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# Environmental Assessment

# Davisville Port Expansion

Prepared For

The Rhode Island Department of Economic Development

By The

Coastal Resources Center
Graduate School of Oceanography
University of Rhode Island

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## SYNOPSIS

This environmental assessment report has been prepared by the Coastal Resources Center of the University of Rhode Island under contract to the Rhode Island Port Authority and Economic Development Corporation, RIPA. Its purpose is to identify and assess the likely environmental effects of the six alternate designs for port expansion at Davisville, Rhode Island as proposed by C.E. Maguire, the engineering consultants who developed the preliminary engineering report. Part A contains the environmental assessment of the proposed expansion plan and several alternatives, following the 1978 guidelines developed by the Council on Environmental Quality (40 CFR pt. 1502). Part B presents the report of geological studies conducted specifically for this project. Part C is a detailed report on the marine biology of the vicinity of Davisville, including scientific surveys conducted specifically for this report. It also contains a thorough review of the relevant scientific literature on the impacts of dredging on marine organisms.

The proposed port expansion design as described in the preliminary engineering report is in essence a general development site plan. C.E. Maguire recommended that RIPA have detailed engineering drawings prepared, which is the next step prior to bidding for construction. Responses to concerns raised in this environmental assessment of the general plan would be addressed in this next phase, along with complete specifications for implementing recommended mitigating measures.

This report was prepared by Donald Robadue, Jr., project coordinator, Stephen Olsen, and George Seavey of the Coastal Resources Center; Sheldon Pratt of the Division of Marine Resources; and Dr. Robert McMaster and Stephen Greenlee of the Graduate School of Oceanography, University of Rhode Island. Jean Krul typed the entire report with precision and patience. Lucia de Leiris prepared the geology and biology maps in Parts B and C.

# 1. SUMMARY

Since 1975, the Rhode Island Port Authority has leased wharf and land space at Davisville to several companies which provide services to offshore oil exploration operations. Several planning and management studies have indicated that in the event of oil and gas exploration and development activity on Georges Bank off the New England coast, a considerable increase in service operations at the Davisville site could occur. The Coastal Energy Impact Program, created by the 1976 amendments to the federal Coastal Zone Management Act, provides funds to states affected by the impacts of energy-related facility development. The Rhode Island Port Authority was awarded funds through the Governor's Energy Office, to conduct port management, engineering and environmental impact assessment studies as part of the state's effort to accommodate growth in oil industry operations in a carefully planned fashion. Booz-Allen, Inc. conducted a management study of port operations. C. E. Maguire, Inc. prepared the preliminary engineering plans for port expansion at Davisville. The Coastal Resources Center of the University of Rhode Island provided the environmental impact assessment of the engineering designs.

Six alternate designs were developed for the Davisville site during the planning phase of preliminary engineering by the project consultants after discussions with the Department of Economic Development and the Quonset-Davisville Planning Task Force; these were presented by C.E. Maguire in its progress reports with the following designation:

Alternate 1: Original 1977 concept, for Dogpatch; Construction of a 2,400 foot bulkhead south of the Navy Bulkhead parallel to Dogpatch Beach.

Alternate 2: Incremental concept for Dogpatch; 675-foot bulkhead along Dogpatch Beach, with the potential for later expansion to the full length of Alternate 1.

Alternate 3: Maximum Dogpatch concept, 3,200 foot bulkhead filling a large portion of Fry Cove between Davisville Pier and the Airport.

Alternate 4: Bulkhead north of Davisville Piers, 2300 feet adjacent to land presently used for oil support operations.

Alternate 5: Replacement or repair of existing Navy Bulkhead south of Pier 1.

Alternate 6: New Pier connected to reconstructed Navy bulkhead as an expansion option for site.

Dredging is required in every alternate design. In addition, sites elsewhere in Narragansett Bay for locating offshore oil service base operators and a 'no'expansion' option were considered.

Alternate 2 was the alternate design preferred by the Rhode Island Port Authority and selected for the preliminary engineering design study. Alternate 5 would have less environmental impact. However, the bulkhead is still retained by the Navy Construction Battalion Center.

Construction of Alternate design 2 will involve dredging 13 acres of sandy bottom in Fry Cove, constructing a 675-foot bulkhead and filling behind it to create 18 acres of land for use as a marine transportation terminal. An estimated 350,000 cubic yards of materials would be removed to create a 25-foot channel. About 160,000 cubic yards of that total would be surplus and must be stockpiled on land. Road and rail service improvements would be made along Marine Road, which passes through the Dogpatch parcel owned by the RIPA.

With the exception of the Dogpatch parcel, the property adjacent to the proposed bulkhead has been extensively modified since 1940 by filling, paving, bulkhead building, pier construction, and Construction Battalion activities by the Navy. The construction of the proposed bulkhead will have certain adverse environmental impacts, principally the permanent elimination by burial of several acres of Fry Cove bottom currently containing commercially harvestable hard clams, Mercenaria mercenaria, and a two-acre marsh, containing about one half acre of smooth cordgrass, Spartina alterniflora bordering a small pool of open water. The Spartina marsh is in turn surrounded by some 1.5 acres of the reed Phragmites communis. A portion of Dogpatch Beach will be covered as well. Adverse effects of turbidity during dredging on marine organisms are not expected if adequate containment and retention of effluent from hydraulic dredging is provided and the water produced from material settling is drained to the bottom of the existing channel. Providing rail and road access to the wharf through the Navy property would reduce encroachment upon the upland stream and woods. However, if development is confined to the land between the proposed new road and rail line, the vegetated area will be protected. A buffer between activity on the wharf and adjacent Navy housing may be required. The dredged material stockpile, which will be located south of Marine Road adjacent to the airport, should be covered or planted to reduce wind and rain erosion (Figure 1-1).

Each of the other designs was assessed by the engineering and environmental consultants. Alternate 1 would have enabled immediate construction of the full length bulkhead along Dogpatch Beach, but was rejected by the Port Authority in favor of the incremental approach incorporated in Alternate 2. The incremental design provides greater flexibility in port expansion planning. Alternate 3, filling a major portion of Fry Cove, was too expensive and provided much more land and wharf space than would be needed. A bulkhead could be built north of the existing piers, following the plan of Alternate 4, avoiding some of the terrestrial impacts at Dogpatch and retaining the integrity of Davisville piers as an offshore

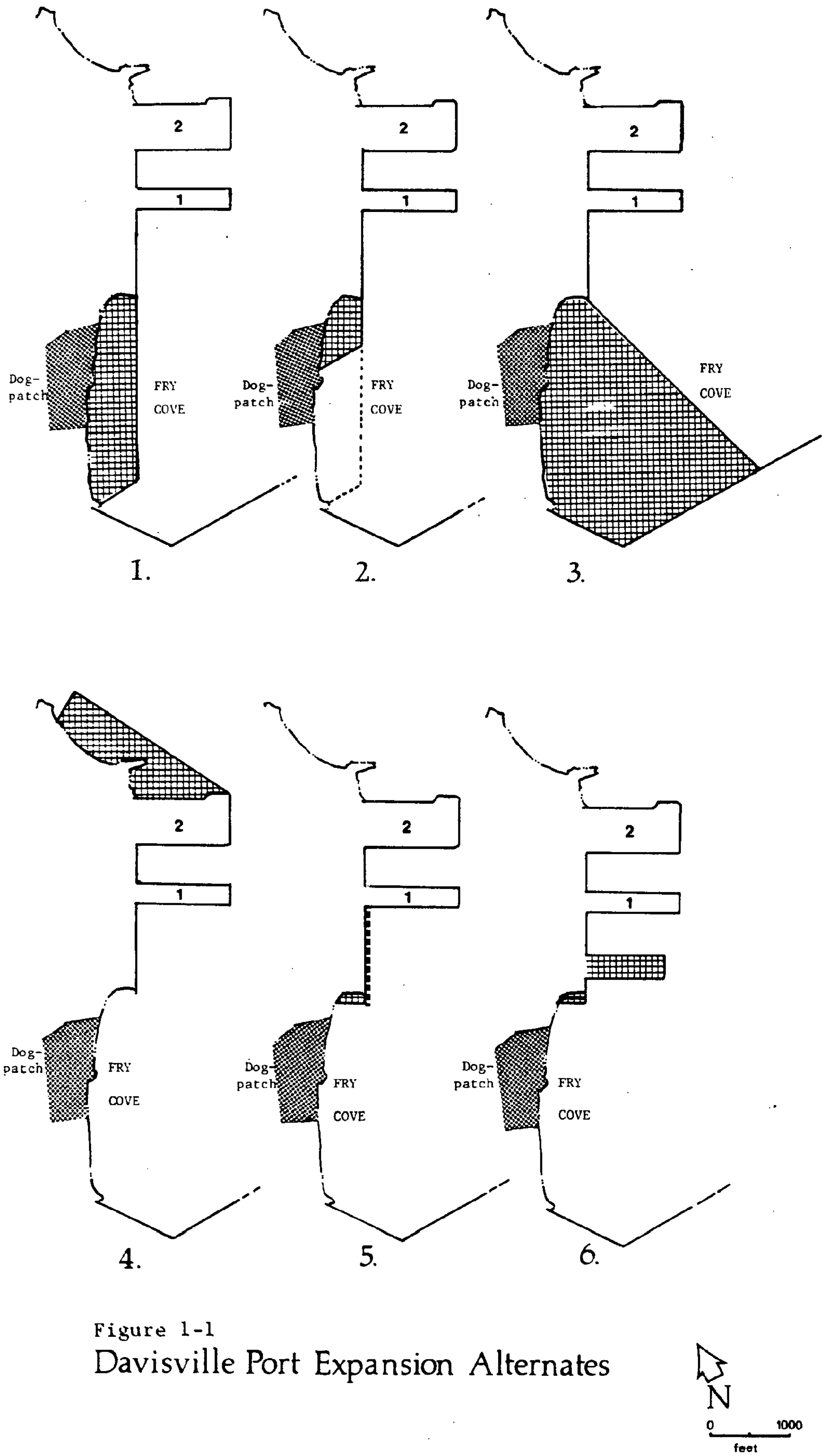


Figure 1-1
Davisville Port Expansion Alternates

oil and gas exploration service base. The configuration and construction details suggested by the consulting engineers was estimated to be much more expensive than Alternate 2 due to the need for a deck along parts of the bulkhead. The dredged channel would also be more exposed to wave action and sedimentation, and present a greater likelihood of commercial operations interfering with recreational uses in the vicinity of Allen Harbor. Reconstruction of the existing Navy bulkhead, Alternate 5, would require the least dredging and provide access to land adjacent to Davisville Piers, avoiding the impact of filling parts of Fry Cove. However, a formal agreement between the Navy and the State of Rhode Island would be required for this option to be pursued further. Alternate 6, construction of a new pier extending out from the Navy bulkhead would be contingent upon the completion of Alternate 5 and was among the most expensive methods for increasing berths and new land.

The environmental assessment in Part A has been prepared following the format recommended by new regulations promulgated by the Council on Environmental Quality in 1978 (43 Fed. Reg. 55994; 40 C.F.R. pt. 1502). Chapter 2 contains a discussion of the purpose and need for the proposed action, Chapter 3 provided a summary evaluation of alternates. Chapter 4 consists of a description of the affected environment. Chapter 5 consists of a detailed evaluation of the consequences of alternative actions. Part B contains "Davisville Port Expansion Assessment, Geology" by Dr. Robert McMaster and Stephen Greenlee, prepared in conjunction with the environmental assessment. Part C is another technical report entitled "Effects of Port Expansion at Davisville, Rhode Island on the Marine Environment" by Sheldon Pratt.

## 2. PURPOSE AND NEED FOR THE PROPOSED ACTION

Since 1973, when the United States Navy first announced the deactivation of Quonset Point Naval Air Rework Facility, followed by reductions in activity at the Construction Battalion Center at Davisville, Rhode Island state government has actively engaged in planning for the re-use of Navy land designated surplus to federal needs. The first proposal, made by a legislative commission in 1973, was to create a major container port at Quonset Point with expansion to Davisville Piers. This effort did not lead to any specific action. In 1974, following cutbacks in Navy operations, several important actions were taken by the state to accelerate the redevelopment effort. Legislation (Title 42,Ch.6 created the Rhode Island Port Authority and Economic Development Corporation which became responsible for the Protection and Maintenance Agreement reached with the Department of Defense. The Port Authority was permitted to issue 30 day cancelable leases, utilizing revenues to provide services and maintain the property until a sales agreement was reached. The Governor's Office prepared a general plan for re-use of surplus military lands as required of its application to acquire the property from the General Services Administration (Governor's Office, 1974). That plan proposed that Davisville Piers be used "for intensive industrial development of a water oriented nature." The Dogpatch parcel, located to the south between Navy retained land and the airport, "should be reserved for future industrial re-use, perhaps related to the re-use of Area D (Davisville Piers) or to the airport." Assuming a direct connection to Davisville Piers, "a similar marine terminal industrial use may be indicated" for Dogpatch.

At the same time re-use planning was proceeding, the federal government was accelerating the leasing of tracts offshore for the purpose of oil and gas exploration. In 1975, industry nominations for tracts on Georges Bank off the New England coast were sought by the Department of Interior, coninciding with efforts by Rhode Island to attract oil industry interest to Quonset Point/Davisville. Reports by the New England River Basins Commission (1976) raised the potential for substantial onshore economic activity in support of oil and gas drilling and production activities. A marketing study by Harbridge House (1976) concluded that "the development of the offshore oil reserves on the East Coast of the United States offers a substantial opportunity for employment in Narragansett Bay."

A master plan for Quonset Point/Davisville was prepared by the Department of Economic Development with the assistance of several consulting firms during 1976 and 1977. Three development scenarios were developed and assessed. Scenario I was based upon the assumption of a high find of petroleum or gas on George's Bank off the New England coast. It was based upon the assumption that Davisville would become a primary location for industry supporting offshore oil exploration and development. Permanent service bases, a pipe laydown and coating yard, and oil production platform fabrication would all occur at Davisville. Scenario II was based on the assumption of a medium level find on George's Bank, and a mixed land use pattern at Davisville. Under this scenario, more service base activity would be accommodated. However, a higher proportion of new firms at Quonset/Davisville would not be associated with petroleum exploration. Scenario III was based upon the assumption that no oil or gas would be discovered and no permanent service base activity would be located at Davisville (Keyes Associates, 1976).

The Rhode Island Port Authority adopted Scenario II as its development plan, which involved the allocation of about 420 acres of land, including Davisville Piers and Dogpatch, to oil support operations. Also included in the plan was the construction of a new bulkhead along Dogpatch Beach, to support future expansion of oil support activity, a concept based upon planning information developed by the New England River Basins Commission in 1976. Service companies have been operating from Davisville since 1976 in support of test well drilling as well as exploration of the Baltimore Canyon off the mid-Atlantic coast.

The goals of the Rhode Island Port Authority for Davisville Piers are to provide full support for firms providing services, materials and equipment to offshore oil exploration and production in the North Atlantic, make the best use of existing and proposed facilities for oil support and other activities, and maintain the competitive advantage of the state for marine transportation. Davisville is located equidistant between areas of interest to the petroleum industry in Baltimore Canyon to the south and George's Bank to the east, making it a convenient location for firms providing services to oil drilling activity in both areas. The port expansion design prepared by C. E. Maguire during 1980 is based upon research into the marine, land, utility and supporting transportation requirements of service bases supporting outer continental shelf oil exploration. In recognition of the need for maintaining full occupancy of new facilities, the requirements of other users of port facilities were also investigated, including commercial cargo and fishing.

The design preferred by the Rhode Island Port Authority, Alternate 2, entails construction of a 675-foot long bulkhead, which contains 18 acres of supporting land in front of Dogpatch Beach. This was determined to be the smallest practical increment of port expansion by C.E. Maguire, based on an analysis of user requirements. This facility could then be extended southward as future needs develop.

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# 3. SUMMARY EVALUATION OF ALTERNATE DESIGNS

## 3.1 SITE REQUIREMENTS AND ASSUMPTIONS

The Rhode Island Coastal Resources Management Council designated Davisville Piers as the primary location in Rhode Island for service base and other operations in support of oil and gas exploration on the outer continental shelf (OCS). Section 540.0-2 of the Coastal Resources Management Program adopted in 1977 states "a high priority of use of the surplus Navy holdings at Davisville shall be commerce and industry related and/or supportive of OCS oil and gas exploration."

The original concept of expanding Davisville Piers by constructing a bulkhead to the south of Pier 1 along Dogpatch Beach was included in Scenario II, the plan adopted by the Rhode Island Port Authority in 1977 in its master plan for the re-use of Quonset/Davisville. The purpose of creating the new wharf was to provide additional marine facilities for supporting oil industry service activities and to make the Dogpatch Beach parcel more closely linked with oil drilling support activity at Davisville Piers.

During the preliminary design of the bulkhead, which began in February 1980 by C.E. Maguire Inc, the user requirements for the facility were more clearly defined and several configurations were examined for their ability to meet user requirements and port activity needs. The basic requirements for potential users of expanded facilities determined by C.E. Maguire were a protected location, with a water depth of the channel and berths of about 25 feet below mean low water, and a minimum of two berths of 250 feet in length for OCS exploration support operation, or feet for a one berth commercial port. Eight to ten acres of supporting land were assumed to be needed to support each berth in the service base operations, or 12 to 20 acres in the case of a commercial berth. The selected design should have a low construction cost, and be capable of incremental expansion as demand warranted. Finally, it was assumed that the Navy control of the land between Davisville Piers and Dogpatch Beach would preclude reconstruction of the existing Navy bulkhead or use of the Navy held land for service base or commercial operations.

The six designs proposed by C.E. Maguire during its preliminary engineering study are shown in Figure 3-1. This chapter provides a summary of the environmental effects of these designs as well as options available to the Port Authority which would have no impacts at Davisville. Since many of the environmental effects of the alternate configurations are similar, the discussions of the designs have been consolidated in the following manner:

Section 3.2: Bulkhead construction along Dogpatch Beach (Alternate 1, 775 feet; Alternate 2, 2400 feet.

Section 3.3: Bulkhead construction north of Davisville Piers (Alternate 4, 2,300 feet).

Section 3.4: Reconstruction of Navy Bulkhead (Alternates 5 and 6).

Section 3.5: Rejected options (Alternate 3, Fry Cove Bulkhead and other sites).

Section 3.6: No construction option

Full discussions of each alternate design are provided in Chapter 5, including more detailed descriptions, maps and identification of impacts. Part C contains a thorough discussion of the impacts of dredging on marine organisms.

## 3.2 BULKHEAD CONSTRUCTION ALONG DOGPATCH BEACH

Description of Action

The Rhode Island Port Authority is proposing to construct a 675-foot long bulkhead, dredge 360,000 cubic yards of material from 13 acres of Fry Cove to

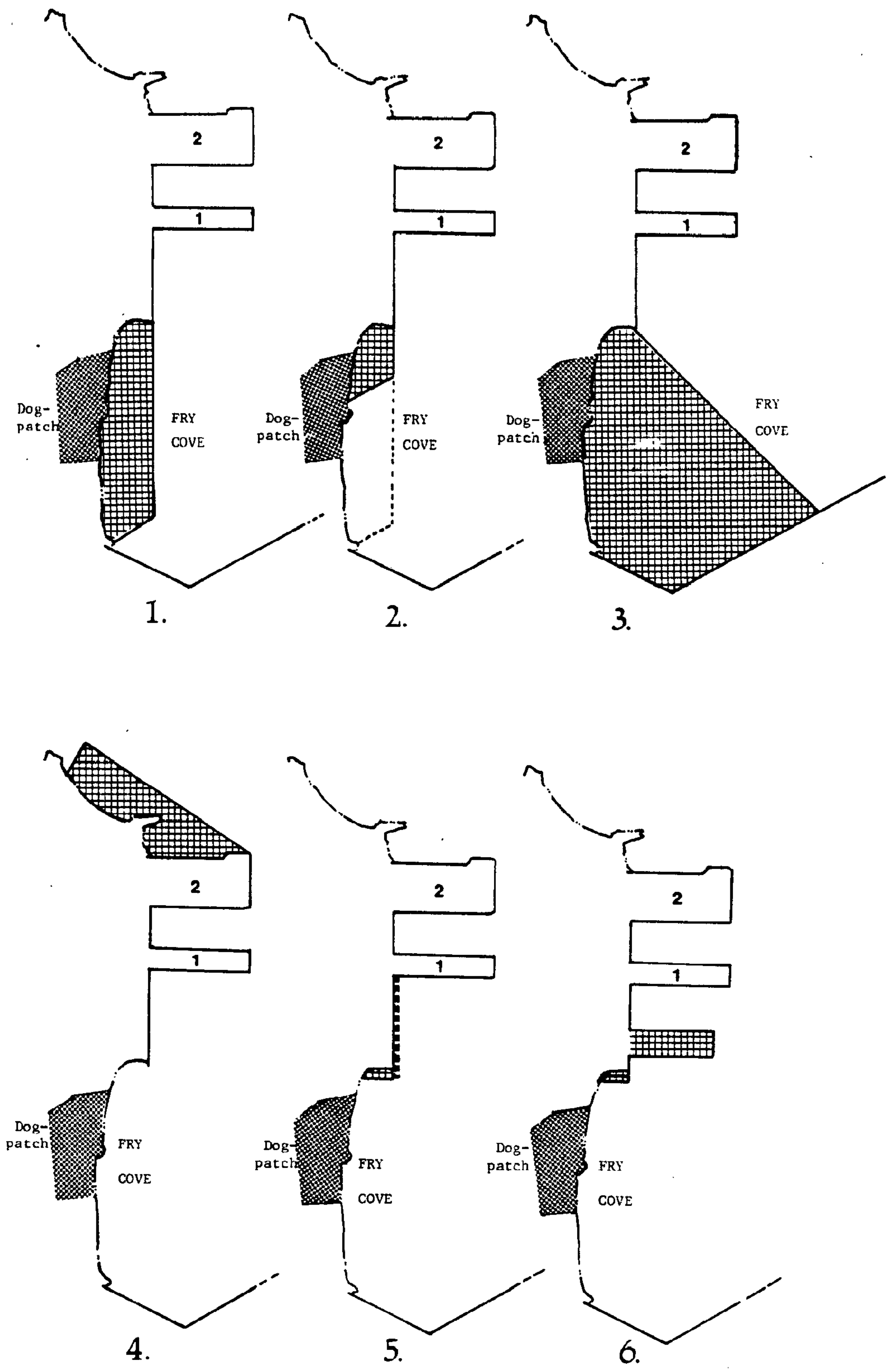



Figure 3-1

Davisville Port Expansion Alternates

create a new channel 25 feet deep; and fill behind the bulkhead to create about 18 acres of land for use as a commercial port (Figure 3-1 Alternate 2). The location of the project is the northeastern corner of the area of Davisville known as Dogpatch Beach, just south of Davisville Piers adjacent to land retained for use by the Navy Construction Battalion Center. Should port activity warrant, the Port Authority would have the ability to expand the wharf as much as 1,800 feet further south, toward the outlet of Fry Pond, creating an additional 12 acres of land. About 160,000 cubic yards of surplus dredged material would be stored between the State Airport and Marine Road in Alternate 2. Maguire Alternate 1, immediate construction of the entire 2,400 foot bulkhead involving 700,000 cubic yards of dredged material, was rejected in favor of the incremental expansion program. Although no construction sequence was specified by C.E. Maguire, dredged material would probably be pumped behind the bulkhead and containment dikes. A weir would control the flow of water back into Fry Cove, permitting settling out of much of the suspended sediment behind the bulkhead in order to minimize the turbitidy caused by dredging.

Summary of Impacts

The primary effect of the proposed action will be the complete alteration of 31 acres of upland, shore and bottom. The principal environmental effects of the proposed action are the permanent destruction of a two acre salt marsh, portions of a sandy beach, and part of shallow subtidal zone by filling 18 acres with dredged material to create a wharf. Patches of a few square yards of oysters and soft shelled clams, and slightly larger areas of hard clams in depths accessible to recreational shellfishing will be lost. The new dredged channel will eliminate 13 acres of productive bottom in Fry Cove which is a portion of the commercial hard clam fishing ground in Fry Cove.

With severe storms inflicting damage to the beach, natural processes would be unable to restore the undeveloped portion of Dogpatch Beach because of its isolation from sand supplies. The result probably will be an unavoidable continuing erosion of the shore line. Later construction of an additional 12 acre wharf and 1625 foot bulkhead to achieve the full expansion proposed in Alternate 1 would lead to the loss of another 30 acres of shore and shallow bottom to filling, and 28 acres of productive deeper bottom due to dredging.

The operation of the port facility will probably lower water quality from SA (suitable for all uses) to SB (shellfishing restricted) leading to the closure of a 1000 foot zone around the wharf to shellfishing by the Department of Health. The temporary stockpile of surplus dredged material, if left unprotected, will be eroded by wind and storm runoff into Fry Cove.

Mitigating Measures

Actions can be taken to lessen the impacts of dredging and bulkhead construction. Hard clams (*Mercenaria mercenaria*) should be removed before dredging. Effluent from dewatered dredged material should be released near the existing channel to reduce surface turbidity and avoid sediment deposition on areas where hard clams are located. The dredging sequence should permit the longest possible retention time of water in the containment structures to minimize the turbidity produced during construction.

Partial compensation for the loss of the beach and marsh could be achieved by beach nourishment or marsh building nearby, for example in the vicinity of Allen Harbor and Calf Pasture Point. However, in case of Alternate 2, surplus material is being reserved for future expansion. The temporary stockpile of dredged materials should be covered or planted to reduce the likelihood of erosion.

Impacts on the Dogpatch parcel could be reduced by providing road and rail access through Navy controlled property rather than making proposed transportation improvements along Marine Road. C.E. Maguire estimated that this alternate route was less expensive to construct. However, since Dogpatch is slated for eventual industrial development, transportation improvements are inevitable. In addition, permission would have to be secured from the Navy for long term access through the property. A policy to confine new industrial construction on Dogpatch south of the proposed rail line would protect the stream and woods, as well as save the vegetated zone dividing the Navy residential compound to the north from activity at Dogpatch and the Quonset State Airport.

## 3.3 BULKHEAD NORTH OF DAVISVILLE PIERS

Description of Action

Twenty-six acres of new land, and 2,300 feet of berthing would be created by building a bulkhead linking Pier 2 to the entrance of Allen Harbor, along land owned by the Port Authority and presently used for offshore oil service base operations. Twenty-two acres of bottom would be dredged to create the new berths. The 770,000 cubic yards of dredged material would be used to fill behind the bulkhead, leaving no surplus.

Summary of Impacts

The upland portion of this site is paved with asphalt which is in poor condition. Bulkhead development will require repavement of much of the area. A marsh of less than 3 acres adjacent to Pier 2 would be filled with dredged materials. This wetland is periodically overwashed by sand because of its exposure to wave action making it less valuable wildlife habitat. The beach leading north from the wetland to the entrance of Allen Harbor would also be filled. Filling of intertidal and shallow subtidal areas will result in the loss of an area of soft-shell clams (*Mya arenaria*) and other animals. However, these areas are less productive than nearby Allen Harbor and Calf Pasture Point.

The area to be dredged has undergone continuous disturbance from hard clam fishing. The hard clam *M. mercenaria* is more resistant to the effects of dredging than its competitors and predators, and therefore may be less affected by disturbances caused by dredging such as siltation and burial. Sediment suspended by dredging, and the effluent from dredged material dewatering will add to the turbidity of the Calf Pasture Point area for the duration of the construction and dredging, with sediment settling in the deeper portions of Allen Harbor, the dredged basins and West Passage. Sand drifts from north of the area to be dredged will probably cause filling in the Northwestern end of the channel, at a rate more rapid than that now occuring to the existing piers and channel due to exposure to the north-easterly storms. During the flood tide dredging operations may produce some visible turbidity off Calf Pasture Point which is actively used for recreational shellfishing and swimming, representing a potential aesthetic concern.

New port activity at the mouth of Allen Harbor will increase the likelihood of conflicts with recreational use. Shellfishing near the wharf would likely be prohibited by the Department of Health due to a change in water quality from SA to SB. The possibility of accidental pollution may affect shellfishing and proposed aquaculutre activity in the Harbor, although marina development would not be hindered.

Mitigating Measures

Release of dredging effluent near the present channel or turning basin would reduce the biological and visual effects of suspended material on shellfishing and swimming. Scheduling the dredging during winter months would avoid the presence of a turbidity plume during peak recreational use. Installation of a storm drainage system on the wharf would increase the ability to control and cleanup spilled material before it enters the water.

The proximity to shellfishing grounds requires careful control of operations on the wharf and by vessels to reduce the impact of pollutants such as sewage, dock preservatives, chemicals or, petroleum products which may enter the water directly or in storm water runoff.

## 3.4 IMPROVEMENTS TO PROPERTY ADJACENT TO DAVISVILLE PIERS RETAINED BY THE UNITED STATES NAVY

Description of Action

A series of incremental actions could be taken utilizing the land behind the presently deteriorating bulkhead which is retained by the U.S. Navy Construction Battalion Center. These were suggested by C.E. Maguire as Alternates 5 and 6. The first step would be to build a new 1,300 foot bulkhead seaward of the present decaying structure, and then dredge about 10 acres of new channel producing 175,000 cubic yards of surplus sediment requiring disposal. About 1.5 acres of new land would be created by a small portion of the dredged material. Access might be obtained to adjacent Navy land presently used for equipment storage. Alternate 6, future expansion, would involve the construction of a new pile supported or earth filled pier parallel to Pier 1, creating 7 new acres of land, and 2,300 linear feet of berthing. Fifteen acres would be dredged in addition to that needed for bulkhead repair, yielding 370,000 cubic yards of surplus material. The earth filled pier would reduce the volume of surplus material to 170,000 cubic yards. The southern end of the Navy Bulkhead will be filled and protected with stone armor.

Summary of Impacts

Upgrading the Navy owned bulkhead will cause fewer environmental impacts than any other construction option. Dredging and material disposal are the primary concerns. The 10 acres of sandy bottom to be dredged contains commercially valuable hard clams which will be eliminated along with other bottom organisms serving as food for fish and ducks. If the sediment stockpile site is located adjacent to the Dogpatch parcel, the habitat of some small mammals will be disturbed. An alternate dredged material storage site is located at the intersection of Marine and Davisville Roads which is nearer to the Navy bulkhead. Any stockpile should be covered to reduce erosion by wind or rain.

The repair work at the southern end of the bulkhead is likely to infringe upon the cobble beach and a corner of the marsh at Dogpatch. Some erosion of the beach at this junction would be expected. Active use of the land adjacent to the bulkhead would produce noise and visual disturbances to the Navy residential compound and birds nesting in the nearby wetland. Pollutants in storm water runoff from the site, and litter may also enter the marsh.

Mitigating Measures

The use of clamshell dredging would avoid creating a large volume of sediment laden slurry which must be contained and settled before release into Fry Cove. Reuse of dredged material for landscaping or marsh building would reduce the problem of dredged material disposal. Additional study would be required to evaluate and plan for marsh construction. Release of dredged effluent into existing channels will reduce the visible turbidity and sedimentation on shallower areas which are most valuable as hard clams and fish food habitat.

Hard clams can be removed before channel dredging, a process already occurring since the area was opened to shellfishing in July, 1980. Additional shore protection and land creation at the southern end of the bulkhead could reduce the amount of surplus dredged material and protect the marsh by improving shoreline stability. Fencing and vegetative buffers would reduce the intrusion of waterfront activity into the residential compound and marsh. Drainage of the site should be directed away from the marsh.

## 3.5 OPTIONS CONSIDERED BUT REJECTED

Bulkhead Between Davisville Piers and the Quonset State Airport

C.E. Maguire suggested a bulkhead configuration, Alternate 3 design, that created the greatest amount of land and berths, and offered a potential for accommodating dredged materials from other locations in Narragansett Bay. This proposal would create 3,200 feet of wharf, involve filling 120 acres of Fry Cove with 4.1 million cubic yards of material, and require 40 acres of dredging. Productive shallow and deeper bottom would be lost, and more sediment would reach the vicinity of Allen Harbor than in other Fry Cove options.

Several factors make this option infeasible, such as high cost, the difficulty of obtaining and unloading two million cubic yards of fill from elsewhere in the Bay. In addition, there is no demonstrable need for a facility of that size.

Alternate Sites

No suitable sites compatible with the design requirements for port operation such as offshore oil drilling service bases are available in the vicinity of Narragansett Bay. Although Providence Harbor and state owned property at Melville possess some potential, development plans for both sites preclude service base development,which does not require use of the deep berths available at both locations. New facilities could be constructed at Melville, but development in that location would not be superior to expansion options at Davisville Piers, since it is a considerable distance away from the center of operations at Davisville, may not be available when needed, and has been identified as a good site for fishing facilities (S. Sedgwick, C. Collins, and S. Olsen. 1980 Commercial Fishing Facility Needs in Rhode Island. Coastal Resources Center, University of Rhode Island, Kingston.

## 3.6 NO CONSTRUCTION

If Davisville develops as projected but no new or expanded facilities were constructed port management problems would likely occur. Most of the marine environmental impacts of constructing and operating the various alternate designs discussed in sections 3.2 to 3.4 would be avoided. Firms desiring to expand or locate at Davisville in order to be near the center of oil support activity could not be accommodated. However, upland development at Dogpatch Beach and small scale improvements to existing facilities would still be likely to occur due to plans for industrial development at Davisville by the Rhode Island Port Authority.

# 4. DESCRIPTION OF THE AFFECTED ENVIRONMENT

## 4.1 INTRODUCTION

The Davisville port expansion proposal will have impacts on both the coastal and marine environments. Research and planning studies conducted since 1974 (see page 2-4) have provided a great deal of information on the upland portion of Davisville, and some data on the vicinity of Fry Cove and Allen Harbor. Additional biological and geological field investigations were conducted during the spring and summer of 1980 in order to obtain greater detail on the vicinity of Davisville Piers. Technical reports describing the methodology and findings of this research are found in Part B, Marine Geology, and Part C, Marine Biology. This chapter begins with an overview of the entire Davisville area, followed by descriptions of major terrestrial, marine geology and biological features of the project area. The terrestrial description of the Davisville and Dogpatch sites in Section 4.3 concentrates on the shore and upland features likely to receive direct and indirect impacts from the proposed port expansion. A summary of the marine geology in the vicinity of Fry Cove and Allen Harbor, is provided in Section 4.4 including bathymetry, sediment type and thickness, depth of bedrock and bottom surface features. The chapter concludes in section 4.5 with a description of aquatic biology focusing on the benthic marine organisms most likely to receive impacts. Data on water turbidity and pollutants in the sediments and water column is also presented.

## 4.2 LOCATION AND GENERAL DESCRIPTION OF DAVISVILLE AND VICINITY

Introduction

Quonset Point/Davisville is located along the West Passage of Narragansett Bay in North Kingstown, Rhode Island (Figure 4-1, Inset). The

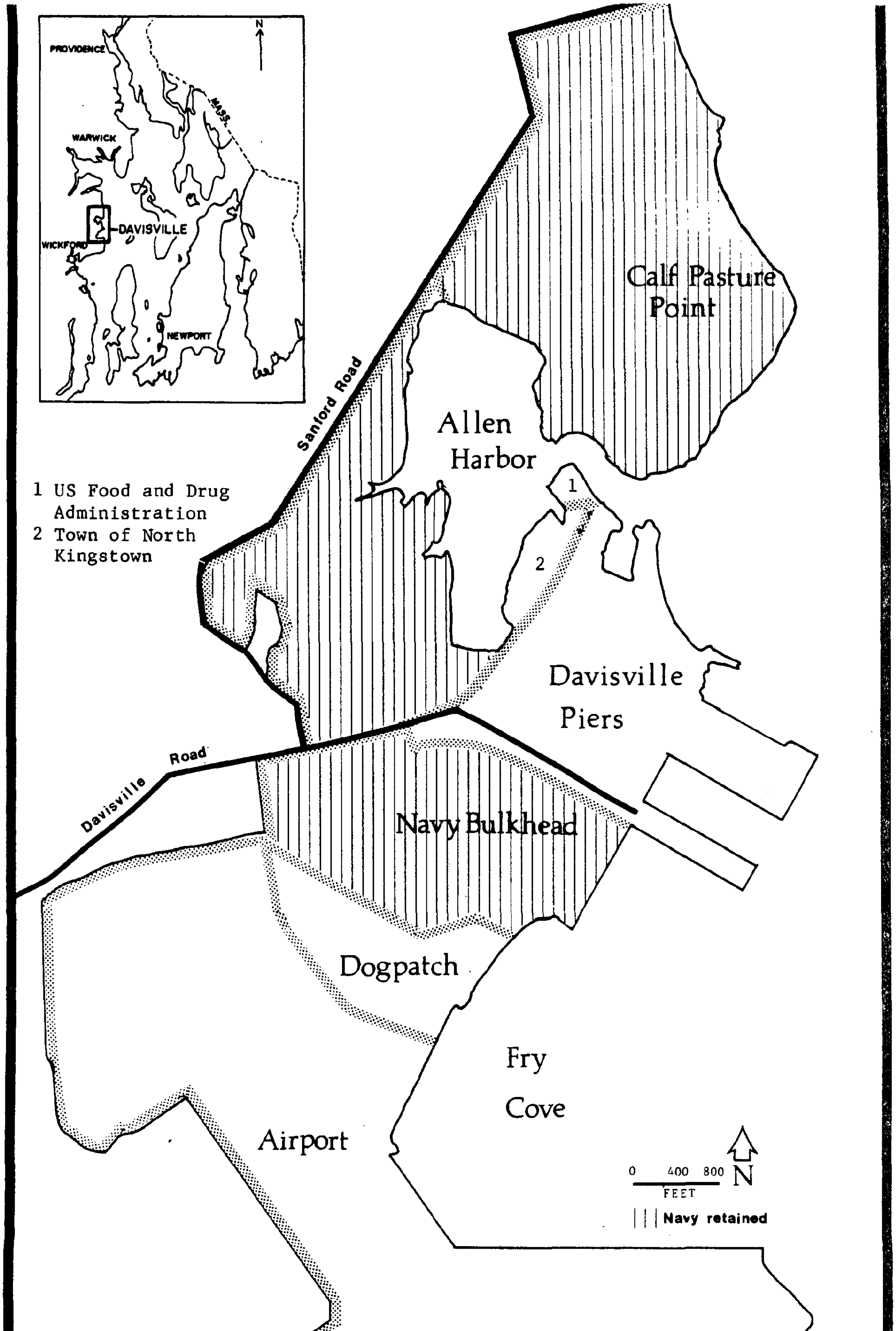



Figure 4-1 Davisville Study Area

coastline of Quonset Point/Davisville extends for approximately six miles between the former carrier pier to the south and the boundary of Navy land at Mount View to the north. A comparison of current with historical National Ocean Survey Charts shows that it has been extensively modified from the original coastal contours and characteristics. Most of these changes occurred when the area was developed for military purposes in the early 1940s. Construction of a second pier at Davisville, and training of construction battalion personnel in the operation of heavy equipment have caused additional changes to the shore.

The Rhode Island Port Authority controls two major parcels of former Navy waterfront land slated for industrial development located between Quonset State Airport and Allen Harbor on the West Passage of Narragansett Bay (Figure 4-1). The more northerly parcel, Davisville Piers, incorporates a total of 96 acres located on the south side of the entrance to Allen Harbor. To the south, separated from Davisville Piers by a Navy retained bulkhead and residential compound, is Dogpatch, a triangular parcel of 35 acres with the sandy beach of Fry Cove as its base, on the east. The Port Authority land is surrounded by the Airport, and Navy controlled land around Allen Harbor and Calf Pasture Point. The Town of North Kingstown owns a 15 acre parcel on Allen Harbor adjacent to Davisville Piers.

The Davisville Piers and Dogpatch

The Davisville piers are now used almost exclusively as the base for the ongoing exploratory offshore drilling. Service boats carrying drilling muds and supplies, fuel, and gear make daily runs to the drilling sites, some 200 miles south of Narragansett Bay in the vicinity of Baltimore Canyon. The two piers, 250 and 600 feet wide, were built by the Navy and extend out from the shore 1200 feet to the southeast of Allen Harbor.

The entire parcel has been heavily altered from its original state and is almost entirely paved. Much of the Davisville Piers vicinity was created by land filling. When dredging was undertaken by the Navy to create berths and navigation channels, large amounts of the material were put on land. Dredged material was also dumped into open water, linking a former island at Spink's Neck to the remainder of the Davisville Pier parcel. Davisville Pier is served by railroad spurs that lead to the piers. The offshore oil drilling companies now using the area have temporary office buildings, warehouses, pollution control equipment, drilling mud tanks and various other equipment and supplies located throughout the site. However, the dockside space on both piers as well as the adjacent paved areas inland of the piers are not intensively used.

Several hundred feet to the south of the Davisville Pier area is the Dogpatch Parcel. It was not as heavily developed and retains a diversity of features including a beach, a small wetland, wooded areas, and largely undisturbed soil. Several abandoned houses and extensive lawns are present on a flat plateau above the beach.

Navy Bulkhead and Residential Compound

The 95 acres of Navy retained land separating the Davisville piers and the Dogpatch parcel is presently used primarily for equipment storage by the Navy. In appearance the Navy waterfront land and bulkhead is quite similar to the adjacent Davisville Piers, consisting of flat, hard-topped land created by filling. Rail lines, and two large warehouses, are prominent features. The Navy bulkhead would require extensive repairs or reconstruction and channel dredging before it could be actively reused.

Along the border between the state-owned Dogpatch parcel and the Navy retained area there is a residential compound consisting of seven single family homes presently occupied by Navy personnel. The area contains several acres of lawns, trees, and ornamental plantings.

The Airport

Between the former Quonset Carrier pier and Dogpatch beach lies the Quonset State Airport, which was formerly used almost exclusively for Navy aircraft training and transport. Today's use is dominated by charter flights, small aircraft training exercises and Air National Guard activities recently relocated to Quonset from the Green State Airport in Warwick. Upon declaration of a national emergency, the federal government could permanently reactivate this airfield for military purposes in a matter of days.

The Quonset Point Airport required the creation of a large expanse of land in order to make the long runways. This was accomplished in the 1940's by filling approximately 200 acres of the Bay behind a steel bulkhead. Also filled was a major section of a small tidal estuary at the southern end of Dogpatch Beach. Today freshwater Fry Pond flows into the Bay through a large double culvert under the runway, which also permits tidal flushing of the pond.

The Rhode Island Department of Transportation operates the airport for general aviation. Future users at Dogpatch will be required to consider such matters as communications interference, noise, height restrictions on structures, and access route development, since the northernmost runway extensions are directly adjacent to Dogpatch.

Allen Harbor

Allen Harbor is a large tidal embayment located directly north of the Davisville Piers. The harbor is connected on its eastern side to the Bay by a large dredged channel. The harbor possesses an extensive salt marsh and tidal flats which extend for one-third mile to the west onto privately owned land. In addition, Allen Harbor has extensive stands of tall reed Phragmites communis and low shrub growth and small trees including bayberry and black cherry. On both sides of the channel entrance are extensive stretches of sand and mud flats which attract considerable numbers of shorebirds, particularly along the northern shore. The harbor is moderately used by waterfowl, especially in the fall and winter months when scaup, black ducks, and others take advantage of the protected waters for feeding and nesting. Gulls and terns are always present at the harbor as they are throughout most of coastal Rhode Island. Common terns have nested for several years in the northern corner of the harbor on grounded barges along the shore. Due largely to the past uses of Allen Harbor, water and bottom sediment quality has declined although considerable recreational shellfishing does occur.

Allen Harbor is presently being used for some recreational boating, a use which will probably increase in the future. The small Quonset Yacht Club services the boats of Navy personnel. The town of North Kingstown plans to utilize a parcel it has acquired on the eastern edge for marina development, and planning for such use began in 1980. Allen Harbor has long been regarded as a logical site for a large marina because of its sheltered central Bay location, good depth and previous use as a large marina when the base was in active use. Numerous opportunities exist at Allen Harbor to upgrade the shoreline by covering exposed trash at the Navy dump, establishment of attractive marina, fishing or restaurant facilities and/or marsh or tidal flat expansion.

Calf Pasture Point

To the north of Allen Harbor lies a two-hundred acre parcel which contains one of the largest sandy beaches on Narragansett Bay. The parcel extends from the channel entrance to Allen Harbor north to the end of the Navy fence bordering the Mount View neighborhood. All of this land is Navy retained and can be used for remobilization at any time. Until this year the beach at the northern end of the parcel has been leased from the Navy by the Town of North Kingstown for use as a swimming beach. A large wooded and ledge bordered hill lies in the center of the parcel on which bunkers have been constructed for military equipment storage.

Aside from the hill, the beach at Calf Pasture Point, a red maple swamp and a salt marsh at the northern end, most of the upland was created by the Navy. A large cove of Allen Harbor which extended into the center of the parcel was diked and transformed into a flat, Phragmites dominated upland. The lack of disturbances in recent years has made Calf Pasture Point more suitable as a wildlife habitat than during the period when it was used for heavy equipment operator training by the Construction Battalion Center.

## 4.3 TERRESTRIAL ENVIRONMENT

Introduction

The land in the vicinity of Davisville Piers is a mixture of land uses including piers, bulkheads, marshalling areas, industrial development, commercial and military aviation, residential districts and quiet woods, fields, and marshes. The development of Quonset Point as a Navy airbase, and Davisville as a Construction Battalion Center during the 1940s left the land in between the two, Dogpatch beach and its upland, relatively undisturbed except for a cluster of single family houses which were abandoned in 1974. This parcel is surrounded by a shoreline and topography which bears little resemblance to its configuration prior to World War II.

Surficial Geology and Soils

Most of the surficial geology of the Quonset/Davisville area is dominated by large expanses of glacial outwash (Figure 4-2). This includes the entire area at Dogpatch. Outwash deposits, being the result of runoff from a retreating or stationary glacier, consist largely of layers of silt, sand or gravel of varying thickness. Large boulders or bedrock exposures are usually notable absent. The outwash deposits at Davisville are extensive, and as much as 135 feet thick in some locations (Coastal Resources Center, 1977). Glacial outwash has good water retention qualities, and as a result some of the better performing wells are those in outwash areas.

The soils covering much of Davisville have been severely disturbed. Only a few areas remain that have not been paved over, stripped of topsoil, or entirely excavated leaving large exposures of the substrata. Other areas have been filled in or covered over and now consist of made land. The runways, the Navy and Davisville Piers (including much of the area north of Pier #2), and the large open lands north of Allen Harbor are examples of filled land. The Dogpatch site, consisting of about 35 acres of land adjoining the waterfront at Fry's Cove, has not received much disturbance to most of its original topsoils.

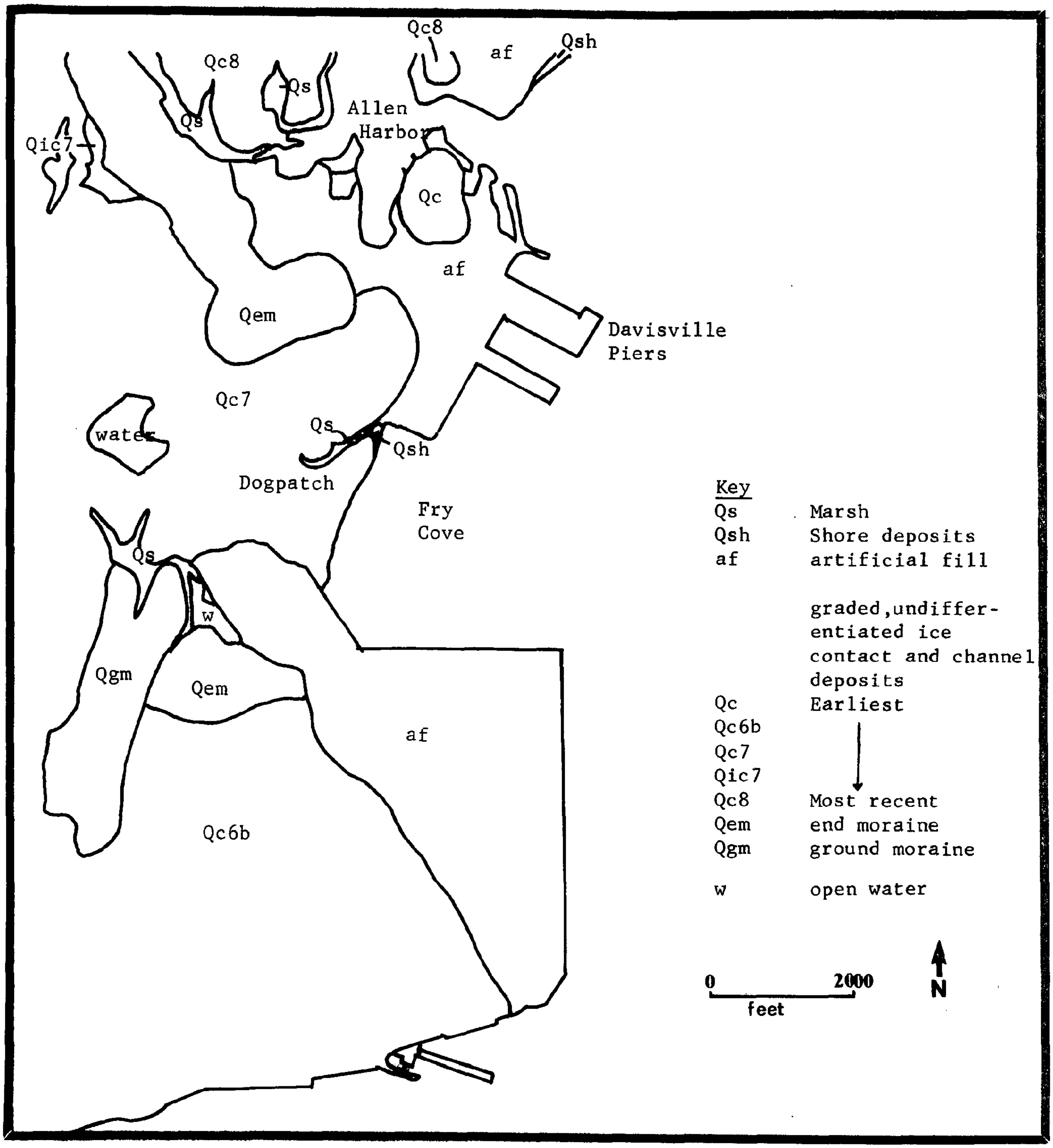



Figure 4-2 Surficial Geology of Davisville
Source: J.P. Schafer, 1961. Surficial Geology of the Wickford Quadrangle. U.S. Geological Survey, Washington D.C.

A total of six different soil types are present in the study area according to the U.S. Department of Agriculture's Soil Conservation Service (Soil Survey, N. Kingstown), (Figure 4-3).

From Calf Pasture Pt. to Airport bulkhead, the shore is comprised of sandy beaches (21), rocks and steel bulkheads. Sand beaches are found north of the ramp to just south of the Allen Harbor entrance at Dogpatch. The beaches, consisting of lenses of coarse-medium sand with gravel admixture, lie upon a coarser surface. The beaches are about 75-100 feet wide; slope 2-4 degrees offshore; and have at times 1-2 foot cusps on their foreshore. A small dune line borders the beach north of the ramp.

Behind the beach at Dogpatch is a small salt marsh which receives tidal waters from a small opening through the beach, and freshwater runoff from a culvert under Broadway draining the uplands. The salt marsh consists largely of organic material which is mixed with sand and other mineral sediments (Figure 4-4). The SCS classified this salt marsh soil type as Matunuck mucky peat (20). Contiguous to and upstream of the salt marsh is a small depression through which a small stream flows during the wet seasons. It becomes nearly dry during the summer months. Soils in this depression are Carlisle muck (19) and like the salt marsh are very poorly drained as the water table remains near the surface all year. The organic material is greater than 51 inches deep. Beaches are highly prone to flooding, erosion, and storm damage. The salt marsh and wet upland soils are inappropriate for most development activities due to high water table, potential for subsidence, and susceptability to frost action. Any major construction activity involving the areas occupied by these soils should be preceeded by a program to totally excavate the area of all organic sediments (Lester Stillson, SCS, personal communication).

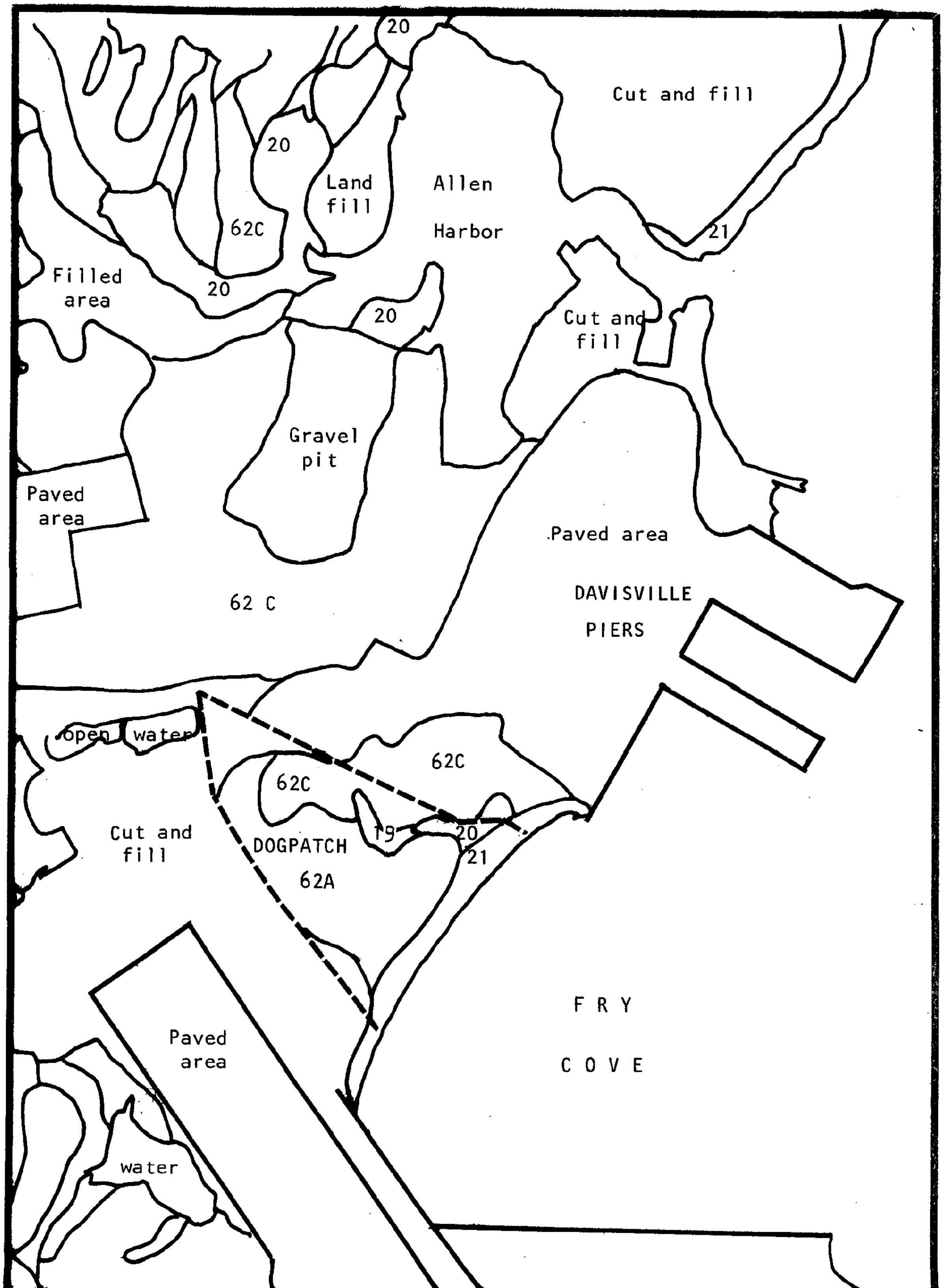



Figure 4-3. Soil types at Davisville. See text for explanation of categories. (source: Soil Conservation Service, 1973)

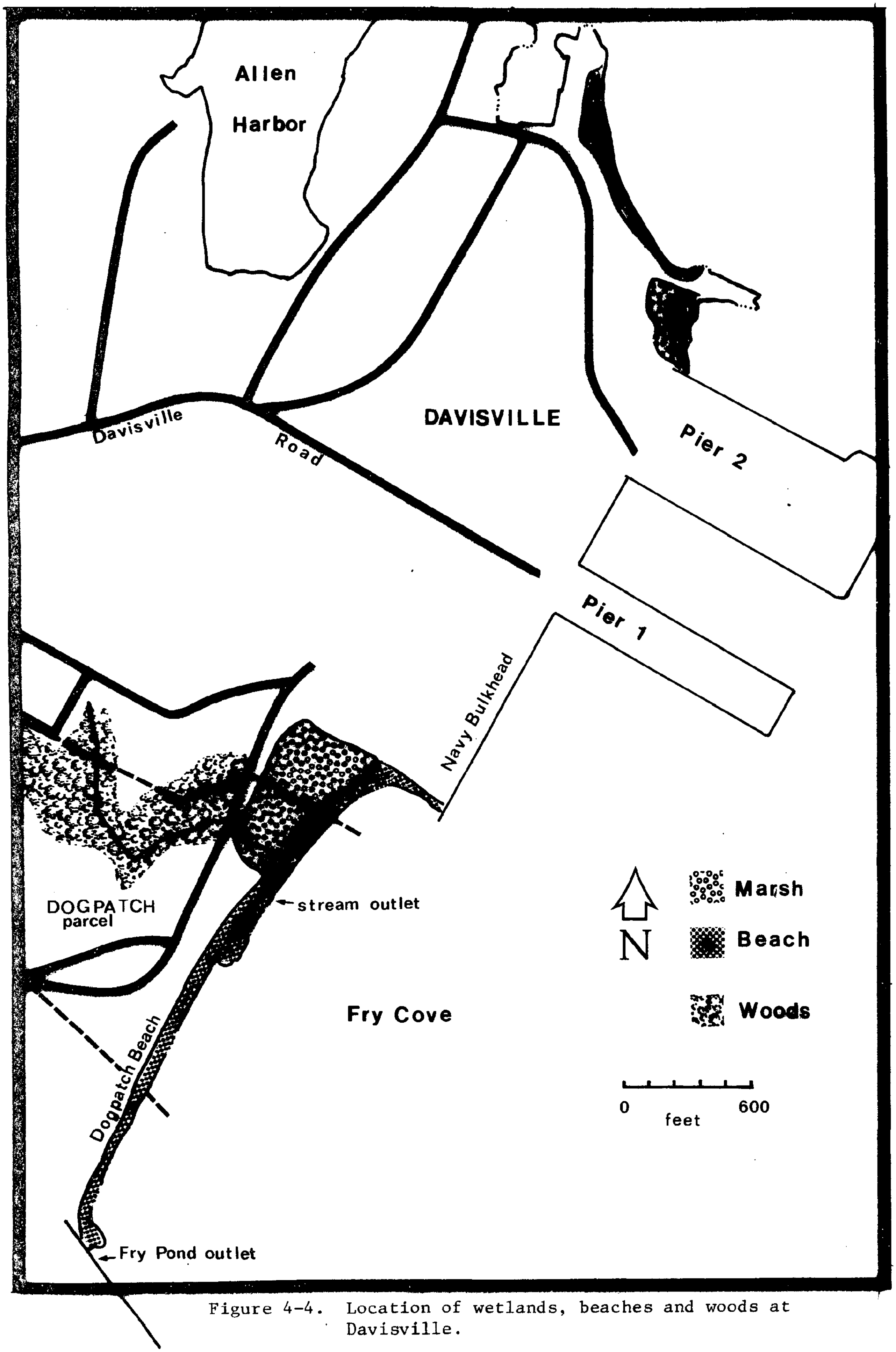



Figure 4-4. Location of wetlands, beaches and woods at Davisville.

Most of the upland soils at Dogpatch are made up of two types of Quonset gravelly sandy loam, one with a 0-3 percent slope (62A) and the other with a 3-15 percent slope (62C). Both consist of somewhat excessively drained soils on the outwash plains and terraces composed predominately of water sorted sands (SCS soil survey). The soils with less slope make up the southern half of Dogpatch while the steeper area encompasses a smaller section bordering the stream's northern shoreline. In general the Quonset series of soils have only slight to moderate limitations for development uses, but because of high permeability, are not suitable for sanitary landfill or other uses which could impact aquifer recharge areas. Quonset gravelly sandy loam soils have been designated by the Soil Conservation Service as soils of statewide importance for agriculture, even though all Quonset soils tend toward droughtiness and have moderate erosion potential. Prior to 1940, the entire area was in agricultural use.

Approximately four acres of cut and fill are present at Dogpatch, and forms a triangular shaped zone at the most inland (northwesterly) section near Davol Pond and Marine Road. This area was probably excavated and regraded during the construction of the Quonset runways since it is contiguous to them. This area has not been classified as to any individual soil type. No cores have been taken and there is no information present as to what is under the cut and filled area.

Hydrology

Although the entire Quonset/Davisville area is situated above the Potowomut-Wickford aquifer, a large ground water recharge area for North Kingstown, this aquifer will not be affected by activities at Dogpatch. Groundwater flow under Quonset/Davisville is towards the Bay (Coastal Resources Center, 1977, p. 82). The recharge area basins are located to the west of the Quonset/Davisville properties.

Surface water flow at Dogpatch is limited to one small unnamed and intermittent stream which emerges from a culvert between two buildings on the adjacent Navy retained land (Figure 4-5). The stream follows a natural depression on the Dogpatch parcel and empties into the small marsh on the beach. This small stream is one of several drainage areas on the Quonset Point/Davisville property that have been channeled and culverted.

Vegetation

Detailed descriptions of the vegetative communities at Quonset/ Davisville are presented in earlier studies. (Coastal Resources Center, CRC, 1977 and General Services Administration, GSA, 1979). Four plant communities have been identified at Davisville: forested areas; shrubby sites which are in the midst of being transformed from open fields to woods; wetlands; and areas where reforestation with pines has been attempted in order to reclaim and revitalize disturbed areas. Dominant species and other significant information has been compiled for Davisville and fifty other sites at Quonset Point/Davisville including a list of the common plant species. Both studies indicated that although most plant communities at Quonset are typical of those found throughout Rhode Island, they may be of more significance at Quonset/Davisville simply because they represent pockets of relatively undisturbed areas

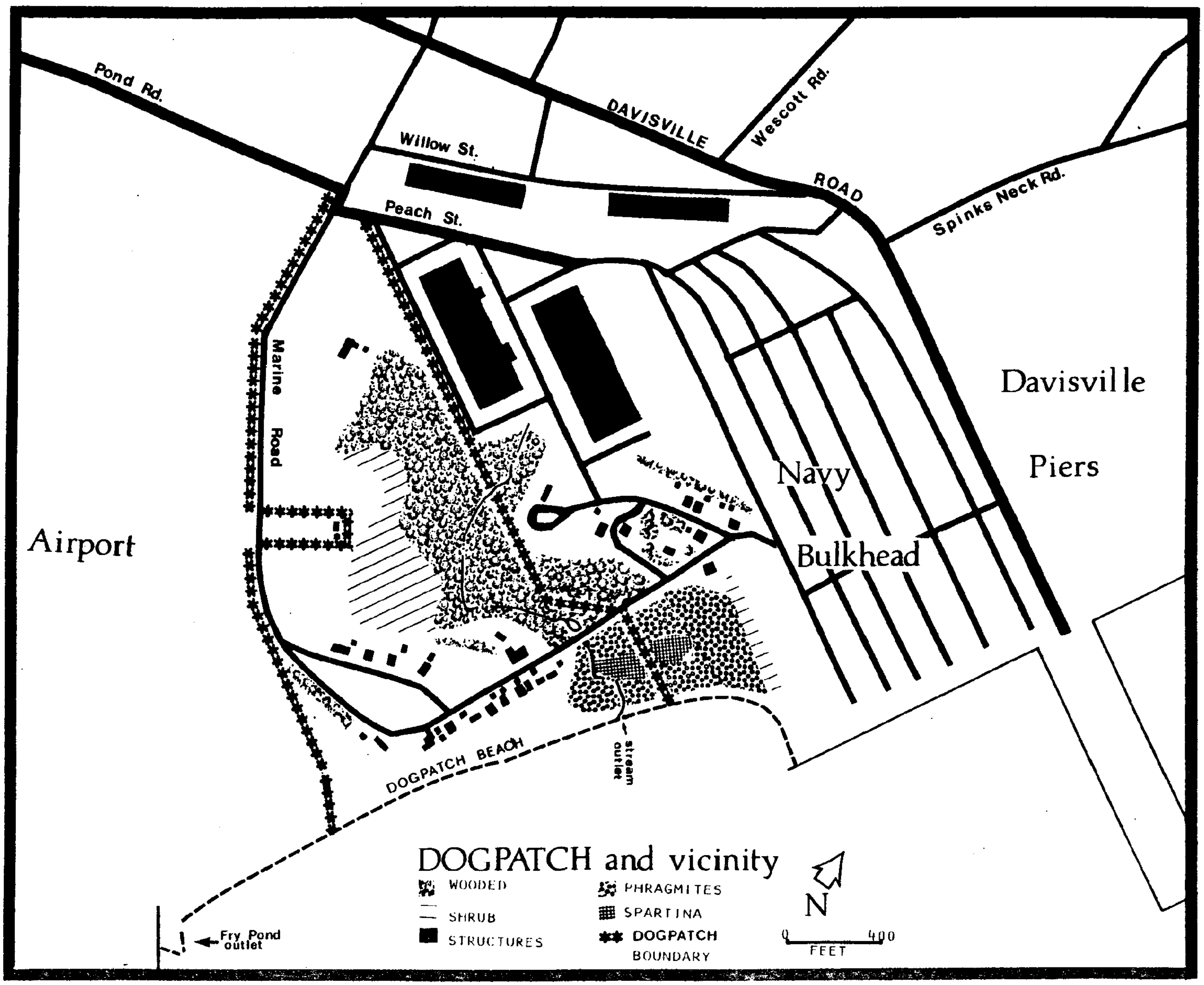



Figure 4-5 Land cover at Dogpatch parcel of study area

within a heavily modified environment and serve to provide a vegetated buffer between heavily developed parcels and those in residential and recreational use.

The Dogpatch area contains a mixture of typical plant communities (late shrubs, marsh, lawn) within a small 35 acre area (Figure 4-5). No intentional reforestation activities are known to have been undertaken at the site although the process of succession in which larger plants replace smaller species over time is occurring rapidly. Because of former use of the area for Naval officer residences, a considerable amount of the Dogpatch uplands adjacent to the houses were planted with lawns and ornamental shrubs. These have largely been abandoned and native vegetation is slowly invading replacing lawns and ornamental shrubs in the process.

Wildlife

A brief examination of mammal populations at Quonset/Davisville was undertaken in 1976 (Millar and Davis, 1976). Included in this inventory was the area adjacent to the small stream which flows through the Dogpatch parcel. This investigation was based on the identification of various wildlife signs including tracks, scat, browse, sightings, and animal remains. The result of this brief survey, together with a small mammal trapping study undertaken at the same time (Howell, 1976), and observations of birds since 1976 indicate that Davisville has an extensive and diverse wildlife population. This is largely due to the wide variety of land cover types on the base and the absence of man and domestic animals.

Structures and Archeological Sites

A discussion of the various buildings and other developed structures in the Dogpatch and Davisville Pier areas and the surrounding vicinity was presented by Harbridge House (1976, Marketability of Surplus Navy Property). In addition to the two piers, seven buildings were identified on the Pier property, and sixteen single family houses and a radio receiving station located at Dogpatch. None have been identified as being of historic or architectural significance, thereby constraining any alternative uses in the area (General Service Administration, 1978, p. III-7).

Likewise, no archeological features of National Register significance exist within Dogpatch or the Davisville Piers (12/20/77 letter of Historical Preservation Commission).

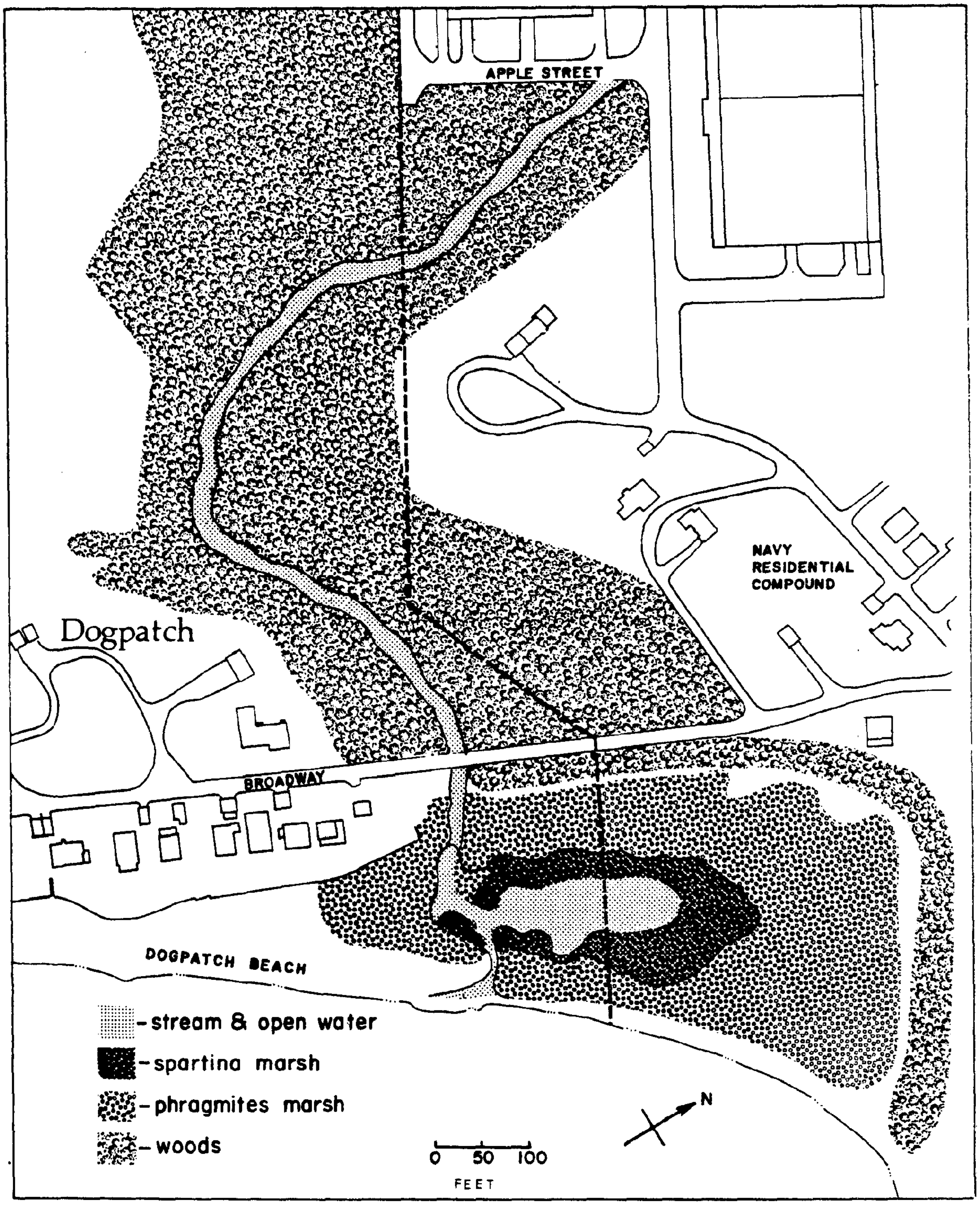
## Features of Special Significance in Vicinity of Proposed Development at Dogpatch

The Dogpatch area has retained most of its original topsoil which is still vegetated to a large extent in contrast to the adjacent Airport and Davisville parcels. The mixture of open fields, shrubs, woods and wetlands accounts for its value as habitat for birds and other wildlife species. Dogpatch contains four major features of special significance in terms of development planning (Figures 4-5, 4-6).

The Beach and Dune:

Dogpatch Beach is comprised primarily of sand and extends for approximately one-third mile from the bulkhead bordering the Quonset runways to another bulkhead at the Navy retained pier to the north. The beach forms the inland border of Fry Cove. The beach has received little recreational use since the Navy presence was reduced in 1974. Numerous sandpipers and plovers and similar shorebirds feed along the beach. According to Division of Fish and Wildlife, Rhode Island Department of Environmental Management, Dogpatch Beach has also been used as nesting habitat for a small colony of rare least terns. However, no nesting activity was observed in 1980.

Figure 4-6
# VEGETATIVE COVER, DOGPATCH PARCEL



The waters of the adjacent Fry Cove are often used by large numbers of waterfowl, especially scaup. The construction of the bulkheads at each end of the beach years ago has trapped the beach sands within the cove interrupting the natural process of long shore drift. As a result sand supply has been effectively cut off, leading to erosion of the beach face.

The southern terminus of the beach is located at two culverts which are the outlets of Fry Pond which is to the east side of the runways. The beach is narrow here, and is backed by a three to four foot high eroding upland plateau. Beach width increases further to the north and sand is plentiful, enough so that a small dune is forming and becoming vegetated with American beachgrass. The dune is approximately 150 to 200 feet long and appears to be slowly lengthening in a northerly direction, perhaps from eroded material from the adjacent escarpment. However, other portions of the beach appear to display some southerly movement of sand.

In the central portion of the beach a concrete seawall was constructed which protects the upland plateau and several now abandoned houses from erosion. Dune grass is gaining a foothold in front of the seawall. North of the houses and seawall is a small tidal creek which flows through the salt marsh into Fry Cove. Due to the unstable nature of beach sediments the creek tends to change position slightly on each tidal cycle. The beach width begins to narrow considerably north of the creek. A dune has formed between the beach and marsh which is completely vegetated, mostly with Phragmites which helps prevent washovers of sand into the marsh. The extreme northern alignment of the beach veers gradually toward the east to meet the Navy bulkhead. This section of beach is cobble with very little sand present.

The Wetland:

A small, two acre wetland is located directly in back of the beach at its extreme northerly end (Figure 4-6). This salt marsh has apparently formed on sand accumulating after the Navy bulkhead was built. This sandy substrate, together with the outlet of a small freshwater stream at this location has presented ideal conditions for salt marsh formation. The stream but not the wetland appears in nautical charts of the Narragansett Bay prepared in 1900 by the Coast and Geodetic Survey.

The salt marsh portion of the wetland encompasses approximately one-half acre of smooth cordgrass, Spartina alternaflora, and open water areas. It is surrounded almost entirely by a wide band of tall reed grass (Phragmites communis) which largely isolates the marsh interior from the outside. The Phragmites encompasses approximately one and one half acres. A small tidal creek through the beach connects the marsh with Fry Cove. An intermittent freshwater stream feeds through a culvert under a road to enter the salt marsh's southwestern corner. The marsh and tidal creek are used frequently by shorebirds and waders for feeding and nesting. Use by birds is enhanced by the lack of disturbance by man and the protective reed fringe. A pair of mallards nested successfully in the marsh in 1980. Successful waterfowl nesting is unusual in many marshes in Rhode Island due to high levels of human or domestic animal disturbance.

The marsh, when viewed in relation to the entire Narragansett Bay, is probably of little significance due to its small size and probably minor contribution to and interaction with the Bay ecosystem. There are numerous larger, more diverse marshes in a more rural settings which are of higher priority to protect because of their broad values for wildlife or as an aesthetic resource.

Woods and Stream:

The small stream which feeds into the salt marshes emerges from a culvert which drains Navy retained land to the north. The stream flows through a densely wooded gully to the salt marsh. The woodland consists largely of a tangle of shrubs and vines including wild grapes, honeysuckle, and bittersweet, and is approximately 10 acres in size. Dominant woody shrubs and trees include wild black cherry, young black oak, alder, aspen and sumac, all more indicative of a late shrub stage than a mature woodland. Several pine trees and juniper are found on the woodland edge but the dominant trees are hardwoods throughout the 400 to 500 foot length of the stream. Remnants of an old orchard are present as well. Although the stream is intermittent and can dry up completely after several days of dry weather, the soils within and along the sloping edges of the stream bed are highly organic and mucky and remain wet all year. The stream bank is heavily shaded in some sections, providing good growing conditions for numerous common groundcover plants such as Virginia creeper, poison ivy, and sensitive fern. Open sunlit areas, more conducive to the growth of taller shrubs contain winterberry, bayberry, arrowwood and alder, all valuable berry producers and attractive to birdlife. Birds observed here include the mockingbird, robin, purple finch, redwinged blackbird as well as numerous warblers. A brief mammal study during 1976 found that, like the rest of Quonset/Davisville, cottontail rabbits are numerous at Dogpatch, particularly the forest/shrubland edge (Millar and Davis, 1976).

The major attribute of this stream and woodland, in addition to its value to wildlife, is the important role it plays as an effective visual buffer between the upland areas and the Navy and oil industry operations at Davisville piers. It adds diversity to the landscape and provides the only distinct separation between various use districts on the Quonset/Davisville shoreline. Scientific names of species are listed on Table 4-1.

Abandoned Lawns and Open Fields:

The central portion of the Dogpatch parcel has experienced some changes to the native vegetative cover during the operation of the Navy base. However, topsoils are for the most part original. The numerous lawns and ornamental plantings associated with the abandoned housing have now been to a large extent abandoned. Land further from the houses is dominated by native plant species. Abandoned fields with grasses and early shrub stage successsional areas lend a diversity to the upland environment and since present levels of disturbance are low, they are of particular value as wildlife feeding and nesting habitat. Large numbers of small mammals such as whitefooted mice and meadow voles utilize this area and birds are everywhere. Although many of the bird species sighted are those that have become associated with the suburban environment such as starlings and English sparrows, the lack of use of this area by man in recent years has made the area more attractive to "wilder" species such as kingbirds, various warblers, and meadowlarks. The latter species is found nesting in sizeable numbers in the abandoned fields and shrubby areas.

TABLE 4-1

List of Common and Scientific Names of Species Observed In Woods and Stream, Dogpatch Site

| | |
|---|---|
| **Woodland** | |
| wild grape | Vitis sp. |
| honeysuckle | Lonicera sp. |
| bittersweet | Celastrus scandens |
| wild black cherry | Prunus serotina |
| black oak | Quercus velutina |
| alder | Alnus rugosa |
| aspen | Populus sp. |
| sumac | Rhus sp. |
| **Stream Bank** | |
| Virginia creeper | Parthenocissus quinquifolia |
| poison ivy | Rhus radicans |
| sensitive fern | Onoclea sensibilis |
| winterberry | Ilex verticillata |
| bayberry | Myrica pensylvanica |
| arrow wood | Viburnum recognitum |
| **Wildlife** | |
| mockingbird | Mimus polyglottos |
| robin | Turdus migratorius |
| bluejay | Cyanocitta cristata |
| red winged blackbird | Agelaius phoeniceus |
| warblers | Parulidae |
| cottontail rabbit | Sylvilagus sp. |
| Eastern meadowlark | Sturnella |
| mallards | Inas platyrhyneas |
| greater scaup | Aythya marica |
| **Shore** | |
| beachgrass | Amnophila brevilingulata |
| smooth cordgrass | Spartina alterniflora |
| reed grass | Phragmites communis |

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## 4.4 GEOLOGICAL FEATURES OF THE MARINE ENVIRONMENT

Introduction

The proposal to build a bulkhead and dredge off Dogpatch Beach raised several concerns pertaining to the geology of the area. Since construction of a dredged channel is enormously more expensive if blasting is involved, it is essential to know the location of bedrock. This is also important for bulkhead design since the foundation of the structure may have to be anchored in bedrock. Further the environmental impacts of dredging activity as well as several engineering considerations are determined in good part by the type of sediment that must be removed. Detailed site investigations of depth to bedrock and sediment characteristics were undertaken as part of this environmental assessment by Dr. Robert McMaster, and are reported in Part B. The result of the 1980 study show that bedrock in the study is 25 to 99 feet below the surface sediment and that the overburden is composed of glacial sediments. These findings indicate no geological constraints to project construction.

A second series of concerns relate to the behavior of the bottom. An active bottom as determined by detailed bathymetry and observation of ripples and waves on the bottom itself may indicate areas where in-filling of a channel might be severe or when construction may interfere with important natural processes. Detailed observations using side scan sonar show that the gentle sloping bottom off Dogpatch is almost featureless and, therefore, largely inactive and that there are equally few signs of activity on the slopes of the dredged channels or the deep basin off the outlet of Fry Pond.

Adjacent to the Dogpatch shoreline, the bottom is essentially flat. This very shallow flat bottom extends many hundreds of feet bayward. Fine sand, light at the surface but dark below, characterizes the bottom. In front of the Dogpatch cottages south of Pier 1 about 2 feet of fine sand overlie a mud layer of 0.5 to 1 ft in thickness. The mud is composed of 85% silt, 10% clay, and 5% sand. The extent of this mud layer in the entire nearshore bottom is unknown. An occasional boulder is also observed in the nearshore zone. A fan-shaped deposit of sand and gravel, extending some 200 feet outward from the shore, lies adjacent to the marsh just north of the line of cottages. Where the airport bulkhead begins the bottom consists of cobbles and boulders which may serve to protect the two large culverts which permit tidal exchange with Fry's Pond.

Some insight into shoreline processes may be inferred. Evidence of net southward beach drift is apparent from the beach accretion on the north side of the Allen Harbor entrance, sand in-filling on the north side of the harbor channel, rip-rapping on south side of harbor entrance, eroded shore south of Pier 1, and southward off setting of swamp channelway south of Pier 1. However, the southward beach drift is believed to be weak south of Allen Harbor entrance.

No evidence was uncovered during the July 1980 field inspection to support the existence of a seasonal exchange of sand from the beach to the nearshore bottom or from the nearshore bottom to the beach.

Bathymetry

Bathymetric data are presented as a contour map (Figure 4-7). The relief in the area is characterized by the dredged ship channel network and a drowned stream channel adjacent to the airport bulkhead. Otherwise, the bottom shows a gradual inclination offshore from 6 to 26 feet. Their edges are well-defined and marked by slopes that range from 1:2.5 to 1:4. Apparent slumps are observed at a few locations.

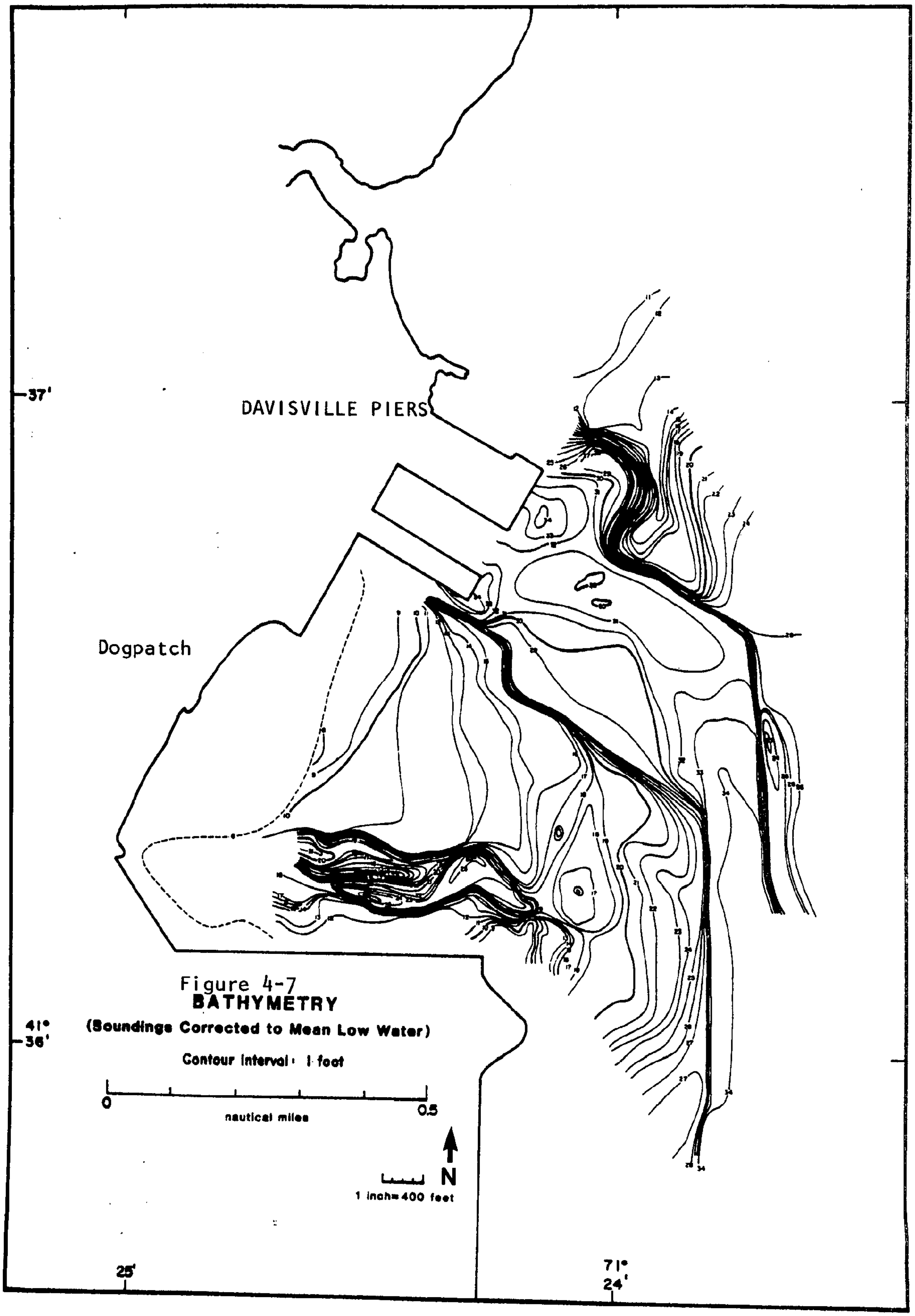


Figure 4-7
**BATHYMETRY**
**(Soundings Corrected to Mean Low Water)**

A drowned stream valley complex lies immediately north of the airport bulkhead and essentially parallels the structure. This valley extends from the vicinity of the shore eastward to a position northeast of the bulkhead where it loses its identity. Depths within the valley reach 18 to 26 feet. The most noteworthy aspect of this feature is that a narrow divide separates the depression into two well-defined channelways.

Aside from these prominent features, the bottom is shallower with no distinct relief except for two small "mounds" that occur between the piers and airport bulkhead at depths of 17 feet.

Bottom surface conditions (side-scan sonar)

A side-viewing sonar survey revealed a small variety of bottom features within the area (Figure 4-8). These features include the edges of channelways; the units of the valley complex adjacent to the airport bulkhead; the divide within the valley complex; rake marks; three arbitrary categories of bottom roughness (i.e. slightly rough, very slightly rough and smooth bottom); and a number of unidentified targets. The distribution of the features follows no pattern except that the smoothest bottom occurs only in the channels and valley complex.

Sediment

Surface sediments range from sands to silts (Figure 4-9). These sediment types reflect sand contents that vary from 98% sand to 4% sand. Across the area, the bottom sediment shows dark sands composed of up to 98% sand inshore grading to dark sediment with 74-54% sand further offshore that contains 20-42% silt and 3-6% clay (particles less than 3.4 microns).

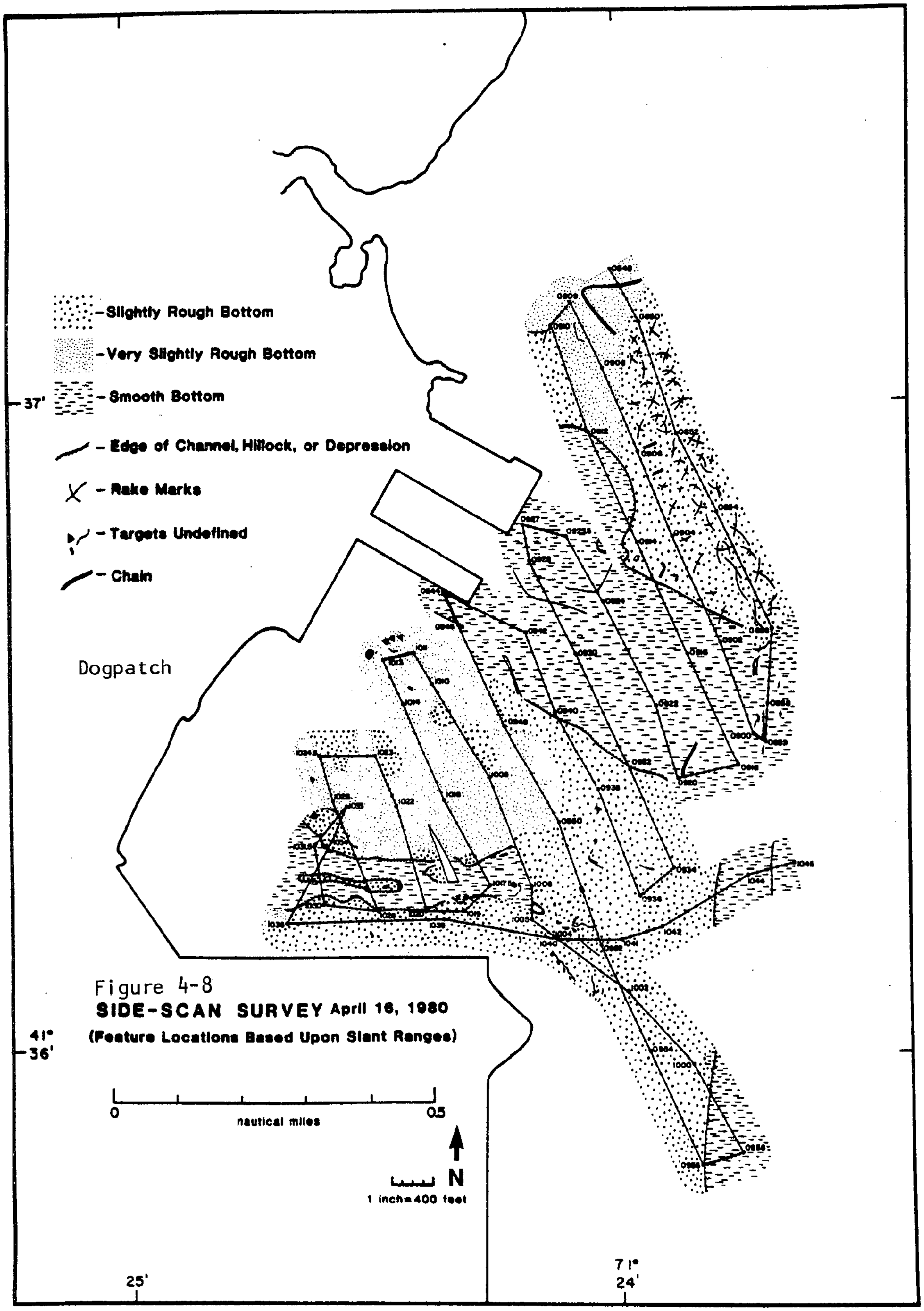


Figure 4-8
**SIDE-SCAN SURVEY April 16, 1980**
**(Feature Locations Based Upon Slant Ranges)**

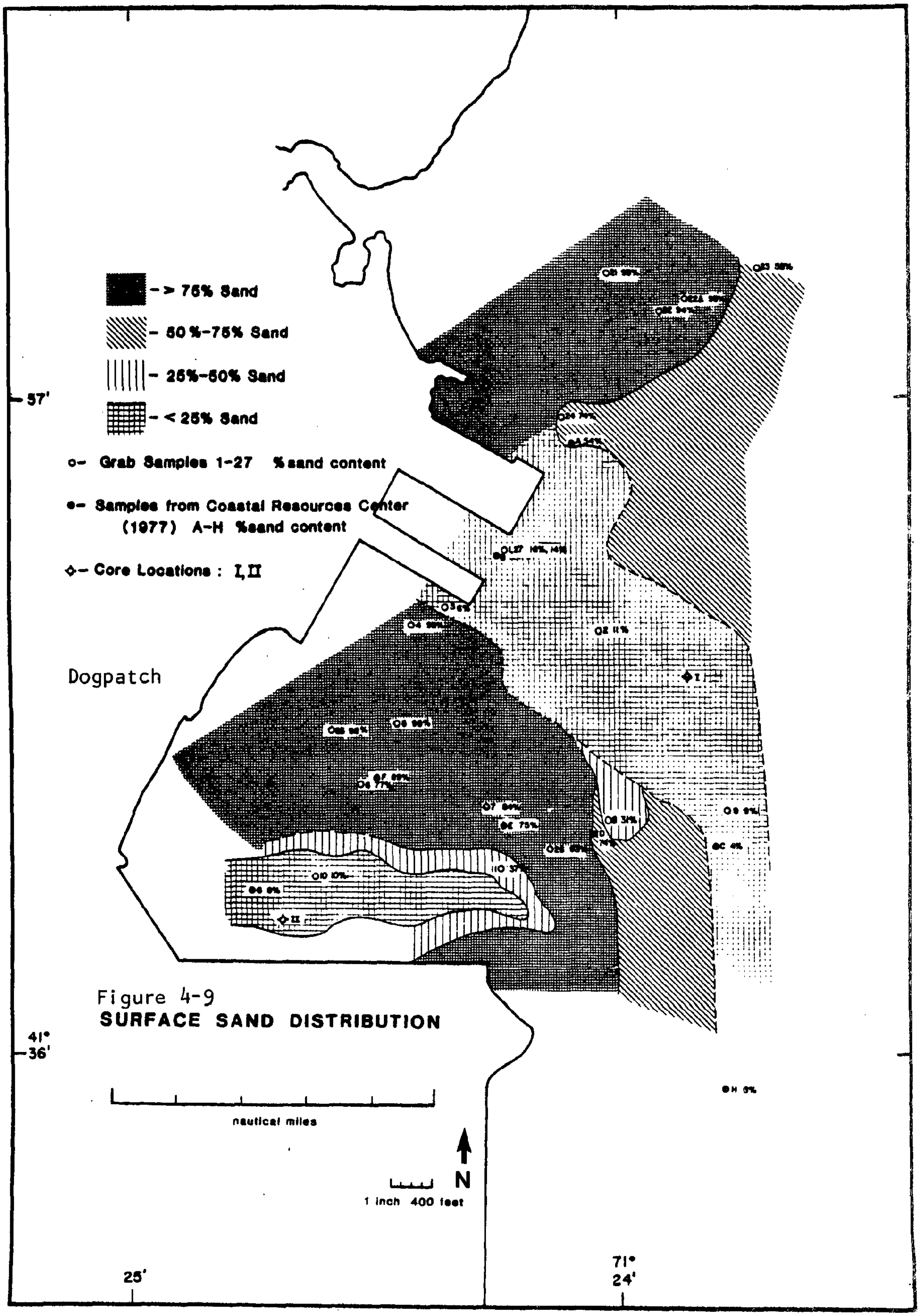


Figure 4-9
**SURFACE SAND DISTRIBUTION**

The finest sediment, silt deposits, are located within the dredged ship channel and the drowned river valley adjacent to the airport bulkhead. In the ship channel, an unstratified silt accumulation, measured by coring to be approximately 18 inches at one location, contains 75-84% silt, 6-17% clay and 4-16% sand and overlies a sandy dredged surface. The silt within the drowned valley shows 77% silt, 13% clay and 10% sand. Beneath the surface silt, the bottom is composed of laminated units of fine sediment at least to a depth of 2.3 feet.

The sand component in all sediment types is dominated by fine to very fine sand. Shells and gravel comprise only 2-7% of the samples.

Bedrock

Bedrock depths are shown in feet (Figure 4-10). C.E. Maguire boring sites with bedrock depths are also plotted. Compilation of bedrock depth data is presented in Part B of this report.

The depth, attitude and shape of the bedrock surface is apparently controlled by the down cutting of an ancient drainage system. The dissected surface lies from 47 to 119 ft below MLW with no obvious attitude. Unfortunately, a significant portion of the surface is hidden because of attenuation of the acoustic signals by gaseous sediments beneath the channels and valley complex.

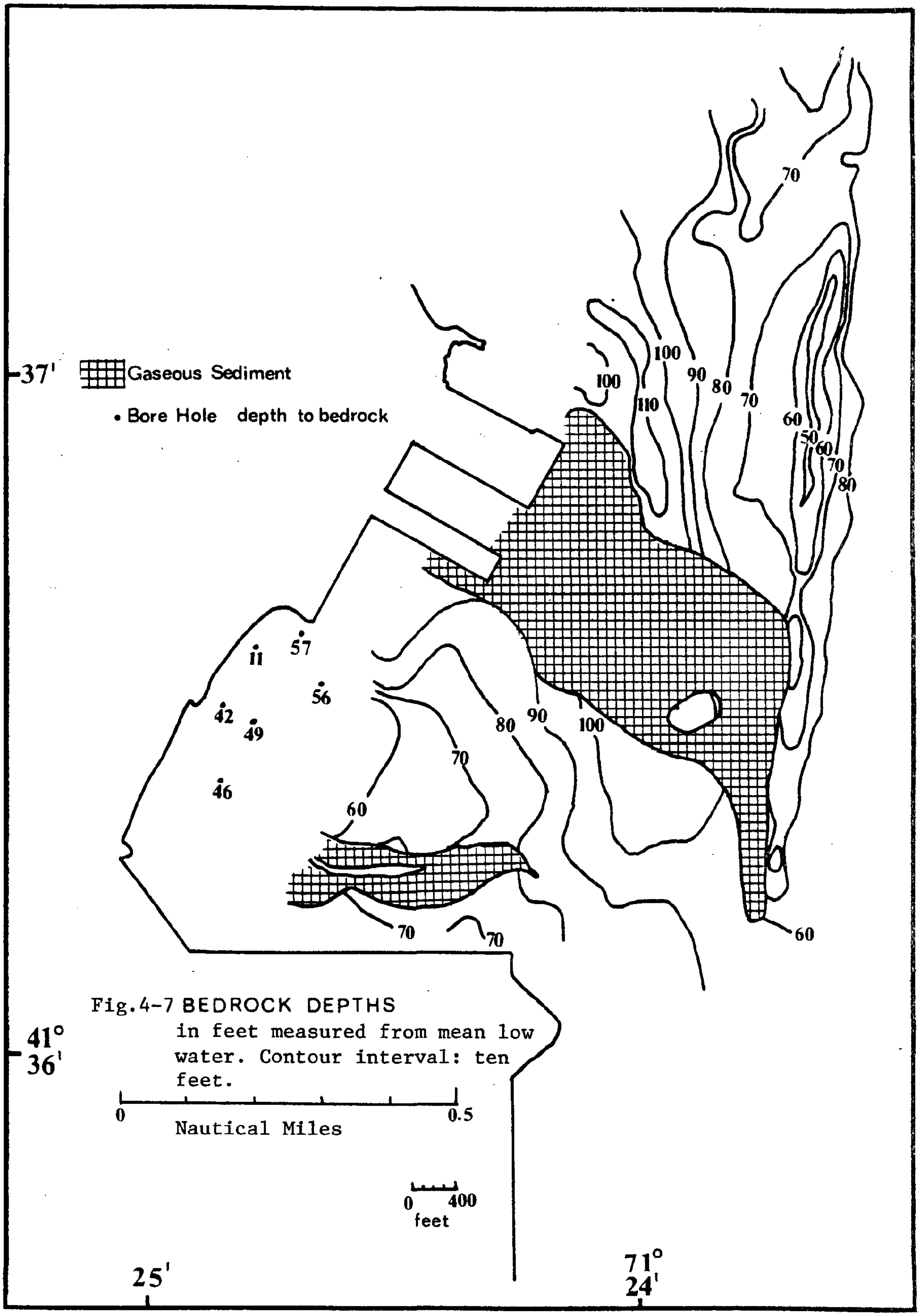


Fig.4-7 BEDROCK DEPTHS in feet measured from mean low water. Contour interval: ten feet.

A major bedrock valley crosses the area from NW to SE. Depths within this valley reach more than 110 feet east of Pier 1 but shoal toward the southeast before apparently connecting with a N-S trending channel that lies adjacent to the study area on the east. A smaller bedrock valley, oriented E-W, appears to join the NW-SE trending valley northeast of the airport bulkhead. Bedrock depths within this valley are less than 90 feet. South of Pier 1, it is uncertain as to how the bedrock depths of almost 100 feet are related to the valley segments described above.

The shallowest bedrock depths, about 50 feet, are associated with the western divide of the N-S trending valley that lies along the study area's eastern side.

Overburden

Sediment thickness is plotted as an isopach map (Figure 4-11). Calculated thickness values are based upon a sediment velocity of 5,000 ft/sec. All data on the overburden are presented in Appendix B. Sediment thickness information from the C.E. Maguire borings and bore holes during U.S. Navy ownership (Coastal Resources Center, 1977) is also shown.

Overburden thickness ranges from 25 to 99 feet. These values are closely related to the configuration of the bedrock surface: the greatest thickness occur in the bedrock valleys with lesser sediment cover lying on the divides. Hence an overburden thickness of over 99 feet is found immediately east of Pier 2 and more than 80 feet lies south of Pier 1. Beneath the E-W trending valley complex, more than 50 feet of overburden covers the bedrock.

The smallest accumulation, about 50 feet, lies above the bedrock divide that occurs along the area's eastern side.

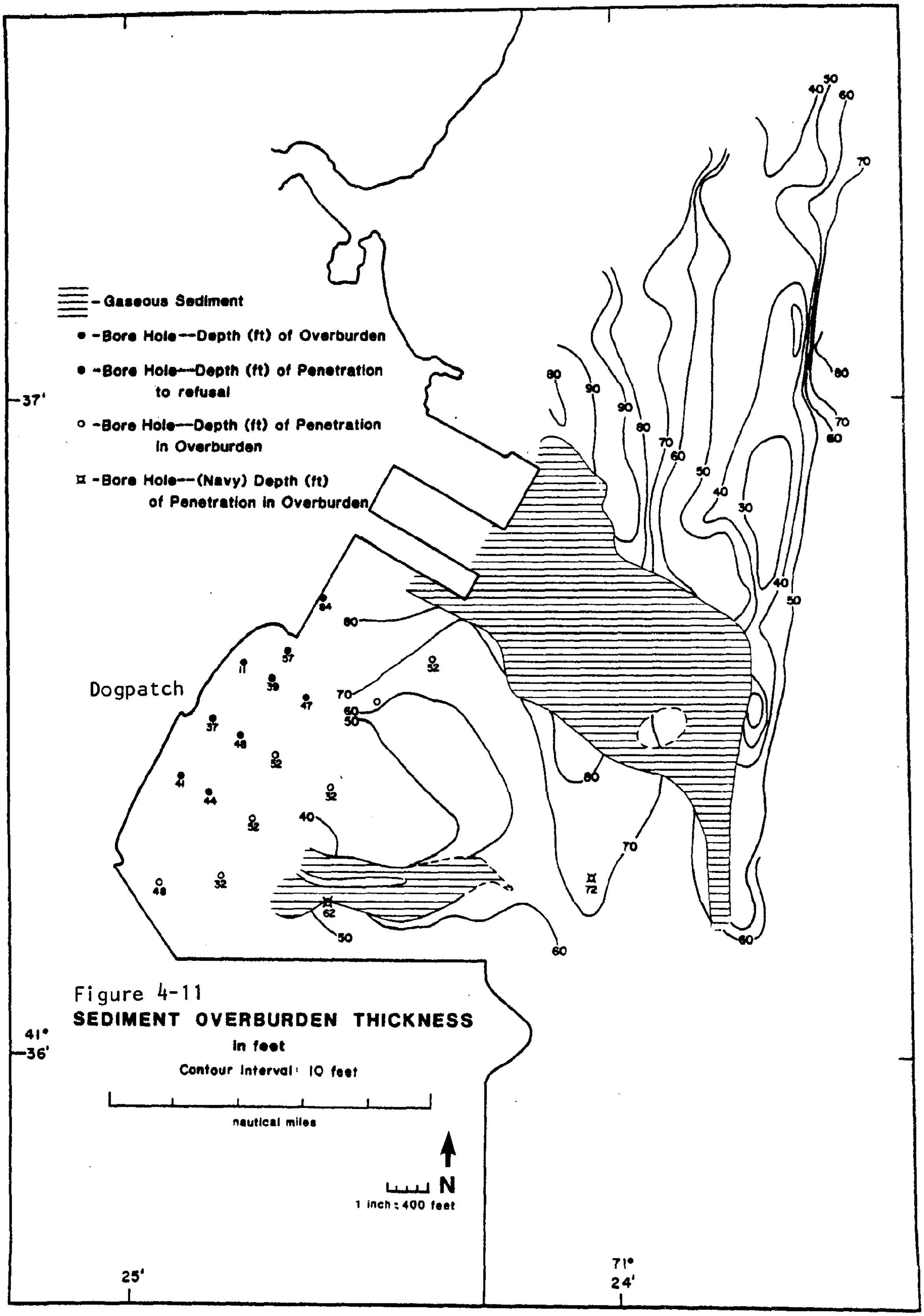


Figure 4-11
**SEDIMENT OVERBURDEN THICKNESS**
in feet
Contour Interval: 10 feet

A close inspection of the seismic records together with an interpretation of C.E. Maguire's boring logs indicates that the overburden is composed primarily of glacial outwash with a smaller amount of glacial till.

## 4.5 BIOLOGICAL FEATURES OF THE MARINE ENVIRONMENT

### Introduction

The primary effects of the proposed port expansion project will be to remove several acres of shallow bottom habitat in Fry Cove by fill or dredging and produce turbidity during dredging and dewatering of the dredged material. For this reason, biological investigations of the project site concentrated on characterizing the bottom communities present, assessing the natural turbidity in the area and compiling from the literature information on the effect of suspended sediments and burial on the organisms present. This information is presented in greater detail in Part C. In addition, this section contains a discussion of suspended sediments and the levels of metals and hydrocarbons in the bottom. Finally information on pollutants in the water column and in organisms at the site is provided and discussed.

The additional sampling undertaken in 1980 and described in Part C, was conducted so that comparisons could be made with the results of a 1976 survey of the Davisville site (Coastal Resources Center, 1977). Although there has been no major change in human activities at Davisville during the four years between studies, noticeable changes took place in both the species composition and abundances of organisms. (Figure 4-12).

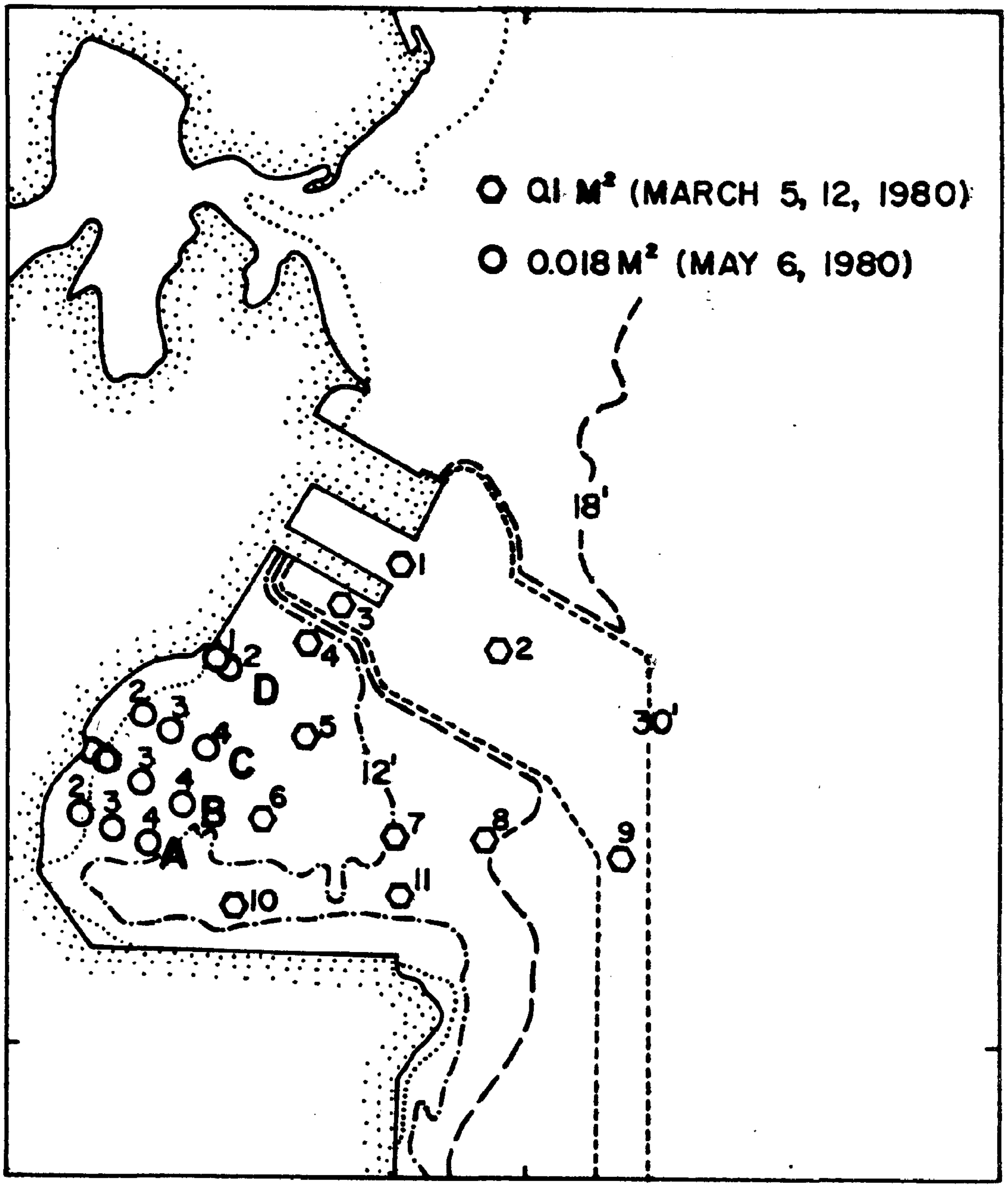


Figure 4-12. Grab Sample Locations for Benthic Survey
Letters A-D designate reference points along Dogpatch Beach for each series of 0.018 $m^2$ samples.

A pilings
B sea wall
C rocks
D navy bulkhead

Characterization of Living Communities

The bottom environments in the Davisville area can be placed into three categories on the basis of depth. The first includes the deeper dredged channels and basins and the natural channel in Fry Cove (sta. 1, 2, 3, 9, 10, in Figure 4-13) which are floored with semi-fluid sediments with 80-69 percent silt and 11-21 percent clay. The second is a shallow sand platform or terrace which extends several hundred feet offshore below the mean low tide level from Dogpatch Beach (see Figure 4-13). The remaining stations (4, 5, 6, 7, 8, 11) are on gently sloping bottom grading from 95 percent sand to 31 percent sand, 69 percent silt/clay between the beach and channel. The shells of clams, oysters, and other bivalves provide hard substrate and shelter in this mid area. Each depth zone/bottom type has its own temperature pattern. The shallower areas warm faster in the spring and have higher summer temperature.

Field collections of bottom animals were made in March and May 1980 using techniques similar to those used in the October 1976 survey for the Coastal Resources Center (Pratt, 1977). The results of both surveys are discussed in terms of the different groups of species present and the adequacy of the baseline data to detect impacts of development. Numbers of individuals identified in each sample are given in Tables 2-1 and 2-2 Part C. The channel stations (1, 2, 3, 9, 10) had very low numbers of species and individuals (1-5, 1-110). The few species present were those adapted for life in the deeper soft bottoms of the Bay. They are commonly found in greater densities in similar environments in the Bay. The Dogpatch beach samples (groups A, B, C, D) contained 4-21 species per sample and high numbers of species adapted for unstable sandy substrates such as the gem clam (*Gemma gemma*), the telline clam (*Tellina*

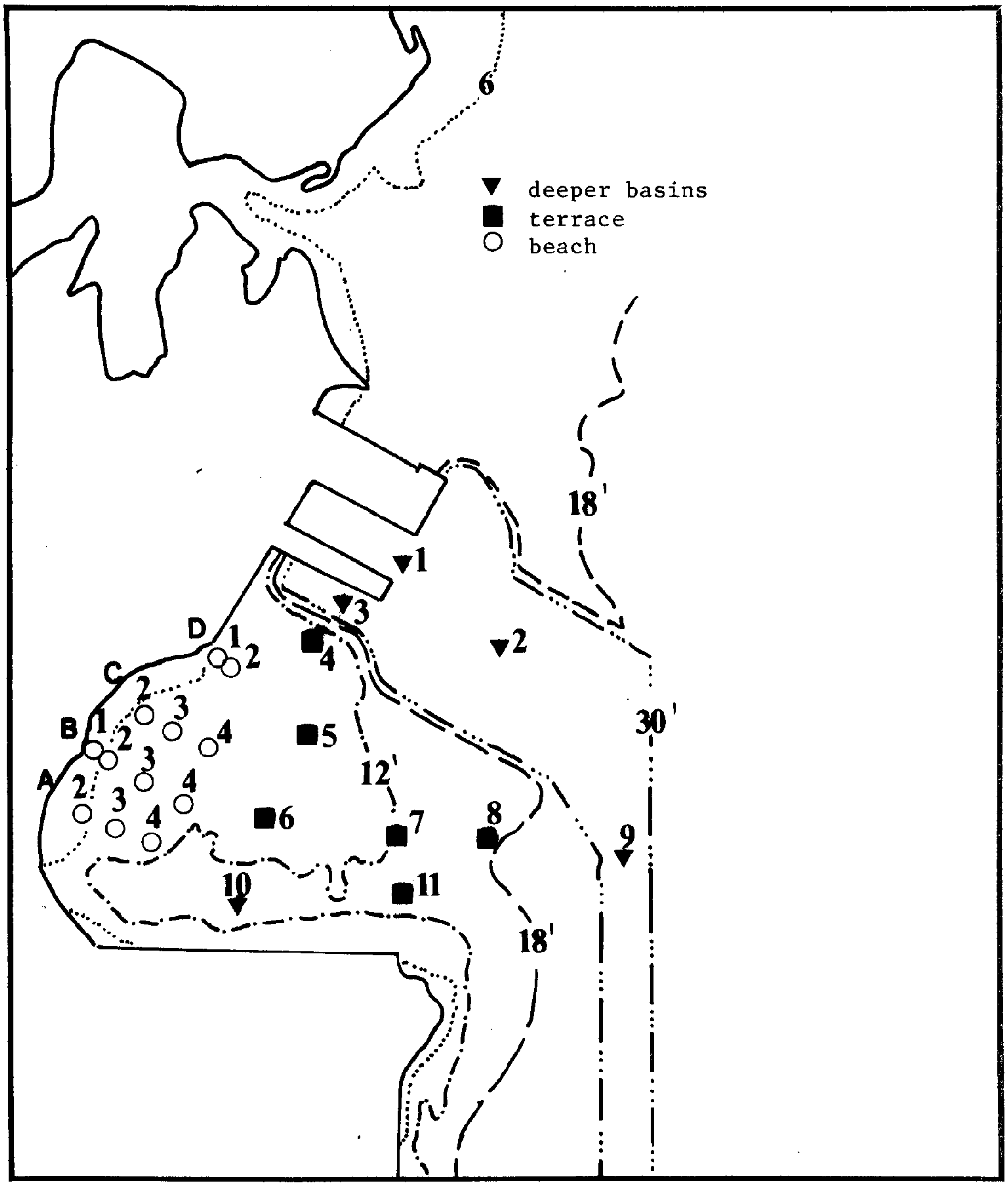


Figure 4-13 Characteristics of benthic sampling stations.
(see figure 4-12 and text for explanation)

agillis) and the polychaete worms Scoloplos robustus and Spio setosa. In the deeper beach samples on the edge of the platform (C-4) the tubes of the large amphipod, Ampelisca verrilli, were evident. Capitella capitata, a polychaete sometimes identified as a pollution or stress indicator was present in this area. Only 2 hardclam (Mercenaria mercenaria) juveniles and no softshell clams (Mya arenaria) were found.

The mid-depth samples (4, 5, 6, 7, 8, 11) contained from 21 to 31 species and 91 to 664 individuals per sample. Dominant species included the bivalve, Tellina agillis; the gastropods, Crepidula fornicata, and C. plana; the tube-dwelling amphipod crustacean, Ampelisca vadorum; and the polychaete Glycera americana (bloodworm). The bivalve, Nucula annulata was found in the deeper, more silty samples. Hard clam juveniles were found in all mid-depth samples. The species present in the mid-depth samples were similar to those found in 1976. The numbers of individuals and species per sample was also similar.

Samples can also be compared in terms of the relative importance of each species within the samples by calculating a percent similarity index (Sanders, 1960). Duplicate samples 7 and 7Q had a 59 percent similarity. Samples from a given bottom type often show a 30 to 40 percent similarity. The values for three stations where samples were taken both in 1976 and 1980 fall within this range:

| Location | Station # 1976 | Station # 1980 | % similarity |
|---|---|---|---|
| mid-depth | 15 | 5 | 31.5 |
| mid-depth | 14 | 7 | 38.8 |
| dredged channel | 12 | 9 | 31.3 |

These comparisons indicate that the mid-depth areas have populations of bottom animals which are stable over seasons and years. This stability may be the result of the presence of many bivalve and polychaete species which have a life span of a year or more, the presence of adequate oxygen throughout the year, ~~and~~ moderate wave effects and stable bottom.

The most significant finding of the survey was the large decrease of individuals and species in the deep areas. This is illustrated by data from matching stations:

| Location | 1976 sta. | 1976 inds. | 1976 species | 1980 sta. | 1980 inds. | 1980 species |
|---|---|---|---|---|---|---|
| Fry Cove channel | 16 | 420 | 23 | 10 | 50 | 3 |
| Dredged channel | 12 | 411 | 32 | 9 | 110 | 5 |
| Dredged channel | 17 | 460 | 27 | -- | -- | -- |
| Turning basin | 11 | 199 | 22 | 1 | 16 | 3 |
| Turning basin | -- | | | 2 | 10 | 2 |
| Turning basin | -- | | | 3 | 1 | 1 |

Additional qualitative samples examined in both years substantiated this pattern. The species which were abundant in 1976 were the bivalves _Necula annulata_, _Macoma tenta_, and _Mulinia lateralis_ and the polychaetes _Pectinaria gouldii_ and _Spiochaetopterous oculatus_. The bottom sediments in all deep areas were very incohesive and anoxic below a few millimeters. Although the previously occurring species are all adapted for life in relatively soft sediments, _M. lateralis_ is a suspension feeder and might not be able to feed on excessively soft bottom while the polychaetes occupy tubes and require some sediment stability. The _M. tenta_ population observed in 1976 probably consisted of animals which had set and grown during the summer. This species may not in fact be adopted for year round survival in very soft sediments. The absence of attached shell pairs, "clappers," of the bivalves indicated that these had not been recent mortalities. It is possible that the animals in these areas were killed during a period of low oxygen levels. An alternative explanation for bivalve reduction in Fry Cove channel is the feeding of very large flocks of diving ducks during the winter.

The beach area was first sampled quantitatively in 1980). These samples (station groups A, B, C, D) show some overlap in species makeup with the mid-depth samples (stations 4, 5, 6, 7, 8, 11) but all of the dominant species are restricted to shallow stations and are known to be characteristic of protected beach environments. The very dense population of the small gem clam, Gemma gemma, at one station may have resulted by concentration by waves and current similar to that which was observed in Charlestown Pond (Phelps, 1964). On Dogpatch Beach softshell clams are restricted to a cove south of the Navy bulkhead and patches around boulders. Apparently wave action and sand movement prevent establishment on the open sand platform.

Shellfish and finfish are abundant in the waters off Quonset/Davisville. The area supports both commercial and recreational fisheries: soft shelled clams, quahogs, flounder, scup, striped bass, bluefish, menhaden, lobster, conch and baitfish. North of the Davisville piers, the water is classified SA and shellfishing is permitted. Calf Pasture Point is an important quahauging ground. South of the Davisville piers in Fry Cove commercial quahauging has been active since the area was opened by the Department of Environmental Management in July 1980.

Data from routine Department of Natural Resources (DNR) fish trawls northwest of the Davisville piers show that commercially important finfish species are present. Several part-time draggers from Newport and Wickford catch winter flounder, scup, fluke, butterfish, and baitfish in the area. Menhaden frequently school in waters adjacent to Quonset (Ganz, 1975). Sportfishing is extremely popular in the West Passage. Sisson (1970) reports that Wickford based sportsfishermen spend an average of 44.6 days a year fishing for bluefish, striped bass, flounder, tautaug, scup, mackerel, and fluke, most of which is caught in the Quonset/Davisville vicinity.

The fisheries resources of Davisville area were inventoried by the former R.I. DNR, Division of Fish and Wildlife (Ganz and Sisson, 1977; summarized in CRC, 1977). They mapped concentrations of softshell clams in the low intertidal immediately south of the Navy Bulkhead and among rocks halfway down Dogpatch Beach. Maximum density in these patches were similar to locations in Allen Harbor ($42/m^2$). These areas have been used by recreational diggers since opening of the fishery in July 1980. In contrast shore between Allen Harbor and Davisville Pier 2 had low densities of softshell clams (mean: $1.35/m^2$, n=17) despite seemingly suitable conditions.

Hard clams are abundant in Fry Cove at subtidal depths. In the 1976 CRC survey all the cove was shown as having abundant clams but this was based on only a few bullrake hauls. Since the Cove was opened in July 1980 it has been heavily fished by commercial quahaugers. As many as 30 or 40 boats have been seen in the cove at one time during periods when preferred upper Bay areas have been closed. According to personnel of the Department of Environmental Management Enforcement Division bullrakers have been concentrated off the Navy "wooden" bulkhead and the airport "steel" bulkhead. A high proportion of more valuable smaller clams were reported off the steel bulkhead. Tongers working in shallower areas along the beach appeared to be recovering higher proportions of larger clams.
A few hundred oysters are found on the rocks along Dogpatch Beach. They are most abundant at the culvert draining Fry Pond but are limited by availability of hard substrate and sand movement. The long double culvert to Fry Pond may be a source of oyster larvae.

Suspended Sediments

During this project, field data on water clarity was obtained on three occasions (March 4, May 25, and June 24, 1980). These data are compared with the results of other studies in Narragansett Bay. Research on the effects of suspended sediment on estuarine fauna and the effect of burial by water deposited sediment on fauna are summarized in Part C. Winter conditions were found on the March 5 sampling trip. Water temperatures were between $0^{o}C$ and $1^{o}C$ and except for a small near-bottom temperature inversion at some stations ($0.25^{o}C$), there was no vertical stratification. At the surface the clearest water was found offshore and downbay. The most turbid water occurred on the shallow shelf off Calf Pasture Point (Figure 4-14). Turbidity was vertically homogeneous except at station 3 and 9 where there was a clear water layer near the bottom and at station 7 in Fry channel where the bottom layer was turbid. Light transmission was generally high for Narragansett Bay (13-28%/m) and indicated low concentrations of phytoplankton growth and the absence of recent storms.

On the May 28 sampling date a strong thermocline occurred at a depth of 10-15 feet (Figure 4-14). At most stations there was a marked increase in turbidity at the thermocline from surface values of 10-15%/m to 0-2% in deeper layers (Figure 4-15). At station 7 in Fry Cove channel transmission/m decreased regularly with depth from surface to bottom. At station 9 in the dredged channel surface water was more turbid than water immediately over the thermocline. Surface and bottom turbidities were similar throughout the study area except in shallow water off Calf Pasture Point where turbidity increased. Water sampled at station 4 showed an abundance of organic detritus and copepod fecal pellets in the turbid deep layer.

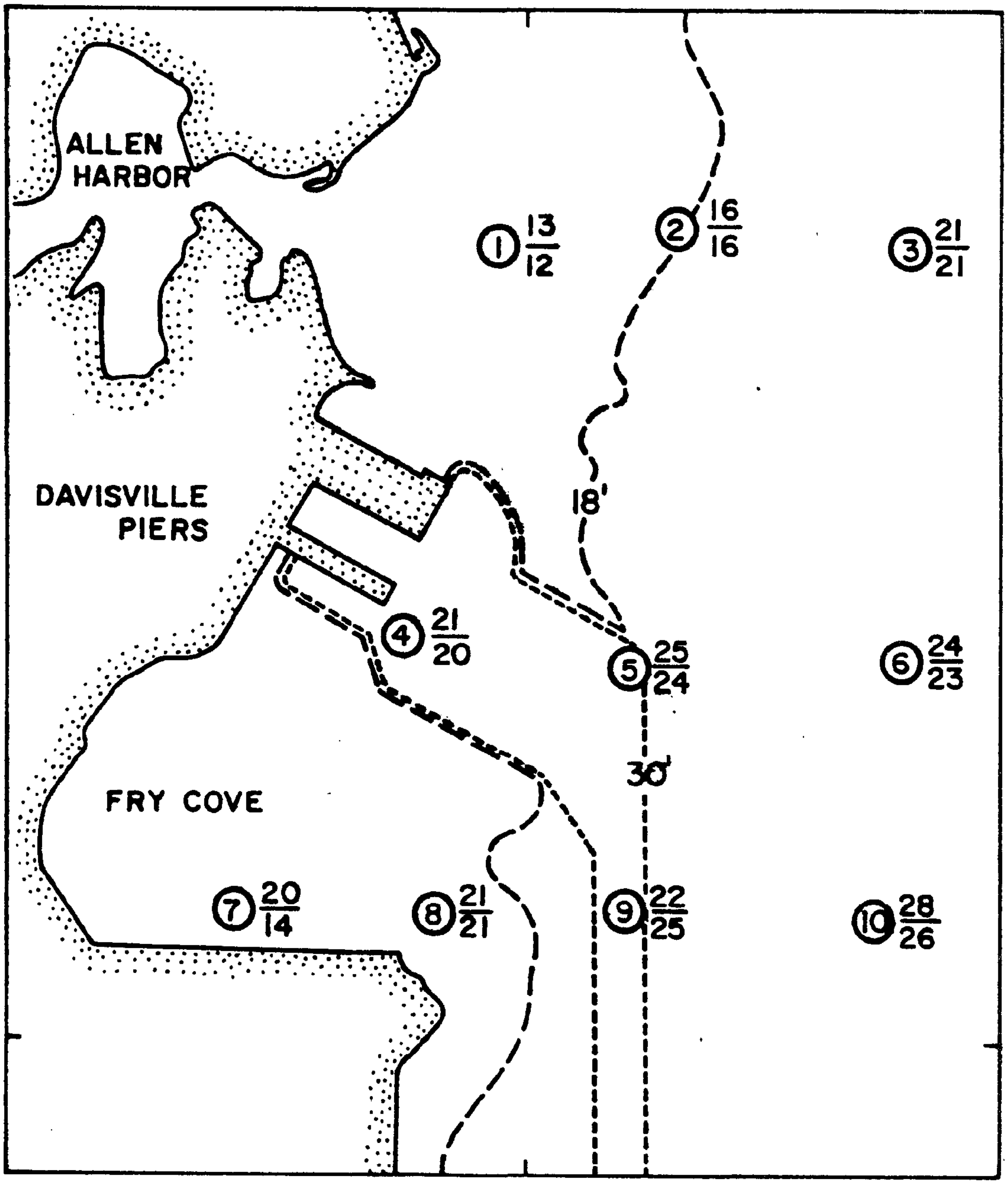


Figure 4-14. Location of turbidity stations (circled numbers) and surface/bottom values of percent light transmission per meter obtained March 5, 1980.

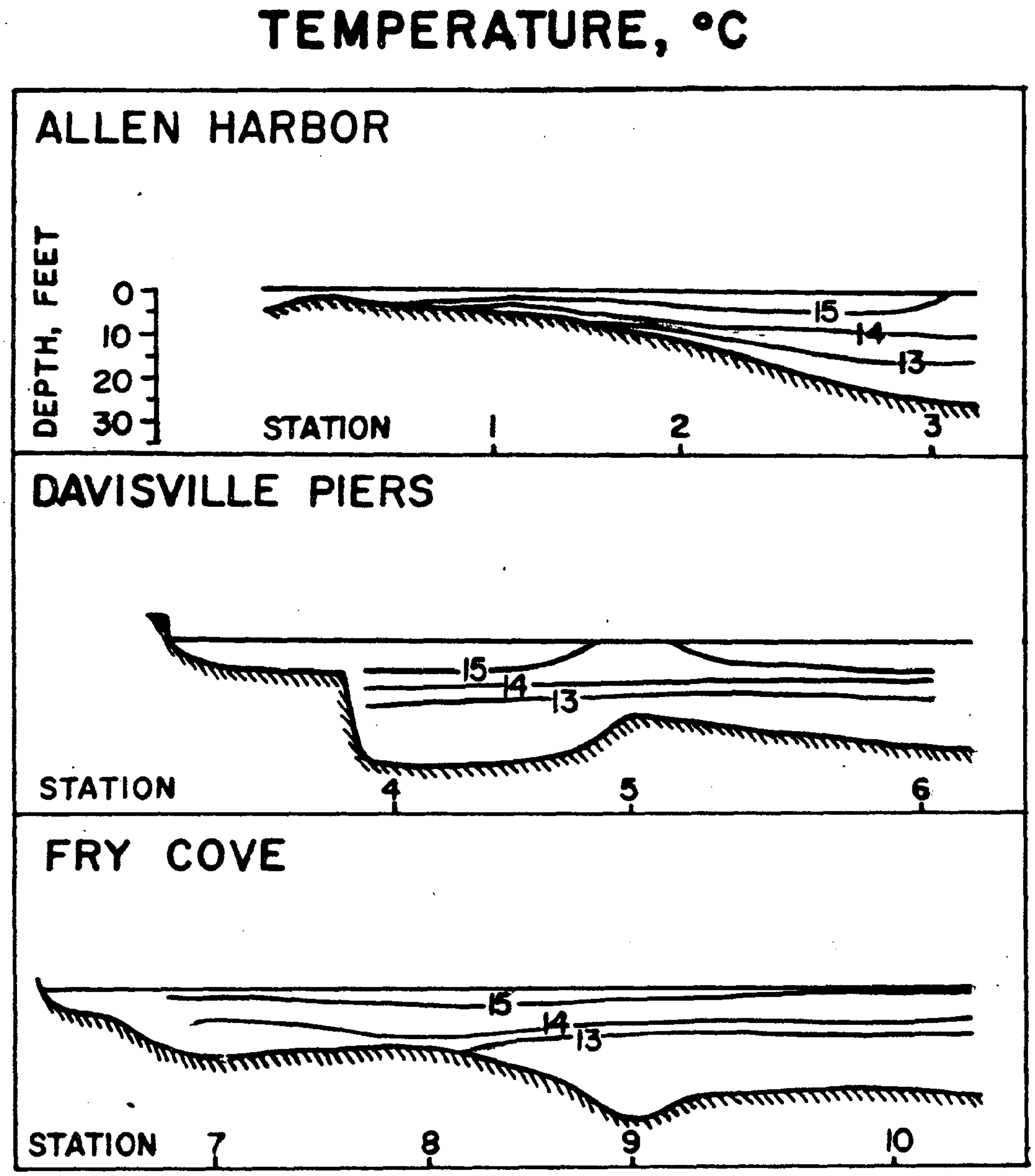


Figure4-15. Temperature sections, May 28, 1980. 11:20-12:30, Low tide 12:53 DST.

Two profiles were made on June 24 in the turning basin and in Fry channel at Station 7 (Figure 4-17). Surface warming had continued and the thermocline was thicker and deeper than in May. The turbidity pattern was very different from that found in May (Figure 4-16). The surface was turbid, almost certainly from high concentrations of phytoplankton. Within the thermocline the water was relatively clear, but turbidity increased rapidly in a thermally homogeneous bottom layer.

The results of these observations show that water was clearest in March and that in both May and June there was a near-bottom layer of turbid water. Since conditions were presumably calmer than in March this layer must form as a result of impact of low density detritus from organic production and stratified conditions leading to concentration in bottom layers. Tidal currents rather than waves keep the particles in suspension.

No transmissometer or suspended particle measurements were made in the study area during storms. Water along Calf Pasture Point becomes visibly turbid when waves from the northeast erode shallow silty sand. It seems likely that concentrations of suspended matter may then reach levels typical of an exposed English coast (50 mg/1, Newton and Grey, 1972) or the most turbid parts of Chesapeake Bay (over 100 mg/1, Schubel, 1972). It can be assumed that estuarine animals in the Davisville area are exposed to such high levels of turbidity for periods of a day or two following storms.

## POLLUTANTS

Water Quality. The Rhode Island Department of Health (DH) conducted a bacteriological survey of the Quonset/Davisville area between August 1975 and November 1976 (RI DH, 1976). Surface water samples were taken at 11 stations on 6 dates. Tests were also run on samples from streams flowing

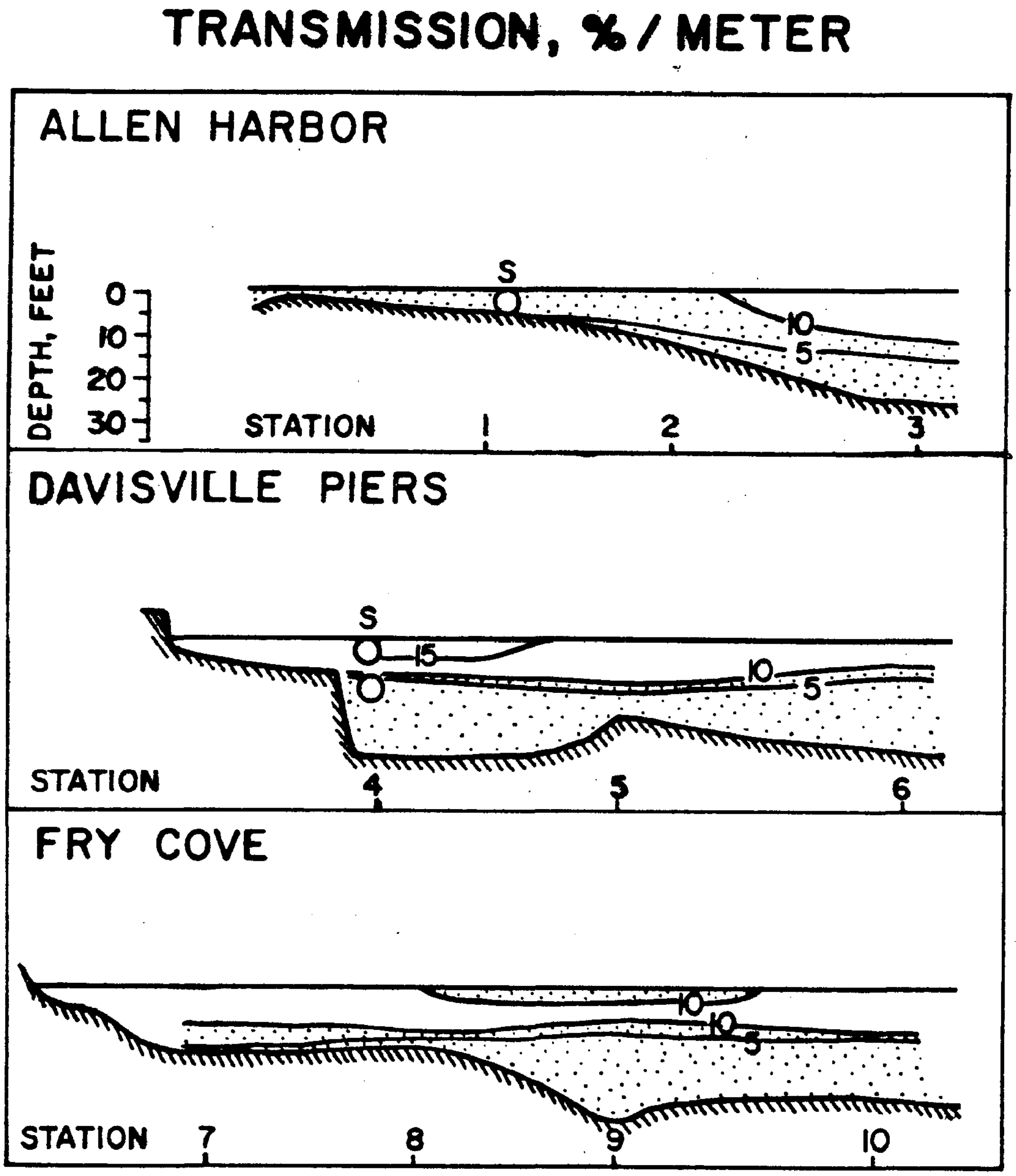


Figure 4-16. Turbidity sections, May 28, 1980. 11:20-12:30, Low Tide 12:53 DST. Wind 5-10 knots NW "S" indicates water sampling station. Stippling indicates relatively turbid water.

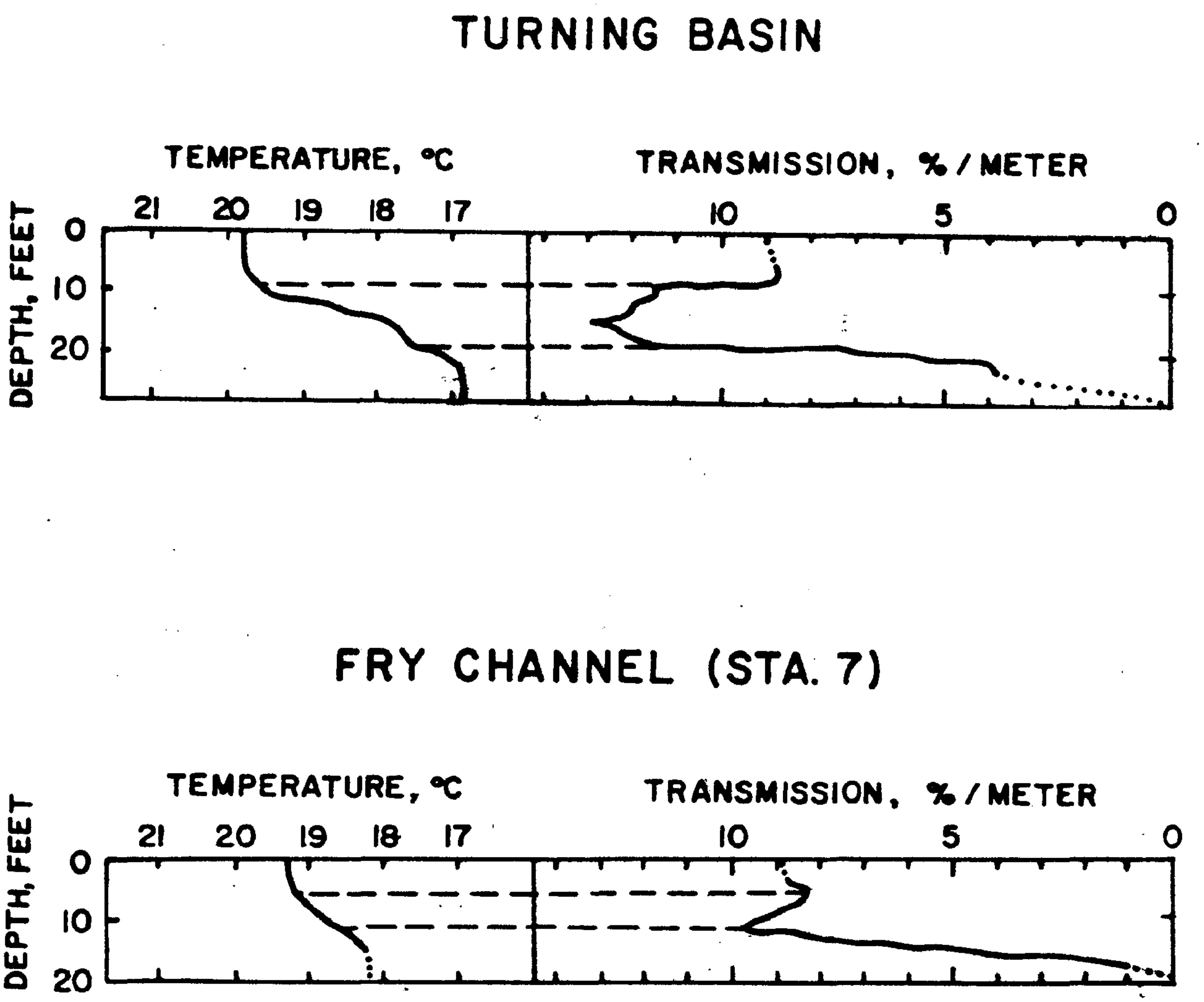


Figure 4-17 Turbidity and temperature profiles at two locations, June 24, 1980. Dashed lines show relationship of temperature and turbidity features.

into Fry Pond and from the Pond itself in August 1976. A summary of results for stations near Davisville are given in Table 4-2 and Figure 4-18. Fecal coliform bacteria were found in very low concentrations in the Bay and Allen Harbor samples. All samples had most probable numbers of less than 9/100 ml (The maximum count for SA waters is 70/100 ml). A small stream entering Fry Pond had high coliform levels which were reduced within the Pond. Fry Cove was closed to shellfishing for a number of years because of possible contamination from houses on the Dogpatch Beach bluff and the presence of berthed vessels at the adjacent piers. Following a conservative policy the RI Department of Health did not open the cove to shellfishing until July 1980, despite the abandonment of the housing in 1974 and negative bacteriological tests in 1977.

Hydrocarbons in Sediments. There is a high to low gradient of sediment hydrocarbons from the upper to lower Bay resulting from sewage effluents and spills. There are additional potential sources in the Davisville area including effluents, spills, and dumping from both land and water based activities. As part of the initial Quonset/Davisville impact study Brown and Franklin (1977) obtained total hydrocarbon levels of 100-641 ug/g dry weight from different environments in the Davisville area (Table 4-3).

Additional hydrocarbon analyses were carried out during this study by the Graduate School of Oceanography Organic Geochemistry Laboratory. The goals of these analyses were to allow comparison with data which the laboratory has obtained from throughout Narragansett Bay and to gain insight into the sources and makeup of materials which will be deposited in the proposed dredged channels.

Duplicate analyses were carried out on a surface sample obtained from the Davisville turning basin, June 1980. Results and preliminary discussion

Table 4-2. Water Quality Data for the Davisville Area.

Estuarine areas sampled on six occasions, August 10, 1975, Nov. 30, 1976. Summarized from RIDH, 1976.

| Station | Dissolved Oxygen min mg/l | min % sat. | max. mg/l | max. % sat. | median mg/l | median %sat. | Fecal Coliform/100 ml min | max | median |
|---|---|---|---|---|---|---|---|---|---|
| 5 off airport | | | | | | | 3- | 3- | 3.5- |
| 6 Fry Cove | 6.4 | 91 | 12.0 | 118 | 8.85 | 100 | 3- | 9 | 3- |
| 7 off D.V. piers | | | | | | | 3- | 9 | 3- |
| 8 off Allen H. | 3.2 | 93 | 11.8 | 116 | 8.7 | 108 | 3- | 9 | 3- |
| 9 Allen Harbor | | | | | | | 3- | 4 | 3- |

Fry Pond areas sampled August 4, 1976, RIDH unpublished data.

| Station | MP/100 ml total coliform | fecal coliform |
|---|---|---|
| brook to pond, Pond and Newcomb Rd. | 2300 | 90 |
| brook to pond, near bld. 884 | 2300 | 2300 |
| 24" pipe to pond | $\leq$ 23 | $\leq$ 23 |
| Fry Pond outlet | 230 | $\leq$ 23 |

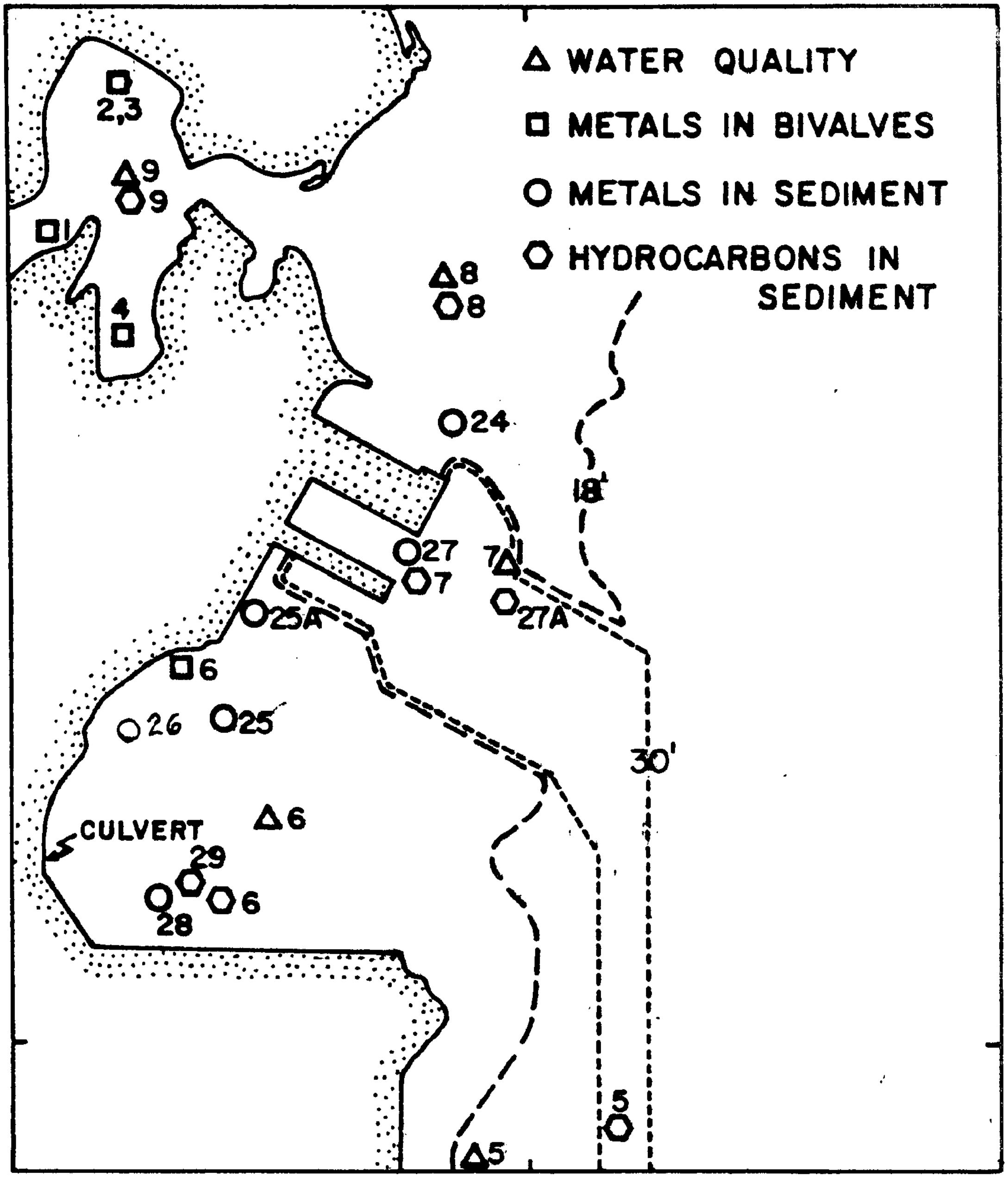


Figure 4-18. Station locations for water and sediment quality samples. Water quality and metals in bivalves (Rhode Island Department of Health) metals in sediment and hydrocarbons in sediment (27A, 27 this study). Hydrocarbons in sediments (5-9. CRC, 1977).

by Quinn, Requejo, and Pruell are given in Part C of the biological impact report. A data summary is given in Table 4-4.

The concentration of total hydrocarbons from the turning basin was 934 ug/g dry weight, significantly higher than in fine-grained natural sediments of surrounding areas studied by Hurtt (1978) of 359,356 and 246 ug/g. This is also an order of magnitude higher than levels in intertidal sediments in Allen Harbor sampled in 1980 (Table 4-3). The high total hydrocarbon level in the Piers turning basin probably represents input of hydrocarbons from the upper bay adsorbed to fine grained organic particles and from local sources. The presence of benzotriazoles (BTAs) from a source on the Pawtucket River, Warwick demonstrates transport down-Bay.

Table 4-3. Summary of sediment hydrocarbon data in study area. (Brown and Franklin, 1977; Coastal Resources Center, 1977)

| | Total Hydrocarbons ug/g Duplicate Samples | | Percentage | | |
|---|---|---|---|---|---|
| | | | sand | silt | clay |
| Allen Harbor | 395 | 641 | 3 | 69 | 28 |
| Channel to A.H. | 196 | 100 | | | |
| Davisville Piers | 294 | 311 | 8 | 53 | 39 |
| Fry Cove Channel | 103 | 427 | 8 | 66 | 26 |

Quinn, Requejo and Pruell, unpub. Davisville turning basin, sampled June 1980. All values ug/g dry weight average of duplicate analysis.

| | identified aromatics | total aromatics | total hydrocarbons | BTA's | phthalate |
|---|---|---|---|---|---|
| 0-10 cm | 9.769 | 60.0 | 934 | 0.699 | 1.17 |

The elevated levels of specific aromatic hydrocarbons and total hydrocarbons suggest additional sources in the Davisville area. Sources may include combustion products in used lubricating oils and weathered fuel oil. Identified aromatics were 83 times higher in the turning basin than in Allen Harbor; total hydrocarbons were 12 times higher; and BTAs only 6 times higher.

The classification scheme used in Connecticut allows dredged material with less than 5000 ug/g hexane soluble fraction (oil and grease) to be disposed of at sea without protective measures. The total hydrocarbon level equivalent to this is higher than the 934 ug/g found in Davisville sediments. Davisville sediments are "clean" when compared to polluted harbors in New England, but are "dirty" compared to immediately adjacent parts of Narragansett Bay. Since hydrocarbons are strongly adsorbed to particulate matter, a dredging and disposal technique which controls release of sediment would also contain hydrocarbon pollutants.

Metals in Sediments. Elutriate tests were carried out on six samples to provide data for future permit applications and to provide baseline information. In these tests (reported in Part C) sediment is shaken with Bay water and the water tested for released metals. The test gives a more realistic measure of the impact of hydraulic dredging effluent release than bulk sediment analysis does.

For five metals (barium, cadmium, chromium, mercury, and lead) all test concentrations were below the limit of detectability of the analytic method used. These results illustrate the low solubility of most metals in sea water: chromium in mid-bay sediments is 50-400 ppm (Olsen and

Lee, 1979), but was less than 0.2 ppm in the tests; lead in mid-bay sediments is about 100 ppm (Olson and Lee, 1979), but less than 1.6 ppm in the tests.

Copper was detectable in all the elutriate tests. Concentrations ranged from 0.114-0.182 ppm. The absence of a relationship between concentration and sediment type or sample location may indicate an unexplained analytic problem. The EPA pollution standard for copper is 0.005 ppm.

Metals in Clams. It has been suggested that there could be high concentrations of heavy metals in sediments and organisms in the Quonset/Davisville area as a result of discharge of metal plating solutions (Eisler et al. 1977, 1978) or of dumping of metal scrap at Allen Harbor (CRC, 1977). Eisler et al. found elevated metal levels in the widgeon clam (*Pitar morrhuana*) near the former Naval Air Rework Facility outfalls at Quonset Point.

The State Department of Health carried out a special study of metals in clams in the Davisville area between December 1976 and June 1977. Soft-shell clams were collected at four stations. In Figure 4-19 metal levels of clams are shown for the stations in order of distance from the Allen Harbor dump. There is no trend for any metal. Except for one Fry Cove sample, all metals are below the U.S. Food and Drug Administration alert levels. Alert levels have no direct relation to safety of consumption, but relate to regional norms (FDA would advise the local management agency of a potential concern, however, there are no legal standards for levels of metals). For most metals similar levels were found in both soft-shell and hard clams and levels did not vary from environment to environment. This constancy suggests that metals are being regulated by physiological mechanisms.

References

A complete bibliography can be found in Part C, section 5.

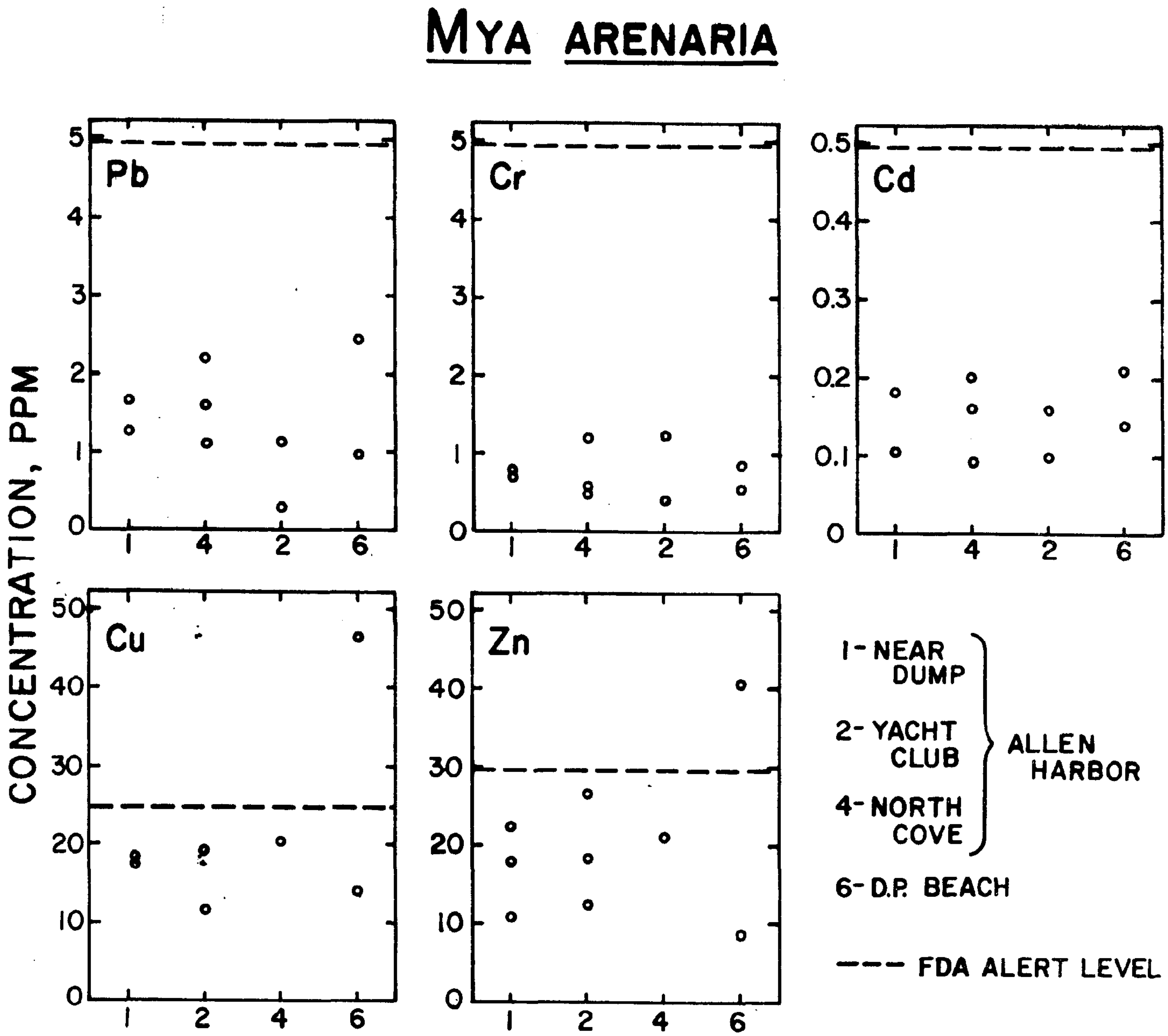


Figure 4-19. Metal levels in soft shell clams (*Mya arenaria*)(dry weight) at four locations. (R.I. Dept. of Health, Dec. 19, 1976-June 1977).

# 5. ENVIRONMENTAL CONSEQUENCES OF ALTERNATIVE ACTIONS

## 5.1 INTRODUCTION

Several alternate development plans were prepared during the preliminary engineering phase of the Davisville Pier extension project. Although all were technically possible, the designs vary considerably in environmental impact, cost feasibility, and compatibility with Port Authority needs and plans. Considerations of cost and feasibility are covered in depth in the Preliminary Engineering Report by C.E. Maguire. This chapter provides a detailed discussion of the environmental effects of the alternate designs as well as a consideration of alternate sites and a no-construction option, in the following manner:

Section 5.2: Bulkhead Construction Along Dogpatch Beach (Alternates 1 and 2)

Section 5.3: Bulkhead Between Davisville Piers and the Quonset State Airport (Alternate 3)

Section 5.4: Bulkhead North of Davisville Piers (Alternate 4)

Section 5.5: Improvements to Property Adjacent to Davisville Piers Retained by the United States Navy (Alternates 5 and 6)

Section 5.6: Actions with No Impact on the Davisville Site

Each Section begins with a description of a design proposal by the consulting engineers, followed by the identification of terrestrial and marine environmental impacts of the option, and recommendations for mitigating measures. The impact assessments include the direct effects caused by the construction of a wharf and associated transportation linkages and indirect effects which are the result of facility operations. Many of the effects of the development will occur during construction, lasting only a short time before disappearing and causing no permanent damage. Some effects from construction and operation, however, will make lasting, irreversible changes to the site. Measures which should be taken to reduce adverse temporary and permanent effects are identified in the concluding portion of each section.

## 5.2 BULKHEAD CONSTRUCTION ALONG DOGPATCH BEACH

Description of Action

Two designs were developed by C.E. Maguire for dredging portions of Fry Cove and constructing a bulkhead on the eastern edge of Rhode Island Port Authority controlled land north of the Quonset State Airport. Alternate 2, the design selected for implementation would create a 665-foot steel bulkhead immediately to the south of Navy owned wooden bulkhead, with the option to extend it further south to a maximum length of 2,400 feet. The northern most portion of proposed development overlaps land presently owned by the Navy. Alternative 2 would create 18 acres of land with the potential for creating an additional 28 acres at a later date (Figure 5-1). Alternate 1 would create the entire 46 acres of new land all at once (Figure 5-2).

The proposed action, Alternate 2, will involve dredging about 13 acres to a depth of 25 feet and removing 350,000 cubic yards of material. Approximately 190,000 cubic yards will be used to fill behind a 675-foot long sheet-pile bulkhead, creating 18 acres of land part of which is presently open water and the remainder a beach and marsh. The channel would begin at the south side of Pier 1, gradually narrowing from 700 to 250 feet at the southern end of the new bulkhead. The southern terminus of the new wharf will be protected by a 700-foot long wall of

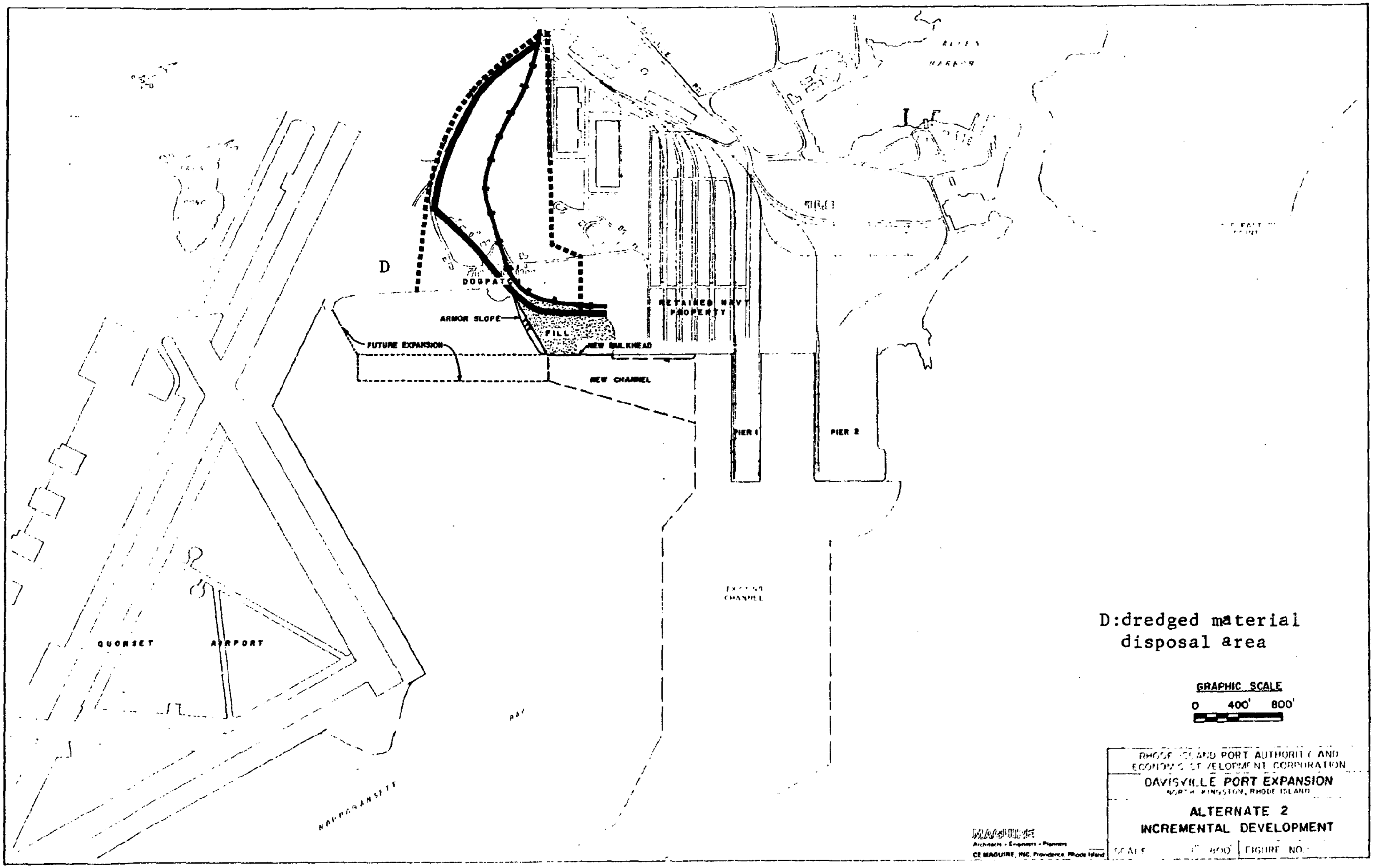


Figure 5-1 Selected Port Expansion Plan

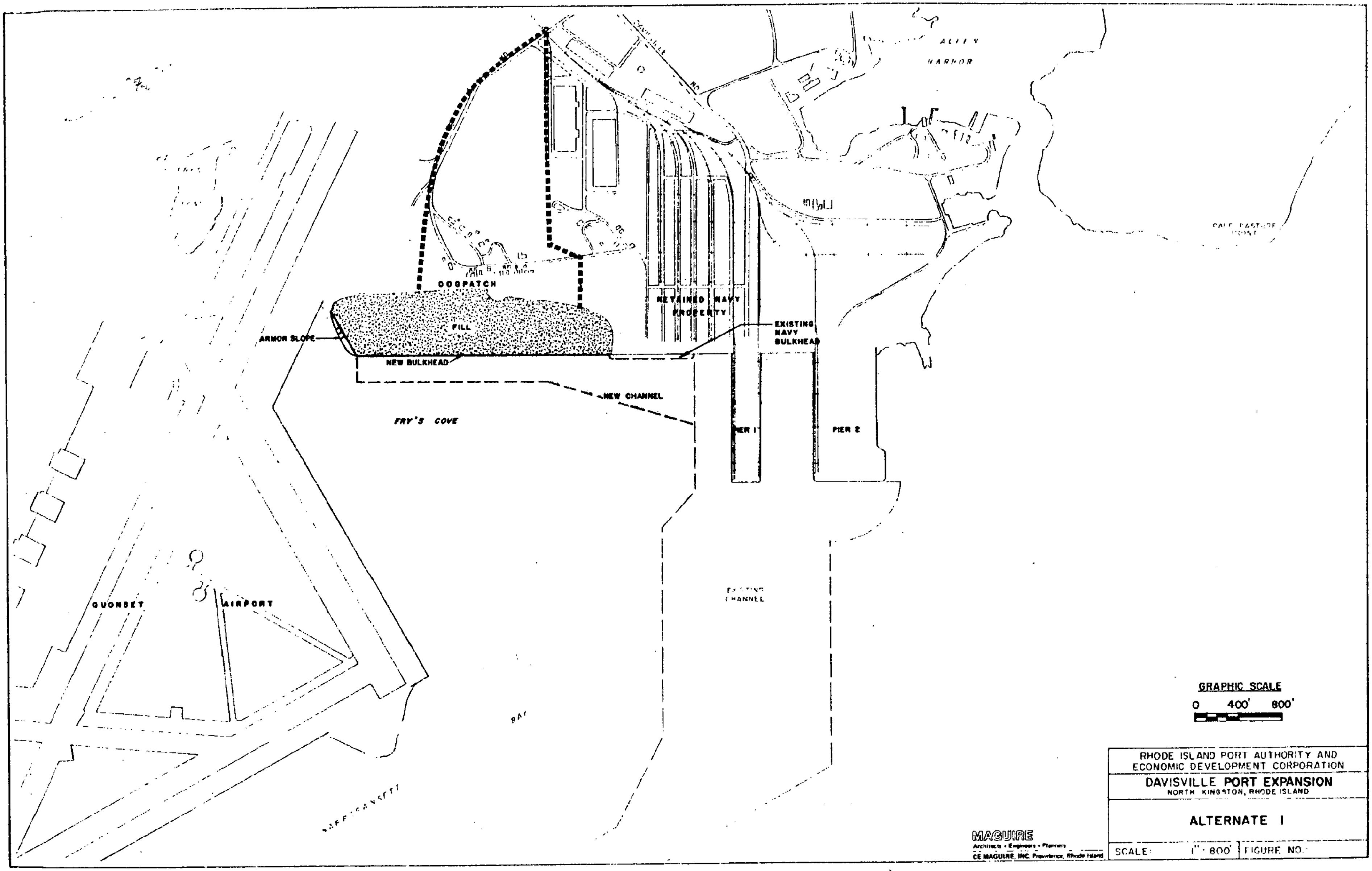


Figure 5-2 Full Development Port Expansion Plan

stone armor. The dredged material which is not used to create the wharf, about 160,000 cubic yards, would be stockpiled on roughly 15 acres adjacent to Dogpatch either for re-use if the bulkhead is extended, sold or used as fill elsewhere by RIPA (Fig. 5-1). For the most part road access would follow Marine Road, cutting along Greenwich Avenue to the back of the wharf. A rail line would originate at the intersection of Pond and Marine Roads, run parallel to the improved Marine Road about 400 feet to the north until just past the Airport communication buildings where it would then rejoin the new road out onto the wharf. An alternate route for both road and rail connections would originate from the vicinity of the Navy bulkhead.

The proposed action would permit extending the bulkhead further south as needed, as much as 1,800 feet. The stockpiled dredged material as well as newly dredged sediment would be used to fill behind the bulkhead to create a wharf similar in size to that proposed in C.E. Maguire Alternate 1. If the entire wharf were constructed at once, approximately 700,000 cubic yards would be removed from the 28 acres of new channel to create a total of 46 acres of new land. The southern end of the wharf would terminate just north of the outlet of Fry Pond. Road and rail access would be provided by extendind the alignments south along the back of the wharf. The dredged channel along the additional bulkhead segment would be 250 feet wide.

Terrestrial Impacts

The construction of a new bulkhead at Dogpatch Beach with back filling of dredged materials will result in major permanent alterations to the existing sand beach, dunes and marsh, to several of the presently abandoned houses above the beach, and to the old fields on the uplands to the rear of the property (Figure 5-3).

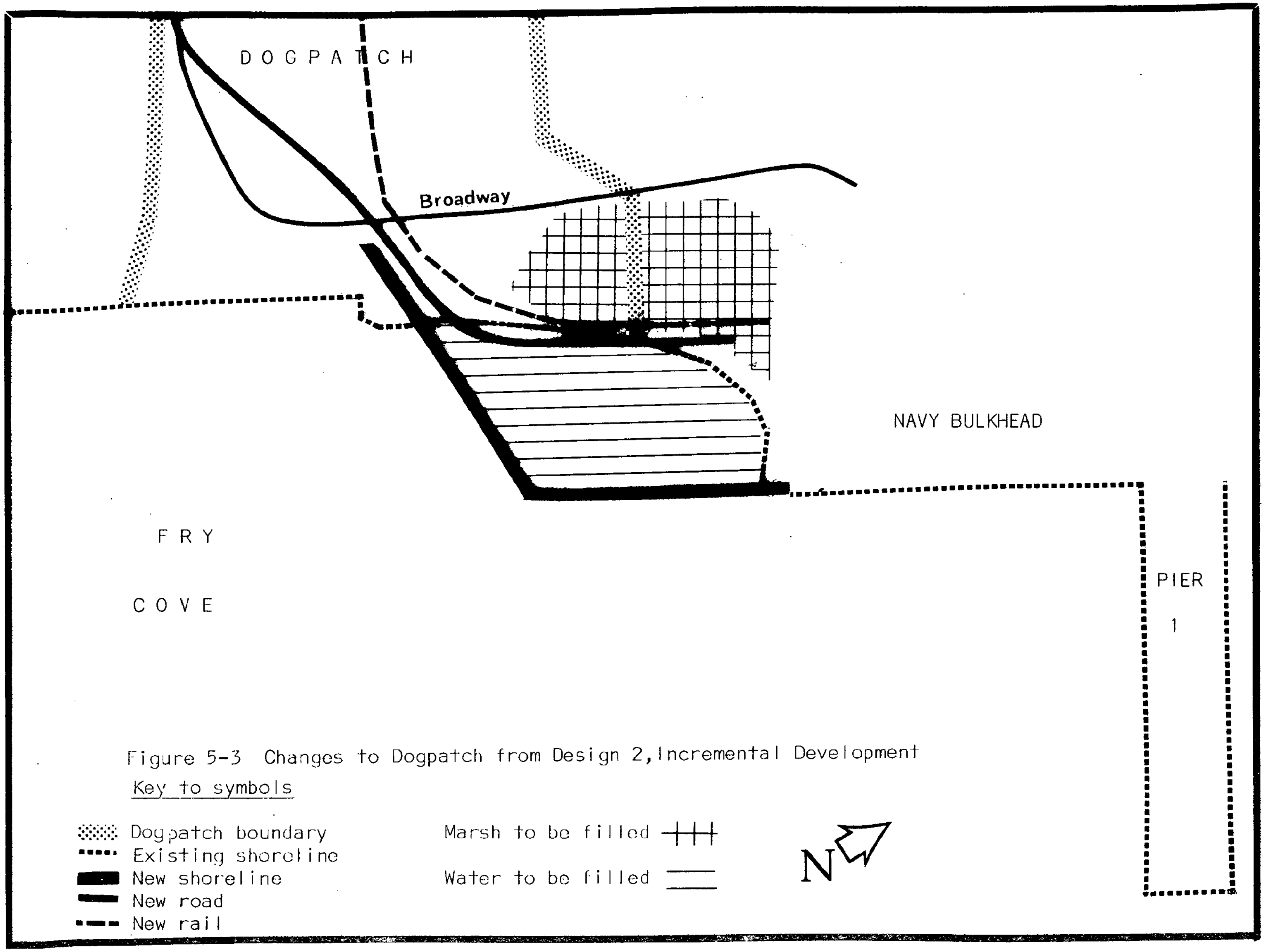


Figure 5-3 Changes to Dogpatch from Design 2, Incremental Development

Key to symbols

- Dogpatch boundary
- Existing shoreline
- New shoreline
- New road
- New rail

Marsh to be filled

Water to be filled

Bulkhead development and back fill (both Alternatives 1 and 2) will cause the complete elimination of the small marsh. In order to properly level the new land in back of the bulkhead, dredged materials will have to be placed over the top of the marsh, and elevated up to the existing road (Broadway) in back of the marsh. This would cover the marsh with approximately 4-6 feet of material and bury the culvert which is presently supplying freshwater to the marsh. In order to allow continued freshwater discharge, a culvert would be installed, through the existing marsh prior to covering it with fill. This would permit stream drainage to continue through the new bulkhead wall and out into the Bay. The elimination of the salt marsh will result in a decrease in habitat for those species which require the salt marsh environment for feeding and shelter. Sessile animals such as bivalves, crustaceans, and tube worms present in the wetland at the time of burial will be killed. Adult birds will escape but will have to go elsewhere for feeding and nesting grounds.

Both Alternatives 1 and 2 will heavily impact the sandy portion of Dogpatch Beach, with Alternative 2 burying the northern half and Alternative 1 totally eliminating all beach frontage. Dunes will be covered up to the upland plateau elevation. The existing concrete seawall in front of the cottages will also be buried. The loss of the sandy beach, whether partial as in Alternative 2 or total as in Alternative 1, will bring a reduction in the available sand beach area within Narragansett Bay. However, Dogpatch Beach has not been accessible to the public for more than forty years, and is slated by the Port Authority for industrial and commercial development that would preclude general public access to the site.

C. E. Maguire proposed that rail and highway access to the newly constructed wharf in Alternative 1 or 2 be provided from the west through the Dogpatch parcel. However, they noted that extending the road bed and rail line from the Navy retained property just north of the bulkhead would be less expensive. Removal or demolition of several unoccupied houses will be required to construct a new road under the proposal for Alternate 2. Site preparation prior to any development of Dogpatch would involve removal of most, if not all existing unoccupied residential structures. The construction of a rail line across the upland through the open fields and shrubby areas at the southern edge of the woods will require removal of vegetative cover and top soils along its entire length. A berm would be constructed across low spots on Dogpatch in order to construct the rail line. If hydraulic dredging is used, a dike about 10 feet high may be needed to contain surplus dredged materials on about 15 acres of land. The pile should be landscaped to prevent erosion by wind and rain.

Acting nesting areas for numerous pairs of Eastern Meadowlarks in the upland meadow along with other birds and small mammals which presently live in Dogpatch will be displaced or disturbed by a renewal of active use of the site.

Aquatic Impacts

The two plans for dredging and bulkheading in front of Dogpatch Beach Alternates 1 and 2 will have similar effects. Portions of a shallow sandy platform at the foot of the beach will be permanently eliminated. This area has small patches of soft-shell clams (*Mya arenaria*), a few oysters as well as several species of bottom animals eaten by fish and wading birds compared to elsewhere in Narragansett Bay. If development is not carried the full length of the beach, there will be little change in the remaining area, although the harvest of bivalves will be restricted by the Department of Health within 1000 feet of the wharf. Oysters on rocky bottom near the Fry Pond culvert would be killed by shallow burial only if effluent sediments accumulated there. Bulkhead construction will also eliminate a small area with depths of 2-5 feet which has quantities of hard clams available to recreational diggers with rakes or tongs.

The areas which would be dredged to channel depth would eliminate either 13 (Alternate 2) or 41 (Alternate 1) acres of estuarine bottom with present depths of 9 to 10 feet. The area is presently used for the harvest of hard clams. In addition other bottom animals which are major food of bottom fish and diving ducks will be killed by dredging. As a result, other species less valuable to man or bottom feeding animals will colonize the soft sediments that will accumulate bottom of the dredged channel.

An important factor in the determination of specific aquatic impacts, is the construction sequence, which is not specified in the preliminary engineering report. Individual contractors will have different approaches to dredging and bulkhead construction. The major concern is the manner in which the slurry of water and sediment created by hydraulic dredging is dewatered and released to the Cove. The longer the slurry is retained behind a dike or weir, the clearer the effluent released to the Cove will be. The placement of the weir close to the existing channel will cause sediment to settle in the channel, which already is a poor habitat for many of the bottom organism desired by man and bottom feeding birds and fish. Bottom animals on the edge of the dredged channel will be subject to burial slumping of the banks. During dredging, organisms will be subject to turbidity from the effluent. Suspended sediment concentration, however, is expected to be below lethal levels for fish and bottom animals even at the effluent outlet. In much of the Cove, suspended sediment will be at levels which will temporarily inhibit feeding of shellfish and zooplankton and reduce growth and survival of shellfish larvae for the duration of dredging. Motile animals will be able to recover from shallow burial (inches) by material settling from the effluent.

A small increase in the silt/clay component of sediments in the mid-depth area of Fry Cove will not cause a radical change in the species presently found there; the bottom fauna will remain similar where the silt/clay percent ranges from 5 to 39 percent. The combination of mechanical disturbance and change to finer sediments could induce setting of the "opportunistic" species, Mulinea lateralis (coot clam) and Ampelisca abdita (an amphipod crustacean).

Deeper areas (20-30 feet deep) surround Fry Cove to the north, east, and south. These are floored with fine grained sediments and when sampled in March 1980, had an "impoverished" bottom fauna. Fine grained sediment from dredging effluent will be deposited in these areas depending on the outlet location. Raising the elevation of the closed basin in Fry Cove channel and lowering the concentration of organic matter on any of the deep bottoms through dredging induced sedimentation, could cause establishment of faunal communities in these areas.

Available evidence suggests that fish movements will be unaffected by moderate turbidity in Fry Cove (see Part C). Fish may actually be attracted to the disturbed bottom. Following completion of dredging, winter flounder will be seasonally concentrated along the slopes of the new channel.

The limited volume of organic sediments which will be dredged will release a small amount of oxygen-consuming and toxic compounds. These might be detectable in oxygen-poor bottom water.

Suspended sediments and dissolved substances released into Fry Cove will be reduced in volume and significantly diluted before reaching the area north of the Davisville Piers and will have no measurable effects on hard clams or finfish there.

Mitigating Measures

Terrestrial Impacts: Although bulkhead construction and dredge and fill activities will have severe impacts on the beach and marsh system at Dogpatch, steps can be taken which can help to lessen consequences of these impacts. Any dredged materials stored temporarily at an upland location should be quickly covered or planted so as to lessen the potential for erosion from wind or storm water runoff. In order to further decrease erosion potential following final implementation of site development at Dogpatch, a sediment erosion control plan should be undertaken for the upland area following the guidelines of the Soil Conservation Service.

Although it would be impossible to entirely compensate for the loss of the beach and marsh system at Dogpatch, it may be possible to provide similar habitat elsewhere near the site through beach nourishment and marsh construction. This would be viable only if the surplus dredged material was not stockpiled for future use. It would appear that the area in and around Allen Harbor has potential, particularly for building a marsh of similar size. This possibility should be examined during the final design phase of the port expansion proposal, prior to construction.

Use of the alternate road and rail route across retained Navy property examined by C.E. Maguire would avoid upland disturbances as a direct result of port expansion. However, the site is already slated for industrial re-use regardless of port development at Davisville, making road improvements necessary. A vegetative buffer and and fencing would help reduce the visual and noise impacts of expanded service base operations to the adjacent Navy residential compound. Fencing along the proposed upland rail line would maintain a separation between commercial activity to the south and the woods and Navy residences to the north. The growth of general aviation at Quonset State Airport, and the recent relocation of the Rhode Island Air National Guard to Quonset constitutes a major source of noise to the area greatly overshadowing that produced by the trucks, equipment and vessels engaged in port activities at Davisville.

Aquatic Impacts: Although several acres of shellfish habitat will be lost, the remaining stock of hard clams could be removed before dredging begins, to reduce the economic loss. A hydraulic dredge should be considered for complete removal of clams including sub-legal sizes, which could be transplanted elsewhere.

Both summer and winter dredging has advantages and disadvantages. Summer dredging may reduce mortality of animals by burial and allow better control of all aspects of the dredging and monitoring program, and avoid interaction with spawning winter flounder. Winter dredging reduces possible effects of oxygen consumption in deep water, increases dispersion of sediment and dissolved substances, avoids interaction with planktonic larvae, and avoids interference with recreational uses.

Release of dredging effluent near the present dredged channel which already has a soft bottom of low productivity, will reduce surface turbidity and prevent deposition of sediment in mid-depth areas where hard clams are present. The slowest rate of dredging consistent with economic operation will result in an increased retention time of the dredged effluent, helping to reduce the suspended matter levels released in effluent. A review of the dredging sequence at the time of construction should be made to insure that a reasonable effort is made to control turbidity.

Even with full development of the Fry Cove Shore, the central portion of the cove should be able to continue to be used for shell fishing and shpport finfish and migrating waterfowl. The present circulation of water into the Cove from the West Passage and the removal of find grained sediment by wave action will continue to maintain the productivity of the bottom. The installation of a storm drainage system to collect wharf runoff in a central location should be considered as a means of aiding the clean up of accidental land spills, particularly if large amounts of petroleum or other potential pollutants will be handled at the site.

## 5.3 BULKHEAD BETWEEN DAVISVILLE PIERS AND THE QUONSET STATE AIRPORT

Description of Action

C.E. Maguire Design 3 proposes a maximum berth and land filling design. A bulkhead would be constructed from the corner of the present Navy bulkhead 3,100 feet to the southeast, connecting with the steel bulkhead that forms the northern edge of the Airport, close to its northeast corner (Figure 5-4). A 25-foot channel would be created by dredging 40 acres of Fry Cove. About 120 acres of new land would be created by placing 4.1 million cubic yards of material behind the bulkhead. Only 1.2 million cubic yards of material would be provided by dredging the channel. The remaining 2.9 million cubic yards would have to be borrowed, perhaps from other dredging projects in Narragansett Bay as an alternative to ocean disposal. The Fry Pond outlet would be channeled through a 2,200 foot long culvert extension. No land use scheme for this alternate was prepared. Aside from technical problems

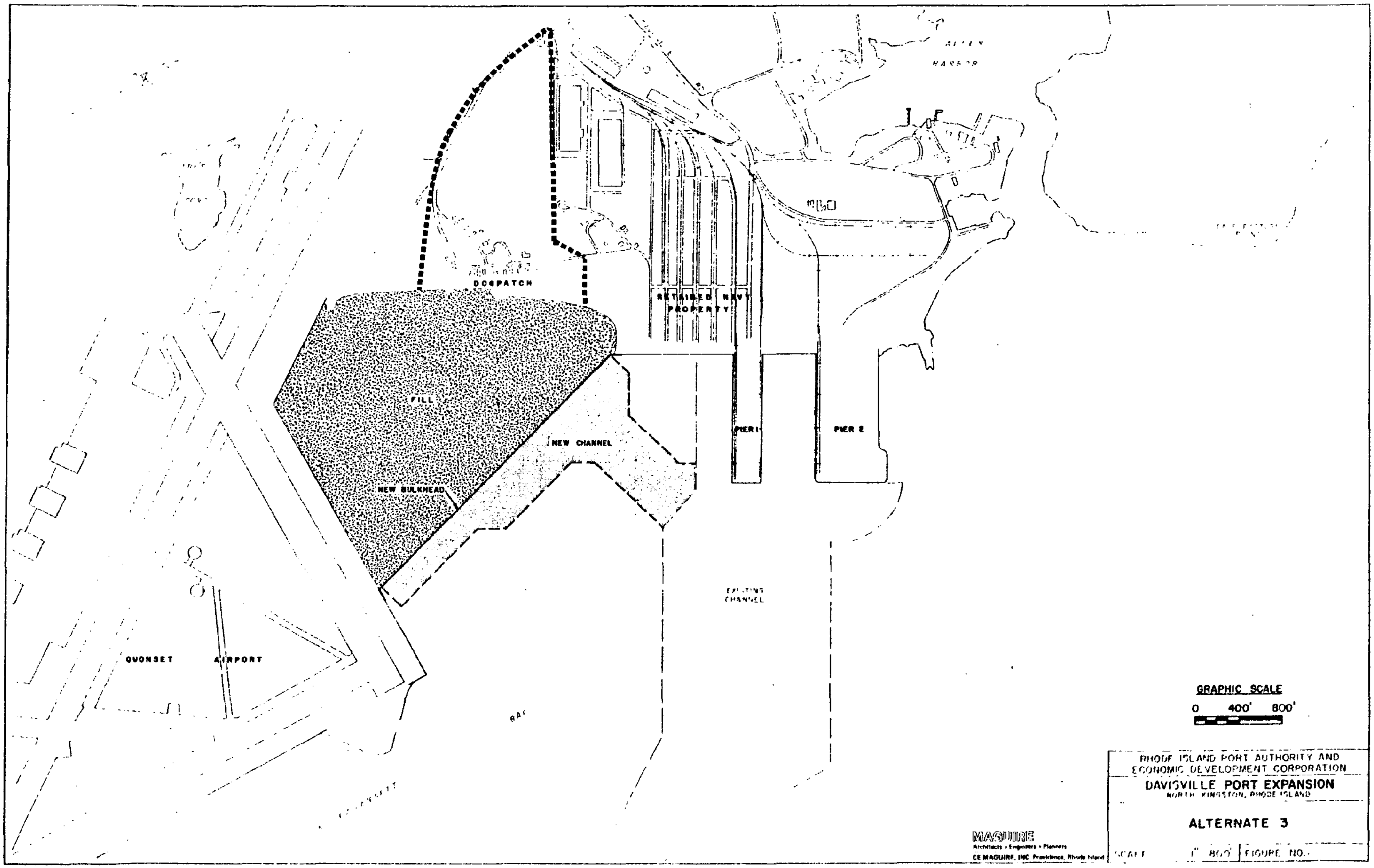


Figure 5-4 Maximum Expansion Design

in creating the large land area, information developed by C.E. Maguire does not substantiate any need for a facility of this size.

Terrestrial Impacts

The impacts resulting from the implementation of C.E. Maguire Design 3 would be similar to those expected in designs 1 and 2 (Section 5.2). Dogpatch Beach and its wetland would be eliminated through burial by dredged material. Land uses and transportation access in the upland Dogpatch area adjacent to Marine Road and the wooded stream would be similar to designs 1 and 2.

Aquatic Impacts

Construction of a bulkhead across Fry Cove will eliminate both the shallow areas described in Section 5.2 and the productive bottom in the center of the cove which has commercially harvestable quantities of hard clams as well as bottom animals useful as food for fish and waterfowl.

The remaining undisturbed bottom will be subject to a larger volume of suspended matter over a longer period than with the other options. More suspended matter and dissolved substances would reach Allen Harbor and Calf Pasture Beach because of the larger size of project and its location further out in the Cove.

The best established techniques for filling a disposal area with spoil from a distant area is bucket dredging into scows, transport to the disposal area, dumping into deep water next to the disposal site, and hydraulic dredging into the containment area. The additional material handling will produce more suspended sediment than the aquatic disturbances described in Section 5.2.

## 5.4 BULKHEAD NORTH OF DAVISVILLE PIERS

Description of Action

An increase in berthing and supporting land at Davisville could be achieved by dredging a channel and constructing a wharf from the mouth of Allen Harbor southeast to the northeast corner of Pier 2 (Figure 5-5). This option, presented by C.E. Maguire as Alternate 4, would expand the land area of the portion of Davisville controlled by the Rhode Island Port Authority and presently leased to various firms supporting the petroleum industry's outer continental shelf exploration program in the North Atlantic. A mixture of bulkhead and pile supported deck structures would be required to create 2,300 feet of berthing. Incremental implementation of this scheme was not examined. About 22 areas of bottom would be dredged, producing 710,000 cubic yards of material which would be completely used in creating 26 acres of new land. The bulkhead would be protected on its northwest end at the entrance to Allen Harbor by a 400 foot sloping wall of stone. The adjacent Davisville Piers area is already largely paved and served by rail spurs.

Terrestrial Impacts

C.E. Maguire Alternate 4 would avoid the terrestrial impacts to the Dogpatch area likely to occur from designs 1, 2 and 3 since it involves construction of pier and bulkhead in a totally different location north of existing pier 2. Likewise, the existing open water area at Fry Cove will be unaffected with the implementation of Alternate 4.

Most of the land adjacent to the newly constructed pier in Alternate 4 is already paved. It is used as supplementary storage of equipment by offshore drilling companies located on Davisville Piers. The immediate

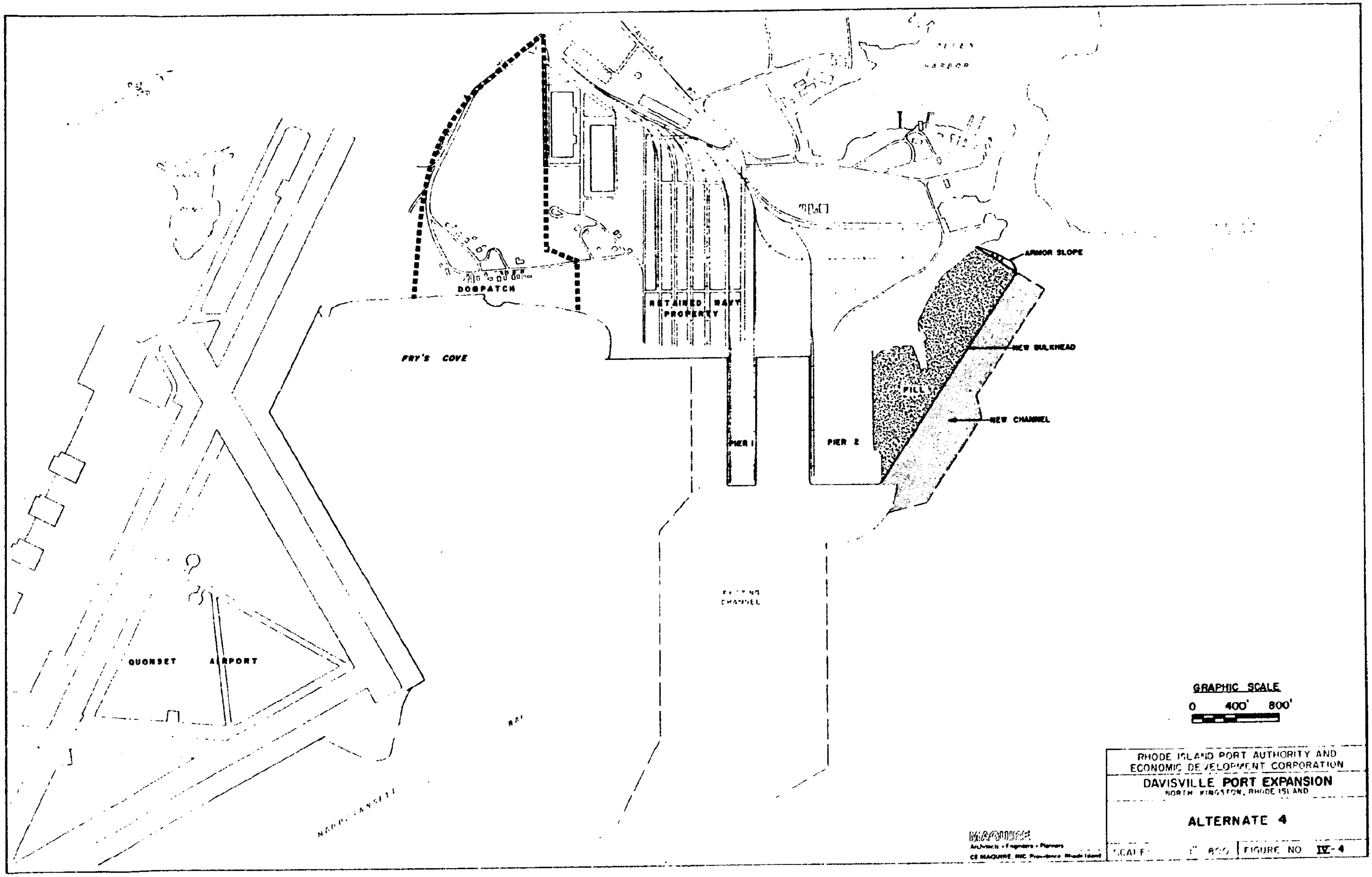


Figure 5-5. Bulkhead North of Davisville Piers

shoreline consists of marsh and sandy beach, but an extensive parking and work area begins just a few feet back from the shore. The Davisville Piers site is predominately filled land, created by the Navy using material obtained from channel dredging along with soil trucked in from outside the site. The area was graded with a slight slope towards the Bay for surface drainage, and then paved with asphalt. A lack of maintenance of the pavement is evident by the effects of weathering and cracking in many areas, which has allowed plants to grow and increase the rate of pavement breakup. The adoption of Alternate 4 would result in greatly increased use of the area and would probably require repaving prior to a heavy increase in use.

Adjacent to the north side of Pier 2 is a marsh of less than 3 acres, which has formed between the pier and a small stone groin. This marsh would be covered with dredged material if design 4 is adopted. This marsh is already highly exposed and is prone to damage from periodic overwash by sand.

North of the stone groin and extending northwesterly towards Allen Harbor entrance channel a sandy beach has formed. The sand probably comes from the extensive beach at Calf Pasture Point. Unless attempts were made to recover the sand prior to bulkhead and pier construction, this small beach would also be covered with dredged material.

Aquatic Impacts

The proposal to dredge a channel north of Davisville Piers and construct a bulkheaded containment area partially in shallow water will have effects similar to those discussed for alternatives 1, 2 and 3 in Fry Cove. The shallow area north of the piers has been considerably modified by construction and dredging and may not have reached equilibrium with wave currents, indicating that rapid sedimentation would occur in the dredged channel. A low density of soft-shell clams and other bottom animals, by comparison to Allen Harbor, will be eliminated by construction in intertidal and shallow subtidal areas.

The area in which dredging will take place is similar in depth and sediment type to the central portion of Fry Cove with the exception that it has undergone continuous disturbance from hard clam fishing. Fishing effort has probably reduced the average size of hard clams and changed the makeup of bottom communities by favoring faster growing "opportunistic" species. Disturbance of the bottom by dredging may actually favor hard clams by inducing setting and reducing the number of competitors and predators.

Suspended sediment from dredging effluents and resuspended dredge material will add to the turbitity of Calf Pasture Point area. Suspended sediment will be deposited in the deep parts of Allen Harbor, in the dredged basin, and the deeper parts of the West Passage. During the incoming tide turbidity may be visable along Calf Pasture Beach where recreational shell-fishing and swimming takes place. Estuarine sediment (material deposited since glaciation) is probably deeper north of the piers than the thin venier at Fry Cove. Therefore more oxygen consuming compounds, nutrients, and possible more fine grained sediment would be released from this sediment than from sandy glacial outwash. Some pollutants are present in surface sediment at the mouth of Allen Harbor. These do not reach toxic levels, will be largely retained through adsorption to sediment in the bulkheaded area.

Dredging would probably not affect the movements of winter flounder into Allen Harbor. However, industrial development north of the piers could interfere with commercial and recreational shellfishing if grounds are closed by the state. The potential of pollution entering Allen Harbor from an oil or chemical spill during operations at Davisville may lead to contamination affecting the future value of Allen Harbor for shellfishing and aquaculture. Industrial development is compatible with use of the harbor for marina operation, however, since channel improvements north of the piers would replace a portion of the present shallow and narrow entrance. Department of Environmental Management Policy will create a closure zone for shellfishing roughly 1000 feet bayward of the new wharf.

Mitigating Measures

Release of dredging effluent near or into the present turning basin would reduce the effects of suspended material on shellfishing and swimming as well as the visibility of the sediment plume. Winter dredging would avoid interaction with recreational use of the area. Clams could be removed from the areas to be dredged. Control of all land and vessel discharges and release of preservatives from dock structures is more important north of the Piers than in Fry Cove because of the extensive use of the area for shellfishing, and the need to avoid additional pollution.

## 5.5 IMPROVEMENTS TO PROPERTY ADJACENT TO DAVISVILLE PIERS RETAINED BY THE UNITED STATES NAVY

Description of Action

Expansion of the capacity of Davisville Piers to accommodate increased offshore oil service or related shipping activity could be achieved by improving the Navy owned wharf immediately adjacent to Pier 1, and then expanding the berth and operating area by building a parallel earth or pile supported pier. These variations are presented as Alternates 5, 6, and 6A in the Preliminary Engineering, Davisville Pier report and supplementary progress report (Figure 5-6 and 5-7). Alternate 5 would create a new bulkhead 1,300 feet long in front of the existing decayed wharf, and provide for a 25-foot dredge depth. A stone armored slope would be built at the southern end, creating 1.5 acres of land. A surplus of approximately 175,000 yards of sediment would be dredged from the 10-acre new channel and require stockpiling. A part of the upland portion of the Navy controlled site, which consists of more than 40 acres of open land, would be required for structures, storage and movement of vehicles and equipment.

Expansion of the capacity of this new bulkhead could be accomplished by constructing a pier parallel to the existing piers 1 and 2. C.E. Maguire suggested an earth or pile supported pier 300 feet wide and 1000 feet long creating 7 acres of new area and 2,300 feet of berthing. The dredged channel would be expanded an additional 15 acres to provide access to both sides of the pier, creating an additional 370,000 yards of surplus material for the piling supported pier (Alternate 6) or only 170,000 additional yards for the earth filled pier (Alternate 6A).

Terrestrial Impacts

Alternatives 5, 6 and 6A will result in surplus amounts of dredged material being produced as a result of dredging in front of the Navy Pier because only limited amounts of dredged material will be necessary as fill material. Design 5 will produce 175,000 cubic yards and design 6 370,000 cubic yards of material which would have to be stored off site.

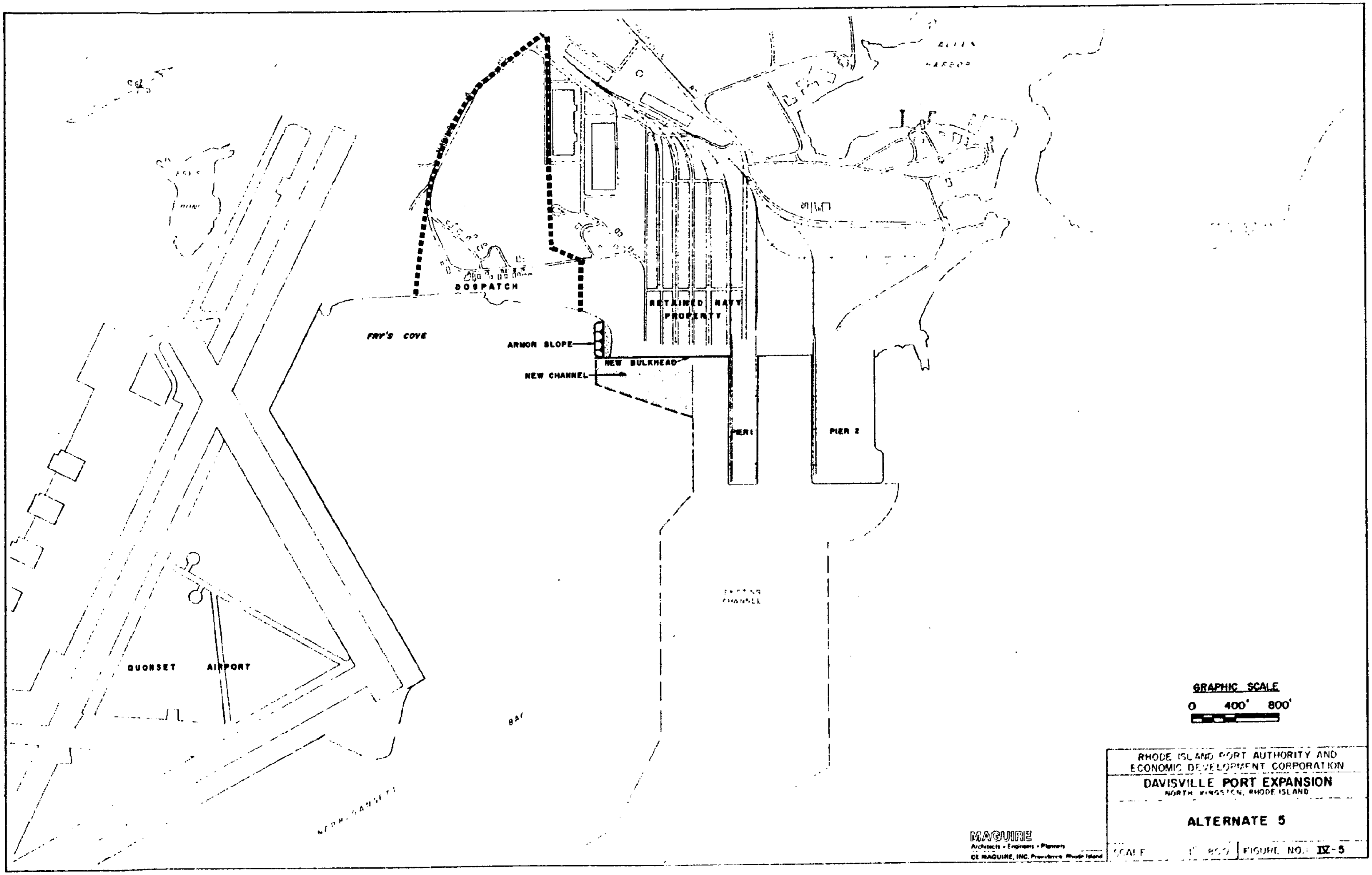


Figure 5-6. Reconstruction of Navy Bulkhead.

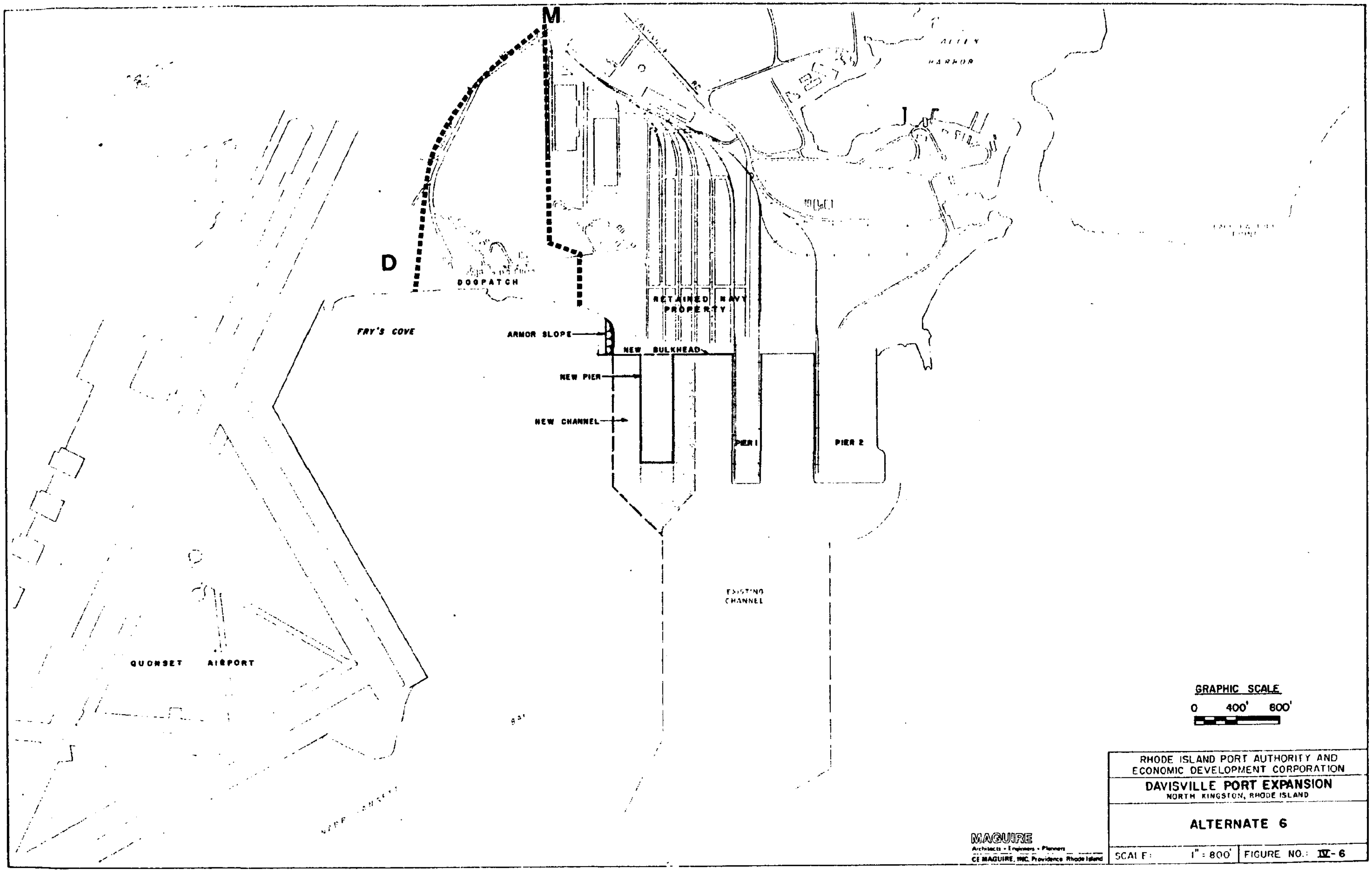


Figure 5-7. Expansion of Navy Bulkhead.

An earth pier, 6A, would reduce the storage requirement to 170,000 cubic yards. Several problems would be created if the surplus material is moved to an upland storage area nearby. The use of hydraulic dredging will produce a slurry of sediment and water. A 16 acre containment area for dewatering must be constructed at the storage site. If a nearshore disposal site at Dogpatch is selected (Figure 5-6, letter D) some adverse effects on wildlife will occur (particularly small mammals and songbirds) since there is moderate wildlife useage presently at this site. Disposal at Site M near Marine Road (largely an old asphalt parking lot) will have little potential impact on wildlife or Fry Cove but could impact Davol Pond if the material is not properly contained during dewatering. The use of a clamshell dredge would mean that little or no containment would be required at either site.

A potential problem with both sites and dredging techniques will be the blowing of surface sediments once they have dried, creating a nuisance for workers and equipment nearby. Dredged material will present little threat to groundwater resources through the natural leaching of salts or contaminants because groundwater flows at both potential disposal areas are towards Narragansett Bay, and not inland towards the Potowomut aquifer (Coastal Resources Center, 1977).

Small amounts of the dredged material will be utilized as fill beside the existing Navy bulkhead causing shoreline modifications. This fill will bury the small cobble beach area which is utilized infrequently by feeding shorebirds. This fill will be retained by the construction of an armor slope on the south side. Depending on the height of the armor slope and the fill behind it, some filling or infringement on the beach or marsh is probable. After construction, it is likely that some beach erosion will occur where the armor slope meets the sandy beach. This could result in a change to flow patterns into and from the marsh which can easily be avoided.

Active use of the Navy pier areas will result in some disturbance to the adjacent Navy housing just inland of the piers. The greatest effect will occur in the form of noise, but some impacts on air quality from engine exhausts or particulate matter could occur depending on the range and intensity of uses. The present privacy of the Navy housing area will likely be somewhat disrupted by active use of the pier.

There could be some indirect effects on the small salt marsh from runoff or drainage from the paved surface of the pier. Runoff into the marsh could have some negative impact, particularly due to the contaminants present in surface runoff from such areas (oils, toxic wastes, etc.). Some disturbance to wildlife usage of the marsh will occur and may diminish its value to nesting birds.

Aquatic Impacts

Dredging in front of the Navy Pier will deepen a sandy bottom which slopes from depths of 3 to 12 feet to the edge of the present dredged channel. Commercially harvestable densities of hard clams found throughout this area will be eliminated and will not recolonize the dredged channel. Bottom organisms used by fish and ducks for food will also be eliminated in the newly dredged area. The location of concentrations of winter flounder will move from the present channel edge to the new edge.

Dredge effluent from bulkhead and stockpile areas will temporarily create turbidity which will not cause mortality of bottom animals or fish, but which may for the duration of dredging slow the rate of growth of planktonic larvae and zooplankton in the immediate area. Shallow burial (less than a few inches) from effluent sedimentation or leakage from the bulkhead will kill attached barnacles and a few oysters and mussels, but will not be severe enough to prevent most species from reaching the surface. Organisms such as hard clams buried more deeply by slope failure will not survive. (A discussion of the ability of various marine organisms to recover from burial is provided in Part C.) Mechanical disturbance of the bottom and sedimentation from dredging effluent in Fry Cove may result in an increase in bottom species adapted for rapid growth in the absence of competition. These could include species with value to man (hard clams) those having the ability to stabilize the bottom (tube building polychaetes and amphipods), and species valuable for fish and duck food (amphipods, coot clams, nut clam).

Sedimentation from dredging effluent will further result in a temporary increase of the silt clay fraction at all depths in Fry Cove. At shallow and mid-depths this may result in small changes in the relative abundance of the present fauna. Fine sediments deposited in natural and dredged channels will remain there. Species of low economic evalue will colonize these sediments.

While organic sediments at the edge of the present channel are being dredged there will be release of oxygen-consuming compounds as well as hydrogen sulfide and ammonia into the water. The released volumes of these substances would have little effect on marine organisms except within the containment areas and possibly in bottom waters which are isolated by vertical temperature stratification in the summer.

The presence of shipping, industrial development, and use of toxic preservatives on structures will lower or threaten to lower the water quality in Fry Cove. Department of Environmental Management policy will create a closure zone for shellfishing roughly 1000 feet bayward of the wharf.

Mitigating Measures

Terrestrial: Problems associated with runoff of dredged material into the Bay, pond or any lower elevated area could be largely corrected by proper initial placement and useage of dredged material and if clamshell dredges were used instead of pumping the material hydraulically. If dredged material were used to construct a landscaped playing field or marsh, this would help solve the problem of dried sediments being blown around or washed away. Careful consideration of marsh sites should occur during the final design phase of the project.

By extending and curving the armor slope around towards the pier it may permit additional amounts of dredged materials to be contained and lessen the potential for direct intrusion onto or into the marsh surface. However, some long term beach erosion adjacent to the armor slop may still occur.

Although retention of complete privacy at the residential area is impossible with renewed pier use, it is feasible to provide additional buffering by the use of vegetative barriers, particularly rapidly growing conifers. The marsh might be given added protection by fencing along the northern edge prior to construction activity at the pier, and also by strict drainage control that could direct all surface runoff away from the marsh.

Aquatic: Hard clams can be removed before dredging is carried out. Intensive fishing since Fry Cove was opened in June 1980 have already reduced the population. Dredging in the winter will reduce potential effects on planktonic larvae, increase dispersion of suspended sediment and dissolved substances from spoil effluent, and avoid possible low oxygen values in deep water. Summer dredging will reduce mortality to bottom animals by burial since many are more active at temperatures greater than 10°C. If containment area effluent is released near channels there will be a reduction in both visible turbidity and the deposition of sediment on the shallower areas that are most valuable for hard clams and fish food organisms.

## 5.6 ACTIONS WITH NO IMPACT ON THE DAVISVILLE SITE

Description of Action

There are two courses of action which would have no effect on the vicinity of Davisville Piers. First the Rhode Island Port Authority could construct facilities for expanded petroleum exploration service operations at another site in Rhode Island waters which it either controls or could acquire an interest. The remaining choice available to the Port Authority is not to make any new investments in port activity in support of petroleum exploration.

Alternate Sites. There are few waterfront locations in Narragansett Bay which have enough developable land adjacent to at least 20 feet of protected water to be of value to companies supporting offshore oil development. Much of Narragansett Bay is navigable by supply boat. A channel with a depth of 40 feet follows the East Passage of Narragansett Bay up to the Providence River. The West Passage of the Bay has a natural navigable depth greater than 20 feet and a 30 foot or greater dredged channel serving Quonset/Davisville. The channel to Fall River has a depth of 35 feet. Smaller coves and harbors are served by shallow channels suitable for recreational craft. However, waterfront along these navigational channels which possesses a potential for accommodating additional marine transportation use and could meet the requirements of the project is confined to Providence Harbor, and the former Navy fueling piers at Melville, in Portsmouth. Other sites such as Coddington Cove, the Quonset Carrier Pier, the Tiverton shipping area, Newport and Jamestown Harbors are occupied by active uses, have little land available, and are in many instances already experiencing overcrowding from competing marine interests (Figure 5-8).

Providence Harbor does have potential for increasing its neobulk and containerized cargo handling an activity similar to that conducted at bases which serve offshore oil exploration and development (New England River Basins Commission, 1980, Ports and Harbors Study, Draft, Boston MA). For example, the Municipal Wharf, owned by the City of Providence, has six deep berths used for export of scrap steel and import of lumber, fuels, steel automobiles, liquids, and chemicals. Other privately operated terminals handle petroleum and some other cargo. Due to the presence of the 40 foot channel, terminal operators and related port users have concentrated on increasing shipping activity by building berths to accommodate larger vessels, attracting new cargoes, and developing the export trade. The shallow draft of the offshore drilling service vessels and the volume of materials handled relative to the needs of other port users makes a service base operation an inefficient use of the Providence Harbor waterfront. The lack of interest in attracting service base operations to Providence reflects this fact.

The Melville Industrial Area, owned by the Rhode Island Port Authority, is an irregular strip of land of some 50 acres located on the western shore of Portsmouth. It was formerly used as a fueling and maintenance

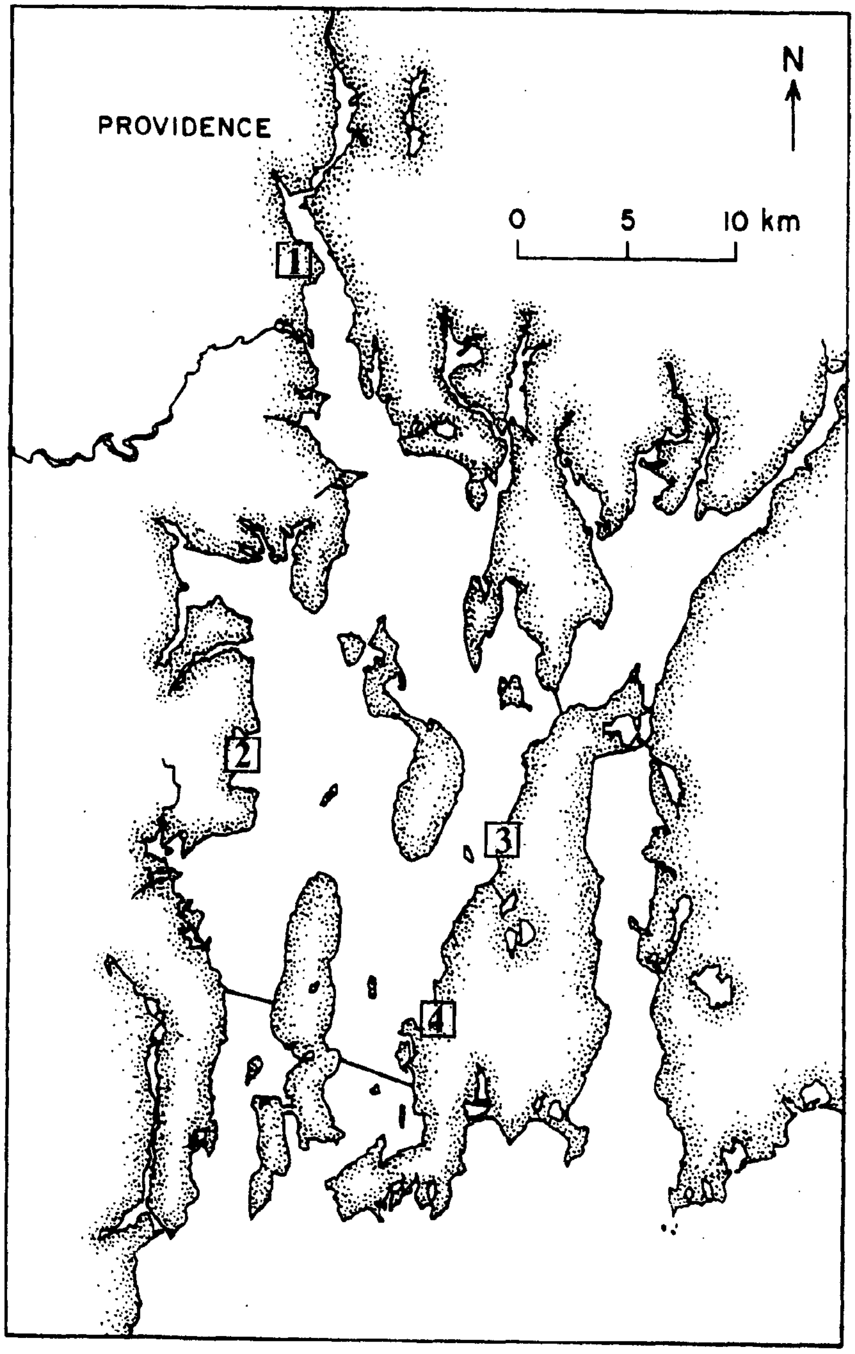


Figure 5-8 Alternate Port Expansion Sites in Narragansett Bay
1. Port of Providence 2. Davisville
3. Melville 4. Coddington Cove

pier and boat basin by the Navy. To the north is Navy retained land and docking facilities, and a large privately operated marina. The Melville site includes two piers 25 and 50 wide respectively which are 1000 feet long, and served by 35 foot deep channels. Neither pier is suitable for service base operations since there is very little room on the piers for vehicle movements. A shorefront wharf, of which the State owns 600 feet, has less than 16 feet of water.

The Rhode Island Port Authority has slated the entire Melville site for industrial development and is in the process of considering a variety of proposed uses. These include a grain shipment and milling operation, commercial fishing offloading and a home port for a portion of the Rhode Island fishing fleet. It is conceivable that a wharf of good depth and useful size could be created by bulkheading and dredging the shoreline to the south of the piers. Some 20 to 25 acres of land, most of it existing, could be allocated to service base operations.

Development of Melville is proceeding concurrently with Davisville Piers. Use of Melville as an offshore oil service base, however, would conflict with established Port Authority policies. Based on extensive planning studies the Port Authority has already decided that offshore oil service companies should be concentrated at Davisville and that other marine industry firms would best be located at Melville. In addition several drawbacks exist to the location of oil service facilities at Melville, including its limited land area, exposure to prevailing southwesterly winds, distance from major highways, and isolation from the existing service base operations at Davisville.

No Construction. The Rhode Island Port Authority could decide that it will not construct the 675 foot bulkhead proposed as C.E. Maguire Alternate 2, with its provision for incremental expansion up to 2,300 feet, or undertake any work to increase facilities for use by the companies servicing offshore oil exploration and production platforms. By doing so, the marine and shoreline impacts of dredging and bulkhead construction described in sections 5.2 to 5.5 would not occur. Although marine environment impacts to Davisville and Dogpatch would be avoided, the use of the Dogpatch Beach parcel for any other industrial or commercial development is likely to have some effects on the woods and stream which feed the small salt marsh, as described in Section 5.3, including demolition, site preparation, road improvements, and construction of buildings and parking lots.

PART B

# DAVISVILLE PORT EXPANSION

# ASSESSMENT

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## GEOLOGY

Prepared by R. L. McMaster and
S.M. Greenlee

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Part B

List of Figures

## Introduction

A geological survey was conducted on the beaches and adjacent near-shore bottom within the general area defined by Calf Pasture Pt. and the airport bulkhead (Fig. 1). In the offshore zone, the investigation was limited to the bottom between the 6 and 26 foot contours but including the dredged channels.

## Scope and Significance

The purpose of the surveywas to (a) describe the general beach conditions; (b) determine the character of the nearshore bottom surface and overlying suspended sediment based upon soundings, side viewing sonar, bottom samples, and transmissometer readings; (c) describe the morphology and position of the bedrock surface; (d) ascertain the thickness and general composition of the overburden above the bedrock; and (e) assess the geologic environmental impact to the area relative to bulkhead installation and bottom dredging.

The findings are used in the following manner. For the shoreline, beach accretion and erosion sites are identified and sand transport, longshore and onshore-offshore, is inferred. In the nearshore, the bottom relief is mapped as well as the general distribution of sand, mud and suspended sediment. These results permit the evaluation of processes responsible for sediment erosion, transportation, and deposition under present environmental conditions and the prediction of sediment responses after dredging and pier construction.

The bedrock surface is mapped so that its attitude, shape and relief are determined. These data are correlated with the borings made by C.E. Maguire, Inc.

Finally, these results are assessed relative to the geologic impact on the nearshore environment due to bulkhead installation, a dredging operation and deepening of the bottom.

## Procedures

1. Field operations: R/V Schock was used to obtain sounding profiles, sub-bottom profiles, side-scan sonographs and bottom sampling. Navigational fixes were made with Loran C. Tracklines for the sub-bottom, soundings and side-scan sonar surveys are shown in Figs. 1 and 2.

The following pieces of equipment were utilized. The bathymetric survey was made with a Raytheon depth system composed of a narrow beam transducer and a 719 Recorder. Continuous depth profiles of the bottom were recorded.

For the sub-bottom investigation, a continuous seismic reflection profiler consisting of a E.G&G Uniboom sound source, a 10 element hydrophone, a filter unit and an EPC Recorder, was used. In this operation, sound signals were directed into the bottom at one second intervals. These pulses were reflected from various sub-bottom features and the returning signals were picked up by the hydrophone array. In turn, the pulses were filtered at a band width of 600-1100 Hz and then printed at a sweep rate of either 1/4 or 1/8 sec. as a continuous sub-bottom profile.

A Klein Associates, Inc., side-scan sonar composed of a towfish and two channel wet paper recorder was used to view the bottom conditions. Operationally, the fish was towed about 3 feet below the water surface. Sound signals, emanating from both sides of the fish were beamed perpindicular to the direction at which the fish was moving. These signals were reflected back from various bottom targets on either side of the fish and recorded. The system was adjusted to survey a 248 ft. wide strip on each side of the fish. The navigation was fixed so that the dual strips of one trackline juxtaposed or overlapped the dual strips of each succeeding line.

In the sediment sampling, grab samples were retrieved from the bottom surface with a Smith-McIntyre sampler and a 5 foot gravity corer was used to collect a vertical section of the bottom.

2. Laboratory techniques: The data generated from bathymetric, sub-bottom and side-scan surveys were processed as follows. Depth measurements were sampled from the record at 12 sec. intervals, corrected to mean low water (MLW) and plotted. For the sub-bottom data, the seismic profiles were sampled at 30 sec. intervals.

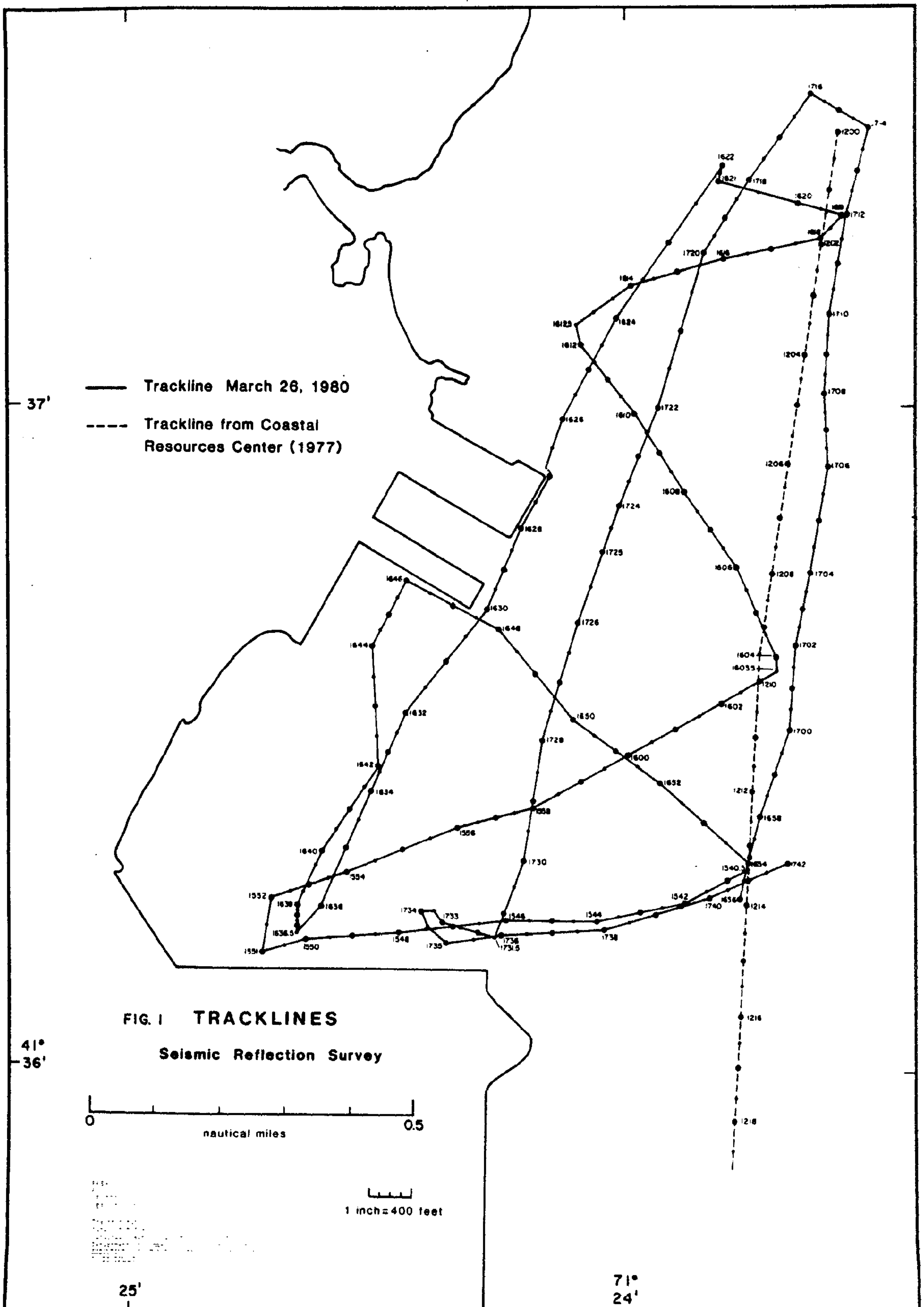


FIG. 1 TRACKLINES

Seismic Reflection Survey

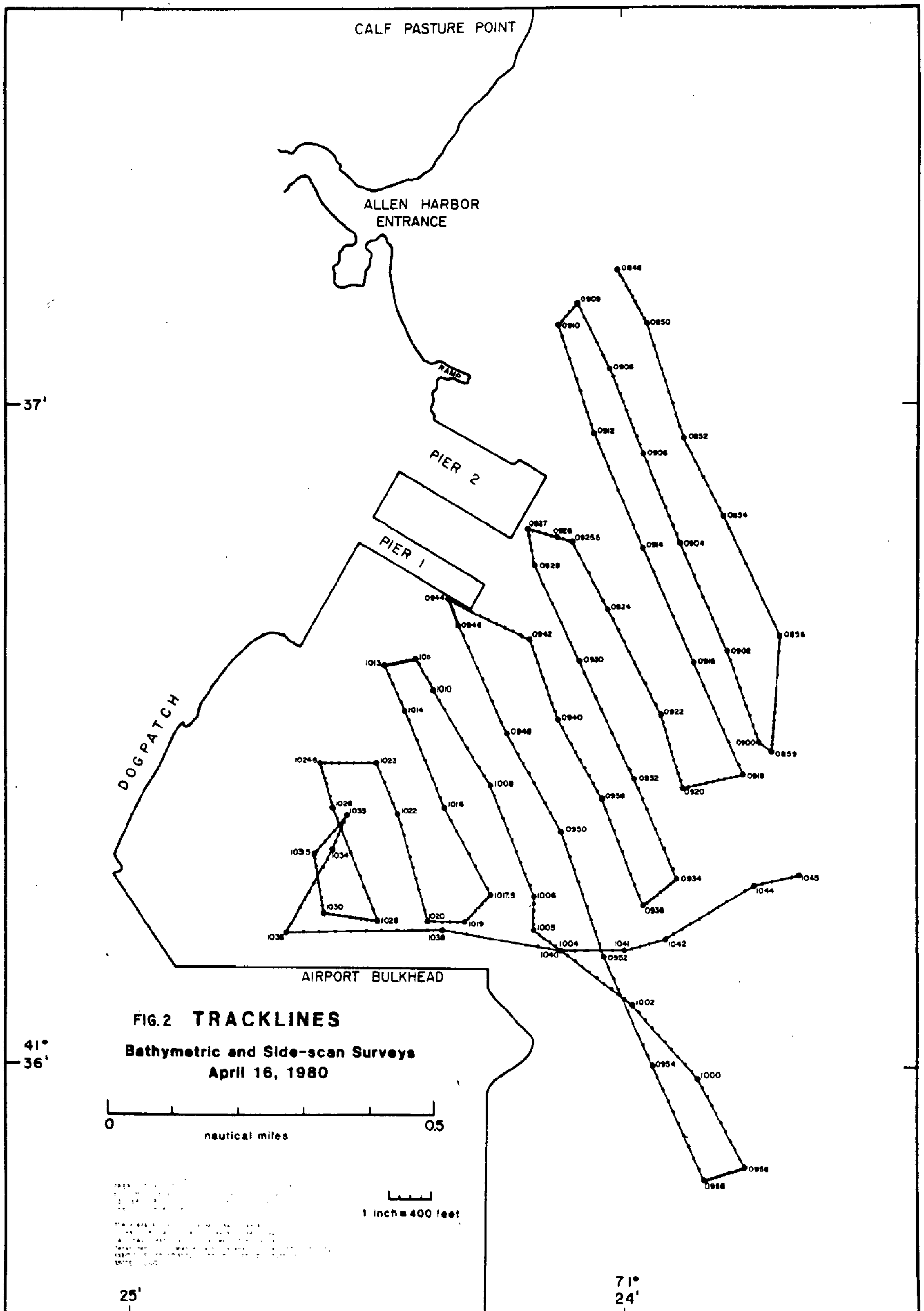


FIG. 2 **TRACKLINES**

**Bathymetric and Side-scan Surveys**
**April 16, 1980**

Measurements, in time units, were determined for the bottom surface and bedrock interface. These time units were converted to feet by using a velocity of 4800 ft/sec for water and 5,000 ft/sec for overburden (Birch and Dietz, 1962). Unfortunately none of the C.E. Maquire boring sites that reached bedrock were within the draft limitations of R/V Schock. Hence the sediment velocity value was taken from a determination that was made previously at a nearby location in Narragansett Bay. Plots of bedrock depths were made in both time units and feet and a plot of the overburden thickness was prepared in feet. Side-scan sonographs were analyzed for distinctive bottom characteristics and these features were plotted on a map to provide a mosaic of the bottom.

Sediments were analyzed by methods used in sedimentary geology. Sands were washed, dried, weighed, sieved through a nest of screens consisting of openings of 2, 1, 0.5, 0.25, o.125 and 0.063 mm. and weighed. The resulting data were used to calculate the proportions of sand and gravel as well as the type of sand present.

Samples composed primarily of silt-clay components were washed, screened through a 2 mm. sieve and semi-dried. A test sub-sample was taken from which one weighed fraction was used for moisture content determination and the other weighed fraction was used to measure the amount of sand, silt and clay present. For the latter fraction, a hydrometer analysis method as described in the American Society for Testing Materials book of standards, was followed. However only the 250 and 1440 minute settling times were recorded. After the analysis, the contents in the hydrometer cylinder were passed through a 0.062 mm screen and the sand fraction was weighed and seived. The data was then utilized in calculating the percentages of sand, silt, and clay. In this analysis, clay is defined as particles that are less than .0034 mm (3.4 micron) rather than the conventional 3.9 micron.

<u>Results</u>

1. <u>Shoreline</u>: From Calf Pasture Pt. to Airport bulkhead, the shore is comprised of sandy beaches, rocks and steel bulkheads. Sand beaches are found north of the ramp to just south of the Allen Harbor entrance at Dogpatch (Fig.2). The beaches, consisting of lenses of coarse-medium sand with gravel admixture, lie upon a coarser surface. The beaches are about 75-100 feet wide; slope 2-4 degrees offshore; and have at times 1-2 foot cusps on their foreshore. A small dune line borders the bench north of the ramp.

On other sections of the shoreline, beaches are poorly developed or absent. These include the south side of Allen Harbor entrance, around the ramp, between the ramp and Pier 2 - where the eroded edge of marsh deposits forms the shore, and south of Pier 2 immediately west of bulkhead terminus.

Adjacent to the shoreline, the bottom is essentially flat. This very shallow flat bottom extends many hundreds of feet seaward. Fine sand, light at the surface but dark below, characterizes the bottom. In front of the cottages south of Pier 1 (Dogpatch), about 2 feet of fine sand overlie a mud layer of 0.5 to 1 ft in thickness. The mud is composed of 85% silt, 10% clay, and 5% sand. The extent of this mud layer in the entire nearshore bottom is unknown. Moreover an occasional boulder is also observed in the nearshore zone. A fan-shaped deposit of sand and gravel, extending some 200 ft outward from the shore, lies adjacent to a swamp that is located just north of the line of shore cottages. This swamp is drained by a well-developed channel that is offset toward the south on the beach face before turning seaward on the fan. Where the bulkhead begins the bottom consists of cobbles and boulders which may serve to protect the two large bulkhead culverts which connect with Fry's Pond.

Some insight into shoreline processes may be inferred from these observations. Evidence of a net southward beach drift is apparent from the beach accretion on the north side of the Allen Harbor entrance, sand infilling on the north side of the harbor channel, rip-rapping on south side of harbor entrance, eroded shore south of Pier 1, and southward off setting of swamp channelway south of Pier 1. However, the southward beach drift is believed to be weak south of Allen Harbor entrance.

No evidence was uncovered during the July field inspection to support the existence of a seasonal exchange of sand from the beach to the nearshore bottom or from the nearshore bottom to the beach.

2. Bathymetry: Bathymetric data are presented as a contour map (Fig. 3). The relief in the area is characterized by the dredged ship channel network and a drowned stream channel adjacent to the airport bulkhead (Fig. 3). Otherwise, the bottom shows a gradual inclination offshore from 6 to 26 feet.

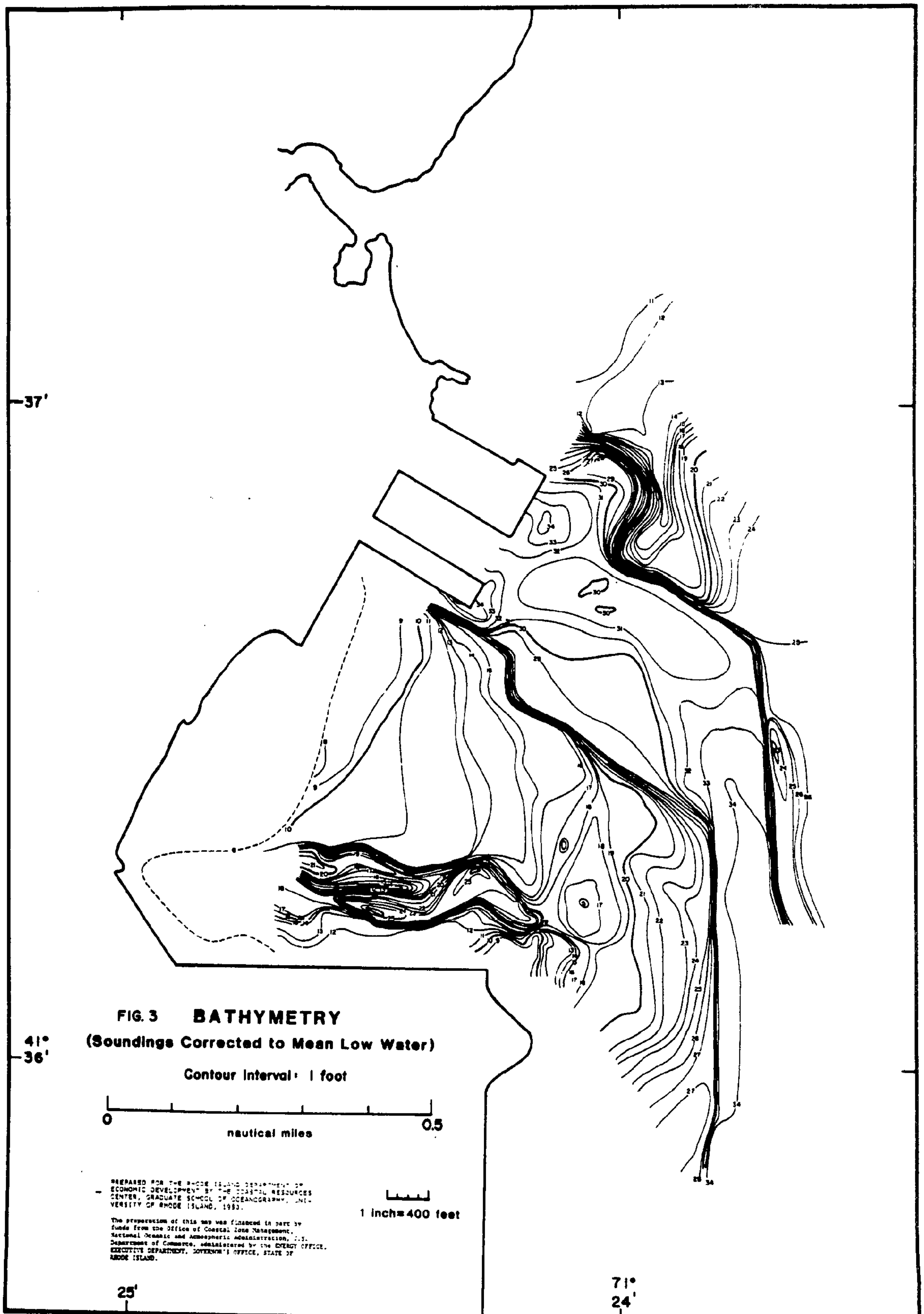


FIG. 3 **BATHYMETRY**

**(Soundings Corrected to Mean Low Water)**

Their edges are well-defined and marked by slopes that range from 1:2.5 1:4. Apparent slumps are observed at a few locations.

A drowned stream valley complex lies immediately north of the airport bulkhead and essentially parallels the structure. This valley extends from the vicinity of the shore eastward to a position northeast of the bulkhead where it loses its identity. Depths within the valley reach 18 to 26 feet. The most noteworthy aspect of this feature is that a narrow divide separates the depression into two well-defined channelways.

Away from these prominent features, the bottom is shallower with no distinct relief except for two small "mounds" that occur between the piers and airport bulkhead at depths of 17 feet.

3. Bottom surface conditions (side-scan sonar): The side-viewing sonar survey reveals a small variety of bottom features within the area (Fig. 4). These features include the edges of channelways; the units of the valley complex adjacent to the airport bulkhead; the divide within the valley complex; rake marks; three arbitrary categories of bottom roughness (i.e. slightly rough, very slightly rough and smooth bottom); and a number of unidentified targets. The distribution of the features follows no pattern except that the smoothest bottom occurs only in the channels and valley complex.

4. Sediment

Surface sediments range from sands to silts (Fig. 5) (Appendix A). These sediment types reflect sand contents that vary from 98% sand to 4% sand. Across the area, the bottom sediment shows dark sands composed of up to 98% sand inshore grading to dark sediment with 74-54% sand further offshore that contains 20-42% silt and 3-6% clay (particles less than 3.4 microns).

The finest sediment, silt deposits, are located within the dredged ship channel and the drowned river valley adjacent to the airport bulkhead. In the ship channel, an unstratified silt accumulation, measured by coring to be approximately 18 inches at one location, contains 75-84% silt, 6-17% clay and 4-16% sand and overlies a sandy dredged surface. The silt within the drowned valley shows 77% silt, 13% clay and 10% sand. Beneath the surface silt, the bottom is composed of laminated units of fine sediment at least to a depth of 2.3 feet.

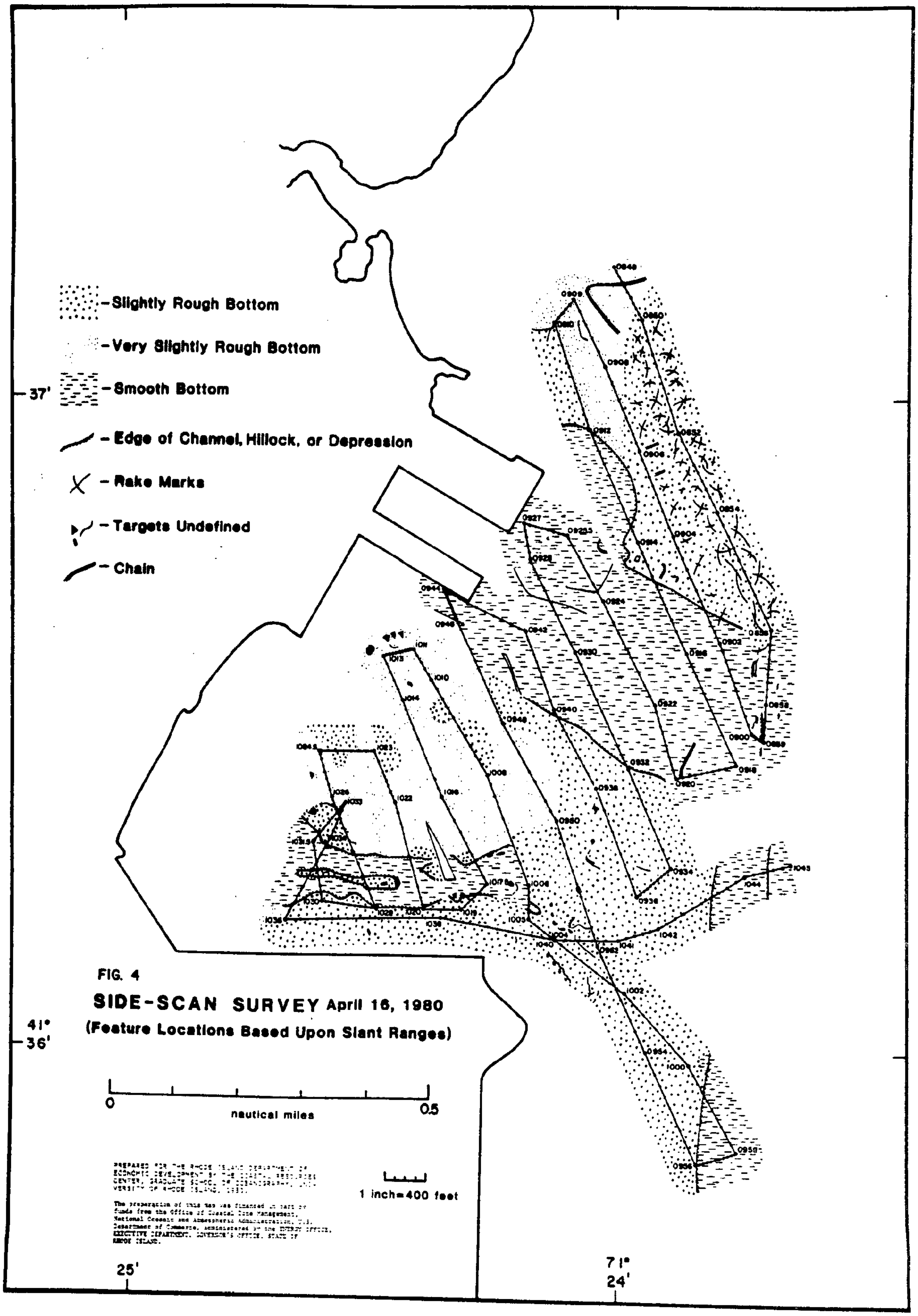


FIG. 4

**SIDE-SCAN SURVEY April 16, 1980**

**(Feature Locations Based Upon Slant Ranges)**

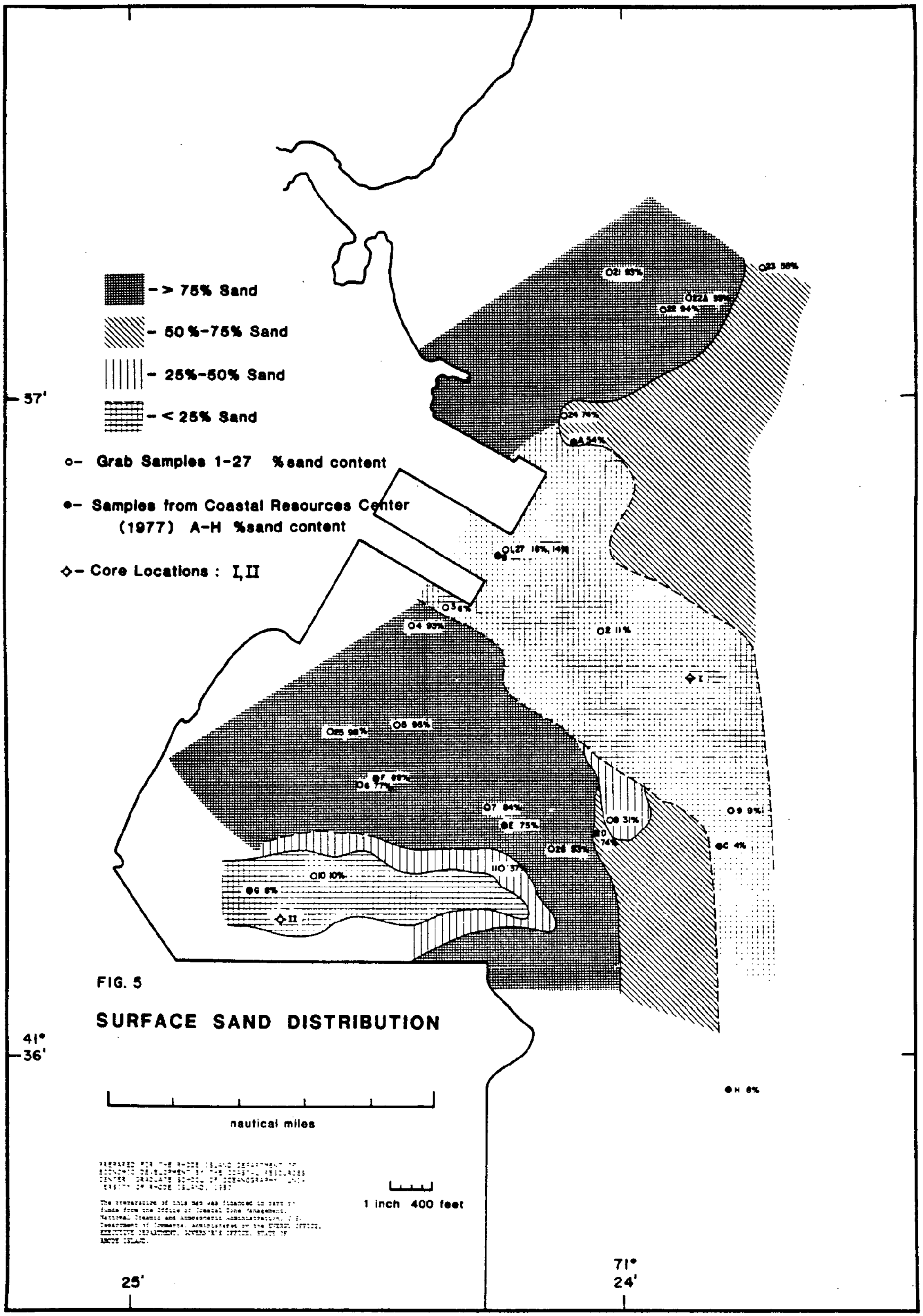


FIG. 5

SURFACE SAND DISTRIBUTION

The sand component in all sediment types is dominated by fine to very fine sand (Appendix A). Shells and gravel comprise only 2-7% of the samples.

5. Bedrock

Bedrock depths are shown in time units (Fig. 6) and feet (Fig. 7) based upon a speed in water of 4800 ft/sec and a sediment velocity of 5,000 ft/sec (Birch and Dietz, 1962). C.E. Maguire boring sites with bedrock depths are also plotted on Figure 7. Compilation of bedrock depth data is presented in Appendix B.

The depth, attitude and shape of the bedrock surface is apparently controlled by the down cutting of an ancient drainage system. The dissected surface lies from 47 to 119 ft below MLW with no obvious attitude. Unfortunately, a significant portion of the surface is hidden because of attenuation of the acoustic signals by gaseous sediments beneath the channels and valley complex.

A major bedrock valley crosses the area from NW to SE. Depths within this valley reach more than 110 feet east of Pier 1 but shoal toward the southeast before apparently connecting with a N-S trending channel that lies adjacent to the study area on the east. A smaller bedrock valley, oriented E-W, appears to join the NW-SE trending valley northeast of the airport bulkhead. Bedrock depths within this valley are less than 90 feet. South of Pier 1, it is uncertain as to how the bedrock depths of almost 100 feet are related to the valley segments described above.

The shallowest bedrock dephts, about 50 feet, are associated with the western divide of the N-S trending valley that lies along the study area's eastern side.

6. Overburden: Sediment thickness is plotted as an isopach map (Fig. 8). Calculated thickness values are based upon a sediment velocity of 5,000 ft/sec. All data on the overburden are presented in Appendix B. Sediment thickness information from the C.E. Maguire borings and bore holes during U.S. Navy ownership (Coastal Resources Center, 1977) is also shown on Figure 8.

Overburden thickness ranges from 25 to 99 feet. These values are closely related to the configuration of the bedrock surface: the greatest thickness occur in the bedrock valleys with lesser sediment cover lying on the divides. Hence an overburden thickness of over 99 feet is found immediately east of Pier 2 and more than 80 feet lies south of Pier 1.

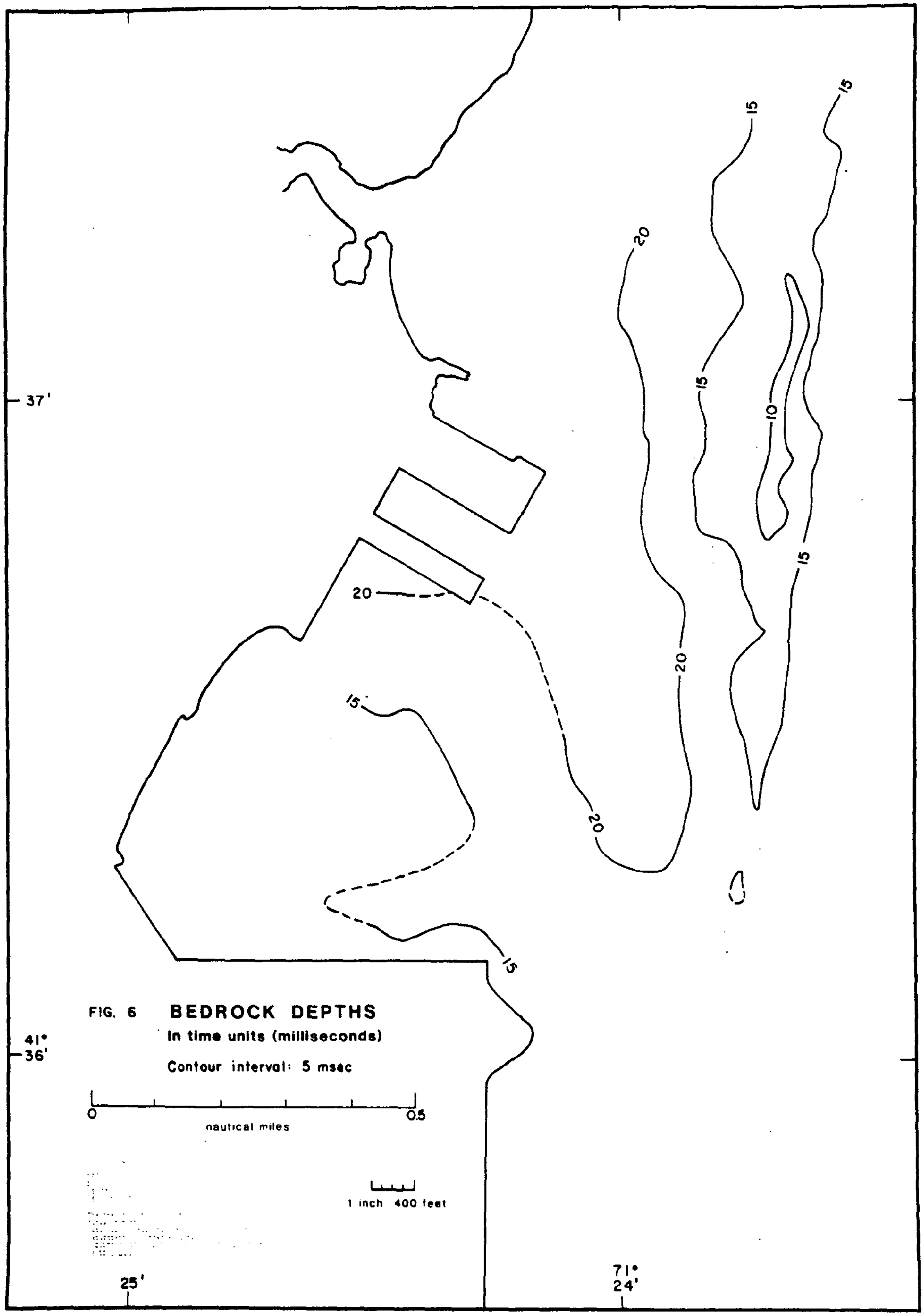


FIG. 6 **BEDROCK DEPTHS**
**In time units (milliseconds)**
**Contour interval: 5 msec**

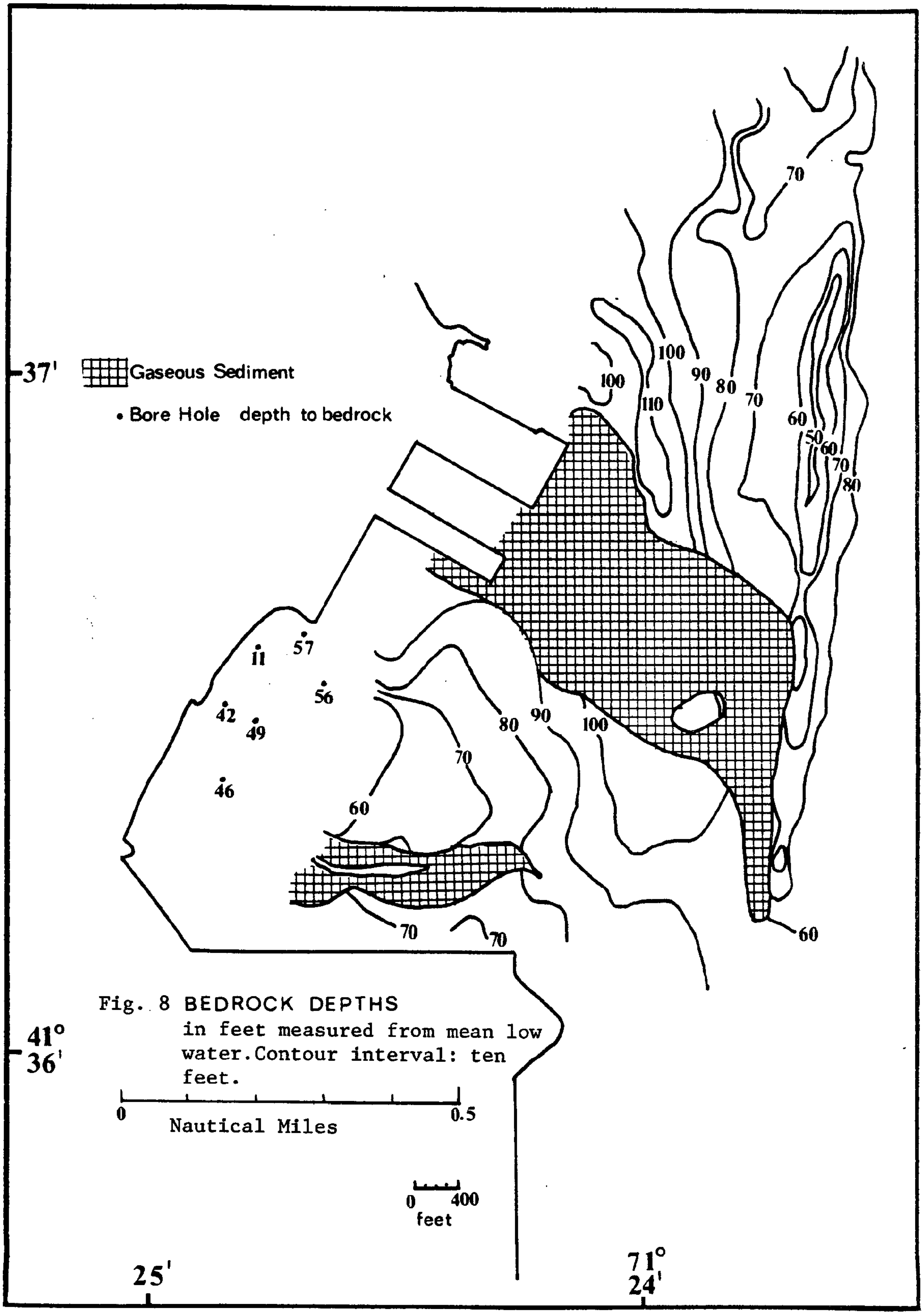


Fig. 8 BEDROCK DEPTHS
in feet measured from mean low water. Contour interval: ten feet.

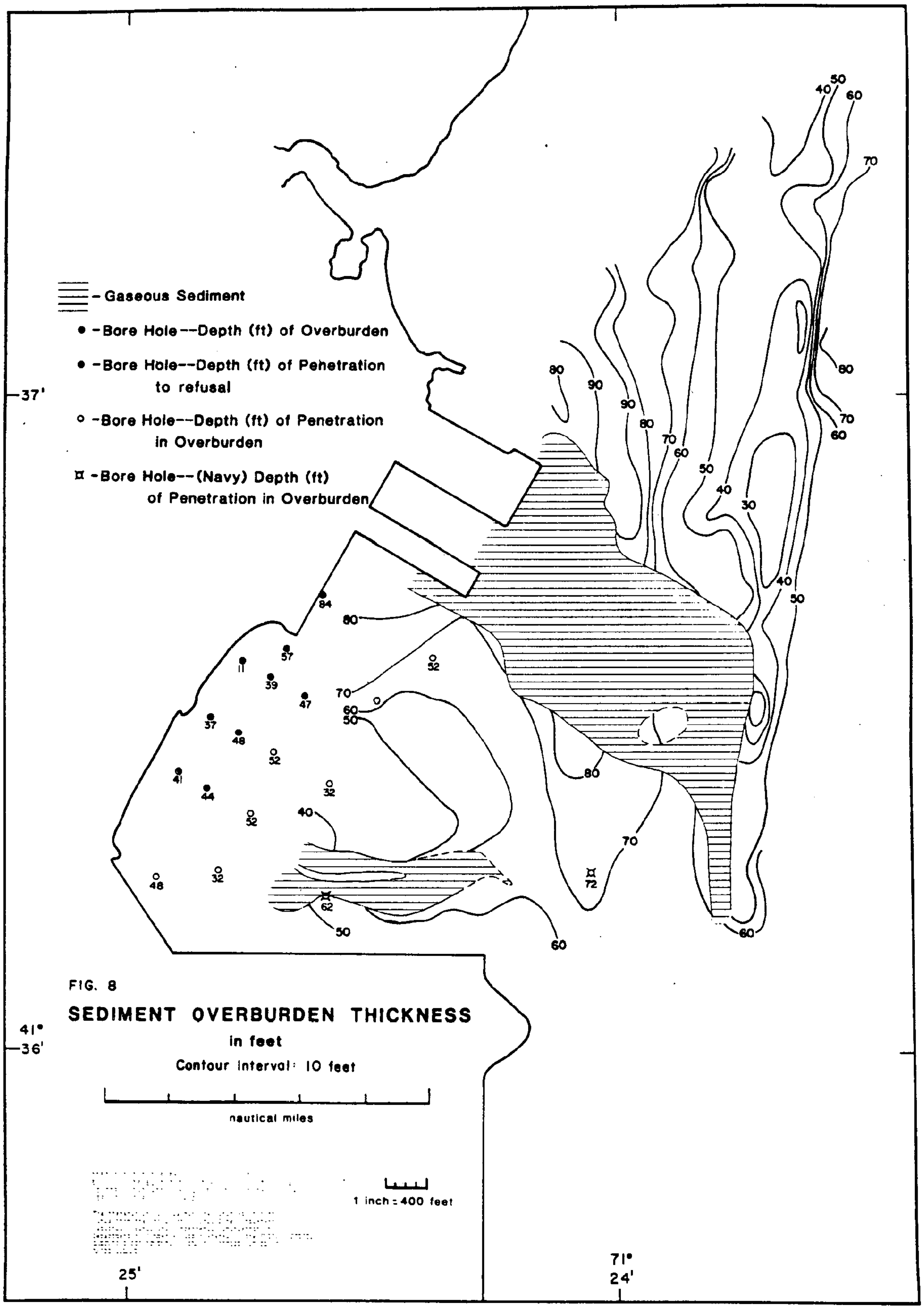


FIG. 8

**SEDIMENT OVERBURDEN THICKNESS**

in feet

Contour interval: 10 feet

Beneath the E-W trending valley complex, more than 50 feet of overburden covers the bedrock.

The smallest accumulation, about 50 feet, lies above the bedrock divide that occurs along the area's eastern side.

A close inspection of the seismic records together with an interpretation of C.E. Maguire's boring logs indicates that the overburden is composed primarily of glacial outwash with a smaller amount of glacial till.

## References

American Society for Testing and Materials, 1968, Book of ASTM Standards. Standard Method for Grain Size Analysis of Soils, p. 205-216, Phila, Pa.

Birch, W.B., and F.T. Dietz, 1962. Seismic refraction investigations in selected areas of Narragansett Bay, RI. J. Geophys. Res. 67: 2813-2821.

Coastal Resources Center, 1977. The Redevelopment of Quonset/Davisville, An Environmental Assessment. Kingston, Univ. of Rhode Island.

APPENDIX A

Sediment Data*

Table 1

| Sample # | %Sand | %Silt | %Clay |
|---|---|---|---|
| 1 + | 14 | 69 | 17 |
| 2 + | 11 | 69 | 20 |
| 3 + | 6 | 81 | 13 |
| 4 | 93 | 7 | - |
| 5 | 95 | 5 | - |
| 6 + | 77 | 18 | 5 |
| 7 | 84 | 16 | - |
| 8 + | 31 | 48 | 21 |
| 9 + | 9 | 80 | 11 |
| 10 + | 10 | 77 | 13 |
| 11 + | 37 | 55 | 8 |
| 21 | 93 | 7 | - |
| 22 | 95 | 5 | - |
| 22A | 93 | 7 | - |
| 23 + | 55 | 39 | 6 |
| 24 + | 74 | 23 | 3 |
| 25 | 98 | 2 | - |
| 26 + | 93 | 4 | 3 |
| 27 + | 16 | 76 | 7 |

+ = hydrometer analysis performed

* = Sand greater than .063 mm.
Silt greater than .0034 mm., less than .063 mm.
Clay less than .0034 mm

SAND SIZE DISTRIBUTIONS

TABLE 2

| Sample # | 2 mm | 1 mm | .5 mm | .25 | .125 | .062 |
|---|---|---|---|---|---|---|
| 1 | - | - | 1.8 | 32.1 | 32.1 | 32.1 |
| 2 | - | 7.4 | 7.4 | 25.9 | 25.9 | 33.3 |
| 3 | - | - | - | - | - | - |
| 4 | - | .1 | 7.4 | 16.3 | 56.4 | 9.3 |
| 5 | 4.9 | 11.6 | 22.0 | 25.1 | 24.0 | 6.5 |
| 6 | .2 | 2.0 | 11.8 | 39.8 | 25.2 | 22.0 |
| 7 | .6 | 2.4 | 4.5 | 16.0 | 28.6 | 22.0 |
| 8 | 1.0 | 4.9 | 4.9 | 9.8 | 48.0 | 30.4 |
| 9 | - | 4.8 | 4.8 | 7.3 | 29.3 | 58.5 |
| 10 | - | 6.5 | 6.5 | 9.7 | 19.4 | 54.8 |
| 11 | .3 | 1.2 | 2.3 | 2.3 | 26.3 | 68.4 |
| 21 | .1 | .6 | 1.0 | 3.0 | 43.4 | 50.0 |
| 22 | .1 | .8 | 1.3 | 5.9 | 67.3 | 23.5 |
| 22A | .1 | .5 | .9 | 1.6 | 61.5 | 33.6 |
| 23 | .2 | 1.1 | 2.5 | 5.7 | 42.2 | 48.2 |
| 24 | - | .5 | 1.9 | 15.7 | 37.0 | 45.4 |
| 25 | .1 | 2.3 | 10.4 | 14.3 | 63.8 | 9.1 |
| 26 | - | .4 | .7 | 12.1 | 49.3 | 37.3 |
| 27 | - | .9 | 1.9 | 3.7 | 18.5 | 74.1 |

APPENDIX B

SUB-BOTTOM DATA

| Position | (a) Time to btm m sec | (b) Btm depth 4800 ft/sec | (c) Time to Bdrk (m sec) | Time Diff c-s (m sec) | (d) Sed Thick (ft) | Depth to Bdrk (b+d)(ft) |
|---|---|---|---|---|---|---|
| 1540 | 5.5 | 26.4 | 19 | 13.5 | 67.5 | 93.9 |
| 1540.5 | 5.75 | 27.6 | 18.5 | 12.7 | 63.5 | 91.1 |
| | 7.5 | 36 | G* | - | - | - |
| | 7.5 | 36 | G* | - | - | - |
| 1542 | 5.5 | 26.4 | 18.5 | 13.0 | 65 | 91.4 |
| | 5.2 | 25 | 19.0 | 13.8 | 69 | 94 |
| | 5.2 | 25 | 18.5 | 13.3 | 66.5 | 91.5 |
| | 5.0 | 24 | 18.5 | 13.5 | 67.5 | 91.5 |
| 1544 | 5.0 | 24 | 19.5 | 14.5 | 72.5 | 96.5 |
| | 4.5 | 21.6 | 18.0 | 13.5 | 67.5 | 89.1 |
| | 4.0 | 19.2 | 17.0 | 13 | 65 | 84.2 |
| | 5.0 | 24 | 16.5 | 11.5 | 57.5 | 81.5 |
| 1546 | 4.75 | 22.8 | 16.5 | 11.7 | 58.5 | 81.3 |
| | 3.5 | 16.8 | 16 | 12.5 | 62.5 | 79.3 |
| | 3.5 | 16.8 | 15.5 | 12 | 60 | 76.8 |
| | 3.0 | 14.4 | 16 | 13 | 65 | 79.4 |
| 1548 | 3.2 | 15.4 | 15.5 | 12.3 | 61.5 | 76.9 |
| | 3.0 | 14.4 | 14.5 | 11.5 | 57.5 | 71.9 |
| | 3.5 | 16.8 | 14 | 10.5 | 52.5 | 69.3 |
| | 3.5 | 16.8 | 13.5 | 10 | 50 | 66.8 |
| 1550 | 4.0 | 19.2 | 13 | 9 | 45 | 64.2 |
| | 3.5 | 16.8 | 13 | 9.5 | 47.5 | 64.3 |
| | 2.5 | 12 | 12.5 | 10 | 50 | 62 |
| | 4.0 | 19.2 | 13 | 9 | 45 | 64.2 |

G* denotes gaseous sediment

Appendix B (con't)

SUB-BOTTOM DATA

| Position | (a) Time to btm m sec | (b) Btm depth 4800 ft/sec | (c) Time to Bdrk (m sec) | Time Diff c-s (m sec) | (d) Sed Thick (ft) | Depth to Bdrk (b+d) (ft) |
|---|---|---|---|---|---|---|
| 1552 | 4.5 | 21.6 | G* | - | - | - |
| | 5.0 | 24.0 | G* | - | - | - |
| 1553 | 4.5 | 21.6 | G* | - | - | - |
| | 5.0 | 24 | G* | - | - | - |
| 1554 | 4.5 | 21.6 | G* | - | - | - |
| | 3.5 | 16.8 | 11.5 | 8 | 40 | 56.8 |
| | 3.5 | 16.8 | 12.5 | 9 | 45 | 61.8 |
| | 4.0 | 19.2 | 13.0 | 9 | 45 | 64.2 |
| 1556 | 3.5 | 16.8 | 13.0 | 9.5 | 47.5 | 64.3 |
| | 3.5 | 16.8 | 15.0 | 11.5 | 57.5 | 74.3 |
| | 4.0 | 19.2 | 15.0 | 11 | 55 | 74.2 |
| | 4.0 | 19.2 | 16.0 | 12 | 60 | 79.2 |
| 1558 | 4.0 | 19.2 | 16.5 | 12.5 | 62.5 | 81.7 |
| | 4.2 | 20.2 | 18.5 | 14.3 | 71.5 | 91.7 |
| | 4.2 | 20.2 | 21.0 | 16.8 | 84 | 104.2 |
| | 6.5 | 31.2 | G* | - | - | - |
| 1600 | 6.5 | 31.2 | G* | - | - | -- |
| | 7.0 | 33.6 | 21.0 | 14 | 70 | 103.6 |
| | 7.0 | 33.6 | 21.0 | 14 | 70 | 103.6 |
| | 7.0 | 33.6 | G* | - | - | - |
| 1602 | 7.0 | 33.6 | G* | - | - | - |
| | 7.2 | 34.6 | G* | - | - | - |
| | 5.0 | 24 | 12.0 | 7.0 | 35 | 59 |
| | 6.5 | 31.2 | 13.5 | 7 | 35 | 66.2 |

* denotes gaseous sediment

Appendix B (con't)

SUB-BOTTOM DATA

| Position | (a) Time to btm m sec | (b) Btm depth 4800 ft/sec | (c) Time to Bdrk (m sec) | Time Diff c-a (m sec) | (d) Sed Thick (ft) | Depth to Bdrk (b+d) (ft) |
|---|---|---|---|---|---|---|
| 1604 | 6.5 | 31.2 | 14.5 | 8 | 40 | 71.2 |
| | 5.5 | 26.4 | 15.0 | 9.5 | 47.5 | 73.9 |
| | 5.5 | 26.4 | 15.5 | 10 | 50 | 76.4 |
| | 5.5 | 26.4 | 15.5 | 10 | 50 | 76.4 |

Appendix B (con't)

SUB-BOTTOM DATA

| Position | (a) Time to btm m sec | (b) Btm depth 4800 ft/sec | (c) Time to Bdrk (m sec) | Time Diff c-a m sec) | (d) Sed Thick (ft) | Depth to Bdrk b+d (ft) |
|---|---|---|---|---|---|---|
| 1606 | 5.5 | 26.4 | 16.0 | 10.5 | 52.5 | 78.9 |
| | 5.5 | 26.4 | 16.0 | 10.5 | 52.5 | 78.9 |
| | 5.2 | 25 | 13.0 | 7.8 | 39 | 64 |
| | 5.0 | 24 | 15.0 | 10 | 50 | 74 |
| 1608 | 5.0 | 24 | 16.0 | 11 | 55 | 79 |
| | 4.5 | 21.6 | 18.0 | 13.5 | 67.5 | 89.1 |
| | 3.5 | 16.8 | 19.0 | 15.5 | 77.5 | 94.3 |
| | 3.5 | 16.8 | 19.5 | 16 | 80 | 96.8 |
| 1610 | 4.0 | 19.2 | 22.0 | 18 | 90 | 109.2 |
| | 3.5 | 16.8 | 23.0 | 19.5 | 97.5 | 114.3 |
| | 3.5 | 16.8 | 23.0 | 19.5 | 97.5 | 114.3 |
| | 3.0 | 14.4 | 22.5 | 19.5 | 97.5 | 111.9 |
| 1612 | 3.0 | 14.4 | 21.5 | 18.5 | 92.5 | 116.9 |
| | - | - | - | - | - | - |
| | 3.5 | 16.8 | 22.0 | 18.5 | 92.5 | 109.3 |
| | 3.2 | 15.4 | 22.0 | 18.8 | 94 | 109.4 |
| 1614 | 3.5 | 16.8 | 19.0 | 15.5 | 77.5 | 94.3 |
| | 3.5 | 16.8 | 17.5 | 14 | 70 | 86.8 |
| | 3.5 | 16.8 | 16.0 | 12.5 | 62.5 | 79.3 |
| | 3.7 | 17.8 | 15.5 | 11.8 | 59 | 76.8 |
| 1616 | 4.2 | 20.2 | 15 | 10.8 | 54 | 64.2 |
| 1616.5 | 4.7 | 22.6 | 14.5 | 9.8 | 49 | 71.6 |
| 1617 | 5.0 | 24 | 15.0 | 10 | 50 | 74 |
| 1617.5 | 5.0 | 24 | 14.5 | 9.5 | 47.5 | 71.5 |
| 1618 | 5.0 | 24 | 15.5 | 10.5 | 52.5 | 76.5 |
| | ? 6.2 | 29.8 | 18.0 | 11.8 | 59 | 88.8 |
| 1619 | 5.0 | 24 | 18.0 | 13 | 65 | 89 |

Appendix B (con't)

SUB-BOTTOM DATA

| Position | (a) Time to btm m sec | (b) Btm depth 4800 ft/sec | (c) Time to Bdrk (m sec) | Time Diff c-a m sec) | (d) Sed Thick (ft) | Depth to Bdrk b+d (ft) |
|---|---|---|---|---|---|---|
| 1619.5 | 5.0 | 24 | 17.0 | 12 | 60 | 84 |
| 1620 | 4.7 | 22.6 | 15.5 | 10.8 | 54 | 76.6 |
| | 4.0 | 19.2 | 13.0 | 9.0 | 45 | 64.2 |
| | 3.5 | 16.8 | 12.5 | 9 | 45 | 61.8 |
| | 3.5 | 15.4 | 17.0 | 13.8 | 69 | 84.4 |
| 1622 | 3.5 | 16.8 | 17.5 | 14 | 70 | 86.8 |
| | 3.2 | 15.4 | 19.0 | 15.8 | 79 | 94.4 |
| | 3.5 | 16.8 | 18.5 | 15 | 75 | 91.8 |
| | 3.5 | 16.8 | 19.0 | 15.5 | 77.5 | 94.3 |
| 1624 | 3.5 | 16.8 | 20.0 | 16.5 | 82.5 | 99.3 |
| | 3.5 | 16.8 | 21.0 | 17.5 | 87.5 | 104.3 |
| | 3.5 | 16.8 | 21.0 | 17.5 | 87.5 | 104.3 |
| | 3.5 | 16.8 | 20.0 | 16.5 | 82.5 | 99.3 |
| 1626 | 3.5 | 16.8 | 19.0 | 15.5 | 77.5 | 94.3 |
| | 6.0 | 28.8 | G* | - | - | - |
| | 7.0 | 33.6 | G* | - | - | - |
| | 7.0 | 33.6 | G* | - | - | - |
| 1628 | 7.0 | 33.6 | G* | - | - | - |
| | 7.5 | 36 | G* | - | - | - |
| | 6.7 | 32.2 | G* | - | - | - |
| | 6.7 | 32.2 | G* | - | - | - |
| 1630 | 7.0 | 33.6 | G* | - | - | - |
| | 4.0 | 19.2 | 16.5 | 12.5 | 62.5 | 81.7 |
| 1631 | 4.0 | 19.2 | 16.5 | 12.5 | 62.5 | 81.7 |
| | 3.5 | 16.8 | 16.0 | 12.5 | 62.5 | 79.3 |

* denotes gaseous sediment

Appendix B (con't)

SUB-BOTTOM DATA

| Position | (a) Time to btm m sec | (b) Btm depth 4800 ft/sec | (c) Time to Bdrk (m sec) | Time Diff c-a (m sec) | (d) Sed Thick (ft) | Depth to Bdrk b+d (ft) |
|---|---|---|---|---|---|---|
| 1632 | 3.5 | 16.8 | 15 | 11.5 | 57.5 | 74.3 |
| | 3.5 | 16.8 | 14 | 10.5 | 52.5 | 69.3 |
| | 3.5 | 16.8 | 13.5 | 10 | 50 | 66.8 |
| | 3.5 | 16.8 | 13 | 9.5 | 47.5 | 64.3 |
| 1634 | 3.5 | 16.8 | 13 | 9.5 | 47.5 | 64.3 |
| | 3.5 | 16.8 | 13 | 9.5 | 47.5 | 64.3 |
| | 3.5 | 16.8 | 12.5 | 9.0 | 45 | 61.8 |
| | 5.0 | 24 | G* | - | - | - |
| 1636 | 5.0 | 24 | G* | - | - | - |
| | - | - | 12.0 | - | - | - |
| | 4.2 | 20.2 | 12.5 | 8.3 | 41.5 | 61.7 |
| | 5.0 | 24 | G* | - | - | - |
| 1639 | 5.0 | 24 | G* | - | - | - |
| | 5.0 | 24 | G* | - | - | - |
| 1640 | 5.2 | 25 | 11.5 | 6.3 | 31.5 | 56.5 |
| | 3.5 | 16.8 | 12.0 | 8.5 | 42.5 | 59.3 |
| | 3.5 | 16.8 | 11.5 | 8 | 40 | 56.8 |
| | 3.5 | 16.8 | 12.0 | 8.5 | 42.5 | 59.3 |
| 1642 | 3.2 | 15.4 | 12.0 | 8.8 | 44 | 59.4 |
| | 3.2 | 15.4 | 12.0 | 8.8 | 44 | 59.4 |
| | 3.5 | 16.8 | 17 | 13.5 | 67.5 | 84.3 |
| | 3.2 | 15.4 | 18.5 | 15.3 | 76.5 | 91.9 |
| 1644 | 3.0 | 14.4 | 18.5 | 15.5 | 77.5 | 91.9 |
| | 3.0 | 14.4 | 19 | 16 | 80 | 94.4 |

* denotes gaseous sediment

Appendix B (con't)

SUB-BOTTOM DATA

| Position | (a) Time to btm m sec | (b) Btm depth 4800 ft/sec | (c) Time to Bdrk (m sec) | Time Diff (c-a m sec) | (d) Sed Thick (ft) | Depth to Bdrk b+d (ft) |
|---|---|---|---|---|---|---|
| 1645 | 3.2 | 15.4 | 19.5 | 16.3 | 81.5 | 96.9 |
| | 3.2 | 15.4 | 20 | 16.8 | 84 | 99.4 |
| 1646 | 3.2 | 15.4 | 20 | 16.8 | 84 | 99.4 |
| | 7.5 | 36 | G* | - | - | - |
| | 7.7 | | G* | - | - | - |
| | 7.5 | 36 | G* | - | - | - |
| 1648 | 6.5 | 31.2 | G* | - | - | - |
| | 6.7 | 32.2 | G* | - | - | - |
| | 6.5 | 31.2 | G* | - | - | - |
| | 6.5 | 31.2 | G* | - | - | - |
| 1650 | 6.7 | 32.2 | G* | - | - | - |
| | 6.7 | 32.2 | G* | - | - | - |
| | 6.7 | 32.2 | G* | - | - | - |
| | 7.0 | 33.6 | G* | - | - | - |
| 1652 | 7.0 | 33.6 | 21.5 | 14.5 | 72.5 | 106.1 |
| | 7.2 | 34.6 | 21.0 | 13.8 | 69 | 103.6 |
| | 7.5 | 36 | G* | - | - | - |
| | 7.5 | 36 | G* | - | - | - |
| 1654 | 7.5 | 36 | 15 ? | 6.5 | 32.5 | 68.5 |
| | 7.0 | 33.6 | 14.5 | 7.5 | 37.5 | 71.1 |
| | 7.0 | 33.6 | 15.0 | 8 | 40 | 73.6 |
| | 7.0 | 33.6 | 14.5 | 7.5 | 37.5 | 71.1 |
| 1656 | 7.0 | 33.6 | 14.5 | 7.5 | 37.5 | 71.1 |
| | 7.5 | 36 | 15.5 | 8 | 40 | 76 |
| | 7.5 | 36 | 15.0 | 7.5 | 37.5 | 73.5 |
| | 6.5 | 31.2 | 15.5 | 8 | 40 | 71.2 |

* denotes gaseous sediment

Appendix B (con't)

SUB-BOTTOM DATA

| Position | (a) Time to Btm m sec | (b) Btm depth 4800 ft/sec | (c) Time to Bdrk (m sec) | Time Diff (c-a m sec) | (d) Sed Thick (ft) | Depth to Bdrk b+d (ft) |
|---|---|---|---|---|---|---|
| 1658 | 6.0 | 28.8 | 15.0 | 9 | 45 | 73.8 |
| | 6.0 | 28.8 | 16.0 | 10 | 50 | 78.8 |
| | 5.5 | 26.4 | 16.0 | 10.5 | 52.5 | 78.9 |
| | 5.5 | 26.4 | 16.5 | 11 | 55 | 81.4 |
| 1700 | 5.5 | 26.4 | 16.0 | 10.5 | 52.5 | 78.9 |
| | 5.7 | 27.4 | 16.5 | 10.8 | 54 | 81.4 |
| | 6.0 | 28.8 | 16.0 | 10 | 50 | 78.8 |
| | 6.0 | 28.8 | 16.5 | 10.5 | 52.5 | 81.3 |
| 1702 | 6.0 | 28.8 | 16.0 | 10.0 | 50 | 78.8 |
| | 6.0 | 28.8 | 16.0 | 10.0 | 50 | 78.8 |
| | 5.5 | 26.4 | 17.0 | 11.5 | 57.5 | 83.9 |
| | 6.0 | 28.8 | 17.0 | 11.0 | 55 | 83.8 |
| 1704 | 5.7 | 27.4 | 16.0 | 10.3 | 51.5 | 78.9 |
| | 5.7 | 27.4 | 16.0 | 10.3 | 51.5 | 78.9 |
| | 5.7 | 27.4 | 16.5 | 10.8 | 54 | 81.4 |
| | 5.7 | 27.4 | 16.5 | 10.8 | 54 | 81.4 |
| 1706 | 5.7 | 27.4 | 17.0 | 11.3 | 56.5 | 83.9 |
| | 5.5 | 26.4 | 15.5 | 10 | 50 | 76.4 |
| | 5.5 | 26.4 | 15.5 | 10 | 50 | 76.4 |
| | 5.5 | 26.4 | 19.0 | 13.5 | 67.5 | 93.9 |
| 1708 | 5.7 | 27.4 | 21.0 | 15.3 | 76.5 | 103.9 |
| | 5.5 | 26.4 | 21.0 | 15.5 | 77.5 | 103.9 |
| | 5.5 | 26.4 | 22.0 | 16.5 | 82.5 | 108.9 |
| | 5.5 | 26.4 | 21.0 | 15.5 | 77.5 | 103.9 |
| 1710 | 5.5 | 26.4 | 20.5 | 15.0 | 75 | 101.4 |
| | 5.0 | 24 | 19.5 | 14.5 | 72.5 | 96.5 |

Appendix B (con't)

SUB-BOTTOM DATA

| Position | (a) Time to btm m sec | (b) Btm depth 4800 ft/sec | (c) Time to Bdrk (m sec) | Time Diff (c-a sec) | (d) Sed Thick (ft) | Depth to Bdrk b+d (ft) |
|---|---|---|---|---|---|---|
| 1711 | 5.2 | 25 | 19.5 | 14.3 | 71.5 | 96.5 |
| | 5.2 | 25 | 19.5 | 14.3 | 71.5 | 96.5 |
| 1712 | 5.2 | 25 | 19.0 | 13.8 | 69 | 94 |
| | 5.0 | 24 | 19.0 | 14 | 70 | 94 |
| | 5.5 | 26.4 | 18.5 | 13 | 65 | 91.4 |
| | 5.5 | 26.4 | 19.0 | 13.5 | 67.5 | 93.9 |
| 1714 | 5.7 | 27.4 | 19.0 | 13.3 | 66.5 | 93.9 |
| | 6.5 | 31.2 | 18.5 | 12 | 60 | 91.2 |
| | 6.0 | 28.8 | 18.0 | 12 | 60 | 88.8 |
| | 6.0 | 28.8 | 13.0 | 7 | 35 | 63.8 |
| 1716 | 4.0 | 19.2 | 12.0 | 8 | 40 | 59.2 |
| | 4.0 | 19.2 | 12.0 | 8 | 40 | 59.2 |
| | 4.0 | 19.2 | 12.0 | 8 | 40 | 59.2 |
| | 3.7 | 17.8 | 13.0 | 9.3 | 46.5 | 64.3 |
| 1718 | 4.0 | 19.2 | 13.0 | 9 | 45 | 64.2 |
| | 4.0 | 19.2 | 13.5 | 9.5 | 47.5 | 66.7 |
| | 4.0 | 19.2 | 13.0 | 9 | 45 | 64.2 |
| | 4.2 | 20.2 | 15.0 | 10.8 | 54 | 74.2 |
| 1720 | 4.5 | 21.6 | 17.5 | 13 | 65 | 86.6 |
| | 4.5 | 21.6 | 18.5 | 14 | 70 | 91.6 |
| | 4.5 | 21.6 | 18.5 | 14 | 70 | 91.6 |
| | 4.5 | 21.6 | 18.0 | 13.5 | 67.5 | 89.1 |
| 1722 | 4.2 | 20.2 | 18.5 | 14.3 | 71.5 | 91.7 |
| | 4.0 | 19.2 | 20.5 | 16.5 | 82.5 | 101.7 |
| | 4.0 | 19.2 | 21.0 | 17 | 85 | 104.2 |
| | 4.0 | 19.2 | 22.5 | 18.5 | 92.5 | 111.7 |

Appendix B (con't)

SUB-BOTTOM DATA

| Position | (a) Time to btm m sec | (b) Btm depth 4800 ft/sec | (c) Time to Bdrk (m sec) | Time Diff c-a (m sec) | (d) Sed Thick (ft) | Depth to Bdrk b+d (ft) |
|---|---|---|---|---|---|---|
| 1724 | 4.2 | 20.2 | 24 | 19.8 | 99 | 119.2 |
| | 7.0 | 33.6 | G* | - | - | - |
| | 7.2 | 34.6 | G* | - | - | - |
| | 7.0 | 33.6 | G* | - | - | - |
| 1726 | 7.0 | 33.6 | G* | - | - | - |
| | 7.0 | 33.6 | G* | - | - | - |
| | 7.0 | 33.6 | G* | - | - | - |
| | 6.5 | 31.2 | G* | - | - | - |
| 1728 | 4.5 | 21.6 | 18.5 | 14 | 70 | 91.6 |
| | 4.2 | 20.2 | 18 | 13.8 | 69 | 89.2 |
| | 4.2 | 20.2 | 17.5 | 13.3 | 66.5 | 86.7 |
| | 4.2 | 20.2 | 17 | 12.8 | 64 | 84.2 |
| 1730 | 4.2 | 20.2 | 16.5 | 12.3 | 61.5 | 81.7 |
| 1730.5 | 3.2 | 15.4 | G* | - | - | - |
| 1731 | 3.5 | 16.8 | G* | - | - | - |
| | 3.7 | 17.8 | 15.5 | 11.8 | 59 | 76.8 |
| 1732 | 3.5 | 16.8 | 16 | 12.5 | 62.5 | 79.3 |
| | 3.7 | 17.8 | 16 | 12.3 | 61.5 | 79.3 |
| 1733 | 4.0 | 19.2 | 15.5 | 11.5 | 57.5 | 76.7 |
| | 5.0 | 24 | G* | - | - | - |
| 1734 | 5.0 | 24 | G* | - | - | - |
| | 5.0 | 24 | G* | - | - | - |
| 1735 | 3.7 | 17.8 | 13 | 9.3 | 46.5 | 54.3 |
| | 3.5 | 16.8 | 14.5 | 11.0 | 55 | 71.8 |

* denotes gaseous sediment

Appendix B (con't)

SUB-BOTTOM DATA

| Position | (a) Time to btm m sec | (b) Btm depth 4800 ft/sec | (c) Time to Bdrk (m sec) | Time Diff c-a (m sec) | (d) Sed Thick (ft) | Depth to Bdrk (b+d) (ft) |
|---|---|---|---|---|---|---|
| 1736 | 3.5 | 16.8 | 14.5 | 11 | 55 | 71.8 |
| | 5.2 | 2.5 | 15.5 | 10.3 | 51.5 | 76.5 |
| | 4.5 | 21.6 | 16.5 | 12 | 60 | 81.6 |
| | 5.0 | 24 | 16.5 | 11.5 | 57.5 | 81.5 |
| 1738 | 5.0 | 24 | 18.0 | 13 | 65 | 89 |
| | 5.0 | 24 | 18.0 | 13 | 65 | 89 |
| | 5.0 | 24 | 18.5 | 13.5 | 67.5 | 91.5 |
| | 5.5 | 26.4 | 19 | 13.5 | 67.5 | 93.9 |
| 1740 | 7.5 | 36 | G* | - | - | - |
| | 7.5 | 36 | G* | - | - | - |
| | 7.5 | 36 | 19.5 | 12.0 | 60 | 96 |
| | 6.0 | 28.8 | 19.0 | 13 | 65 | 93.8 |
| 1742 | 6.0 | 28.8 | 19.5 | 13.5 | 13.5 | 96.3 |

* denotes gaseous sediment

Appendix C

SUB-BOTTOM DATA (Profile from Coastal Resources Center, 1977)

| Position | (a) Time to btm m sec | (b) Btm depth (4800 ft/sec) | (c) Time to Bdrk (m sec) | Time Diff c-a (m sec) | (d) Sed Thick (ft) | Depth to Bdrk b+d (ft) |
|---|---|---|---|---|---|---|
| 1200 | 4.6 | 22.1 | 16.0 | 11.4 | 57 | 79.1 |
| | 4.6 | 22.1 | 14.5 | 9.9 | 49.5 | 71.6 |
| 01 | 4.6 | 22.1 | 14.5 | 9.9 | 49.5 | 71.6 |
| | 4.6 | 22.1 | 14 | 9.4 | 47 | 69.1 |
| 02 | 4.7 | 22.6 | 15 | 10.4 | 52 | 74.6 |
| | 4.7 | 22.6 | 14 | 9.3 | 46.5 | 69.1 |
| 03 | 4.7 | 22.6 | 12.0 | 7.3 | 36.5 | 59.1 |
| | 4.7 | 22.6 | 10 | 5.3 | 26.5 | 49.1 |
| 04 | 5.0 | 24 | 10.5 | 5.5 | 27.5 | 51.5 |
| | 5.0 | 24 | 11.5 | 6.5 | 32.5 | 56.5 |
| 1205 | 5.0 | 24 | 12.5 | 7.5 | 37.5 | 61.5 |
| | 4.7 | 22.6 | 11 | 6.3 | 31.5 | 54.1 |
| 06 | 4.5 | 21.6 | 9.5 | 5.0 | 25 | 46.6 |
| | 4.5 | 21.6 | 11.0 | 6.5 | 32.5 | 54.1 |
| 07 | 4.5 | 21.6 | 95 | 5.0 | 25 | 46.6 |
| | 5.0 | 24 | 11 | 6.0 | 30 | 54 |
| 08 | 6.0 | 28.8 | 11.5 | 5.5 | 27.5 | 56.3 |
| | 6.0 | 28.8 | 12.0 | 6.0 | 30 | 58.8 |
| 09 | 6.5 | 31.2 | 13 | 6.5 | 32.5 | 63.7 |
| | 6.5 | 31.2 | 11 | 4.5 | 22.5 | 53.7 |
| 1210 | 6.5 | 31.2 | 12.0 | 5.5 | 27.5 | 58.7 |
| | 6.5 | 31.2 | 11.5 | 5.0 | 25 | 56.2 |
| 11 | 7.5 | 36 | 13.5 | 6.0 | 30 | 66 |
| | 7.0 | 33.6 | 14.0 | 7.0 | 35 | 68.6 |

Appendix C

SUB-BOTTOM DATA (Profile from Coastal Resources Center, 1977)

| Position | (a) Time to Btm m sec | (b) Btm depth 4800 ft/sec | (c) Time to Bdrk m sec | Time Diff c-a (m sec) | (d) Sed Thick (ft) | Depth b+d (ft) |
|---|---|---|---|---|---|---|
| 1212 | 6.5 | 31.2 | 15.0 | 8.5 | 42.5 | 73.7 |
| | 6.5 | 31.2 | 15.5 | 9.0 | 45 | 76.2 |
| 13 | 6.5 | 31.2 | 15.5 | 9.0 | 45 | 76.2 |
| | 6.5 | 31.2 | 17.0 | 10.5 | 52.5 | 83.7 |
| 14 | 6.7 | 32.2 | 15.5 | 8.8 | 44 | 76.2 |
| | 6.7 | 32.2 | 16.5 | 9.8 | 49 | 81.2 |
| 1215 | 6.5 | 31.2 | 19.0 | 12.5 | 62.5 | 93.7 |
| | 6.5 | 31.2 | 19.0 | 12.5 | 62.5 | 93.7 |
| 16 | 6.5 | 31.2 | 19.0 | 12.5 | 62.5 | 93.7 |
| | 6.5 | 31.2 | 19.0 | 12.5 | 62.5 | 93.7 |
| 17 | 6.5 | 31.2 | 19.0 | 12.5 | 62.5 | 93.7 |
| | 6.5 | 31.2 | 17.0 | 10.5 | 52.5 | 83.7 |
| 18 | 6.5 | 31.2 | 18.0 | 11.5 | 57.5 | 88.7 |
| | 6.5 | 31.2 | 17.0 | 10.5 | 52.5 | 83.7 |
| 19 | 6.5 | 31.2 | 16.0 | 9.5 | 47.5 | 78.7 |
| | 6.5 | 31.2 | 16.0 | 9.5 | 47.5 | 78.7 |
| 1220 | 6.5 | 31.2 | 15.5 | 9.0 | 45 | 76.2 |

PART C

# EFFECTS OF DEVELOPMENT AT DAVISVILLE, RHODE ISLAND ON THE MARINE ENVIRONMENT

Prepared For

The Rhode Island Department of Economic Development

By

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1980

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# 1. INTRODUCTION

This report was prepared in support of environmental assessment work for the Rhode Island Department of Economic Development by the Coastal Resources Center (CRC) in order to evaluate designs for port expansion at Davisville Piers proposed by C.E. Maguire, Inc.

Baseline data were collected and some potential biological effects of development were identified in a 1977 report on redevelopment of Quonset/ Davisville by CRC. In response to the issues raised in 1977 for the Davisville project area, both from special field observations and from recent studies by other agencies.

Field collections and baseline data are presented in three subsections (Aquatic Biology, Suspended Sediments, Pollutants) with some discussion of the effects of alternative plans. The major conclusions of this report as they pertain to specific designs are summarized in the Environmental Assessment of Davisville Port expansion.

# 2 AQUATIC BIOLOGY

## 2.1 Introduction

Development in the Davisville area will affect all elements of the estuarine ecosystem including planktonic plants and animals and free-swimming fish and crustaceans. Only the bottom-dwelling animals (benthos) are considered in detail in this report. Bottom animals will be directly effected by removal or burial and by changes in bottom type and pollutant concentration. They can be sampled quantitatively because they are mainly small in size and have limited mobility. They include commercially important species and species which indicate stress or changed bottom conditions.

Field collections of bottom animals were made in March and May 1980 using techniques similar to those used in the October 1976 survey (Pratt, 1977). The results of both surveys are discussed in terms of the different groups of species present and the adequacy of the baseline to detect impacts of development.

Recent literature on the effects of suspended sediment and burial on estuarine animals is reviewed to identify the potential impact of dredging alternatives.

## 2.2 Field Collections

Methods. The study area for benthic biology included the area between the airbase bulkhead and the Davisville piers as far out as the dredged turning basin and approach channel. Quantitative grab samples were taken by two methods.

In depths of more than 6 feet bottom samples were taken with a 0.1 $m^2$ Smith-McIntyre grab with weight adjusted for bottom hardness. A subsample was removed for grain size analysis. Stations were located near those sampled for the 1976 Quonset-Davisville study where practical (Fig. 2.1). A single

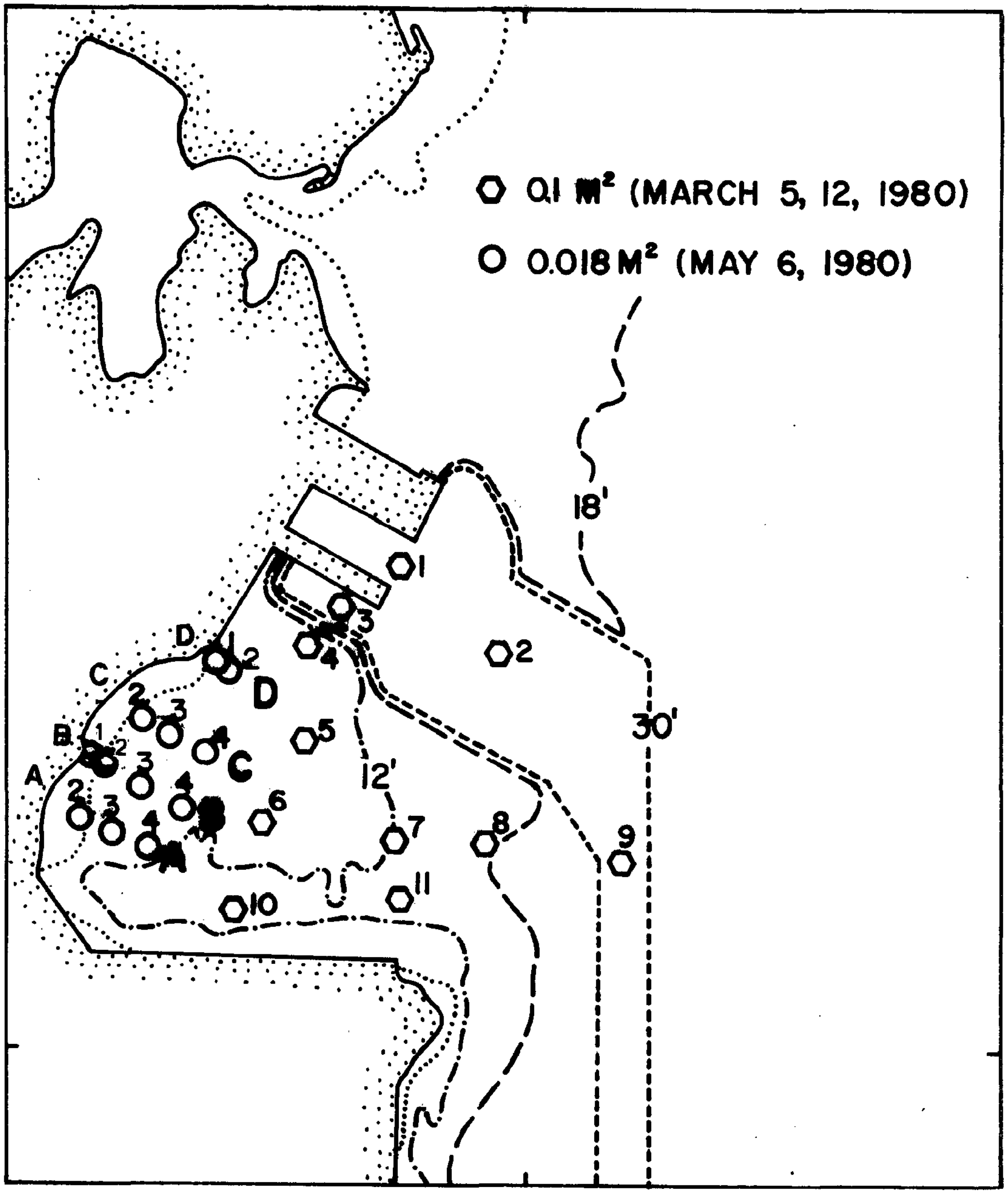


Figure 2-1. Grab Sample Locations for Benthic Survey
Letters A-D designate reference points along Dogpatch Beach for each series of 0.018 $m^2$ samples.

A pilings
B sea wall
C rocks
D navy bulkhead

sample was taken at 11 stations. Three partially full grabs were combined in 7Q to provide a qualitative sample.

The shallow flat at the foot of Dogpatch beach was sampled by hand with a "gas can" sampler which collects a deep sample (40 cm) 0.018 $m^2$ in area. Single samples were taken along 4 transects perpendicular to the beach.

All samples were sieved on a 1.0 mm screen as in the 1976 study. The residue was preserved and stained in rosebengal-formaldehyde. Animals were separated from debris and identified to species. Shell lengths of mollusks were measured and sample residues such as animal tubes and shells were recorded.

Results. The bottom environments in the Davisville area can be placed into three categories on the basis of depth. The dredged channels and basin and the natural channel in Fry Cove (sta. 1, 2, 3, 9, 10) are floored with semi-fluid sediments with 80-69 percent silt and 11-21 percent clay. Along Dogpatch Beach a sand platform extends several hundred feet offshore below the mean low tide level. This area was sampled by "gascan" stations. The remaining stations (6, 5, 4, 7, 11, 8) are on gently sloping bottom grading from 95 percent sand to 31 percent sand, 69 percent silt/clay between the beach and channel. The shells of clams, oysters, and "deckers" (*Crepidula*) and live "deckers" provide hard substrate and shelter in this mid area.

Each depth zone/bottom type has its own temperature pattern. The shallower areas warm faster in the spring and have higher summer temperature. The deep samples were taken in March when water temperature was 1°C throughout the water column. The shallow "gascan" samples were taken on a sunny day in May with water temperature about 15°C.

Numbers of individuals identified in each sample are given in Tables 2-1 and 2-2. The 0.018 m samples are 5.5 smaller than 0.1 $m^2$samples. Parameters for 1976 and 1980 samples from similar locations are given in Table 2-3.

The channel stations (1, 2, 3, 9, 10) had very low numbers of species and individuals (1-5, 1-110). The few species present were those adapted for life in the deeper soft bottoms of the Bay, but are usually found in greater densities (Table 2-1).

The Dogpatch Beach samples contained 4-21 species per sample and high numbers of species adapted for unstable sandy substrates such as the gem clam (*Gemma gemma*), the tellin clam (*Tellina agillis*) and the polychaete

Table 2-1

. Davisville Benthic Survey. Number of individuals recovered from 0.1 $m^2$ grab samples (March 5,12, 1980).

| SPECIES | STATIONS 1 | 2 | 3 | 4 | 5 | 6 | 7 | Q7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Polychaeta | | | | | | | | | | | | |
| *Glycera americana* | | | | 7 | 3 | 15 | 7 | 18 | 3 | | | 12 |
| *Pectinaria gouldii* | | | | | 2 | 2 | | | | | | 8 |
| *Nephtys incisa* | 4 | | | | | | | | | 9 | | |
| *Mediomastus ambyseta* | | | | | | 1 | 13 | 36 | 20 | | | |
| *Maldonopsis elongata* | | | | | 12 | 1 | | 6 | 7 | | | 1 |
| *Clymenella torquata* | | | | | | 2 | | | 1 | | | 1 |
| *Spiochaetopterus oculatus* | | | | | | 2 | | 1 | | | | |
| *Tharyx* sp. | | | | | | | 1 | | 28 | | 1 | |
| *Pholoe minuta* | | | | | | 1 | | | | | | |
| *Scoloplos robustus* | | | 1 | | | | | | | | | |
| *Capitella capitata* | | | | 1 | 2 | | | 5 | 5 | | | |
| *Sabellaria vulgaris* | | | | 3 | | | 10 | 8 | | | | |
| *Harmothoe extenuata* | | | | 1 | | 1 | | 1 | 2 | | | |
| *Nereis succinea* | | | | | 3 | 1 | | | 4 | | | |
| *Strebiospio benedicti* | | | | | 3 | | 9 | 3 | 1 | | 3 | 6 |
| *Ninoe nigripes* | | | | | 6 | 1 | 6 | | | | | |
| *Phyllodoce arenae* | | | | | 1 | 1 | | 1 | | | | |
| *Polydora ligni* | | | | | | 2 | 1 | 1 | | | | |
| *Glycinde solitaria* | | | | | | | 1 | | | | | |
| *Lumbrinereis fragilis* | | | | | | | | 1 | | | | |
| *Paraornis fulgens* | | | | | | | 2 | | | | | |
| *Goniadella gracillis* | | | | | | | | | 1 | | | 2 |
| *Amphitrite ornata* | | | | | | | | | 2 | | | |
| *Amphitrite cerrata* | | | | | | | | | 1 | | | |
| Polydora sp. | | | | 1 | 1 | | | | 1 | | | 1 |
| lumbrinereid sp. | | | | 1 | | | 1 | 1 | 1 | | | |
| Paranaitis sp. | | | | 1 | 4 | | | | 3 | | | |
| syllid sp. | | | | | 1 | | | 1 | | | | |
| *Notomastus?* | | | | | | | | | | | | |
| *Micropthalmus?* | | | | 1 | 1 | | | | | | | |
| *Polycirrus?* | | | | | | | | | 2 | | | |
| *Scoloplos?* | | | | | | 2 | | 2 | | | | |
| Oligochaeta | | | | | 1 | | | 1 | | | | |
| Nemertines | | | | | | | 2 | 10 | | 1 | | 1 |
| Anthozoa | | | | | | | | | | | | |
| *Edwardsia sipunculoides* | | | | | | | | | 1 | | | |

Table 2-1. (cont'd.)

| SPECIES | STATIONS 1 | 2 | 3 | 4 | 5 | 6 | 7 | Q7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mollusca | | | | | | | | | | | | |
| *Nucula annulata* | | | | | | 13 | | 1 | 1 | 87 | | 95 |
| *Tellina agilis* | 9 | | | 13 | 2 | 24 | 16 | 41 | 2 | | | 4 |
| *Mulinea lateralis* | 3 | 9 | | | 10 | 11 | 1 | | | 2 | | 13 |
| *Yoldia limatula* | | | | | | 2 | 1 | | 1 | 11 | | 3 |
| *Pitar morrhuana* | | | | 3 | | | 1 | | | | | 4 |
| *Mercenaria mercenaria* | | | | 1 | 7 | 7 | 1 | 3 | 3 | | | |
| *Mya arenaria* | | | | | | | | | | | | |
| *Pandora gouldiaria* | | | | 2 | | 2 | 1 | 11 | 1 | | | |
| *Lyonsia hyalina* | | | | | | | 1 | | | | | |
| *Acteon caniculata* | | | | 15 | | 19 | 10 | 1 | | | | |
| *Acteon punctostriatus* | | | | 5 | | 2 | | | | | | |
| *Nassarius trivittatus* | | 1 | | 22 | 13 | | | | 2 | | | |
| *Crepidula fornicata* | | | | 120 | 86 | 19 | | 14 | 224 | | | |
| *Crepidula plana* | | | | 74 | 95 | 23 | | 6 | 175 | | | |
| *Anomia simplex* | | | | 1 | 2 | 4 | 1 | 10 | 12 | | | |
| Crustacea | | | | | | | | | | | | |
| *Ampelisca vadorum/abdita* | | | | 52 | 364 | 488 | 4 | 7 | | | 46 | 108 |
| *Ampelisca verrilli* | | | | 1 | 2 | 8 | 1 | 3 | | | | 1 |
| *Unciola irrorata* | | | | | | | 3 | 3 | | | | |
| *Batea catharinesis* | | | | 1 | | 3 | | | | | | |
| *Upogebia affinis* | | | | 1 | | | | | | | | |
| *Microdeutopus gryllotalpa* | | | | 1 | 10 | 2 | | | | | | |
| *Elasmopus levis* | | | | | | 2 | | | | | | |
| *Paraphoxus spinosus* | | | | | | | | 1 | | | | |
| *Corophium* spp. | | | | | 12 | 1 | | 2 | | | | |
| *Rhithropanopeus harrisi* | | | | 4 | 4 | 2 | | 1 | 5 | | | |
| *Pagurus longicarpus* | | | | 1 | | | | 1 | | | | |

Table 2-2

Davisville Benthic Survey- number of individuals recovered from 0.018 $m^2$ grab samples (May 6, 1980).

| | A (pilings) | | | B (wall) | | | | C (rocks) | | | D (bulkhead) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 2 | 3 | 4 | 1 | 2 |
| Polychaeta | | | | | | | | | | | | |
| Glycera americana | | 1 | 3 | | | | 1 | | 4 | 3 | | 1 |
| Mediomastus ambyseta | | | 4 | | | 1 | 7 | | | | 1 | 15 |
| Capitella capitata | 13 | 2 | 25 | | | 15 | 10 | | 1 | | | 3 |
| Notomastus luridus | | | | | | | | | | | | 1 |
| Goniadella gracillis | 1 | | | | | | | | | | | |
| Clymenella torquata | 1 | 2 | | | | | | | | 4 | | 2 |
| Spiochaetopterus oculatus | | | | | | 2 | 2 | | | 2 | | 2 |
| Tharyx sp. | 1 | | 1 | | | 2 | | | | | 2 | 7 |
| Scoloplos robustus | 16 | 9 | 10 | | | 15 | 4 | 7 | 4 | 3 | 15 | 27 |
| Streblospio benedicti | 1 | 3 | | | | 3 | 3 | 4 | 4 | 1 | | |
| Polydora ligni | | | 9 | | | | 3 | | | 2 | | 1 |
| Spio setosa | 10 | | 82 | | | 14 | 19 | | 18 | 26 | 15 | 37 |
| Pygospio sp. | 7 | 1 | 3 | | | | 13 | | 9 | 63 | | 1 |
| Dispio sp. | 4 | 5 | 2 | | | 2 | 7 | 1 | 1 | 2 | 1 | 3 |
| Nereis arenaceodonta | 1 | 2 | 2 | | | | | | | | | |
| Podarke obscura | | 1 | | | | | | | | | | |
| Eteone heteropoda | 6 | | 6 | | | 1 | 9 | | | 4 | | 1 |
| Eteone longa | | | | | | | 1 | | | 3 | | |
| Drilonereis tenuis | | | | | | | 1 | | | 5 | | |
| Diopatra cuprea | | | | | | | 1 | | | 1 | | |
| Parapionosyllis longicerrata | | | | | | | | | | | | 8 |
| Syllis #1 | 1 | | 1 | | | | | | | 1 | | |
| Exogene | | 1 | | | | | | | | 1 | | |
| Oligocheate I | | 11 | 10 | | | 14 | | | 3 | 6 | 1 | 3 |
| II | 1 | | 25 | | | | 2 | | | | | |
| III | | | 1 | | | | | | | | | |
| Nemertines | 1 | | 2 | | | 1 | | | 1 | 1 | 1 | 1 |

Table 2-2 (cont'd.)

| | A (pilings) | | | B (wall) | | | | C (rocks) | | | D (bulkhead) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 2 | 3 | 4 | 1 | 2 |
| Mollusca | | | | | | | | | | | | |
| *Nucula annulata* | | | | | | | 1 | | | | | |
| *Tellina agilis* | 4 | 1 | 20 | | | 1 | 6 | 1 | 2 | 10 | 2 | 2 |
| *Gemma gemma* | 357 | 87 | 2369 | | | 2 | | | 6 | 6 | 8 | 13 |
| *Mercenaria mercenaria* | | | | | | 1 | | | | | | 1 |
| *Crepidula fornicata* | | 1 | | | | | | | 1 | | | |
| *Acteon caniculata* | | 2 | 17 | | | | | | 1 | 2 | | 2 |
| *Mysella* sp.? | | 1 | | | | | | | | | | |
| Crustacea | | | | | | | | | | | | |
| *Ampelisca verrilli* | | | | | | | | | | 14 | | |
| *Ovalipes ocellatus* | | | | | | | | | | | 1 | |
| Number of Species | 16 | 16 | 19 | | | 14 | 17 | 4 | 13 | 21 | 10 | 20 |

worms (Scoloplos robustus) and Spio setosa. In the deeper beach samples on the edge of the platform (C-4) the tubes of the large amphipod, Ampelisca verrilli, were evident. Capitella capitata, a polychaete sometimes identified as a pollution or stress indicator was present in this area. Only 2 hardclam juveniles and no softshell clams were found (Table 2-2).

The mid-depth samples contained from 21 to 31 species and 91 to 664 individuals per sample. Dominant species included the bivalve, Tellina agillis; the gastropods, Crepidula fornicata, and C. plana; the tube-dwelling amphipod crustacean, Ampelisca vadorum; and the polychaete Glycera americana (bloodworm). The bivalve, Nucula annulata was found in the deeper, more silty samples. Hard clam juveniles were found in all mid-depth samples.

Discussion of Field Data. The species present in the mid-depth samples were similar to those found in 1976. The numbers of individuals and species per sample was also similar as shown below for matched samples.

| | 1976 | | | 1980 | | |
|---|---|---|---|---|---|---|
| Location & depth | sta. | inds. | species | sta. | inds. | species |
| Fry Cove 10' | 15 | 609 | 37 | 6 | 664 | 31 |
| Fry Cove 10' | -- | -- | -- | 5 | 647 | 25 |
| Fry Cove 8' | -- | -- | -- | 4 | 333 | 25 |
| Fry Cove 12' | 14 | 289 | 19 | 7 | 91 | 21 |
| Fry Cove 15' | -- | -- | -- | 11 | 261 | 17 |
| Fry Cove 15', 18' | 13 | 333 | 26 | 8 | 510 | 28 |
| North of piers | 10 | 473 | 32 | | | |

Samples can also be compared in terms of the relative importance of each species within the samples by calculating a percent similarity index. This is calculated by summing the smaller percent abundance in which each species is found in the pair. Duplicate samples often show a 70 percent similarity (Sanders, 1960). Duplicate samples 7 and 7Q had a 59 percent similarity.

Samples from a given bottom type often show a 30 to 40 percent similarity. The values for three sample pairs taken in 1976 and 1980 fall within this range.

| Location | Station 1976 | Station 1980 | % similarity |
|---|---|---|---|
| mid-depth | 15 | 5 | 31.5 |
| mid-depth | 14 | 7 | 38.8 |
| dredged channel | 12 | 9 | 31.3 |

All of preceeding comparisons indicate that the mid-depth areas have populations of bottom animals which are stable over seasons and years. This stability may be the result of the presence of many bivalve and polychaete species which live a year or more, the presence of adequate oxygen throughout the year, and moderate wave effects. Heavy colonization by amphipods of the species Ampelisca could occur at these depths as at the 1976 stations off Allen Harbor. This would change relative abundances but not species makeup.

Any large change in the makeup of species or species numbers caused by dredging could probably be detected in the mid-water areas. One problem which exists is the unknown effects of the extensive hard clam fishery now taking place there. It is likely that soft bodied tube dwelling polychaetes will be at a disadvantage and that fast growing "opportunistic" species such as the "coot clam" Mulinea lateralis will increase. Removal of competitors and disturbance of the bottom may also increase setting of hard clams.

The most significant finding of the survey was the large decrease of individuals and species in the deep areas. This is illustrated by data from matching stations.

| Location | 1976 sta. | 1976 inds. | 1976 species | 1980 sta. | 1980 inds. | 1980 species |
|---|---|---|---|---|---|---|
| Fry Cove channel | 16 | 420 | 23 | 10 | 50 | 3 |
| Dredged channel | 12 | 411 | 32 | 9 | 110 | 5 |
| Dredged channel | 17 | 460 | 27 | -- | -- | -- |
| Turning basin | 11 | 199 | 22 | 1 | 16 | 3 |
| Turning basin | -- | | | 2 | 10 | 2 |
| Turning basin | -- | | | 3 | 1 | 1 |

Additional qualitative samples examined in both years substantiated this pattern.

The species which were abundant in 1976 were the bivales _Nucula annulata_, _Macoma tenta_, and _Mulinia lateralis_ and the polychaetes _Pectinaria gouldii_ and _Spiochaetopterous oculatus_. In 1980 moderate numbers of _N. annulata_ and _A. abdita_ were found at stations 9 and 10 respectively, but only a few individuals were found in the turning basin samples.

The bottom sediments in all deep areas was very incohesive and anoxic below a few millimeters. Although the previously occurring species are all adopted for life in relatively soft sediments, _M. lateralis_ is a suspension feeder and might not be able to feed on excessively soft bottom while the polychaetes occupy tubes and require some sediment stability.

The _M. tenta_ population observed in 1976 probably consisted of animals which had set and grown during the summer. This species may not in fact be adapted for year round survival in very soft sediments.

The absence of attached shell pairs, "clappers", of the bivalves indicated that these had not been recent mortalities. It is possible that the animals in these areas were killed during a period of low oxygen levels in a previous summer. The absence of animal activity would allow the sediment to remain anoxic below the surface throughout the year.

An alternative explanation for bivalve reduction in Fry Cove channel is the feeding of very large flocks of diving ducks during the winter. Scaup species are abundant in the cove. They have a diverse diet which varies with the availability of food species. In a Long Island Sound study Cronan (1957) found that important animal food of scaups included the nut clam, N. annulata; the coot clam M. lateralis; the barrel bubble, Retusa canaliculata; and the blue mussel, Mytilus edulis. All these species are present in Fry Cove. The small size and thin shell of M. tenera would also make it a likely duck food. Scoters, which are usually found on the open coast, sometimes enter the Bay where they feed on mollusks including juvenile hard clams (Cronan and Halla, 1968). Whether or not ducks are responsible for the improverishment of the Fry Cove channel, they must have effects on bottom animals throughout the cove.

The beach area was first sampled quantitatively in 1980. These samples show some overlap in species makeup with the mid-depth samples but all of the dominant species are restricted to shallow stations and are known to be characteristic of protected beach environments. The very dense population of the small gem clam, Gemma gemma, at one station may have resulted from concentration by waves and currents similar to that which was observed in Charlestown Pond (Phelps, 1964). On Dogpatch Beach softshell clams are restricted to a cove south of the Navy bulkhead and patches around boulders. Apparently wave action and sand movement prevent establishment on the open sand platform.

The shallow, sandy platform, mid-depth area, and deep channel will be affected differently by proposed development and respond to the changes in different ways. The shallow sandy platform off Dogpatch Beach has a relatively high density of infaunal species, including some which are eaten by winter flounder and wading birds. Wave action prevents development of clam beds here. This area would be eliminated by bulkheading and filling in Fry Cove. Shallow bottom adjacent to developed areas will be subject to mechanical disturbance and turbidity during construction, but wave action will return the topography and grain size to that existing previously.

The mid-depth area (much of it 10 feet deep) had the largest number of species and individuals. The species present and their densities remained similar between the 1976 and 1980 sampling periods. Abundant crustaceans and small bivalves provide potential sources of food for winter flounder, and other fish and diving ducks. Significant populations of hard clams are found at these depths both north and south of the Davisville Pier. Portions of this area would be permanently lost by dredging. Mid-depth areas adjacent to a dredged channel would be subject to burial by slumping and sedimentation, to turbidity during construction, and to changes in sediment grain size and water quality following construction.

The deep areas (20-30 feet) with soft, organic bottoms have the lowest value to man in that harvestable bivalves and bottom animals eaten by fish are nearly absent. Infaunal populations were much lower in these areas in 1980 than in 1976. Deep areas will receive fine grained sedimentation from dredging activities. Newly dredged channels will fill with soft sediments and develop benthic populations similar to those found in the present dredged areas.

## 2.3 Fisheries Resources

Shellfish and finfish are abundant in the waters off Quonset/Davisville. The area supports both commercial and recreational fisheries: soft shelled clams, quahogs, flounder, scup, striped bass, bluefish, menhaden, lobster, conch and baitfish. North of the Davisville piers, the water is classified SA and shellfishing is permitted. Calf Pasture Point is an important quahoging ground. South of the Davisville piers in Fry Cove commercial quahogging has been active since the area was opened by the Department of Environmental Management in July 1980.

Data from routine Department of Natural Resources fish trawls northwest of the Davisville piers show that commercially important finfish species are present. Several part-time draggers from Newport and Wickford catch winter flounder, scup, fluke, butterfish, and baitfish in the area. Menhaden frequently school in waters adjacent to Quonset (Ganz, 1975). Sportfishing is extremely popular in the West Passage. Sisson (1970) reports that Wickford based sportsfishermen spend an average of 44.6 days a year fishing for bluefish, striped bass, flounder, tautaug, scup, mackerel, and fluke, most of which is caught in the Quonset/Davisville vicinity.

The fisheries resources of Davisville area were inventoried by the R.I. DNR, Division of Fish and Wildlife (Ganz and Sisson, 1977; summarized in CRC, 1977). They mapped concentrations of softshell clams in the low intertidal immediately south of the Navy Bulkhead and among rocks halfway down Dogpatch Beach. Maximum density in these patches were similar to locations in Allen Harbor ( $42/m^2$). These areas have been used by recreational diggers since opening of the fishery in July 1980. The shore between Allen Harbor and Davisville Pier 2 had low densities of softshell clams (mean: $1.35/m^2$, n=17) despite seemingly suitable conditions.

Hard clams are abundant in Fry Cove at subtidal depths. In the previous CRC report (1977) all the cove was shown as having abundant clams but this was based on only a few bullrake hauls. Since the cove has been opened it has been heavily fished by commercial quahogers. As many as 30 or 40 boats have been seen in the cove at one time during periods when preferred upper Bay areas have been closed. According to personnel of the RIDEM Enforcement Division, bullrakers have been concentrated off the Navy "wooden" bulkhead and the airport "steel" bulkhead. A high proportion of more valuable smaller clams (Mercenaria mercenaria) were reported off the steel bulkhead. Tongers working in shallower areas along the beach appeared to be recovering a higher proportion of larger clams. A few oysters are found on the rocks along Dogpatch Beach. They are most abundant where the Fry Pond culvert empties but are limited by availability of hard substrate and sand movement. At this location harvestable individuals were 90-110 mm in length and most had smooth eroded shells from the action of sand. About 15 percent had patches of sand within the inner shell resulting from sand being forced in by waves and covered by new shell. Near the bulkhead shells were heavily rust stained but the tissue appeared normal. The long double culvert to Fry Pond may be a source of oyster larvae. Fry Pond itself has little hard substrate for oysters.

## 2.4 Effects of Development on Organisms

A long list of "potential" effects of development could be prepared. It is believed that only removal, burial, and exposure to suspended sediments will measurably effect biota during construction. Pollutants are not present in the glacial outwashed sediments which make up most of the volume to be dredged, and moderate pollutant levels in the sediments flooring the present dredged channels are not readily available to organisms. Deepening will change a number of sediment and water variables and will permanently change the makeup of the bottom community in the dredged area.

Burial. The fauna transported to bulkheaded disposal areas and the fauna within the bulkhead will be killed by deep burial and drying. Fauna around the dredging effluent and adjacent to unstable slopes may be subject to shallow burial.

Maurer et al. (1978) reviewed the literature on the ability of fauna to recover from burial and report the results of their own experiments with estuarine species. They concluded that "many of the species tested ... showed a surprising ability to vertically migrate and survive remarkably well in relatively thick depths of native and exotic sediments under laboratory conditions."

The results of short-term burial experiments with characteristic estuarine species are summarized below. For each taxonomic group larger species are given first.

### Bivalves

*Mercenaria mercenaria* (hard clam, juveniles, 1.5-2 cm) recover from 32 cm of sand at summer temp. Less recovery in silt/clay in summer, but no difference due to sediment type in winter (Maurer et al., 1978).

Mya arenaria (soft shell clam) recover from 10 cm sand in 2-10 hours. (Glude, 1954).

Nucula proxima (nut clam 1 cm) 90 percent and 32 percent reach the surface in 8 cm and 16 cm of silt/clay in one day (Maurer et al., 1978).

Gemma gemma (gem clam 0.8 cm) recovers from 23 cm sand, 5.7 cm silt (Shulenberger, 1970).

Polychaetes

Diopatra cuprea (tube dweller, 10 cm) recovers from 30 cm of sand (Myers, 1972).

Nereis succinea (burrower, 8 cm) rapidly recovers from up to 85 cm Maurer et al., 1978).

Nephtys incisa (burrower, 6 cm) rapidly recovers from at least 21 cm silt/clay (Saila et al., 1972).

Scoloplos sp. (tube dweller, 4 cm) recovers in up to 30 cm of sand but have low recovery in 8 cm silt/clay (Maurer et al., 1978).

Streblospio benedicti (tube dweller, 1 cm) can recover from up to 6 cm silt/clay (Saila et al, 1972).

Crustaceans

Crangon sp. (shrimp) swims through and above sediment slurry (Peddicord et al., 1975).

Neopanope sayi (xanthid crab, 2.3 cm) moves upward through unconsolidated sediment but become trapped if migration is delayed (Maurer, et al. 1978).

In summary recovery from burial is greater in larger species. Polychaetes seem to be particularly well adopted for recovery while some crustacea may become trapped by moderate burial. Species adapted for either silt/clay or sand have difficulty moving through the other sediment type.

These results indicate that most motile benthic species in the Davisville area will attain the surface after burial at the rate of a few cm a day such as might occur from effluent release. Attached species would be affected by shallow burial, but these are restricted to intertidal rocks and bulkhead and a few subtidal boulders. In the intertidal areas wave motion will tend to prevent permanent deposition of fine sediment.

Burial by sediment slumps and flows at the construction site to a depth of 1-50 cm would kill some small species but some larger worms and bivalves including hard and softshell clams would reach the surface.

Suspended Sediment. Suspended sediment could potentially cause mortality by clogging the gills of aquatic animals, it could also reduce the efficiency of filter feeding, and cause avoidance by swimming fish. The following table summarizes the results of laboratory exposure experiments with species and genera present in the Davisville area. In general very high sediment concentrations are necessary to cause mortality, even in static tests which introduce additional stress. The larvae and juveniles of open water fish were much more sensitive than adults of species occupying shallow channels. The Bay scallop was the most sensitive of the commercially important bivalves tested (Table 2-4).

Pumping rates of bivalves and ingestion rates of planktonic copepods are reduced by suspended sediment concentrations of around 100 ug/l. Recovery of adults will take place when turbidity is reduced, but larvae may have decreased survival and settling success if growth is retarded.

Table 2-3. Response of marine fauna to suspended sediment.

Bioassays

Sherk et al. (1973) 24 hr. static test, percent survival

| | |
|---|---|
| 1. *Fundulus majalis* (striped killifish) | 90% in 47,000 mg/l silt |
| 2. *Fundulus heteroclitus* (mummichog) | 90% in 24,470 mg/l silt |
| 3. *Tautogolabrus adspersus* (cunner) | 90% in 10,000 mg/l fullers earth |
| 4. *Morone americana* (white perch larvae) | 50% in 3,750 mg/l natural sediment |
| 5. *Morone saxatilis* (striped bass larvae) | 50% in 4,850 mg/l natural sediment |
| 6. *Menidia menidia* (Atl. silversides) | 90% in 580 mg/l fullers earth |
| 7. *Pomatomus saltatrix* (bluefish juv.) | 90% in 800 mg/l fullers earth |

Peddicord and McFarland (1978) 21 day flowing water test, percent survival.

| | |
|---|---|
| 1. *Mytilus edulis* (blue mussel) | 80% in 15,500 mg/l clean silt |
| 2. *Crangon nigricauda* (shrimp) | 85% in 19,700 mg/l clean silt |
| 3. *Cancer magister* (Dungeness crab) | 62% in 9,200 mg/l contaminated sand/silt (mortality during molting) |

Raytheon Co. (1974) 96 hour static test, no mortality observed at the given concentrations of fine fraction of natural sediments.

| | |
|---|---|
| 1. *Mercenaria mercenaria* (quahog) | 83,200 mg/l |
| 2. *Mercenaria mercenaria* larvae | 10,200 mg/l |
| 3. *Mya arenaria* (soft shell clam) | 83,200 mg/l |
| 4. *Crassostrea virginica* (oyster) | 83,200 mg/l |
| 5. *Crassostrea virginica* larvae | 9,600 mg/l |

Table 2-3. (cont'd.)

| | |
|---|---|
| 6. Pecten irradians (bay scallop) | 500 (50% survival at 96 hrs. 1,760 mg/l) |
| 7. Pecten irradians larvae | 10,000 mg/l |
| 8. Homarus americanus (lobster) | 20,400 mg/l |
| 9. Pseudopleuronectes americanus (winter flounder) | 20,000 mg/l |

Sublethal Effects

Davis (1960) and Davis and Hindu (1969) growth and survival of clam and oyster eggs and larvae reduced at 125 mg/l suspended matter.

Loosanoff (1961) pumping rate of oyster reduced at 100 mg/l suspended matter.

Sherk et al. (1976) reduction in ingestion rates of algae by estuarine copepods.

| | |
|---|---|
| 1. Eurytemora affinis | 55% in 250 mg/l silt but stimulated at 100 mg/l |
| 2. Acartia tonsa | 50% in 100 mg/l silt |

# 3 SUSPENDED SEDIMENTS

## 3.1 Introduction

Hydraulic dredging will be used to transport sediments from the channels to bulkhead and stockpile areas. Available equipment produces a slurry with about 13% solids. Without confinement much of the fine grained fraction would return to the estuary in runoff. Containment within dikes with long retention times and with shallow "skimming" type outlet weirs will provide retention of all but clay size particles. The degree of attention placed on control of suspended sediments will depend on the grain size and pollutant level of the dredged material and on the sensitivity of the aquatic environment in the effluent area.

Suspended sediments are usually a source of concern where hydraulic dredging is being carried out. While this is to some extent the result of the visability of turbid water plumes, there are many ways in which suspended sediments would potentially effect marine life. Natural turbidity levels and patterns of resuspension must be known in order to project the impact of dredging on the environment and to determine whether dredge-produced turbidity will be detectable. During this project field data on water clarity was obtained on three occasions. These data are compared with the results of other studies in Narragansett Bay. Research on the effects of suspended sediment on estuarine fauna and the effect of burial by water deposited sediment on fauna are summarized in the previous section.

## 3.2 Field Collections

On March 4, May 28, and June 24, 1980 water clarity was measured at 10 stations along three transects extending approximately one mile from Fry Pond outlet, Davisville Pier 1, and Allen Harbor entrance (Fig. 3-1). The

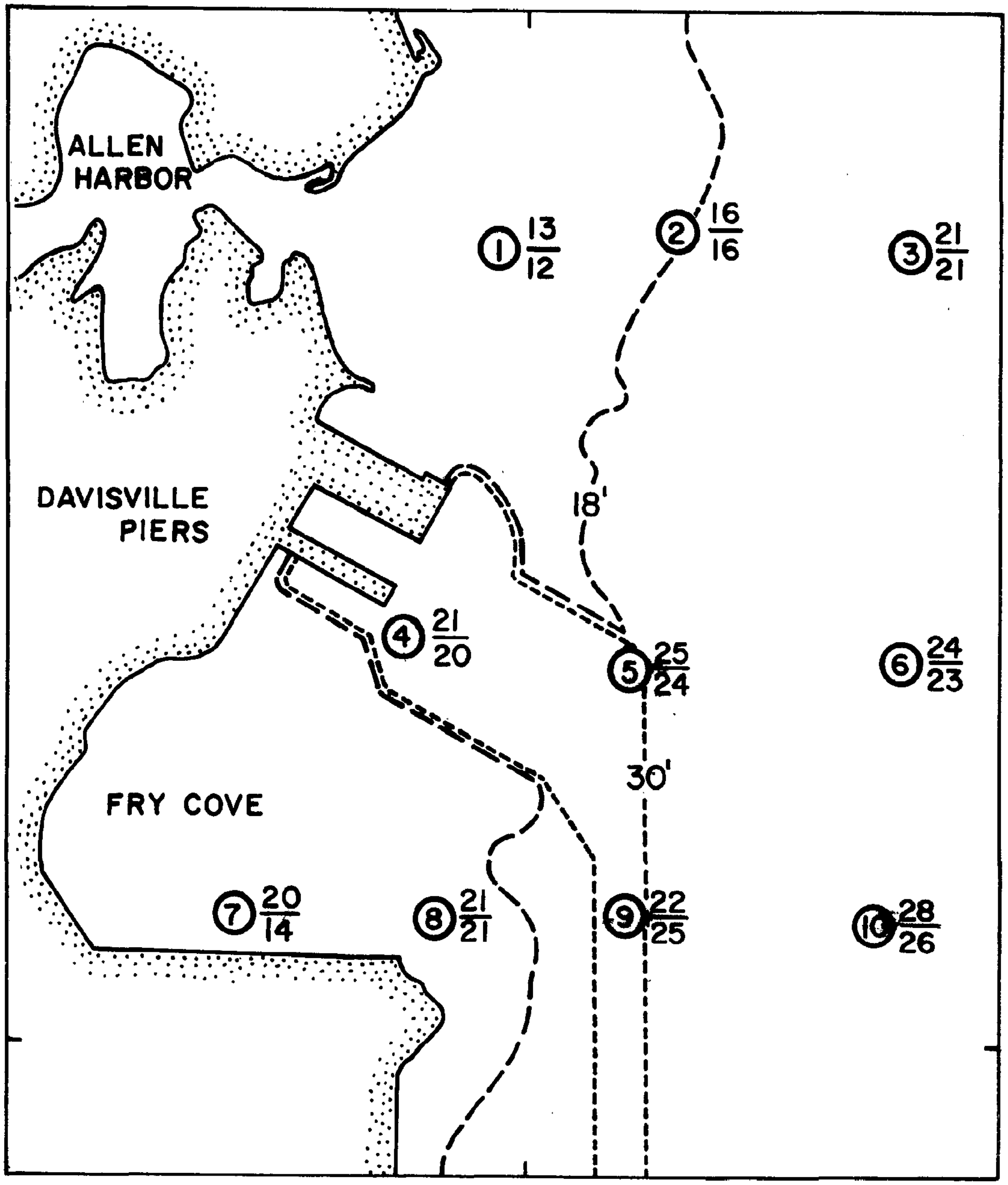


Figure 3-1. Location of turbidity stations (circled numbers) and surface/bottom values of percent light transmission per meter obtained March 5, 1980.

instrument used was a Martek XMS transmissometer with a one meter path length and white light. Depth and temperature sensors were attached to the transmissometer. Percent transmission versus depth and temperature versus depth were recorded on a portable X-Y recorder during lowering and raising of the instrument package. On May 28 surface and subsurface water samples were taken through a tube attached to the transmissometer into an evacuated flask. Particles were collected on 8 μm nucleopore and 0.45 μm millipore filters for microscopic examination.

Results

Winter conditions were found on the March 5 sampling trip. Water temperatures were between 0°C and 1°C and except for a small near-bottom temperature inversion at some stations ( 0.25°C), there was no vertical stratification. At the surface the clearest water was found offshore and down-bay. The most turbid water occurred on the shallow shelf off Calf Pasture Point (Fig. 3-1). Turbidity was vertically homogeneous except at station 3 and 9 where there was a clear water layer near the bottom and at station 7 in Fry channel where the bottom layer was turbid. Light transmission was generally high for Narragansett Bay (13-28%/m) and indicated a low level of phytoplankton and the absence of recent storms.

On the May 28 sampling date a strong thermocline occurred at a depth of 10-15 feet (Fig.3-2). At most stations there was a marked increase in turbidity at the thermocline from surface values of 10-15%/m to 0-2% in deeper layers (Fig. 3-3, Table 3-1). At station 7 in Fry Cove channel transmission/m decreased regularly with depth from surface to bottom. At station 9 in the dredged channel surface water was more turbid than water immediately over the thermocline. Surface and bottom turbidities were similar throughout the study area except in shallow water off Calf Pasture Point where turbidity increased.

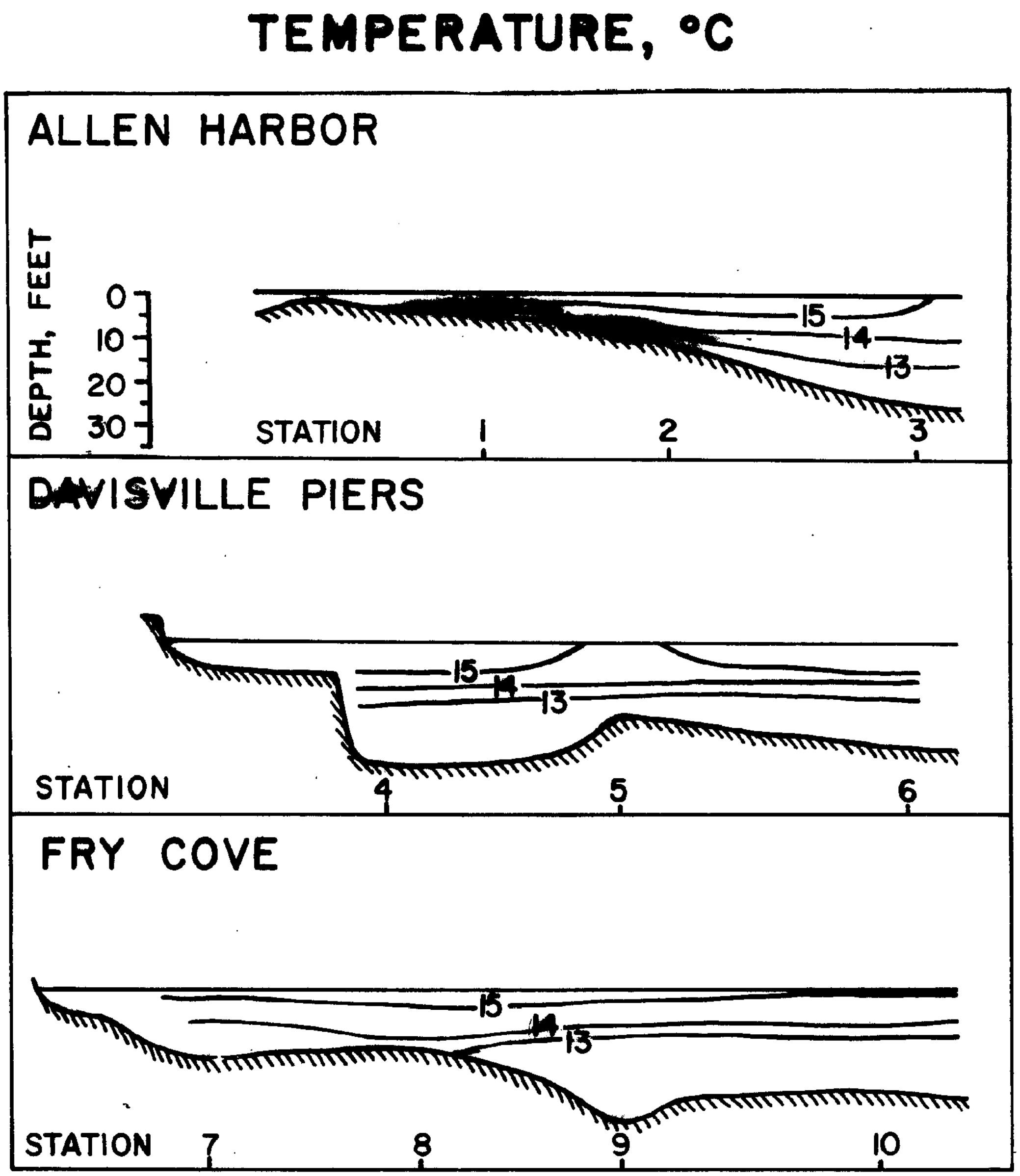


Figure 3-2. Temperature sections, May 28, 1980. 11:20-12:30, Low tide 12:53 DST.

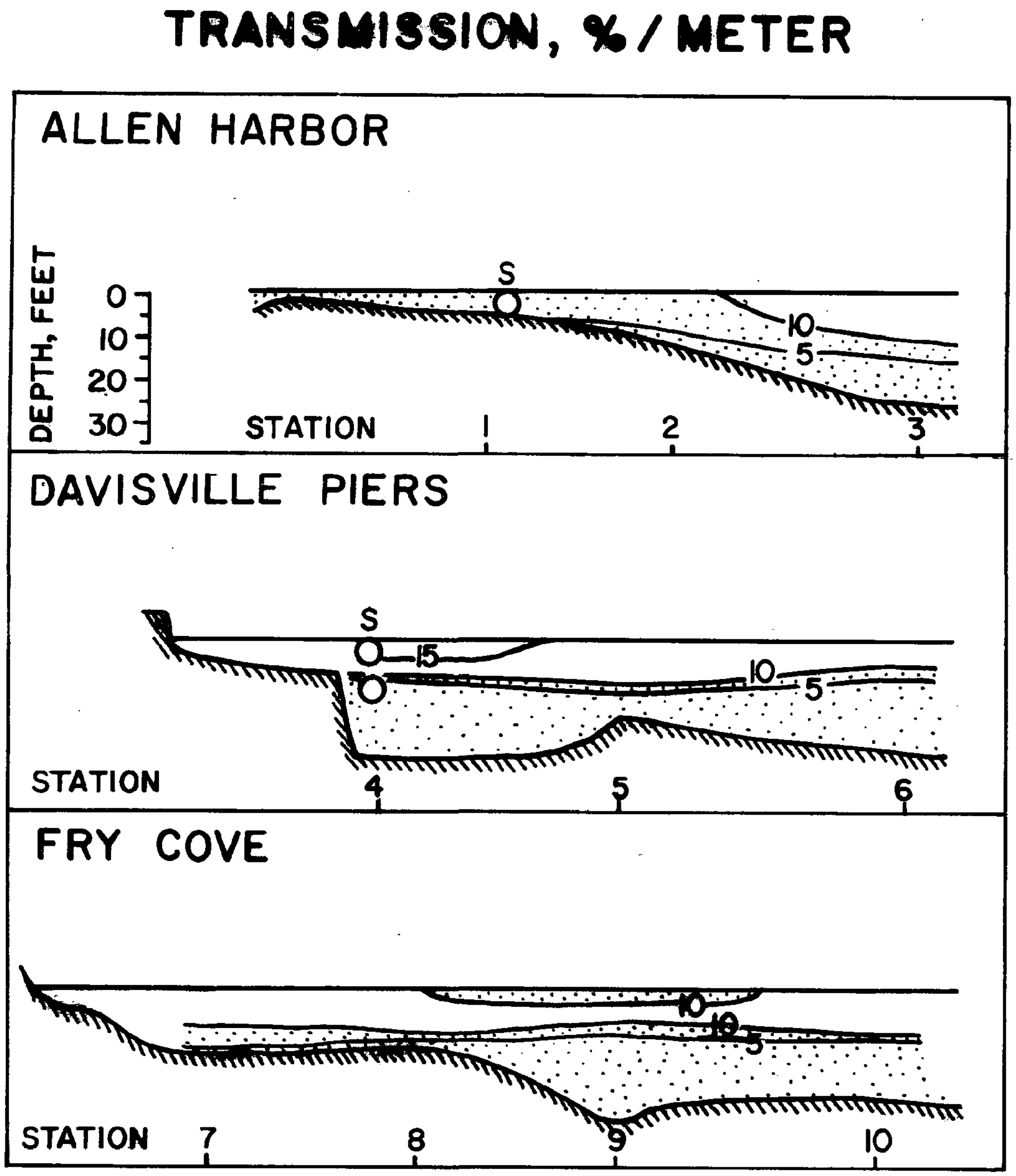


Figure 3-3. Turbidity sections, May 28, 1980. 11:20-12:30, Low Tide 12:53 DST. Wind 5-10 knots NW "S" indicates water sampling station. Stippling indicates relatively turbid water.

Table 3-1 Transmission (%/m) and temperature (°C) of surface and bottom water in the Davisville area.

| Station | Depth (Ft.) | MARCH 5 | | | | MAY 28 | | | | JUNE 24 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Trans | | Temp | | Trans | | Temp | | Trans | | Temp | |
| | | Surf | Bot | Surf | Bot | Surf | Bot | Surf | Bot | Surf | Bot | Surf | Bot |
| 1 Off Allen H. | 6 | 13 | 12 | 0.5 | 0.5 | 6 | 3 | 16 | 13.4 | | | | |
| 2 | 18 | 16 | 16 | 0.5 | 0.8 | 8 | 0.5 | 15.1 | 12.6 | | | | |
| 3 | 27 | 21 | 21 | 0.7 | 1.0 | 11.5 | 1.5 | 14.7 | 12.5 | | | | |
| 4 Off DV Dock | 29 | 21 | 20 | 0.5 | 0.5 | 15.5 | 0 | 15.5 | 12.2 | 9 | 0 | 19.8 | 16.5 |
| 5 | 29 | 25 | 24 | 0.2 | 0.5 | 14 | 2 | 14.9 | 12.5 | | | | |
| 6 | 25 | 24 | 23 | 0.2 | 0.5 | 15 | 1 | 15.2 | 12.7 | | | | |
| 7 Fry Cove | 20 | 20 | 14 | 0.5 | 0.5 | 13 | 0 | 15.3 | 12.2 | 9 | 0 | 19.3 | 18.2 |
| 8 | 10 | 21 | 21 | 0.5 | 0.5 | 10 | 0 | 15.7 | 13.0 | | | | |
| 9 | 30 | 22 | 25 | 0.0 | 0.0 | 8.5 | 1.5 | 15.2 | 12.5 | | | | |
| 10 | 25 | 28 | 26 | 0.0 | 0.0 | 14 | 1 | 15.1 | 12.6 | | | | |

Water sampled at station 4 showed an abundance of organic detritus and copepod fecal pellets in the turbid deep layer.

Two profiles were made on June 24 in the turning basin and in Fry channel (station 7). Surface warming had continued and the thermocline was thicker and deeper than in May. The turbidity pattern was very different from that found in May (Fig. 3-4). The surface was turbid, almost certainly from high concentrations of phytoplankton. Within the thermocline the water was relatively clear, but turbidity increased rapidly in a thermally homogeneous bottom layer.

## 3.3 Discussion

Seasonal and spatial pattern. At the study site the water was clearest in March despite the frequency of winter storms. The surface values of 13-28% transmission/m compares well with values of 17-22% recorded at the Graduate School of Oceanography dock during calm periods in January and February (Pratt and Heavers, 1975). In the GSO dock study, storms reduced transmission to zero, but recovery was complete within 3-4 days. Oviatt and Nixon (1975) measured sedimentation in Narragansett Bay with traps collected at weekly intervals. They concluded that forces responsible for sediment resuspension and deposition operated over shorter time periods. The shortness of episodes of sediment transport suggest that most particles have settling rates faster than clays. Oviatt and Nixon, and Collins (1974) both found that most suspended particles in the Bay were silt size.

In both the May and June records there was a near-bottom layer of turbid water. Since conditions were presumably calmer than in March this layer must form as a result of input of low density detritus from organic production, and stratified conditions leading to concentration in bottom layers. Tidal currents rather than waves keep the particles in suspension.

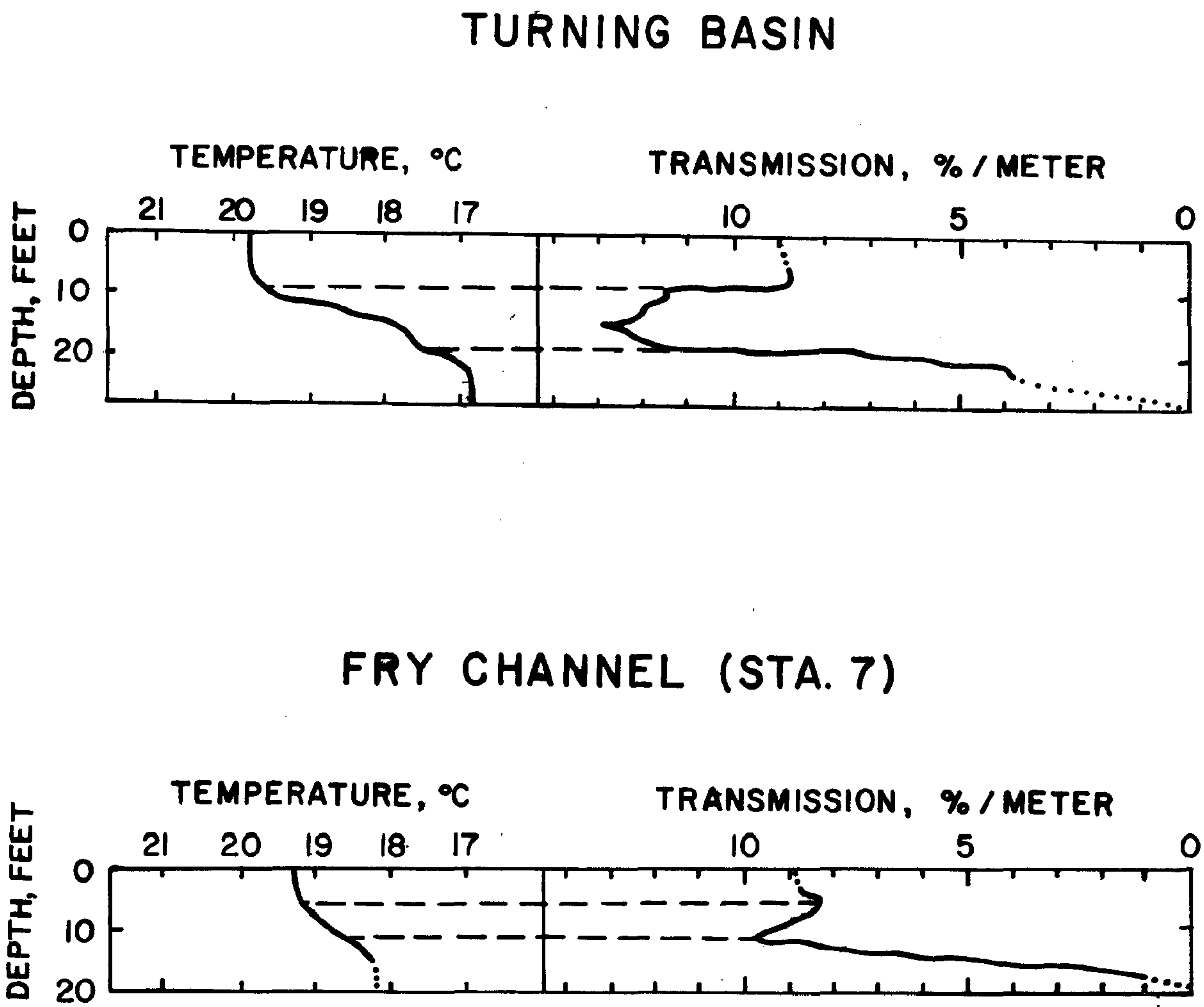


Figure 3-4. Turbidity and temperature profiles at two locations, June 24, 1980. Dashed lines show relationship of temperature and turbidity features.

Particle concentration. Concentration of suspended matter was not measured in this study. It is only possible to convert light transmission values to dry weight concentrations if the makeup of particles does not change. Changing proportions of small particles and organic matter (with large light stopping area relative to weight) complicates the relationship. Measurements in Narragansett Bay and Rhode Island Sound by Pratt and Heavers (1975) suggest the following approximate transmission-concentration conversions: 20%/m=1-2 mg/l; 10%/m = 3.5 mg/l; 5%/m=4.5 mg/l; and 2%/m=5 mg/l. Concentrations in the Davisville area derived in this way range from 1-5 mg/l. These levels are comparable to Morton's (1972 winter) Baywide mean of 3.7 mg/l and Collins', (1974) Baywide surface and bottom means of 1.1 and 3.2 mg/l. (both authors removed some organic matter from the samples). Turbid bottom water from the upper Bay with less than 1%/m transmission contained 21.6 mg/l of suspended matter (Pratt and Bisagni, 1976).

No transmissometer or suspended particle measurements were made in the study area during storms. Water along Calf Pasture Point becomes visibly turbid when waves from the northeast erode shallow silty sand. It seems likely that concentrations of suspended matter may reach levels typical of an exposed English coast (50 mg/l, Newton and Grey, 1972) or the most turbid parts of Chesapeake Bay (over 100 mg/l, Schubel, 1972). It can be assumed that estuarine animals in the Davisville area are exposed to such high levels of turbidity for periods of a day or two following storms.

Turbidity produced by dredging. Hydraulic cutterhead dredges creates suspended solid levels below "a few hundred mg/l" only in the immediate vicinity of the dredging site according to Peddicord and McFarland (1978). Much more suspended matter is released in the dredge effluent. Palermo et al. (1978) analyse the design, operation, and management of spoil containment areas. They state that a well designed containment area can reduce suspended matter from 145 g/l (13% sediment) to 1-2 g/l in effluent from silt/clay spoil. The rate of release of effluent depends on dredge size, pipeline length, dredging depth, and hours per day of operation. For a medium size cutterhead dredge with 18" outlet pipe roughly 5,000 cubic yards of effluent are produced per hour. If 2000 mg/l of sediment in the effluent remained in suspension it would be necessary to dilute it 43 times with 5 mg/l water to achieve a concentration of 50 mg/l, a "high natural" level. Each hour 44 acres of water 9' deep would be needed for dilution.

The actual concentration of spoil-derived sediments in Bay waters will depend on distance from the discharge, mixing rate, and settling rate of particles. No field observations of water circulation have been made in the Davisville area. The circulation model of the area prepared by Isaji (1977) shows north and south tidal flows entering Fry Cove and the Allen Harbor entrance cove, but at a reduced velocity. Small gyres flowing contrary to tidal flow formed in the southwest corner of Fry Cove. When the model was run with dredged depths similar to development alternative 1, current velocities were further reduced in the deepened area.

Reduced velocities and partially closed circulation would allow suspended sediment to settle within the coves. Containment seems to be best developed in Fry Cove. It appears from the model that during flood tide water and suspended sediment from Fry Cove would enter the main west passage flow and not be carried directly into the Allen Harbor entrance cove.

When hydraulic dredging effluent is discharged into water without containment, a fluid mud may be formed on the bottom with up to 20 g/l sediment. Ponded deposits of this material will kill sessel animals and will not support larger motile species (Peddicord and McFarland, 1978). It is possible that a limited volume of fluid mud could collect in the Fry Cove channel and the dredged channels and basins from either containment area effluent or sediment released by the cutterhead.

In summary it may be concluded that the maximum concentrations of suspended sediments to which organisms will be exposed are 1-2 g/l (1000-2000 mg/l) in the immediate area of the containment area effluent. Suspended sediment levels within the coves would be an order of magnitude higher than background under calm conditions and similar to storm conditions.

Effects of alternative designs. Most of the material which would be dredged in any of the suggested designs would consist of water-deposited glacial sediments containing no organic matter or chemical pollutants. Small volumes of estuarine sediments and recent channel-bottom fillings contain moderate levels of pollutants which tend to remain adsorbed to particles. We are not concerned with toxic pollutants but with the visual quality of the water and the effects of suspended sediment and changes in bottom sediment type on organisms.

It is most likely that effluent will be released into Fry Cove (designs 1,2,3,5,6). There will be a tendency for suspended particles to remain within the cove. Fine material deposited on shallow sandy bottom (less than 10' depth) will be subject to resuspension. It is unlikely that there would be a permanent change in grain size in these areas. Ultimately, fine sediments will be deposited in natural deep areas and dredged channels where they will contribute to the softness of the bottom. Layers of dredge derived material might be identifiable from absence of organic matter. Clay size particles will be transported the greatest distance and may be deposited in silt/clay bottom within the bay or be carried outside the bay. From April to October water density stratification will inhibit upward mixing of sediments in near-bottom water. Locating discharge points near deeper areas might speed the deposition of sediment in natural settling basins and reduce effects on organisms in shallow water. It is unlikely that high concentrations of suspended matter could reach Allen Harbor or Calf Pasture Point beach from Fry Cove.

Release of effluent from a bulkhead north of the Davisville Piers (design 4) would create temporary turbidity in the Allen Harbor entrance cove and off Calf Pasture Point. Some sedimentation within Allen Harbor is likely. Release into the turning basin or newly dredged channel would induce settling in deeper water and also aid dispersion by north-south tidal currents.

# 4. POLLUTION

## 4.1. Introduction

In this section data is given on the pollutants present in the sediment which may be dredged and on the likelihood of pollutant release from sediments during dredging. The levels of pollutants in sediment and fauna of areas adjacent to the proposed dredged area are tabulated as a basis for monitoring future development. The pollutant status within the present dredged channels and developed area is used to project conditions which will be found in future dredged channels.

The Quonset/Davisville environmental assessment (CRC, 1977) directed concern toward the possible effects of a large industrial dump on the environment of Allen Harbor. A number of studies on pollutants and the condition of fauna in the Harbor have been carried out since that report was released. Data from those studies are summarized here as baseline data for monitoring during development outside the Harbor and to guide future management of the Harbor itself.

Pollutant data is presented by subject and then discussed in terms of alternative development plans.

## 4.2. Pollutant Data

Water Quality. The Rhode Island Department of Health conducted a bacteriological survey of the Quonset/Davisville area between August 1975 and November 1976 (RIDH 1976). Surface water samples were taken at 11 stations on 6 dates. Tests were also run on samples from streams flowing into Fry Pond and from the pond outlet in August 1976. A summary of results for stations near Davisville are given in Table 4-1.

Table 4-1. Water quality data for the Davisville area.
(See Figure 4-1 for station locations).

Estuarine areas sampled on six occasions, August 19, 1975, Nov. 30, 1976. Summarized from RIDH, 1976.

| Station | Dissolved Oxygen min mg/l | min % sat. | max mg/l | max % sat. | median mg/l | median % sat. | Fecal Coliform/100 ml min | max | median |
|---|---|---|---|---|---|---|---|---|---|
| 5 off airport | | | | | | | 3- | 3- | 3.5- |
| 6 Fry Cove | 6.4 | 91 | 12.0 | 118 | 8.85 | 100 | 3- | 9 | 3- |
| 7 off D.V. piers | | | | | | | 3- | 9 | 3- |
| 8 off Allen H. | 8.2 | 93 | 11.8 | 116 | 8.7 | 108 | 3- | 9 | 3- |
| 9 Allen Harbor | | | | | | | 3- | 4 | 3- |

Fry Pond areas sampled August 4, 1976, RIDH unpublished data.

| Station | MPN /100 ml total coliform | fecal coliform |
|---|---|---|
| brook to pond, Pond and Newcomb Rd. | 2300 | 90 |
| brook to pond, near bld. 884 | 2300 | 2300 |
| 24" pipe to pond | ≤ 23 | ≤ 23 |
| Fry Pond outlet | 230 | ≤ 23 |

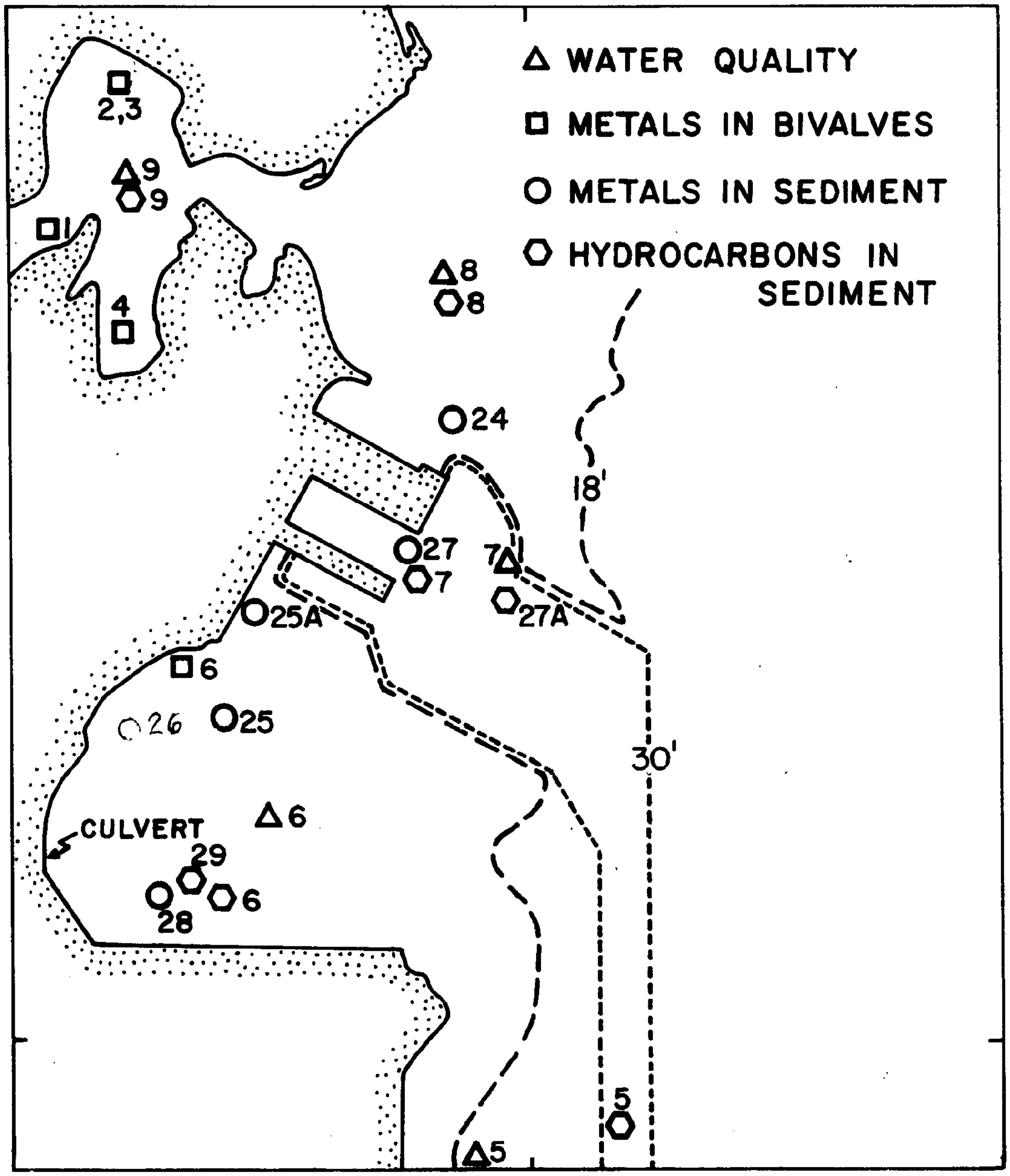


Figure 4-1. Station locations for water and sediment quality samples. Water quality and metals in bivalves (Rhode Island Department of Health) metals in sediment and hydrocarbons in sediment (27A, 27 this study). Hydrocarbons in sediments (5-9. CRC, 1977).

Oxygen concentrations were high on all dates as expected for that portion of the Bay. Concentrations may have been lower in bottom water, however. Olsen and Lee (1979) show July (1972) bottom values of 3-4 mg/l beneath surface water with 6-8 mg/l. During the summer vertical stratification partially isolates bottom water and oyxgen may be consumed by degradation of organic matter in bottom water and on the bottom. Sensitive animals are affected by oxygen levels of less than 2 ml/l.

Fecal coliform bacteria were found in very low concentrations in the Bay and Allen Harbor samples. All samples had most probable numbers of less than 9/100/ml/l. The maximum count for SA waters is 70/100 ml/l. A small stream entering Fry Pond had high coliform levels which were reduced within the Pond.

Fry Cove was closed to shellfishing for a number of years because of possible contamination from houses on the Dogpatch Beach bluff and the presence of berthed vessels at the adjacent piers. Following a conservative policy the RIDH did not open the cove to shellfishing until July 1980, despite the abandonment of the housing in 1974 and negative bacteriological tests in 1977.

Coliform bacteria were uniformly low in hard clams from Narragansett Bay north of Allen Harbor (Mount View, Table 4-5). Levels in both hard clams and soft-shell clams from Allen Harbor in 1976-1977 are clearly higher (Table 4-4). Sources of bacteria at that time may have included buildings in the vicinity of the harbor and in its watershed and vessel discharge. The intestinal bacteria of seabirds also gave positive coliform tests.

Hydrocarbons in Sediments. High sediment hydrocarbon levels in the upper Bay resulting from sewage effluents and oil spills decrease gradually down-Bay. There are additional potential sources in the Davisville area including effluents, spills, and dumping from both land and water based activities. As part of the initial Quonset/Davisville impact study Brown and Franklin (1977) obtained total hydrocarbon levels of 100-641 ug/g dry weight from different environments in the Davisville area (Table 4-2).

Additional hydrocarbon analyses were carried out during this study by the Graduate School of Oceanography Organic Geochemistry Laboratory. The goals of these analyses were to allow comparison with data which the laboratory has obtained from throughout Narragansett Bay and to gain insight into the sources and makeup of materials which will be deposited in the proposed dredged channels.

Duplicate analyses were carried out on a surface sample obtained from the Davisville turning basin, June 1980. Results and preliminary discussion by Quinn, Requejo, and Pruell are given in Appendix 3. A data summary is given in Table 4-2.

The concentration of total hydrocarbons from the turning basin was 934 ug/g dry weight, significantly higher than in fine-grained natural sediments of surrounding areas studied by Hurtt (1978) of 359,356 and 246 ug/g. This is also an order of magnitude higher than levels in intertidal sediments in Allen Harbor sampled in 1980 (Table 4-2). The high total hydrocarbon level in the turning basin probably results from deposition of fine grained organic particles with adsorbed hydrocarbons from both upper Bay and local sources. The presence of benzotriazoles (BTAs) from a source on the Pawtucket River, Warwick demonstrates down-Bay transport.

The eleveted levels of specific aromatic hydrocarbons and total hydrocarbons suggest additional sources in the Davisville area. Sources may include compustion products in used lubricating oils and weathered fuel oil. Identified aromatics were 83 times higher in the turning basin than in Allen Harbor; total hydrocarbons were 12 times higher; and BTAs only 6 times higher.

The classification scheme used in Connecticut allows dredged material with less than 500 ug/g hexane soluble fraction (oil and grease) to be disposed of at sea without protective measures. Total hydrocarbon level equivalent to this is higher than the 934 ug/g found in Davisville sediments. Davisville sediments are "clean" when compared to polluted harbors in New England, but are "dirty" compared to immediately adjacent parts of Narragansett Bay. Since hydrocarbons are strongly adsorbed to particulate matter, a dredging and disposal technique which controls release of sediment would also contain hydrocarbon pollutants.

Baseline data from Allen Harbor is of interest because of the use of the harbor for shellfishing and the potential for pollutant introduction from the former dump on its shores.

Table 4-2. Sediment hydrocarbon concentration in the Davisville area

Brown and Franklin, 1977. replicate subtidal samples, 0-3", October 1976

| | ug/g THC | | % sand, silt, clay (CRC, 1977) | | |
|---|---|---|---|---|---|
| Allen Harbor | 395 | 641 | 3 | 69 | 28 |
| Channel to A.H. | 196 | 100 | | | |
| Davisville Piers | 294 | 311 | 8 | 53 | 39 |
| Fry Cove Channel | 103 | 427 | 8 | 66 | 26 |

Brown et al., 1979. samples from Allen Harbor intertidal flat

ug/g THC

| 4/6/77 | a | b | c | composite |
|---|---|---|---|---|
| 0-3" | 107 | 186* | 65 | 286 |
| 3/6" | 228 | 272 | 101 | |

*Franklin, unpublished.

| 4/77 (from Fig. 2) | |
|---|---|
| 0-3" | 205 |
| 3-6" | 100 |
| 6-9" | 60 |
| 9-12" | |

Appledorn et al, 1979. Allen Harbor flat (ug/g THC)

| | | |
|---|---|---|
| 10/77 | 67 | 101 |

sampled April 1980. All values ug/g dry weight

Quinn and Pruell, unpub. Allen Harbor flat

| | identified aromatics | total aromatics | total hydrocarbons | BTA's | phthalate |
|---|---|---|---|---|---|
| 0-2 cm | 0.117 | 4.7 | 75.2 | 0.124 | 0.114 |
| 18-20 cm | 0.129 | 2.6 | 46.9 | -- | 0.036 |
| 26-28 cm | 0.541 | 9.4 | 50.1 | -- | 1.192 |

Quinn, Requejo and Pruell, unpub. Davisville turning basin, sampled June 1980. All values ug/g dry weight average of duplicate analysis.

| | identified aromatics | total aromatics | total hydrocarbons | BTA's | phthalate |
|---|---|---|---|---|---|
| 0-10 cm | 9.769 | 60.0 | 934 | 0.699 | 1.17 |

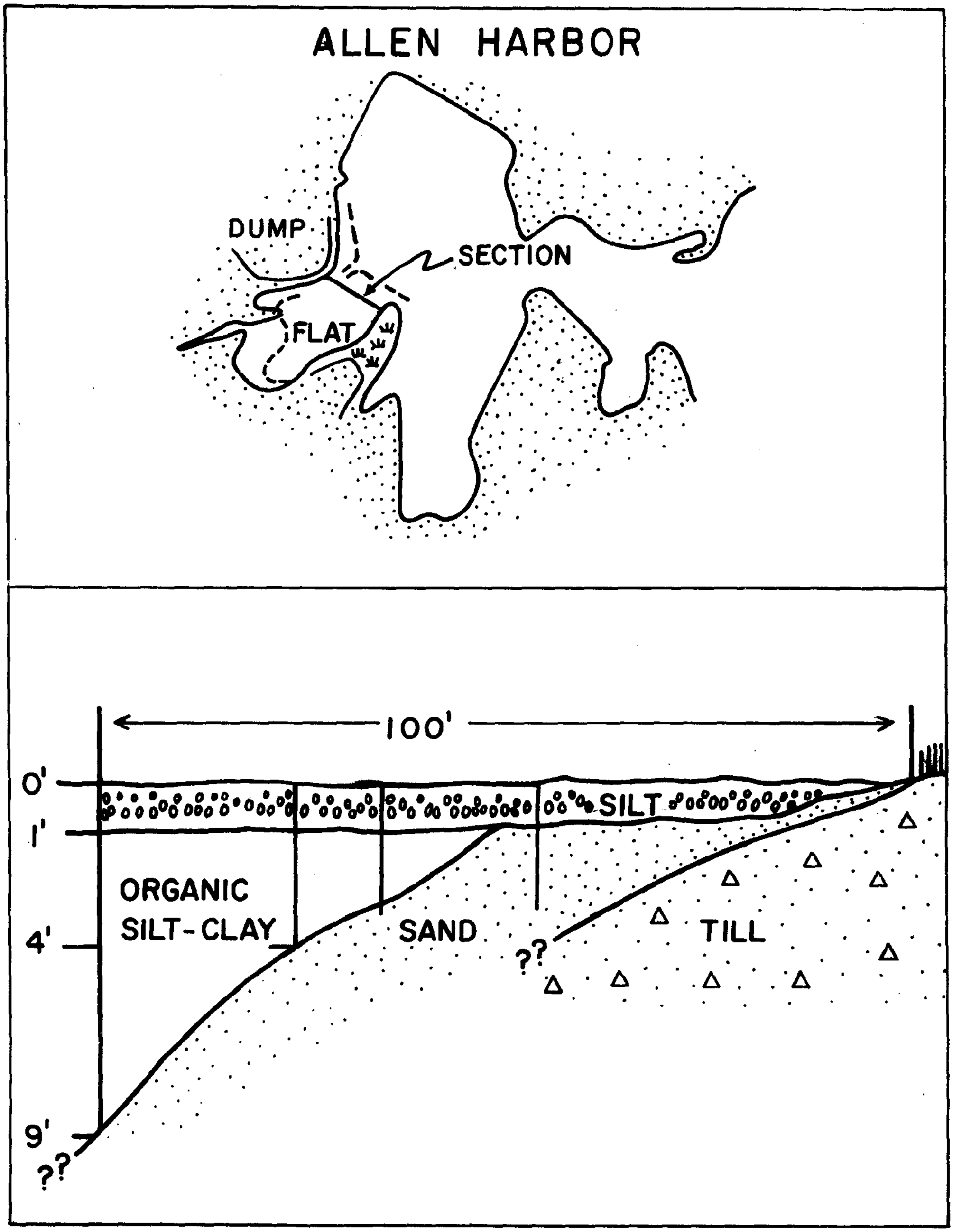


Figure 4-2. Allen Harbor stratigraphy and location of samples, a granular silt layer, thought to be deposited from hydraulic dredging overflow, overlies estuarine silt-clay. Analyses were taken at the top and bottom of the silt layer (0-2 cm, 18-20 cm) and at the top of the silt-clay layer (26-28 cm).

An intertidal flat in Allen Harbor (Figure 4-2) has been studied extensively in conjunction with a study of neoplastic disease in clams. Brown et al. (1979) and Appeldoorn (1979) report total sediment hydrocarbon values ranging from 65-286 ug/g dry weight. Pratt (1977) noted that the flat appeared to be made up of hydraulically dredged sediment overlaying normal subtidal estuarine sediments. As part of this study samples were taken at three depths at two locations on the flat and analysed for hydrocarbons in an attempt to contrast conditions before and after the harbor was used for disposal. Results obtained by Quinn and Pruell are given in Appendix 1 and are summarized in Table 4-2.

Benzotriazoles (BTAs) which have been produced since 1963, were found only in surface sediment. Total hydrocarbons and aromatic fraction of surface sediments were relatively low. The mid level sample was taken in the hydraulic fill, but below the level of animal activity; BTA's were absent, proving a pre-1963 data of deposition. The deepest sample contains total hydrocarbons levels similar to the surface but aromatic hydrocarbons and phthalate are relatively high. Apparently these pollutants had been deposited in the harbor in the early years of development and then buried by dredged material. Pre-development sediments were not sampled.

Brown and Franklin (1977) measured higher levels of phthalates outside Allen Harbor than within it. The removal or burial of sediments over the past 30 years may explain this distribution. The complex pattern of dredging and filling in the Davisville area will make any further understanding of pollutant dynamics difficult to obtain.

Metals in Sediments. There has been concern about metals entering the Davisville area through discharge of plating solutions at Quonset Point and dumping at the Allen Harbor dump. Eisler (1977) found elevated levels of metals around Quonset Point and in deeper areas of adjacent West Passage. It is likely that some metals from this source can be found in the dredged channels at Davisville. Sediment samples from an intertidal area immediately adjacent to the dump at Allen Harbor did not have high metal levels (EPA, Narragansett analysis for CRC, 1977). Metal analyses of clams from Allen Harbor suggest that there is higher than normal copper available in the water column but that other metals are normal. Continued sedimentation, dredging, and spoil deposition in Allen Harbor make interpretation of sediment contamination difficult (see discussion of hydrocarbons in sediments).

The proposed Fry Cove and dredging area consists of a thin layer of reworked sand over sandy sediments deposited during glacial retreat. The layer of estuarine sediment is thicker north of the piers. There is no evidence of release of toxic effluents or dumping toxic solids in either of these areas. It is very likely that these sediments contain high levels of metals. Nevertheless a small program of analyses of metals in sediment has been conducted to provide data for future permitting processes, to demonstrate any enhancement of metal deposition in dredted channels, and to provide background information on this portion of the Bay. Sample locations are shown in Fig. 4-1.

Elutriate tests were carried out on six samples to provide data for future permit applications and to provide baseline information. In these tests sediment is shaken with Bay water and the water tested for released metals. The test gives a more realistic measure of the impact of hydraulic dredging effluent release than bulk sediment analysis does.

For five metals (barium, cadmium, chromium, mercury, and lead) all test concentrations were below the limit of detectability of the analytic method used. These results illustrate the low solubility of most metals in water: chromium in mid-bay sediments is 50-400 ppm (Olsen and Lee, 1979), but was less than 0.2 ppm in the tests; lead in mid-bay sediments is about 100 ppm (Olson and Lee, 1979), but less than 1.6 ppm in the tests.

Copper was detectable in all the elutriate tests. Concentrations ranged from 0.114-0.182 ppm. The absence of a relationship between concentration and sediment type or sample location may indicate an unexplained analytic problem. The EPA pollution standard for copper is 0.005 ppm.

Hydrocarbons in clams. A single value for concentration of hydrocarbons in soft-shell clams in the Davisville area was available at the time of the previous report. Additional values obtained by Brown et al. (1979) and Appledoorn et al. (1980) (Table 4-3) indicate that Allen Harbor levels are higher than those found in a southern Rhode Island barrier beach lagoon (Winnapaug Pond (30 vs 5 ug/g wet weight).

Quinn and Pruell analysed hydrocarbons in softshell clams from the same flat in Allen Harbor as part of this study (Appendix 2). They found levels similar to those previously reported (37.9 and 30.2 ug/g wet weight). These levels can be compared with those of hard clams in the polluted Providence River measured by Boehm and Quinn (42 ug/g).

The pattern of abundance of specific aromatic hydrocarbons in Allen Harbor clams reported by Quinn and Pruell and by the U.S. Public Health Service is similar to that found in the sediments throughout the Bay. The major aromatic hydrocarbons phenanthrene, fluoranthene, and pyrene probably originate from the combustion of coal and petroleum products (Quinn and Pruell, appendix 2 ).

Table 4-3. Hydrocarbon concentration of soft-shell clams (*Mya arenaria*) from Allen Harbor

CRC, 1977. Total hydrocarbons: 59.2 ug/g wet weight

Brown et al., 1979.

Total hydrocarbons of clams transplanted to and from Winnapaug Pond (Table VIII) sampled in October 1977

| | ug/g dry weight | approx. ug/g wet weight |
|---|---|---|
| Win. to Win. | 32 | 4 |
| A.H. to Win. | 60 | 7 |
| Win. to A.H. | 215 | 26 |
| A.H. to A.H. | 271 | 33 |

Appeldoorn et al., 1980

Total hydrocarbons of clams adjacent to transplant experiment.

| | ug/g dry weight | approx. ug/g wet weight |
|---|---|---|
| July | 125 | 15 |
| October | 315 | 38 |

Quinn and Pruell, unpub. Sampled April 1980, 15-20 clams/analysis, concentrations ug/g wet weight

| | Identified aromatics | Total aromatics | Total hydrocarbons | Benzotriazoles |
|---|---|---|---|---|
| mid cove | 0.345 | 7.7 | 37.9 | 0.036 |
| near navy dump | 0.230 | 6.7 | 30.2 | 0.049 |

Appledoorn et al. (1980) found that Allen Harbor clams suffering from neoplastic disease had a hydrocarbon makeup similar to the sediment. Metabolic dysfunction or stress appeared to have prevented these individuals from metabolizing or depurating hydrocarbons.

Neoplasia in soft-shell clams. There is a high prevalence of neoplastic disease in soft-shell clams in Allen Harbor. This disease consists of a proliferation of abnormal blood cells and is often fatal to the clam.

Cooper (1979) described techniques of diagnosis and the stages of neoplasia in soft-shell clams and monitored disease levels in Allen Harbor at monthly intervals from July 1977 to March 1979. They found that adult clams were more susceptible than juveniles (1st year). During the study period incidence of neoplasia varied over a range of 19-43% with the highest levels in October and May and the lowest level in the summer. Neoplasm severity and clam mortality was highest in late winter.

Cooper found that the disease could be transmitted through the water and transplanted by injection. Other bivalves in Allen Harbor including hard clams did not have neoplasia. A virally induced disease specific to soft-shell clams would best fit these facts.

It has been suggested that pollution stress could have some effect on clam susceptability, but there was no clear cut relation of disease and environments studied by Brown et al. 1979. Polluted areas such as the Providence River had low incidences. It is possible that the high density of clams in Allen Harbor contributes to a high level of this transmitted disease. Since hydrocarbon pollutants in the surface sediments and metal levels in clams are not unusually high, it seems necessary to deemphasize pollutants and consider natural stress and disease transmission.

Appledoorn et al (1980) estimate that soft-clam production at Allen Harbor was reduced by as much as one-fifth due to neoplasia. Soft-shell clams have only been examined within Allen Harbor. Brown (1977) conducted a histopathological examination of hard clams from south of Quonset Point, Fry Cove, and Calf Pasture Point. These clams had no neoplasia but did have unusual accumulations of lipofuscia pigment. Brown discussed as possible causes of this accumulation ingestion and storage of unsaturated hydrocarbons from natural sources or petroleum pollution and metabolic disorders caused by pollutants. The equal incidence of this condition at all locations would argue against the effect of a pollutant from a point source.

Metals in Clams. It has been suggested that there could be high concentrations of heavy metals in sediments and organisms in the Quonset/ Davisville area as a result of discharge of metal plating solutions (Eisler et al (1977, 1978) or of dumping of metal scrap at Allen Harbor (CRC, 1977).

Eisler et al. found elevated metal levels in the widgeon clam (Pitar morrhuana) near the former Naval Air Rework Facility outfalls at Quonset Point. Metals which showed clear increased near the outfalls were found at normal concentrations in the Davisville area.

The Rhode Island Department of Health carried out a special study of metals in clams in the Davisville area between December 1976 and June 1977. Station locations and a summary of data are shown in Figure 4-1 and Table 4-4.

Soft-shell clams were collected at four stations. In Fig. 4-3 metal levels of clams are shown for the stations in order of distance from the Allen Harbor dump. There is no trend for any metal. Except for one Fry

Table 4-4. Clam analyses, RIDH Allen Harbor Project

| Date | Sta. | Species | Coliform bacteria MPN/100 ul | Ph | metals,ppm dry wt. Cd | Cr | Cu | Zn |
|---|---|---|---|---|---|---|---|---|
| 12/20/76 | 1 | softshell | 220 | 1.7 | 0.18 | 18.2 | 0.82 | 22.3 |
| 12/20/76 | 4 | softshell | 140 | 2.2 | 0.20 | 19.3 | 1.17 | 26.8 |
| 12/20/76 | 6 | softshell | 230 | 2.5 | 0.21 | 48.2 | 0.87 | 40.8 |
| 3/21/77 | 2 | hard | 0 | 1.17 | 0.25 | 10.3 | 1.16 | 17.4 |
| 3/21/77 | 2 | softshell | 110 | -- | -- | -- | -- | -- |
| 3/21/77 | 4 | softshell | ? | 1.62 | 0.16 | -- | 0.62 | 18.0 |
| 3/?/77 | 6 | softshell | 790 | 1.0 | 0.14 | 14.1 | 0.56 | 8.5 |
| 3/?/77 | 4 | softshell | 330 | 1.1 | 0.09 | 11.4 | 0.52 | 12.5 |
| 4/18/77 | 2 | softshell | 490 | -- | -- | -- | -- | -- |
| 4/18/77 | 3 | hard | 490 | -- | -- | -- | -- | -- |
| 4/18/77 | 2 | softshell | 0 | 0.31 | 0.16 | -- | 0.42 | -- |
| 5/23/77 | 2 | hard | ? | 0.65 | 0.13 | 7.1 | 0.88 | 10.4 |
| 5/23/77 | 1 | softshell | 330 | 1.3 | 0.11 | 17.5 | 0.76 | 11.5 |
| 6/13/77 | 3 | hard | 90 | 0.74 | 0.08 | 12.7 | 0.31 | 11.2 |
| 6/13/77 | 2 | softshell | 490 | 1.2 | 0.10 | 20.4 | 1.2 | 21.0 |

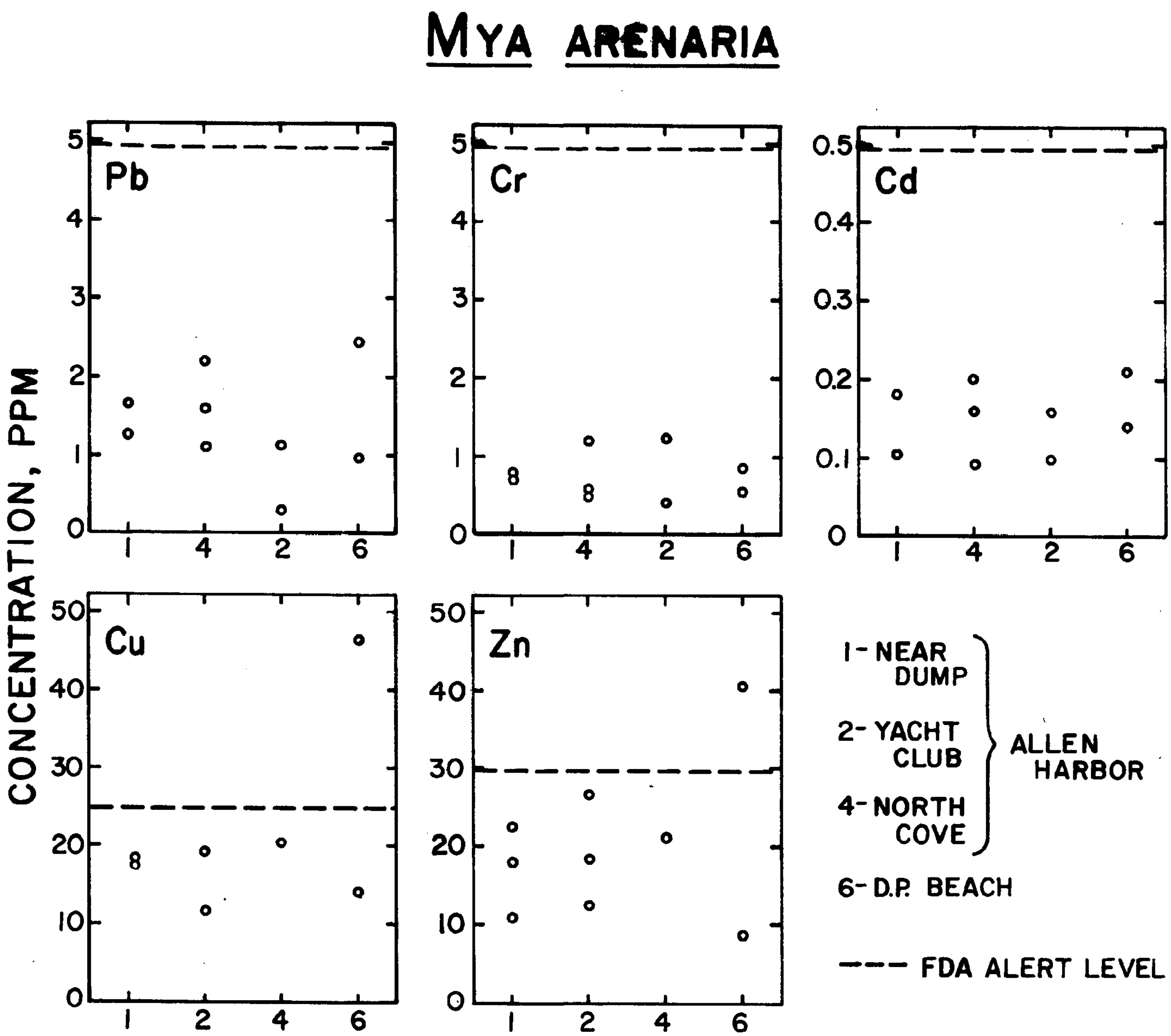


Figure 4-3. Metal levels in soft shell clams (*Mya arenaria*)(dry weight) at four locations. (R.I. Dept. of Health, Dec. 19, 1976-June 1977).

Cove sample, all metals are below FDA alert levels. Alert levels have no relation to safety of consumption, but relate to regional norms.

Hard clams were sampled from one location in Allen Harbor. A baseline for assessing Allen Harbor values is provided by data from a location north of the Harbor monitored regularly by the RIDH. Data from January 1978 to March 1980 is available from that station (Table 4-5). Hard clams within Allen Harbor had metal levels similar to those from the reference station with the exception of copper which was higher (Fig. 4-4). Chromium and copper in Allen Harbor and chromium at the reference stations are at the FDA alert levels.

The copper increase in Allen Harbor is probably real since copper and copper alloys can be seen in the former dump and copper bottom point is used on vessels moored in the harbor.

Phelps and Myers (1977) measured heavy metals in hard clams from clean and polluted locations in Narragansett Bay. They found that zinc levels remained the same in both areas, but that copper and chromium increased by about 3 times and cadmium and lead increased by about 0.7 times in the polluted area. For the Davisville samples it would appear that the constancy of zinc levels is due to physiological regulation by the clams and that zinc could not be a hazard to man or useful as a bioindication of pollution. The similarity of lead, chromium and cadmium in Allen Harbor and control clams indicate that the Harbor is not polluted with these metals. The elevated levels of copper in Allen Harbor clams is consistant with the presence of the metal in the dump and the ability of the clams to concentrate it.

Table 4-3. Hard clam analyses, RIDH, Station 9 of Mount View, North Kingstown

| Date | | Coliform bacteria MPN/100 ml | metals, ppm dry wt. Pb | Cd | Cr | Cu | Zn |
|---|---|---|---|---|---|---|---|
| 1978 | Jan. | 0 | 1.18 | -- | 0.08 | 6.1 | 19.7 |
| | March | 0 | 0.72 | -- | 0.03 | 2.6 | 7.3 |
| | April | 20 | 0.46 | -- | 0.50 | 16.9 | 10.0 |
| | November | 20 | -- | -- | 0 | 2.18 | 19.04 |
| 1979 | May | 20 | 0.45 | -- | 0.06 | 1.09 | 27.4 |
| | June | 20 | 0.62 | -- | 0.29 | 4.5 | 27.3 |
| | July | 20 | 0.55 | -- | 1.89 | 0.18 | 17.3 |
| | Aug. | 20 | 0.91 | -- | 0.10 | 4.9 | 18.4 |
| | Oct. | 20 | 0.54 | -- | 0.16 | 3.56 | 17.3 |
| | Nov. | 20 | 0.47 | -- | 0.12 | 3.8 | 23.7 |
| 1980 | March | 20 | 0.68 | 0.09 | 0.11 | 2.5 | 10.7 |
| | March | 20 | 0.59 | 0.11 | 0.13 | 0.71 | 13.44 |
| | FDA Alert levels, northern | | | | | | |
| | hard clams | | 4.0 | 0.5 | 1.0 | 10 | 65 |
| | softshell clams | | 5.0 | 0.5 | 5.0 | 25 | 30 |

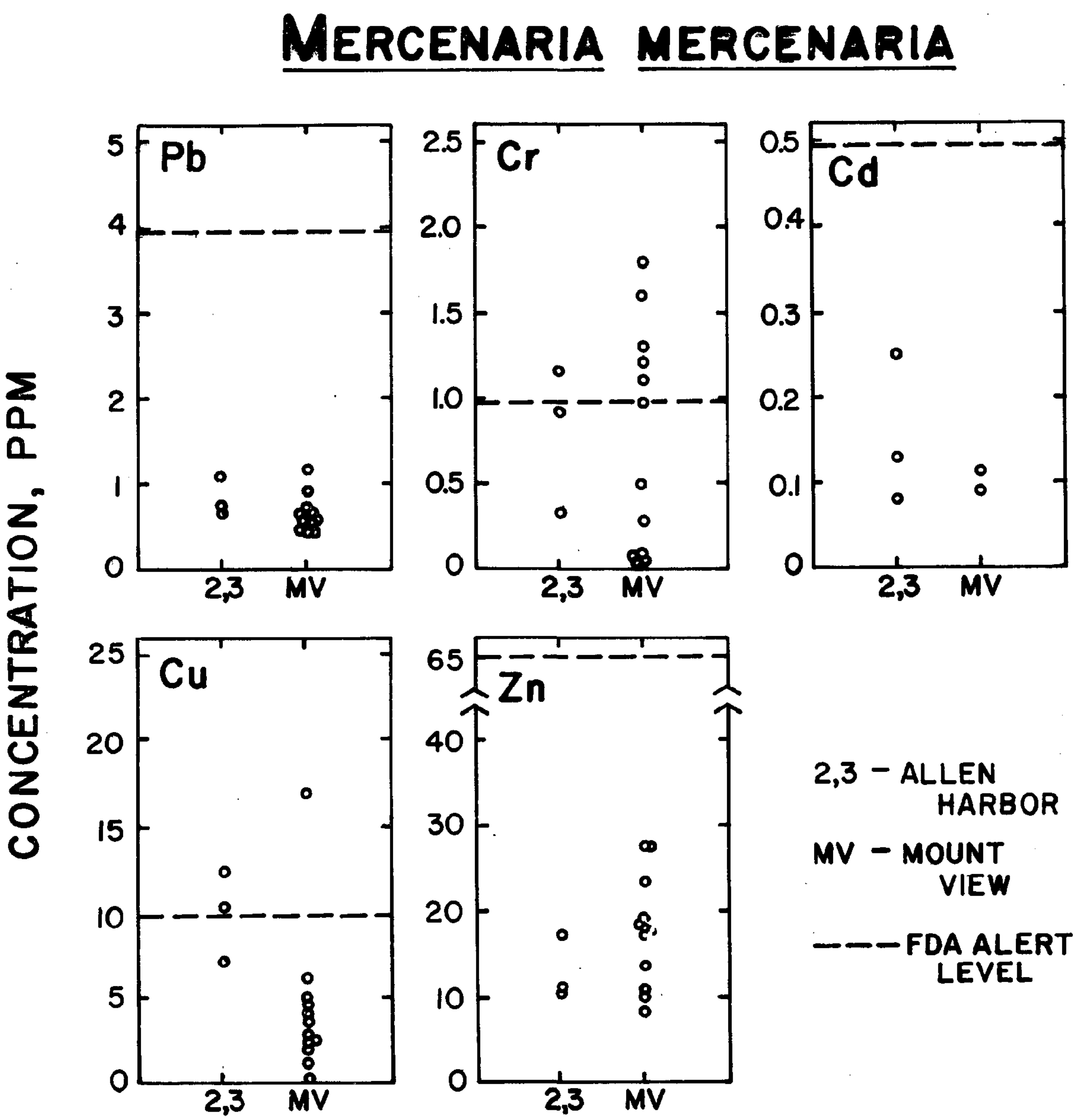


Figure 4-4. Metal levels in hard clams (Mercenaria mercenaria) in Allen Harbor (Stations 2,3 north cove, December 1976-June 1977); north of harbor (January 1978-March 1980).

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APPENDIX 1

Allen Harbor Sediment Analysis
September 10,1980
J.G.Quinn and R.J.Pruell

Our interpretation of the data (enclosed) is as follows:

0-2 cm section

Based on the presence of di-2-ethyl hexyl phthalate (DEHP), this section was deposited after 1945. Based on the presence of Benzotriazole B, this section of the core was deposited after 1963. The $f_1$ (saturated) and $f_2$ (aromatic) hydrocarbons are relatively low in comparison with other areas of the bay. The major source of these hydrocarbons is probably a combination of petroleum products and fossil fuel combustion products.

18-20 cm section

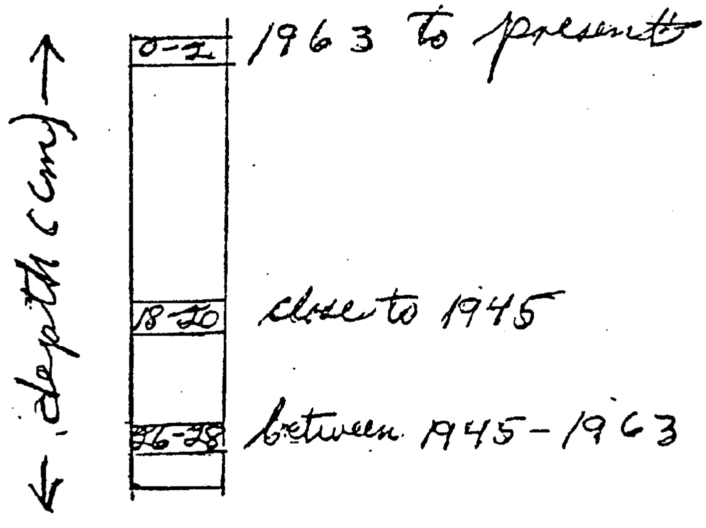
Based on the absence of Benzotriazole B and low value of DEHP, this section was probably deposited close to 1945. The hydrocarbon distribution is in agreement with this observation.

26-28 cm section

Based on the absence of Benzotriazole B and the high value of DEHP, this section was probably deposited between 1945 and 1963. The high concentration of DEHP and the increased level of $f_2$ hydrocarbons suggest considerable industrial or defense related activities during this time.

One possible explanation of these trends would be the input of dredged material containing organic pollutants (phthalate and $f_2$ hydrocarbons) deposited between 1945 and 1963, followed by 'cleaner' material deposited close to 1945. These materials may have been deposited in the early to mid-60's or over a longer time period (e.g. 1950-60). They have since been covered by recently accumulated sediment (1963 to present).

/d
Enc.



Allen Harbor Sediment Analysis[a]

Mid-cove core
(4/14/80)

| | 0-2 cm | 18-20 cm | 26-28 cm |
|---|---|---|---|
| | | (ng/g) | |
| Naphthalene | --[b] | 1.7 | 5.0 |
| 2-methyl naphthalene | -- | 1.5 | 2.4 |
| 1-methyl naphthalene | -- | 0.6 | 1.5 |
| Biphenyl | -- | 0.6 | 1.7 |
| $C_2$ naphthalene | -- | 0.5 | 1.2 |
| Fluorene | 2.4 | 2.3 | 16.8 |
| Dibenzothiophene | 6.5 | 2.2 | 12.3 |
| Phenanthrene | 18.7 | 12.4 | 115.1 |
| Fluoranthene | 43.8 | 43.5 | 183.8 |
| Pyrene | 28.9 | 45.6 | 132.9 |
| B[a]anthracene | 8.1 | 6.0 | 30.8 |
| Chrysene & triphenylene | 8.6 | 12.5 | 37.3 |
| Total identified aromatics (12) | 117.0 | 129.4 | 540.8 |
| | | (μg/g) | |
| Total $f_1$ hydrocarbons | 70.5 | 44.3 | 40.7 |
| Total $f_2$ hydrocarbons | 4.7 | 2.6 | 9.4 |
| Total $f_1 + f_2$ hydrocarbons | 75.2 | 46.9 | 50.1 |
| | | (ng/g) | |
| Benzotriazole A[c] | 51.7 | -- | -- |
| Benzotriazole B[d] | 72.2 | -- | -- |
| Di-2-ethyl hexyl phthalate | 114.0 | 36.4 | 1192.5 |

[a]All concentrations on a dry wt. basis.

[b]<1 ng/g.

[c]Benzotriazole A = 2-(2'-Hydroxy-3',5-di-t-amylphenyl)-2H-benzotriazole.

[d]Benzotriazole B = 2-(2'-Hydroxy-3',5'-di-butylphenyl)-5-chloro-2H-benzotriazole.

APPENDIX 2

Analysis of Mya Arenaria collected from Allen Harbor on April 14,1980
November 12, 1980
J.G. Quinn and R.J. Pruell

Attached are the results of our analysis of clam samples from Allen Harbor. Our interpretation of the data is as follows:

Aromatic Hydrocarbons: We have identified at least fourteen specific aromatic hydrocarbons in these samples. The most abundant hydrocarbons were phenanthrene, fluoranthene and pyrene. These three compounds are the major hydrocarbons found in sediments from Allen Harbor and throughout Narragansett Bay, and probably originate from the combustion of coal or petroleum products. Our values for fluoranthene (104-151 ng/g), and pyrene (44-69 ng/g) are in fair agreement with those reported by the FDA for a sample of Mya collected from Allen Harbor on 12/20/76 (fluoranthene: 75 ng/g, and pyrene: 48 n/g/).

Total $f_1$ (saturated) and $f_2$ (unsaturated) Hydrocarbons: These values for total hydrocarbons (30-38 μg/g) are in general agreement with values reported by the CRC in 1977 (59 μg/g). The sample collected from the mid-cove area shows slightly higher levels of total hydrocarbons (and aromatic hydrocarbons) but lower levels of benzotriazoles. These differences are probably not significant.

JGQ/d
Att.

Hydrocarbons and selected organic compounds in softshell clams (*Mya arenaria*) from Allen Harbor. (4/14/80)

| | Mid-Cove[a] | Near dump[a] |
|---|---|---|
| Aromatic Hydrocarbons | (ng/g)[b] | |
| Naphthalene | -- | -- |
| 2-methyl naphthalene | 3.9 | 3.2 |
| 1-methyl naphthalene | 1.9 | 1.1 |
| Biphenyl | 2.0 | 1.4 |
| $C_2$ naphthalene | 1.8 | 0.9 |
| 1,4 + 2,3 dimethyl naphthalene | 3.2 | 1.6 |
| Acenaphthalene | 7.6 | 4.5 |
| 2,3,5 trimethylnaphthalene | 7.6 | 2.7 |
| Fluorene | 8.4 | 4.6 |
| Dibenzothiophene | 8.6 | 5.9 |
| Phenanthrene | 68.2 | 44.3 |
| Fluoranthene | 151.1 | 104.2 |
| Pyrene | 69.2 | 44.4 |
| B[a]anthracene | 4.2 | 4.7 |
| Chrysene and triphenylene | 8.1 | 6.7 |
| Total identified aromatics | 345.8 | 230.2 |
| Benzotriazole A[c] | 34.1 | 46.3 |
| Benzotriazole B[d] | 2.3 | 2.9 |
| | (μg/g)[b] | |
| Total $f_1$ hydrocarbons | 30.2 | 23.5 |
| Total $f_2$ hydrocarbons | 7.7 | 6.7 |
| Total $f_1 + f_2$ hydrocarbons | 37.9 | 30.2 |

[a]analysis done on an aliquot of homogenate produced using 15-20 clams.

[b]All concentrations on a wet wt. basis.

[c]Benzotriazole A = 2-(2'-Hydroxy-3',5'-di-t-amylphenyl)-2H-benzotriazole.

[d]Benzotriazole B = 2-(2'-Hydroxy-3',5'-di-t-butylphenyl)-5-chloro-2H-benzotriazole.

APPENDIX 3

Analysis of surface sediment collected on June 24,1980 from the dredged basin off Davisville
November 10, 1980
J.G.Quinn, A.G.Requejo, and R.J.Pruell

Attached are the results of our analysis of this sample. Our interpretation of the data is as follows:

Aromatic Hydrocarbons: We have identified at least twelve specific aromatic hydrocarbons in this sample. The high concentrations of phenanthrene, fluoranthene and pyrene suggest a combustion source for these hydrocarbons (e.g. burning of coal or petroleum products).

Benzotriazoles and Di-2-ethylhexylphthalate: These compounds are somewhat higher than expected based on our previous analyses of sediments from the West Passage of Narragansett Bay. The organic carbon values are also slightly higher than expected. The data suggest that some particulate organic material (containing benzotriazoles, phthalate, and hydrocarbons) from the Providence River may be transported to the mid-bay area via tidal currents, and eventually settle out and accumulate in the dredged basin off Davisville.

Total $f_1$ (saturated) and $f_2$ (unsaturated) Hydrocarbons: These values are about three times higher than expected based on our previous analyses of sediments from the West Passage of Narragansett Bay. The data suggest a second source (other than the Providence River) of petroleum hydrocarbons in the vicinity of the Davisville area.

Our conclusions are:

1) The slightly elevated levels of benzotriazoles, phthalate and organic carbon are probably due to transport, deposition and accumulation of particulate organic material from the Providence River.

2) The high levels of three specific aromatic hydrocarbons and total hydrocarbons suggest an additional source in the vicinity of the Davisville area. This source includes polycyclic aromatic hydrocarbons from the combustion of fossil fuels as well as a complex mixture of hydrocarbons from petroleum products.

3) The concentration of aromatic hydrocarbons, total hydrocarbons, benzotriazoles and phthalate is significantly higher in Davisville surface sediment compared to Allen Harbor surface sediment (see enclosed report of September 10, 1980).

JGQ/d
Enc.
cc: S. Pratt

## Davisville Sediment Analysis[a]

| | Subsample 1 | Subsample 2 | $\bar{x}$ |
|---|---|---|---|
| Aromatic hydrocarbons | | ng/g | |
| naphthalene | --[b] | 33.0 | 33.0 |
| 2-methyl naphthalene | -- | 31.6 | 31.6 |
| 1-methyl naphthalene | -- | 22.9 | 22.9 |
| biphenyl | -- | 20.3 | 20.3 |
| $C_2$ naphthalene | -- | 12.3 | 12.3 |
| fluorene | 500.5 | 367.5 | 434.0 |
| dibenzothiophene | 222.2 | 173.8 | 198.0 |
| phenanthrene | 1947.5 | 1482.4 | 1714.9 |
| fluoranthene | 4862.0 | 4104.1 | 4483.0 |
| pyrene | 2541.2 | 2141.2 | 2341.2 |
| B[a]anthracene | 172.0 | 248.7 | 210.3 |
| chrysene & triphenylene | 270.2 | -- | 270.2 |
| | | µg/g | |
| Total $f_1$ hydrocarbons | 929.4 | 818.9 | 874.1 |
| Total $f_2$ hydrocarbons | 68.5 | 51.5 | 60.0 |
| Total $f_1 + f_2$ hydrocarbons | 997.9 | 870.4 | 934.1 |
| | | ng/g | |
| Benzotriazole A[c] | 626.9 | 432.1 | 531.0 |
| Benzotriazole B[d] | 190.7 | 145.3 | 168.0 |
| | | µg/g | |
| Di-2 ethylhexylphthalate | 1.34 | 1.00 | 1.17 |
| Cycloalkene M.W. 344 | 3.97 | 3.33 | 3.65 |
| Organic carbon | 24.0 ± 0.5 mg/g[e] | | |

[a]All values reported on a dry weight basis.

[b]not analyzed.

[c]Benzotriazole A = 2-(2'-hydroxy-3',5'-di-t-amylphenyl)-2H-benzotriazole.

[d]Benzotriazole B = 2-(2'-hydroxy-3',5'-di-t-butylphenyl)-5-chloro-2H-benzotriazole.

[e]triplicate analysis.