GENERAL INVESTIGATION

RHODE ISLAND SOUTH COAST HABITAT RESTORATION

APPENDICES I - IV

June 2002

US Army Corps
of Engineers

New England District

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	June 2002	General Investigation

4. TITLE AND SUBTITLE
Rhode Island South Coast Habitat Restoration
Appendices I - IV

5. FUNDING NUMBERS

6. AUTHOR(S)
U.S. Army Corps of Engineers
New England District

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Corps of Engineers
New England District
696 Virginia Road
Concord, MA 01742

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Corps of Engineers
New England District
696 Virginia Road
Concord, MA 01742

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION AVAILABILITY STATEMENT
Approved for public release,
distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
The Rhode Island South Coast Feasibility Study determined that aquatic habitat restoration in Ninigret, Winnapaug, and Quonochontaug ponds along the southern coast of Rhode Island is both feasible and cost effective. The selected plans will improve the aquatic habit of up to 57 acres of the shoaled-in salt ponds through selective dredging, planting of eelgrass, and establishing sedimentation basins to prevent future shoaling and subsequent loss of restored and existing eelgrass beds. The dredged material consists of medium to fine sands and is suitable for placement along nearby beaches. Restoring the migratory pathway of herring and other anadromous species to Cross Mills Pond in Charlestown will further improve the ecosystem through the restoration of about 20 acres of spawning habitat. The District Engineer recommends that the selected plans be implemented in accordance with the Feasibility Report recommendations at an estimated first cost of $7.6 million. The Federal share of this cost is $4.9 million and the non-Federal share is $2.7 million. This is in accordance with Federal statute, which requires that environmental restoration projects be constructed at 65 percent Federal cost and 35 percent non-Federal cost. This recommendation is subject to the non-Federal sponsor securing the necessary lands, easements, and rights of way for construction and assuming future operation, repair, rehabilitation, and replacement of the project.

14. SUBJECT TERMS	15. NUMBER OF PAGES
Rhode Island, coastal lagoons, eelgrass, aquatic vegetation, anadromous fish, ecosystem restoration	340
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	

Appendix I

Hydrodynamic Analysis

RHODE ISLAND SOUTH COAST FEASIBILITY STUDY

HYDRODYNAMIC ANALYSIS

JUNE 2002

WATER MANAGEMENT SECTION

TABLE OF CONTENTS
HYDRODYNAMIC ANALYSIS
RHODE ISLAND SOUTH COAST FEASIBILITY STUDY

TABLE OF CONTENTS (CONT.)
HYDRODYNAMIC ANALYSIS
RHODE ISLAND SOUTH COAST FEASIBILITY STUDY

TABLE OF CONTENTS (CONT.)
HYDRODYNAMIC ANALYSIS
RHODE ISLAND SOUTH COAST FEASIBILITY STUDY

LIST OF TABLES

TABLE OF CONTENTS
HYDRODYNAMIC ANALYSIS
RHODE ISLAND SOUTH COAST FEASIBILITY STUDY

LIST OF FIGURES

TABLE OF CONTENTS
HYDRODYNAMIC ANALYSIS
RHODE ISLAND SOUTH COAST FEASIBILITY STUDY

LIST OF FIGURES (cont.)

RHODE ISLAND SOUTH COAST FEASIBILITY STUDY
HYDRODYNAMIC ANALYSIS

EXECUTIVE SUMMARY

Problem Identification

Prior to the mid-1900s, inlets from Block Island Sound to the three major salt ponds on Rhode Island's south coast, Ninigret/Green Hill, Quonochontaug, and Winnapaug, had been opening and closing intermittently due to coastal storms and manual breaching. In 1978, an initial study funded by the Rhode Island Coastal Resources Management Council (CRMC) identified that construction of permanent openings in the 1950s and 1960s had dramatically changed the character of Rhode Island's south coastal salt ponds. These changes included; lowering of the water level as the ponds equilibrated with sea level, developing higher and less variable salinities, which dramatically modify the habitats of fish and wildlife, and accelerating sedimentation within the pond due to increased movement of sediment through the breach. In addition, the permanent openings have caused more rapid flushing of the ponds and periodic episodes of extremely low water when sustained northwest winds force much of the water out of the ponds. Growth of land development surrounding the ponds have also adversely affected the ponds, as deteriorating water quality from increased nutrient and bacteria loading by surface and ground water has resulted in rapid algae growth, depleted oxygen levels and closure of shellfish beds.

Numerous studies were undertaken in the early 1980s to provide assistance to the coastal management community in balancing the many conflicting demands for use of the tidal inlet and coastal systems of Rhode Island. Fishery interests are frequently in conflict with the recreational boating interests, since boaters desire increasing the depth or width of the inlet channel. Increasing the depth significantly would change the salinity regime and cause an even greater influx of sediment into the ponds. Both are unacceptable measures in managing the existing habitat.

Data Collection Program

Our data collection program provided information so that we could analyze impacts of various dredging scenarios using a hydrodynamic computer model. Physical data, collected to provide calibration characteristics of the hydrodynamic model, included: an aerial survey of the ponds that provided topographic sounding data; measurements of pond levels over full tide cycles; and peak velocity measurements collected during flood tide conditions in the inlet channel of each salt pond.

Based on the sounding data, all three of the ponds possess a tidal inlet having a minimum depth of 3 feet below mean low water (-4 feet NGVD). However, in some cases the channel is narrow with the deepest portions of the channel meandering within the shoaled breachway area, at times creating a hazard to mariners.

Monitored tide cycles show that the inlets to the ponds provide a restriction to tidal flow. The Ninigret\Green Hill inlet provides the largest restriction, followed by Winnapaug, and finally by Quonochontaug inlet. Mean tide range for Ninigret Pond is slightly over 0.5 foot, while Green Hill, Winnapaug and Quonochontaug were 0.3 feet, 1.6 feet and 1.8 feet, respectively. Peak flood tide velocities measured in the thalweg of the inlet channel north of the jetties during spring tide range conditions, are high enough to easily transport of non-cohesive fine sand particles, which are generic to the shoals of the ponds.

Results of the Computer Simulations

For each pond, estimated tidal conditions, correlated to data from the nearby Newport, RI NOAA tide gage, were used to develop the boundary conditions for the computer model. Computed water surface results were compared to measured stages at tide gage stations within each pond and modeling parameters were adjusted to match the measured data. After initial development of the model, two other tidal events including at least one where peak inlet channel velocities were measured were used to provide further calibration of each model for existing conditions.

After a representation of the existing conditions, each pond's geometry was changed to incorporate anticipated project modifications, which include the addition of sedimentation basins and proposed areas of flood tidal delta dredging. The initial basin locations and proposed dredged shoal areas were provided after consultation with a technical group made up of: RICRMC, RIDEM, RI Fish and Wildlife Department, and URI Department of Geosciences. The hydrodynamic model was used to ensure that the sedimentation basin is positioned such that the leading edge of the basin would be perpendicular to the direction of the flood flow velocity vectors.

As shown in the modeling, the major improvement for all the ponds will be in the circulation pattern in the immediate vicinity of the dredged area of the sedimentation basin and the dredged shoaled areas. The change in circulation in the far reaches of the pond is considered minimal. For both Winnapaug and Quonochontaug ponds, modeling results show a nearly immeasurable (less 0.1-foot) change in tidal prism for a spring tide event. For Ninigret and Green Hill for the proposed conditions, there will be a small increase in high tide elevation for a spring tide range of 0.15 to 0.2 feet. This amounts to about a 15% change in the tidal prism.

In addition, an estimated 10-year tidal flood was simulated to determine the impacts of flooding with the proposed project. For both Winnapaug and Quonochontaug ponds modeling, the increase in elevation was less than a 0.1-foot. In Ninigret and Green Hill ponds, the increase in elevation expected would be between 0.35 to 0.45-foot for this event at the extremities of the pond.

A second basin was also considered for Ninigret/Green Hill ponds. The silty dredge material from the inner basin in Ninigret Pond was determined by the RI Department of Environmental Management to be too fine for beach/nearshore disposal.

If this basin were dredged then a suitable upland site would need to be found. No such disposal site was pursued during the feasibility study for the following reasons:

• Most of the silty material (at the lower dredging depths) is native material from the pond bottom that was covered by the delta as shoaling took place. This native material is very fine sands and silts deposited prior to the delta migration that did not originate from the beach side of the barrier system.

• There is also no guarantee that when this basin is dredged that the channel location will remain constant. In fact, history shows that this end of the channel tends to migrate. Each time the channel end migrated a new basin would need to be dredged that would encounter the same disposal issues. This was not desirable to the RICRMC who will be responsible for maintaining the restoration project.

Further analysis included development of an approximate sediment transport model. The hydrodynamic results were input to the transport model that developed erosion and deposition patterns for existing and proposed conditions and assisted in quantifying the amount of sediment that can be expected within the proposed sediment basins. The modeled shoaling pattern created by the sediment transport model for the existing condition appeared to generally follow the delta configuration from the aerial photos for the ponds. With the proposed conditions, the sediment transport model shows that there were no large changes in shoaling or erosion patterns for any of the ponds except for increased deposition in the proposed sedimentation basins.

Based upon sediment transport modeling, the amount of material that could potentially deposit yearly in the proposed Ninigret, Winnapaug and Quonochontaug basins was determined to be about 1-foot, 2-foot, and 2-foot, respectively. This is based upon extrapolation of the volume of material that deposits here for an entire year for a mean tide condition. This amounts to more material than the historical shoaling rate that was developed by Jon Boothroyd, URI Chief Coastal Geologist. Therefore, historical shoaling rates recommended to be used as a more accurate estimate of dredged maintenance requirements.

I. Introduction

As part of the investigation to restore seagrass, a computer model was developed to analyze the impact of proposed dredged conditions on circulation (velocity magnitude and direction, tidal elevation, and to a lesser extent on sediment transport) within the three ponds in the study area; Winnapaug Pond, Quonochontaug Pond, and Ninigret/Green Hill Pond. Major tasks included collecting and analyzing tidal and current data, collecting sediment samples for grain size analysis, estimating shoaling rates based on historical aerial photography, and developing a two-dimensional hydrodynamic model of each pond for existing conditions and proposed dredged conditions.

II. Physical Setting

A. General

Ninigret/Green Hill, Quonochontaug, and Winnapaug, are coastal lagoons, locally known as 'saltponds', which are shallow, productive marine embayments separated from the ocean by barrier spits. The salt ponds and their watersheds are located along the south coast of Rhode Island in the towns of Narragansett, Charlestown, South Kingston, and Westerly. The total drainage area of these three ponds is 21.3 square miles, with the combined areas of Ninigret and Green Hill Pond about twice as large as the combined pond areas of Winnapaug and Quonochontaug. Figure 1 is a map of the salt pond area.

B. Historical Perspective

Prior to the mid-1900s, inlets from Block Island Sound to the three major salt ponds on Rhode Island's south coast, Ninigret/Green Hill, Quonochontaug, and Winnapaug, had been opening and closing intermittently due to coastal storms and manual breaching. In 1978, an initial study funded by the Rhode Island Coastal Resources Management Council (CRMC) identified that construction of permanent openings in the 1950s and 1960s had dramatically changed the character of Rhode Island's south coastal salt ponds. These changes included; lowering of the water level as the ponds equilibrated with sea level, developing higher and less variable salinities, which dramatically modify the habitats of fish and wildlife, and accelerating sedimentation within the pond due to increased movement of sediment through the breach. In addition, the permanent openings have caused more rapid flushing of the ponds and periodic episodes of extremely low water when sustained northwest winds during winter months force much of the water out of the ponds (prior to building jetties, this action may have resulted in natural breaching). Growth of land development surrounding the ponds have also adversely affected the ponds, as deteriorating water quality from increased nutrient and bacteria loading by surface and ground water has resulted in rapid algae growth, depleted oxygen levels and closure of shellfish beds.

Numerous studies were undertaken in the early 1980s to provide assistance to the coastal management community in balancing the many conflicting demands for use of the tidal inlet and coastal systems of Rhode Island. Fishery interests are frequently in conflict with the recreational boating interests, since boaters desire increasing the depth or width of the inlet channel. Increasing the depth significantly would change the salinity regime and cause an even greater influx of sediment into the ponds. Both are unacceptable measures in managing the existing habitat.

C. Tidal Hydrology

1. General

The combined ponds of Ninigret and Green Hill have by far the largest surface and drainage area with 2,142 acres and 9,064 acres, respectively, followed by Quonochontaug with 732 acres and 2,307 acres, respectively, and finally by Winnapaug with 446 acres and 2,294 acres, respectively. There are only a few minor streams emptying into these ponds as most freshwater enters primarily as groundwater and runoff. Groundwater flow is especially important in the salt pond region according to the June 1997 draft Salt Pond Region Special Area Management Plan. Two minor streams enter Green Hill Pond at the northeastern portion (Factory Pond Stream and Teal Pond Stream) and one minor stream enters Ninigret Pond at Fortneck Cove (Cross Mills Stream). Several small, unnamed streams also enter the northern side of Quonochontaug Pond. As a result of the minimal freshwater sources and the permanent inlets, tidal movement dominates the flow within the ponds.

In the study area, tides are semidiurnal, with two high and two low tides occurring during each lunar day (approximately 24 hours, 50 minutes). The resulting tide range is constantly varying in response to the relative positions of the earth, moon, and sun; with the moon having the primary tide producing effect. Maximum tide ranges occur when orbital cycles of these are in phase. A complete sequence of the tide ranges is approximately repeated over an interval of 19 years, which is known as a tidal epoch. Estimated tide ranges and stillwater frequency relationships for tidal flooding are taken from Corps Tidal Flood Profiles, New England Coastline dated 1988. These profiles are based on tide ranges and stage-frequency curves developed for the New London, CT and Newport, RI NOAA tide gages and high watermarks observed during the 1938 and 1954 (Hurricane Carol) hurricanes. Estimated mean and spring tide range at Block Island Sound adjacent to the opening of the ponds, are based upon NOAA predicted tide tables, is approximately 2.6 and 3.2 feet, respectively. Because of the continual variation in water level due to tides, several reference planes, called tidal datums, have been defined to serve as reference zero for measuring elevations of both land and water. Tidal datum information, representing the ocean level outside of the ponds for the study area, is presented in Table 1.

2. Hurricanes

Along the Rhode Island coastal pond area, the most severe flooding results from storm surge associated with hurricanes. These tropical storms are characterized by low barometric pressure, winds in excess of 75 miles per hour, torrential rain, and huge waves. The September 1938 and August 1954 hurricanes caused tidal floods of record with high water marks of 11.8 feet and 11.5 feet National Geodetic Vertical Datum (NGVD) along the Rhode Island coast.

3. Nor'easters

In New England, severe winter storms that have strong onshore winds are commonly referred to as "nor'easters". These extratropical low-pressure systems move more slowly than hurricanes, and can even stall in one place, exposing the shore to continual wave attack and storm surge over several tide cycles. An example of a recent nor'easter, which affected southern New England, occurred in mid-December 1992. Estimated high tide during the storm reached approximately 6 feet NGVD, which is approximately 4 feet higher than mean spring high water. The frequency of recurrence associated with this storm's maximum observed tide level is approximately once every 5-years.

D. Coastal Processes

The geology of Ninigret/Green Hill Pond is analyzed in detail and described as part of Sea Grant Research Project by URI (Boothroyd, et.al.,1981) in the report, "The Geology of Selected Microtidal Coastal Lagoons". The formation of Ninigret/Green Hill Pond, Winnapaug Pond, and Quonochontaug Pond are similar ("Geology of Microtidal Coastal Lagoons: Rhode Island," Boothroyd, et. al., May 1984). All three ponds are part of a barrier/headland system with underlying glacial topography. As sea level rose following the melting of the Laurentide Ice Sheet, the lower lying areas were inundated. Glacially deposited sediment, primarily sand and gravel, eroded from the headland areas and was deposited as barrier spits by waves, tides and currents. The barrier spits eventually enclosed the coastal lagoons.

In an attempt to provide navigation and continuous flushing of the pond, the State of Rhode Island constructed a stabilized, wider and deeper opening to Ninigret Pond in 1952. (Boothroyd, et.al. 1981) This permanently altered the conditions within the Ninigret/Green Hill lagoon system. A channel was also dredged between Ninigret Pond and Green Hill Pond in 1962. Stabilized inlets were constructed at Winnapaug and Quonochontaug Ponds in 1954 and 1961, respectively. ("A Geological Survey of Sedimentation in Quonochontaug, Winnapaug and Maschaug Ponds, Westerly, Rhode Island," Boothroyd, June 1985)

With the construction of the channels, jetties and inlet throat stabilization, water discharge and net bed-load transport of sand has increased into all the lagoons, causing significant sediment buildup. Accretion of the flood-tidal lobes has also created multiple flood ramps and terminal lobes; creating a navigational challenge to boaters using the ponds, particularly in Ninigret and Green Hill ponds. As reported for Ninigret, the main channel thalweg moves in response to the growth of flood ramps, spillover lobes, and ebb spits on these bars. This has resulted in the elimination of a navigable channel through the east lobe, a significantly lengthened Green Hill channel thalweg, and accretion at the terminal lobe of the main channel along the west side of the flood tidal delta.

From analyses completed in the report (Boothroyd, et.al.,1981), URI researchers determined that the primary source of sand entering the breachway of Ninigret/Green Hill Pond is the eroding beach west of the opening. Storms cause sand to be moved from the beach face and enter the nearshore transport systems. Littoral transport of sand, identified in the report as moving in a west to east direction, results from wave energy impacting against the sandy beach outside the tidal inlet. Sand moved in this manner enters the breachway where it is transferred inward by the high velocities that exist in the breachway. Moderate to severe hurricanes and southeasterly winter storms provide a great deal of sand to the pond in this manner. As the channel widens, material deposits, forming point bars and terminal lobes of the flood tidal delta.

The other result of storm surges is the erosion of the barrier spit as elevated water level and waves overtop the low foredune ridges. The temporary channels that form in the barrier spit function as subtidal washover lobes or platforms, which result in added deposition within the pond. (Generally, severe storms, such as hurricanes and nor'easters, are necessary before significant material is eroded and deposited in this manner.) From a 1981 paper, entitled "Inlet Modification: an example of a holistic approach to the management of lagoons," by Olson and Lee, the formation of several temporary inlets in Ninigret Pond during major hurricanes in 1938 and 1954 were described. Sediment washed over the barrier during major storms such as these contributes sediment into the ponds. However according to the paper, the material from the washover lobes is an order of magnitude less than the most recent flood tidal shoal, which has been forming in Ninigret Pond since the early 1950's.

Other important information gained in research studies (Olsen and Lee, 1981) describes the processes that drive sediment through the breachway. At the time of the 1981 study, there were conflicting ideas about when most shoaling occurred. The researchers believed initially that storms, rather than every day tides, deposited the majority of the material in the shoals while local residents were convinced that sand has been flowing in continuously ever since the breachway was stabilized. As part of Boothroyd's study, florescent dyed sand was placed on the ocean beaches on either side of Ninigret breachway and in the channel itself and sampled for 3 months during calm summer weather. The experiment showed that once the sand gets into the breachway, it is rapidly and continuously transported onto the tidal flats. It was concluded that the energy to erode sand off the beach face and into the nearshore transport systems of the breachway is generally storm dependent. However, after it enters the breach's nearshore transport system, normal tidal conditions carry the material into the pond. According to Boothroyd there was approximately a 3-year lag between when sediment eroded from the barrier during the 'Blizzard of 1978' and when the last of the eroded sand passed through the breachway and was deposited on the delta. Although similar research was not completed for Winnapaug and Quonochontaug ponds, it appears as the processes on how sediment enters through the breachway as described by Boothroyd for the Ninigret/Green Hill Ponds can be generally applied to those of Winnapaug and Quonochontaug.

Significant analyses were also conducted in the 1981 study on the distribution of currents within the Ninigret breachway and pond (Boothroyd, et. al. 1981). Spring tide current data collected for this study, shows flood velocities drop from approximately 160 centimeters per second (cm/sec) at the inlet to the breachway, to 20 cm/sec on the margins of the delta, and then to less than 6 cm/sec at the Green Hill Pond channel. Fine sand does not move when velocities drop below 20 cm/sec, therefore, material is deposited at the margins of the delta. In addition, tidal currents within Ninigret and Green Hill Pond were estimated generally to be less then 5-10 cm/sec. This velocity is barely able to move coarse silt. As reported, asymmetric flow patterns exist during tidal flows. The asymmetry within the inlet throat results in the dominance of flood-oriented sand dunes, which have average heights of 40 cm (1.2 feet) and are spaced between 6 (20 feet) and 15 (50 feet) meters apart. In addition to these sand waves, flood-oriented megaripples are superimposed on the sand waves based upon current velocities that are greater than 80 cm/sec. After passing through the riprap-lined throat, it was noted that an ebb-dominant flow channel developed on the west side of the channel and a flood-dominant flow channel developed on the east side of the channel. Ebb flow velocity measurements were less than flood flow velocities at all locations. In many cases, flood currents were more than twice as large as the ebb channel currents.

Isaji (ASA) and Spaulding (URI) undertook one-dimensional modeling evaluations of different inlet modification scenarios and their impact on shoaling and water quality conditions in Ninigret and Green Hill Pond (Isaji and Spaulding, Nov. 1981). Specifically, their purpose was to investigate modifications to the breachway-channel system such that: 1) boats would have a safer passage, 2) sedimentation rate would decrease in Ninigret Pond, 3) salinity variation would increase such that mean salinity values would decrease, and 4) flushing rate of Green Hill and portions of Ninigret ponds would increase to aid in decreasing local pollution problems. In addition to modeling the existing condition, nine cases of inlet modifications were evaluated. The modifications included: width reduction of the Ninigret Breachway for its total length and also for a portion leading up to the branch channels of Ninigret Pond and Green Hill, widening the Green Hill Inlet, dredging a 10 meter wide by 1 meter depth channel in the Ninigret Breachway, extension of the 10 meter wide by 1 meter deep channel to Green Hill Pond and miscellaneous other combinations of these options. Included in the findings was that satisfying all the management objectives is impossible. It was determined that optimizing the inlets for boating would involve dredging that would open the pond to further sedimentation and slightly higher salinity. Reduction of the width into Ninigret Pond was shown to reduce the salinity, however recreation boating would suffer. Based upon modeling one particularly important scenario from boating interests, the 10 meter wide by 1 meter deep alternative, produced approximately a 6 % increase in flushing volume with only a slight increase in salinity (0.1%). This option was also described as opening up the pond to more rapid sedimentation.

It should be noted here that should the existing condition continue, Boothroyd (Boothroyd, et. al., 1981) indicates that the shoaling would extend across the width of the pond, splitting the lagoon in two and cutting off Green Hill Pond and the east basin from the ocean.

E. Existing Water Quality Conditions

Water quality conditions have also been affected by the development around the ponds and by construction of the permanent openings. The largest impact occurred during the 1950s, when construction of the permanent stabilized openings for Ninigret, Quonochontaug, and Winnapaug were completed. Their purpose was to aid in flushing out concentrated pollutants collected within the ponds and to enhance navigation for recreational boating. However, the greatest effect of the permanent opening was to change the ponds from a brackish water environment to high salinity conditions. The increase in flushing first envisioned did not materialize as expected and as a result water quality concerns have not diminished. For further information on water quality issues in the salt ponds refer to Salt Pond Region Special Area Management Plan (SAMP) by the Rhode Island Coastal Resources Management Council.

III. Data Collection Program

A. Water Quality Collection Program

For this study, we also contracted with the University of Rhode Island's Graduate School of Oceanography (URI GSO) to provide a brief survey of existing base-line water quality conditions. Even though there are currently known problems with bacteria (shellfish bed closings), the primary purpose was to define and quantify water quality factors, which may affect eelgrass growth within the salt ponds. Included in URI's field measurement program were the parameters of total suspended solids, dissolved inorganic nitrogen (DIN) and phosphorous, chlorophyll a, and light attenuation. After general conditions in the ponds were identified, proposed projects to improve eelgrass growth could be evaluated. Three water quality stations were set-up in Quonochontaug, Winnapaug, and Ninigret Ponds and one station in Green Hill Pond. Water quality surveys were conducted at these stations twice each month from April – September 1999 and monthly from October 1999 to March 2000. A detailed discussion of the water quality data is presented in the URI GSO report (see Appendix A).

B. Physical Data Collection Program

1. General

Based on the directions of the public scoping meetings and the study formulation process, it became clear that the list of potential improvements that we were to evaluate was limited to the construction of sedimentation basins and removal of shoaled material located at the flood tidal deltas of each pond. The purpose of our data collection program was to provide information so that we could analyze impacts of various dredging scenarios using a hydrodynamic model. Physical data, collected to provide calibration characteristics of the hydrodynamic model, included: an aerial survey of the ponds that provided topographic sounding data; measurements of pond levels over full tide cycles; and peak velocity measurements collected during flood tide conditions in the inlet channel of each salt pond. In addition, a recording tide gage was placed in Ninigret Pond for a three-month period. Summaries of the physical measurements undertaken in the ponds are presented below.

2. Aerial Survey

An aerial survey of each pond was flown by helicopter in May 1998 as an inexpensive means to collect approximate soundings for the ponds. The Scanning Hydrographic Operational Airborne Lidar Survey System (SHOALS) system, which employs airborne lasers to collect horizontal position and water depth, was used to perform this operation. Lidar is and acronym for Light Detection And Ranging. The system operates by emitting a pulse of light that travels from an airborne platform to the water surface where a small portion of the laser energy is reflected back to the airborne receiver. The remaining energy propagates through the water column, reflects off the sea bottom and returns to the airborne detector. The time difference between the surface return and the bottom return corresponds to the water depth. The maximum depth the system is able to sense is related to the complex interaction of radiance of bottom material, incident sun angle and intensity, and the type and quantity of organics or sediments in the water column. As a rule-of-thumb, the SHOALS system should be capable of sensing bottom to depths equal to two or three times the Secchi depth.

Based on the results of this mapping effort, all three of the ponds possess a tidal inlet having a minimum depth of 3 feet below mean low water (-4 feet NGVD). It should be noted, however, that the deepest portions of the channel meanders within the breachway area; at times creating a hazard to mariners. This is particularly true in Ninigret where the main breachway is nearly entirely shoaled and the deeper, narrow channel is generally 20-30 feet wide. Ninigret's meandering inlet channel leading up to the flood tidal shoal generally has an elevation of -4 feet NGVD. Quonochontaug's inlet channel, which is fairly straight, generally has an elevation below -8 feet NGVD. Winnapaug's inlet channel generally has elevations below -6 feet NGVD. The survey also showed that the deepest pond depths occurred in Quonochontaug Pond, which had soundings ranging from -4 to -12 feet NGVD. Winnapaug follows with soundings ranging from -2 to -5 feet NGVD. Lastly, Ninigret-Green Hill Pond is shallowest with a majority of the pond having soundings ranging from -0.5 to -2 feet NGVD. Field verification showed that the bathymetric data generated by the SHOALS survey underestimated the deeper pond portions of the Ninigret and Green Hill pond basins. However, it is important to note that the deeper areas of the tidal inlets of Ninigret, Winnapaug and Quonochontaug were accurate and were verified through numerous field visits during velocity measurements.

The reason for the erroneous measurements in the deeper pond areas of Ninigret and Green Hill is unknown at this time. However, since LIDAR survey is based upon laser readings, the generally higher turbidity of the ponds particularly in Green Hill or problems of interpreting the denser stands of eelgrass or algae build-up on the bottom of the pond (Ninigret) may have produced erroneous readings in the SHOALS data. Some of the deeper pond areas of Green Hill and Ninigret ponds could be 1 to 2 feet lower than elevations produced by SHOALS.

The effect of underestimated bathymetric data for Ninigret\Green Hill Pond was evaluated using a sensitivity analysis performed with the hydrodynamic computer model. Further information on this analysis is described in Section IV.C.3. Contour mapping of the data for each pond, generated from SHOALS, is presented in Figures 2 to 4.

3. Tidal Measurements

A total of eight staff tide gages and one recording tide gage were mounted and surveyed to NGVD datum by Corps personnel in August 1998. Three staff tide gages and one recording tide gage (acoustic sensor with datalogger) were placed in Ninigret Pond, three staff tide gages in Quonochontaug Pond, and two staff tide gages in Winnapaug Pond. The locations of the tide gages are shown in Figures 5 through 7. The recording tide gage data was collected continuously over a three month period (October 1, 1998 through January 6, 1999). Data was collected for full tidal cycles on three occasions at the staff tide gages.

Mean tide range for the Ninigret Pond, based upon a three-month monitoring period, is slightly over 0.5 foot. Estimated mean tide ranges for Green Hill, Winnapaug and Quonochontaug, based upon a correlation of tidal monitoring with the longer-term Ninigret Pond monitoring, were 0.3 feet, 1.6 feet and 1.8 feet, respectively. The National Oceanic and Atmospheric Administration (NOAA), estimated mean and spring tide range in Newport is 3.5 feet and 4.4 feet, respectively, and the mean and spring tide range in Block Island Sound just outside of the inlets to the ponds (based upon correlation of data gathered by NOAA from the predicted tide tables for Westerly, RI) is 2.6 feet and 3.2 feet, respectively. The estimated 10-year frequency tidal flood elevations are based upon historic storm data obtained from the Corps Tidal Flood Profiles, New England Coastline, dated September 1988, was correlated to levels developed from tidal monitoring for the ponds. Table 2 shows a summary of the estimated tidal characteristics for each pond. Figures 8 through 10 show plots of the tidal measurements made during the monitoring events. Newport NOS measurements and estimated ocean level at the inlets to the ponds are also presented on these plots.

4. Current Measurements in the Breachway Channel

Point velocity measurements were collected using an electromagnetic flowmeter (Marsh McBirney Flowmate) to assist in developing a more accurate representative computer model. Measurements were conducted during a 3-hour period of a tidal flood current, in the thalweg of the channel, for the period 2-4 November 1999. Current measurements had previously been collected for a Ninigret Pond spring tide event on 9 October 1998 with the assistance of EPA's Narragansett Laboratory. Velocities are significant in each of the inlets, especially in the riprap-lined, southerly ocean entrance to each inlet, such that navigation is hazardous during peak ebb and peak flood conditions. In particular, it is noted that in the shallow ocean entrance to Ninigret, standing waves occur regularly during peak flow conditions as a result of high velocities. Mid-depth velocities in the thalweg of the channel during peak flood tide conditions were measured twice for the Ninigret Pond inlet and once each for Quonochontaug and Winnapaug inlets. (Figure 11 shows the locations of the velocity measurements. Results are presented in Table 3 and Figure 12. The data shows that peak flood tide velocities measured during a spring and mean tide condition in Ninigret ranged from 1.37 fps to 3.44 feet per second (fps) in the inlet channel north of the riprapped portion. During a neap tide, velocities in Quonochontaug ranged from 1.52 fps to 3.52 fps in the inlet channel while during a mean tide condition in Winnapaug, velocities ranged from 1.36 to 2.17 fps in the inlet channel. Velocities were not measured in the riprapped-lined jetty portions because of the difficulties of measuring currents in the turbulent area and because it was known that velocities would be greater than the minimum measured during peak flood flow conditions. Measured velocities are high enough to easily transport non-cohesive fine sand particles, which are generic to the shoals of the ponds.

IV. Hydrodynamic Computer Model

A. Model Development

A two-dimensional hydrodynamic model using FASTTABS was developed to simulate currents and tide heights, providing a mechanism to be used for predictive studies. FASTTABS is the PC-based version of TABS-2, which is the part of a family of computer programs (Surface Modeling System, SMS), used in two-dimensional modeling of hydrodynamics, sedimentation, and constituent transport in rivers, reservoirs, bays, and estuaries. The system, developed by the Hydraulics Laboratory at U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi, includes the finite-element, hydrodynamic, and sediment transport models originally developed by Resource Management Associates, Inc., in Davis, California. Significant enhancements to the codes have allowed applications to a wide class of computational hydraulic problems. The system contains all necessary pre- and post-processing utilities need to allow user-friendly applications.

The two-dimensional model used for this study, estimates velocities in the x and y direction (in the horizontal plane) while averaging velocities in the vertical direction. We believe the two-dimensional model that was developed provides a reasonable representation of the ponds and is appropriate to access the changes that are likely to occur in the ponds after construction of the sediment basins and dredging the shoals. A three dimensional model would be needed if significant depths were encountered in the ponds while a one dimensional model would be appropriate if we were not interested in the change in circulation patterns which we expected with the dredging of the shoals.

B. Mesh Design

A finite-element mesh was used for each pond, covering the main body of the pond and the inlet channel from the mouth at Block Island Sound. In the case of Ninigret Pond, the connected Green Hill Pond was included. Inaccuracies are expected at the boundary interface at Block Island Sound so the channel was extended slightly into the sound. The overall grid for the ponds and the channel are shown in Figure 13 through 15. The meshes were developed from the SHOALS data that was completed in December 1998. The number of data points was reduced for those areas where too much information was collected and in certain areas, where there was insufficient data due to problems with the laser "seeing" through turbid conditions, interpolation between points was necessary.

C. Calibration

1. Winnapaug Pond

Initially, tidal conditions occurring on 9 September 1998 (spring tide range = 5.26 feet, high tide elevation = 4.17 feet NGVD at Newport) were used to define boundary conditions for model simulation. This tide range was nearly a foot larger than a mean spring tide condition and provided a better estimate of the maximum non-storm conditions that could be expected for the pond. Tide data from the Newport, RI NOS tide gage were used along with established correlation relationships with Block Island Sound tides (Westerly, RI) to develop boundary tide conditions at the inlet for input into the hydrodynamic model. Computed water surface results were compared to measured stages at our tidal gage stations and the viscosity and friction parameters inherent in the model were adjusted to provide a better fit.

In addition, after initial development of the model, two more tidal events occurring on November 5, 1998 (spring tide range = 6.03 feet, high tide = 4.07 feet NGVD at Newport) and November 4, 1999 (mean tide range = 3.63 feet, high tide = 1.59 feet NGVD at Newport) were used. They provided verification that the model was representative of existing conditions. See Figures 16 and 17 that compares the computed versus measured tide elevations at the breach and at the west-end of the pond.

The variation at peak high tide was less than a few tenths of a foot for these events. The greatest variation between computed and measured tide elevations occurred at the west-end of the pond for the November 4, 1999 mean tide event, particularly during low tide conditions (See Figure 17). A strong 15-20 knot wind blowing from the west for almost the entire day on November 4th affected the tidal elevation. The wind caused the interior high tide to be reduced and the interior low tide to be lower than expected as wind driven currents forced water out through the breach.

In addition, it is more difficult during computer simulations to match the low tide than the high tide measurements. Exact duplication of the channel configuration is required for accurate flow portrayal, as the water depth becomes shallow. Since the salt ponds' topographic data is based on the SHOALS process, there may also have been some error in precisely matching the channel configuration within the pond and the breachway.

Peak velocities measured in the thalweg during flood current conditions on November 4, 1999 were compared to computed average velocity results of the model (negative velocities are considered ebb flow conditions) after the model had been calibrated and verified with the tide data. Despite the slight variation in tide, the peak thalweg currents measured were fairly close to the peak depth-averaged currents that were developed after the calibration process. See Figure 18. The differences could be attributed to the method of single point current measurements used. Mid-depth location was measured and this measurement represented the average current in the channel. This is not actually what occurs in nature since point velocities in the midpoint of the channel are generally higher than the average velocities since bottom friction reduces currents in the channel. The computed velocities would in general be expected to be slightly less than these point measurement velocities since the computed velocities are average velocities over the entire depth. Also, in general, it is noted that velocities (and erosion) that occur in nature will vary depending upon the localized conditions that exist.

To provide a better fit of velocities and tides (and sediment movement) within the model, a more detailed survey with further velocity characterization, as well as further refinement of the model (possibly using a three-dimensional model), would be required. This fine-tuning (with its associated increase in cost) was not pursued since there would be significant problems in gaining a good understanding of the channel configuration. For instance, the channel bottom is fairly erosive and the channels would be subject to rapid changes in bathymetry) caused by high velocities. Also, since the model is only to be used to estimate long-term buildup of sediment in proposed detention basins, the model is believed to provide a sufficiently accurate representation of the existing conditions and can provide a good estimate of the sedimentation processes for the proposed condition.

2. Quonochontaug Pond

As at Winnapaug Pond, tidal conditions occurring on 9 September 1998 were used to initially define the boundary conditions for model simulation of Quonochontaug Pond. Tide data from the Newport, RI NOS tide gage were collected along with established correlation relationships with Block Island Sound tides to develop boundary tide conditions at the inlet for input into the hydrodynamic model. Computed water surface results were compared to measured stages at our tidal gage stations and the viscosity and friction parameters inherent in the model were adjusted to provide a better fit.

In addition, after initial development of the model, two more tidal events occurring on November 5, 1998 and November 3, 1999 (neap tide range = 2.85 feet, high tide elevation = 2.72 feet) were used to provide verification of the model. Further model adjustment was made to develop a reasonably accurate representation of the actual conditions at Quonochontaug Pond. See Figures 19 through 21 that compares the computed versus measured tide elevations at the breach, at the east end (Quonochontaug Yacht Club), and at the west end of the pond (Weekapaug Yacht Club). The variation at peak high tide was less than a few tenths of a foot for any of these events. The September and November 1998 events were spring tide conditions and produced the highest tide within the pond. The November 3, 1999 event was an approximate neap tide range. As before, since the salt ponds' topographic data is based on the SHOALS process there may be some error in precisely matching the channel configuration within the pond and the breachway. The wind conditions were different during the November 3rd tide monitoring. Generally, it was from the south-southeast at about 12 knots, which may have affected the pond slightly, but not as significant as the next day at Winnapaug.

Peak velocities measured in the thalweg during flood current conditions on November 3, 1999 were compared to computed average velocity results of the model after the model had been calibrated and verified with the tide data. See Figure 22 for comparison of compute vs. observed velocities in the channel. Despite the slight variation in tide, the peak thalweg currents measured were fairly close to the peak depth-averaged currents that were developed after the calibration process. The differences could be attributed to the method of single point current measurements used. Mid-depth location was measured and this measurement represented the average current in the channel. Again to provide a better fit of velocities and tides within the model, a more detailed survey with further velocity characterization, as well as further refinement of the model, would be required. The fine-tuning (with its associated increase in cost) was not pursued since the channel bottom is fairly erosive and the channels would be subject to rapid changes in configuration. Also, since the model is to be used to estimate long-term buildup of sediment in proposed detention basins, the model is believed to provide a sufficiently accurate representation of the existing conditions and can provide a good estimate of the sedimentation processes for the proposed condition.

3. Ninigret and Green Hill Ponds

Ninigret Pond and Green Hill Pond were combined during these analyses since they have but one tidal inlet, which produces the majority of the circulation within the two ponds. This pond system was the most complex of the three ponds to analyze. There is a substantial amount of shoaled areas in the Ninigret tidal channel. In general, modeling of shallow conditions caused by the excessive shoaling is very difficult if each small tidal channel is not represented properly. A minor error in topography in the inlet area where the velocities are high could have large impacts on matching conditions.

In addition, there was some concern about the SHOALS data being one to two feet too shallow in the wider, main-pond portions of Ninigret and Green Hill Ponds. (Inaccurate depth was not a concern for the narrow inlet leading to the ponds since SHOALS depth is this area were verified during velocity measurements.) It is not believed that even a two-foot depth change in the wider pond areas would have much influence on tidal movement for two reasons. One, the velocities are very small and resultant impacts on loss of energy in the computer model will be minimal, and, two, the small tide range which occurs because of the restricted inlet channel will not be affected by a change in the deeper portions of the pond. To confirm this assumption, the depth of the wider portions of the pond was artificially lowered in the geometry file for the hydrodynamic model, and this scenario was simulated as a sensitivity test. Results of the computer simulation showed that the computed tidal elevations under existing conditions changed less than a few hundredths of a foot with the artificial deepening of the pond.

Therefore, even if the depths are off by as much as two feet, the computer model provides a reasonably good representation of actual conditions.

Tidal conditions occurring on 9 September 1998 were used to define boundary conditions for model simulation for Ninigret and Green Hill Pond. More effort was spent on ensuring that the model of the Ninigret breachway (where any proposed sediment basins were to be placed) was accurate rather than on the connection to Green Hill Pond. Tide data from the Newport, RI NOS tide gage were collected along with established correlation relationships with Block Island Sound tides to develop boundary tide conditions at the inlet to the breachway for input into the hydrodynamic model. Computed water surface results were compared to measured stages at our tidal gage stations and the viscosity and friction parameters inherent in the model were adjusted to provide a better fit.

After initial development of the model, two more tidal events occurring on October 9, 1998 (spring tide range = 5.05 feet, high tide elevation = 3.61 feet NGVD at Newport) and November 2, 1999 (mean tide range = 3.62 feet, high tide elevation = 3.29 feet NGVD at Newport), were used to provide verification. Further adjustment was made to develop a reasonably accurate representation of the actual conditions at Ninigret and Green Hill Pond. See Figures 23 through 25 that compare the computed versus measured tide elevations at the north end (Ocean House Marina), at the west end (Twin Dolphins Yacht Club), at the Green Hill Bridge and at the east end of Green Hill Pond (Mautucket). The variation at peak high tide was less than a few tenths of a foot for nearly all the locations in Ninigret Pond, including the Green Hill bridge, however, at the east end of Green Hill Pond the variation was on occasion slightly larger. The model indicated a 0.2 to 0.3 foot higher high tide than what was measured. The variation at the east end of Green Hill again is related to the inexact portrayal of the small channels leading up to the bridge. Because of the differences in measured to computed elevations in Green Hill Pond, it is believed the model is not a particularly accurate representation of the east end of Green Hill Pond.

As stated previously, rather than focusing on matching the tide elevations, particularly at Green Hill Pond, more emphasis was placed upon matching measured point velocities. Velocities from two flood tidal flow events on October 9, 1998 and November 2, 1999 were collected to provide another source of data for verification as well as for calibration. Peak velocities measured in the thalweg during flood current conditions were compared to computed average velocities after model calibration using strictly tide data. (See figures 26 and 27 for the results for four locations in the channel.) Despite the slight variation in tide, the peak thalweg currents measured were fairly close to the peak depth-averaged currents that were developed for both the calibration currents of October 1998 and the verification currents of November 1999. Again, the differences could be attributed to the single point current measurements used. Mid-depth location was measured and this measurement represents the channel's average current as computed by the model. To provide a better fit to computed velocities and tides, a more detailed survey, particularly in the area leading up to and into Green Hill Pond, as well as further velocity characterization, would be required. Further fine-tuning of the model (with its associated increase in cost) was not pursued since it is believed the fairly erosive nature of the channels could at any time create rapid changes in the channel configuration. Also, since the model is only to be used to estimate long-term buildup of sediment in proposed detention basins and general circulation pattern differences, it is believed to be a sufficiently accurate representation of the existing conditions. It is believed that dredging changes developed can also provide a good estimate of the sedimentation processes for the proposed condition.

D. Results of Hydrodynamic Modeling

1. General

After a representation of the existing conditions was developed for each pond, the pond was changed to incorporate anticipated project modifications. To this end, each grid of the hydrodynamic model of the three ponds was adapted to include the sedimentation basins and proposed areas of dredging. The initial location was provided after consultation with a technical group made up of: RICRMC, RIDEM, RI Fish and Wildlife Department, and URI Department of Geosciences. The intent of the technical group's pre-selection was to identify an area that not only was located in an area of reduced velocity; but also could be readily accessible for future maintenance; would be located directly in the path of the prevailing flood tide; and could be expected to be relatively stable over time. The placement of the detention basin within any narrow breachway sections was avoided as much as possible, since the limited width of the channel in these areas could potentially affect the banks of the surrounding upland areas as a result of dredging. Selection of a basin having the widest possible width would provide extra capacity that would lengthen the period before future maintenance dredging is required. The reported success of the original sedimentation basin in the Ninigret inlet was also taken into consideration when locating this basin.

Initial estimates of depth were based upon previous experience with sediment basins within the salt pond system. Ninigret Pond, for instance, had a former basin that had been constructed in the early 1950's and dredged in the 1980's. Anecdotal information about the performance of the sediment basin was that this basin had generally provided good sediment removal capability until its capacity was reached within a couple of years time. Since the target material to be removed is of similar granular characteristics, a comparable depth was used as a starting elevation in all the basins. The depth of the former Ninigret Pond basin was determined to be about three to five feet beneath the estimated average depth of the deepest inlet channel. Therefore, the proposed detention basin bottom was estimated to be about minus eight or nine feet NGVD. No other depths were evaluated directly using the hydrodynamic model. Scenarios involving different depths in each basin were evaluated in greater detail based upon economic considerations and anticipated filling rates.

The same technical group provided input into possible locations where flood tidal shoals could be dredged for restoration purposes. In general, the areas selected were located on the outer edges of the existing flood tidal shoals of each pond, and away from the main channel as it enters the pond. The dredging of these areas, defined by the technical group, was evaluated for each pond by subtracting up to one meter from the appropriate portions of the grid. Anything less than a meter was not modeled as the removal of a thinner layer of material from the outer edge of the shoal was difficult to portray. In addition, the dredging of the flood tidal shoal areas is expected to have minimal impact on currents and circulation, since they are not located directly in the path of the main flow channel.

A description of the modifications to each individual pond, along with the impact to the currents and tide conditions, follows.

2. Winnapaug Pond

a. Locating the Sediment Basin

As flow enters the breach for Winnapaug Pond, a riprap-lined jetty has been constructed to maintain a constant opening size. Beyond this point, placement of the sediment basin within the north-south oriented portion was not considered possible, since the inlet channel in this area has a consistent narrow width which is maintained by the developed docks and bank protection that line the channel. The narrow width prevents any significant shoaling within this portion of the channel and also limits the amount of meandering that can take place. In addition, private and public docking facilities lining the channel in this reach provides an incentive to leaving the channel at the same width, rather than to make the channel wider so as to create a sediment basin. As the channel turns to the west from the north-south portion of the channel, the channel is still restricted for an additional 1,000 feet in an S-shaped turn before it widens in the east-west oriented flow pattern, allowing the velocities to reduce and sediment to deposit. It is in this area that shoaling begins to occur, and it is for this reason based upon considerations and input from the technical group that the basin was initially located here. The initial location of the basin that is located approximately 5,000 feet from the entrance jetties.

However, after hydrodynamic computer simulations, the eastern end of the sedimentation basin appeared to be located in an erosional area based upon the magnitude of the velocity vectors. As a result, the basin was shifted approximately 400 feet to the west.

Based upon considerations and input from the technical group, the estimated location of where the shoaled restoration areas are to be dredged were selected in areas where shorebirds do not use.

One use of the hydrodynamic model is to ensure that the sedimentation basin is positioned such that the leading edge of the basin would be perpendicular to the direction of the flood flow velocity vectors. The sediment basin does not guarantee all material will settle out here, however, since some sediment particle sizes may be smaller or with a lesser fall velocity, and would pass right over the basin. In addition, there will be instances when localized channel configuration or flow patterns may allow material to by-pass the basin. Future maintenance dredging should be flexible enough to allow the basin to be shifted slightly to correct for this short-circuiting.

b. Impacts on Circulation Pattern

The second use of the hydrodynamic model is to generally understand the changes in circulation pattern created by dredging a sedimentation basin and excavating material from the shoaled areas of the flood tidal delta. The results show that with the dredging changes there is less than a 0.1-foot of difference in the tidal elevations between existing and proposed conditions. Therefore, there will be minimal if any change expected in the tidal prism and generally minimal if any changes in circulation at the western extremity of Winnapaug Pond.

As a check, velocities were also compared at several locations in the wider areas of pond west of the inlet. From simulations for a spring tide range condition, it was determined that existing peak velocities in the quiescent areas of the pond (the western portion) are very small, varying from less than a few centimeters/second (cm/s) to about 10 cm/s. The proposed simulation shows that there is less than a 5% increase (a few tenths of a centimeter/second increase) in peak velocities at the western edge of the pond resulting from proposed construction of the sedimentation basin and removal of a portion of the shoal. This amount of increase in the western end of the pond would provide nearly immeasurable circulation change.

It was noted, however, that there would be some change in the circulation pattern at the immediate vicinity of the sedimentation basin and the dredged shoaled areas. Figure 28 shows the location of the proposed sedimentation basin and dredged shoal areas. The most dramatic change shown is the sudden drop off in velocities at the location of the sedimentation basin. Modeling shows peak velocities are approximately 1.5 fps for the existing condition versus about 1fps for the proposed condition in the area of the basin.

An estimated 10-year tidal flood was simulated to determine the impacts of flooding with the proposed project. The increase in elevation between existing and proposed conditions was less than 0.1 foot for this event in the extremities of the pond for a purely, tidally-driven event. The estimated existing 10-year flood elevation is shown in Table 2.

3. Quonochontaug Pond

a. Locating the Sedimentation Basin

Based upon general considerations described previously and as a result of input from the technical group, the sediment basin for Quonochontaug Pond was located in the northern end of the breachway, beginning approximately 3200 feet from the end of the inlet jetties. Placement of the sediment basin in the defined, narrow channel less than 2800 from Block Island Sound was not considered necessary since the inlet channel in this area has a consistent narrow width that prevents any significant sediment buildup within the channel or in any areas outside the main channel. Widening the channel in this area could also result in severe impacts to the upland areas bordering the breachway. As the channel widens, after about 2800 feet, material begins to deposit and provides an opportunity to locate a sediment basin, which can be widened as needed to provide sufficient volume for reducing future maintenance dredging. The estimated location of where the shoaled areas are to be dredged based upon considerations and input from the technical group is shown in Figure 29.

Based on review of the velocity vectors from the hydrodynamic model, placement of the sedimentation basin's leading edge is, in general, perpendicular to the direction of the flood flow condition. In addition, through the use of aerial photos, the basin could be located properly since it was placed at the end of the main flow channel entering the pond. During construction, it will be placed perpendicular to the flow pattern in the field. As stated before, the sediment basin does not guarantee all material will settle out here, since some sediment particle sizes may be smaller or have a lesser fall velocity, and would pass right over the basin. In addition, there will be instances when localized channel configuration or flow patterns may allow material to by-pass the basin. Future maintenance dredging should be flexible enough to allow the basin to be shifted slightly to correct for this short-circuiting.

b. Impacts on Circulation Pattern

The second use of the hydrodynamic model is to generally understand the changes in circulation pattern created by dredging a sedimentation basin and excavating material from the shoaled areas of the flood tidal delta. Modeling shows that with dredging there is less than a 0.1-foot difference in the tidal elevations between existing and proposed conditions. Therefore, similar to Winnapaug Pond, there will be minimal if any change expected in the tidal prism and generally minimal if any changes in circulation at the eastern and western extremities of Quonochontaug Pond. As a check, velocities were also compared at several locations in the wider areas of the pond, both west and east of the inlet. From simulations for a spring tide range condition, it was determined that existing peak velocities in the quiescent areas of the pond vary from less than a few centimeters/second (cm/s) at the extremities of the pond to about 10 cm/s as you approach the inlet. The proposed simulation shows that although the percentage velocity change is slightly larger than for Winnapaug, there would still be less than a 10% increase in peak velocities at the extremities of the pond. This amount of increase would provide nearly immeasurable flushing increase because the velocities are so small to begin with.

Again, as at Winnapaug, there will be some change in the circulation pattern in the immediate vicinity of the dredged area of the sedimentation basin and the dredged shoaled areas as shown in Figure 29. The most dramatic change is the sudden drop off in peak velocities of similar magnitude (1.5 fps vs 1.0 fps) as in Winnapaug Pond at the location of the sedimentation basin; however, velocity vectors are changing in the dredged shoaled areas slightly.

An estimated 10-year tidal flood was simulated to determine the impacts of flooding with the proposed project. Similar to Winnapaug, the increase in elevation between existing and proposed conditions was less than 0.1 foot for this event in the extremities of the pond for a purely, tidally-driven event. The estimated existing 10-year flood elevation is shown in Table 2.

4. Ninigret and Green Hill Pond

a. Locating the Sediment Basin

As a result of having the most complex shoaling pattern and the largest historical delta growth rate of all the ponds studied, two options were evaluated for Ninigret\Green Hill Pond. The first option was construction of only one basin just north of the jettied inlet. The second option would be to provide two basins for the Ninigret breachway. Two sediment basins would provide additional capacity for this pond system that has historically averaged twice as much shoaling as either Winnapaug or Quonochontaug ponds.

Perhaps the most significant reason for the higher shoaling rate appears to be that the inlet to the Ninigret breachway is situated near a significant source of sand (East Beach and Charlestown Beach). This sand can easily be made available (through the normal west to east littoral drift pattern, and from the prevailing northern and northeastern winds of tropical and extratropical storms) to enter the breachway transport system. The other two ponds, Winnapaug and Quonochontaug, do not have significantly less tidal exchange than Ninigret, however, the historical shoaling rate in Ninigret is more than twice as large than either pond (4,900 cubic meters/year versus 2,300 cubic meters/year, respectively). The estimated mean tidal prism (the volume of water that enters the ponds) of Ninigret/Green Hill (985 acre-ft) is only slightly greater than Winnapaug (713 acre-ft) and is actually less than Quonochontaug (1,318 acre-ft). It should be noted the Quonochontaug shoaling rate could be underestimated compared to the other two ponds since its characteristic greater depth lends itself to inaccurate measurements of shoaling. The reason for the difference in shoaling is possibly due to local topographic conditions. Both Winnapaug and Quonochontaug appear to have hard points of land located directly east of the inlet that helps to prevent beach material from being transported in a westerly direction during tropical and extratropical storm events.

The first sediment basin location considered for the Ninigret breachway was situated in the general area that the former sediment basin was located, beginning about 1,400 feet inland from the jetty's southerly opening. This basin is critical since it will collect material moving toward Ninigret Pond and also traveling toward Green Hill Pond. It is also the first location where the velocities drop off from the rip rapped lined portion of the jetty inlet structure. The width appears to be sufficient to provide a relatively wide basin that will not undermine the upland areas bordering the channel. Placement of a second possible basin was also considered at the northern end of the breachway, beginning approximately 4,300 feet from the southerly end of the jetties.

As before, an important use of the hydrodynamic model is to ensure that the potential sedimentation basin locations for Ninigret Pond are positioned such that the leading edge of the basin would be perpendicular to the direction of the flood flow velocity vectors. All material will not settle out here, however, since some sediment particle sizes may be smaller or with a lesser fall velocity, and would undoubtedly pass right over the basin.

This is one of the major reasons why a second more northerly basin was evaluated in the second option. It would provide another opportunity for any finer-grained material to settle out that bypasses the first basin. In general, the second basin was located in an area that was perpendicular to the velocity vectors, however, through the use of aerial photos, the location of the basin was adjusted slightly. Future maintenance dredging should be flexible enough to allow the basin to be shifted slightly to correct for any short-circuiting.

b. Impacts on Circulation Pattern

The changes in circulation pattern created by dredging the both basin options (one and two sedimentation basins) and excavating material from the shoaled areas of the flood tidal delta are more pronounced for Ninigret and Green Hill ponds than they were for Winnapaug and Quonochontaug. The reason is apparently the result of increasing the throat width close to Rhode Island Sound. With the dredging, there is a small change in tidal elevation from the existing to proposed conditions at the extremities of Ninigret and Green Hill Pond. Comparison between modeled proposed and existing conditions show that water levels at high tide increase 0.15 to 0.2 feet. This occurs for both the single and two-basin option. For the spring tide range condition of about 1.1 feet within Ninigret Pond, the range will increase approximately 0.2 of a foot. For both options, this amounts to about a 15% change in the tidal prism. Circulation patterns are projected to change slightly in the immediate vicinity of the dredged area of the sedimentation basin and the dredged shoaled areas as shown in Figure 30. The most dramatic change is the sudden drop off in velocities at the location of the southern sedimentation basin which shows peak velocities dropping from 2.6 fps for an existing condition to about 1.6 fps for a proposed condition. In the area of the proposed northern basin, the peak velocity reduction is not as apparent as velocities only change from about 0.5 fps to about 0.4 fps, respectively. This is somewhat expected since the velocity vectors even in the existing conditions in the dredged shoaled areas slightly.

An estimated 10-year tidal flood was simulated to determine the impacts of flooding with the proposed project. Unlike the other two ponds, the increase in elevation between existing and proposed conditions was larger, but still not significant. The difference varied from 0.35-foot to 0.45-foot for this event in the extremities of the pond for this purely, tidally-driven event. The estimated existing 10-year flood elevation is shown in Table 2.

V. SEDIMENT TRANSPORT

A. General Description of Processes

Sediment is transported by flowing water as a bed-load, a saltation load, or as a suspended load. Each mode of transport may occur singly, or combined with one or both remaining modes. Normally, sediment transport occurs intermittently by all three modes. The bed-load is composed of larger particles that move on or near the bed. This load travels along the bed by rolling or sliding, and is in substantially continuous contact with the bed. The saltation load consists of material that bounces along the bed. It is moved directly or indirectly by the impact of the bouncing particles. It is difficult to distinguish the saltation load from the suspended load. The suspended load is composed of small particles that are kept in suspension by turbulent flow. Bed load is believed to be the major mode of problematic sediment movement in the ponds since sediment sampling of shoaled areas of all three ponds has shown that the majority of the material is made up of fine and very fine sand.

B. Data Collection

Several grab samples were collected at mid-depth during the velocity measurements made during peak flood conditions in the Ninigret Pond inlet channel for a spring tide range condition on 9 October 1998. Results of the analysis showed that, the estimated suspended solids portion in the water column was very low with a maximum concentration measured at 10 mg/l. It is believed that although there may be some variation occurring, even an order of magnitude change would not result in suspended solids having a significant input to the sediment movement into the pond. Quonochontaug and Winnapaug Ponds are expected to have even less suspended solids load because apparently the source of sand from nearby beaches is less at these ponds than at Ninigret. This is based on the estimated shoaling rate from the historical analysis provided by Jon Boothroyd, the State of Rhode Island's coastal geologist. His analysis has shown that since 1939, the flood tidal deltas of Ninigret/Green Hill, Winnapaug and Quonochontaug have grown at an annual rate of 4,900 cubic meters, 2,300 cubic meters, and 2,300 cubic meters, respectively. Table 4 presents the summary of Boothroyd's analyses for flood tidal delta growth for the period 1939 to 1995.

The underlying physics of how water moves sediment is not well understood; as a result, there are a large number of formulas (often conflicting) that have been proposed to predict transport. The formulas for bed-load movement, which is the major component of shoal development in the salt ponds, are normally based upon empirical evidence and are generally functions of fluid, flow condition, and sediment properties. Sediment properties commonly used include grain size and density, fall velocity, angle of repose, and volume concentration. Sediment size, distribution, and grain shape are also important. All natural sediment samples contain grains having a range of sizes. However, it is frequently necessary to characterize the sample using a single typical grain diameter as a measure of the central tendency of distribution. The median grain diameter is the sample characteristic most often chosen and is defined as that point by weight where half the particles in the sample will have a larger diameter and half will be smaller. The median diameter is generally written as D_{50}. The sand tested at the shoals in the salt ponds generally had D_{50} ranging from 0.0625 mm to 0.25 mm which is considered very fine to fine sand under the Modified Wentworth Classification of soils. Sand particles are considered to behave in a noncohesive and chemically inert manner and to have a larger fall velocity (settling velocity) than clay or silt. Estimated fall velocity for the majority of the shoal material particles (particle size 0.0625 mm, very fine sand, to 0.25 mm, fine sand) is expected to range from 0.3 cm/sec (0.01 ft/sec) to 3.0 cm/sec (0.1 ft/sec). Estimated critical velocity before movement is initiated for these non-cohesive sand particles is between 15 to 20 cm/sec (0.6 to 0.8 ft/sec). Therefore, when flood velocities are greater than this value, sand will move into the basin.

C. Sediment Transport Computer Modeling

1. General

As a reasonable representation of a hydrodynamic model has been developed for existing conditions for each pond, it is believed that a sediment transport model, even if not fully calibrated, would provide estimated existing erosional and sedimentation patterns. Aerial photography and measured shoals could then be used to qualitatively evaluate the sediment model results to see if erosional and shoaling patterns are similar. If so, information from this transport model can approximate what will happen with the proposed conditions. Even if the existing modeled conditions did not match actual conditions, the differences in the existing to proposed conditions would provide a reasonable estimate of the changes expected.

2. Description of Model

The sediment transport computer model, SED2D-WES, is part of the family of computer programs (Surface Modeling System, SMS) developed at the U. S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi. The system, developed by the Hydraulics Laboratory at the U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi, includes the finite-element, hydrodynamic, and sediment transport models originally developed by Resource Management Associates, Inc., in Davis, California. SED2D-WES had been distributed previously under the earlier model named STUDH. Development of the original STUDH computer program was performed by Dr. Ranjan Ariathurai under the direction of Dr. R. B. Krone at the University of California, Davis (UCD) in 1974. Later versions of the STUDH program were a standard tool for sediment transport analysis during the period 1983 to 1993. From 1993 to the present time, the model was substantially rewritten and modernized by WES personnel to its present state in development.

The SED2D-WES component can be used to compute sediment loading and bed elevation changes when supplied with a hydrodynamic computer solution computed by FASTTABS. It can be used where flow velocities are considered two-dimensional in the horizontal plane (i.e., the speed and direction can be represented as a depth averaged velocity). It can be applied for both noncohesive sediment (sand) and cohesive sediment (clay) for deposition and erosion studies, but the two bed types cannot be contained within the same model. In addition, it is limited for non-cohesive sediment since only one effective grain size can be considered during each simulation.

3. Development of Sediment Transport Model

The hydrodynamic solution was used as input to the SED2D-WES model. A spring tide range condition was used as the boundary condition, similar to what occurred on 9 September 1998. In addition, as a check, an estimated 10-year frequency tidal condition was simulated using the hydrodynamic model for each pond to estimate what impact a storm tide condition would have on interior flood elevations, inlet channel velocities, and sedimentation rates for the proposed conditions. The estimated interior elevation of each pond was presented in Table 2. In general, the inlet channel velocities for the 10-year tidal storm were shown to be approximately twice as large as those velocities that were developed for the 9 September 1998 spring tidal event. Based upon computer modeling, sediment erosion and deposition rates behaved similarly for this more potent tidal condition. The erosion occurred twice as fast, and in areas where deposition occurred, the sedimentation rate was approximately twice as much as a normal spring tidal event. It was important to note that there was not an order of magnitude difference in the amount of sedimentation that occurred during a 10-year event; only about twice the volume of a normal spring tidal event.

The majority of the sediment transport simulations used fine sand as the single grain size, with the estimate of D_{50} set equal to 0.0625 mm and a fall velocity estimated at 0.01ft/sec. This grain size was selected since our purpose was to attempt to determine the capability of the basins to capture most of the smallest expected grain size. If the sedimentation basin could capture fine sand, it is expected that larger grain size would also be captured. The problem that occurs, however, with using the smaller grain size is that this one size exists throughout the grid. The channel bed will therefore easily be eroded in the narrow parts of the breachway. As it erodes, the channel deepens and the cross-section area changes. Due to a safety feature in the model, too large a cross-section change causes the simulation to have computational difficulties since the hydrodynamic solution is no longer accurate with this changed condition. As a result, long-term simulations could not easily be completed without significant manipulation of the model. Therefore, the results of shorter period simulation (generally a minimum length of about 3 tide cycles) were used and the results extrapolated assuming similar erosion and deposition patterns would exist. In this way, long-duration estimates of deposition could be developed for the sedimentation basins. This approach seemed reasonable since, in reality, a continual scouring producing a deep hole will not occur, as the scoured areas will be continuously filled with the sand source from the beaches outside the breachway jetties. It was also believed that the historical shoaling rate provided by Boothroyd would be a check on the anticipated outside limit developed for estimating deposition from this model.

In the case of the 10-year frequency storm tide, only a partial tide cycle (generally from low to high tide) was simulated since so much of the channel eroded that the simulation stopped prematurely.

D. Results of Sediment Transport Model

1. General

Although both existing and proposed project conditions were evaluated using the sediment transport model, more emphasis was placed upon the proposed project conditions since it was to be used to quantify the sediment build up in the proposed basins. The existing conditions were reviewed to determine if the shoaling pattern generally followed what we know of the delta configuration from the aerial photos. As an additional check on qualifying the change in circulation patterns, sediment concentration patterns were monitored for both existing conditions and for the proposed conditions. The particular scenario compared was one, which the fine sand particles were given a fall velocity equal to 0 ft/sec, such that they never settled out. Therefore, if changes were noted in distance of particle spread from the existing condition to that of the proposed condition extent of particle spread, then it can be assumed, at least qualitatively, that circulation has increased with the proposed project. The following sections summarize the result of the sediment transport analyses.

2. Winnapaug Pond

a. Locating the Sediment Basin

Based upon modeled existing conditions for the spring tide range for approximately four tide cycles, sediment deposition patterns appear to mimic delta development displayed in the aerial photography. Although there could be a myriad of other conditions which could change the tidal movement (wind, storms, etc.); these general patterns show the repetitive major forces that cause sediment to erode or deposit in the channels and shoaled areas. From the modeling, it was noted that the narrow channel of Winnapaug leading up to the existing shoal area is erosive and as such, sedimentation will not occur without significant modification to the channel.

Compared to the existing condition, the shoaling pattern does not change that significantly for the proposed condition. However, since the basin is located directly in the path of the main flow pattern of the inlet channel, material deposits to a greater depth in the sediment basin than in the other portions of the shoal. A greater number of tidal cycles would cause similar patterns and add to the depth, however, limitations of the model allow only a finite amount of erosion in the narrow channel areas (high shear stress areas) before simulations end prematurely. In addition, typical or average conditions can be compared, whereas, if long term simulation is desired there is a significant degree of uncertainty in predicting potential unusual shoaling events (i.e. nor'easters, hurricanes, etc.). Due to the difficulties of running long-term simulations for the target grain size, we feel extrapolation of sediment buildup will provide sufficient information for this study.

Two other sediment transport conditions were simulated; one for an estimated 10-year tidal flood event (estimated peak tide of 8 feet NGVD in Block Island Sound) and one for a mean tide condition. The estimated 10-year tidal event produced maximum velocities that were twice as large as the spring tide event and resulted in some erosion of fine grain material along the southern side of the basin with slightly greater than normal deposition occurring along the northern side. The velocities exiting the bend for this size storm event have a tendency to try to move the channel to the south. The erosion, although problematic, occurs during larger storms (10-year frequency) and will not offset the amount of settling occurring during non-storm events. The mean tide condition produced maximum flood tide velocities that were about 70 % of the maximum spring tide velocities. An effort was also made to determine how quickly the proposed sediment basin would fill in. Assuming that there is a sufficient supply of material entering the breach from Block Island Sound, the amount of material that could potentially deposit in the basin would be about 1-foot in depth during the course of one year. This is based upon extrapolating of the volume of material that deposits here for a mean tide condition for an entire year. This would amount to slightly over 3,000 cubic yards.

An analysis was performed to determine the efficiency of collecting the material that would pass through the basin. The grain size results were averaged, for the eight samples collected in the shoaled areas of Winnapaug. These averaged results were input into a relationship developed by Vetter (Hansen, 1973) which describes deposition of a sediment is a function of the fall velocity of sediment, the basin length, and the stream discharge per foot of basin width. This relationship is shown in the following formula:

$$W/W_o = -V_s L/e^q$$

Where W = weight of sediment leaving basin
W_o = weight of sediment entering basin
L = length of basin
q = stream discharge per foot width of basin
e = base of natural logs
V_s = fall velocity of sediment particle

The basin width and length was taken from the modeled grid used for the proposed condition. The stream discharge used velocities and flow area through the basin to come up with discharge. Based on the results of this analysis, approximately 80% of the material that passes through the basin will be captured.

b. Impacts on Circulation Pattern

As a check on determining the impact of changed circulation pattern, a minimal amount of fine-grained suspended solids was input to the ocean-side inlet of the grid and a simulation of spring tidal conditions completed. Comparisons were made to see the maximum extent that the fine-grained material was carried into Winnapaug Pond for both existing and proposed conditions. The results show that there was nearly an imperceptible change in the final distance that the suspended concentration reached into the pond for the proposed versus the existing condition. This difference is representative of the change in flushing that would occur with the proposed condition over what already occurs with the existing condition. This confirms the circulation assessment utilized when comparing velocities in the previous hydrodynamic result section.

3. Quonochontaug Pond

a. Locating the Sediment Basin

Based upon modeled existing conditions for spring tide range for about four tide cycles, sediment deposition patterns at the northern end of the Quonochontaug's inlet channel appear to mimic the delta development displayed in the aerial photo in Figure 29. From modeling, it was noted that the narrow channel of Quonochontaug leading up to the existing shoal area is erosive and as such, sedimentation will not occur without significant modification to the channel.

Compared to the existing condition, the shoaling pattern for the proposed condition does not change that significantly. However, since the basin is located directly in the path of the main flow pattern of the inlet channel, material deposits to a greater depth in the sediment basin than in the other portions of the shoal. A greater number of tidal cycles would cause similar patterns and add to the depth, however, limitations of the model allow only a finite amount of erosion in the narrow channel areas (high shear stress areas) before simulations end prematurely. In addition, typical or average conditions can be compared, whereas, if long-term simulation is desired there is a significant degree of uncertainty in predicting potential unusual shoaling events (i.e. nor'easters, hurricanes, etc.) Due to the difficulties of running long-term simulations for the target grain size, we feel extrapolation of sediment buildup will provide sufficient information for this study.

Two other sediment transport conditions were simulated; one for an estimated 10-year tidal flood event (estimated peak tide of 8 feet NGVD in Block Island Sound) and one for a mean tide condition. Similar to what happened in Winnapaug, the estimated 10-year tidal event produced maximum velocities that were approximately twice as large as the spring tide event. Unlike what occurred in Winnapaug, there was no erosion occurring in the southern basin for this event. The amount of deposition occurred was approximately twice as much as a spring tide event. Similar to the Winnapaug results, the mean tide condition produced maximum flood tide velocities that were approximately 70% of the maximum spring tide velocities. An effort was also made to determine how quickly the proposed sediment basin would fill in. Assuming that there is a sufficient supply of material entering the breach from Block Island Sound, the amount of material that could potentially deposit in the basin could be greater than 2 feet in depth over the course of one year. This is based upon extrapolation of the volume of material that deposits here for a mean tide condition over an entire year. This could amount to greater than 5,000 cubic yards (an amount over twice that calculated by Boothroyd).

An analysis was performed using the Vetter relationship described previously to determine the efficiency of collecting the material that would pass through the basin. The grain size results were averaged, for the six samples collected in the shoaled areas of Quonochontaug. Based on the results of this analysis, approximately 70% of the material that passes through the basin will be captured.

b. Impacts on Circulation Pattern

As a check on determining the impact of changed circulation pattern, a minimal amount of fine-grained suspended solids was input to the ocean-side inlet of the grid and a simulation of spring tidal conditions completed. Comparisons were made to see the maximum extent that the fine-grained material was carried into Quonochontaug Pond for both existing and proposed conditions. Again, there was only a very small change in the final distance that the suspended concentration reached into the pond for the proposed versus the existing condition. This difference is representative of the change in flushing that would occur with the proposed condition over what already occurs with the existing condition. This confirms the circulation assessment utilized when comparing velocities in the previous hydrodynamic result section.

4. Ninigret and Green Hill ponds

a. Locating the Sediment Basins

Based upon modeled existing conditions for spring tide range for about four tide cycles, sediment deposition patterns at the northern end of the Ninigret's inlet channel appear to mimic the delta development displayed in the aerial photo in Figure 30. From modeling, it was found that certain portions of the narrow channel of Ninigret leading up to the existing shoal area are erosive and sedimentation will not occur without significant modification to the channel. These portions include the riprapped lined jetty and in the sinuous channel north of the cutoff to Green Hill Pond. Other portions are only marginally erosive such a north of the riprapped jetty section.

Compared to the existing condition, the shoaling pattern for the two-basin option at the north end of the inlet does not change that significantly. However, since both the north and south basins would be located directly in the path of the main flow pattern of the inlet channel, material deposits to a greater depth in the sediment basin than in the other portions of the shoal. A greater number of tidal cycles would cause similar patterns and add to the depth, however, limitations of the model allow only a finite amount of erosion in the narrow channel areas (high shear stress areas) before simulations end prematurely. In addition, typical or average conditions can be compared, whereas, if long term simulation is desired there is a significant degree of uncertainty in predicting potential unusual shoaling events (i.e. nor'easters, hurricanes, etc.). Due to the difficulties of running long-term simulations for the target grain size, we feel extrapolation of sediment buildup will provide sufficient information for this study.

Two other sediment transport conditions were simulated; one for an estimated 10-year tidal flood event (estimated peak tide of 8 feet NGVD in Block Island Sound) and one for a mean tide condition. Similarly to other two ponds, the estimated 10-year tidal event produced maximum velocities that were twice as large as the spring tide event. At the southern end of the southern basin, velocities were sufficient to cause erosion of larger grain particles (approximately 0.125 millimeter-diameter fine sand). However, at the northern end of the southern basin, velocities dropped off sufficiently to result in deposition of this same fine grain sand. For the two-basin option, the northern basin experienced deposition of this same fine grain sand, however, some erosion may occur at least in the southern portion of the northern basin if very fine sand is present. The erosion, occurring during larger storms (10-year frequency), would be very minor compared to the amount of settling occurs during non-storm events. Again, the mean tide condition produced maximum flood tide velocities that were about 70 % of the maximum spring tide velocities. An effort was also made to determine how quickly the proposed sediment basin would fill in. <u>Assuming that there is a sufficient supply of material entering the breach from Block Island Sound</u>, the amount of material that could potentially deposit in the basin could be greater than 2 feet in depth for the southern basin and greater than 1-foot for the northern basin. This is based upon extrapolation of the volume of material that deposits here for an entire year for a mean tide condition. This could amount to greater than 5,000 cubic yards for the southern basin and greater than 3,500 yards for the northern basin (a total almost twice that calculated in Boothroyd's study).

As before, an analysis was performed using the Vetter relationship described previously to determine the efficiency of collecting the material that would pass through both basins evaluated for the Ninigret. The grain size results were averaged, for the twelve samples collected in the shoaled areas of Ninigret. Based on the results of this analysis, approximately 65% would be captured in the southern basin for both options and an additional 20% would be captured in the northern basin for the two-basin option resulting in a total 85% capture rate for two-basin option. As before, this analysis assumes that only that portion of sediment that passes through the basin will be captured

b. Impacts on Circulation Pattern

As a check on determining the impact of changed circulation pattern, a minimal amount of fine-grained suspended solids was input to the ocean-side inlet of the grid and a simulation of spring tidal conditions completed. A comparison was made to show the maximum extent that the fine-grained material was carried into Ninigret and Green Hill Pond for both existing and proposed conditions. The two-basin option and the single-basin option produced very similar results since the southern basin causes the largest impact on water levels in the far reaches of the pond. Since the northern basin is located in an area which has very low velocities to begin with, whether there is a basin there or not does not make that much of a difference between existing and proposed conditions.

When comparing the proposed options versus the existing conditions, modeling shows that there was only a small increase in the final distance that the suspended concentration reached into the pond for the proposed versus the existing condition. This difference is representative of the change in flushing that would occur with the proposed condition over what already occurs with the existing condition. The change in difference between the distance that the suspended sediment reaches between the proposed condition and the existing condition appears to be minimal. However, it confirms the conclusion that circulation will be somewhat increased.

VI. Conclusions

A computer model was developed to analyze the impact of proposed dredged conditions on circulation (velocity magnitude and direction, tidal elevation, etc.) within the three ponds in the study area: Winnapaug Pond, Quonochontaug Pond, and Ninigret/Green Hill Pond. Major tasks included collecting and analyzing tidal and current data, developing of a two-dimensional hydrodynamic model of each pond in the study area for existing conditions, and using this model to compare present conditions to proposed restoration conditions. Approximate analyses were also performed using results of the hydrodynamic model in tandem with a sediment transport computer model to identify sediment movement within the ponds. The majority of the sediment analyses focused on the shoaled areas and on potential sedimentation basins in the inlet channels.

To identify potential water quality problems associated with seagrass restoration, the University of Rhode Island Graduate School of Oceanography (URI GSO) also completed an abbreviated water quality, data-collection program. They measured selected water quality parameters that could affect seagrass growth in the pond. Detailed discussion of the water quality data is presented in the URI GSO report (see Appendix A).

From mapping developed during the study (SHOALS), all three of these ponds possess a tidal inlet having a minimum depth of 3 feet below mean low water. It is noted, however, that the channel location meanders periodically within the shoaled area at times creating a hazard to mariners. This is particularly true in Ninigret where the main tidal inlet is nearly entirely shoaled, with a deeper, narrow channel generally varying from 20-30 feet wide. Ninigret's meandering inlet channel leading up to the flood tidal shoal area generally had an elevation of minus 4 feet NGVD. Quonochontaug's inlet channel, which is fairly straight, generally had an elevation below minus 8 feet NGVD. Winnapaug's inlet channel generally had elevations below minus 6 feet NGVD.

Mean tide range for the Ninigret Pond, based upon a three-month monitoring period, is slightly over 0.5 feet. Estimated mean tide ranges for Green Hill, Winnapaug and Quonochontaug, based upon correlation of short-term tidal monitoring with the longer-term Ninigret Pond monitoring, were 0.3 feet, 1.6 feet and 1.8 feet, respectively. Mid-depth velocities in the thalweg of the channel during peak flood tide conditions were measured twice for the Ninigret Pond inlet and once each for Quonochontaug and

Winnapaug inlets. Measured velocities are high enough to easily produce transport of non-cohesive fine sand particles, which are generic to the shoals of the ponds.

After a representation of the existing conditions was developed for each pond, the pond was changed to incorporate anticipated project modifications. The initial location for the restoration areas and sedimentation basins was provided after consultation with a technical group made up of: RICRMC, RIDEM, the RI Fish and Wildlife Department, and URI Department of Geosciences. One basin was placed in both Winnapaug and Quonochontaug in an area where the model predicted velocities would drop off sufficiently to enhance sedimentation. Two options, a two-basin and a single-basin option were analyzed in the Ninigret inlet channel. For both options, a southerly basin is located just north of the riprapped jetty portion of the inlet. For the two-basin option, the second basin is located along the north edge of the flood tidal shoal area. In general, the sedimentation basin areas selected for Winnapaug and Quonochontaug were located on the outer edges of the existing flood tidal shoals of each pond, and away from the main channel as it enters the pond. For analysis purposes, the proposed detention basin bottom elevations were estimated to be about minus eight or nine feet NGVD.

The majority of the sediment transport simulations used fine sand as the single grain size, with the estimate of D_{50} set equal to 0.0625 mm and a fall velocity estimated at 0.01ft/sec. This grain size was selected since our purpose was to attempt to determine the capability of the basins to capture most of the smallest expected grain size.
Based upon the modeling completed, typical sediment present in the shoaled areas of the pond will settle out within the proposed basin locations. However, all transported sediment may not settle out there, since some particle sizes may be smaller or with a lesser fall velocity, and could pass right over the basins. In addition, there will be instances that localized channel configuration or flow patterns may allow material to by-pass the basin. Future maintenance dredging should be flexible enough to allow the basin to be shifted slightly to correct for this short-circuiting.

The proposed condition of partial shoal removal and basin construction shows that there will be less than a 10% increase (a few tenths of a centimeter/second increase) in peak velocities at the extremities of Winnapaug and Quonochontaug Pond. An estimated 10-year tidal flood event will increase flood levels by less than a 0.1-foot in these ponds over what would occur under existing conditions. This amount of increase in the extremities of the pond would provide nearly immeasurable circulation change. The construction of either the two-basin or single-basin option with partial flood tidal shoal removal for Ninigret/Green Hill ponds will provide an increase of about 15% from the original estimated tidal prism. An estimated 10-year tidal flood event will increase flood levels between 0.35-foot to 0.45-foot in Ninigret and Green Hill ponds over what would occur under existing conditions. The change in circulation is still considered minimal; however, there will be an improvement. As in the case of all ponds, the major improvement will be in the circulation pattern in the immediate vicinity of the dredged shoal area and the sedimentation basins.

TABLE 1

TIDAL DATUM PLANES
ESTIMATED OCEAN LEVELS AT
RHODE ISLAND COASTAL PONDS

DESCRIPTION	ELEVATION (FT. NGVD)
100-YEAR FREQUENCY STORM	11.9
50-YEAR FREQUENCY STORM	11.3
10-YEAR FREQUENCY STORM	7.9
1-YEAR FREQUENCY STORM	3.9
MEAN SPRING HIGH WATER	2.0
MEAN HIGH WATER	1.6
MEAN TIDE LEVEL	0.4
NATIONAL GEODETIC VERTICAL DATUM	0.0
MEAN LOW WATER	-1.0
MEAN SPRING LOW WATER	-1.2

TABLE 2
ESTIMATED TIDAL CHARACTERISTICS

	Newport NOAA gage	Estimated Ocean Condition at ponds inlet	Estimated Ninigret Pond Tidal Condition	Estimated Green Hill Pond Tidal Condition	Estimated Winnapaug Pond Tidal Condition	Estimated Quonochon. Pond Tidal Condition
Mean tide range	3.5 feet	2.6 feet	0.5 feet	0.3 feet	1.6 feet	1.8 feet
Mean Spring tide range	4.4 feet	3.2 feet	0.6 feet	0.4 feet	2.0 feet	2.3 feet
Mean spring high water	2.7 feet NGVD	2.0 feet NGVD	1.3 feet NGVD	1.0 feet NGVD	1.7 feet NGVD	1.7 feet NGVD
Mean high water NGVD (Est. lag time in hours from Newport NOAA gage)	2.25 feet NGVD (0.0 hours)	1.6 feet NGVD (+0.5 to +1.0 hours)	1.1 feet NGVD (+2.5 to +3.0 hours)	0.95 feet NGVD (+4.0 to +5.0 hours)	1.4 feet NGVD (+2.3 to +2.8 hours)	1.4 feet NGVD (+2.0 to +2.5 hours)
Mean tide level	0.5 feet NGVD	0.4 feet NGVD	0.8 feet NGVD	0.8 feet NGVD	0.6 feet NGVD	0.5 feet NGVD
Mean low water (Est. lag in hours from Newport NOAA gage)	-1.25 feet NGVD (0.0 hours)	-1.0 feet NGVD (+1.0 to +1.5 hours)	0.6 feet NGVD (+4.0 to +4.5 hours)	0.65 feet NGVD (+6.0 to +7.0 hours)	-0.2 feet NGVD (+3.5 to +4.0 hours)	-0.4 feet NGVD (+3.0 to +3.5 hours)
Mean lower low water	-1.4 feet NGVD	-1.1 feet NGVD	0.5 feet NGVD	0.6 feet NGVD	-0.3 feet NGVD	-0.5 feet NGVD
Mean spring low water	-1.7 feet NGVD	-1.2 feet NGVD	0.4 feet NGVD	0.6 feet NGVD	-0.4 feet NGVD	-0.6 feet NGVD
Estimated pond area (from RI Fish and Wildlife – 1976)			1711 acres	431 acres	446 acres	732 acres
Estimated tidal prism during mean tide range (pond area x mean tide range =)			856 acre-ft	129 acre-ft	713 acre-ft	1318 acre-ft
Est. 10-year stillwater flood elevation	6.5 feet NGVD	8.0 feet NGVD	4.3 feet NGVD	4.2 feet NGVD	5.9 feet NGVD	6.6 feet NGVD

TABLE 3

SUMMARY OF PEAK FLOOD TIDAL CURRENTS
COLLECTED IN THE BREACHWAY OF SALT PONDS

NINIGRET BREACHWAY

9 OCTOBER 1998 (ESTIMATEDTIDE RANGE AT NEWPORT - 5.05 FEET)

MARKER 1 - 3.06 FPS (CLOSEST TO OCEAN)
MARKER 2 - 3.44 FPS
MARKER 3 - 1.65 FPS
MARKER 4 - 2.6 FPS
MARKER 5 - 3.1 FPS

2 NOVEMBER 1999 (ESTIMATED TIDE RANGE AT NEWPORT – 3.62 FEET)

MARKER 1 - 3.1 FPS (CLOSEST TO OCEAN)
MARKER 2 - 2.91 FPS
MARKER 3 - 1.37 FPS
MARKER 4 - 2.01 FPS
MARKER 5 - 2.86 FPS

QUONOCHONTAUG BREACHWAY

3 NOVEMBER 1999 (ESTIMATED TIDE RANGE AT NEWPORT – 2.85 FEET)

MARKER 1 - 1.52 FPS
MARKER 2 - 2.1 FPS
MARKER 3 - 2.88 FPS
MARKER 4 - 3.52 FPS (CLOSEST TO OCEAN)

WINNAPAUG BREACHWAY

4 NOVEMBER 1999 (ESTIMATED TIDE RANGE AT NEWPORT – 3.44 FEET)

MARKER 1 - 1.65 FPS
MARKER 2 - 1.36 FPS
MARKER 3 - 2.17 FPS
MARKER 4 - 1.56 FPS (CLOSEST TO OCEAN)

TABLE 4

FLOOD-TIDAL DELTA GROWTH 1939-1995
DEVELOPED BY JOHN BOOTHROYD

NINIGRET

Time	Total Area Change (Sq. meters)	Years	Area Change/Year (Sq. meters)
1939	82,300		Start
1939 – 1951	25,980	12	2,165
1951 – 1963	78,160	12	6,513
1963 – 1972	62,000	11	5,636
1972 – 1975	8,374	3	2,791
1975 – 1980	19,020	5	3.804
1980 – 1985	43,210	5	8,642
1985 - 1992	13,360	7	1,909
1992 – 1995	22,200	3	7,400

Total Area 354,604

(Assume 1 meter thick, volume rate of buildup = 4,900 cubic meters/56 years (1939-1995))
Area/ year = 52,745 sq. ft., 11.5 feet/year of linear growth of shoals

QUONOCHONTAUG

Time	Total Area Change (Sq. meters)	Years	Area Change/Year (Sq. meters)
1939	156,200		Start
1939 – 1951	8,935	12	745
1951 – 1963	72,400	12	6,033
1963 – 1972	11,230	11	1,021
1972 – 1975	3,818	3	1,273
1975 – 1981	9,522	6	1,587
1985 – 1995	14,020	10	1,402

Total Area 276,125

(Assume 1 meter thick, volume rate of buildup = 2,300 cubic meters/52 years (1939-1995))
Area/ year = 24,758 sq. ft., 14.5 feet/year of linear growth of shoals

TABLE 4 (cont.)

FLOOD-TIDAL DELTA GROWTH 1939-1995
DEVELOPED BY JOHN BOOTHROYD

WINNAPAUG

Time	Total Area Change (Sq. meters)	Years	Area Change/Year (Sq. meters)
1939	185,900		Start
1939 – 1951	18,290	12	1,524
1951 – 1963	57,310	12	4,776
1963 – 1972	16,020	11	1,456
1972 – 1975	10,030	3	3,343
1975 – 1980	9,886	5	1,977
1980 – 1985	6,059	5	1,212
1985 - 1992	8,502	7	1,215
1992 – 1995	3,799	3	1,266
Total Area	315,796		

(Assume 1 meter thick, volume rate of buildup = 2,300 cubic meters/56 years (1939-1995))
Area/ year = 24,758 sq. ft., 11.0 feet/year of linear growth of shoals

RHODE ISLAND BARRIERS AND HEADLANDS

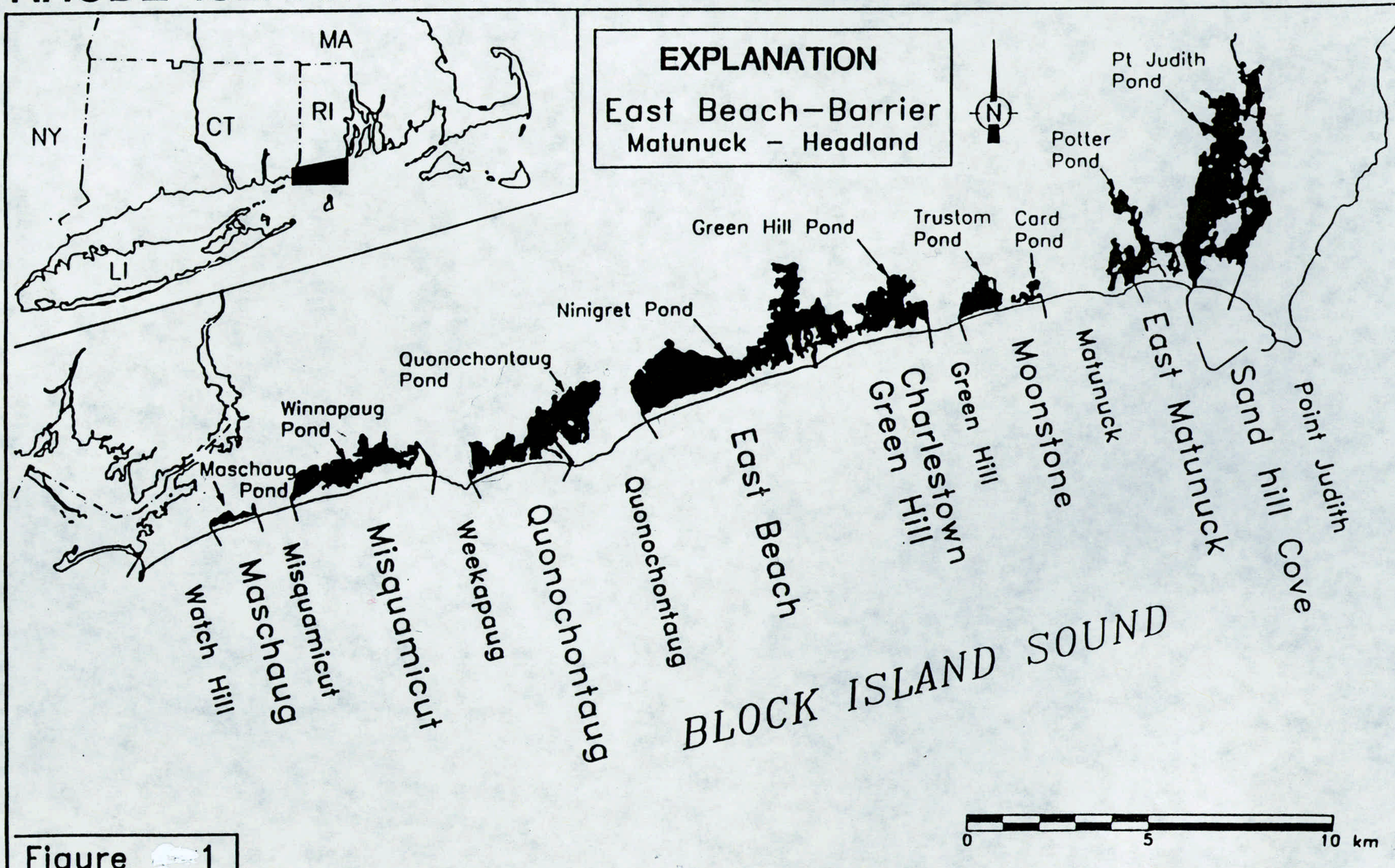


Figure 1

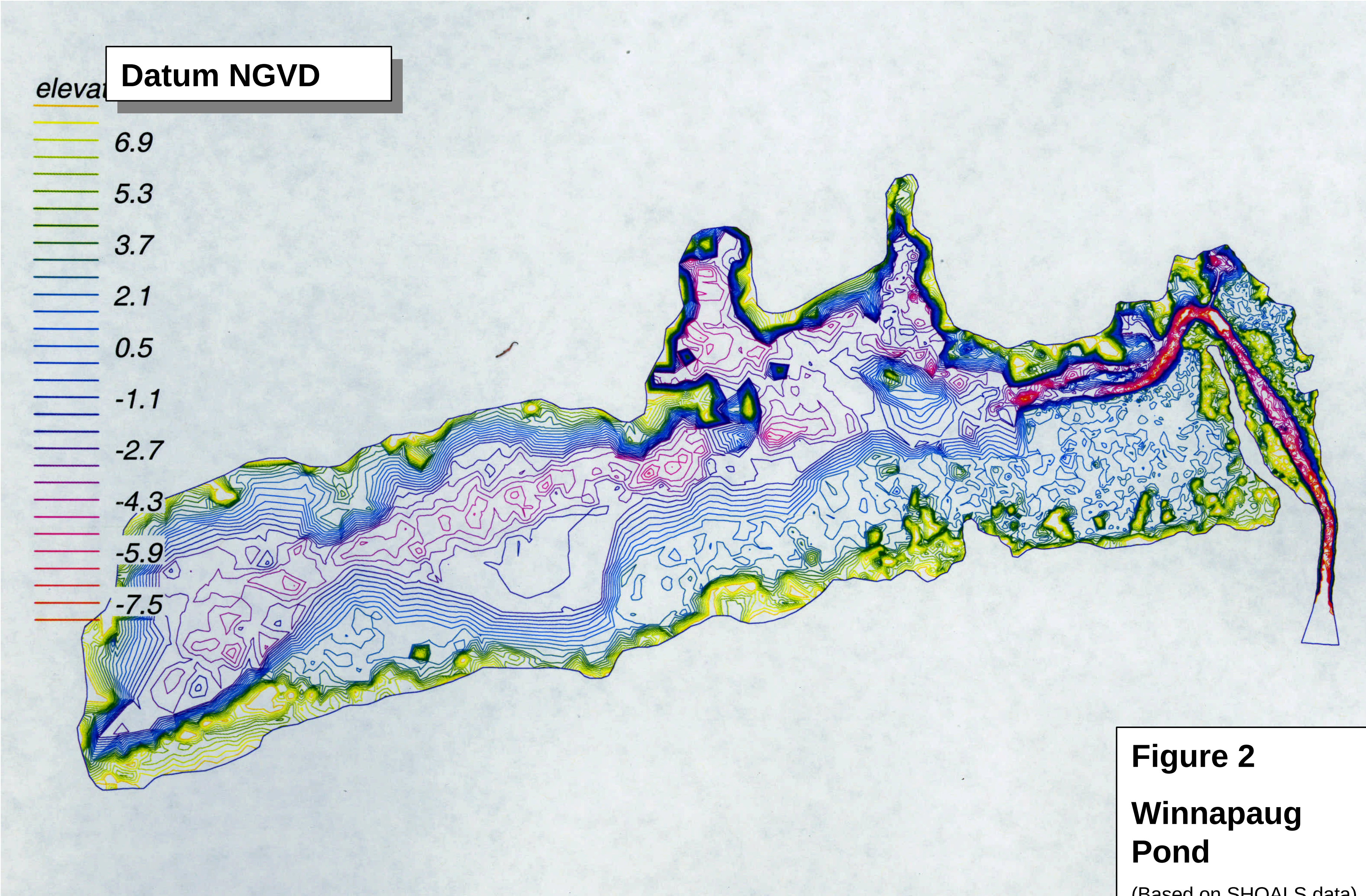


Figure 2

Winnapaug Pond

(Based on SHOALS data)

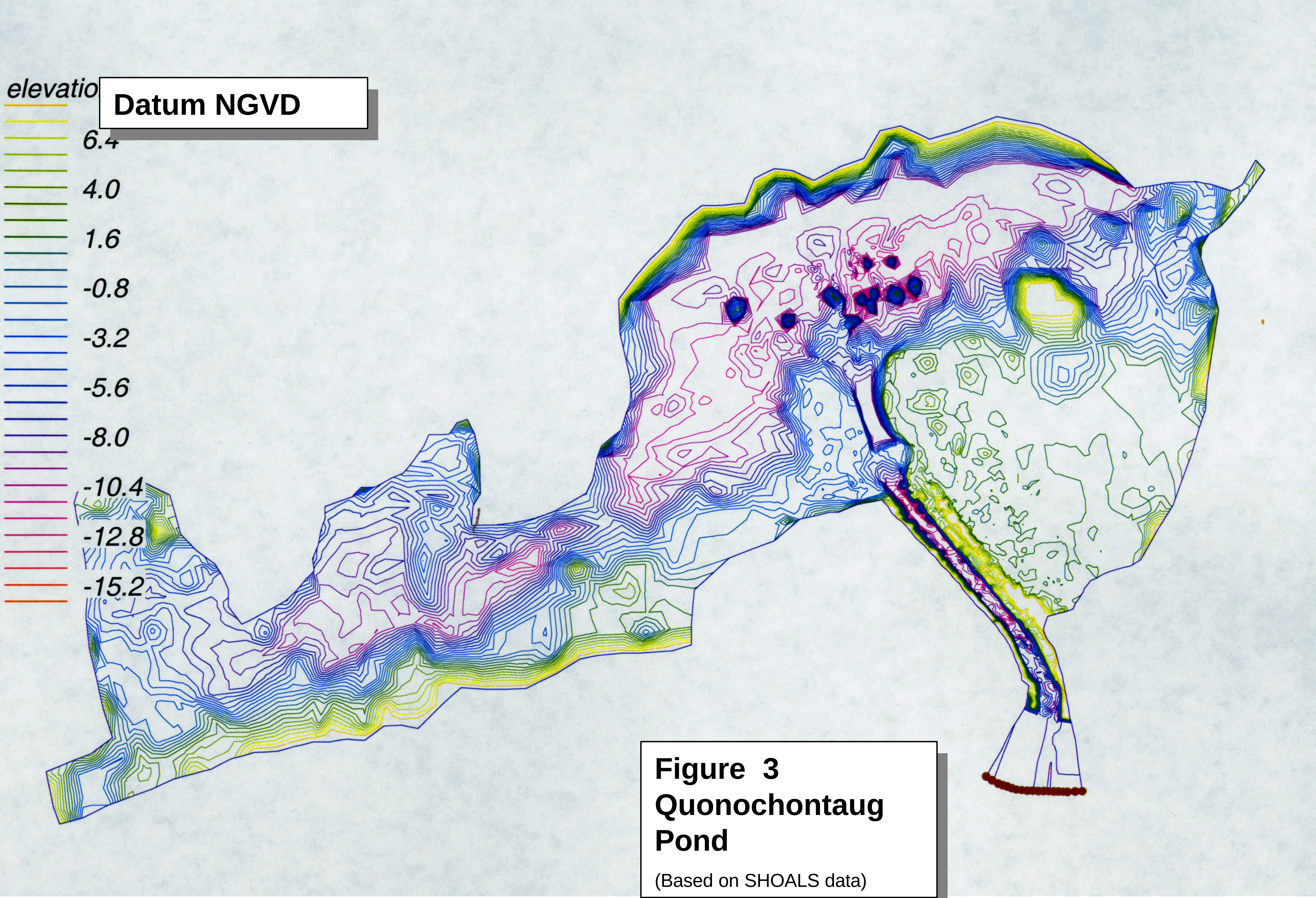


Figure 3
Quonochontaug Pond

(Based on SHOALS data)

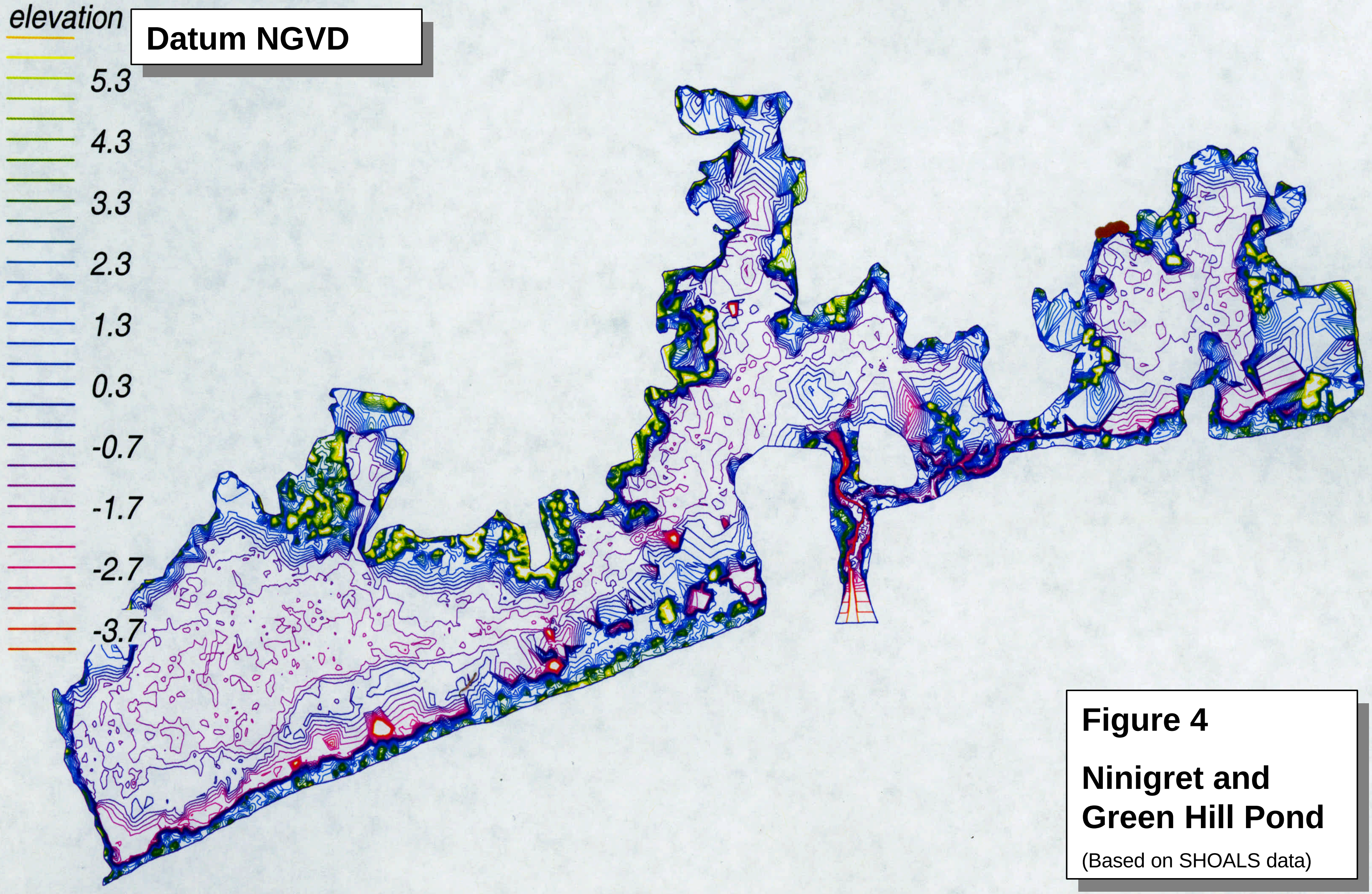


Figure 4

Ninigret and Green Hill Pond

(Based on SHOALS data)

NINIGRET POND TIDE GAGE LOCATIONS

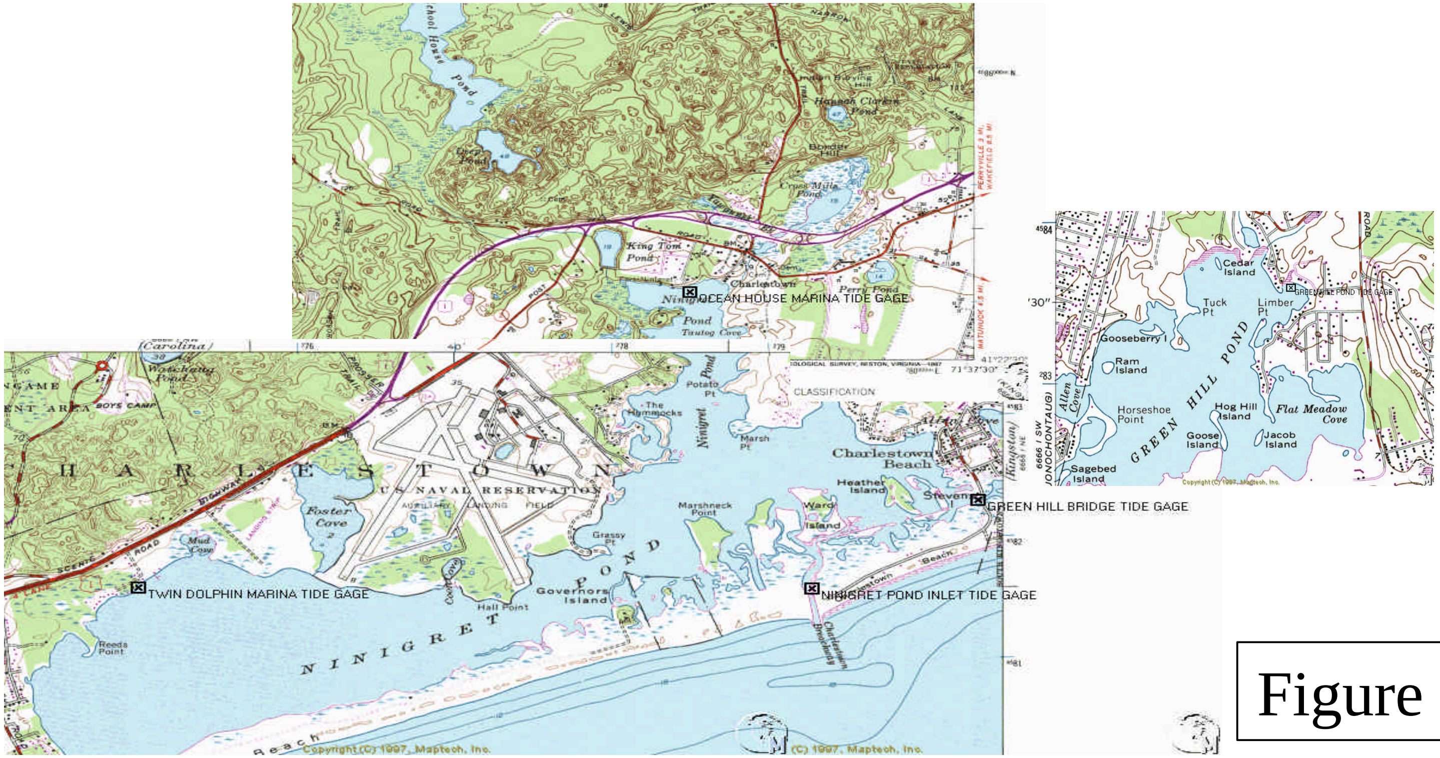


Figure 5

FIGURE 6
QUONOCHONTAUG POND TIDE GAGE LOCATIONS

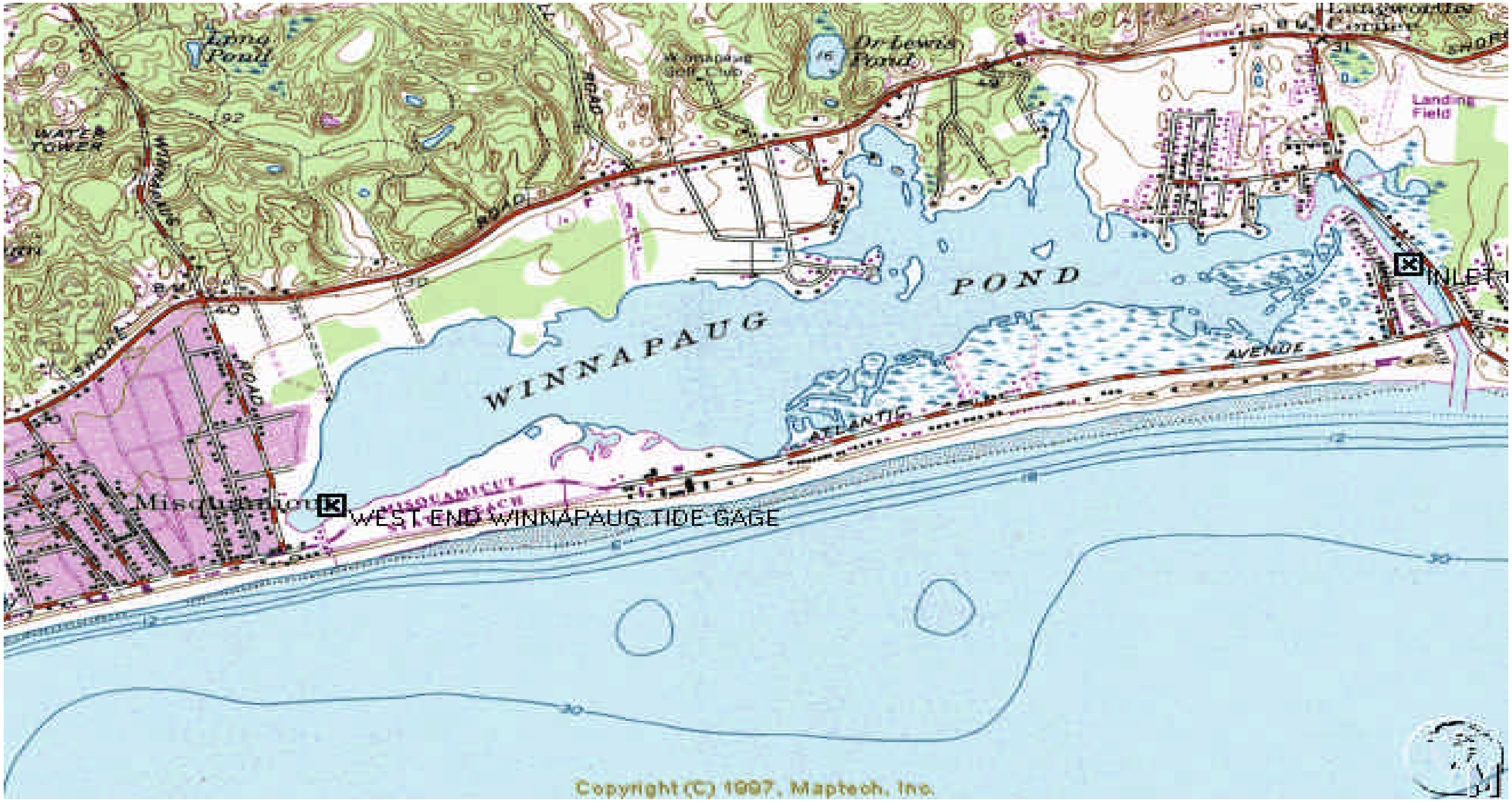
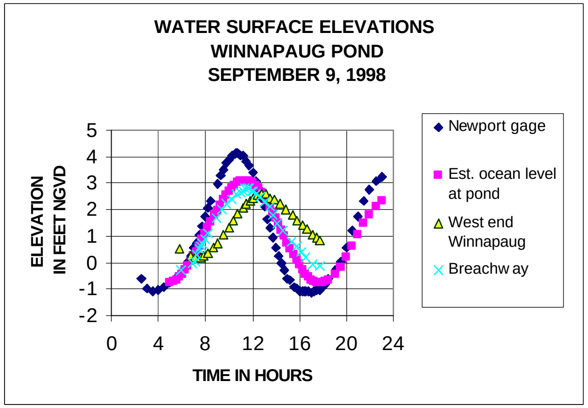
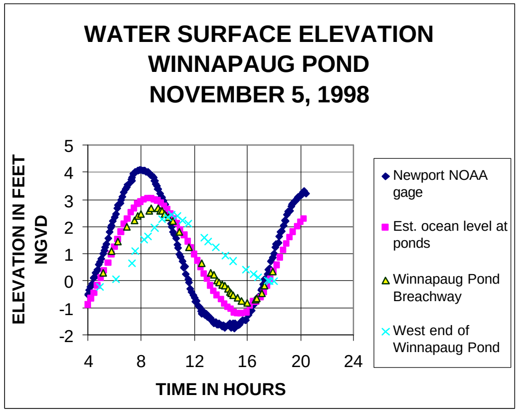


FIGURE 7
WINNAPAUG POND
TIDE GAGE LOCATIONS

MEASURED WATER SURFACE ELEVATION WINNAPAUG POND





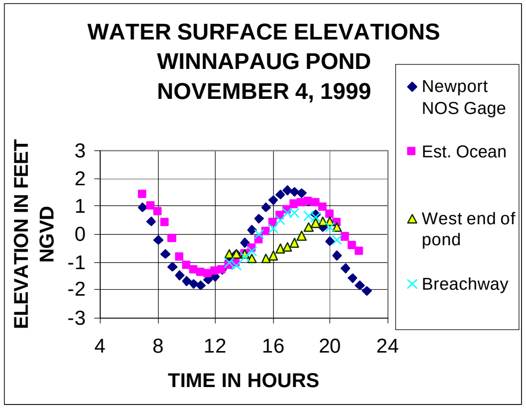
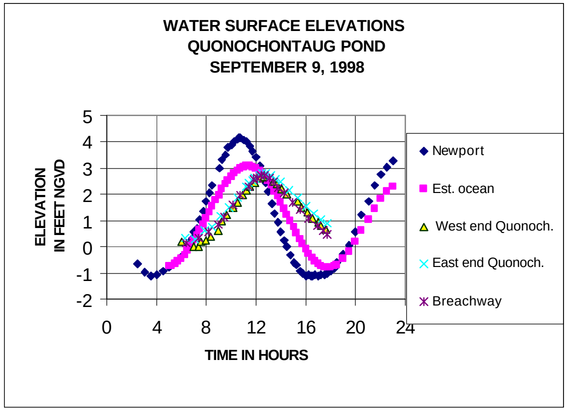
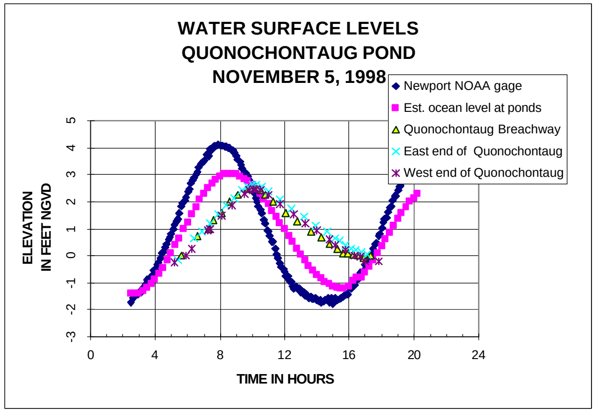


Figure 8

MEASURED WATER SURFACE ELEVATION
QUONOCHONTAUG POND





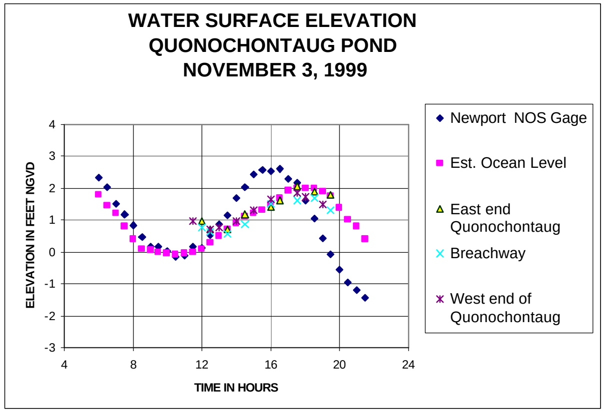
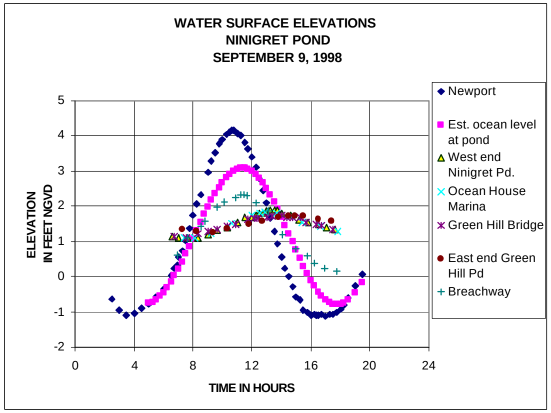
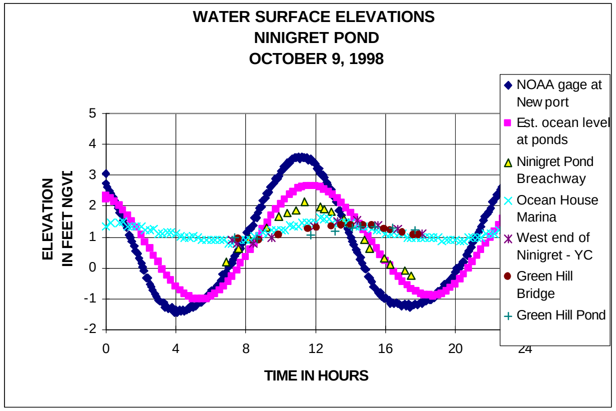


Figure 9

MEASURED WATER SURFACE ELEVATION
NINIGRET/GREEN HILL PONDS





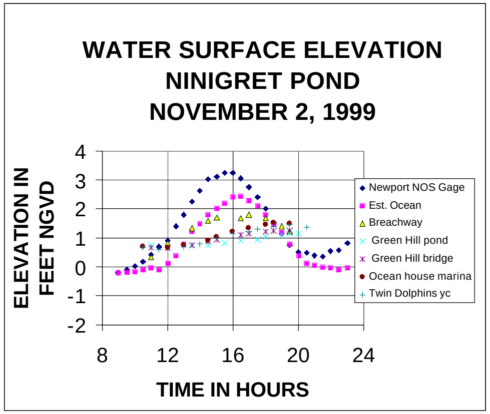
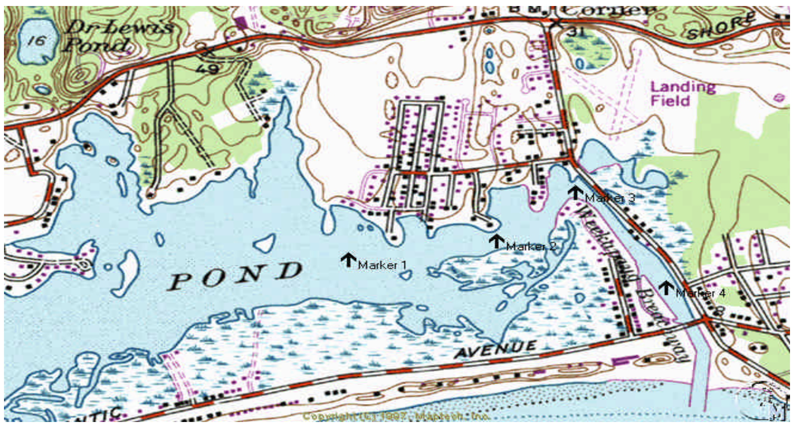
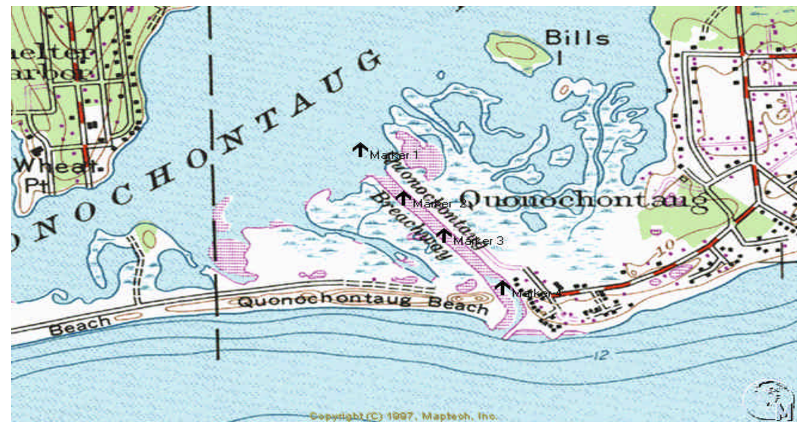


Figure 10

LOCATION OF VELOCITY MEASUREMENTS
WINNAPAUG, QUONOCHONTAUG, NINIGRET PONDS





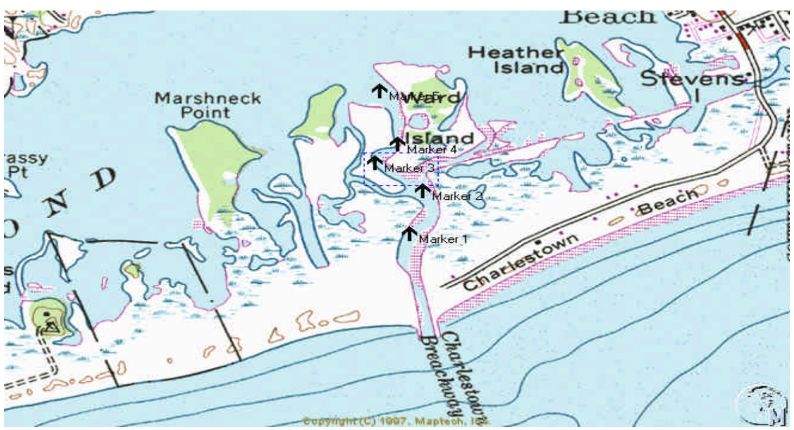
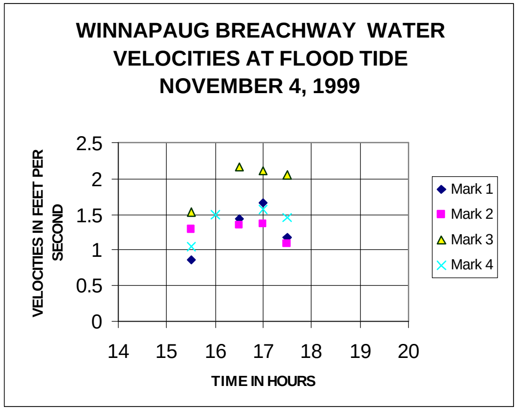
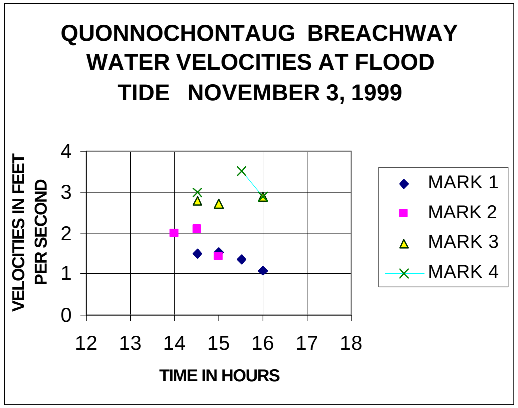
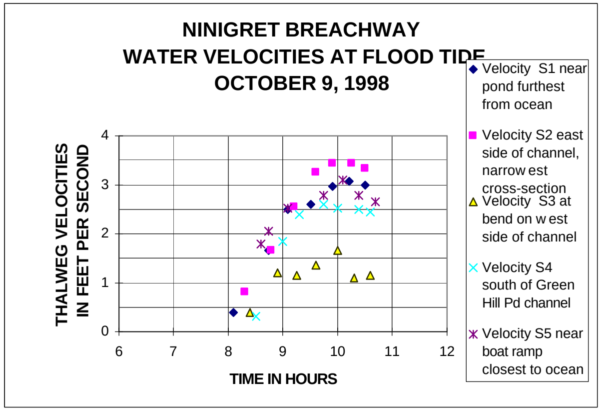


FIGURE 11

MEASURED INLET VELOCITIES
WINNAPAUG, QUONOCHONTAUG, NINIGRET PONDS







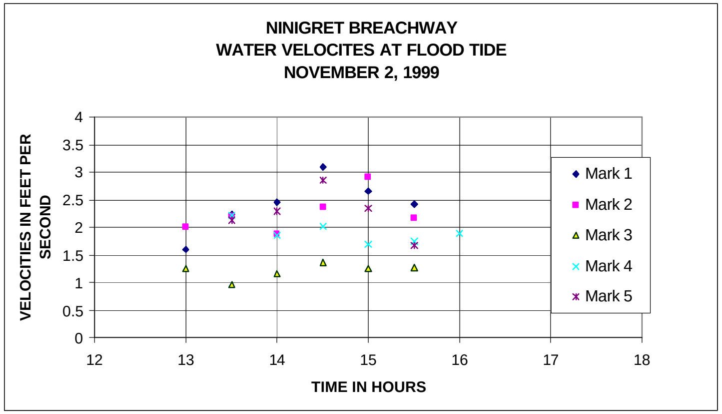


Figure 12

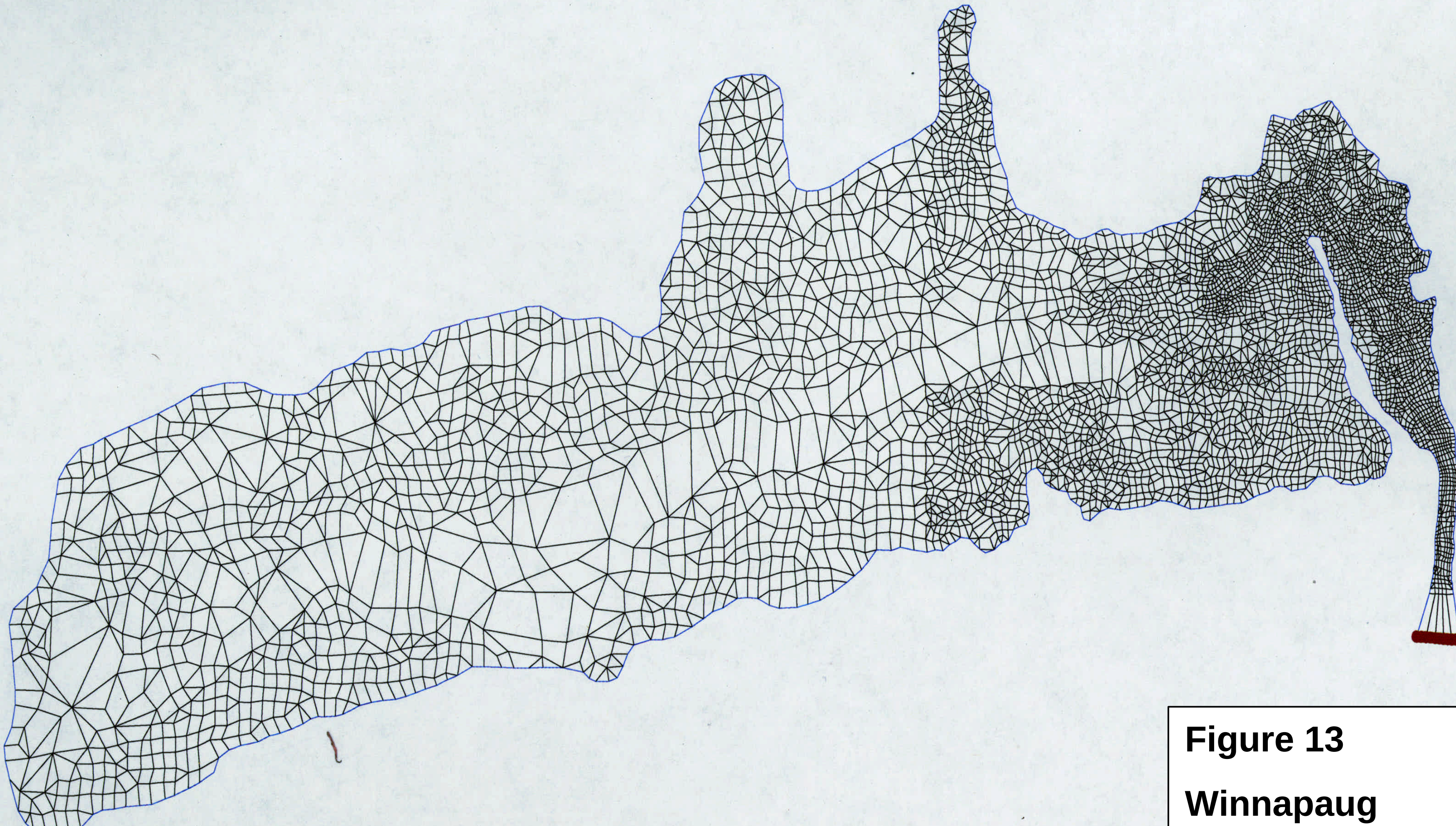


Figure 13

Winnapaug Pond

ModelingGrid

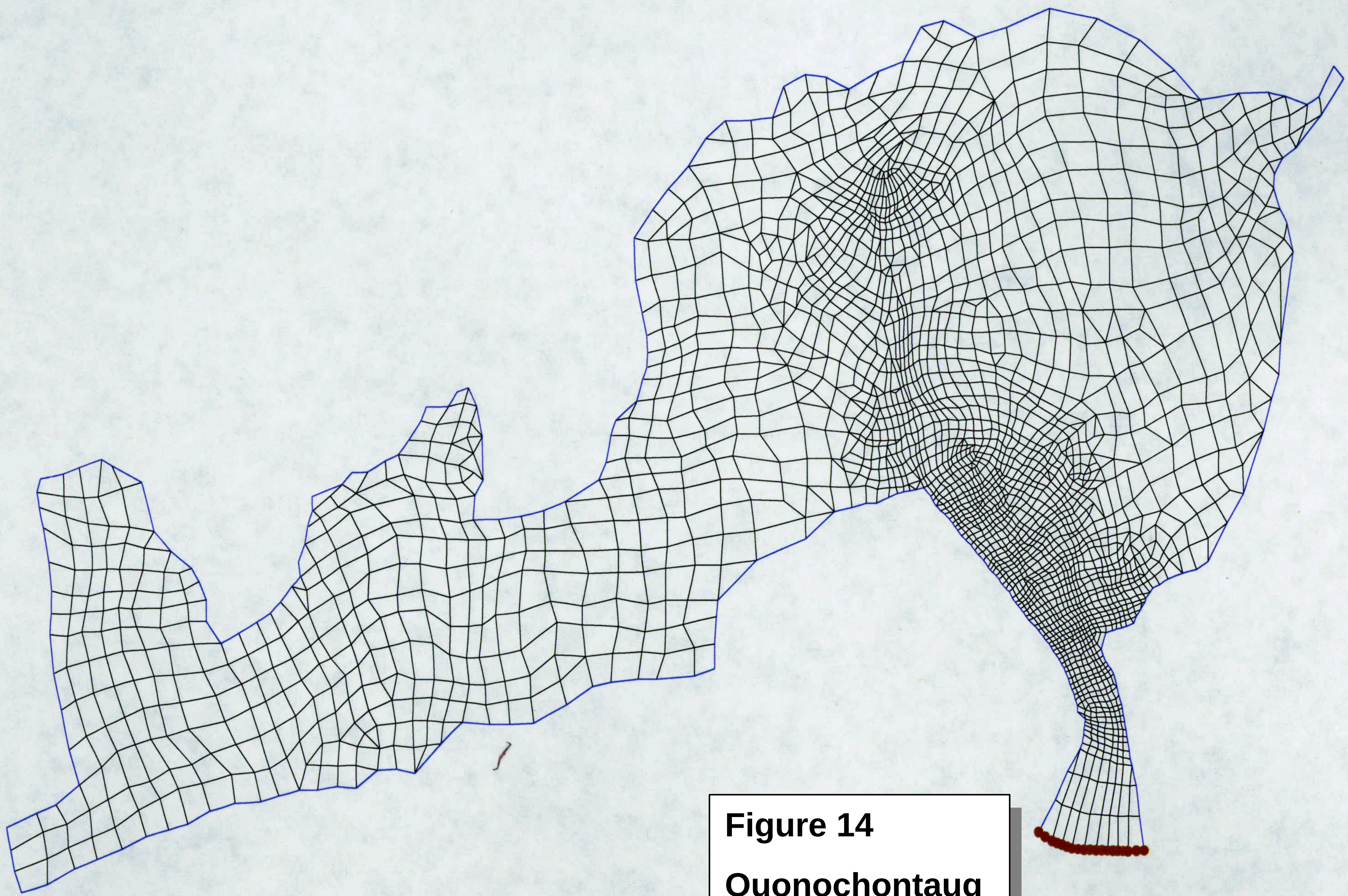


Figure 14

Quonochontaug Pond

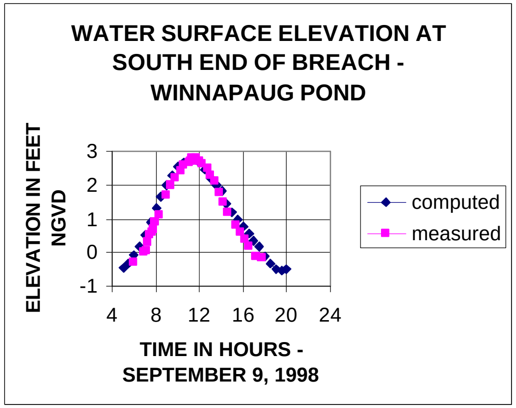
Modeling Grid

Figure 15

Ninigret and Green Hill Pond

Modeling Grid

COMPARISON OF WATER SURFACE ELEVATIONS COMPUTED VS OBSERVED WINNAPAUG POND 9 SEPT 1998



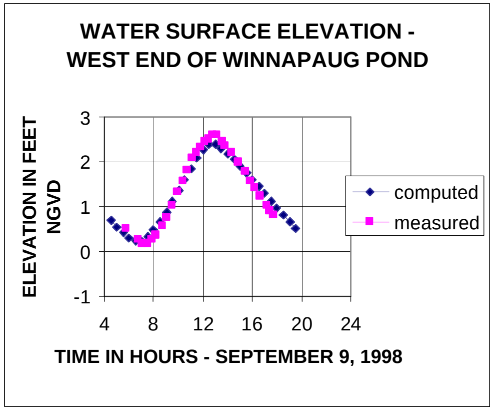


Figure 16

COMPARISON OF WATER SURFACE ELEVATIONS COMPUTED VS OBSERVED WINNAPAUG POND

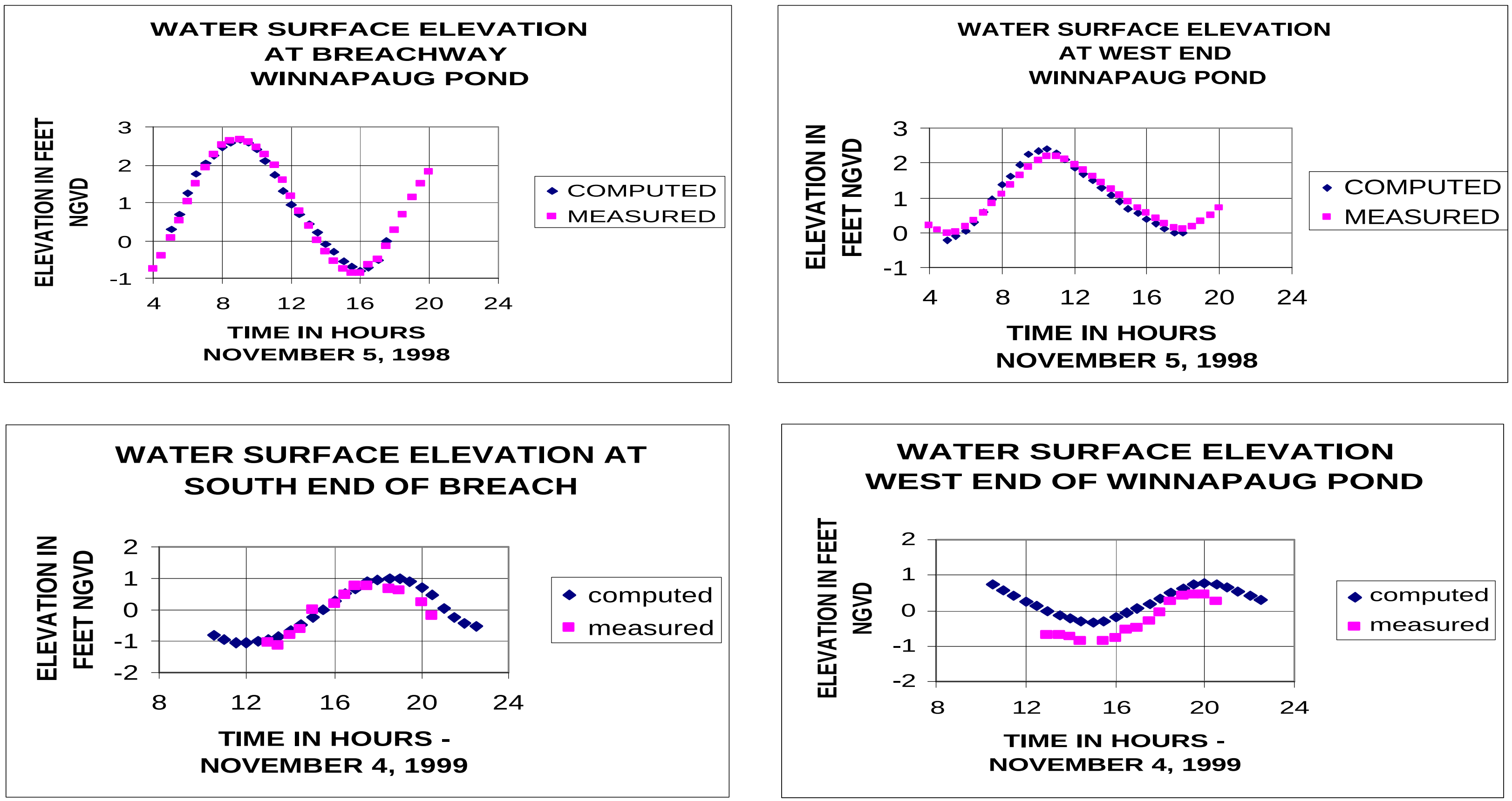


Figure 17

COMPARISON OF INLET VELOCITIES
COMPUTED VS OBSERVED
WINNAPAUG POND

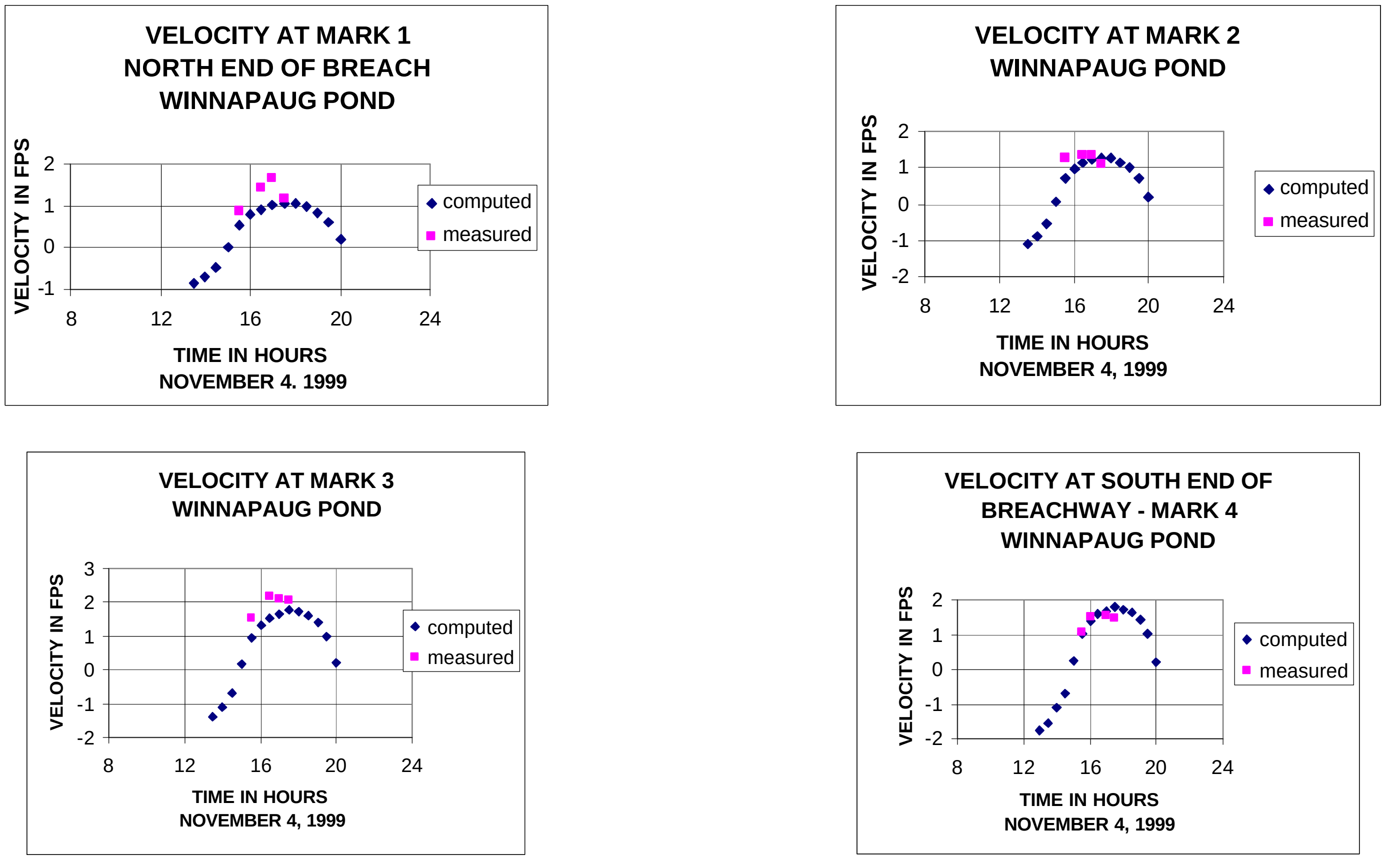
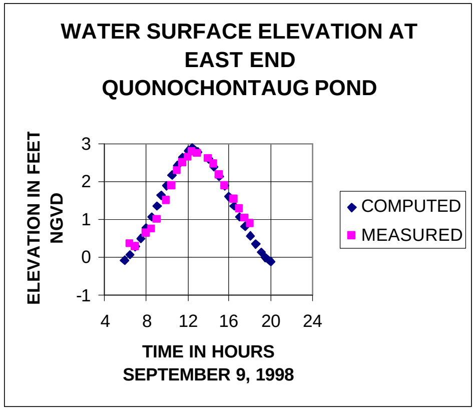
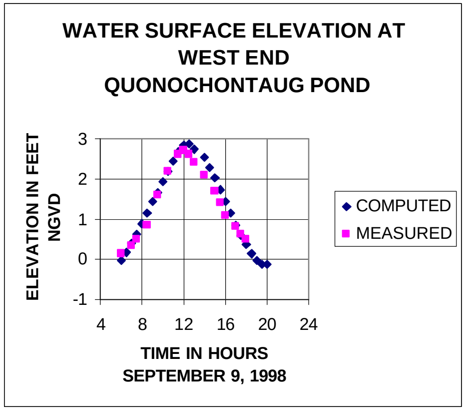


Figure 18

COMPARISON OF WATER SURFACE ELEVATIONS COMPUTED VS OBSERVED QUONOCHONTAUG POND 9 SEPTEMBER 1998





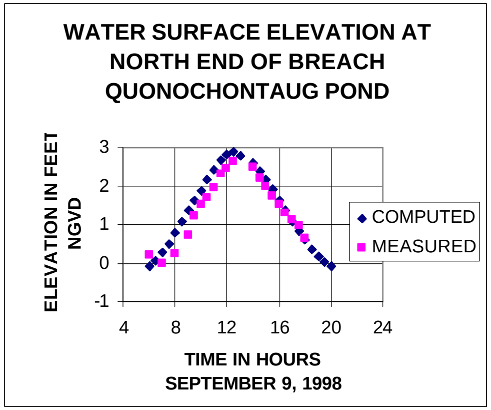
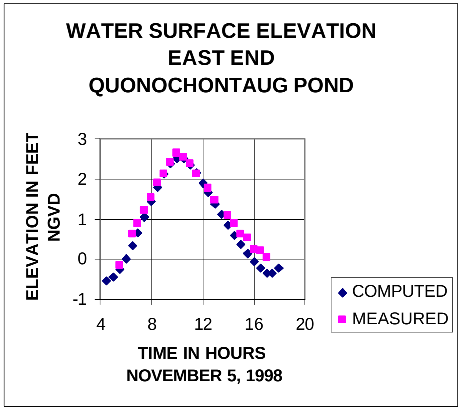
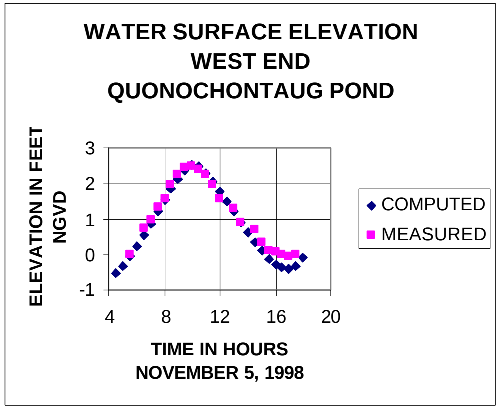


Figure 19

COMPARISON OF WATER SURFACE ELEVATIONS COMPUTED VS OBSERVED QUONOCHONTAUG POND 5 NOVEMBER 1998





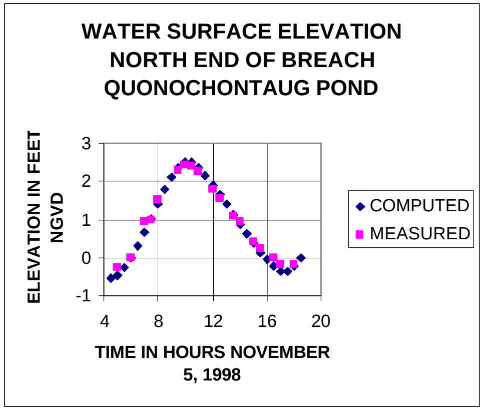
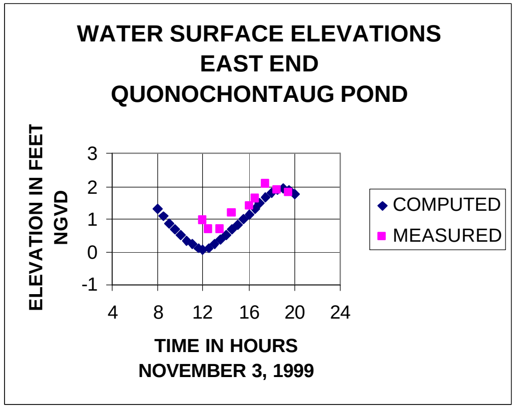
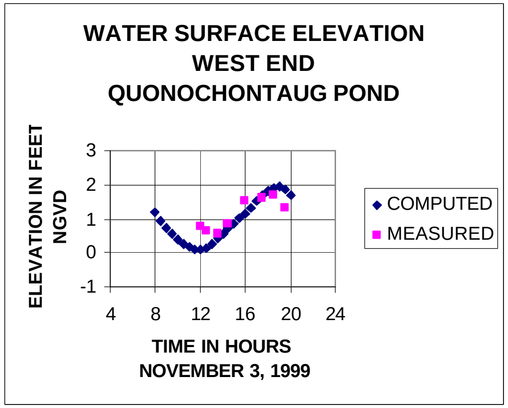


Figure 20

COMPARISON OF WATER SURFACE ELEVATIONS COMPUTED VS OBSERVED QUONOCHONTAUG POND 3 NOVEMBER 1999





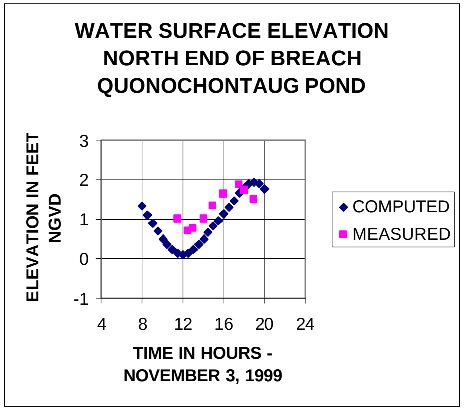
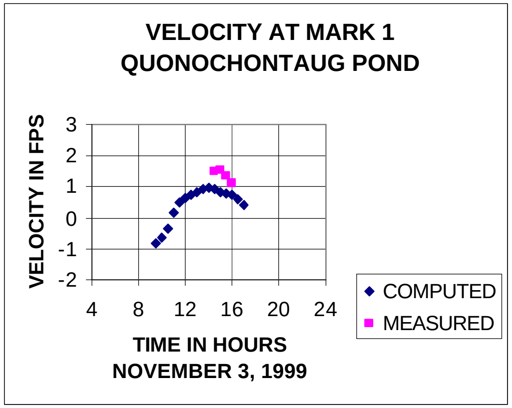
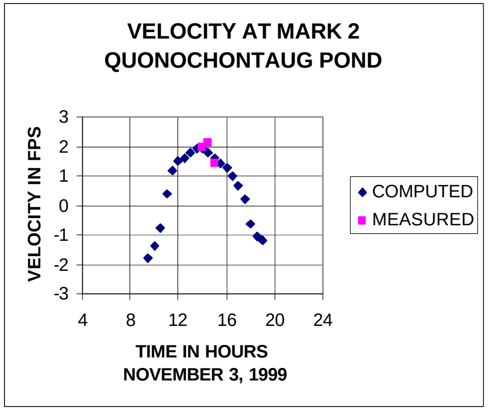
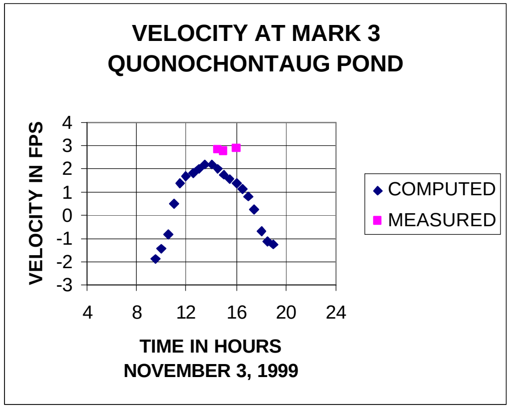


Figure 21

COMPARISON OF INLET VELOCITIES COMPUTED VS OBSERVED QUONOCHONTAUG POND







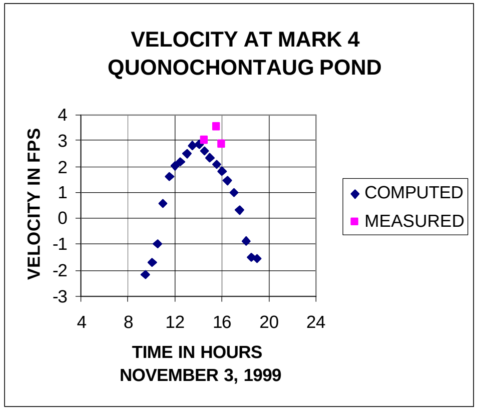
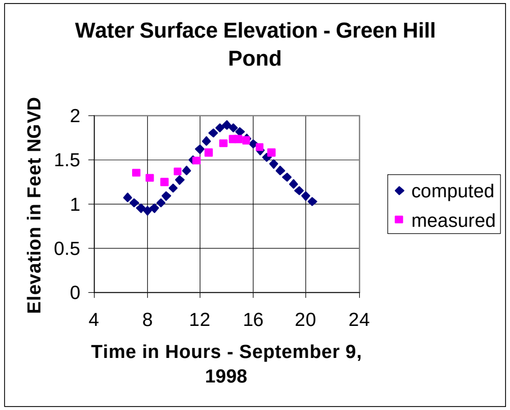
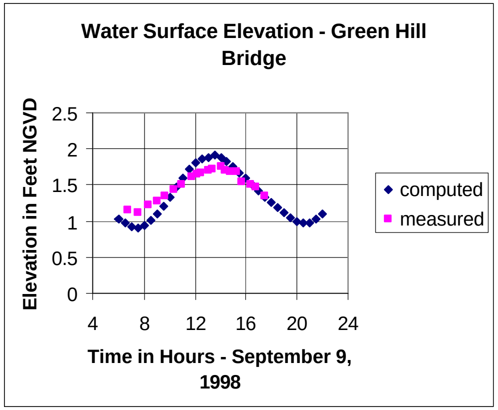
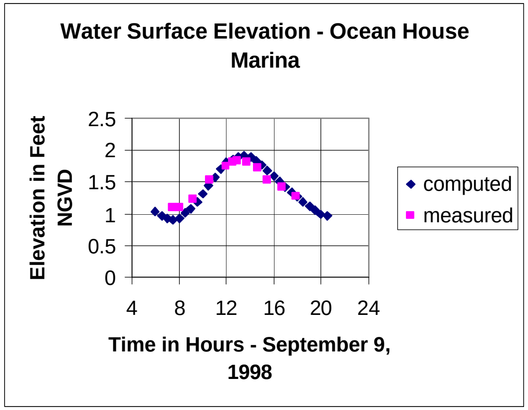


Figure 22

COMPARISON OF WATER SURFACE ELEVATIONS COMPUTED VS OBSERVED NINIGRET POND 9 SEPTEMBER 1998







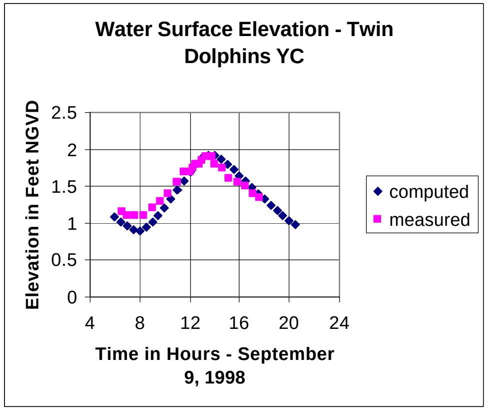
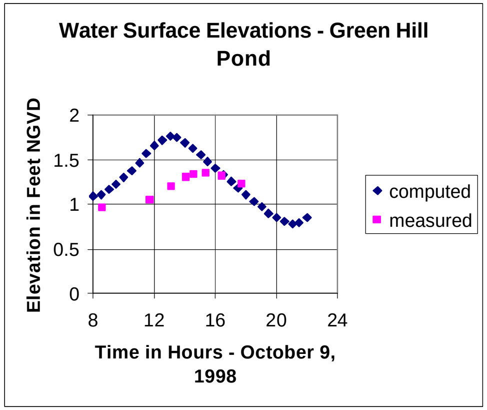
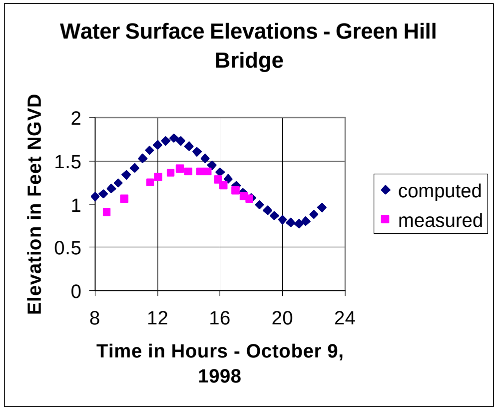
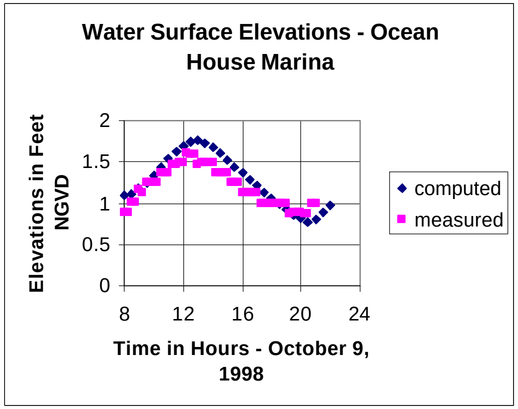


Figure 23

COMPARISON OF WATER SURFACE ELEVATIONS COMPUTED VS OBSERVED NINIGRET POND 9 OCTOBER 1998







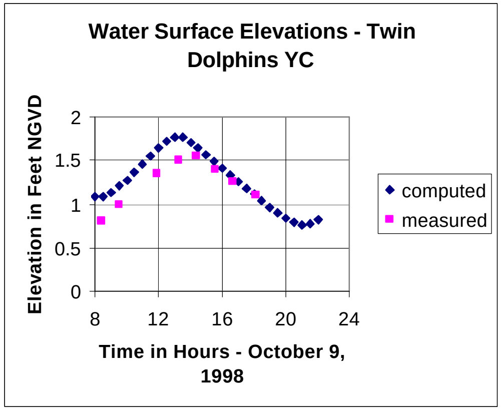
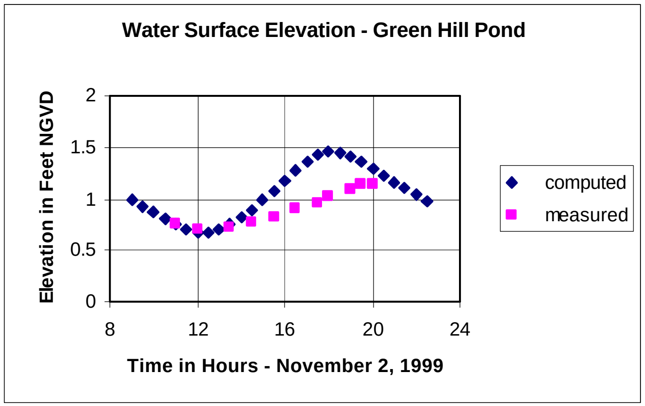
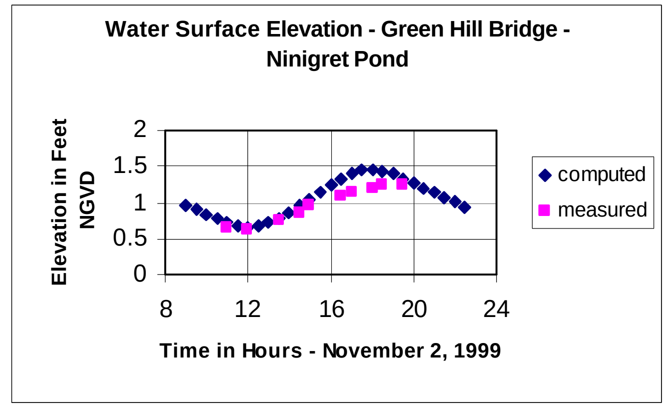
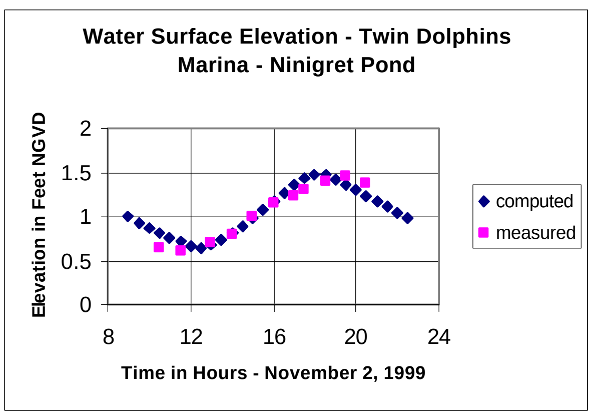


Figure 24

COMPARISON OF WATER SURFACE ELEVATIONS
COMPUTED VS OBSERVED
NINIGRET POND 2 NOVEMBER 1999







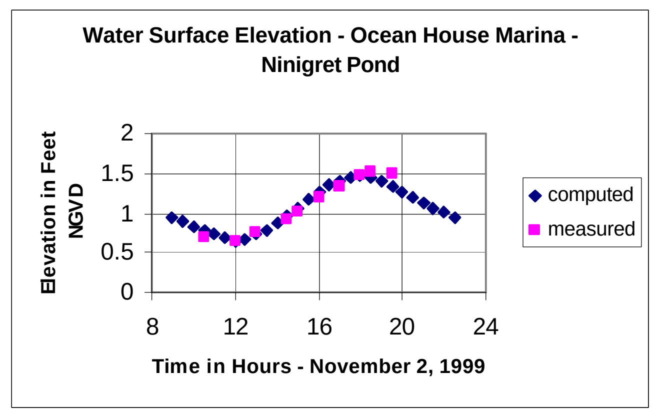
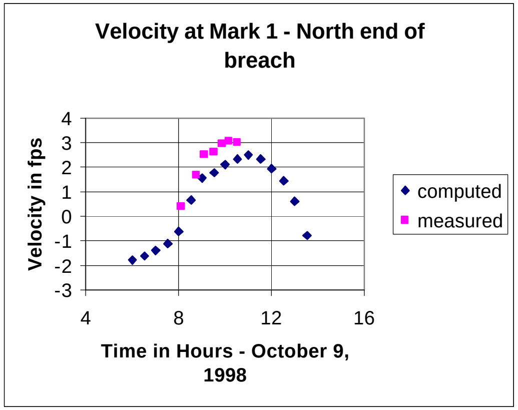
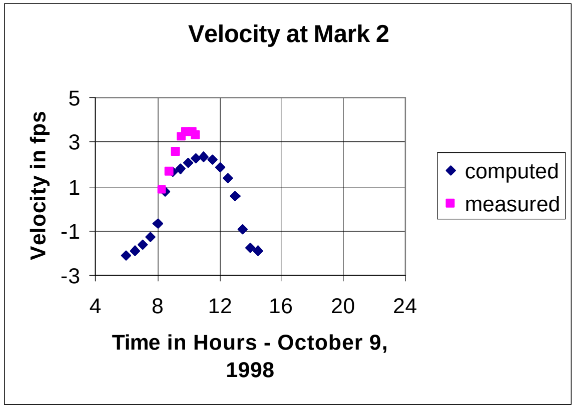
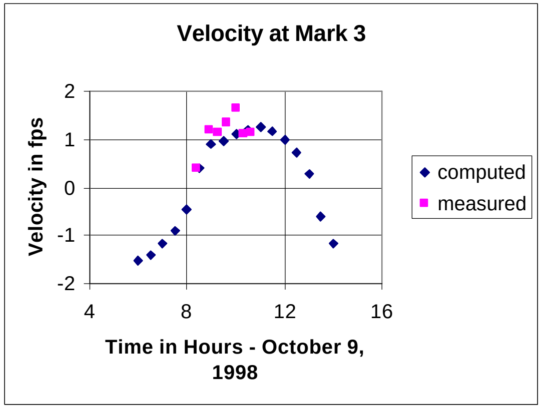


Figure 25

COMPARISON OF INLET VELOCITIES COMPUTED VS OBSERVED NINIGRET POND







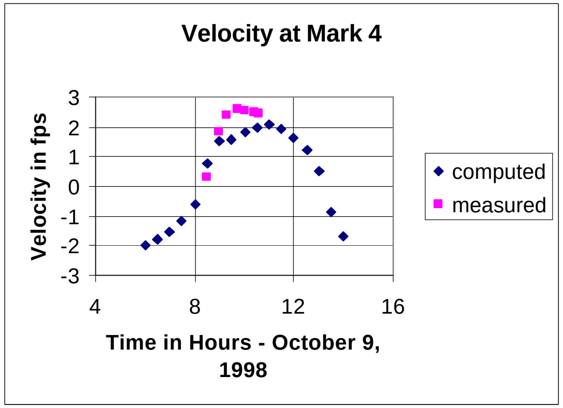
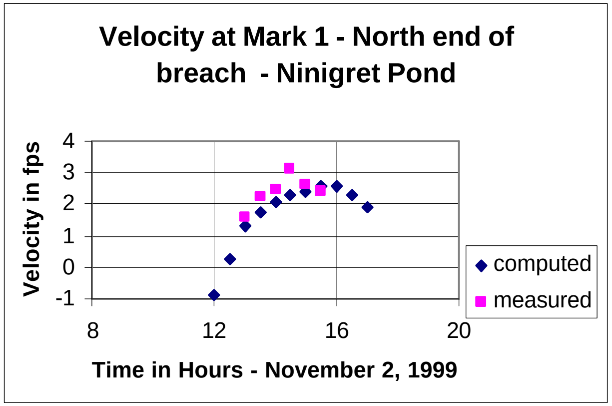
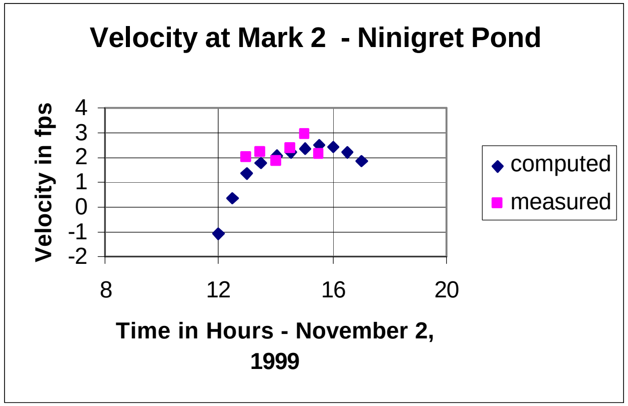
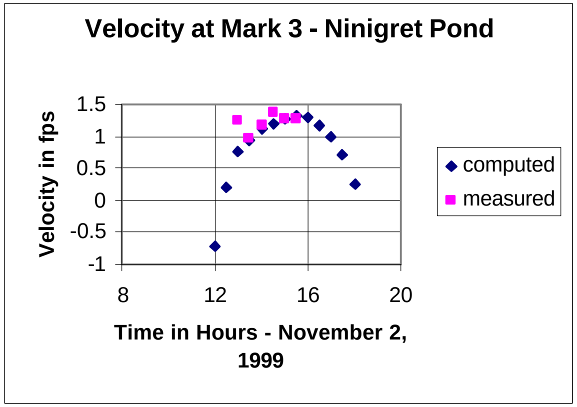


Figure 26

COMPARISON OF INLET VELOCITIES COMPUTED VS OBSERVED NINIGRET POND 2 NOVEMBER 1999







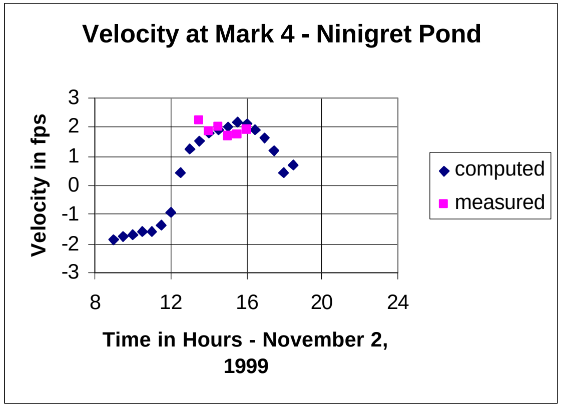


Figure 27

Figure 28

Eelgrass Restoration Sites
Sedimentation Basin
Potential Disposal Areas

300 0 300 600 Meters

1000 0 1000 2000 Feet

Rhode Island South Coast Feasibility Study

Winnapaug Pond

Figure 29

Rhode Island South Coast
Feasibility Study

Quonochontaug Pond

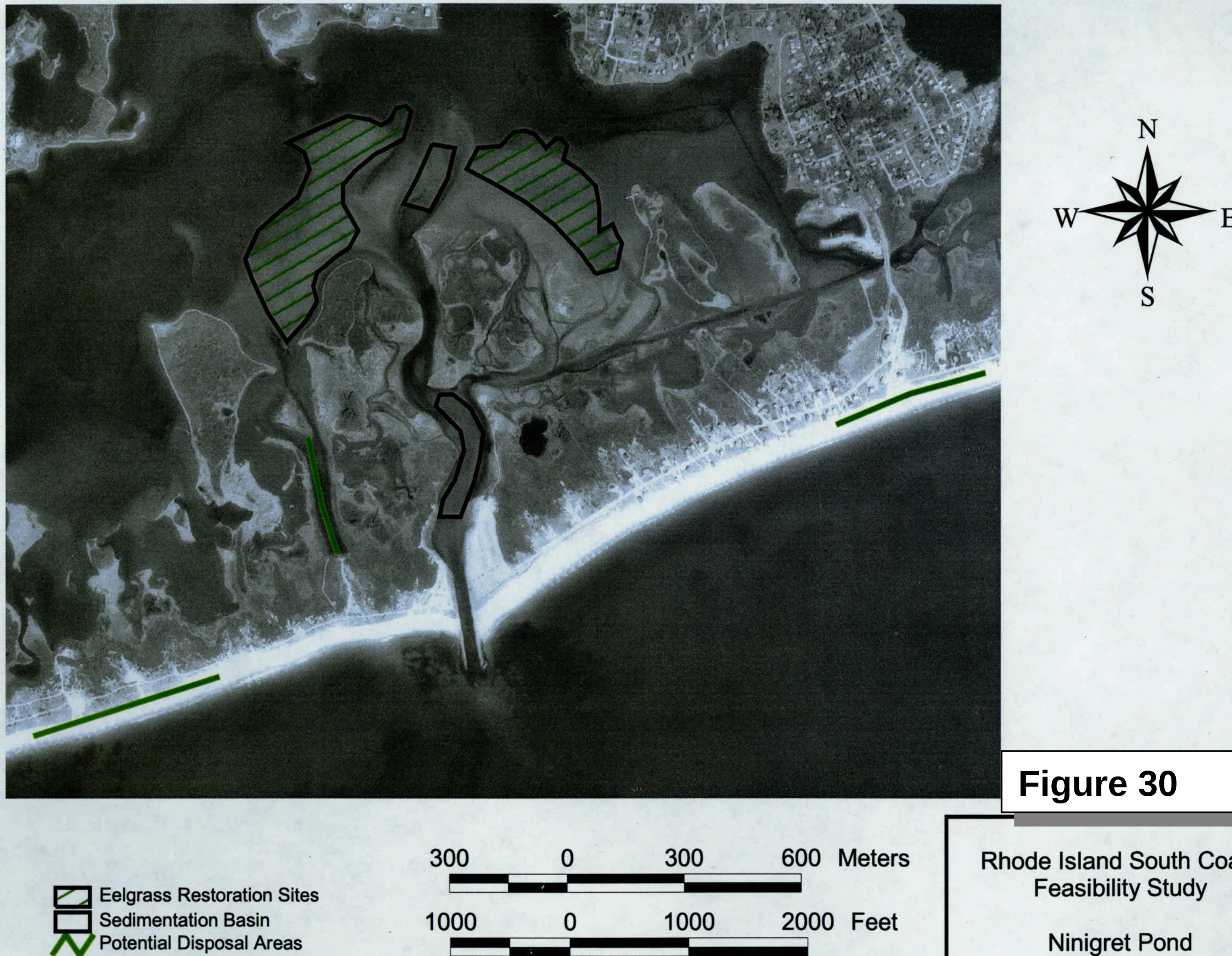


Figure 30

Rhode Island South Coast Feasibility Study

Ninigret Pond

VII. REFERENCES

Boothroyd, J.C., “The Geology of Selected Microtidal Coastal Lagoons, I: Data Summary and Management Questions,” TR No. 2-SRG, Dept. of Geol., URI, Kingston, RI, August, 1981.

Boothroyd, J.C., “A Geological Survey of Sedimentation in Quonochontaug, Winnapaug, and Maschaug Ponds, Westerly, Rhode Island,” (Draft), Earth Science Research, Inc., Narragansett, RI, June 13, 1985.

Boothroyd, J.C., Friedrich, N.E, and McGinn, S.R., 1985. “Geology of Microtidal Coastal Lagoons: Rhode Island,” In: G.F Oertel and S.P. Leatherman (Editors), Barrier Islands, Mar. Geol., 63: 35-76.

Hansen, E.A., “In-Channel Sedimentation Basins—A Possible Tool for Trout Habitat Management,” The Progressive Fish-Culturist, Vol. 35, No. 3, July 1973, pp. 138-142.

Isaji, T., Spaulding, M.L., “Simplified Model for Assessing the Impact of Breachway Modifications on Coastal Pond Circulation and Flushing Dynamics,” Proc. of Oceans 81, Boston, MA, Sept. 16-18, 1981.

Isaji, T., Spaulding, M.L., “Assessment of the Impact of Breachway Modifications and Channel Dredging on Charlestown Pond Tidal Circulation and Salinity Distribution,” Dept. of Ocean Engineering, URI, Kingston, RI, Nov. 1981.

Isaji, T., Spaulding, M.L., Stace, J., “Tidal Exchange between a Coastal Lagoon and Offshore Waters,” Estuaries, Vol. 8, No. 2B, pp. 203-216, June 1985.

Lee, V., “An Elusive Compromise: Rhode Island Caostal Ponds and Their People,” Coastal Resources Center, Marine Technical Report 73, URI, 1980.

Lee, V., Ernst, L., Marino, J., “Rhode Island Salt Pond Water Quality, Salt Pond Watchers Monitoring Data, 1985-1994, Well and Stream Monitoring Data, 1994, Technical Report,” CRC, URI, Narragansett, RI, October 1997.

Nixon, S.W., Furnas, B.N., Chinman, R., Granger, S., Heffernan, S., “Nutrient Inputs to Rhode Island Coastal Lagoons and Salt Ponds,” Final Report ot Rhode Island Statewide Planning, GSO, URI, Kingston, RI, January 1982.

Olsen, S., Lee, V.,”Inlet Modification: an example of an holistic approach to the management of lagoons,” Proc. International Symposium on Coastal Lagoons, SCOR/IABO/UNESCO, Bordeaux, France, 8-14 Sept. 1981.

Olsen, S., Lee, V., “Rhode Island’s Salt Pond Region: A Special Area Management Plan, (Ninigret to Point Judith Ponds),” Coastal Resources Management Council, GSO, URI, Kingston, RI, June 1985.

Draft “Salt Pond Region, Special Area Management Plan,” RI Coastal Resources Management Council, June 27, 1997.

Appendix A

Field Observations of Seagrass Coverage and Water Quality in Ninigret, Green Hill, Quonochontaug and Winnapaug Ponds

by
Stephen Granger
Scott Nixon
and
Benjamin Allen

University of Rhode Island
Graduate School of Oceanography
Narragansett, RI 02882

This report is submitted as partial completion of the scope of work outlined in contracts DACW33-99-M-0135, DACW33-99-M-0207 and DACW33-99-M-0283

I. SEAGRASS DISTRIBUTION AND COVERAGE

Introduction:

In our study of the delta area in the Rhode Island coastal ponds, we proposed to use the distribution of seagrass around the delta areas, as well as its abundance, to provide information about the environmental integrity of this region. Seagrass can be viewed as a biological integrator, expressing the effects of a highly variable environment by its density and health. The area coverage as well as the density of shoots reflects the vitality of a seagrass bed. Thus, both individual plant survival and lateral shoot production, expressed by the density of the plants, are indicators of long-term environmental conditions.

Photosynthesis, metabolism and growth of seagrass are extremely light-sensitive processes. Hence, seagrass survival and its range are dependent on the availability of light with sufficient intensity (20% of incident light) and for an adequate duration (6 or more hours of saturated light level) to meet the metabolic needs of the plant. Field studies have demonstrated that water clarity, i.e. light attenuation (-k, m), and determine the maximum depth of seagrass distribution. Alternatively, the exposure of the habitat to wave energy, range of tide, and sediment stability determine the minimum depth in which seagrass can survive. With this in mind, the theoretical distribution of seagrass biomass as a function of depth when moving along a transect line extending from the shallow edge of the bed to its deep-water edge is hyperbolic. That is, the greatest seagrass biomass should be encountered at the mid-depth range of its habitat, with diminishing biomass moving closer to the shallow or deep-water edges of the meadow. The relationship of present seagrass abundance, expressed here as percent cover, around the flood-tide delta region in the coastal ponds can be used to locate the depth where locate optimum conditions exist for seagrass growth and biomass. It therefore can also be used to indicate the optimum depth for dredging and future restoration efforts.

Bathymetric Information:

Depth profiles around a flood-tide delta are constantly changing from the deposition and resuspension of sediment. First, we needed to review the available bathymetry data for the ponds to determine the most accurate bathymetry data for the study area. Bathymetry information for the coastal ponds is available from NOAA shiptrack data (Ninigret 1960, Quonochontaug 1997) and more recently from the Army Corps of Engineers (ACOE, 1999). In order to establish a reference for comparison with the NOAA and ACOE data, we established a contour line locating the low-tide edge of the delta in Ninigret and Quonochontaug. The occurrence of low tide was determined by relying on tidal records taken at the NOAA tide gauge in Newport, Rhode Island and by Army Corps of Engineers tide records measured in Ninigret Pond, September 1998, and Quonochontaug Pond, November 1998. We estimated a 3 hour delay and a 2 hour delay between the time of low tide in Ninigret and Quonochontaug ponds, respectively, and that of low tide in Newport. Our surveys were then scheduled to begin shortly before the predicted time of low tide in the ponds.

A small skiff, equipped with a Trimble differential GPS (model NT200-D) which recorded positions at 30-second intervals, was towed around the edge of the deltas. The skiff was kept over a depth of 0.5 meters (approximately) during the survey. Latitude and longitude coordinates were entered into Geographic Information System (GIS) software and used to map the 0.5 meter depth contour (referenced to low tide) in the pond (Appendix I&II). A comparison between our coordinates for the edge of the delta and recent bathymetric data from the Army Corps of Engineers (ACOE) and NOAA ship track data was made. Agreement was poor between our observations and the older NOAA shiptrack data. Differences were attributed to the age of the data and to difficulties in determining depth from the larger NOAA boat in very shallow water. The bathymetry data from the ACOE produced similar depth contours to ours in Quonochontaug pond and was used in its original form for this analysis. However, we encountered a problem with the ACOE data from Ninigret pond; while the depth data displayed the geographic features of the pond, the values for the pond as a whole were too shallow. If we considered the ACOE depth observations were taken in meters instead of feet, the resulting bathymetry was a fair representation of the hypsographic profile of the pond. (This conversion was used by Fred Short to obtain depth information for Ninigret in his model.) As a result, we chose to use the modified ACOE bathymetry data in the Ninigret delta region for this analysis.

The ACOE bathymetric data were converted from NAD 27 state plane feet to NAD 83 decimal degrees in PC ARC/INFO. Data were then converted from NGVD 29 to mean sea level tidal datum using the difference of 0.50 feet at the NOAA National Ocean Service tidal bench mark in Newport. We were able to interpolate depth values for each observation of seagrass coverage recorded around the delta by relying on the transformed ACOE depth information. A more detailed description of the interpolation procedure follows in the seagrass coverage section.

<u>Seagrass Coverage</u>:

For this study, divers visually located seagrass beds near the deltas in Ninigret and Quonochontaug ponds. A bed of sufficient size was not available in Winnapaug Pond, which, therefore, will not be included in this discussion. Seagrass abundance was measured using a modified Braun-Blanquet technique; a one square meter quadrat was subdivided into squares measuring 20 centimeters by 20 centimeters (Appendix III&IV). Divers deployed the quadrat along a number of transects extending from the shallow edge of the seagrass bed on the delta into deeper water (Figs. 1 & 2). Each diver recorded the number of grid squares in the quadrat which contained seagrass plants, and expressed the result as abundance, i.e. percent of bottom covered with *Zostera marina*. Each observation was located using a differential GPS and entered into GIS contouring software for analysis. In Ninigret pond and Quonochontaug pond, 469 and 183 individual observations, respectively, of seagrass coverage were recorded. Because transect lines were, in part, situated to traverse the beds and determine their boundaries, measurements of seagrass coverage were not uniformly distributed through an area. Therefore, bathymetric and percent-coverage data were interpolated within the areas indicated in Figs. 1 & 2. Interpolations were performed in ArcView Spatial Analyst using the inverse distance weighting nearest neighbor method. Cell size was 0.0002 degrees (33 x 45 cells) and 0.00007 degrees (99 x 142 cells) for Ninigret and Quonochontaug Ponds, respectively. The resulting grids of depth and percent cover were combined in ArcView and exported for analysis. Grid cells falling on land were removed from the data set prior to analysis.

Field observations of seagrass coverage and the ACOE bathymetry data along with interpolated values produced by the ArcView Spatial Analyst software were averaged by 0.1 meter depth increments to determine the relationship of seagrass coverage as a function of depth (Fig. 3).

Discussion:

The relationship of seagrass coverage as a function of depth reveals several useful aspects of the habitat around the delta. It should be reiterated that these findings reflect the response of seagrass to present environmental conditions. Any future alterations that significantly effect water quality in this region will, naturally, also effect the ability of seagrass to survive in this region.

The maximum depth of seagrass distribution can be viewed as an index of water clarity, i.e., ponds supporting seagrass at deeper depths have clearer water. The maximum depth seagrass survives in Quonochontaug pond is 3 to 4 meters. Unfortunately, the water depth around the delta region in Ninigret pond is fairly shallow; as a result, we did not reach the deep-water cut-off where light would become limiting to seagrass. This is evidenced by a truncated seagrass distribution curve at the 1.5-meter depth interval. However, it is clear that the abundance of seagrass declines at water depths greater than 1.5 meters. This finding supports our survey data, which indicate that the water in Quonochontaug is clearer than in Ninigret Pond.

The relationship of depth versus bottom coverage reveals the depths at which maximum seagrass standing stock is observed. This is particularly relevant when determining the depth of dredging that will yield the maximum standing stock of seagrass. In Quonochontaug Pond the greatest seagrass coverage is observed between 1.5 and 2.5 meters in depth, with a distinctive peak at 2.4 meters (Fig. 3). In Ninigret Pond seagrass distribution displays two distinctive peaks at, and greatest coverage between, 0.75 meters and 1.25 meters in depth (Fig. 3). A“hole” in this seagrass bed can clearly be seen in an overflight photograph taken by the Rhode Island Department of Environmental Management (Fig. 4); the drop in seagrass abundance at water depths around 1 meter in this pond was attributed to the fact that a number of diver observations were taken in this area. The cause of the low plant biomass in this area was not immediately obvious and may be caused from recreational use or commercial shellfishing efforts.

Seagrass beds are dynamic, expanding and contracting with changes in water quality and environmental conditions. In previous years, we have observed areas within the seagrass bed along the flood-tide delta in Ninigret pond that have experienced similar mortality during the summer. In each case the defoliated area was virtually completely revegetated within a year or two.

We can also gain information about the energetics and suitability of habitat for seagrass by looking at the landward edges of the beds (located closest to the delta). We found that seagrass can survive at considerably shallower depths in Ninigret Pond than in Quonochontaug; this is due, in part, to the significantly greater tidal range in Quonochontaug Pond. The combination of greater tidal range and higher exposure acts to restrict seagrass to deeper water in Quonochontaug Pond. Therefore, if the production of optimum seagrass habitat is a goal of dredging in the delta, a final depth greater than one meter is an obvious requirement.

II. WATER QUALITY

Introduction:

Light penetration has been identified as the most important attribute of water quality affecting seagrass growth and survival. Water quality, in part, determines the suitability of an environment as habitat for seagrass, because the transparency of water and the resulting amount of light available to rooted macrophytes, such as eelgrass (*Zostera marina* L.), are affected directly or indirectly by three major influences on light attenuation. The first is the result of nutrient enrichment where increases in phytoplankton abundance, measured as an increase in chlorophyll pigment concentration, and/or an increase in microalgal and macroalgal biomass, compete with the seagrass for available light. The second is a change in water column total suspended solids, resulting from the resuspension of sediments or increased inflow into the system. And the third is a change in the transparency of the water caused from color due to dissolved organic matter, typically the result of runoff from land.

As part of our work for the Army Corp of Engineers, we proposed a field study to establish base-line water quality conditions in Ninigret, Quonochontaug, Winnapaug and Green Hill Ponds. Included in our field measurements were total suspended solids, dissolved inorganic nitrogen and phosphorus, chlorophyll-a, and light attenuation. These parameters are historically correlated with the growth and survival of seagrass. Total suspended solids and chlorophyll-a directly affect water clarity while dissolved inorganic nitrogen and phosphorus act indirectly on light attenuation by stimulating primary production in phytoplankton, microalgal, and macroalgal communities. Light attenuation is a direct measure of water clarity, quantifying the effect of the other parameters. Measurements of salinity and temperature were also included to compare conditions in the ponds during our surveys against data sets collected in previous years. Finally, dissolved oxygen was measured during each survey to confirm anecdotal evidence of hypoxic events.

Method:

Three stations were located with a Trimble GPS system equipped with differential correction (model # NT200-D, accuracy ˜ 1 meter) in each pond, with the exception of Green Hill, where a single mid-pond station was established (Figs. 5-8). Stations were monitored every two weeks from April through September and monthly thereafter to complete an annual cycle. However, ice cover prevented monitoring surveys in Ninigret and Green Hill ponds in January and February 2000. Surveys in Green Hill and Ninigret ponds, and those in Winnapaug and Quonochontaug occurred on separate days, due to the significant amount of time needed to transport equipment to the ponds and launch the boat. The shallow nature of the coastal lagoons necessitated use of a small (14 foot) skiff for fieldwork to make the entire area accessible.

The skiff was anchored at each station and a YSI 600xl multiparameter probe, equipped with sensors for temperature, salinity, dissolved oxygen, and depth, was lowered through the water column. Typically, the water column in the ponds was vertically well mixed; however, we did encounter periods during the late spring, summer and early autumn when wind and tidal amplitudes were low and the water column was thermally stratified. We sampled both surface and bottom water, when the water depth was greater than one meter, in order to document mean water conditions.

On the day prior to each survey, the salinity sensor was calibrated using a YSI conductivity standard (50,000 µsiemens cm^{-1}, part #3169). A one-point calibration of the dissolved oxygen sensor was accomplished by placing the probe in an air-saturated seawater tank and confirmed by Winkler titrations, and held at a constant water temperature (determined by ambient water temperature). The depth sensor was calibrated by zeroing the instrument at sea level. The temperature sensor was factory set and did not require calibration.

We attached a 40 cm length of PVC pipe, connected to a 4 meter length of vinyl tubing, to the YSI sonde as an intake line for a hand-operated diaphragm pump (Gyser pump, Cole Parmer catalogue #P-0709-10) mounted aboard the boat; in this way we were able to collect a water sample at the same depth as the probe. We lowered the probe and sample tubing to a depth of 20 cm, recording salinity, temperature, depth, and dissolved oxygen, then collected a water sample. Water collected by the first six strokes of the pump was discarded to ensure that the tubing and pump body were purged of the previous sample. This process was then repeated at 30 centimeters above the bottom.

Surface and bottom water samples were used to rinse a 60 ml syringe two times; this syringe was subsequently fitted with a cartridge containing a Whatman GF/F filter (retention of 0.4 micrometers). Duplicate 50 ml samples were filtered through separate filter cartridges, immediately transferred to a dark plastic box, placed on ice, and held in a cooler for later chlorophyll analysis. The filtrate was captured in a 60-ml polyethylene bottle, placed on ice and transported back to the laboratory for the analysis of ammonia, dissolved inorganic phosphate, nitrate and nitrite. Additionally, 1500 ml of unfiltered water was collected in a brown polyethylene bottle for the analysis of total suspended solids. Before the determination of total suspended solids, the sample was shaken to resuspend any particles that may have settled, filtered through a preweighed Whatman GF/F filter, rinsed with deionized water to remove any salts, dried to a constant weight in a 60 ºC forced-air oven, and weighed to the nearest 0.1 mg.

After collecting water samples, attenuation of light was measured using a Li-Cor quantum light sensor (model LI-192SA), referenced to a surface sensor in the boat (model LI-190SA). The percent of surface photosynthetically active radiation (PAR) received at depth was recorded every 25 cm and recorded by a Li-Cor LI-1000 Data Logger.

Results and Discussion:

As we stated earlier water clarity is affected by plankton abundance, suspended solids, and dissolved organic matter; differences in turbidity between ponds are related to differences in these parameters. Dissolved organic matter is transported into coastal waters via freshwater runoff from land, and as these coastal ponds do not receive freshwater from large rivers, it is unlikely that dissolved organic matter plays a significant role in determining water quality in the ponds. Therefore, this discussion will focus on the relationship between water clarity, total suspended solids and plankton abundance.

In Table 1, we have presented the results of our field surveys as an annual mean of the stations in each pond. Extinction coefficients indicate that the water in Quonochontaug pond is clearest, followed by Ninigret, Winnapaug and Green Hill ponds, in descending order (Table 1 and Fig. 9). Quonochontaug pond has the lowest mean annual temperature and the highest salinity among our study sites (Table 1 and Figs. 10&11), indicating that Quonchontaug pond exchanges water with Rhode Island Sound (RIS) at a greater rate than that of the other ponds. Tidal flushing improves water quality by advecting clearer RIS water into the pond and transporting biologically produced particles offshore; further evidence of this process can be seen in low chlorophyll concentrations and higher total suspended solids (Table 1 and Figs. 12&13). Increased flushing also generates greater current velocities and therefore the potential for holding more particles in suspension.

The mean annual salinity and temperature of Winnapaug pond indicate the second greatest tidal exchange with RIS. Again, chlorophyll concentrations are quite low, however, water clarity is similar to that found in Ninigret pond, due to the fact that the greatest amount of suspended solids is found in Winnapaug.

Ninigret and Green Hill ponds display the highest mean extinction coefficients. In addition we find the lowest mean salinity and highest temperatures, evidence of a lower exchange rate with RIS. A time-line of chlorophyll concentrations measured in the ponds reveals elevated summertime concentrations in both ponds (Fig. 12). The reduced flushing in these two ponds allows for a more complete processing of nutrients and the resultant production of organic particles, increasing the turbidity.

The seasonal variation in freshwater inflow to these coastal ponds has little effect on the mean salinity, with the exception of Green Hill (Fig. 11), in which we find the salinity in the winter and spring is lowered by freshwater inputs from the small streams and wetlands around its perimeter. The lower salinity in accompanied by an increase in the concentration of dissolved inorganic nitrogen (DIN), indicating that the source of the nutrients is terrestrial (Fig. 14). During the fall, DIN concentrations also increase in Quonochontaug and Winnapaug ponds without the decrease in salinity observed in Green Hill pond, due to the fact that nutrient concentrations increase in Rhode Island Sound and can act as a source of nutrients to the ponds through tidal exchange.

The light attenuation of Rhode Island's coastal ponds, and therefore their suitability as seagrass habitat, is contingent upon the interplay between nutrient inflow, the resulting stimulation of primary production, and the mitigating influences of water exchange with Rhode Island Sound.

III. HISTORIC POND DATA AND FACTORS AFFECTING WATER CLARITY

Water clarity as a function of chlorophyll-a concentrations and total suspended solids:

Measurements of light attenuation, chlorophyll concentration and total suspended solids were collected for each station in Ninigret and Quonochontaug Ponds (April through September 1999, Appendix V) and used to calculate a multiple linear regression in the form:

$$\text{Light attenuation } (-k,m) = m_1x_1+m_2x_2+m_3x_3+m_4x_4+b \qquad (1)$$

where;
x_1= mean chlorophyll-a concentration (ug l^{-1}) in the surface water,
x_2= mean total suspended solids (mg ml^{-1}) in the surface water,
x_3= mean chlorophyll-a concentration (ug l^{-1}) in the bottom water,
x_4= mean total suspended solids (mg ml^{-1}) in the bottom water,
b= the y axis intercept.

The results of this regression analysis for each station are presented below.

Table 2: Tabulated results from the multiple linear regression of light attenuation (dependant variable) versus chlorophyll-a and total suspended solids in surface and bottom water (independent variables). Measurements of light attenuation, chlorophyll-a and total suspended solids occurred from May through September, 1999. Slope coefficients (m_1-m_4) are presented by station for each pond. Values of m_1-m_4, b, and measurements of chlorophyll-a and suspended solids can be used in equation (1) to predict light attenuation:

	Ninigret Pond			Quonochontaug		
	Station 1	Station 2	Station 3	Station 1	Station 2	Station 3
m_1	-0.01	0.001	-0.003	-0.12	-0.16	-0.04
m_2	16.29	53.43	-15.66	26.00	-10.19	-2.80
m_3	-0.02	-0.001	0.006	0.03	0.05	0.00
m_4	40.19	-71.39	-40.96	-25.38	-7.14	-11.39
b	-0.94	-0.45	-0.43	-0.33	-0.26	-0.30
r^2	0.88	0.70	0.71	0.71	0.75	0.97

A similar analysis of the survey data was not possible for Winnapaug Pond due to the shallow depths encountered at the monitoring stations resulting in a limited number of discrete surface and bottom samples.

The coefficient of determination (r^2) indicates that from 70 to 90 % of the variation in light attenuation observed at the monitoring stations could be attributed to changes in chlorophyll-a concentrations and total suspended solids in the surface and bottom water of these two ponds. A comparison of the F-critical value to the F-observed value for each regression indicates that in a single-tailed test each regression is significant when Alpha=0.1. When a t-test was applied to each variable in the regressions we could determine the variable (chlorophyll and total suspended solids) was statistically significant for each station.

In Ninigret pond we found both surface and bottom concentrations of chlorophyll and total suspended solids had a significant relationship with water clarity at station 1 (located in Fort Neck Cove). Since this is the only area in the pond receiving significant runoff from land it is logical that turbidity in this area would respond to nutrients and particles transported into the pond via freshwater inflow. At station 2, located near the delta, we found that water clarity was most closely linked to the amount of total suspended solids in the water column. The delta region is vigorously flushed with low nutrient offshore water and therefore turbidity is likely to be affected by energy produced from the flood and ebbing of tides more than changes in plankton abundance (chlorophyll-a) stimulated by nutrient availability. Finally at station 3, in the west basin of the pond, we found that turbidity was sensitive to surface and bottom chlorophyll concentrations with little correlation to total suspended solids. Since the residence time of water in this area of the pond is long, biological activity stimulated by nutrients would be most evident here.

In Quonochontaug Pond we found that water clarity demonstrated a weak relationship to both total suspended solids and chlorophyll concentrations at all stations. A review of the survey data indicated that water clarity, chlorophyll-a and total suspended solids did not experience as great a variation as those observed in Ninigret Pond. As a result both chlorophyll-a and total suspended solids played a role in determining water clarity from April through September. The t-test did indicate that total suspended solids had a greater effect upon water clarity at stations 1 and 2 with slightly more dependence upon changes in chlorophyll concentrations at station 3.

Historic Pond Watchers Data:

Our work in Rhode Island's coastal ponds and the review of our data presented in this report would benefit from a comparison to previous information gathered by the Rhode Island Pond Watchers Association (1985 to 1994). First, we can compare information about mean salinity and temperatures to determine if our sample years of 1999 and 2000 are typical of previous years. Secondly a comparison of chlorophyll concentrations, water clarity and dissolved nutrients between our survey data and the Pond Watchers will indicate if there any long term changes in water quality in the ponds that can be seen by a comparison of the data sets.

Since the Pond Watchers data was for the most part collected by volunteers from access points along the shoreline, their stations represent surface nearshore conditions. This has several important ramifications when interpreting the data. For example, salinity and temperature measurements taken near the shore tend to be slightly higher than mid-pond samples. Measurements of light attenuation were taken with a secchi disk and were often limited by shallow depths near the access points. A secchi disk was lowered through the water and the depth at which the disk disappeared from sight was used to determine the light attenuation ($-k=1.7/D$, where D is the depth, in meters, at which the disk is no longer visible). In many cases, the sampling station was not deep enough to reach this depth and therefore many of the values were not used in this analysis. With these considerations in mind, we made pond-wide comparisons between the data sets to increase the number of comparable observations and eliminate some spatial inconsistencies.

Table 3: Mean annual values for salinity, temperature, dissolved oxygen, chlorophyll-a, light attenuation, dissolved inorganic phosphorus and nitrate collected by the URI research group (1999-2000) (ACOE project) and the Rhode Island Pond Watchers Association (1985-1994) in Ninigret, Green Hill, Quonochontaug and Winnapaug Ponds. Values represent a mean of all stations located in each pond during the surveys.

		Ninigret		Green Hill	
		URI	Pond Watchers	URI	Pond Watchers
Salinity	psu	29.8	25.1	26.6	19.2
Temperature	ºC	17.3	17.2	20.1	15.9
Dissolved Oxygen	g m^{-3}	9.2	9.3	9.6	10.9
Chlorophyll-a	µg l^{-1}	7.0	7.4	6.5	4.3
Light Attenuation	–k,m	0.73	1.4	0.87	1.3
Dissolved Inorganic Phosphorus	µM	0.2	0.5	0.1	0.5
Nitrate	µM	0.2	1.7	2.0	7.3

		Quonochontaug		Winnapaug	
		URI	Pond Watchers	URI	Pond Watchers
Salinity	psu	31.2	29.0	30.6	27.9
Temperature	ºC	15.3	16.8	16.7	18.2
Dissolved Oxygen	g m^{-3}	8.8	9.9	8.6	10.6
Chlorophyll-a	µg l^{-1}	2.6	3.2	3.5	6.0
Light Attenuation	–k,m	0.52	1.0	0.79	1.7
Dissolved Inorganic Phosphorus	µM	0.6	0.6	0.4	0.6
Nitrate	µM	0.5	0.8	0.8	2.1

Several interesting features are evident from a review of the URI survey data and water quality measurements collected from 1985-1994. First, mean salinity and temperature measurements indicate that the 1999-2000 field season was drier and cooler than the nine year average taken by the Pond Watchers. Since rainfall and mean salinity were lower during the time of our surveys, the transport of nutrients from land was also lower. With lower nutrient inflows water column production is less likely to be stimulated. We observed lower chlorophyll-a concentrations in all of the ponds, except

Green Hill. The weir system between Ninigret and Green Hill Ponds has been replaced in the recent past and regulates the rate at which Green Hill Pond flushes. A change in the hydrology of the pond may have played a role in longer water residence times and higher chlorophyll concentrations observed during URI surveys. Mean nutrient concentrations taken during the URI surveys were the same or lower than previous conditions documented by the Pond Watchers. It is difficult to determine if the significantly clearer water observed during the URI surveys was the result of lower nutrient inflow and lower biological activity or an artifact of the method used to measure light attenuation by the Pond Watchers (discussed earlier).

While differences between the mean conditions observed during the URI and Pond Watcher surveys are apparent, the magnitude of the differences are not so great as to make the information gathered during 1999&2000 less useful. The nine year mean value of salinity, temperature, etc. measured by the Pond Watchers and offered here, represent average conditions for each pond. While the summer of 1999 was quite dry, the resulting difference between average conditions and those observed during the URI surveys are relatively small and should be viewed as the range of variation one is likely to observe from year to year.

Fig. 1 Seagrass distribution expressed as percent cover, in Ninigret Pond, Charlestown, Rhode Island. Divers using a modified version of the Braun-Blanquet technique determined the percent of bottom covered with seagrass at 183 locations. The position of the observations of seagrass coverage are indicated with black dots and were located with a Trimble differential GPS system (model NT200-d, accuracy ≈ 1 meter) at the time of the survey. The edge of the flood-tide delta is indicated by a yellow line and represents water with a constant depth of 0.5 meters measured from 10:45 AM to 11:45 AM on August 6, 1999 during low tide (see text for a more complete description of the method). The red box indicates the area of the seagrass bed and the observations of seagrass coverage used to determine the relationship of seagrass coverage with depth Fig 3.

Seagrass Coverage as a Function of Depth Below Mean Sea Level

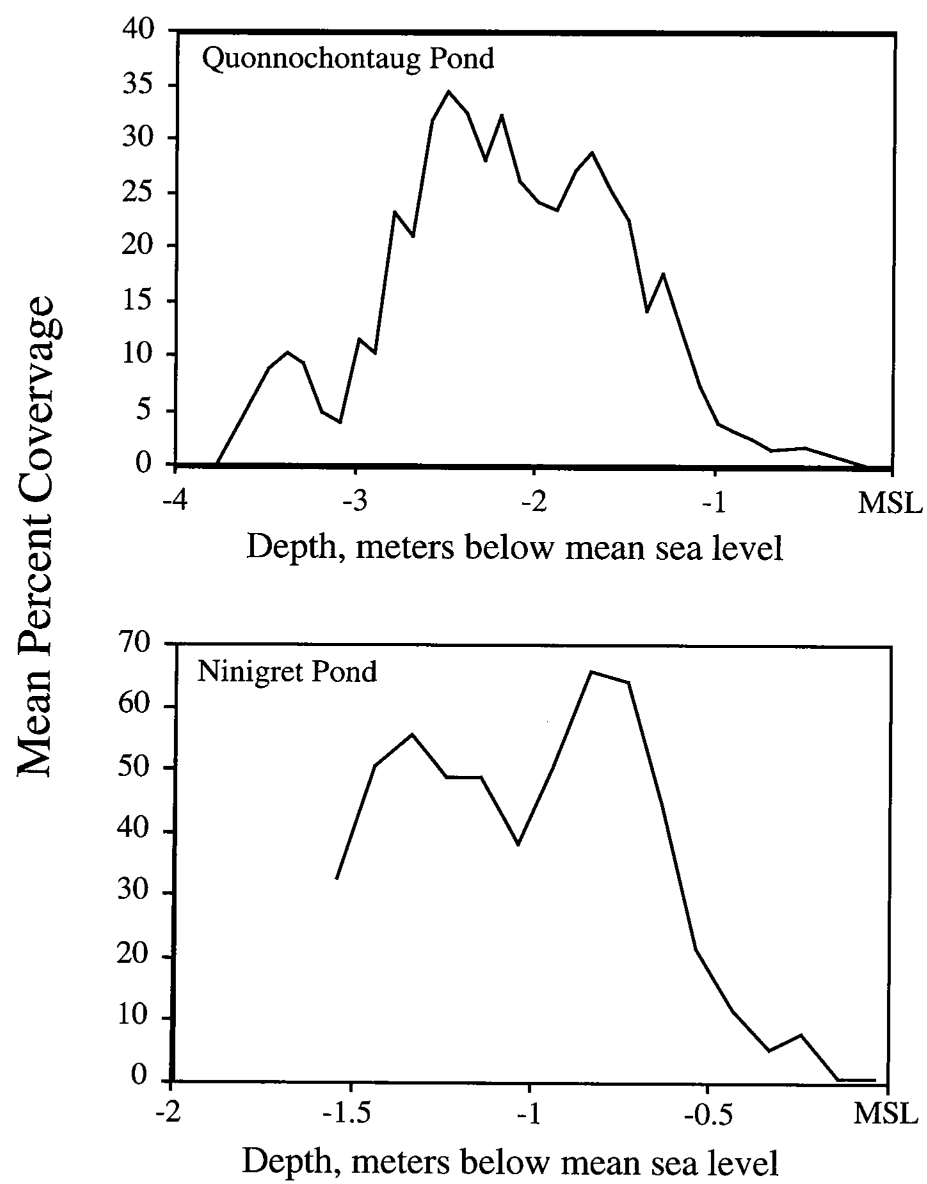


Fig. 2 Seagrass distribution expressed as percent cover, in Quonochontaug, Westerly and Charlestown, Rhode Island. Divers using a modified version of the Braun-Blanquet technique determined the percent of bottom covered with seagrass at 183 locations. The position of the observations of seagrass coverage are indicated with black dots and were located with a Trimble differential GPS system (model NT200-d, accuracy ≈ 1 meter) at the time of the survey. The edge of the flood-tide delta is indicated by a yellow line and represents water with a constant depth of 0.5 meters measured from 10:45 AM to 11:45 AM on August 6, 1999 during low tide (see text for a more complete description of the method). The red box indicates the area of the seagrass bed and the observations of seagrass coverage used to determine the relationship of seagrass coverage with depth Fig 3.

Ninigret Pond Eelgrass Survey 1999

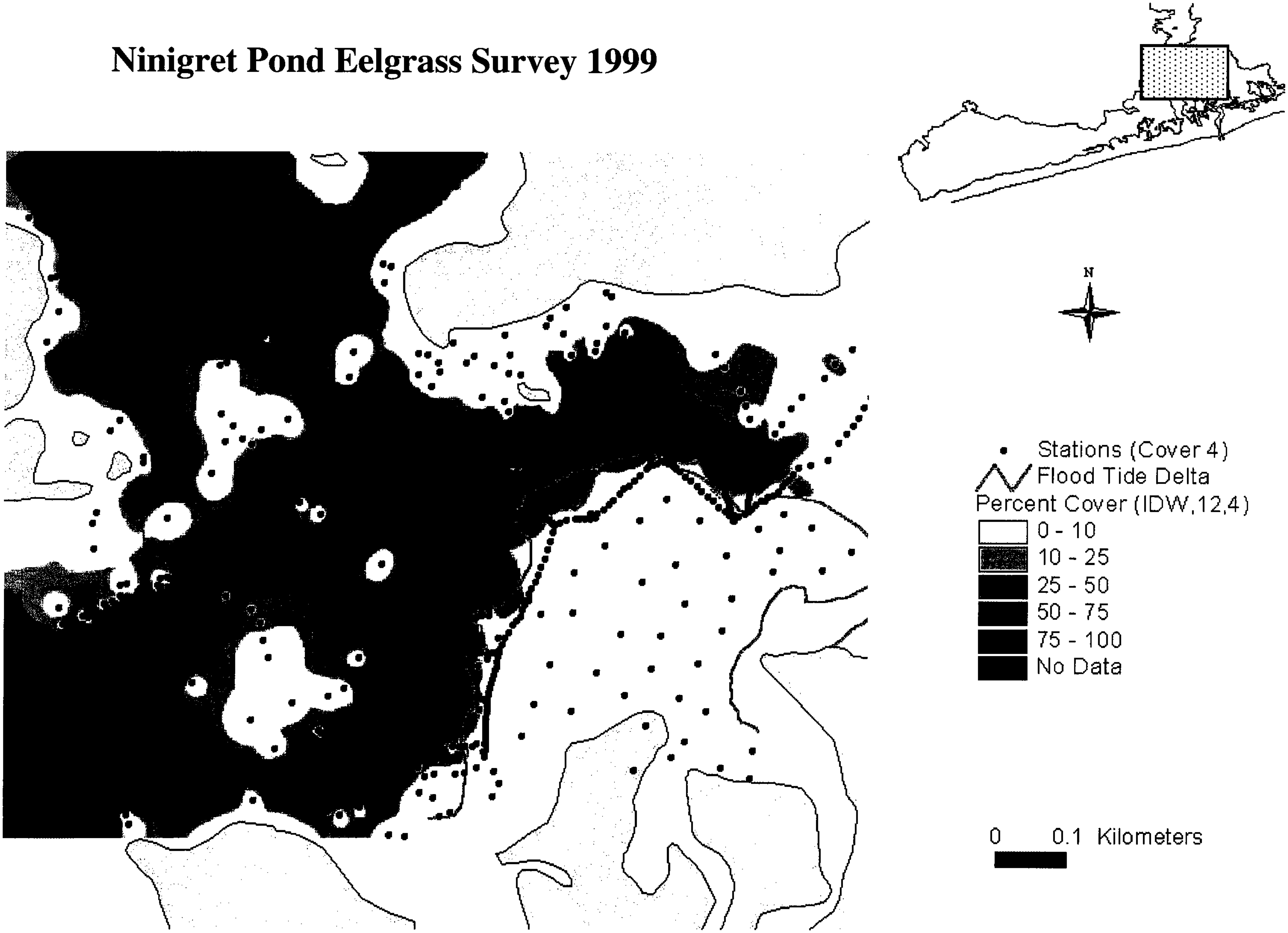


Figure 3. Seagrass coverage measured using a modified Braun-Blanquet technique, in the flood tide delta region of Ninigret and Quonnochontaug Ponds. Divers deployed a one meter square grid, sub-divided into 20 cm2 sections, along transects extending from the shallow water of the delta to the deep water edge of the meadow and recorded the percent of the bottom covered with seagrass (see Figures 1&2). Observations of coverage were located with a Trimble diffential GPS (model NT-200D) then entered and contoured with Geographical Information System software (see methods section for details). Observations of bottom coverage were averaged by 0.1 meter increments and plotted as a function of depth.

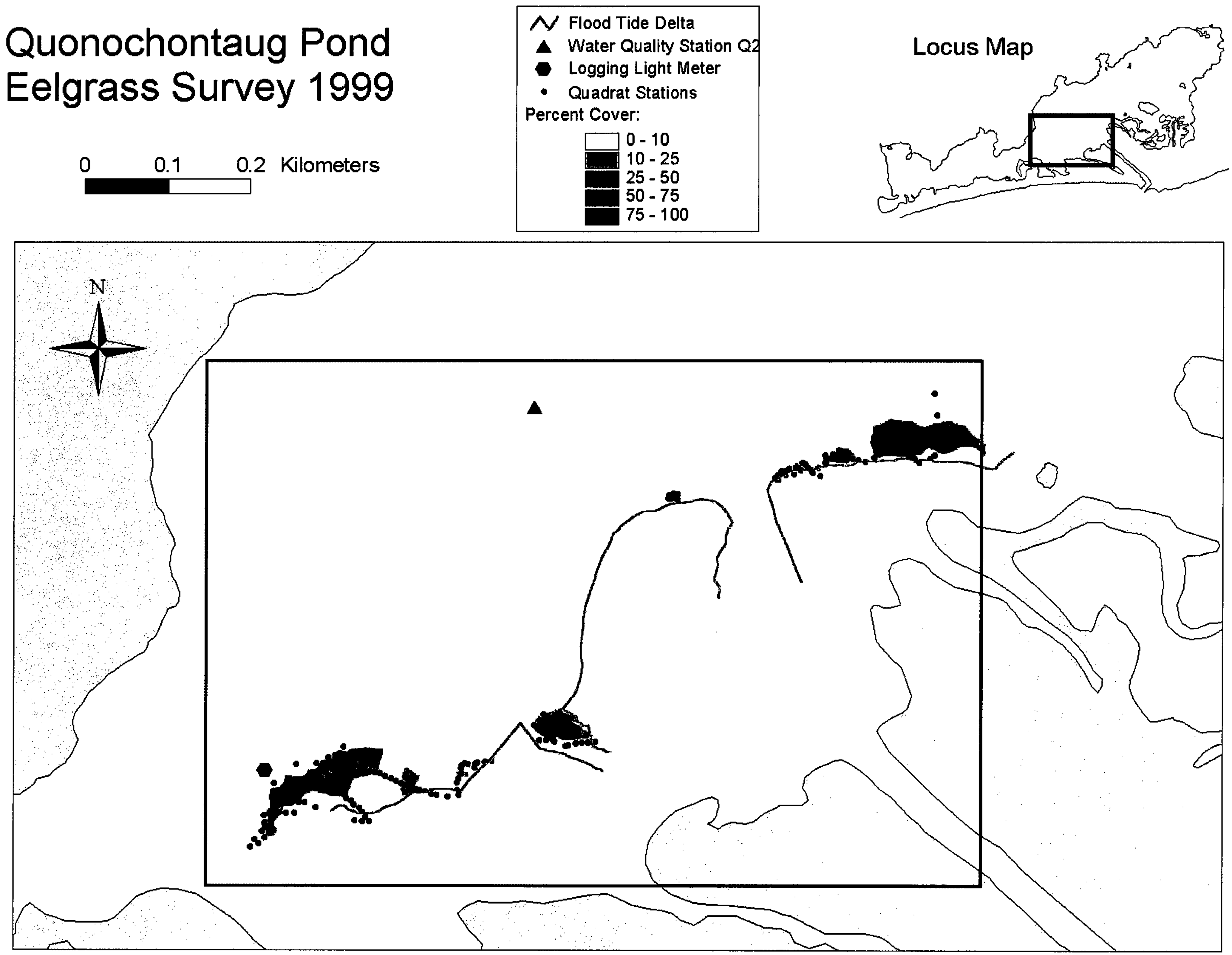

Quonochontaug Pond
Eelgrass Survey 1999
0
0.1
0.2 Kilometers
Flood Tide Delta
Water Quality Station Q2
Logging Light Meter
Quadrat Stations
Percent Cover:
0 - 10
10 - 25
25 - 50
50 - 75
75 - 100
Locus Map
N

Figure 4. Aerial photograph (1:12,000 scale) of the breachway and flood-tide delta region in Ninigret Pond, Charlestown, Rhode Island. The fan shaped flood tide delta is seen in the photograph as a light colored area located where the breachway channel enters the pond. Seagrass beds can be seen in the water as dark areas along the margin of the delta. Original photograph provided by Helen Cottrel, Water Resources Division of the Rhode Island Department of Environmental Management.

Figure 5. Map of Ninigret Pond showing the location of three water quality monitoring stations that were surveyed bi-weekly from April through September 1999 and monthly from October 1999 through March 2000. Latitude and Longitude for each station is given in degress/decimal minutes.

Ninigret Pond

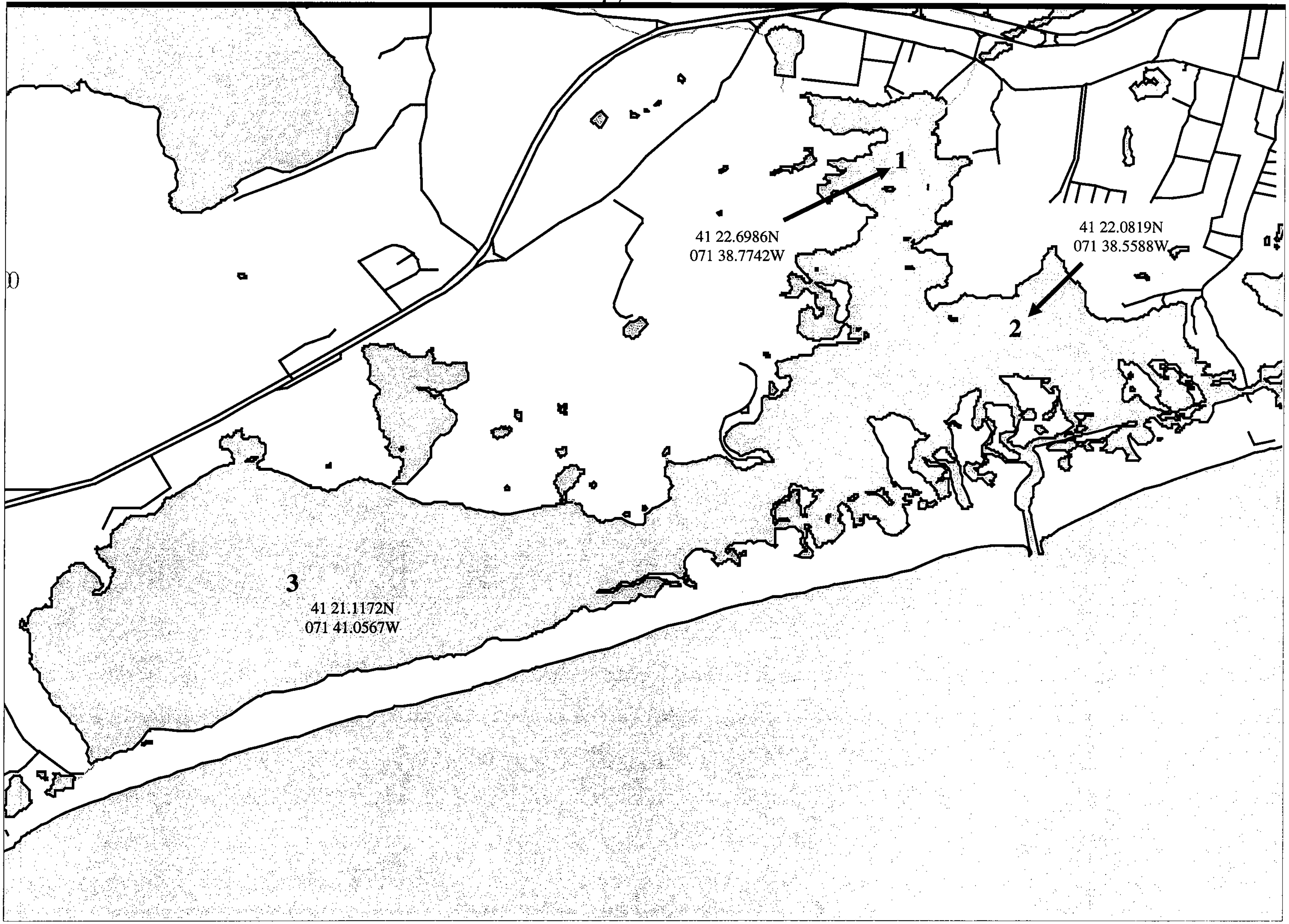


Figure 6. Map of Green Hill Pond showing the location of the water quality monitoring station that was surveyed bi-weekly from April through September 1999 and monthly from October 1999 through March 2000. Latitude and Longitude for each station is given in degress/decimal minutes.

Green Hill Pond

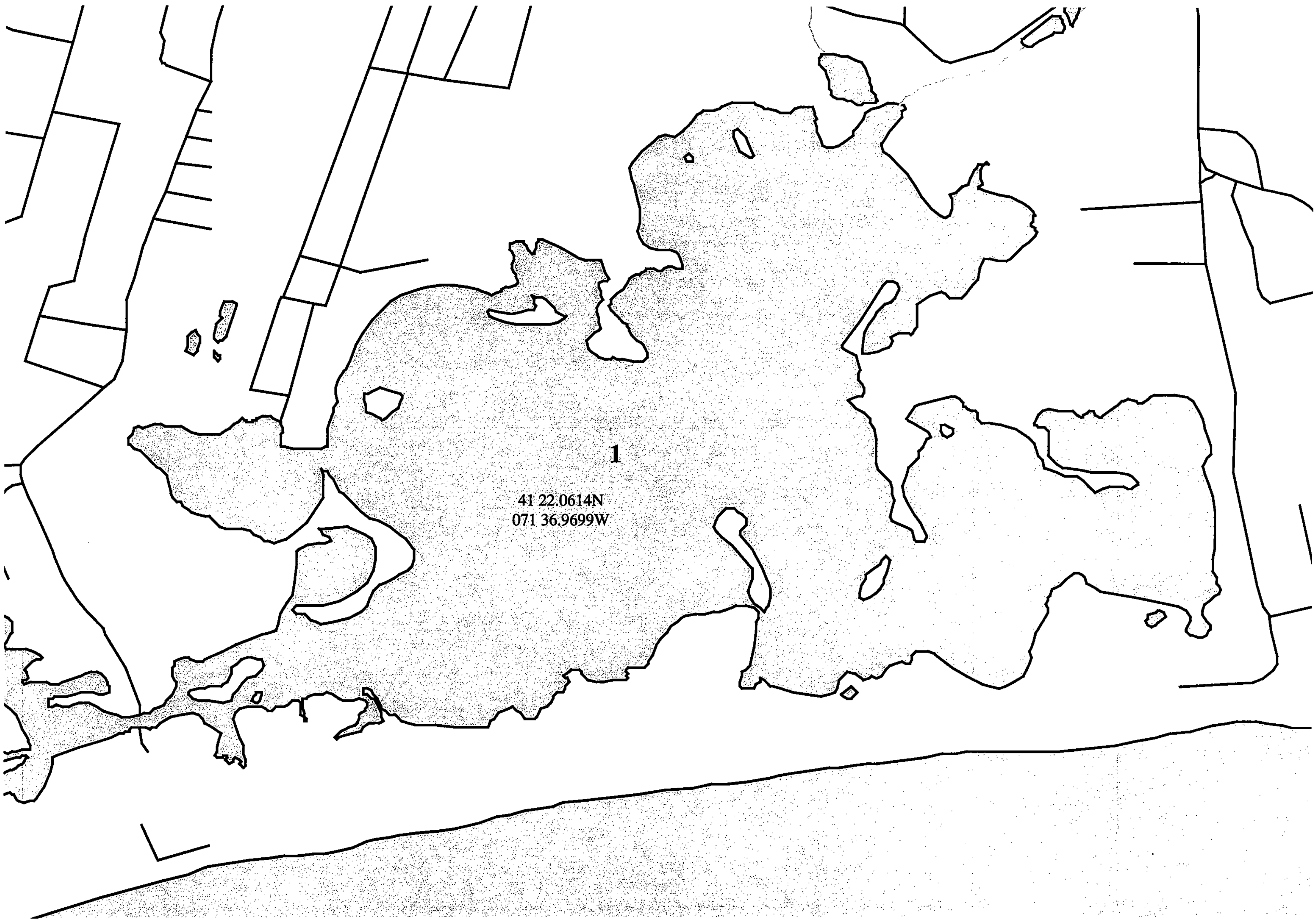


Figure 7. Map of Quonochontaug Pond showing the location of three water quality monitoring stations that were surveyed bi-weekly from April through September 1999 and monthly from October 1999 through March 2000. Latitude and Longitude for each station is given in degress/decimal minutes.

Quonochontaug Pond

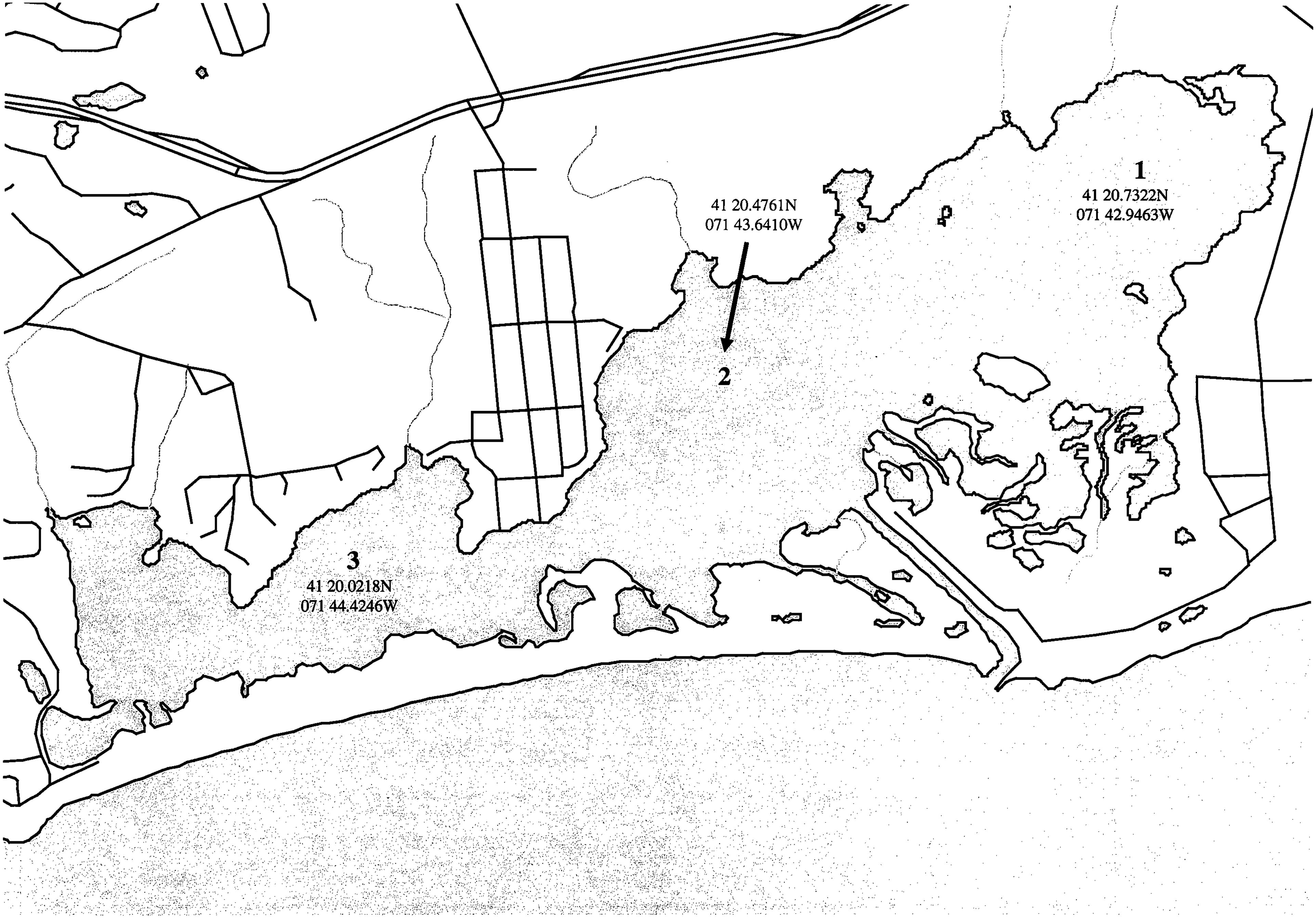


Figure 8. Map of Winnapaug Pond showing the location of three water quality monitoring stations that were surveyed bi-weekly from April through September 1999 and monthly from October 1999 through March 2000. Latitude and Longitude for each station is given in degress/decimal minutes.

Winnapaug Pond

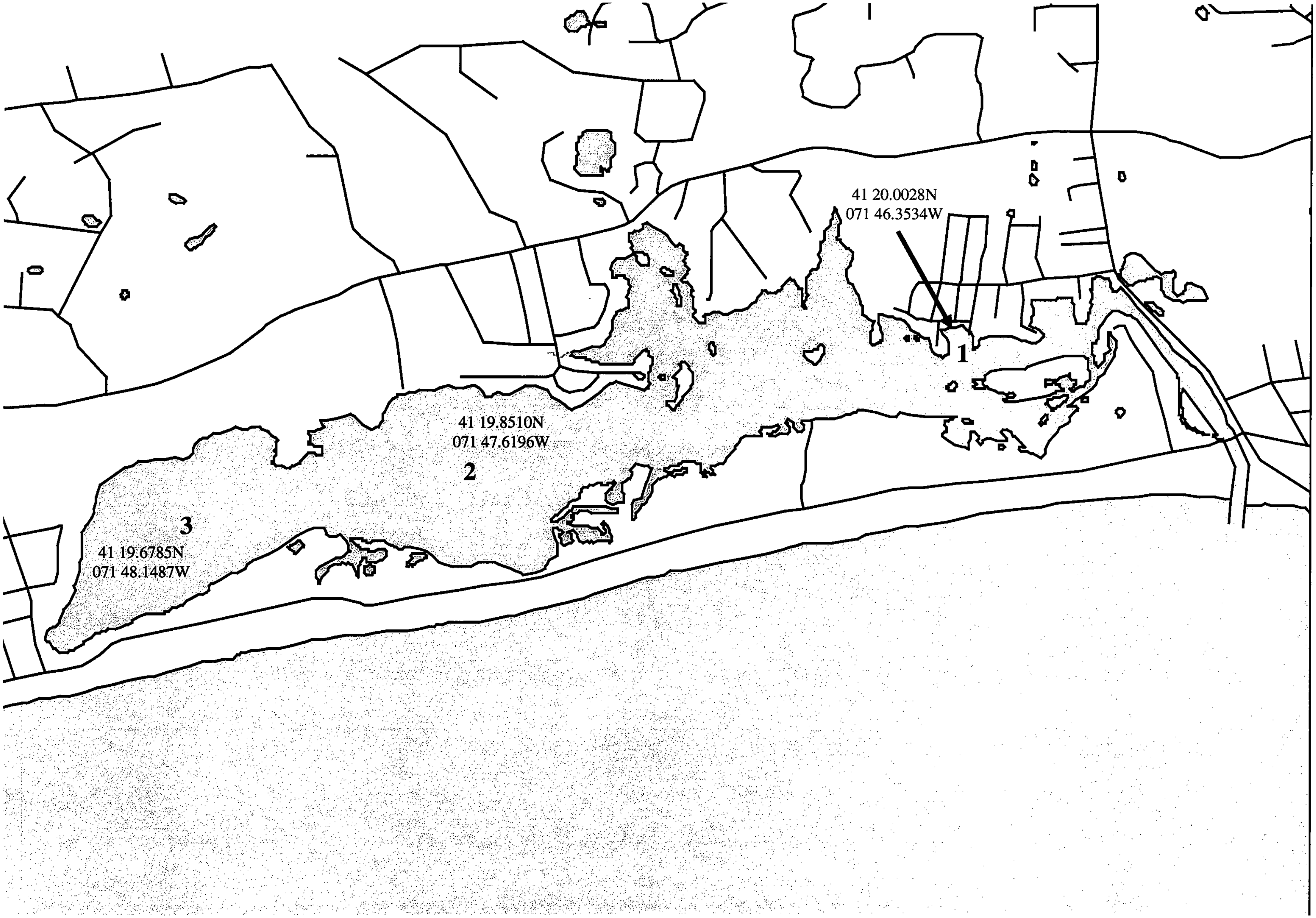
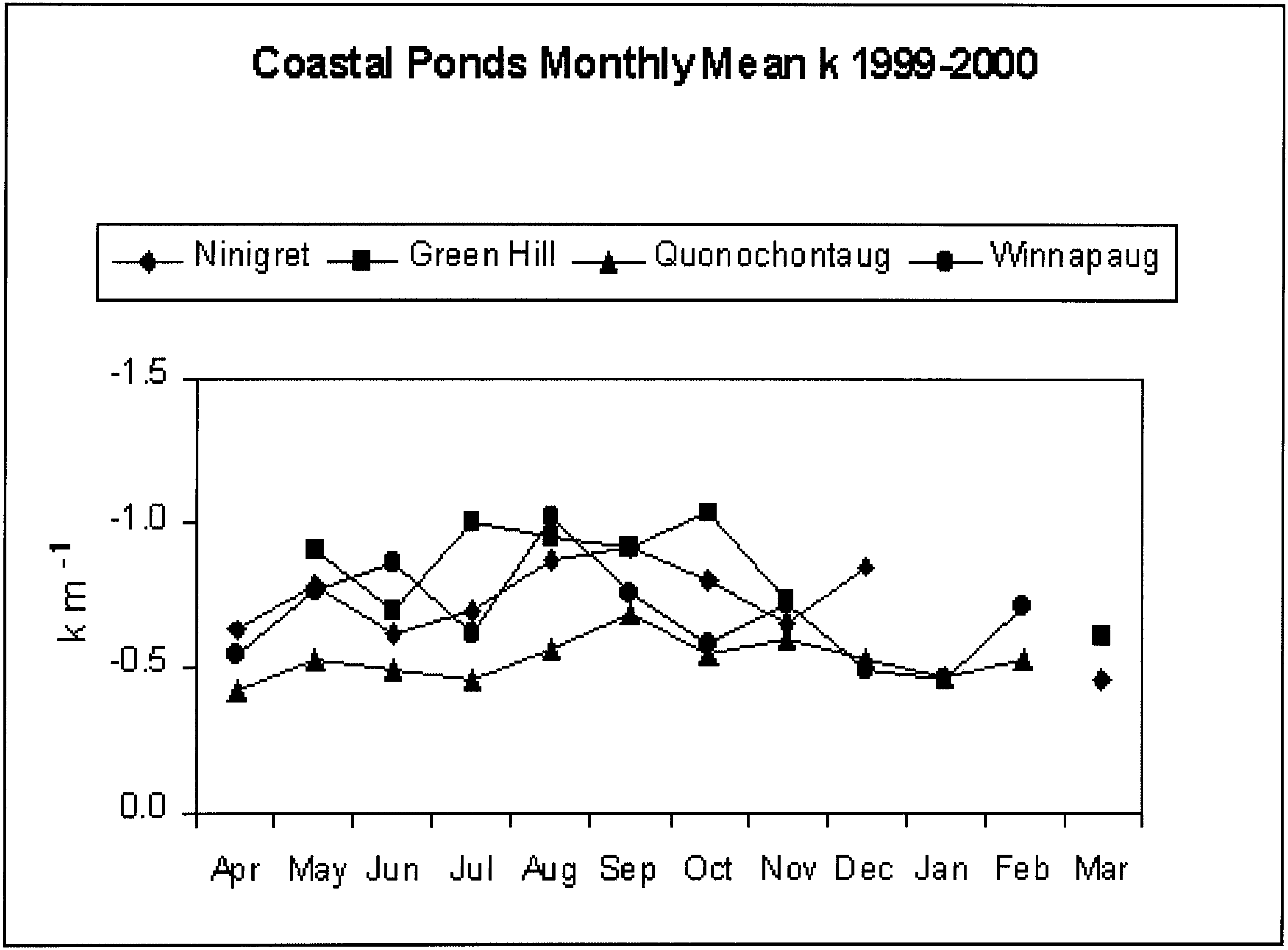


Figure 9. Monthly mean extinction coefficients (k, m^{-1}) for Ninigret, Green Hill, Quonochontaug and Winnapaug ponds. Surveys were conducted twice a month from April 1999 through September 1999 and monthly thereafter until March 2000. Ice cover prevented a January and February survey in Ninigret and Green Hill ponds. Mean monthly values were determined by averaging surface and bottom measurements taken at three stations located in each pond except Green Hill pond which contained a single monitoring station.



Coastal Ponds Monthly Mean k 1999-2000
Ninigret
Green Hill
Quonochontaug
Winnapaug
-1.5
-1.0
-0.5
0.0
k m -1
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar

Figure 10. Monthly mean temperature (°C) for Ninigret, Green Hill, Quonochontaug and Winnapaug ponds. Surveys were conducted twice a month from April 1999 through September 1999 and monthly thereafter until March 2000. Ice cover prevented a January and February survey in Ninigret and Green Hill ponds. Mean monthly values were determined by averaging surface and bottom measurements taken at three stations located in each pond except Green Hill pond which contained a single monitoring station.

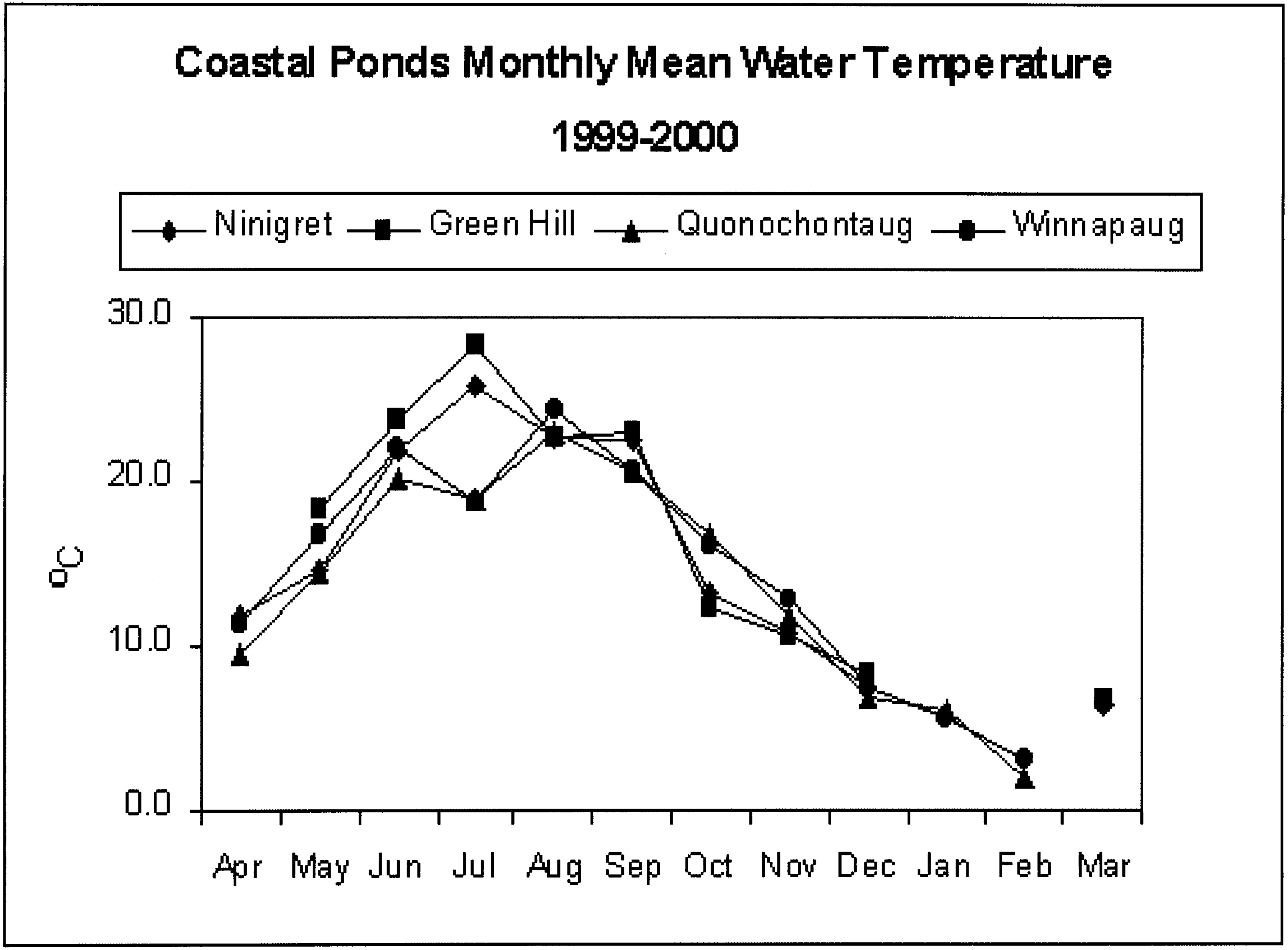

Coastal Ponds Monthly Mean Water Temperature
1999-2000
Ninigret
Green Hill
Quonochontaug
Winnapaug
30.0
20.0
10.0
0.0
ºC
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar

Figure 11. Monthly mean salinity (psu) for Ninigret, Green Hill, Quonochontaug and Winnapaug ponds. Surveys were conducted twice a month from April 1999 through September 1999 and monthly thereafter until March 2000. Ice cover prevented a January and February survey in Ninigret and Green Hill ponds. Mean monthly values were determined by averaging surface and bottom measurements taken at three stations located in each pond except Green Hill pond which contained a single monitoring station.

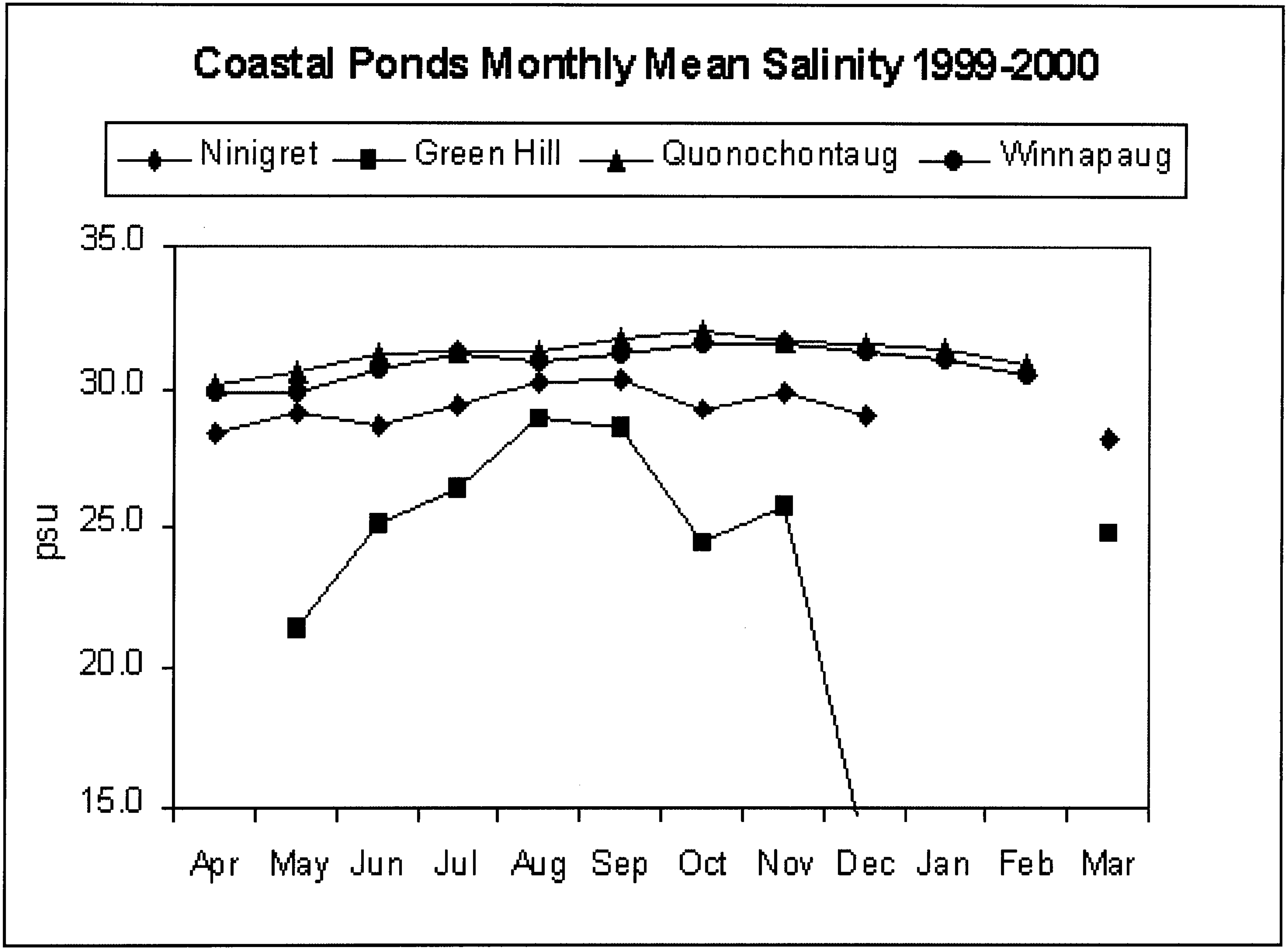

Coastal Ponds Monthly Mean Salinity 1999-2000
Ninigret
Green Hill
Quonochontaug
Winnapaug
35.0
30.0
25.0
20.0
15.0
psu
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar

Figure 12. Monthly mean chlorophyll-a ($\mu g\ l^{-1}$) for Ninigret, Green Hill, Quonochontaug and Winnapaug ponds. Surveys were conducted twice a month from April 1999 through September 1999 and monthly thereafter until March 2000. Ice cover prevented a January and February survey in Ninigret and Green Hill ponds. Mean monthly values were determined by averaging surface and bottom measurements taken at three stations located in each pond except Green Hill pond which contained a single monitoring station.

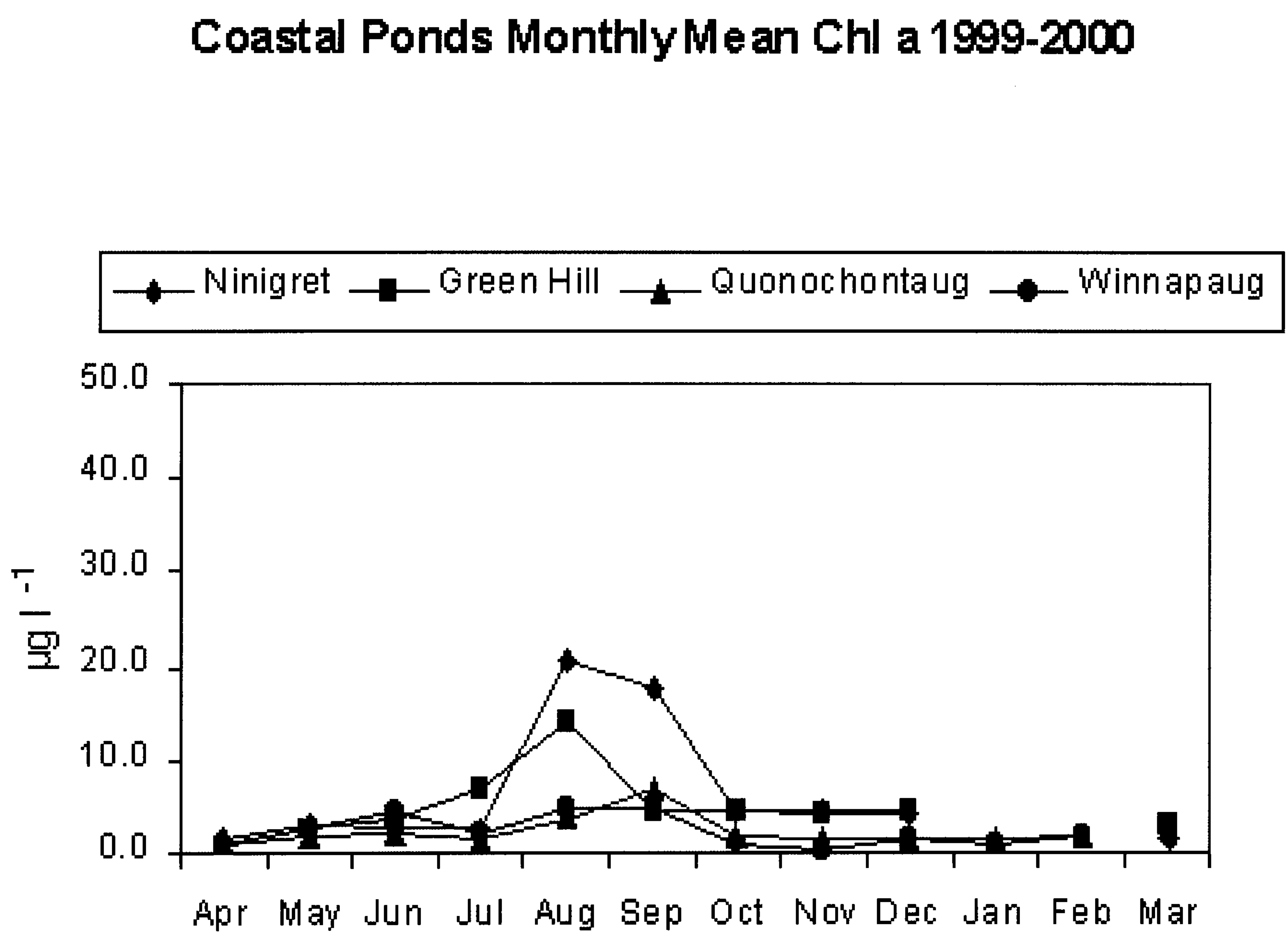

Coastal Ponds Monthly Mean Chl a 1999-2000
Ninigret
Green Hill
Quonochontaug
Winnapaug
50.0
40.0
30.0
20.0
10.0
0.0
µg l -1
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar

Figure 13. Monthly mean total suspended solids (mg l^{-1}) for Ninigret, Green Hill, Quonochontaug and Winnapaug ponds. Surveys were conducted twice a month from April 1999 through September 1999 and monthly thereafter until March 2000. Ice cover prevented a January and February survey in Ninigret and Green Hill ponds. Mean monthly values were determined by averaging surface and bottom measurements taken at three stations located in each pond except Green Hill pond which contained a single monitoring station.

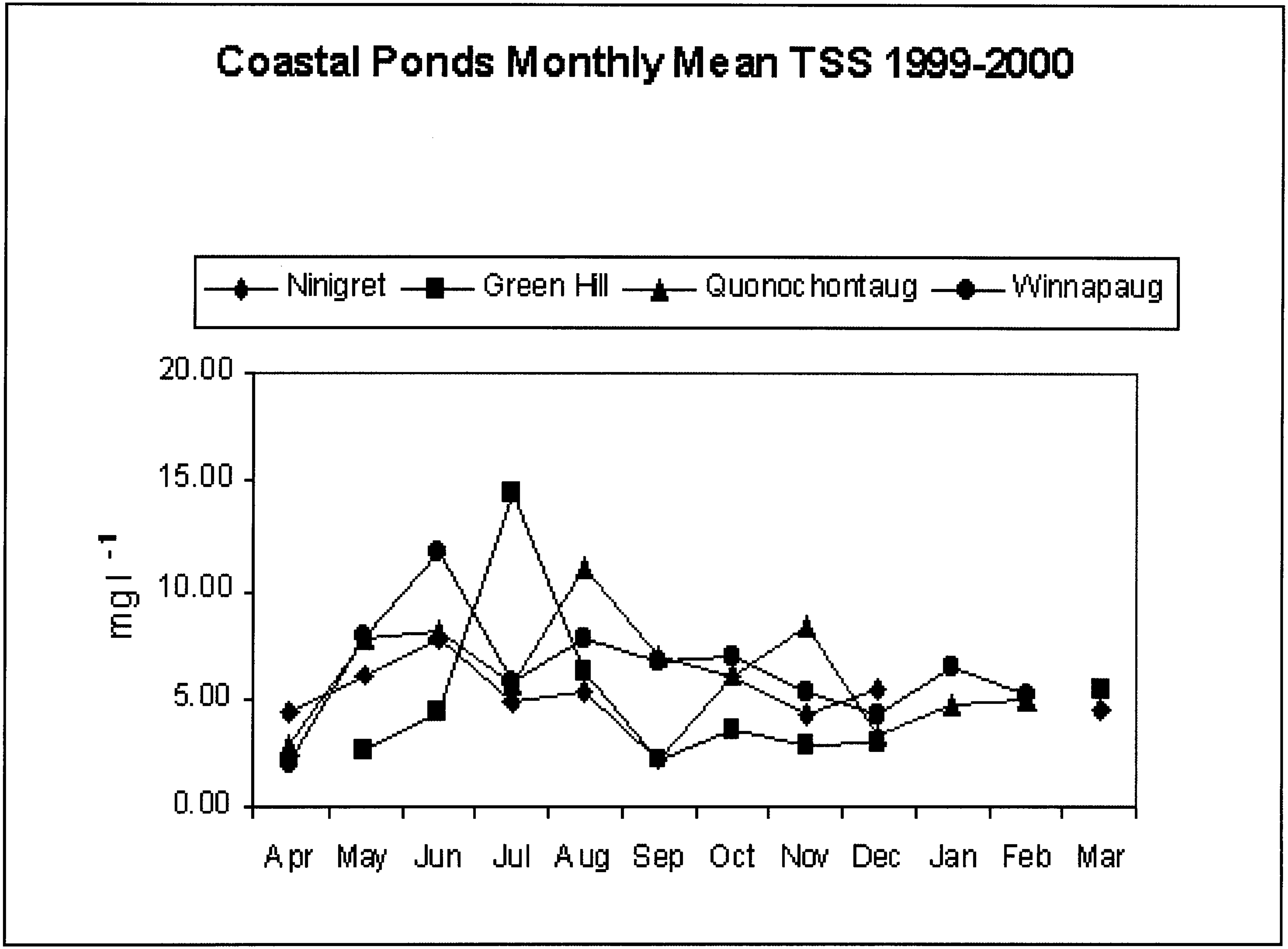
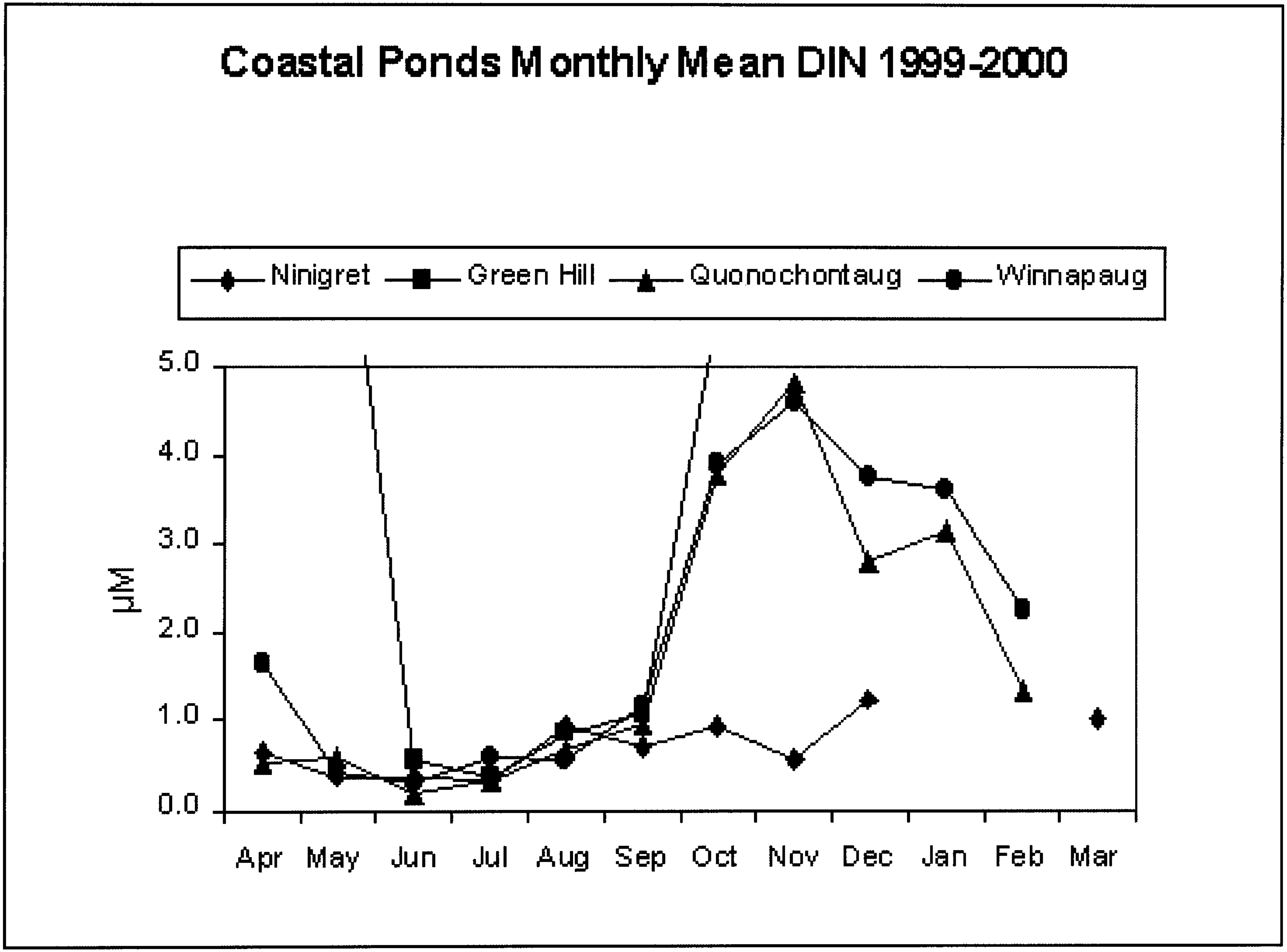

Coastal Ponds Monthly Mean TSS 1999-2000
Ninigret
Green Hill
Quonochontaug
Winnapaug
20.00
15.00
10.00
5.00
0.00
mg l -1
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar

Figure 14. Monthly mean dissolved inorganic nitrogen (μM) for Ninigret, Green Hill, Quonochontaug and Winnapaug ponds. Surveys were conducted twice a month from April 1999 through September 1999 and monthly thereafter until March 2000. Ice cover prevented a January and February survey in Ninigret and Green Hill ponds. Mean monthly values were determined by averaging surface and bottom measurements taken at three stations located in each pond except Green Hill pond which contained a single monitoring station.



Coastal Ponds Monthly Mean DIN 1999-2000
Ninigret
Green Hill
Quonochontaug
Winnapaug
µM
5.0
4.0
3.0
2.0
1.0
0.0
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar

Appendix I.

Latitude and longitude coordinates, taken with a Trimble GPS (model NT-200D), locating the 0.5 meter depth contour (referenced to low tide) around the flood-tide delta in Ninigret Pond. Survey occurred on 5/10/99 from 1:35 PM to 3:45 PM around the time of low tide in Ninigret Pond.

Latitude decimal degrees	Longitude decimal degrees	Latitude decimal degrees	Longitude decimal degrees	Latitude decimal degrees	Longitude decimal degrees
4121.9571	7138.0332	4122.0146	7138.2898	4121.9774	7138.3181
4121.9571	7138.0894	4122.0178	7138.2907	4121.9746	7138.3191
4121.9641	7138.0941	4122.0210	7138.2931	4121.9711	7138.3205
4121.9676	7138.0988	4122.0249	7138.2941	4121.9676	7138.3224
4121.9712	7138.1035	4122.0288	7138.2951	4121.9641	7138.3248
4121.9747	7138.1081	4122.0320	7138.2970	4121.9609	7138.3272
4121.9747	7138.1132	4122.0358	7138.2989	4121.9577	7138.3295
4121.9783	7138.1226	4122.0390	7138.3017	4121.9546	7138.3319
4121.9783	7138.1273	4122.0422	7138.3036	4121.9514	7138.3334
4121.9818	7138.1319	4122.0465	7138.3065	4121.9482	7138.3357
4121.9853	7138.1413	4122.0500	7138.3093	4121.9458	7138.3381
4121.9888	7138.1507	4122.0529	7138.3117	4121.9440	7138.3423
4121.9924	7138.1600	4122.0550	7138.3145	4121.9416	7138.3461
4121.9942	7138.1673	4122.0575	7138.3178	4121.9391	7138.3499
4121.9959	7138.1743	4122.0585	7138.3216	4121.9363	7138.3532
4121.9977	7138.1813	4122.0607	7138.3253	4121.9338	7138.3569
4121.9984	7138.1842	4122.0603	7138.3296	4121.9317	7138.3602
4121.9998	7138.1880	4122.0596	7138.3300	4121.9289	7138.3635
4122.0005	7138.1917	4122.0593	7138.3300	4121.9271	7138.3668
4122.0019	7138.1955	4122.0593	7138.3310	4121.9254	7138.3701
4122.0026	7138.1983	4122.0600	7138.3300	4121.9226	7138.3735
4122.0027	7138.2021	4122.0561	7138.3315	4121.9198	7138.3767
4122.0027	7138.2058	4122.0536	7138.3315	4121.9170	7138.3801
4122.0027	7138.2086	4122.0512	7138.3325	4121.9135	7138.3843
4122.0027	7138.2105	4122.0473	7138.3306	4121.9113	7138.3885
4122.0027	7138.2124	4122.0449	7138.3283	4121.9082	7138.3923
4122.0027	7138.2161	4122.0417	7138.3264	4121.9047	7138.3956
4122.0027	7138.2190	4122.0385	7138.3246	4121.9015	7138.3989
4122.0020	7138.2209	4122.0354	7138.3237	4121.8980	7138.4018
4122.0013	7138.2237	4122.0319	7138.3219	4121.8969	7138.3999
4122.0013	7138.2280	4122.0283	7138.3209	4121.8467	7138.4424
4122.0013	7138.2322	4122.0259	7138.3186	4121.8495	7138.4434
4122.0006	7138.2360	4122.0245	7138.3154	4121.8509	7138.4467
4121.9999	7138.2402	4122.0213	7138.3144	4121.8541	7138.4551
4122.0003	7138.2440	4122.0182	7138.3140	4121.8559	7138.4556
4122.0006	7138.2487	4122.0146	7138.3145	4121.8573	7138.4566
4122.0010	7138.2525	4122.0118	7138.3136	4121.8594	7138.4566
4122.0010	7138.2567	4122.0090	7138.3127	4121.8619	7138.4566
4122.0003	7138.2610	4122.0062	7138.3146	4121.8647	7138.4585
4122.0004	7138.2657	4122.0030	7138.3141	4121.8672	7138.4609
4122.0000	7138.2699	4121.9995	7138.3151	4121.8693	7138.4633
4122.0000	7138.2737	4121.9971	7138.3137	4121.8715	7138.4633
4122.0007	7138.2784	4121.9939	7138.3119	4121.8732	7138.4624
4122.0022	7138.2812	4121.9911	7138.3119	4121.8761	7138.4624
4122.0053	7138.2827	4121.9872	7138.3133	4121.8800	7138.4629
4122.0078	7138.2860	4121.9841	7138.3143	4121.8828	7138.4629
4122.0114	7138.2879	4121.9809	7138.3162	4121.8853	7138.4624

Latitude decimal degrees	Longitude decimal degrees	Latitude decimal degrees	Longitude decimal degrees	Latitude decimal degrees	Longitude decimal degrees
4121.8888	7138.4625	4121.9674	7138.3495	4122.0402	7138.4920
4121.8924	7138.4616	4121.9713	7138.3504	4122.0416	7138.4948
4121.8956	7138.4607	4121.9744	7138.3514	4122.0416	7138.4976
4121.8988	7138.4593	4121.9773	7138.3524	4122.0423	7138.4995
4121.9023	7138.4579	4121.9801	7138.3533	4122.0423	7138.5015
4121.9055	7138.4556	4121.9826	7138.3538	4122.0423	7138.5033
4121.9087	7138.4528	4121.9851	7138.3548	4122.0444	7138.5033
4121.9119	7138.4491	4121.9872	7138.3557	4122.0458	7138.5043
4121.9147	7138.4459	4121.9890	7138.3572	4122.0472	7138.5061
4121.9183	7138.4435	4121.9908	7138.3581	4122.0494	7138.5099
4121.9222	7138.4412	4121.9933	7138.3600	4122.0494	7138.5118
4121.9254	7138.4403	4121.9957	7138.3619	4122.0508	7138.5137
4121.9289	7138.4399	4121.9975	7138.3643	4122.0515	7138.5165
4121.9328	7138.4395	4122.0000	7138.3666	4122.0515	7138.5203
4121.9360	7138.4386	4122.0039	7138.3723	4122.0522	7138.5231
4121.9388	7138.4367	4122.0085	7138.3803	4122.0529	7138.5250
4121.9420	7138.4348	4122.0092	7138.3813	4122.0536	7138.5278
4121.9449	7138.4330	4122.0106	7138.3832	4122.0543	7138.5316
4121.9480	7138.4307	4122.0120	7138.3860	4122.0536	7138.5353
4121.9509	7138.4284	4122.0138	7138.3883	4122.0515	7138.5391
4121.9534	7138.4251	4122.0152	7138.3907	4122.0508	7138.5419
4121.9552	7138.4209	4122.0170	7138.3935	4122.0515	7138.5456
4121.9562	7138.4177	4122.0184	7138.3963	4122.0515	7138.5495
4121.9559	7138.4144	4122.0195	7138.4001	4122.0508	7138.5532
4121.9545	7138.4088	4122.0199	7138.4039	4122.0487	7138.5560
4121.9527	7138.4074	4122.0209	7138.4072	4122.0473	7138.5598
4121.9506	7138.4070	4122.0216	7138.4104	4122.0452	7138.5635
4121.9496	7138.4070	4122.0216	7138.4130	4122.0424	7138.5683
4121.9475	7138.4066	4122.0227	7138.4201	4122.0424	7138.5711
4121.9457	7138.4070	4122.0220	7138.4229	4122.0424	7138.5748
4121.9440	7138.4066	4122.0220	7138.4266	4122.0417	7138.5786
4121.9436	7138.4033	4122.0220	7138.4294	4122.0403	7138.5823
4121.9436	7138.3996	4122.0220	7138.4323	4122.0382	7138.5852
4121.9440	7138.3959	4122.0213	7138.4341	4122.0367	7138.5899
4121.9454	7138.3917	4122.0206	7138.4369	4122.0346	7138.5937
4121.9458	7138.3870	4122.0181	7138.4403	4122.0325	7138.5974
4121.9465	7138.3838	4122.0160	7138.4450	4122.0304	7138.6012
4121.9465	7138.3796	4122.0139	7138.4492	4122.0290	7138.6050
4121.9475	7138.3764	4122.0115	7138.4530	4122.0276	7138.6097
4121.9493	7138.3731	4122.0115	7138.4569	4122.0248	7138.6134
4121.9514	7138.3699	4122.0143	7138.4579	4122.0220	7138.6172
4121.9532	7138.3661	4122.0172	7138.4598	4122.0184	7138.6182
4121.9546	7138.3629	4122.0225	7138.4648	4122.0149	7138.6211
4121.9564	7138.3587	4122.0260	7138.4718	4122.0114	7138.6229
4121.9585	7138.3554	4122.0296	7138.4765	4122.0086	7138.6239
4121.9599	7138.3527	4122.0331	7138.4812	4122.0058	7138.6239
4121.9620	7138.3508	4122.0366	7138.4845	4122.0022	7138.6239
4121.9645	7138.3499	4122.0388	7138.4883	4121.9994	7138.6230

Latitude decimal degrees	Longitude decimal degrees
4121.9945	7138.6184
4121.9917	7138.6156
4121.9889	7138.6129
4121.9846	7138.6129
4121.9811	7138.6129
4121.9776	7138.6129
4121.9734	7138.6130
4121.9698	7138.6139
4121.9656	7138.6158
4121.9621	7138.6178
4121.9593	7138.6196
4121.9558	7138.6216
4121.9522	7138.6235
4121.9487	7138.6263
4121.9452	7138.6292
4121.9424	7138.6320
4121.9410	7138.6357
4121.9396	7138.6405
4121.9382	7138.6452
4121.9367	7138.6499
4121.9339	7138.6527
4121.9304	7138.6546
4121.9276	7138.6537
4121.9248	7138.6528
4121.9220	7138.6519
4121.9184	7138.6519
4121.9142	7138.6520
4121.9114	7138.6538
4121.9086	7138.6558
4121.9065	7138.6586
4121.9036	7138.6605
4121.9001	7138.6605
4121.8952	7138.6605
4121.8924	7138.6596
4121.8881	7138.6578
4121.8846	7138.6569
4121.8811	7138.6551
4121.8776	7138.6541
4121.8741	7138.6542
4121.8691	7138.6542
4121.8649	7138.6552
4121.8614	7138.6571
4121.8586	7138.6590
4121.8550	7138.6609
4121.8515	7138.6619
4121.8487	7138.6629
4121.8452	7138.6638

Latitude decimal degrees	Longitude decimal degrees
4121.8381	7138.6639
4121.8346	7138.6639
4121.8311	7138.6630
4121.8276	7138.6611
4121.8241	7138.6612
4121.8212	7138.6603
4121.8177	7138.6603
4121.8142	7138.6613
4121.8128	7138.6613
4121.8110	7138.6609
4121.8089	7138.6613
4121.8061	7138.6618
4121.8030	7138.6623
4121.8002	7138.6624
4121.7970	7138.6629
4121.7942	7138.6629
4121.7910	7138.6639
4121.7886	7138.6648
4121.7872	7138.6658
4121.7865	7138.6667
4121.7854	7138.6677
4121.7836	7138.6691
4121.7819	7138.6747
4121.7819	7138.6780
4121.7823	7138.6818
4121.7809	7138.6856
4121.7802	7138.6884

Appendix II.

Latitude and longitude coordinates, taken with a Trimble GPS (model NT-200D), locating the 0.5 meter depth contour (referenced to low tide) around the flood-tide delta in Quonochontaug Pond. Survey occurred on 8/1/99 around the time of low tide.

Latitude decimal degrees	Longitude decimal degrees	Latitude decimal degrees	Longitude decimal degrees	Latitude decimal degrees	Longitude decimal degrees
4120.3375	7143.4350	4120.4335	7143.3228	4120.3593	7143.5884
4120.3482	7143.4394	4120.4334	7143.3176	4120.3510	7143.5915
4120.3518	7143.4410	4120.4335	7143.3152	4120.3454	7143.5935
4120.3622	7143.4449	4120.4332	7143.3107	4120.3395	7143.5947
4120.3708	7143.4482	4120.4327	7143.3078	4120.3327	7143.5968
4120.3757	7143.4507	4120.4309	7143.3013	4120.3259	7143.5990
4120.3798	7143.4519	4120.4292	7143.2963	4120.3199	7143.6009
4120.3873	7143.4549	4120.4275	7143.2890	4120.3130	7143.6025
4120.3968	7143.4572	4120.4282	7143.2863	4120.3087	7143.6029
4120.4067	7143.4604	4120.4309	7143.2840	4120.3040	7143.6031
4120.4087	7143.4609	4120.4343	7143.2801	4120.2987	7143.6036
4120.4115	7143.4612	4120.4362	7143.2780	4120.2933	7143.6042
4120.4128	7143.4610	4120.4388	7143.2744	4120.2853	7143.6046
4120.4148	7143.4595	4120.4404	7143.2713	4120.2789	7143.6045
4120.4166	7143.4592	4120.3242	7143.4974	4120.2709	7143.6040
4120.4190	7143.4573	4120.3260	7143.4996	4120.2678	7143.6042
4120.4204	7143.4539	4120.3302	7143.4980	4120.2634	7143.6046
4120.4218	7143.4516	4120.3347	7143.4986	4120.2583	7143.6060
4120.4250	7143.4469	4120.3382	7143.5020	4120.2539	7143.6074
4120.4252	7143.4465	4120.3416	7143.5024	4120.2507	7143.6090
4120.4257	7143.4456	4120.3501	7143.4999	4120.2479	7143.6103
4120.4260	7143.4444	4120.3574	7143.5003	4120.2440	7143.6134
4120.4259	7143.4411	4120.3634	7143.4972	4120.2374	7143.6188
4120.4271	7143.4352	4120.3682	7143.4937	4120.2359	7143.6174
4120.4263	7143.4325	4120.3730	7143.4939	4120.2349	7143.6152
4120.4278	7143.4255	4120.3789	7143.4927	4120.2327	7143.6103
4120.4295	7143.4199	4120.3832	7143.4896	4120.2286	7143.6084
4120.4300	7143.4159	4120.3856	7143.4886	4120.2245	7143.6035
4120.4307	7143.4087	4120.3891	7143.4903	4120.2242	7143.6007
4120.4308	7143.4039	4120.3942	7143.4934	4120.2238	7143.5989
4120.4298	7143.4023	4120.3967	7143.4957	4120.2505	7143.5953
4120.4299	7143.3969	4120.3992	7143.4983	4120.2526	7143.5945
4120.4331	7143.3924	4120.4022	7143.5031	4120.2254	7143.5975
4120.4338	7143.3835	4120.4037	7143.5118	4120.2082	7143.5955
4120.4335	7143.3765	4120.4036	7143.5136	4120.2062	7143.5917
4120.4338	7143.3756	4120.4016	7143.5218	4120.2056	7143.5881
4120.4342	7143.3733	4120.4011	7143.5250	4120.2035	7143.5846
4120.4342	7143.3668	4120.4002	7143.5321	4120.2032	7143.5814
4120.4342	7143.3628	4120.4002	7143.5370	4120.2108	7143.5753
4120.4357	7143.3585	4120.3958	7143.5444	4120.1822	7143.5911
4120.4357	7143.3538	4120.3947	7143.5473	4120.1879	7143.5879
4120.4348	7143.3499	4120.3931	7143.5577	4120.1903	7143.5899
4120.4346	7143.3479	4120.3897	7143.5654	4120.1905	7143.5933
4120.4344	7143.3441	4120.3836	7143.5727	4120.1931	7143.5974
4120.4342	7143.3384	4120.3785	7143.5778	4120.1960	7143.6028
4120.4340	7143.3337	4120.3754	7143.5807	4120.1975	7143.6067
4120.4336	7143.3298	4120.3699	7143.5824	4120.1992	7143.6126

Latitude decimal degrees	Longitude decimal degrees
4120.2024	7143.6191
4120.2029	7143.6233
4120.2049	7143.6306
4120.2066	7143.6365
4120.2214	7143.6356
4120.2135	7143.6436
4120.2562	7143.6344
4120.2597	7143.6337
4120.2168	7143.6416
4120.2120	7143.6515
4120.2258	7143.6514
4120.2026	7143.6702
4120.1996	7143.6731
4120.1996	7143.6731
4120.1996	7143.6731
4120.1996	7143.6731
4120.1996	7143.6731
4120.1996	7143.6731
4120.1807	7143.6912
4120.1718	7143.6978
4120.1745	7143.7040
4120.1746	7143.7150
4120.1742	7143.7183
4120.1737	7143.7206
4120.1708	7143.7257
4120.1718	7143.7284
4120.1718	7143.7299
4120.1711	7143.7357
4120.1670	7143.7401
4120.1649	7143.7431
4120.1622	7143.7485
4120.1601	7143.7557
4120.1573	7143.7594
4120.1558	7143.7621
4120.1549	7143.7663
4120.1545	7143.7698
4120.1549	7143.7739
4120.1553	7143.7777
4120.1581	7143.7842
4120.1605	7143.7863
4120.1605	7143.7924
4120.1570	7143.7975

Appendix III.

Field observations of seagrass abundance in Ninigret and Quonnochontaug Ponds using a modified Braun-Blanquet technique; a one square meter quadrat was subdivided into squares measuring 20 centimeters by 20 centimeters. Diver observations were located with a Trimble differential GPS (model NT200-D).

Latitude decimal degrees	Longitude decimal degrees	Cover Percent	Latitude decimal degrees	Longitude decimal degrees	Cover Percent
4122.0222	7138.4321	0	4122.0255	7138.4487	12
4122.0257	7138.4282	4	4122.0248	7138.4493	0
4122.0292	7138.4247	0	4122.0230	7138.4502	0
4122.0324	7138.4232	32	4122.0203	7138.4505	0
4122.0348	7138.4197	8	4122.0183	7138.4510	0
4122.0390	7138.4171	0	4122.0161	7138.4507	0
4122.0435	7138.4132	0	4122.0134	7138.4507	0
4122.0459	7138.4043	4	4122.0108	7138.4506	0
4122.0497	7138.3917	0	4122.0035	7138.4613	0
4122.0620	7138.3833	8	4122.0074	7138.4623	0
4122.0698	7138.3773	0	4122.0114	7138.4641	4
4122.0753	7138.3723	0	4122.0148	7138.4648	0
4122.0811	7138.3681	0	4122.0181	7138.4663	0
4122.0893	7138.3647	0	4122.0210	7138.4673	0
4122.0975	7138.3591	0	4122.0228	7138.4676	16
4122.1026	7138.3488	0	4122.0237	7138.4678	0
4122.1090	7138.3392	4	4122.0261	7138.4681	0
4122.1123	7138.3241	0	4122.0286	7138.4679	32
4122.1226	7138.3171	28	4122.0308	7138.4688	88
4122.1305	7138.3025	16	4122.0316	7138.4691	4
4122.1431	7138.2912	20	4122.0346	7138.4677	52
4122.1541	7138.2832	24	4122.0385	7138.4644	100
4122.1680	7138.2749	20	4122.0491	7138.4681	100
4122.1784	7138.2714	8	4122.0481	7138.4568	96
4122.1595	7138.3210	24	4122.0662	7138.4490	56
4122.1462	7138.3409	4	4122.0679	7138.4572	52
4122.1400	7138.3540	8	4122.0805	7138.4498	8
4122.1329	7138.3736	0	4122.0899	7138.4527	20
4122.1218	7138.3861	24	4122.1012	7138.4573	8
4122.1112	7138.3942	12	4122.1103	7138.4634	44
4122.0972	7138.4109	16	4122.1189	7138.4693	12
4122.0881	7138.4194	0	4122.1288	7138.4758	12
4122.0765	7138.4262	0	4122.1451	7138.5434	8
4122.0690	7138.4312	8	4122.1408	7138.5444	76
4122.0596	7138.4349	84	4122.1355	7138.5478	100
4122.0569	7138.4272	56	4122.1276	7138.5546	100
4122.0548	7138.4362	8	4122.1166	7138.5602	100
4122.0513	7138.4382	88	4122.1078	7138.5683	100
4122.0471	7138.4404	100	4122.1008	7138.5740	100
4122.0458	7138.4420	100	4122.0934	7138.5815	100
4122.0433	7138.4426	84	4122.0517	7138.6016	100
4122.0424	7138.4445	100	4122.0463	7138.6092	100
4122.0396	7138.4458	100	4122.0362	7138.6197	100
4122.0372	7138.4468	100	4122.0300	7138.6120	100
4122.0342	7138.4484	88	4122.0262	7138.6120	64
4122.0301	7138.4488	88	4122.0237	7138.6123	80
4122.0271	7138.4488	44	4122.0223	7138.6130	80

Latitude decimal degrees	Longitude decimal degrees	Cover Percent	Latitude decimal degrees	Longitude decimal degrees	Cover Percent
4122.0194	7138.6129	96	4122.0497	7138.6212	100
4122.0177	7138.6130	100	4122.0787	7138.6185	100
4122.0148	7138.6108	76	4122.0843	7138.6115	100
4122.0132	7138.6103	80	4122.0934	7138.6329	0
4122.0109	7138.6078	16	4122.0854	7138.6301	0
4122.0082	7138.6054	48	4122.0809	7138.6245	100
4122.0061	7138.6022	40	4122.0781	7138.6191	100
4122.0039	7138.5993	4	4121.9441	7138.6147	0
4122.0015	7138.5971	0	4121.9441	7138.6171	28
4121.9999	7138.5958	0	4121.9444	7138.6203	12
4122.0443	7138.5068	8	4121.9447	7138.6244	92
4122.0486	7138.5066	12	4121.9460	7138.6278	96
4122.0500	7138.5071	16	4121.9473	7138.6318	84
4122.0517	7138.5074	100	4121.9474	7138.6362	100
4122.0539	7138.5072	100	4121.9473	7138.6394	100
4122.0607	7138.5415	80	4121.9420	7138.6492	100
4122.0580	7138.5357	32	4121.9402	7138.6510	20
4122.0556	7138.5308	96	4121.9388	7138.6489	0
4122.0537	7138.5281	60	4121.9372	7138.6447	0
4122.0530	7138.5241	28	4121.9327	7138.6492	0
4122.0504	7138.5232	0	4121.9324	7138.6534	8
4122.0486	7138.5240	12	4121.9311	7138.6566	0
4122.0455	7138.5217	0	4121.9300	7138.6608	100
4122.0055	7138.5648	0	4121.9293	7138.6697	100
4122.0083	7138.5688	0	4121.9288	7138.6750	100
4122.0175	7138.5790	20	4121.9238	7138.6825	100
4122.0215	7138.5830	16	4121.9201	7138.6828	100
4122.0248	7138.5887	76	4121.9156	7138.6803	96
4122.0278	7138.5922	60	4121.9122	7138.6766	100
4122.0307	7138.5966	92	4121.9072	7138.6600	100
4122.0329	7138.5993	100	4121.9070	7138.6567	96
4122.0361	7138.6019	100	4121.9057	7138.6536	68
4122.0466	7138.6183	100	4121.9048	7138.6506	4
4122.0450	7138.6227	0	4121.9045	7138.6453	24
4122.0454	7138.6274	0	4121.9048	7138.6416	8
4122.0447	7138.6314	100	4121.9063	7138.6377	0
4122.0502	7138.6271	100	4121.9070	7138.6358	0
4122.0483	7138.6251	100	4121.9000	7138.6450	4
4122.0444	7138.6232	0	4121.8956	7138.6523	0
4122.0399	7138.6239	100	4121.8932	7138.6572	80
4122.0050	7138.6032	36	4121.8893	7138.6618	100
4122.0103	7138.6086	68	4121.8869	7138.6643	100
4122.0146	7138.6133	76	4121.8793	7138.6643	100
4122.0189	7138.6151	92	4121.8763	7138.6609	88
4122.0225	7138.6145	80	4121.8738	7138.6580	88
4122.0263	7138.6182	100	4121.8716	7138.6530	44
4122.0321	7138.6185	100	4121.8706	7138.6492	0

Latitude decimal degrees	Longitude decimal degrees	Cover Percent	Latitude decimal degrees	Longitude decimal degrees	Cover Percent
4121.8686	7138.6461	0	4121.8856	7138.8753	80
4121.8622	7138.6509	12	4121.8865	7138.8851	100
4121.8564	7138.6586	76	4121.8996	7138.8971	100
4121.8564	7138.6586	68	4121.9337	7138.9407	100
4121.8523	7138.6720	88	4121.9324	7138.9479	0
4121.8500	7138.6830	100	4121.9384	7138.9655	0
4121.8483	7138.6945	100	4121.9265	7138.9629	0
4121.8459	7138.7063	100	4121.9258	7138.9601	100
4121.8430	7138.6969	100	4121.9293	7138.9541	20
4121.8421	7138.6929	96	4121.9256	7138.9478	100
4121.8419	7138.6906	100	4121.9313	7138.9436	0
4121.8400	7138.6856	100	4121.9406	7138.9321	0
4121.8371	7138.6786	20	4121.9376	7138.9299	100
4121.8345	7138.6707	0	4121.9403	7138.9307	0
4121.8340	7138.6665	28	4121.9430	7138.9265	0
4121.8340	7138.6625	16	4121.9406	7138.9245	100
4121.8347	7138.6561	0	4121.9375	7138.9223	100
4121.8361	7138.6531	4	4121.9454	7138.9184	100
4121.8367	7138.6474	0	4121.9466	7138.9203	0
4121.8360	7138.6459	0	4121.9559	7138.9149	0
4121.8316	7138.6459	0	4121.9467	7138.8986	100
4121.8267	7138.6469	0	4121.9427	7138.8959	100
4121.8188	7138.6529	0	4121.9506	7138.8905	32
4121.8148	7138.6624	0	4121.9541	7138.8906	0
4121.8132	7138.6687	4	4121.9548	7138.8920	0
4121.8131	7138.6846	0	4121.9601	7138.8899	0
4121.8183	7138.6965	16	4121.9609	7138.8853	0
4121.8208	7138.7003	20	4121.9596	7138.8829	0
4121.8240	7138.7038	48	4121.9586	7138.8808	60
4121.8265	7138.7077	100	4121.9582	7138.8764	100
4121.8288	7138.7129	100	4121.9587	7138.8688	100
4121.8295	7138.7175	100	4121.9566	7138.8595	100
4121.8207	7138.7274	100	4121.9536	7138.8564	96
4121.7994	7138.7381	100	4121.9489	7138.8515	88
4121.7963	7138.7393	100	4121.9465	7138.8419	12
4121.7922	7138.7422	0	4121.9440	7138.8324	52
4121.7891	7138.7425	0	4121.9373	7138.8228	12
4121.7829	7138.7557	8	4121.9273	7138.8157	20
4121.7859	7138.7643	20	4121.9145	7138.8136	0
4121.7902	7138.7688	100	4121.9010	7138.8090	0
4121.7918	7138.7702	100	4121.8671	7138.7914	0
4121.7986	7138.7770	100	4121.8448	7138.7700	16
4121.8189	7138.7967	80	4121.8419	7138.7663	100
4121.8237	7138.8005	12	4121.8391	7138.7635	72
4121.8326	7138.8043	0	4121.8323	7138.7595	88
4121.8547	7138.8229	0	4121.8277	7138.7520	100
4121.8821	7138.8663	0	4121.8314	7138.7440	100

Latitude decimal degrees	Longitude decimal degrees	Cover Percent	Latitude decimal degrees	Longitude decimal degrees	Cover Percent
4121.8459	7138.7590	100	4122.4178	7138.8039	100
4121.8462	7138.7597	56	4122.4334	7138.6905	0
4121.8466	7138.7714	12	4122.4538	7138.7022	0
4121.8721	7138.7645	0	4122.4632	7138.7111	100
4121.8778	7138.7528	0	4122.4979	7138.7521	100
4121.8860	7138.7401	48	4122.5372	7138.7633	100
4121.8869	7138.7401	100	4122.5787	7138.7683	100
4121.8928	7138.7314	84	4122.6455	7138.7836	0
4121.9006	7138.7180	100	4122.6765	7138.7726	0
4121.9030	7138.7308	64	4122.1565	7138.5999	0
4121.9012	7138.7421	0	4122.1440	7138.5896	0
4121.9176	7138.7482	48	4122.1280	7138.5834	0
4121.9287	7138.7278	32	4122.1233	7138.5806	100
4121.9444	7138.7125	20	4122.1127	7138.5776	100
4121.9545	7138.7023	100	4122.1197	7138.5709	100
4121.9630	7138.7114	20	4122.1311	7138.5659	4
4121.9706	7138.7248	0	4122.1372	7138.5641	0
4121.9865	7138.7432	0	4122.1499	7138.5573	0
4121.9995	7138.7597	24	4122.1715	7138.5535	0
4122.0037	7138.7650	100	4122.1754	7138.5576	0
4122.0077	7138.7710	0	4122.1640	7138.5873	0
4122.0169	7138.7869	0	4122.1501	7138.6026	0
4122.0194	7138.7917	100	4122.1431	7138.6330	0
4122.0330	7138.7999	100	4122.1283	7138.6288	0
4122.0562	7138.8145	100	4122.1130	7138.6212	0
4122.0607	7138.8225	24	4122.1144	7138.6308	0
4122.0641	7138.8289	0	4122.1204	7138.6414	0
4122.0744	7138.8363	0	4122.1269	7138.6558	0
4122.0830	7138.8458	0	4122.1367	7138.6722	0
4122.1408	7138.8157	100	4122.1218	7138.6620	0
4122.1315	7138.8420	100	4122.0965	7138.6501	0
4122.1200	7138.8466	0	4122.0782	7138.6457	100
4122.1221	7138.8410	0	4122.0309	7138.6644	100
4122.1416	7138.8132	0	4121.9579	7138.6957	100
4122.1471	7138.8078	40	4121.9171	7138.6917	100
4122.1551	7138.7877	28	4121.8725	7138.7017	100
4122.1628	7138.7837	100	4121.8432	7138.7003	100
4122.1747	7138.7852	100	4121.8305	7138.6982	42
4122.2544	7138.7144	100	4121.8119	7138.6916	2
4122.2987	7138.6620	100	4121.7959	7138.6860	0
4122.3045	7138.6885	100	4121.7812	7138.6816	0
4122.2939	7138.7446	100	4121.7666	7138.7066	0
4122.2869	7138.7631	0	4121.7681	7138.7185	0
4122.2820	7138.7928	0	4121.7889	7138.7411	0
4122.2824	7138.7981	100	4121.7931	7138.7447	82
4122.3326	7138.8157	100	4121.8008	7138.7449	100
4122.3571	7138.8230	100	4121.8112	7138.7495	100

Latitude decimal degrees	Longitude decimal degrees	Cover Percent
4121.8152	7138.7754	100
4121.8020	7138.8062	100
4121.7939	7138.8200	0
4121.7984	7138.8427	100
4121.7969	7138.8551	100
4121.8246	7138.8786	100
4121.8400	7138.8904	100
4121.8636	7138.9085	100
4121.8261	7138.9163	100
4121.7925	7138.9170	100
4121.7823	7138.9155	0
4121.7752	7138.9126	0
4121.7792	7138.9233	100
4121.8000	7138.9605	100
4121.8112	7138.9943	100
4121.8276	7139.0165	100
4121.8342	7138.9158	100
4121.7992	7138.6962	0
4121.7841	7138.6734	0
4121.7967	7138.6408	0
4121.8155	7138.6405	0
4121.8309	7138.6486	0
4121.9165	7138.6372	0
4121.9325	7138.6445	0
4121.9385	7138.6490	24
4121.9420	7138.6506	100
4121.9551	7138.6620	100
4121.9879	7138.6872	100
4122.0248	7138.7111	100
4122.0629	7138.7303	100
4122.0993	7138.7471	100
4122.1114	7138.7501	0
4122.1697	7138.7809	100
4122.2360	7138.8010	100
4122.2021	7138.7446	100
4122.1956	7138.7246	100
4122.1941	7138.7194	0
4122.1817	7138.7241	0
4122.1711	7138.7374	0
4122.1667	7138.7680	100
4122.1623	7138.7987	100
4122.1456	7138.7893	100
4122.1301	7138.7467	100
4122.1296	7138.6978	0
4122.1282	7138.6909	0
4122.1224	7138.6827	0
4122.1130	7138.6978	0

Latitude decimal degrees	Longitude decimal degrees	Cover Percent
4122.1075	7138.7146	0
4122.1012	7138.7373	100
4122.0879	7138.7700	100
4122.0790	7138.7955	76
4122.0718	7138.8160	0
4122.0622	7138.8427	0
4122.0499	7138.8734	0
4122.0500	7138.8906	60
4122.0500	7138.9028	100
4122.0494	7138.8878	0
4122.0386	7138.8521	100
4122.0353	7138.7797	0
4122.0413	7138.7534	100
4122.0516	7138.7279	100
4122.0696	7138.7126	100
4122.0912	7138.6957	100
4122.1039	7138.6883	100
4122.1148	7138.6825	0
4122.2313	7138.8754	0
4122.2333	7138.9061	100
4122.2160	7138.9629	100
4122.2312	7138.9825	100
4122.2297	7138.9896	100
4122.2252	7138.9783	0
4122.2140	7138.9443	100
4122.2041	7138.9082	100
4122.1914	7138.9238	100
4122.1869	7138.9408	100
4122.1866	7138.9648	100
4122.1859	7138.9686	100
4122.1852	7138.9728	0
4122.1600	7138.9670	0
4122.1369	7138.9760	0
4122.1251	7138.9677	0
4122.1183	7138.9173	100
4122.0920	7138.9094	100
4122.0785	7138.9211	100
4122.0702	7138.9285	0
4122.0461	7138.9032	0
4122.0283	7138.9053	0
4122.0048	7138.8847	100
4122.0090	7138.9375	0
4122.0006	7138.9406	0
4121.9821	7138.9400	0
4121.9548	7138.9200	0
4121.9285	7138.9046	0

Appendix IV.

Field observations taken on 8/5/99 of seagrass abundance in Quonnochontaug Pond using a modified Braun-Blanquet technique where a one square meter quadrat was subdivided into squares measuring 20 centimeters by 20 centimeters. Seagrass cover is expressed as percent of the bottom covered with seagrass, ie percentage of 20 centimeters by 20 centimeters squares in the quadrat containing one or more seagrass plants. Diver observations were located with a Trimble differential GPS (model NT200-D).

Latitude ecimal degree:	Longitude ecimal degree:	Cover Percent
4120.4198	7143.4553	0
4120.4209	7143.4550	94
4120.4214	7143.4537	92
4120.4230	7143.4535	0
4120.4239	7143.4511	92
4120.4261	7143.4506	0
4120.4261	7143.4476	54
4120.4282	7143.4449	0
4120.4285	7143.4392	52
4120.4325	7143.4344	0
4120.4323	7143.4331	44
4120.4310	7143.4315	46
4120.4283	7143.4296	0
4120.4248	7143.4266	0
4120.4285	7143.4220	0
4120.4329	7143.4162	2
4120.4327	7143.4169	16
4120.4341	7143.4161	48
4120.4369	7143.4159	62
4120.4383	7143.4163	0
4120.4393	7143.4108	0
4120.4384	7143.4099	100
4120.4372	7143.4054	100
4120.4362	7143.4014	70
4120.4360	7143.3959	20
4120.4345	7143.3912	4
4120.4333	7143.3861	0
4120.4366	7143.3790	14
4120.4396	7143.3764	30
4120.4418	7143.3749	100
4120.4433	7143.3727	100
4120.4449	7143.3674	96
4120.4463	7143.3640	100
4120.4471	7143.3606	94
4120.4489	7143.3572	100
4120.4442	7143.3590	100
4120.4521	7143.3589	100
4120.4432	7143.3523	100
4120.4411	7143.3509	80
4120.4382	7143.3493	16
4120.4356	7143.3471	8
4120.4326	7143.3442	4
4120.4359	7143.3356	0
4120.4384	7143.3323	0
4120.4430	7143.3275	92
4120.4458	7143.3261	100
4120.4495	7143.3249	100

Latitude decimal degree:	Longitude ecimal degree:	Cover Percent
4120.4540	7143.3234	100
4120.4194	7143.4524	0
4120.4230	7143.4475	0
4120.4236	7143.4408	0
4120.4268	7143.4357	12
4120.4269	7143.4279	26
4120.4222	7143.4206	0
4120.4046	7143.5319	0
4120.4048	7143.5355	100
4120.4044	7143.5379	0
4120.4072	7143.5368	0
4120.4061	7143.5346	100
4120.4033	7143.5305	0
4120.4077	7143.5302	0
4120.4086	7143.5339	0
4120.4066	7143.5340	100
4120.2300	7143.6089	0
4120.2298	7143.6128	30
4120.2304	7143.6184	48
4120.2308	7143.6219	100
4120.2316	7143.6252	22
4120.2317	7143.6299	26
4120.2335	7143.6334	0
4120.2276	7143.6336	44
4120.2246	7143.6333	98
4120.2210	7143.6327	86
4120.2147	7143.6283	76
4120.2118	7143.6243	0
4120.2084	7143.6162	0
4120.2105	7143.6081	8
4120.2110	7143.6035	2
4120.2107	7143.5993	12
4120.2114	7143.5929	0
4120.2168	7143.6007	14
4120.2172	7143.6056	14
4120.2182	7143.6105	100
4120.2182	7143.6148	100
4120.2197	7143.6197	100
4120.2210	7143.6233	100
4120.2221	7143.6290	100
4120.2244	7143.6376	100
4120.2250	7143.6404	0
4120.2128	7143.6362	0
4120.2127	7143.6310	0
4120.2087	7143.6141	0
4120.1965	7143.6729	0
4120.1959	7143.6783	0

Latitude ecimal degree:	Longitude ecimal degree:	Cover Percent
4120.1956	7143.6840	0
4120.1948	7143.6854	2
4120.1913	7143.6858	0
4120.1938	7143.6911	0
4120.1946	7143.6937	8
4120.1935	7143.6960	0
4120.1905	7143.6966	0
4120.1870	7143.6968	18
4120.1828	7143.6986	0
4120.1795	7143.6996	0
4120.1737	7143.7001	0
4120.1697	7143.6986	0
4120.1683	7143.7073	0
4120.1698	7143.7153	0
4120.1704	7143.7193	2
4120.1726	7143.7245	0
4120.1738	7143.7287	0
4120.1746	7143.7317	4
4120.1761	7143.7366	58
4120.1773	7143.7400	16
4120.1791	7143.7430	10
4120.1807	7143.7469	10
4120.1828	7143.7509	0
4120.1848	7143.7551	0
4120.1866	7143.7591	0
4120.1875	7143.7633	20
4120.1881	7143.7672	22
4120.1902	7143.7710	10
4120.1914	7143.7742	44
4120.1932	7143.7786	8
4120.1945	7143.7820	36
4120.1960	7143.7845	98
4120.1979	7143.7884	100
4120.1987	7143.7911	100
4120.1997	7143.7930	82
4120.1936	7143.8036	100
4120.1909	7143.8034	64
4120.1875	7143.8009	14
4120.1850	7143.7992	18
4120.1825	7143.7971	76
4120.1797	7143.7959	74
4120.1773	7143.7938	84
4120.1745	7143.7917	74
4120.1720	7143.7893	30
4120.1697	7143.7866	30
4120.1668	7143.7852	8
4120.1650	7143.7813	0

Latitude decimal degree:	Longitude ecimal degree:	Cover Percent
4120.1619	7143.7793	6
4120.1590	7143.7753	6
4120.1558	7143.7728	6
4120.1520	7143.7707	0
4120.1489	7143.7678	0
4120.1487	7143.7731	0
4120.1493	7143.7792	0
4120.1603	7143.8092	0
4120.1640	7143.8178	2
4120.1639	7143.8219	14
4120.1671	7143.8255	84
4120.1686	7143.8285	100
4120.1693	7143.8329	98
4120.1705	7143.8367	40
4120.1706	7143.8398	38
4120.1554	7143.8257	0
4120.1555	7143.8320	0
4120.1561	7143.8372	18
4120.1555	7143.8410	100
4120.1550	7143.8447	26
4120.1534	7143.8489	0
4120.1473	7143.8484	20
4120.1444	7143.8470	100
4120.1423	7143.8451	100
4120.1414	7143.8409	0
4120.1400	7143.8444	100
4120.1356	7143.8481	0
4120.1309	7143.8527	0
4120.1288	7143.8591	0
4120.1348	7143.8563	0
4120.1413	7143.8499	0

Appendix V.

Surface and bottom measurements of salinity, temperature, dissolved oxygen, total suspended solids, light attenuation, dissolved inorganic nitrogen (NH_4, NO_2 and NO_3) and dissolved inorganic phosphorus taken in Ninigret (N), Green Hill (G), Quonochontaug (Q) and Winnapaug Ponds from April, 1999 through March, 2000.

Date Time	Pond	Station	Depth, m	Temp., °C	Salinity, psu	DO, mg l -1	Chl a, μg l-1	T.S.S., mg ml -1	k,m-1	NH4, μM	NO3+2, μM	NO3, μM	DIN, μM	DIP, μM
04/19/1999 10:50	N	1	0.2	13.0	27.1	9.9	2.2	0.0070	-0.66	0.22	0.06	0.03	0.27	0.02
04/19/1999 10:50	N	1	1.3	11.5	29.1	10.1	2.0	0.0037	-0.66	0.21	0.02	0.01	0.23	0.05
04/19/1999 13:00	N	2	0.2	11.3	27.6	9.9	0.5	0.0050	-0.72	0.16	0.20	0.18	0.37	0.29
04/19/1999 13:00	N	2	0.9	11.0	28.9	9.7	1.8	0.0049	-0.72	0.76	0.73	0.69	1.50	0.16
04/19/1999 15:10	N	3	0.2	12.8	27.9	9.7	1.9	0.0046	-0.65	0.15	0.05	0.03	0.20	0.00
04/19/1999 15:10	N	3	1.0	12.8	27.9	9.4	2.2	0.0041	-0.65	0.19	0.02	0.01	0.22	0.04
04/19/1999 10:00	N	10	0.2	12.8	28.3	10.4	3.1	0.0046	-0.62	0.26	0.13	0.10	0.39	0.06
04/19/1999 10:00	N	10	0.9	12.5	28.7	10.0	4.3	0.0050	-0.62	0.21	0.03	0.02	0.24	0.04
04/19/1999 10:40	N	11	0.2	13.3	27.2	10.2	2.4	0.0029	-0.58	0.23	0.20	0.18	0.42	0.03
04/19/1999 10:40	N	11	0.9	12.7	28.6	10.3	2.7	0.0064	-0.58	0.15	0.01	0.00	0.16	0.03
04/19/1999 11:10	N	12	0.2	10.8	28.4	9.9	1.0	0.0050	-0.59	0.20	0.12	0.10	0.32	0.08
04/19/1999 11:10	N	12	1.1	9.5	30.2	10.1	3.9	0.0154	-0.59	0.14	0.02	0.01	0.15	0.33
04/19/1999 12:15	N	13	0.2	12.4	26.7	10.1	0.7	0.0079		1.40	1.70	1.62	3.10	0.02
04/19/1999 12:15	N	13												
04/19/1999 12:30	N	14	0.2	12.0	28.0	9.8	0.8	0.0050	-0.63	0.90	0.97	0.91	1.87	0.13
04/19/1999 12:30	N	14	0.7	11.8	29.2	9.8	1.3	0.0074	-0.63	0.60	0.30	0.28	0.91	0.30
04/19/1999 12:45	N	15	0.2	8.9	30.6	10.4	1.2	0.0037	-0.63	0.12	0.06	0.05	0.18	0.39
04/19/1999 12:45	N	15							-0.63					
04/19/1999 13:00	N	16	0.2	11.3	27.6	9.9	0.5	0.0050	-0.72	0.88	1.48	1.41	2.36	0.05
04/19/1999 13:00	N	16	0.9	11.0	28.9	9.7	1.8	0.0049	-0.72	0.76	0.73	0.69	1.50	0.16
04/19/1999 13:55	N	17	0.2	11.6	29.0	10.0	1.3		-0.52	0.18	0.06	0.03	0.24	0.18
04/19/1999 13:55	N	17							-0.52					
04/19/1999 14:15	N	18	0.2	11.8	28.7	10.1	1.2	0.0049	-0.53	0.18	0.07	0.05	0.26	0.04
04/19/1999 14:15	N	18	1.0	11.5	28.9	10.1	1.2	0.0036	-0.53	0.13	0.07	0.04	0.20	0.11
04/19/1999 14:30	N	19	0.2	12.2	28.5	9.8	1.2	0.0041	-0.63	0.23	0.06	0.04	0.29	0.07
04/19/1999 14:30	N	19	0.9	11.9	28.6	9.6	1.1	0.0059	-0.63	0.17	0.03	0.01	0.20	0.12
04/19/1999 15:00	N	20	0.2	12.6	28.2	9.6	1.2		-0.67	0.18	0.10	0.07	0.29	0.05
04/19/1999 15:00	N	20	1.2	12.6	28.2	9.2	1.6		-0.67	0.19	0.09	0.06	0.28	0.02
04/21/1999 11:30	Q	1	0.2	10.1	29.8	9.3	1.0	0.0022	-0.43	0.18	0.11	0.09	0.29	0.25
04/21/1999 11:30	Q	1	2.5	9.1	30.3	9.3	1.4	0.0036	-0.43	0.91	0.09	0.01	1.00	0.43
04/21/1999 12:35	Q	2	0.2	9.8	30.2	9.9	0.7	0.0037	-0.44	0.31	0.19	0.17	0.50	0.32
04/21/1999 12:35	Q	2	3.0	8.6	30.2	9.9	1.0	0.0036	-0.44	0.27	0.07	0.06	0.34	0.38
04/21/1999 13:00	Q	3	0.2	10.5	29.9	9.5	0.5	0.0019	-0.35	0.39	0.32	0.30	0.71	0.30
04/21/1999 13:00	Q	3	2.8	9.2	30.1	9.7	0.6	0.0023	-0.35	0.49	0.16	0.14	0.65	0.36
04/21/1999 10:00	Q	4	0.2	9.5	29.9	9.6	1.1	0.0023	-0.47	0.41	0.12	0.10	0.53	0.29
04/21/1999 10:00	Q	4	1.5	9.0	30.1	9.5	0.8	0.0034	-0.47	0.49	0.11	0.09	0.60	0.31
04/21/1999 10:20	Q	5	0.2	9.5	30.1	9.8	0.5	0.0024	-0.38	0.33	0.19	0.17	0.52	0.29
04/21/1999 10:20	Q	5	2.8	8.4	30.3	9.7	1.5	0.0035	-0.38	0.35	0.21	0.17	0.55	0.37
04/21/1999 11:05	Q	6	0.2	10.1	29.9	9.6	0.8	0.0021	-0.38	0.22	0.10	0.08	0.32	0.23
04/21/1999 11:05	Q	6	2.8	8.4	30.3	9.7	1.1	0.0034	-0.38	0.84	0.07	0.06	0.92	0.42
04/21/1999 11:45	Q	7	0.2	10.3	30.0	9.3	0.9	0.0019	-0.45	0.18	0.09	0.07	0.27	0.27
04/21/1999 11:45	Q	7	1.8	10.3	30.1	8.9	1.6	0.0028	-0.45	0.27	0.09	0.07	0.36	0.30
04/21/1999 13:20	Q	8	0.2	10.1	30.2	9.5	1.0	0.0039	-0.42	0.41	0.20	0.18	0.61	0.33
04/21/1999 13:20	Q	8	2.7	9.5	30.2	9.3	0.7	0.0044	-0.42	0.66	0.08	0.06	0.75	0.38
04/21/1999 13:50	Q	9	0.2	8.4	30.3	10.1	1.0	0.0019		0.13	0.07	0.05	0.19	0.37
04/21/1999 13:50	Q	9												
04/28/1999 11:35	W	1	0.2	9.7	30.3	10.5	0.5	0.0024	-0.47	0.65	0.96	0.92	1.61	0.48
04/28/1999 11:35	W	1							-0.47					
04/28/1999 12:55	W	2	0.2	12.3	29.7	9.6	1.8	0.0028	-0.56	0.14	0.20	0.17	0.34	0.21
04/28/1999 12:55	W	2	0.9	12.2	29.8	9.3			-0.56					
04/28/1999 13:15	W	3	0.2	13.1	29.5	9.8	2.5	0.0041	-0.53	0.24	0.20	0.16	0.43	0.24
04/28/1999 13:15	W	3	1.1	13.0	29.7	10.5			-0.53					
04/28/1999 12:00	W	4	0.3	10.1	30.2	10.3	0.5	0.0026	-0.69	0.60	0.91	0.87	1.51	0.45
04/28/1999 12:00	W	4							-0.69					
04/28/1999 12:30	W	5	0.2	11.1	29.8	10.0	0.3	0.0041	-0.48	0.62	2.76	2.69	3.38	0.40
04/28/1999 12:30	W	5	1.2	10.1	30.0	10.4	0.8	0.0035	-0.48	0.49	2.14	2.09	2.63	0.39
05/05/1999 14:20	G	1	0.2	15.2	16.1	10.0	2.2	0.0054		2.05	11.57	11.34	13.61	0.10
05/05/1999 14:20	G	1												
05/05/1999 11:40	N	1	0.2	14.6	26.5	10.9	6.5	0.0069	-0.79	0.44	0.08	0.03	0.52	0.39
05/05/1999 11:40	N	1	1.2	13.2	28.7	9.2	3.2	0.0033	-0.79	0.20	0.04	0.01	0.24	0.17
05/05/1999 12:40	N	2	0.2	10.7	30.5	9.8	0.4	0.0055	-0.53	0.24	0.09	0.04	0.32	0.48
05/05/1999 12:40	N	2	0.5	10.5	30.7	9.9			-0.53					
05/05/1999 12:05	N	3	0.2	13.5	28.4	9.2	1.6	0.0064	-0.56	0.20	0.06	0.02	0.27	0.03
05/05/1999 12:05	N	3	1.2	13.5	28.4	9.1	1.7	0.0040	-0.56	0.16	0.06	0.02	0.23	0.03
05/05/1999 12:50	N	21	0.2	10.2	30.7	9.9	0.7	0.0071	-0.53	0.13	0.07	0.06	0.21	0.50
05/05/1999 12:50	N	21							-0.53					
05/05/1999 13:10	N	22	0.2	13.3	26.3	9.2	2.5	0.0079	-0.65	0.35	0.96	0.88	1.31	0.05
05/05/1999 13:10	N	22							-0.65					
05/11/1999 10:35	Q	1	0.2	13.8	30.7	8.5	1.0	0.0056	-0.48	0.67	0.15	0.13	0.82	0.48
05/11/1999 10:35	Q	1	2.9	11.9	30.8	8.5	1.7	0.0082	-0.48	1.16	0.13	0.10	1.29	0.65
05/11/1999 11:12	Q	2	0.2	13.4	30.7	8.9	0.6	0.0024	-0.38	0.39	0.08	0.06	0.47	0.50
05/11/1999 11:12	Q	2	3.2	11.2	30.8	9.7	1.7	0.0070	-0.38	0.83	0.05	0.03	0.88	0.64
05/11/1999 11:43	Q	3	0.2	15.2	30.5	8.8	1.0	0.0046	-0.44	0.15	0.05	0.02	0.20	0.39
05/11/1999 11:43	Q	3	2.8	13.8	30.6	8.4	1.0	0.0062	-0.44	0.87	0.09	0.05	0.96	0.57

05/11/1999 14:05	W	1	0.2	16.6	30.1	9.6	1.8	0.0059		0.10	0.07	0.04	0.17	0.25
05/11/1999 14:05	W	1												
05/11/1999 14:25	W	2	0.2	16.5	30.2	9.6	2.2	0.0101	-0.89	0.13	0.28	0.25	0.42	0.32
05/11/1999 14:25	W	2	0.6	16.9	30.2	9.7	2.4	0.0087	-0.89	0.19	0.14	0.12	0.34	0.25
05/11/1999 14:28	W	3	0.2	18.0	29.9	9.4	3.1	0.0106	-0.83	0.17	0.03	0.01	0.20	0.15
05/11/1999 14:28	W	3	0.9	17.9	29.9	9.3	3.2	0.0114	-0.83	0.16	0.03	0.01	0.19	0.14
05/11/1999 12:09	Q	10	0.2	15.3	30.4	9.4	1.3	0.0052	-0.52	0.10	0.05	0.02	0.14	0.42
05/11/1999 12:09	Q	10	2.5	14.3	30.5	8.0	3.4	0.0099	-0.52	1.71	0.09	0.04	1.80	0.56
05/11/1999 12:55	Q	11	0.2	14.5	30.6	9.0								
05/11/1999 12:55	Q	11												
05/19/1999 14:30	G	1	0.2	21.5	26.7	9.7	3.1	0.0054	-0.91	0.86	1.06	0.98	1.92	0.09
05/19/1999 14:30	G	1							-0.91					
05/19/1999 11:00	N	1	0.2	18.9	26.4	10.2	2.2	0.0051	-0.84	0.21	0.03	0.01	0.24	0.07
05/19/1999 11:00	N	1	1.4	18.6	30.3	10.2	7.4	0.0040	-0.84	0.15	0.04	0.01	0.19	0.36
05/19/1999 12:00	N	2	0.2	14.8	31.1	9.4	0.7	0.0102	-1.40	0.28	0.14	0.11	0.42	0.50
05/19/1999 12:00	N	2	0.7	14.9	31.1	9.4	0.7	0.0191	-1.40	0.29	0.11	0.09	0.40	0.51
05/19/1999 12:57	N	3	0.2	19.4	29.1	8.6	6.5	0.0087	-0.90	0.18	0.03	0.00	0.21	0.14
05/19/1999 12:57	N	3	1.2	19.3	29.1	8.3	7.7	0.0084	-0.90	0.15	0.04	0.01	0.20	0.16
05/27/1999 13:46	Q	1	0.2	17.5	29.3	9.0	2.1	0.0065	-0.67	0.09	0.02	0.00	0.12	0.35
05/27/1999 13:46	Q	1	2.5	14.7	30.8	7.9	3.3	0.0116	-0.67	0.03	0.01	0.01	0.05	0.48
05/27/1999 14:27	Q	2	0.2	16.1	30.5	7.7	1.0	0.0200	-0.57	0.11	0.07	0.06	0.19	0.53
05/27/1999 14:27	Q	2	2.9	14.4	30.8	7.9	2.4	0.0099	-0.57	0.66	0.06	0.04	0.72	0.66
05/27/1999 15:00	Q	3	0.2	17.7	30.2	7.5	2.4	0.0070	-0.64	0.10	0.01	0.01	0.11	0.48
05/27/1999 15:00	Q	3	2.6	15.0	30.6	7.2	3.3	0.0193	-0.64	0.47	0.04	0.02	0.52	0.64
05/27/1999 10:15	W	1	0.2	14.3	30.6	9.7	0.7	0.0010	-0.46	0.53	0.94	0.91	1.47	0.46
05/27/1999 10:15	W	1	1.6	14.4	30.7	8.5	0.7	0.0058	-0.46	0.57	0.64	0.61	1.21	0.54
05/27/1999 11:16	W	2	0.2	16.6	29.4	6.0	2.9	0.0058	-0.81	0.10	0.04	0.01	0.14	0.25
05/27/1999 11:16	W	2	0.9	16.6	29.5	6.1	2.9	0.0114	-0.81	0.08	0.02	0.01	0.10	0.23
05/27/1999 11:49	W	3	0.2	17.7	28.9	6.6	3.5	0.0120	-0.85	0.09	0.02	0.00	0.11	0.09
05/27/1999 11:49	W	3	0.8	17.7	29.0	6.6	4.2	0.0126	-0.85	0.10	0.02	0.01	0.12	0.09
06/02/1999 13:05	G	1	0.2	24.5	23.3	9.1	2.9	0.0054	-0.76	0.36	0.13	0.07	0.49	0.03
06/02/1999 13:05	G	1	0.8	24.4	24.8	9.0	4.0	0.0074	-0.76	0.46	0.17	0.11	0.63	0.03
06/02/1999 10:05	N	1	0.2	25.5	24.5	11.2	3.8	0.0169	-0.70	0.23	0.07	0.03	0.30	0.05
06/02/1999 10:05	N	1	1.3	23.2	29.2	14.4	2.4	0.0024	-0.70	0.12	0.06	0.03	0.17	0.03
06/02/1999 11:05	N	2	0.2	19.4	29.7	9.4	1.8	0.0052	-0.39	0.13	0.10	0.07	0.23	0.05
06/02/1999 11:05	N	2	0.7	16.8	31.1	9.5	0.7	0.0077	-0.39	0.57	0.07	0.06	0.64	0.38
06/02/1999 11:40	N	3	0.2	24.0	27.0	9.8	3.8	0.0059	-0.76	0.21	0.10	0.04	0.32	0.02
06/02/1999 11:40	N	3	1.2	23.6	27.9	8.5	4.4	0.0072	-0.76	0.59	0.17	0.08	0.76	0.09
06/08/1999 10:10	Q	1	0.2	22.1	31.1	8.1	1.6	0.0022	-0.56	0.05	0.02	0.01	0.07	0.30
06/08/1999 10:10	Q	1	1.3	22.0	31.1	7.5	2.0	0.0043	-0.56	0.11	0.02	0.01	0.13	0.36
06/08/1999 10:45	Q	2	0.2	19.9	31.2	8.6	1.0	0.0026	-0.40	0.05	0.22	0.21	0.27	0.36
06/08/1999 10:45	Q	2	2.9	16.7	31.3	8.6	1.9	0.0147	-0.40	0.39	0.04	0.03	0.43	0.47
06/08/1999 11:15	Q	3	0.2	20.5	31.1	8.8	1.7	0.0081	-0.50	0.10	0.02	0.02	0.13	0.35
06/08/1999 11:15	Q	3	2.5	18.4	31.3	7.8	5.3	0.0111	-0.50	0.15	0.04	0.03	0.19	0.48
06/08/1999 14:30	W	1	0.2	17.4	31.1	9.3	0.7	0.0083		0.42	0.14	0.12	0.56	0.42
06/08/1999 14:30	W	1	1.0	17.4	31.1	8.6	0.5	0.0091		0.37	0.10	0.09	0.47	0.43
06/08/1999 13:40	W	2	0.2	23.4	30.7	8.7	3.6	0.0152	-1.19	0.08	0.11	0.09	0.18	0.20
06/08/1999 13:40	W	2	0.7	24.0	30.7	7.9	4.9	0.0210	-1.19	0.11	0.05	0.03	0.17	0.21
06/08/1999 14:00	W	3	0.2	24.7	30.5	8.5	5.8	0.0135	-0.77	0.16	0.07	0.05	0.22	0.27
06/08/1999 14:00	W	3	0.7	24.4	30.5	7.9	3.8	0.0122	-0.77	0.24	0.09	0.07	0.32	0.31
06/15/1999 13:40	G	1	0.2	23.5	25.2	10.7	4.2	0.0047	-0.64	0.37	0.19	0.13	0.56	0.03
06/15/1999 13:40	G	1	0.8	23.0	27.5	11.1			-0.64					
06/15/1999 11:15	N	1	0.2	23.5	26.0	11.1	2.4	0.0029	-0.57	0.27	0.11	0.07	0.39	0.04
06/15/1999 11:15	N	1	1.5	22.3	29.8	14.2	1.0	0.0091	-0.57	0.13	0.05	0.03	0.18	0.10
06/15/1999 13:00	N	2	0.2	19.9	29.7	9.9	1.7	0.0120	-0.51	0.27	0.11	0.09	0.38	0.23
06/15/1999 13:00	N	2	0.8	19.0	31.0	9.6	1.5	0.0119	-0.51	0.29	0.16	0.14	0.45	0.35
06/15/1999 12:10	N	3	0.2	23.3	28.9	9.1	3.3	0.0068	-0.77	0.37	0.06	0.03	0.43	0.08
06/15/1999 12:10	N	3	1.5	23.2	29.0	9.6	4.2	0.0051	-0.77	0.24	0.06	0.03	0.30	0.09
06/23/1999 13:50	Q	1	0.2	22.0	31.2	9.8	1.3	0.0055	-0.48	0.05	0.06	0.04	0.10	0.55
06/23/1999 13:50	Q	1	2.8	19.6	31.1	9.6	3.1	0.0163	-0.48	0.46	0.07	0.06	0.53	0.59
06/23/1999 14:25	Q	2	0.2	21.5	31.2	9.6	1.2	0.0047	-0.44	0.06	0.05	0.04	0.11	0.41
06/23/1999 14:25	Q	2	3.1	19.2	31.1	9.4	2.1	0.0100	-0.44	0.11	0.03	0.02	0.15	0.48
06/23/1999 15:05	Q	3	0.2	22.7	31.0	9.5	1.9	0.0081	-0.56	0.11	0.05	0.05	0.16	0.34
06/23/1999 15:05	Q	3	2.9	19.7	31.0	9.9	4.1	0.0100	-0.56	0.11	0.07	0.05	0.17	0.61
06/23/1999 10:50	W	1	0.2	21.1	30.8	9.4	4.1	0.0049	-0.67	0.18	0.05	0.03	0.23	0.17
06/23/1999 10:50	W	1	1.2	21.0	30.8	9.7	4.8	0.0063	-0.67	0.21	0.08	0.06	0.28	0.22
06/23/1999 11:30	W	2	0.2	22.8	30.6	10.0	5.8	0.0087	-0.81	0.24	0.04	0.02	0.28	0.10
06/23/1999 11:30	W	2	0.9	22.7	30.7	9.0	5.6	0.0172	-0.81	0.37	0.03	0.01	0.41	0.09
06/23/1999 12:00	W	3	0.2	23.8	30.4	10.3	6.0	0.0099	-0.86	0.39	0.03	0.00	0.43	0.06
06/23/1999 12:00	W	3	0.9	23.6	30.4	9.4	7.3	0.0144	-0.86	0.20	0.04	0.02	0.24	0.06
07/06/1999 12:30	G	1	0.2	29.1	26.2	8.8	3.6	0.0043	-0.72	0.29	0.07	0.04	0.36	0.04
07/06/1999 12:30	G	1	0.7	28.9	26.3	8.7	3.1	0.0032	-0.72	0.20	0.06	0.03	0.27	0.04
07/06/1999 10:10	N	1	0.2	28.9	24.0	11.4	3.5	0.0087	-0.90	0.28	0.03	0.00	0.31	0.33
07/06/1999 10:10	N	1	1.3	25.0	29.6	9.9	1.3	0.0052	-0.90	0.20	0.03	0.01	0.23	0.77
07/06/1999 11:43	N	2	0.2	24.5	30.1	9.8	5.0	0.0038	-0.48	0.16	0.06	0.05	0.22	0.26
07/06/1999 11:43	N	2	0.8	21.4	30.7	9.0	4.5	0.0044	-0.48	0.13	0.04	0.03	0.17	0.28
07/06/1999 10:57	N	3	0.2	27.7	29.9	9.7	1.7	0.0046	-0.70	0.20	0.03	0.02	0.23	0.09

07/06/1999 10:57	N	3	1.2	27.6	29.7	9.4	1.9	0.0041	-0.70	0.19	0.02	0.00	0.21	0.08
07/12/1999 13:24	Q	1	0.2	18.7	31.3	7.2	1.5	0.0048	-0.50	0.13	0.04	0.02	0.18	0.52
07/12/1999 13:24	Q	1	2.9	17.4	31.2	9.8	2.4	0.0107	-0.50	0.39	0.03	0.01	0.42	0.58
07/12/1999 13:52	Q	2	0.2	19.4	31.4		1.3	0.0055	-0.39	0.25	0.11	0.10	0.36	0.47
07/12/1999 13:52	Q	2	2.9	18.4	31.4		0.8	0.0042	-0.39	0.09	0.04	0.03	0.13	0.45
07/12/1999 14:44	Q	3	0.2	20.8	31.2		2.3	0.0037	-0.46	0.05	0.04	0.02	0.09	0.54
07/12/1999 14:44	Q	3	2.8	19.1	31.4		1.7	0.0049	-0.46	0.79	0.08	0.07	0.88	0.69
07/12/1999 10:05	W	1	0.2	16.4	31.1	9.1	0.8	0.0037	-0.37	0.63	0.29	0.27	0.93	0.50
07/12/1999 10:05	W	1	1.1	16.1	31.4	9.3	0.9	0.0039	-0.37	0.69	0.15	0.12	0.84	0.51
07/12/1999 10:46	W	2	0.2	19.1	31.1	7.6	2.0	0.0062	-0.60	0.17	0.08	0.04	0.24	0.44
07/12/1999 10:46	W	2	1.3	19.1	31.2	8.0	1.9	0.0061	-0.60	0.05	0.07	0.03	0.13	0.49
07/12/1999 11:10	W	3	0.2	21.2	31.1	6.9	4.3	0.0079	-0.90	0.24	0.17	0.08	0.42	0.68
07/12/1999 11:10	W	3	0.8	21.2	31.3	7.1	3.9	0.0063	-0.90	0.43	0.52	0.41	0.95	0.70
07/19/1999 10:05	N	1	0.2	28.4	25.1	10.4	3.00	0.0058	-0.79	0.31	0.06	0.02	0.36	0.16
07/19/1999 10:05	N	1	1.2	26.2	29.5	7.2	1.94	0.0062	-0.79	0.34	0.10	0.06	0.44	0.55
07/19/1999 11:32	N	2	0.2	24.6	30.4	7.8	1.28	0.0068	-0.77	0.73	0.07	0.04	0.81	0.53
07/19/1999 11:32	N	2	0.7	21.9	30.7	8.0	2.30	0.0061	-0.77	0.33	0.06	0.04	0.39	0.52
07/19/1999 10:48	N	3	0.2	26.7	30.5	6.7	3.02	0.0059	-0.66	0.15	0.11	0.08	0.26	0.31
07/19/1999 10:48	N	3	1.2	26.7	30.5	6.5	3.49	0.0062	-0.66	0.22	0.04	0.01	0.26	0.29
07/19/1999 11:15	N	4	0.8	26.2	30.6	11.0			-0.62					
07/19/1999 11:15	N	4							-0.62					
07/21/1999 15:10	G	1	0.2	27.4	26.4	11.3	13.4	0.0500	-1.27	0.40	0.05	0.01	0.45	0.13
07/21/1999 15:10	G	1							-1.27					
08/03/1999 12:56	Q	1	0.2	23.6	31.2	7.9	1.9	0.0076	-0.50	0.39	0.07	0.06	0.46	0.43
08/03/1999 12:56	Q	1	3.1	22.4	31.3	6.5	4.6	0.0093	-0.50	0.52	0.19	0.16	0.71	0.59
08/03/1999 13:23	Q	2	0.2	23.4	31.2	8.1	1.9	0.0065	-0.69	0.11	0.04	0.04	0.15	0.45
08/03/1999 13:23	Q	2	3.6	21.9	31.3	8.3	1.5	0.0208	-0.69	1.04	0.23	0.21	1.27	0.60
08/03/1999 13:55	Q	3	0.2	24.8	31.2	8.4	2.3	0.0095	-0.46	0.42	0.05	0.04	0.47	0.46
08/03/1999 13:55	Q	3	3.2	23.5	31.2	7.9	2.8	0.0061	-0.46	0.22	0.10	0.07	0.31	0.48
08/03/1999 09:54	W	1	0.2	23.4	30.9	7.5	3.0	0.0052	-0.76	0.33	0.18	0.16	0.51	0.43
08/03/1999 09:54	W	1	1.0	22.9	30.9	7.3	3.4	0.0063	-0.76	0.57	0.66	0.61	1.23	0.43
08/03/1999 10:17	W	2	0.2	25.2	30.9	6.0	5.5	0.0072	-0.96	0.13	0.05	0.02	0.18	0.65
08/03/1999 10:17	W	2	1.0	24.8	31.0	6.0	5.1	0.0091	-0.96	0.04	0.14	0.11	0.19	0.69
08/03/1999 10:40	W	3	0.2	25.9	30.9	6.4	4.0	0.0084	-1.71	0.04	0.08	0.04	0.12	0.80
08/03/1999 10:40	W	3	0.9	25.9	30.9	6.2	3.7	0.0109	-1.71	0.25	0.25	0.21	0.50	0.80
08/11/1999 12:06	G	1	0.2	22.1	29.1	6.8	2.4	0.0047	-0.80	0.54	0.06	0.03	0.60	0.15
08/11/1999 12:06	G	1	0.8	21.8	30.3	6.3	3.0	0.0064	-0.80	1.86	0.24	0.19	2.10	0.71
08/11/1999 10:00	N	1	0.2	23.5	28.2	6.1	23.3	0.0122	-1.16	0.44	0.55	0.47	1.00	0.41
08/11/1999 10:00	N	1	1.6	24.2	28.8	5.9	22.2	0.0068	-1.16	1.52	0.16	0.10	1.68	0.54
08/11/1999 11:30	N	2	0.2	20.9	31.6	8.0	8.2	0.0056	-0.46	2.03	0.19	0.13	2.21	0.64
08/11/1999 11:30	N	2	0.9	20.9	31.6	7.6	6.9	0.0040	-0.46	1.56	0.19	0.17	1.75	0.59
08/11/1999 10:44	N	3	0.2	22.9	30.7	6.4	5.6	0.0061	-0.82	0.97	0.18	0.15	1.15	0.23
08/11/1999 10:44	N	3	1.5	22.9	30.7	6.2	8.7	0.0090	-0.82	0.59	0.11	0.06	0.70	0.20
08/11/1999 11:17	N	4	0.8	22.1	30.7	6.9			-0.86					
08/11/1999 11:17	N	4							-0.86					
08/18/1999 10:00	Q	1	0.2	24.3	31.2	8.6	4.2	0.0126	-0.59	0.21	0.07	0.06	0.28	0.30
08/18/1999 10:00	Q	1	2.7	21.5	31.4	6.1	6.0	0.0206	-0.59	0.25	0.17	0.13	0.43	0.76
08/18/1999 10:30	Q	2	0.2	23.7	31.3	8.1	3.3	0.0065	-0.60	0.45	0.15	0.13	0.60	0.30
08/18/1999 10:30	Q	2	3.2	21.3	31.5	6 5	7.2	0.0210	-0.60	2.61	0.21	0.16	2.82	0.63
08/18/1999 10:58	Q	3	0.2	23.9	31.2	8.9	3.5	0.0054	-0.53	0.42	0.13	0.11	0.55	0.46
08/18/1999 10:58	Q	3	2.8	22.3	31.4	7.0	7.3	0.0056	-0.53	0.18	0.04	0.02	0.22	0.79
08/18/1999 13:05	W	1	0.2	21.1	31.4	7.5	1.0	0.0058		0.78	0.19	0.14	0.97	0.44
08/18/1999 13:05	W	1	0.8	21.1	31.4	7.6	1.1	0.0061		1.08	0.32	0.25	1.39	0.73
08/18/1999 13:24	W	2	0.2	25.1	30.6	8.6	5.0	0.0073	-0.75	0.35	0.06	0.04	0.41	0.31
08/18/1999 13:24	W	2	1.0	25.1	30.7	8.7	5.7	0.0067	-0.75	0.39	0.07	0.02	0.46	0.34
08/18/1999 13:43	W	3	0.2	26.0	30.5	8.7	9.1	0.0103	-0.95	0.35	0.11	0.06	0.46	0.54
08/18/1999 13:43	W	3	1.1	25.7	30.6	7.8	12.4	0.0103	-0.95	0.23	0.09	0.04	0.32	0.59
08/24/1999 14:57	G	1	0.2	24.1	28.0	11.4	25.7	0.0056	-1.12	0.53	0.09	0.06	0.62	0.21
08/24/1999 14:57	G	1	0.8	23.0	28.2	12.4	25.4	0.0078	-1.12	0.10	0.08	0.04	0.18	0.24
08/24/1999 12:35	N	1	0.2	24.3	28.2	11.4	5.1	0.0054	-0.83	0.43	0.16	0.01	0.59	0.37
08/24/1999 12:53	N	1	1.4	22.5	30.4	8.9	10.2	0.0073	-0.83	0.38	0.07	0.04	0.45	0.08
08/24/1999 14:23	N	2	0.2	23.5	30.4	11.1	13.7	0.0071	-0.87	0.40	0.16	0.13	0.56	0.27
08/24/1999 14:23	N	2	0.9	23.4	30.4	11.3	10.8	0.0109	-0.87	0.33	0.10	0.07	0.43	0.25
08/24/1999 13:28	N	3	0.2	22.9	30.2	8.9	8.9	0.0078	-0.87	0.13	0.13	0.10	0.26	0.07
08/24/1999 13:28	N	3	1.5	22.0	30.3	11.9	22.3	0.0113	-0.87	0.53	0.13	0.08	0.67	0.16
08/24/1999 14:00	N	4	0.7	24.1	30.6	14.0	67.6		-1.08					
08/24/1999 14:00	N	4							-1.08					
08/24/1999 13:53	N	5					76.6		-0.95					
08/24/1999 13:53	N	5							-0.95					
09/02/1999 08:29	Q	1	0.2	19.5	31.9	7.8	4.5	0.0063	-0.72	0.14	0.08	0.06	0.22	0.57
09/02/1999 08:29	Q	1	2.8	19.5	31.9	7.4	4.7	0.0077	-0.72	0.10	0.02	0.00	0.12	0.57
09/02/1999 09:00	Q	2	0.2	19.6	31.9	7.1	4.3	0.0109	-0.68	0.30	0.12	0.09	0.42	0.69
09/02/1999 09:00	Q	2	2.6	19.5	31.9	6.9	4.6	0.0059	-0.68	0.44	0.11	0.09	0.56	0.67
09/02/1999 09:30	Q	3	0.2	20.0	31.8	7.7	3.4	0.0037	-0.56	0.17	0.07	0.05	0.24	0.65
09/02/1999 09:30	Q	3	2.8	19.9	31.8	7.3	4.1	0.0053	-0.56	0.24	0.03	0.01	0.27	0.69
09/02/1999 11:00	W	1	0.2	19.4	31.4	7.8	3.8	0.0049	-0.66	0.93	0.76	0.69	1.69	0.50
09/02/1999 11:00	W	1	1.6	19.4	31.4	7.4	3.4	0.0057	-0.66	1.62	0.73	0.65	2.35	0.63

09/02/1999 11:23	W	2	0.2	19.6	31.5	6.1	5.3	0.0052	-0.78	1.21	0.40	0.24	1.61	0.51
09/02/1999 11:23	W	2	0.9	19.6	31.5	6.0	5.0	0.0059	-0.78	1.28	0.39	0.24	1.67	0.57
09/02/1999 11:42	W	3	0.2	20.1	31.3	7.0	9.0	0.0093	-0.94	0.16	0.15	0.10	0.31	0.29
09/02/1999 11:42	W	3	0.9	20.1	31.3	6.7	8.4	0.0076	-0.94	0.47	0.11	0.04	0.58	0.29
09/07/1999 15:39	G	1	0.2	26.6	29.1	8.9	6.5	0.0042	-0.96	0.28	0.33	0.23	0.61	0.08
09/07/1999 16:39	G	1	0.6	26.5	29.1	8.7	6.9	0.0046	-0.96	0.12	0.04	0.00	0.16	0.04
09/07/1999 13:14	N	1	0.2	26.0	27.8	10.6	8.0	0.0018	-1.12	0.50	0.17	0.04	0.67	0.32
09/07/1999 13:14	N	1	1.6	25.4	30.4	6.5	4.5	0.0012	-1.12	0.20	0.13	0.07	0.33	0.05
09/07/1999 14:34	N	2	0.2	25.4	31.2	8.3	1.6	0.0045	-0.88	0.54	0.31	0.22	0.85	0.25
09/07/1999 14:34	N	2	0.8	25.4	31.2	8.2	6.5	0.0089	-0.88	0.43	0.08	0.06	0.51	0.31
09/07/1999 13:51	N	3	0.2	26.1	30.5	10.9	102.9	0.0178	-0.90	0.60	0.34	0.26	0.94	0.20
09/07/1999 13:51	N	3	1.4	25.7	30.5	8.9	53.5	0.0057	-0.90	0.41	0.47	0.42	0.88	0.09
09/07/1999 14:19	N	4	0.7	26.2	30.8	9.4								
09/08/1999 06:15	N	6	1.2			6.1								
09/08/1999 06:20	N	7	1.5			4.3								
09/08/1999 06:30	N	8	3.3			1.0								
09/08/1999 06:44	N	9	0.9			7.0								
09/14/1999 12:29	Q	1	0.2	21.9	31.7	9.4	12.5	0.0042	-0.69	0.27	0.03	0.02	0.30	0.22
09/14/1999 12:29	Q	1	3.2	21.5	31.7	5.8	9.3	0.0065	-0.69	4.83	0.06	0.03	4.89	0.56
09/14/1999 12:54	Q	2	0.2	21.9	31.6	8.4	7.2	0.0066	-0.70	0.29	0.19	0.18	0.48	0.27
09/14/1999 12:54	Q	2	3.6	21.4	31.8	5.0	7.5	0.0143	-0.70	3.44	0.14	0.11	3.58	0.96
09/14/1999 13:18	Q	3	0.2	22.2	31.3	9.1	9.9	0.0061	-0.76	0.33	0.06	0.01	0.40	0.30
09/14/1999 13:18	Q	3	3.4	22.0	31.5	8.5	8.9	0.0064	-0.76	0.07	0.03	0.02	0.10	0.18
09/14/1999 10:00	W	1	0.2	21.2	31.8	8.4	1.2	0.0071	-0.48	1.42	0.32	0.27	1.74	0.65
09/14/1999 10:00	W	1	1.3	21.2	31.8	7.9	1.3	0.0070	-0.48	1.49	0.30	0.26	1.79	0.62
09/14/1999 10:36	W	2	0.2	22.2	30.5	7.3	4.8	0.0074	-0.84	0.20	0.22	0.13	0.42	0.48
09/14/1999 10:36	W	2	1.0	22.2	30.5	7.2	5.6	0.0068	-0.84	0.41	0.13	0.07	0.54	0.44
09/14/1999 11:08	W	3	0.2	22.3	30.3	7.3	5.2	0.0064	-0.85	0.27	0.34	0.22	0.61	0.51
09/14/1999 11:08	W	3	1.0	22.2	30.2	6.9	5.1	0.0064	-0.85	0.46	0.38	0.24	0.84	0.56
09/29/1999 10:32	G	1	0.2	19.3	27.0	8.6	2.5		-0.87	1.16	0.58	0.52	1.74	0.04
09/29/1999 10:32	G	1	0.8	19.3	29.1	6.4	2.6		-0.87	1.30	0.48	0.44	1.78	0.02
09/29/1999 08:45	N	1	0.2	20.3	28.6	9.7	3.9		-0.73	0.08	0.49	0.44	0.57	0.07
09/29/1999 08:45	N	1	1.5	19.6	30.5	8.2	2.6		-0.73	0.31	0.16	0.13	0.48	0.11
09/29/1999 09:57	N	2	0.2	19.1	31.8	8.5	16.8		-0.66	0.56	0.15	0.12	0.71	0.33
09/29/1999 09:57	N	2	0.8	19.1	32.0	8.5	2.6		-0.66	0.78	0.16	0.14	0.95	0.34
09/29/1999 09:22	N	3	0.2	19.1	28.6	8.2	3.8		-1.19	0.63	0.28	0.23	0.92	0.09
09/29/1999 09:22	N	3	1.4	19.5	29.9	4.4	4.9		-1.19	0.67	0.22	0.18	0.89	0.18
09/29/1999 09:46	N	4	0.8	19.4	30.1	6.0								
10/12/1999 12:45	Q	1	0.2	17.0	31.93	7.72	3.03	0.00732	-0.549	1.83	0.54	0.39	2.37	0.63
10/12/1999 12:45	Q	1	3.3	16.9	32.21	6.89	1.62	0.00518	-0.549	2.60	0.31	0.27	2.91	0.72
10/12/1999 13:09	Q	2	0.2	17.0	32.1	7.01	1.15	0.00471	-0.564	3.70	0.32	0.27	4.02	0.69
10/12/1999 13:09	Q	2	3.5	16.8	32.19	6.55	2.75	0.00673	-0.564	4.10	0.28	0.21	4.38	0.76
10/12/1999 13:38	Q	3	0.2	17.0	31.74	7.18	1.74	0.00517	-0.515	4.19	0.50	0.38	4.69	0.78
10/12/1999 13:38	Q	3	3.3	16.3	31.82	6.86	1.84	0.00679	-0.515	3.87	0.49	0.39	4.36	0.71
10/12/1999 10:02	W	1	0.2	17.12	32.35	7.58	0.55	0.00428	-0.480	1.03	0.35	0.31	1.38	0.70
10/12/1999 10:02	W	1	1.8	17.16	32.35	6.91	0.52	0.00477	-0.480	1.01	0.36	0.31	1.37	0.80
10/12/1999 10:30	W	2	0.2	15.65	31.34	7.01	1.22	0.00716	-0.539	2.71	1.54	1.44	4.25	0.68
10/12/1999 10:30	W	2	1.3	15.77	31.44	6.73	1.16	0.00837	-0.539	2.53	1.41	1.32	3.94	0.64
10/12/1999 11:05	W	3	0.2	15.9	30.75	7.18	1.62	0.01126	-0.720	5.08	1.02	0.87	6.10	0.72
10/12/1999 11:05	W	3	1.3	15.67	30.69	6.81	1.80	0.00617	-0.720	5.32	1.00	0.84	6.32	0.77
10/27/1999 10:50	G	1	0.2	12.3	24.4	9.7	4.62	0.0038	-1.04	1.70	4.14	3.93	5.84	0.07
10/27/1999 10:50	G	1	0.6	12.3	24.4	9.4	4.74	0.0034	-1.04	1.29	4.02	3.83	5.31	0.05
10/27/1999 09:06	N	1	0.2	13.4	28.1	9.7	5.38	0.0055	-0.75	0.52	0.27	0.24	0.79	0.08
10/27/1999 09:06	N	1	1.5	13.8	29.6	8.7	3.98	0.0042	-0.75	0.35	0.05	0.03	0.40	0.08
10/27/1999 10:15	N	2	0.2	14.0	30.5	8.6	3.10	0.0063	-0.67	1.08	0.98	0.86	2.05	0.44
10/27/1999 10:15	N	2	0.9	14.4	31.3	8.5	3.57	0.0073	-0.67	0.75	0.59	0.48	1.34	0.60
10/27/1999 09:43	N	3	0.2	11.9	27.8	9.2	6.08	0.0063	-1.00	0.53	0.21	0.15	0.74	0.04
10/27/1999 09:43	N	3	1.4	12.0	27.8	8.8	6.20	0.0062	-1.00	0.23	0.11	0.05	0.34	0.04
10/12/1999 10:02	W	1	0.2	17.12	32.35	7.58	0.55	0.00428	-0.480	1.03	0.35	0.31	1.38	0.70
10/12/1999 10:02	W	1	1.8	17.16	32.35	6.91	0.52	0.00477	-0.480	1.01	0.36	0.31	1.37	0.80
10/12/1999 10:30	W	2	0.2	15.65	31.34	7.01	1.22	0.00716	-0.539	2.71	1.54	1.44	4.25	0.68
10/12/1999 10:30	W	2	1.3	15.77	31.44	6.73	1.16	0.00837	-0.539	2.53	1.41	1.32	3.94	0.64
10/12/1999 11:05	W	3	0.2	15.9	30.75	7.18	1.62	0.01126	-0.720	5.08	1.02	0.87	6.10	0.72
10/12/1999 11:05	W	3	1.3	15.67	30.69	6.81	1.80	0.00617	-0.720	5.32	1.00	0.84	6.32	0.77
11/10/1999 13:00	W	1	0.2	13.9	31.8	9.9	0.34	0.0062	-0.53	1.38	3.96	3.46	5.34	0.89
11/10/1999 13:00	W	1	0.8	13.8	31.8	9.4	0.30	0.0064	-0.53	1.12	3.88	3.41	5.00	0.90
11/10/1999 13:28	W	2	0.2	13.1	31.5	9.8	0.22	0.0032	-0.67	2.05	3.28	2.88	5.33	0.74
11/10/1999 13:28	W	2	1.0	13.1	31.5	9.5	0.22	0.0068	-0.67	1.55	3.11	2.75	4.66	0.76
11/10/1999 13:50	W	3	0.2	11.7	31.1	9.7	0.32	0.0051	-0.96	1.77	1.90	1.63	3.67	0.58
11/10/1999 13:50	W	3	0.9	11.7	31.1	9.5	0.26	0.0034	-0.96	1.65	1.76	1.51	3.42	0.60
11/10/1999 09:54	Q	1	0.2	11.3	31.4	9.5	1.29	0.0086	-0.62	2.36	2.45	1.97	4.80	0.78
11/10/1999 09:54	Q	1	3.2	11.3	31.5	8.5	1.05	0.0111	-0.62	2.09	2.40	1.93	4.49	0.78
11/10/1999 10:27	Q	2	0.2	12.2	31.8	8.9	1.35	0.0096	-0.60	2.55	2.73	2.26	5.29	0.83
11/10/1999 10:27	Q	2	3.5	12.2	31.8	8.5	1.40	0.0059	-0.60	2.41	2.59	2.12	5.00	0.86
11/10/1999 10:54	Q	3	0.2	11.5	31.6	9.2	1.52	0.0049	-0.57	2.53	2.19	1.77	4.72	0.72
11/10/1999 10:54	Q	3	3.1	11.7	31.7	8.7	1.58	0.0106	-0.57	2.42	2.16	1.73	4.58	0.77
11/22/1999 09:42	N	1	0.2	10.6	28.4	11.6	5.07	0.0038	-0.65	0.44	0.49	0.44	0.93	0.15

11/22/1999 09:42	N	1	1.8	11.7	30.8	9.0	6.20	0.0047	-0.65	0.27	0.04	0.00	0.31	0.22
11/22/1999 11:11	N	2	0.2	11.7	31.4	10.3	4.47	0.0068	-0.63	0.23	0.19	0.14	0.42	0.50
11/22/1999 11:11	N	2	0.9	11.8	31.5	10.1	4.95	0.0055	-0.63	0.36	0.16	0.13	0.52	0.53
11/22/1999 10:30	N	3	0.2	9.6	28.4	10.9	2.17	0.0023	-0.66	0.42	0.29	0.22	0.70	0.10
11/22/1999 10:30	N	3	1.8	9.2	28.7	10.7	3.84	0.0019	-0.66	0.21	0.36	0.28	0.57	0.09
11/22/1999 11:54	G	1	0.2	10.1	24.1	11.1	3.64	0.0023	-0.73	1.15	8.75	8.44	9.89	0.15
11/22/1999 11:54	G	1	0.8	10.8	27.4	10.1	4.59	0.0033	-0.73	0.83	6.95	6.72	7.79	0.17
12/13/1999 09:35	Q	1	0.2	6.6	31.3	10.3	1.36	0.0045	-0.66	1.15	1.67	1.49	2.82	0.61
12/13/1999 09:35	Q	1	3.0	6.6	31.3	10.0	1.27	0.0037	-0.66	1.03	1.64	1.47	2.67	0.62
12/13/1999 10:17	Q	2	0.2	8.0	31.9	10.1	1.49	0.0030	-0.39	1.05	2.64	2.45	3.69	0.76
12/13/1999 10:17	Q	2	3.3	7.7	31.8	9.8	1.49	0.0036	-0.39	0.98	2.42	2.24	3.39	0.74
12/13/1999 10:58	Q	3	0.2	6.0	31.3	10.8	1.26	0.0010	-0.50	0.90	1.21	1.07	2.12	0.47
12/13/1999 10:58	Q	3	3.2	5.9	31.4	10.6	1.23	0.0037	-0.50	0.97	1.21	1.05	2.18	0.51
12/13/1999 13:27	W	1	0.2	10.1	32.0	10.4	1.15	0.0025	-0.45	0.52	3.95	3.77	4.48	0.86
12/13/1999 13:27	W	1	1.2	10.1	32.1	9.9	1.18	0.0016	-0.45	0.41	3.81	3.64	4.22	0.88
12/13/1999 13:46	W	2	0.2	6.9	31.1	10.6	0.92	0.0050	-0.47	0.66	2.98	2.82	3.64	0.49
12/13/1999 13:46	W	2	1.3	8.0	31.6	10.4	1.31	0.0082	-0.47	0.80	3.71	3.52	4.50	0.70
12/13/1999 14:10	W	3	0.2	4.3	29.7	10.8	0.51	0.0022	-0.53	0.52	2.55	2.44	3.07	0.22
12/13/1999 14:10	W	3	1.3	5.7	31.1	11.0	3.39	0.0053	-0.53	0.42	2.34	2.20	2.75	0.44
12/16/1999 14:12	G	1A	0.0	8.4	13.6	11.1	4.74	0.0029		1.20	28.35	28.04	29.55	0.11
12/16/1999 11:53	N	1	0.2	7.9	27.2	10.8	3.51	0.0029	-0.82	0.30	2.03	1.94	2.33	0.13
12/16/1999 12:53	N	1	1.3	7.7	30.0	8.8	5.56	0.0038	-0.82	0.20	0.38	0.33	0.58	0.09
12/16/1999 12:53	N	2	0.2	7.8	29.8	9.9	2.93	0.0067	-0.96	1.08	0.65	0.57	1.73	0.21
12/16/1999 12:53	N	2	0.9	8.5	31.0	9.9	3.57	0.0094	-0.96	1.11	0.91	0.83	2.01	0.43
12/16/1999 12:24	N	3	0.2	6.2	28.1	10.2	4.97	0.0046	-0.75	0.17	0.16	0.12	0.33	0.02
12/16/1999 12:24	N	3	1.4	6.2	28.1	10.1	3.74	0.0049	-0.75	0.25	0.19	0.14	0.44	0.00
01/07/2000 08:30	Q	1	0.2	5.8	30.8	11.8	2.07	0.0080	-0.47	0.48	2.56	2.42	3.04	0.63
01/07/2000 08:30	Q	1	3.2	6.6	31.5	10.3	1.16	0.0041	-0.47	1.07	3.09	2.97	4.16	0.87
01/07/2000 09:12	Q	2	0.2	6.0	31.5	11.2	1.53	0.0038	-0.48	0.54	3.10	2.98	3.63	0.70
01/07/2000 09:12	Q	2	2.7	6.7	31.8	10.6	1.69	0.0040	-0.48	0.41	3.27	3.17	3.68	0.98
01/07/2000 09:42	Q	3	0.2	5.0	30.9	11.6	2.05	0.0031	-0.44	0.26	1.16	1.05	1.41	0.36
01/07/2000 09:42	Q	3	3.2	6.1	31.5	10.7	1.52	0.0047	-0.44	0.91	2.00	1.87	2.91	0.69
01/07/2000 11:02	W	1	0.2	6.5	31.5	11.3	1.15	0.0059	-0.37	0.53	4.77	4.66	5.30	0.79
01/07/2000 11:02	W	1	1.2	6.7	31.6	10.9	1.14	0.0041	-0.37	0.41	4.58	4.46	4.99	0.78
01/07/2000 11:25	W	2	0.2	5.8	.31.17	11.3	0.92	0.0198	-0.56	0.35	3.48	3.38	3.83	0.67
01/07/2000 11:25	W	2	1.4	6.1	31.4	11.2	1.36	0.0038	-0.56	0.36	3.54	3.44	3.90	0.65
01/07/2000 11:46	W	3	0.2	4.3	30.2	11.6	0.91	0.0022	-0.41	0.19	1.54	1.46	1.73	0.28
01/07/2000 11:46	W	3	1.4	4.4	30.2	11.1	0.59	0.0035	-0.41	0.27	1.65	1.54	1.92	0.33
02/10/2000 10:15	Q	1	0.2	1.9	30.3	11.6	1.22	0.0040	-0.56	0.19	0.88	0.81	1.07	0.41
02/10/2000 10:15	Q	1	2.9	2.2	30.9	10.6	2.69	0.0060	-0.56	0.51	1.13	1.06	1.64	0.64
02/10/2000 11:09	Q	2	0.2	2.1	30.9	11.4	2.27	0.0036	-0.53	0.18	1.08	1.01	1.26	0.52
02/10/2000 11:09	Q	2	3.3	2.3	31.1	11.2	1.64	0.0074	-0.53	0.40	1.19	1.12	1.59	0.66
02/10/2000 11:53	Q	3	0.2	2.0	30.8	11.8	1.27	0.0040	-0.50	0.34	0.99	0.92	1.33	0.46
02/10/2000 11:53	Q	3	3.2	2.0	31.1	11.3	2.81	0.0044	-0.50	0.39	0.91	0.84	1.30	0.56
02/10/2000 13:17	W	1	0.2	3.6	31.3	11.3	1.79	0.0069	-0.77	0.38	1.65	1.58	2.03	0.71
02/10/2000 13:17	W	1	1.0	3.5	31.3	11.0	2.81	0.0045	-0.77	0.21	1.41	1.35	1.63	0.61
02/10/2000 13:51	W	2	0.2	3.1	30.4	11.4	1.13	0.0052	-0.66	0.45	2.41	2.34	2.86	0.44
02/10/2000 13:51	W	2	1.2	3.2	30.5	11.6	1.56	0.0059	-0.66	0.44	2.31	2.24	2.75	0.49
02/10/2000 14:21	W	3	0.2	2.7	29.0	11.8	0.67	0.0044	-0.71	0.86	2.24	2.14	3.10	0.29
02/10/2000 14:21	W	3	1.2	3.0	30.1	12.2	2.87	0.0041	-0.71	0.16	1.08	1.03	1.24	0.32
03/01/2000 15:13	G	1	0.2	6.9	23.2	11.1	2.44	0.0054	-0.60	1.32	8.99	8.77	10.32	0.11
03/01/2000 15:13	G	1	1.0	6.5	26.3	11.7	3.87	0.0055	-0.60	0.92	5.95	5.78	6.87	0.00
03/01/2000 13:24	N	1	0.2	7.2	27.4	10.4	1.38	0.0036	-0.52	0.47	1.37	1.30	1.84	0.06
03/01/2000 13:24	N	1	1.5	6.8	29.0	11.0	2.21	0.0047	-0.52	0.41	0.49	0.43	0.90	0.26
03/01/2000 14:39	N	2	0.2	5.4	29.2	10.9	0.49	0.0046	-0.30	0.35	0.70	0.63	1.05	0.38
03/01/2000 14:39	N	2	1.0	5.4	30.2	11.3	0.88	0.0043	-0.30	0.35	0.75	0.71	1.10	0.32
03/01/2000 14:05	N	3	0.2	6.7	26.4	10.8	2.09	0.0048	-0.55	0.55	0.26	0.20	0.82	0.00
03/01/2000 14:05	N	3	1.4	6.6	26.6	11.0	2.37	0.0052	-0.55	0.30	0.14	0.10	0.44	0.00

Appendix II

Engineering Quantities

RHODE ISLAND SOUTH COAST FEASIBILITY STUDY
ENGINEERING QUANTITIES

Localized restoration of aquatic habitat in Winnapaug, Quonochontaug, and Ninigret Ponds (Figure 1) required identification of the areas to be dredged, calculation of the quantities to be dredged, and analysis of disposal alternatives. Using on-site investigations and aerial photographs, potential eelgrass restoration areas were identified at five sites in Winnapaug Pond, three sites in Quonochontaug Pond, and two sites in Ninigret Pond. Sedimentation basins were likewise located in the breachways to trap the future movement of sand into the ponds and prevent the degradation of the restoration efforts as well as existing eelgrass beds (Figures 2 and 3).

Restoration Areas and Sedimentation Basins

To determine the quantities of material to be dredged from the restoration areas and sedimentation basins it was necessary to place hydrographic survey information gathered in May 1998 into a MicroStation design file along with waterline boundaries contained in the Rhode Island Geographical Information System (RIGIS). The survey information was supplemented by field surveys to identify the Mean Low Water (MLW) elevations in each pond (see Table 1). The locations of the restoration areas and sedimentation basins were first drawn using ArcView GIS software on RIGIS digital orthophotos and then later transferred to the design file.

Alternative depths were investigated for both the restoration areas and the sedimentation basins to provide a range of quantities for economic evaluation. Dredging depths for the restoration areas were evaluated for depths ranging between 1.75 – 4.0 feet (about 0.5 and 1.2 meters) below MLW. A side slope of one-foot vertical to six feet horizontal was selected as a conservative value for the conditions in each pond. The sedimentation basins were located to intercept the maximum volume of sand migrating through the breachways. A side slope of one foot vertical to six feet horizontal was assumed for the basins as well since the breachway channels are bordered by either saltmarsh or intertidal areas and it was essential that any dredging would not impact these sensitive areas.

Volumes of material to be dredged were calculated (Tables 2 & 3) by comparing the existing surface as defined by the survey information to a design surface using InRoads software. Areas of each restoration area were recorded along with the volume of material (cubic yards) required to be dredged to produce a flat bottom at a particular elevation below MLW. All of the restoration areas were initially located to avoid impacts to intertidal areas. Two sedimentation basins (the entrance to Ninigret Pond and Quonochontaug Pond) were relocated slightly to avoid impacts to either saltmarsh or intertidal areas. Figures 4 through 6 illustrate how the restoration areas and sedimentation basins, at their largest depth, avoid impacting the intertidal flats (MLW line) and any adjacent saltmarsh areas.

Primary Disposal - Beach Nourishment

It is expected that the majority of the dredged material to be removed from the ponds will be placed directly in the intertidal zone along nearby beaches. Due to the shallowness of the ponds it is difficult to predict the size of the equipment that will be used during construction. A 14-inch hydraulic pipeline dredge was used for initial estimating purposes. As the selected alternatives were identified, estimates were also done using a smaller (8 inch "mudcat") hydraulic dredge plant. A booster pump may be required if the pumping distance is longer than the selected dredge can pump alone. The pipeline will be routed along the southern edge of the pond and then cross the roadway to Misquamicut Beach. The floating pipelines at Quonochontaug Pond and Ninigret Pond will both follow the respective inlets back to the beach and thence make use of shoreline pipe at the back of the beach to avoid wave damage. Average pipeline distances are 10,700 feet for Winnapaug, 14,000 feet for Quonochontaug and 8,000 feet for Ninigret.

The dredged material will be deposited in the intertidal zone of the beaches, drain, and then be shaped by wave action. The beach profiles shown in Figures 7-10 were developed to approximate the capacity of each disposal area. It is unlikely that the beach profiles will resemble these figures once the material has spread out over the intertidal and subtidal zones along the beaches. This is due to the fact that the material being placed is medium to fine sand and that dredged material protruding seaward of the existing beach face will concentrate wave action and speed erosion of the newly placed material. Table 4 summarizes the potential capacities at four beach disposal areas. The material will have a dark color when initially placed. This coloration will gradually lighten through natural actions such as rain and sunlight.

Alternative Disposal - De-watering Locations

Four potential sites for de-watering material to be dredged from the ponds were initially evaluated. The site for Winnapaug Pond is north of the pond adjacent to a golf course and consists of approximately 4.0 acres. A potential 1.6-acre de-watering area for Ninigret Pond would be located in the Department of Environmental Management parking area at the east entrance to the pond inlet. An additional site adjacent to Ninigret Pond would be a 1.3-acre site located in the Charlestown Town Beach parking area. A site consisting of 0.3 acres located on the east side of the Quonochontaug Pond inlet at the north end of the road was also examined. The Quonochontaug site is very small and was not considered further. The Winnapaug site was evaluated but will likely not be pursued due to difficulties in obtaining the lands.

The average distance to the de-watering sites from the areas being dredged was estimated to be 4,600 feet.

None of the de-watering sites will handle all the material to be dredged. It is estimated that the Winnapaug Pond site can handle 43,000 cy and the Ninigret Pond sites can handle 13,000 and 10,000 cy, respectively (see Table 5 for quantity calculations).

Construction of the de-watering areas would be the same regardless of location. It is anticipated that a gravel dike would surround the site and have a height of about 10 feet with side slopes of one vertical to two horizontal. Effluent from the de-watered material would be directed back to the pond or inlet. The material is medium to fine sand and therefore will dry within a few months. After drying, the material would be trucked, by non-Federal interests, to nourish nearby beaches.

Fish Passage Restoration – Cross Mills Pond, Charlestown

The State has identified the restoration of anadromous fish to Cross Mills Pond as a desirable environmental project. A plan was developed with the help of the U.S. Fish and Wildlife Service and the State's Division of Fish and Wildlife to re-establish a migration pathway for the fish. A fishway passing to the east of the Dartmouth Homes Realty building includes two fish ladders and a segment of concrete culvert and open channel (see Figures 3, 11 and 12). Construction quantities for the fish passage project were calculated by the New England District office and are shown in Table 6.

Cross Mills Pond consists of a series of ponds that are bisected by Route 1. The drainage area for the pond is about 2.5 square miles at its outlet. There are two existing water control structures located in Cross Mills Pond. One, presently not functioning, is located directly behind the Dartmouth Homes Realty building, site of a former gristmill. The other, the primary spillway, is located behind a residence about two hundred feet to the west. The primary spillway is a concrete weir with stop logs that discharges under a building to an underground culvert system that takes a circuitous route around the structure that includes Dartmouth Homes Realty, and under Route 1, before discharging to the brook. No information was available on the existing culvert (e.g., size, obstructions..), though it is obviously too long of an enclosed run for anadromous species to make. The proposed fishway bypasses the existing culvert system and follows a more direct pathway into the pond; adjacent to the original stream course that flowed under the former mill.

Based on the U.S. Fish and Wildlife Service's design, the existing spillway and culvert system will remain and work in tandem with the added fishway. The fishway will be operated seasonally; passing fish upstream for about a six-week period in the spring. Flows discharging from the pond are typically as low as 2 cubic feet per second (cfs) to as high as 20 cfs. The fishway will be constructed with an adjustable opening that will maintain flows during operation that range from a minimum flow of 2 cfs (about 8 inches of water in the channel) to a maximum flow of 5 cfs (about 18 inches of water in the channel). Normal or desired flow is about 3 cfs (about 12 inches of water in the channel) for migrating fish. Therefore, when the fishway is in use, flows over the primary spillway could vary from minimal to as much as 15 cfs, depending on the conditions at the time.

Downstream passage of fish typically occurs after the first strong rain in late summer. The primary spillway will be used to pass fish downstream unless it is later determined that the existing culvert system has obstructions that prevent the fish from passing. To do this, the primary spillway will be modified by notching a 10-inch to 12-inch high board so that the width of the opening is about 2 feet in total length. This board would replace the top board in the primary spillway. The depth of the notch would be set so that about 6 inches of water passes through the notch with no flow passing over the top of the board. This is equivalent to about 2 cfs of flow. In the event the primary spillway is inadequate for downstream passage, flows can be increased through the fishway (by restricting the primary spillway and slightly raising the pond level) to draw the fish through that exit point.

Table 1

Rhode Island South Coast Feasibility Study

Tidal Information by Pond

	Winnapaug	Quonochontaug	Ninigret
MLW (NGVD)==>	-0.2	-0.4	+0.6
MLLW (NGVD)=>	-0.3	-0.5	+0.5
Side Slope====>	1:6	1:6	1:6

TABLE 2

Rhode Island South Coast Feasibility Study

Restoration Area Quantities (Cubic Yards)

	Winnapaug	Quonochontaug	Ninigret
Total Area (SF)	525,728	226,953	1,731,850

Depth Below MLW 1.75 Feet

Depth Below NGVD	(-0.2-1.75 = -1.95)		(-0.4-1.75 = -2.15)		(+0.6-1.75 = -1.15)	
	A	12206	A	3398	A	36197
	B	4791	B	1157	B	21935
	C	4731	C	3316		58132
	D	4751		7871		
	E	1477				
		27956				

Depth Below MLW 2.5 Feet

Depth Below NGVD	(-0.2-2.5 = -2.7)		(-0.4-2.5 = -2.9)		(+0.6-2.5 = -1.9)	
	A	17511	A	7363	A	67238
	B	6938	B	1993	B	40297
	C	7113	C	5602		107535
	D	7605		14958		
	E	2569				
		41736				

Depth Below MLW 3.25 Feet

Depth Below NGVD	(-0.2-3.25 = -3.45)		(-0.4-3.25 = -3.65)		(+0.6-3.25 = -2.65)	
	A	23890	A	11739	A	98975
	B	9240	B	2930	B	59528
	C	9874	C	8084		158503
	D	10698		22753		
	E	4421				
		58123				

Depth Below MLW 4.0 Feet

Depth Below NGVD	(-0.2-4.0 = -4.2)		(-0.4-4.0 = -4.4)		(+0.6-4.0 = -3.4)	
	A	30601	A	16356	A	131412
	B	11701	B	3969	B	79466
	C	12927	C	10761		210878
	D	13973		31086		
	E	6728				
		75930				

TABLE 3

Rhode Island South Coast Feasibility Study

Sedimentation Basin Quantities (Cubic Yards)
(1:6 Side Slopes)

Winnapaug — Area = 121,332 SF

Excavate to: (Below MLW)	(Below NGVD)	Cut	Fill
-3	(-0.2-3.0= -3.2)	6207	2333
-4	(-0.2-4.0= -4.2)	10084	1013
-5	(-0.2-5.0= -5.2)	14868	355
-6	(-0.2-6.0= -6.2)	20423	92
-7	(-0.2-7.0= -7.2)	26617	10
-8	(-0.2-8.0= -8.2)	33399	0

Quonochontaug — Area = 146,692 SF

Excavate to: (Below MLW)	(Below NGVD)	Cut	Fill
-3	(-0.4-3.0= -3.4)	3516	5595
-4	(-0.4-4.0= -4.4)	7089	2829
-5	(-0.4-5.0= -5.4)	11981	984
-6	(-0.4-6.0= -6.4)	18331	151
-7	(-0.4-7.0= -7.4)	25837	1
-8	(-0.4-8.0= -8.4)	33974	0

Ninigret (inside pond) — Area = 141,901 SF

Excavate to: (Below MLW)	(Below NGVD)	Cut	Fill
-3	(+0.6-3.0= -2.4)	12117	0
-4	(+0.6-4.0= -3.4)	18376	0
-5	(+0.6-5.0= -4.4)	25045	0
-6	(+0.6-6.0= -5.4)	32131	0
-7	(+0.6-7.0= -6.4)	39641	0
-8	(+0.6-8.0= -7.4)	47583	0

Ninigret (entrance) — Area = 154,449 SF

Excavate to: (Below MLW)	(Below NGVD)	Cut	Fill
-3	(+0.6-3.0= -2.4)	10178	0
-4	(+0.6-4.0= -3.4)	16927	0
-5	(+0.6-5.0= -4.4)	24190	0
-6	(+0.6-6.0= -5.4)	31974	0
-7	(+0.6-7.0= -6.4)	40293	0
-8	(+0.6-8.0= -7.4)	49164	0

Table 4

Rhode Island South Coast Feasibility Study

Beach Sandfill Capacities

Charlestown Town Beach

Crest Elevation ==>	9
Crest Width ==>	160
Back Slope (1:?) ==>	
Seaward Slope (1:?) ==>	3

Section	Area	Avg Area	Distance	Capacity
CHATB0	0			
		694.5	200	5144
CHATB3	1389			
		1389	1200	61733
CHATB1	1389			
		1389.5	527	27121
CHATB2	1390			
		1390	1200	61778
CHATB4	1390			
		695	200	5148
CHATB5				
			Total	160925

East Beach

Crest Elevation ==>	9
Crest Width ==>	100
Back Slope (1:?) ==>	3
Seaward Slope (1:?) ==>	3

Section	Area	Avg Area	Distance	Capacity
EAST0	0			
		400	200	2963
EAST1	800			
		801.5	1262	37463
EAST2	803			
		401.5	200	2974
EAST4	0			
			Total	43400

Table 4 (Cont.)

Misquamicut State Beach

Crest Elevation ==>	8.1 (NGVD)
Crest Width ==>	100
Back Slope (1:?) ==>	
Seaward Slope (1:?) ==>	3

Section	Area	Avg Area	Distance	Capacity
MSQ0	0			
		282.5	200	2093
MSQ1	565			
		709	887	23292
MSQ2	853			
		706.5	1316	34435
MSQ3	560			
		280	200	2074
MSQ4	0			
			Total	61894

South Kingstown Town Beach

Crest Elevation ==>	9
Crest Width ==>	100
Back Slope (1:?) ==>	
Seaward Slope (1:?) ==>	3

Section	Area	Avg Area	Distance	Capacity
SKTB0	0			
		309	200	2289
SKTB1	618			
		566.5	488	10239
SKTB2	515			
		257.5	200	1907
SKTB3	0			
			Total	14435

Table 5

Rhode Island South Coast Feasibility Study

De-watering Area Capacities

s = dike side slope (1 on ?)
c = dike crest width
w = width of site
l = length of site
y = dike height (no freeboard)
x1 = w - 2(sy + c + sy)
x2 = l - 2(sy + c + sy)
Q = capacity

Q = [(x1 * x2) * y / 27] + [s * y^2 * x1 / 27] + [s * y^2 * x2 / 27]

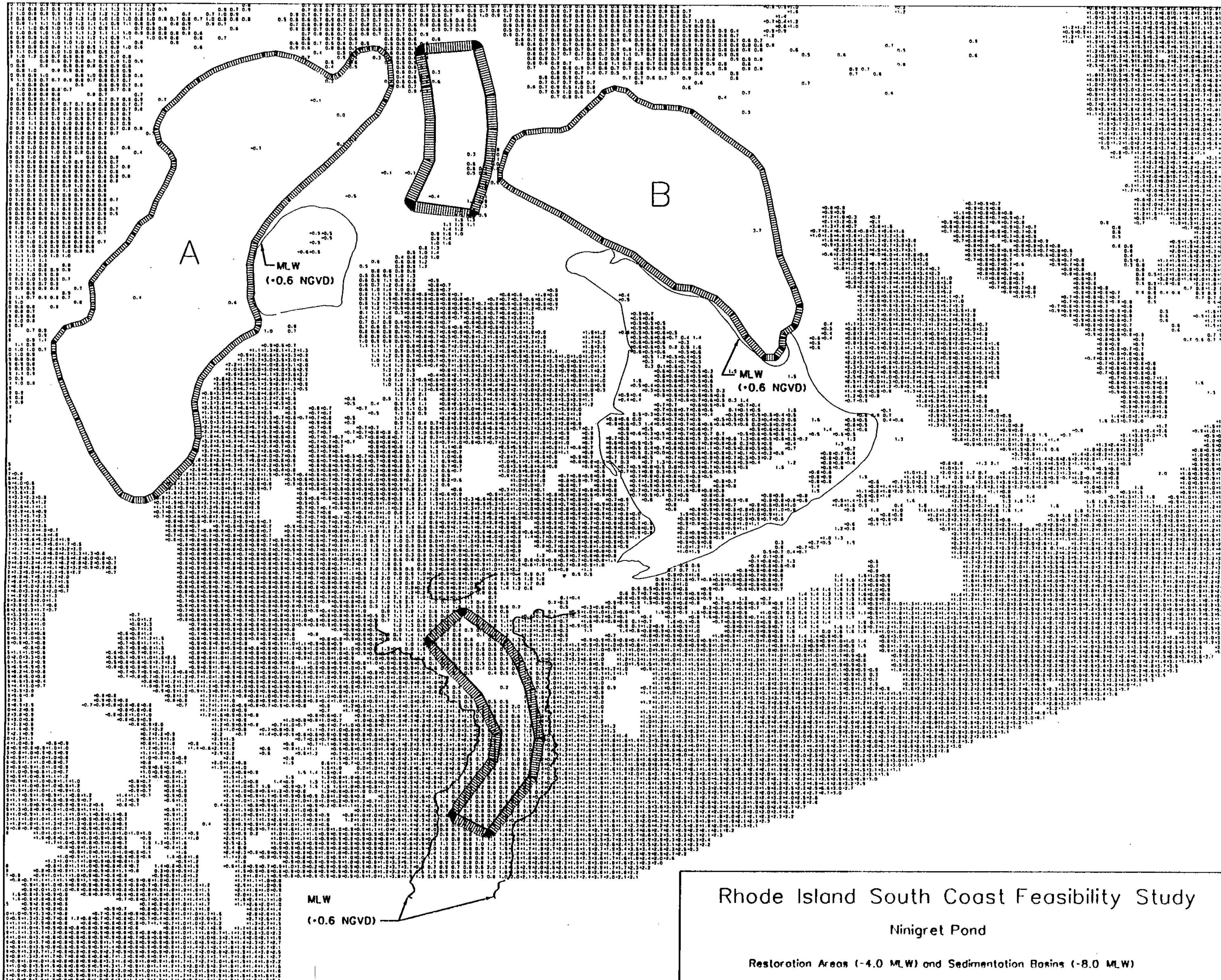
s	c	w	l	y	x1	x2	Q
2	5	300	580	5	250	530	25,981
2	10	300	580	5	240	520	24,519
2	5	300	580	10	210	490	43,296
2	10	300	580	10	200	480	40,593
2	5	75	175	5	25	125	856
2	10	75	175	5	15	115	560
2	5	75	175	10	-15	85	46
2	10	75	175	10	-25	75	-324
2	5	200	350	5	150	300	9,167
2	10	200	350	10	100	250	11,852
2	5	200	350	10	110	260	13,333
2	10	200	350	5	140	290	8,315

Table 6

Rhode Island South Coast Feasibility Study

Fish Passage Quantities for Cross Mills Pond, Charlestown

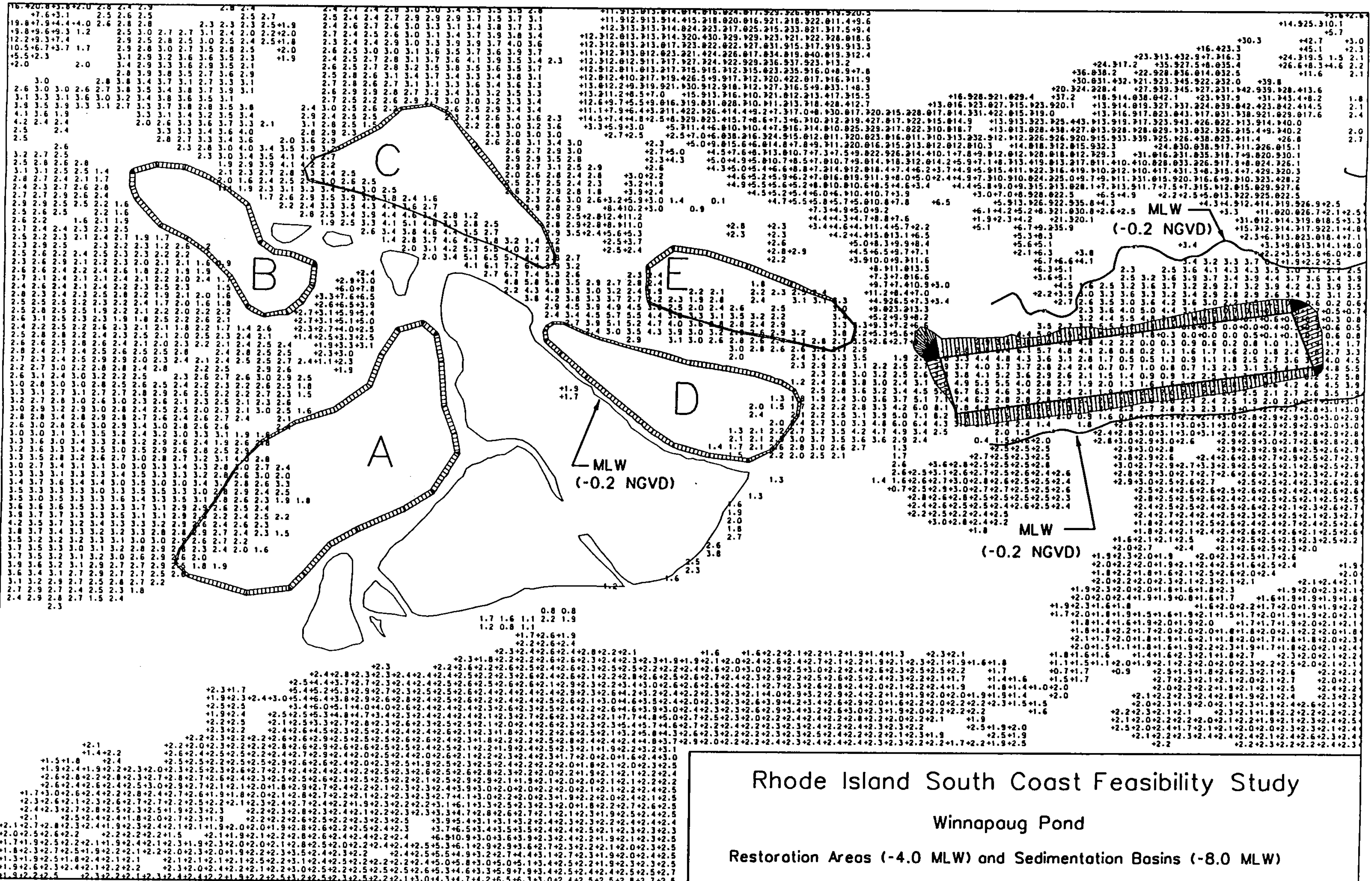
Item	Quanity	Units
Excavation (to be removed)	130	CY
Excavation (to be used for backfill)	80	CY
Pavement (to be removed)	40	SY
Sawcut	60	LF
Compacted gravel base course	10	CY
Pavement (1/2" surface course, binder course and tack coat)	40	SY
6" Pipe bedding	17	CY
Concrete fish ladder	50	CY
Precast concrete box culvert	5	EA
Trash rack	1	EA
Dredge to elev. 12	1.5	CY
Steeppass fish ladder	4	EA
Exterior floor grating	60	LF
Sewer pipe	1	Job
Seals at ends of Steeppass	2	Job
Stop logs (2 x 6 x 18)	4	EA



Rhode Island South Coast Feasibility Study

Ninigret Pond

Restoration Areas (-4.0 MLW) and Sedimentation Basins (-8.0 MLW)

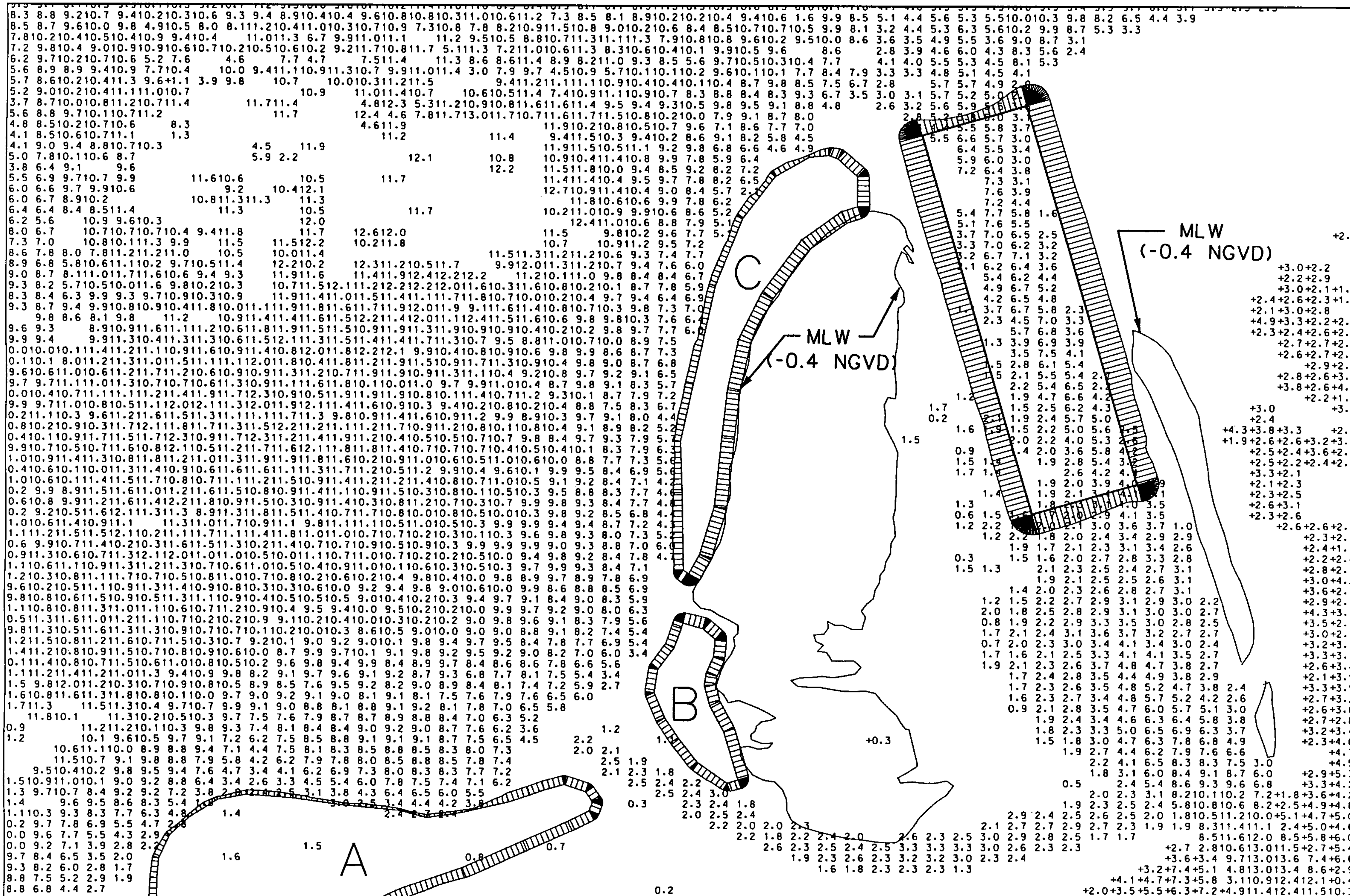


Rhode Island South Coast Feasibility Study

Winnapaug Pond

Restoration Areas (-4.0 MLW) and Sedimentation Basins (-8.0 MLW)

d:\temp\risc\winn.dgn Dec. 28, 2000 17:06:23

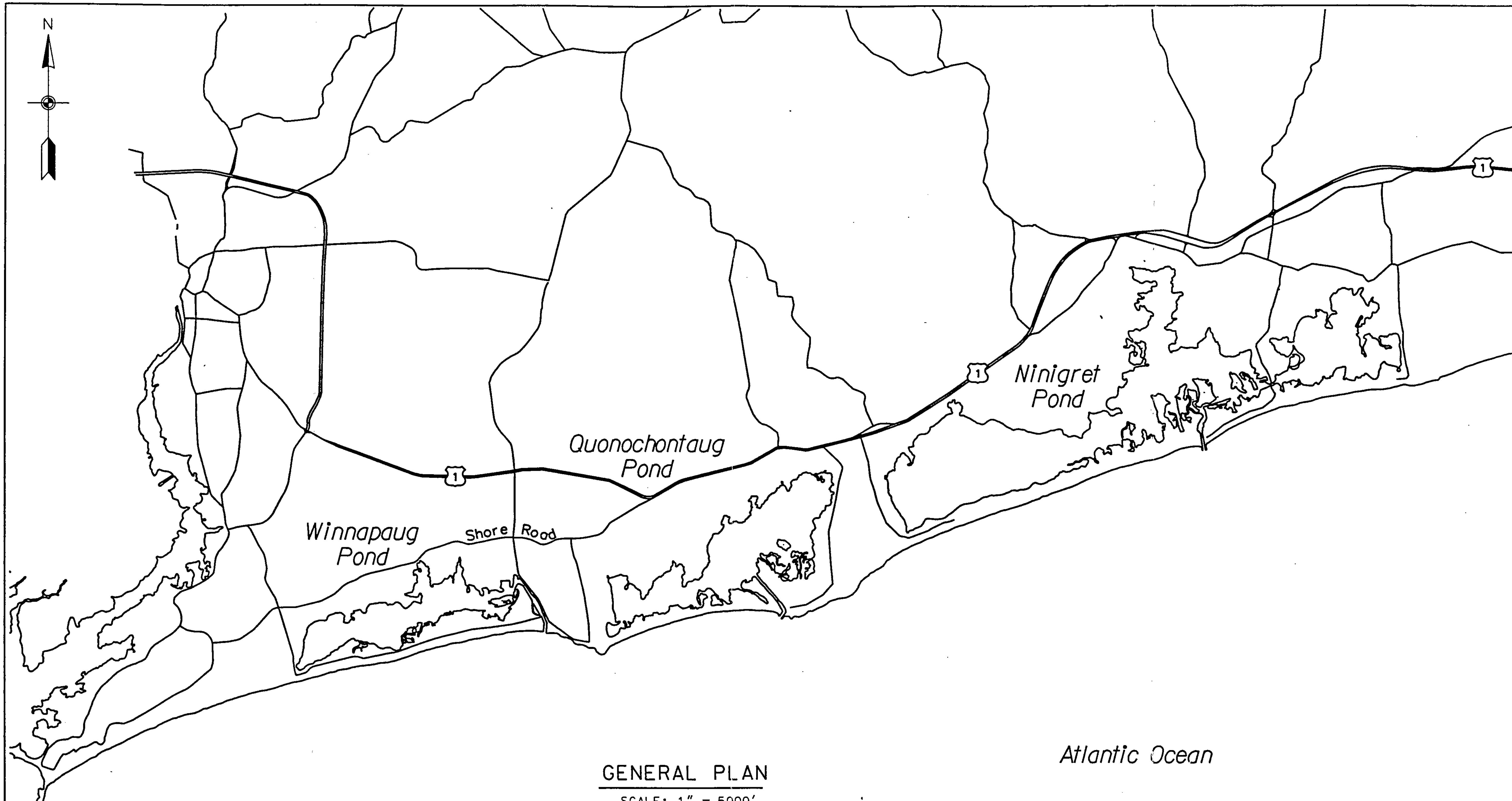


Rhode Island South Coast Feasibility Study

Quonochontaug Pond

Restoration Areas (-4.0 MLW) and Sedimentation Basin (-8.0 MLW)

n:\civ\misc\risc\quon.dgn Jan. 17, 2001 14:23:10



GENERAL PLAN

SCALE: 1" = 5000'

GRAPHIC SCALE

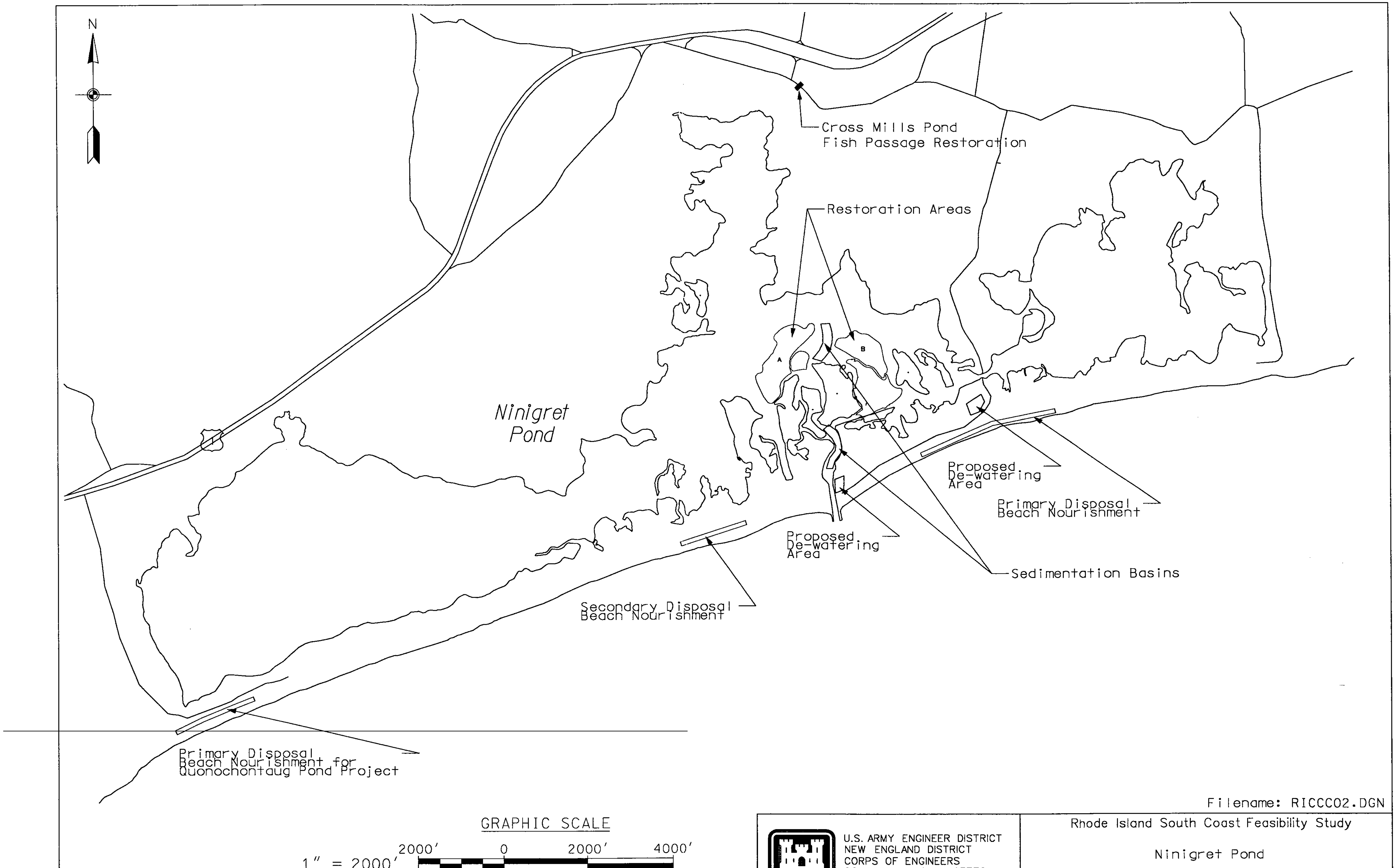
1" = 5000' 5000' 0 5000' 10000'

Filename: RICG101A.DGN

U.S. ARMY ENGINEER DISTRICT
NEW ENGLAND DISTRICT
CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS

Rhode Island South Coast Feasibility Study

GENERAL PLAN



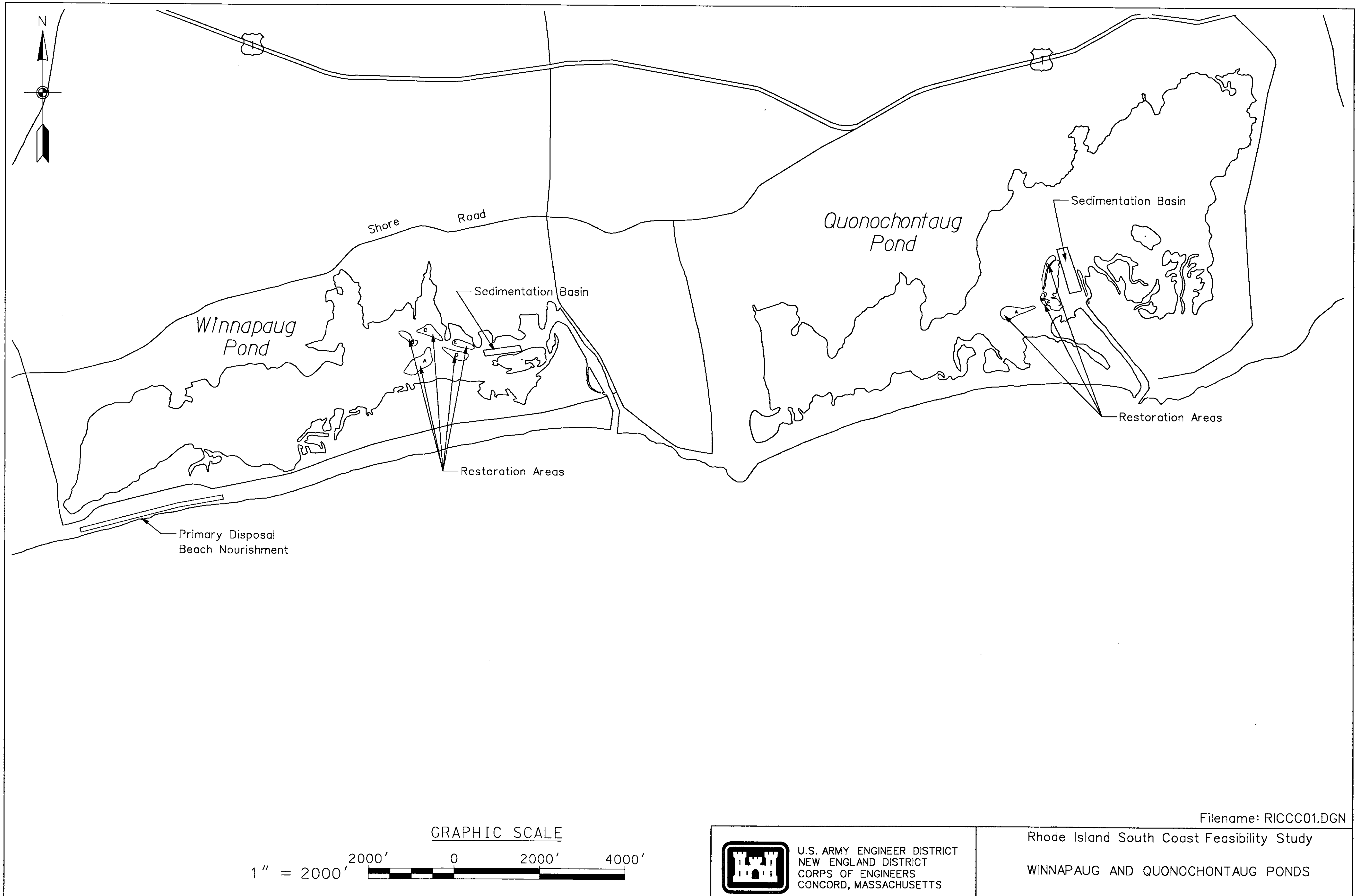
Filename: RICCC02.DGN

U.S. ARMY ENGINEER DISTRICT
NEW ENGLAND DISTRICT
CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS

Rhode Island South Coast Feasibility Study

Ninigret Pond

n:\civ\misc\risc\ricc02.dgn 05/03/02 03:50:19 PM



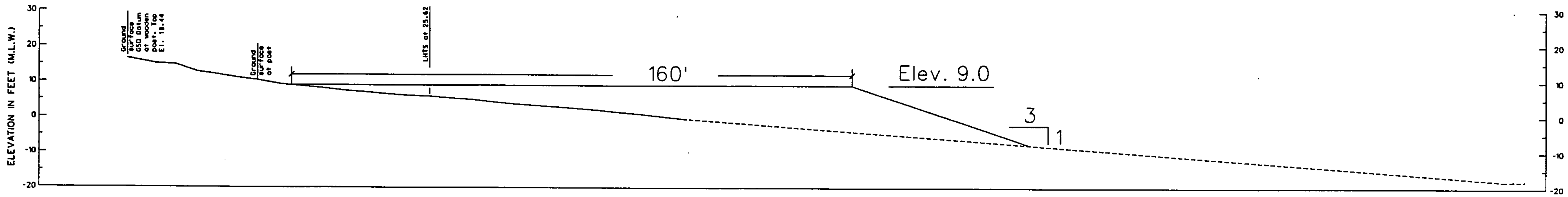
Filename: RICCC01.DGN

U.S. ARMY ENGINEER DISTRICT
NEW ENGLAND DISTRICT
CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS

Rhode Island South Coast Feasibility Study

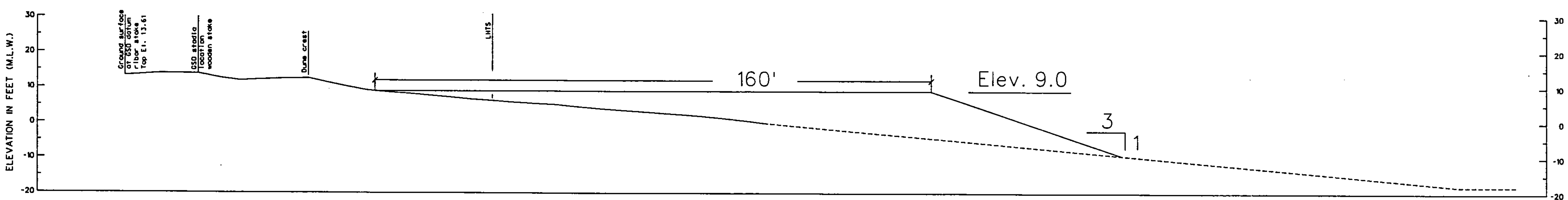
WINNAPAUG AND QUONOCHONTAUG PONDS

n:\clv\misc\risc\riccc01.dgn 05/03/02 03:02:41 PM



CHATB2

ATTENTION!: Measure in M.L.W.
"Charlestown Town Beach"



CHATB1

ATTENTION!: Measure in M.L.W.
"Charlestown Town Beach"

GRAPHIC SCALE

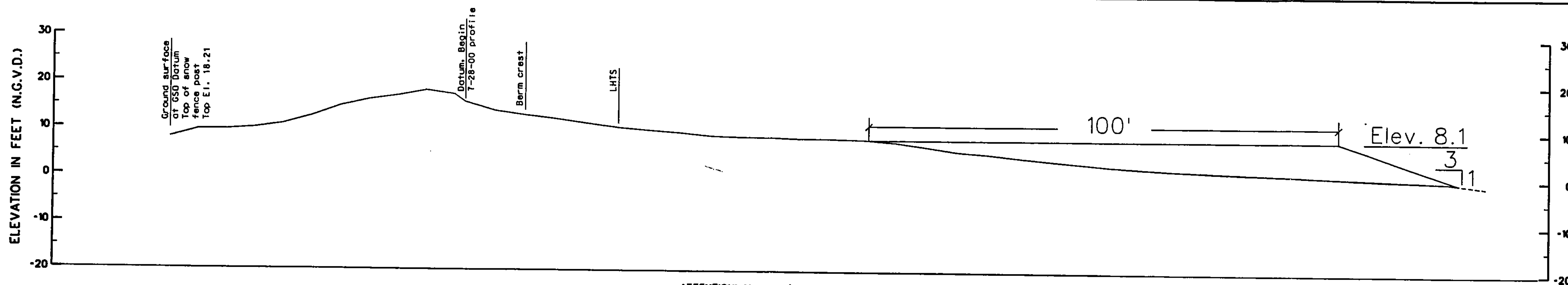
20' 0 20' 40'

Filename: CHATB1.DGN

U.S. ARMY ENGINEER DISTRICT
NEW ENGLAND DISTRICT
CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS

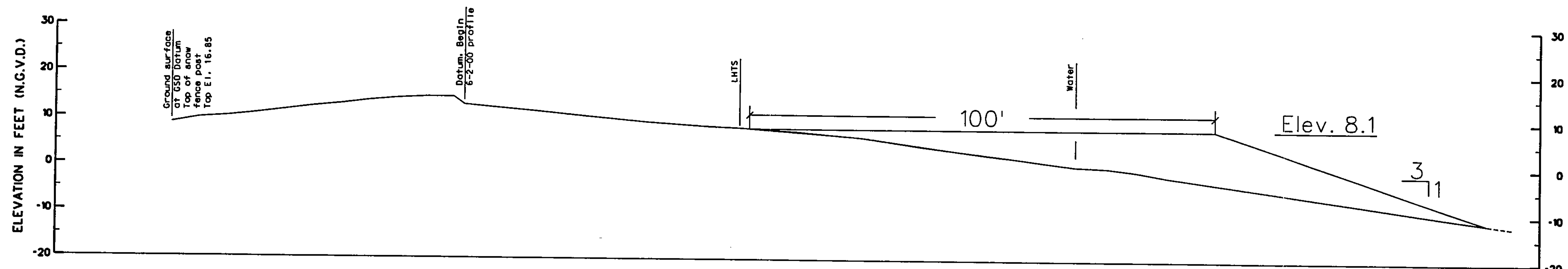
Rhode Island South Coast Feasibility Study

CHARLESTOWN TOWN BEACH



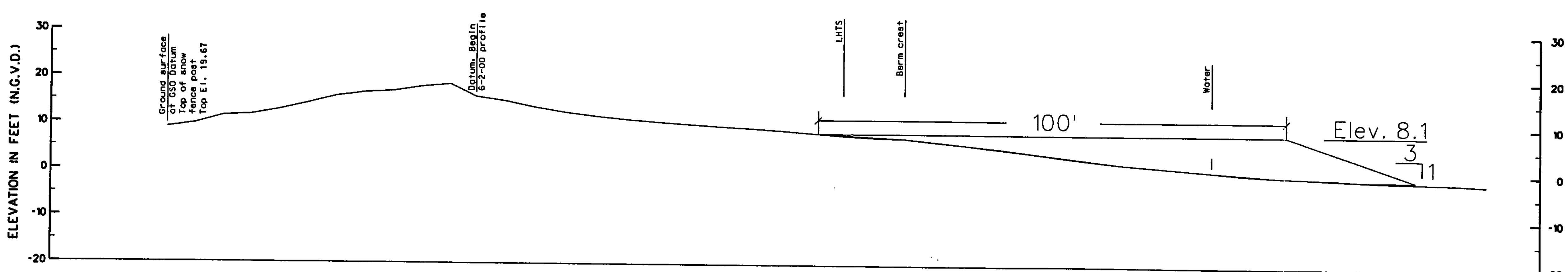
MSQ3
SCALE: 1" = 10'

ATTENTION!: Measure in N.G.V.D.
Only in "Misquamicut State Beach"



MSQ2
SCALE: 1" = 10'

ATTENTION!: Measure in N.G.V.D.
Only in "Misquamicut State Beach"



MSQ1
SCALE: 1" = 10'

ATTENTION!: Measure in N.G.V.D.
Only in "Misquamicut State Beach"

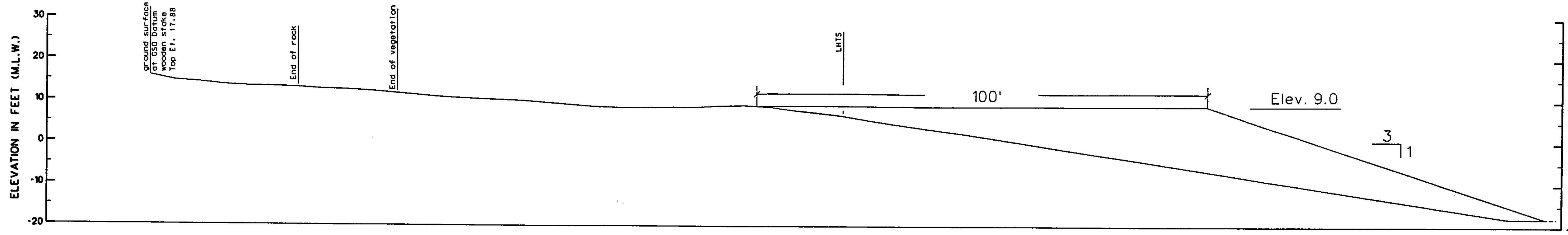
GRAPHIC SCALE
20' 0 20' 40'

Filename: MISQ1.DGN

U.S. ARMY ENGINEER DISTRICT
NEW ENGLAND DISTRICT
CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS

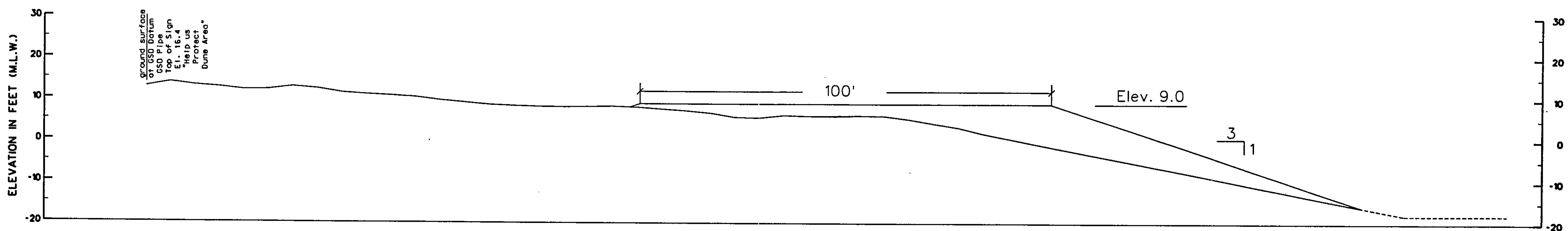
Rhode Island South Coast Feasibility Study

MISQUAMICUT STATE BEACH



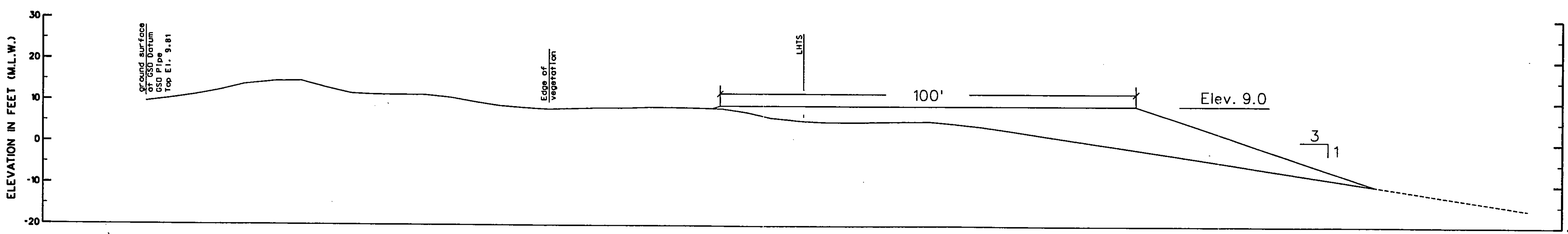
EAST3

ATTENTION!: Measure in M.L.W.
"East Beach"



EAST2

ATTENTION!: Measure in M.L.W.
"East Beach"



EAST1

ATTENTION!: Measure in M.L.W.
"East Beach"

Filename: EAST1.DGN

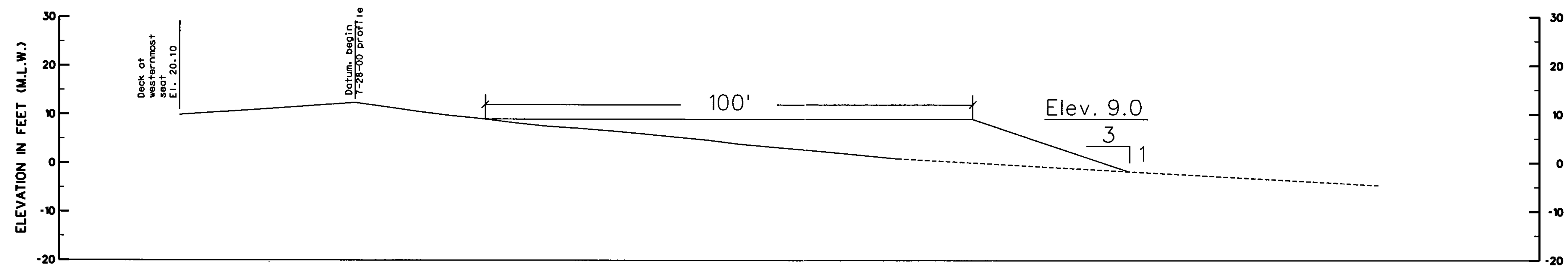
GRAPHIC SCALE

20' 0 20' 40'

U.S. ARMY ENGINEER DISTRICT
NEW ENGLAND DISTRICT
CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS

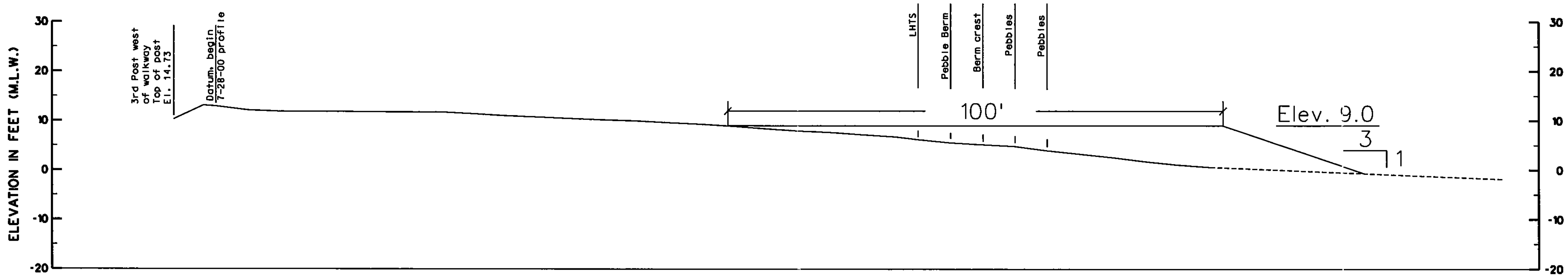
Rhode Island South Coast Feasibility Study

EAST BEACH



SKTB1

ATTENTION!: Measure in M.L.W.
"South Kingstown Town Beach"



SKTB5

ATTENTION!: Measure in M.L.W.
"South Kingstown Town Beach"

GRAPHIC SCALE

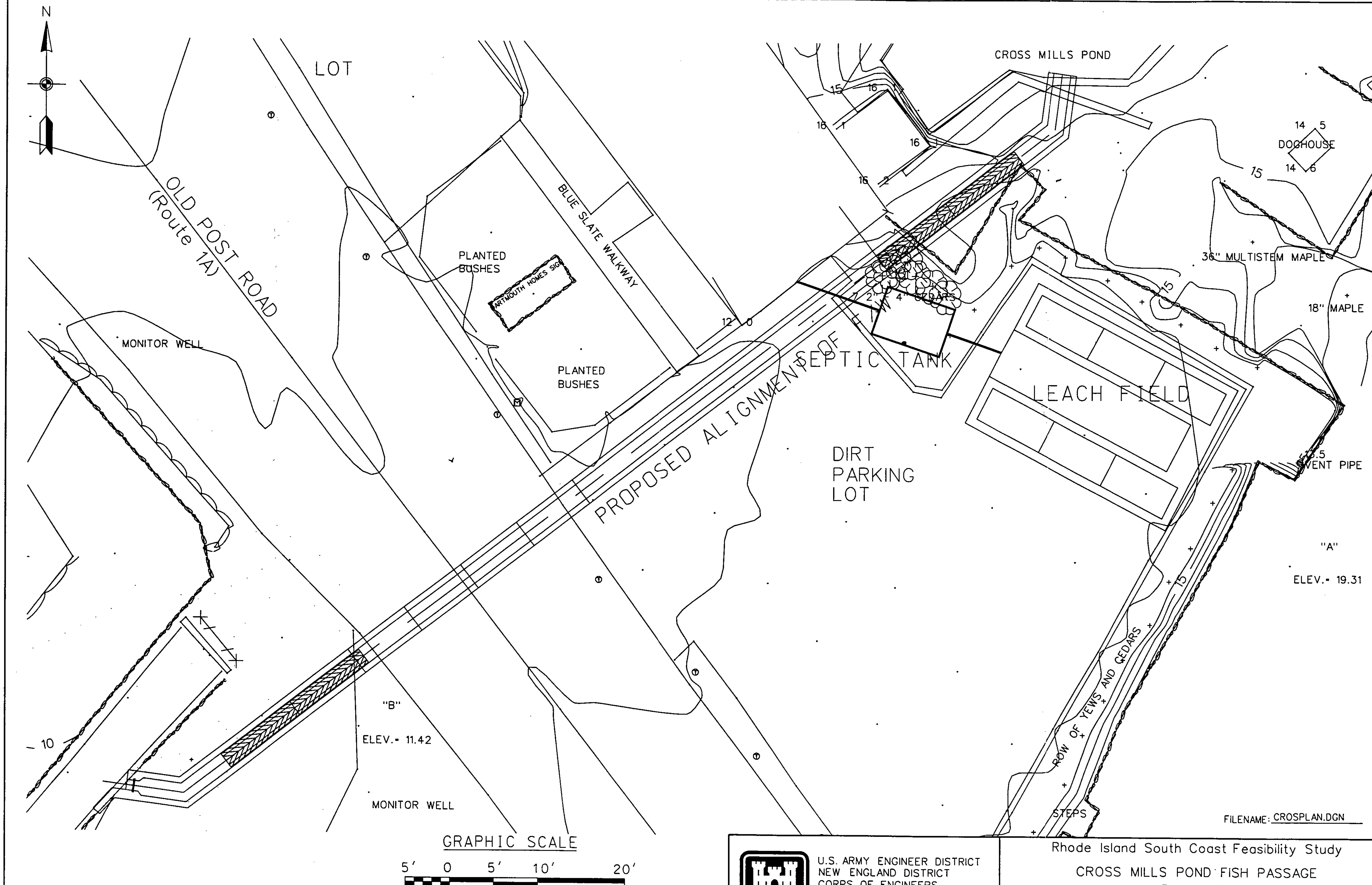
20' 0 20' 40'

Filename: SKTB1.DGN

U.S. ARMY ENGINEER DISTRICT
NEW ENGLAND DISTRICT
CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS

Rhode Island South Coast Feasibility Study

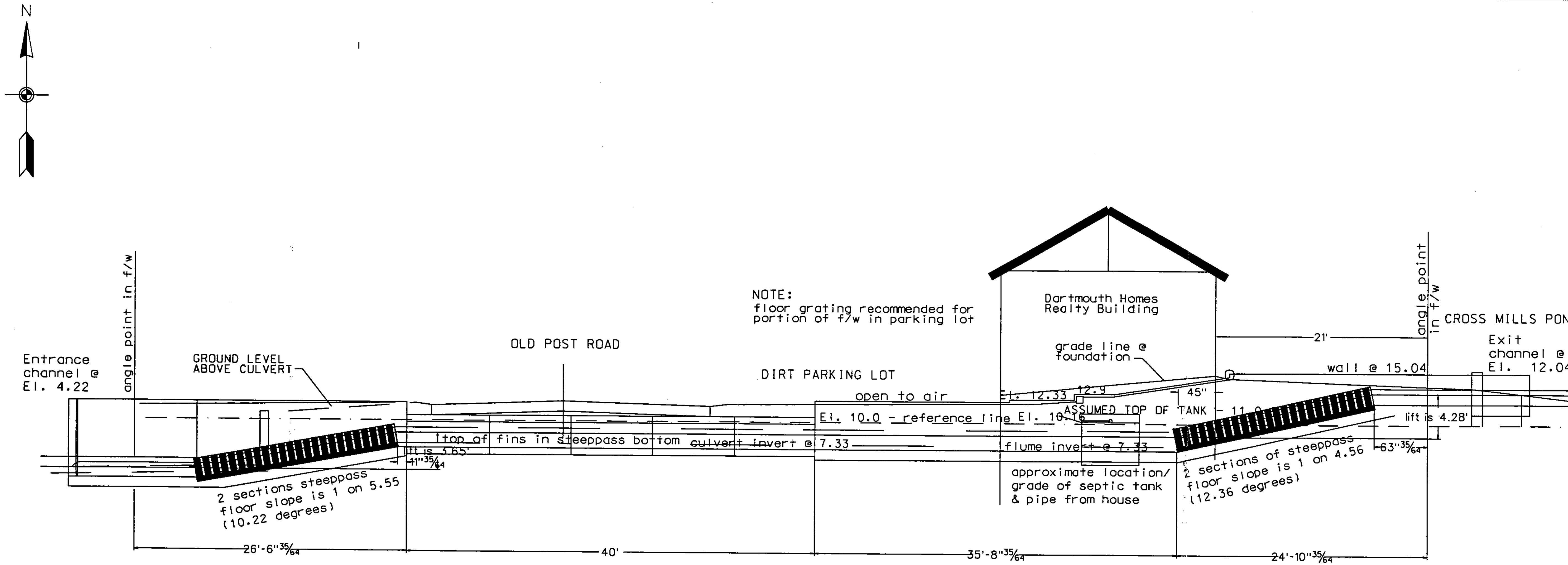
SOUTH KINGSTOWN BEACH



U.S. ARMY ENGINEER DISTRICT
NEW ENGLAND DISTRICT
CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS

Rhode Island South Coast Feasibility Study

CROSS MILLS POND FISH PASSAGE
PLAN VIEW



SECTION VIEW ALONG PROP F/W

GRAPHIC SCALE

5' 0 5' 10' 20'

FILENAME: CROSPLAN.DGN

U.S. ARMY ENGINEER DISTRICT
NEW ENGLAND DISTRICT
CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS

Rhode Island South Coast Feasibility Study

CROSS MILLS POND FISH PASSAGE

SECTION

Appendix III

Project Cost Estimates

RHODE ISLAND SOUTH COAST FEASIBILITY STUDY
PROJECT COST ESTIMATES

1. GENERAL

This project consists of the work necessary to dredge sand from Winnapaug, Quonochontaug, and Ninigret ponds in Rhode Island and pump the dredged material to a beach disposal site or an upland de-watering site. Construction cost estimates were prepared assuming the use of a hydraulic dredging plant and a conceptual design for several disposal sites. Dredging quantities vary with dredge footprint and depth. Due to the shallowness of the ponds it is difficult to predict the size of the equipment that will be used during construction. A 14-inch hydraulic pipeline dredge was used for initial estimating purposes. As the selected alternatives were identified, estimates were also done using a smaller (8-inch "mudcat") hydraulic dredge plant.

2. DREDGING AND MATERIAL HANDLING

The hydraulic dredging cost estimates were initially performed using the Corps of Engineers Dredge Estimating Program (CEDEP). Tables 1, 2, 3 (based on CEDEP), and 4 (based on MCACES) were developed to perform the economic analysis. Tables 1a., 2a., 3a. (CEDEP), and the attached MCACES (Current Working Estimates for the study) estimates were developed later in the study in support of the recommended plans for each site. Engineering and Design (E&D), construction management (S&A), escalation/verification, and contingency costs are included in the cost estimates and are reflective of the nature of the work being done.

3. DISPOSAL SITES

It is expected that the majority of the dredged material removed form the ponds will be placed directly in the intertidal zone along nearby beaches. A booster pump will be required where pumping distances are greater than a mile. Average pipeline distances are 10,700 feet for Winnapaug Pond, 14,000 feet for Quonochontaug Pond, and 8,000 feet for Ninigret Pond. The average pumping distance from the sedimentation basin at the entrance of Ninigret Pond to the beach was estimated to be about 5,500 feet.

4. DE-WATERING FACILITY

Four potential sites for de-watering dredged material were also evaluated. A potential de-watering site for Winnapaug Pond is located north of the pond, adjacent to a golf course, and is approximately 4.0 acres in size. A potential 1.6-acre de-watering area for Ninigret Pond would be located in the State parking area at the entrance to the pond. There is also the potential for a 1.3-acre site at the Charlestown Town Beach parking lot. A site consisting of 0.3 acres located in the State parking lot at Quonochontaug Pond breachway was determined to be too small to be of any use. The Winnapaug site was initially evaluated but was not pursued further due to difficulties in obtaining the lands.

The average distance to the de-watering sites from the areas being dredged was estimated to be 4,600 feet. It is estimated that the Winnapaug Pond site can handle 43,000 cubic yards of material and the two Ninigret Pond sites can handle 13,000 and 10,000 cubic yards, respectively. The dewatering site construction quantities and capacities were determined according to Table 5 located in Appendix II. For example, the 1.6 acre site at Ninigret will be 200'x 350'x10' in size with a top width of 5' and a side slope of 1:2. This size facility will require 10,200 cubic yards of material to construct and have a holding capacity of about 13,000 cubic yards. The cost estimates for dredging and disposal at the de-watering areas are displayed at the bottom of Tables 1 and 2.

5. FISH PASSAGE RESTORATION- CROSS MILLS POND, CHARLESTOWN

A fishway was designed by the U.S. Fish and Wildlife Service to restore blueback herring to Cross Mills Pond in Charlestown. The fishway consists of two fish ladders, a segment of concrete culvert (Route 1A), and a section of concrete open channel. The U.S. Army Corps of Engineers, New England District, developed the quantities and costs for the fishway. The current working estimate for the study was developed using the Corps' cost estimating software, MCACES, and is displayed in the attached MCACES tables.

TABLE 1 (14" Hydraulic Dredge Plant)

NINIGRET POND

	1	2	3	4	5	6	7	8	9	10
Dredging&Beach Disposal	**Dist.**	**Quantity**	**Dredge**	**Booster**	**Unit cost**	**Mob/Dem**	**Time**	**Total cost**	**x 1.35**	**Unit cost**
	Feet	**CY**	**#**	**#**	**$/CY**	**$**	**Mon**	**$**	**$**	**$/CY**
Restoration (A+B) 1.75'	8000	58132	1	1	16.9	250000	1.60	1232430	1663780	28.6
Restoration (A+B) 2.5'	8000	107535	1	1	11.4	250000	2.00	1475899	1992463	18.5
Restoration (A+B) 3.25'	8000	158503	1	1	8.9	250000	2.20	1660676	2241913	14.1
Restoration (A+B) 4.0'	8000	210878	1	1	6.6	250000	2.30	1641795	2216422	10.5
Southern Sedimentation Basin -3'	5500	10178	1	1	11.2	250000	0.17	363993	491391	48.3
Sedimentation Basin -4'	5500	16927	1	1	7.5	250000	0.19	376952	508885	30.1
Sedimentation Basin -5'	5500	24190	1	1	5.7	250000	0.21	387883	523642	21.6
Sedimentation Basin -6'	5500	31974	1	1	5.5	250000	0.27	425857	574906	18.0
Sedimentation Basin -7'	5500	40293	1	1	5.2	250000	0.33	459523	620356	15.4
Sedimentation Basin -8'	5500	49164	1	1	5.1	250000	0.40	500736	675994	13.7
Dredging to Dewatering Site	4600	13000	1	0	12.0	0	1.50	156000	210600	16.2
Northern Sedimentation Basin -3'	8000	12117	1	1	12.1	250000	0.18	396615	534431	44.2
Sedimentation Basin -4'	8000	18376	1	1	8.0	250000	0.20	397008	535960	29.2
Sedimentation Basin -5'	8000	25045	1	1	6.3	250000	0.23	407783	550507	22.0
Sedimentation Basin -6'	8000	32131	1	1	6.2	250000	0.30	449212	606436	18.9
Sedimentation Basin -7'	8000	39641	1	1	6.0	250000	0.38	487846	658592	16.6
Sedimentation Basin -8'	8000	47583	1	1	5.8	250000	0.45	525981	710074	14.9

1. Average pumping distance
2. Quantity of the dredged material
3. Number of dredges used
4. Number of booster pumps
5. Unit cost of dredging and disposal
6. Cost of mobilization and demobilization
7. Time of actual construction (months)
8. Total cost including mob & demob
9. Markup includes E&D(2%), S&A (8%), escalation, verification and contingency(25%) cost
10. Final unit cost per cubic yard of dredged material

Note: Optional Dewatering Dike Construction Cost: 10200 CY x 25 = $255,000..
Use average $12/cy for 13,000 cy of material pumped to dewatering site

TABLE 1a (Hydraulic "Mudcat" Dredge Plant)
NINIGRET POND

	1	2	3	4	5	6	7	8	9	10
Dredging&Beach Disposal	**Dist.**	**Quantity**	**Dredge**	**Booster**	**Unit cost**	**Mob/Dem**	**Time**	**Total cost**	**x 1.35**	**Unit cost**
	Feet	**CY**	**#**	**#**	**$/CY**	**$**	**Mon**	**$**	**$**	**$/CY**
Restoration (A+B) 2.5'	8000	107535	1	1	7.5	60000	4.00	866512	1169791	10.9
Southern Sedimentation Basin -8'	5500	49164	1	1	8.5	60000	2.00	477894	645156	13.1
Dredging to Dewatering Site	4600	13000	1	0	12.0	0	0.80	156000	210600	16.2
Northern Sedimentation Basin -5'	8000	25045	1	1	10.0	60000	1.00	310450	419107	16.7

1. Average pumping distance
2. Quantity of the dredged material
3. Number of dredges used
4. Number of booster pumps
5. Unit cost of dredging and disposal
6. Cost of mobilization & demobilization
7. Time of actual construction (months)
8. Total cost including mob & demob
9. Markup includes E&D(2%), S&A (8%), escalation, verification and contingency(25%) cost
10. Final unit cost per cubic yard of dredged material

Note: Optional Dewatering Dike Construction Cost: 10200 CY x 25 = $255,000..
Use Ave. $12/CY for 13000 CY matreial pumped to dewatering site

Eelgrass Planting Cost = 39.76 acres x 0.5 x $40,000/acre = $795,200.

TABLE 2 (14" Hydraulic Dredge Plant)
WINNAPAUG POND

	1	2	3	4	5	6	7	8	9	10
Dredging&Beach Disposal	**Dist. Feet**	**Quantity CY**	**Dredge #**	**Booster #**	**Unit cost $/CY**	**Mob/Dem $**	**Time Mon**	**Total cost $**	**x 1.35 $**	**Unit cost $/CY**
Restoration(A+B+C+D+E) 1.75'	10700	27956	1	1	15.4	250000	0.60	680522	918700	32.9
Restoration(A+B+C+D+E) 2.5'	10700	41736	1	1	11.4	250000	0.70	725790	979820	23.5
Restoration(A+B+C+D+E) 3.25'	10700	58123	1	1	8.6	250000	0.80	749860	1012300	17.4
Restoration(A+B+C+D+E) 4.0'	10700	75930	1	1	7.2	250000	0.90	796696	1075540	14.2
Sedimentation Basin -3'	10700	6207	1	1	17.3	250000	0.15	357380	482500	77.7
Sedimentation Basin -4'	10700	10084	1	1	12.0	250000	0.20	371000	500860	50.0
Sedimentation Basin -5'	10700	14868	1	1	8.5	250000	0.22	376378	508110	34.2
Sedimentation Basin -6'	10700	20423	1	1	7.1	250000	0.25	395000	533250	26.1
Sedimentation Basin -7'	10700	26617	1	1	6.9	250000	0.30	433657	585440	22.0
Sedimentation Basin -8'	10700	33399	1	1	6.6	250000	0.32	470433	635100	19.0
Dredging to Dewatering Site	4600	43000	1	1	10.0	0	0.70	430000	580500	13.5

1. Average pumping distance
2. Quantity of the dredged material
3. Number of dredges used
4. Number of booster pumps
5. Unit cost of dredging and disposal
6. Cost of mobilization & demobilization
7. Time of actual construction (months)
8. Total cost including mob & demob
9. Markup includes E&D(2%), S&A (8%), escalation, verification and contingency(25%) cost
10. Final unit cost per cubic yard of dredged material

Note: Optional Dewatering Dike Construction Cost: 16300 CY x 25 = $407,500.
Use Ave. $10/CY for 43000 CY matreial pumped to dewatering site

TABLE 2a (Hydraulic "Mudcat" Dredge Plant)
WINNAPAUG POND

	1	2	3	4	5	6	7	8	9	10
Dredging&Beach Disposal	**Dist. Feet**	**Quantity CY**	**Dredge #**	**Booster #**	**Unit cost $/CY**	**Mob/Dem $**	**Time Mon**	**Total cost $**	**x 1.35 $**	**Unit cost $/CY**
Restoration(A+B+C+D+E) 2.5'	10700	41736	1	1	8.5	60000	2.00	414756	559920	13.4
Sedimentation Basin -8'	10700	33399	1	1	9.0	60000	1.50	360591	486797	14.6

1. Average pumping distance
2. Quantity of the dredged material
3. Number of dredges used
4. Number of booster pumps
5. Unit cost of dredging and disposal
6. Cost of mobilization & demobilization
7. Time of actual construction (months)
8. Total cost including mob & demob
9. Markup includes E&D(2%), S&A (8%), escalation, verification and contingency(25%) cost
10. Final unit cost per cubic yard of dredged material

Eelgrass Planting = 12.07 acre x 0.5 x $40,000/acre = $241,400

TABLE 3 (14" Hydraulic Dredge Plant)
Quonochontaug Pond

	1	2	3	4	5	6	7	8	9	10
Dredging&Beach Disposal	**Dist.**	**Quantity**	**Dredge**	**Booster**	**Unit cost**	**Mob/Dem**	**Time**	**Total cost**	**x 1.35**	**Unit cost**
	Feet	**CY**	**#**	**#**	**$/CY**	**$**	**Mon**	**$**	**$**	**$/CY**
Restoration(A+B+C) 1.75'	14000	7871	1	1	21.2	250000	0.25	416865	562800	71.5
Restoration(A+B+C) 2.5'	14000	14958	1	1	13.8	250000	0.30	456420	616200	41.2
Restoration(A+B+C) 3.25'	14000	22753	1	1	9.9	250000	0.32	475250	641600	28.2
Restoration(A+B+C) 4.0'	14000	31086	1	1	7.7	250000	0.35	489400	660640	21.3
Sedimentation Basin -3'	14000	3516	1	1	28.6	250000	0.14	350557	473252	134.6
Sedimentation Basin -4'	14000	7089	1	1	18.0	250000	0.18	377602	509762	71.9
Sedimentation Basin -5'	14000	11981	1	1	12.0	250000	0.20	393772	531592	44.4
Sedimentation Basin -6'	14000	18331	1	1	8.4	250000	0.22	403980	545373	29.8
Sedimentation Basin -7'	14000	25837	1	1	6.9	250000	0.27	428275	578171	22.4
Sedimentation Basin -8'	14000	33974	1	1	6.5	250000	0.34	470831	635621	18.7

1. Average pumping distance
2. Quantity of the dredged material
3. Number of dredges used
4. Number of booster pumps
5. Unit cost of dredging and disposal
6. Cost of mobilization & demobilization
7. Time of actual construction (months)
8. Total cost including mob & demob
9. Markup includes E&D(2%), S&A (8%), escalation, verification and contingency(25%) cost
10. Final unit cost per cubic yard of dredged material

TABLE 3a (Hydraulic "Mudcat" Dredge Plant)
Quonochontaug Pond

	1	2	3	4	5	6	7	8	9	10
Dredging&Beach Disposal	**Dist.**	**Quantity**	**Dredge**	**Booster**	**Unit cost**	**Mob/Dem**	**Time**	**Total cost**	**x 1.35**	**Unit cost**
	Feet	**CY**	**#**	**#**	**$/CY**	**$**	**Mon**	**$**	**$**	**$/CY**
Restoration(A+B+C) 2.5'	14000	14958	1	1	12.0	60000	0.80	239496	323319	21.6
Sedimentation Basin -8'	14000	33974	1	1	9.0	60000	1.50	365766	493784	14.5

1. Average pumping distance
2. Quantity of the dredged material
3. Number of dredges used
4. Number of booster pumps
5. Unit cost of dredging and disposal
6. Cost of mobilization & demobilization
7. Time of actual construction (months)
8. Total cost including mob & demob
9. Markup includes E&D(2%), S&A (8%), escalation, verification and contingency(25%) cost
10. Final unit cost per cubic yard of dredged material

Eelgrass Planting = 5.21 acre x 0.5 x $40,000/acre = $104,200

TABLE 4

FISH PASSAGE

Items	1 Contract $	2 Contingency $	3 Escalation $	4 E&D $	5 S&A $	6 Total cost $
Mob/Demob	17500	3500	700	430	1800	23930
Site Work	12600	2500	500	300	1300	17200
Fish Ladder	166800	33400	6570	4200	16900	227870
Total Fish Passge cost	**196900**	**39400**	**7770.0**	**4930**	**20000.00**	**269000**

MCACES Estimates

For

Recommended Plans

Habitat Restoration
Ninigret Pond, RI

Designed By: NAE-EP-D
Estimated By: NAE-EP-D

Prepared By: John Yen

Preparation Date: 01/15/02
Effective Date of Pricing: 04/13/01
Est Construction Time: 300 Days

Sales Tax: 0.0%

The project consists of the work necessary to dredge sand from Ninigret pons in the south cove, RI. and pump the dredged material to a disposal site or upland dewatering site. This is a Current Cost Estimate (CWE) supporting the NED plan. It was prepared assuming the use of a small hydraulic dredging plant, labor and a conceptual design for several disposal sites. Due to the shallowness of the pond, 8" mudcat dredging equipment is used for dredging. Quantitites are provided by the survey and PM. The production rate for the Mutcat dredging are quoted from the contractors and historical data.

Davis-Bacon labor rate of R.I.(2001) is included for the cost estimate. Contingency cost of 20% and escalation cost up to the mid construction date (2003) are inclusded in the current cost estimate. The E&D cost includes the design cost during plans and specification and constsruction phase. Construction management cost (S&A) are provided by the PM. Real Estate cost and plans and specification costs are also provided by PM.

SUMMARY REPORTS — SUMMARY PAGE

DETAILED ESTIMATE — DETAIL PAGE

BACKUP REPORTS — BACKUP PAGE

* * * END TABLE OF CONTENTS * * *

** PROJECT OWNER SUMMARY - Level 5 **

	QUANTY UOM	CONTRACT	CONTINGN	ESCALATN	E&D	S&A	REAL EST	TOTAL COST	UNIT
6 Fish and Wildlife									
6. 3 Wildlife Facility Sanctury									
6. 3.73 Habitat & Feeding									
6. 3.73.02 Site Work									
6. 3.73.02.01 Mob/Demob		53,267	10,653	4,566	3,356	3,017	823	75,683	
6. 3.73.02.02 Dredging for Eelgrass Restoratio		897,333	179,467	76,914	56,532	50,830	13,872	1,274,948	
6. 3.73.02.03 Dredging of Lower Sedi. Basin		485,724	97,145	41,634	30,601	27,514	7,509	690,127	
6. 3.73.02.04 Eelgrass Planting		621,921	124,384	53,308	39,181	35,229	9,614	883,637	
6. 3.73.02.05 Eelgrass Monitoring		51,946	10,389	4,453	3,273	2,943	803	73,806	
6. 3.73.02.06 Eelgrass Replantishment		393,772	78,754	33,752	24,808	22,306	6,087	559,479	
6. 3.73.02.07 Dewatering Dike/Transport		429,919	85,984	36,850	27,085	24,353	6,646	610,838	
TOTAL Site Work		2,933,883	586,777	251,476	184,835	166,193	45,355	4,168,518	
TOTAL Habitat & Feeding		2,933,883	586,777	251,476	184,835	166,193	45,355	4,168,518	
TOTAL Wildlife Facility Sanctury		2,933,883	586,777	251,476	184,835	166,193	45,355	4,168,518	
TOTAL Fish and Wildlife		2,933,883	586,777	251,476	184,835	166,193	45,355	4,168,518	
TOTAL Habitat Restoration	1.00 EA	2,933,883	586,777	251,476	184,835	166,193	45,355	4,168,518	4168518

** PROJECT INDIRECT SUMMARY - Level 5 **

	QUANTY UOM	DIRECT	FIELD OH	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT
6 Fish and Wildlife								
6. 3 Wildlife Facility Sanctury								
6. 3.73 Habitat & Feeding								
6. 3.73.02 Site Work								
6. 3.73.02.01 Mob/Demob		40,552	4,055	3,569	4,047	1,044	53,267	
6. 3.73.02.02 Dredging for Eelgrass Restoratio		683,137	68,314	60,116	68,172	17,595	897,333	
6. 3.73.02.03 Dredging of Lower Sedi. Basin		369,781	36,978	32,541	36,901	9,524	485,724	
6. 3.73.02.04 Eelgrass Planting		473,467	47,347	41,665	47,248	12,195	621,921	
6. 3.73.02.05 Eelgrass Monitoring		39,546	3,955	3,480	3,946	1,019	51,946	
6. 3.73.02.06 Eelgrass Replantishment		299,778	29,978	26,380	29,915	7,721	393,772	
6. 3.73.02.07 Dewatering Dike/Transport		327,296	32,730	28,802	32,662	8,430	429,919	
TOTAL Site Work		2,233,556	223,356	196,553	222,891	57,527	2,933,883	
TOTAL Habitat & Feeding		2,233,556	223,356	196,553	222,891	57,527	2,933,883	
TOTAL Wildlife Facility Sanctury		2,233,556	223,356	196,553	222,891	57,527	2,933,883	
TOTAL Fish and Wildlife		2,233,556	223,356	196,553	222,891	57,527	2,933,883	
TOTAL Habitat Restoration	1.00 EA	2,233,556	223,356	196,553	222,891	57,527	2,933,883	2933883
Contingency							586,777	
SUBTOTAL							3,520,660	
Escalation							251,476	
SUBTOTAL							3,772,135	
Engineering and Design							184,835	
SUBTOTAL							3,956,970	
Construction and Supervision							166,193	
SUBTOTAL							4,123,163	
Real Estate							45,355	
TOTAL INCL OWNER COSTS							4,168,518	

** PROJECT DIRECT SUMMARY - Level 5 **

	QUANTY	UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
6 Fish and Wildlife								
6. 3 Wildlife Facility Sanctury								
6. 3.73 Habitat & Feeding								
6. 3.73.02 Site Work								
6. 3.73.02.01 Mob/Demob			25,326	11,681	1,945	1,600	40,552	
6. 3.73.02.02 Dredging for Eelgrass Restoratio			527,991	126,346	28,800	0	683,137	
6. 3.73.02.03 Dredging of Lower Sedi. Basin			305,136	52,644	12,000	0	369,781	
6. 3.73.02.04 Eelgrass Planting			423,991	49,476	0	0	473,467	
6. 3.73.02.05 Eelgrass Monitoring			31,300	8,246	0	0	39,546	
6. 3.73.02.06 Eelgrass Replantishment			258,548	41,230	0	0	299,778	
6. 3.73.02.07 Dewatering Dike/Transport			98,404	45,293	183,600	0	327,296	
TOTAL Site Work			1670696	334,916	226,345	1,600	2,233,556	
TOTAL Habitat & Feeding			1670696	334,916	226,345	1,600	2,233,556	
TOTAL Wildlife Facility Sanctury			1670696	334,916	226,345	1,600	2,233,556	
TOTAL Fish and Wildlife			1670696	334,916	226,345	1,600	2,233,556	
TOTAL Habitat Restoration	1.00	EA	1670696	334,916	226,345	1,600	2,233,556	2233556
Prime Contractor's Field Overhead							223,356	
SUBTOTAL							2,456,912	
Prime's Home Office Expense							196,553	
SUBTOTAL							2,653,465	
Prime Contractor's Profit							222,891	
SUBTOTAL							2,876,356	
Prime Contractor's Bond							57,527	
TOTAL INCL INDIRECTS							2,933,883	
Contingency							586,777	
SUBTOTAL							3,520,660	
Escalation							251,476	
SUBTOTAL							3,772,135	
Engineering and Design							184,835	
SUBTOTAL							3,956,970	
Construction and Supervision							166,193	
SUBTOTAL							4,123,163	

** PROJECT DIRECT SUMMARY - Level 5 **

	QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
Real Estate						45,355	
TOTAL INCL OWNER COSTS						4,168,518	

6. 3. Wildlife Facility Sanctury

6. 3.73. Habitat & Feeding

6. 3.73.02. Site Work

6. 3.73.02.01. Mob/Demob

6. 3.73.02.01.01. Personnel

		QUANTY	UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
MIL AA <	> Outside Laborers, (Semi-Skilled)			41.51	0.00	0.00	0.00	41.51
		160.00	HR	6,642	0	0	0	6,642
MIL AA <	> Outside Equip. Operators, Medium			39.53	0.00	0.00	0.00	39.53
		80.00	HR	3,163	0	0	0	3,163
MIL AA <	> Outside Equip. Operators, Heavy			42.00	0.00	0.00	0.00	42.00
		80.00	HR	3,360	0	0	0	3,360
MIL AA <	> Outside Truck Drivers, Heavy			38.44	0.00	0.00	0.00	38.44
		80.00	HR	3,075	0	0	0	3,075
FOP AA <	> General Superintendents (P.M.)			52.67	0.00	0.00	0.00	52.67
		80.00	HR	4,213	0	0	0	4,213
FOP AA <	> Project Managers			60.91	0.00	0.00	0.00	60.91
		80.00	HR	4,873	0	0	0	4,873
	TOTAL Personnel			25,326	0	0	0	25,326

6. 3.73.02.01.02. Equipment

		QUANTY	UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
MAP AA <	> AIR COMPR, 720 CFM, 300 PSI			0.00	33.34	0.00	0.00	33.34
	(ADD HOSES & ATTACHMENTS)	80.00	HR	0	2,667	0	0	2,667
MAP AA <	> HYD EXCAV BKT, 1.50CY, W/TIPS			0.00	1.99	0.00	0.00	1.99
		80.00	HR	0	159	0	0	159
EP AA <	> TRK,HWY, 21,000 GVW, 4X2, 2 AXLE			0.00	10.34	0.00	0.00	10.34
		80.00	HR	0	827	0	0	827
EP AA <	> TRK,HWY, 4,900GVW,4X2, 1/2T-PKUP			0.00	6.21	0.00	0.00	6.21
		80.00	HR	0	497	0	0	497
GEN AA <	> TUG BOAT, 150 - 400HP			0.00	25.66	0.00	0.00	25.66
	(112 - 298KW)	80.00	HR	0	2,053	0	0	2,053
NON AA <	> MISC. POWER TOOLS			0.00	6.40	0.00	0.00	6.40
		80.00	HR	0	512	0	0	512

6. 3. Wildlife Facility Sanctury		QUANTY	UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
EP AA <	> AUGERHD MUDCAT, 8' DISCHARGE DIA	80.00	HR	0.00 0	62.08 4,966	0.00 0	20.00 1,600	82.08 6,566
	TOTAL Equipment			0	11,681	0	1,600	13,281
6. 3.73.02.01.03. Facility								
AF AA <01594 0550 >	Office trailer, rent per month, furnished, no hookups, 50' x 12'	5.00	MO	0.00 0	0.00 0	343.33 1,717	0.00 0	343.33 1,717
AF AA <01594 1400 >	Toilet, portable chemical, rent per month	3.00	EA	0.00 0	0.00 0	76.00 228	0.00 0	76.00 228
	TOTAL Facility			0	0	1,945	0	1,945
	TOTAL Mob/Demob			25,326	11,681	1,945	1,600	40,552
6. 3.73.02.02. Dredging for Eelgrass Restoratio								
6. 3.73.02.02. 5. Labor								
MIL AA <	> Outside Equip. Operators, Heavy	2880.00	HR	42.00 120,960	0.00 0	0.00 0	0.00 0	42.00 120,960
MIL AA <	> Outside Equip. Operators, Medium	2880.00	HR	39.53 113,858	0.00 0	0.00 0	0.00 0	39.53 113,858
MIL AA <	> Outside Equip. Oilers	1440.00	HR	39.53 56,929	0.00 0	0.00 0	0.00 0	39.53 56,929
MIL AA <	> Outside Laborers, (Semi-Skilled)	2880.00	HR	41.51 119,560	0.00 0	0.00 0	0.00 0	41.51 119,560
MIL AA <	> Outside Divers	1440.00	HR	81.03 116,684	0.00 0	0.00 0	0.00 0	81.03 116,684
	TOTAL Labor			527,991	0	0	0	527,991
6. 3.73.02.02.10. Equipment								
GEN AA <	> TUG BOAT, 150 - 400HP (112 - 298KW)	1440.00	HR	0.00 0	25.66 36,950	0.00 0	0.00 0	25.66 36,950
M EP AA <	> AUGERHD MUDCAT, 8' DISCHARGE DIA	1440.00	HR	0.00 0	62.08 89,395	20.00 28,800	0.00 0	82.08 118,195

6. Fish and Wildlife

6. 3. Wildlife Facility Sanctury			QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
		TOTAL Equipment		0	126,346	28,800	0	155,146
		TOTAL Dredging for Eelgrass Restoratio		527,991	126,346	28,800	0	683,137
6. 3.73.02.03. Dredging of Lower Sedi. Basin								
6. 3.73.02.03. 5. Labor								
	MIL AA <	> Outside Equip. Operators, Heavy		42.00	0.00	0.00	0.00	42.00
			1500.00 HR	63,000	0	0	0	63,000
	MIL AA <	> Outside Equip. Operators, Medium		39.53	0.00	0.00	0.00	39.53
			1500.00 HR	59,301	0	0	0	59,301
	MIL AA <	> Outside Equip. Oilers		39.53	0.00	0.00	0.00	39.53
			1000.00 HR	39,534	0	0	0	39,534
	MIL AA <	> Outside Laborers, (Semi-Skilled)		41.51	0.00	0.00	0.00	41.51
			1500.00 HR	62,271	0	0	0	62,271
	MIL AA <	> Outside Divers		81.03	0.00	0.00	0.00	81.03
			1000.00 HR	81,030	0	0	0	81,030
		TOTAL Labor		305,136	0	0	0	305,136
6. 3.73.02.03.10. Equipment								
	GEN AA <	> TUG BOAT, 150 - 400HP		0.00	25.66	0.00	0.00	25.66
		(112 - 298KW)	600.00 HR	0	15,396	0	0	15,396
	M EP AA <	> AUGERHD MUDCAT, 8' DISCHARGE DIA		0.00	62.08	20.00	0.00	82.08
			600.00 HR	0	37,248	12,000	0	49,248
		TOTAL Equipment		0	52,644	12,000	0	64,644
		TOTAL Dredging of Lower Sedi. Basin		305,136	52,644	12,000	0	369,781
6. 3.73.02.04. Eelgrass Planting								
6. 3.73.02.04. 5. Labor								
	MIL AA <	> Outside Equip. Operators, Medium		39.53	0.00	0.00	0.00	39.53
			3000.00 HR	118,602	0	0	0	118,602
	MIL AA <	> Outside Equip. Oilers		39.53	0.00	0.00	0.00	39.53
			1500.00 HR	59,301	0	0	0	59,301

6. 3. Wildlife Facility Sanctury			QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
	MIL AA <	> Outside Laborers, (Semi-Skilled)		41.51	0.00	0.00	0.00	41.51
			3000.00 HR	124,542	0	0	0	124,542
	MIL AA <	> Outside Divers		81.03	0.00	0.00	0.00	81.03
			1500.00 HR	121,546	0	0	0	121,546
		TOTAL Labor		423,991	0	0	0	423,991
6. 3.73.02.04.10. Equipment								
	GEN AA <	> TUG BOAT, 150 - 400HP		0.00	25.66	0.00	0.00	25.66
		(112 - 298KW)	1200.00 HR	0	30,792	0	0	30,792
	USR AA <	> BARGE 120X45		0.00	15.57	0.00	0.00	15.57
			1200.00 HR	0	18,684	0	0	18,684
		TOTAL Equipment		0	49,476	0	0	49,476
		TOTAL Eelgrass Planting		423,991	49,476	0	0	473,467
6. 3.73.02.05. Eelgrass Monitoring								
6. 3.73.02.05. 5. Labor								
	MIL AA <	> Outside Equip. Operators, Medium		39.53	0.00	0.00	0.00	39.53
			150.00 HR	5,930	0	0	0	5,930
	MIL AA <	> Outside Laborers, (Semi-Skilled)		41.51	0.00	0.00	0.00	41.51
			150.00 HR	6,227	0	0	0	6,227
	MIL AA <	> Outside Divers		81.03	0.00	0.00	0.00	81.03
			150.00 HR	12,155	0	0	0	12,155
	FOP AA <	> Engineers, Quality Control		46.59	0.00	0.00	0.00	46.59
			150.00 HR	6,989	0	0	0	6,989
		TOTAL Labor		31,300	0	0	0	31,300
6. 3.73.02.05.10. Equipment								
	GEN AA <	> TUG BOAT, 150 - 400HP		0.00	25.66	0.00	0.00	25.66
		(112 - 298KW)	200.00 HR	0	5,132	0	0	5,132
	USR AA <	> BARGE 120X45		0.00	15.57	0.00	0.00	15.57
			200.00 HR	0	3,114	0	0	3,114

6. 3. Wildlife Facility Sanctury			QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
		TOTAL Equipment		0	8,246	0	0	8,246
		TOTAL Eelgrass Monitoring		31,300	8,246	0	0	39,546
6. 3.73.02.06. Eelgrass Replantishment								
6. 3.73.02.06. 5. Labor								
	MIL AA <	> Outside Equip. Operators, Medium		39.53	0.00	0.00	0.00	39.53
			2000.00 HR	79,068	0	0	0	79,068
	MIL AA <	> Outside Equip. Oilers		39.53	0.00	0.00	0.00	39.53
			800.00 HR	31,627	0	0	0	31,627
	MIL AA <	> Outside Laborers, (Semi-Skilled)		41.51	0.00	0.00	0.00	41.51
			2000.00 HR	83,028	0	0	0	83,028
	MIL AA <	> Outside Divers		81.03	0.00	0.00	0.00	81.03
			800.00 HR	64,824	0	0	0	64,824
		TOTAL Labor		258,548	0	0	0	258,548
6. 3.73.02.06.10. Equipment								
	GEN AA <	> TUG BOAT, 150 - 400HP (112 - 298KW)		0.00	25.66	0.00	0.00	25.66
			1000.00 HR	0	25,660	0	0	25,660
	USR AA <	> BARGE 120X45		0.00	15.57	0.00	0.00	15.57
			1000.00 HR	0	15,570	0	0	15,570
		TOTAL Equipment		0	41,230	0	0	41,230
		TOTAL Eelgrass Replantishment		258,548	41,230	0	0	299,778
6. 3.73.02.07. Dewatering Dike/Transport								
6. 3.73.02.07. 5. 5 laborer + 2 Hand Compaction R (CLACA)								
	MIL AA <	> ROLLER, VIB, DD, SP 2.1T (1.90MT),21.6"(550MM)W,WALK-BHND		0.00	8.43	0.00	0.00	8.43
			1360.00 HR	0	11,458	0	0	11,458
	MIL AA <	> Laborers, (Semi-Skilled)		24.81	0.00	0.00	0.00	24.81
			680.00 HR	16,872	0	0	0	16,872
	MIL AA <	> Laborers, (Semi-Skilled)		23.81	0.00	0.00	0.00	23.81
			2720.00 HR	64,766	0	0	0	64,766

6. 3. Wildlife Facility Sanctury		QUANTY	UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
	TOTAL 5 laborer + 2 Hand Compaction R			81,638	11,458	0	0	93,096
6. 3.73.02.07.10. 1 trkdvrhv + 1 trk, off-highway, (CTDHB34F)								
MIL AA <	> Truck Drivers, Heavy			24.66	0.00	0.00	0.00	24.66
		680.00	HR	16,766	0	0	0	16,766
GEN AA <	> TRUCK, OFF-HWY, REAR-DUMP, 36T			0.00	49.76	0.00	0.00	49.76
	(32.7MT) 23-29CY (17.6-22.2CM)	680.00	HR	0	33,834	0	0	33,834
	TOTAL 1 trkdvrhv + 1 trk, off-highway,			16,766	33,834	0	0	50,600
	TOTAL Backfi;ll			0	0	183,600	0	183,600
	TOTAL Dewatering Dike/Transport			98,404	45,293	183,600	0	327,296
	TOTAL Site Work			1670696	334,916	226,345	1,600	2,233,556
	TOTAL Habitat & Feeding			1670696	334,916	226,345	1,600	2,233,556
	TOTAL Wildlife Facility Sanctury			1670696	334,916	226,345	1,600	2,233,556
	TOTAL Fish and Wildlife			1670696	334,916	226,345	1,600	2,233,556
	TOTAL Habitat Restoration			1670696	334,916	226,345	1,600	2,233,556

** CREW BACKUP **

SRC	ITEM ID	DESCRIPTION	NO.	UOM	RATE	**** LABOR **** HOURS	**** LABOR **** COST	**** EQUIP **** HOURS	**** EQUIP **** COST	TOTAL COST

** LABOR BACKUP **

SRC	LABOR ID	DESCRIPTION	BASE	OVERTM	TXS/INS	FRNG	TRVL	RATE	UOM	UPDATE	**** TOTAL **** DEFAULT	HOURS
MIL	B-LABORER	Laborers, (Semi-Skilled)	14.06	0.0%	38.7%	4.31	0.00	23.81	HR	01/01/96	23.81	3400
MIL	B-TRKDVRHV	Truck Drivers, Heavy	15.40	0.0%	33.8%	4.05	0.00	24.66	HR	01/01/96	24.66	680
FOP	FA-AGENS	General Superintendents (P.M.)	26.00	0.0%	18.6%	21.83	0.00	52.67	HR	06/11/98	33.76	80
FOP	FA-PROJM	Project Managers	30.07	0.0%	18.6%	25.25	0.00	60.91	HR	06/11/98	31.68	80
FOP	FC-ENGQC	Engineers, Quality Control	23.00	0.0%	18.6%	19.31	0.00	46.59	HR	06/11/98	26.19	150
MIL	X-DIVER	Outside Divers	35.65	0.0%	48.2%	28.20	0.00	81.03	HR	06/11/98	57.90	4890
MIL	X-EQOPRHVY	Outside Equip. Operators, Heavy	22.00	0.0%	40.9%	11.00	0.00	42.00	HR	01/18/02	31.93	4460
MIL	X-EQOPRMED	Outside Equip. Operators, Medium	22.00	0.0%	29.7%	11.00	0.00	39.53	HR	01/18/02	30.68	9610
MIL	X-EQOPROIL	Outside Equip. Oilers	22.00	0.0%	29.7%	11.00	0.00	39.53	HR	01/18/02	24.82	4740
MIL	X-LABORER	Outside Laborers, (Semi-Skilled)	22.00	0.0%	38.7%	11.00	0.00	41.51	HR	01/18/02	24.50	9690
MIL	X-TRKDVRHV	Outside Truck Drivers, Heavy	22.00	0.0%	33.8%	9.00	0.00	38.44	HR	01/18/02	24.81	80

** EQUIPMENT BACKUP **

SRC	ID.NO.	EQUIPMENT DESCRIPTION	DEPR	FCCM	FUEL	FOG	TR WR	TR REP	EQ REP	** TOTAL ** TOTAL RATE	** TOTAL ** HOURS
MAP	A15SR001	AIR COMPR, 720 CFM, 300 PSI	7.79	2.32	10.76	3.58	0.11	0.02	8.75	33.34 HR	80
GEN	C10Z1430	ROLLER, VIB, DD, SP 2.1T	2.75	0.40	0.34	0.09			4.84	8.43 HR	1360
MAP	H25BS004	HYD EXCAV BKT, 1.50CY, W/TIPS	0.85	0.15					1.00	1.99 HR	80
EP	M10EL008	AUGERHD MUDCAT, 8' DISCHARGE DIA	21.25	5.20	8.60	2.86			24.17	62.08 HR	2120
EP	T50FO001	TRK,HWY, 4,900GVW,4X2, 1/2T-PKUP	1.54	0.34	1.95	0.65	0.14	0.02	1.56	6.21 HR	80
EP	T50FO007	TRK,HWY, 21,000 GVW, 4X2, 2 AXLE	2.39	0.60	3.58	1.11	0.34	0.06	2.25	10.34 HR	80
GEN	T55Z7720	TRUCK, OFF-HWY, REAR-DUMP, 36T	13.03	7.82	7.25	2.90	6.67	1.11	10.98	49.76 HR	680
NON	XMIXX010	MISC. POWER TOOLS	2.17	0.76	0.60	0.27			2.60	6.40 HR	80
GEN	XX0Z9720	TUG BOAT, 150 - 400HP	8.57	3.06	2.41	1.06			10.56	25.66 HR	4520
USR	ZAB1000	BARGE 120X45	4.96	1.90	1.60	0.61			6.50	15.57 HR	2400

Habitat Restoration
Winnapaug Pond, RI

Designed By: NAE-EP-D
Estimated By: NAE-EP-D

Prepared By: John Yen

Preparation Date: 01/15/02
Effective Date of Pricing: 04/13/01
Est Construction Time: 180 Days

Sales Tax: 0.0%

The project consists of the work necessary to dredge sand from Winnapaub pond in the south cove, RI. and pump the dredged material to a disposal site or upland dewatering site. This is a Current Cost Estimate (CWE) supporting the NED plan. It was prepared assuming the use of a small hydraulic dredging plant, labor and a conceptual design for several disposal sites. Due to the shallowness of the pond, 8" mudcat dredging equipment is used for dredging. Quantitites are provided by the survey and PM. The production rate for the Mutcat dredging are quoted from the contractors and historical data.

Davis-Bacon labor rate of R.I.(2001) is included for the cost estimate. Contingency cost of 20% and escalation cost up to the mid construction date (2003) are inclusded in the current cost estimate. The E&D cost includes the design cost during plans and specification and constsruction phase. Construction management cost (S&A) are provided by the PM. Real Estate cost and plans and specification cost are also provided by PM.

SUMMARY REPORTS — SUMMARY PAGE

DETAILED ESTIMATE — DETAIL PAGE

BACKUP REPORTS — BACKUP PAGE

* * * END TABLE OF CONTENTS * * *

** PROJECT OWNER SUMMARY - Level 5 **

	QUANTY UOM	CONTRACT	CONTINGN	ESCALATN	E&D	S&A	REAL EST	TOTAL COST	UNIT
6 Fish and Wildlife									
6. 3 Wildlife Facility Sanctury									
6. 3.73 Habitat & Feeding									
6. 3.73.02 Site Work									
6. 3.73.02.01 Mob/Demob		40,589	8,118	3,479	4,958	3,029	1,745	61,917	
6. 3.73.02.02 Dredging for Eelgrass Restoratio		352,020	70,404	30,173	42,997	26,266	15,134	536,994	
6. 3.73.02.03 Dredging of Lower Sedi. Basin		321,705	64,341	27,575	39,294	24,004	13,831	490,749	
6. 3.73.02.04 Eelgrass Planting		233,975	46,795	20,055	28,578	17,458	10,059	356,921	
6. 3.73.02.05 Eelgrass Monitoring		21,736	4,347	1,863	2,655	1,622	934	33,157	
6. 3.73.02.06 Eelgrass Replantishment		95,696	19,139	8,202	11,689	7,140	4,114	145,980	
TOTAL Site Work		1,065,720	213,144	91,347	130,170	79,520	45,817	1,625,719	
TOTAL Habitat & Feeding		1,065,720	213,144	91,347	130,170	79,520	45,817	1,625,719	
TOTAL Wildlife Facility Sanctury		1,065,720	213,144	91,347	130,170	79,520	45,817	1,625,719	
TOTAL Fish and Wildlife		1,065,720	213,144	91,347	130,170	79,520	45,817	1,625,719	
TOTAL Habitat Restoration	1.00 EA	1,065,720	213,144	91,347	130,170	79,520	45,817	1,625,719	1625719

** PROJECT INDIRECT SUMMARY - Level 5 **

	QUANTY UOM	DIRECT	FIELD OH	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT
6 Fish and Wildlife								
6. 3 Wildlife Facility Sanctury								
6. 3.73 Habitat & Feeding								
6. 3.73.02 Site Work								
6. 3.73.02.01 Mob/Demob		30,900	3,090	2,719	3,084	796	40,589	
6. 3.73.02.02 Dredging for Eelgrass Restoratio		267,992	26,799	23,583	26,743	6,902	352,020	
6. 3.73.02.03 Dredging of Lower Sedi. Basin		244,913	24,491	21,552	24,440	6,308	321,705	
6. 3.73.02.04 Eelgrass Planting		178,125	17,812	15,675	17,775	4,588	233,975	
6. 3.73.02.05 Eelgrass Monitoring		16,547	1,655	1,456	1,651	426	21,736	
6. 3.73.02.06 Eelgrass Replantishment		72,853	7,285	6,411	7,270	1,876	95,696	
TOTAL Site Work		811,329	81,133	71,397	80,964	20,896	1,065,720	
TOTAL Habitat & Feeding		811,329	81,133	71,397	80,964	20,896	1,065,720	
TOTAL Wildlife Facility Sanctury		811,329	81,133	71,397	80,964	20,896	1,065,720	
TOTAL Fish and Wildlife		811,329	81,133	71,397	80,964	20,896	1,065,720	
TOTAL Habitat Restoration	1.00 EA	811,329	81,133	71,397	80,964	20,896	1,065,720	1065720
Contingency							213,144	
SUBTOTAL							1,278,864	
Escalation							91,347	
SUBTOTAL							1,370,211	
Engineering and Design							130,170	
SUBTOTAL							1,500,381	
Construction and Supervision							79,520	
SUBTOTAL							1,579,902	
Real Estate							45,817	
TOTAL INCL OWNER COSTS							1,625,719	

** PROJECT DIRECT SUMMARY - Level 5 **

	QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
6 Fish and Wildlife							
6. 3 Wildlife Facility Sanctury							
6. 3.73 Habitat & Feeding							
6. 3.73.02 Site Work							
6. 3.73.02.01 Mob/Demob		18,995	8,761	1,945	1,200	30,900	
6. 3.73.02.02 Dredging for Eelgrass Restoratio		171,025	78,966	18,000	0	267,992	
6. 3.73.02.03 Dredging of Lower Sedi. Basin		158,721	70,192	16,000	0	244,913	
6. 3.73.02.04 Eelgrass Planting		153,387	24,738	0	0	178,125	
6. 3.73.02.05 Eelgrass Monitoring		14,486	2,062	0	0	16,547	
6. 3.73.02.06 Eelgrass Replantishment		60,484	12,369	0	0	72,853	
TOTAL Site Work		577,097	197,088	35,945	1,200	811,329	
TOTAL Habitat & Feeding		577,097	197,088	35,945	1,200	811,329	
TOTAL Wildlife Facility Sanctury		577,097	197,088	35,945	1,200	811,329	
TOTAL Fish and Wildlife		577,097	197,088	35,945	1,200	811,329	
TOTAL Habitat Restoration	1.00 EA	577,097	197,088	35,945	1,200	811,329	811329
Prime Contractor's Field Overhead						81,133	
SUBTOTAL						892,462	
Prime's Home Office Expense						71,397	
SUBTOTAL						963,859	
Prime Contractor's Profit						80,964	
SUBTOTAL						1,044,823	
Prime Contractor's Bond						20,896	
TOTAL INCL INDIRECTS						1,065,720	
Contingency						213,144	
SUBTOTAL						1,278,864	
Escalation						91,347	
SUBTOTAL						1,370,211	
Engineering and Design						130,170	
SUBTOTAL						1,500,381	
Construction and Supervision						79,520	
SUBTOTAL						1,579,902	
Real Estate						45,817	

** PROJECT DIRECT SUMMARY - Level 5 **

	QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
TOTAL INCL OWNER COSTS						1,625,719	

6. Fish and Wildlife

6. 3. Wildlife Facility Sanctury		QUANTY	UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
6. 3.73. Habitat & Feeding								
6. 3.73.02. Site Work								
6. 3.73.02.01. Mob/Demob								
6. 3.73.02.01.01. Personnel								
MIL AA <	> Outside Laborers, (Semi-Skilled)			41.51	0.00	0.00	0.00	41.51
		120.00	HR	4,982	0	0	0	4,982
MIL AA <	> Outside Equip. Operators, Medium			39.53	0.00	0.00	0.00	39.53
		60.00	HR	2,372	0	0	0	2,372
MIL AA <	> Outside Equip. Operators, Heavy			42.00	0.00	0.00	0.00	42.00
		60.00	HR	2,520	0	0	0	2,520
MIL AA <	> Outside Truck Drivers, Heavy			38.44	0.00	0.00	0.00	38.44
		60.00	HR	2,306	0	0	0	2,306
FOP AA <	> General Superintendents (P.M.)			52.67	0.00	0.00	0.00	52.67
		60.00	HR	3,160	0	0	0	3,160
FOP AA <	> Project Managers			60.91	0.00	0.00	0.00	60.91
		60.00	HR	3,655	0	0	0	3,655
	TOTAL Personnel			18,995	0	0	0	18,995
6. 3.73.02.01.02. Equipment								
MAP AA <	> AIR COMPR, 720 CFM, 300 PSI			0.00	33.34	0.00	0.00	33.34
	(ADD HOSES & ATTACHMENTS)	60.00	HR	0	2,000	0	0	2,000
MAP AA <	> HYD EXCAV BKT, 1.50CY, W/TIPS			0.00	1.99	0.00	0.00	1.99
		60.00	HR	0	119	0	0	119
EP AA <	> TRK,HWY, 21,000 GVW, 4X2, 2 AXLE			0.00	10.34	0.00	0.00	10.34
		60.00	HR	0	620	0	0	620
EP AA <	> TRK,HWY, 4,900GVW,4X2, 1/2T-PKUP			0.00	6.21	0.00	0.00	6.21
		60.00	HR	0	373	0	0	373
GEN AA <	> TUG BOAT, 150 - 400HP			0.00	25.66	0.00	0.00	25.66
	(112 - 298KW)	60.00	HR	0	1,540	0	0	1,540
NON AA <	> MISC. POWER TOOLS			0.00	6.40	0.00	0.00	6.40
		60.00	HR	0	384	0	0	384

6. 3. Wildlife Facility Sanctury	QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
EP AA < > AUGERHD MUDCAT, 8' DISCHARGE DIA		0.00	62.08	0.00	20.00	82.08
	60.00 HR	0	3,725	0	1,200	4,925
TOTAL Equipment		0	8,761	0	1,200	9,961
6. 3.73.02.01.03. Facility						
AF AA <01594 0550 > Office trailer, rent per month,		0.00	0.00	343.33	0.00	343.33
furnished, no hookups, 50' x 12'	5.00 MO	0	0	1,717	0	1,717
AF AA <01594 1400 > Toilet, portable chemical, rent		0.00	0.00	76.00	0.00	76.00
per month	3.00 EA	0	0	228	0	228
TOTAL Facility		0	0	1,945	0	1,945
TOTAL Mob/Demob		18,995	8,761	1,945	1,200	30,900
6. 3.73.02.02. Dredging for Eelgrass Restoratio						
6. 3.73.02.02. 5. Labor						
MIL AA < > Outside Equip. Operators, Heavy		42.00	0.00	0.00	0.00	42.00
	900.00 HR	37,800	0	0	0	37,800
MIL AA < > Outside Equip. Operators, Medium		39.53	0.00	0.00	0.00	39.53
	900.00 HR	35,581	0	0	0	35,581
MIL AA < > Outside Equip. Oilers		39.53	0.00	0.00	0.00	39.53
	500.00 HR	19,767	0	0	0	19,767
MIL AA < > Outside Laborers, (Semi-Skilled)		41.51	0.00	0.00	0.00	41.51
	900.00 HR	37,363	0	0	0	37,363
MIL AA < > Outside Divers		81.03	0.00	0.00	0.00	81.03
	500.00 HR	40,515	0	0	0	40,515
TOTAL Labor		171,025	0	0	0	171,025
6. 3.73.02.02.10. Equipment						
GEN AA < > TUG BOAT, 150 - 400HP		0.00	25.66	0.00	0.00	25.66
(112 - 298KW)	900.00 HR	0	23,094	0	0	23,094
M EP AA < > AUGERHD MUDCAT, 8' DISCHARGE DIA		0.00	62.08	20.00	0.00	82.08
	900.00 HR	0	55,872	18,000	0	73,872

6. 3. Wildlife Facility Sanctury			QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
		TOTAL Equipment		0	78,966	18,000	0	96,966
		TOTAL Dredging for Eelgrass Restoratio		171,025	78,966	18,000	0	267,992
6. 3.73.02.03. Dredging of Lower Sedi. Basin								
6. 3.73.02.03. 5. Labor								
	MIL AA <	> Outside Equip. Operators, Heavy		42.00	0.00	0.00	0.00	42.00
			800.00 HR	33,600	0	0	0	33,600
	MIL AA <	> Outside Equip. Operators, Medium		39.53	0.00	0.00	0.00	39.53
			800.00 HR	31,627	0	0	0	31,627
	MIL AA <	> Outside Equip. Oilers		39.53	0.00	0.00	0.00	39.53
			500.00 HR	19,767	0	0	0	19,767
	MIL AA <	> Outside Laborers, (Semi-Skilled)		41.51	0.00	0.00	0.00	41.51
			800.00 HR	33,211	0	0	0	33,211
	MIL AA <	> Outside Divers		81.03	0.00	0.00	0.00	81.03
			500.00 HR	40,515	0	0	0	40,515
		TOTAL Labor		158,721	0	0	0	158,721
6. 3.73.02.03.10. Equipment								
	GEN AA <	> TUG BOAT, 150 - 400HP		0.00	25.66	0.00	0.00	25.66
		(112 - 298KW)	800.00 HR	0	20,528	0	0	20,528
	M EP AA <	> AUGERHD MUDCAT, 8' DISCHARGE DIA		0.00	62.08	20.00	0.00	82.08
			800.00 HR	0	49,664	16,000	0	65,664
		TOTAL Equipment		0	70,192	16,000	0	86,192
		TOTAL Dredging of Lower Sedi. Basin		158,721	70,192	16,000	0	244,913
6. 3.73.02.04. Eelgrass Planting								
6. 3.73.02.04. 5. Labor								
	MIL AA <	> Outside Equip. Operators, Medium		39.53	0.00	0.00	0.00	39.53
			1000.00 HR	39,534	0	0	0	39,534
	MIL AA <	> Outside Equip. Oilers		39.53	0.00	0.00	0.00	39.53
			600.00 HR	23,720	0	0	0	23,720

6. 3. Wildlife Facility Sanctury		QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
MIL AA <	> Outside Laborers, (Semi-Skilled)		41.51	0.00	0.00	0.00	41.51
		1000.00 HR	41,514	0	0	0	41,514
MIL AA <	> Outside Divers		81.03	0.00	0.00	0.00	81.03
		600.00 HR	48,618	0	0	0	48,618
	TOTAL Labor		153,387	0	0	0	153,387
6. 3.73.02.04.10. Equipment							
GEN AA <	> TUG BOAT, 150 - 400HP		0.00	25.66	0.00	0.00	25.66
	(112 - 298KW)	600.00 HR	0	15,396	0	0	15,396
USR AA <	> BARGE 120X45		0.00	15.57	0.00	0.00	15.57
		600.00 HR	0	9,342	0	0	9,342
	TOTAL Equipment		0	24,738	0	0	24,738
	TOTAL Eelgrass Planting		153,387	24,738	0	0	178,125
6. 3.73.02.05. Eelgrass Monitoring							
6. 3.73.02.05. 5. Labor							
MIL AA <	> Outside Equip. Operators, Medium		39.53	0.00	0.00	0.00	39.53
		100.00 HR	3,953	0	0	0	3,953
MIL AA <	> Outside Laborers, (Semi-Skilled)		41.51	0.00	0.00	0.00	41.51
		100.00 HR	4,151	0	0	0	4,151
MIL AA <	> Outside Divers		81.03	0.00	0.00	0.00	81.03
		50.00 HR	4,052	0	0	0	4,052
FOP AA <	> Engineers, Quality Control		46.59	0.00	0.00	0.00	46.59
		50.00 HR	2,330	0	0	0	2,330
	TOTAL Labor		14,486	0	0	0	14,486
6. 3.73.02.05.10. Equipment							
GEN AA <	> TUG BOAT, 150 - 400HP		0.00	25.66	0.00	0.00	25.66
	(112 - 298KW)	50.00 HR	0	1,283	0	0	1,283
USR AA <	> BARGE 120X45		0.00	15.57	0.00	0.00	15.57
		50.00 HR	0	779	0	0	779

6. 3. Wildlife Facility Sanctury		QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
	TOTAL Equipment		0	2,062	0	0	2,062
	TOTAL Eelgrass Monitoring		14,486	2,062	0	0	16,547
6. 3.73.02.06. Eelgrass Replantishment							
6. 3.73.02.06. 5. Labor							
MIL AA <	> Outside Equip. Operators, Medium		39.53	0.00	0.00	0.00	39.53
		300.00 HR	11,860	0	0	0	11,860
MIL AA <	> Outside Equip. Oilers		39.53	0.00	0.00	0.00	39.53
		300.00 HR	11,860	0	0	0	11,860
MIL AA <	> Outside Laborers, (Semi-Skilled)		41.51	0.00	0.00	0.00	41.51
		300.00 HR	12,454	0	0	0	12,454
MIL AA <	> Outside Divers		81.03	0.00	0.00	0.00	81.03
		300.00 HR	24,309	0	0	0	24,309
	TOTAL Labor		60,484	0	0	0	60,484
6. 3.73.02.06.10. Equipment							
GEN AA <	> TUG BOAT, 150 - 400HP		0.00	25.66	0.00	0.00	25.66
	(112 - 298KW)	300.00 HR	0	7,698	0	0	7,698
USR AA <	> BARGE 120X45		0.00	15.57	0.00	0.00	15.57
		300.00 HR	0	4,671	0	0	4,671
	TOTAL Equipment		0	12,369	0	0	12,369
	TOTAL Eelgrass Replantishment		60,484	12,369	0	0	72,853
	TOTAL Site Work		577,097	197,088	35,945	1,200	811,329
	TOTAL Habitat & Feeding		577,097	197,088	35,945	1,200	811,329
	TOTAL Wildlife Facility Sanctury		577,097	197,088	35,945	1,200	811,329
	TOTAL Fish and Wildlife		577,097	197,088	35,945	1,200	811,329
	TOTAL Habitat Restoration		577,097	197,088	35,945	1,200	811,329

** CREW BACKUP **

SRC	ITEM ID	DESCRIPTION	NO. UOM	RATE	**** LABOR **** HOURS	**** LABOR **** COST	**** EQUIP **** HOURS	**** EQUIP **** COST	TOTAL COST

** LABOR BACKUP **

SRC	LABOR ID	DESCRIPTION	BASE	OVERTM	TXS/INS	FRNG	TRVL	RATE	UOM	UPDATE	**** TOTAL **** DEFAULT	HOURS
FOP	FA-AGENS	General Superintendents (P.M.)	26.00	0.0%	18.6%	21.83	0.00	52.67	HR	06/11/98	33.76	60
FOP	FA-PROJM	Project Managers	30.07	0.0%	18.6%	25.25	0.00	60.91	HR	06/11/98	31.68	60
FOP	FC-ENGQC	Engineers, Quality Control	23.00	0.0%	18.6%	19.31	0.00	46.59	HR	06/11/98	26.19	50
MIL	X-DIVER	Outside Divers	35.65	0.0%	48.2%	28.20	0.00	81.03	HR	06/11/98	57.90	1950
MIL	X-EQOPRHVY	Outside Equip. Operators, Heavy	22.00	0.0%	40.9%	11.00	0.00	42.00	HR	01/18/02	31.93	1760
MIL	X-EQOPRMED	Outside Equip. Operators, Medium	22.00	0.0%	29.7%	11.00	0.00	39.53	HR	01/18/02	30.68	3160
MIL	X-EQOPROIL	Outside Equip. Oilers	22.00	0.0%	29.7%	11.00	0.00	39.53	HR	01/18/02	24.82	1900
MIL	X-LABORER	Outside Laborers, (Semi-Skilled)	22.00	0.0%	38.7%	11.00	0.00	41.51	HR	01/18/02	24.50	3220
MIL	X-TRKDVRHV	Outside Truck Drivers, Heavy	22.00	0.0%	33.8%	9.00	0.00	38.44	HR	01/18/02	24.81	60

** EQUIPMENT BACKUP **

SRC	ID.NO.	EQUIPMENT DESCRIPTION	DEPR	FCCM	FUEL	FOG	TR WR	TR REP	EQ REP	TOTAL RATE	** TOTAL ** HOURS
MAP	A15SR001	AIR COMPR, 720 CFM, 300 PSI	7.79	2.32	10.76	3.58	0.11	0.02	8.75	33.34 HR	60
MAP	H25BS004	HYD EXCAV BKT, 1.50CY, W/TIPS	0.85	0.15					1.00	1.99 HR	60
EP	M10EL008	AUGERHD MUDCAT, 8' DISCHARGE DIA	21.25	5.20	8.60	2.86			24.17	62.08 HR	1760
EP	T50F0001	TRK,HWY, 4,900GVW,4X2, 1/2T-PKUP	1.54	0.34	1.95	0.65	0.14	0.02	1.56	6.21 HR	60
EP	T50F0007	TRK,HWY, 21,000 GVW, 4X2, 2 AXLE	2.39	0.60	3.58	1.11	0.34	0.06	2.25	10.34 HR	60
NON	XMIXX010	MISC. POWER TOOLS	2.17	0.76	0.60	0.27			2.60	6.40 HR	60
GEN	XX0Z9720	TUG BOAT, 150 - 400HP	8.57	3.06	2.41	1.06			10.56	25.66 HR	2710
USR	ZAB1000	BARGE 120X45	4.96	1.90	1.60	0.61			6.50	15.57 HR	950

Habitat Restoration
Quonochontaug Pond, RI

Designed By: NAE-EP-D
Estimated By: NAE-EP-D

Prepared By: John Yen

Preparation Date: 01/15/02
Effective Date of Pricing: 04/13/01
Est Construction Time: 160 Days

Sales Tax: 0.0%

The project consists of the work necessary to dredge sand from Quonochontaug pond in the south cove, RI. and pump the dredged material to a disposal site or upland dewatering site. This is a Current Cost Estimate (CWE) supporting the NED plan. It was prepared assuming the use of a small hydraulic dredging plant, labor and a conceptual design for several disposal sites. Due to the shallowness of the pond, 8" mudcat dredging equipment is used for dredging. Quantitites are provided by the survey and PM. The production rate for the Mutcat dredging are quoted from the contractors and historical data.

Davis-Bacon labor rate of R.I.(2001) is included for the cost estimate. Contingency cost of 20% and escalation cost up to the mid construction date (2003) are inclusded in the current cost estimate. The E&D cost includes the design cost during plans and specification and constsruction phase. Construction management cost (S&A) are provided by the PM. Real Estate cost and plans and specification costs are also provided by PM.

SUMMARY REPORTS — SUMMARY PAGE

DETAILED ESTIMATE — DETAIL PAGE

BACKUP REPORTS — BACKUP PAGE

* * * END TABLE OF CONTENTS * * *

** PROJECT OWNER SUMMARY - Level 5 **

	QUANTY UOM	CONTRACT	CONTINGN	ESCALATN	E&D	S&A	REAL EST	TOTAL COST	UNIT
6 Fish and Wildlife									
6. 3 Wildlife Facility Sanctury									
6. 3.73 Habitat & Feeding									
6. 3.73.02 Site Work									
6. 3.73.02.01 Mob/Demob		34,201	6,840	2,932	5,717	2,534	6,580	58,804	
6. 3.73.02.02 Dredging for Eelgrass Restoratio		207,683	41,537	17,801	34,713	15,388	39,957	357,080	
6. 3.73.02.03 Dredging of Lower Sedi. Basin		305,868	61,174	26,217	51,124	22,664	58,848	525,894	
6. 3.73.02.04 Eelgrass Planting		95,696	19,139	8,202	15,995	7,091	18,411	164,534	
6. 3.73.02.05 Eelgrass Monitoring		21,736	4,347	1,863	3,633	1,611	4,182	37,371	
6. 3.73.02.06 Eelgrass Replantishment		47,848	9,570	4,101	7,997	3,545	9,206	82,267	
TOTAL Site Work		713,032	142,606	61,117	119,178	52,833	137,184	1,225,950	
TOTAL Habitat & Feeding		713,032	142,606	61,117	119,178	52,833	137,184	1,225,950	
TOTAL Wildlife Facility Sanctury		713,032	142,606	61,117	119,178	52,833	137,184	1,225,950	
TOTAL Fish and Wildlife		713,032	142,606	61,117	119,178	52,833	137,184	1,225,950	
TOTAL Habitat Restoration	1.00 EA	713,032	142,606	61,117	119,178	52,833	137,184	1,225,950	1225950

** PROJECT INDIRECT SUMMARY - Level 5 **

	QUANTY UOM	DIRECT	FIELD OH	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT
6 Fish and Wildlife								
6. 3 Wildlife Facility Sanctury								
6. 3.73 Habitat & Feeding								
6. 3.73.02 Site Work								
6. 3.73.02.01 Mob/Demob		26,037	2,604	2,291	2,598	671	34,201	
6. 3.73.02.02 Dredging for Eelgrass Restoratio		158,109	15,811	13,914	15,778	4,072	207,683	
6. 3.73.02.03 Dredging of Lower Sedi. Basin		232,856	23,286	20,491	23,237	5,997	305,868	
6. 3.73.02.04 Eelgrass Planting		72,853	7,285	6,411	7,270	1,876	95,696	
6. 3.73.02.05 Eelgrass Monitoring		16,547	1,655	1,456	1,651	426	21,736	
6. 3.73.02.06 Eelgrass Replantishment		36,426	3,643	3,206	3,635	938	47,848	
TOTAL Site Work		542,829	54,283	47,769	54,170	13,981	713,032	
TOTAL Habitat & Feeding		542,829	54,283	47,769	54,170	13,981	713,032	
TOTAL Wildlife Facility Sanctury		542,829	54,283	47,769	54,170	13,981	713,032	
TOTAL Fish and Wildlife		542,829	54,283	47,769	54,170	13,981	713,032	
TOTAL Habitat Restoration	1.00 EA	542,829	54,283	47,769	54,170	13,981	713,032	713032
Contingency							142,606	
SUBTOTAL							855,638	
Escalation							61,117	
SUBTOTAL							916,755	
Engineering and Design							119,178	
SUBTOTAL							1,035,933	
Construction and Supervision							52,833	
SUBTOTAL							1,088,766	
Real Estate							137,184	
TOTAL INCL OWNER COSTS							1,225,950	

** PROJECT DIRECT SUMMARY - Level 5 **

	QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
6 Fish and Wildlife							
6. 3 Wildlife Facility Sanctury							
6. 3.73 Habitat & Feeding							
6. 3.73.02 Site Work							
6. 3.73.02.01 Mob/Demob		14,132	8,761	1,945	1,200	26,037	
6. 3.73.02.02 Dredging for Eelgrass Restoratio		109,626	39,483	9,000	0	158,109	
6. 3.73.02.03 Dredging of Lower Sedi. Basin		146,664	70,192	16,000	0	232,856	
6. 3.73.02.04 Eelgrass Planting		60,484	12,369	0	0	72,853	
6. 3.73.02.05 Eelgrass Monitoring		14,486	2,062	0	0	16,547	
6. 3.73.02.06 Eelgrass Replantishment		30,242	6,185	0	0	36,426	
TOTAL Site Work		375,633	139,051	26,945	1,200	542,829	
TOTAL Habitat & Feeding		375,633	139,051	26,945	1,200	542,829	
TOTAL Wildlife Facility Sanctury		375,633	139,051	26,945	1,200	542,829	
TOTAL Fish and Wildlife		375,633	139,051	26,945	1,200	542,829	
TOTAL Habitat Restoration	1.00 EA	375,633	139,051	26,945	1,200	542,829	542829
Prime Contractor's Field Overhead						54,283	
SUBTOTAL						597,112	
Prime's Home Office Expense						47,769	
SUBTOTAL						644,881	
Prime Contractor's Profit						54,170	
SUBTOTAL						699,051	
Prime Contractor's Bond						13,981	
TOTAL INCL INDIRECTS						713,032	
Contingency						142,606	
SUBTOTAL						855,638	
Escalation						61,117	
SUBTOTAL						916,755	
Engineering and Design						119,178	
SUBTOTAL						1,035,933	
Construction and Supervision						52,833	
SUBTOTAL						1,088,766	
Real Estate						137,184	

** PROJECT DIRECT SUMMARY - Level 5 **

	QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
TOTAL INCL OWNER COSTS						1,225,950	

6. Fish and Wildlife

6. 3. Wildlife Facility Sanctury		QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
6. 3.73. Habitat & Feeding							
6. 3.73.02. Site Work							
6. 3.73.02.01. Mob/Demob							
6. 3.73.02.01.01. Personnel							
MIL AA <	> Outside Laborers, (Semi-Skilled)	60.00 HR	41.51 2,491	0.00 0	0.00 0	0.00 0	41.51 2,491
MIL AA <	> Outside Equip. Operators, Heavy	60.00 HR	42.00 2,520	0.00 0	0.00 0	0.00 0	42.00 2,520
MIL AA <	> Outside Truck Drivers, Heavy	60.00 HR	38.44 2,306	0.00 0	0.00 0	0.00 0	38.44 2,306
FOP AA <	> General Superintendents (P.M.)	60.00 HR	52.67 3,160	0.00 0	0.00 0	0.00 0	52.67 3,160
FOP AA <	> Project Managers	60.00 HR	60.91 3,655	0.00 0	0.00 0	0.00 0	60.91 3,655
	TOTAL Personnel		14,132	0	0	0	14,132
6. 3.73.02.01.02. Equipment							
MAP AA <	> AIR COMPR, 720 CFM, 300 PSI (ADD HOSES & ATTACHMENTS)	60.00 HR	0.00 0	33.34 2,000	0.00 0	0.00 0	33.34 2,000
MAP AA <	> HYD EXCAV BKT, 1.50CY, W/TIPS	60.00 HR	0.00 0	1.99 119	0.00 0	0.00 0	1.99 119
EP AA <	> TRK,HWY, 21,000 GVW, 4X2, 2 AXLE	60.00 HR	0.00 0	10.34 620	0.00 0	0.00 0	10.34 620
EP AA <	> TRK,HWY, 4,900GVW,4X2, 1/2T-PKUP	60.00 HR	0.00 0	6.21 373	0.00 0	0.00 0	6.21 373
GEN AA <	> TUG BOAT, 150 - 400HP (112 - 298KW)	60.00 HR	0.00 0	25.66 1,540	0.00 0	0.00 0	25.66 1,540
NON AA <	> MISC. POWER TOOLS	60.00 HR	0.00 0	6.40 384	0.00 0	0.00 0	6.40 384
EP AA <	> AUGERHD MUDCAT, 8' DISCHARGE DIA	60.00 HR	0.00 0	62.08 3,725	0.00 0	20.00 1,200	82.08 4,925

6. Fish and Wildlife

6. 3. Wildlife Facility Sanctury	QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
TOTAL Equipment		0	8,761	0	1,200	9,961
6. 3.73.02.01.03. Facility						
AF AA <01594 0550 > Office trailer, rent per month, furnished, no hookups, 50' x 12'	5.00 MO	0.00 0	0.00 0	343.33 1,717	0.00 0	343.33 1,717
AF AA <01594 1400 > Toilet, portable chemical, rent per month	3.00 EA	0.00 0	0.00 0	76.00 228	0.00 0	76.00 228
TOTAL Facility		0	0	1,945	0	1,945
TOTAL Mob/Demob		14,132	8,761	1,945	1,200	26,037
6. 3.73.02.02. Dredging for Eelgrass Restoratio						
6. 3.73.02.02. 5. Labor						
MIL AA < > Outside Equip. Operators, Heavy	450.00 HR	42.00 18,900	0.00 0	0.00 0	0.00 0	42.00 18,900
MIL AA < > Outside Equip. Operators, Medium	450.00 HR	39.53 17,790	0.00 0	0.00 0	0.00 0	39.53 17,790
MIL AA < > Outside Equip. Oilers	450.00 HR	39.53 17,790	0.00 0	0.00 0	0.00 0	39.53 17,790
MIL AA < > Outside Laborers, (Semi-Skilled)	450.00 HR	41.51 18,681	0.00 0	0.00 0	0.00 0	41.51 18,681
MIL AA < > Outside Divers	450.00 HR	81.03 36,464	0.00 0	0.00 0	0.00 0	81.03 36,464
TOTAL Labor		109,626	0	0	0	109,626
6. 3.73.02.02.10. Equipment						
GEN AA < > TUG BOAT, 150 - 400HP (112 - 298KW)	450.00 HR	0.00 0	25.66 11,547	0.00 0	0.00 0	25.66 11,547
M EP AA < > AUGERHD MUDCAT, 8' DISCHARGE DIA	450.00 HR	0.00 0	62.08 27,936	20.00 9,000	0.00 0	82.08 36,936
TOTAL Equipment		0	39,483	9,000	0	48,483

6. 3. Wildlife Facility Sanctury		QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
	TOTAL Dredging for Eelgrass Restoratio		109,626	39,483	9,000	0	158,109
6. 3.73.02.03. Dredging of Lower Sedi. Basin							
6. 3.73.02.03. 5. Labor							
MIL AA <	> Outside Equip. Operators, Heavy		42.00	0.00	0.00	0.00	42.00
		800.00 HR	33,600	0	0	0	33,600
MIL AA <	> Outside Equip. Operators, Medium		39.53	0.00	0.00	0.00	39.53
		800.00 HR	31,627	0	0	0	31,627
MIL AA <	> Outside Equip. Oilers		39.53	0.00	0.00	0.00	39.53
		400.00 HR	15,814	0	0	0	15,814
MIL AA <	> Outside Laborers, (Semi-Skilled)		41.51	0.00	0.00	0.00	41.51
		800.00 HR	33,211	0	0	0	33,211
MIL AA <	> Outside Divers		81.03	0.00	0.00	0.00	81.03
		400.00 HR	32,412	0	0	0	32,412
	TOTAL Labor		146,664	0	0	0	146,664
6. 3.73.02.03.10. Equipment							
GEN AA <	> TUG BOAT, 150 - 400HP		0.00	25.66	0.00	0.00	25.66
	(112 - 298KW)	800.00 HR	0	20,528	0	0	20,528
M EP AA <	> AUGERHD MUDCAT, 8' DISCHARGE DIA		0.00	62.08	20.00	0.00	82.08
		800.00 HR	0	49,664	16,000	0	65,664
	TOTAL Equipment		0	70,192	16,000	0	86,192
	TOTAL Dredging of Lower Sedi. Basin		146,664	70,192	16,000	0	232,856
6. 3.73.02.04. Eelgrass Planting							
6. 3.73.02.04. 5. Labor							
MIL AA <	> Outside Equip. Operators, Medium		39.53	0.00	0.00	0.00	39.53
		300.00 HR	11,860	0	0	0	11,860
MIL AA <	> Outside Equip. Oilers		39.53	0.00	0.00	0.00	39.53
		300.00 HR	11,860	0	0	0	11,860
MIL AA <	> Outside Laborers, (Semi-Skilled)		41.51	0.00	0.00	0.00	41.51
		300.00 HR	12,454	0	0	0	12,454

6. Fish and Wildlife

6. 3. Wildlife Facility Sanctury			QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
	MIL AA <	> Outside Divers		81.03	0.00	0.00	0.00	81.03
			300.00 HR	24,309	0	0	0	24,309
		TOTAL Labor		60,484	0	0	0	60,484
6. 3.73.02.04.10. Equipment								
	GEN AA <	> TUG BOAT, 150 - 400HP		0.00	25.66	0.00	0.00	25.66
		(112 - 298KW)	300.00 HR	0	7,698	0	0	7,698
	USR AA <	> BARGE 120X45		0.00	15.57	0.00	0.00	15.57
			300.00 HR	0	4,671	0	0	4,671
		TOTAL Equipment		0	12,369	0	0	12,369
		TOTAL Eelgrass Planting		60,484	12,369	0	0	72,853
6. 3.73.02.05. Eelgrass Monitoring								
6. 3.73.02.05. 5. Labor								
	MIL AA <	> Outside Equip. Operators, Medium		39.53	0.00	0.00	0.00	39.53
			100.00 HR	3,953	0	0	0	3,953
	MIL AA <	> Outside Laborers, (Semi-Skilled)		41.51	0.00	0.00	0.00	41.51
			100.00 HR	4,151	0	0	0	4,151
	MIL AA <	> Outside Divers		81.03	0.00	0.00	0.00	81.03
			50.00 HR	4,052	0	0	0	4,052
	FOP AA <	> Engineers, Quality Control		46.59	0.00	0.00	0.00	46.59
			50.00 HR	2,330	0	0	0	2,330
		TOTAL Labor		14,486	0	0	0	14,486
6. 3.73.02.05.10. Equipment								
	GEN AA <	> TUG BOAT, 150 - 400HP		0.00	25.66	0.00	0.00	25.66
		(112 - 298KW)	50.00 HR	0	1,283	0	0	1,283
	USR AA <	> BARGE 120X45		0.00	15.57	0.00	0.00	15.57
			50.00 HR	0	779	0	0	779
		TOTAL Equipment		0	2,062	0	0	2,062

6. 3. Wildlife Facility Sanctury		QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
	TOTAL Eelgrass Monitoring		14,486	2,062	0	0	16,547
6. 3.73.02.06. Eelgrass Replantishment							
6. 3.73.02.06. 5. Labor							
MIL AA <	> Outside Equip. Operators, Medium		39.53	0.00	0.00	0.00	39.53
		150.00 HR	5,930	0	0	0	5,930
MIL AA <	> Outside Equip. Oilers		39.53	0.00	0.00	0.00	39.53
		150.00 HR	5,930	0	0	0	5,930
MIL AA <	> Outside Laborers, (Semi-Skilled)		41.51	0.00	0.00	0.00	41.51
		150.00 HR	6,227	0	0	0	6,227
MIL AA <	> Outside Divers		81.03	0.00	0.00	0.00	81.03
		150.00 HR	12,155	0	0	0	12,155
	TOTAL Labor		30,242	0	0	0	30,242
6. 3.73.02.06.10. Equipment							
GEN AA <	> TUG BOAT, 150 - 400HP		0.00	25.66	0.00	0.00	25.66
	(112 - 298KW)	150.00 HR	0	3,849	0	0	3,849
USR AA <	> BARGE 120X45		0.00	15.57	0.00	0.00	15.57
		150.00 HR	0	2,336	0	0	2,336
	TOTAL Equipment		0	6,185	0	0	6,185
	TOTAL Eelgrass Replantishment		30,242	6,185	0	0	36,426
	TOTAL Site Work		375,633	139,051	26,945	1,200	542,829
	TOTAL Habitat & Feeding		375,633	139,051	26,945	1,200	542,829
	TOTAL Wildlife Facility Sanctury		375,633	139,051	26,945	1,200	542,829
	TOTAL Fish and Wildlife		375,633	139,051	26,945	1,200	542,829
	TOTAL Habitat Restoration		375,633	139,051	26,945	1,200	542,829

** CREW BACKUP **

SRC	ITEM ID	DESCRIPTION	NO. UOM	RATE	**** LABOR **** HOURS	**** LABOR **** COST	**** EQUIP **** HOURS	**** EQUIP **** COST	TOTAL COST

** LABOR BACKUP **

SRC	LABOR ID	DESCRIPTION	BASE	OVERTM	TXS/INS	FRNG	TRVL	RATE	UOM	UPDATE	**** TOTAL **** DEFAULT	HOURS
FOP	FA-AGENS	General Superintendents (P.M.)	26.00	0.0%	18.6%	21.83	0.00	52.67	HR	06/11/98	33.76	60
FOP	FA-PROJM	Project Managers	30.07	0.0%	18.6%	25.25	0.00	60.91	HR	06/11/98	31.68	60
FOP	FC-ENGQC	Engineers, Quality Control	23.00	0.0%	18.6%	19.31	0.00	46.59	HR	06/11/98	26.19	50
MIL	X-DIVER	Outside Divers	35.65	0.0%	48.2%	28.20	0.00	81.03	HR	06/11/98	57.90	1350
MIL	X-EQOPRHVY	Outside Equip. Operators, Heavy	22.00	0.0%	40.9%	11.00	0.00	42.00	HR	01/18/02	31.93	1310
MIL	X-EQOPRMED	Outside Equip. Operators, Medium	22.00	0.0%	29.7%	11.00	0.00	39.53	HR	01/18/02	30.68	1800
MIL	X-EQOPROIL	Outside Equip. Oilers	22.00	0.0%	29.7%	11.00	0.00	39.53	HR	01/18/02	24.82	1300
MIL	X-LABORER	Outside Laborers, (Semi-Skilled)	22.00	0.0%	38.7%	11.00	0.00	41.51	HR	01/18/02	24.50	1860
MIL	X-TRKDVRHV	Outside Truck Drivers, Heavy	22.00	0.0%	33.8%	9.00	0.00	38.44	HR	01/18/02	24.81	60

** EQUIPMENT BACKUP **

SRC	ID.NO.	EQUIPMENT DESCRIPTION	DEPR	FCCM	FUEL	FOG	TR WR	TR REP	EQ REP	TOTAL RATE	** TOTAL ** HOURS
MAP	A15SR001	AIR COMPR, 720 CFM, 300 PSI	7.79	2.32	10.76	3.58	0.11	0.02	8.75	33.34 HR	60
MAP	H25BS004	HYD EXCAV BKT, 1.50CY, W/TIPS	0.85	0.15					1.00	1.99 HR	60
EP	M10EL008	AUGERHD MUDCAT, 8' DISCHARGE DIA	21.25	5.20	8.60	2.86			24.17	62.08 HR	1310
EP	T50F0001	TRK,HWY, 4,900GVW,4X2, 1/2T-PKUP	1.54	0.34	1.95	0.65	0.14	0.02	1.56	6.21 HR	60
EP	T50F0007	TRK,HWY, 21,000 GVW, 4X2, 2 AXLE	2.39	0.60	3.58	1.11	0.34	0.06	2.25	10.34 HR	60
NON	XMIXX010	MISC. POWER TOOLS	2.17	0.76	0.60	0.27			2.60	6.40 HR	60
GEN	XX0Z9720	TUG BOAT, 150 - 400HP	8.57	3.06	2.41	1.06			10.56	25.66 HR	1810
USR	ZAB1000	BARGE 120X45	4.96	1.90	1.60	0.61			6.50	15.57 HR	500

FISH PASSAGE
CROSS MILL POND, CHARLESTOWN, RI

Designed By: NAE-EP-D
Estimated By: NAE-EP-D

Prepared By: John Yen

Preparation Date: 01/15/02
Effective Date of Pricing: 04/13/01
Est Construction Time: 120 Days

Sales Tax: 0.0%

The project consists of construction of a concrete fish passage and aluminum grate in an open channel. Also a box concrete culvert is required under the road. Quantities are taken from the conceptual plan.

Davis-Bacon labor rate of R.I.(2001) is included for the cost estimate. Contingency cost of 20% and escalation cost up to the mid construction date (2003) are inclusded in the cost estimate. The design cost during plans and specification and construction is also included. The S&D and CM fees are provided by the PM.
Large plans and specification cost and real estate cost are provided by PM.

SUMMARY REPORTS — SUMMARY PAGE

DETAILED ESTIMATE — DETAIL PAGE

BACKUP REPORTS — BACKUP PAGE

* * * END TABLE OF CONTENTS * * *

** PROJECT OWNER SUMMARY - Sub Feat **

	QUANTY UOM	CONTRACT	CONTINGN	ESCALATN	E&D	S&A	RE	TOTAL COST	UNIT
01 Mob/Demob									
01.01 Personnel		4,977	995	427	3,648	502	1,741	12,290	
01.02 Equipment		2,193	439	188	1,607	221	767	5,414	
01.03 Facility		2,015	403	173	1,476	203	705	4,975	
TOTAL Mob/Demob		9,185	1,837	787	6,731	927	3,212	22,679	
02 Site Work									
02.01 Excavation									
02.01. 5 1 eqoprcrn + 1 hydr excavator, c	210.00 CY	3,755	751	322	2,752	379	1,313	9,273	44.16
TOTAL Excavation		3,755	751	322	2,752	379	1,313	9,273	
02.02 Demolition									
02.02.10 5 laborer/operatr + 2 89# Paveme	40.00 SY	2,161	432	185	1,584	218	756	5,336	133.41
TOTAL Demolition		2,161	432	185	1,584	218	756	5,336	
02.03 Pavement		1,070	214	92	784	108	374	2,642	
02.04 Pipe Bedding		2,088	418	179	1,530	211	730	5,156	
02.05 Dredging									
02.05. 5 1 eqoprcrn + 1 hydr excavator, c	2.00 CY	3,050	610	261	2,235	308	1,067	7,532	3765.91
TOTAL Dredging		3,050	610	261	2,235	308	1,067	7,532	
TOTAL Site Work		12,125	2,425	1,039	8,886	1,224	4,240	29,939	
03 Fish Ladder									
03.01 Concrete Fish Ladder									
03.01.01 Crew		46,127	9,225	3,954	33,805	4,656	16,132	113,899	
03.01.02 Concrete		23,114	4,623	1,981	16,939	2,333	8,083	57,074	
TOTAL Concrete Fish Ladder		69,242	13,848	5,935	50,744	6,988	24,215	170,973	
03.03 Trash Rack									
03.03.01 Crew		4,545	909	390	3,331	459	1,589	11,223	

** PROJECT OWNER SUMMARY - Sub Feat **

	QUANTY UOM	CONTRACT	CONTINGN	ESCALATN	E&D	S&A	RE	TOTAL COST	UNIT
03.03.02 Steel		3,962	792	340	2,904	400	1,386	9,784	
TOTAL Trash Rack		8,507	1,701	729	6,235	859	2,975	21,007	
03.04 Steeppass		26,416	5,283	2,264	19,359	2,666	9,238	65,228	
03.05 Ext. Floor grating									
03.05.01 Crew		3,636	727	312	2,665	367	1,272	8,978	
03.05.02 Grating		1,981	396	170	1,452	200	693	4,892	
TOTAL Ext. Floor grating		5,617	1,123	481	4,117	567	1,964	13,870	
03.06 Seals									
03.06.01 Crew		4,545	909	390	3,331	459	1,589	11,223	
03.06.02 Material		5,283	1,057	453	3,872	533	1,848	13,046	
TOTAL Seals		9,828	1,966	842	7,203	992	3,437	24,268	
03.07 Stop log boards									
03.07.01 Crew		5,334	1,067	457	3,909	538	1,865	13,170	
03.07.02 Board		2,642	528	226	1,936	267	924	6,523	
TOTAL Stop log boards		7,975	1,595	684	5,845	805	2,789	19,693	
TOTAL Fish Ladder		127,586	25,517	10,936	93,503	12,877	44,619	315,038	
04 Concrete Culvert									
04.01 Crew									
04.01. 5 1 eqoprmed + 1 loader, F/E, craw	5.00 EA	24,943	4,989	2,138	18,280	2,517	8,723	61,590	12318
04.01.10 4 laborers + 1 concrete mixer/co	5.00 EA	10,251	2,050	879	7,512	1,035	3,585	25,311	5062.16
TOTAL Crew		35,194	7,039	3,017	25,792	3,552	12,308	86,901	
04.02 Material delivered		39,625	7,925	3,396	29,039	3,999	13,857	97,842	
TOTAL Concrete Culvert		74,818	14,964	6,413	54,831	7,551	26,165	184,742	
TOTAL FISH PASSAGE	1.00 EA	223,714	44,743	19,175	163,950	22,579	78,237	552,398	552398

** PROJECT INDIRECT SUMMARY - Sub Feat **

	QUANTY UOM	DIRECT	FIELD OH	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT
01 Mob/Demob								
01.01 Personnel		3,768	377	332	403	98	4,977	
01.02 Equipment		1,660	166	146	177	43	2,193	
01.03 Facility		1,525	153	134	163	40	2,015	
TOTAL Mob/Demob		6,954	695	612	744	180	9,185	
02 Site Work								
02.01 Excavation								
02.01. 5 1 eqoprcrn + 1 hydr excavator, c	210.00 CY	2,843	284	250	304	74	3,755	17.88
TOTAL Excavation		2,843	284	250	304	74	3,755	
02.02 Demolition								
02.02.10 5 laborer/operatr + 2 89# Paveme	40.00 SY	1,636	164	144	175	42	2,161	54.03
TOTAL Demolition		1,636	164	144	175	42	2,161	
02.03 Pavement		810	81	71	87	21	1,070	
02.04 Pipe Bedding		1,581	158	139	169	41	2,088	
02.05 Dredging								
02.05. 5 1 eqoprcrn + 1 hydr excavator, c	2.00 CY	2,309	231	203	247	60	3,050	1525.14
TOTAL Dredging		2,309	231	203	247	60	3,050	
TOTAL Site Work		9,180	918	808	981	238	12,125	
03 Fish Ladder								
03.01 Concrete Fish Ladder								
03.01.01 Crew		34,923	3,492	3,073	3,734	904	46,127	
03.01.02 Concrete		17,500	1,750	1,540	1,871	453	23,114	
TOTAL Concrete Fish Ladder		52,423	5,242	4,613	5,605	1,358	69,242	
03.03 Trash Rack								
03.03.01 Crew		3,441	344	303	368	89	4,545	

** PROJECT INDIRECT SUMMARY - Sub Feat **

	QUANTY UOM	DIRECT	FIELD OH	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT
03.03.02 Steel		3,000	300	264	321	78	3,962	
TOTAL Trash Rack		6,441	644	567	689	167	8,507	
03.04 Steeppass		20,000	2,000	1,760	2,138	518	26,416	
03.05 Ext. Floor grating								
03.05.01 Crew		2,753	275	242	294	71	3,636	
03.05.02 Grating		1,500	150	132	160	39	1,981	
TOTAL Ext. Floor grating		4,253	425	374	455	110	5,617	
03.06 Seals								
03.06.01 Crew		3,441	344	303	368	89	4,545	
03.06.02 Material		4,000	400	352	428	104	5,283	
TOTAL Seals		7,441	744	655	796	193	9,828	
03.07 Stop log boards								
03.07.01 Crew		4,038	404	355	432	105	5,334	
03.07.02 Board		2,000	200	176	214	52	2,642	
TOTAL Stop log boards		6,038	604	531	646	156	7,975	
TOTAL Fish Ladder		96,596	9,660	8,500	10,328	2,502	127,586	
04 Concrete Culvert								
04.01 Crew								
04.01. 5 1 eqoprmed + 1 loader, F/E, craw	5.00 EA	18,885	1,888	1,662	2,019	489	24,943	4988.61
04.01.10 4 laborers + 1 concrete mixer/co	5.00 EA	7,761	776	683	830	201	10,251	2050.11
TOTAL Crew		26,645	2,665	2,345	2,849	690	35,194	
04.02 Material delivered		30,000	3,000	2,640	3,208	777	39,625	
TOTAL Concrete Culvert		56,645	5,665	4,985	6,057	1,467	74,818	
TOTAL FISH PASSAGE	1.00 EA	169,375	16,938	14,905	18,110	4,387	223,714	223714
Contingency							44,743	
SUBTOTAL							268,457	
Escalation							19,175	

** PROJECT INDIRECT SUMMARY - Sub Feat **

	QUANTY UOM	DIRECT	FIELD OH	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT
SUBTOTAL							287,632	
Engineering and Design							163,950	
SUBTOTAL							451,583	
Construction and Supervision							22,579	
SUBTOTAL							474,162	
Real Estate							78,237	
TOTAL INCL OWNER COSTS							552,398	

** PROJECT DIRECT SUMMARY - Sub Feat **

	QUANTY	UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
01 Mob/Demob								
01.01 Personnel			3,768	0	0	0	3,768	
01.02 Equipment			0	1,660	0	0	1,660	
01.03 Facility			0	0	1,525	0	1,525	
TOTAL Mob/Demob			3,768	1,660	1,525	0	6,954	
02 Site Work								
02.01 Excavation								
02.01. 5 1 eqoprcrn + 1 hydr excavator, c	210.00	CY	1,504	1,339	0	0	2,843	13.54
TOTAL Excavation			1,504	1,339	0	0	2,843	
02.02 Demolition								
02.02.10 5 laborer/operatr + 2 89# Paveme	40.00	SY	1,486	151	0	0	1,636	40.90
TOTAL Demolition			1,486	151	0	0	1,636	
02.03 Pavement			130	68	612	0	810	
02.04 Pipe Bedding			477	594	510	0	1,581	
02.05 Dredging								
02.05. 5 1 eqoprcrn + 1 hydr excavator, c	2.00	CY	1,222	1,087	0	0	2,309	1154.70
TOTAL Dredging			1,222	1,087	0	0	2,309	
TOTAL Site Work			4,819	3,239	1,122	0	9,180	
03 Fish Ladder								
03.01 Concrete Fish Ladder								
03.01.01 Crew			31,189	3,734	0	0	34,923	
03.01.02 Concrete			0	0	17,500	0	17,500	
TOTAL Concrete Fish Ladder			31,189	3,734	17,500	0	52,423	
03.03 Trash Rack								
03.03.01 Crew			3,198	243	0	0	3,441	

** PROJECT DIRECT SUMMARY - Sub Feat **

	QUANTY	UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
03.03.02 Steel			0	0	3,000	0	3,000	
TOTAL Trash Rack			3,198	243	3,000	0	6,441	
03.04 Steeppass			2,000	0	18,000	0	20,000	
03.05 Ext. Floor grating								
03.05.01 Crew			2,559	194	0	0	2,753	
03.05.02 Grating			0	0	1,500	0	1,500	
TOTAL Ext. Floor grating			2,559	194	1,500	0	4,253	
03.06 Seals								
03.06.01 Crew			3,198	243	0	0	3,441	
03.06.02 Material			0	0	4,000	0	4,000	
TOTAL Seals			3,198	243	4,000	0	7,441	
03.07 Stop log boards								
03.07.01 Crew			3,714	324	0	0	4,038	
03.07.02 Board			0	0	2,000	0	2,000	
TOTAL Stop log boards			3,714	324	2,000	0	6,038	
TOTAL Fish Ladder			45,858	4,738	46,000	0	96,596	
04 Concrete Culvert								
04.01 Crew								
04.01. 5 1 eqoprmed + 1 loader, F/E, craw	5.00	EA	9,501	9,384	0	0	18,885	3776.91
04.01.10 4 laborers + 1 concrete mixer/co	5.00	EA	6,931	830	0	0	7,761	1552.15
TOTAL Crew			16,432	10,214	0	0	26,645	
04.02 Material delivered			0	0	30,000	0	30,000	
TOTAL Concrete Culvert			16,432	10,214	30,000	0	56,645	
TOTAL FISH PASSAGE	1.00	EA	70,877	19,851	78,647	0	169,375	169375
Prime Contractor's Field Overhead							16,938	
SUBTOTAL							186,313	
Prime's Home Office Expense							14,905	

** PROJECT DIRECT SUMMARY - Sub Feat **

	QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
SUBTOTAL						201,218	
Prime Contractor's Profit						18,110	
SUBTOTAL						219,327	
Prime Contractor's Bond						4,387	
TOTAL INCL INDIRECTS						223,714	
Contingency						44,743	
SUBTOTAL						268,457	
Escalation						19,175	
SUBTOTAL						287,632	
Engineering and Design						163,950	
SUBTOTAL						451,583	
Construction and Supervision						22,579	
SUBTOTAL						474,162	
Real Estate						78,237	
TOTAL INCL OWNER COSTS						552,398	

01. Mob/Demob

01.01. Personnel		QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
MIL AA <	> Outside Laborers, (Semi-Skilled)		41.51	0.00	0.00	0.00	41.51
		16.00 HR	664	0	0	0	664
MIL AA <	> Outside Equip. Operators, Heavy		42.00	0.00	0.00	0.00	42.00
		16.00 HR	672	0	0	0	672
MIL AA <	> Outside Truck Drivers, Heavy		38.44	0.00	0.00	0.00	38.44
		16.00 HR	615	0	0	0	615
FOP AA <	> General Superintendents (P.M.)		52.67	0.00	0.00	0.00	52.67
		16.00 HR	843	0	0	0	843
FOP AA <	> Project Managers		60.91	0.00	0.00	0.00	60.91
		16.00 HR	975	0	0	0	975
	TOTAL Personnel		3,768	0	0	0	3,768
MAP AA <	> AIR COMPR, 720 CFM, 300 PSI		0.00	33.34	0.00	0.00	33.34
	(ADD HOSES & ATTACHMENTS)	32.00 HR	0	1,067	0	0	1,067
MAP AA <	> HYD EXCAV BKT, 1.50CY, W/TIPS		0.00	1.99	0.00	0.00	1.99
		32.00 HR	0	64	0	0	64
EP AA <	> TRK,HWY, 21,000 GVW, 4X2, 2 AXLE		0.00	10.34	0.00	0.00	10.34
		32.00 HR	0	331	0	0	331
EP AA <	> TRK,HWY, 4,900GVW,4X2, 1/2T-PKUP		0.00	6.21	0.00	0.00	6.21
		32.00 HR	0	199	0	0	199
	TOTAL Equipment		0	1,660	0	0	1,660
AF AA <01594 0550	> Office trailer, rent per month,		0.00	0.00	343.33	0.00	343.33
	furnished, no hookups, 50' x 12'	4.00 MO	0	0	1,373	0	1,373
AF AA <01594 1400	> Toilet, portable chemical, rent		0.00	0.00	76.00	0.00	76.00
	per month	2.00 EA	0	0	152	0	152
	TOTAL Facility		0	0	1,525	0	1,525
	TOTAL Mob/Demob		3,768	1,660	1,525	0	6,954

02.01. Excavation			QUANTY	UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
02.01. 5. 1 eqoprcrn + 1 hydr excavator, c (CODEB12B)									
	MIL AA <	> Equip. Operators, Crane/Shovel			32.62	0.00	0.00	0.00	32.62
			26.25	HR	856	0	0	0	856
	MIL AA <	> Equip. Operators, Oilers			24.69	0.00	0.00	0.00	24.69
			26.25	HR	648	0	0	0	648
	GEN AA <	> HYD EXCV, CRAWLER, 55,000LBS,			0.00	51.00	0.00	0.00	51.00
		(24,948KG) 1.50CY, (1.2M3) BKT	26.25	HR	0	1,339	0	0	1,339
		TOTAL 1 eqoprcrn + 1 hydr excavator, c			1,504	1,339	0	0	2,843
		TOTAL Excavation			1,504	1,339	0	0	2,843
02.02.10. 5 laborer/operatr + 2 89# Paveme (CLADC)									
	MIL AA <	> AIR COMPRESSOR, 375CFM, 100 PSI			0.00	12.71	0.00	0.00	12.71
		(11CMM, 689 KPA)(W/O HOSES&ATCH)	10.00	HR	0	127	0	0	127
	MIL AA <	> PAVING BREAKER, 66LB (30KG)			0.00	0.85	0.00	0.00	0.85
		(ADD 50CFM (1.4CMM) COMPR)	20.00	HR	0	17	0	0	17
	MIL AA <	> Laborers, (Semi-Skilled)			23.81	0.00	0.00	0.00	23.81
			40.00	HR	952	0	0	0	952
	MIL AA <	> Laborers, (Semi-Skilled)			24.81	0.00	0.00	0.00	24.81
			10.00	HR	248	0	0	0	248
	MIL AA <	> Equip. Operators, Light			28.51	0.00	0.00	0.00	28.51
			10.00	HR	285	0	0	0	285
	MIL AA <	> AIR HOSE,1.0"X 100'L (25MMX 31M)			0.00	0.33	0.00	0.00	0.33
		HARDROCK (USE AS DRILLING ACCES)	20.00	HR	0	7	0	0	7
		TOTAL 5 laborer/operatr + 2 89# Paveme			1,486	151	0	0	1,636
		TOTAL Demolition			1,486	151	0	0	1,636
	B RSM AA <02505 0810	> Asphaltic conc pavement,			14.11	6.23	75.00	0.00	95.35
		highway, binder course, 1.5" thick	4.00	TON	56	25	300	0	381
	B RSM AA <02505 0850	> Asphaltic conc pavement,			15.63	8.27	75.00	0.00	98.90
		highway, wearing course, 1" thick	4.00	TON	63	33	300	0	396

02.03. Pavement		QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
B MIL AA <02545 3260 >	Surface treatment, tack coat, bituminous, 0.1 gal/SY	4.00 CSF	2.75 11	2.52 10	3.00 12	0.00 0	8.26 33
	TOTAL Pavement		130	68	612	0	810
B AF AA <02244 1505 >	Base course, loaded at pit, sand, 6" deep washed & graded, large areas	17.00 CY	28.05 477	34.94 594	30.00 510	0.00 0	93.00 1,581
	TOTAL Pipe Bedding		477	594	510	0	1,581
02.05. 5. 1 eqoprcrn + 1 hydr excavator, c (CODEB12B)							
MIL AA < >	Equip. Operators, Crane/Shovel	21.32 HR	32.62 695	0.00 0	0.00 0	0.00 0	32.62 695
MIL AA < >	Equip. Operators, Oilers	21.32 HR	24.69 526	0.00 0	0.00 0	0.00 0	24.69 526
GEN AA < >	HYD EXCV, CRAWLER, 55,000LBS, (24,948KG) 1.50CY, (1.2M3) BKT	21.32 HR	0.00 0	51.00 1,087	0.00 0	0.00 0	51.00 1,087
	TOTAL 1 eqoprcrn + 1 hydr excavator, c		1,222	1,087	0	0	2,309
	TOTAL Dredging		1,222	1,087	0	0	2,309
	TOTAL Site Work		4,819	3,239	1,122	0	9,180

03.01. Concrete Fish Ladder		QUANTY	UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
03.01.01. Crew								
03.01.01. 5. 4 laborers + 1 concrete mixer/co (CLABB61)								
MIL AA <	> Laborers, (Semi-Skilled)			24.81	0.00	0.00	0.00	24.81
		125.00	HR	3,101	0	0	0	3,101
MIL AA <	> Laborers, (Semi-Skilled)			23.81	0.00	0.00	0.00	23.81
		375.00	HR	8,929	0	0	0	8,929
MIL AA <	> Equip. Operators, Light			28.51	0.00	0.00	0.00	28.51
		125.00	HR	3,564	0	0	0	3,564
GEN AA <	> CONC MIXER/CONVEYOR, 2CY HOPPER			0.00	8.38	0.00	0.00	8.38
	15CY/HR (11.5M3/HR)STA DISPENSER	125.00	HR	0	1,047	0	0	1,047
GEN AA <	> AIR COMPRESSOR, 175CFM, 100 PSI			0.00	6.23	0.00	0.00	6.23
	(5CMM, 689 KPA)(W/O HOSES&ATCH)	125.00	HR	0	779	0	0	779
GEN AA <	> AIR HOSE,1.0"X 100'L (25MMX 31M)			0.00	0.33	0.00	0.00	0.33
	HARDROCK (USE AS DRILLING ACCES)	125.00	HR	0	41	0	0	41
	TOTAL 4 laborers + 1 concrete mixer/co			15,595	1,867	0	0	17,462
03.01.01.10. 4 laborers + 1 concrete mixer/co (CLABB61)								
MIL AA <	> Laborers, (Semi-Skilled)			24.81	0.00	0.00	0.00	24.81
		125.00	HR	3,101	0	0	0	3,101
MIL AA <	> Laborers, (Semi-Skilled)			23.81	0.00	0.00	0.00	23.81
		375.00	HR	8,929	0	0	0	8,929
MIL AA <	> Equip. Operators, Light			28.51	0.00	0.00	0.00	28.51
		125.00	HR	3,564	0	0	0	3,564
GEN AA <	> CONC MIXER/CONVEYOR, 2CY HOPPER			0.00	8.38	0.00	0.00	8.38
	15CY/HR (11.5M3/HR)STA DISPENSER	125.00	HR	0	1,047	0	0	1,047
GEN AA <	> AIR COMPRESSOR, 175CFM, 100 PSI			0.00	6.23	0.00	0.00	6.23
	(5CMM, 689 KPA)(W/O HOSES&ATCH)	125.00	HR	0	779	0	0	779
GEN AA <	> AIR HOSE,1.0"X 100'L (25MMX 31M)			0.00	0.33	0.00	0.00	0.33
	HARDROCK (USE AS DRILLING ACCES)	125.00	HR	0	41	0	0	41
	TOTAL 4 laborers + 1 concrete mixer/co			15,595	1,867	0	0	17,462

03. Fish Ladder

03.01. Concrete Fish Ladder			QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
		TOTAL Crew		31,189	3,734	0	0	34,923
03.01.02. Concrete								
	USR AA <	> Concrete delivered		0.00	0.00	350.00	0.00	350.00
			50.00 CY	0	0	17,500	0	17,500
		TOTAL Concrete		0	0	17,500	0	17,500
		TOTAL Concrete Fish Ladder		31,189	3,734	17,500	0	52,423
03.03.01. Crew								
03.03.01. 5. 4 laborer + 1 Air Compressor, 1 (CLABB)								
	MIL AA <	> AIR COMPRESSOR, 250CFM, 100 PSI		0.00	9.39	0.00	0.00	9.39
		(7CMM, 689 KPA)(W/O HOSES&ATCH)	25.00 HR	0	235	0	0	235
	MIL AA <	> Carpenters		31.68	0.00	0.00	0.00	31.68
			25.00 HR	792	0	0	0	792
	MIL AA <	> Laborers, (Semi-Skilled)		24.81	0.00	0.00	0.00	24.81
			25.00 HR	620	0	0	0	620
	MIL AA <	> Laborers, (Semi-Skilled)		23.81	0.00	0.00	0.00	23.81
			75.00 HR	1,786	0	0	0	1,786
	MIL AA <	> AIR HOSE,1.0"X 100'L (25MMX 31M)		0.00	0.33	0.00	0.00	0.33
		HARDROCK (USE AS DRILLING ACCES)	25.00 HR	0	8	0	0	8
		TOTAL 4 laborer + 1 Air Compressor, 1		3,198	243	0	0	3,441
		TOTAL Crew		3,198	243	0	0	3,441
03.03.02. Steel								
	USR AA <	> Steel delivered		0.00	0.00	3000.00	0.00	3000.00
			1.00 EA	0	0	3,000	0	3,000
		TOTAL Steel		0	0	3,000	0	3,000
		TOTAL Trash Rack		3,198	243	3,000	0	6,441
	USR AA <	> Alum. Steeppass		500.00	0.00	4500.00	0.00	5000.00
			4.00 EA	2,000	0	18,000	0	20,000

03. Fish Ladder

03.04. Steeppass			QUANTY	UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
		TOTAL Steeppass			2,000	0	18,000	0	20,000
03.05.01. Crew									
03.05.01. 5. 4 laborer + 1 Air Compressor, 1 (CLABB)									
	MIL AA <	> AIR COMPRESSOR, 250CFM, 100 PSI (7CMM, 689 KPA)(W/O HOSES&ATCH)	20.00	HR	0.00 0	9.39 188	0.00 0	0.00 0	9.39 188
	MIL AA <	> Carpenters	20.00	HR	31.68 634	0.00 0	0.00 0	0.00 0	31.68 634
	MIL AA <	> Laborers, (Semi-Skilled)	20.00	HR	24.81 496	0.00 0	0.00 0	0.00 0	24.81 496
	MIL AA <	> Laborers, (Semi-Skilled)	60.00	HR	23.81 1,429	0.00 0	0.00 0	0.00 0	23.81 1,429
	MIL AA <	> AIR HOSE,1.0"X 100'L (25MMX 31M) HARDROCK (USE AS DRILLING ACCES)	20.00	HR	0.00 0	0.33 7	0.00 0	0.00 0	0.33 7
		TOTAL 4 laborer + 1 Air Compressor, 1			2,559	194	0	0	2,753
		TOTAL Crew			2,559	194	0	0	2,753
03.05.02. Grating									
	USR AA <	> Grating delivered	60.00	LF	0.00 0	0.00 0	25.00 1,500	0.00 0	25.00 1,500
		TOTAL Grating			0	0	1,500	0	1,500
		TOTAL Ext. Floor grating			2,559	194	1,500	0	4,253
03.06.01. Crew									
03.06.01. 5. 4 laborer + 1 Air Compressor, 1 (CLABB)									
	MIL AA <	> AIR COMPRESSOR, 250CFM, 100 PSI (7CMM, 689 KPA)(W/O HOSES&ATCH)	25.00	HR	0.00 0	9.39 235	0.00 0	0.00 0	9.39 235
	MIL AA <	> Carpenters	25.00	HR	31.68 792	0.00 0	0.00 0	0.00 0	31.68 792
	MIL AA <	> Laborers, (Semi-Skilled)	25.00	HR	24.81 620	0.00 0	0.00 0	0.00 0	24.81 620

03.06. Seals			QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
	MIL AA <	> Laborers, (Semi-Skilled)		23.81	0.00	0.00	0.00	23.81
			75.00 HR	1,786	0	0	0	1,786
	MIL AA <	> AIR HOSE,1.0"X 100'L (25MMX 31M)		0.00	0.33	0.00	0.00	0.33
		HARDROCK (USE AS DRILLING ACCES)	25.00 HR	0	8	0	0	8
		TOTAL 4 laborer + 1 Air Compressor, 1		3,198	243	0	0	3,441
		TOTAL Crew		3,198	243	0	0	3,441
03.06.02. Material								
	USR AA <	> Material delivered		0.00	0.00	2000.00	0.00	2000.00
			2.00 EA	0	0	4,000	0	4,000
		TOTAL Material		0	0	4,000	0	4,000
		TOTAL Seals		3,198	243	4,000	0	7,441
03.07.01. Crew								
03.07.01. 5. 5 laborers + 1 loader, BH, wheel (CLABB14)								
	MIL AA <	> Laborers, (Semi-Skilled)		24.81	0.00	0.00	0.00	24.81
			25.00 HR	620	0	0	0	620
	MIL AA <	> Laborers, (Semi-Skilled)		23.81	0.00	0.00	0.00	23.81
			100.00 HR	2,381	0	0	0	2,381
	MIL AA <	> Equip. Operators, Light		28.51	0.00	0.00	0.00	28.51
			25.00 HR	713	0	0	0	713
	GEN AA <	> LOADER/BCK-HOE,WH, 0.80CY(0.6M3)		0.00	12.96	0.00	0.00	12.96
		F/E BKT, 9.8'(3.0M)DEPTH OF HOE	25.00 HR	0	324	0	0	324
		TOTAL 5 laborers + 1 loader, BH, wheel		3,714	324	0	0	4,038
		TOTAL Crew		3,714	324	0	0	4,038
03.07.02. Board								
	USR AA <	> Board delivered		0.00	0.00	500.00	0.00	500.00
			4.00 EA	0	0	2,000	0	2,000
		TOTAL Board		0	0	2,000	0	2,000

03. Fish Ladder

03.07. Stop log boards	QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
TOTAL Stop log boards		3,714	324	2,000	0	6,038
TOTAL Fish Ladder		45,858	4,738	46,000	0	96,596

04.01. Crew			QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
04.01. 5. 1 eqoprmed + 1 loader, F/E, craw (CODFB3)								
	MIL AA <	> Laborers, (Semi-Skilled)		24.81	0.00	0.00	0.00	24.81
			62.50 HR	1,551	0	0	0	1,551
	MIL AA <	> Laborers, (Semi-Skilled)		23.81	0.00	0.00	0.00	23.81
			125.00 HR	2,976	0	0	0	2,976
	MIL AA <	> Equip. Operators, Medium		30.27	0.00	0.00	0.00	30.27
			62.50 HR	1,892	0	0	0	1,892
	MIL AA <	> Truck Drivers, Heavy		24.66	0.00	0.00	0.00	24.66
			125.00 HR	3,082	0	0	0	3,082
	GEN AA <	> LOADER, F/E, CRWLR, 2.60CY		0.00	71.45	0.00	0.00	71.45
		(2.0M3)	62.50 HR	0	4,465	0	0	4,465
	GEN AA <	> TRUCK, HWY 45,000 (20,412KG)GVW		0.00	37.22	0.00	0.00	37.22
		6X4, 3 AXLE, (ADD ACCESSORIES)	125.00 HR	0	4,653	0	0	4,653
	GEN AA <	> REAR DUMP BODY, 16-23.5CY (12.2-		0.00	2.13	0.00	0.00	2.13
		18M3) (ADD 40,000-45,000GVW TRK)	125.00 HR	0	266	0	0	266
		TOTAL 1 eqoprmed + 1 loader, F/E, craw		9,501	9,384	0	0	18,885
04.01.10. 4 laborers + 1 concrete mixer/co (CLABB61)								
	MIL AA <	> Laborers, (Semi-Skilled)		24.81	0.00	0.00	0.00	24.81
			55.56 HR	1,378	0	0	0	1,378
	MIL AA <	> Laborers, (Semi-Skilled)		23.81	0.00	0.00	0.00	23.81
			166.67 HR	3,969	0	0	0	3,969
	MIL AA <	> Equip. Operators, Light		28.51	0.00	0.00	0.00	28.51
			55.56 HR	1,584	0	0	0	1,584
	GEN AA <	> CONC MIXER/CONVEYOR, 2CY HOPPER		0.00	8.38	0.00	0.00	8.38
		15CY/HR (11.5M3/HR)STA DISPENSER	55.56 HR	0	466	0	0	466
	GEN AA <	> AIR COMPRESSOR, 175CFM, 100 PSI		0.00	6.23	0.00	0.00	6.23
		(5CMM, 689 KPA)(W/O HOSES&ATCH)	55.56 HR	0	346	0	0	346
	GEN AA <	> AIR HOSE,1.0"X 100'L (25MMX 31M)		0.00	0.33	0.00	0.00	0.33
		HARDROCK (USE AS DRILLING ACCES)	55.56 HR	0	18	0	0	18
		TOTAL 4 laborers + 1 concrete mixer/co		6,931	830	0	0	7,761

04. Concrete Culvert

04.01. Crew		QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
	TOTAL Crew		16,432	10,214	0	0	26,645
USR AA <	> Material delivered		0.00	0.00	6000.00	0.00	6000.00
		5.00 EA	0	0	30,000	0	30,000
	TOTAL Material delivered		0	0	30,000	0	30,000
	TOTAL Concrete Culvert		16,432	10,214	30,000	0	56,645
	TOTAL FISH PASSAGE		70,877	19,851	78,647	0	169,375

** CREW BACKUP **

SRC	ITEM ID	DESCRIPTION	NO. UOM	RATE	LABOR HOURS	LABOR COST	EQUIP HOURS	EQUIP COST	TOTAL COST
	COFGB36C	3 eqoprmed + 1 dozer, crawler, 251-340 HP		PROD =	100%			CREW HOURS =	3
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00 HR	24.81	1.00	24.81			24.81
MIL	B-EQOPRMEDL	Equip. Operators, Medium	3.00 HR	30.27	3.00	90.81			90.81
MIL	B-TRKDVRHVL	Truck Drivers, Heavy	1.00 HR	24.66	1.00	24.66			24.66
GEN	G15Z3080 E	GRADER, MOTOR, 135 HP (101KW)	1.00 HR	30.33			1.00	30.33	30.33
GEN	T15Z6570 E	DOZER, CRAWLER, 300-340HP	1.00 HR	69.94			1.00	69.94	69.94
GEN	R45Z5690 E	ROLLER, VIB, DD, SP 12.0T	1.00 HR	40.76			1.00	40.76	40.76
GEN	T60Z7910 E	TRUCK, OFF-HWY, WATER, 5000GAL	1.00 HR	33.67			1.00	33.67	33.67
	TOTAL				5.00	140.27	4.00	174.71	314.98
	COKBB45	1 eqoprmed + 1 asphalt distributor, 3,000 gal		PROD =	100%			CREW HOURS =	0
MIL	B-EQOPRMEDL	Equip. Operators, Medium	1.00 HR	30.27	1.00	30.27			30.27
MIL	B-TRKDVRHVL	Truck Drivers, Heavy	1.00 HR	24.66	1.00	24.66			24.66
GEN	A25Z0580 E	ASPHALT DISTR, 3,000GAL (11355L	1.00 HR	15.58			1.00	15.58	15.58
GEN	T50Z7580 E	TRUCK, HWY 45,000 (20,412KG)GVW	1.00 HR	34.75			1.00	34.75	34.75
	TOTAL				2.00	54.92	2.00	50.33	105.26
	COKCB25	8 laborers + 1 asph finisher, w/screed, 10' wide		PROD =	100%			CREW HOURS =	0
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00 HR	24.81	1.00	24.81			24.81
MIL	B-LABORER L	Laborers, (Semi-Skilled)	7.00 HR	23.81	7.00	166.68			166.68
MIL	B-EQOPRMEDL	Equip. Operators, Medium	3.00 HR	30.27	3.00	90.81			90.81
GEN	A30Z0640 E	ASPHALT PAVER, 10.0' (3.1M)W,SP	1.00 HR	67.08			1.00	67.08	67.08
GEN	R45Z5690 E	ROLLER, VIB, DD, SP 12.0T	1.00 HR	40.76			1.00	40.76	40.76
GEN	R30Z5645 E	ROLLER, STATIC, 9 TIRES, SP,14T	1.00 HR	16.84			1.00	16.84	16.84
	TOTAL				11.00	282.30	3.00	124.69	406.99
	COKCB25B	8 laborers + 1 roller,vib,tandem,S/P,12Ton,84"w		PROD =	100%			CREW HOURS =	0
MIL	B-LABORER F	Laborers, (Semi-Skilled)	1.00 HR	24.81	1.00	24.81			24.81
MIL	B-LABORER L	Laborers, (Semi-Skilled)	7.00 HR	23.81	7.00	166.68			166.68
MIL	B-EQOPRMEDL	Equip. Operators, Medium	4.00 HR	30.27	4.00	121.08			121.08
GEN	A30Z0640 E	ASPHALT PAVER, 10.0' (3.1M)W,SP	1.00 HR	67.08			1.00	67.08	67.08
GEN	R45Z5690 E	ROLLER, VIB, DD, SP 12.0T	2.00 HR	40.76			2.00	81.53	81.53
GEN	R30Z5645 E	ROLLER, STATIC, 9 TIRES, SP,14T	1.00 HR	16.84			1.00	16.84	16.84
	TOTAL				12.00	312.57	4.00	165.45	478.02

** LABOR BACKUP **

SRC	LABOR ID	DESCRIPTION	BASE	OVERTM	TXS/INS	FRNG	TRVL	RATE	UOM	UPDATE	**** TOTAL **** DEFAULT	HOURS
MIL	B-CARPNTER	Carpenters	18.84	0.0%	38.7%	5.55	0.00	31.68	HR	01/01/96	31.68	70
MIL	B-EQOPRCRN	Equip. Operators, Crane/Shovel	20.13	0.0%	29.7%	6.51	0.00	32.62	HR	01/01/96	32.62	48
MIL	B-EQOPRLT	Equip. Operators, Light	17.21	0.0%	29.7%	6.19	0.00	28.51	HR	01/01/96	28.51	341
MIL	B-EQOPRMED	Equip. Operators, Medium	18.65	0.0%	29.7%	6.08	0.00	30.27	HR	01/01/96	30.27	74
MIL	B-EQOPROIL	Equip. Operators, Oilers	14.61	0.0%	29.7%	5.74	0.00	24.69	HR	01/01/96	24.69	48
MIL	B-LABORER	Laborers, (Semi-Skilled)	14.06	0.0%	38.7%	4.31	0.00	23.81	HR	01/01/96	23.81	1871
MIL	B-TRKDVRHV	Truck Drivers, Heavy	15.40	0.0%	33.8%	4.05	0.00	24.66	HR	01/01/96	24.66	129
FOP	FA-AGENS	General Superintendents (P.M.)	26.00	0.0%	18.6%	21.83	0.00	52.67	HR	06/11/98	33.76	16
FOP	FA-PROJM	Project Managers	30.07	0.0%	18.6%	25.25	0.00	60.91	HR	06/11/98	31.68	16
MIL	X-EQOPRHVY	Outside Equip. Operators, Heavy	22.00	0.0%	40.9%	11.00	0.00	42.00	HR	01/18/02	31.93	16
MIL	X-LABORER	Outside Laborers, (Semi-Skilled)	22.00	0.0%	38.7%	11.00	0.00	41.51	HR	01/18/02	24.50	16
MIL	X-TRKDVRHV	Outside Truck Drivers, Heavy	22.00	0.0%	33.8%	9.00	0.00	38.44	HR	01/18/02	24.81	16

** EQUIPMENT BACKUP **

SRC	ID.NO.	EQUIPMENT DESCRIPTION	DEPR	FCCM	FUEL	FOG	TR WR	TR REP	EQ REP	TOTAL RATE	** TOTAL ** HOURS
MAP	A15SR001	AIR COMPR, 720 CFM, 300 PSI	7.79	2.32	10.76	3.58	0.11	0.02	8.75	33.34 HR	32
GEN	A15Z0130	AIR COMPRESSOR, 175CFM, 100 PSI	1.43	0.43	2.05	0.68	0.03	0.00	1.61	6.23 HR	306
GEN	A15Z0140	AIR COMPRESSOR, 250CFM, 100 PSI	2.29	0.68	2.87	0.96	0.03	0.00	2.57	9.39 HR	70
GEN	A15Z0150	AIR COMPRESSOR, 375CFM, 100 PSI	2.89	0.88	4.13	1.37	0.15	0.02	3.26	12.71 HR	10
GEN	A20Z0400	PAVING BREAKER, 66LB (30KG)	0.26	0.03					0.55	0.85 HR	20
GEN	A20Z0475	AIR HOSE,1.0"X 100'L (25MMX 31M)	0.11	0.01					0.20	0.33 HR	396
GEN	A25Z0580	ASPHALT DISTR, 3,000GAL (11355L)	5.52	1.21		1.80			7.05	15.58 HR	0
GEN	A30Z0640	ASPHALT PAVER, 10.0' (3.1M)W,SP	20.53	5.73	4.71	3.07	1.69	0.28	31.09	67.08 HR	0
GEN	C40Z1680	CONC MIXER/CONVEYOR, 2CY HOPPER	3.39	0.50	0.33	0.19			3.97	8.38 HR	306
GEN	G15Z3080	GRADER, MOTOR, 135 HP (101KW)	9.66	3.96	3.85	1.54	0.47	0.08	10.78	30.33 HR	3
MAP	H25BS004	HYD EXCAV BKT, 1.50CY, W/TIPS	0.85	0.15					1.00	1.99 HR	32
GEN	H25Z3185	HYD EXCV, CRAWLER, 55,000LBS,	17.45	5.54	5.10	2.26			20.65	51.00 HR	48
GEN	L35Z4260	LOADER, F/E, CRWLR, 2.60CY	19.95	4.39	5.30	2.35			39.45	71.45 HR	63
GEN	L50Z4640	LOADER/BCK-HOE,WH, 0.80CY(0.6M3)	3.73	1.17	1.82	0.69	0.72	0.12	4.70	12.96 HR	25
GEN	R30Z5645	ROLLER, STATIC, 9 TIRES, SP,14T	5.95	1.34	2.43	0.67	0.34	0.06	6.06	16.84 HR	0
GEN	R45Z5690	ROLLER, VIB, DD, SP 12.0T	12.42	2.73	4.23	1.60			19.78	40.76 HR	4
GEN	T15Z6570	DOZER, CRAWLER, 300-340HP	19.06	8.83	10.60	3.53			27.92	69.94 HR	3
GEN	T40Z6860	REAR DUMP BODY, 16-23.5CY (12.2-	0.95	0.21					0.97	2.13 HR	125
EP	T50F0001	TRK,HWY, 4,900GVW,4X2, 1/2T-PKUP	1.54	0.34	1.95	0.65	0.14	0.02	1.56	6.21 HR	32
EP	T50F0007	TRK,HWY, 21,000 GVW, 4X2, 2 AXLE	2.39	0.60	3.58	1.11	0.34	0.06	2.25	10.34 HR	32
GEN	T50Z7420	TRUCK, HWY 45,000 (20,412KG)GVW	10.79	2.44	10.04	3.34	0.97	0.16	9.48	37.22 HR	125
GEN	T50Z7580	TRUCK, HWY 45,000 (20,412KG)GVW	10.68	2.45	7.91	2.63	1.43	0.24	9.41	34.75 HR	0
GEN	T60Z7910	TRUCK, OFF-HWY, WATER, 5000GAL	10.15	3.42	5.31	2.01	1.82	0.30	10.66	33.67 HR	3

Appendix IV

Real Estate Plan

TABLE OF CONTENTS

AUTHORITY

Authority to perform this investigation is authorized under a resolution adopted by the Committee on Environmental and Public Works of the United States Senate dated 2 August 1995.

PURPOSE

The purpose of this project is to determine the most technically and economically feasible, and socially, environmentally, and culturally acceptable project to restore valuable aquatic habitat in the form of eelgrass, fish, and shellfish habitat in Ninigret, Winnapaug, and Quonochontaug ponds. Eelgrass provides important habitat for finfish, shellfish, and other aquatic animals. Anadromous fish are important commercial, recreational, and ecological resources. Modifying obstacles to fish passage will enhance their populations.

INSPECTION

The property being affected by the proposed project was inspected in the field during the week of 6 June 2001 by Mr. Robert P. Abbott, Staff Appraiser, U. S. Army Corps of Engineers, New England District, Real Estate Division.

PROJECT DESCRIPTION

Restoration efforts of two types are included in this report. A major portion of the study will focus on restoration of Eelgrass beds in the vicinity of flood tidal shoals at the entrance of Ninigret, Quonochontaug, and Winnapaug Ponds. The report will also examine fish passage restoration at Cross Mill Pond and Factory Pond.

The salt pond restoration projects focus on restoring eelgrass in areas buried by flood tidal shoals near the entrances to the ponds. Historically, the salt ponds were managed by local residents who periodically opened temporary breachways between the ocean and the ponds. During the 1950's, permanent, stabilized openings were constructed in Ninigret, Quonochontaug, and Winnapaug Ponds.

The permanent breachways increased the salinity, altering the brackish habitat. This made the salt ponds more suitable for such species as eelgrass and scallops. However, with shoaling and reductions in water quality, these species have decreased in vigor and abundance. The breachways caused sedimentation rates to increase, resulting in the loss of productive aquatic habitat.

Sedimentation basins at one time existed in the Winnapaug and Ninigret breachways. However, the basins have filled with sediment and no longer function.

As presently envisioned, restoration will most likely be accomplished through a combination of selective dredging, re-establishing a sedimentation basin to control future shoaling, and planting eelgrass in the dredged areas.
The flood tidal shoal areas in each pond are shown in this report. The sand dredged from the shoals will most likely be placed on nearby barrier beaches. The study will investigate the possibility of restoring shorebird habitat with this dredged material.

The fish passage projects for Factory Pond in South Kingstown and Cross Mill Pond in Charlestown are smaller in scope. Anadromous fish (e.g., herring) passage will be enhanced by constructing fish passage structures that allow migration across man-made barriers.

COORDINATION

The proposed work is being coordinated with the following Federal, State, and local agencies.

U. S. Fish and Wildlife Service
National Marine fisheries Service
U. S. Environmental Protection Agency
Rhode Island Coastal Resources Management Council
Rhode Island Department of Environmental Management
Rhode Island Department of Administration, Office of Planning
Rhode Island Natural Heritage Program
Rhode Island Historic Preservation
Towns of Westerly, Charlestown, and South Kingston, R.I.
Narragansett Indian Land & Water Resources Commission

VIEWS OF SPONSORS

Both the U. S. Government and the State of Rhode Island support the initiative to restore the South Coastal Area to its historic condition and recognize the benefit such a project would bring to the local communities and the watershed area.

GOVERNMENT OWNED FACILITIES

Section III of the Act of Congress approved July 8, 1958 (PL 85-500) authorized the protection, realteration, reconstruction, relocation or replacement of municipally owned facilities. A preliminary inspection of the property area indicated Government-owned facilities are not affected.

PROTECTION AND ENHANCEMENT OF CULTURAL ENVIRONMENT

An Environmental Assessment and Finding of No Significant Impact will be prepared and will be available for public review upon request.

Upon review, a determination has been made that an Environmental Impact Statement for the proposed restoration project is not required under the provisions of the National Environmental Policy Act of 1969.

ENDANGERED SPECIES

Coordination with the U. S. Fish and Wildlife Service and National Marine Fisheries Service will be conducted in compliance with the Endangered Species Act of 1973 to determine whether there are Federally listed endangered or threatened species in the area of the proposed projects. Coordination with the Rhode Island Natural Heritage Program will also be conducted to determine whether there are State-listed species in the project areas.

CLEAN WATER ACT

A Clean Water Act, Section 404(b)(1) evaluation will be completed for the project. State Water Quality Certification will be obtained prior to implementation.

MINERAL ACTIVITY

There is no present or anticipated mineral activity in the vicinity of the project that may affect the operation thereof.

CONTAMINANTS

There are no known or suspected contaminants which would impact the real estate acquisition process.

RIGHTS TO BE ACQUIRED

The Local Sponsor will be required to provide all lands, easements, rights-of-way, relocations, and disposal areas (LERRDS) necessary for project purposes. It is anticipated that a number of easements, both permanent and temporary, will be required to complete the project. In addition, the local sponsor will be required to obtain irrevocable rights of entry for the pipeline use between the dredged areas and the disposal beaches. These rights of entry are not considered real estate rights and any costs would not creditable as LERRDS.

There is no existing Federal project that lies fully or partially within the proposed project, nor are there any Federal lands within the LER required for the project.

Navigation servitude does not apply to any of the real estate acquisition areas.

FEE ACQUISITION

The highest type of interest in real estate is complete ownership, known as ownership in fee simple, or in fee simple absolute. There are no fee acquisitions with this project.

PERMANENT EASEMENT AREAS

Permanent easements areas for construction and maintenance purposes will be necessary. Preliminary investigation indicates permanent easement areas will total one (1.0) acre involving two (2) ownerships and will be needed for the proposed fish ladders at Cross Mill and Factory Pond areas.

TEMPORARY EASEMENTS

Temporary Easements involving twenty eight (28) ownerships and 90 acres, will be required for dredging/construction and staging areas.

CONTINGENCIES

A contingency allowance of 25 percent is considered to be reasonably adequate to provide for possible appreciation of property values from the time of this estimate to the acquisition date, for possible minor property line adjustments or for additional hidden ownership's which may be developed by refinement to taking lines, for adverse condemnation awards and to allow for practical and realistic negotiations.

ACQUISITION COSTS

Acquisition costs will include Sponsor's costs for mapping, surveying, legal description, title evidence, appraisals, negotiations, closing and administrative costs for possible condemnations. The acquisition costs are based upon this office's experience in similar civil works projects in the general area and are estimated at $7,500 per ownership. A total of thirty (30) ownerships will be affected by the project.

EXECUTIVE ORDER 11988 FLOOD PLAIN MANAGEMENT

This project is located in a floodplain zoned area. No induced flooding is anticipated due to the proposed project.

RELOCATION COSTS

Public Law 91-646, Uniform Relocations Assistance Act of 1970, provide for uniform and equitable treatment of persons displaced from their homes, businesses, or farms by a Federally Assisted Program. It also established uniform and equitable land acquisitions policies for these projects. Included among the items under PL 91-646 are following:

a. Moving Expenses
b. Relocation Allowance (Business)
c. Replacement Housing (Tenants)
d. Relocation Advisory Services
e. Recording Fees
f. Transfer Taxes
g. Mortgage Prepayment Costs
h. Real Estate Tax Refunds (Pro-Rata)

The land is unimproved and preliminary investigations indicate that there are no ownerships requiring relocation assistance. Should the existing preliminary taking lines be changed to include improvements, then the taking authority must certify that there will be available, in areas generally not less desirable and at rents/prices within the financial means of the those that would be displaced, decent, safe, and sanitary facilities, equal in number to the number of, and available to, such displaced persons who require such dwellings and reasonably accessible to their places of employment. The ownerships affected by the permanent easement interests vary according to the plan and are reflected in the real estate costs.

Therefore, final estimates will include, for planning purposes, an estimate of $250.00 per ownership is carried for planning purposes and is limited to the expenses, incidental to the transfer of real estate interests.

SEVERANCE DAMAGES

Severance damages usually occur when partial takings are acquired which restrict the remaining portion from full economic development. The severance damages are measured and estimated on the basis of a "Before" and "After" appraisal method and will reflect actual value loss incurred to the remainder as a result of partial acquisition. Detailed appraisals will reflect these losses.

SUMMARY OF REAL ESTATE COSTS

The following are preliminary estimates of the real estate costs for the interests being considered in this report:

Ninigret Pond	
Fee Acquisitions	$0
Permanent Easements	$0
Temporary Easements - 24 acres	$4,800
Sub-Total	$4,800
Contingency @ 25%	$1,200
Total estimated easement costs	$6,000
Relocation Assistance Costs, 4 owners	$1,000
Acquisition Costs, 4 owners	$30,000
Total Estimated Real Estate Costs	$37,000

Quonochontaug Pond	
Fee Acquisitions	$0
Permanent Easements	$0
Temporary Easements - 12 acres	$2,400
Sub-Total	$2,400
Contingency @ 25%	$ 600
Total estimated easement costs	$3,000
Relocation Assistance Costs, 17 owners	$4,250
Acquisition Costs, 17 owners	$127,500
Total Estimated Real Estate Costs	$134,750
Rounded to	$135,000

Winnapaug Pond

Fee Acquisitions	$0
Permanent Easements	$0
Temporary Easements - 24 acres	$4,800
Sub-Total	$4,800
Contingency @ 25%	$1,200
Total estimated easement costs	$6,000
Relocation Assistance Costs, 5 owners	$1,250
Acquisition Costs, 5 owners	$37,500
Total Estimated Real Estate Costs	$44,750
Rounded to	$45,000

Cross Mill Pond Fish Ladder

Fee Acquisitions	$0
Permanent Easements 21,780 sf	$46,000
Temporary Easements - 1 acre	$ 200
Sub-Total	$46,200
Contingency @ 25%	$11,550
Total estimated easement costs	$57,750
Relocation Assistance Costs, 2 owners	$ 500
Acquisition Costs, 2 owners	$15,000
Total Estimated Real Estate Costs	$73,250
Rounded to	$73,000

Factory Pond Fish Ladder

Fee Acquisitions	$0
Permanent Easements 21,780 sf	$46,000
Temporary Easements - 1 acre	$ 200
Sub-Total	$46,200
Contingency @ 25%	$11,550
Total estimated easement costs	$57,750
Relocation Assistance Costs, 2 owners	$ 500
Acquisition Costs, 2 owners	$15,000
Total Estimated Real Estate Costs	$73,250
Rounded to	$73,000

SUMMARY

Fee Acquisitions	$0
Permanent Easements – 1 acre	$ 92,000
Temporary Easements - 62 acres	$ 12,400
Sub-Total	$104,400
Contingency @ 25%	$ 26,100
Total estimated easement costs	$130,500
Relocation Assistance Costs, 30 Owners	$ 7,500
Acquisition Costs, 30 owners	$225,000
Total Estimated Real Estate Costs	$363,000

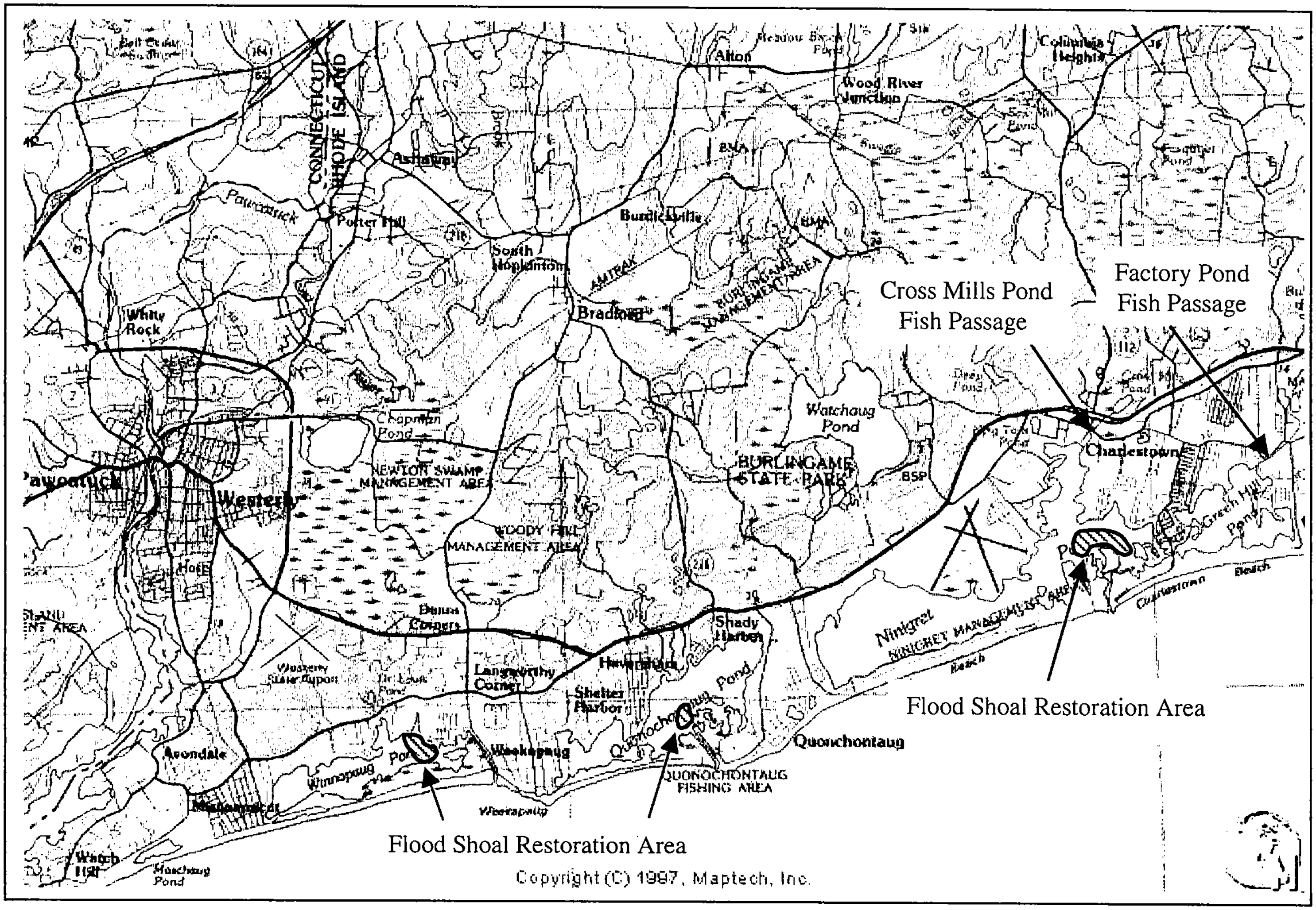
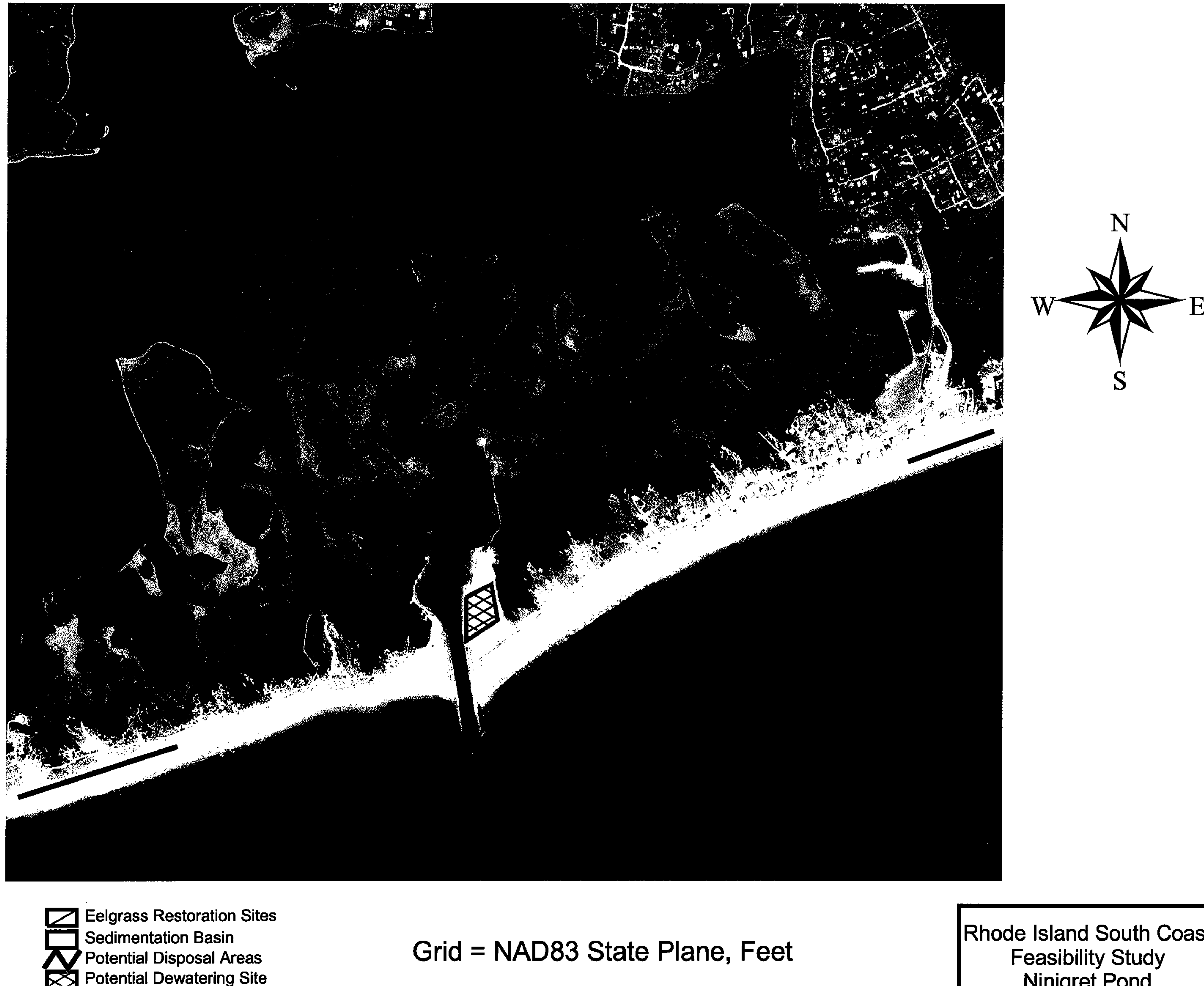
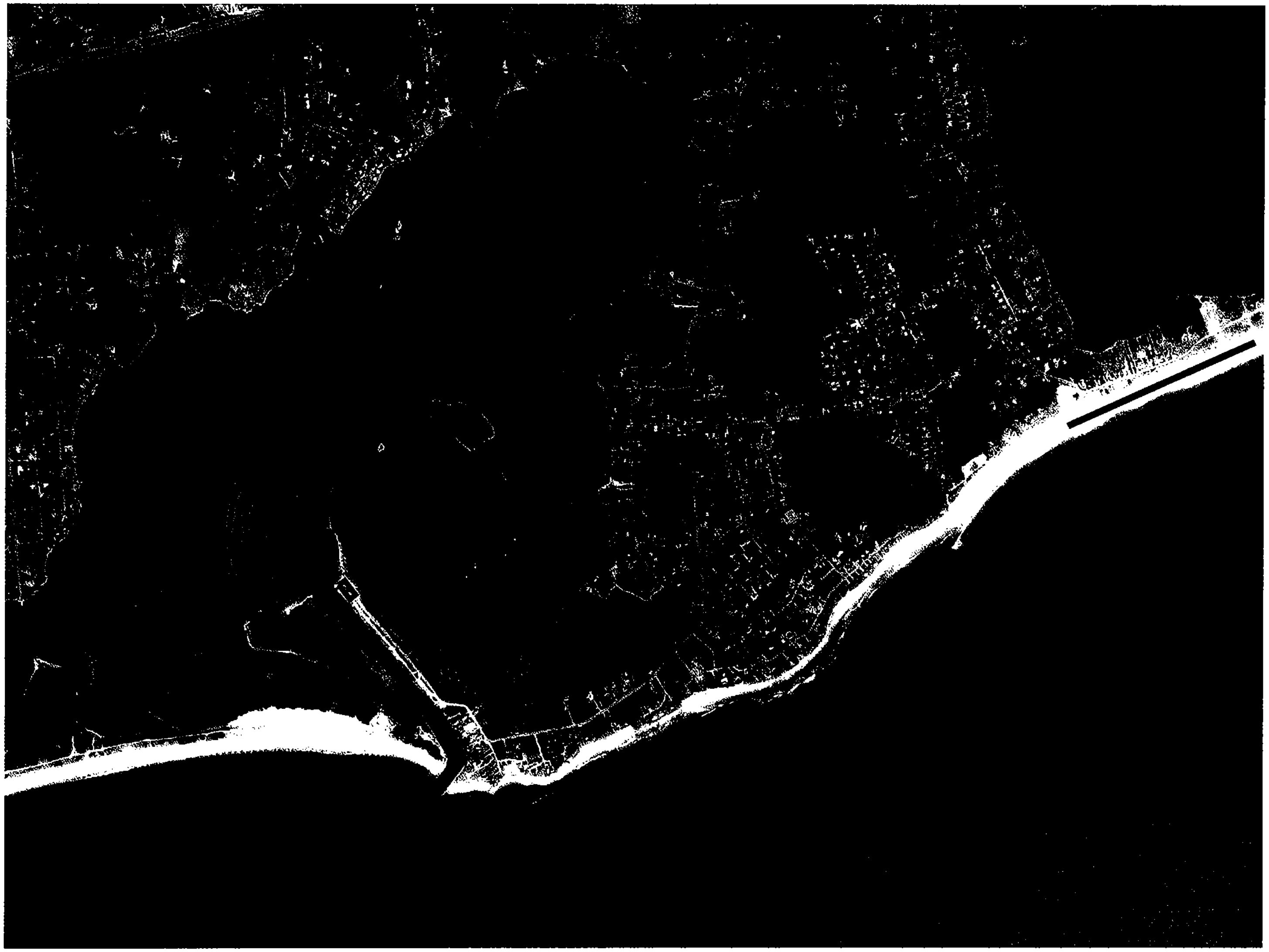


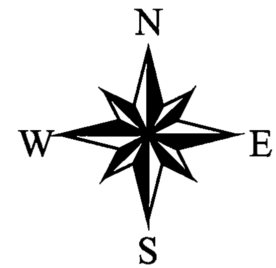
Figure 1
Rhode Island South Coast Feasibility Study
Location Map



Grid = NAD83 State Plane, Feet

Rhode Island South Coast
Feasibility Study
Ninigret Pond

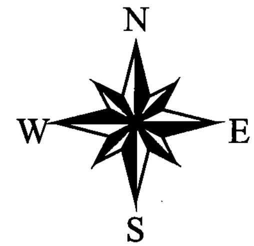




Eelgrass Restoration Sites
Sedimentation Basin
Potential Disposal Areas
Potential Dewatering Site

Grid = NAD83 State Plane, Feet

Rhode Island South Coast
Feasibility Study
Quonochontaug Pond



- Eelgrass Restoration Sites
- Sedimentation Basin
- Potential Disposal Areas
- Potential Dewatering Site

Grid = NAD83 State Plane, Feet

Rhode Island South Coast
Feasibility Study
Winnapaug Pond