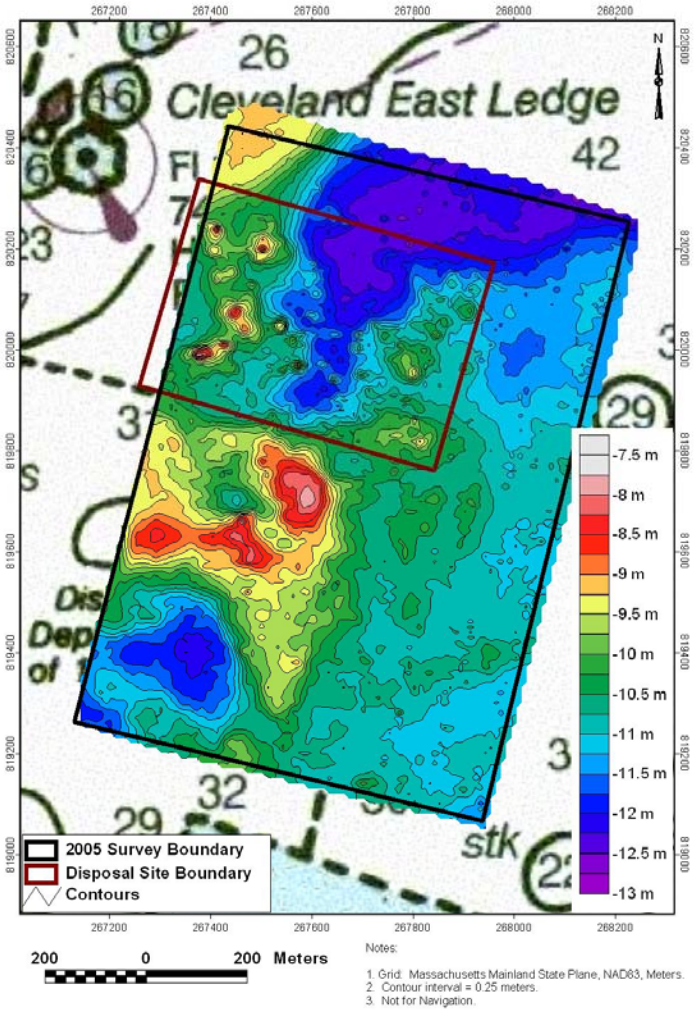
Monitoring Survey at the Buzzards Bay Disposal Site at Cleveland East Ledge
June 2005

Disposal Area Monitoring System DAMOS



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In 2002, sandy sediments from the Cape Cod Canal were deposited at the Buzzards Bay Disposal Site at the Cleveland East Ledge in Buzzards Bay, Massachusetts. This site was last used for disposal in 1986. A single-beam bathymetric survey was conducted at the deposition area in June 2005 to identify changes in seabed topography potentially associated with the most recent disposal. Maps produced from survey data revealed the presence of several mounds commonly associated with open water disposal. Baseline bathymetric data were not available for evaluation, and these mounds were most likely produced by several episodes of disposal (1986 and 2002). Additional characterization of the seafloor using some combination of side-scan sonar, video, sediment-profile imaging (SPI), or grab sampling would allow the identification of textural discontinuities associated with disposal, clarifying the interpretation of the seafloor topography.

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EXECUTIVE SUMMARY

In 2002, sandy sediments from the Cape Cod Canal were deposited at the Buzzards Bay Disposal Site at the Cleveland East Ledge in Buzzards Bay, Massachusetts. This site was last used for disposal in 1986. A single-beam bathymetric survey was conducted at the deposition area in June 2005 to identify changes in seabed topography potentially associated with the most recent disposal. Maps produced from survey data revealed the presence of several mounds commonly associated with open water disposal. Baseline bathymetric data were not available for evaluation, and these mounds were most likely produced by several episodes of disposal (1986 and 2002). Additional characterization of the seafloor using some combination of side-scan sonar, video, sediment-profile imaging (SPI), or grab sampling would allow the identification of textural discontinuities associated with disposal, clarifying the interpretation of the seafloor topography.

1.0 INTRODUCTION

The Cape Cod Canal serves as a major thoroughfare for recreational and commercial vessels transiting Massachusetts' waters. To maintain a safe and navigable waterway, maintenance dredging is periodically conducted by the U.S. Army Corps of Engineers (USACE). In 2002, sandy sediment was dredged and placed at the Buzzards Bay Disposal Site at Cleveland East Ledge in Buzzards Bay about 2 nautical miles (3.7 km) northwest of West Falmouth Harbor, MA (Figure 1-1). The Corps of Engineers selected this location using their authority under the Clean Water Act (404) for disposal site selection in coastal waters (USACE 1998). This site was last used in 1986 for disposal of dredged material from the Cape Cod Canal. Optimally, predisposal and postdisposal bathymetric surveys are conducted to help map the areal distribution of the deposited dredged material. However, because of the sandy nature of the sediments and the expectations for disposal, no baseline bathymetric survey was conducted prior to disposal at the Buzzards Bay Disposal Site at Cleveland Ledge East. A postdisposal survey was conducted in June 2005. An introduction to the Disposal Area Monitoring System (DAMOS) Program under which this investigation was performed is provided below, as well as background information on Buzzards Bay Disposal Sites.

1.1 Overview of the DAMOS Program

DAMOS is a comprehensive monitoring and management program that addresses environmental concerns associated with the use of open-water disposal sites throughout the New England region. For over 25 years, the DAMOS Program has collected and evaluated disposal site data. Based on these data, patterns of physical, chemical, and biological responses of seafloor environments to dredged material disposal activity have been documented. The DAMOS Program features a tiered approach to monitoring that allows for assessment of compliance with disposal permit regulations, validation of predictions and assumptions of models that are the foundation of the sampling design, and identification of long-term environmental trends that could be related to disposal activity (Fredette and French 2004). The tiered approach provides recommendations for monitoring techniques, and guidelines for defining when additional, more intensive monitoring is warranted (Germano et al. 1994).

Disposal site monitoring surveys provide data for environmental evaluation of each disposal site relative to conditions after recent dredged material disposal, and to conditions in nearby reference areas unaffected by disposal activities. Monitoring survey results are evaluated to determine the next step in the management of each disposal site. Focused studies are periodically undertaken within the DAMOS Program to evaluate inactive or historical disposal sites. The June 2005 investigation of the Buzzards Bay Disposal Site at Cleveland Ledge East was an interim survey conducted to track the location and bottom elevations of disposed dredged material at an infrequently used site.

1.2 Background on Cape Cod Canal and Buzzards Bay Disposal Sites

The Cape Cod Canal extends from Cape Cod Bay on the east to Buzzards Bay on the west. The Canal is the world's widest sea level canal, providing commercial and recreational passage through the neck connecting Cape Cod to the mainland. Originally developed as a private canal, it was purchased by the Federal Government in 1928 and authorized in the River and Harbor Acts of 1935, 1945 and 1958 as a federal navigation project. The project was completed in April 1963 to project dimensions of 32 feet deep and 540 feet wide in the land cut, 500 feet wide in a straight channel in Buzzards Bay to Wings Neck and 700 feet wide beyond Wings Neck. Although navigation charts show the channel ending at Cleveland Ledge, the authorized channel continues about 3,000 feet beyond the lighthouse into deeper water (USACE 1998).

In 1998, several dredging projects were proposed to maintain safe navigation in the Cleveland Ledge entrance channel and to eliminate shoals in the Hog Island channel (USACE 1998). Up to 230,000 cubic meters of material was projected to be dredged with some material potentially providing cap material for the Boston Harbor Navigation Project. Sampling indicated that the Cleveland Ledge channel material was light brown grey and medium brown grey, poorly graded sand with an average of 3% fines and 97% sand. Hog Island Channel material was similar, light brown-tan poorly graded sand with an average of 4% gravel and 96% sand. This material was determined to be suitable for unconfined open water disposal (USACE 1998).

Disposal of dredged material in northern Buzzards Bay has occurred at several locations since at least 1920. The Cleveland Ledge Disposal Site was a large disposal site used until 1980 (Figure 1-1). Since 1980, the Buzzards Bay Disposal Site (BBDS), a discrete area within the Cleveland Ledge Disposal Site, has received dredged material from private and municipal projects within Buzzards Bay. The BBDS is a 500 yd (457 m) diameter circle located 1.4 nautical miles (2.6 km) from Chappaquoit Point, West Falmouth, MA (Figure 1-1). In 1986, material dredged from the Cape Cod Canal was disposed at the Buzzards Bay Disposal at Cleveland East Ledge, a rectangular area (610 m x 427 m) 700 m southeast of Cleveland Ledge Light (center point: 41˚37´40˝ N, 70˚41´19˝ W (USACE 1986, 1998). More recently, the State of Massachusetts has proposed a one square mile (2.6 km^2) state-managed site (Candidate site 1) located about 1000 meters southwest of the center of the BBDS and partially within the southern region of the historical Cleveland Ledge Site (Maguire 2005).

In 2002 about 174,000 cubic meters of sandy sediment were dredged by hopper dredge from the Cape Cod Canal. This material was placed east of buoy R "14" at the southern end of the Cape Cod Canal approach channel and in the Buzzards Bay Disposal Site at Cleveland East Ledge (USACE 1998). There was no baseline bathymetry for this disposal

location. Therefore, in June 2005 a single-beam bathymetric survey was conducted to determine bottom topography over an area described as the Cape Cod Canal Disposal Survey Area (Figure 1-2). The survey boundary was based on reported dredged material disposal locations provided by the New England Division (NAE). It was predicted that at least one discernable feature in the range of 0.5 to 1.5 m above the surrounding bottom would be present. This was based on the assumption that the disposal of sediment was concentrated toward the central portion of the Buzzards Bay Disposal Site at Cleveland East Ledge.

1.3 Project Objective

The June 2005 bathymetric survey was designed to address the following objective, following placement of the dredged material from the Cape Cod Canal:

- Assess the general physical status of the surface of the Cape Cod Canal Disposal Survey Area, June 2005 in the vicinity of the Buzzards Bay Disposal Site at Cleveland East Ledge to discern the distribution and mounding of the recently disposed sediment. A bathymetric feature in the range of 0.5 to 1.5 m above the surrounding bottom was predicted.

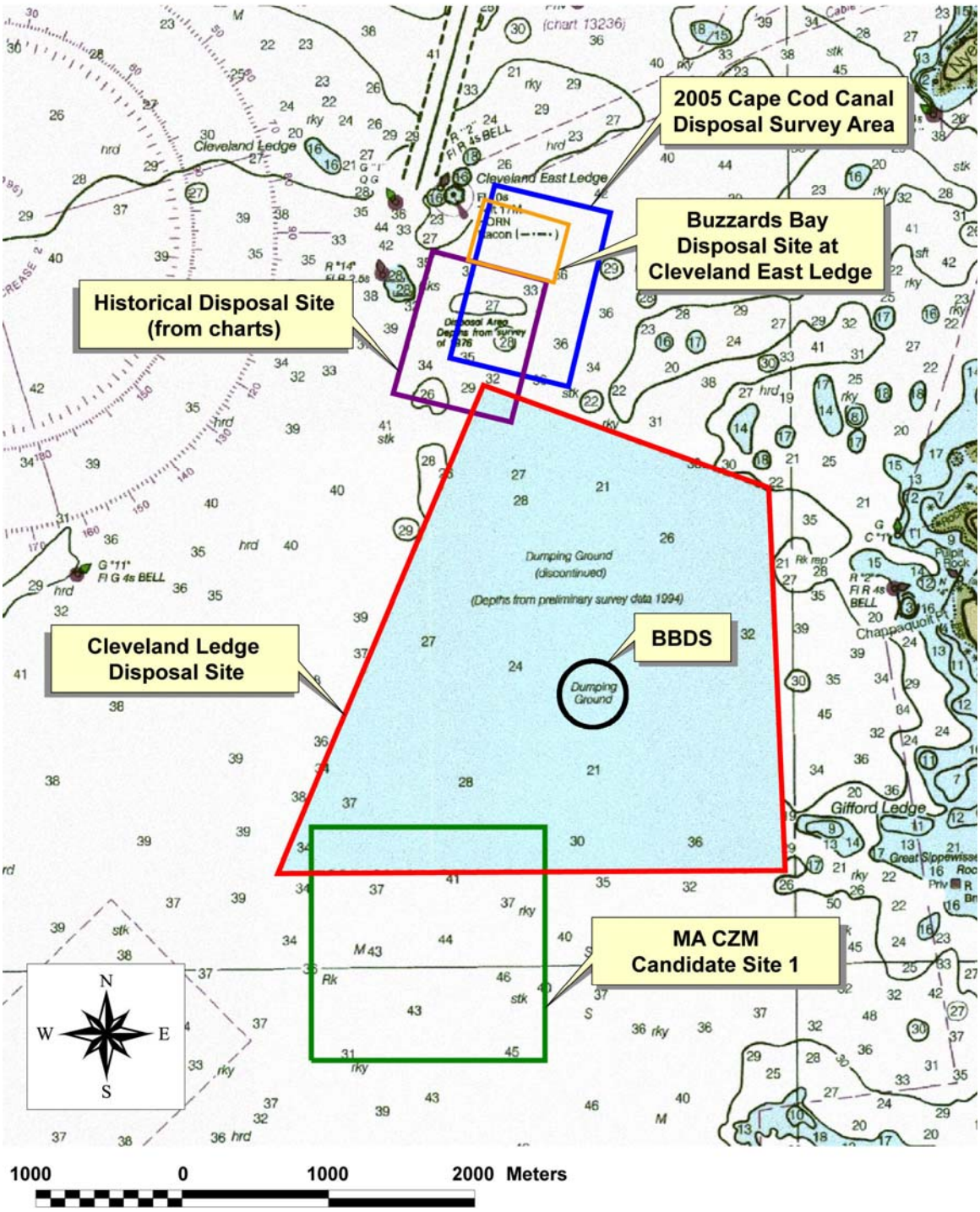

Figure 1-1. Cape Cod Canal Disposal Survey Area in Buzzards Bay, Massachusetts, and other Buzzards Bay Disposal Site locations

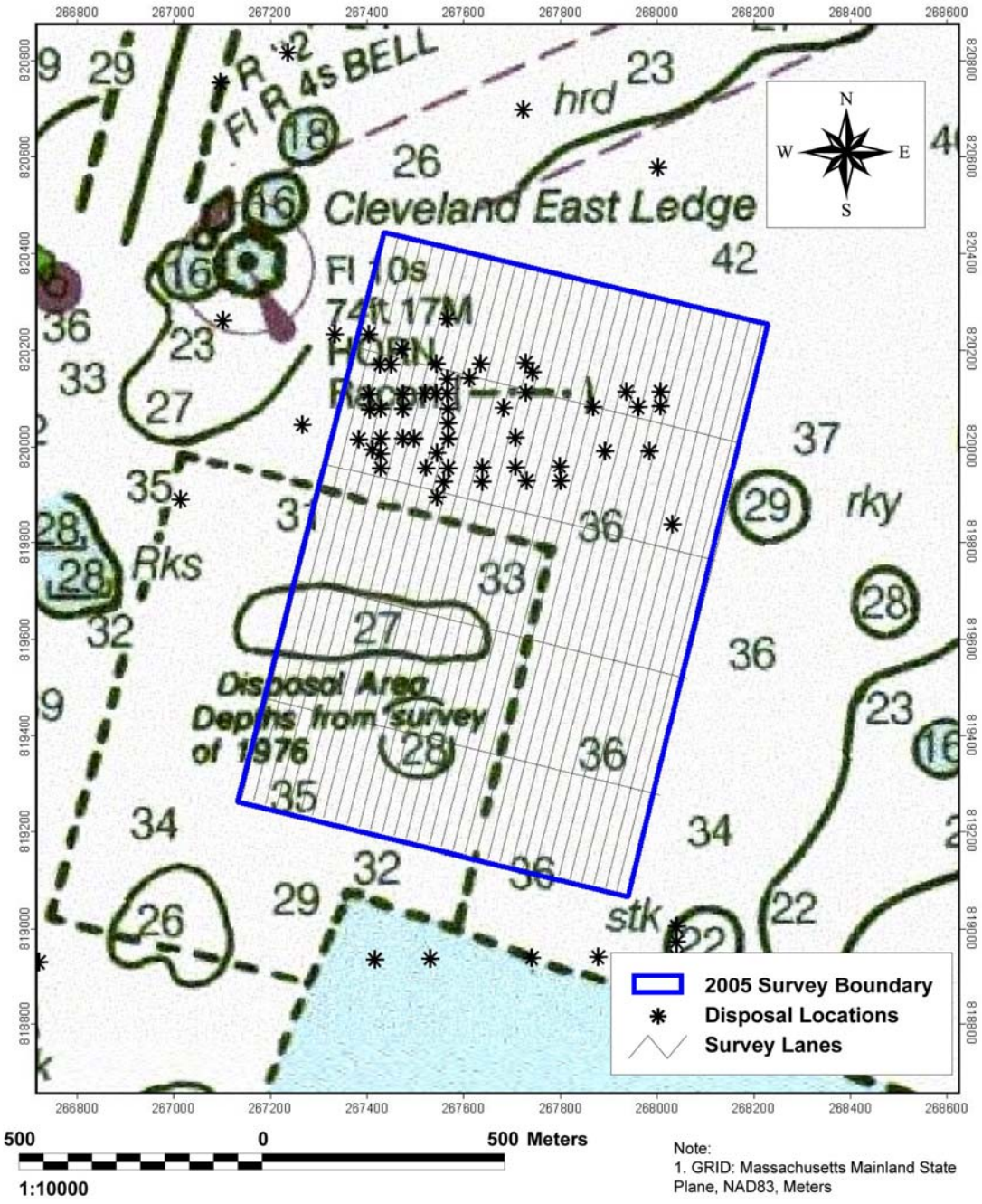

Figure 1-2. Cape Cod Canal Disposal Survey Area and reported dredged material disposal locations

2.0 METHODS

On 17 June 2005, a team of investigators from DAMOSVision performed a single-beam bathymetric survey over the Cape Cod Canal Disposal Survey Area, June 2005 located southeast of Cleveland East Ledge and about 3.2 km northwest of West Falmouth Harbor, Massachusetts. Survey work was conducted off the 32-ft R/V *Cyprinodon* and the base of operations was West Falmouth Harbor. The survey area was 1,200 x 800 m and encompassed the Buzzards Bay Disposal Site at Cleveland Ledge East, and a disposal area to the south that may have received Canal dredged material in 1976 and earlier. Field activities are summarized in Table 2-1 and an overview of the methods used to collect, process, and analyze the survey data is provided below.

2.1 Survey Planning

To determine the position of the survey area, DAMOSVision hydrographers coordinated with NAE scientists and obtained a GIS-formatted digital file with approximate dredged material disposal coordinates. These coordinates were imported to ArcView GIS software and to HYPACK® hydrographic acquisition and processing software. A proposed survey area with 25-m trackline spacing that encompassed the majority of reported dredged material disposal coordinates and nearby geologic features of interest was developed. In HYPACK® a series of survey lines spaced 25 m apart were designed for the survey area with a few additional "crosstie" lines to assess data quality. The proposed survey area and trackline design was then reviewed and approved by NAE (Figure 1-2).

2.2 Navigation

A Differential Global Positioning System (DGPS) was used to accurately measure and record vessel and sampling locations during the bathymetric survey. The DGPS system calculates geographic position by monitoring signals from a network of U.S. government satellites. Real-time corrections are applied to the system's satellite-based position calculations using UHF signals transmitted from nearby U.S. Coast Guard base stations. These "differential" corrections are required to achieve sub-meter horizontal accuracy due to atmospherically induced interferences to the satellite signals. The DGPS system used for this survey was a Trimble AG132. The DGPS outputs digital position, time, and satellite quality data once a second to the HYPACK® hydrographic acquisition software.

2.3 Data Acquisition

The bathymetric data acquisition system consisted of the following components:

- Trimble AG132 Differential GPS with sub-meter accuracy for precision navigation,
- Ocean Data Equipment Corporation (ODEC) MF-500 precision echosounder and narrow beam 200-kHz transducer with a vertical accuracy of 0.1% of the water depth,
- Laptop computer equipped with multiple serial ports and loaded with HYPACK® Windows PC-based hydrographic survey software for data acquisition and processing software,
- InSitu, Inc., Mini-Troll® data logging pressure transducer used to monitor and record water level fluctuations at a nearby vertical control point, and
- Seabird Electronics, Inc. (SBE) Model SBE-19 CTD for recording sound velocity profiles.

The DGPS and MF-500 precision echosounder were interfaced to HYPACK® software via laptop serial ports. Throughout the survey, the HYPACK® data acquisition system received DGPS and bathymetric data. These incoming data streams were digitally integrated and stored on the PC's hard drive. HYPACK® also displayed real-time vessel position, provided a steering display for the vessel pilot, and displayed a color-coded depth "matrix" which enabled survey scientists to review and evaluate survey data in real-time (Figure 2-1).

The echosounder functions by transmitting and receiving a narrow (3-degree) 200-kHz signal from a transducer installed at a known depth on a rail-mounted vertical boom. Water depth is calculated by measuring the time delay from signal transmits to receive. This time delay is divided by two (because the delay includes signal travel time to the bottom and back) and is multiplied by the measured sound velocity to calculate depth. These depths are exported digitally from the echosounder at approximately 2- to 10-Hz, depending on water depth. As the vessel transits, the echosounder continuously collects, records, and displays digital water depth measurements.

The accuracy of the bathymetric system used in this survey is approximately 0.1% of the water depth. System accuracy was checked at the dock prior to the survey by comparing echosounder water depth measurements to known water depths. Known water depths were obtained by placing a metal plate (or bar) beneath the echosounder's transducer to several

known distances (1.0, 2.0, 3.0 and 4.0 m) below the water surface (i.e., the bar check method). Based on these comparisons, the echosounder was calibrated for shallow water conditions. Because shallow water profile characteristics did not accurately represent water profile characteristics at the survey site, water column profiles of sound velocity were collected in situ. Local in-situ measurements of water column salinity and temperature were performed at the survey site using the SBE-19 CTD water quality profiler. These profiles were used to adjust bathymetric data, as described in Section 2.4 below.

Local tidal water level data were collected and recorded at a project benchmark established by BSS Design of Falmouth, a Massachusetts-registered land surveyor, at the town dock in West Falmouth Harbor. A six-minute series of water levels was recorded using a pressure transducer (InSitu, Inc. Mini-Troll®). Water level data were applied to correct the bathymetric data during data processing as described below in Section 2.4.

2.4 Bathymetric Data Processing

Data were processed using HYPACK®'s SBMAX single-beam editing program. Components of bathymetric data processing included: (1) correction of raw data for local tidal conditions, (2) adjustment for site-specific speed of sound in water, (3) adjustment for acquisition system latency (delays in digital signal recording), and (4) removal of outlying data points.

Tidal correction consisted of transforming raw measurements of depth below the transducer to measurements relative to Mean Lower Low Water (MLLW) using tidal elevation data collected by the data logging tide gage installed at the West Falmouth Harbor town dock. The surveyed land benchmark was reported as an elevation of 1.69 m (NGVD-29). The difference between NGVD-29 and MLLW was reported to be 0.36 m for NOAA station 8452660 in Newport using the "old" 1960-1978 tidal epoch. NOAA reported an increase in the MLLW elevation of 0.07 m between the 1960-1978 epoch and the "current" 1983-2001 epoch. Therefore, the elevation of the land benchmark as a "current" MLLW elevation was calculated as:

1.69 m + 0.36 m + 0.07 m = 2.12 m MLLW

The vertical offset of the tide gage sensor was -2.72 m. Therefore, the elevation of the tide gage sensor was 2.12 m – 2.72 m = -0.60 m MLLW. This elevation was used to adjust raw soundings from uncorrected depths to MLLW elevations.

As previously described, the echosounder calculated water depths based on the travel time of acoustic signals in water and the accuracy of the reported depth was largely dependent upon the velocity of sound in the water column during the survey. The speed of

sound in water is primarily dependent on water salinity and temperature, and measurements of these parameters collected with the SBE-19 CTD were used to calculate the site-specific sound velocity and adjust soundings.

Raw bathymetric data were also reviewed for outlying data points caused by biological interference (e.g., fish, wakes, and water column debris). The project hydrographer removed these outlying data points, while simultaneously inspecting thermal hard-copy printouts from the echosounder.

Processed bathymetric data were exported from HYPACK® as a single, comma-delimited ASCII text file in Northing, Easting, MLLW Elevation format. This data file was imported to Golden Software's Surfer for Windows V. 8.1 and a 10-meter elevation grid (i.e., Digital Elevation Model or DEM) was calculated using Kriging methods. This grid was used to construct GIS maps of the survey area. Contour maps were exported from Surfer as geo-referenced TIF and DXF files suitable for inclusion in GIS or Computer Assisted Drawing (CAD) projects.

Table 2-1

June 2005 Field Activities Summary

Survey Activity	Date	Summary
Local Water Level Data and Benchmark Elevation	17 June 2005	In-situ tide gage installed at West Falmouth Harbor town dock; benchmark provided by BSS Design, registered MA land surveyors
Bar Check and Speed of Sound Check for the Echosounder	17 June 2005	Check accuracy of echosounder against known depth information; record salinity and temperature of the water column to correct for the site-specific speed of sound in water
Bathymetry	17 June 2005	37 lanes covering a 1,200 x 800 m area at the Cape Cod Canal disposal location

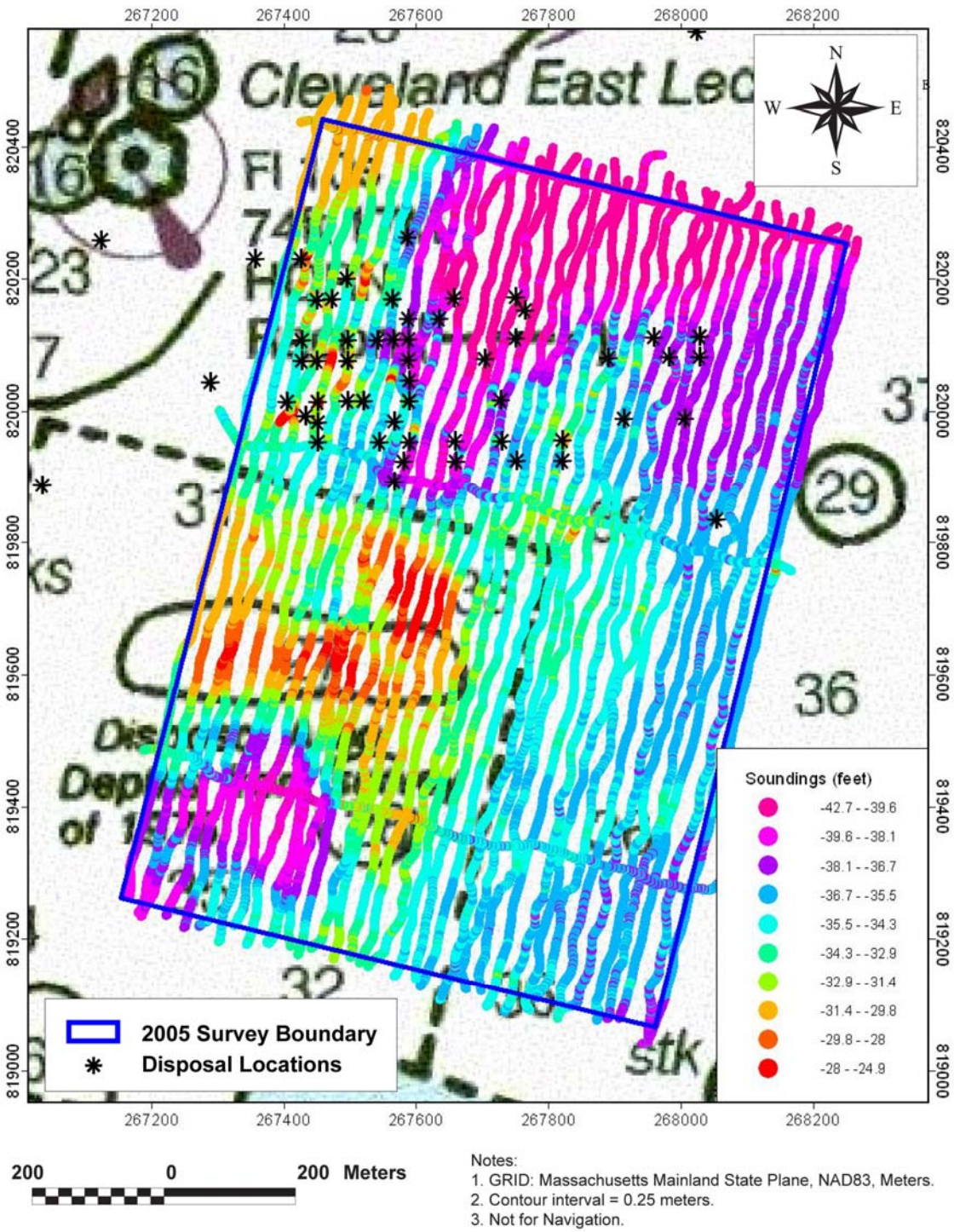

Figure 2-1. Cape Cod Canal Disposal Survey Area bathymetry survey tracklines, June 2005

3.0 RESULTS

3.1 Bathymetry

The bathymetric contour map (0.25-m contour) of the survey area revealed areas of shallow rough topography (red-orange-yellow in Figure 3-1) presumed to be either rocky ledge or deposits of dredged material (see correspondence with 27 foot contour in Figure 2-1); areas of flat, gently sloping bottom (green in Figure 3-1) presumed to be softer dispersed historical dredged material; and areas of deeper water (blues in Figure 3-1) assumed to be soft sediment based on knowledge of the seafloor characteristics in Buzzards Bay. A three-dimensional "surface map" of the survey area was constructed using 10x vertical exaggeration and artificial "sun-illumination" to highlight seabed morphology (Figure 3-2). The three-dimensional image highlights areas of steep topography and reveals the pockmarked surface typical of dredged material disposal mounds (Figure 3-2).

The average elevation recorded at the Cape Cod Canal Disposal Location was -10.77 meters MLLW. The minimum recorded elevation in the survey area was -13.01 meters MLLW and the maximum elevation -7.59 meters, a difference of 5.42 meters. The area appears to be bounded by ledge at its northwestern extent.

The survey area had one T-shaped area of shallow depth (8-9 m depth) that corresponded to the 27 foot contour recorded in 1976 (Figure 1-2). This area has a sharp edge oriented NE-SW that corresponds to the boundary of the historical disposal site on nautical charts. East of this edge, the seafloor slopes gently to the east from 9.5 m to 11+ m. Two spurs of shallow depth (9-10 m) extend to the north parallel to the boundaries of survey area. Between them is an area of deeper water (11.5 m to 12.5 m) extending to the north. The western spur appears to connect to the ledge area on the northern margin of the survey area (Cleveland East Ledge). Many of the reported disposal locations are clustered around the two spurs of shallow water within the Buzzards Bay Disposal Site at Cleveland East Ledge (Figure 3-1).

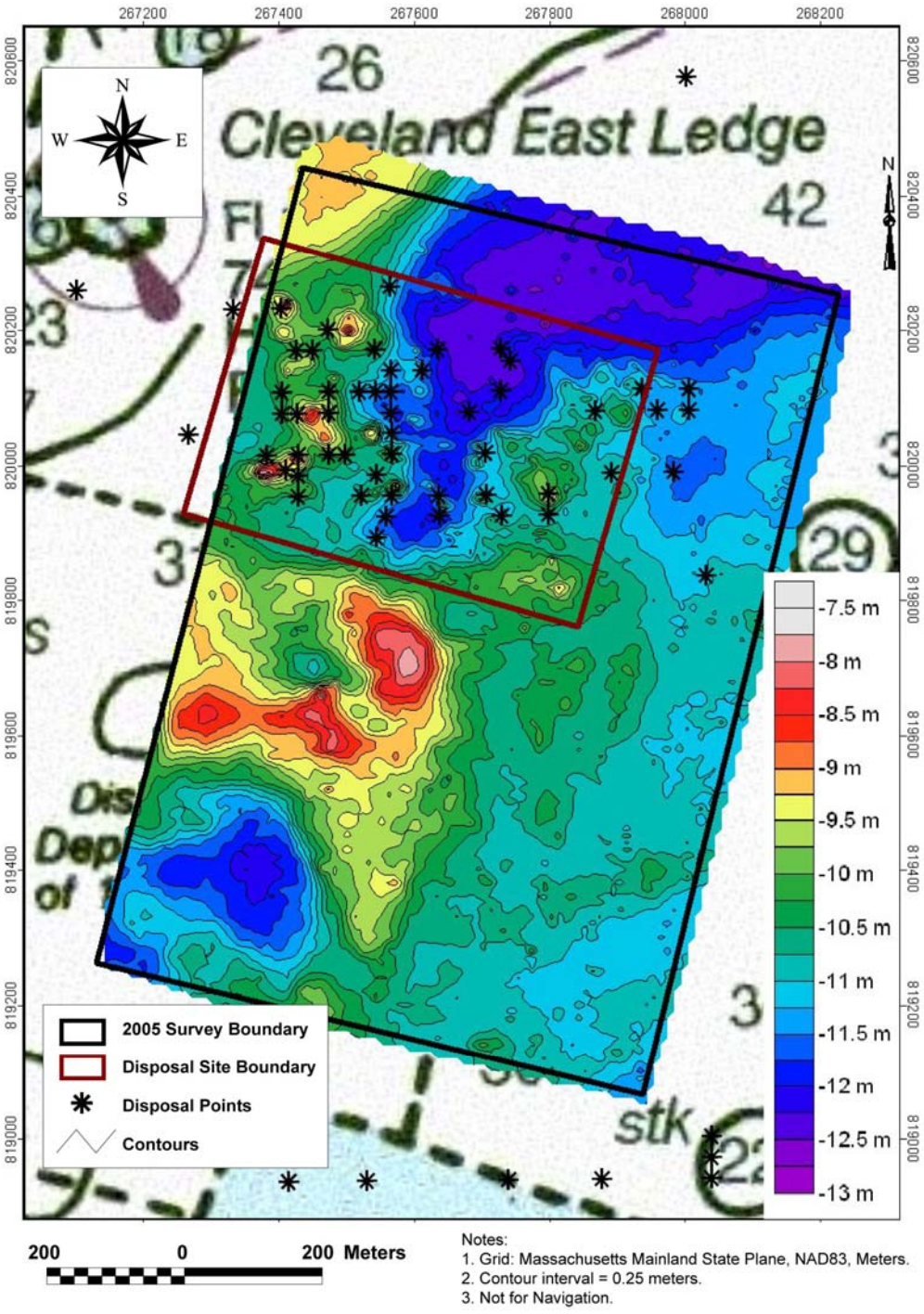

Figure 3-1. Bathymetric contour map of Cape Cod Canal Disposal Survey Area, June 2005 (0.25-m contour interval)

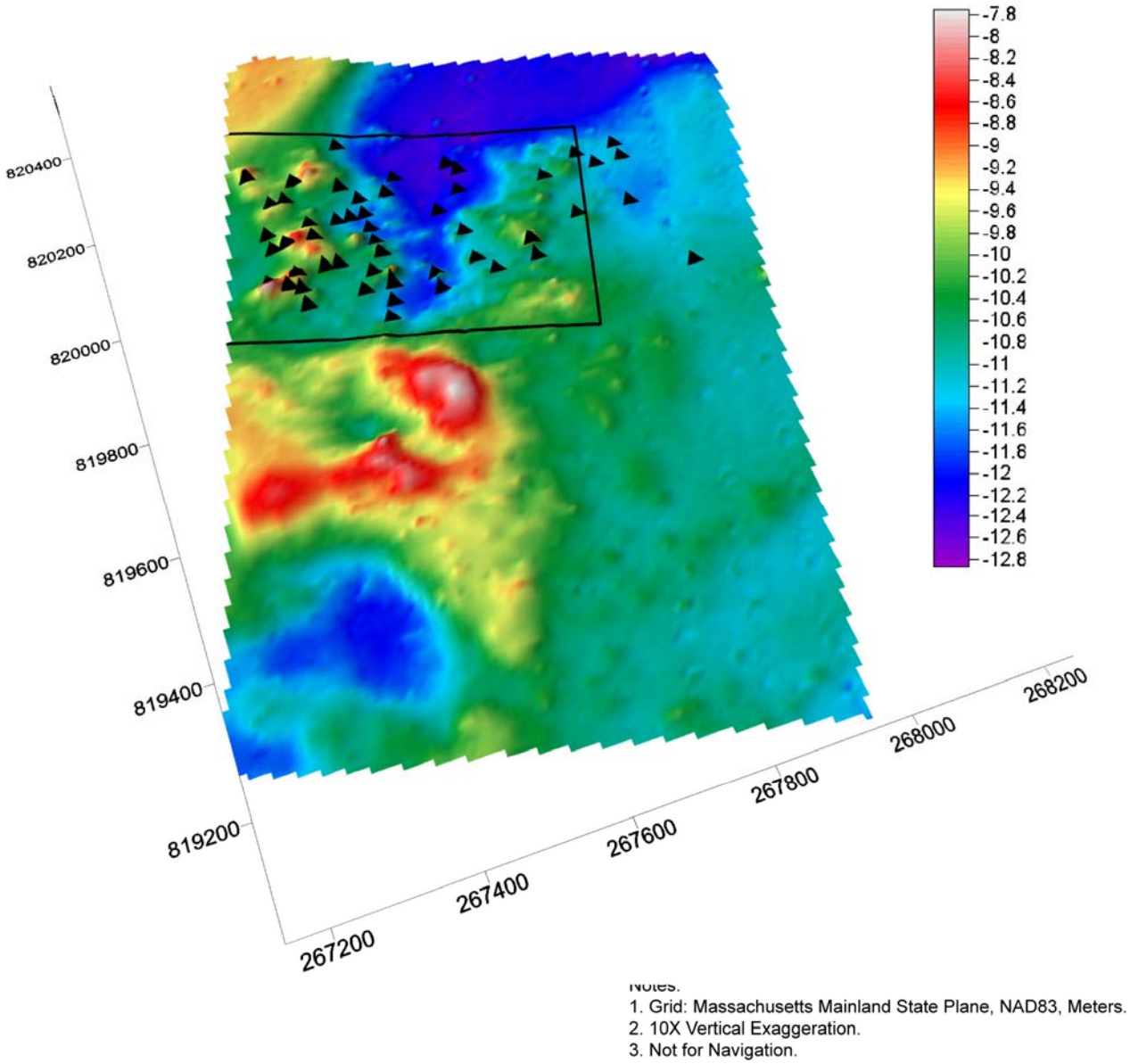

Figure 3-2. Bathymetric surface model of Cape Cod Canal Disposal Survey Area, June 2005 (10 x vertical exaggeration).

4.0 DISCUSSION

Processed bathymetric survey data provided an accurate depiction of bottom topography and measured depths, but the single beam 200-kHz echosounder signal is not capable of documenting textural discontinuities and cannot independently distinguish dredged material from ambient material. Predisposal water depths and topographic measurements were unavailable for the survey area (apart from nautical charts). As a result, interpretation of bathymetric results was limited to assumptions about bottom topography and disposal locations. When disposal points are tightly grouped, a bottom feature is often distinguishable above ambient contours, especially on level-bottom. The disposal location was located in an area that historically has received periodic placement of dredged material, particularly from the Cape Cod Canal. Some of these deposits were evident in the bathymetric results of this survey but cannot be unequivocally distinguished from ledge or gravel deposits that form much of the bottom in northern Buzzards Bay (Maguire 2005).

Preliminary examination of the bathymetric model relative to the locations of the most recent dredge disposal points suggested formation of a two disposal-related features and the presence of one historical disposal mound. These mounds were discernable above the surrounding bottom in the vicinity of the dredged material disposal points. The reported disposal points cluster within the disposal area, but some appear outside of the disposal area (Figure 1-2). Some of the anomalous points are arrayed in a line due south of the disposal area and are most likely a latitude entry error in the disposal logs (the have identical latitude values). If these are assumed to be grouped with the other locations, the shallow areas in the Buzzards Bay Disposal Site at Cleveland East Ledge are likely to have been formed from disposal activities in 1986 and 2002.

High resolution multibeam sonar and side-scan sonar surveys in other disposal areas (Massachusetts Bay Disposal Site and Central Long Island Sound Disposal Site) have been very successful in distinguishing dredged material signatures from ambient bottom based on surface texture, acoustic backscatter intensity and bathymetric features (Butman et al, 2004, Poppe et al, 2001, ENSR 2006).

5.0 CONCLUSIONS

The Cape Cod Canal disposal location survey carried out in June 2005 was performed as an interim survey, three years after disposal of sandy dredged material from the Cape Cod Canal, to assess the general physical status of the surface of the Buzzards Bay Disposal Site at Cleveland East Ledge.

The single beam bathymetric data collected revealed the presence of three apparent disposal mounds. Each mound could be tentatively associated with disposal activities prior to 1976, in 1986 and 2002. Because the baseline bathymetry is not available, supplemental data from future side-scan sonar or multibeam sonar could help clarify the interpretation of the seafloor topography in this region of Buzzards Bay.

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