

**ADDENDUM TO
MARINE GEOPHYSICAL SURVEYS:
SEISMIC REFRACTION, SUB-AQUEOUS
DISPOSAL CELL FEASIBILITY STUDIES,
UPDATED DATA AND MODEL REVISION**

**NEW BEDFORD HARBOR
New Bedford, Massachusetts**

Prepared for:

**Massachusetts Coastal Zone Management Agency
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Submitted by:

Maguire Group Inc.



July 2003

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Prepared for:

Maguire Group Inc.



Prepared by:

**Apex Environmental, Inc.
Boston, Massachusetts**

July 2003

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INTRODUCTION

This "Addendum to Marine Geophysical Surveys: Seismic Refraction, Sub-aqueous Disposal Cells Feasibility Studies -- Updated Data and Model Revision, New Bedford Harbor" was prepared by Apex Environmental, Inc. (Apex) for The Maguire Group, Inc. (Maguire). Apex is supporting Maguire in its completion of feasibility studies concerning proposed Confined Aquatic Disposal (CAD) cells in New Bedford Harbor for The Massachusetts Coastal Zone Management (MACZM). MACZM is assessing the feasibility of locating a CAD cell or cells in New Bedford Harbor in order to alleviate the shortage of permanent dredge spoils disposal sites in the area under a comprehensive Dredged Material Management Plan (DMMP). Two discrete areas of interest within New Bedford Harbor are being evaluated as potential CAD sites: the Popes Island North Area, located northeast of Popes Island in New Bedford Harbor; and the Channel Inner Area, located north of Palmer Island in the lower portion of New Bedford Harbor (See Figure 1).

The initial geophysical investigation entitled "Marine Geophysical Surveys: Seismic Refraction, Sub-aqueous Disposal Cells Feasibility Studies, New Bedford Harbor-2001", was undertaken to provide information and data on the topography and character of the bedrock surface within the survey area. This report is an addendum to the 2001 investigation, and describes the methodology of merging additional geotechnical boring information into updated bedrock models, and the re-calculation of the capacity of the proposed CAD cells.

Seismic Refraction Background

Marine geophysical data was collected in two separate areas: Popes Island North Area, located north of Popes Island in the middle portion of New Bedford Harbor; and the Channel Inner Area, located northwest of the hurricane dike within the lower portion of New Bedford Harbor. These two areas represent the potential locations of the Confined Aquatic Disposal (CAD) cells proposed under MACZM's DMMP. Apex collected the initial seismic refraction data over the proposed CAD cell locations from April 19th through May 11th, 2001. Data was collected across a total of 23 seismic refraction spreads (or lines) in the two areas. Ten refraction spreads were collected in the Popes Island North Area, and thirteen spreads in the Channel Inner Area. Each refraction spread was collected utilizing a 48-channel seismograph (data was collected from 48 hydrophones deployed on the harbor bottom simultaneously), with a nominal hydrophone spacing of 30 feet, such that each spread measured approximately 1,410 feet in length. (Details of the data collection and processing techniques utilized for the 2001 investigation can be found in section 2 of Apex's initial report entitled "*Marine Geophysical Surveys: Seismic Refraction, Sub-aqueous Disposal Cell Feasibility Studies, New Bedford Harbor, 2001.*")

Small seismic charges were emplaced into the sediment of the harbor bottom to provide seismic energy. The charges were set off, and a digital seismograph recorded the resulting voltage generated by each hydrophone on the harbor bottom. The voltage is displayed as a "wiggle trace" (or waveform) for each channel. The "wiggle trace" voltage fluctuations were recorded with respect to the time (in milliseconds) after the seismic shot was initiated. Selected example seismograph records are included in Appendix A. The computer program "SIP2" (Seismic Interpretation Program - Version 2) was utilized to enhance and filter the raw seismogram records.

Time vs. Distance plots (See Illustration 1) were created using the SIP program. These graphs are a plot of the time taken for energy to reach each hydrophone along the "seismic array" and are used to determine the number of layers (apparent in the data). Layer numbers were then assigned to the various layer segments interpreted from the "Time vs. Distance" plots - these layer numbers form the basis on which the model calculates the seismic velocities that it uses in the production of the resultant "depth

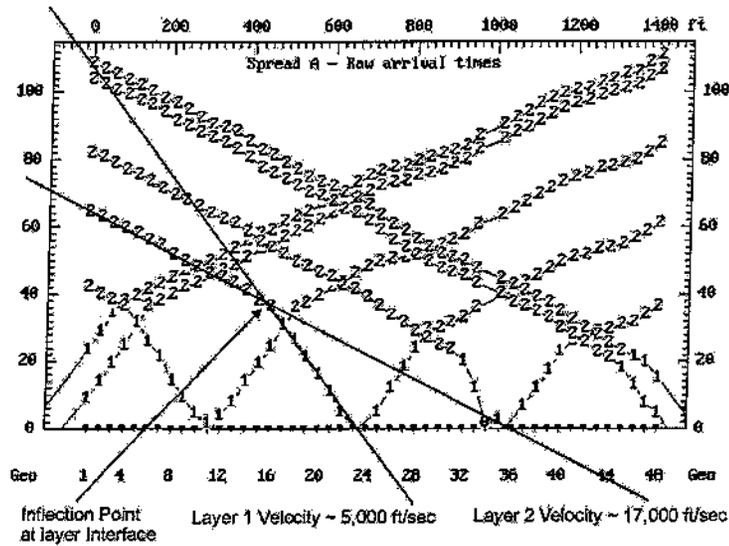


Illustration 1
Time-Distance Plot Example

Structure of the Report Presentation

This report summarizes the information obtained during this additional phase of the geophysical model preparation. This phase involved the merging of additional Phase II geotechnical boring information with the original (2001) seismic refraction data in order to update the bedrock models and calculate the potential capacity of the proposed CAD cells. The revised models for both Popes Island North and Channel Inner Areas are presented in this report.

This report is organized by sections that provide a functional framework for the presentation of additional boring information and model refinements. The following provides an outline of the approach to the presentation of the information.

Section 1.0 (Introduction) Describes the contractual framework for the program and background information and a brief description of the means and methods by which the initial seismic refraction data was collected.

Section 2.0 (Methods) Describes the means and methods by which the Phase II geotechnical information was incorporated into the previously generated seismic refraction models.

Section 3.0 (Results) Describes the revised findings of the Seismic Refraction investigation and also includes a discussion of the maps generated as part of the additional seismic data reduction process.

Section 4.0 (Conclusions) presents the conclusions of the investigation, including an assessment of the potential volumes of the proposed CAD cells.

Section 5.0 presents the limitations of the program.

Section 6.0 provides a list of references cited throughout this report.

RE-INTERPRETATION AND ADDITION OF NEW INFORMATION

Calibration Data

The depth to bedrock information collected from two phases of geotechnical borings drilled in the harbor was used to calibrate the parameters utilized as inputs to the seismic models. The calibration of the Seismic Interpretation Program (SIP) models was an iterative process that involved changing the input parameters of layer velocities and "first pick" layer assignments until there was agreement with existing information (boring logs, other seismic model lines at crossing points, and other geophysical information). The calibration took as many as several dozen iterations to resolve all discrepancies, depending on the data particulars and the line location. The initial 2001 models were used to select the Phase II boring locations in order to provide the most beneficial bedrock elevation calibration data. The additional calibration points were selected based upon locations where seismic lines crossed within areas of low model confidence in order to take advantage of higher data density in those areas. Coincident line boring selection also allows the boring information to be used to calibrate more than one line. Calibration borings were also performed in areas that had the greatest change in elevation over a short distance in order to minimize the discrepancies within the models.

The Phase I geotechnical-drilling program was conducted between June 20 and July 13, 2001 and provided seven calibration points (NBH-1 through 7). These boring locations were used in the calibration of the initial model. The Phase II drilling program was conducted between October 15 – 23, 2002, providing an additional four calibration points (NBH-8 thru NBH-11), which were used for this re-interpretation.

Both Phase I & II geotechnical drilling programs were conducted with a barge mounted drill rig in the harbor. Samples of soil were collected during the drilling program using a split-spoon sampler. Rock-core samples were collected from the borings using a diamond-bit rock core barrel.

Data Re-Processing

Initial re-processing of the data was performed using the United States Geological Survey (USGS) seismic interpretation software "SIP" ('Seismic Interpretation Program'). This software is a standard processing software package recognized by the industry and has been used by the USGS for many of the seismic refraction applications completed by the government.

Data processing began as additional depth to bedrock information was made available. Initial depth-to-bedrock information was re-run using the final models from 2001 as a starting point. Based on the comparisons between the existing models and the new depth to bedrock elevation information gained through the 2002 drilling program, various lines were re-analyzed using the following steps:

1. From the bedrock elevation corrected data, "Time vs. Distance" (see Illustration 1) plots were created, allowing the interpreter to determine the number of layer responses (apparent in the data), which are used by the program to create "layer models".
2. Layer numbers were assigned to the various layer segments interpreted from the "Time vs. Distance" plots. These layer numbers form the basis on which the model calculates the seismic velocities that it uses in the production of the resultant "depth models".
3. SIP modeling was conducted using the above as input information, and resultant depth profiles were generated. Models were re-run adjusting the layer velocities until the resulting model was correctly calibrated to specific boring elevations. The velocity issues were studied in further runs of the modeling program, and the inconsistencies were rectified, as were errors

resulting from improper initial “picks” or elevation errors. A more detailed examination of the “Time vs. Distance” plots was completed to refine the models in both areas. Additional velocity calculations were utilized to help correct for (as well as to illustrate) potential fractures, high velocity zones (HVZ) and low velocity zones (LVZ). This information was inserted back in the SIP software in order to re-run partial lines (zeroing out particular phones) at the modified velocities. The resulting information, analyzed using the newly calculated differing velocities, were combined to produce a more accurate final seismic line. The approach utilized was an iterative process that involved the merging and interpretation of all lines into a single model in order to identify potential modeling problems.

Synthesis of Geophysics with Geotechnical Borings

The geophysical data from the Seismic Refraction program was processed and interpreted with historical geotechnical boring information as well as that collected in the Phase II geotechnical program. Where the seismic lines crossed directly over a boring location, the boring data was utilized to calibrate the depth of bedrock models generated as part of the seismic data processing.

Table 1. Geotechnical borings collected as part of this program were utilized in the calibration of the following seismic lines (See Figures 3 and 4 for locations).

Phase	Area	Boring ID	Bedrock Ele (NGVD29)	Line/Positions
I	Popes Island	NBH-1	-90.2 feet	Seismic Line 20 & 3
I	Popes Island	NBH-2	-63.8 feet	Seismic Lines 4 & 5
I	Popes Island	NBH-3	-61.7 feet	Seismic Lines 1, 2 & 7
I	Channel Inner	NBH-4	-58.5 feet	Seismic Line 11
I	Channel Inner	NBH-5	-48.1 feet	Seismic Lines 13 & 15
I	Channel Inner	NBH-6	-54.6 feet	Seismic Lines 16 & 19
I	Channel Inner	NBH-7	-62.7 feet	Seismic Lines 7, 18 & 21
II	Popes Island	NBH-8	-92.5 feet	Seismic Lines 5 & 7
II	Channel Inner	NBH-9	-49.0 feet	Seismic Lines 11 & 18
II	Channel Inner	NBH-10	-51.1 feet	Seismic Lines 14 & 22
II	Channel Inner	NBH-11	-62.2 feet	Seismic Lines 10 & 17

Additional historic boring information (Ebasco, 1988) was used in the contouring process to create the bedrock surfaces. However, this data was not used for direct calibration purposes because details of the data collection process were not known. Ebasco borings utilized are listed below.

- Boring BW-103 (-34 feet)
- Boring BW-104 (-39 feet)
- Boring BW-109 (-52 feet)
- Boring BW-110 (-72 feet)
- Boring BW-111 (-79 feet), and
- Boring BW-112 (-49 feet).

The calibrated seismic lines and selected borings were incorporated into a single interpretation of the bedrock surface (see Figures 3 and 4). The bedrock surface was created by integrating lines of bedrock elevation data (along the seismic profiles) with spot elevation data (from the selected borings listed above as well as elevations obtained from the calibration borings noted above), and gridding and contouring the resulting merged data set.

Data Interpretation

Interpretation of the data involved the refining of the models and comparison of the seismic data with calibration data until the most likely model (most reasonable interpretation of data) was found. The computer program Geosoft Oasis Montaj (Montaj) V 5.15, a data processing and analysis (DPA) system for earth science applications, was used to produce color-contoured maps for the project. The Montaj software was used to integrate the revised modeled bedrock elevation surface information and boring elevation into geo-referenced maps.

Data interpretation involved repeating many of the initial data processing steps described previously until the most appropriate best-fit model was generated. For some of the records, the "first breaks" of the seismic records were "re-picked", where the initial "first break" interpretation could be improved in order to achieve a better-fit model.

Another adjustment that was made during data interpretation was the modification of hydrophone layer assignments on the "Time vs. Distance" plots. These layer assignments form the basis upon which the model calculates seismic velocities which are used in the production of the resultant depth models. Changing the layer assignments revises the morphology of the model, both the shape and depth of interface.

RESULTS

Profiles generated from the data, using the subsurface modeling software package SIP2, indicated that the bedrock character in both areas of interest is irregular, and marked by undulations of the bedrock surface. The results of the re-interpretation of the refraction data are best conveyed as contoured surface maps of the bedrock as determined from the interpreted seismic data. Figures 2 and 3 depict the results of the seismic data interpretation for Popes Island and Channel Inner area respectively. The figures display the inferred top of bedrock surface as determined from the seismic refraction data as a color-coded contour elevation (referenced to NGVD29), in order to aid in the identification of trends in the surface (i.e., blue areas are deeper and red/pink/orange areas are shallower). The location of borings used to "calibrate" the seismic interpretations is also shown on these figures. The bedrock models were calibrated such that the elevation of bedrock, at any given line crossing, is within three feet at line intersection points.

The "highest" bedrock surface elevation noted in the Popes Island North Area is in the range of -28 feet (NGVD29). The "lows" in the bedrock topography, noted from the data within the possible CAD footprint are in the -95 foot range (NGVD29). The mean elevation of the bedrock surface in the Popes Island North area is -66 feet (NGVD29). (See Figure 2). The "highest" bedrock surface elevation noted in the Channel Inner Area is in the range of -35 feet (NGVD29). The "lows" in the bedrock topography, noted from the data within the possible CAD footprint are in the -66 foot range (NGVD29). The mean elevation of the bedrock surface in the Channel Inner area is -52 feet (NGVD29). (See Figure 3).

Model Confidence

Maps showing the seismic model confidence have been generated and are shown in Figures 4 and 5. These maps were constructed based on the quality of the raw data collected in the field and on issues inherent in the data such as LVZ and potential fracturing, which can reduce the accuracy of the velocities and corresponding depths.

Popes Island North Area

Data collected in the Popes Island North Area exhibited low "noise" and was of high quality. As a result, there is a high confidence in the modeled bedrock surface there. Adding to the confidence in this area is supporting seismic data northwest of the survey area (Foster Wheeler, 2001). There is an area on the western edge of the model which has been assessed a "moderate" confidence level, due in part to the deep bedrock and the changing harbor topography.

Channel Inner Area

Data collected in the Channel Inner Area had a large amount of inherent "noise" due to the many shipping and fishing businesses around the harbor front. Background noise was greatest on the western (New Bedford) side of the harbor, and affected the western extents of most seismic lines. Extremely shallow bedrock found in the southern portion of the study area added to the "noisy" or low quality data. Potential faulting or fracturing that trends north-south through the center of the area also affected seismic velocities and the models calculated using these velocities. Every effort was made to filter and compensate for the effects of LVZs on the models, but the amplitude and strength of the raw signal was severely diminished after passing through these zones. The Channel Inner Area confidence map (Figure 5) shows a moderate model confidence level on approximately the western ¼ of the survey area because of the uncertainties discussed above.

Volume Calculations

Utilizing cell configuration parameters provided by Maguire engineers, existing bathymetric information, and the results of the seismic refraction survey, Apex performed preliminary volume calculations for both the Popes Island North and Channel Inner Areas. Calculations were performed using a combination of US Army Corps of Engineers (USACE) (Conditions survey 1996) and Apex Environmental, Inc. (Post dredge survey State Pier Dredge Project, 2002) bathymetry data, and the revised 2002 seismic refraction bedrock surface elevation calculated as part of this program. In calculating the volume of each cell, a slope of 3:1 was assumed.

It should be noted that the bathymetry data obtained from the USACE was supplied to Apex as a subset of the shallowest soundings within a 1"=100' paper plot. As such this data provides only an approximate pre-engineering mudline surface. Possible artifacts or errors may also exist in the Seismic Refraction surface due to the contouring algorithms that extrapolate the data between successive survey lines. In order to account for these uncertainties, contingency volumes have been incorporated into the various volume estimates. The volume calculations completed for this program, along with the relevant contingency volumes, are presented in the subsections below.

Popes Island Area

Volumes were calculated using a proposed configuration of six cells in the Popes Island North Area (See Illustration 2). Cell 1 was designed for a capacity of 1.8 million cubic yards. Cells 2 through 6 were designed to accommodate approximately 50,000 cubic yards of material each. A separation distance of 100 feet was maintained between each of the cells. For the cell volume calculations, a bedrock "buffer" of 10 feet was assumed so that the base of the cells terminate in sediment material. There is an additional loss of cell volume since the upper four (4) feet of sediment in the Popes Island North Area is assumed to be contaminated and should be placed back into the cell taking up volume associated with the top four (4) feet of material. Additionally, a cap of four (4) feet of "clean" material will be placed on top, for a cell total of eight (8) feet of depth subtracted from the calculations for each cell. Table 2 below summarizes the calculations for the Popes Island North Area. Illustration 3 shows a graphical breakdown of the division of available volume and geological types.

Table 2. Volume Calculation summary for the Popes Island North Area CAD configuration shown in Illustration 2.

Cell	Average Bedrock Elevation	Average Bathymetric Elevation	Sediment Thickness	Available Dredge Depth	Total Dredged Volume	Total Storage Capacity
1	-75 ft	-8 ft	67 ft	57 ft	2,275,000 CY	1,841,000 CY
2	-50 ft	-6 ft	44 ft	34 ft	82,375 CY	48,100 CY
3	-54 ft	-8 ft	46 ft	36 ft	83,800 CY	49,500 CY
4	-57 ft	-9 ft	48 ft	38 ft	84,950 CY	50,700 CY
5	-58 ft	-9 ft	47 ft	39 ft	65,450 CY	51,200 CY
6	-57 ft	-8 ft	49 ft	39 ft	85,450 CY	51,200 CY

Average Bedrock Elevation – Average Bathymetric Elevation = Sediment Thickness

Sediment Thickness – Bedrock buffer (10-feet) = Available Dredge Depth

Total Dredged volume = Available Dredge Depth X (length and width of cell) using 3:1 slope

Total Storage Capacity = Total Volume dredge – (top 4-foot contaminated material)

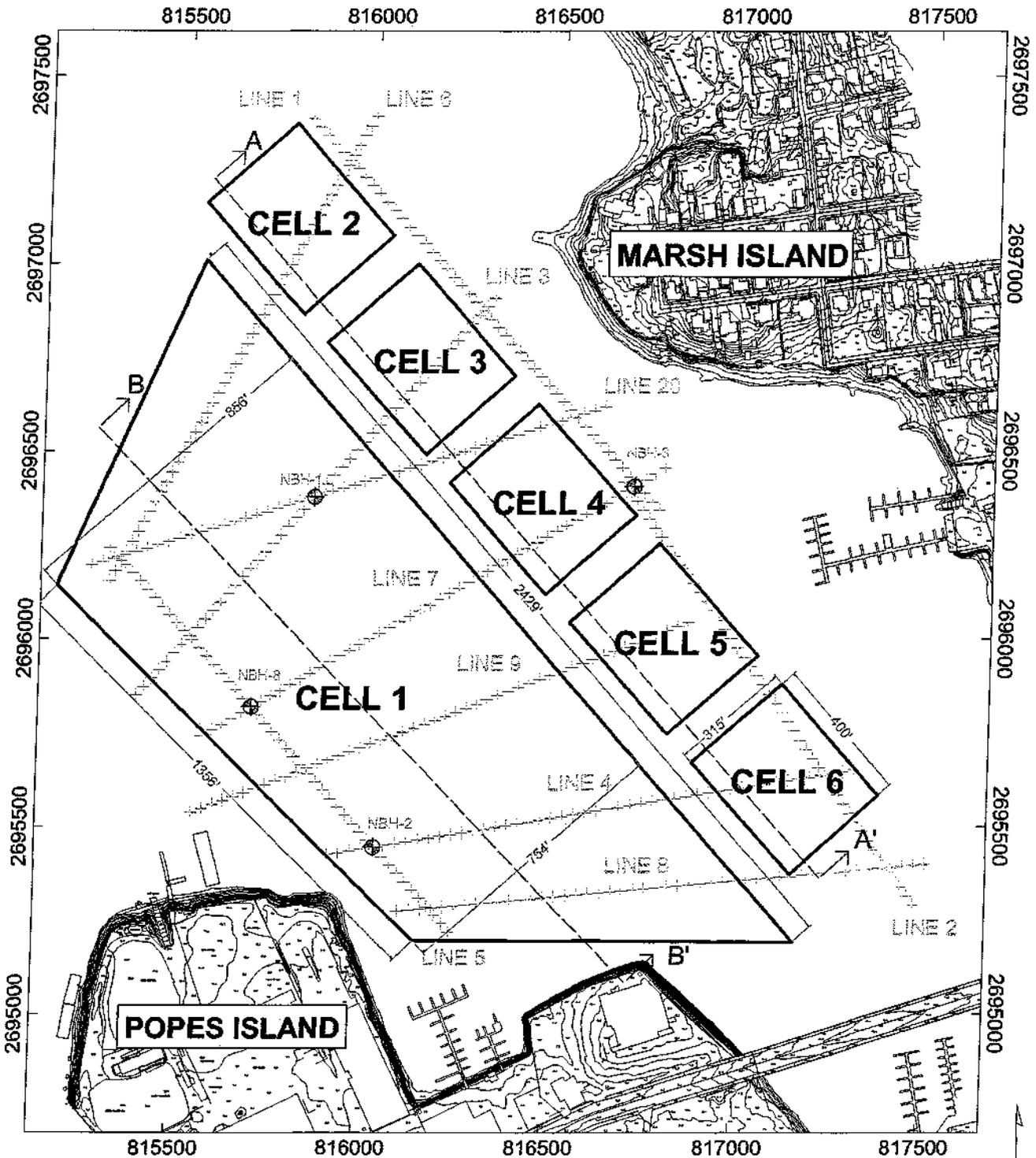
Table Assumptions:

- All volumes were calculated as Volume-Of-the-Void (VOV) and do not take into account sediment properties (i.e. bulking, etc.). The volumes are approximate, and are based on average elevations within each proposed cell.
- **Average Bedrock Elevations** were calculated using Oasis Montaj V5.16 minimum curvature model of the bedrock surfaces within each of the proposed CAD cells. A mathematical modeling cell size of 12 was maintained to construct the minimum curvature model of the bedrock surface.
- **Average Bathymetric Elevations** were calculated in a manner similar to the Average Bedrock Elevations, utilizing the USACE bathymetric data 1997 and a mathematical cell size of 8.
- **Sediment Thickness** was calculated by subtracting Bathymetric/Mud line Elevation from the Bedrock Elevation.
- **Available Dredge Depth** is the depth of material excavated in order to leave a 10-foot buffer so that the proposed CAD cell terminates in sediment material above modeled bedrock. The available dredge depth can also be thought of as the depth of material to the bottom of the proposed CAD cell.
- **Total Volume Dredged** is the amount of material needed to be removed to form the proposed CAD cell given the average dredge depth and assuming a 3:1 (H:V) side slope for each cell.
- **Total Storage Capacity** is the final volume after disposing of the top 4-feet of "contaminated" material back into the cell and allowing for the 4-feet of clean cap material.

Cross Section Profiles –Popes Island North Area

Stratigraphic cross sections were extracted from profile cuts through proposed CAD Cells 2 – 6 (A-A') and CAD Cell 1 (B-B' in the Pope Island North Area). The locations of the cross sections are shown on Illustration 2. The cross sections are presented in Illustrations 4 (A-A') and 5 (B-B'). The cross sections were constructed by digitizing the modeled bedrock surface and the bathymetric surface over the length of the profile. Boring information collected as part of the project was extrapolated to the profile center line to depict the types and thickness of geology encountered.

Illustration 2 Popes Island Area Proposed CAD Cell Configuration



LEGEND

- PROPOSED CELL EXTENT
- HYDROPHONE LOCATION
- BORING LOCATION
- CROSS SECTION LOCATION

Scale 1:4800

250 0 250

US survey foot

NAD83(CSRS98) / Massachusetts CS83 Meiland zone

NOTES:

1. Base Plan of the New Bedford harbor area was obtained from the US Army Corps of Engineers and has not been field verified.
2. Coordinates are shown in the State Plane Coordinate System, Massachusetts Meiland Zone 2001, Referenced to the 1983 North American Datum (NAD83). Vertical Datum referenced to NGVD23.
3. Boring information and position supplied by The Maguire Group.

REV.	DESCRIPTION	BY	DATE

ILLUSTRATION 2

POPES ISLAND NORTH AREA - CELL CONFIGURATION
SEISMIC REFRACTION - 2002 REVISED MODEL

MIDDLE NEW BEDFORD HARBOR
BRISTOL COUNTY, NEW BEDFORD, MASSACHUSETTS

374 Deane St.
Suite 200
Bristol, MA 02520
617-729-0070

Apex

SCALE 1" = 400'

DRAWN	DESIGN	CHECKED	PAIRED
TOM	TOM	JAB	

SHEET 1 OF 1

HARBOR BOTTOM

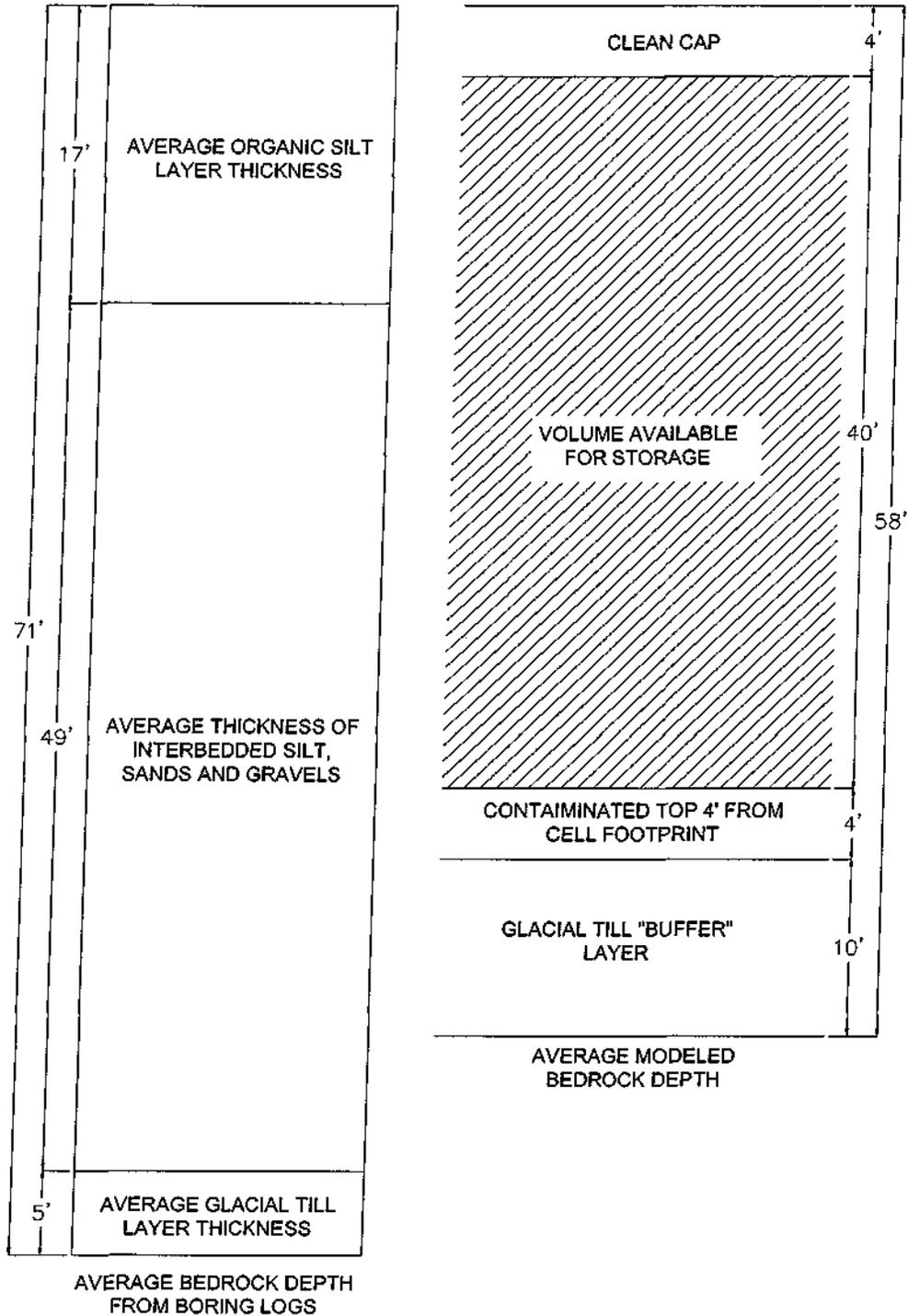
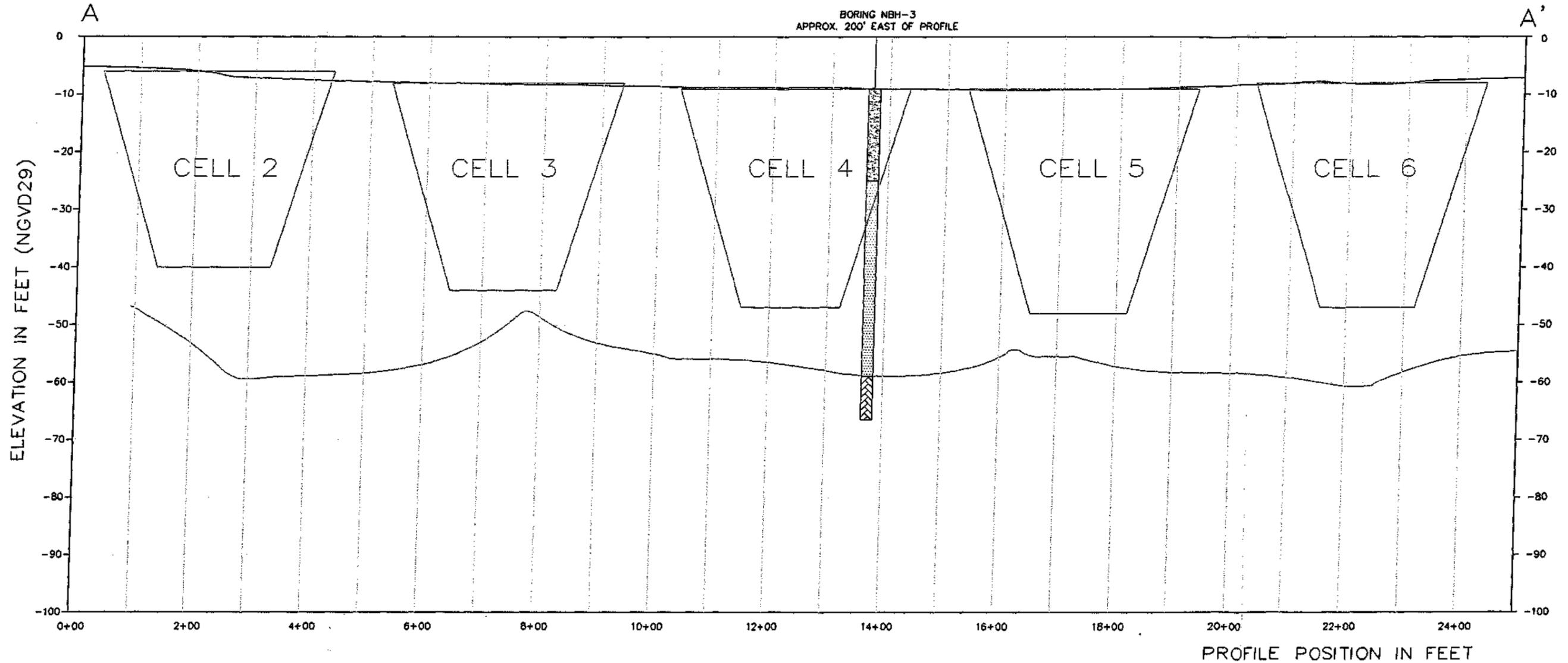


Illustration 3

Breakdown of the division of available storage capacity and an average geological cross section from the borings conducted in the Popes Island Area.

Illustration 4 Popes Island Area Cross Section Profile A-A'

PROFILE - A-A'



PROFILE LEGEND

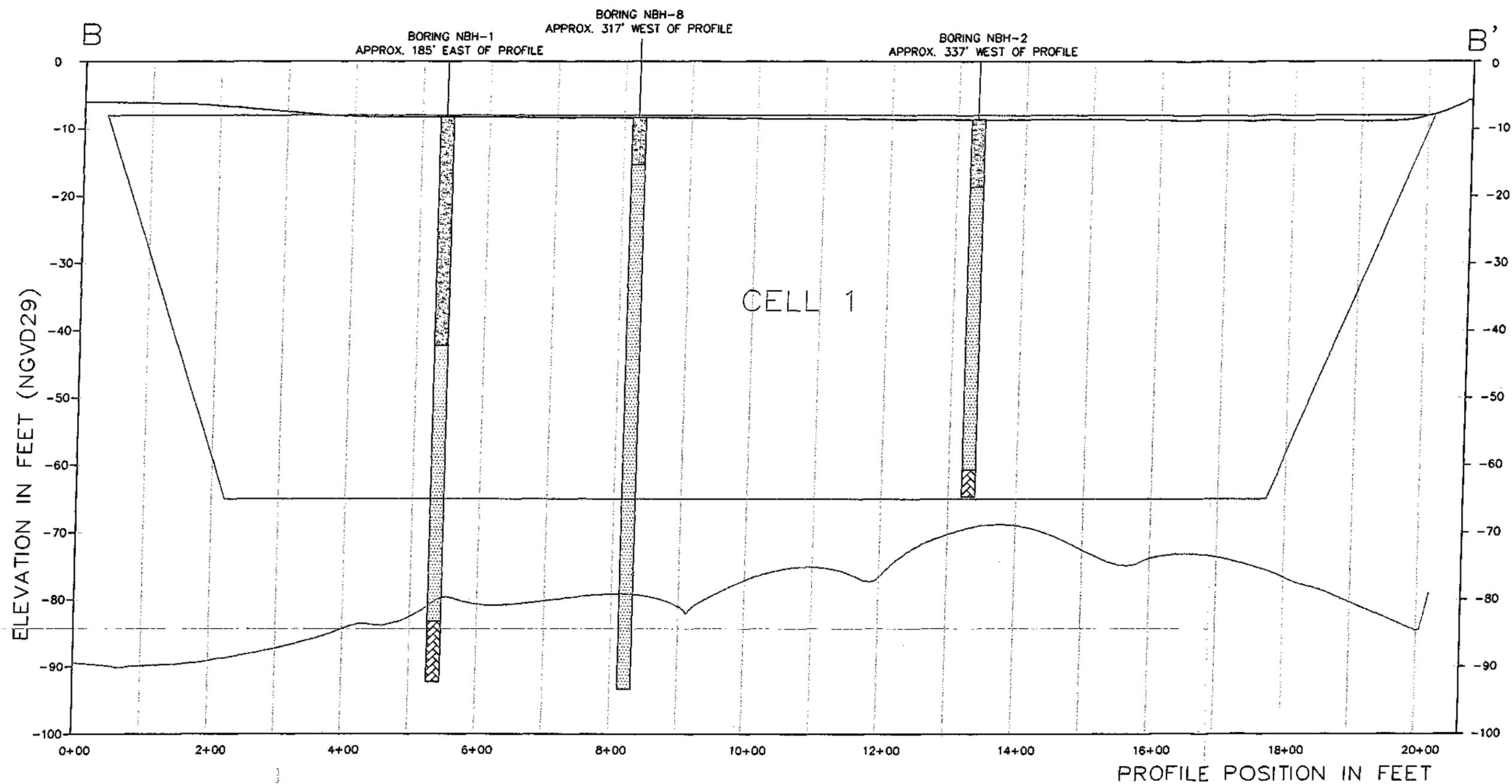
<ul style="list-style-type: none"> ————— EXISTING MUDLINE ELEVATION ————— MODELED BEDROCK SURFACE ————— EXTRAPOLATED BORING LOCATION ————— PROPOSED CAD CELL EXTENT 	<ul style="list-style-type: none"> ORGANIC SILT INTERBEDDED: SILTS, SAND AND GRAVELS GLACIAL TILL
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ILLUSTRATION 4 POPES ISLAND PROFILE A-A'.

Stratigraphic cross section was extracted from a profile cut through proposed CAD Cells 2 - 6 (A-A'). The cross section digitizes the modeled bedrock surface and the bathymetric surface over the length of the profile shown on Illustration 2. Proposed CAD cells used in the volume calculations are also shown utilizing the proposed 3:1 side slopes. Boring information collected as part of the project is extrapolated to the profile center line to depict basic geological units encountered.

Illustration 5 Popes Island Area Cross Section Profile B-B'

PROFILE - B-B'



PROFILE LEGEND

- | | |
|---|---|
| <ul style="list-style-type: none"> ————— EXISTING MUDLINE ELEVATION ————— MODELED BEDROCK SURFACE ————— EXTRAPOLATED BORING LOCATION ————— PROPOSED CAD CELL EXTENT | <ul style="list-style-type: none"> ORGANIC SILT INTERBEDDED: SILTS, SAND AND GRAVELS GLACIAL TILL |
|---|---|

ILLUSTRATION 5 POPES ISLAND PROFILE B-B'

Stratigraphic cross section was extracted from a profile cut through proposed CAD Cell 1 (B-B'). The cross section digitizes the modeled bedrock surface and the bathymetric surface over the length of the profile shown on Illustration 2. Proposed CAD cells used in the volume calculations are also shown utilizing the proposed 3:1 side slopes. Boring information collected as part of the project is extrapolated to the profile center line to depict basic geological units encountered.

Channel Inner Area

After investigating the potential storage volume within the Channel Inner Area, it is apparent that the shallow bedrock and general location of the proposed cell may severely limit the potential capacity in this area. Volumes were calculated assuming three cells in the Channel Inner Area (See Illustration 7). All Cells were designed to accommodate approximately 50,000 cubic yards of material. A separation distance of 100-feet was maintained between each of the cells. Illustration 6 shows the cell configuration.

For the cell volume calculations, a bedrock "buffer" of 10 feet was assumed so that the base of the cells terminate in sediment material approximately 10-feet higher than modeled bedrock. There is an additional loss of cell volume since the upper four (4) feet of sediment in the Popes Island North Area is assumed to be contaminated and should be placed back into the cell taking up volume associated with the top four (4) feet of material. Additionally, a cap of four (4) feet of "clean" material will be placed on top, for a cell total of eight (8) feet of depth subtracted from the calculations for each cell.

In addition, the proposed CAD cells are located within the federal channel and associated maneuvering /anchorage area. In order to account for future dredging activities, which may disturb the "clean" material cap, an additional contingency of three (3) feet was assumed. This additional contingency is expected to be either an additional cap thickness of 3-feet, or a depressed surface (i.e. leaving the final grade 3-feet below required depths). This extra compensation was added to protect the cap from being dredged as part of on going maintenance dredging during normal harbor/port operations. Illustration 7 below shows an estimate of the division of the available volume for the Channel Inner Area. Table 3 below summarizes the calculations for the Channel Inner Area.

Table 3. Volume Calculation summary for the Channel Inner Area CAD configuration shown in Illustration 6.

Cell	Average Bedrock Elevation	Average Bathymetric Elevation	Sediment Thickness	Available Dredge Depth	Total Dredged Volume	Total Storage Capacity
1	-57 ft	-31 ft	26 ft	16	213,000 CY	48,500 CY
2	-57 ft	-31 ft	26 ft	16	213,000 CY	48,500 CY
3	-58 ft	-28 ft	30 ft	20	111,900 CY	55,750 CY

Average Bedrock Elevation – Average Bathymetric Elevation = Sediment Thickness

Sediment Thickness – Bedrock buffer (10-feet) = Available Dredge Depth

Total Dredged volume = Available Dredge Depth X (length and width of cell) using 3:1 slope

Total Storage Capacity = Total Volume dredge – (top 4-foot contaminated material)

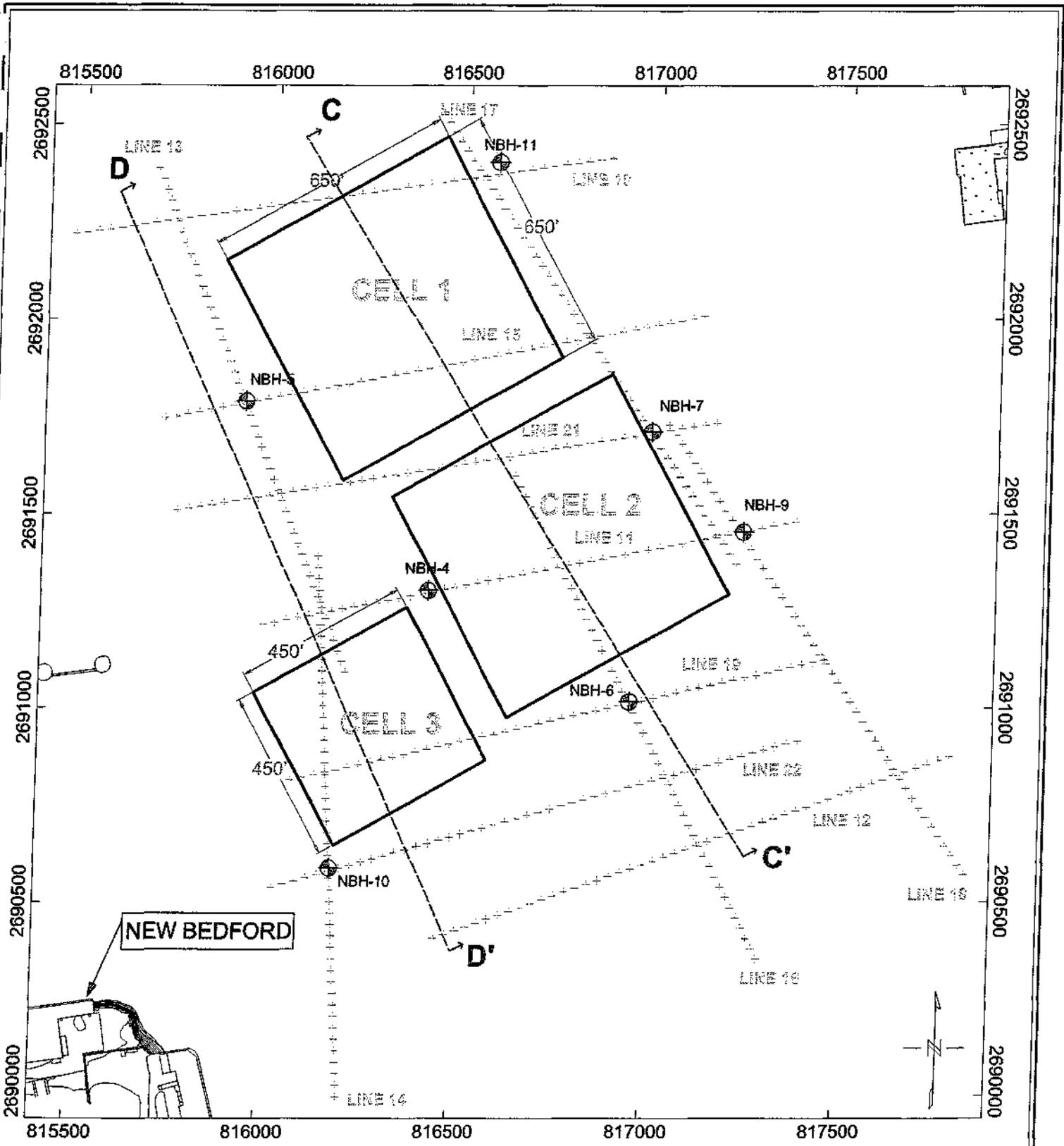
Table Assumptions:

- All volumes are calculated as Volume of the Void (VOV) and do not take into account sediment properties (i.e. bulking, etc.). The volumes are approximate, and are based on average elevations within each proposed cell.
- **Average Bedrock Elevations** were calculated using Oasis Montaj V5.16 minimum curvature model of the bedrock surfaces within each of the proposed CAD cells. A mathematical modeling cell size of 12 was maintained to construct the minimum curvature model of the bedrock surface.
- **Average Bathymetric Elevations** were calculated similarly to the Average Bedrock Elevations using the USACE bathymetric data 1997 and a mathematical cell size of 8.

- **Sediment Thickness** was calculated by subtracting Bathymetric/Mud line Elevation from the Bedrock Elevation.
- **Available Dredge Depth** is the depth of material excavated allowing the proposed CAD cell to terminate allowing a 10-foot sediment buffer between the bottom of the CAD cell and the bedrock surface. The available dredge depth can also be thought of as the depth of material to the bottom of the proposed CAD cell.
- **Total Volume Dredged** is the amount of material needed to be removed to form the proposed CAD cell given the average dredge depth and assuming a 3:1 (H:V) side slope for each cell.
- **Total Storage Capacity** is the final volume after disposing of the top 4-feet of “contaminated” material back into the cell and allowing for the 4-feet of clean cap material. A maintenance dredge contingency of 3-feet is also allowed for.

Cross Section Profiles – Channel Inner Area

Two Stratigraphic Cross Section were extracted from a profile cut through the Channel Inner Area proposed CAD cells 1 and 2 (C-C') and proposed CAD cell 3 (D-D'). Cross section locations can be seen in Illustration 6. Cross sections are shown on Illustration 8 and 9. The cross sections were constructed by digitizing the modeled bedrock surface and the bathymetric surface over the length of the profile. Boring information collected as part of the project was also extrapolated to the profile center line to depict the types and thickness of geology encountered.



NEW BEDFORD

LEGEND

- PROPOSED CELL EXTENT
- HYDROPHONE LOCATION
- BORING LOCATION
- CROSS SECTION LOCATION

NOTES:

1. Base Plan of the New Bedford harbor area was obtained from the US Army Corps of Engineers and has not been field verified.
2. Coordinates are shown in the State Plane Coordinate System, Massachusetts Mainland Zone 2001, Referenced to the 1983 North American Datum (NAD83). Vertical Datum referenced to NGVD29.
3. Boring information and position supplied by The Maguire Group.

Scale 1:4200



US survey foot
NAD83 / Massachusetts CS83 Mainland zone

REV.	DESCRIPTION	BY	DATE
1	MOD CAD CONFIGURATION	TDM	06/23/05

ILLUSTRATION 6
CHANNEL INNER AREA
SEISMIC REFRACTION - REVISED MODEL

LOWER NEW BEDFORD HARBOR
BRISTOL COUNTY, NEW BEDFORD, MASSACHUSETTS

Apex
geotechnical, inc.

374 Congress St
Bristol, MA 02210
617 728-0070

SCALE:	DRAWN:	DESIGN:	CHECKED:	PROJECT# 621061.D1
	TDM	TDM	JAS	

HARBOR BOTTOM

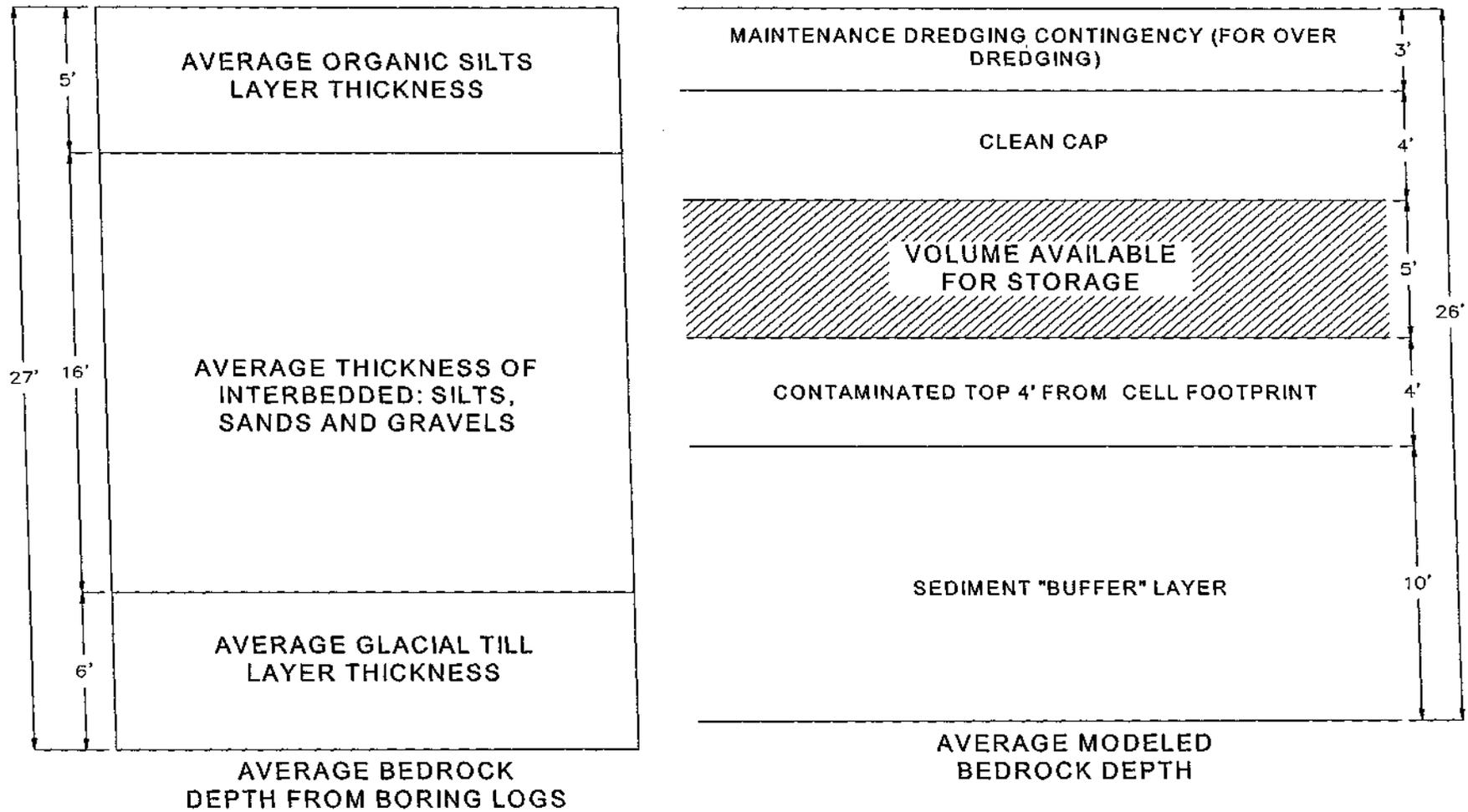
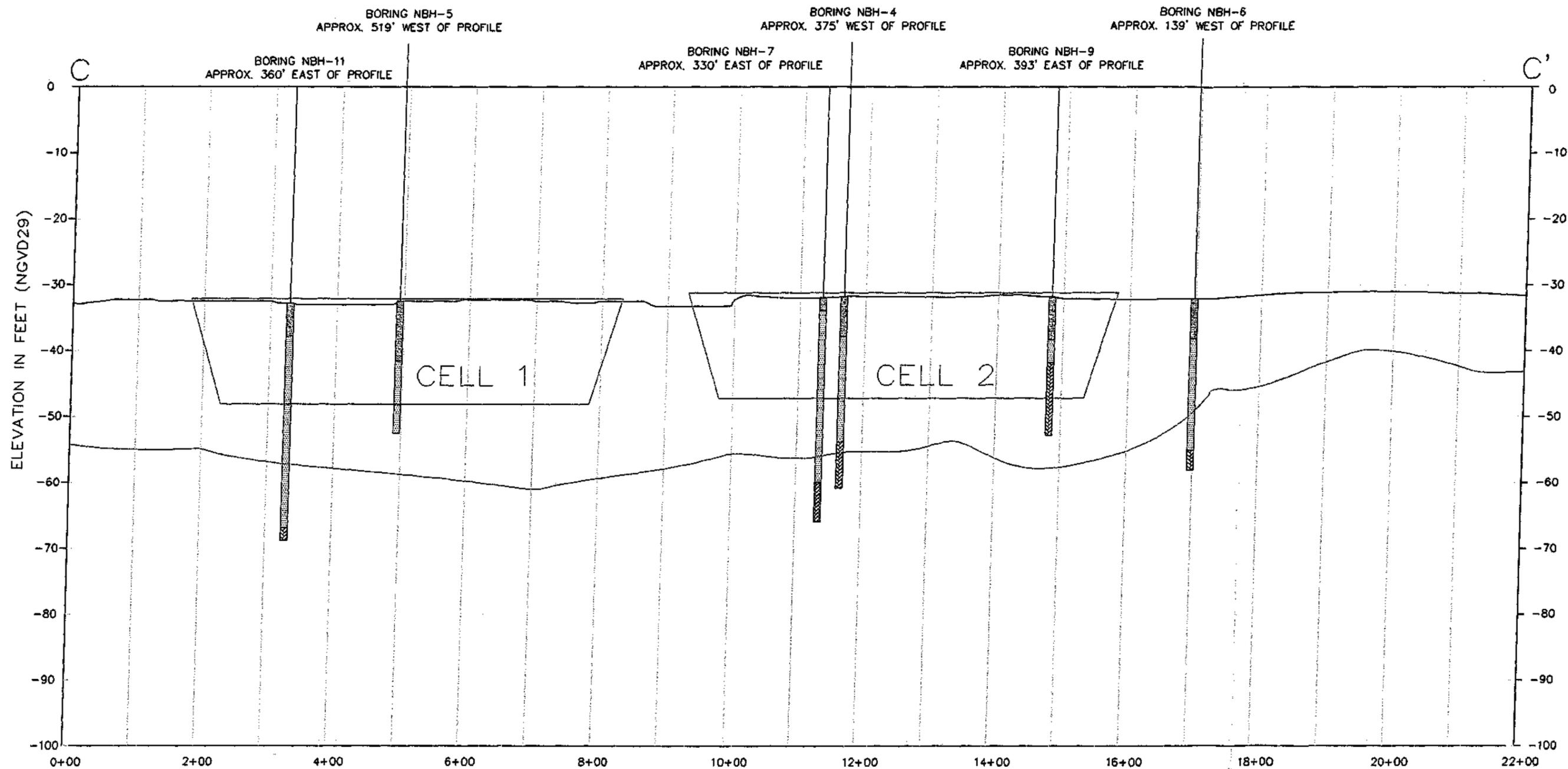


Illustration 7

Breakdown of the division of available storage capacity and average geological cross section as seen in the borings conducted in the Channel Inner Area

Illustration 8 Channel Inner Area Cross Section Profile C-C'

PROFILE - C-C'



PROFILE LEGEND

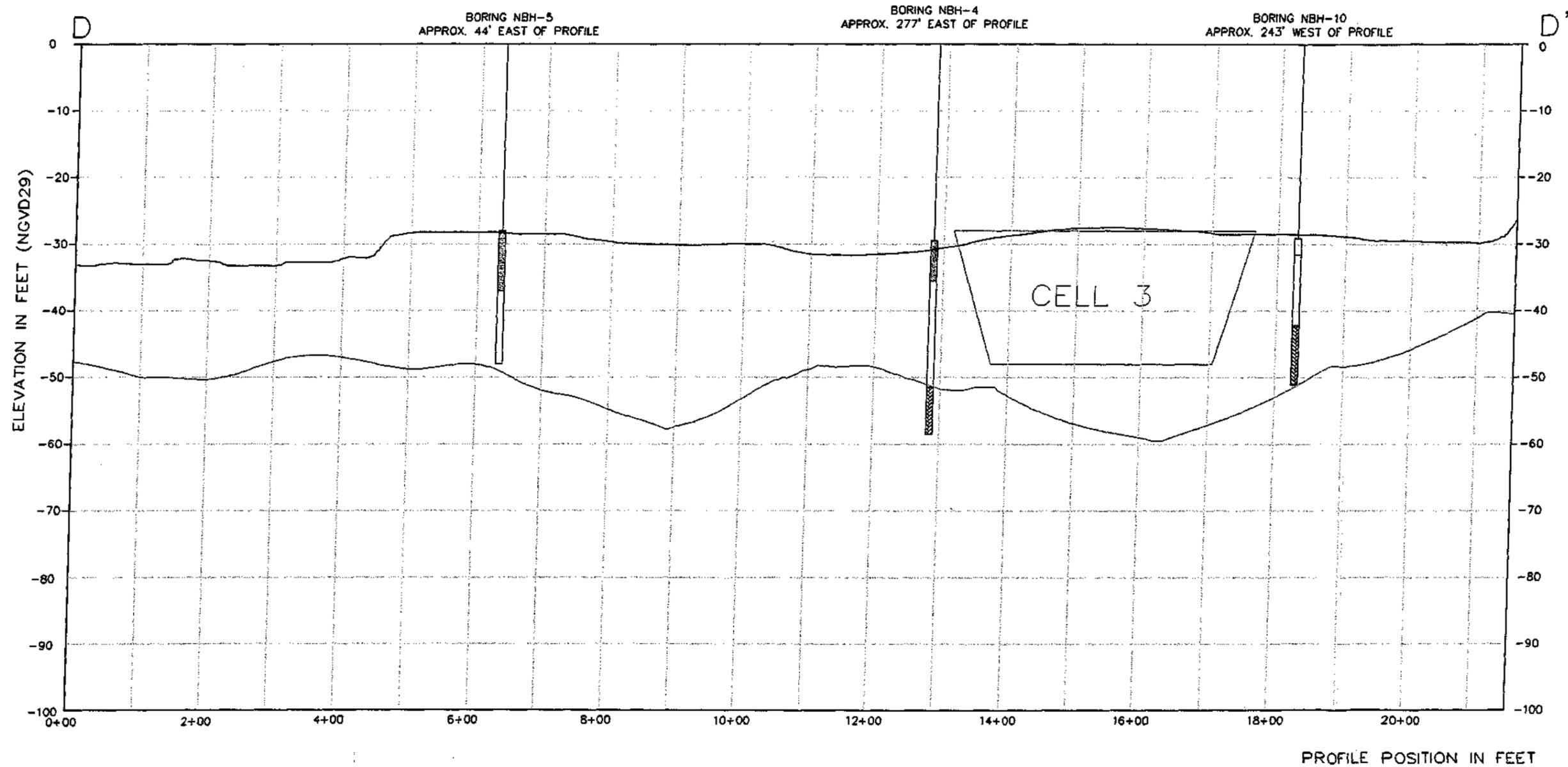
- | | |
|---|---|
| <ul style="list-style-type: none"> EXISTING MUDLINE ELEVATION MODELED BEDROCK SURFACE EXTRAPOLATED BORING LOCATION PROPOSED CAD CELL EXTENT | <ul style="list-style-type: none"> ORGANIC SILT INTERBEDDED: SILTS, SAND AND GRAVELS GLACIAL TILL |
|---|---|

ILLUSTRATION 8 CHANNEL INNER AREA PROFILE C-C'.

Stratigraphic cross section was extracted from a profile cut through proposed Channel Inner Area CAD Cells 1 and 2 (C-C'). The cross section digitizes the modeled bedrock surface and the bathymetric surface over the length of the profile shown on Illustration 6. Proposed CAD cells used in the volume calculations are also shown utilizing the proposed 3:1 side slopes. Boring information collected as part of the project is extrapolated to the profile center line to depict basic geological units encountered.

Illustration 9 Channel Inner Area Cross Section Profile D-D'

PROFILE - D-D''



PROFILE LEGEND

<ul style="list-style-type: none"> — EXISTING MUDLINE ELEVATION — MODELED BEDROCK SURFACE — EXTRAPOLATED BORING LOCATION — PROPOSED CAD CELL EXTENT 	<ul style="list-style-type: none"> ORGANIC SILT INTERBEDDED: SILTS, SAND AND GRAVELS GLACIAL TILL
---	---

ILLUSTRATION 9 CHANNEL INNER AREA PROFILE D-D'.

Stratigraphic cross section was extracted from a profile cut through proposed Channel Inner Area CAD Cell 3 (D-D'). The cross section digitizes the modeled bedrock surface and the bathymetric surface over the length of the profile shown on Illustration 6. Proposed CAD cells used in the volume calculations are also shown utilizing the proposed 3:1 side slopes. Boring information collected as part of the project is extrapolated to the profile center line to depict basic geological units encountered.

CONCLUSIONS

Seismic refraction models were re-interpreted utilizing additional boring information obtained in a recent boring program to construct the new revised bedrock models.

Models generated by the re-interpretation of the data collected in the initial field program indicate that the bedrock character in both areas of interest is irregular and small adjustments have been made to refine the existing models.

Popes Island Area

The shallowest bedrock encountered in the seismic data was -31 feet on Lines 1 and 6 at the northeastern end of the survey area. This is within approximately 500 feet of where bedrock outcrops on Marsh Island. The deepest bedrock, at -93 feet, is found at the farthest northwestern edge of the survey area where lines 5, 6 and 20 meet. The thickness of sediment above modeled bedrock varies from between 24 - 86 feet, with an average of 58 feet. A possible relict bedrock channel trending northwest to southeast runs through the middle of the survey area. This lineal feature is approximately 250 to 300 feet wide and runs through the study area from northwest to southeast. At its deepest point, the bedrock channel may extend below -90 feet NGVD29. This channel inference is further supported by bedrock surface elevation data to the northeast of the survey area collected by another contractor (Foster Wheeler, 2001) in a report submitted to the USACE. In some places the bedrock elevation varies by as much as 36-feet of elevation change over 120-feet of lateral change (or approximately a 25% slope), indicating that there is some relatively steep bedrock topographic variation within the possible CAD footprint.

Channel Inner Area

The shallowest bedrock encountered in the seismic data was -36 feet on Lines 14 and 16 at the southern end of the survey area. This is within approximately 1100 feet north of where bedrock outcrops on Palmer Island. The deepest bedrock, at -65 feet, is found in the center of the survey area at line 16. The thickness of sediment over bedrock varies between 3 and 39 feet, with an average thickness of 22 feet. This average sediment thickness was used in the volume estimates of the area. Due to construction requirements, there is a limited capacity for a potential CAD cell in this area. The presence of several "Low Velocity Zones" (or "LVZs") was noted on several seismic lines in this area. These anomalies in the data occur at locations where the velocity of the energy wave traveling through the bedrock material is locally reduced, usually because the bedrock is fractured or severely weathered in that zone. LVZs are often indicators of faulted or severely fractured bedrock, and the locations of the LVZs noted in the data during this study are shown in Figure 3. These areas of possible fracturing were further supported by information on rock quality (RQD) obtained in borings at or near to these zones. For example boring NBH-7, in which nine feet of weathered rock was recovered, exhibited 33% RQD values. It should be noted that data in the LVZs may be subjectively interpreted, as the actual velocity within such a zone can only be determined relatively, and can vary dramatically depending upon the material, the amount of fracturing, and the amount of weathering.

In the Channel Inner Area, the presence of LVZs imply that a northeast-southwest trending fracture zone and two north-south trending fracture zones may cross in this area. These fracture zones are evident in the Time-Distance plots for most of the east-west refraction spreads (lines 10, 11, 12, 15, 16, 17, 19, 21 and 22). Fracturing in the rock is made evident on Time-Distance plots as a time offset in the linear normal move-out of first breaks. An example of a Time-Distance plot showing the effects of fracturing is shown below in Illustration 10. In areas of fracturing, void spaces or sediment filled fractures (or even highly weathered rock) create a localized Low Velocity Zone (LVZ). Within these zones, the seismic velocity is much slower than that of the surrounding material. Because Seismic Refraction utilizes time

and distance measurements to calculate bedrock geometry, data that contains LVZ's will tend to imply that a bedrock surface is lower than it actually is (increase in time at a fixed velocity increases distance by the geometric relation $T=d/v$).

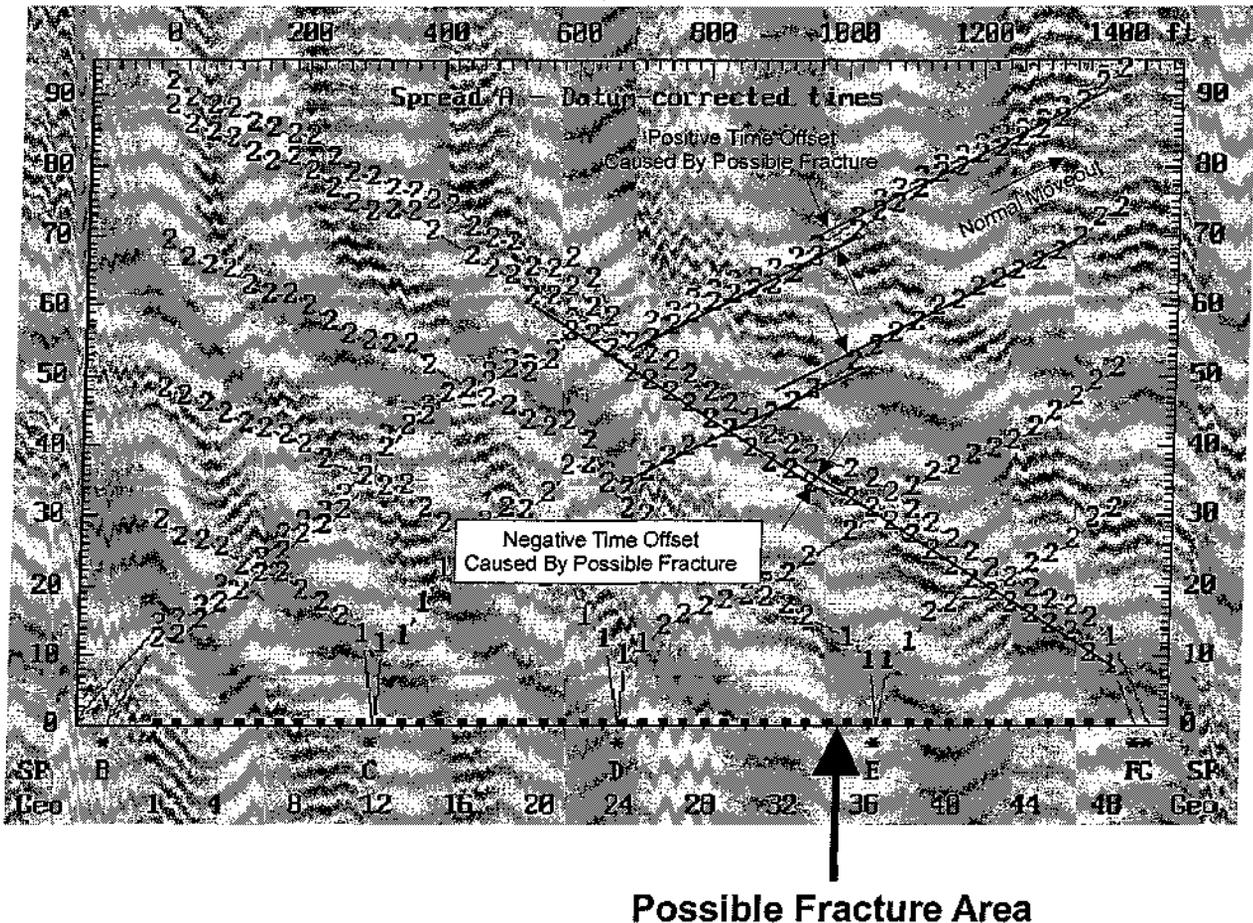


Illustration 10.
Time-Distance Plot Showing Areas of Possible Fracturing

In order to refine the thickness of contaminated organic silts to be deposited back into the proposed CAD cells a sub-bottom profiler survey could be utilized. The sub-bottom profiler uses high frequency seismic reflection to image stratigraphic interfaces such as those between organic silts and interbedded silts, sands and gravels. A survey using a similar approach was attempted within the harbor to help and identify depth to bedrock but was unsuccessful due to large amounts of reflective gasses. However, it is anticipated that a focused high resolution program is likely to yield the results necessary to define this layer, more accurately. By better defining this layer, a more accurate volume estimate can be achieved of the CAD cell parameters, which is expected, in turn, to yield a better overall design.

Summary

The Plan Map in Figure 6 is a depiction of the modeled total thickness of sediment within the two proposed CAD areas (Popes Island North & Channel Inner). As can be seen through a comparison of these two areas, there is limited sediment thickness (capacity) in the Channel Inner area. The average sediment thickness in the Channel Inner area is approximately 23 feet; with average water depths in the

area of approximately 30 feet. The Popes Island North area has an average sediment thickness of approximately 58 feet; while the bathymetric depths range between approximately 8-10 feet of water.

LIMITATIONS

The following limitations apply to all geophysical surveys conducted by Apex Environmental, Inc. its subsidiaries and subcontractors. Every attempt has been made to conduct this survey to maximize the quality of the data collected and the interpretations rendered. However, a geophysical investigation is an indirect method of subsurface exploration whereby subsurface characteristics are inferred or interpreted from measurements collected at the ground or water surface. Many variables may affect these measurements. Due to the indirect, interpretive nature of geophysics, findings are generally considered precursory and subject to verification by more direct methods of investigation such as test borings or test pits. The following limitations are considered when evaluating geophysical data:

1. Subsurface features can be interpreted from the appropriate geophysical methods only insofar as they produce a discernible geophysical signature. They must have adequate homogeneity, size, and appropriate physical or chemical properties sufficient to contrast with the surrounding medium and be within reasonable proximity to the sensors. Additionally, their signature must be distinguishable from and not masked by background noise or interference.
2. Lithologic data inferred on the basis of geophysical data may not be identical to geologic or hydrogeologic data. Lithologies are generally interpreted from some geophysical signature (e.g., velocity differences) that may be the result of many factors (including density, susceptibility, angle to the sensors, amount of weathering, etc.). Lithology divisions based upon seismic velocity for example may not necessarily be identical to lithology changes identified by drilling. The discrepancy is generally related to formation density and/or compaction (i.e., a dense till may have a higher density than a weathered bedrock, and the difference can be difficult to resolve with seismic data).
3. Complex geological configurations may be impossible to resolve with surface geophysical methods. The resolution of geophysical data is limited by the spatial geometry of sensors, strength of signal, and distance of the object or layer of interest from the energy source and the sensor array used. Resulting interpretations are rendered by modeling geophysical response to known or presumed geometric relationships. The complexity of the relationships that can be modeled is limited by the resolution allowed by the method and geometry of equipment layout used, and the limitations of the software used.
4. Apex is not responsible for data quality in areas having excessive "background noise" which affect the specific physical parameters of the subsurface that are being measured by a particular geophysical technique. Examples of background noise include: heavy traffic on a nearby roadway, which induces vibrational energy into the ground which in turn interferes with seismic data collection; heavy machinery (i.e., boat, sand-blaster, or torch) operation adjacent to or in the water near a marine seismic survey line; or underground utilities (such as electric lines, tunnels, sewers, etc.), which can interfere with seismic instrumentation.

No guarantee or warranty (other than that stipulated in the contract under which this work was promulgated), expressly stated or implied, is given concerning the data and interpretations rendered in this report. All information is presented as "for information only." Apex Environmental, Inc., its parent company or any subsidiary, is not liable for any losses resulting from the misuse, misrepresentation, or misinterpretation of any information presented in this report by any person or entity.

REFERENCES

Goldsmith, Richard, 1978, Geologic Map of the Fall River – New Bedford Area, Massachusetts, U.S. Geological Survey Open File Map 78-484, Department of the Interior, U.S. Geological Survey, publications center, Lakewood, CO.

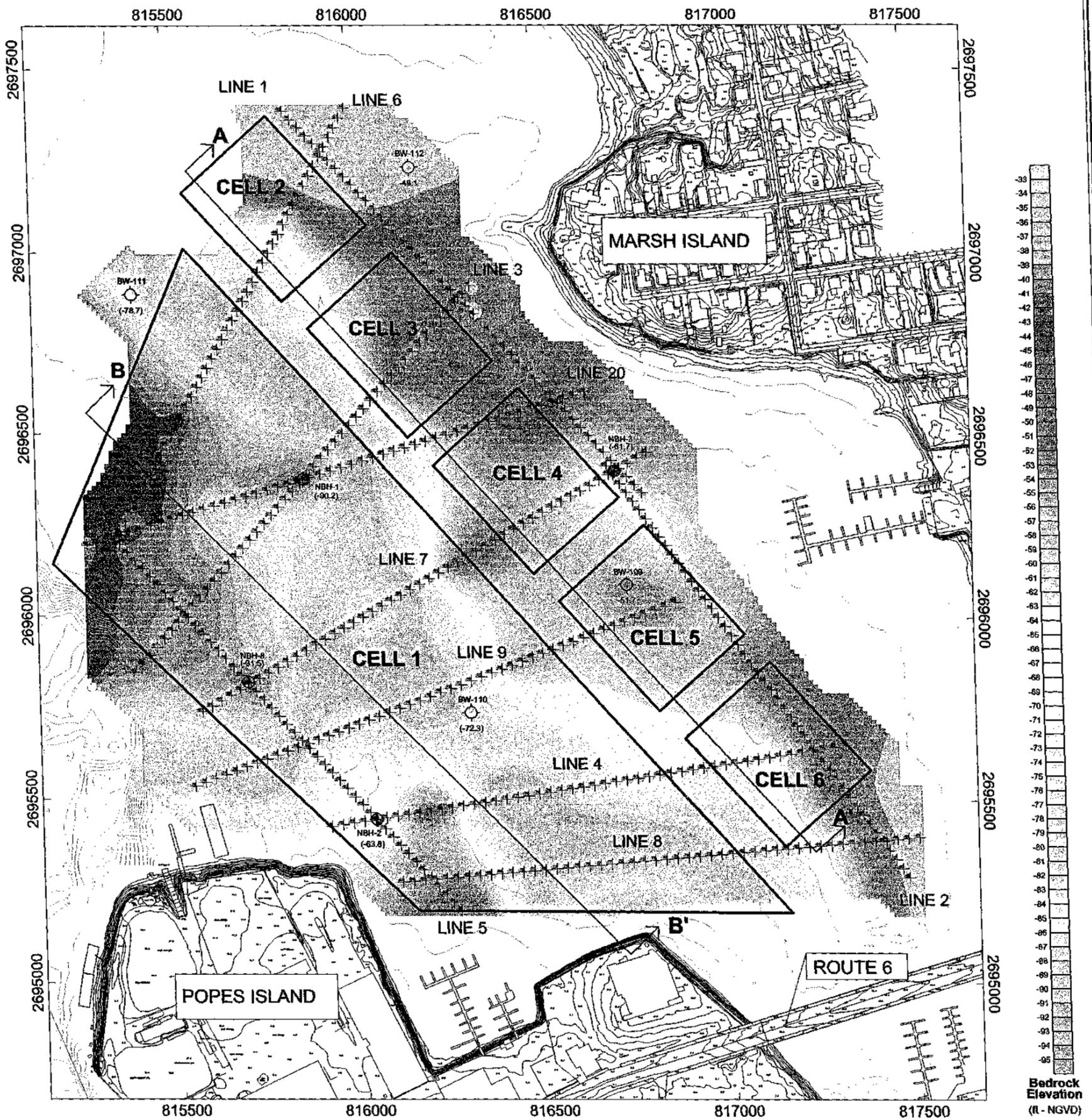
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 NAD83(CSR898) / Massachusetts CS83 Mainland zone

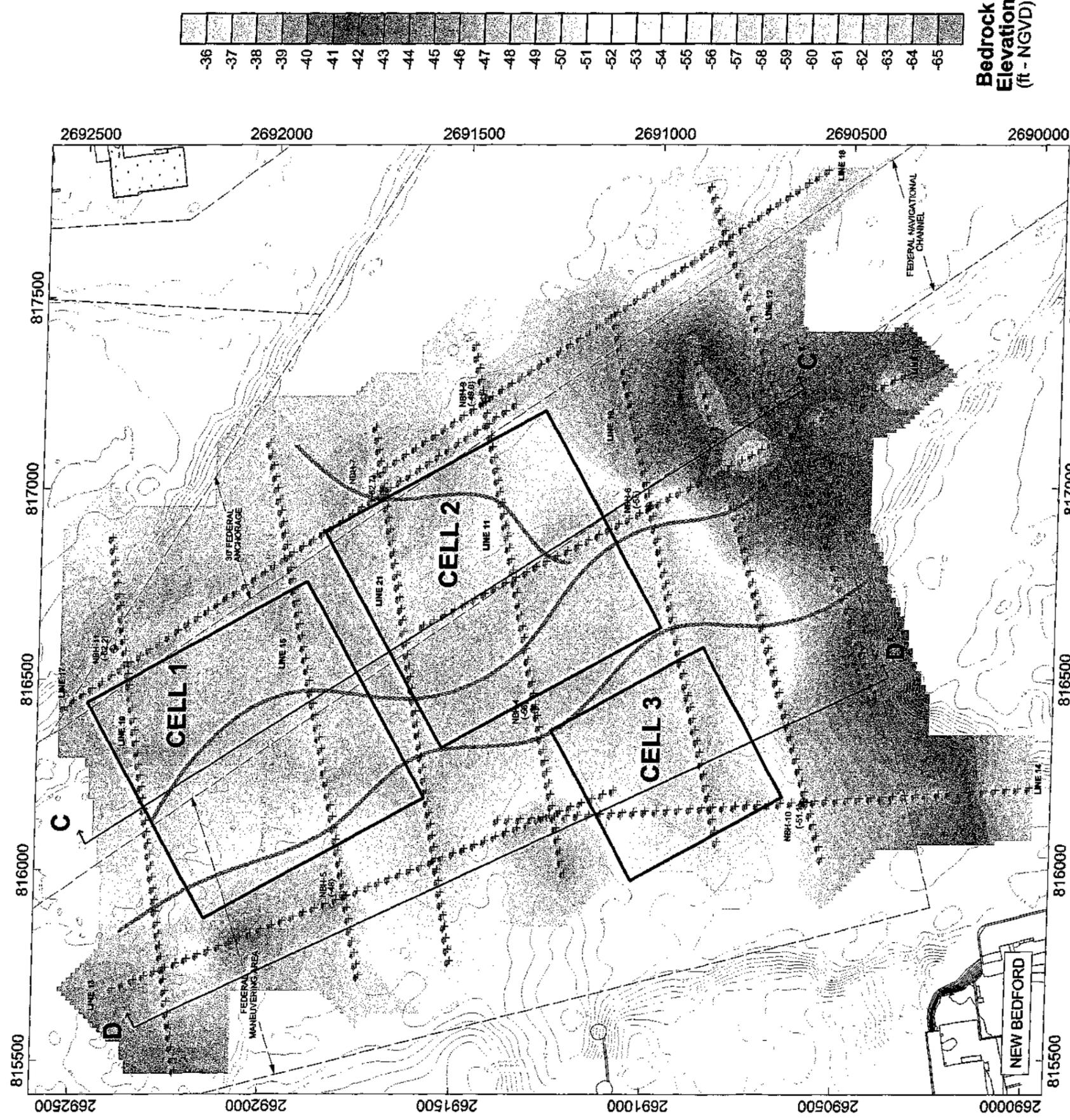
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	SEISMIC CALIBRATION BORING
	EBASCO BORING (APPROXIMATE LOCATION)
	HYDROPHONE LOCATION (PHONE NUMBER & BEDROCK ELEVATION)
	1' BATHYMETRIC CONTOUR
	PROPOSED CAD CELL EXTENTS
	CROSS SECTION LOCATION

NOTES:

1. Base Plan of the New Bedford harbor area was obtained from the US Army Corps of Engineers and has not been field verified.
2. Coordinates are shown in the State Plane Coordinate System, Massachusetts Mainland Zone 2001, Referenced to the 1983 North American Datum (NAD83). Vertical datum NGVD29.
3. Boring information and position supplied by The Maguire Group.

FIGURE 2 - BEDROCK ELEVATION				
POPES ISLAND NORTH AREA				
SEISMIC REFRACTION - REVISED MODEL				
MIDDLE NEW BEDFORD HARBOR				
BRISTOL COUNTY, NEW BEDFORD, MASSACHUSETTS				
		374 Congress St Suite 500 Boston MA 02210 517 728-0070		
SCALE: 1" = 100'	DRAWN: TDM	DESIGN: TDM	CHECKED: JAB	PROJECT: 0510.021.01

REV.	DESCRIPTION	BY	DATE
1.	MODIFIED DEPTH TO BEDROCK	TDM	01/08/02
2.	CAD CELL CONFIGURATION	TDM	05/05/03



Scale 1:3600

250 0 250
US survey feet
NAD83 / Massachusetts CS83 Mainland zone

LEGEND:

- POSSIBLE FRACTURE ZONE INFERRED FROM SEISMIC DATA
- SEISMIC CALIBRATION BORING (MAGUIRE)
- FEDERAL CHANNEL ANCHORAGE AND MANEUVERING AREA LINE
- HYDROPHONE LOCATION (PHONE NUMBER & BEDROCK ELEVATION INDICATED)
- Z' BATHYMETRIC CONTOUR
- PROPOSED CAD CELL EXTENT
- CROSS SECTION LOCATION

NOTES:

1. Base Plan of the New Bedford harbor area was obtained from the US Army Corps of Engineers and has not been field verified.
2. Coordinates are shown in the State Plane Coordinate System, Massachusetts Mainland Zone 2001, Referenced to the 1983 North American Datum (NAD83). Vertical Datum referenced to NGVD29.
3. Boring information and position supplied by The Maguire Group.

FIGURE 3 - BEDROCK ELEVATION

CHANNEL INNER AREA

SEISMIC REFRACTION - REVISED MODEL

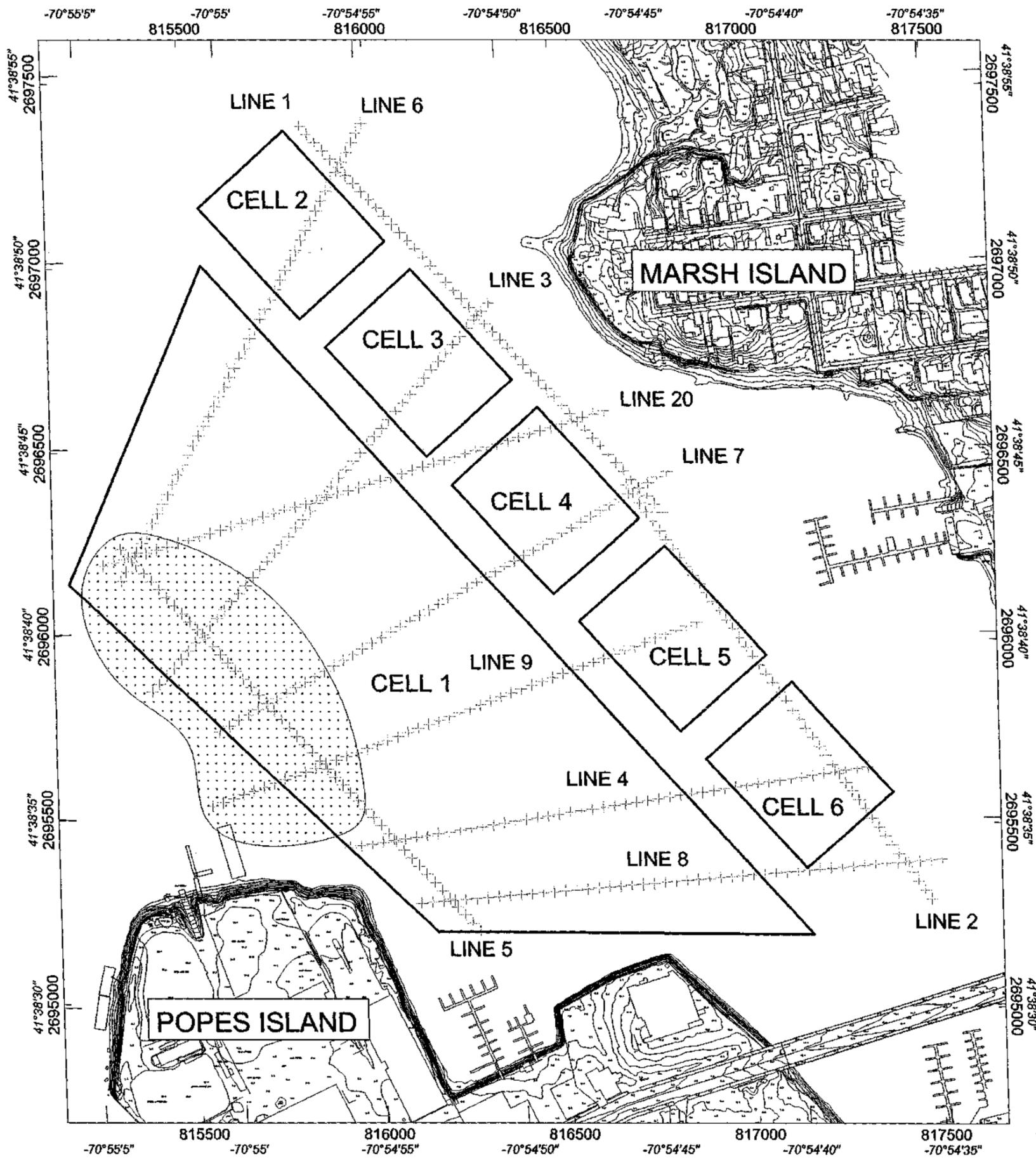
LOWER NEW BEDFORD HARBOR
BRISTOL COUNTY, NEW BEDFORD, MASSACHUSETTS

Apex
ENGINEERS, INC.

374 Congress St
Suite 600
Boston MA 02210
617 728-0070

SCALE:	DRAWN:	DESIGN:	CHECKED:	PROJECT#
	TDM	TDM	JAB	06100104

REV.	DESCRIPTION	BY	DATE
1.	MODIFIED DEPTH TO BEDROCK	TDM	01/18/02
2.	POSSIBLE CAD CELL CONFIGURATION	TDM	06/06/03
3.	MOD. CAD CELL CONFIGURATION	TDM	06/13/03



LEGEND

-  MODERATE DATA CONFIDENCE LEVEL
-  HYDROPHONE LOCATION
-  PROPOSED CAD CELL EXTENT

Scale 1:3600
 250 0 250
 US survey foot
 NAD83(CSRS98) / Massachusetts CS83 Mainland zone

FIGURE 4
 POPES ISLAND NORTH AREA - CONFIDENCE LEVELS
 SEISMIC REFRACTION - REVISED MODEL

MIDDLE NEW BEDFORD HARBOR
 BRISTOL COUNTY, NEW BEDFORD, MASSACHUSETTS

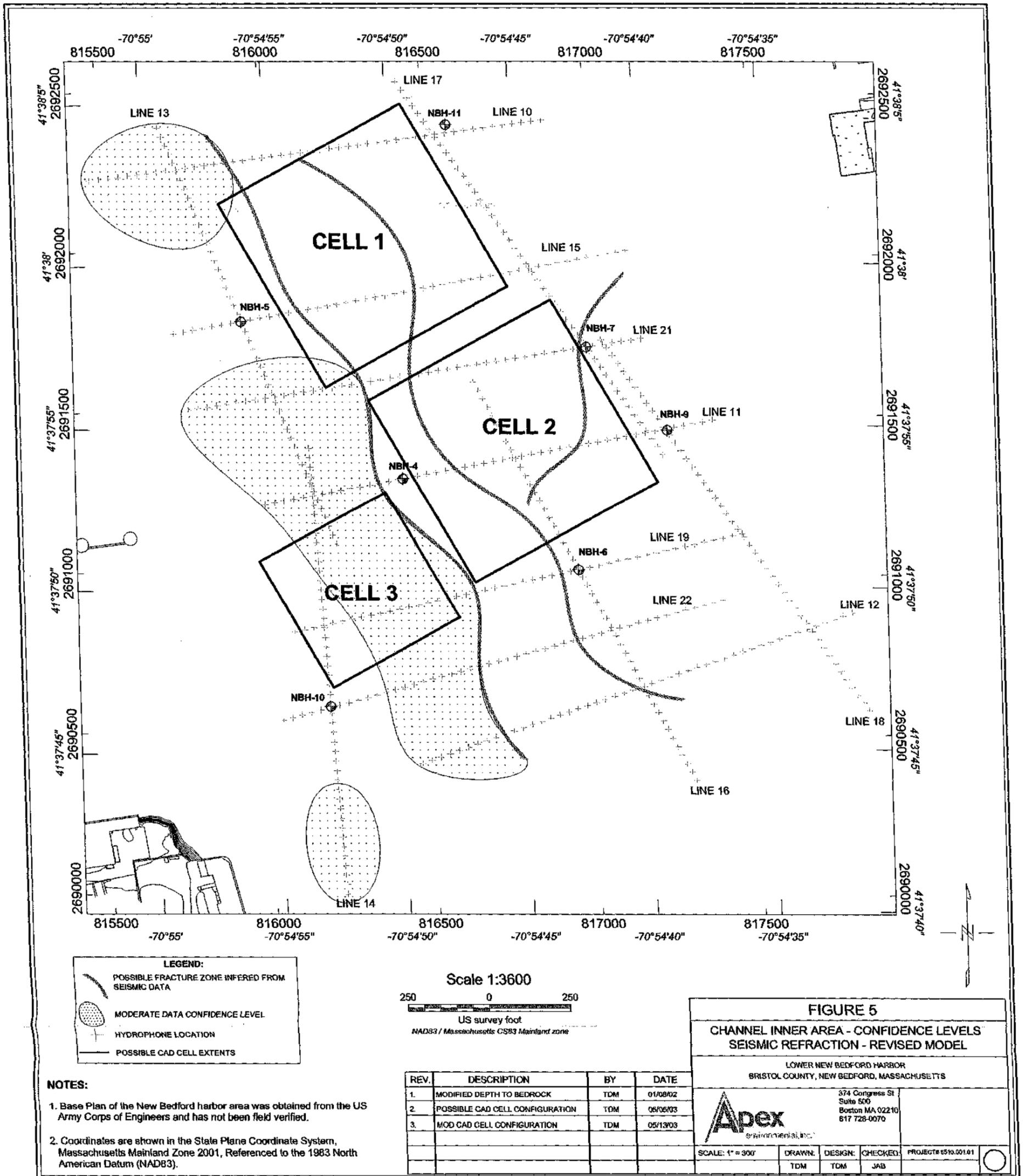
374 Congress St
 Suite 500
 Boston MA 02210
 617 728-0070

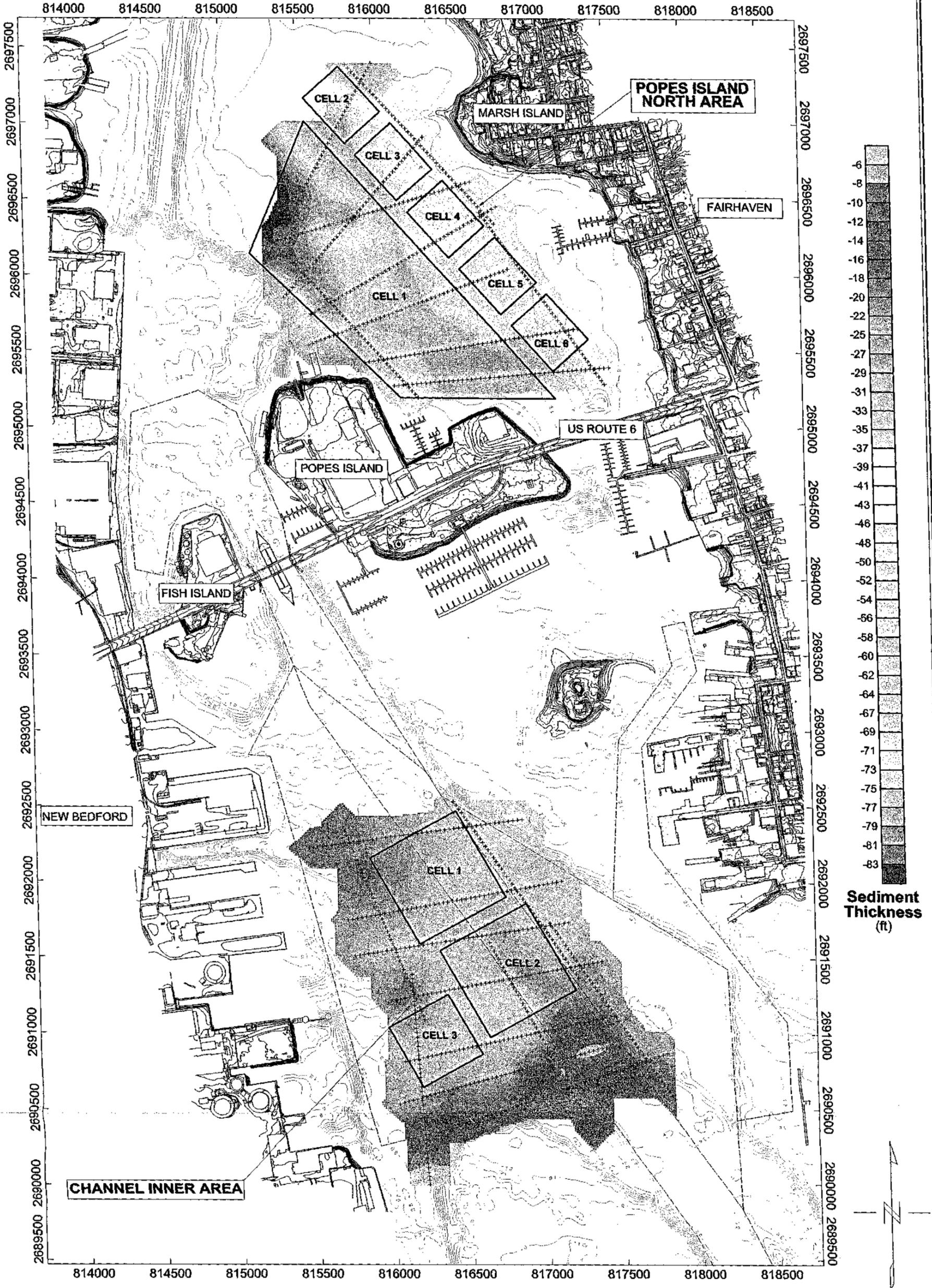
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				SHEET 4 OF 6

NOTES:

1. Base Plan of the New Bedford harbor area was obtained from the US Army Corps of Engineers and has not been field verified.
2. Coordinates are shown in the State Plane Coordinate System, Massachusetts Mainland Zone 2001, Referenced to the 1983 North American Datum (NAD83).

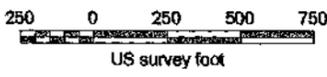
REV.	DESCRIPTION	BY	DATE
1.	MODIFIED DEPTH TO BEDROCK	TDM	01/08/02
2.	CAD CELL CONFIGURATION	TDM	05/05/03





Sediment Thickness (ft)

Scale 1:7200



NOTES:

1. Base Plan of the New Bedford harbor area was obtained from the US Army Corps of Engineers and has not been field verified.
2. Coordinates are shown in the State Plane Coordinate System, Massachusetts Mainland Zone 2001, Referenced to the 1983 North American Datum (NAD83).
3. Sediment Thickness Calculated as the Difference Between Bedrock and Mudline Elevations.

LEGEND

- FEDERAL CHANNEL, ANCHORAGE AND MANEUVERING AREA
- 2 FOOT BATHYMETRIC CONTOUR
- + HYDROPHONE LOCATION
- POSSIBLE CAD CELL CONFIGURATION

FIGURE 6 - SEDIMENT THICKNESS MAP
CHANNEL INNER & POPES ISLAND NORTH AREAS
SEISMIC REFRACTION - REVISED MODEL

NEW BEDFORD HARBOR
BRISTOL COUNTY, NEW BEDFORD, MASSACHUSETTS

374 Congress St
Suite 500
Boston MA 02210
617 728-0070

Apex
SYNTHETIC APERTURE RADAR, INC.

SCALE:	DRAWN:	DESIGN:	CHECKED:	PROJECT# 0518 001.01
	TDM	TDM	JAB	

REV.	DESCRIPTION	BY	DATE
1.	POSSIBLE GAD CONFIGURATION	TDM	05/05/03
2.	MOD CAD CONFIGURATION	TDM	05/13/03