
High Tide 10:00 AM
At after Hours
8'6" Low Tide

Rods-"AW"

	CASING	SAMPLER	CORE BAR.
Type	BW	S/S	S/T
Size I.D.	2½"	1 3/8"	1 3/8"
Hammer Wt.	300#	140#	BIT
Hammer Fall	24"	30"	Dia.

	Date	Time
START	3/17/80	a.m. p.m.
COMPLETE	3/19/80	a.m. p.m.
TOTAL HRS.		

BORING FOREMAN E. Peterson
INSPECTOR D. Calvi
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler From 0-6	6-12	To 12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
	1	0'-1'6"	D	1	3	4	Wet loose		Dark Gray fine to medium SAND & Organic Silt, trace of shells	1	18'	12"
	4											
	7											
	10											
	14							5'				
	10	5'-6'6"	D	5	6	6	Wet medium dense		Brown Gray fine SAND, little silt & fine to medium gravel	2	18'	12"
	13											
	13											
	15							9'				
	18											
	14	10'-11'6"	D	3	5	9	"		Dark Brown & Gray fine SAND, little silt (thin layers of silt)	3	18'	18"
	14											
	18											
	19											
	22											
	11	15'-16'6"	D	5	10	17	"			4	18'	18"
	11											
	24											
	26											
	28							20'				
	20	20'-21'6"	D	6	10	13	"		Dark Brown & Gray silty very fine SAND (layered)	5	18'	18"
	21											
	24											
	46											
	33							25'				
	38	25'-26'6"	D	10	12	14	"		Gray fine SAND, some silt (layered)	6	18'	18"
	38											
	50											
	85											
	92							30'				
	43	30'-31'6"	D	12	16	21	Wet dense	32'	Brown fine SAND with layers of Gray Silt, trace of mica	7	18'	18"
	36											
	48											
	67											
	71											
	65	35'-36'6"	D	12	20	32	Wet very dense		Brown Gray silty very fine SAND (layered)	8	18'	12"
	57											
	68											
	70											
	62							40'				

GROUND SURFACE TO 47' USED BW "CASING: THEN Cored

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used
trace 0 to 10%
little 10 to 20%
some 20 to 35%
and 35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency		
0-10	Loose	0-4	Soft	30 + Hard
10-30	Med. Dense	4-8	M/Stiff	
30-50	Dense	8-15	Stiff	
50 +	Very Dense	15-30	V-Stiff	

SUMMARY:
Earth Boring 47'
Rock Coring 5'
Samples 10

HOLE NO. BH-5

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 2 OF 2
DATE
HOLE NO. BH-5
LINE & STA.
OFFSET
SURF. ELEV.

TO
PROJECT NAME
REPORT SENT TO
SAMPLES SENT TO
ADDRESS
LOCATION
PROJ. NO. 3603
OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS		CASING	SAMPLER	CORE BAR.
At ___ after ___ Hours	Type			
	Size I.D.			
At ___ after ___ Hours	Hammer Wt.			BIT
	Hammer Fall			

	Date	Time
START		a.m. p.m.
COMPLETE		a.m. p.m.
TOTAL HRS.		

BORING FOREMAN
INSPECTOR
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler From 0-6	To 6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
	52	40'-41'6"	D	10	16	26	Wet		Dark Gray SILT, little	9	18'	18"
	60						Hard		very fine sand			
	67											
	82							44'				
	98						Wet		Gray Brown silty fine SAND,			
	120	45'-46'6"	D	11	15	18	dense		little clay & fine to	10	18'	18"
	130							47'	medium gravel			
		47'-52'	C				5		Blue Gray & White GNEISS	C	60"	54"
							5					
							5					
							5					
							5	52'				
									Bottom of Boring 52'			
									Note: Rock Core was lost with barge.			

GROUND SURFACE TO ___ USED ___ "CASING: THEN

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used
trace 0 to 10%
little 10 to 20%
some 20 to 35%
and 35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency		
0-10	Loose	0-4	Soft	30 + Hard
10-30	Med. Dense	4-8	M/Stiff	
30-50	Dense	8-15	Stiff	
50 +	Very Dense	15-30	V-Stiff	

SUMMARY:
Earth Boring
Rock Coring
Samples

HOLE NO. BH-5

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

TO C. E. Maguire, Inc. ADDRESS Providence, R.I.
PROJECT NAME Davisville Bulkhead LOCATION Quonset Point, R.I.
REPORT SENT TO above PROJ. NO. 3603
SAMPLES SENT TO " OUR JOB NO. 80-256

SHEET 1 OF 1
DATE
HOLE NO. BH-6
LINE & STA.
OFFSET
SURF. ELEV.

GROUND WATER OBSERVATIONS
At 4'3" after 9:20 AM Hours
Wed. Tide Board + 1'6"
At ~~after~~ ~~Hours~~
Thur. " " + 6"

Rods-"AW"	CASING	SAMPLER	CORE BAR.
Type	BW	S/S	Hi Core 200
Size I.D.	2½"	1 3/8"	1 3/8"
Hammer Wt.	300#	140#	BIT
Hammer Fall	24"	30"	Dia.

	Date	Time
START	4/2/80	a.m. p.m.
COMPLETE	4/3/80	a.m. p.m.
TOTAL HRS.		

BORING FOREMAN P. Brescia
INSPECTOR D. Calvi
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler 0-6	6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
	2	0'-1'6"	D	1	3	5	Wet loose		Gray Brown fine SAND, little silt (organic matter)	1	18"	10"
	7											
	6							3'				
	5											
	5											
	3	5'-6'6"	D	1	2	8	"		Brown fine SAND, some silt	2	18"	14"
	15											
	26											
	32											
	36											
	29	10'-11'6"	D	4	4	4	"		" with Orange layers of fine sand	3	18"	14"
	29											
	31							13'				
	34											
	36											
	45	15'-16'6"	D	3	4	5	"		Brown Gray very fine silty SAND (layered)	4	18"	18"
	37											
	42											
	52											
	63							20'				
	66	20'-21'6"	D	4	5	5	Wet stiff		Gray very fine sandy SILT	5	18"	14"
	65											
	80											
	86											
	117											
	81	25'-26'6"	D	5	6	5	"			6	18"	18"
	54											
	63											
	71											
	75							30'6"				
	109											
	72	30'6"-32'	D	27	38	53	Wet very dense		Dark Gray fine to medium SAND, Silt & weathered Shale (Till)	7	18"	15"
	91											
	100											
	148											
	160	35'-36'6"	D	56	72	84	"			8	18"	14"
	190							37'3"	Top of Rock			
		37'3"-42'3'	C					42'3"	Dark Gray Graphitic SHALE, fractured & seamy	C1	60"	50"

GROUND SURFACE TO 37' USED BW "CASING: THEN Cored to Bottom of Boring 42'3"

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used	
trace	0 to 10%
little	10 to 20%
some	20 to 35%
and	35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency		
0-10	Loose	0-4	Soft	30 + Hard
10-30	Med. Dense	4-8	M/Stiff	
30-50	Dense	8-15	Stiff	
50 +	Very Dense	15-30	V-Stiff	

SUMMARY:
Earth Boring 37'3"
Rock Coring 5'
Samples 8

HOLE NO. BH-6

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 1 OF 2
DATE
HOLE NO. BH-7
LINE & STA.
OFFSET
SURF. ELEV.

TO C. E. Maguire, Inc. ADDRESS Providence, R.I.
PROJECT NAME Davisville Bulkhead LOCATION Quonset Point, R.I.
REPORT SENT TO above PROJ. NO. 3603
SAMPLES SENT TO " OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS
At + 2'3" after Time: 1:20 PM Hours
At - 1.25 MSL after Hours

Rods-"AW"

	CASING	SAMPLER	CORE BAR. Hi Core
Type	BW	S/S	~~200~~
Size I.D.	2½"	1 3/8"	1 3/8"
Hammer Wt.	300#	140#	BIT
Hammer Fall	24"	30"	Dia.

	Date	Time
START	3/6/80	a.m. p.m.
COMPLETE	3/7/80	a.m. p.m.

TOTAL HRS.
BORING FOREMAN P. Brescia
INSPECTOR D. Erickson
SOILS ENGR.

LOCATION OF BORING: On the Water

DEPTH	Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler 0-6	6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
	5	0'-1'6"	D	3	6	6	Wet medium dense		Gray fine SAND, little silt, trace of shells (organic)	1	18"	15"
	9											
	3											
	6											
	9											
	11	5'-6'6"	D	4	6	7	"			2	18"	18"
	21							7'				
	16											
	15											
	16											
	16	10'-11'6"	D	4	6	6	"		Brown fine SAND, trace of silt	3	18"	18"
	13											
	21											
	29											
	32											
	23	15'-16'6"	D	5	6	8	"			4	18"	18"
	21											
	22											
	33											
	43											
	44	20'-21'6"	D	7	7	8	"			5	18"	14"
	43											
	41											
	40							24'				
	32											
	24	25'-26'6"	D	7	8	12	"		Gray Brown fine SAND varved with Silt Layers	6	18"	18"
	33											
	41											
	29											
	34											
	31	30'-31'6"	D	7	14	69	Wet very dense	31'2"		7	18"	18"
	51								Dark Gray fine SAND, Silt & fine to coarse Gravel			
	82											
	158							34'				
	98											
Washed ahead from 35'	30	35'-36'6"	D	29	21	23	Wet dense		Dark Gray fine to medium SAND, Silt with little fine to medium gravel	8	18"	-
	38											
	31											
	51											
	64											

GROUND SURFACE TO 47'7" USED BW "CASING: THEN Cored

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used	
trace	0 to 10%
little	10 to 20%
some	20 to 35%
and	35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency		
0-10	Loose	0-4	Soft	30 + Hard
10-30	Med. Dense	4-8	M/Stiff	
30-50	Dense	8-15	Stiff	
50 +	Very Dense	15-30	V-Stiff	

SUMMARY:
Earth Boring 45'7"
Rock Coring 7'
Samples 10

HOLE NO. BH-7

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 2 OF 2
DATE
HOLE NO. BH-7
LINE & STA.
OFFSET
SURF. ELEV.

TO
ADDRESS
PROJECT NAME
LOCATION
REPORT SENT TO
PROJ. NO.
SAMPLES SENT TO
OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS		CASING	SAMPLER	CORE BAR.
At ____ after ____ Hours	Type			
At ____ after ____ Hours	Size I.D.			
	Hammer Wt.			BIT
	Hammer Fall			

	Date	Time
START		a.m. p.m.
COMPLETE		a.m. p.m.
TOTAL HRS.		

BORING FOREMAN
INSPECTOR
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler From 0-6	To 6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
	28	40'-41'6"	D	33	20	16	Wet		Dark Gray fine to medium	9	18"	12"
	35						dense		SAND, Silt with some fine			
	43								to medium gravel			
	26			(300# Wt.)								
	250	44'4"-44'8"	D	100					Brown fine to coarse GRAVEL	10	4"	4"
	37								& Sand, some silt			
	81	44'8"-46'8"	C						Dark Gray TILL	C	24"	3"
	334							47'7"	Top of Rock			
		47'7"-52'7"	C		Min/ft		4			C	60"	50"
							6		Gray SHALE, fractured			
							6		& seamy			
							6					
							7	52'7"				
									Bottom of Boring 52'7"			

GROUND SURFACE TO ______ USED ______ " CASING: THEN ______

Sample Type	Proportions Used	140 lb Wt. x 30" fall on 2" O.D. Sampler		SUMMARY:
D=Dry C=Cored W=Washed	trace 0 to 10%	Cohesionless Density	Cohesive Consistency	Earth Boring
UP=Undisturbed Piston	little 10 to 20%	0-10 Loose	0-4 Soft 30 + Hard	Rock Coring
TP=Test Pit A=Auger V=Vane Test	some 20 to 35%	10-30 Med. Dense	4-8 M/Stiff	Samples
UT=Undisturbed Thinwall	and 35 to 50%	30-50 Dense	8-15 Stiff	HOLE NO. BH-7
		50 + Very Dense	15-30 V-Stiff	

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 1 OF 2
DATE
HOLE NO. BH-8
LINE & STA.
OFFSET
SURF. ELEV.

TO C. E. Maguire, Inc. ADDRESS Providence, R.I.
PROJECT NAME Davisville Bulkhead LOCATION Quonset Point, R.I.
REPORT SENT TO above PROJ. NO. 3603
SAMPLES SENT TO " OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS
At ___ after ___ Hours
7'8" Low Tide
At ___ after ___ Hours

Rods-"AW"	CASING	SAMPLER	CORE BAR.
Type	BW	S/S	
Size I.D.	2½"	1 3/8"	
Hammer Wt.	300#	140#	BIT
Hammer Fall	24"	30"	

	Date	Time
START	3/20/80	a.m. p.m.
COMPLETE	3/21/80	a.m. p.m.
TOTAL HRS.		

BORING FOREMAN E. Peterson
INSPECTOR D. Calvi
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler From 0-6	To 6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
	3	0'-1'6"	D	5	4	3	Wet/m		Black oily & fine sandy	1	18"	18"
	5						stiff	2'	Organic SILT			
	8											
	11											
	10											
	5	5'-6'6"	D	6	5	4	Wet		Gray Brown fine to coarse	2	18"	12"
	11						loose		SAND, little silt, trace			
	15								of fine gravel			
	19											
	19							10'				
	17	10'-11'6"	D	5	6	8	Wet		Brown fine to medium SAND,	3	18"	12"
	19						medium		little silt			
	18						dense					
	21								(Running Sand 2' to 3' up			
	20								casing from 10' to 25')			
	17	15'-16'6"	D	7	5	7	"			4	18"	12"
	22											
	27											
	48											
	62											
	29	20'-21'6"	D	5	6	7	"			5	18"	12"
	28											
	30											
	33											
	36											
	20	25'-26'6"	D	6	7	8	"			6	18"	12"
	36											
	38											
	41											
	44											
	30	30'-31'6"	D	6	10	15	"			7	18"	12"
	38											
	48											
	50											
	50											
	31	35'-36'6"	D	6	10	16	"			8	18"	12"
	44											
	56											
	61											
	66											

GROUND SURFACE TO 50'. USED BW "CASING: THEN S/S to 51'6"

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used
trace 0 to 10%
little 10 to 20%
some 20 to 35%
and 35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density
0-10 Loose
10-30 Med. Dense
30-50 Dense
50 + Very Dense

Cohesive Consistency
0-4 Soft
4-8 M/Stiff
8-15 Stiff
15-30 V-Stiff
30 + Hard

SUMMARY:
Earth Boring 51'6"
Rock Coring
Samples 5 (11)

HOLE NO. BH-8

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 2 OF 2
DATE
HOLE NO. BH-8
LINE & STA.
OFFSET
SURF. ELEV.

TO
PROJECT NAME
REPORT SENT TO
SAMPLES SENT TO

ADDRESS
LOCATION
PROJ. NO.
OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS		CASING	SAMPLER	CORE BAR.
At ___ after ___ Hours	Type			
	Size I.D.			
At ___ after ___ Hours	Hammer Wt.			BIT
	Hammer Fall			

	Date	Time
START		a.m. p.m.
COMPLETE		a.m. p.m.
TOTAL HRS.		

BORING FOREMAN
INSPECTOR
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler From 0-6	To 6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
	58	40'-41'6"	D	8	10	15	Wet		Gray fine to medium SAND,	9	18"	12"
	68						medium		trace of silt & gravel			
	76						dense					
	80											
	78											
	53	45'-46'6"	D	7	11	16	"			10	18"	12"
	65											
	84											
	88											
	90						Wet					
		50'-51'6"	D	10	15	22	dense	51'6"		11	18"	6"
									Bottom of Boring 51'6"			
								Note:	Samples #6 through #11 were lost with barge.			

GROUND SURFACE TO ______ USED ______ " CASING: THEN ______

Sample Type	Proportions Used	140 lb Wt. x 30" fall on 2" O.D. Sampler		SUMMARY:
D=Dry C=Cored W=Washed	trace 0 to 10%	Cohesionless Density	Cohesive Consistency	Earth Boring
UP=Undisturbed Piston	little 10 to 20%	0-10 Loose	0-4 Soft 30 + Hard	Rock Coring
TP=Test Pit A=Auger V=Vane Test	some 20 to 35%	10-30 Med. Dense	4-8 M/Stiff	Samples
UT=Undisturbed Thinwall	and 35 to 50%	30-50 Dense	8-15 Stiff	
		50 + Very Dense	15-30 V-Stiff	HOLE NO. BH-8

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 1 OF 2
DATE
HOLE NO. BH-9
LINE & STA.
OFFSET
SURF. ELEV.

TO C. E. Maguire, Inc. ADDRESS Providence, R.I.
PROJECT NAME Davisville Bulkhead LOCATION Quonset Point, R.I.
REPORT SENT TO above PROJ. NO. 3603
SAMPLES SENT TO " OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS
At 2' after 8:30 AM Hours
At Tide Board + 6" after Hours

Rods-"AW"	CASING	SAMPLER	CORE BAR.
Type	BW	S/S	
Size I.D.	2½"	1 3/8"	
Hammer Wt.	300#	140#	BIT
Hammer Fall	24"	30"	

	Date	Time
START	4/3/80	a.m. p.m.
COMPLETE	4/3/80	a.m. p.m.

TOTAL HRS.
BORING FOREMAN P. Brescia
INSPECTOR D. Calvi
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler From 0-6	6-12	To 12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
	7	0'-1'6"	D	5	4	4	Wet		Brown Gray fine SAND,	1	18'	10"
	15						loose		trace of shells &			
	10								organic matter			
	11											
	15							5'				
	16	5'-6'6"	D	5	5	8	Wet		Brown fine SAND,	2	18"	12"
	19						medium		trace of silt			
	20						dense	7'6"				
	14											
	24											
	39	10'-11'6"	D	6	10	11	"		Gray Brown fine SAND,	3	18"	18"
	31								little silt (layered)			
	38											
	35											
	30							15'				
	30	15'-16'6"	D	11	10	14	"		Brown Gray very fine	4	18"	18"
	30								SAND, some silt (layered)			
	36											
	36											
	41											
	22	20'-21'6"	D	9	8	9	"			5	18"	14"
	29											
	32											
	40											
	46											
	28	25'-26'6"	D	9	9	10	"			6	18"	18"
	39							27'				
	46											
	51											
	50											
	32	30'-31'6"	D	10	14	13	"		Gray very fine silty SAND	7	18"	18"
	41											
	56											
	59											
	62							35'				
	42	35'-36'6"	D	15	14	14	"		Gray Brown fine SAND,	8	18"	10"
	61								Silt with trace of			
	73								fine gravel			
	91											
	110							40'				

GROUND SURFACE TO 40' USED BW "CASING: THEN S/S to 40'8"

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used
trace 0 to 10%
little 10 to 20%
some 20 to 35%
and 35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency		
0-10	Loose	0-4	Soft	30 + Hard
10-30	Med. Dense	4-8	M/Stiff	
30-50	Dense	8-15	Stiff	
50 +	Very Dense	15-30	V-Stiff	

SUMMARY:
Earth Boring 40'8"
Rock Coring
Samples 9

HOLE NO. BH-9

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 2 OF 2
DATE
HOLE NO. BH-9
LINE & STA.
OFFSET
SURF. ELEV.

TO
ADDRESS
PROJECT NAME
LOCATION
REPORT SENT TO
PROJ. NO.
SAMPLES SENT TO
OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS		CASING	SAMPLER	CORE BAR.
At ___ after ___ Hours	Type			
	Size I.D.			
At ___ after ___ Hours	Hammer Wt.			BIT
	Hammer Fall			

	Date	Time
START		a.m. p.m.
COMPLETE		a.m. p.m.
TOTAL HRS.		

BORING FOREMAN
INSPECTOR
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From – To	Type of Sample	Blows per 6" on Sampler From 0-6	To 6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
		40'-40'8"	D	100	90/2"		Wet/v dense	40'8"	Gray fine SAND, Silt with fractured Rock or Boulders	9	8'	6"
				300# Wt.					Refusal at 40'8"			

GROUND SURFACE TO ___ USED ___ "CASING: THEN

Sample Type	Proportions Used		140 lb Wt. x 30" fall on 2" O.D. Sampler			SUMMARY:
D=Dry C=Cored W=Washed	trace	0 to 10%	Cohesionless Density	Cohesive Consistency		Earth Boring
UP=Undisturbed Piston	little	10 to 20%	0-10 Loose	0-4 Soft	30 + Hard	Rock Coring
TP=Test Pit A=Auger V=Vane Test	some	20 to 35%	10-30 Med. Dense	4-8 M/Stiff		Samples
UT=Undisturbed Thinwall	and	35 to 50%	30-50 Dense	8-15 Stiff		
			50 + Very Dense	15-30 V-Stiff		HOLE NO. BH-9

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 1 OF 2
DATE
HOLE NO. BH-10
LINE & STA.
OFFSET
SURF. ELEV.

TO C. E. Maguire, Inc. ADDRESS Providence, R.I.
PROJECT NAME Davisville Bulkhead LOCATION Quonset Point, R.I.
REPORT SENT TO above PROJ. NO. 3603
SAMPLES SENT TO " OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS		CASING	SAMPLER	CORE BAR.
At ____ after ____ Hours	Rods-"AW" Type	BW	S/S	Hi Core 200
Water 2' M.L.T.	Size I.D.	2½"	1 3/8"	1 3/8"
At ____ after ____ Hours	Hammer Wt.	300#	140#	BIT
	Hammer Fall	24"	30"	Dia.

	Date	Time
START	3/19/80	a.m. p.m.
COMPLETE	3/20/80	a.m. p.m.
TOTAL HRS.		

BORING FOREMAN A. D'Aiello
INSPECTOR D. Calvi
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler 0-6	6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	Sample No.	Pen	Rec.
	3	0'-1'6"	D	2	3	4	Wet loose		Brown fine SAND, little silt & sea shells (organic odor noted)	1	18"	10"
	4											
	4											
	5											
	5							5'				
	11	5'-6'6"	D	4	4	5	"		Brown Black fine SAND, some silt, trace of sea shells (organic odor noted)	2	18"	11"
	11											
	8											
	8							9'				
	7											
	11	10'-11'6"	D	3	4	5	"		Brown fine SAND, little silt (layered)	3	18"	11"
	18											
	19											
	20											
	26											
	33	15'-16'6"	D	4	6	5	Wet medium dense			4	18"	11"
	38											
	36											
	38											
	31							20'				
	28	20'-21'6"	D	3	9	12	"		Brown fine SAND, trace of silt & medium sand	5	18"	12"
	54											
	40											
	27											
	55							25'				
	26	25'-26'6"	D	6	9	15	"		Brown fine SAND, little silt, trace of medium sand	6	18"	11"
	24											
	47							28'				
	52											
	60											
	34	30'-31'6"	D	10	12	12	"		Gray silty very fine SAND	7	18"	9"
	25											
	40											
	50											
	105							35'				
	29								(35' to 36' - Broke Boulder)			
	58	36'-37'6"	DX	21	30	29	Wet very dense		Gray fine SAND, Silt & fine Gravel (Till)	8	18"	-
	73											
	89											
	97											

GROUND SURFACE TO 44' . USED BW "CASING: THEN Cored

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used
trace 0 to 10%
little 10 to 20%
some 20 to 35%
and 35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency	
0-10	Loose	0-4	Soft
10-30	Med. Dense	4-8	M/Stiff
30-50	Dense	8-15	Stiff
50 +	Very Dense	15-30	V-Stiff
		30 +	Hard

SUMMARY:
Earth Boring 44'
Rock Coring 5'
Samples 9

HOLE NO. BH-10

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 2 OF 2
DATE
HOLE NO. BH-10
LINE & STA.
OFFSET
SURF. ELEV.

TO
ADDRESS
PROJECT NAME
LOCATION
REPORT SENT TO
PROJ. NO. 3603
SAMPLES SENT TO
OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS		CASING	SAMPLER	CORE BAR.
At ____ after ____ Hours	Type			
	Size I.D.			
At ____ after ____ Hours	Hammer Wt.			BIT
	Hammer Fall			

	Date	Time
START		a.m. p.m.
COMPLETE		a.m. p.m.
TOTAL HRS.		

BORING FOREMAN
INSPECTOR
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From – To	Type of Sample	Blows per 6" on Sampler From 0-6	To 6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
		40'-41'6"	DX	29	31	37	Wet/v dense		Gray fine to medium SAND, Silt & Gravel (Till)	9	18'	-
							Min/ft	44'				
		44'-49'	C				4		Gray SHALE, fractured & seamy	C	60'	44"
							5					
							4					
							3					
							5	49'				
									Bottom of Boring 49'			
									DX open end AW rod 140#-30"			

GROUND SURFACE TO ____ USED ____ " CASING: THEN ____

Sample Type	Proportions Used		140 lb Wt. x 30" fall on 2" O.D. Sampler Cohesionless Density		Cohesive Consistency			SUMMARY:
D=Dry C=Cored W=Washed	trace	0 to 10%	0-10	Loose	0-4	Soft	30 + Hard	Earth Boring
UP=Undisturbed Piston	little	10 to 20%	10-30	Med. Dense	4-8	M/Stiff		Rock Coring
TP=Test Pit A=Auger V=Vane Test	some	20 to 35%	30-50	Dense	8-15	Stiff		Samples
UT=Undisturbed Thinwall	and	35 to 50%	50 +	Very Dense	15-30	V-Stiff		HOLE NO. BH-10

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 1 OF 2
DATE
HOLE NO. BH-11
LINE & STA.
OFFSET
SURF. ELEV.

TO C. E. Maguire, Inc. ADDRESS Providence, R.I.
PROJECT NAME Davisville Bulkhead LOCATION Quonset Point, R.I.
REPORT SENT TO above PROJ. NO. 3603
SAMPLES SENT TO " OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS		CASING	SAMPLER	CORE BAR.
At ____ after ____ Hours	Rods-"AW" Type	BW	S/S	
6'5" at 12:00 Noon	Size I.D.	2½"	1 3/8"	
At ____ after ____ Hours	Hammer Wt.	300#	140#	BIT
	Hammer Fall	24"	30"	

	Date	Time
START	3/17/80	a.m. p.m.
COMPLETE	3/19/80	a.m. p.m.
TOTAL HRS.		

BORING FOREMAN P. Brescia &
INSPECTOR D. Calvi/ A.D.
SOILS ENGR.

LOCATION OF BORING: One the Water

DEPTH	Casing Blows per foot	Sample Depths From – To	Type of Sample	Blows per 6" on Sampler 0-6	6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	Sample No.	Pen	Rec.
	6	0'-1'6"	D	3	4	5	W/loose	1'	Dark Gray fine SAND, Shells & Organic Matter	1	18"	18"
	7											
	6											
	8								Gray fine to coarse SAND, little silt & fine gravel			
	8											
	10	5'-6'6"	D	4	5	5	"			2	18"	14"
	11							7'6"				
	11											
	15											
	16											
	14	10'-11'6"	D	5	6	7	Wet medium dense		Brown coarse to fine SAND (running), trace of silt & fine gravel	3	18"	14"
	15											
	11											
	13											
	15											
	17	15'-16'6"	D	6	7	9	"		" little fine to medium gravel	4	18"	18"
	17											
	18											
	20							19'				
	31											
	37	20'-21'6"	D	4	5	7	"		Brown fine to coarse SAND, little fine gravel, trace of silt	5	18"	12"
	38											
	38											
	34											
	33							25'				
	22	25'-26'6"	D	3	4	6	"		Brown medium to fine SAND (running), trace of silt & coarse sand	6	18"	14"
	27											
	29											
	27											
	21											
	32	30'-31'6"	D	3	5	7	"			7	18"	10"
	35											
	34											
	34											
	46											
	48	35'-36'6"	D	4	7	6	"			8	18"	12"
	52											
	56							37'6"				
	60											
	41											

GROUND SURFACE TO 50' USED BW "CASING: THEN S/S to 51'6"

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used	
trace	0 to 10%
little	10 to 20%
some	20 to 35%
and	35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency		
0-10	Loose	0-4	Soft	30 + Hard
10-30	Med. Dense	4-8	M/Stiff	
30-50	Dense	8-15	Stiff	
50 +	Very Dense	15-30	V-Stiff	

SUMMARY:
Earth Boring 51'6"
Rock Coring
Samples 11

HOLE NO BH-11

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 2 OF 2
DATE
HOLE NO. BH-11
LINE & STA.
OFFSET
SURF. ELEV.

TO
ADDRESS
PROJECT NAME
LOCATION
REPORT SENT TO
PROJ. NO. 3603
SAMPLES SENT TO
OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS		CASING	SAMPLER	CORE BAR.
At ____ after ____ Hours	Type			
	Size I.D.			
At ____ after ____ Hours	Hammer Wt.			BIT
	Hammer Fall			

	Date	Time
START		a.m. p.m.
COMPLETE		a.m. p.m.
TOTAL HRS.		
BORING FOREMAN		
INSPECTOR		
SOILS ENGR.		

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler From To 0-6	6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
	40	40'-41'6"	D	8	11	13	Wet		Gray Brown fine SAND,	9	18"	18"
	30						medium		some silt			
	42						dense					
	44											
	56											
	31	45'-46'6"	D	8	8	19	"			10	18"	11"
	42											
	56							48'				
	60								Gray silty fine SAND			
	62						Wet/v		(compact), trace of			
		50'-51'6"	D	27	32	37	dense	51'6"	coarse sand	11	18"	9"
									Bottom of Boring 51'6"			

GROUND SURFACE TO ____ USED ____ "CASING: THEN ____

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used	
trace	0 to 10%
little	10 to 20%
some	20 to 35%
and	35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency			
0-10	Loose	0-4	Soft	30 +	Hard
10-30	Med. Dense	4-8	M/Stiff		
30-50	Dense	8-15	Stiff		
50 +	Very Dense	15-30	V-Stiff		

SUMMARY:
Earth Boring ____
Rock Coring ____
Samples ____

HOLE NO BH-11

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 1 OF 2
DATE
HOLE NO. BH-12
LINE & STA.
OFFSET
SURF. ELEV.

TO C. E. Maguire, Inc. ADDRESS Providence, R.I.
PROJECT NAME Davisville Bulkhead LOCATION Quonset Point, R.I.
REPORT SENT TO above PROJ. NO. 3603
SAMPLES SENT TO " OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS
At 1'6" after 7:30 AM Hours
Tide Board -1'4"
Mean Low Water
At ______ after ______ Hours

Rods-"AW"

	CASING	SAMPLER	CORE BAR.
Type	BW	S/S	
Size I.D.	2½"	1 3/8"	
Hammer Wt.	300#	140#	BIT
Hammer Fall	24"	30"	

	Date	Time
START	4/8/80	a.m. p.m.
COMPLETE	4/8/80	a.m. p.m.

TOTAL HRS.
BORING FOREMAN P. Brescia
INSPECTOR D. Calvi
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler 0-6	6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
	3	0'-1'6"	D	2	5	4	Wet loose		Gray Brown fine SAND, little silt (organic odor noted)	1	18"	10"
	4											
	5							3'				
	9								Gray Brown fine to medium SAND, little silt, trace of coarse sand & fine grvl.			
	7											
	8	5'-6'6"	D	4	4	5	"			2	18"	11"
	10							7'				
	13											
	17											
	19											
	18	10'-11'6"	D	3	5	6	Wet medium dense		Gray Brown fine to medium SAND, little silt, trace of fine gravel	3	18"	14"
	22											
	4											
	3											
	16							15'				
	24	15'-16'6"	D	4	5	5	Wet loose		Brown fine SAND, trace of silt & fine to coarse gravel	4	18"	12"
	28											
	28											
	31											
	31							19'6"				
	33	20'-21'6"	D	3	3	6	"		Light Brown & Brown silty very fine SAND	5	18"	12"
	31											
	26											
	31											
	28											
	31	25'-26'6"	D	4	5	4	"			6	18"	18"
	29											
	33											
	47											
	59							30'				
	60	30'-31'6"	D	3	5	9	Wet medium dense		Light Brown silty fine SAND (compact)	7	18"	14"
	62											
	56											
	60											
	67							35'				
	72	35'-36'6"	D	9	10	11	"		Gray Brown silty very fine SAND	8	18"	18"
	81											
	71											
	131											
	130											

GROUND SURFACE TO 50' USED BW "CASING: THEN O. E. Rod to 51'4"

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used
trace 0 to 10%
little 10 to 20%
some 20 to 35%
and 35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency			
0-10	Loose	0-4	Soft	30 +	Hard
10-30	Med. Dense	4-8	M/Stiff		
30-50	Dense	8-15	Stiff		
50 +	Very Dense	15-30	V-Stiff		

SUMMARY:
Earth Boring 51'4"
Rock Coring
Samples 11

HOLE NO. BH-12

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 2 OF 2
DATE
HOLE NO. BH-12
LINE & STA.
OFFSET
SURF. ELEV.

TO
ADDRESS
PROJECT NAME
LOCATION
REPORT SENT TO
PROJ. NO.
SAMPLES SENT TO
OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS		CASING	SAMPLER	CORE BAR.
At ___ after ___ Hours	Type			
	Size I.D.			
At ___ after ___ Hours	Hammer Wt.			BIT
	Hammer Fall			

	Date	Time
START		a.m. p.m.
COMPLETE		a.m. p.m.
TOTAL HRS.		

BORING FOREMAN
INSPECTOR
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler From 0-6	To 6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
	71	40'-41'6"	D	10	13	14	Wet medium dense		Gray silty fine SAND (compact)	9	18"	18"
	84											
	90											
	74											
	74							45'6"				
	124	45'-46'6"	D	11	22	18	Wet dense		Dark Gray fine SAND, Silt with little fine to coarse gravel	10	18"	14"
	89											
	130											
	142											
	157							50'1"				
		50'1"-51'4"	DXX	46	51	75/3"	Wet/v dense	51'4"	Gray silty fine to medium SAND & Gravel, fractured rock or boulders (Till)	11	15"	-
									Refusal at 51'4"			
									DXX open end AW rod 300#-30"			

GROUND SURFACE TO ___ USED ___ "CASING: THEN ___

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used
trace 0 to 10%
little 10 to 20%
some 20 to 35%
and 35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency	
0-10	Loose	0-4 Soft	30 + Hard
10-30	Med. Dense	4-8 M/Stiff	
30-50	Dense	8-15 Stiff	
50 +	Very Dense	15-30 V-Stiff	

SUMMARY:
Earth Boring
Rock Coring
Samples

HOLE NO. BH-12

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 1 OF 2
DATE
HOLE NO. BH-13
LINE & STA.
OFFSET
SURF. ELEV.

TO C. E. Maguire, Inc. ADDRESS Providence, R.I.
PROJECT NAME Davisville Bulkhead LOCATION Quonset Point, R.I.
REPORT SENT TO above PROJ. NO. 3603
SAMPLES SENT TO " OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS
At ____ after ____ Hours
12'6" at 9:45 AM
At ____ after ____ Hours

Rods-"AW"

	CASING	SAMPLER	CORE BAR.
Type	BW	S/S	Hi Core 200
Size I.D.	2½"	1 3/8"	1 3/8"
Hammer Wt.	300#	140#	BIT
Hammer Fall	24"	30"	Dia.

	Date	Time
START	3/10/80	a.m. p.m.
COMPLETE	3/11/80	a.m. p.m.

TOTAL HRS.
BORING FOREMAN P. Brescia
INSPECTOR D. Erickson
SOILS ENGR.

LOCATION OF BORING: On the Water

DEPTH	Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler 0-6	6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
	P	0'-1'6"	D	P U	S H E	D	Wet soft		Black MUCK - Organic Matter	1	18"	12"
	P											
	P											
	P							4'				
	P											
	1	5'-6'6"	D	1	1 =	12"	"		Dark Gray Organic SILT, trace of very fine sand	2	18"	18"
	2											
	1											
	1											
	3							10'				
	4	10'-11'6"	D	1	1 =	12"	"		Dark Gray fine sandy Organic SILT	3	18"	18"
	9											
	9											
	6											
	5							15'				
	2	15'-16'6"	D	P U	S H E	D	"		Dark Gray Organic SILT	4	18"	18"
	2											
	4							18'				
	7											
	9						Wet		Gray Brown fine SAND,			
	7	20'-21'	D	2	3		loose	21'	trace of silt	5	12"	12"
	7	21'-21'6"	D			2	Wet soft		Gray Clayey SILT & fine Sand	5A	6"	6"
	6											
	6							24'				
	5						Wet/m		Brown F-M SAND, little silt,			
	24	25'-26'	D	4	9		dense	26'	tr. coarse sand & F. gravel	6	12"	12"
	19	26'-26'6"	D			9	Wet loose		Brown silty very fine SAND	6A	6"	6"
	25											
	25											
	32							30'				
	12	30'-31'6"	D	4	8	9	Wet medium dense		Brown Gray fine SAND, little silt	7	18"	14"
	12											
	18											
	18											
	19											
	23	35'-36'6"	D	5	9	9	"			8	18"	18"
	31											
	33							38'6"				
	57								Gray M-C SAND, F-M Gravel			
	54								(change from Wash)			

GROUND SURFACE TO 43' USED BW "CASING: THEN Cored

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used
trace 0 to 10%
little 10 to 20%
some 20 to 35%
and 35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency		
0-10	Loose	0-4	Soft	30 + Hard
10-30	Med. Dense	4-8	M/Stiff	
30-50	Dense	8-15	Stiff	
50 +	Very Dense	15-30	V-Stiff	

SUMMARY:
Earth Boring 43'
Rock Coring 5'
Samples 9

HOLE NO. BH-13

GUILD DRILLING CO., INC.
100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 2 OF 2
DATE
HOLE NO. BH-13
LINE & STA.
OFFSET
SURF. ELEV.

TO | ADDRESS
PROJECT NAME | LOCATION
REPORT SENT TO | PROJ. NO.
SAMPLES SENT TO | OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS		CASING	SAMPLER	CORE BAR.
At after Hours	Type			
	Size I.D.			
At after Hours	Hammer Wt.			BIT
	Hammer Fall			

	Date	Time
START		a.m. p.m.
COMPLETE		a.m. p.m.
TOTAL HRS.		

BORING FOREMAN
INSPECTOR
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler From 0-6	To 6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
								40'6"				
		40'-41'6"	D	25	19	30	Wet Hard		Dark Gray SILT varved with very fine Sand Layers (compact)	9	18"	12"
								43'				
		43'-48'	C						Granite Boulders - Till	C	60"	13"
								48'				
									Bottom of Boring 48'			

GROUND SURFACE TO ______ USED ______ " CASING: THEN ______

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used
trace 0 to 10%
little 10 to 20%
some 20 to 35%
and 35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency	
0-10	Loose	0-4	Soft
10-30	Med. Dense	4-8	M/Stiff
30-50	Dense	8-15	Stiff
50 +	Very Dense	15-30	V-Stiff
		30 +	Hard

SUMMARY:
Earth Boring
Rock Coring
Samples

HOLE NO. BH-13

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 1 OF 1
DATE
HOLE NO. BH-14
LINE & STA.
OFFSET
SURF. ELEV.

TO C. E. Maguire, Inc. | ADDRESS Providence, R.I.
PROJECT NAME Davisville Bulkhead | LOCATION Quonset Point, R.I.
REPORT SENT TO above | PROJ. NO. 3603
SAMPLES SENT TO " | OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS
At + 1.5 ~~after~~ 19'3" ~~Hours~~
8:30 AM 4/2/80
At ______ after ______ Hours

Rods-"AW"

	CASING	SAMPLER	CORE BAR.
Type	BW	S/S	
Size I.D.	2½"	1 3/8"	
Hammer Wt.	300#	140#	BIT
Hammer Fall	24"	30"	

	Date	Time
START	4/1/80	a.m. p.m.
COMPLETE	4/2/80	a.m. p.m.

TOTAL HRS.
BORING FOREMAN E. Peterson
INSPECTOR D. Calvi
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler 0-6	6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	Sample No.	Pen	Rec.
		0'-1'6"	D	Weight of Rods			Wet soft		Dark Gray Organic SILT	1	18"	18"
		5'-6'6"	D	1	-	-	"			2	18"	18"
		10'-11'6"	D	Weight of Rods			"			3	18"	18"
	1											
	-											
	1	15'-16'6"	D	-	-	3	Wet loose	16'		4	18"	18"
	3								Gray Brown silty very fine SAND			
	4											
	6							19'				
	6											
	2	20'-21'6"	D	4	5	5	"		Brown fine to medium SAND, trace of silt	5	18"	12"
	5											
	11							23'				
	12											
	14								Brown fine to coarse SAND,			
	5	25'-26'6"	D	5	6	7	Wet medium dense		little silt & fine gravel	6	18"	12"
	9							27'				
	16											
	14								Light Gray Brown fine			
	16								SAND, little silt,			
		30'-31'6"	D	10	12	11	"	31'6"	trace of fine gravel	7	18"	12"
									Bottom of Boring 31'6"			

GROUND SURFACE TO 30' USED BW " CASING: THEN S/S to 31'6"

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used
trace 0 to 10%
little 10 to 20%
some 20 to 35%
and 35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency	
0-10	Loose	0-4	Soft
10-30	Med. Dense	4-8	M/Stiff
30-50	Dense	8-15	Stiff
50 +	Very Dense	15-30	V-Stiff
		30 +	Hard

SUMMARY:
Earth Boring 31'6"
Rock Coring
Samples 7

HOLE NO. BH-14

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 1 OF 1
DATE
HOLE NO. BH-14A
LINE & STA.
OFFSET
SURF. ELEV.

TO C. E. Maguire, Inc. ADDRESS Providence, R.I.
PROJECT NAME Davisville Bulkhead LOCATION Quonset Point, R.I.
REPORT SENT TO above PROJ. NO. 3603
SAMPLES SENT TO " OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS
At ______ after ______ Hours
Same as Hole No. BH-14
At ______ after ______ Hours

	CASING	SAMPLER	CORE BAR.
Type	HW	UP	
Size I.D.	4"	3"	
Hammer Wt.	300#		BIT
Hammer Fall	24"		

	Date	Time
START	4/2/80	a.m. p.m.
COMPLETE	4/2/80	a.m. p.m.
TOTAL HRS.		

BORING FOREMAN E. Peterson
INSPECTOR D. Calvi
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler From 0-6	To 6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
									Very soft Organic SILT			
		6'-8'	UP	P R	E S S	E D				UP1	24'	18"
		8'6"-10'6"	UP	P R	E S S	E D				UP2	24'	23"
								10'6"				
									Bottom of Boring 10'6"			

GROUND SURFACE TO ______ USED ______ "CASING: THEN ______

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used
trace 0 to 10%
little 10 to 20%
some 20 to 35%
and 35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency			
0-10	Loose	0-4	Soft	30 +	Hard
10-30	Med. Dense	4-8	M/Stiff		
30-50	Dense	8-15	Stiff		
50 +	Very Dense	15-30	V-Stiff		

SUMMARY:
Earth Boring 10'6"
Rock Coring
Samples 2 Tubes

HOLE NO. BH-14A

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 1 OF 1
DATE
HOLE NO. BH-15
LINE & STA.
OFFSET
SURF. ELEV.

TO C. E. Maguire, Inc. ADDRESS Providence, R.I.
PROJECT NAME Davisville Bulkhead LOCATION Quonset Point, R.I.
REPORT SENT TO above PROJ. NO. 3603
SAMPLES SENT TO " OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS
At 13'3" after 9:30 AM Hours
At 11'8" @ 0.0 Hours
Gauge

Rods-"AW"	CASING	SAMPLER	CORE BAR.
Type	BW	S/S	
Size I.D.	2½"	1 3/8"	
Hammer Wt.	300#	140#	BIT
Hammer Fall	24"	30"	

	Date	Time
START	4/1/80	a.m. p.m.
COMPLETE	4/1/80	a.m. p.m.
TOTAL HRS.		

BORING FOREMAN Peterson
INSPECTOR D. Calvi
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From-To	Type of Sample	Blows per 6" on Sampler 0-6	6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
	6	0'-1'6"	D	3	4	4	Wet loose		Dark Gray fine to coarse SAND, some silt, trace of fine gravel & shells (org.)	1	18'	18"
	11											
	17							2'6"				
	18											
	20						Wet medium dense		Gray fine to coarse SAND, little silt & fine gravel			
	10	5'-6'6"	D	6	7	8				2	18'	18"
	14							7'				
	16											
	15											
	14											
	11	10'-11'6"	D	6	4	6	Wet loose		Brown fine SAND, trace of silt & medium sand	3	18'	12"
	12											
	15											
	13											
	12											
	10	15'-16'6"	D	4	4	7	Wet medium dense			4	18'	12"
	12											
	18											
	22											
	25											
	18	20'-21'6"	D	3	4	4	Wet loose			5	18'	8"
	20											
	27											
	32											
	40							25'				
	21	25'-26'6"	D	4	6	6	Wet medium dense		Brown fine to medium SAND, trace of silt	6	18'	10"
	30											
	35											
	29											
	30											
		30'-31'6"	D	7	8	9	"	31'6"		7	18'	12"
									Bottom of Boring 31'6"			

GROUND SURFACE TO 30' USED BW "CASING: THEN S/S to 31'6"

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used	
trace	0 to 10%
little	10 to 20%
some	20 to 35%
and	35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency			
0-10	Loose	0-4	Soft	30 +	Hard
10-30	Med. Dense	4-8	M/Stiff		
30-50	Dense	8-15	Stiff		
50 +	Very Dense	15-30	V-Stiff		

SUMMARY:
Earth Boring 31'6"
Rock Coring
Samples 5

HOLE NO. BH-15

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 1 OF 2
DATE
HOLE NO. BH-17
LINE & STA.
OFFSET
SURF. ELEV.

TO C. E. Maguire, Inc. ADDRESS Providence, R.I.
PROJECT NAME Davisville Bulkhead LOCATION Quonset Point, R.I.
REPORT SENT TO above PROJ. NO. 3603
SAMPLES SENT TO " OUR JOB NO. 80-256

~~GROUND~~ WATER OBSERVATIONS
At 11'6" after 9:30 AM Hours
At ______ after ______ Hours

Rods-"AW"	CASING	SAMPLER	CORE BAR.
Type	BW	S/S	
Size I.D.	2½"	1 3/8"	
Hammer Wt.	300#	140#	BIT
Hammer Fall	24"	30"	

	Date	Time
START	3/28/80	a.m. p.m.
COMPLETE	3/28/80	a.m. p.m.

TOTAL HRS.
BORING FOREMAN E. Peterson
INSPECTOR
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler From 0-6	6-12	To 12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
	3	0'-1'6"	D	2	3	3	Wet loose		Gray fine to coarse SAND, little fine gravel, trace silt & shells	1	18"	12"
	5											
	11											
	14											
	12											
	8	5'-6'6"	D	4	5	5	"			2	18"	10"
	12											
	8											
	13											
	20							10'				
	22	10'-11'6"	D	11	10	9	Wet medium dense		Brown fine to coarse SAND & fine to medium Gravel, trace of silt	3	18"	12"
	25											
	21											
	15											
	18							15'				
	14	15'-16'6"	D	8	8	12	"		Dark Brown silty fine to coarse SAND & Gravel	4	18"	12"
	20											
	27											
	31							19'				
	30								Gray Brown fine to medium SAND, Silt & Gravel, cobbles & boulders (Till)			
	24	20'-21'6"	D	36	47	60	Moist very dense			5	18"	12"
	145											
	80											
	176											
	45							25'				
	83	25'-26'6"	D	35	29	24	Wet very dense		Brown fine to coarse SAND & fine to medium Gravel, some silt (casing bent)	6	18"	12"
	126											
	15											
	28											
	37											
	30	30'-31'6"	D	26	18	15	Wet dense	31'6"		7	18"	6"
	36											
	45											
	33											
	30											
	26	35'-36'6"	D	15	11	11	Wet medium dense		Brown fine to coarse SAND, some fine gravel, little silt, cobbles	8	18"	18"
	33											
	26											
	31											
	33											

GROUND SURFACE TO 60' USED BW "CASING: THEN O. E. Rod to 61'6"

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used
trace 0 to 10%
little 10 to 20%
some 20 to 35%
and 35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency			
0-10	Loose	0-4	Soft	30 +	Hard
10-30	Med. Dense	4-8	M/Stiff		
30-50	Dense	8-15	Stiff		
50 +	Very Dense	15-30	V-Stiff		

SUMMARY:
Earth Boring 61'6"
Rock Coring
Samples 13

HOLE NO. BH-17

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 2 OF 2
DATE
HOLE NO. BH-17
LINE & STA.
OFFSET
SURF. ELEV.

TO
ADDRESS
PROJECT NAME
LOCATION
REPORT SENT TO
PROJ. NO.
SAMPLES SENT TO
OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS

At ______ after ______ Hours

At ______ after ______ Hours

	CASING	SAMPLER	CORE BAR.
Type			
Size I.D.			
Hammer Wt.			BIT
Hammer Fall			

	Date	Time
START		a.m. p.m.
COMPLETE		a.m. p.m.
TOTAL HRS.		

BORING FOREMAN
INSPECTOR
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler From 0-6	To 6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
	31	40'-41'6"	D	9	10	10	Wet medium dense		Brown fine to coarse SAND, some fine gravel, trace of silt, cobbles	9	18"	12"
	38											
	45											
	48											
	48							45'				
	40	45'-46'6"	D	15	16	18	Wet dense		Gray Brown silty fine to coarse SAND, some fine gravel, trace of cobbles	10	18"	8"
	48											
	56											
	50											
	53											
	47	50'-51'6"	D	15	16	18	"			11	18"	4"
	58											
	63											
	71											
	73						Wet					
	62	55'-56'6"	D	17	17	18	medium dense			12	18"	10"
	68											
	78							58'				
	95								Gray silty fine to medium SAND (compact), little fine to coarse gravel			
	116						Wet					
		60'-61'6"	DXX	15	16	16	dense	61'6"		13	18"	12"
									Bottom of Boring 61'6"			

DXX open end AW rod 300#-30"

GROUND SURFACE TO ______ USED ______ "CASING: THEN ______

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used
trace 0 to 10%
little 10 to 20%
some 20 to 35%
and 35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency	
0-10	Loose	0-4	Soft
10-30	Med. Dense	4-8	M/Stiff
30-50	Dense	8-15	Stiff
50 +	Very Dense	15-30	V-Stiff
		30 +	Hard

SUMMARY:
Earth Boring
Rock Coring
Samples

HOLE NO. BH-17

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 1 OF 2
DATE
HOLE NO. BH-18
LINE & STA.
OFFSET
SURF. ELEV.

TO C. E. Maguire, Inc. ADDRESS Providence, R.I.
PROJECT NAME Davisville Bulkhead LOCATION Quonset Point, R.I.
REPORT SENT TO above PROJ. NO. 3603
SAMPLES SENT TO " OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS			CASING	SAMPLER	CORE BAR.
At 14'6" after 12:10 PM Hours	Rods-"AW"	Type	BW	S/S	
0.3 Tide Gauge		Size I.D.	2½"	1 3/8"	
At ______ after ______ Hours		Hammer Wt.	300#	140#	BIT
		Hammer Fall	24"	30"	

	Date	Time
START	3/10/80	a.m. p.m.
COMPLETE		a.m. p.m.
TOTAL HRS.		

BORING FOREMAN E. Peterson
INSPECTOR D. Erickson
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler From 0-6	6-12	To 12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
	-	0'-1'6"	D	-	1	2	Wet soft		Dark Gray oily SILT & fine Sand, trace shells (organic)	1	18"	18"
	1							2'				
	3											
	4											
	2											
	1	5'-6'6"	D	2	3	4	Wet loose	6'6"	Gray silty fine to medium SAND, trace of shells & fine to medium gravel (organic)	2	18"	12"
	1											
	1											
	1											
	1											
	1	10'-11'6"	D	1	-	1	Wet soft		Gray Marine SILT	3	18"	18"
	3							12'				
	10											
	12											
	13											
	10	15'-16'6"	D	6	7	8	Wet medium dense		Gray Brown coarse to fine SAND & fine Gravel, trace of silt	4	18"	12"
	13							17'				
	13											
	15											
	18											
	15	20'-21'6"	D	15	17	17	Wet dense		Dark Brown fine SAND, little silt	5	18"	18"
	25											
	28											
	32											
	34							25'				
	30	25'-26'6"	D	8	11	11	Wet medium dense		Dark Brown fine SAND, some silt, trace of fine to medium gravel	6	18"	12"
	33											
	36											
	40											
	43											
	44	30'-31'6"	D	12	16	16	Wet dense		" trace of fine to coarse gravel	7	18"	12"
	48											
	49							33'				
	56											
	57											
	55	35'-36'6"	D	12	16	17	"		Brown fine to medium SAND, little silt & fine gravel	8	18"	12"
	58											
	65											
	63											
	66							40'				

GROUND SURFACE TO 50' USED BW "CASING: THEN O.E. Rod to 51'6"

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used
trace 0 to 10%
little 10 to 20%
some 20 to 35%
and 35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density
0-10 Loose
10-30 Med. Dense
30-50 Dense
50 + Very Dense

Cohesive Consistency
0-4 Soft
4-8 M/Stiff
8-15 Stiff
15-30 V-Stiff
30 + Hard

SUMMARY:
Earth Boring 51'6"
Rock Coring
Samples 11

HOLE NO. BH-18

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 2 OF 2
DATE
HOLE NO. BH-18
LINE & STA.
OFFSET
SURF. ELEV.

TO
ADDRESS
PROJECT NAME
LOCATION
REPORT SENT TO
PROJ. NO.
SAMPLES SENT TO
OUR JOB NO. 80-256

GROUND WATER OBSERVATIONS

At ______ after ______ Hours

At ______ after ______ Hours

	CASING	SAMPLER	CORE BAR.
Type			
Size I.D.			
Hammer Wt.			BIT
Hammer Fall			

	Date	Time
START		a.m. p.m.
COMPLETE		a.m. p.m.
TOTAL HRS.		

BORING FOREMAN
INSPECTOR
SOILS ENGR.

LOCATION OF BORING:

DEPTH	Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler From 0-6	To 6-12	12-18	Moisture Density or Consist.	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No.	Pen	Rec.
	60	40'-41'6"	D	5	10	11	Wet		Brown fine to coarse SAND,	9	18"	12"
	66						medium		some fine gravel, little			
	68						dense		silt			
	60											
	55											
	53	45'-46'6"	D	10	14	15	"			10	18"	12"
	65							47'6"				
	80											
	115						Wet					
	130						very		Dark Gray TILL			
		50'-51'6"	DXX	24	29	34	dense	51'6"		11	18"	12"
									Bottom of Boring 51'6"			
									DXX open end AW rod 300#-30"			

GROUND SURFACE TO ______ USED ______ "CASING: THEN ______

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used	
trace	0 to 10%
little	10 to 20%
some	20 to 35%
and	35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency			
0-10	Loose	0-4	Soft	30 +	Hard
10-30	Med. Dense	4-8	M/Stiff		
30-50	Dense	8-15	Stiff		
50 +	Very Dense	15-30	V-Stiff		

SUMMARY:
Earth Boring
Rock Coring
Samples

HOLE NO. BH-18

DAVISVILLE BULKHEAD
DAVISVILLE, RHODE ISLAND

LABORATORY TESTING DATA SUMMARY

Reviewed by ____________
Date ____________

Project No. 2655 Project Engr. DS Assigned By JM Date: Assigned 4/9/80 Required ____________

Boring No.	Sample No.	Depth ft.	Laboratory or Test No.	IDENTIFICATION TESTS: Water Content %	LL %	PL %	Sieve -200 %	Hyd -2μ %	G_s	γ_d pcf	Organic Content (%)	STRENGTH TESTS: Torvane or Type Test	σ_c or $\overline{\sigma}_c$ or σ psf	Failure Criteria	$\sigma_1 - \sigma_3$ or τ psf	Strain %	CONSOL.: $C_c / 1+e_o$	Laboratory Log and Soil Description
B14A	1	6.0–8.0	1			Average total unit weight (6.0-7.4') = 91.4 pcf												Dark grey Clayey ORGANIC SILT, fine grained soil of high plasticity, very soft consistency (OH)
		6.1		105														
		6.2		97.6								TV = 0.03 tsf						
		6.4		95.6								TV = 0.03 tsf						
		6.1–6.5		69.3	67	34	98	17	2.62		3.7							
		6.5		68.7														
		6.5–6.6		67.6						59.3							0.17	
		6.6		71.5								TV = 0.04 tsf						
		6.8		82.1								TV = 0.04 tsf						
		7.0		74.4								TV = 0.04 tsf						
		7.0–7.2		62.5						63.4							0.14	
		7.2		62.5								TV = 0.05 tsf						

DAVISVILLE BULKHEAD
DAVISVILLE, RHODE ISLAND

LABORATORY TESTING DATA SUMMARY

Reviewed by ________
Date ________

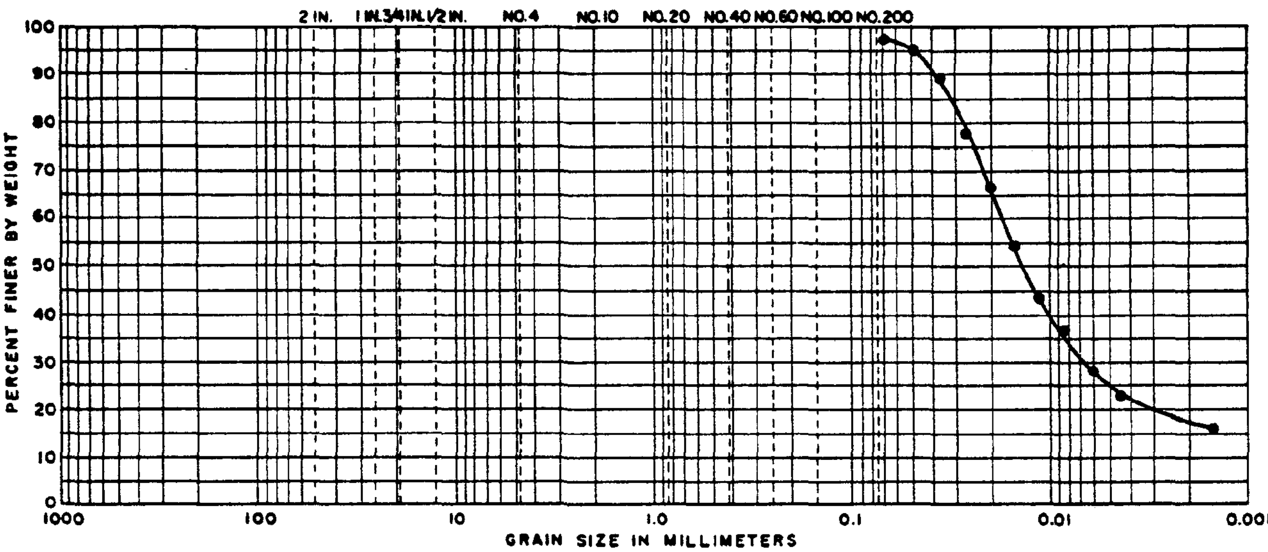
Project No. 2655 Project Engr. D.S. Assigned By J.M. Date: Assigned 4/9/80 Required ________

Boring No.	Sample No.	Depth ft.	Laboratory or Test No.	IDENTIFICATION TESTS: Water Content %	LL %	PL %	Sieve -200 %	Hyd -2μ %	G_s	γ_d pcf	Organic Content (%)	STRENGTH TESTS: Torvane or Type Test	σ_c or $\overline{\sigma}_c$ or σ psf	Failure Criteria	$\sigma_1 - \sigma_3$ or τ psf	Strain %	CONSOL. $C_c/1+e_o$	Laboratory Log and Soil Description
B14A	2	8.5–10.0	2			Average total unit weight (8.5–10.4') = 92.1 pcf												Dark grey <u>Clayey ORGANIC SILT</u>, fine grained soil of high plasticity, very soft consistency (OH). Sample color becomes stratified with light grey below 9.4' depth. <u>Note</u>: from 8.5'–9.2' depth, sample disturbed along outside edge (1"± deep) on one side.
		8.7		75.9								TV = 0.02 tsf						
		9.0		78.4														
		9.2		82.7								TV = 0.05 tsf						
		9.2–9.5		80.7	62	33	98	17		51.3	3.8	$\overline{\text{CIU}}$	$\overline{\sigma}_c$ = 995	$\sigma_1-\sigma_3$ max	397	10.4		
		9.5		84.5								TV = 0.06 tsf						
		9.5–9.7		85.1						50.6							0.21	
		9.7		88.4								TV = 0.07 tsf						
		9.7–10.0		80.5						51.7		$\overline{\text{CIU}}$	$\overline{\sigma}_c$ = 1500	$\sigma_1-\sigma_3$ max	721	6.9		
		10.0–10.3		74.8						52.7		$\overline{\text{CIU}}$	$\overline{\sigma}$ = 2000	$\sigma_1-\sigma_3$ max	1138	10.9		

GOLDBERG, ZOINO, DUNNICLIFF & ASSOCIATES, INC.
CONSULTANTS IN GEOTECHNICAL ENGINEERING

SUMMARY OF LAB TESTS
TABLE NUMBER

GRAIN SIZE DISTRIBUTION

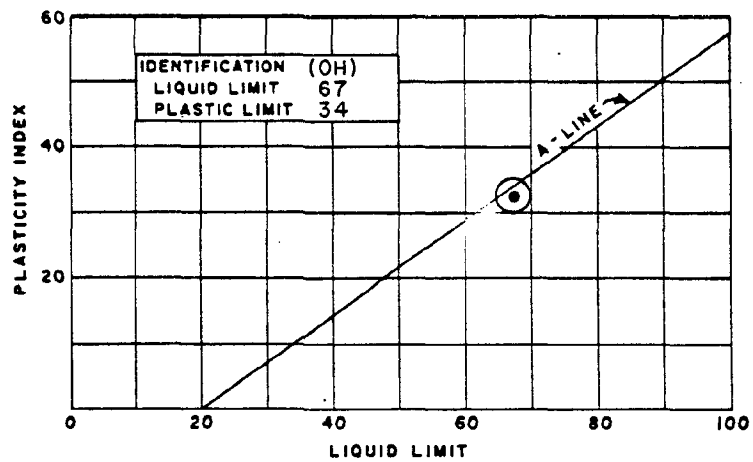


COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

UNIFIED SOIL CLASSIFICATION SYSTEM

PLASTICITY CHART

(COHESIVE SOIL ONLY)



SOIL PROPERTIES		
SOIL DESCRIPTION: DARK GREY CLAYEY ORGANIC SILT (OH)		
INITIAL WATER CONTENT ____ %	DRY UNIT WEIGHT ____	
PLASTICITY INDEX 33 %	ACTIVITY ____	SPECIFIC GRAVITY 2.62

DAVISVILLE BULKHEAD
DAVISVILLE, R.I.

SOIL CLASSIFICATION TESTS

BORING NO. B14A
SAMPLE 1
DEPTH 6.1' - 6.5'
TECH. ____
REVIEWER ____

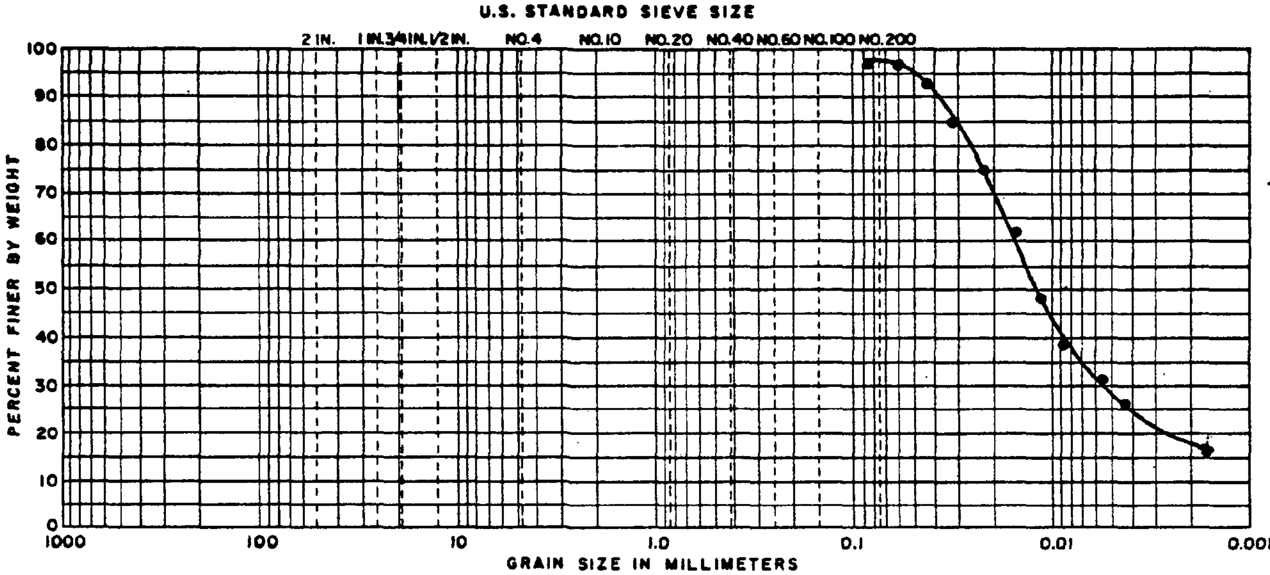
TEST SERIES NO. 1
DATE APRIL 1980

FIGURE

GOLDBERG, ZOINO, DUNNICLIFF & ASSOCIATES, INC.

FILE 2655

GRAIN SIZE DISTRIBUTION

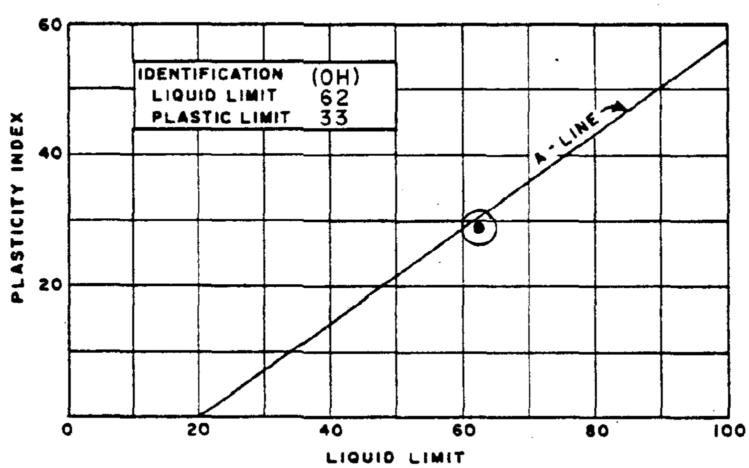


COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

UNIFIED SOIL CLASSIFICATION SYSTEM

PLASTICITY CHART

(COHESIVE SOIL ONLY)



SOIL PROPERTIES

SOIL DESCRIPTION: DARK GREY CLAYEY ORGANIC SILT (OH)

INITIAL WATER CONTENT 80.7 % DRY UNIT WEIGHT 51.3 pcf

PLASTICITY INDEX 29 % ACTIVITY ____ SPECIFIC GRAVITY 2.62

DAVISVILLE BULKHEAD
DAVISVILLE, R.I.

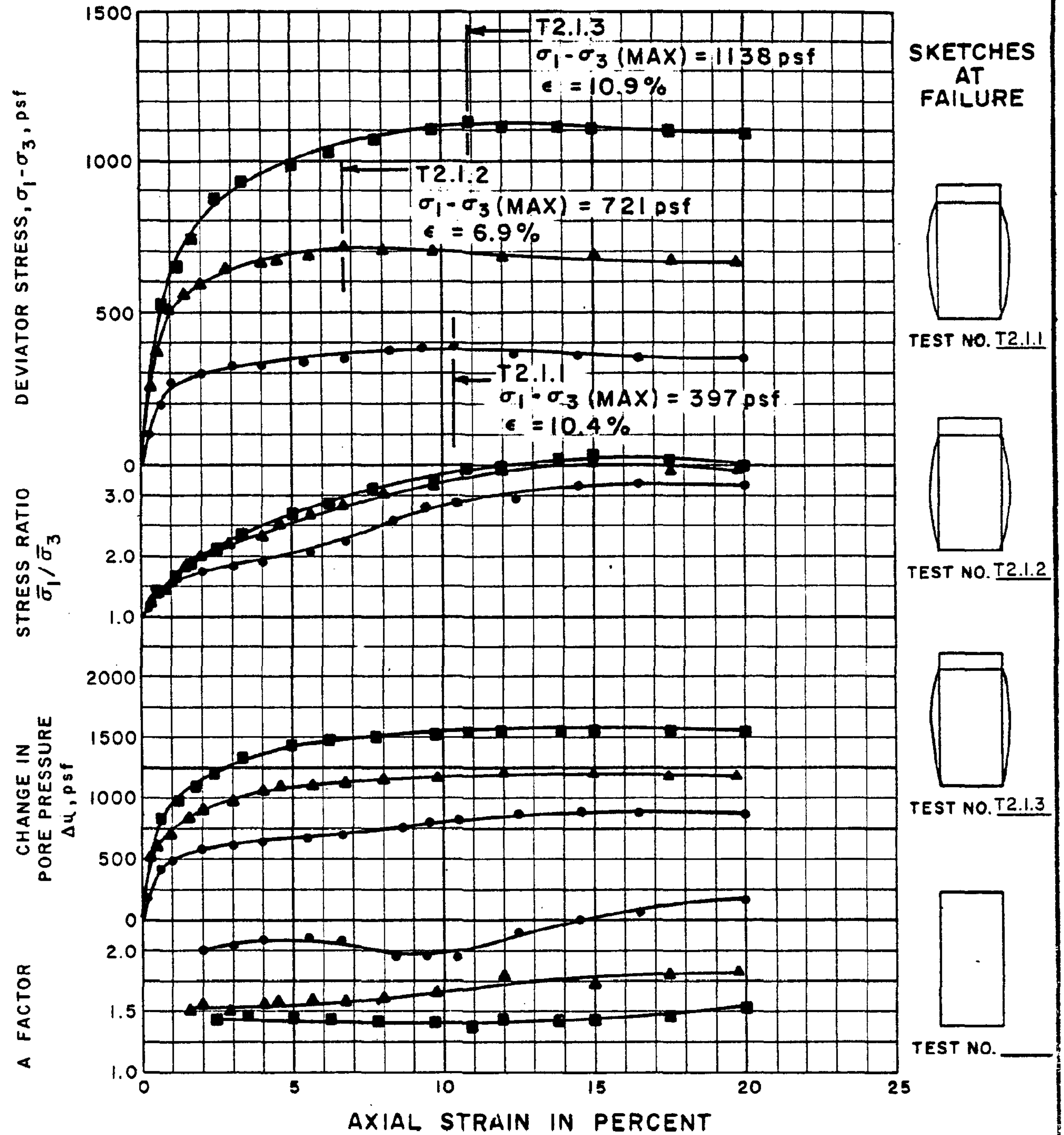
SOIL CLASSIFICATION TESTS

BORING NO. B14A TEST SERIES
SAMPLE 2 NO. 2
DEPTH 9.2' - 9.5' DATE APRIL 1980
TECH. ____
REVIEWER ____

FILE 2655

FIGURE

GOLDBERG, ZOINO, DUNNICLIFF & ASSOCIATES, INC.



TEST NO./SYMBOL	INITIAL CONDITIONS			CONDITIONS BEFORE SHEAR				FINAL CONDITIONS		RATE OF STRAIN, PERCENT PER MINUTE
	INITIAL WATER CONTENT, %	INITIAL DRY UNIT WEIGHT, pcf	SAMPLE HEIGHT & DIAMETER, in.	INITIAL STRESSES $\bar{\sigma}_1 = \bar{\sigma}_3$, psf	FINAL BACK PRESSURE, psf	VOLUMETRIC STRAIN, %	PORE PRESSURE RESPONSE, %	FINAL WATER CONTENT, %	FINAL DRY UNIT WEIGHT, pcf	
T2.1.1 ●	80.7	51.3	3.11 / 1.40	995	4320	13.4	95	59.8	59.3	.015
T2.1.2 ▲	80.5	51.7	3.13 / 1.40	1500	5040	16.8	97	58.4	62.2	.015
T2.1.3 ■	74.8	52.7	2.98 / 1.40	2000	4320	18.5	95	51.9	64.7	.015

SOIL DESCRIPTION: DARK GREY CLAYEY ORGANIC SILT (OH)

LIQUID LIMIT 62 % PLASTIC LIMIT 33 % SPECIFIC GRAVITY ____

DAVISVILLE BULKHEAD
DAVISVILLE, R.I.

TRIAXIAL COMPRESSION TESTS ($\overline{CIU}$)

BORING NO. B14A TEST SERIES
SAMPLE 2 NO. 2
DEPTH 9.2' - 10.3' DATE APRIL 1980
TECH. ____
REVIEWER ____ FILE 2655

GOLDBERG, ZOINO, DUNNICLIFF & ASSOCIATES, INC.
CONSULTANTS IN GEOTECHNICAL ENGINEERING

FIGURE

LABORATORY TEST PROCEDURES

DAVISVILLE BULKHEAD
DAVISVILLE, RHODE ISLAND

1. The following tests were performed with the noted ASTM test designations:

Test	ASTM Designation
Moisture Content	D2216-71
Liquid Limit	D423-66
Plastic Limit	D424-59
Grain Size	D422-63 (Hydrometer only)
Specific Gravity	D854-58
Organic Content	D2974-71
Consolidation Properties	D2435-70 (see Item 2)
Triaxial Compression Tests	(See Item 3)

2. Test procedure for consolidation properties (addenda)

The procedure outlined under ASTM designation D2435-70 was used as a guide during consolidation testing. Undisturbed samples were trimmed by means of a soil lathe, carving each specimen to test dimensions of 2.50 inches diameter and 0.80 inch height. The sample was weighed, placed in a consolidometer and there seated under a load of 1/16 ton per square foot. This load was sequentially doubled (1/16-1/8 tsf, 1/8-1/4 tsf, 1/4-1/2 tsf, etc.)

One of the test samples was rebounded after the 1 tsf load increment. Unloading was accomplished in one step to 1/8 tsf.

Using the doubling sequence established during the initial loading, the sample was then reloaded to a maximum of 16 tons per square foot. Each load and/or unload was allowed to act for a controlled time increment. In this case the increment used was 24 hours± . During application of these and all other loads, the change in thickness of the sample was recorded at regular time intervals.

A final rebound sequence followed (16-4, 4-1, 1-1/4) and the sample was removed, weighed, and oven dried for water content determination.

3. Test procedures for triaxial compressive strength of soil

a. Consolidated undrained triaxial tests ($\overline{\text{CIU}}$)

The procedure outlined under U.S. Army Corps of Engineers Manual EM 1110-2-1906, Appendix X (R test) used as a guide during testing. Test samples were trimmed in a vertical lathe to dimensions of approximately 1.40 inch diameter and 3.50 inch length. Water contents were obtained from trimmings adjacent to the test sample, the specimen's weight was determined, and its dimensions verified.

After trimming, the test specimen was placed on a previusly de-aired triaxial cell base and porous stone. Filter strips were placed in contact with the porous stone at hexagonal points of the specimen; a membrane was added and the sample was sealed top and bottom by 'O' rings.

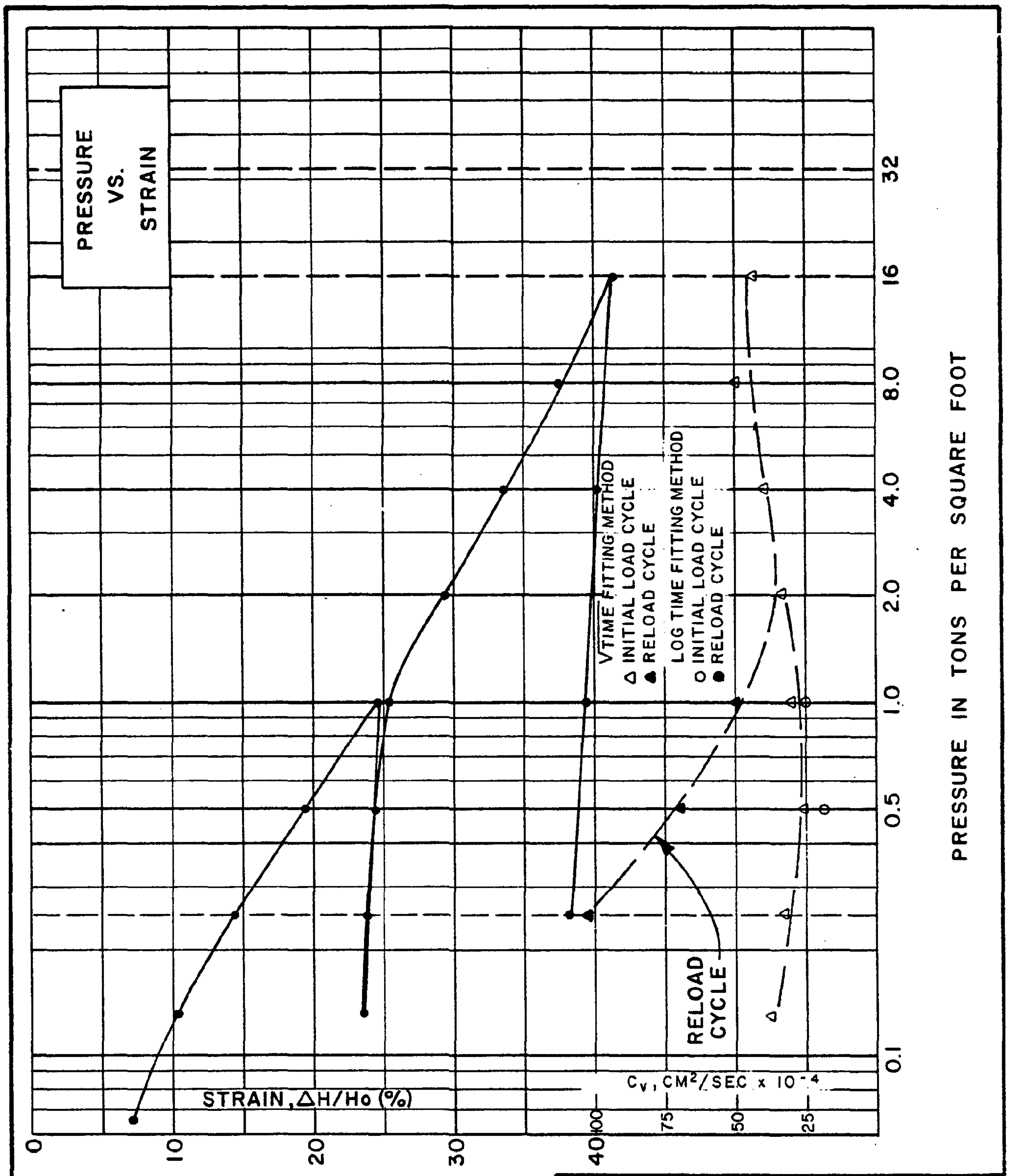
Samples were back pressured under a small effective stress to create complete saturation of the samples. The chamber pressure was then increased such that the desired consolidation effective stress was obtained. This effective consolidation stress was allowed to act for 24 hours±. During the consolidation phase, readings of volume change versus time were recorded.

After consolidation, the response of the soil samples was checked by increasing the cell pressure and monitoring the pore pressure. Where required, additional back pressure was applied so as to achieve a pore pressure response equal to or greater than 95%.

Load application rates were estimated using formula's described in "The Triaxial Test," Bishop, A. W. and Henkel, D. J., Edward Arnold Publisher, 1957, pp. 124-127, 204-206.

The specimens were loaded under strain-controlled conditions allowing no drainage during shear. The applied load, pore pressure change, and change in height of the samples were recorded at regular intervals during the test. When 20% strain was reached, the samples were removed from the loading apparatus. A sketch of the sample was made, the entire weight was obtained, and its water content determined.

Applied pressures were corrected for the effects of membrane and filter strips in accordance with procedures outlined by Seed, H. B. and Duncan, J. M., "Corrections for Strength Test Data," Journal of Soil Mechanics and Foundation Division, September 1967.



SOIL DESCRIPTION: DARK GREY CLAYEY ORGANIC SILT (OH)

SAMPLE DIAM. 2.50 IN. LIQUID LIMIT 67 % PLASTIC LIMIT 34 % SPECIFIC GRAVITY 2.62

	WATER CONTENT, %	DRY UNIT WEIGHT, pcf	VOID RATIO	SATURATION, %	SAMPLE HEIGHT, INCH
INITIAL	67.6	59.3	1.76	100	0.800
FINAL	33.0	95.8	0.71	-	0.495

DAVISVILLE BULKHEAD
DAVISVILLE, R.I.

CONSOLIDATION TEST

BORING NO. B14A
SAMPLE 1
DEPTH 6.5' - 6.6'
TECH.
REVIEWER

TEST SERIES NO. 1
DATE APRIL 1980

FILE 2655

FIGURE

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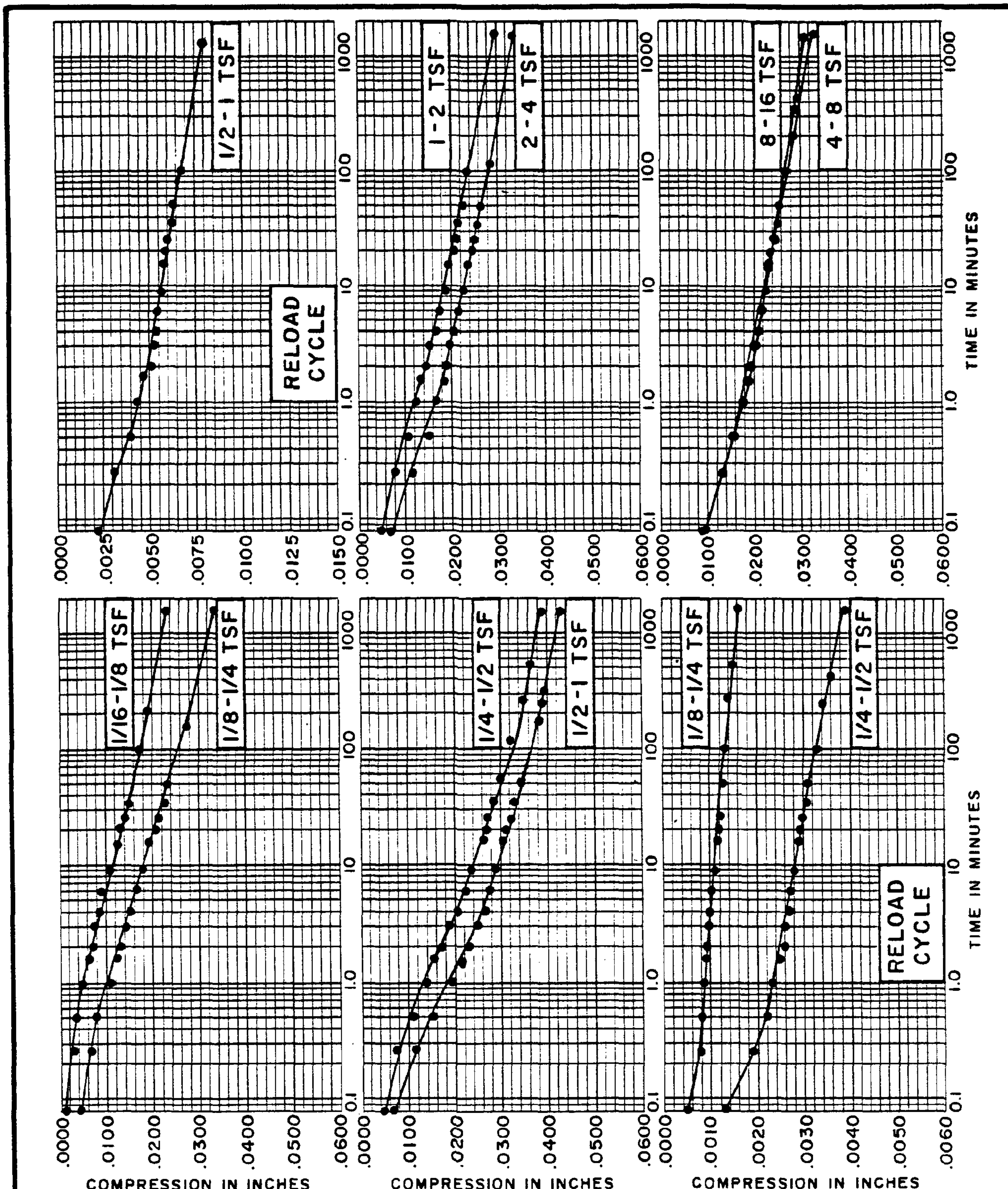
CONSULTANTS IN GEOTECHNICAL ENGINEERING



SOIL DESCRIPTION: DARK GREY CLAYEY ORGANIC SILT (OH)

SAMPLE DIAM. 2.50 IN. LIQUID LIMIT 67 % PLASTIC LIMIT 34 % SPECIFIC GRAVITY 2.62

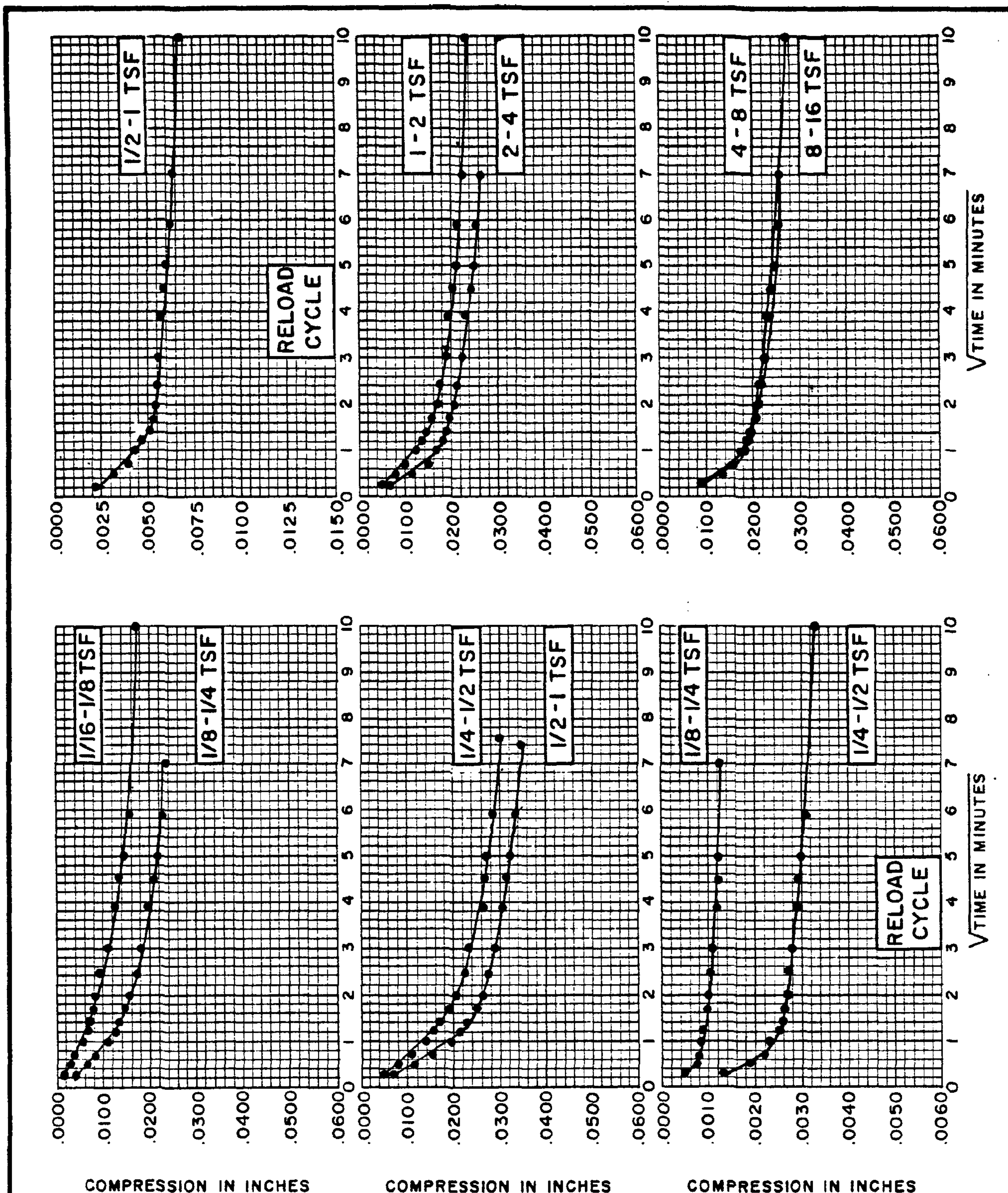
	WATER CONTENT, %	DRY UNIT WEIGHT, pcf	VOID RATIO	SATURATION, %	SAMPLE HEIGHT, INCH
INITIAL	67.6	59.3	1.76	100	0.800
FINAL	33.0	95.8	0.71	-	0.495

DAVISVILLE BULKHEAD
DAVISVILLE, R.I.

CONSOLIDATION TEST
TIME VS. COMPRESSION CURVES

BORING NO. B14A TEST SERIES NO. 1
SAMPLE 1
DEPTH 6.5' - 6.6' DATE APRIL 1980
TECH. ______
REVIEWER ______ FILE 2655

GOLDBERG, ZOINO, DUNNICLIFF & ASSOCIATES, INC.
CONSULTANTS IN GEOTECHNICAL ENGINEERING



SOIL DESCRIPTION: DARK GREY CLAYEY ORGANIC SILT (OH)

SAMPLE DIAM. 2.50 IN. LIQUID LIMIT 67 % PLASTIC LIMIT 34 % SPECIFIC GRAVITY 2.62

	WATER CONTENT, %	DRY UNIT WEIGHT, pcf	VOID RATIO	SATURATION, %	SAMPLE HEIGHT, INCH
INITIAL	67.6	59.3	1.76	100	0.800
FINAL	33.0	95.8	0.71	-	0.495

DAVISVILLE BULKHEAD
DAVISVILLE, R.I.

CONSOLIDATION TEST
TIME VS. COMPRESSION CURVES

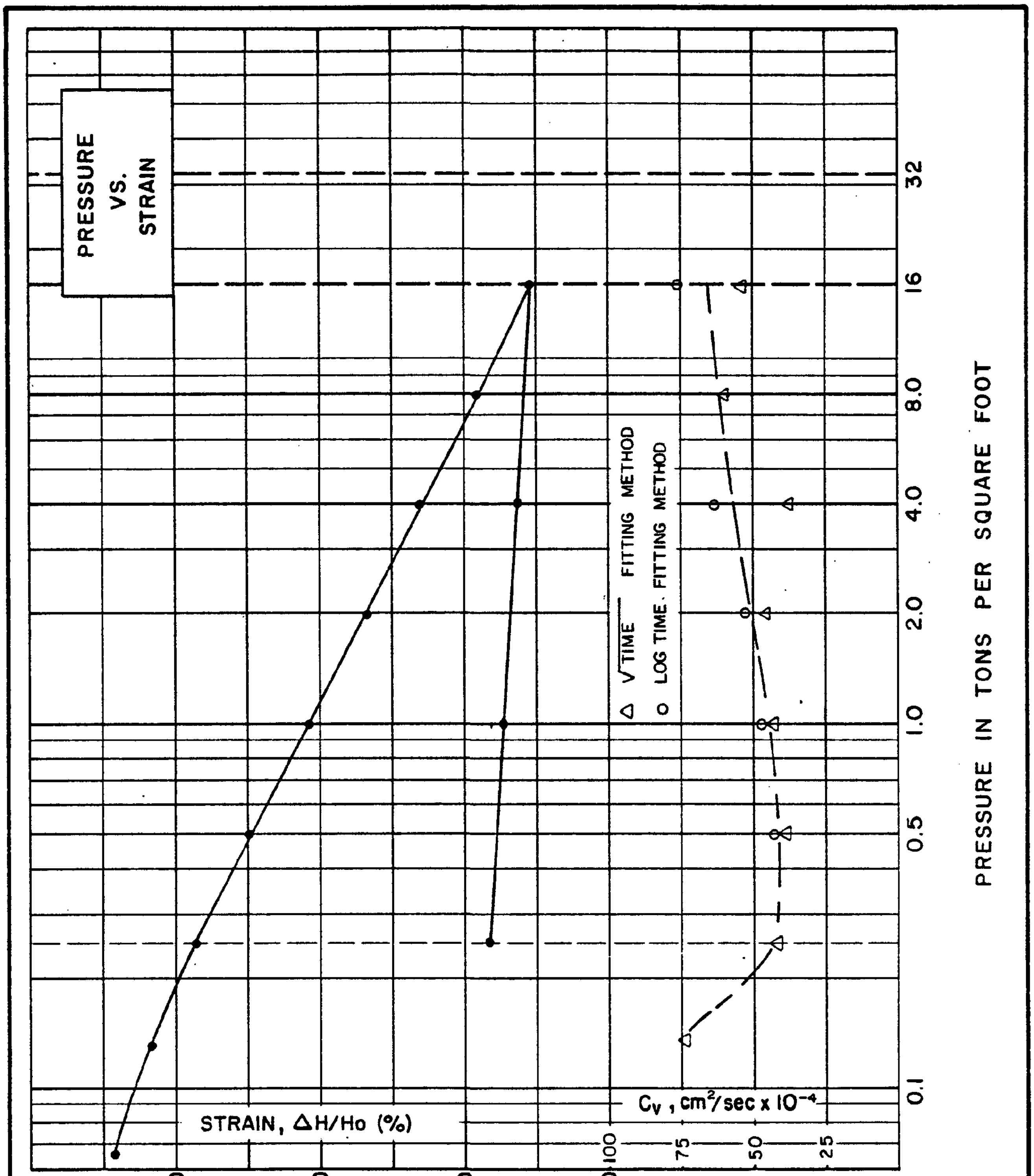
BORING NO. B14A
SAMPLE 1
DEPTH 6.5'-6.6'
TECH.
REVIEWER

TEST SERIES NO. 1
DATE APRIL 1980

FILE 2655

GOLDBERG, ZOINO, DUNNICLIFF & ASSOCIATES, INC.

FIGURE



SOIL DESCRIPTION: DARK GREY CLAYEY ORGANIC SILT(OH)

SAMPLE DIAM. 2.50 IN. LIQUID LIMIT 67 % PLASTIC LIMIT 34 % SPECIFIC GRAVITY 2.62

	WATER CONTENT, %	DRY UNIT WEIGHT, pcf	VOID RATIO	SATURATION, %	SAMPLE HEIGHT, INCH
INITIAL	62.5	63.4	1.61	100	0.800
FINAL	32.4	92.0	0.78	—	0.545

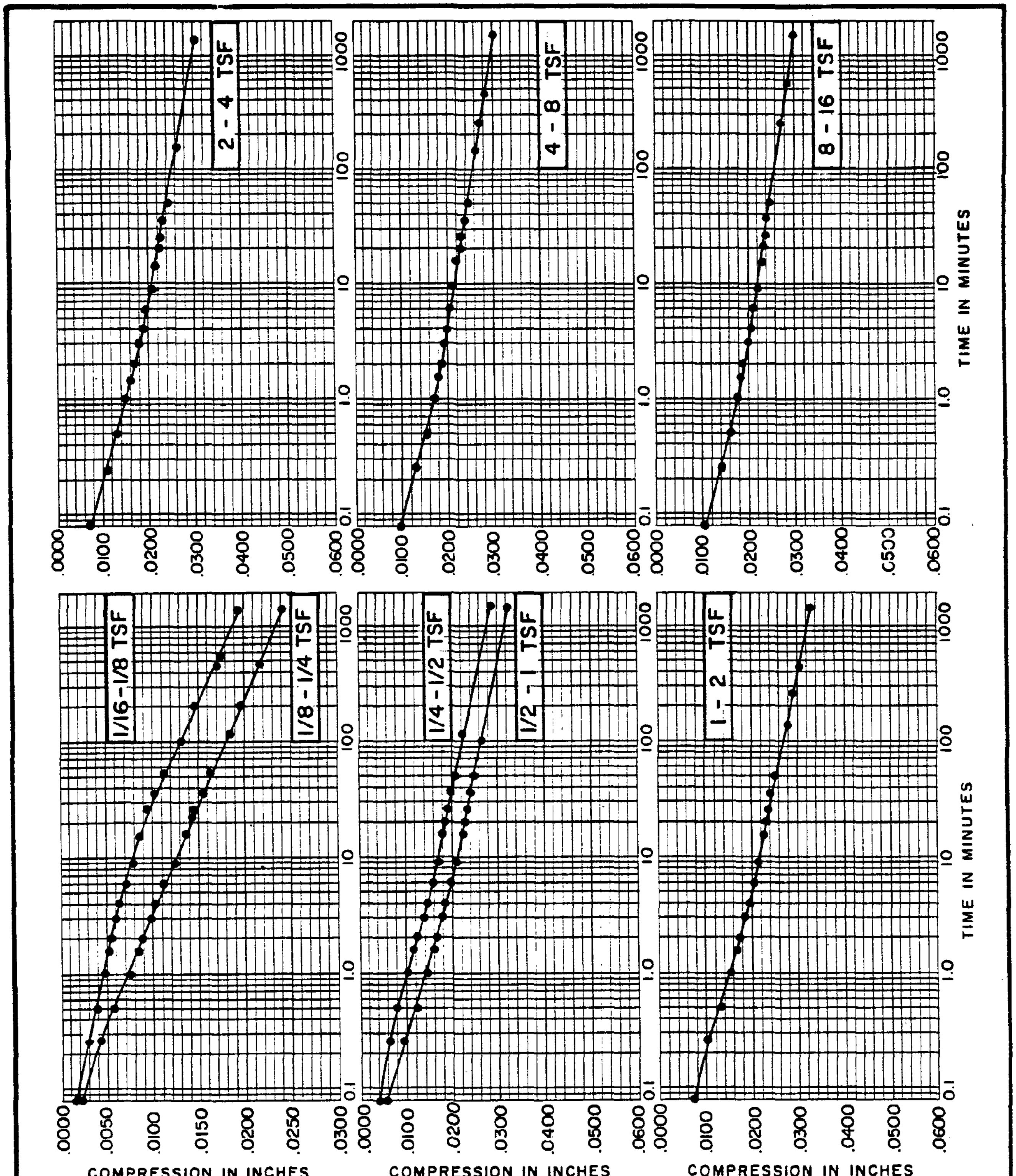
DAVISVILLE BULKHEAD
DAVISVILLE, R.I.

CONSOLIDATION TEST

BORING NO. B 14A TEST SERIES
SAMPLE 1 NO. 1
DEPTH 7.0 - 7.2 DATE MAY 1980
TECH.
REVIEWER
FILE 2655

FIGURE

GOLDBERG, ZOINO, DUNNICLIFF & ASSOCIATES, INC.



SOIL DESCRIPTION: DARK GREY CLAYEY ORGANIC SILT(OH)

SAMPLE DIAM. 2.50 IN. LIQUID LIMIT 67 % PLASTIC LIMIT 34 % SPECIFIC GRAVITY 2.62

	WATER CONTENT, %	DRY UNIT WEIGHT, pcf	VOID RATIO	SATURATION, %	SAMPLE HEIGHT, INCH
INITIAL	62.5	63.4	1.61	100	0.800
FINAL	32.4	92.0	0.78	—	0.545

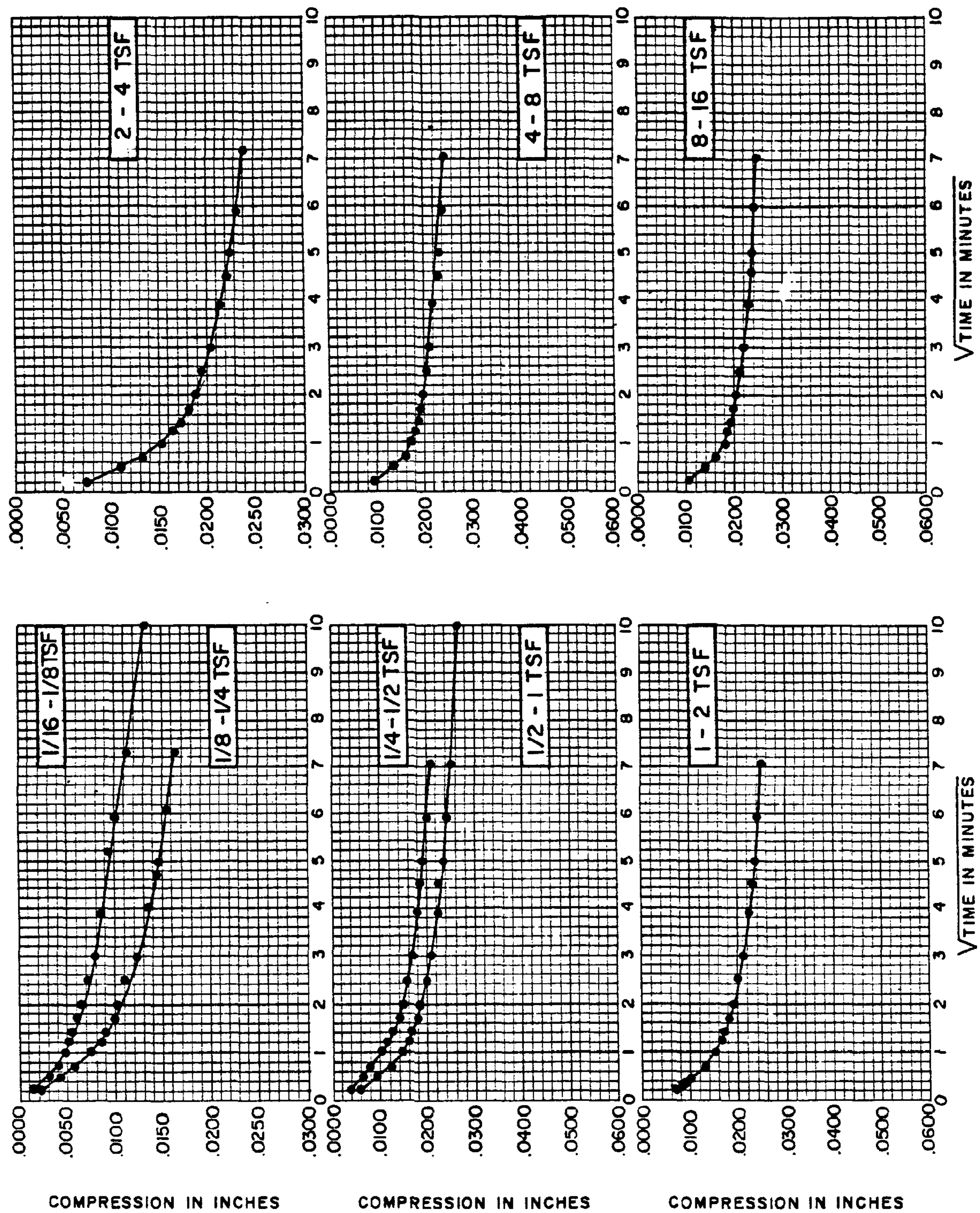
DAVISVILLE BULKHEAD
DAVISVILLE, R.I.

CONSOLIDATION TEST
TIME VS. COMPRESSION CURVES

BORING NO. B14A
SAMPLE 1
DEPTH 7.0 - 7.2
TECH.
REVIEWER

TEST SERIES NO. 1
DATE MAY 1980
FILE 2655

GOLDBERG, ZOINO, DUNNICLIFF & ASSOCIATES, INC.
CONSULTANTS IN GEOTECHNICAL ENGINEERING



SOIL DESCRIPTION: DARK GREY CLAYEY ORGANIC SILT (OH)

SAMPLE DIAM. 2.50 IN. LIQUID LIMIT 67 % PLASTIC LIMIT 34 % SPECIFIC GRAVITY 2.62

	WATER CONTENT, %	DRY UNIT WEIGHT, pcf	VOID RATIO	SATURATION, %	SAMPLE HEIGHT, INCH
INITIAL	62.5	63.4	1.61	100	0.800
FINAL	32.4	92.0	0.78	—	0.545

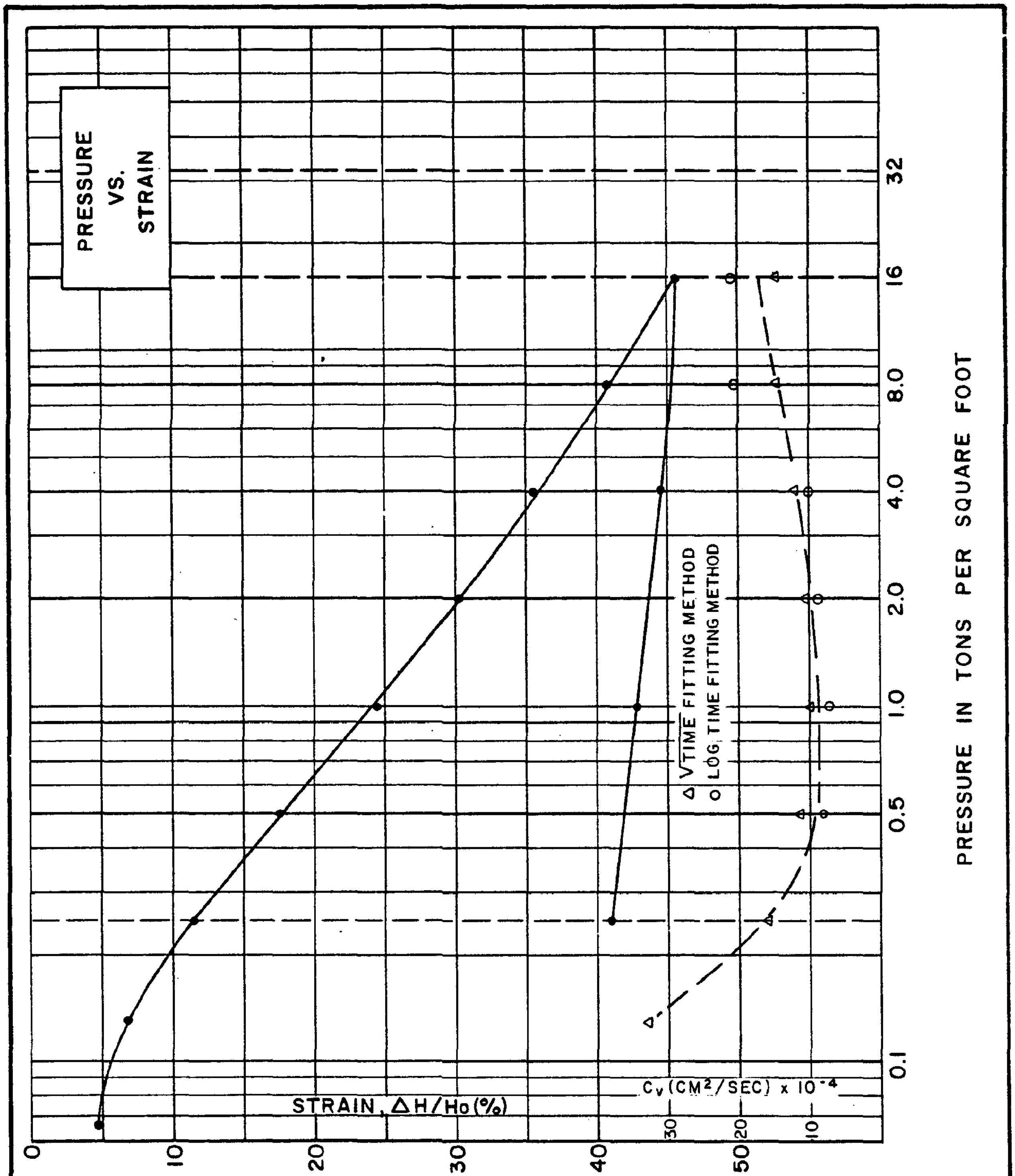
DAVISVILLE BULKHEAD
DAVISVILLE, R.I.

CONSOLIDATION TEST
TIME VS. COMPRESSION CURVES

BORING NO. B14A TEST SERIES NO. 1
SAMPLE 1
DEPTH 7.0 - 7.2 DATE MAY 1980
TECH.
REVIEWER
FILE 2655

FIGURE

GOLDBERG, ZOINO, DUNNICLIFF & ASSOCIATES, INC.
CONSULTANTS IN GEOTECHNICAL ENGINEERING



SOIL DESCRIPTION: DARK GREY CLAYEY ORGANIC SILT (OH)

SAMPLE DIAM. 2.50 IN. LIQUID LIMIT 62 % PLASTIC LIMIT 33 % SPECIFIC GRAVITY ____

	WATER CONTENT, %	DRY UNIT WEIGHT, pcf	VOID RATIO	SATURATION, %	SAMPLE HEIGHT, INCH
INITIAL	85.1	50.6	2.23	100	0.800
FINAL	38.0	85.9	0.90	-	0.471

DAVISVILLE BULKHEAD
DAVISVILLE, R.I.

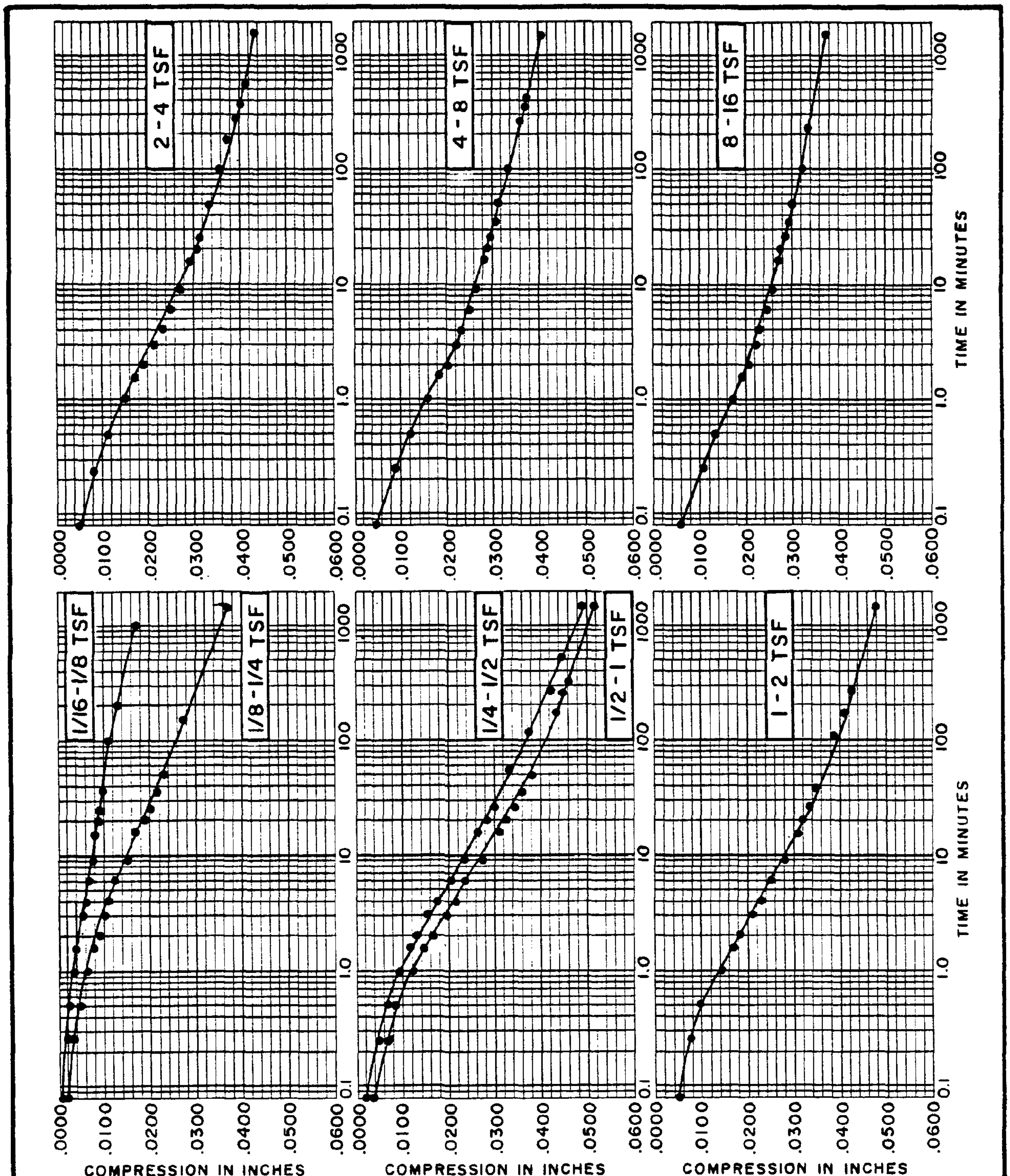
CONSOLIDATION TEST

BORING NO. B14A
SAMPLE 2
DEPTH 9.5'-9.7'
TECH. ____
REVIEWER ____

TEST SERIES NO. 2
DATE APRIL 1980
FILE 2655

FIGURE ____

GOLDBERG, ZOINO, DUNNICLIFF & ASSOCIATES, INC.
CONSULTANTS IN GEOTECHNICAL ENGINEERING



SOIL DESCRIPTION: DARK GREY CLAYEY ORGANIC SILT (OH)

SAMPLE DIAM. 2.50 IN. LIQUID LIMIT 62 % PLASTIC LIMIT 33 % SPECIFIC GRAVITY ____

	WATER CONTENT, %	DRY UNIT WEIGHT, pcf	VOID RATIO	SATURATION, %	SAMPLE HEIGHT, INCH
INITIAL	85.1	50.6	2.23	100	0.800
FINAL	38.0	85.9	0.90	-	0.471

DAVISVILLE BULKHEAD
DAVISVILLE, R.I.

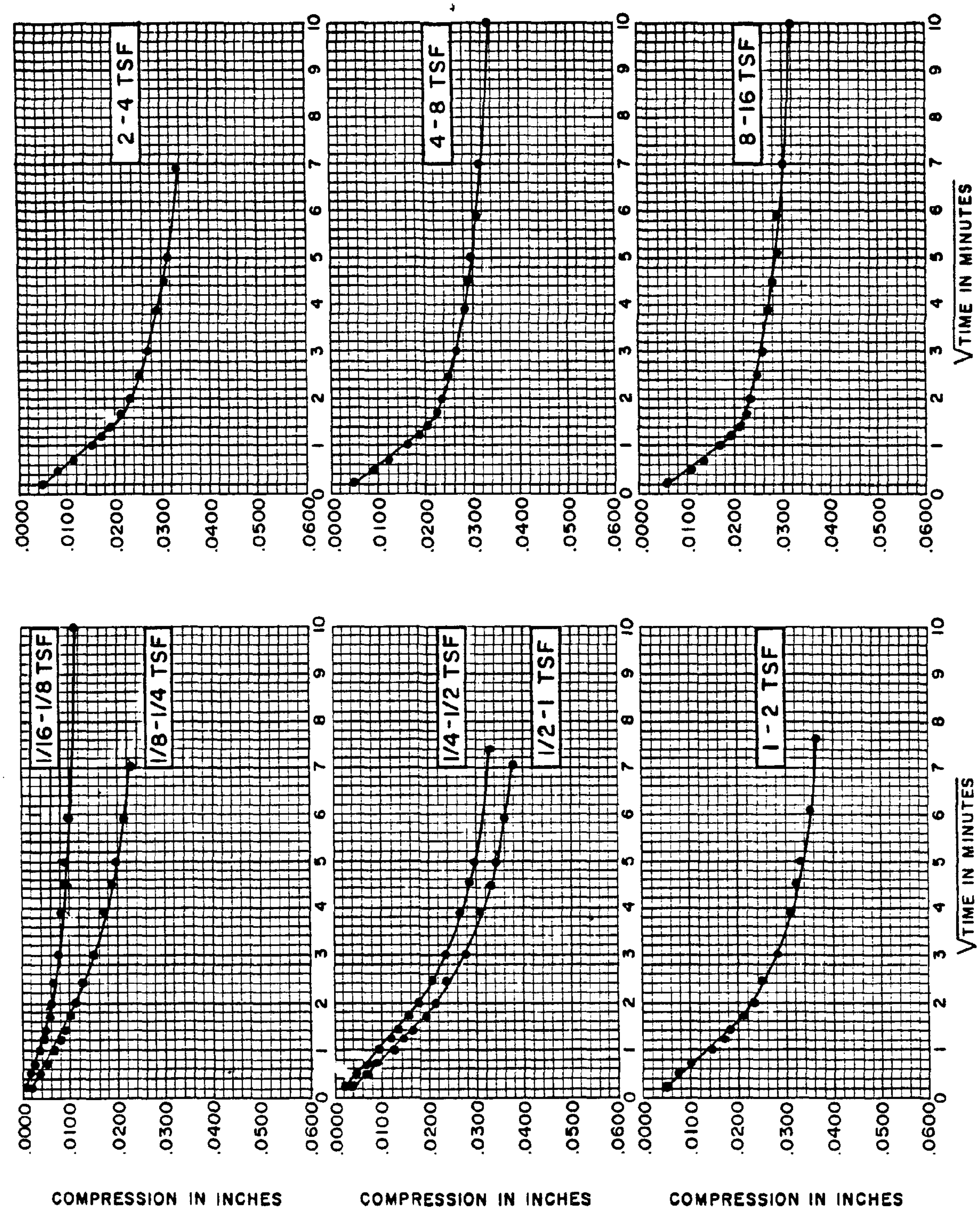
CONSOLIDATION TEST
TIME VS. COMPRESSION CURVES

BORING NO. B14A
SAMPLE 2
DEPTH 9.5' - 9.7'
TECH. ____
REVIEWER ____

TEST SERIES NO. 2
DATE APRIL 1980

FILE 2655

GOLDBERG, ZOINO, DUNNICLIFF & ASSOCIATES, INC.
CONSULTANTS IN GEOTECHNICAL ENGINEERING



SOIL DESCRIPTION: DARK GREY CLAYEY ORGANIC SILT (OH)

SAMPLE DIAM. 2.50 IN. LIQUID LIMIT 62 % PLASTIC LIMIT 33 % SPECIFIC GRAVITY ____

	WATER CONTENT, %	DRY UNIT WEIGHT, pcf	VOID RATIO	SATURATION, %	SAMPLE HEIGHT, INCH
INITIAL	85.1	50.6	2.23	100	0.800
FINAL	38.0	85.9	0.90	-	0.471

DAVISVILLE BULKHEAD
DAVISVILLE, R.I.

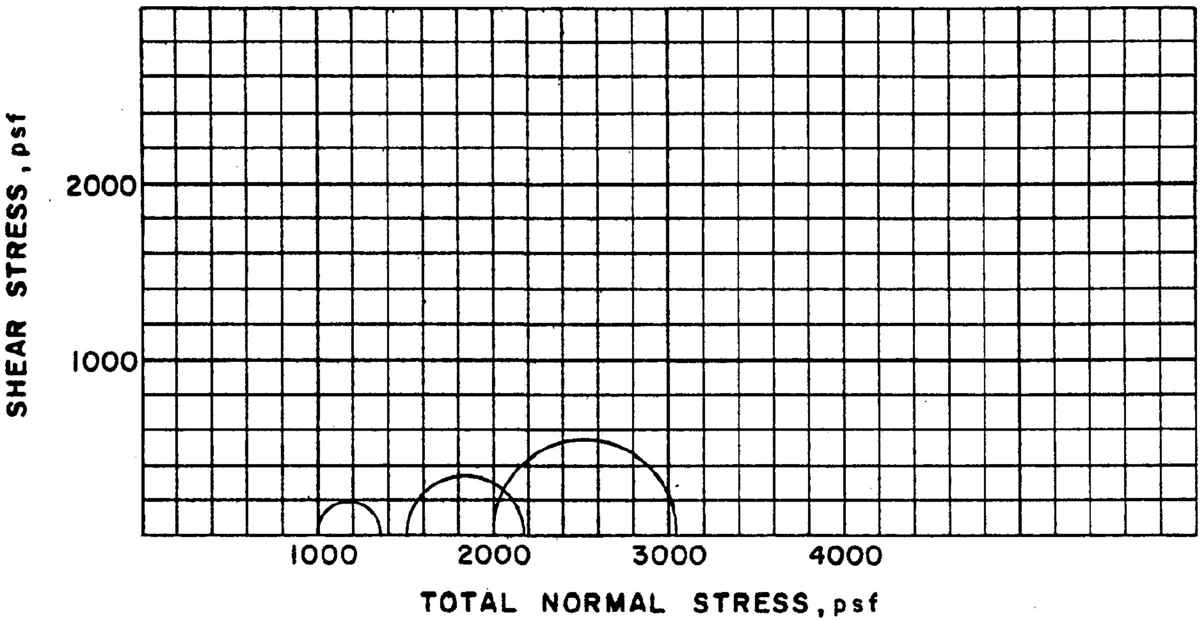
CONSOLIDATION TEST
TIME VS. COMPRESSION CURVES

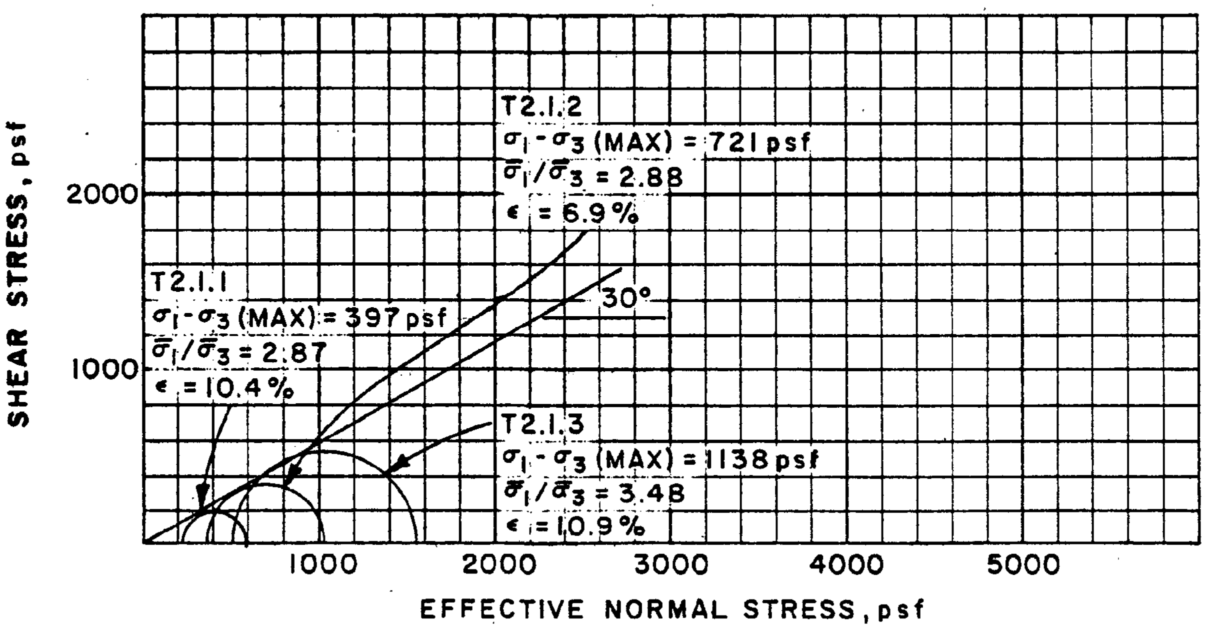
BORING NO. B14A
SAMPLE 2
DEPTH 9.5' - 9.7'
TECH. ____
REVIEWER ____

TEST SERIES NO. 2
DATE APRIL 1980

FILE 2655

GOLDBERG, ZOINO, DUNNICLIFF & ASSOCIATES, INC.
CONSULTANTS IN GEOTECHNICAL ENGINEERING





SOIL DESCRIPTION: DARK GREY CLAYEY ORGANIC SILT (OH)

LIQUID LIMIT 62 % PLASTIC LIMIT 33 % SPECIFIC GRAVITY ______

FAILURE CRITERIA $\sigma_1 - \sigma_3$ MAX

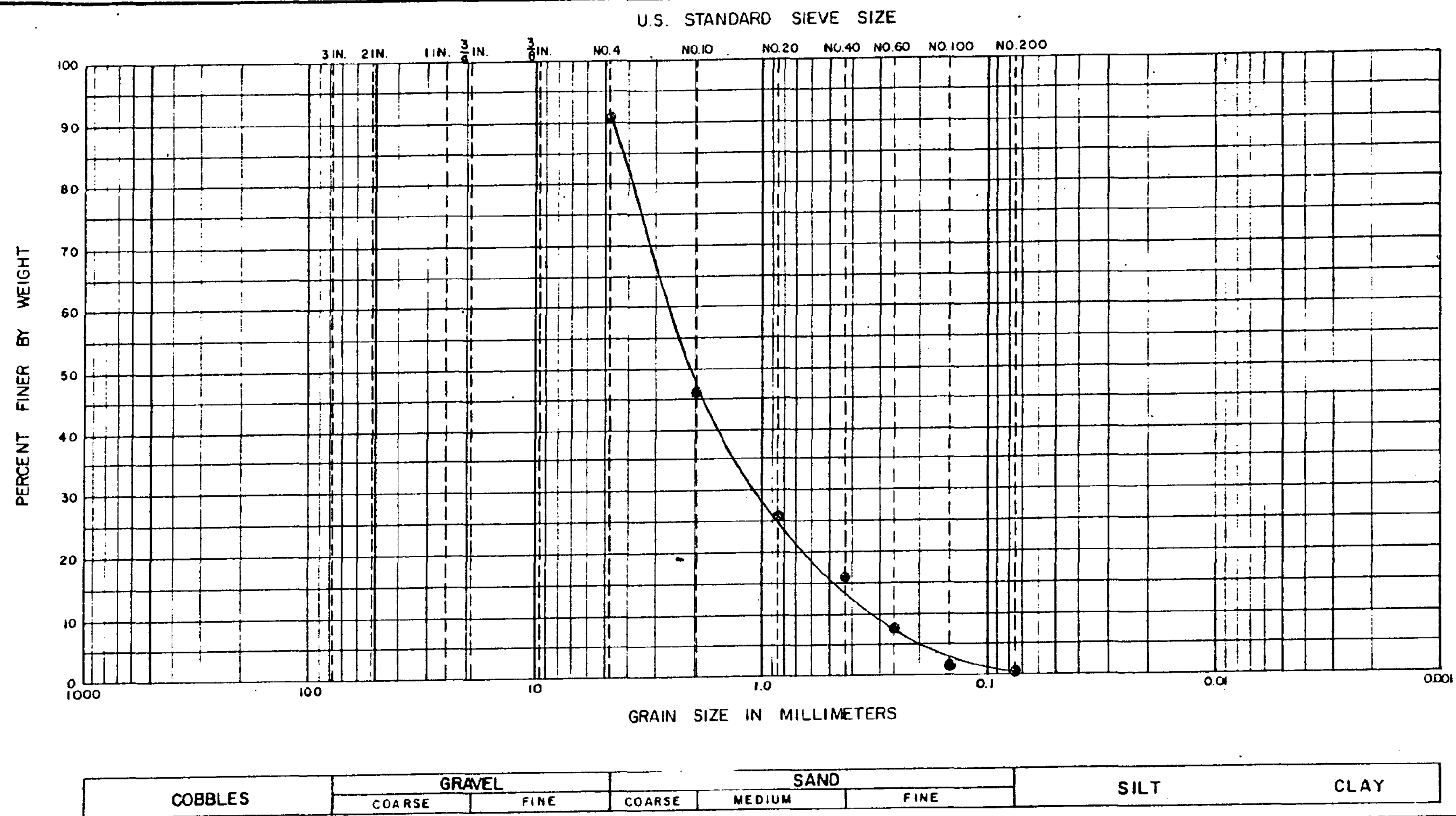
REMARKS ______________________

DAVISVILLE BULKHEAD
DAVISVILLE, R.I.
MOHR STRENGTH ENVELOPE

TRIAXIAL COMPRESSION TESTS ($\overline{\text{CIU}}$)

BORING NO. B14A TEST SERIES
SAMPLE 2 NO. 2
DEPTH 9.2'-10.3' DATE APRIL 1980
TECH. ________
REVIEWER ________ FILE 2655

FIGURE



Sample No.	Elev or Depth	Classification	NatWC	LL	PL	PI	
S-4	15'	GRAY-BROWN, SATURATED, MEDIUM DENSE, VERY FINE TO COARSE SAND, TRACE FINE GRAVEL					

GRADATION CURVES

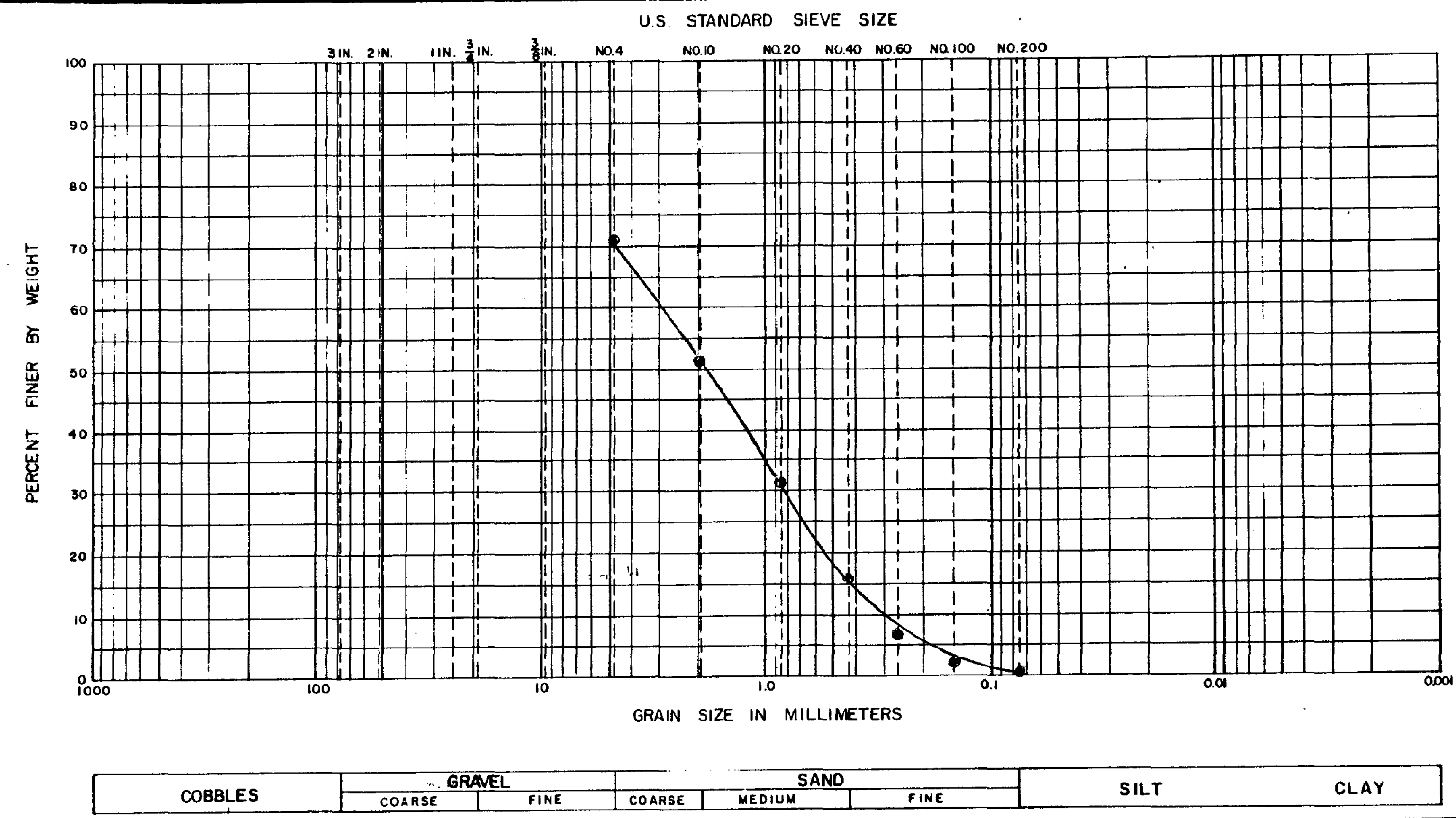
C E MAGUIRE, INC.

PROJECT DAVISVILLE PORT EXPANSION

AREA DAVISVILLE, R. I.

BORING NO. BH-18

DATE



Sample No.	Elev or Depth	Classification	NatWC	LL	PL	PI	
S-2, S-3	5'-11-6"	GRAY-BROWN, LOOSE/MEDIUM DENSE,					
		VERY FINE TO COARSE SAND, SOME					
		FINE TO MEDIUM GRAVEL					

GRADATION CURVES

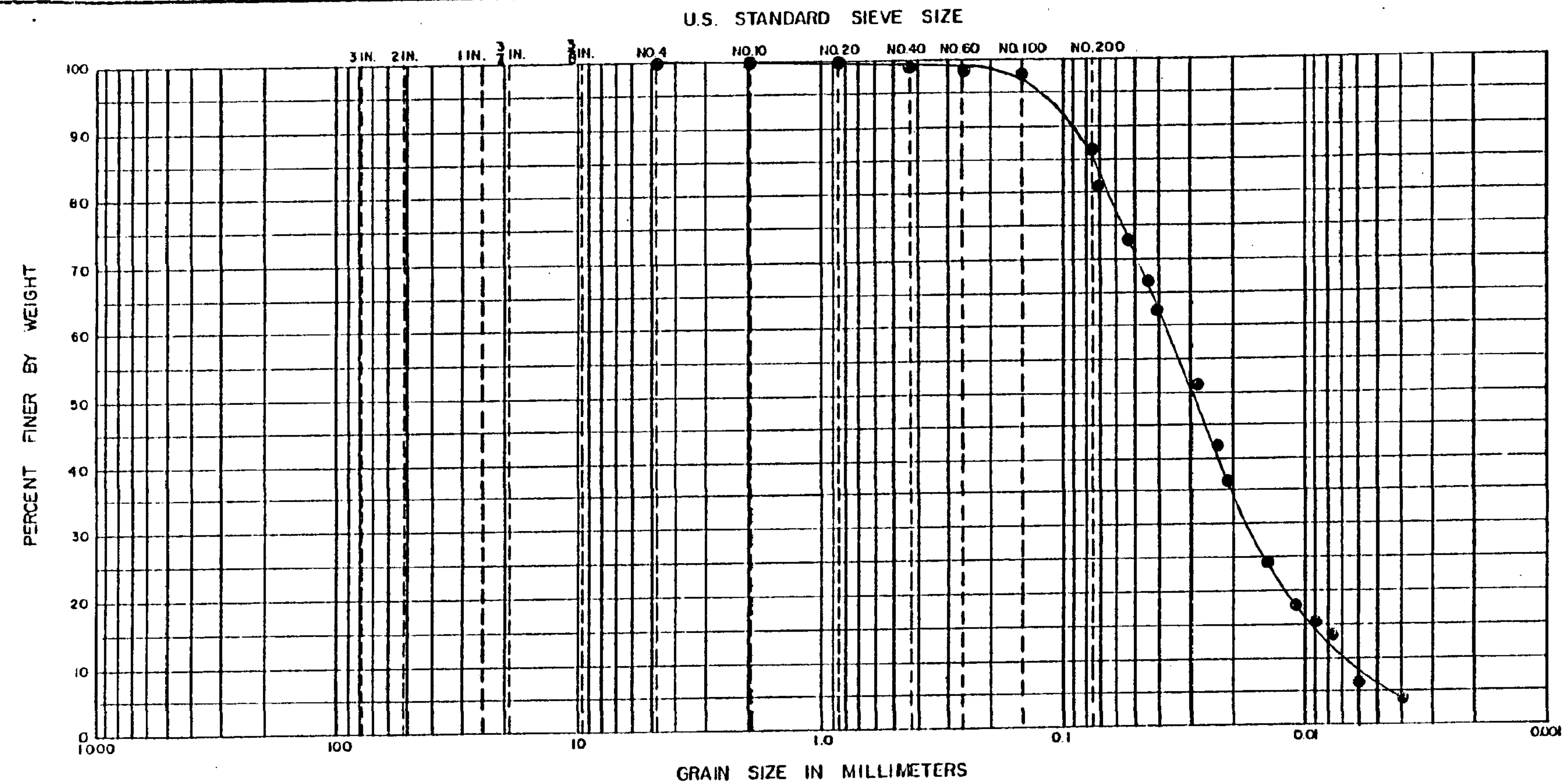
C E MAGUIRE, INC.

PROJECT DAVISVILLE PORT EXPANSION

AREA DAVISVILLE, R.I.

BORING NO. BH-17

DATE



COBBLES	GRAVEL		SAND			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

Sample No.	Elev or Depth	Classification	Nat WC	LL	PL	PI	
S-6	25'	GRAY-BROWN, SATURATED, LOOSE, SILT LITTLE VERY FINE SAND (LAYERED)					

GRADATION CURVES

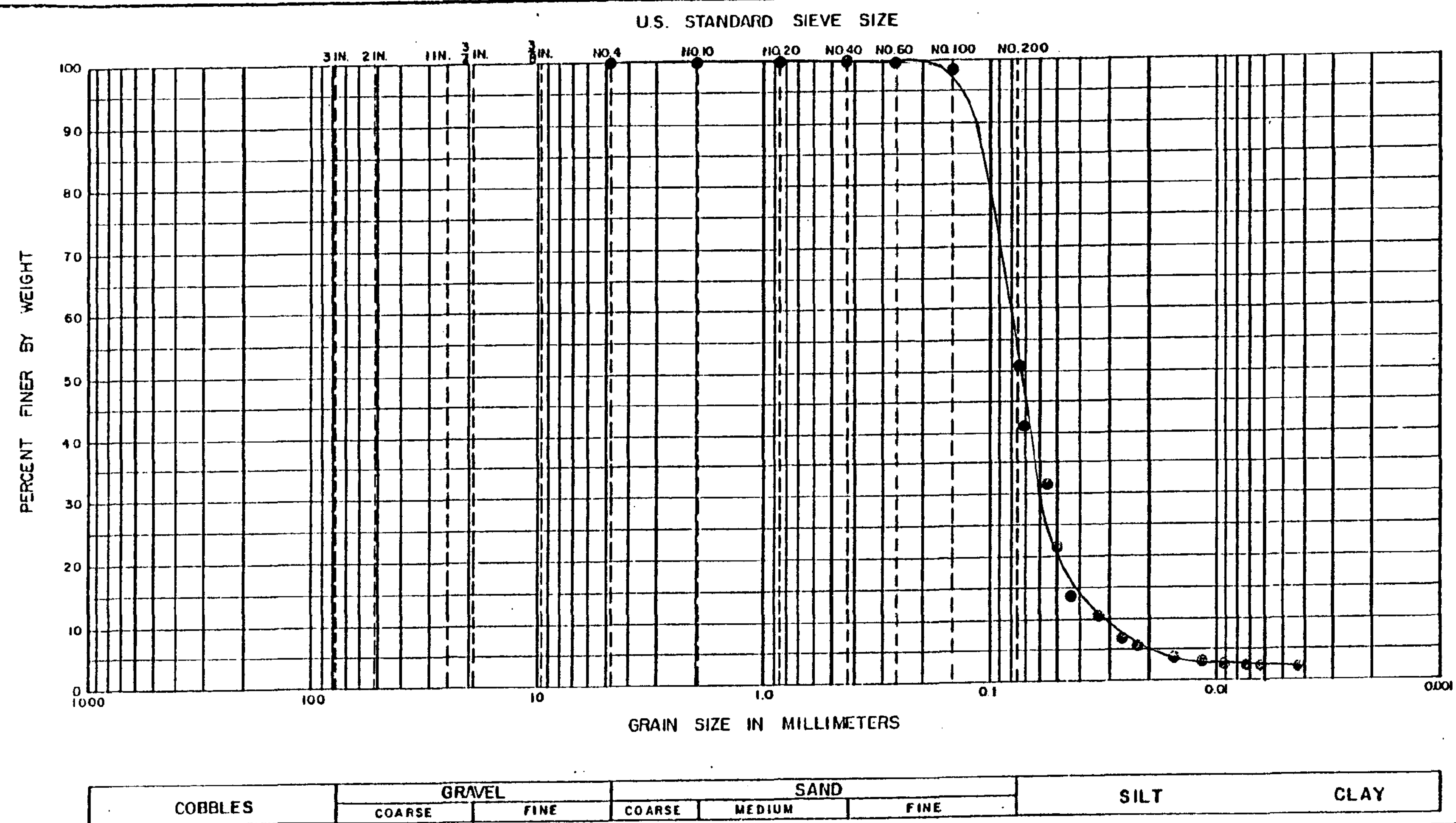
C E MAGUIRE, INC.

PROJECT DAVISVILLE PORT EXPANSION

AREA DAVISVILLE, R.I.

BORING NO. BH-1

DATE



Sample No.	Elev or Depth	Classification	NatWC	LL	PL	PI
S-5	20'	GRAY-BROWN, MEDIUM DENSE, VERY FINE SAND AND SILT (LAYERED)				

GRADATION CURVES

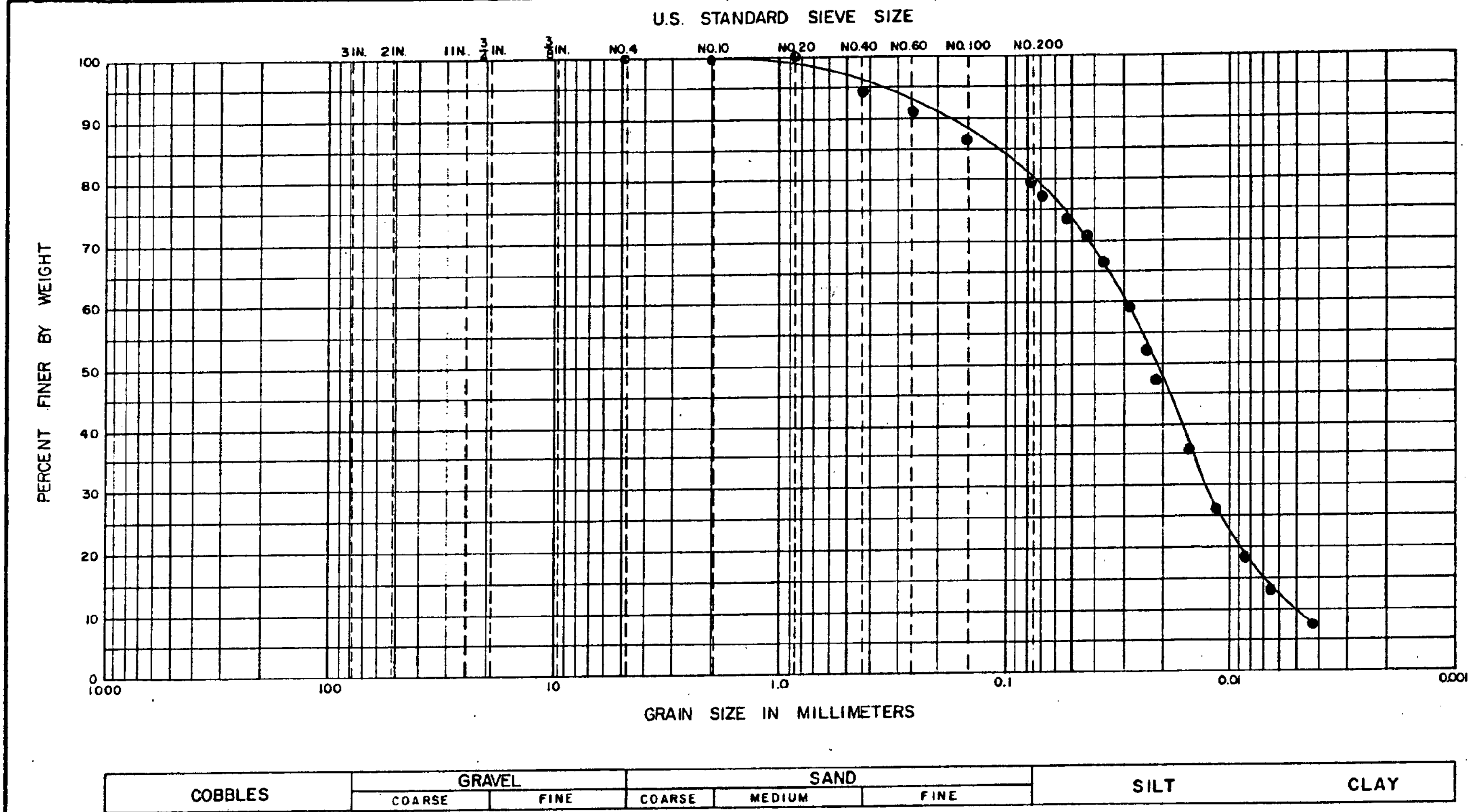
C E MAGUIRE, INC.

PROJECT DAVISVILLE PORT EXPANSION

AREA DAVISVILLE, R.I.

BORING NO. BH-1

DATE



Sample No.	Elev or Depth	Classification	NatWC	LL	PL	PI
S-7	30'	GRAY-BROWN, SATURATED, DENSE SILT LITTLE FINE SAND				

GRADATION CURVES

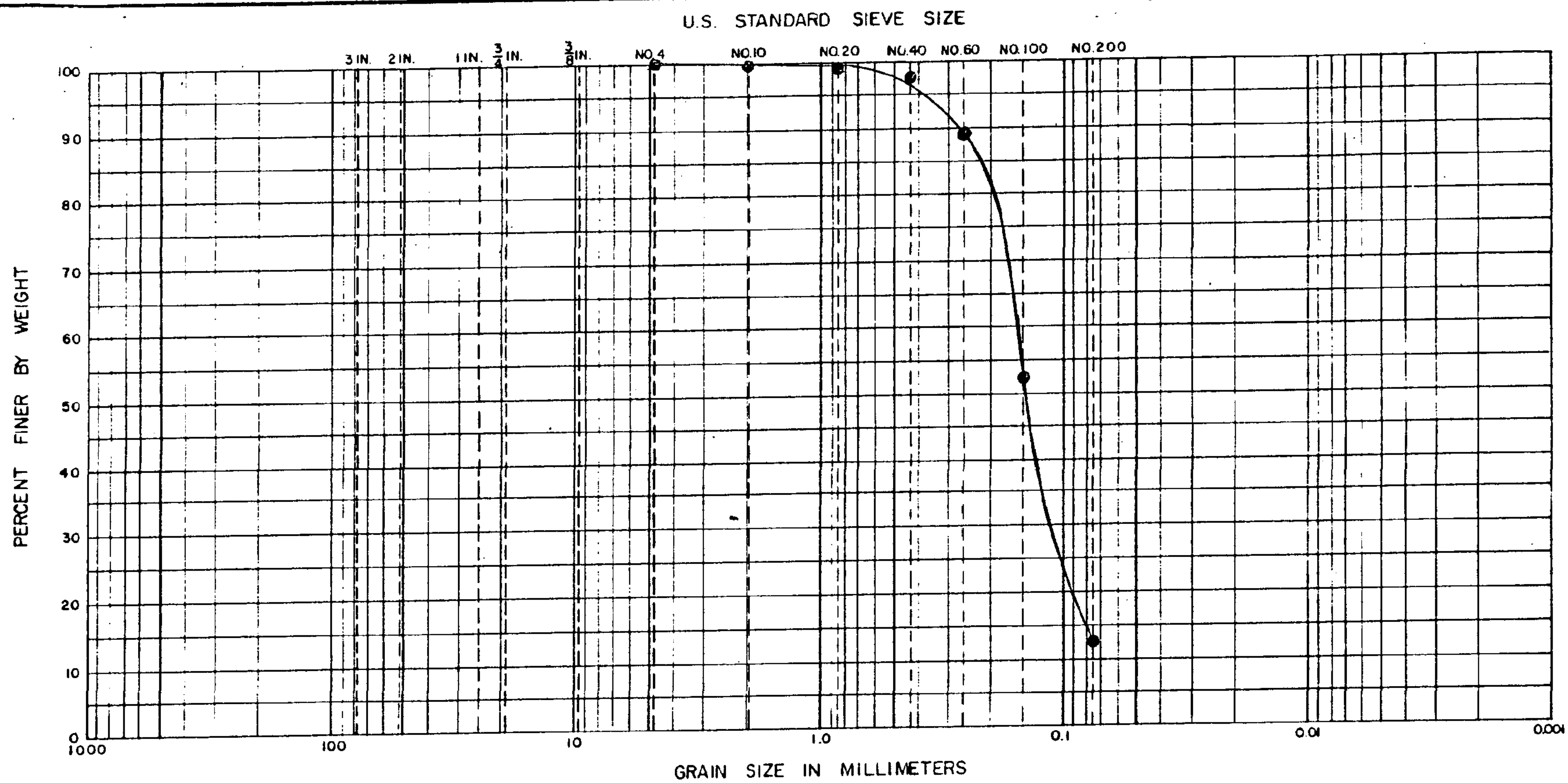
C E MAGUIRE, INC.

PROJECT DAVISVILLE PORT EXPANSION

AREA DAVISVILLE, R.I.

BORING NO. BH-4

DATE



COBBLES	GRAVEL		SAND			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

Sample No.	Elev or Depth	Classification	NatWC	LL	PL	PI	
S-3, S-4	10'–16'-6"	BROWN, SATURATED, MEDIUM DENSE, FINE SAND, LITTLE SILT, TRACE MEDIUM SAND					

GRADATION CURVES

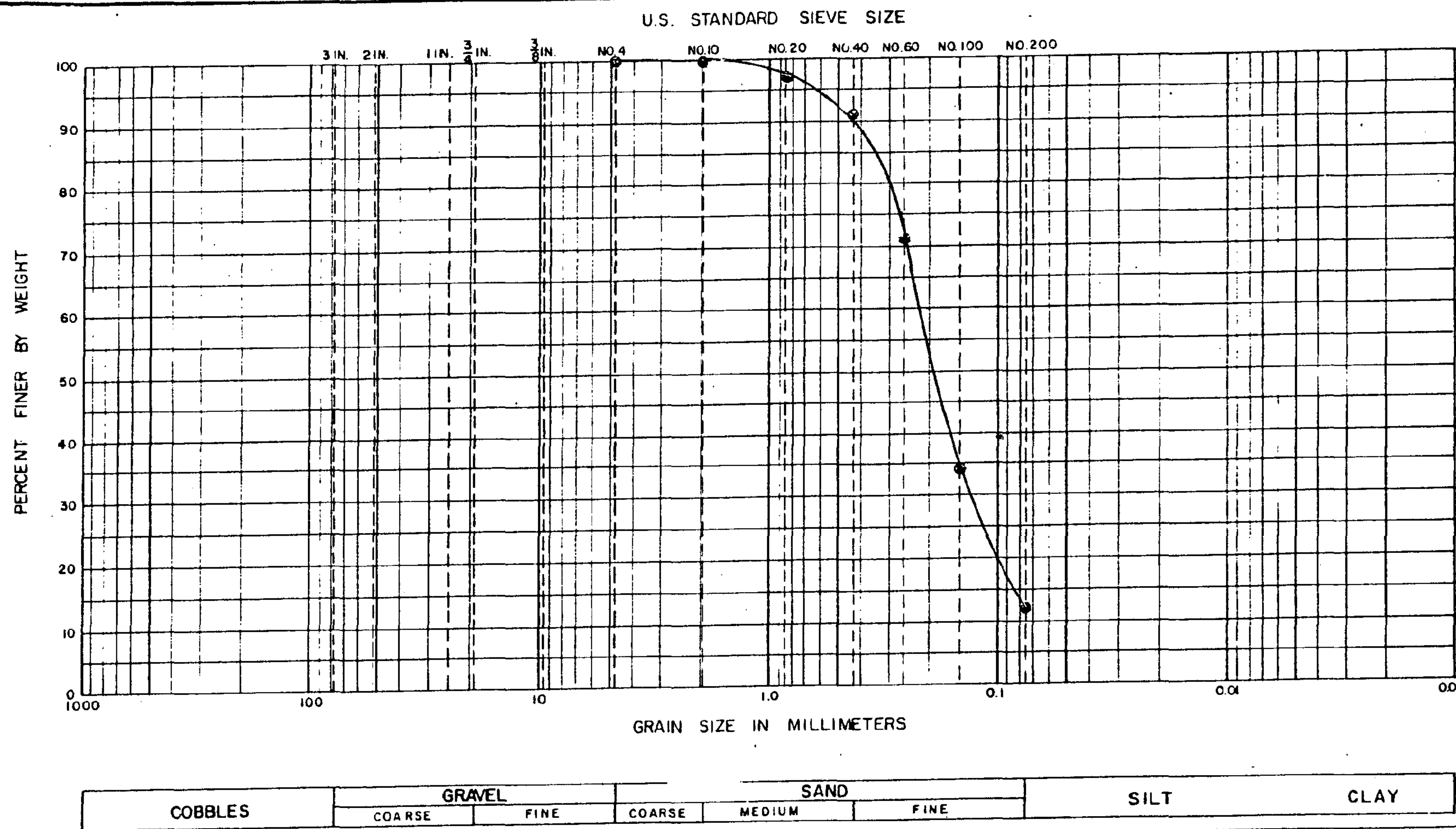
C E MAGUIRE, INC.

PROJECT DAVISVILLE PORT EXPANSION

AREA DAVISVILLE, R.I.

BORING NO. BH-7

DATE



Sample No.	Elev or Depth	Classification	NatWC	LL	PL	PI
S-5	20'	DARK BROWN, SATURATED, DENSE, VERY FINE / MEDIUM SAND, LITTLE SILT				

GRADATION CURVES

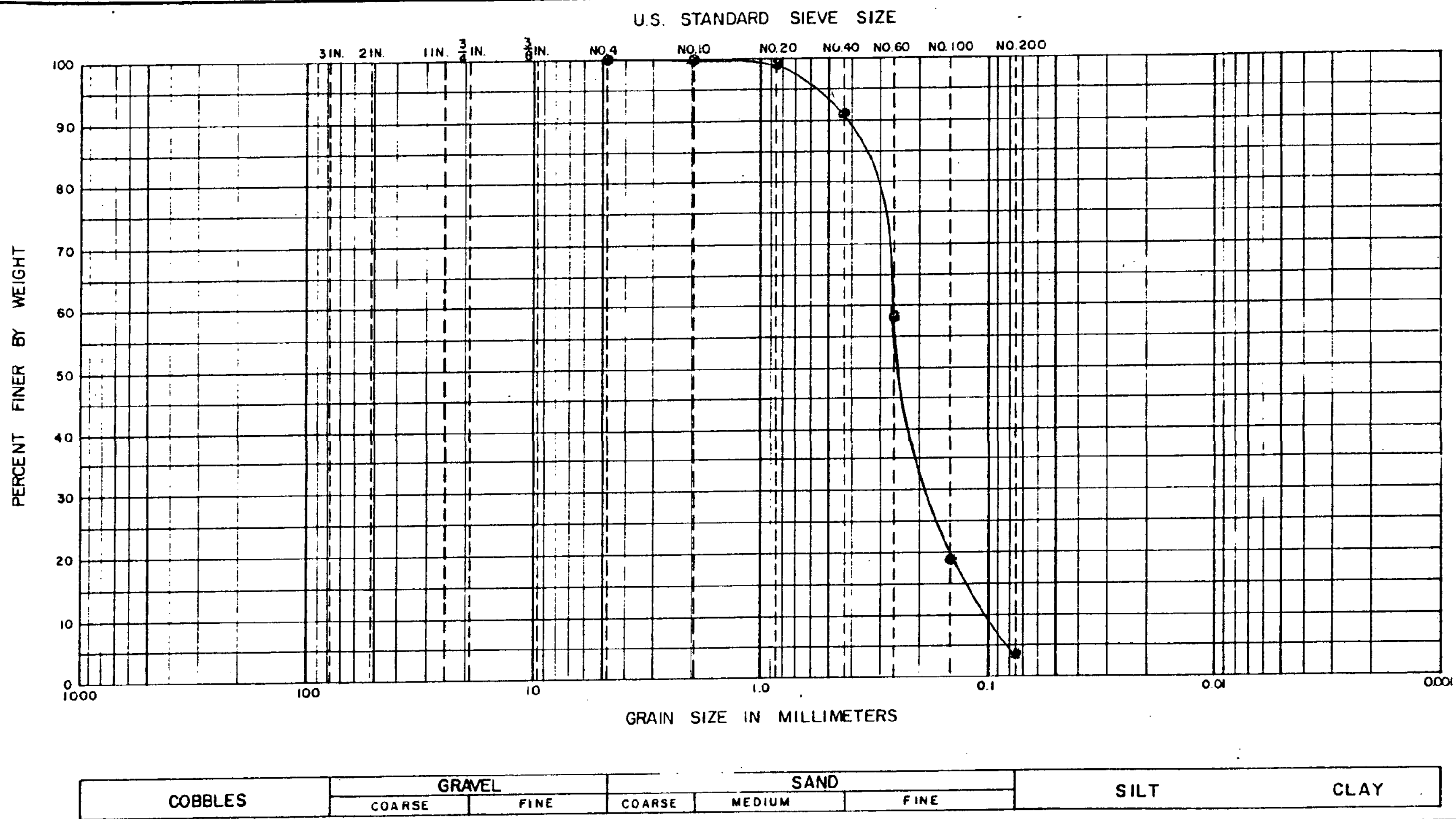
C E MAGUIRE, INC.

PROJECT DAVISVILLE PORT EXPANSION

AREA DAVISVILLE, R.I.

BORING NO. BH-18

DATE



Sample No.	Elev or Depth	Classification	NatWC	LL	PL	PI
S-5	15' - 21'-6"	BROWN, SATURATED, LOOSE/MEDIUM DENSE, VERY FINE TO MEDIUM SAND, TRACE SILT				

GRADATION CURVES

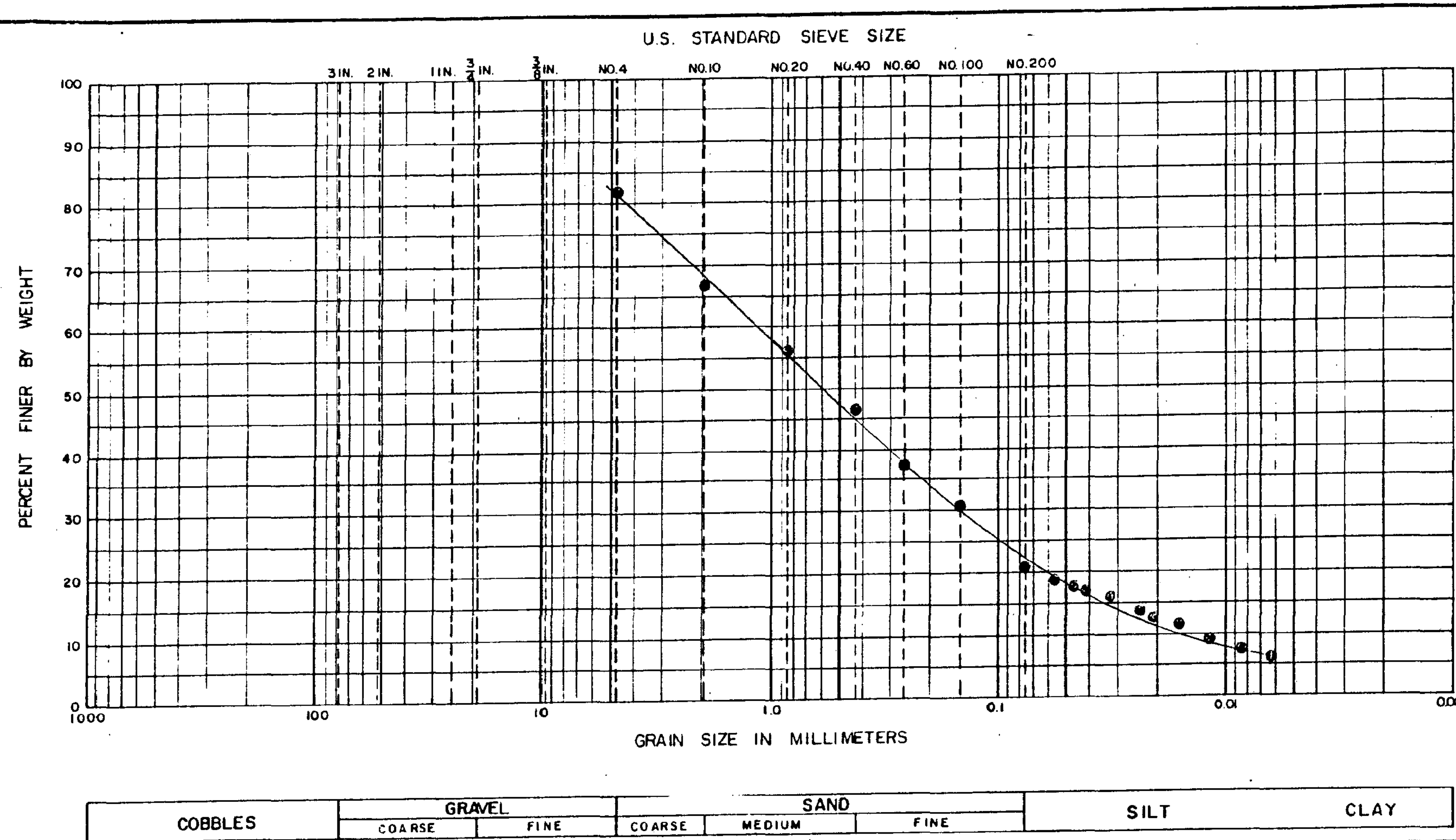
C E MAGUIRE, INC.

PROJECT DAVISVILLE PORT EXPANSION

AREA DAVISVILLE, R.I.

BORING NO. BH-15

DATE



Sample No.	Elev or Depth	Classification	NatWC	LL	PL	PI	
S-8	35'	DARK GRAY, SATURATED, VERY DENSE FINE/COARSE SAND, LITTLE SILT, LITTLE FINE GRAVEL					

C E MAGUIRE, INC.

PROJECT DAVISVILLE PORT EXPANSION

AREA DAVISVILLE, R.I.

BORING NO. BH-4

DATE

GRADATION CURVES

F

APPENDIX F

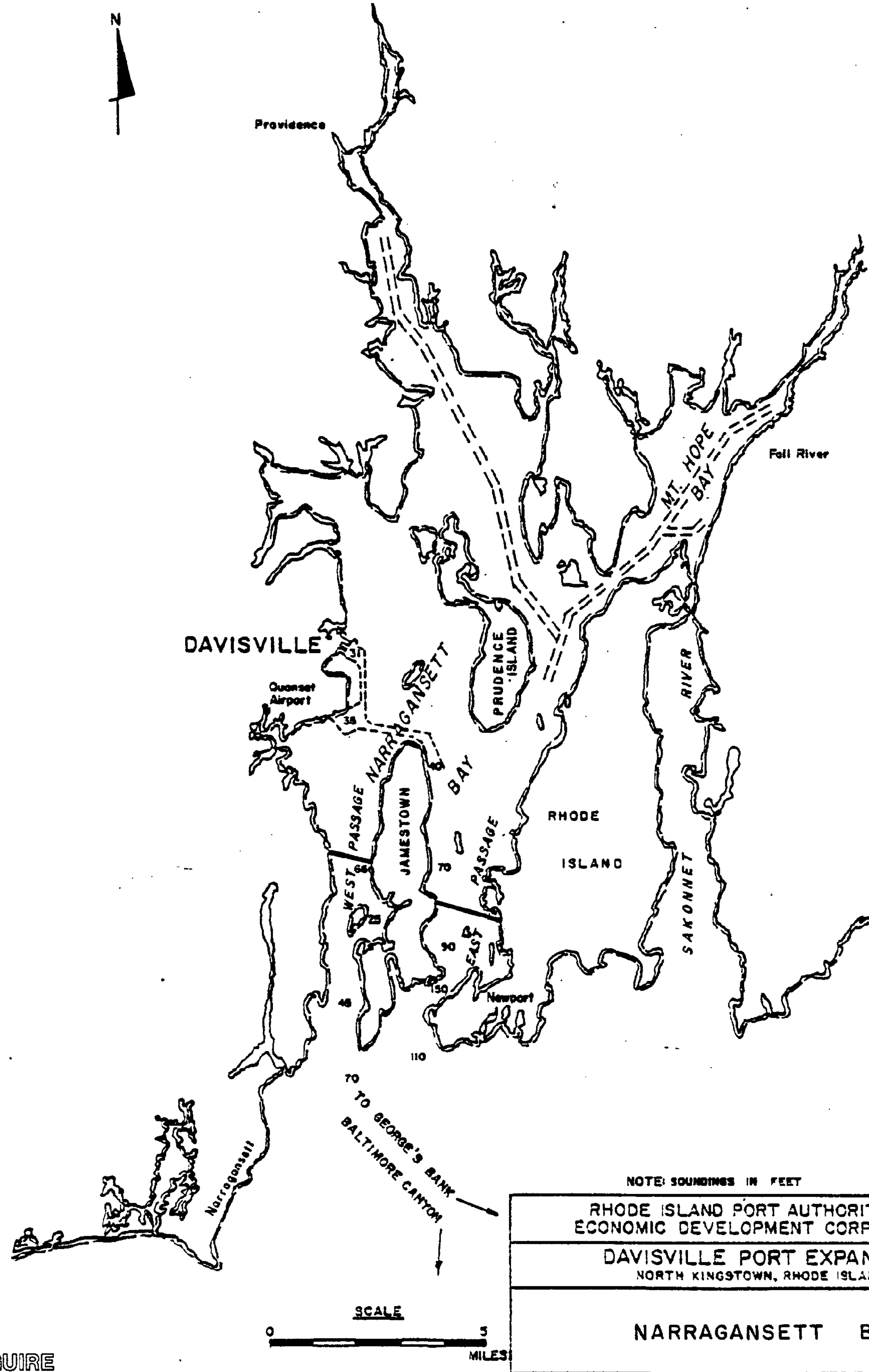
OCEAN ENGINEERING ANALYSIS

A. Introduction

Baseline data for the oceanographic analysis was obtained from meteorological information from the National Climatic Center, Ashville, N.C., Army Corps of Engineers, New England Division, Hurricane Study for Narragansett Bay, and hind-casting methodology for wave prediction utilizing solitary wave theory. The oceanographic analysis consists of review of normal wind and wave conditions, extreme wind and wave criteria, frequency of tidal flooding and storm surge analysis.

B. General Conditions of Narragansett Bay

Narragansett Bay (See Figure F-1) reaches inland about 26 miles in a northerly direction from the ocean to Providence and has a water area, including Mt. Hope Bay and the Sakonnet River, of approximately 140 square miles. The width of the bay across the mouths of the East and West Passages is 4 miles, and across the mouth of the Sakonnet River at Sachuest Point is slightly over 2.5 miles. The widest stretch of bay is just south of Prudence Island where there is close to 6 miles of open water. Depths range from shallow and shoal water in the innumerable small inlets and indentations in the Upper Bay down to 50 feet in the lower West Passage, 160 feet in the East Passage, and 50 feet in the mouth of the Sakonnet River. South of Narragansett Bay is Rhode Island Sound and the Atlantic Ocean, with Block Island



RHODE ISLAND PORT AUTHORITY AND ECONOMIC DEVELOPMENT CORPORATION

DAVISVILLE PORT EXPANSION
NORTH KINGSTOWN, RHODE ISLAND

NARRAGANSETT BAY

MAGUIRE
Architects • Engineers • Planners
CE MAGUIRE, INC. Providence, Rhode Island

DATE JAN., 1981	SCALE AS SHOWN	FIGURE NO. F-1

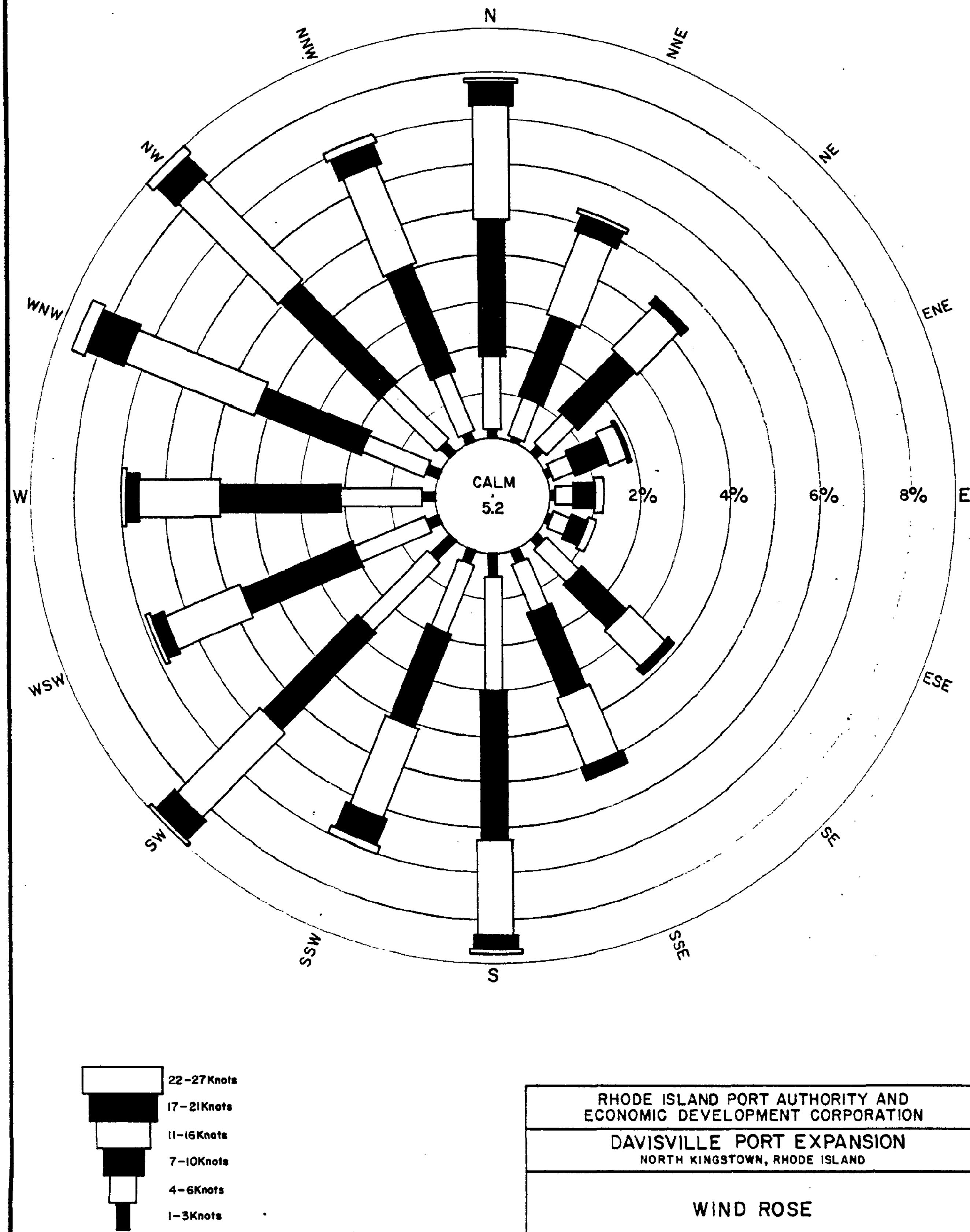
Sound and Long Island Sound to the west and Buzzards Bay and the Elizabeth Islands to the east. Approximately 90 miles outside the bay lies the edge of the Continental Shelf where the water drops in depth from 600 feet to 3,000 feet in 12 miles.

C. Winds

1. Normal Conditions

Wind records were obtained from the National Climatic Center, in Asheville, North Carolina, for the Providence area. Table F-1 is an annual summary for 1978. The period of record for information presented in Table F-2 is from 1941 to 1970. The period of record for frequency distribution information, shown graphically in Figure F-2, is from 1951 to 1970.

Under normal conditions, the average wind speed is 9.3 knots (10.7 mph), from the southwest. However, both wind direction and speed vary seasonably. Generally, the wind is from the northwest during the winter months of December, January, and February, with an average velocity of 10.0 knots (11.5 mph). In spring, there is a transition from northwest winter winds to the southwest and, with the beginnings of a sea breeze, there may be frequent gustiness. Average spring wind velocity is 10.3 knots (11.8 mph). Summer winds of June, July, and August are generally milder and from the south or southwest, with an average velocity of 8.5 knots



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RHODE ISLAND PORT AUTHORITY AND
ECONOMIC DEVELOPMENT CORPORATION

DAVISVILLE PORT EXPANSION
NORTH KINGSTOWN, RHODE ISLAND

WIND ROSE

DATE JAN., 1981	SCALE	FIGURE NO. F-2

TABLE F-1

WIND INFORMATION

Annual Summary for 1978

Station: Providence, Rhode Island

Month	Resultant Direction	Resultant Speed (mph)	Average Speed (mph)	Maximum Speed	Direction	Date
January	28	4.7	11.8	46	20	26
February	31	6.0	9.0	29	05	6
March	29	4.7	11.0	31	28	22
April	30	4.6	11.9	33	29	2
May	16	0.8	10.6	28	03	16
June	24	4.6	10.3	23	30	14
July	22	3.2	10.0	23	01	5
August	25	1.9	8.2	21	35	4
September	28	1.7	9.2	22	34	28
October	27	3.3	9.3	24	20	25
November	34	3.5	9.4	24	21	14
December	28	6.8	10.7	32	30	18
Year	28	3.2	10.1	46	20	Jan. 26

Wind Direction: Numerals indicate tens of degrees clockwise from true north.

TABLE F-2

MEAN AND EXTREME WINDS AT PROVIDENCE

1953 - 1978

	MEAN WINDS		EXTREME WINDS		
Month	Mean Speed (mph)	Prevailing Direction	Speed (mph)	Direction	Year
January	11.5	NW	46	20	1978
February	11.7	NNW	46	16	1972
March	12.3	WNW	60	18	1959
April	12.3	SW	51	20	1956
May	11.0	S	42	20	1956
June	10.0	SW	40	20	1957
July	9.5	SW	35	34	1964
August	9.3	SSW	90	11	1964
September	9.5	SW	58	18	1960
October	9.7	NW	41	14	1954
November	10.5	SW	52	18	1957
December	11.0	WNW	48	14	1957
Yearly Average	10.7	SW	90	11	Aug. 1954

(9.7 mph). In the fall, there is more equal distribution of wind direction generally from the west, with an average speed of 8.7 knots (10.0 mph).

From an analysis of wind frequency percentages, the wind speed is below 24 mph 98.1 percent of the time, on an annual average. From any direction, the wind speed between 25 and 31 mph is 1.7 percent, and greater than 32 mph, the frequency drops to 0.2 percent, from any direction.

2. Extreme Conditions

The most extreme cases in record in recent history (recorded in the twentieth century) of storms and hurricanes in Rhode Island are the hurricanes of September, 1938, September, 1944, and August, 1954, (see Table F-3). In 1938, the most severe of the three, the five-minute sustained maximum wind velocity measured at Providence was 95 mph from the southwest, with gusts reaching 125 mph. The maximum five-minute sustained wind measured in 1944 at Warwick was 49 mph from the southeast, with gusts reaching 90 mph. The maximum five-minute sustained wind velocity from the 1954 hurricane, also measured in Warwick, was 90 mph from the east-southeast, with gusts reaching 105 mph.

D. Bathymmetry

Wave behavior is directly related to the bottom topography adjacent to the project site. The hydrographic surveys conducted for

TABLE F-3

HURRICANE WIND VELOCITIES

Date	Station	Sustained Wind Velocity		Peak Gust Direction	Peak Gust Speed
1938, September	Providence	5-minute	95 mph	SW	125 mph
1944, September	Warwick	1-minute	49 mph	SE	90 mph
1954, August	Warwick	1-minute	90 mph	ESE	105 mph

this analysis indicate a low wave energy environment. The bathymmetry is characterized by very gently sloping and extremely regular bottom surface. The bottom of the "Dogpatch" area is characterized by a surface sediment of brown fine sand. Sediment size is a good indicator of the type of wave activity in an area, since fine material would be kept in suspension in a more active environment. Similarly, the area north of Piers 1 & 2 is also very shallow with very slightly undulating surface topography. The surface sediment is typically a dark grey organic silt which indicates very little wave activity, and is characteristic of many sheltered areas of Narragansett Bay. Consequently, the worst approaching waves will neither converge nor diverge on the proposed bulkhead alignments. With a given local bottom topography, incoming waves will be refracted, similar to what happens when a light ray hits glass and bends through the new medium. As the wave train bends to align with bottom contours, the wave energy may be either focused on or diverted from points along the coastline. For instance, wave energy will be concentrated on protruding headlands, and will be diminished in embayments and coves, contributing to the protective quality of natural harbors. There will not be a focus of wave energy on the proposed structure in the Davisville area.

The waves approaching any of the proposed bulkhead alignments are shallow water waves and during storm conditions would be shallow water waves or in the transitional range between shallow and deep water waves for waves with periods between 4 and 8 seconds.

E. Waves

1. General

The wave heights generated at the project site are dependent on three factors:

a) The velocity of the wind which blows across the surface of the water;

b) The duration, or length of time for which the wind blows; and,

c) The fetch, or unobstructed distance of water over which the wind blows.

Fetch lengths relative to the location of the project are approximately:

From the northeast	3½ nautical miles
From the east	4 nautical miles
From the southeast	6 nautical miles

Water depths over these fetch lengths range between 20 and 70 feet below MLW, with an average depth over the area of 25 feet below MLW. Shallow water wave forecasting was based on these depths.

A north-south approach channel, 500 feet wide, to the Davisville site is maintained at a dredge depth of 31 feet MLW broadening into a channel 1,500 feet wide at a depth of 27½ feet MLW. Water depths adjacent to each of the existing pier facilities at Davisville are generally 30 feet MLW or greater.

2. Normal Waves

Wave conditions at the site are generally mild, due to the protected nature of the many coves and indentations of Narragansett Bay. The primary force responsible for wave generation in the bay is the surface drag and frictional stress of the wind as it blows across the water. Long-period ocean swells are effectively limited from the area by the bathymetry of the bay.

It is accepted practice, in the absence of recorded wave height data, to utilize wind data in forecasting wave conditions at a particular site. Based on fetch length, water depth, and wind velocity, the significant wave height (average height of the one-third highest waves of a given wave group) and significant wave periods can be established. Table F-4 shows the significant waves developed for a given wind speed over the fetches available to the project site. The longest fetch available is to the southeast, and under normal conditions, with a wind speed of 20 mph, the generated wave height is 1.8 feet, having an associated period of 2.8 seconds. Waves generated from the east or northeast are slightly less.

TABLE F-4

SHALLOW WATER WAVE ANALYSIS

Fetch = 3½ nautical miles from the Northeast
Fetch = 4 nautical miles from the East
Fetch = 6 nautical miles from the Southeast

	Wind Speed V (mph)	Significant Wave Height H_s (feet)	Significant Wave Period T_s (sec.)
Constant Water Depth of 20 feet:			
From Northeast	20	1.4	2.4
	40	2.7	3.3
	60	3.8	4.0
	80	4.7	4.5
From East	20	1.45	2.5
	40	2.8	3.4
	60	3.9	4.1
	80	4.8	4.6
From Southeast	20	1.7	2.7
	40	3.0	3.6
	60	4.1	4.3
	80	5.0	4.8
Constant Water Depth of 25 feet:			
From Northeast	20	1.5	2.5
	40	3.0	3.5
	60	4.5	4.2
	80	5.9	4.7
From East	20	1.6	2.6
	40	3.2	3.6
	60	4.7	4.3
	80	6.0	4.8
From Southeast	20	1.8	2.6
	40	3.6	3.8
	60	5.2	4.6
	80	6.5	5.3

TABLE F-4

SHALLOW WATER WAVE ANALYSIS

(Continued)

	Wind Speed V (mph)	Significant Wave Height H_s (feet)	Significant Wave Period T_s (sec.)
Constant Water Depth of 30 feet:			
From Northeast	20	1.5	2.5
	40	3.2	3.6
	60	4.8	4.3
	80	6.2	4.8
From East	20	1.6	2.6
	40	3.3	3.7
	60	5.0	4.4
	80	6.5	5.0
From Southeast	20	1.8	2.8
	40	3.8	4.0
	60	5.5	4.8
	80	7.0	5.4

NOTE: Depth of water influences height of shallow water waves generated. Depths analyzed above correspond to approximate Mean Low Water depth of the adjacent channel area, approximate high tide and a seven-foot surge over Mean Sea Level (5-feet over Mean High Water), which corresponds approximately to a 5-year storm.

Since the percentage of time that wind speeds are greater than 21 knots (24 mph) is very low (less than 1.9 percent), the occurance of waves heights greater than 2 feet is limited.

3. Extreme Waves

Data on wave heights during storms and hurricanes in Narragansett Bay are not clearly established; however, during a hurricane survey in Narragansett Bay by the Army Corps of Engineers, New England Division, significant wave heights propagated from the open ocean were tabulated for various sections of the bay and are given in Table F-5.

Based on an analysis of previous storm conditions in the bay, for a given sustained wind speed of 60 mph from an easterly, northeasterly, or southeasterly direction, the resultant significant wave height is five feet, which has been selected for further wave analysis including wave run-up and overtopping of the proposed facility. This assumes a fairly constant water depth of 30 feet in the nearshore vicinity which is conservative in this analysis. Under hurricane conditions, with winds from south, it is conceivable that significant wave heights in the middle portion of the West Passage could reach 7.5 feet.

TABLE F-5

HURRICANE WINDS - WINDS FROM THE SOUTH

Location	Significant Wave Height (feet	Wave Period (seconds)
Lower Bay, East Passage	25.0	11.0
Lower Bay, West Passage	20.0	11.0
Middle Bay, East Passage	6.0	5.0
Middle Bay, West Passage	7.5	5.5
Tiverton - Island Park	9.0	7.0
Fields Point	8.0	6.0
Fox Point	6.0	5.0

SOURCE: Army Corps of Engineers, New England Division
"Hurricane Survey, Narragansett Bay Area", 1957

F. Tides

1. Normal

The entire bay area experiences two high and two low tides each lunar day. The time between high and low tide varies between 4 hours, 41 minutes, and 7 hours, 47 minutes, averaging 7 hours, 12 minutes. The greatest variation - both in range and in time lag - occurs at times of spring tides, which prevail at new and full noons. The mean tide range at Wickford Harbor adjacent to the project site, is 3.8 feet, and the spring range is 4.7 feet. Tidal ranges for various locations within Narragansett Bay are presented in Table F-6.

2. Extreme

During strong, coastal storms such as a northeaster, tide levels build up within the confines of the bay, frequently one to two feet above predicted elevations. During severe storms and hurricanes, the tidal storm surge can far exceed normal storm tide elevations.

During the hurricane of September 21, 1938, the tide rose to 15.7 feet above NGVD. During the hurricane of September 14-15, 1944, tidal elevations were 9.9 feet above NGVD. The hurricane of August 21, 1954 caused water levels in the upper bay to rise 14.7 feet above NGVD. When severe storm such as the above, occur coincident with low pressure,

TABLE F-6

ASTRONOMICAL TIDES FOR NARRAGANSETT BAY

	Newport	Providence	Fall River
Mean Range (feet)	3.5	4.6	4.4
Mean Low Water (below NGVD)	1.6	2.2	2.1
Mean High Water	1.9	2.4	2.3
Average Spring Tide Range (feet)	4.4	5.7	5.5
Maximum Spring Tide (above NGVD)	3.3	3.9	3.8
Minimum Low Water (below NGVD)	4.1	5.2	5.1

strong southerly winds, and at times of high predicted astronomical tide, the resultant surge produces extreme water elevations.

The hurricane tide corresponding to a 500-year event is 18.7 feet above NGVD at Providence. The 10- and 20-year events are 10.3 and 12.0 feet above NGVD, respectively. The ten-year event was selected for further analysis. Tidal surge elevations are slightly higher at Providence than in Davisville because of the funneling effect of bay geomorphology.

G. Wave Run-Up and Overtopping Analysis

Wave run-up (the vertical height above the still water level, SWL, to which water from an incident wave will run-up the face of the structure) was analyzed for the case of a vertical wall impinged upon by a design storm wave of five feet.

Assuming a ten-year frequency of tidal surge at 10.3 feet above NGVD, run up for the five foot wave is 9.7 feet above SWL. This represents a vertical distance of 22 feet above MLW in order to prevent overtopping of the bulkhead for a storm of this frequency. This elevation is much too high for the apron of a port facility. It is therefore impractical to design for a "no-overtopping" condition. A modified solution has been selected which represents minimal overtopping under normal conditions. It must be recognized that under infrequent storm conditions there is likely to be significant wave run-up and consequent overtopping.

Given the frequencies of tidal flooding as developed by the Army Corps of Engineers, New England Division, and applying the design storm wave of 5 feet to a structure crest evelation of +10 MLW, the anticipated rate of storm wave overtopping is approximately 11 cubic feet per second per linear foot (cfs/l.f.). With the inevitable onshore winds blowing under these circumstances, the overtopping rate could be increased an additional 20 to 50%.

H. <u>Range of Depth of Breaking Waves</u>

As the wave propagates into shallow water, the wave form increases in height until a point of instability is reached. This "limiting steepness" is a function of the relative depth (ratio of depth of water to wave length) and the beach slope. Determination of the depth that initiates breaking in this analysis was based upon a wave height of 5 feet, period of 6 seconds and a bottom slope of 1:50. The relationships were used are from modifications to solitary wave theory by Goda (1970) accounting for variations in beach slope. The analysis indicates that the wave will break when it is approximately 330 feet from the shoreline, assuming in fairly constant nearshore slope.

Since the breaking point of a wave is a midpoint in the range of initial instability and complete breaking, the actual depth that initiates breaking in a structure is really some distance seaward.

I. Currents

The currents in the major portion of Narragansett Bay are generally weak and variable. There is a pronounced irregularity which is evidenced at times during the month by a long period of slack water preceding the flood and at other times by a double flood of two distinct maximums of velocity separated by a period of lesser velocity. While the flood current is sometimes unstable, the ebb current is fairly regular. In the vicinity of Wickford Harbor, and Davisville, currents, both ebb and flow, have average maximum velocities of 0.3 knots. Currents may be slightly higher during times of spring tides and during storms, as an increase in volume of water surging into the bay will increase water velocity.

J. Armor Stone Shore Protection

The size of rip rap stone to be used in armoring fill slopes was determined by Hudson's formula, to be approximately 300 pound stone for the outer layer with properly graded filter stones underneath. This figure is based on the significant design wave height of five feet propagated shoreward while undergoing shoaling and minor refraction, resulting in a three feet wave nearshore impinging on the rock slope. This armor stone layer will be sufficient for maintaining the desired nearshore fill slope as well as providing for storm wave and propellor backwash protection.

G

APPENDIX G

ECONOMIC ANALYSIS

Cost estimates have been prepared based on September, 1980 construction prices and esculated as appropriate in accordance with "Engineering News-Record" Construction Cost Indexes. General Contractor's overhead and profit has been included in each unit price and a contingency factor of 20 percent applied to the cost estimate. Quantities were determined from site investigations and facilities as shown on Figures IV-1 through IV-6. Table G-1 presents a summary of the budget cost estimates for the six primary alternates. The budget cost, have been esculated to a mid-point of construction of September, 1982. Total project costs have also been prepared to include costs associated with engineering and technical services. The remainder of this Appendix presents an economic analysis of the project in terms of structural elements and overall configuration costs which led to the budget costs presented in Table G-1.

The first step in preparing cost estimates for this project was to determine the costs of various waterfront structural systems that could be utilized for providing berth space. To allow for comparison on an essentially equivalent basis, a set of five basic assumptions were made:

1. Costs have been prepared specifically for site conditions at Davisville.

TABLE G-1

BUDGET COSTS OF ALTERNATE CONFIGURATIONS

	Alternate	Budget Cost*	Total Project** Cost Estimate
1.	Development of 2,400 l.f. of berth in Dogpatch area 46 acres of new land.	$11,382,000	$12,155,000
2.	Increment 1 - development of 675 l.f. of berth in Dogpatch, 18 acres of new land.	$ 6,071,000	$ 6,513,000
	Increment 2 - expansion of 1,725 l.f. of berth, 28 acres of new land.	$ 8,010,000	$ 8,542,000
	Total Expanded Alternate 2	$14,081,000	$15,055,000
3.	Development of 3,000 l.f. of berth, 120 acres of new land between Davisville and Airport.	$47,858,000	$50,856,000
4.	Development of 2,300 l.f. of berth north of Pier 2, 30 acres of new land.	$12,744,000	$13,729,000
5.	Rehabilitation of 1,300 l.f. of Navy bulkhead, 1 acre of new land created.	$ 6,053,000	$ 6,519,000
6.	New 300' x 1,000' pier - Pile-supported pier, 2,300 l.f. of berth, 7 acres of new area.	$33,711,000	$35,818,000
	Earthfill pier, 2,300 l.f. of berth, 7 acres of new land.	$12,966,000	$13,929,000

*Costs have been esculated to mid-point of construction of September 1982.

**Total Project Cost includes allowance for engineering and Technical Services.

2. A dredge depth of Elevation -25 MLW with filling to Elevation +10.

3. Comparison was made on a per linear foot basis for a width of structure of 150 feet (measured perpendicular to the berthing face).

4. A volume of 100 cubic yards of dredging per linear foot was allowed. For the bulkhead, relieving platform, and cofferdam options, this material was assumed to be used for landfilling. For rehabilitation of the Navy bulkhead and the pile-supported deck option, stockpiling/disposal was assumed.

5. Prices are exclusive of roadway, railroad, utilities and common site work.

The results of these cost estimates are summarized in Table G-2. As can be seen in the table, where site conditions allow, an anchored steel sheetpile bulkhead is the cost effective waterfront structure for the project. Where site conditions are less favorable (as in areas of high bedrock or loose sediments), a relieving platform is the next most economical waterfront system followed by a steel sheet pile cellular cofferdam. The most costly system was found to be the pile-supported reinforced concrete pier. Rehabilitation of the existing Navy bulkhead is appropriate only to that specific area and, therefore, is not applicable to new construction systems.

Table G-3 presents, for the five primary alternate site configurations, unit costs on the basis of cost per foot of berth length and

TABLE G-2

RELATIVE COST OF VARIOUS CONSTRUCTION METHODS

STRUCTURE	NORMALIZED COST PER LINEAR FOOT
Anchored Steel Sheet Pile Bulkhead	$ 1,635
Rehabilitation of the Navy Bulkhead	$ 1,925
Relieving Platform - Anchored Steel Sheet Pile Bulkhead with Pile Supported Deck	$ 2,585
Cellular Cofferdam	$ 3,050
Pile Supported Reinforced Concrete Pier	$ 11,500

TABLE G-3

COMPARISON OF COST FOR ALTERNATE CONFIGURATIONS

Alternate	Cost Per Foot of Berth*	Cost Per Acre of New Land *	
1	$ 4,742	$ 247,435	
3	$ 15,953	$ 398,817	
4	$ 5,541	$ 424,800	
5	$ 4,656	N/A**	
6	$ 14,657	$4,815,857	Pile-supported deck
	$ 5,637	$1,852,286	Earthfill

* Costs have been esculated to a mid-point of construction of September 1982. Do not include Engineering and Technical Services.

** Cost per acre is not applicable to Alternate 5, rehabilitation of the Navy Bulkhead.

cost per acre of newly created land. These two units were utilized because they are elements most essential to port facilities. Alternate 2, which is an incremental expansion, has been eliminated from this comparison to avoid confusion and will be discussed later in this Appendix.

The data presented in Table G-3 indicates that the least cost method of expansion at Davisville is Alternate 1 both in terms of new land created and berth length.

It should be noted that a portion of the northern limit of the Dogpatch development of Alternate 2 will take place on Navy property. In addition other work will be required on Navy property for utilities and for connecting the new bulkhead to the existing bulkhead. At present, much of this area is below the mean high water level and the remainder is undeveloped low lying area not now useable by the Navy. It has been assumed that easements with mutually beneficial terms can be negotiated for the use of this property. Development can occur in the Dogpatch area without doing work on Navy property, however, there would be a reduction in both berth length and new land area without a corresponding reduction in price. This would result in unit costs for development in the Dogpatch area higher than those presented for Alternate 1.

If no supporting land was needed, Alternate 5 could be an economical option for providing berth space. It is noted that the cost estimate for Alternate 5 is within two percent of the cost estimate for Alternate 1 in terms of berth length. Within the degree of accuracy of these estimates, the two costs should be considered as equal. This option is not practical unless the Navy releases an adequate apron and access area adjacent to the bulkheads. At the time of this study, it is understood that the Navy intends to retain this property for use, since it was not declared surplus with the other Quonset/ Davisville property.

The third least cost means of expanding the port facilities at Davisville on the basis of per-foot-of-berth costs is the area north of pier 2 presented as Alternate 4. This alternate also has the third lowest cost-per-acre of new land. This alternate does not create as much acreage per unit length of berth as Alternate 1. A more costly method of providing the required port facilities is the pier (Alternate 6). If land area is a requirement in port expansion, a pier is not a very economical method of accomplishing this end.

Of the alternates considered, the most costly on a per-foot-of-berth basis was Alternate 3. This is due primarily to the large quantity of borrow material necessary to create the land. The high unit cost and overall total cost of Alternate 3, coupled with the lack of justification for the large acreage created, resulted in this alternate not being recommended for consideration.

Based upon analyses performed by CE Maguire, a majority of the projected potential port users (specifically OCS support and commercial cargo) require several acres of supporting upland area per berth. For this reason, Alternate 1 was selected over Alternate 5 as the most appropriate development for Davisville.

An incremental approach to the development of the recommemded configuration (Alternate 1) was also investigated. This development has been presented as Alternate 2 which would produce 675 feet of new berth space. Table G-4 presents budget cost estimates for Alternates 1 and 2. This table shows the affect that incremental development has on unit costs. The per-foot-of-berth cost for the first increment is significantly higher and the second increment cost slightly lower than if the project was built in one phase as with Alternate 1. The per-acre-of-new-land cost for incremental development are higher for both phases. The total cost for the project when completed in two phases is about 20 percent higher than one-step construction. A similar premium would be associated with the incremental development of any alternative.

With all alternates, there are certain costs that are essentially fixed, and do not vary significantly, regardless of the length of berth. These including the cost of bringing road, rail and utility services to the site, contractor mobilization, and disposal area preparation. For this reason, the first phase cost of the incremental development appears abnormally high when looked at from an overall unit cost such as cost per foot of berth. Cost of subsequent phases of an incremental approach appear lower because the costs of providing services to the site have already taken place. The total of all increments higher than if the project was constructed all at once.

TABLE G-4

INCREMENTAL DEVELOPMENT OF DOGPATCH AREA*

	Budget Cost	Cost Per Foot of Berth	Cost Per Acre of New Land
Alternate 1 (one phase)	$11,382,000	$ 4,742	$ 247,435
Alternate 2 (two phases)			
Phase 1	$ 6,071,000	$ 8,994	$ 337,278
Phase 2	$ 8,010,000	$ 4,643	$ 286.071
Total phase 1 and 2	$14,081,000	$ 5,867	$ 306,109

* Costs have been esculated to a mid-point of construction of September 1982. Costs do not include engineering and technical services.

This is the result of paying for fixed cost such as mobilization each time a contract is begun. An additional factor is that all land filling alternates require closure dikes for each phase. The cost if the dike is essentially the same regardless of the length of the berth. For a single phase construction, the cost would only be incurred once, whereas a multi-phase development will pay for a closure structure for each phase. In addition, since there may be an imbalance of dredge and fill until the total project is completed. The incremental development costs reflect the double handling of dredge material to and from an interim stockpile area.

While incremental development results in higher project final costs, the premium may be warranted if at the time construction is begun there are uncertainities as to the operational necessity of total expansion. When expansion does occur, the economics of the various approaches can be reanalyzed incrementally. At present, it is recommended that the incremental approach be pursued as the more conservative developmental route until such time as firm user committments are obtained.

Normalized Per Foot of Berth

Budget Costs Estimates

The following are budget costs for September, 1982 for an anchored steel sheetpile bulkhead, rehabilitation of Navy bulkhead, relieving platform (pile supported deck with bulkhead), cellular cofferdam and pile supported deck. Budget costs have been based upon the following major assumptions.

1. Costs have been prepared specifically for site conditions at Davisville.
2. A dredge depth of Elevation -25 MLW with filling to Elevation +10.
3. Comparison was made on a per linear foot basis for a width of structure of 150 feet (measured perpendicular to the berthing face.)
4. A volume of 100 cubic yards of dredging per linear foot was assumed. For the bulkhead, relieving platform, and cofferdam options, this material was assumed to be used for landfilling. For rehabilitation of the Navy bulkhead and the pile-supported deck option, stockpiling/disposal was assumed.
5. Prices are exclusive of roadway, railroad and utilities.

MAGUIRE

COST ESTIMATE

PROJECT DAVISVILLE BULKHEAD - ALTERNATE STRUCTURAL SYSTEMS ACC. NO. 3603
SUBJECT ANCHORED STEEL SHEETPILE BULKHEAD
BUDGET X SHEET NO. 1 OF 5
PRELIMINARY DATE AUG. 1980
COMP. J.K.M. CHECK L.J.M. Jr. FINAL CONT. NO.

ITEM NO.	DESCRIPTION	QUANTITY UNIT	QUANTITY AMOUNT	COST UNIT		COST TOTAL
	BULKHEAD	T	0.842	1120		943
	DEADMAN	T	0.17	1080		184
	WALES	T	0.092	950		87
	TIE ROD	T	0.077	1050		81
	CONCRETE CAP	C.Y.	0.2	200		40
	DREDGE & FILL	C.Y.	100	3		300
	NORMALIZED PER FOOT OF BERTH COST			TOTAL		1635
	NOTES: 1. COST ESTIMATES ARE FOR COMPARISON OF STRUCTURAL SYSTEMS ONLY AND DO NOT REFLECT PROJECT COSTS. SEE TEXT.					
	2. COSTS BASED ON SEPTEMBER, 1980 CONSTRUCTION PRICES.					
	3. COSTS DO NOT INCLUDE CONTINGENCIES OR ENGINEERING COSTS.					
				SHEET TOTAL		

MAGUIRE

COST ESTIMATE

PROJECT DAVISVILLE BULKHEAD - ALTERNATE STRUCTURAL SYSTEMS ACC. NO. 3603
SUBJECT REHABILITATION OF NAVY BULKHEAD BUDGET X SHEET NO. 2 OF 5
PRELIMINARY DATE AUG. 1980
COMP. J.K.M. CHECK L.J.M.Jr. FINAL CONT. NO.

ITEM NO.	DESCRIPTION	QUANTITY UNIT	QUANTITY AMOUNT	COST UNIT		COST TOTAL
	BULKHEAD	T	0.91	1120		1020
	DEADMAN	T	0.17	1080		184
	WALES	T	0.092	950		87
	TIE ROD	T	0.077	1050		81
	CONCRETE CAP	C.Y.	0.2	200		40
	DREDGE & STOCKPILE	C.Y.	100	4		400
	EXCAVATE	C.Y.	19.5	4		78
	BORROW	C.Y.	5	7		35
	NORMALIZED PER FOOT OF BERTH COST			TOTAL		1925
	NOTES: SEE SHEET 1 OF 5					
				SHEET TOTAL		

MAGUIRE

COST ESTIMATE

PROJECT DAVISVILLE BULKHEAD - ALTERNATE STRUCTURAL SYSTEMS ACC. NO. 3603
SUBJECT BELIEVING PLATFORM - PILE SUPPORTED DECK WITH BULKHEAD BUDGET X SHEET NO. 3 OF 5
PRELIMINARY DATE AUG. 1980
COMP J.K.M. CHECK L.J.M. Jr. FINAL CONT. NO.

ITEM NO.	DESCRIPTION	QUANTITY UNIT	QUANTITY AMOUNT	COST UNIT		COST TOTAL
	DECK	S.F.	17.5	50		875
	PILES	L.F.	10	42		420
	SHEETING	T	0.565	1120		633
	DEADMAN	T	0.14	1080		150
	WALES	T	0.068	950		65
	TIE ROD	T	0.040	1050		42
	DREDGE & FILL	C.Y.	100	3		300
	STONE ARMOR	C.Y.	4	25		100
	NORMALIZED PER FOOT OF BERTH COST			TOTAL		2585
	NOTES: SEE SHEET 1 OF 5					
					SHEET TOTAL	

MAGUIRE

COST ESTIMATE

PROJECT: DAVISVILLE BULKHEAD - ALTERNATE STRUCTURAL SYSTEMS ACC. NO. 3603
SUBJECT: CELLULAR COFFERDAM BUDGET X SHEET NO. 4 OF 5
PRELIMINARY DATE AUG. 1980
COMP. J.K.M. CHECK L.J.M.Jr. FINAL CONT. NO.

ITEM NO.	DESCRIPTION	QUANTITY UNIT	QUANTITY AMOUNT	COST UNIT		COST TOTAL
	SHEETING	T	2.277	1120		2550
	CONCRETE CAP	C.Y.	1	200		200
	DREDGE & FILL	C.Y.	100	3		300
	NORMALIZED PER FOOT OF BERTH COST			TOTAL		3050
	NOTES: SEE SHEET 1 OF 5					
				SHEET TOTAL		

MAGUIRE

COST ESTIMATE

PROJECT DAVISVILLE BULKHEAD - ALTERNATE STRUCTURAL SYSTEMS ACC. NO. 3603
SUBJECT PILE SUPPORTED DECK BUDGET X SHEET NO. 5 OF 5
PRELIMINARY DATE AUG. 1980
COMP. J.K.M. CHECK L.J.M.Jr. FINAL CONT. NO.

ITEM NO.	DESCRIPTION	QUANTITY UNIT	QUANTITY AMOUNT	COST UNIT		COST TOTAL
	DECK	S.F.	150	50		7500
	PILES	L.F.	80	45		3600
	DREDGE & STOCKPILE	C.Y.	100	4		400
	NORMALIZED PER FOOT OF BERTH COST			TOTAL		11,500
	NOTES: SEE SHEET 1 OF 5					
					SHEET TOTAL	

Alternate Site Configuration

Budget Cost Estimates

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COST ESTIMATE

PROJECT DAVISVILLE BULKHEAD — ACC. NO. 3603

SUBJECT ALTERNATE 1 — BUDGET X — SHEET NO. 1 OF 8

PRELIMINARY — DATE SEPT. 1980

COMP. J.K.M. — CHECK L.J.M. Jr. — FINAL — CONT. NO.

ITEM NO.	DESCRIPTION	QUANTITY UNIT	QUANTITY AMOUNT	COST UNIT		COST TOTAL
	MOBILIZATION/DEMOBILIZATION	L.S.	1	200,000		200,000
	SITE WORK	L.S.	1	142,100		142,100
	ROAD					
	NEW	L.F.	3,700	50		185,000
	UPGRADE	L.F.	2,200	23		50,600
	RAILROAD					
	NEW	L.F.	5,500	70		385,000
	SWITCH	EA.	2	30,000		60,000
	WATER	L.F.	2,650	45		119,250
	SEWER	L.F.	2,700	35		94,500
	ELECTRIC, TELEPHONE, FIRE ALARM, STREET					
	LIGHTING	L.S.	1	800,000		800,000
	DREDGE & FILL	C.Y.	700,000	3		2,100,000
	EFFLUENT CONTROL	L.S.	1	225,000		225,000
	STONE ARMORED SLOPE	S.Y.	3360	50		168,000
	BULKHEAD, NEW	L.F.	2,500	1431		3,577,500
		TOTAL ENGINEERING ESTIMATE				8,106,950
		CONTINGENCY 20%				1,621,390
		SUBTOTAL				9,728,340
		ESCALATION (SEPT.'82) 17%				1,653,818
		BUDGET ESTIMATE				11,382,158
	ENGINEERING AND TECHNICAL SERVICES					773,000
	TOTAL PROJECT COST ESTIMATE					12,155,000
	ESTIMATED TIME FOR CONSTRUCTION – 18 MONTHS					
					SHEET TOTAL	

MAGUIRE

COST ESTIMATE

PROJECT: DAVISVILLE BULKHEAD ACC. NO. 3603
SUBJECT: ALTERNATE 2 - INCREMENT 1 BUDGET X SHEET NO. 2 OF 8
PRELIMINARY DATE SEPT. 1980
COMP. J.K.M. CHECK L.J.M. Jr. FINAL CONT. NO.

ITEM NO.	DESCRIPTION	QUANTITY UNIT	QUANTITY AMOUNT	COST UNIT	COST TOTAL
	MOBILIZATION / DEMOBILIZATION	L.S.	1	200,000	200,000
	SITE WORK	L.S.	1	157,000	157,000
	ROAD				
	NEW	L.F.	2300	50	115,000
	UPGRADE	L.F.	2300	23	52,900
	RAILROAD				
	NEW	L.F.	4000	70	280,000
	SWITCH	EA.	1	30,000	30,000
	WATER	L.F.	1250	45	56,250
	SEWER	L.F.	1300	35	45,500
	ELECTRIC, TELEPHONE, FIRE ALARM, STREET LIGHTING	L.S.	1	700,000	700,000
	DREDGE & FILL	C.Y.	190,000	3	570,000
	DREDGE & STOCKPILE	C.Y.	160,000	4	640,000
	EFFLUENT CONTROL	L.S.	1	200,000	200,000
	STONE ARMORED SLOPE	S.Y.	3360	50	168,000
	BULKHEAD, NEW	L.F.	775	1431	1,109,025
		TOTAL ENGINEERING ESTIMATE			4,323,775
		CONTINGENCY 20%			864,755
		SUBTOTAL			5,188,530
		ESCALATION (SEPT.82) 17%			882,050
		BUDGET ESTIMATE			6,070,580
	ENGINEERING AND TECHNICAL SERVICES				442,000
	TOTAL PROJECT COST ESTIMATE				6,513,000
	ESTIMATED TIME FOR CONSTRUCTION - 15 MONTHS				
				SHEET TOTAL	

MAGUIRE

COST ESTIMATE

PROJECT DAVISVILLE BULKHEAD ACC. NO. 3603
SUBJECT ALTERNATE 2 - INCREMENT 2 BUDGET X SHEET NO. 3 OF 8
COMPLETION OF ALTERNATE 2 TO ALTERNATE 1 PRELIMINARY DATE SEPT. 1980
COMP. J.K.M. CHECK L.J.M. Jr. FINAL CONT. NO.

ITEM NO.	DESCRIPTION	QUANTITY UNIT	QUANTITY AMOUNT	COST UNIT		COST TOTAL
	MOBILIZATION/DEMOBILIZATION	L.S.	1	200,000		200,000
	SITE WORK	ACRE	38	1,000		38,000
	DIKING & EFFLUENT CONTROL	L.S.	1	150,000		150,000
	DREDGE & FILL	C.Y.	350,000	3		1,050,000
	FILL FROM STOCKPILE	C.Y.	160,000	3		480,000
	BULKHEAD, NEW	L.F.	1775	1431		2,540,025
	ARMORED SLOPE	S.Y.	3360	50		168,000
	ACCESS ROAD, NEW	L.F.	1400	50		700,000
	SEWER	L.F.	1400	35		49,000
	TELEPHONE, ELECTRIC, FIREALARM	L.S.	1	125,000		125,000
	WATER	L.F.	1400	45		63,000
	STORM DRAINAGE 24"	L.F.	200	35		7,000
	RAIL, NEW	L.F.	1500	70		105,000
	SWITCH	L.S.	1	30,000		30,000
		TOTAL ENGINEERING ESTIMATE				5,705,025
		CONTINGENCY 20%				1,141,005
		SUBTOTAL				6,846,030
		ESCALATION (SEPT.'82)		17%		1,163,825
		BUDGET ESTIMATE				8,009,855
	ENGINEERING AND TECHNICAL SERVICES					532,000
	TOTAL PROJECT COST ESTIMATE					8,542,000
	ESTIMATED TIME FOR CONSTRUCTION - 12 MONTHS					
				SHEET TOTAL		

MAGUIRE

COST ESTIMATE

PROJECT DAVISVILLE BULKHEAD ACC. NO. 3603
SUBJECT ALTERNATE 3 BUDGET X SHEET NO. 4 OF 8
PRELIMINARY DATE SEPT. 1980
COMP. J.K.M. CHECK L.J.M. Jr. FINAL CONT. NO.

ITEM NO.	DESCRIPTION	QUANTITY		COST		
		UNIT	AMOUNT	UNIT		TOTAL
	MOBILIZATION / DEMOBILIZATION	L.S.	1	300,000		300,000
	SITE WORK	L.S.	1	831,500		831,500
	ROAD					
	NEW	L.F.	8100	50		405,000
	UPGRADE	L.F.	2200	23		50,600
	RAILROAD					
	NEW	L.F.	8900	70		623,000
	SWITCH	EA.	3	30,000		90,000
	WATER	L.F.	6800	45		306,000
	SEWER	L.F.	6700	35		234,500
	ELECTRIC, TELEPHONE, FIRE ALARM, STREET					
	LIGHTING	L.S.	1	1,200,000		1,200,000
	DREDGE & FILL	C.Y.	1,200,000	3		3,600,000
	EFFLUENT CONTROL	L.S.	1	600,000		600,000
	BORROW	C.Y.	2,900,000	7		20,300,000
	BULKHEAD, NEW	L.F.	1800	1431		2,575,800
	RELIEVING PLATFORM	L.F.	1300	2285		2,970,500
		TOTAL ENGINEERING ESTIMATE				34,086,900
		CONTINGENCY 20%				6,817,380
		SUBTOTAL				40,904,280
		ESCALATION (SEPT. '82)		17%		6,953,728
		BUDGET ESTIMATE				47,858,008
	ENGINEERING AND TECHNICAL SERVICES					2,998,000
	TOTAL PROJECT COST ESTIMATE					50,856,000
	ESTIMATED TIME FOR CONSTRUCTION — 30 MONTHS					
					SHEET TOTAL	

MAGUIRE

COST ESTIMATE

PROJECT DAVISVILLE BULKHEAD — ACC. NO. 3603
SUBJECT ALTERNATE 4. — BUDGET X — SHEET NO. 5 OF 8
PRELIMINARY — DATE SEPT. 1980
COMP. J.K.M. — CHECK L.J.M. Jr. — FINAL — CONT. NO.

ITEM NO.	DESCRIPTION	QUANTITY UNIT	QUANTITY AMOUNT	COST UNIT		COST TOTAL
	MOBILIZATION/DEMOBILIZATION	L.S.	1	200,000		200,000
	SITE WORK	L.S.	1	89,900		89,900
	ROAD, NEW	L.F.	2200	50		110,000
	RAILROAD					
	NEW	L.F.	2600	70		182,000
	REHABILITATION	L.F.	400	40		16,000
	SWITCH	EA.	1	30,000		30,000
	WATER	L.F.	1250	45		56,250
	SEWER	L.F.	3300	35		115,500
	ELECTRIC, TELEPHONE, FIRE ALARM, STREET LIGHTING	L.S.	1	800,000		800,000
	DREDGE & FILL	C.Y.	710,000	3		2,130,000
	EFFLUENT CONTROL	L.S.	1	200,000		200,000
	STONE ARMORED SLOPE	S.Y.	1800	50		90,000
	BULKHEAD, NEW	L.F.	500	1431		715,500
	RELIEVING PLATFORM	L.F.	1900	2285		4,341,500
		TOTAL	ENGINEERING	ESTIMATE		9,076,650
		CONTINGENCY 20%				1,815,330
		SUBTOTAL				10,891,980
		ESCALATION (SEPT.'82)		17%		1,851,637
		BUDGET	ESTIMATE			12,743,617
	ENGINEERING AND TECHNICAL SERVICES					985,000
	TOTAL PROJECT COST ESTIMATE					13,729,000
	ESTIMATED TIME FOR CONSTRUCTION - 24 MONTHS					
					SHEET TOTAL	

MAGUIRE

COST ESTIMATE

PROJECT DAVISVILLE BULKHEAD — ACC. NO. 3603
SUBJECT ALTERNATE 5 — BUDGET X — SHEET NO. 6 OF 8
PRELIMINARY — DATE SEPT. 1980
COMP J.K.M. — CHECK L.J.M. Jr. — FINAL — CONT. NO.

ITEM NO.	DESCRIPTION	QUANTITY UNIT	QUANTITY AMOUNT	COST UNIT		COST TOTAL
	MOBILIZATION/DEMOBILIZATION	L.S.	1	200,000		200,000
	SITE WORK	L.S.	1	29,500		29,500
	ROAD					
	NEW	L.F.	1300	50		65,000
	RAILROAD					
	NEW	L.F.	1200	70		84,000
	REHABILITATION	L.F.	1800	40		72,000
	WATER	L.F.	300	45		13,500
	SEWER	L.F.	300	35		10,500
	ELECTRIC, TELEPHONE, FIRE ALARM, STREET LIGHTING	L.S.	1	800,000		800,000
	DREDGE & STOCKPILE	C.Y.	175,000	4	50	787,500
	EFFLUENT CONTROL	L.S.	1	150,000		150,000
	BORROW	C.Y.	6000	7		42,000
	STONE ARMORED SLOPE	S.Y.	2400	50		120,000
	BULKHEAD, REHABILITATION	L.F.	1300	1490		1,937,000
		TOTAL	ENGINEERING	ESTIMATE		4,311,000
		CONTINGENCY 20%				862,200
		SUBTOTAL				5,173,200
		ESCALATION (SEPT.'82)		17%		879,444
		BUDGET	ESTIMATE			6,052,644
	ENGINEERING AND TECHNICAL SERVICES					466,000
	TOTAL PROJECT COST ESTIMATE					6,519,000
	ESTIMATED TIME FOR CONSTRUCTION - 12 MONTHS					
					SHEET TOTAL	

MAGUIRE

COST ESTIMATE

PROJECT DAVISVILLE BULKHEAD ACC. NO. 3603
SUBJECT ALTERNATE 6 - EARTH FILLED PIER BUDGET X SHEET NO. 7 OF 8
PRELIMINARY DATE SEPT. 1980
COMP. J.K.M. CHECK L.J.M.Jr. FINAL CONT. NO.

ITEM NO.	DESCRIPTION	QUANTITY UNIT	QUANTITY AMOUNT	COST UNIT		COST TOTAL
	MOBILIZATION/DEMOBILIZATION	L.S.	1	200,000		200,000
	SITE WORK	L.S	1	65,750		65,750
	RAILROAD					
	NEW	L.F	1700	70		119,000
	REHABILITATION	L.F.	1800	40		72,000
	PAVING	S.Y.	33,500	8	25	276,375
	WATER	L.F.	2400	30		72,000
	SEWER	L.F.	1000	30		30,000
	ELECTRIC, TELEPHONE, FIRE ALARM, STREET LIGHTING	L.S.	1	1,000,000		1,000,000
	DREDGE & FILL	C.Y.	200,000	3		600,000
	DREDGE & STOCKPILE	C.Y.	170,000	4	50	765,000
	EFFLUENT CONTROL	L.S.	1	150,000		150,000
	BULKHEAD	L.F.	800	1431		1,144,800
	REHABILITATE NAVY BULKHEAD	L.F.	600	1490		894,000
	RELIEVING PLATFORM	L.F.	600	2285		1,371,000
	CELLULAR COFFERDAM	L.F.	900	2750		2,475,000
		TOTAL	ENGINEERING	ESTIMATE		9,234,925
		CONTINGENCY	20%			1,846,985
		SUBTOTAL				11,081,910
		ESCALATION	(SEPT. '82)	17%		1,883,925
		BUDGET	ESTIMATE			12,965,835
	ENGINEERING AND TECHNICAL SERVICES					963,000
	TOTAL PROJECT COST ESTIMATE					13,929,000
	ESTIMATED TIME FOR CONSTRUCTION - 21 MONTHS					
					SHEET TOTAL	

MAGUIRE

COST ESTIMATE

PROJECT DAVISVILLE BULKHEAD ACC. NO. 3603
SUBJECT ALTERNATE 6-PILE SUPPORTED DECK BUDGET X SHEET NO. 8 OF 8
PRELIMINARY DATE SEPT. 1980
COMP. J.K.M. CHECK L.J.M. Jr. FINAL CONT. NO.

ITEM NO.	DESCRIPTION	QUANTITY UNIT	QUANTITY AMOUNT	COST UNIT		COST TOTAL
	MOBILIZATION/DEMOBILIZATION	L.S.	1	200,000		200,000
	SITE WORK	L.S.	1	19,000		19,000
	RAILROAD					
	NEW	L.F.	1700	70		119,000
	REHABILITATION	L.F.	1800	40		72,000
	WATER	L.F.	2400	30		72,000
	SEWER	L.F.	1000	30		30,000
	ELECTRIC, TELEPHONE, FIRE ALARM, STREET LIGHTING	L.S.	1	500,000		500,000
	DREDGE & STOCKPILE	C.Y.	370,000	4	50	1,665,000
	EFFLUENT CONTROL	L.S.	1	190,000		190,000
	BULKHEAD					
	REHABILITATION	L.F.	600	1490		894,000
	REHABILITATION NO DREDGING	L.F.	300	1000		300,000
	PILE SUPPORTED DECK	S.F.	300,000	66	50	19,950,000
		TOTAL	ENGINEERING	ESTIMATE		24,011,000
		CONTINGENCY 20%				4,802,200
		SUBTOTAL				28,813,200
		ESCALATION (SEPT. '82)		17%		4,898,244
		BUDGET	ESTIMATE			33,711,444
	ENGINEERING AND TECHNICAL SERVICES					2,107,000
	TOTAL PROJECT COST ESTIMATE					35,818,000
	ESTIMATED TIME FOR CONSTRUCTION - 21 MONTHS					
				SHEET TOTAL		