Monitoring Cruise at the
Central Long Island Sound
Disposal Site
July 1996

Disposal Area Monitoring System DAMOS

D A M O S

DISPOSAL AREA MONITORING SYSTEM

Contribution 120
May 1998

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
May 1998

3. REPORT TYPE AND DATES COVERED
FINAL REPORT

4. TITLE AND SUBTITLE
MONITORING CRUISE AT THE CENTRAL LONG ISLAND SOUND DISPOSAL SITE, JULY 1996

5. FUNDING NUMBERS

6. AUTHOR(S)
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8. PERFORMIGORGANIZATION REPORT NUMBER
SAIC No. 385

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
US Army Corps of Engineers-New England District
696 Virginia Rd
Concord, MA 01742-2751

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
DAMOS Contribution #120

11. SUPPLEMENTARY NOTES
Available from DAMOS Program Manager, Regulatory District
USACE-NAE, 696 Virginia Rd, Concord MA 01742-2751

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

12b. DISTRIBUTION CODE

13. ABSTRACT

A monitoring survey was conducted at the Central Long Island Sound Disposal Site (CLIS) from 10 to 15 July 1996 as part of the Disposal Area Monitoring System (DAMOS) Program. Field operations were concentrated over the new CLIS 1995 disposal mound, as well as the historic New Haven 1993 (NHAV 93), CLIS 1994 (CLIS 94), and Mill-Quinnipiac River (MQR) mounds. The July 1996 field effort consisted of precision bathymetric and Remote Ecological Monitoring of the Seafloor (REMOTS®) surveys. These surveying techniques were employed to monitor the development of CLIS 95, as well as the stability, consolidation rates, and benthic recolonization of CLIS 94, NHAV 93, and MQR capped mounds.

The CLIS 95 mound is the newest bottom feature at the disposal site and is an example of a small, capped, dredged material disposal mound. An estimated barge volume of 16,300 m³ of unacceptably contaminated dredged material (UDM) was deposited buoy, forming a small mound. The UDM deposit was then completely covered with 50,100 m³ of capping dredged material (CDM).

The results of the July 1996 field effort indicate the formation of a small, but distinct, bottom feature on the CLIS seafloor. This sediment mound was found to be 3.75 m high at the apex and approximately 200 m in diameter. REMOTS® photographs documented deep Redox Potential Discontinuity (RPD) depths, mature benthic infaunal populations, and high Organism-Sediment Index (OSI) values, indicating rapid recolonization of these sediments.

The CLIS 94 mound, developed during the 1994-95 disposal season, is also an example of a capped mound. Approximately 129,000 m³ of UDM and 161,000 m³ of CDM were placed to form an irregular-shaped, moderate-sized disposal mound. A 0.25 m to 0.5 m decrease in mound height was discovered at the mound apex, while smaller cells of consolidation were detected over the broader southern region of the mound. The five REMOTS® stations occupied over the center of CLIS 94 displayed some improvement relative to the conditions found during the September 1995 survey. The NHAV 93 mound was developed during the 1993-94 disposal season as part of a large scale confined aquatic disposal (CAD) project. In 1993, approximately 590,000 m³ of UDM dredged from the inner New Haven Harbor was deposited within the containment cell and capped to a thickness of 0.5 m to 1.0 m by 569,000 m³ of CDM.

A total of eight bathymetric and five REMOTS® sediment-profile photography surveys have been conducted over the NHAV 93 mound since September 1993. At 2.5 years after the completion of capping operations, the July 1996 survey has shown 0.25 m to 0.75 m of consolidation over the majority of the mound with little change in size or shape. The results of the REMOTS® sediment-profile photography survey indicate the benthic community is continuing to recover as expected.

The MQR mound is a historic bottom feature formed along the southern boundary of CLIS. This capped sediment mound is actually composed of alternating layers of UDM and CDM deposited during the 1981-82, 1982-83, and 1993-94 disposal seasons. Approximately 65,000 m³ of additional CDM was deposited over the MQR mound during the 1993-94 disposal season in response to anomalous REMOTS® sediment-profile photography results

Depth difference calculations based on the July 1994 bathymetric data discovered small to moderate pockets of consolidation near the apex and southwestern flank of MQR. This consolidation over the surface of the MQR mound is apparently the result of de-watering of the underlying silts and clays, related to the loading that resulted from the recent deposition of CDM.

Seasonal hypoxia (DO concentrations ≤3.0 mg·l⁻¹) generally occurs within the western and central Long Island Sound regions in mid to late August. However, the onset and severity of seasonal hypoxia are directly dependent on many other environmental factors (i.e., nutrient input, frequency of storms, rainfall, fresh water input, water temperature, etc.). It appears that, by conducting benthic community assessment survey operations in early summer (mid-June to mid-July), before the development of hypoxia and the deterioration of benthic conditions, a more realistic perspective on the condition of the benthic environment can be gained.

14. SUBJECT TERMS Central Long Island Sound (CLIS), Capping Dredged Material (CDM), Unacceptably Contaminated Dredged Material (UDM), New Haven Habor

15. NUMBER OF PAGE 65

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT Unclassified

18. SECURITY CLASSIFICATION OF THIS PAGE

19. SECURITY CLASSIFICATION OF ABSTRACT

20. LIMITATION OF ABSTRACT

MONITORING CRUISE AT THE CENTRAL LONG ISLAND SOUND DISPOSAL SITE JULY 1996

CONTRIBUTION #120

MAY 1998

Report No.
SAIC 385

Submitted to:
Regulatory Branch
New England District
U.S. Army Corps of Engineers
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Concord, MA 01742-2751

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EXECUTIVE SUMMARY

Science Applications International Corporation (SAIC) conducted a monitoring survey at the Central Long Island Sound Disposal Site (CLIS) from 10 to 15 July 1996 aboard the M/V *Beavertail* as part of the Disposal Area Monitoring System (DAMOS) Program. Field operations were concentrated over the new CLIS 1995 disposal mound, as well as the historic New Haven 1993 (NHAV 93), CLIS 1994 (CLIS 94), and Mill-Quinnipiac River (MQR) mounds. The July 1996 field effort consisted of precision bathymetric and Remote Ecological Monitoring of the Seafloor (REMOTS®) surveys. These surveying techniques were employed to monitor the development of CLIS 95, as well as the stability, consolidation rates, and benthic recolonization of CLIS 94, NHAV 93, and MQR capped mounds.

The CLIS 95 mound is the newest bottom feature at the disposal site and is an example of a small, capped, dredged material disposal mound. In September 1995, the CDA buoy was deployed at 41°08.660' N, 72°53.042' W (NAD 27) approximately 450 m southwest of the historic NHAV 74 mound apex. An estimated barge volume of 16,300 m^3 of unacceptably contaminated dredged material (UDM) was removed from Milford and Bridgeport Harbors and deposited in close proximity to the CDA 95 buoy, forming a small mound. The UDM deposit was then completely covered with 50,100 m^3 of capping dredged material (CDM) generated from dredging projects in the West River and Bridgeport Harbor to yield a CDM to UDM ratio of 3.1:1.0.

The results of the July 1996 field effort indicate the formation of a small, but distinct, bottom feature on the CLIS seafloor. This discrete sediment mound was found to be 3.75 m high at the apex and approximately 200 m in diameter. The CLIS 95 mound has taken on a slightly irregular shape due to the slope of the bottom as well as the distribution of capping material. REMOTS® photographs obtained over CLIS 95 documented deep Redox Potential Discontinuity (RPD) depths, mature benthic infaunal populations, and high Organism-Sediment Index (OSI) values, indicating rapid recolonization of these sediments.

No bathymetric data documenting the interim stages of development were available. However, the compact nature of the deposit, the reported barge release positions, the CDM to UDM ratio, and the results of the REMOTS® sediment-profile photography survey over CLIS 95 suggest the UDM deposit has been completely capped. Continued monitoring of the CLIS 95 mound is recommended for the next one to two years to document consolidation and detect changes in benthic community structure.

The CLIS 94 mound, developed during the 1994-95 disposal season, is also an example of a capped mound. Approximately 129,000 m^3 of UDM and 161,000 m^3 of CDM were placed at the CDA 94 buoy to form an irregular-shaped, moderate-sized disposal mound 630 m northeast of the NHAV 93 mound apex. Field operations over this bottom feature were conducted to observe changes in bathymetry due to consolidation, as well as to confirm the continued stability of the benthic infaunal community.

Depth difference calculations indicated the presence of several pockets of consolidation over the surface of the CLIS 94 mound. A 0.25 m to 0.5 m decrease in mound height was discovered at the mound apex, while smaller cells of consolidation were detected over the broader southern region of the mound. The five REMOTS® stations occupied over the center of CLIS 94 displayed some improvement relative to the conditions found during the September 1995 survey. A healthy Stage I on III benthic assemblage and deeper RPD depths over the center of CLIS 94 indicate higher dissolved oxygen (DO) concentrations and continued benthic recovery.

The NHAV 93 mound was developed during the 1993-94 disposal season as part of a large scale confined aquatic disposal (CAD) project. The management strategy of controlling the deposition of small to moderate volumes of dredged material over a ten-year period resulted in the formation of a ring of disposal mounds on the CLIS seafloor. Upon completion in 1992, this network of disposal mounds formed an artificial containment cell capable of accepting large volumes of UDM, limiting the lateral spread of the deposit, and facilitating efficient capping operations. In 1993, approximately 590,000 m^3 of UDM dredged from the inner New Haven Harbor was deposited within the containment cell and capped to a thickness of 0.5 m to 1.0 m by 569,000 m^3 of CDM.

SAIC has conducted a total of eight bathymetric and five REMOTS® sediment-profile photography surveys over the NHAV 93 mound since September 1993. This latest field effort adds to the comprehensive time-series data set that currently exists for the 2.56 km^2 area of CLIS seafloor. At 2.5 years after the completion of capping operations, the July 1996 survey has shown 0.25 m to 0.75 m of consolidation over the majority of the mound with little change in size or shape. The results of the REMOTS® sediment-profile photography survey indicate the benthic community is continuing to recover as expected.

The MQR mound is a historic bottom feature formed along the southern boundary of CLIS. This capped sediment mound is actually composed of alternating layers of UDM and CDM deposited during the 1981-82, 1982-83, and 1993-94 disposal seasons. Approximately 65,000 m^3 of additional CDM was deposited over the MQR mound during the 1993-94 disposal season in response to anomalous REMOTS® sediment-profile photography results. A survey conducted in July 1994 detected a 1.5 m increase in mound height, a change in the position of the mound apex, and an improved benthic community structure, resulting from the deposition of additional CDM.

The boundaries of the 2100 m × 2100 m July 1996 bathymetric survey at CLIS incorporated approximately 75% of the historic MQR mound. Depth difference calculations based on the July 1994 bathymetric data discovered small to moderate pockets of consolidation near the apex and southwestern flank of MQR. This consolidation over the surface of the MQR mound is apparently the result of de-watering of the underlying silts and clays, related to the loading that resulted from the recent deposition of CDM.

The sediment-profile photographs collected over the CLIS project mounds and reference areas provided a wealth of information pertaining to the physical, biological, and chemical status of the surficial sediment layers. Data pertaining to the physical appearance of the material displayed no evidence of particle re-suspension or erosion at the sediment-water interface. The detection of Stage III activity was widespread indicating the presence of a stable benthic community population over the majority of the stations sampled. Although increased sediment oxygen demand may have affected the results obtained from a few stations, the benthic conditions detected during the July 1996 REMOTS® sediment-profile photography survey show distinct improvement relative to September 1995. Comparisons between REMOTS® images collected over the disposal mounds and CLIS reference areas (2500W, 4500E, and CLIS-REF) show significant increases in RPD depths, resulting in higher OSI values. In 1995, a trend of shallower than expected RPD depths and indications of low dissolved oxygen (DO) concentrations was observed due to the development of hypoxic conditions across the region. The 1996 Connecticut Department of Environmental Protection (CTDEP), Bureau of Water Management water quality data set was used to evaluate and compare the onset and severity of seasonal hypoxia in the bottom waters of Long Island Sound relative to 1995.

Seasonal hypoxia (DO concentrations $\leq 3.0\ mg \cdot l^{-1}$) generally occurs within the western and central Long Island Sound regions in mid to late August. However, the onset and severity of seasonal hypoxia are directly dependent on many other environmental factors (i.e., nutrient input, frequency of storms, rainfall, fresh water input, water temperature, etc.). It appears that, by conducting benthic community assessment survey operations in early summer (mid-June to mid-July), before the development of hypoxia and the deterioration of benthic conditions, a more realistic perspective on the condition of the benthic environment can be gained.

1.0 INTRODUCTION

1.1 Background

The New England District (NAE) of the US Army Corps of Engineers regulates all coastal dredging operations from Eastport, Maine, to Byram, Connecticut. In 1977, the Disposal Area Monitoring System (DAMOS) Program was developed in response to the recognized need for the managed disposal of the volumes of sediments dredged from the ports and harbors of the northeastern United States. The DAMOS Program currently manages ten closely monitored open water disposal sites along coastal New England (Figure 1-1A). These sites are utilized for the cost-effective and environmentally sound disposal of dredged material.

The Central Long Island Sound Disposal Site (CLIS) is one of four DAMOS disposal sites located in the waters of Long Island Sound. CLIS covers a 6.86 km^2 (2 nmi^2) area and is centered at 41°08.900' N latitude and 72°52.850' W longitude in North American Datum of 1927 (NAD 27; Morris 1996). It is located approximately 10.89 km (5.6 nmi) south of South End Point, East Haven, Connecticut (Figure 1-2). Historically, CLIS has been one of the most active disposal sites in the New England region (Figure 1-1B). Sediments deposited at CLIS have been dredged from New Haven, Bridgeport, Stamford, and Norwalk Harbors, as well as adjacent coastal areas.

Before dredging operations commence, the proposed project sediments are sampled and tested to determine their physical and chemical properties. Sediments originating from most of coastal New England are classified as suitable for unconfined open water disposal due to low or undetectable contaminant levels. This material may be deposited at CLIS or other New England disposal sites, used as capping dredged material (CDM), or utilized in other beneficial use projects. The sediments dredged from industrialized areas tend to contain a variety of contaminants associated with urbanization (i.e., trace metals, organic compounds, etc.; NOAA 1991). Some of these sediments may be determined to be unsuitable for unconfined open water disposal, but with special handling can be placed at disposal sites. Sediments that require special handling for open water disposal are classified as unacceptably contaminated dredged material (UDM; Fredette 1994).

During the 1978-79 disposal season at CLIS, subaqueous capping was introduced as a new dredged material management approach with the formation of the Stamford-New Haven mounds (STNH-N and STNH-S; SAI 1979). Capping is a containment method which uses sediments determined to be suitable for unconfined open water disposal, or CDM, to overlay and isolate deposits of UDM from the environment. As a result of the

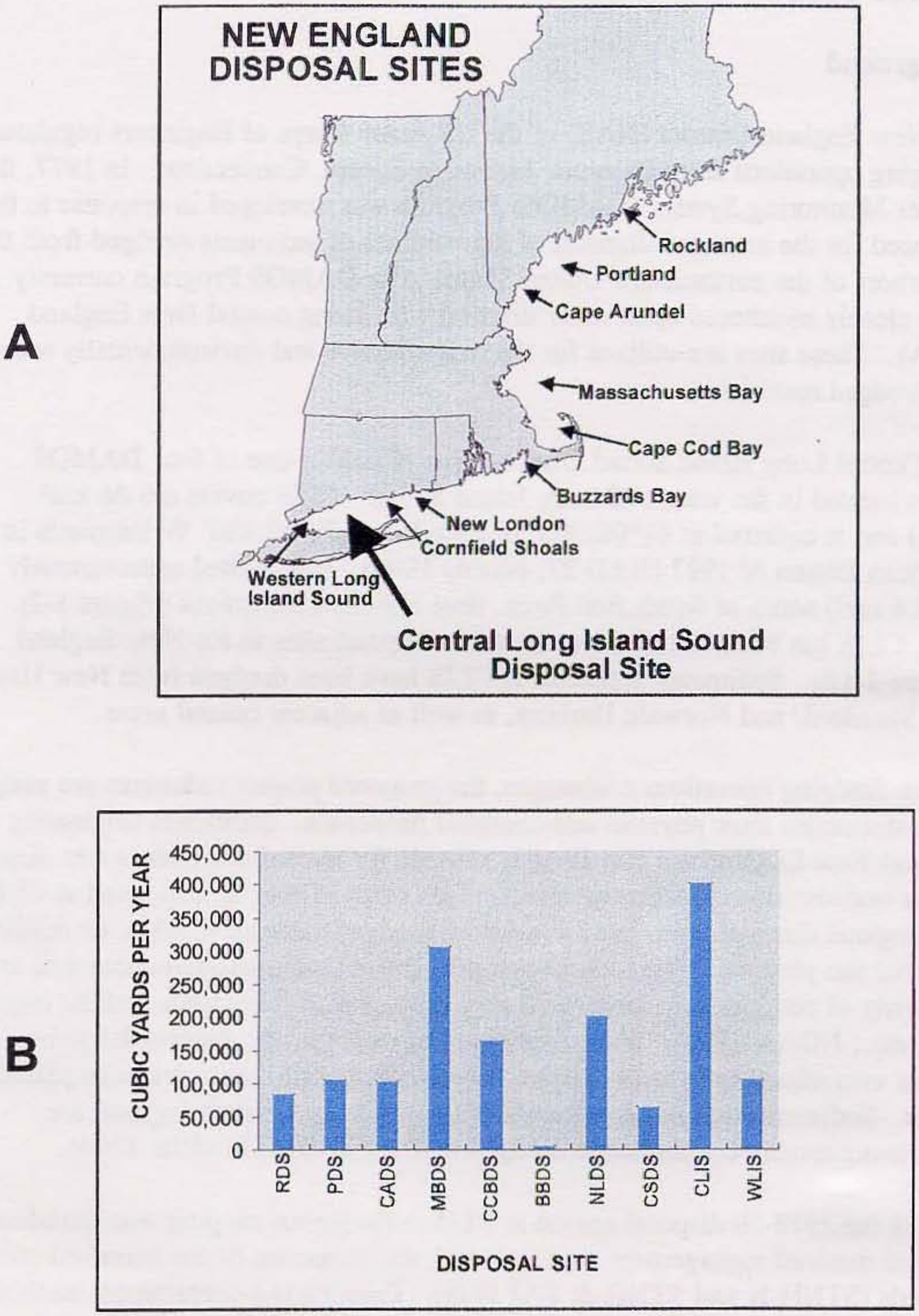


Figure 1-1. Location of disposal sites along coastal New England (A) and average annual dredged material disposal volumes for the ten New England disposal sites from 1982 to 1996 (B)

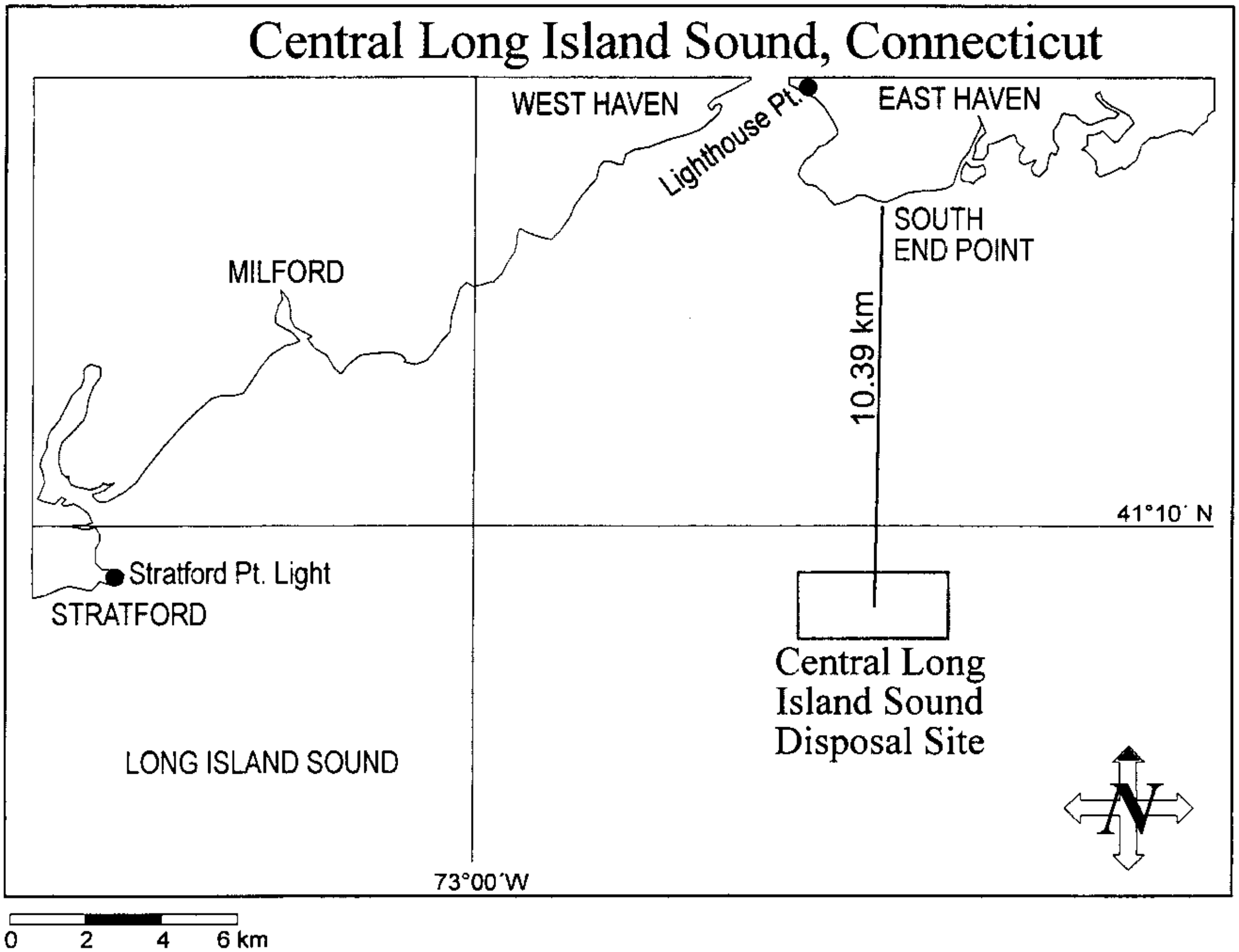


Figure 1-2. Location of the Central Long Island Sound Disposal Site and shore station benchmarks

operational success of the 1979 capping project, many capped mounds have been developed over the CLIS seafloor.

Science Applications International Corporation (SAIC) conducted a monitoring survey at CLIS from 10 to 15 July 1996 as part of the DAMOS Program. The field efforts were concentrated over the newly completed CLIS 1995 mound, as well as three historic capped mounds, CLIS 1994 (CLIS 94), New Haven 1993 (NHAV 93), and Mill-Quinnipiac River (MQR). The July 1996 field operations consisted of precision bathymetric and Remote Ecological Monitoring of the Seafloor (REMOTS®) surveys.

1.2 CLIS 95

The CLIS 95 mound is the newest bottom feature at the disposal site and is an example of a small, capped mound. In September 1995, the CDA buoy was deployed at 41°08.660' N, 72°53.042' W (NAD 27) approximately 450 m southwest of the historic NHAV 74 mound apex (Figure 1-3). An estimated barge volume of 16,300 m^3 of UDM dredged from Milford and Bridgeport Harbors was deposited in close proximity to the CDA 95 buoy, forming a small mound.

Capping operations commenced on 30 October 1995 and continued through 4 March 1996. A total of 50,100 m^3 of CDM generated from dredging projects in the West River and Bridgeport Harbor was used to completely isolate the UDM deposit. The end result was a small, stable, completely capped mound yielding a CDM to UDM ratio of 3.1:1.0.

1.3 CLIS 94

The CLIS 94 mound is another capped mound developed on the CLIS seafloor during the 1994-95 disposal season. A disposal buoy (CDA 94) was positioned in close proximity to the small, historic CS-90-1 mound and received approximately 129,000 m^3 of UDM dredged from Norwalk and New Haven Harbors. The UDM deposit was then capped with a total of 161,000 m^3 of CDM from West River, Stony Creek, and Pine Orchard Marine Terminal. The resulting bottom feature was found to be an irregular-shaped, moderate-sized disposal mound, 630 m northeast of the historic NHAV 93 mound apex (Figure 1-3; Morris 1997). Furthermore, the sediments forming the CLIS 94 mound completely enveloped the historic CS-90-1 mound.

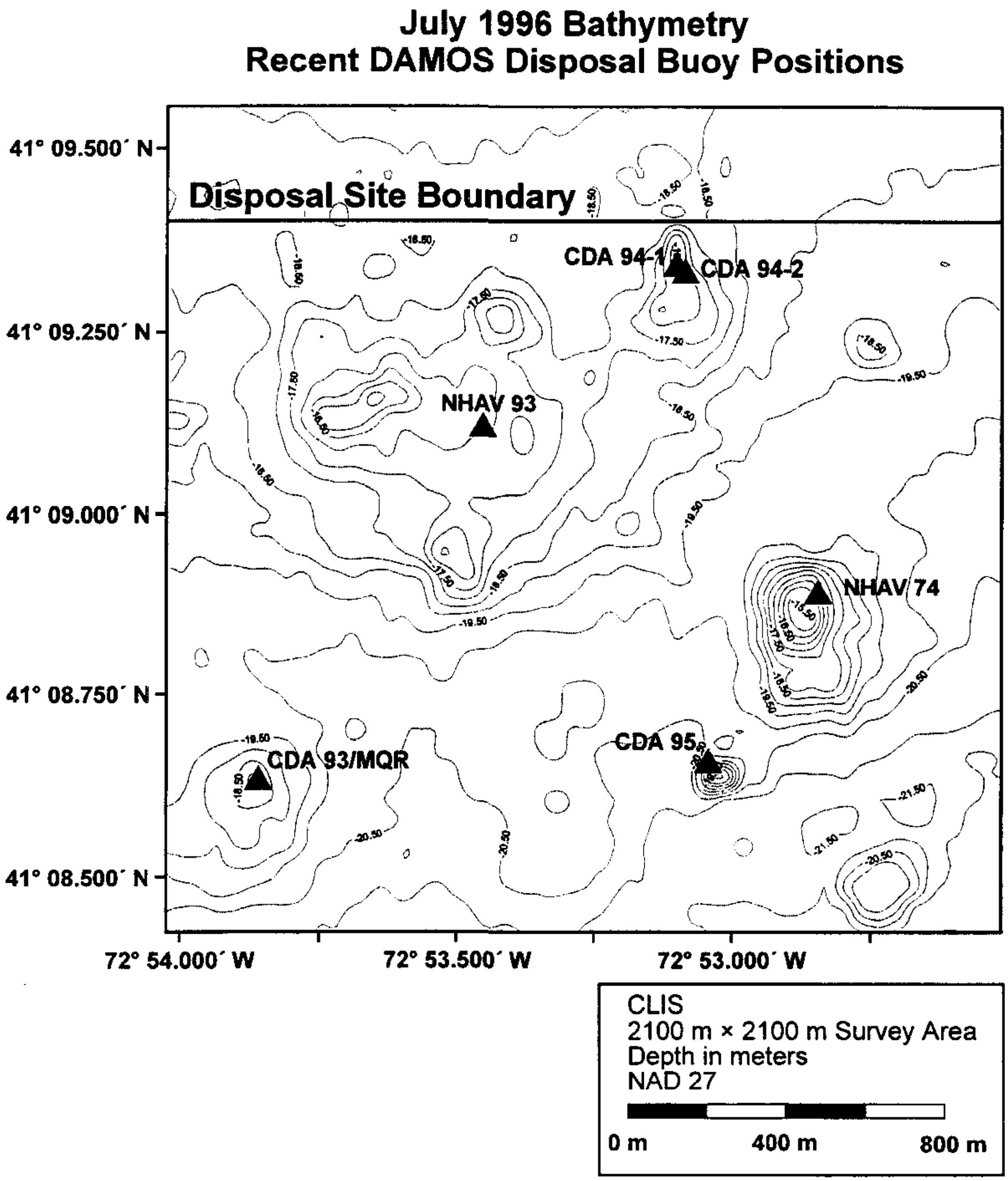


Figure 1-3. Bathymetric chart of the 2100 m × 2100 m survey area over CLIS with plotted DAMOS disposal buoy positions for the 1993-94, 1994-95, and 1995-96 disposal seasons relative to the northern disposal site boundary, 0.5 m contour interval

1.4 NHAV 93

The NHAV 93 mound was developed during the 1993-94 disposal season as part of a large scale confined aquatic disposal (CAD) project. The management strategy of controlling the deposition of small to moderate volumes of dredged material over a ten-year period resulted in the formation of a ring of disposal mounds on the CLIS seafloor. Upon completion in 1992, this network of disposal mounds formed an artificial containment cell capable of accepting large volumes of UDM, limiting the lateral spread of the deposit, and facilitating efficient capping operations.

In 1993, approximately 590,000 m^3 of UDM dredged from the inner New Haven Harbor was deposited within the containment cell and capped to a thickness of 0.5 m to 1.0 m by 569,000 m^3 of CDM (Morris et al. 1996). The completed CAD mound was found to be broad, stable, adequately capped, and exhibiting a CDM to UDM ratio of 0.96:1.0. In the past, CDM to UDM ratios have varied from 2:1 to 6:1 when initiating a capping operation on a flat or gently sloping area of seafloor. This highly successful strategy resulted in the formation of the first capped mound composed of a smaller volume of CDM than the initial UDM deposit. In addition, the completed NHAV 93 mound formed a distinct, broad, and flat mound complex as the project sediments merged with the seven perimeter mounds (Morris and Tufts 1997).

The development of the CLIS 94 and CLIS 95 mounds represents the continuation of this successful management strategy. By constructing networks of disposal mounds with small to moderate volumes of dredged material, numerous artificial containment cells will be formed, and the overall site capacity can be maximized (Morris et al. 1996). The development of the CLIS 94 mound begins to close a second containment cell northeast of the NHAV 93 mound complex. The formation of the CLIS 95 mound southwest of the historic NHAV 74 mound initiates the formation of a third artificial containment structure to the southeast of the NHAV 93 mound complex.

1.5 MQR Mound

The MQR mound is an historic, discrete, capped mound composed of alternating layers of UDM and CDM deposited during the 1981-82, 1982-83, and 1993-94 disposal seasons. In the spring of 1982, an estimated barge volume of 42,000 m^3 of UDM was dredged from the Mill River and placed on a relatively flat area of CLIS seafloor. The UDM deposit was quickly capped with approximately 133,200 m^3 of CDM removed from the Quinnipiac River. During the 1982-83 disposal season, an additional 67,000 m^3 of UDM from Black Rock Harbor was released over the MQR mound followed by 400,000 m^3 of CDM originating from New Haven Harbor (SAIC 1995).

A sediment cap of 400,000 m^3 was expected to fully cover the original MQR mound, as well as the deposit of UDM originating from Black Rock Harbor. However, complications in the disposal sequence during the 1982-83 disposal season caused two barge loads of Black Rock Harbor UDM to be placed over the final CDM deposit, resulting in a thin layer of UDM exposed at the sediment-water interface. From 1983 to 1992, the MQR mound had shown cycles of benthic habitat decline and slow recovery, relative to other capped mounds at CLIS (Murray 1996).

In response to the unexpected benthic conditions, supplemental capping material was deposited over the MQR mound during the 1993-94 disposal season. An additional 65,000 m^3 of CDM generated by several small dredging projects along the Connecticut coast was deposited at the CDA 93 buoy position (Figure 1-3; Morris and Tufts 1997). The supplemental CDM collected over the center of MQR increased the mound height by 1.5 m and improved benthic conditions.

1.6 CLIS Reference Areas

As part of the DAMOS monitoring protocols, reference area data are collected to provide a baseline against which the results from the dredged material mounds are compared. These areas are utilized due to their reflection of ambient conditions within the central Long Island Sound region. On occasion, indications of natural (hypoxia) or anthropogenic (trawling activity) disturbances are found within the confines of a CLIS reference area.

During the July 1996 survey, one replicate photograph collected over CLIS-REF documented the presence of a limited quantity of dark, organically enriched sediment within a 300 m radius of the central reference point. CLIS-REF has been used for comparison with CLIS sediments since the inception of the DAMOS Program in 1977. Due to the long history of use as a CLIS reference area, this disturbance warranted considerable investigation.

1.7 Objectives and Predictions

The specific objectives of the July 1996 Central Long Island Sound seasonal monitoring cruise were to

- conduct a bathymetric survey capable of delineating the footprint of the new CLIS 95 mound while examining any topographic changes of the CLIS 94, NHAV 93, and MQR mounds; and

- assess the benthic recolonization status over the entire CLIS 95 mound, as well as the centers of the CLIS 94 and NHAV 93 mounds, relative to three reference areas surrounding CLIS.

The July 1996 field effort tested the following predictions:

- The dredged material deposited during the 1995-96 disposal season will result in a small disposal mound, conical in shape and completely capped.

- The sediments of the CLIS 95 mound are expected to be supporting a solid Stage I population with some progression into Stage II assemblages as predicted by the DAMOS tiered monitoring protocols.

- The surface sediments of the NHAV 93 and CLIS 94 mounds should be supporting mature benthic assemblages with Stage I, II, and III individuals present in relative abundance.

- Benthic conditions over the disposal mounds and reference areas are expected to show improvement relative to those detected during the September 1995 survey.

2.0 METHODS

2.1 Survey Area

In order to fulfill the objectives of the 1996 CLIS monitoring survey, a bathymetric survey area was defined to examine the CLIS 95, CLIS 94, NHAV 93, and MQR mounds. The July 1996 bathymetric survey over CLIS occupied a 2100 m × 2100 m area, centered at 41°08.990' N, 72°53.272' W (NAD 27). A total of 85 survey lanes at 25 m lane spacing were required to delineate the topography of the four disposal mounds of interest (Figure 2-1). Detailed bathymetric charts were generated for the 4.41 km^2 survey area as well as four areas of concentrated analysis to accurately quantify mound height, lateral spread of dredged material, consolidation, and position relative to other disposal mounds.

2.2 Navigation

In an effort to provide strong comparisons with historic data sets, bathymetric data were collected with the use of SAIC's Integrated Navigation and Data Acquisition System (INDAS). This system utilizes a Hewlett-Packard 9920® series computer to provide real-time navigation, as well as collect position, depth, and time data for later analysis. A Del Norte Trisponder® System provided positioning data to an accuracy of ±3 m in the horizontal control NAD 27. Shore stations were established along the Connecticut coast at the known benchmarks of Stratford Point (41°09.112' N, 72°06.227' W) and Lighthouse Point (41°14.931' N, 72°54.255' W) (Figure 1-2). A detailed description of the navigation system and its operation can be found in the DAMOS Navigation and Bathymetry Reference Report (Murray and Selvitelli 1996).

In order to maximize the efficiency of survey operations at CLIS, differential Global Positioning System (DGPS) data in conjunction with SAIC's Portable Integrated Navigation and Survey System (PINSS) were used to position the survey vessel over the July 1996 REMOTS® camera stations. A Magnavox 4200D GPS receiver and a Magnavox MX50R differential beacon receiver provided DGPS positioning data to PINSS in the horizontal control of North American Datum of 1983 (NAD 83) to an accuracy of ±5 m. The Coast Guard differential beacon broadcasting from Montauk Point, Long Island, New York, (293 kHz) was utilized for satellite corrections due to its geographic position relative to CLIS.

The target REMOTS® station locations were calculated in NAD 27, then converted to NAD 83 for real-time navigation with the use of the US Army Topographic Engineering Center's CORPSCON version 3.01. The actual positions of the REMOTS® replicate

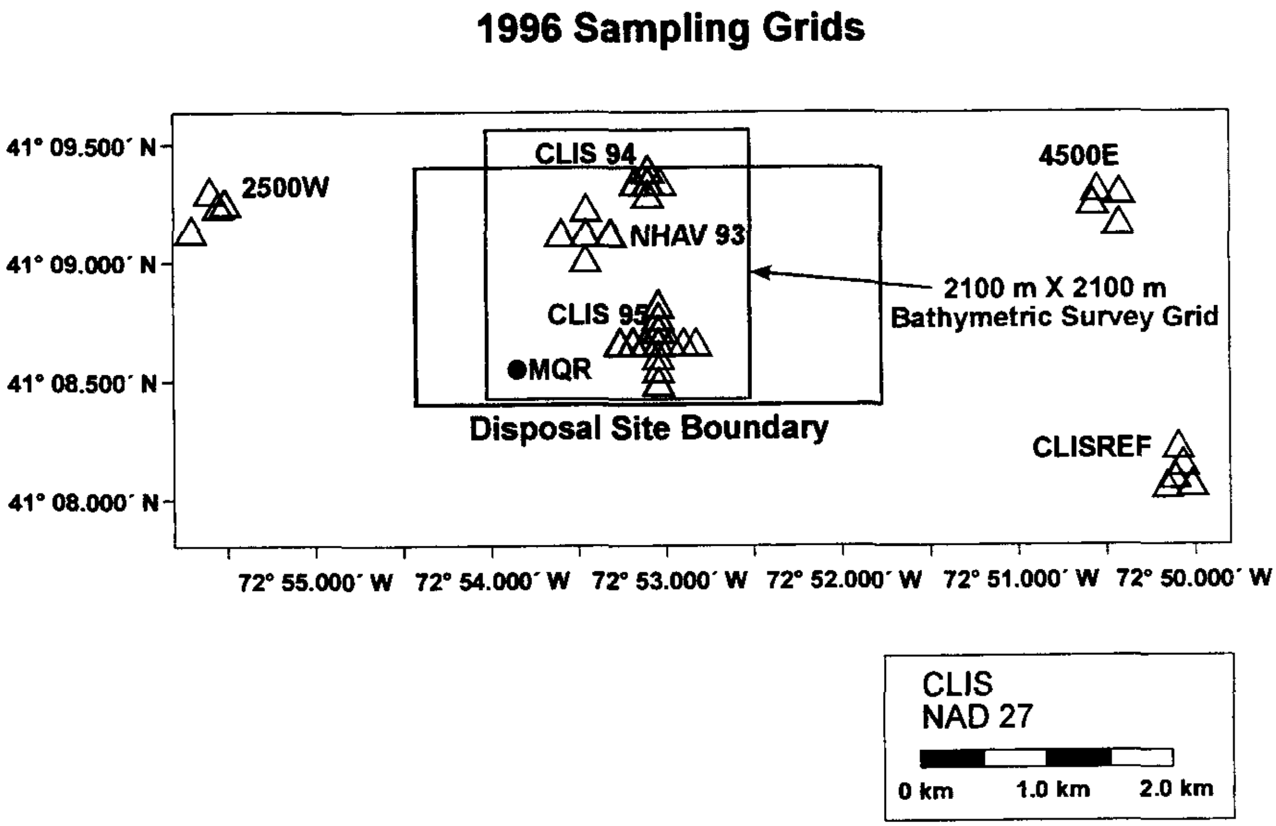


Figure 2-1. Chart of the 2100 m × 2100 m bathymetric survey area and REMOTS® stations (△) relative to the Central Long Island Sound Disposal Site boundaries

photographs were later reconverted to NAD 27 with CORPSCON for DAMOS database entry and reporting within this document.

2.3 Bathymetric Data Collection and Processing

An ODOM DF3200 Echotrac® Survey Fathometer with a narrow beam 208 kHz transducer measured individual depths to a resolution of 3.0 cm (0.1 ft.) as described in the DAMOS Navigation and Bathymetry Reference Report (Murray and Selvitelli 1996). Depth values transmitted to INDAS were adjusted for transducer depth. The acoustic returns of the fathometer can reliably detect changes in depth of 20 cm or greater due to the accumulation of errors introduced by the positioning system, vertical motion of the survey vessel, changes in sound velocity through the water column, the slope of the bottom, and tidal corrections.

Observed tidal data were obtained through the National Oceanographic and Atmospheric Administration (NOAA), Ocean and Lake Levels Division's (OLLD) National Water Level Observation Network. This network is composed of 181 water level stations that are located throughout the Great Lakes and coastal regions of United States interest. These stations are equipped with the Next Generation Water Level Measurement System tide gauges and satellite transmitters that have collected and transmitted tide data to the central NOAA facility every six minutes, since 1 January 1994.

Observed tide data are available 1 to 6 hours from the time of collection in a station datum or referenced to Mean Lower Low Water (MLLW) and based on Coordinated Universal Time (UTC). For the 1996 CLIS survey, data from NOAA tide station 8467150 in Bridgeport Harbor, Bridgeport, CT, was used for tidal calculations. The NOAA 6-minute tide data was downloaded in the MLLW datum, corrected to local time, and tidal differences based on the entrance to New Haven Harbor, New Haven, CT, were applied.

During the bathymetric survey, a Seabird Instruments, Inc. SBE 26-03 Sea Gauge wave and tide recorder was used to collect tidal data on-site. The tide gauge, deployed in the survey area, recorded pressure values every six minutes. After conversion, the pressure readings provided a constant record of tidal variations in the survey area. These observed tidal data were later used to compare and verify the corrected NOAA data generated from the Bridgeport Harbor station (Figure 2-2).

A Seabird Instruments, Inc. SEACAT SBE 19-01 Conductivity, Temperature, and Depth (CTD) probe was used to obtain sound velocity measurements at the start, midpoint, and end of each survey day. The data collected by the CTD probe were bin-averaged to 1 meter depth intervals to account for any pycnoclines, rapid changes in density that create

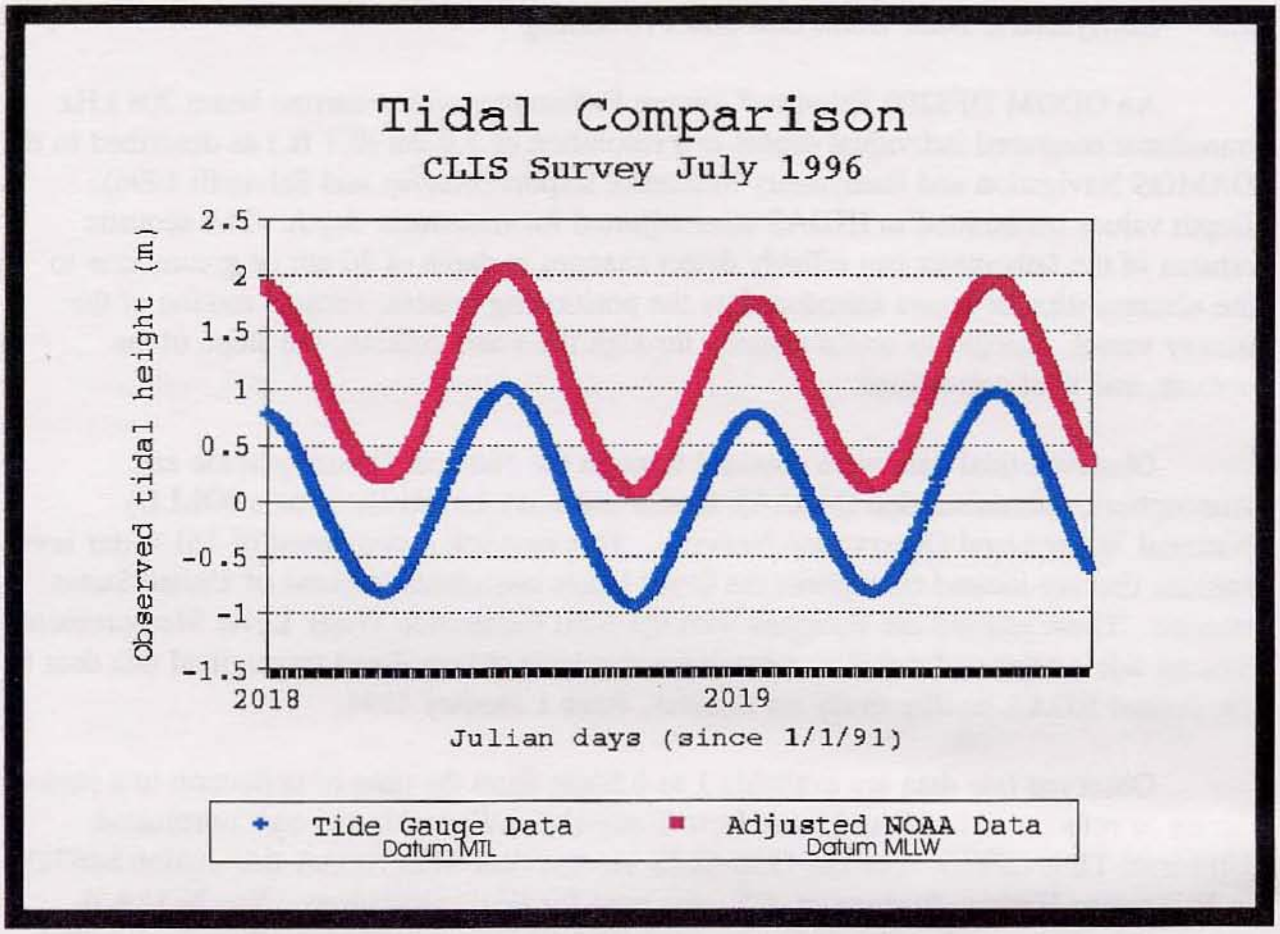


Figure 2-2. Comparison of the two types of tidal data collected for the July 1996 bathymetric survey at CLIS

distinct layers within the water column. Sound velocity correction factors were then calculated using the bin-averaged values.

The bathymetric data were analyzed using SAIC's Hydrographic Data Analysis System (HDAS), version 1.03. Raw bathymetric data were imported into HDAS, corrected for sound velocity, and standardized to mean lower low water using the NOAA observed tides. The bathymetric data were then used to construct depth models of the surveyed area. A detailed discussion of the bathymetric analysis technique is provided in the DAMOS Bathymetry and Navigation Reference Report (Murray and Selvitelli 1996).

2.4 REMOTS® Sediment-Profile Photography

REMOTS® photography was used to detect the distribution of dredged material layers, map benthic disturbance gradients, and monitor the benthic infaunal recolonization and/or successional status of the CLIS 95, CLIS 94, and NHAV 93 disposal mounds. Cross-sectional photographs of the top 20 cm of sediment were taken for analysis and intercomparison with data collected at the adjacent CLIS reference areas, as well as previous surveys.

The REMOTS® sampling grids over the disposal mounds formed a cross-shaped pattern over the centers of the project mounds. Three replicate photographs were taken at 13 stations over CLIS 95 and five stations over the CLIS 94 and NHAV 93 disposal mounds. The sampling pattern over the CLIS 95 mound consisted of three stations over each of four arms and one station in the center. The pattern over the CLIS 94 and NHAV 93 mounds consisted of one station over each of four arms and one station in the center (Figure 2-1). The REMOTS® survey over the new CLIS 95 mound was centered at the CDA 95 buoy position (41°08.660' N, 72°53.042' W), with station spacing at 100 m (Appendix A, Table 2-1). The CLIS 94 grid, centered at 41°09.343' N, 72°53.099' W, was sampled every 100 m (Appendix A, Table 2-1). The REMOTS® survey over the NHAV 93 mound was centered at 41°09.122' N, 72°53.453' W with station spacing at 200 m (Appendix A, Table 2-1).

Data from three reference areas (2500W, 4500E, and CLIS-REF) were used for comparison of ambient central Long Island Sound sediments relative to the sediments deposited at CLIS through disposal operations. Reference areas 2500W (41°09.254' N, 72°55.569' W) and 4500E (41°09.254' N, 72 50.565' W) were sampled at four randomly selected stations. CLIS-REF (41°08.085' N, 72°50.109' W) was sampled at five randomly selected stations (Figure 2-1; Appendix A, Table 2-1).

3.0 RESULTS

The 2100 m × 2100 m precision bathymetric survey at CLIS was conducted to monitor changes in bottom topography and long-term stability of the sediment mounds occupying the most active region of the disposal site. This survey yielded a bathymetric chart of the 4.41 km^2 area with a minimum depth of 15.5 m over the NHAV 74 mound (Figure 3-1). A total of seventeen discrete and/or coalesced dredged material disposal mounds were detected within the surveyed area.

To improve the resolution and focus on each of the subject disposal mounds (CLIS 95, CLIS 94, NHAV 93, and MQR), the data collected over the 2100 m × 2100 m survey area was regridded into smaller analysis areas. Depth difference calculations for apparent accumulation and consolidation of dredged material were performed within the analysis area for each mound.

3.1 CLIS 95 Mound

3.1.1 Bathymetry

The CLIS 95 mound is a capped mound composed of an estimated barge volume of 66,400 m^3 of dredged material (16,300 m^3 UDM and 50,100 m^3 CDM) deposited at the CDA 95 buoy from 2 October 1995 through 4 March 1996. Based on the relatively small volume of dredged material disposed, a 600 m × 600 m analysis area was defined around the CDA 95 buoy position. The bathymetric chart of this smaller area displays a sediment mound approximately 150 m wide along its north-south axis with a minimum depth of 17.25 m at the apex (Figure 3-2).

Depth difference calculations based on comparisons with bathymetric data collected at CLIS during the July 1994 survey indicate the deposition of new material succeeded in forming a discrete sediment mound with a height of 3.75 m (Figures 3-3 and 3-4). The CLIS 95 mound appears to be irregularly shaped along the east-west axis as a lobe of material extends 110 m eastward from the base of the mound. DAMOS disposal logs indicate the release of approximately 12,500 m^3 of CDM 80 m to 90 m east of the disposal buoy in order to achieve proper cap thickness, accounting for the irregular shape.

A total of 28 barge loads of UDM were transported to the CDA 95 buoy and deposited on the CLIS seafloor followed by 86 barge loads of CDM. Detailed analysis of the disposal pattern shows a slight difference between the reported disposal position and the areas of accumulation (Figure 3-5). However, this 75 m to 100 m offset can be

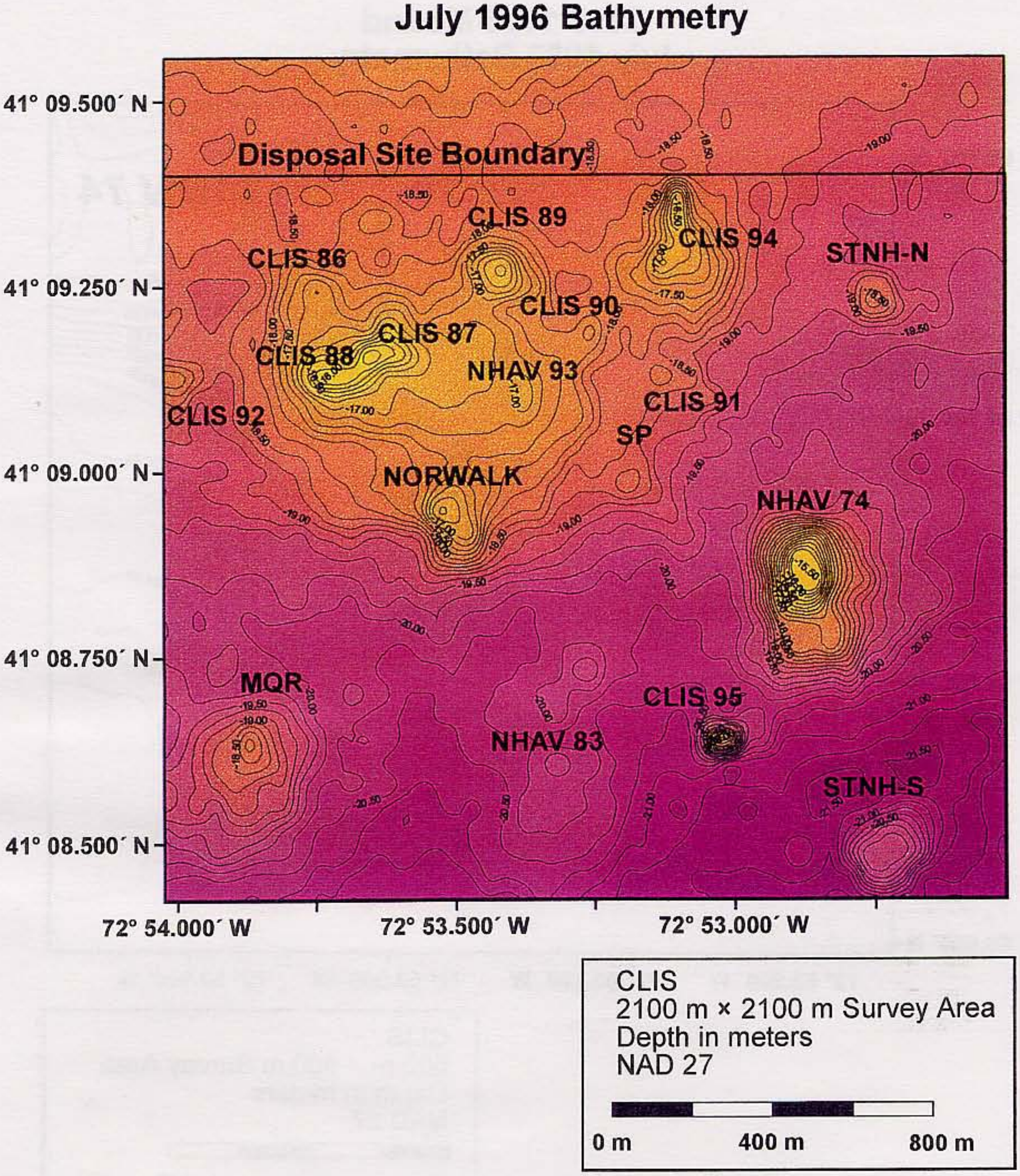


Figure 3-1. Bathymetric chart of the 2100 m × 2100 m survey area relative to the northern disposal site boundary, 0.25 m contour interval

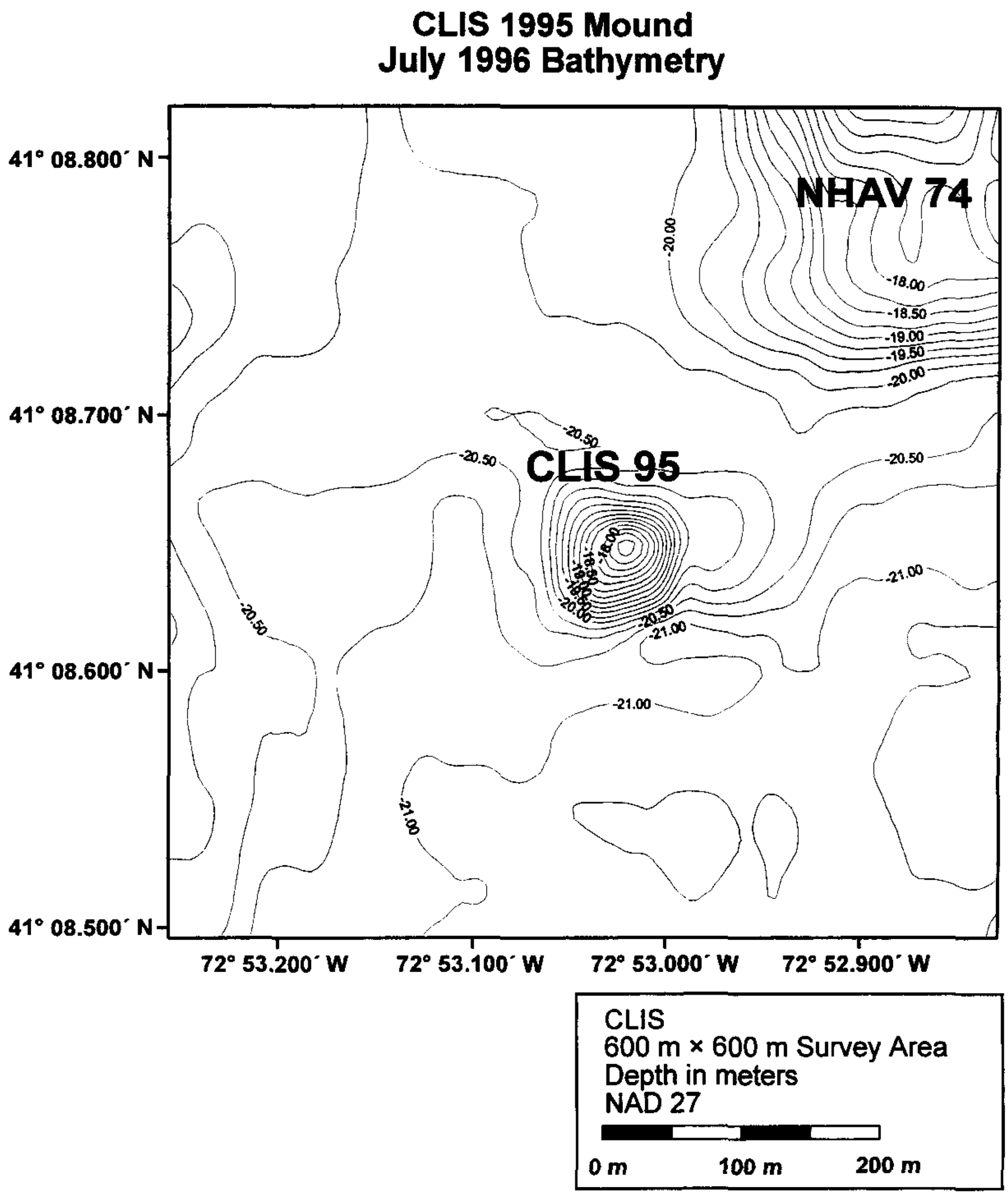


Figure 3-2. Bathymetric chart of the 600 m × 600 m analysis area around the CLIS 95 mound, July 1996, 0.25 m contour interval

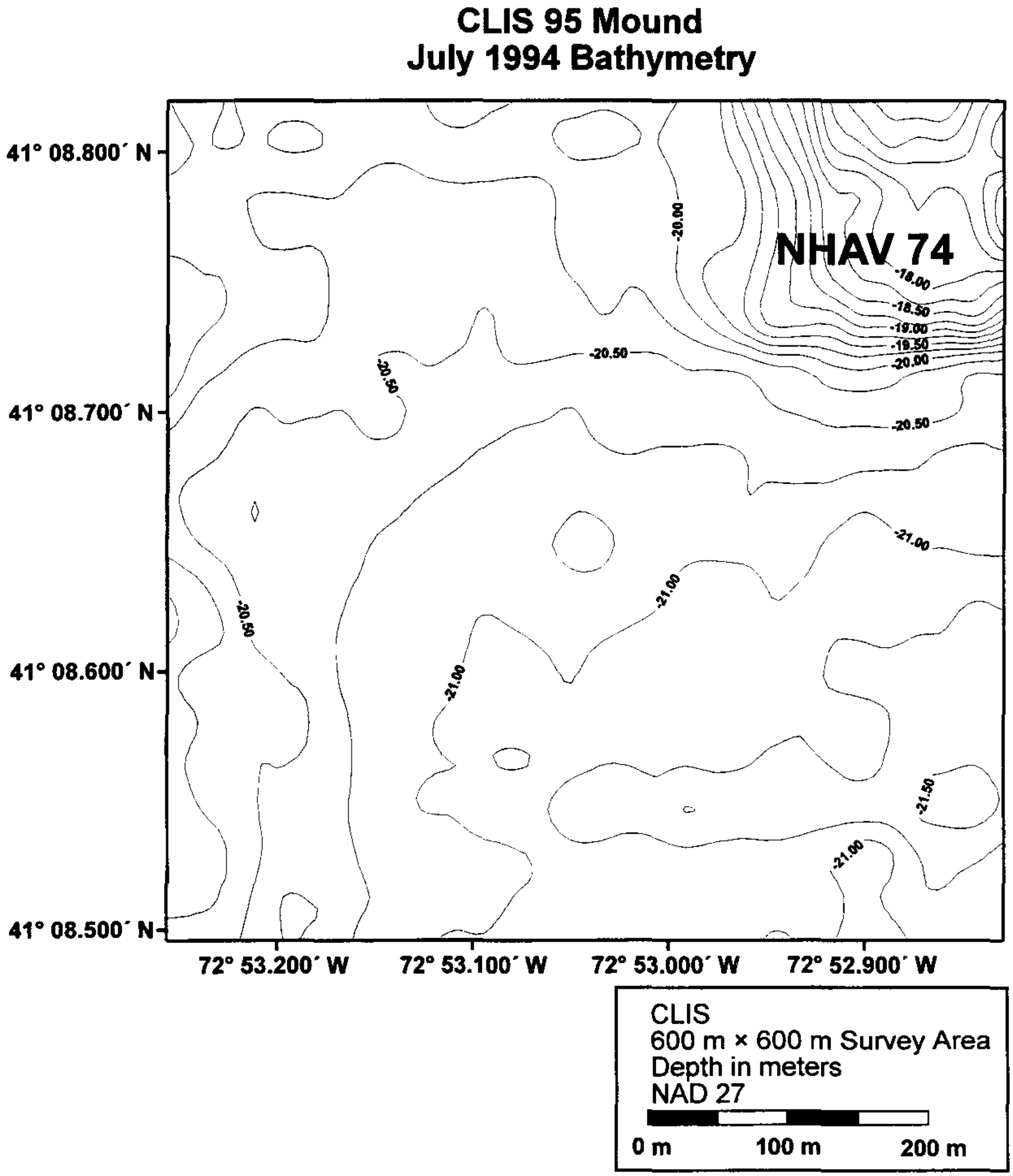


Figure 3-3. Bathymetric chart of the 600 m × 600 m analysis area around the CLIS 95 mound, July 1994, 0.25 m contour interval

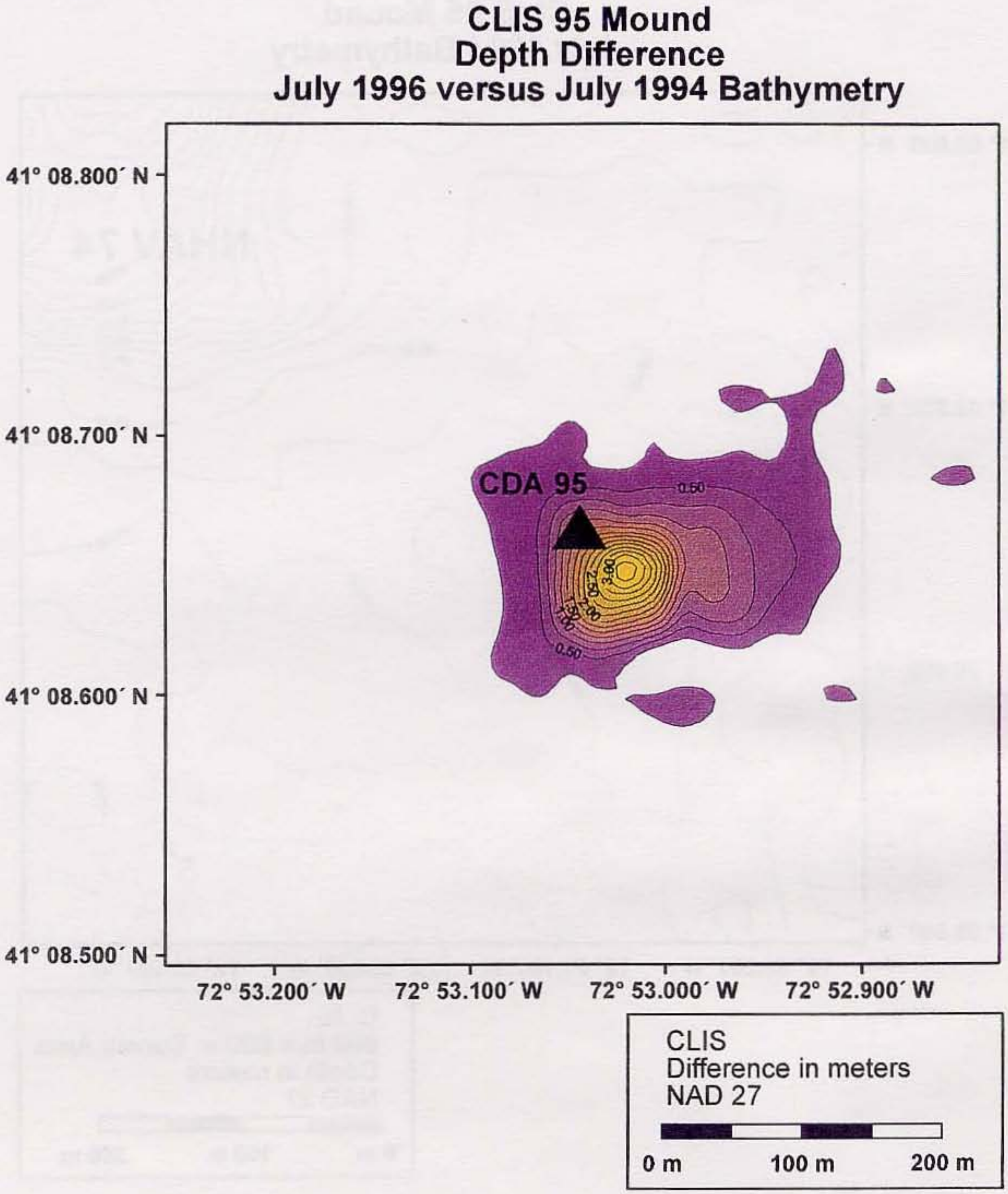


Figure 3-4. Depth difference plot of the July 1996 data vs. the July 1994 data, 0.25 m contour interval

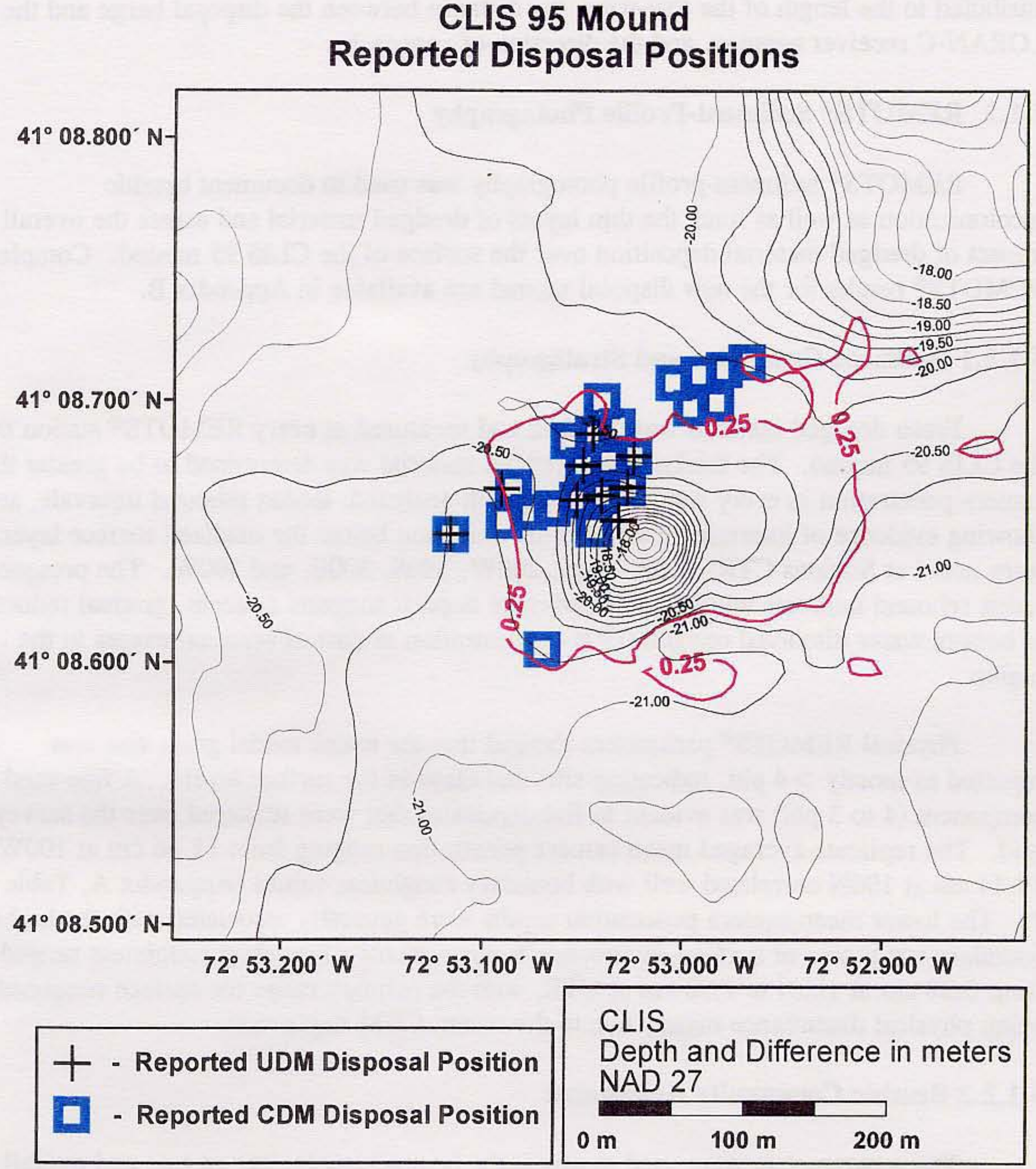


Figure 3-5. Distribution of reported barge release positions (UDM and CDM) over the detectable margins of the CLIS 95 mound

attributed to the length of the tow-wire, the distance between the disposal barge and the LORAN-C receiver antenna, and the direction of approach.

3.1.2 REMOTS® Sediment-Profile Photography

REMOTS® sediment-profile photography was used to document benthic recolonization as well as track the thin layers of dredged material and assess the overall impact of dredged material deposition over the surface of the CLIS 95 mound. Complete REMOTS® results for the new disposal mound are available in Appendix B.

3.1.2.1 Sediment Grain Size and Stratigraphy

Fresh dredged material was detected and measured at every REMOTS® station over the CLIS 95 mound. The thickness of dredged material was determined to be greater than camera penetration in every replicate photograph analyzed. Redox rebound intervals, areas showing evidence of intermittent or seasonal oxidation below the oxidized surface layer, were noted at Stations CTR, 100E, 200S, 200W, 300S, 300E, and 300W. The presence of redox rebound intervals within a new sediment deposit suggests a recent, gradual reduction in bottom water dissolved oxygen (DO) concentration as part of seasonal events in the region.

Physical REMOTS® parameters showed that the major modal grain size was reported as mostly >4 phi, indicating silts and clays in the surface layers. A fine sand component (4 to 3 phi) was evident in five replicates that were scattered over the survey grid. The replicate-averaged mean camera penetration ranging from 11.46 cm at 100W to 18.44 cm at 100N correlated well with boundary roughness values (Appendix A, Table 3-1). The lower mean camera penetration depths were generally associated with the higher boundary roughness or surface disturbance measurements. Boundary roughness ranged from 0.38 cm at 100N to 1.98 cm at CTR, with the primary cause for surface roughness being physical disturbance mainly due to the recent CDM deposition.

3.1.2.2 Benthic Community Assessment

Three parameters were used to assess the benthic recolonization rate and overall health of the project mounds relative to the CLIS reference areas. The apparent Redox Potential Discontinuity (RPD) depth, infaunal successional status, and the Organism-Sediment Index (OSI) were mapped on station location plots to outline the biological conditions at each station.

The apparent RPD depth is a measure of the level of oxygenation in the upper sediment layers. This value indicates dissolved oxygen conditions within sediment pore water as well as the availability and consumption of molecular oxygen (O_2) in the surface sediments. Since actual oxygen status in the sediment is not measured, the apparent RPD is estimated by measuring the thickness of the layer of high reflectance oxidized sediments in contrast to the usually gray to black reduced material at depth (Rhoads and Germano 1982).

The mapping of successional stages is based on the theory that organism-sediment interactions follow a predictable sequence after a major seafloor disturbance (Rhoads and Germano 1982). This sequence is defined by end-member assemblages of benthic organisms. Stage I is made up of pioneering assemblages usually consisting of dense aggregations of near-surface, tube-dwelling polychaetes. If left undisturbed, Stage II infaunal deposit feeders such as shallow-dwelling bivalves or tubicolous amphipods then colonize the recovering seafloor. Stage III organisms are generally head-down deposit-feeding invertebrates whose presence results in distinctive subsurface feeding voids. Stage III taxa are associated with relatively low-disturbance regimes (Rhoads and Germano 1986).

Organism-sediment index values are calculated by summarizing the apparent RPD depth, successional status, and indicators of methane or low oxygen. OSIs can range from -10 (azoic with methane gas present in sediment) to 11 (aerobic bottom with deep apparent RPD, evidence of mature macrofaunal assemblage, and no apparent methane). OSI values are useful in mapping disturbances and quantifying ecosystem recovery (Rhoads and Germano 1982).

The replicate-averaged mean redox potential discontinuity (RPD) depths over the CLIS 95 mound ranged from 0.94 cm at 100S to 3.18 cm at 200N (Figure 3-6). There was no distinct pattern in the RPD values within the REMOTS® grid; however, the range was relatively high for a new dredged material deposit. No methane was noted at any station over the CLIS 95 mound, but low dissolved oxygen (DO) was detected in one replicate of Station 100S, effecting the OSI value for that station.

With the exception of 100S, median OSI values were higher than expected for a sediment mound at five months postdisposal, ranging from 3.0 to 10.0 (Figure 3-6). Deep RPD depths and a mature benthic assemblage were the reasons for the elevated OSI values. The successional stage status of CLIS 95 was quite advanced for an area recovering from a recent benthic disturbance. Stage III activity was detected at every station over the CLIS 95 mound with most replicates being classified as Stage I on III. One replicate over Station 300W failed to show evidence of Stage III organisms in the surface or subsurface

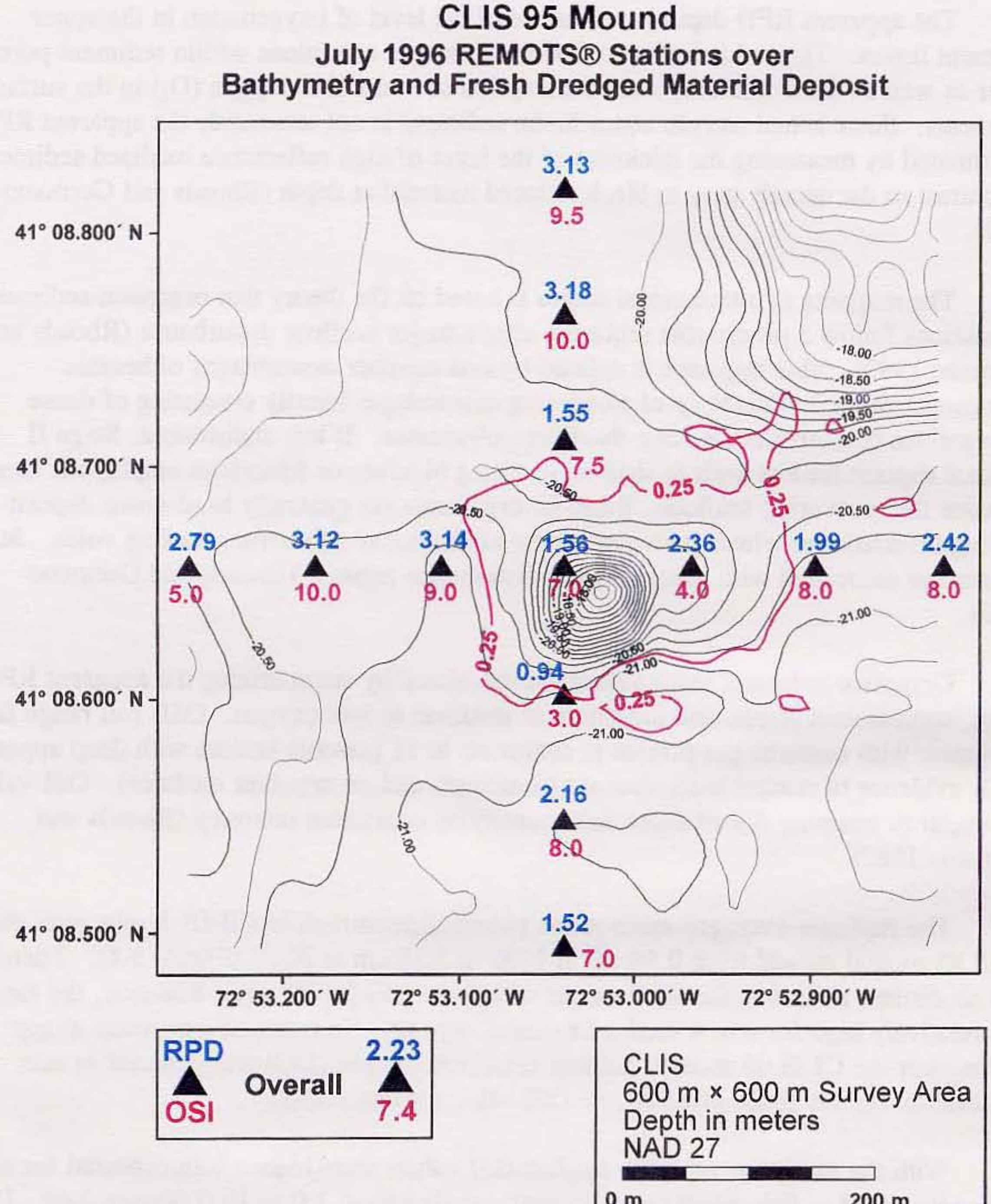


Figure 3-6. Bathymetric chart of the 600 m × 600 m analysis area overlaid with footprint of fresh dredged material detected by depth difference calculations (see Figure 3-4) as well as replicate-averaged RPD and OSI values from 1996 REMOTS® survey

sediment layers. However, a deep RPD and mature Stage I benthic assemblage in this replicate suggest that the surface sediments are comparable to the remainder of the CLIS 95 mound (Figure 3-7A). Overall, the benthic conditions over the entire CLIS 95 mound indicate a rapid recovery as demonstrated by the photographs collected over CTR (Figure 3-7B).

3.2 CLIS 94 Mound

3.2.1 Bathymetry

The CLIS 94 mound is readily apparent in the large 4.41 km^2 survey area; however, in order to focus on the smaller aspects of the disposal mound, the July 1996 bathymetric data were narrowed to a 1.0 km^2 analysis area. The mound is approximately 470 m wide at the center with a minimum depth of 16.25 m at the apex (Figure 3-8). The CLIS 94 mound maintained its irregular shape, being broader and less pronounced south of the apex. Depth difference plots utilizing the September 1995, 1000 m × 1000 m survey over the CLIS 94 mound indicate a 0.25 to 0.5 m decrease in mound height at the apex as well as several pockets of consolidation to the south (Figures 3-9 and 3-10). Comparisons with the July 1994 baseline bathymetry show that the bottom feature now has a maximum mound height of 2.5 m (Figures 3-11 and 3-12).

3.2.2 REMOTS® Sediment-Profile Photography

REMOTS® sediment-profile photography was used to document benthic recolonization over the center of the disposal mound and assess the overall recovery of the dredged material deposit. Complete REMOTS® results for the disposal mound are available in Appendix C.

3.2.2.1 Sediment Grain Size and Stratigraphy

Dredged material was detected and measured at every station over the center of the CLIS 94 mound. Dredged material was greater than camera penetration in every replicate photograph. Redox rebound intervals were noted at stations 100 m south and east of the center, lending further support to the observations at CLIS 95 which suggest the occurrence of a recent, gradual reduction in water column DO.

Physical REMOTS® parameters showed that the major modal grain size was reported as >4 phi (silt and clay) at most stations, indicating the deposition of predominantly fine-grained dredged material with no detectable coarsening of surficial

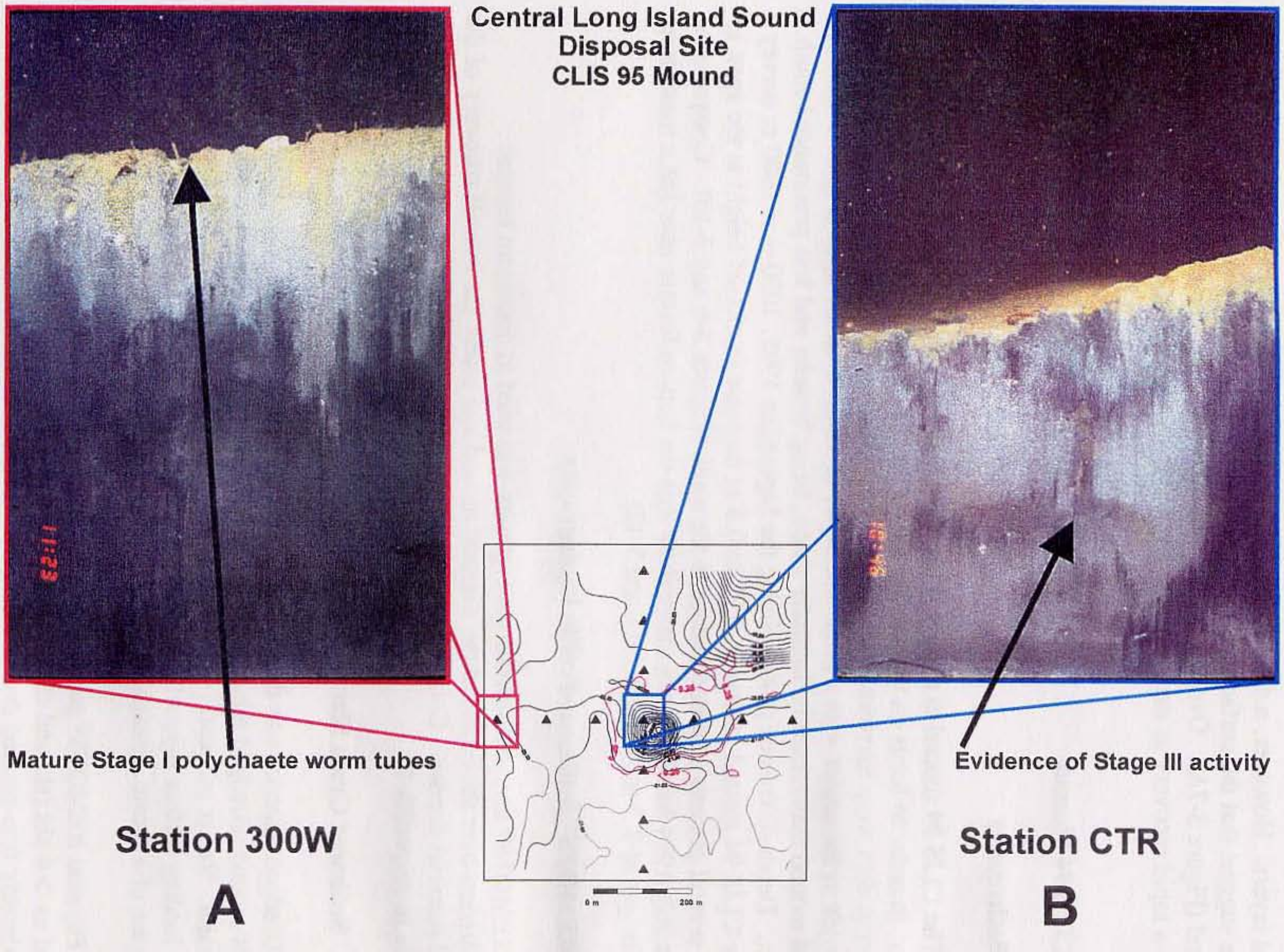


Figure 3-7. REMOTS® photographs collected over Stations 300W and CTR of the CLIS 95 mound providing examples of Stage I benthic recolonization status versus Stage III

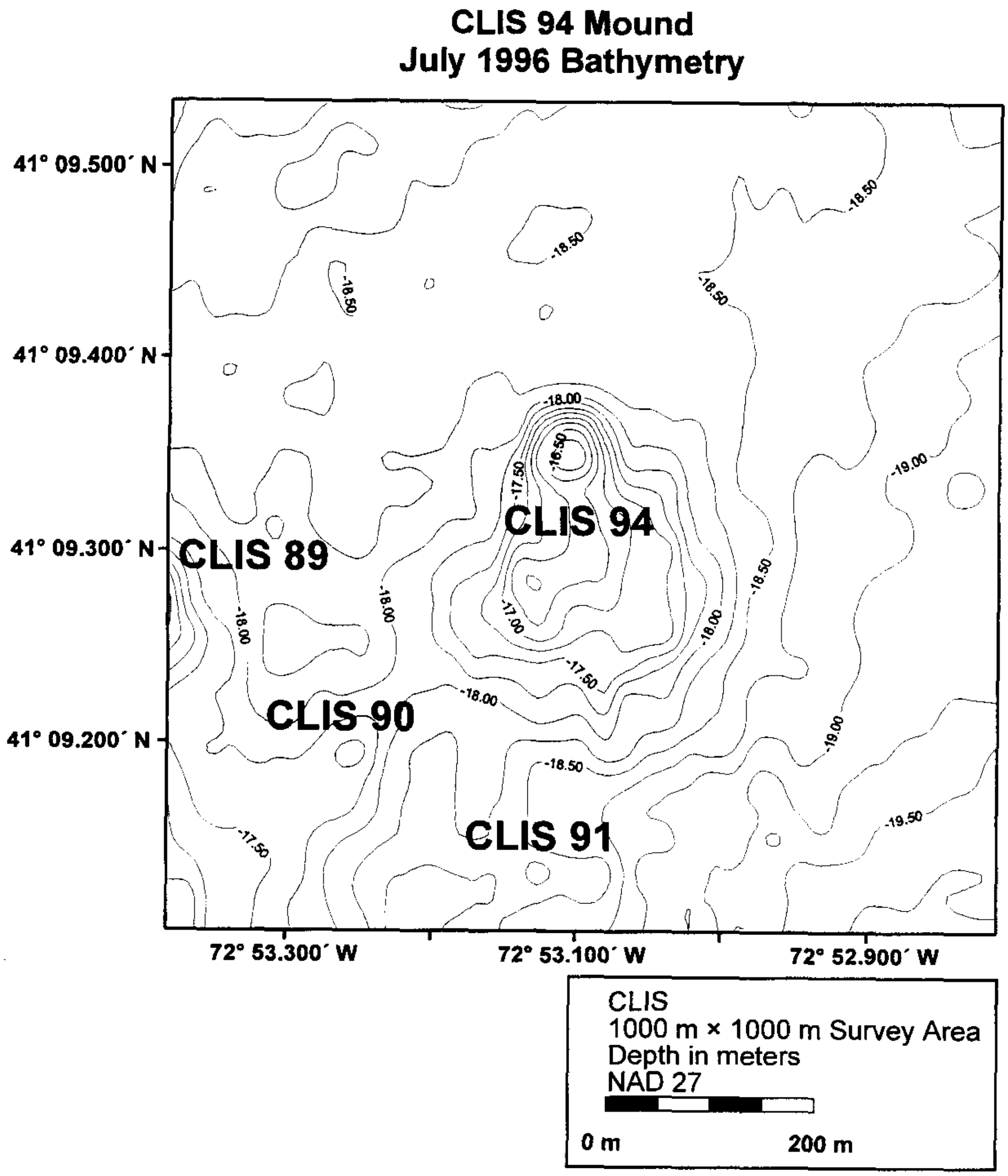


Figure 3-8. Bathymetric chart of the 1000 m × 1000 m analysis area over the CLIS 94 mound, July 1996, 0.25 m contour interval

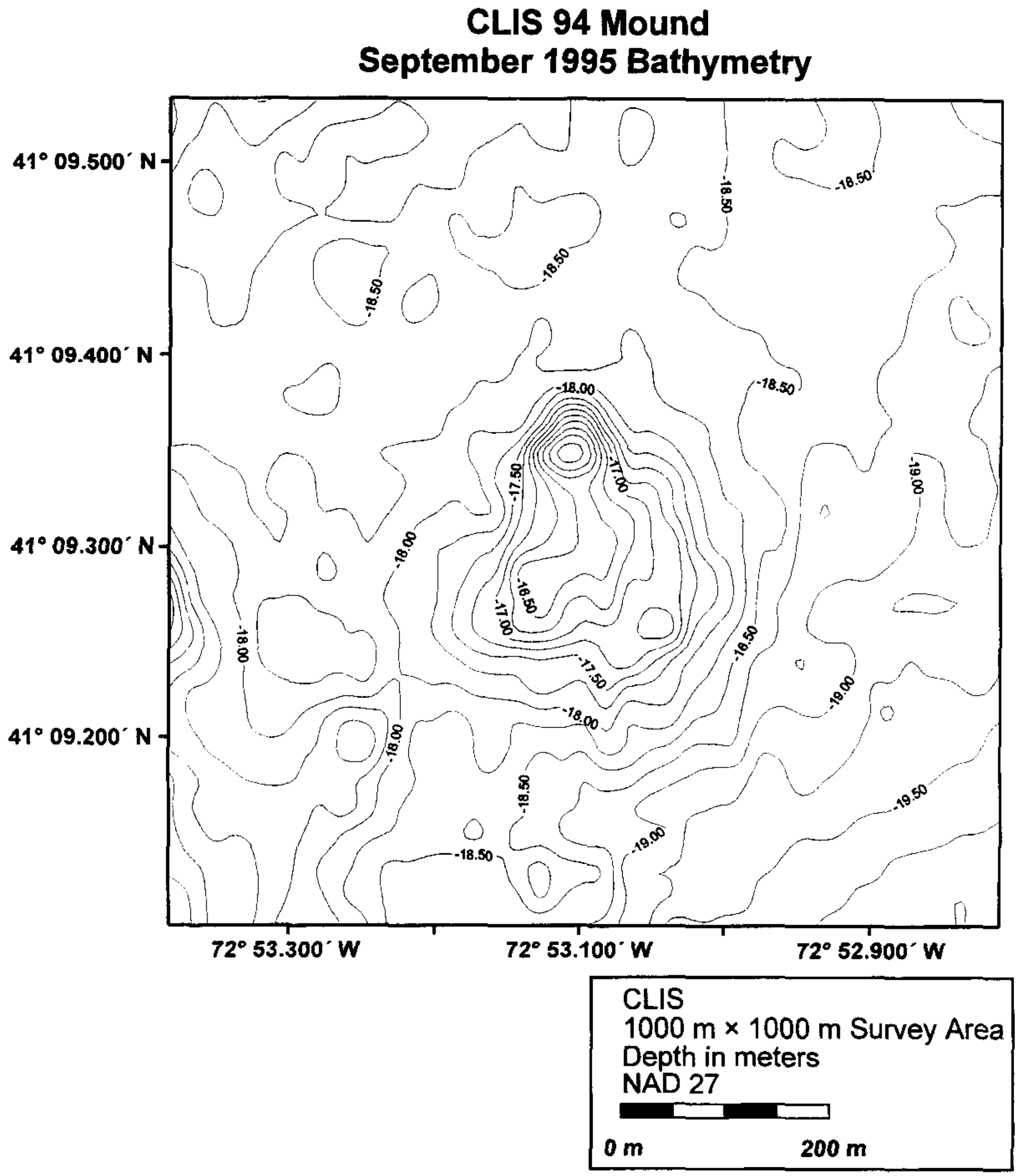


Figure 3-9. Bathymetric chart of the 1000 m × 1000 m analysis area over the CLIS 94 mound, September 1995, 0.25 m contour interval

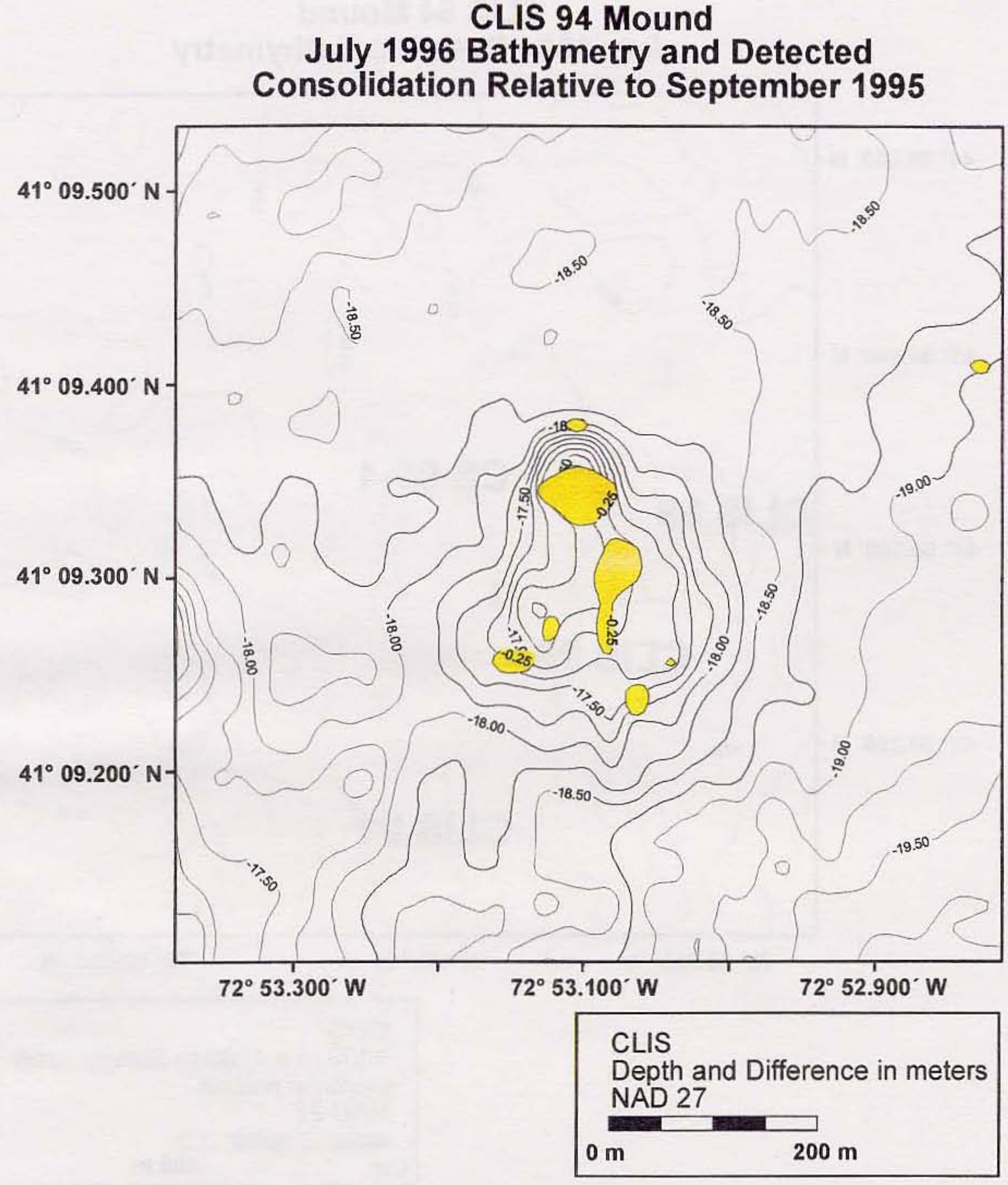


Figure 3-10. Bathymetric chart showing pockets of apparent consolidation over the CLIS 94 mound since September 1995, 0.25 m contour interval

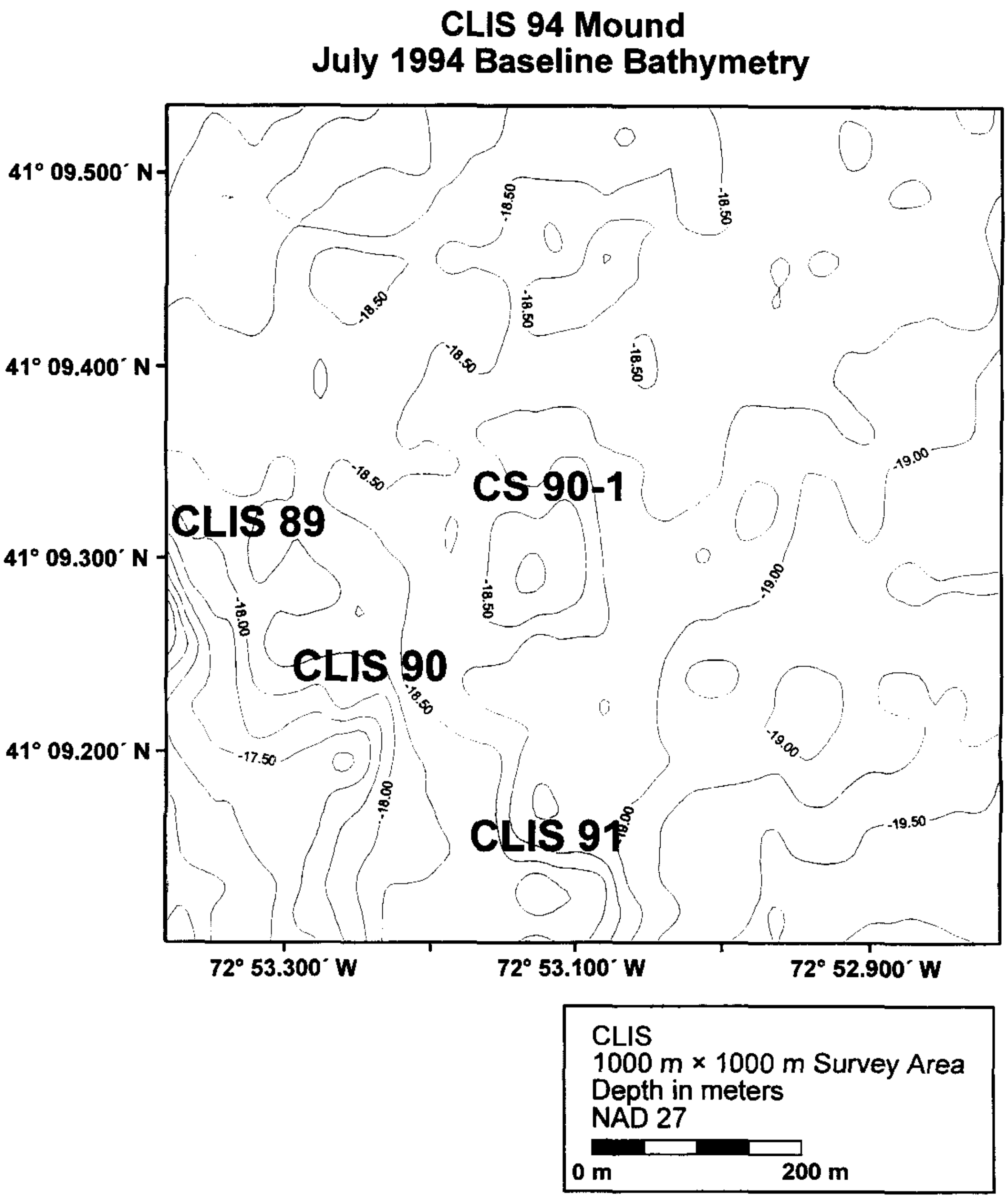


Figure 3-11. Bathymetric chart of the 1000 m × 1000 m analysis area over the CLIS 94 mound, July 1994 baseline, 0.25 m contour interval

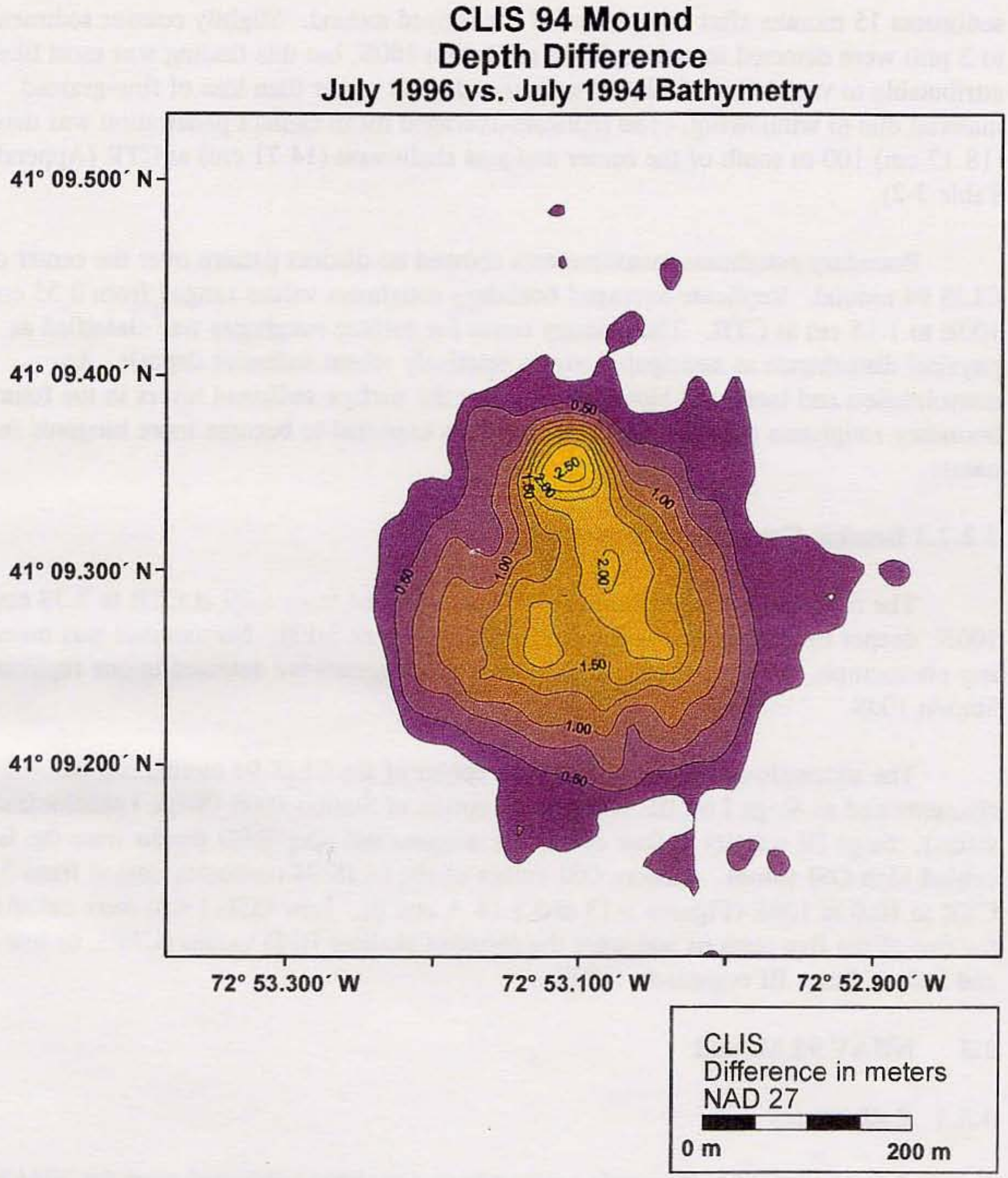


Figure 3-12. Depth difference plot of the July 1996 data vs. the July 1994 data showing the current status of the CLIS 94 mound, 0.25 m contour interval

sediments 15 months after completion of the capped mound. Slightly coarser sediments (4 to 3 phi) were detected in one replicate of Station 100S, but this finding was most likely attributable to variability within the sediment deposit rather than loss of fine-grained material due to winnowing. The replicate-averaged mean camera penetration was deepest (18.12 cm) 100 m south of the center and was shallowest (14.71 cm) at CTR (Appendix A, Table 3-2).

Boundary roughness measurements showed no distinct pattern over the center of the CLIS 94 mound. Replicate-averaged boundary roughness values ranged from 0.35 cm at 100E to 1.15 cm at CTR. The primary cause for surface roughness was classified as physical disturbance as anticipated over a relatively recent sediment deposit. As consolidation and increased bioturbation affect the surface sediment layers in the future, boundary roughness over the CLIS 94 mound is expected to become more biogenic in nature.

3.2.2.2 Benthic Community Assessment

The replicate-averaged mean RPD values ranged from 1.09 at CTR to 3.38 cm at 100N, deeper in comparison to the 1995 results (Figure 3-13). No methane was noted in any photograph, but indications of low dissolved oxygen were detected in one replicate of Station 100S.

The successional stage status for the center of the CLIS 94 mound can be characterized as Stage I on III, with the exception of Station 100S (Stage I recolonization status). Stage III activity at four of the five stations and deep RPD depths were the factors behind high OSI values. Median OSI values of the CLIS 94 replicates ranged from 3.0 at CTR to 10.0 at 100E (Figures 3-13 and 3-14 A and B). Low OSIs (<6) were calculated for two of the five stations and were the result of shallow RPD values (CTR), or low DO and lack of Stage III organisms (100S).

3.3 NHAV 93 Mound

3.3.1 Bathymetry

A total of eight bathymetric surveys have now been conducted over the NHAV 93 mound since September 1993 to monitor the progress of the CAD mound construction, stability, and consolidation over time. The latest bathymetric survey, 2.5 years after capping operations were completed, displays a mound complex approximately 820 m wide and composed of eight disposal mounds (CLIS 87, CLIS 88, CLIS 89, CLIS 90, CLIS 91, SP, Norwalk, and NHAV 93) (Figure 3-15).

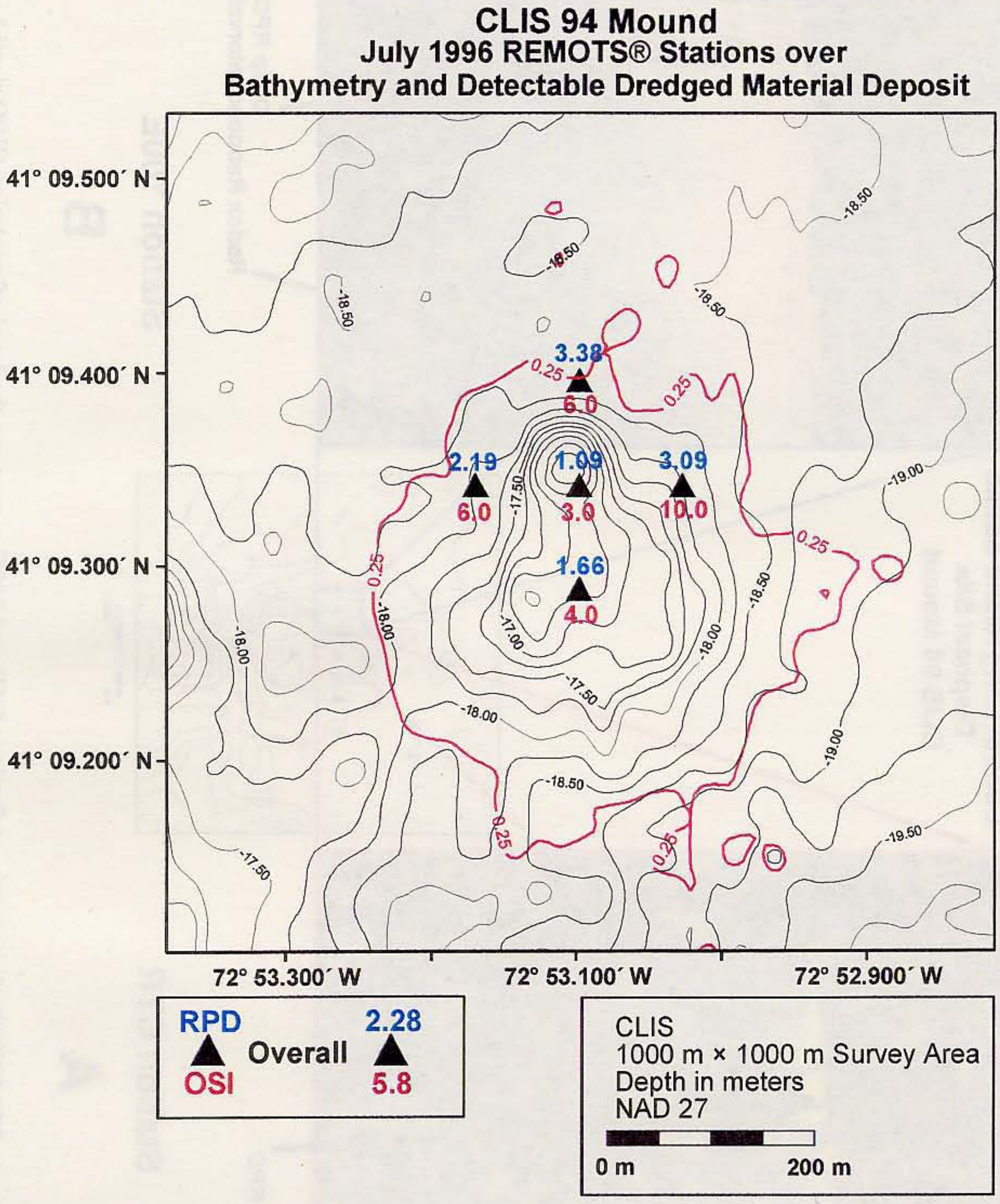


Figure 3-13. Bathymetric chart of the 1000 m × 1000 m analysis area overlaid with footprint of detectable dredged material (see Figure 3-12) as well as replicate-averaged RPD and OSI values from 1996 REMOTS® survey

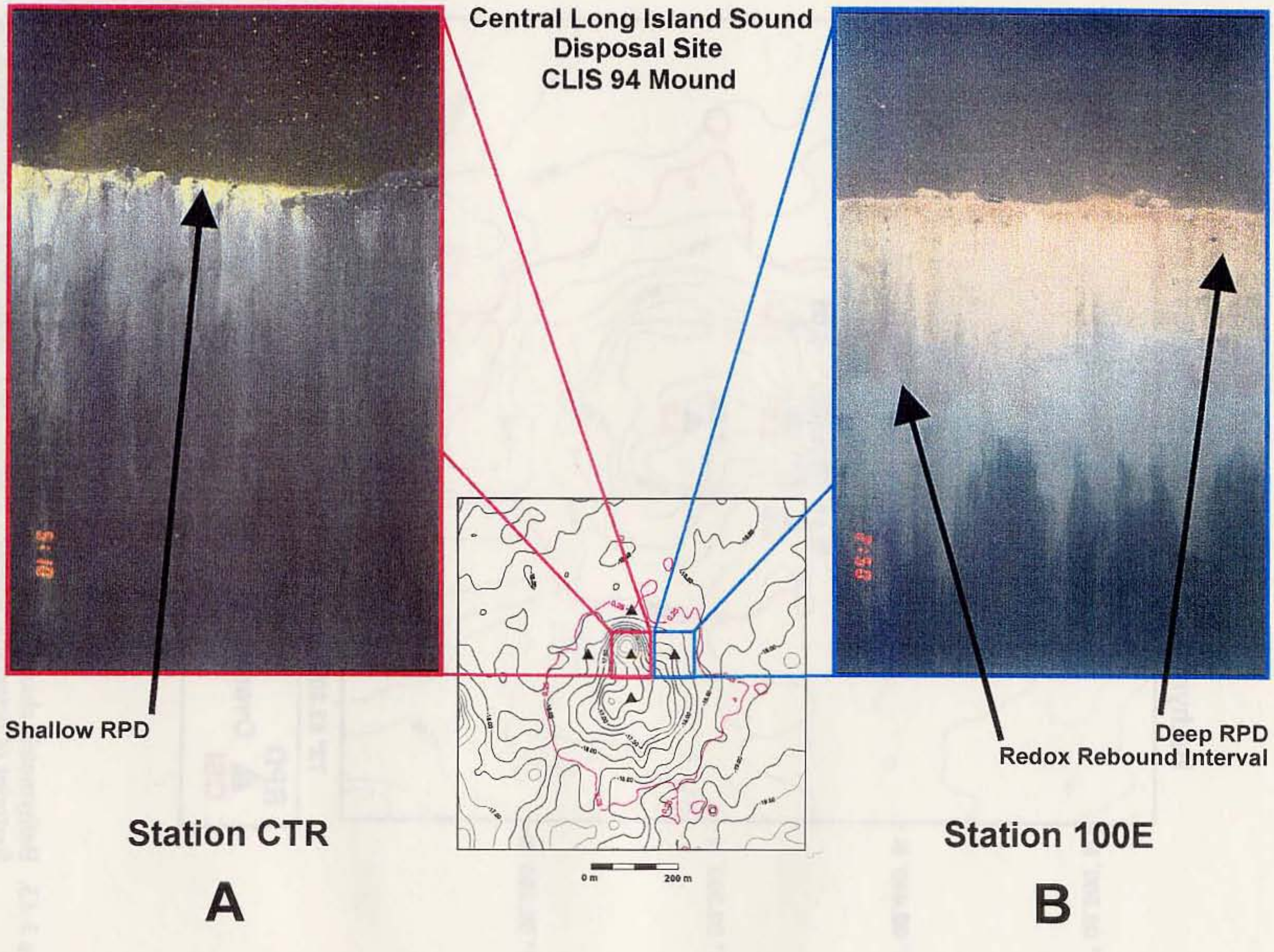


Figure 3-14. REMOTS® photographs at Stations CTR and 100E comparing the level of oxidation (RPD depth) in the surface sediments over the CLIS 94 mound

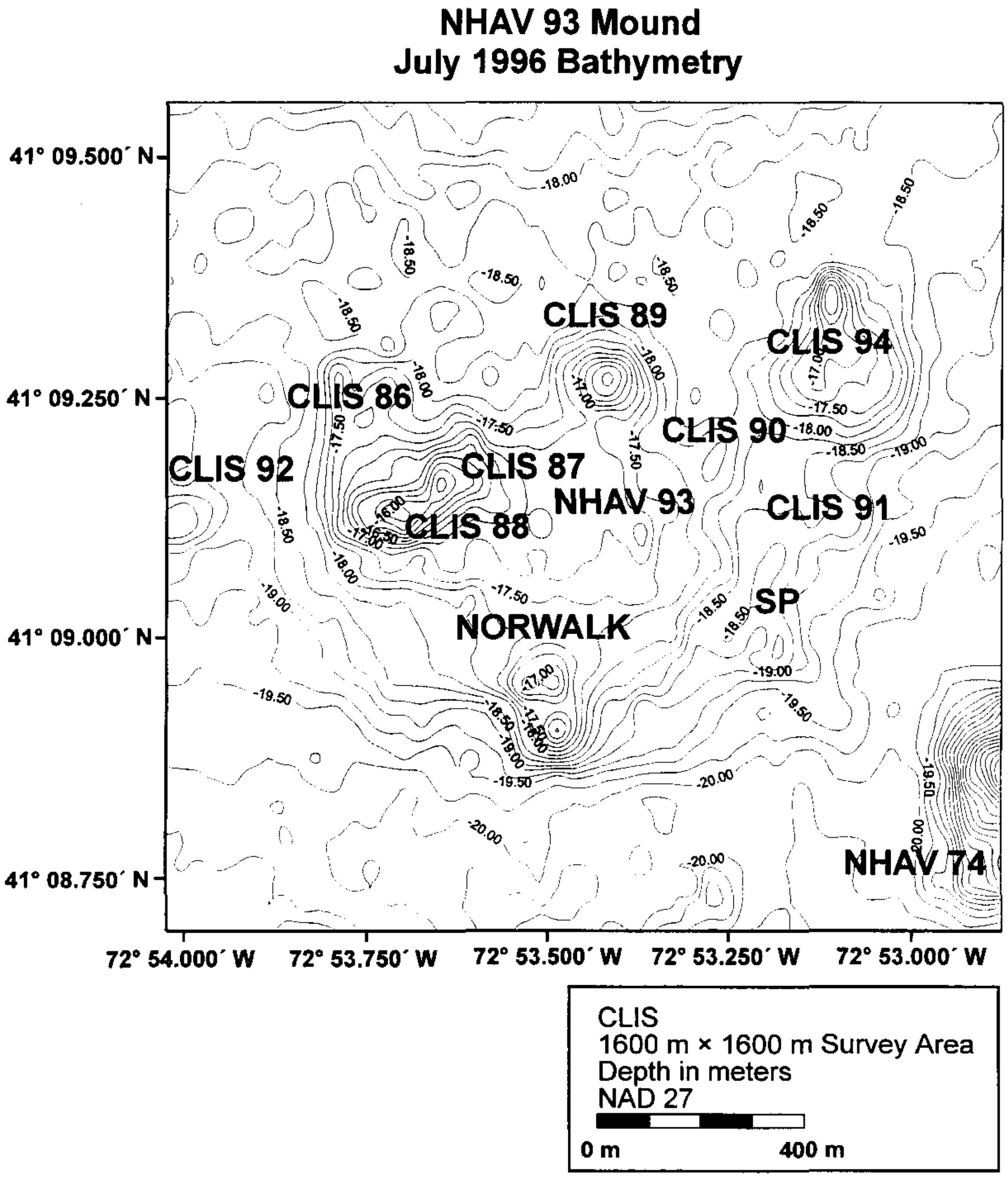


Figure 3-15. Bathymetric chart of the 1600 m × 1600 m analysis area over the NHAV 93 mound, July 1996, 0.25 m contour interval

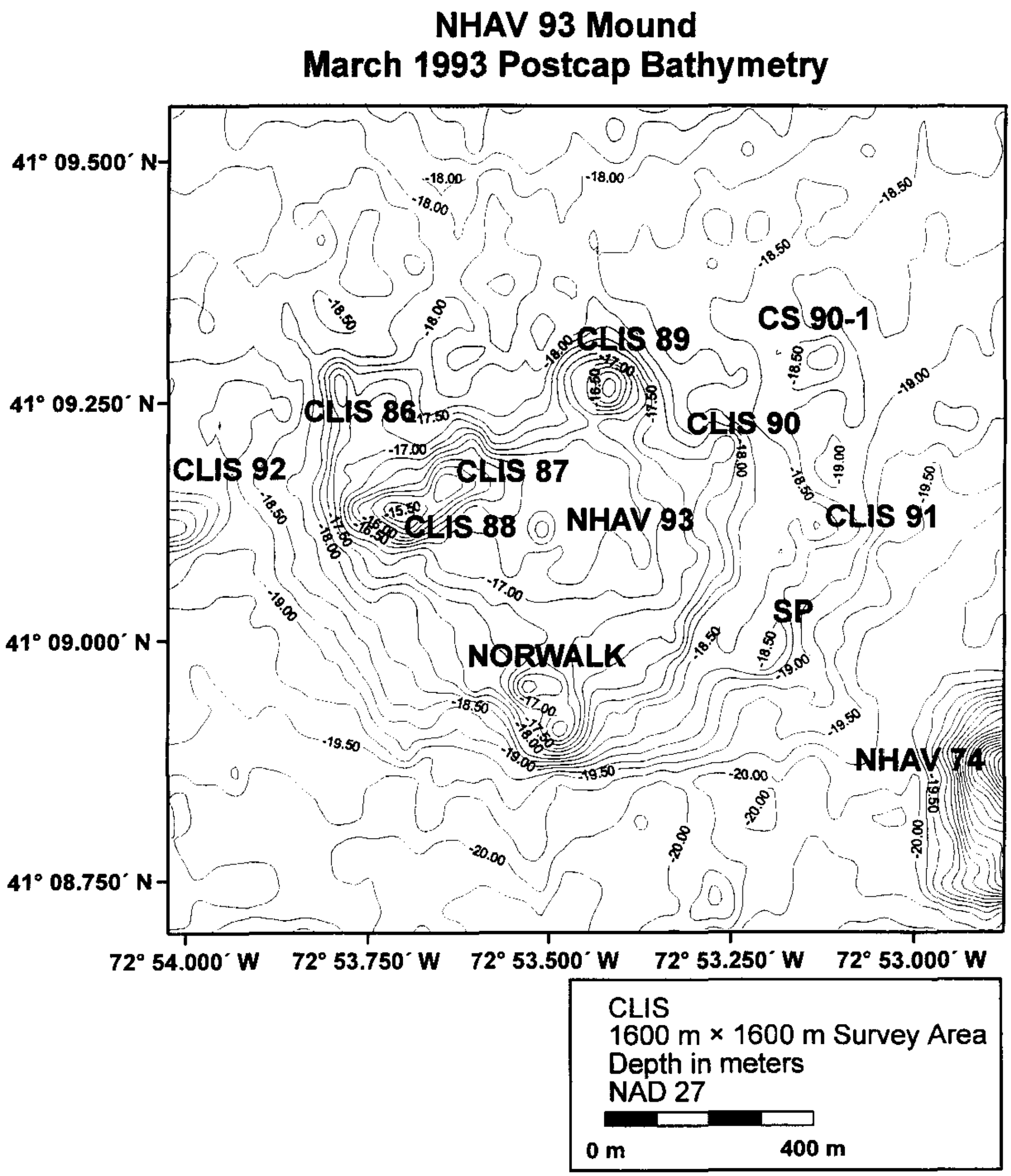


Figure 3-16. Bathymetric chart of the 1600 m × 1600 m analysis area over the NHAV 93 mound, March 1993 postcap survey, 0.25 m contour interval

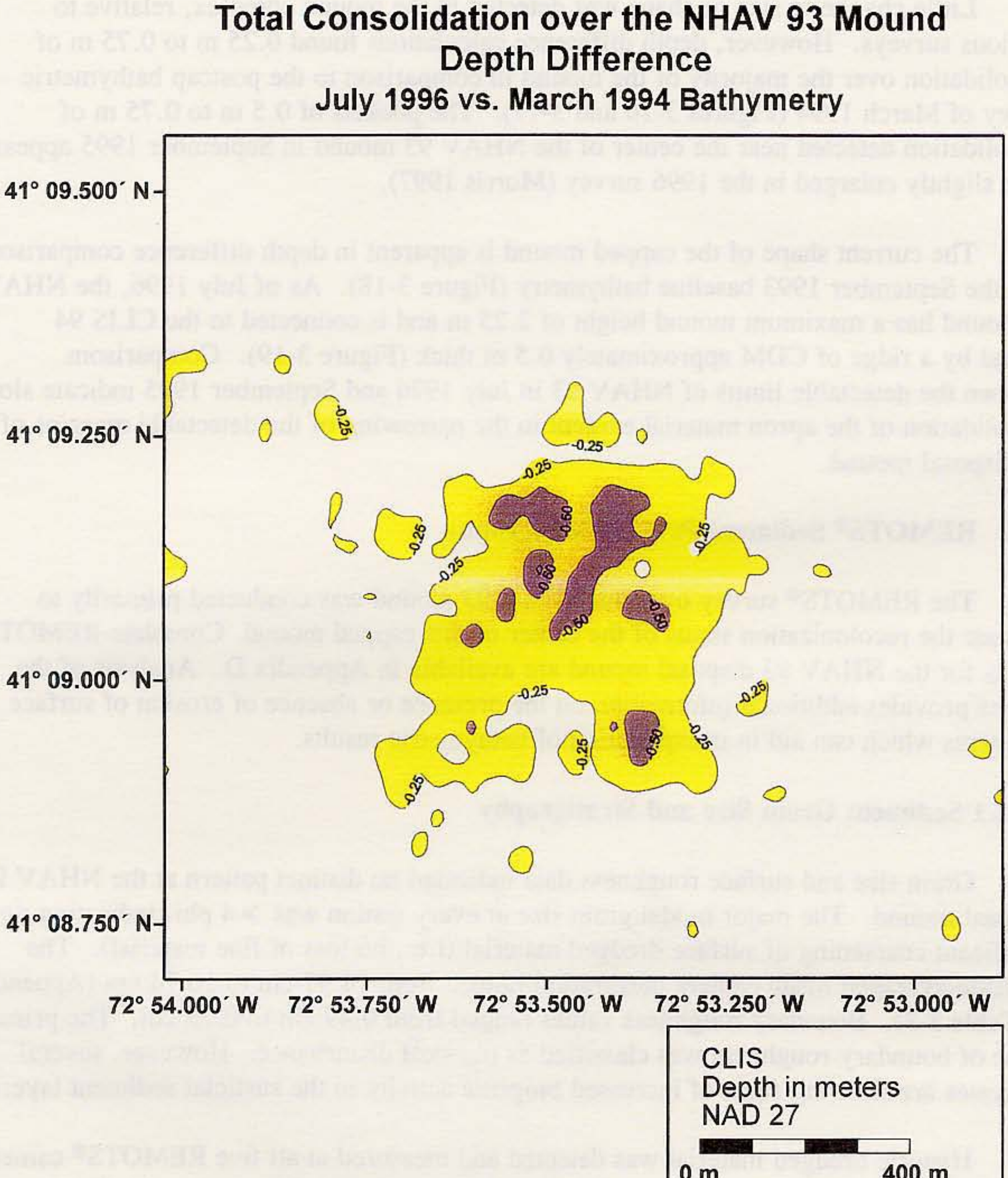


Figure 3-17. Depth difference plot of the July 1996 data versus March 1994 data showing consolidation over the NHAV 93 mound since cap completion

Little change in size or shape was detected in the mound complex, relative to previous surveys. However, depth difference calculations found 0.25 m to 0.75 m of consolidation over the majority of the mound in comparison to the postcap bathymetric survey of March 1994 (Figures 3-16 and 3-17). The pockets of 0.5 m to 0.75 m of consolidation detected near the center of the NHAV 93 mound in September 1995 appear to be slightly enlarged in the 1996 survey (Morris 1997).

The current shape of the capped mound is apparent in depth difference comparisons with the September 1993 baseline bathymetry (Figure 3-18). As of July 1996, the NHAV 93 mound has a maximum mound height of 2.25 m and is connected to the CLIS 94 mound by a ridge of CDM approximately 0.5 m thick (Figure 3-19). Comparisons between the detectable limits of NHAV 93 in July 1996 and September 1995 indicate slow consolidation of the apron material evident in the narrowing of the detectable margins of the disposal mound.

3.3.2 REMOTS® Sediment-Profile Photography

The REMOTS® survey over the NHAV 93 mound was conducted primarily to evaluate the recolonization status of the center of this capped mound. Complete REMOTS® results for the NHAV 93 disposal mound are available in Appendix D. Analysis of the images provides additional information on the presence or absence of erosion of surface sediments which can aid in interpretation of bathymetric results.

3.3.2.1 Sediment Grain Size and Stratigraphy

Grain size and surface roughness data indicated no distinct pattern at the NHAV 93 disposal mound. The major modal grain size at every station was >4 phi, indicating no significant coarsening of surface dredged material (i.e., no loss of fine material). The replicate-averaged mean camera penetration ranged from 14.97 cm to 16.74 cm (Appendix A, Table 3-3). Boundary roughness values ranged from 0.49 cm to 0.75 cm. The primary cause of boundary roughness was classified as physical disturbance. However, several replicates are showing signs of increased biogenic activity in the surficial sediment layers.

Historic dredged material was detected and measured at all five REMOTS® camera stations. As expected, dredged material thickness was greater than penetration in all replicate photographs. Redox rebound intervals were noted at each station over the center of the NHAV 93 mound. These results provide no indication of winnowing (coarsened grain sizes) or scour (≥ 3.0 cm physical boundary roughness) which is consistent with a conclusion of no erosion of the cap sediments during the study period.

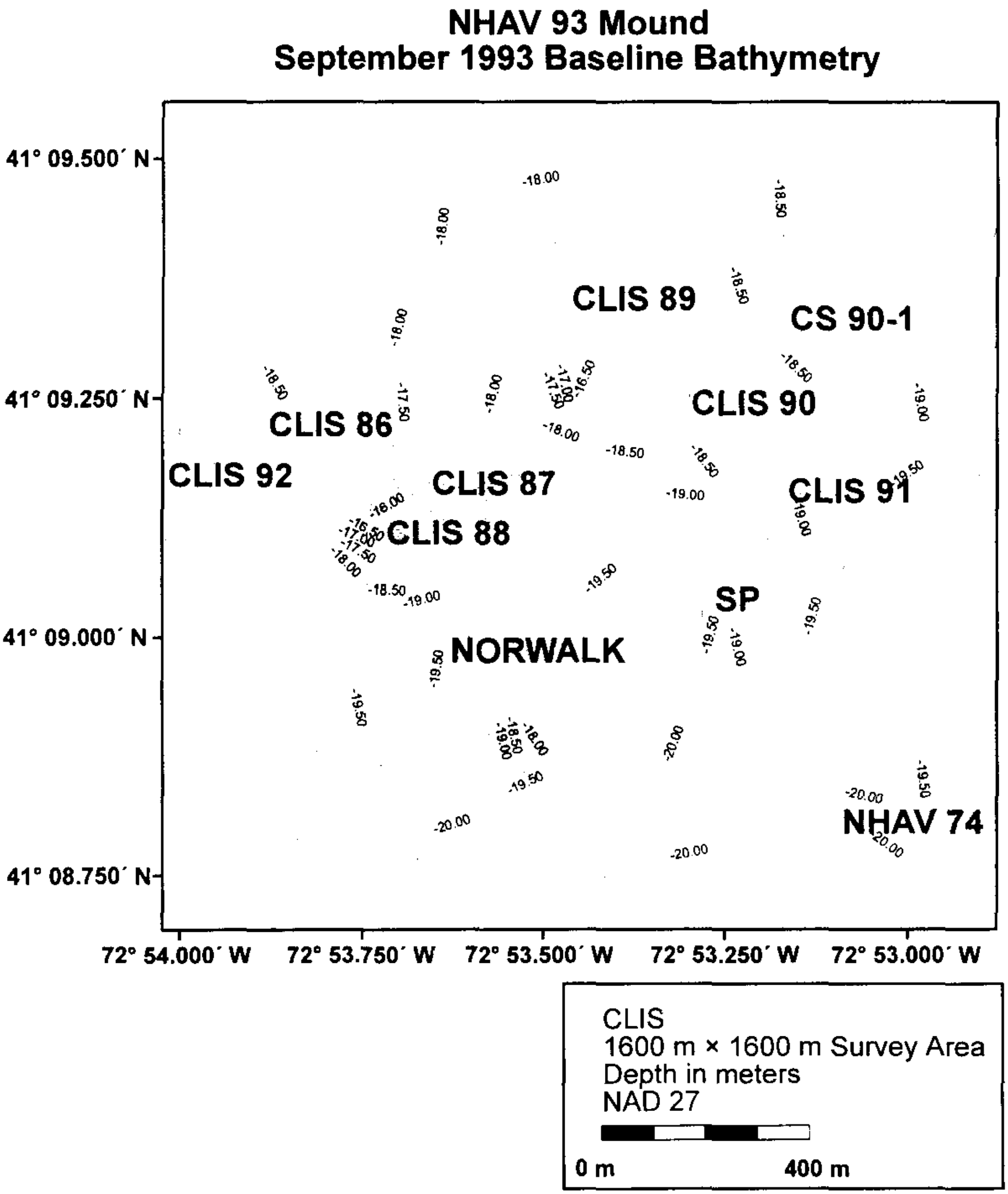


Figure 3-18. Bathymetric chart of the 1600 m × 1600 m analysis area over the NHAV 93 mound, September 1993 baseline, 0.25 m contour interval

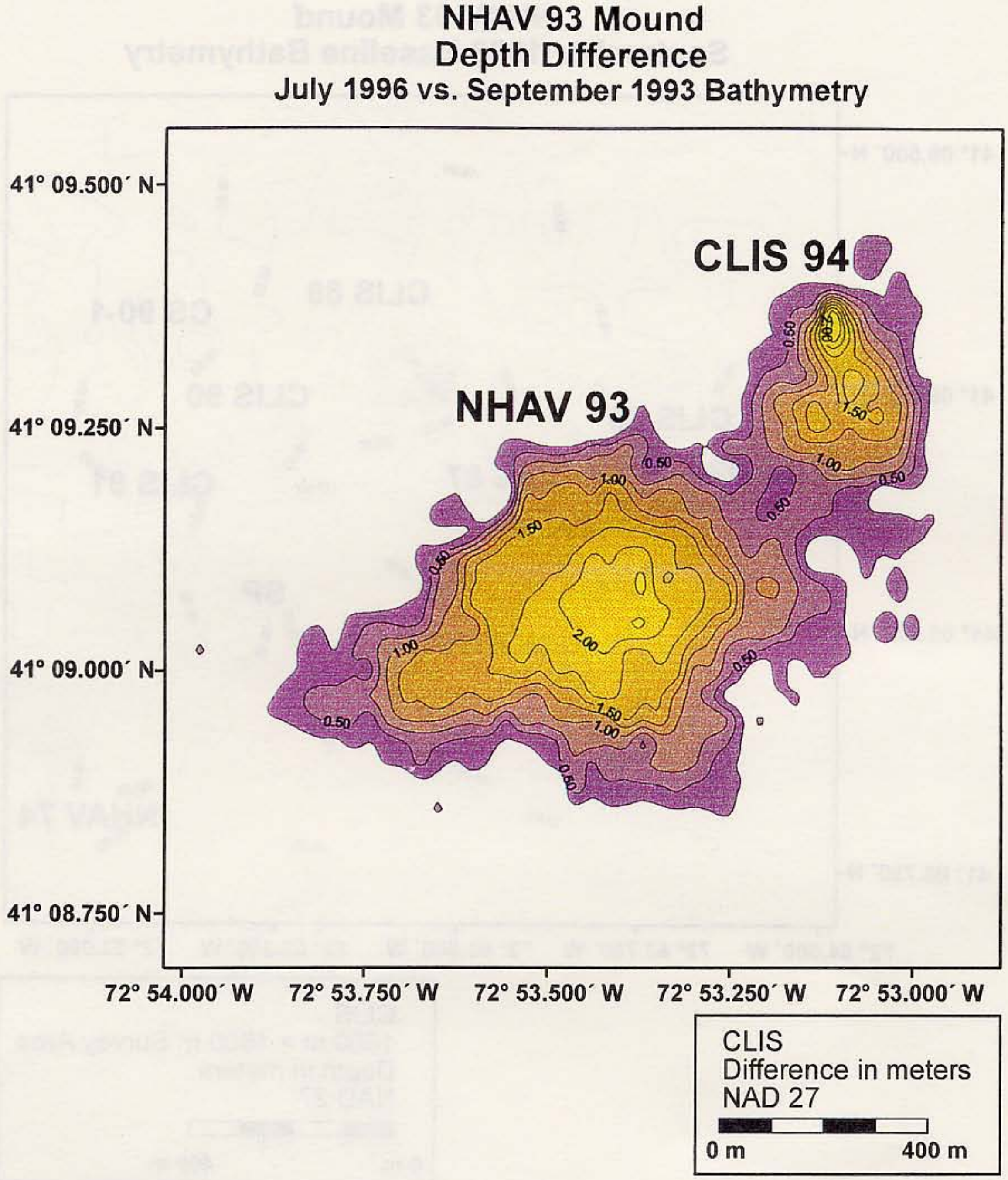


Figure 3-19. Depth difference plot of the July 1996 data versus the September 1993 data showing the current status of the NHAV 93 mound, 0.25 m contour interval

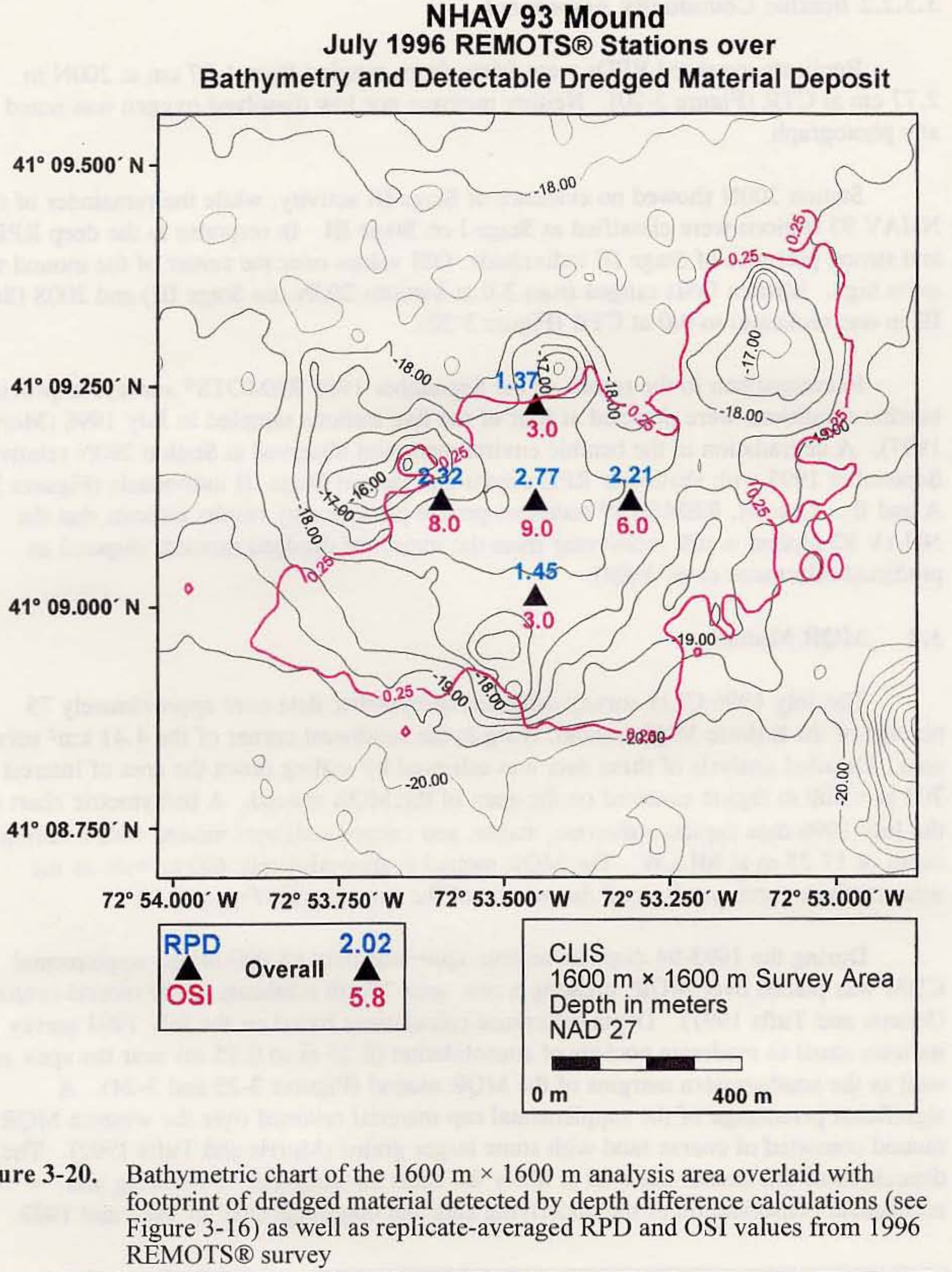


Figure 3-20. Bathymetric chart of the 1600 m × 1600 m analysis area overlaid with footprint of dredged material detected by depth difference calculations (see Figure 3-16) as well as replicate-averaged RPD and OSI values from 1996 REMOTS® survey

3.3.2.2 Benthic Community Assessment

Replicate-averaged RPDs were fairly deep, ranging from 1.37 cm at 200N to 2.77 cm at CTR (Figure 3-20). Neither methane nor low dissolved oxygen was noted in any photograph.

Station 200N showed no evidence of Stage III activity, while the remainder of the NHAV 93 stations were classified as Stage I on Stage III. In response to the deep RPDs and strong presence of Stage III individuals, OSI values over the center of the mound were quite high. Median OSIs ranged from 3.0 at Stations 200N (no Stage III) and 200S (Stage III in one replicate) to 9.0 at CTR (Figure 3-20).

In comparison to the results of the September 1995 REMOTS® survey, improving benthic conditions were detected at four of the five stations sampled in July 1996 (Morris 1997). A degradation in the benthic environment was observed at Station 200N relative to September 1995 with shallower RPD depths and lack of Stage III individuals (Figures 3-21 A and B). Overall, REMOTS® sediment-profile photography results indicate that the NHAV 93 mound is still recovering from the impact of dredged material disposal as predicted (Germano et al. 1994).

3.4 MQR Mound

The July 1996 CLIS survey collected bathymetric data over approximately 75 percent of the historic MQR mound, lying in the southwest corner of the 4.41 km^2 survey area. Detailed analysis of these data was achieved by scaling down the area of interest to a 700 m × 500 m region centered on the apex of the MQR mound. A bathymetric chart of the July 1996 data depicts a discrete, stable, and capped sediment mound with a minimum depth of 17.25 m at MLLW. The MQR mound is approximately 400 m wide as the western flank continues beyond the margin of the survey grid (Figure 3-22).

During the 1993-94 disposal season, approximately 65,000 m^3 of supplemental CDM was placed over MQR, creating a new apex 100 m northeast of the mound center (Morris and Tufts 1997). Depth difference calculations based on the July 1994 survey indicate small to moderate pockets of consolidation (0.25 m to 0.75 m) near the apex as well as the southwestern margins of the MQR mound (Figures 3-23 and 3-24). A significant percentage of the supplemental cap material released over the western MQR mound consisted of coarse sand with some larger grains (Morris and Tufts 1997). The deposition of this denser material is likely the basis for sediment de-watering and subsequent consolidation of the underlying silts and clays deposited in 1982 and 1983.

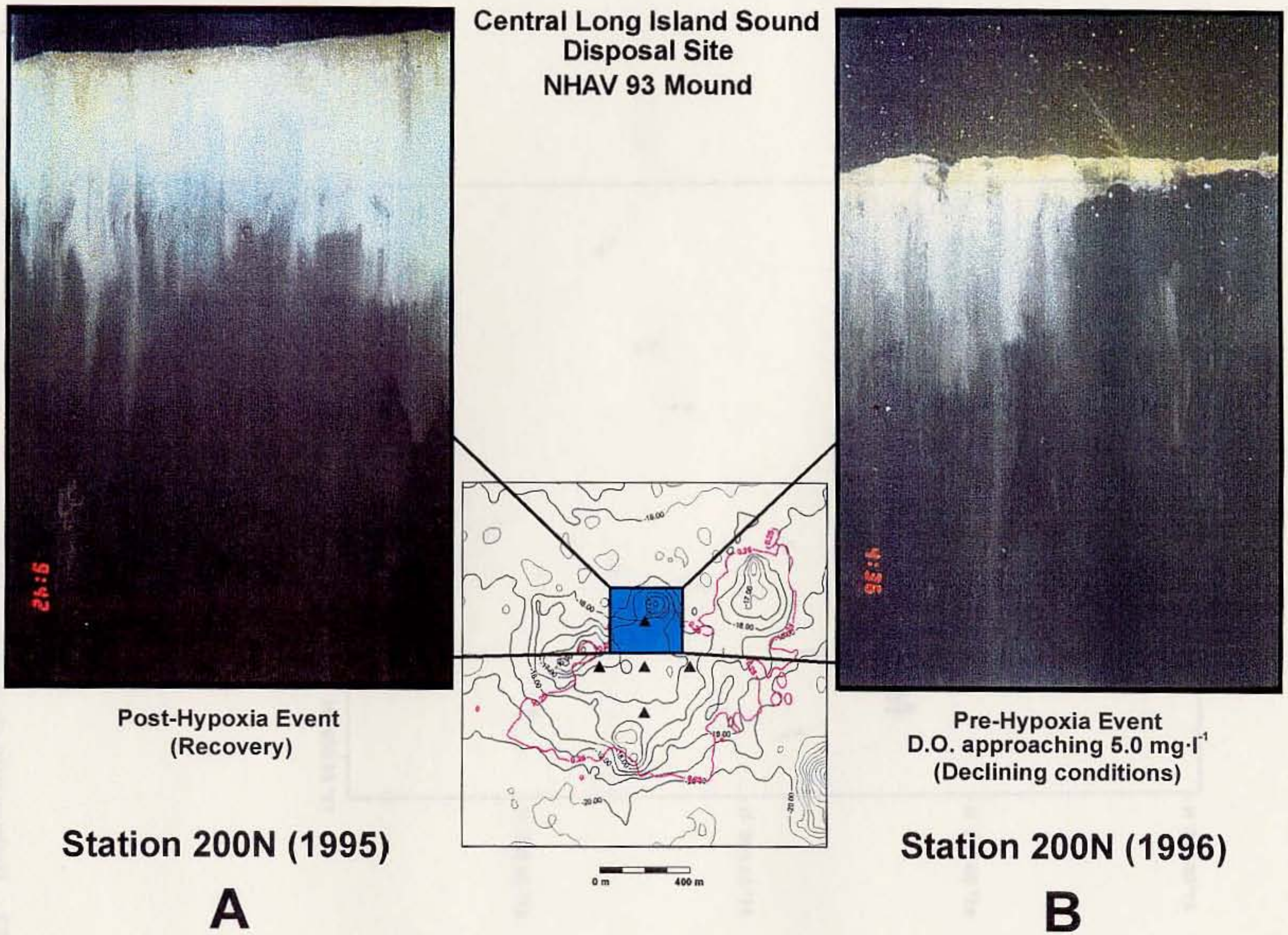


Figure 3-21. REMOTS® photographs at Station 200N comparing the level of oxidation and overall appearance of the surface sediments in 1995 (recovery from hypoxia) versus 1996 (declining conditions)

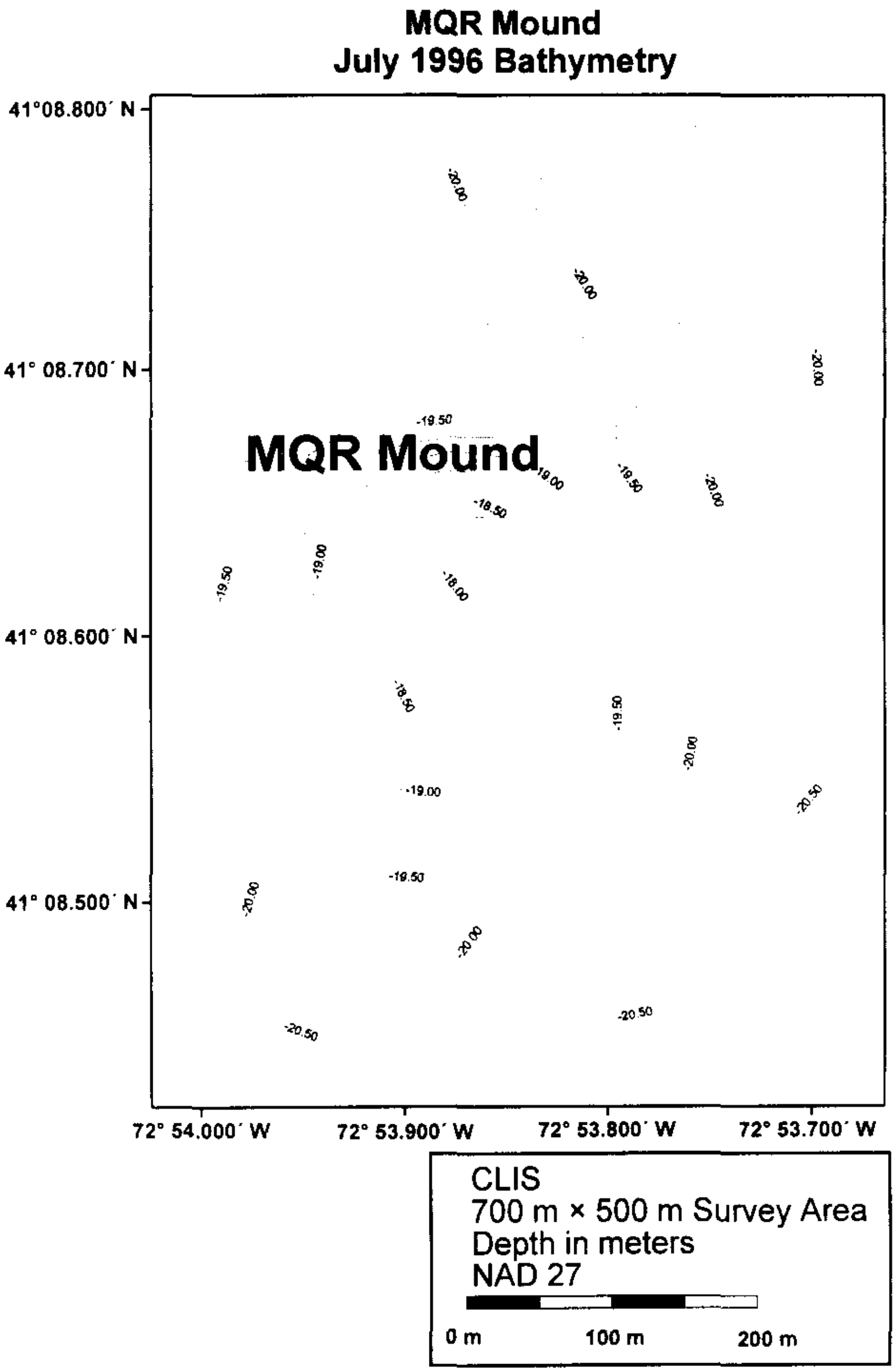


Figure 3-22. Bathymetric chart of the 700 m × 500 m analysis area over the MQR mound, July 1996, 0.25 m contour interval

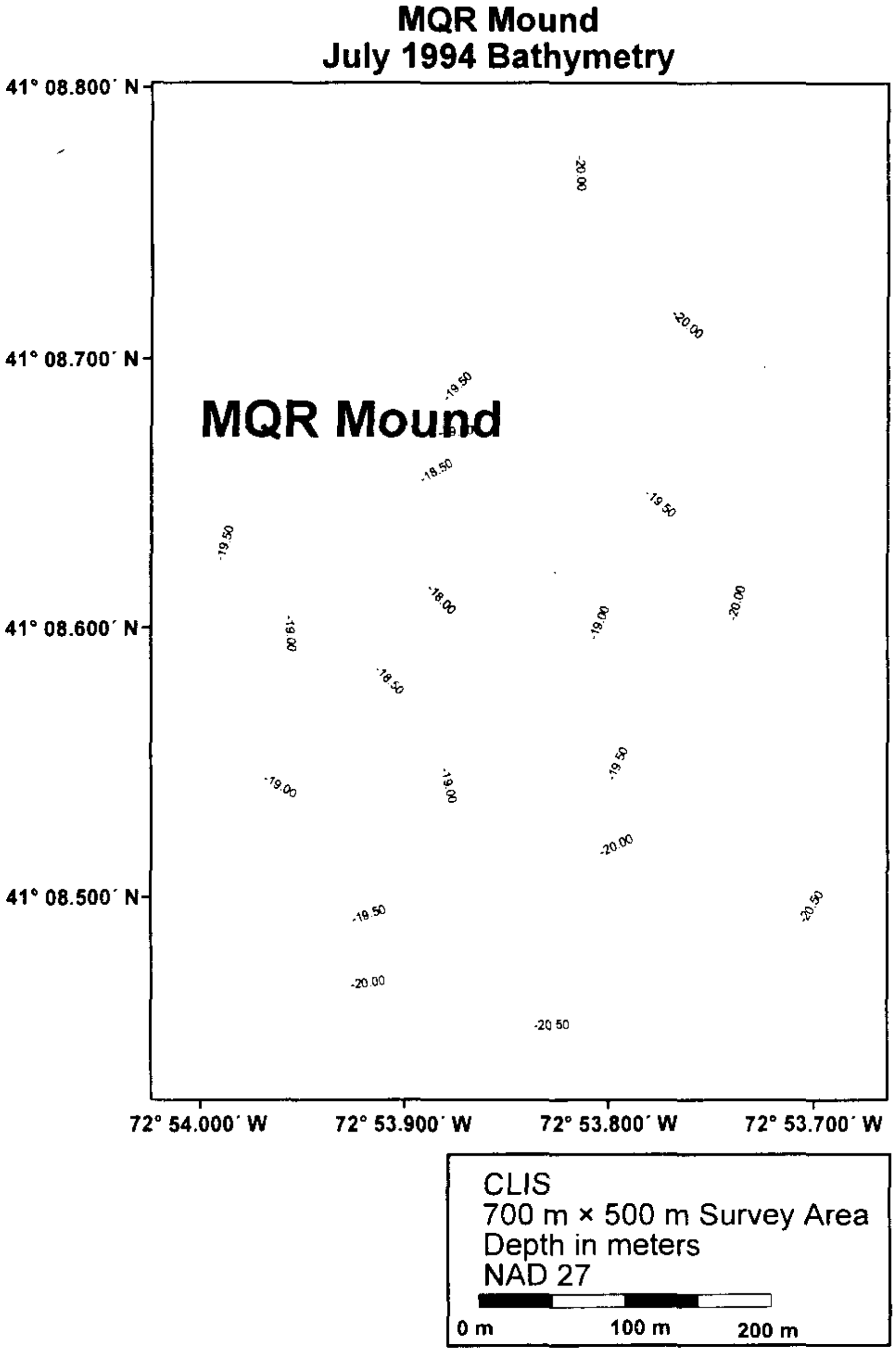


Figure 3-23. Bathymetric chart of the 700 m × 500 m analysis area over the MQR mound, July 1994, 0.25 m contour interval

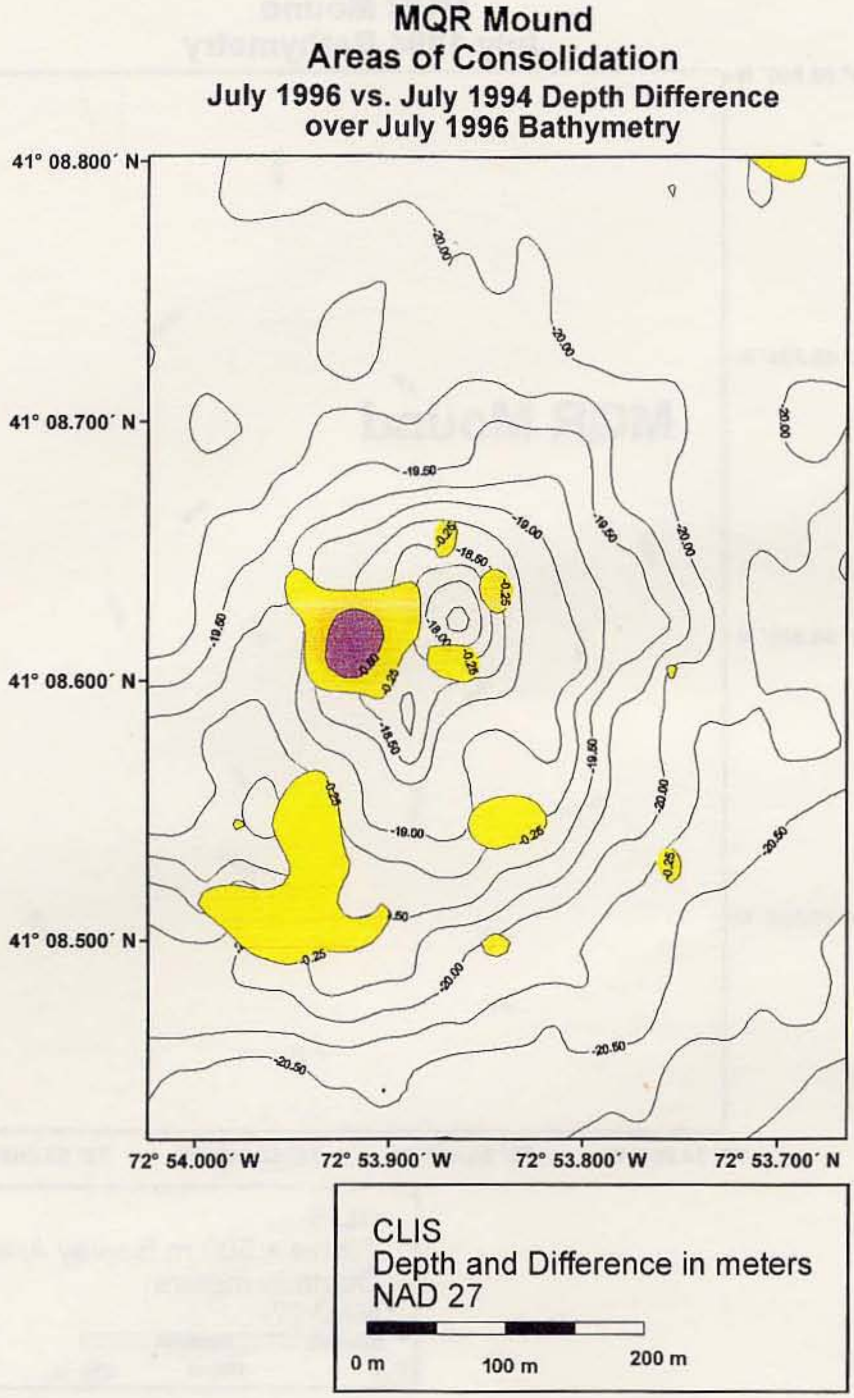


Figure 3-24. Bathymetric chart showing pockets of apparent consolidation over the MQR mound since July 1994, 0.25 m contour interval

3.5 CLIS Reference Areas

Complete REMOTS® results for the CLIS reference areas (2500W, 4500E, and CLIS-REF) are available in Appendix E. Reference area data are collected to provide a baseline against which results from the dredged material mounds are compared. CLIS-REF has been a reference area for CLIS since the beginning of the DAMOS Program. The two newer reference areas, 2500W and 4500E, have been monitored since approximately 1987.

3.5.1 Sediment Grain Size and Stratigraphy

Physical indicators of the benthic environment include the grain size and boundary roughness of the sediment surface. The major modal grain size was >4 phi in all reference station replicates indicative of ambient Long Island Sound sediments. Replicate-averaged camera penetration ranged from 10.59 cm to 14.26 cm (Appendix A, Table 3-4). Boundary roughness values ranged from 0.32 cm to 2.36 cm. Surface disturbance determinations of biogenic processes, physical disturbance, and "unidentifiable" were represented and equally distributed among the 39 replicates.

In contrast to the other reference area photographs, one replicate image obtained from Station 9 at CLIS-REF displayed an anomalous pocket of low reflectance, fine-grained material approximately 5 cm below the sediment-water interface. In addition, the surface sediment layers in this replicate photograph indicated a recent physical disturbance. However, the lack of similar conditions in the remaining two replicates suggests this is a localized benthic disturbance.

Redox rebound intervals were identified in several reference area photographs, indicating a change in water column dissolved oxygen concentrations. No methane gas was detected in the subsurface sediments of the CLIS reference areas, but one replicate photograph collected at 2500W was classified as low DO.

3.5.2 Benthic Community Assessment

Replicate-averaged RPDs at all three reference areas ranged from 1.5 cm to 2.62 cm. These levels indicate healthy benthic conditions and an improvement relative to the September 1995 REMOTS® survey.

The successional stage status at all reference stations was most commonly Stage I on Stage III, indicating a mature benthic assemblage. Stage II individuals were not identified in any replicate REMOTS® image. Median OSIs at the reference areas consistently ranged from 6.0 to 9.0, except for a minimum OSI of 4.0 at 2500W Station 3 (low DO in one replicate) and 4500E Station 5 (Stage III activity in only one replicate). OSIs of >6 were present at three of four 2500W stations, three of four 4500E stations, and four of five CLIS-REF stations sampled. These solid OSI values are due primarily to the deep RPDs and the presence of Stage III organisms at every station.

4.0 DISCUSSION

4.1 Seasonal Hypoxia

As predicted, comparisons between the July 1996 and September 1995 REMOTS® data sets for the CLIS disposal mounds and reference areas indicate a marked improvement in benthic conditions. With no distinct change in successional stage status, the OSI values calculated for the July 1996 REMOTS® stations were considerably higher. This improvement was primarily due to the incorporation of more molecular oxygen (O_2) in the surficial sediment layers, resulting in deeper RPD depths. The level of oxygenation at the sediment-water interface is controlled by the extent of bioturbation, as well as the concentration of dissolved oxygen (DO) in the bottom waters to support biological (respiration) and chemical (oxidation) consumption requirements.

During the September 1995 REMOTS® sediment-profile photography surveys over NHAV 93, CLIS 94, FVP, and the CLIS reference areas, a trend of shallower than expected RPD depths and indications of low DO concentrations was observed despite the presence of mature benthic assemblages (Morris 1997). In addition, water quality data obtained from the Connecticut Department of Environmental Protection (CTDEP) documented the occurrence of a seasonal hypoxic event within the central Long Island Sound region two weeks prior to the September 1995 monitoring cruise at CLIS (Figures 4-1 and 4-2; Morris 1997).

The 1996 CTDEP water quality data indicate the July 1996 monitoring cruise was completed before the seasonal reduction of available oxygen reached critical levels within the central Long Island Sound region (Figures 4-1 and 4-2). In early July, bottom water DO concentrations at the primary (H2 and H4) and secondary (23, 26, and 27) water quality monitoring stations ranged from 5.0 $mg \cdot l^{-1}$ to 6.5 $mg \cdot l^{-1}$. Oxygen concentrations of $\geq$ 5.0 $mg \cdot l^{-1}$ are thought to be protective of most Long Island Sound marine life (LISS 1990). Warm bottom waters and a consistent supply of molecular oxygen (O_2) promote increased bioturbational activity within the infaunal populations of the disposal mounds and reference areas. The feeding and foraging efforts of errant polychaete worms composing the Stage III assemblage incorporate oxygen-rich bottom waters into the surficial sediments, resulting in deeper RPD depths and elevated OSI values.

As expected, the CTDEP data recorded the occurrence of a seasonal hypoxic event in the bottom waters of the central Long Island Sound region approximately four weeks after the 1996 survey activity (Julian Day 233; Figures 4-1 and 4-2). Bottom water DO concentrations reached a seasonal low at five of six water quality monitoring stations

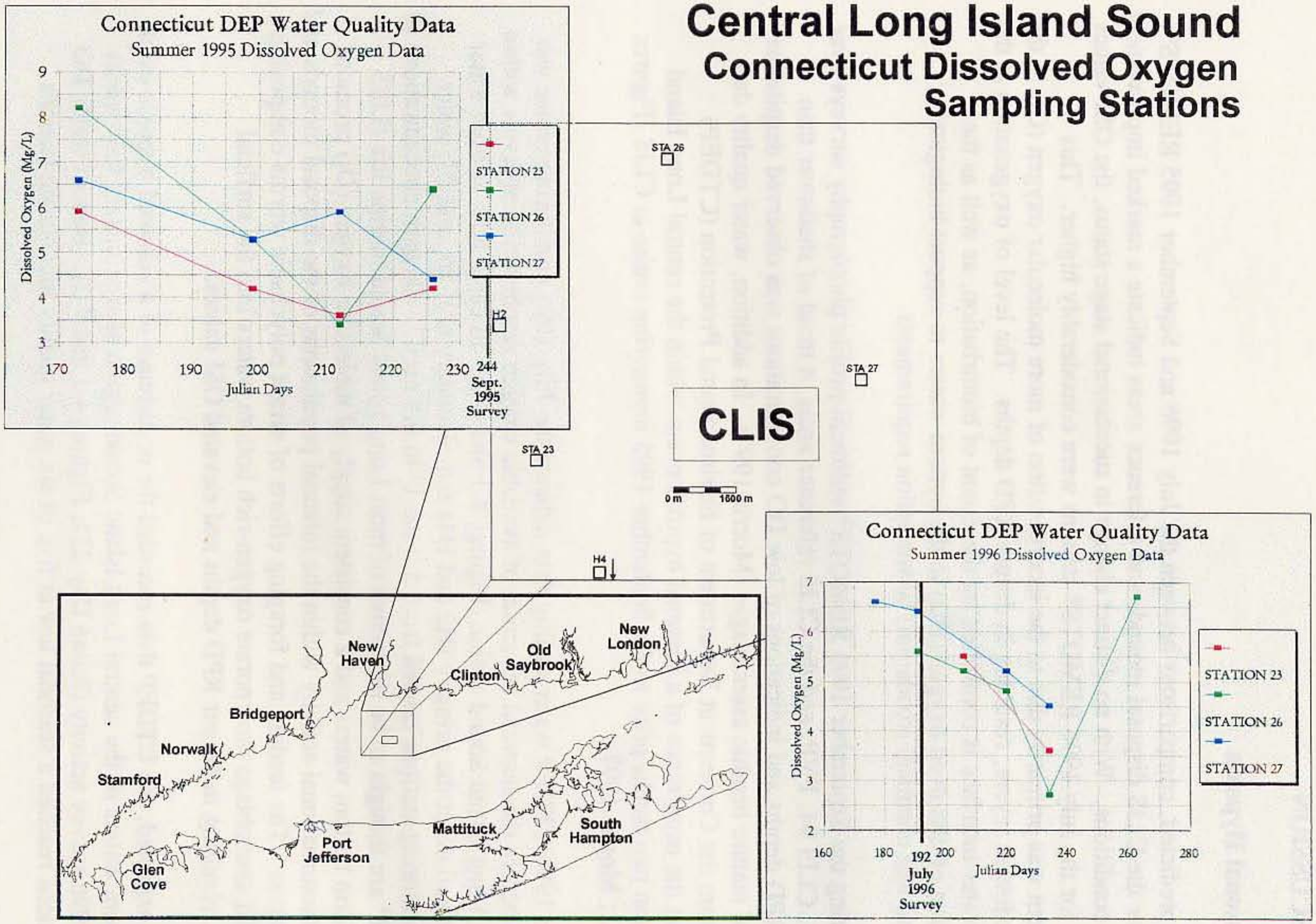
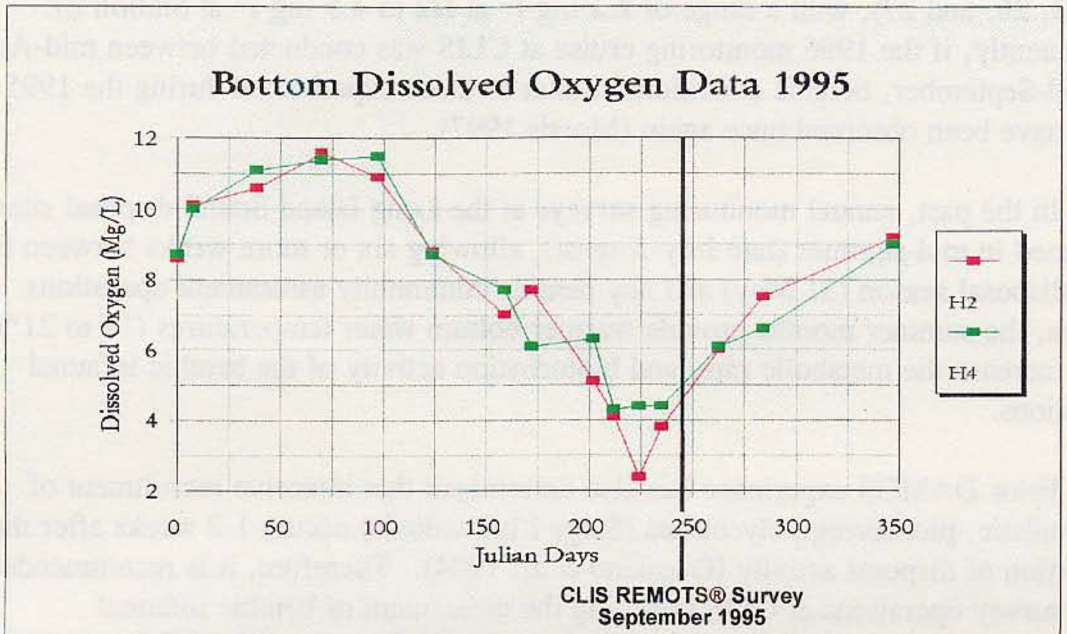


Figure 4-1. Position of the Connecticut Department of Environmental Protection Dissolved Oxygen Sampling Stations and bottom DO trends at summer monitoring stations 23, 26, and 27 for 1995 and 1996



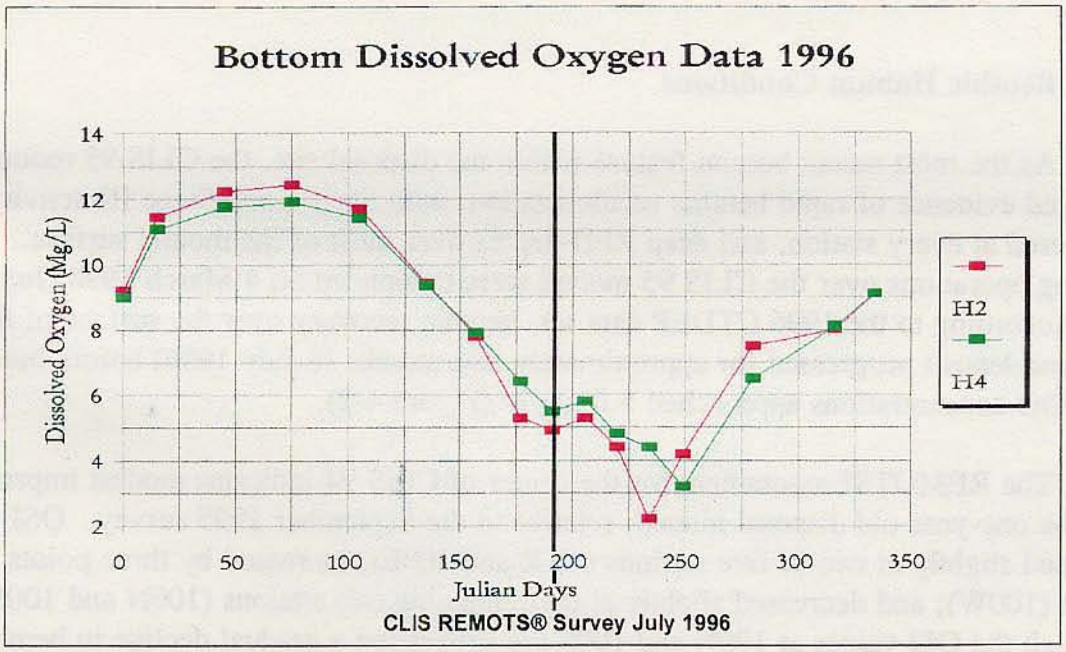


Figure 4-2. Observed changes in bottom DO concentrations at Connecticut Department of Environmental Protection Dissolved Oxygen sampling stations H2 and H4 for 1995 and 1996

(H2, 23, 26, and 27), with a range of 2.2 $mg \cdot l^{-1}$ at H2 to 4.5 $mg \cdot l^{-1}$ at Station 27. Consequently, if the 1996 monitoring cruise at CLIS was conducted between mid-August and mid-September, benthic conditions similar to those experienced during the 1995 survey would have been observed once again (Morris 1997).

In the past, annual monitoring surveys at the Long Island Sound disposal sites were performed in mid-summer (late July-August), allowing six or more weeks between the end of the disposal season (31 May) and any benthic community assessment operations. In addition, the summer months provide warmer bottom water temperatures (17 to 21°C), which increase the metabolic rates and bioturbation activity of the benthic infaunal populations.

Prior DAMOS experience has also determined that intensive recruitment of opportunistic, pioneering polychaetes (Stage I individuals) occurs 1-2 weeks after the completion of disposal activity (Germano et al. 1994). Therefore, it is recommended that future survey operations at CLIS requiring the assessment of benthic infaunal recolonization be scheduled for the period between 21 June through 15 July or after the end of September. Monitoring surveys conducted within this time frame should provide adequate recruitment time on the surface of a new dredged material deposit, as well as avoid confounding the monitoring interpretation with the effects of summer hypoxia in the region.

4.2 Benthic Habitat Conditions

As the most recent bottom feature within the disposal site, the CLIS 95 mound displayed evidence of rapid benthic recolonization, with Stage I and Stage III activity discovered at every station, and deep RPD depths over most of the mound surface. Capping operations over the CLIS 95 mound were completed on 4 March 1996 (Julian Day 63). According to the 1996 CTDEP data set, benthic recovery over the surface of this sediment deposit progressed for approximately five months (8 July 1996) before bottom water DO concentrations approached 5.0 $mg \cdot l^{-1}$ (Figure 4-2).

The REMOTS® assessment for the center of CLIS 94 indicates modest improvement over the one-year-old disposal mound, relative to the September 1995 survey. OSI values increased slightly at two of five stations (CTR and 100E); increased by three points at one station (100W); and decreased slightly at the remaining two stations (100N and 100S). Although the OSI values at 100N and 100S are suggesting a gradual decline in benthic conditions, they are comparable to the 1996 CLIS reference area data and remain relatively high for a recent dredged material deposit.

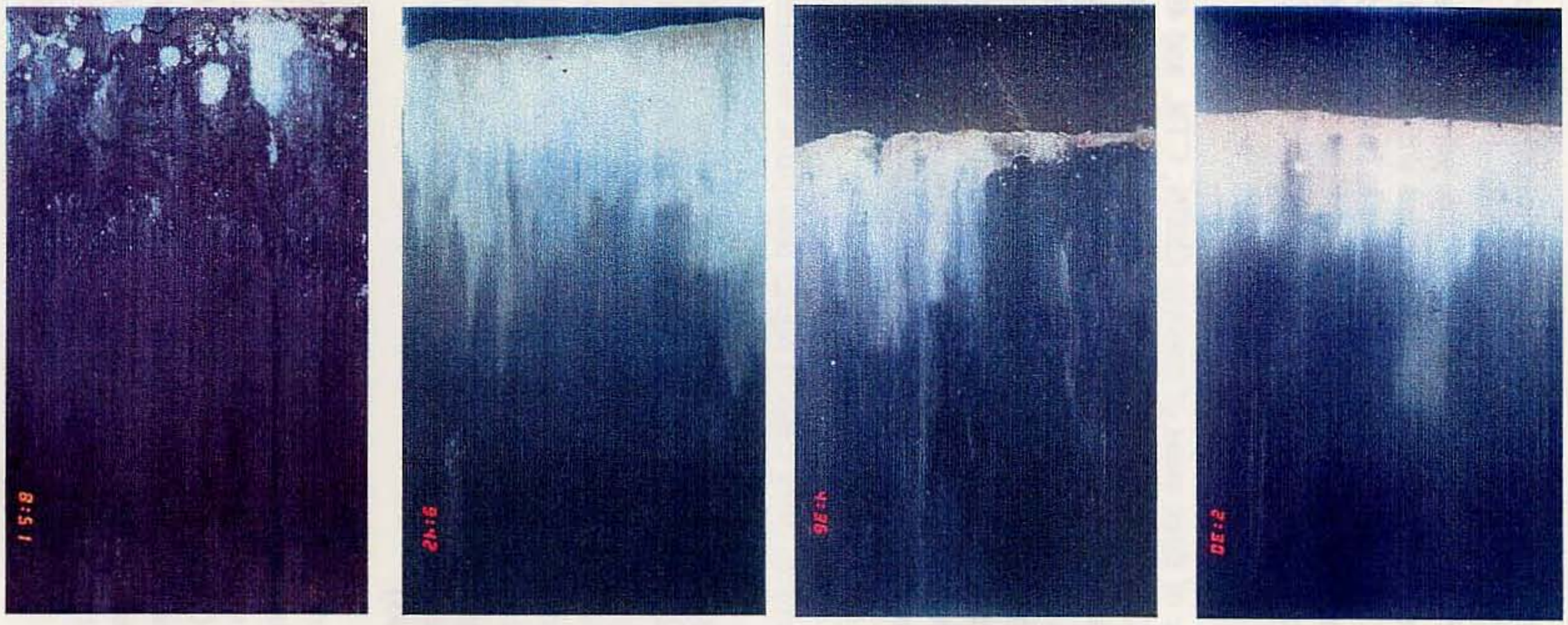
Data collected over the NHAV 93 mound provided mixed results, in comparison to the September 1995 survey (Morris 1997). Station CTR showed dramatic improvement with a 6-point increase in OSI values within a ten-month time period. Stations 200E and 200W also displayed solid improvement in benthic conditions with 2- and 1-point increases in OSI values, respectively. However, a significant decline in benthic conditions was noted in the July 1996 versus September 1995 comparison of results for 200N. The 1996 median OSI value fell 4 points relative to 1995, due to the lack of Stage III activity and shallower RPD depths.

Station 200N was one of three areas of concern (200N, CTR, and 400S) discovered during the July 1994 REMOTS® survey over the NHAV 93 mound due to the appearance of dark sulphidic sediments and diffusional RPDs (Figure 4-3A; Morris and Tufts 1997). As part of the DAMOS tiered monitoring protocol, sediment toxicity testing was performed to verify the quality of the CDM at the sediment-water interface. *Ampelisca abdita* bioassay testing found no significant difference in toxicity between the NHAV 93 CDM and sediments obtained from the historic Southern Reference Area (Morris and Tufts 1997). The benthic conditions observed in July 1994 were attributed to high labile organic content within the CDM.

Newly deposited sediments often support higher population densities of foraging invertebrates by providing a concentrated food source within a competition-free space, relative to ambient material (Germano et al. 1994). Fresh dredged material often possesses a higher inorganic nutrient (N, P, Si, Fe, etc.) and organic material (bio-available Carbon) content, in comparison to the depleted ambient sediments surrounding the disposal site (Rhoads and Germano 1986). Disposal mounds composed of sediments that yield small to moderate increases in nutrients and organic detritus tend to promote a healthy benthic environment through faster recolonization and increased bioturbation (CLIS 95, CLIS 94, etc.). Dredged material mounds with higher levels of organic material tend to recover at a slower rate due to the increased sediment oxygen demand (SOD) caused by oxidation of the labile organics (NHAV 93).

During the September 1995 REMOTS® survey, Station 200N, as well as CTR and 400S, displayed significant improvement with deep RPDs and Stage III activity in the subsurface sediment layers, despite the passage of a hypoxic event in the region two weeks prior to monitoring activity (Figure 4-3B; Morris 1997). Apparently, a sufficient amount of organic material was consumed within the dredged material deposit eighteen months after the completion of the project, decreasing the SOD and allowing the development of a stable benthic infaunal population. The degradation of conditions observed at Station 200N during the July 1996 survey may be attributable to variability in SOD within a patchy

NHAV 93 Mound
Station 200N



July 1994 | **September 1995** | **July 1996** | **September 1997**

A | **B** | **C** | **D**

Figure 4-3. REMOTS® photographs comparing the benthic conditions at Station 200N over three years of environmental monitoring surveys benthic environment (Figure 4-3C). However, the consistency between the three replicate photographs collected in July 1996 suggests otherwise.

Studies pertaining to seasonal cycles throughout Long Island Sound have documented higher SOD within both deposited sediments and ambient material in late spring (May-June; Rhoads et al. 1975). Eutrophication of the water column via waste water input and terrestrial run-off promotes the development of a winter-spring plankton bloom. Phytoplankton populations quickly grow and exploit the abundance of primary nutrients in solution. As nutrient concentrations in the water column return to normal levels, much of the phytoplankton dies, accumulates at the sediment-water interface, and decays. Aerobic microbes exploit the organic detritus as a food source, producing carbon dioxide (CO_2) and recycling many of the nutrients. Microbial respiration begins to consume a significant percentage of the available molecular oxygen in the bottom waters. As bottom water temperatures increase during the spring months, microbial activity at the sediment-water interface and total SOD also increase, as the supply of organic material at the sediment-water interface is slowly exhausted.

Both aerobic and anaerobic processes continue below the sediment-water interface as complex organic molecules are broken down by bacterial action as well as chemical oxidation. Bioturbation by the resident benthic infauna population also continues, as molecular oxygen is incorporated within the surficial sediment layers through pore water exchange. The relatively high DO concentrations (6 to 8 $mg \cdot l^{-1}$) within the water column in late spring tend to support the greater oxygen demand associated with the annual phytoplankton extinction without impacting the infaunal communities residing in most dredged material deposits (CLIS 95, CLIS 94, etc.) or ambient Long Island Sound sediments (CLIS Reference Areas).

However, the REMOTS® data obtained over Station 200N in July 1994 and July 1996 suggest the impacts of this seasonal introduction of organic material (phytoplankton) may be of a greater magnitude, due to the pre-existing organic load and SOD within the highly enriched CDM. Therefore, the surficial sediment layers at Station 200N appear to be more susceptible to naturally occurring shifts in the oxygen budget, in comparison to other stations over the NHAV 93 mound. During environmental monitoring surveys conducted in September of 1995 and 1997, Station 200N displayed moderate to deep RPD depths, Stage III activity, and correspondingly high OSI values (Morris 1997 and Cole 1998). The results of the September REMOTS® surveys suggest the benthic conditions present at 200N promote rapid recolonization upon the reduction of organic material input, stabilization of SOD, and return of adequate DO concentrations (Figure 4-3D).

4.3 CLIS Reference Areas

Reference area data are collected to provide a baseline against which results from the dredged material mounds are compared. The majority of the July 1996 REMOTS® results for the CLIS 95, CLIS 94, and NHAV 93 mounds were found to be analogous to the conditions found at the three CLIS reference areas. Although the majority of the REMOTS® photographs collected over the project mounds documented improving conditions relative to previous surveys, limited signs of habitat degradation were apparent. Replicate photographs collected at Stations 100N and 100S over the CLIS 94 mound, as well as Station 200N over NHAV 93, discovered conditions indicative of a low DO environment. However, the decline in habitat quality at these stations may also be attributed to a high SOD within the surface sediments caused by oxidation of labile organics and gradually decreasing DO concentrations, rather than a hypoxic event (DO concentrations $\leq$3.0 mg·l-1) in the bottom waters. Barring a dramatic benthic disturbance, complete recovery should be achieved within the next few years. Therefore, continued REMOTS® sediment-profile photography over CLIS 95, CLIS 94, and NHAV 93 is recommended for the 1997 monitoring effort, and periodically thereafter.

Throughout the 19-year history of the DAMOS Program, CLIS-REF has been utilized as a control area, representative of the ambient sediments of central Long Island Sound. Located approximately 4.5 km southeast of the center of CLIS, this area should be free of the effects of dredged material disposal and display the characteristics of an undisturbed seafloor. On occasion, anomalous benthic conditions are detected at the CLIS reference areas due to natural or anthropogenic effects. Benthic disturbances due to hypoxia and commercial fishing activity have been documented within CLIS reference areas in past years.

As part of standard benthic community assessment techniques, the July 1996 REMOTS® survey required random selection of several sediment-profile photography stations within a 300 m radius of CLIS-REF. One replicate photograph collected from STA 9 revealed a pocket of dark, anoxic sediment approximately 5 cm below the sediment water interface (Figure 4-4A). A thin nepheloid layer of loose silt and clay, expelled from a void in the subsurface sediments by the bisecting action of the REMOTS® camera, is visible at the sediment-water interface as well as within the water column. The remaining two replicates obtained from STA 9 displayed conditions indicative of an undisturbed ambient bottom, suggesting a highly localized disturbance (Figure 4-4B). Although physical disturbances can be attributed to a wide variety of sources (infaunal burrowing, boat anchors, trawling scars, etc.) the presence of low reflectance, sulphidic sediment is often used as an indicator of dredged material deposition.

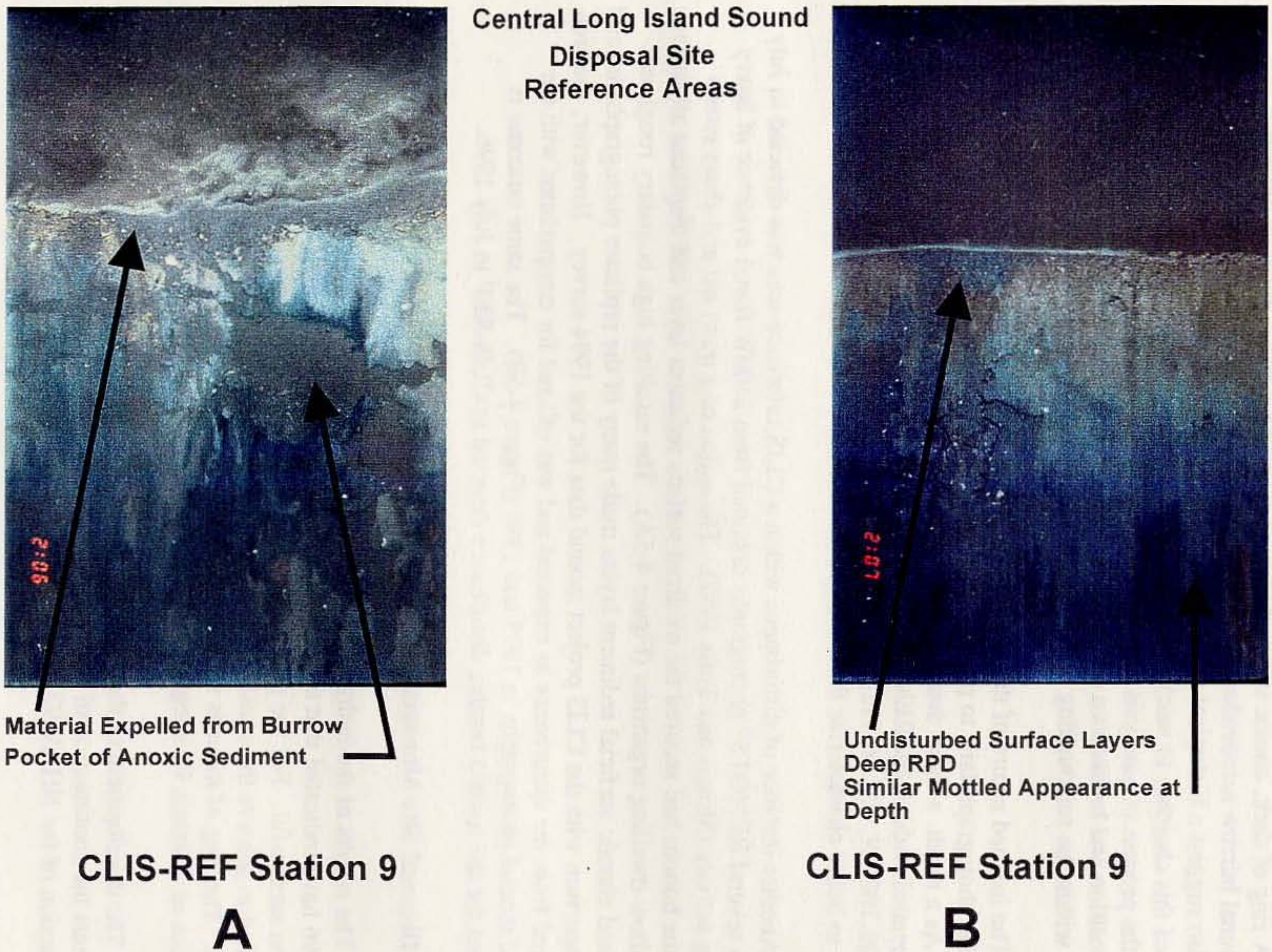


Figure 4-4. REMOTS® photographs displaying differences in the benthic conditions within two replicate photographs over CLIS-REF Station 9

A ring of dark, anoxic silts and clay surrounding a large, partially collapsed macrofaunal burrow surrounded by a chaotic fabric of oxidized and reduced sediments could also suggest a biological origin. The excavator or inhabitant of this burrow may have used this chamber to stockpile organic debris (food, waste material, etc.) which is now in the process of autolysis and decay. The aerobic microbes that expedite the decomposition and breakdown of organic material may be exhausting the limited supply of oxygen within the surrounding sediments causing the development of a pocket of anoxia.

The isolated nature of this disturbance and the presence of mixed layers of sediment within the photograph fails to provide strong evidence that would support one specific cause. As a result, a more detailed investigation of the area surrounding STA 9 is recommended. Additional REMOTS® photographs should be collected in close proximity to 41° 08.100′ N, 72° 50.112′ W (NAD 27) during the 1997 monitoring activity in an attempt to better characterize these sediments.

Another instance of disturbance within a CLIS reference area was detected in July 1994 as several REMOTS® photographs obtained from 2500W found evidence of heavy trawling activity (Morris and Tufts 1997). The action of a trawl net and chain sweep across the bottom had scoured the oxidized surface sediment layer and displaced all surface and shallow-dwelling organisms (Figure 4-5A). The resulting high boundary roughness values and chaotic surficial sediment layers made many of the replicate photographs invalid for comparison with the CLIS project mound data for the 1994 survey. However, the area recovered from the disturbance as expected and was utilized for comparisons with the disposal mound photographs in 1995 and 1996 (Figure 4-5B). The same outcome is predicted for the limited benthic disturbance detected at CLIS-REF in July 1996.

4.4 Disposal Site Management, Mound Stabilization, and Consolidation

The results of the bathymetric surveying activity performed at CLIS in 1994, 1995, and 1996 have indicated that the dredged material management strategy adopted in 1984 has been successful. For the past twelve years, disposal activity at CLIS has been controlled to achieve the construction of artificial containment cells on a relatively flat bottom. The ring of mounds formed by smaller disposal projects from 1984 through 1992 continues to maintain its integrity and support the central dredged material deposit.

The development of the CLIS 95 mound in close proximity to the NHAV 74 mound represents the continuation of the successful management strategy demonstrated with the construction of the NHAV 93 mound (Morris et al. 1996). Deposition of additional

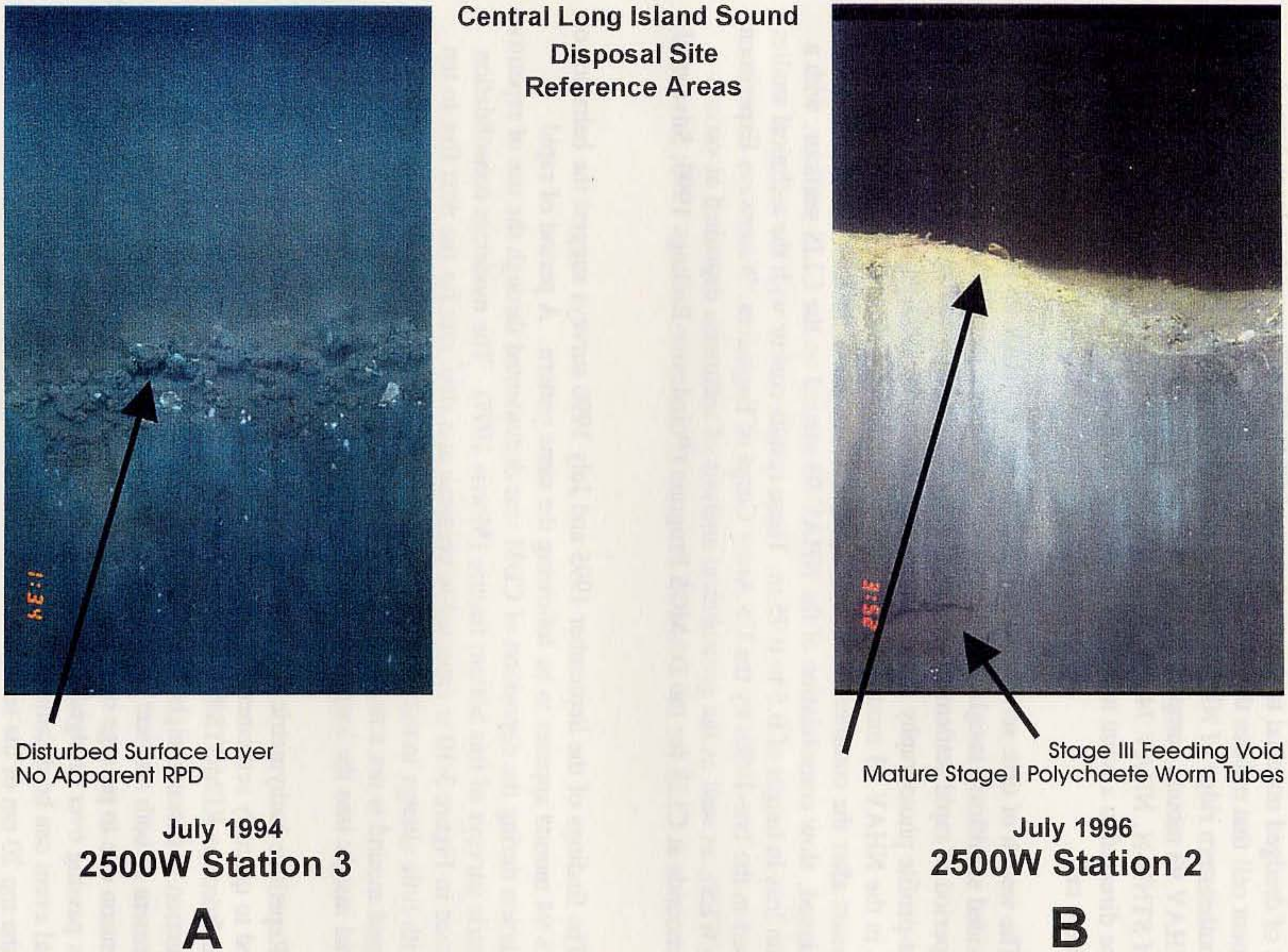


Figure 4-5. REMOTS® photographs comparing the benthic conditions at, and displaying recovery over, Reference Area 2500W

volumes of dredged material to the northwest of CLIS 95 will provide a large lateral containment cell that utilizes the historic NHAV 74, SP, and NORWALK mounds as well as the southeastern ridge of NHAV 93 (Figure 4-6). The CLIS 94 mound to the northeast of the NHAV 93 mound complex begins to close another basin at CLIS that will utilize the slopes of STNH-N, NHAV 74, SP, and CLIS 91 (Figure 4-6). Future disposal activity should be directed to a point northeast of the NHAV 74 mound to complete that containment cell.

The wealth of time series data collected over the NHAV 93 and CLIS 94 mounds has provided significant insight into the process of disposal mound consolidation at CLIS. After a period of rapid settlement documented by the multiple bathymetric and REMOTS® sediment-profile photography surveys conducted during the 1993-94 disposal season, changes in the NHAV 93 mound morphology appear to have slowed (Morris et al. 1996). At 2.5 years after the completion of capping operations, precision bathymetry documents the continued, slow consolidation of the NHAV 93 mound on the CLIS seafloor, with a maximum loss in height of 0.5 to 0.75 m. These results concur with the technical studies performed in the late-1980s by the US Army Corps of Engineers, Waterways Experiment Station (WES), as well as the geotechnical analysis of sediments deposited at various capped mounds at CLIS for the DAMOS Program (Poindexter-Rollings 1990; Silva et al. 1994).

The findings of the September 1995 and July 1996 surveys suggest the behavior of the CLIS 94 mound appears to be following the same pattern. A period of rapid consolidation during the deposition of CDM was documented through the use of repetitive bathymetric surveys of this bottom feature (Morris 1997). The moderate consolidation represented in Figure 3-10 is expected to continue at a slow rate for the next five to ten years with little change in overall width or shape. Continued bathymetric monitoring of this capped mound is not a necessity; however, occasional monitoring will provide additional insight into the longer term behavior of silt/clay disposal mounds.

Repetitive bathymetric surveys over established disposal mounds are the primary tool used to quantify settlement by measuring apparent loss in mound height. The images obtained from the REMOTS® surveys are also helpful in consolidation studies by ruling out reduction in mound height due to erosion of the surficial sediment layers. The displacement of both ambient and deposited sediments can be generated by particle resuspension due to passage of storm events, or through transport by tidally derived bottom currents passing over dredged material deposits. The occurrence and severity of an erosional event can be documented by observing distinct changes in physical appearance within the top 20 cm of the sediment. Significant coarsening of sediment grains within the top 5 cm of the benthos (winnowing), high boundary roughness values ($\geq$3.0 cm; scour),

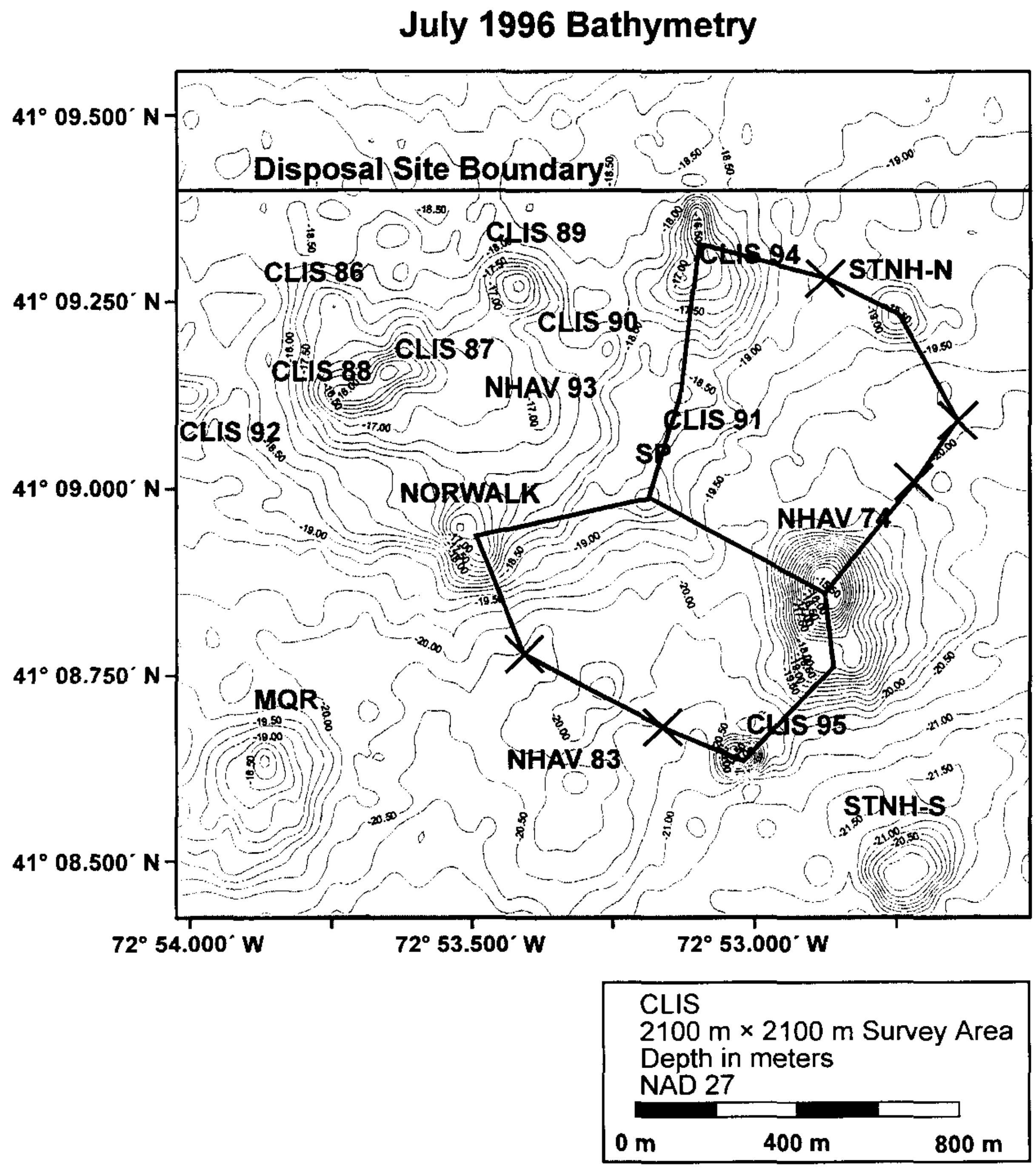


Figure 4-6. Bathymetric chart of the July 1996 2100 m × 2100 m survey area overlaid with suggested points for future disposal, 0.25 m contour interval

presence of a distinct nepheloid layer, or total absence of an RPD, are indications of possible sediment resuspension or erosion.

The depositional nature of the central Long Island Sound region provides adequate containment of the dredged material deposited within the confines of CLIS. The low current regime and restricted fetch associated with the central basin of Long Island Sound minimize the risk of storm waves and tidal flow transporting dredged material outside the disposal site boundaries. No sediment-profile photographs collected over the CLIS disposal mounds have detected conditions indicative of dredged material loss or movement within the past 11 years.

In the fall of 1985, evidence of moderate disposal mound erosion was documented at CLIS after the passage of Hurricane Gloria. REMOTS® images collected from six CLIS disposal mounds (CS-1, CS-2, FVP, MQR, STNH-N, and STNH-S) found small to moderate changes in replicate-averaged boundary roughness, RPD, and OSI values relative to the pre-storm, annual monitoring survey (Parker and Revelas 1989). However, the physical effects of the storm-induced currents and waves were restricted to the top 5 cm of sediment, and directly related to sediment shear strength, a function of composition and age of the deposit. As expected, mound centers displayed the most evidence of material movement, but it was concluded that all capping layers remained intact.

The NHAV 93 and CLIS 94 disposal mounds have been exposed to several strong storm events during the past several years. These storms typically generate current velocities and waves that surpass monthly averages, but tend to fall below the intensities caused by passage of a hurricane. Although fluctuations in RPD depth and OSI values related to SOD and hypoxia have been observed, neither disposal mound has displayed signs of erosion in the surficial sediment layers. Low boundary roughness values and the presence of silt and clay at the sediment-water interface reinforce the conclusion that the apparent loss in mound height over these mounds is directly attributable to consolidation of the dredged material deposit.

5.0 CONCLUSIONS

As the most active disposal site in New England, CLIS has been closely monitored since 1979. The July 1996 survey over CLIS was performed to delineate the areal extent and initial colonization of the disposal mound formed during the 1995-96 disposal season. In addition, monitoring of the CLIS 94, NHAV 93, and MQR mounds was conducted to document disposal mound consolidation and continued benthic habitat recovery.

The CLIS 95 mound is the newest bottom feature at the disposal site and is an example of a small, capped dredged material disposal mound. An estimated barge volume of 16,300 m^3 of UDM followed by 50,100 m^3 of CDM yielded a small, but distinct, bottom feature on the CLIS seafloor 3.75 m high and approximately 200 m in diameter, with a CDM to UDM ratio of 3.1:1.0. No bathymetric data documenting the interim stages of development were available. However, the compact nature of the deposit, the reported barge release positions, the CDM to UDM ratio, and the results of the benthic recolonization survey over CLIS 95 suggest the UDM deposit has been completely capped. Continued monitoring of the CLIS 95 mound is not a necessity, but the collection of bathymetric data over the next one to two years will add to our understanding of long-term consolidation patterns within capped dredged material disposal mounds.

The benthic conditions, as characterized by REMOTS® sediment-profile photography, indicate rapid benthic community recovery over the surface of the CLIS 95 mound. The OSI values calculated for the CLIS 95 mound met or exceeded that of the reference areas, facilitated by a higher organic content within the newly deposited sediments. Periodic monitoring of the infaunal community occupying the surface sediments of the CLIS 95 mound is recommended for the next several years to ensure that a decline in benthic conditions does not occur.

The continuing REMOTS® benthic community assessment for the centers of CLIS 94 and NHAV 93 indicates significant improvement over the majority of historic disposal mounds. However, some reduction in the quality of the benthic environment was detected at several stations, relative to the September 1995 survey. Stations 100N and 100S over CLIS 94 and Station 200N over NHAV 93 displayed lower OSI values in comparison to 1995 results, as well as indications of a low DO environment despite higher dissolved oxygen concentrations in the central Long Island Sound region. The decline in habitat quality at these stations may be attributed to high SOD rather than a hypoxic event in the overlying water. Barring a dramatic disturbance, complete benthic recovery should be achieved within the next few years as continued chemical oxidation and increased biological activity dissipate the organic load within the sediment deposits. Monitoring of the benthic environment over the CLIS 94 and NHAV 93 mounds should continue for the next one to two years.

The bathymetric data collected over the CLIS 94, NHAV 93, and MQR mounds during the July 1996 field operations adds to the comprehensive time-series data set currently in existence for CLIS. Comparisons to earlier stages of development for the capped mounds find small to moderate pockets of consolidation over the surfaces of the three bottom features, suggesting the long-term behavior patterns are in agreement with the results of previous consolidation studies (Poindexter-Rollings 1990; Silva et al. 1994). All three mounds are expected to consolidate slowly over the next five to ten years as gradual pore water extrusion and compression of the underlying ambient material are driven by the weight of the dredged material deposits. It is recommended that bathymetric data be collected over the NHAV 93 mound on an every other year basis for the next five to ten years as the disposal mound fully consolidates to enhance our understanding of the physical processes and effects of consolidation within large sediment deposits.

Results from the July 1996 REMOTS® sediment-profile photography survey indicate that all three reference areas exhibited healthy benthic conditions as demonstrated by deep RPDs and mature benthic assemblages, yielding relatively high reference OSI values. However, one replicate photograph collected at STA 9, within a 300m of the center of CLIS-REF, exhibited an anomalous pocket of low reflectance material within a chaotic sediment fabric. Benthic disturbances that display these characteristics are often related to the deposition of non-ambient sediments, but are usually more widespread. The presence of a large macrofaunal burrow structure and the localized nature of this disturbance may suggest another origin. A detailed investigation of the seafloor surrounding STA 9 is recommended during the 1997 environmental monitoring effort at CLIS to better characterize these sediments.

Past DAMOS monitoring activity at the Long Island Sound disposal sites was performed in mid-summer (late July to August) to allow an increase in bottom water temperatures to increase bioturbational activity and promote benthic community recovery after the conclusion of the disposal season. This practice tended to promote the completion of community assessment activities during a period of seasonal hypoxia or near-hypoxia ($5.0\ mg \cdot l^{-1}$ to $3.0\ mg \cdot l^{-1}$), skewing the entire data set. Comparisons between the July 1996 benthic community assessment survey and previous data sets suggest that the improvement in benthic health is attributed to conducting community assessment survey operations in mid-July. The timing of 1996 survey activity at CLIS was successful in avoiding the recurring seasonal hypoxia in the central Long Island Sound region. As a result, the data collected during this survey did not exhibit the profoundly negative effects associated with the lower bottom water DO concentrations. The continued practice of conducting benthic community assessment activities at CLIS and other Long Island Sound disposal sites between 30 June and 15 July should provide a more realistic perspective into the condition of the benthic environment.

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Appendix A

Appendix A, Table 2-1

CLIS REMOTS® Camera Stations

CLIS 1996 REMOTS® Stations			
North American Datum of 1927			
Area	Station	Latitude	Longitude
CLIS 1995 MOUND 41° 08.660′ N 72° 53.042′ W	CTR	41° 08.660′ N	72° 53.042′ W
	100N	41° 08.714′ N	72° 53.042′ W
	200N	41° 08.768′ N	72° 53.042′ W
	300N	41° 08.822′ N	72° 53.042′ W
	100S	41° 08.605′ N	72° 53.042′ W
	200S	41° 08.551′ N	72° 53.042′ W
	300S	41° 08.497′ N	72° 53.042′ W
	100E	41° 08.660′ N	72° 52.970′ W
	200E	41° 08.660′ N	72° 52.899′ W
	300E	41° 08.660′ N	72° 52.827′ W
	100W	41° 08.660′ N	72° 53.113′ W
	200W	41° 08.660′ N	72° 53.184′ W
	300W	41° 08.660′ N	72° 53.256′ W
Reference Areas			
2500W 41° 09.254′ N 72° 55.569′ W	STA 1	41° 09.138′ N	72° 55.697′ W
	STA 2	41° 09.305′ N	72° 55.593′ W
	STA 3	41° 09.242′ N	72° 55.547′ W
	STA 4	41° 09.254′ N	72° 55.508′ W
4500E 41° 09.254′ N 72° 50.565′ W	STA 5	41° 09.312′ N	72° 50.551′ W
	STA 6	41° 09.301′ N	72° 50.424′ W
	STA 7	41° 09.168′ N	72° 50.430′ W
	STA 8	41° 09.255′ N	72° 50.575′ W
CLISREF 41° 08.085′ N 72° 50.109′ W	STA 9	41° 08.100′ N	72° 50.112′ W
	STA 10	41° 08.058′ N	72° 50.154′ W
	STA 11	41° 08.066′ N	72° 50.015′ W
	STA 12	41° 08.156′ N	72° 50.064′ W
	STA 13	41° 08.228′ N	72° 50.092′ W
Supplemental Areas			
NHAV 1993 MOUND 41° 09.122′ N 72° 53.453′ W	CTR	41° 09.122′ N	72° 53.453′ W
	200N	41° 09.230′ N	72° 53.453′ W
	200S	41° 09.014′ N	72° 53.453′ W
	200E	41° 09.122′ N	72° 53.310′ W
	200W	41° 09.122′ N	72° 53.596′ W
CLIS 1994 MOUND 41° 09.343′ N 72° 53.099′ W	CTR	41° 09.343′ N	72° 53.099′ W
	100N	41° 09.397′ N	72° 53.099′ W
	100S	41° 09.289′ N	72° 53.099′ W
	100E	41° 09.343′ N	72° 53.028′ W
	100W	41° 09.343′ N	72° 53.171′ W

Appendix A, Table 3-1

REMOTS® Parameters Summary Table for the CLIS 95 Disposal Mound

Station	Mean RPD (cm)	Median OSI	Mean Camera Penetration (cm)	Mean Boundary Roughness (cm)
CTR	1.56	7.0	13.79	1.98
100N	1.55	7.5	18.44	0.38
100S	0.94	3.0	12.31	1.60
100E	2.36	4.0	18.25	0.66
100W	3.14	9.0	11.46	0.85
200N	3.18	10.0	17.20	0.91
200S	2.16	8.0	14.52	0.84
200E	1.99	8.0	16.51	1.05
200W	3.12	10.0	14.95	0.68
300N	3.13	9.5	14.32	1.15
300S	1.52	7.0	16.21	0.56
300E	2.42	8.0	14.90	0.94
300W	2.79	5.0	14.59	0.98

Appendix A, Table 3-2

REMOTS® Parameters Summary Table for the CLIS 94 Disposal Mound

Station	Mean RPD (cm)	Median OSI	Mean Camera Penetration (cm)	Mean Boundary Roughness (cm)
CTR	1.09	3	14.71	1.15
100N	3.38	6	15.79	1.01
100S	1.66	4	18.12	0.90
100E	3.09	10	15.83	0.35
100W	2.19	6	17.72	0.56

Appendix A, Table 3-3

REMOTS® Parameters Summary Table for the NHAV 93 Disposal Mound

Station	Mean RPD (cm)	Median OSI	Mean Camera Penetration (cm)	Mean Boundary Roughness (cm)
CTR	2.77	9.0	14.97	0.64
200N	1.37	3.0	15.76	0.51
200S	1.45	3.0	16.74	0.49
200E	2.21	6.0	15.06	0.63
200W	2.32	8.0	15.73	0.75

Appendix A, Table 3-4

REMOTS® Parameters Summary Table for the CLIS Reference Areas

REMOTS® Parameters Summary Table CLIS Reference Areas

Station	Mean RPD (cm)	Median OSI	Mean Camera Penetration (cm)	Mean Boundary Roughness (cm)
2500W				
STA1	2.28	9.00	11.92	0.84
STA2	2.27	8.00	13.17	1.55
STA3	1.75	4.00	12.33	2.36
STA4	2.60	7.00	14.03	1.01
4500E				
STA5	1.67	4.0	10.60	1.38
STA6	1.51	8.0	12.18	1.26
STA7	2.55	8.0	14.26	1.05
STA8	2.62	6.0	13.50	0.65
CLIS-REF				
STA9	2.39	7.0	12.81	0.83
STA10	2.02	8.0	11.40	0.66
STA11	2.38	9.0	10.59	0.74
STA12	1.94	5.0	11.40	0.32
STA13	2.04	8.0	12.50	0.92

Appendix B

Appendix B

REMOTS® Data from the CLIS 95 Mound

Station	Replicate	Date	Successional Stage	Grain Size (phi) Min	Grain Size (phi) Max	Grain Size (phi) Maj Mode	Mud Clasts Count	Mud Clasts Avg Diam	Camera Penetration Min	Camera Penetration Max	Camera Penetration Range	Camera Penetration Mean	Dredged Material Thickness Area	Dredged Material Thickness Min	Dredged Material Thickness Max	Dredged Material Thickness Mean	Redox Rebound Thickness Min	Redox Rebound Thickness Max	Redox Rebound Thickness Mean	Apparent RPD Thickness Area	Apparent RPD Thickness Min	Apparent RPD Thickness Max	Apparent RPD Thickness Mean	Methane	OSI	Surface Roughness	Low DO	Comments
CTR	A	7/11/96	ST_I_ON_III	3	>4	>4	0	0	10.16	12.86	2.71	11.51	151.89	6.41	12.76	11.12	0	0	0	11.557	0.1	2.66	0.95	NO	7	PHYSICAL	NO	DGP,collapsed oxygenated void,patches of sulfidic
CTR	B	7/11/96	ST_III	3	>4	4 to 3	0	0	10.11	11.41	1.3	10.76	84.48	4.64	10.76	7.2	0	0	0	23.625	0.78	3.44	2.15	NO	4	PHYSICAL	NO	DGP,burrow on interclast void
CTR	C	7/11/96	ST_I_ON_III	3	>4	>4	0	0	18.12	20.05	1.93	19.09	259.27	17.97	20.05	19.08	1.82	4.32	3.07	22.2	0.51	2.49	1.59	NO	8	INDET	NO	DGP,S/M,active void?
100N	A	7/11/96	ST_I_ON_III	3	>4	4 to 3	0	0	16.82	17.45	0.62	17.13	234.81	17.13	17.45	17.27	0	0	0	23.262	1.02	2.33	1.69	NO	8	BIOGENIC	NO	DGP,dissected worm at depth,layered fabric,old DM?
100N	B	7/11/96	ST_I_ON_III	3	>4	4 to 3	0	0	20.26	20.26	0	20.26	272.24	5.99	20.15	19.69	0	0	0	NA	NA	NA	NA	NO	99	INDET	NO	DGP,OVERPEN,active feeding void at depth,retracted anemone?S/M,old DM?
100N	C	7/11/96	ST_I_ON_III	3	>4	>4	0	0	17.65	18.18	0.52	17.92	241.84	17.65	18.23	17.83	0	0	0	19.994	0.51	1.93	1.4	NO	7	PHYSICAL	NO	DGP,active void at depth,camera shear artifact,stranded tube erosional?old DM? SPHYSICAL
100S	E	7/18/96	ST_III	3	>4	>4	0	0	11.25	12.55	1.3	11.9	161.78	4.69	12.81	11.9	0	0	0	14.635	0.15	1.98	1.02	NO	3	INDET	NO	DGP,S/M,patchy RPD
100S	F	7/18/96	ST_I_ON_III	3	>4	>4	0	0	11.61	12.6	0.99	12.11	165.09	9.37	12.6	12.14	0	0	0	16.282	0.41	1.78	1.17	NO	7	BIOGENIC	NO	DGP,feeding void at depth,S/M
100S	G	7/18/96	ST_III	3	>4	>4	0	0	11.67	14.17	2.5	12.92	179.99	6.04	14.11	13	0	0	0	8.54	0.05	1.41	0.82	NO	-2	PHYSICAL	YES	DGP,shallow RPD,shell fragment,erosional
100E	A	7/11/96	INDET	3	>4	>4	0	0	19.74	19.74	0	19.74	271.83	19.84	20.05	19.89	0	0	0	NA	NA	NA	NA	NO	99	INDET	NO	DGP,overpen IND stage,fresh DM?
100E	C	7/11/96	ST_I_ON_III	3	>4	>4	0	0	18.58	20.21	1.62	19.4	268.19	18.48	20.28	19.67	2.54	7.51	5.02	28.178	1.37	2.99	2.01	NO	99	INDET	NO	DGP,slight OP,S/M
100E	D	7/18/96	ST_I_ON_III	3	>4	>4	3	0.54	15.42	15.78	0.36	15.6	209.83	15.42	15.99	15.81	0	0	0	38.052	0.26	4.25	2.71	NO	4	PHYSICAL	NO	DGP
100W	A	7/11/96	ST_III	2	2	>4	0	1.46	10.63	11.57	0.94	11.1	9999	10.63	11.57	11.1	0	0	0	0	NA	NA	NA	NO	99	PHYSICAL	NO	DGP,clasts on surface, pullaway camera disturbance?macrofaunal burrow,worm mid dPHYSICAL
100W	B	7/11/96	ST_I_ON_III	3	>4	4 to 3	0	0	13.82	14.5	0.68	14.16	194.4	7.28	14.66	14.17	5	7	6	30.108	0.16	4.66	2.38	NO	9	PHYSICAL	NO	DGP,active void at depth,burrow?,S/M
100W	C	7/11/96	INDET	3	>4	>4	0	0	8.64	9.58	0.94	9.11	102.21	2.88	9.42	7.72	0	0	0	49.55	0.42	6.13	3.89	NO	99	INDET	NO	DGP,camera shearing/fracture?,S/M
200N	A	7/11/96	ST_I_ON_III	3	>4	>4	0	0	15.45	16.07	0.63	15.76	214.05	7.75	15.92	15.6	0	0	0	21.554	0.21	5.81	3.82	NO	10	BIOGENIC	NO	DGP,active voids,burrow,stage I assem,S/M,old DM?
200N	B	7/11/96	ST_I_ON_III	3	>4	>4	0	0	18.07	18.75	0.68	18.41	246.35	4.01	18.8	17.73	0	0	0	30.174	0.82	4.22	2.18	NO	8	INDET	NO	DGP,active void middepth,S/M,old DM?
200N	C	7/11/96	ST_I_ON_III	3	>4	>4	0	0.53	16.72	18.12	1.41	17.42	234.22	16.67	18.07	17.22	0	0	0	51.216	0.42	6.98	3.74	NO	10	PHYSICAL	NO	DGP,active feeding voids,reduced wiper clasts,old DM
200S	A	7/11/96	ST_I_ON_III	3	>4	>4	0	0	13.82	14.87	1.05	14.34	191.51	13.61	14.71	14.1	4.35	6.96	5.65	34.597	0.99	3.35	2.45	NO	9	INDET	NO	DGP,active feeding void,worm at depth,old DM?
200S	B	7/11/96	ST_I_ON_III	3	>4	>4	1	0.61	14.61	15.44	0.84	15.03	204.3	11.31	15.5	14.89	0	0	0	28.753	0.94	3.82	2.09	NO	8	PHYSICAL	NO	DGP,camera shear,old DM
200S	C	7/11/96	ST_I_ON_III	3	>4	>4	0	0	13.87	14.5	0.63	14.19	190.11	10.21	14.34	13.98	2.73	4.66	4.5	27.151	0.63	2.98	1.93	NO	8	PHYSICAL	NO	DGP,active void at depth,S/M sulfidic,old DM
200E	A	7/11/96	ST_I_ON_III	3	>4	4 to 3	0	0	15.39	15.76	0.37	15.58	214.68	15.29	15.97	15.55	0	0	0	27.983	0.68	4.45	2.23	NO	8	INDET	NO	DGP,worm at depth,S/M
200E	B	7/11/96	ST_I_ON_III	3	>4	>4	0	0	15.03	16.81	1.78	15.92	215.55	14.82	16.81	15.62	0	0	0	25.088	0.42	3.61	1.78	NO	8	PHYSICAL	NO	DGP,worm middepth,S/M,air bubble on mirror
200E	C	7/11/96	ST_III	3	>4	>4	0	0	17.54	18.53	0.99	18.04	247.08	9.32	18.74	17.93	6	7.5	7	13.897	0.05	3.3	1.97	NO	4	PHYSICAL	NO	DGP,camera artifact(reduced clast in RPD),sulfidic
200W	A	7/11/96	ST_I_ON_III	3	>4	>4	0	0	12.25	13.35	1.1	12.8	235.92	13.04	17.69	17.2	6	8	7	42.556	2.46	3.51	3.06	NO	10	PHYSICAL	NO	DGP,mulinia or tellinaceans,neyphtes?in RPD,S/M
200W	B	7/11/96	ST_I_ON_III	3	>4	>4	0	0	16.18	16.49	0.31	16.33	223.7	6.09	16.65	16.36	1.68	8.12	4.9	45.252	0.89	4.35	3.26	NO	10	PHYSICAL	NO	DGP,wiper clast smear on RPD?,void
200W	C	7/11/96	ST_I_ON_III	3	>4	>4	0	0	15.39	16.02	0.63	15.71	214.12	15.44	16.07	15.81	5	7	6	42.35	0.89	5.18	3.05	NO	10	BIOGENIC	NO	DGP,active void in RPD,S/M
300N	B	7/11/96	ST_I_ON_III	3	>4	>4	0	0	13.25	14.19	0.94	13.72	185.34	13.09	14.03	13.51	0	0	0	49.364	1.2	4.71	3.55	NO	10	BIOGENIC	NO	DGP,macrofaunal burrow?,worms middepth,S/M old DM
300N	C	7/11/96	ST_I_ON_III	3	4	>4	0	0	14.24	15.8	1.36	14.92	201.81	14.08	15.34	14.84	0	0	0	37.91	1.57	3.51	2.7	NO	9	INDET	NO	DGP,active feeding voids, large shell frag S/M,old DM?
300S	A	7/11/96	ST_I_ON_III	3	>4	>4	0	0	14.24	14.82	0.58	14.53	194.93	0.94	14.53	14	1.63	6.25	3.94	16.912	0.25	2.08	1.21	NO	7	BIOGENIC	NO	DGP,acive voids,worms at depth
300S	B	7/11/96	ST_I_ON_III	3	>4	>4	0	0	14.55	15.02	0.47	14.79	201.06	14.4	15.08	14.77	3.56	9.05	6.3	18.701	0.1	1.78	1.28	NO	7	BIOGENIC	NO	DGP,possible collasped void,mollusc farfield
300S	C	7/11/96	ST_I_ON_III	3	>4	>4	4	0.46	19	19.63	0.63	19.32	263.24	14.29	19.68	19.19	1.52	9.6	5.56	28.861	1.07	2.99	2.06	NO	8	INDET	NO	DGP,S/M
300E	A	7/11/96	ST_I_ON_III	3	>4	>4	0	0	15.18	16.02	0.84	15.6	219.23	15.39	16.28	15.59	4.45	7.7	6.08	45.61	0.63	5.97	3.58	NO	10	BIOGENIC	NO	DGP,active & collasped voids sulfidic
300E	B	7/11/96	ST_I_ON_III	3	>4	>4	0	0	12.67	14.03	1.36	13.35	181.97	12.67	14.03	13.24	0	0	0	29.225	0.1	3.35	2.22	NO	8	BIOGENIC	NO	DGP,active feeding void,S/M
300E	C	7/11/96	ST_I_ON_III	3	>4	>4	0	0	15.44	16.06	0.62	15.75	221.53	5.98	16.06	15.79	0	0	0	20.506	0.57	2.54	1.46	NO	7	INDET	NO	DGP,macrofaunal burrow,collasped void, sulfidic at depth Stage III?
300W	A	7/11/96	ST_I	3	>4	>4	0	0	15.5	16.65	1.18	16.07	216.75	2.88	16.6	15.54	4.21	8.07	6.14	27.43	1.07	2.49	1.98	NO	4	PHYSICAL	NO	DGP,live mulinia,erosional, stranded tubes
300W	B	7/11/96	ST_III	3	>4	>4	1	1.23	14.55	15.23	0.68	14.89	207.9	14.5	15.55	14.75	6	8	7	34.142	1.57	3.56	2.47	NO	5	PHYSICAL	NO	DGP,reduced wiper clast S/M
300W	C	7/11/96	ST_I_ON_III	3	>4	>4	0	0	12.25	13.35	1.1	12.8	173.67	11.94	13.51	12.66	5	7	6	50.344	0.89	5.34	3.92	NO	11	INDET	NO	DGP,macrofaunal burrow,mulinia S/M

Appendix C

Appendix C

REMOTS® Data from the CLIS 94 Mound

Station	Replicate	Date	Successional	Grain Size (phi)			Mud Clasts		Camera Penetration				Dredged Material Thickness				Redox Rebound Thickness			Apparent RPD Thickness				Methane	OSI	Surface	Low	Comment
			Stage	Min	Max	Maj. Mode	Count	Avg.Diam	Min	Max	Range	Mean	Area	Min	Max	Mean	Min	Max	Mean	Area	Min	Max	Mean			Roughness	DO	
CTR	A	7/11/96	ST_I_ON_III	3	>4	>4	0	0	13.51	13.82	0.31	13.66	184.54	13.25	13.82	13.52	0	0	0	20.793	0.63	2.2	1.49	NO	7	PHYSICAL	NO	DGP;sulfidic;feeding voids;burrow at depth
CTR	B	7/11/96	ST_I	3	>4	>4	2	0.69	14.66	15.39	0.73	15.03	205.51	4.61	15.55	14.84	0	0	0	8.223	0.05	1.94	0.72	NO	2	INDET	NO	DGP;reduced clasts at surface;sulfidic
CTR	C	7/11/96	ST_I	3	>4	>4	0	0	14.24	16.65	2.41	15.45	218.25	7.96	17.7	16.22	0	0	0	8.646	0.42	1.68	1.05	NO	3	PHYSICAL	NO	DGP;shallow RPD;collapsed burrow;sulfidic
100N	A	7/11/96	ST_I	3	>4	>4	0	0	15.92	16.23	0.31	16.07	215.45	7.91	16.23	15.78	0	0	0	44.916	1.15	4.82	3.38	NO	6	BIOGENIC	NO	DGP;sulfidic;S/M;layered fabric
100N	B	7/11/96	ST_I_ON_III	3	>4	>4	3	0.66	15.81	17.12	1.31	16.47	223.11	15.97	17.17	16.47	0	0	0	NA	NA	NA	NA	NO	99	PHYSICAL	NO	DGP;sulfidic;reduced wiper clasts obscures most of RPD
100N	C	7/11/96	ST_I_ON_III	3	>4	>4	0	0	14.14	15.55	1.41	14.84	206.42	7.64	15.5	15.12	0	0	0	NA	NA	NA	NA	NO	99	PHYSICAL	NO	DGP;wiper smear RPD;worm at depth;burrow/void
100S	A	7/11/96	ST_I	3	>4	4 to3	1	0.49	17.02	17.44	0.42	17.23	232.83	12.57	17.43	17.05	0	0	0	27.387	0.94	3.51	2.13	NO	4	PHYSICAL	NO	DGP;layers of old DM and Shell;S/M
100S	B	7/11/96	ST_I	3	>4	>4	0	0	19.3	20.64	1.34	19.97	256.27	18.43	20.05	18.93	3.82	6.29	5.05	19.157	0.05	3.3	1.34	NO	-1	PHYSICAL	YES	DGP;patchy RPD;shell hash
100S	C	7/11/96	ST_I	3	>4	>4	3	0.45	16.68	17.63	0.95	17.16	230.6	12.84	17.37	16.64	0	0	0	21.151	0.42	2.74	1.51	NO	4	PHYSICAL	NO	DGP;layer of old DM;clasts on surface;patchy RPD
100E	A	7/11/96	ST_I_ON_III	3	>4	>4	0	0	18.22	18.32	0.1	18.27	248.49	6.75	18.43	17.79	9	10	9.5	43.761	1.36	5.92	3.18	NO	10	BIOGENIC	NO	layered fabric DM;DGP
100E	B	7/11/96	ST_I	3	>4	>4	0	0	14.61	15.39	0.79	15	204.31	11.2	15.29	14.98	0	0	0	21.125	0.47	3.09	1.53	NO	4	BIOGENIC	NO	DGP;sulfidic;layers of old DM
100E	D	7/11/96	ST_I_ON_III	3	>4	>4	0	0	14.13	14.29	0.16	14.21	192.39	14.08	14.45	14.24	4.98	7.8	7.5	59.994	2.98	5.6	4.55	NO	11	INDET	NO	DGP;feeding void with sorted particles
100W	A	7/11/96	ST_I	3	>4	>4	0	0	18.32	18.32	0	18.32	247.61	9.28	18.63	18.14	4	6	5	38.694	0.32	4.79	2.96	NO	5	BIOGENIC	NO	DGP;layered old DM;sulfidic;layered fabric
100W	B	7/11/96	ST_I	3	>4	>4	2	0.88	17.05	17.84	0.79	17.45	236.62	16.84	18.05	17.3	0	0	0	NA	NA	NA	NA	NO	99	INDET	NO	DGP;sulfidic;reduced wiper clasts
100W	C	7/11/96	ST_I_ON_III	3	>4	>4	2	0.95	16.95	17.84	0.9	17.39	236.1	17	17.84	17.31	0	0	0	8.918	0.31	3.09	1.42	NO	7	PHYSICAL	NO	DGP;reduced clasts on surface

Appendix D

Appendix D

REMOTS® Data from the CLIS NHAV 93 Mound

Station	Replicate	Date	Successional Stage	Grain Size (phi) Min	Grain Size (phi) Max	Grain Size (phi) Maj Mode	Mud Clasts Count	Mud Clasts Avg Diam	Camera Penetration Min	Camera Penetration Max	Camera Penetration Range	Camera Penetration Mean	Dredged Material Thickness Area	Dredged Material Thickness Min	Dredged Material Thickness Max	Dredged Material Thickness Mean	Redox Rebound Thickness Min	Redox Rebound Thickness Max	Redox Rebound Thickness Mean	Apparent RPD Thickness Area	Apparent RPD Thickness Min	Apparent RPD Thickness Max	Apparent RPD Thickness Mean	Methane	OSI	Surface Roughness	Low DO	Comments
CTR	A	7/11/96	ST_I_ON_III	3	>4	>4	0	0	14.76	15.71	0.94	15.24	204.25	7.8	15.6	14.82	2.93	4.98	3.96	35.655	1.41	3.72	2.77	NO	9	BIOGENIC	NO	DGP;sulfidic;voids;hydroids?
CTR	B	7/11/96	ST_I	3	>4	>4	1	1.55	13.87	14.4	0.52	14.14	196.71	14.45	14.5	14.38	0	0	0	NA	NA	NA	NA	NO	99	PHYSICAL	NO	DGP;reduced wiper clast at surface;sulfidic;hydroids
CTR	C	7/11/96	ST_I_ON_III	3	>4	>4	3	1.63	15.29	15.76	0.47	15.52	211.86	5.88	15.76	15.37	0	0	0	NA	NA	NA	NA	NO	99	PHYSICAL	NO	DGP;feeding void;sulfidic;reduced wiper clast;hydroids
200N	A	7/11/96	ST_I	3	>4	>4	0	0	16.49	16.91	0.42	16.7	224.41	16.44	16.75	16.39	3.51	5.45	4.48	20.916	0.94	1.36	1.26	NO	3	BIOGENIC	NO	DGP,sulfidic;relic void
200N	B	7/11/96	ST_I	3	>4	>4	2	0.53	14.24	15.03	0.79	14.63	193.21	7.07	15.18	14.28	0	0	0	15.02	0.47	2.83	1.48	NO	3	PHYSICAL	NO	DGP,sulfidic,reduced wiper clast surface
200N	C	7/11/96	ST_I	3	>4	>4	0	0	15.79	16.1	0.32	15.95	216.85	6	16.1	15.65	2.85	5.23	4.04	19.502	0.42	2.84	1.36	NO	3	BIOGENIC	NO	DGP,sulfidic;wiper smear,sulfidic
200S	A	7/11/96	ST_I	3	>4	>4	0	0	15.95	16.95	1	16.45	222.9	4.79	17.05	15.94	0	0	0	9.295	0.05	2.37	1.48	NO	3	BIOGENIC	NO	DGP; possible stage III;feeding void below RPD?
200S	B	7/11/96	ST_I_ON_III	3	>4	>4	0	0	14.74	15.1	0.36	14.92	203.39	15.05	15.16	14.98	3.65	5.31	4.48	21.685	1.26	1.97	1.56	NO	8	INDET	NO	DGP;collapsed feeding voids;S/M.sulfidic
200S	C	7/11/96	ST_I	3	>4	>4	3	0.51	18.79	18.89	0.11	18.84	255.35	14.16	18.95	18.58	0	0	0	17.559	0.47	3.05	1.28	NO	3	BIOGENIC	NO	DGP;sulfidic;shell at surface;hydroids
200E	A	7/11/96	ST_I	3	>4	>4	0	0	15.88	16.65	0.79	16.26	217.74	15.81	16.6	16	4.14	5.39	4.76	44.998	1.1	5.08	3.44	NO	6	PHYSICAL	NO	DGP,sulfidic;shell frags,hydroids
200E	B	7/11/96	ST_I_ON_III	3	>4	>4	1	0.71	14.14	14.92	0.79	14.53	197	5.13	15.03	14.22	3.46	5.44	4.45	23.315	0.52	3.04	1.64	NO	8	PHYSICAL	NO	DGP;sulfidic;void at mid depth;reduced wiper clast
200E	C	7/11/96	ST_I	3	>4	>4	0	0	14.24	14.55	0.31	14.4	193.39	14.14	14.45	14.31	3.04	5.03	4.03	21.744	0.37	2.77	1.56	NO	4	INDET	NO	DGP;sulfidic;S/M
200W	A	7/11/96	ST_I_ON_III	3	>4	>4	0	0	16.7	17.28	0.58	16.99	227.94	16.44	17.07	16.75	0	0	0	41.962	0.79	3.61	3	NO	9	INDET	NO	DGP;sulfidic;S/M
200W	B	7/11/96	ST_I_ON_III	3	>4	>4	2	0.73	17.17	17.75	0.58	17.46	234.87	17.28	17.8	17.39	3.77	6.75	5.26	23.818	0.21	2.57	1.76	NO	4	PHYSICAL	NO	DGP;relic void;reduced wiper clasts in RPD,sulfidic
200W	D	7/18/96	ST_I_ON_III	3	>4	>4	0	0	12.2	13.3	1.1	12.75	171.98	4.61	13.09	12.59	0	0	0	29.259	1.15	3.09	2.21	NO	8	PHYSICAL	NO	DGP;feeding voids;sulfidic; some shell

Appendix E

Appendix E

REMOTS® Data from the CLIS Reference Areas

Station	Replicate	Date	Successional Stage	Grain Size (phi) Min	Grain Size (phi) Max	Grain Size (phi) Maj Mode	Mud Clasts Count	Mud Clasts Avg Diam	Camera Penetration Min	Camera Penetration Max	Camera Penetration Range	Camera Penetration Mean	Dredged Material Thickness Area	Dredged Material Thickness Min	Dredged Material Thickness Max	Dredged Material Thickness Mean	Redox Rebound Thickness Min	Redox Rebound Thickness Max	Redox Rebound Thickness Mean	Apparent RPD Thickness Area	Apparent RPD Thickness Min	Apparent RPD Thickness Max	Apparent RPD Thickness Mean	Methane	OSI	Surface Roughness	Low DO	Comments
2500E																												
STA1	A	7/11/96	ST_I_ON_III	3	>4	>4	0	0	10.94	11.62	0.68	11.28	0	0	0	0	3.98	6.49	5.24	42.406	1.82	3.83	3.08	NO	11	PHYSICAL	NO	active feeding voids,stage I tubes,sulfidic at depth,erosional
STA1	B	7/11/96	ST_I_ON_III	3	>4	>4	0	0.78	10.94	11.62	0.68	11.28	0	0	0	0	0	0	0	30.308	0.98	3.23	2.18	NO	9	PHYSICAL	NO	boundary roughness;dragged down anemone,erosional
STA1	C	7/11/96	ST_I_ON_III	3	>4	>4	0	0	12.62	13.77	1.15	13.19	0	0	0	0	0	0	0	21.357	0.58	2.3	1.58	NO	6	BIOGENIC	NO	active voids at depth,shell hash
STA2	A	7/11/96	ST_I_ON_III	3	>4	>4	0	0	9.89	13.66	3.77	11.78	0	0	0	0	5	6	5.5	27.375	0.21	3.4	1.96	NO	6	INDET	NO	,void at depth,erosional
STA2	B	7/11/96	ST_I	3	>4	>4	0	0	14.58	14.74	0.16	14.66	0	0	0	0	3.18	5.78	4.48	39.713	1.77	4.22	2.9	NO	5	BIOGENIC	NO	dense stage i tubes,some shell,
STA2	C	7/11/96	ST_I_ON_III	3	>4	>4	0	0	12.71	13.44	0.73	13.07	0	0	0	0	0	0	0	24.337	0.16	3.28	1.94	NO	6	INDET	NO	active feeding void at depth,S/M,some shell
STA3	A	7/11/96	ST_I_ON_III	3	>4	>4	0	0	13.96	14.64	0.68	14.3	0	0	0	0	3.49	5.73	4.61	30.779	0.28	4.37	2.5	NO	9	INDET	NO	active feeding void or fracture?at depth,macrofaunal burrow,hydroids
STA3	B	7/11/96	ST_I	3	>4	>4	0	0	12.55	12.97	0.42	12.76	0	0	0	0	0	0	0	26.647	0.78	3.7	2.08	NO	4	PHYSICAL	NO	possible stage III,voids at frame edge left?dense stage I tubes
STA3	C	7/11/96	ST_I_ON_III	3	>4	>4	0	0	6.93	12.92	5.99	9.92	0	0	0	0	0	0	0	5.203	0.1	1.51	0.67	NO	2	PHYSICAL	YES	sloping topography,active voids,old dm?
STA4	A	7/11/96	ST_I_ON_III	3	>4	>4	0	0	14.32	14.74	0.42	14.53	0	0	0	0	0	0	0	47.855	1.67	5.62	3.72	NO	10	INDET	NO	feeding void at depth,feeding pit,dense stage I tubes
STA4	B	7/11/96	ST_I	3	>4	>4	0	0	12.71	14.38	1.67	13.54	0	0	0	0	4.17	7.46	5.81	39.029	1.77	3.96	2.8	NO	5	BIOGENIC	NO	poss9ble stage III?deep RPD,collapsed feeding void?
STA4	C	7/11/96	ST_I_ON_III	3	>4	>4	3	0.65	13.54	14.48	0.94	14.01	0	0	0	0	0	0	0	15.308	0.26	2.34	1.26	NO	7	BIOGENIC	NO	active void with fecal pellets,macrofaunal burrow (or drag down)with reduced claBIOGENIC
4500E																												
STA5	A	7/11/96	ST_I_ON_III	3	>4	>4	0	0	7.85	8.79	0.94	8.32	0	0	0	0	0	0	0	42.092	0.94	4.08	3.22	NO	10	INDET	NO	sulfidic,worms at depth
STA5	B	7/11/96	ST_I	3	>4	>4	1	1.32	10.57	12.14	1.57	11.36	0	0	0	0	0	0	0	22.91	0	0	0	NO	3	PHYSICAL	NO	clasts of clay at surface,sulfidic
STA5	c	7/11/96	ST_I	3	>4	>4	1	0.53	11.31	12.93	1.62	12.12	0	0	0	0	0	0	0	18.186	0.16	4.71	1.79	NO	4	INDET	NO	sulfidic;shell frags in sed,reduced clast in RPD,erosional,voids?
STA6	A	7/11/96	ST_I_ON_III	3	>4	>4	0	0	14.29	14.97	0.68	14.63	0	0	0	0	0	0	0	28.175	1.67	2.37	1.99	NO	8	PHYSICAL	NO	active feeding voids,hydroids,sulfidic
STA6	B	7/11/96	ST_I_ON_III	3	>4	>4	4	0.56	10.1	12.56	2.46	11.33	0	0	0	0	0	0	0	22.052	0.47	2.51	1.59	NO	8	PHYSICAL	NO	sulfidic,clasts on surface,shell,void at depth,old DM,stageIII?
STA6	C	7/11/96	ST_I	3	>4	>4	0	0	10.26	10.89	0.63	10.57	0	0	0	0	0	0	0	13.581	0.37	2.25	0.95	NO	3	PHYSICAL	NO	sulfidic,shallow RPD;old DM?
STA7	A	7/11/96	ST_I	3	>4	>4	0	0	14.97	15.23	0.26	15.1	0	0	0	0	3.87	5.97	4.92	54.243	2.77	5.39	4.11	NO	7	BIOGENIC	NO	some smearing of RPD,some shell
STA7	B	7/11/96	ST_I_ON_III	3	>4	>4	1	0.94	11.46	13.61	2.15	12.54	0	0	0	0	4	6	5	26.62	0.42	2.83	1.94	NO	8	INDET	NO	active feeding voids with sorted particles burrow?
STA7	C	7/11/96	ST_I_ON_III	3	>4	>4	0	0	14.76	15.49	0.73	15.13	0	0	0	0	0	0	0	22.253	0.16	2.51	1.59	NO	8	INDET	NO	active feeding voids,reduced wiper clast at surface,some shell,patchy RPD
STA8	A	7/11/96	ST_I_ON_III	3	>4	>4	0	0	13.14	13.87	0.73	13.51	0	0	0	0	0	0	0	33.807	1.31	3.03	2.42	NO	9	INDET	NO	many active voids,worms at depth,puzzle fabric(trawler dist?)
STA8	B	7/11/96	ST_I	3	>4	>4	0	0	12.41	12.98	0.58	12.69	0	0	0	0	0	0	0	31.541	0.69	3.87	2.26	NO	5	PHYSICAL	NO	anemone dragged down by camera
STA8	C	7/11/96	ST_I	3	>4	>4	1	0.54	13.98	14.6	0.63	14.29	0	0	0	0	7	8	7.5	43.419	2.56	3.98	3.17	NO	6	INDET	NO	deep RPD,sulfidic at depth
CLIS-REF																												
STA9	A	7/11/96	INDET	3	>4	>4	0	0	14.11	15.31	1.2	14.71	202.6	7.61	15.13	14.67	0	0	0	25.946	1.15	3.12	1.91	NO	99	PHYSICAL	NO	smearing of RPD,fresh DM? chaotic fabric
STA9	B	7/11/96	ST_I_ON_III	3	>4	>4	0	0	12.6	13.07	0.47	12.84	0	0	0	0	0	0	0	37.149	0.36	4.01	2.69	NO	9	BIOGENIC	NO	edge of active void at depth,collapsed void(camera artifact?)
STA9	C	7/11/96	ST_I	3	>4	>4	0	0	10.47	11.3	0.83	10.89	0	0	0	0	0	0	0	36.265	1.56	3.7	2.57	NO	5	INDET	NO	possible stage III?feeding tube?S/clay
STA10	A	7/11/96	ST_III	3	>4	>4	0	0	8.75	9.27	0.52	9.01	0	0	0	0	0	0	0	22.759	0.52	3.44	1.78	NO	8	BIOGENIC	NO	active feeding voids/tubes,mulinia?,sulfidic
STA10	B	7/11/96	ST_I_ON_III	3	>4	>4	1	1.13	12.49	13.3	0.81	12.89	0	0	0	0	0	0	0	43.125	0.05	4.72	3.39	NO	10	BIOGENIC	NO	artifact reduced clast at surface;shallow feeding void/burrow?
STA10	C	7/11/96	INDET	3	>4	>4	1	0.9	11.98	12.64	0.66	12.31	0	0	0	0	5.33	6.9	6.12	12.771	0.5	1.36	0.9	NO	3	INDET	NO	possible stage III?shallow RPD,reduced clast at surface,some shell
STA11	A	7/11/96	ST_I	3	>4	>4	0	0	9.09	9.95	0.86	9.52	0	0	0	0	0	0	0	20.219	0.66	2.39	1.44	NO	3	PHYSICAL	NO	some reduced material in RPD,S/clay,erosional
STA11	B	7/11/96	ST_I_ON_III	3	>4	>4	1	0.91	10	11.07	1.07	10.53	0	0	0	0	3.4	4.87	4.14	34.651	0.61	3.65	2.52	NO	9	PHYSICAL	NO	worm at depth,feeding mound?
STA11	C	7/11/96	ST_I_ON_III	3	>4	>4	0	0	11.57	11.88	0.3	11.73	0	0	0	0	3.15	5.13	4.14	43.612	1.88	4.37	3.17	NO	10	BIOGENIC	NO	active voids with worms at depth,tube
STA12	A	7/11/96	ST_I	3	>4	>4	0	0	11.12	11.47	0.36	11.29	0	0	0	0	3.81	5.13	4.47	36.793	1.73	3.45	2.62	NO	5	BIOGENIC	NO	some shell in RPD,no voids
STA12	B	7/11/96	ST_I_ON_III	>4	>4	>4	3	1.15	11.67	11.88	0.2	11.78	0	0	0	0	0	0	0	10.687	0.05	2.94	1.63	NO	8	PHYSICAL	NO	void at depth with organism,feeding pit or burrow at surface;chaotic fabric,old Physical
STA12	C	7/11/96	ST_I	3	>4	>4	2	2.27	10.91	11.32	0.41	11.12	0	0	0	0	0	0	0	22.178	0.51	2.59	1.57	NO	4	PHYSICAL	NO	erosional?reduced clasts in RPD(oldDM?),PULLAWAY
STA13	A	7/11/96	ST_I_ON_III	3	>4	>4	0	0	13.4	14.21	0.81	13.81	0	0	0	0	7	7	7	38.534	1.62	4.08	2.86	NO	9	INDET	NO	feeding voids at depth,feeding pit left?
STA13	B	7/11/96	ST_I	4	>4	>4	4	0.95	11.88	12.84	0.96	12.36	0	0	0	0	7.5	8.5	8	26.549	0.36	3.5	1.93	NO	4	INDET	NO	reduced wiper clasts in RPD (oldDM?)collapsed voids
STA13	D	7/18/96	ST_I_ON_III	3	>4	>4	3	0.72	11.78	12.08	0.3	11.93	0	0	0	0	2.95	5.79	4.37	34.278	1.67	3.25	2.47	NO	9	BIOGENIC	NO	reduced clasts(old DM?) near surface
STA13	E	7/18/96	ST_I_ON_III	3	>4	>4	0	0	11.07	12.69	1.62	11.88	0	0	0	0	0	0	0	12.631	0.3	1.41	0.89	NO	7	PHYSICAL	NO	large macrofaunal burrow,erosional,tubes at surface

Appendix F

Appendix F, Table 1

Summary of UDM Disposal at the CDA 95 buoy

permittee	project	disparea	dispdate	wtd	xtd	ytd	ztd	latdeg	latmin	longdeg	longmin	cyvol
CITY OF MILFORD	MILFORD HARBOR	CLIS	02-Oct-95	0	26545	43996.2	0	41	8.689	72	53.047	500
CITY OF MILFORD	MILFORD HARBOR	CLIS	03-Oct-95	15045.5	0	43996.1	0	41	8.668	72	53.093	600
CITY OF MILFORD	MILFORD HARBOR	CLIS	03-Oct-95	0	26545	43996	0	41	8.664	72	53.055	625
CITY OF MILFORD	MILFORD HARBOR	CLIS	04-Oct-95	0	26544.9	43996	0	41	8.666	72	53.043	975
CITY OF MILFORD	MILFORD HARBOR	CLIS	05-Oct-95	0	26544.9	43996	0	41	8.666	72	53.043	700
CITY OF MILFORD	MILFORD HARBOR	CLIS	07-Oct-95	0	26545	43996	0	41	8.664	72	53.055	600
CITY OF MILFORD	MILFORD HARBOR	CLIS	07-Oct-95	0	26545	43996	0	41	8.664	72	53.055	700
CITY OF MILFORD	MILFORD HARBOR	CLIS	08-Oct-95	0	26544.9	43996	0	41	8.666	72	53.043	550
CITY OF MILFORD	MILFORD HARBOR	CLIS	08-Oct-95	0	26545	43996	0	41	8.664	72	53.055	575
CITY OF MILFORD	MILFORD HARBOR	CLIS	09-Oct-95	0	26545	43996	0	41	8.664	72	53.055	975
CITY OF MILFORD	MILFORD HARBOR	CLIS	10-Oct-95	0	26544.9	43996	0	41	8.666	72	53.043	825
CITY OF MILFORD	MILFORD HARBOR	CLIS	11-Oct-95	0	26545	43996	0	41	8.664	72	53.055	725
CITY OF MILFORD	MILFORD HARBOR	CLIS	12-Oct-95	0	26544.9	43996	0	41	8.666	72	53.043	700
CITY OF MILFORD	MILFORD HARBOR	CLIS	13-Oct-95	0	26545	43996	0	41	8.664	72	53.055	975
CITY OF MILFORD	MILFORD HARBOR	CLIS	13-Oct-95	0	26544.9	43996	0	41	8.666	72	53.043	775
CITY OF MILFORD	MILFORD HARBOR	CLIS	16-Oct-95	0	26544.8	43995.9	0	41	8.656	72	53.034	750
CITY OF MILFORD	MILFORD HARBOR	CLIS	16-Oct-95	0	26544.9	43996	0	41	8.666	72	53.043	700
CITY OF MILFORD	MILFORD HARBOR	CLIS	17-Oct-95	0	26544.8	43996	0	41	8.669	72	53.03	800
CITY OF MILFORD	MILFORD HARBOR	CLIS	18-Oct-95	0	26544.9	43996	0	41	8.666	72	53.043	600
CITY OF MILFORD	MILFORD HARBOR	CLIS	18-Oct-95	0	26544.9	43996	0	41	8.666	72	53.043	600
CITY OF MILFORD	MILFORD HARBOR	CLIS	19-Oct-95	0	26544.8	43996	0	41	8.669	72	53.03	750
CITY OF MILFORD	MILFORD HARBOR	CLIS	19-Oct-95	0	26544.8	43996.1	0	41	8.681	72	53.027	625
CITY OF MILFORD	MILFORD HARBOR	CLIS	20-Oct-95	0	26544.8	43996	0	41	8.669	72	53.03	700
CITY OF MILFORD	MILFORD HARBOR	CLIS	23-Oct-95	0	26544.8	43996	0	41	8.669	72	53.03	775
CITY OF MILFORD	MILFORD HARBOR	CLIS	24-Oct-95	0	26544.9	43996	0	41	8.666	72	53.043	800
CITY OF MILFORD	MILFORD HARBOR	CLIS	25-Oct-95	0	26544.8	43996	0	41	8.669	72	53.03	875
CITY OF MILFORD	MILFORD HARBOR	CLIS	25-Oct-95	0	26545	43996.1	0	41	8.677	72	53.051	650
SHELL OIL CO	SHELL OIL MARINE TERMINAL DOCK	CLIS	11-Nov-95	15045.7	0	43996	0	41	8.651	72	53.118	1875
									Total UDM yd^3			21300
									Total UDM m^3			16285.98

Appendix F, Table 2

Summary of CDM Deposition at the CDA 95 buoy

permittee	project	disparea	dispdate	wtd	xtd	ytd	ztd	latdeg	latmin	longdeg	longmin	cyvol
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	30-Oct-95	0	26545.3	43996	0	41	8.656	72	53.091	750
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	31-Oct-95	0	26545.2	43996	0	41	8.659	72	53.079	875
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	31-Oct-95	0	26545.3	43996	0	41	8.656	72	53.091	925
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	01-Nov-95	0	26545.2	43996	0	41	8.659	72	53.079	950
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	01-Nov-95	0	26545.3	43996	0	41	8.656	72	53.091	975
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	02-Nov-95	0	26545.2	43996	0	41	8.659	72	53.079	975
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	02-Nov-95	0	26544.8	43996	0	41	8.669	72	53.03	850
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	03-Nov-95	0	26545	43996	0	41	8.664	72	53.055	850
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	06-Nov-95	0	26544.8	43996.1	0	41	8.681	72	53.027	875
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	06-Nov-95	0	26544.9	43996	0	41	8.666	72	53.043	900
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	08-Nov-95	0	26545	43996	0	41	8.664	72	53.055	1000
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	08-Nov-95	0	26544.9	43996	0	41	8.666	72	53.043	1000
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	09-Nov-95	0	26545	43996.1	0	41	8.677	72	53.051	1000
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	09-Nov-95	0	26545	43996	0	41	8.664	72	53.055	1000
SHELL OIL CO	SHELL OIL MARINE TERMINAL DOCK	CLIS	12-Nov-95	15045.7	0	43996	0	41	8.651	72	53.118	1400
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	13-Nov-95	0	26545	43996.1	0	41	8.677	72	53.051	1000
SHELL OIL CO	SHELL OIL MARINE TERMINAL DOCK	CLIS	16-Nov-95	15045.7	0	43996	0	41	8.651	72	53.118	1200
SHELL OIL CO	SHELL OIL MARINE TERMINAL DOCK	CLIS	16-Nov-95	15045.7	0	43996	0	41	8.651	72	53.118	1100
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	16-Nov-95	0	26545	43996	0	41	8.664	72	53.055	875
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	17-Nov-95	15045.5	26545	0	0	41	8.607	72	53.072	1000
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	17-Nov-95	0	26545	43996	0	41	8.664	72	53.055	1000
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	18-Nov-95	0	26544.9	43996.1	0	41	8.679	72	53.039	1000
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	20-Nov-95	0	26544.9	43996.1	0	41	8.679	72	53.039	1000
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	20-Nov-95	0	26544.9	43996	0	41	8.666	72	53.043	1000
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	21-Nov-95	0	26545	43996	0	41	8.664	72	53.055	950
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	21-Nov-95	0	26545	43996.1	0	41	8.677	72	53.051	1000
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	22-Nov-95	0	26545	43996.1	0	41	8.677	72	53.051	1000
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	27-Nov-95	0	26544.9	43995.9	0	41	8.653	72	53.046	1000
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	28-Nov-95	0	26545	43996.1	0	41	8.677	72	53.051	1000
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	28-Nov-95	0	26544.9	43996.1	0	41	8.679	72	53.039	1000
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	29-Nov-95	0	26544.9	43996	0	41	8.666	72	53.043	975
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	30-Nov-95	0	26544.9	43996.1	0	41	8.679	72	53.039	950
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	30-Nov-95	0	26545	43996.1	0	41	8.677	72	53.051	925
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	04-Dec-95	0	26544.9	43996	0	41	8.666	72	53.043	950
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	05-Dec-95	0	26545	43996.1	0	41	8.677	72	53.051	1000
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	05-Dec-95	0	26545	43996.1	0	41	8.677	72	53.051	925
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	06-Dec-95	0	26544.9	43996.1	0	41	8.679	72	53.039	975
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	07-Dec-95	0	26545	43996.1	0	41	8.677	72	53.051	950
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	07-Dec-95	0	26545	43996.1	0	41	8.677	72	53.051	975
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	08-Dec-95	0	26545	43996.2	0	41	8.689	72	53.047	950
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	12-Dec-95	0	26545	43996.2	0	41	8.689	72	53.047	975
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	13-Dec-95	0	26545	43996.2	0	41	8.689	72	53.047	975
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	13-Dec-95	0	26544.9	43996.2	0	41	8.692	72	53.035	975
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	14-Dec-95	0	26544.5	43996.2	0	41	8.701	72	52.986	1000
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	14-Dec-95	0	26544.6	43996.2	0	41	8.699	72	52.998	1000
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	15-Dec-95	0	26544.4	43996.3	0	41	8.717	72	52.97	1000
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	15-Dec-95	0	26544.5	43996.3	0	41	8.714	72	52.982	1000
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	18-Dec-95	0	26544.5	43996.2	0	41	8.701	72	52.986	1000
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	18-Dec-95	0	26544.5	43996.2	0	41	8.701	72	52.986	950
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	26-Dec-95	0	26544.5	43996.3	0	41	8.714	72	52.982	950
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	27-Dec-95	0	26544.6	43996.3	0	41	8.712	72	52.995	650
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	27-Dec-95	0	26544.6	43996.3	0	41	8.712	72	52.995	900
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	28-Dec-95	0	26544.5	43996.2	0	41	8.701	72	52.986	600
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	29-Dec-95	0	26544.5	43996.3	0	41	8.714	72	52.982	975
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	04-Jan-96	0	26544.5	43996.3	0	41	8.714	72	52.982	900
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	30-Jan-96	0	26544.7	43996.3	0	41	8.709	72	53.007	975
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	31-Jan-96	0	26545.3	43996.1	0	41	8.669	72	53.087	1000
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	01-Feb-96	0	26545	43996.2	0	41	8.689	72	53.047	975
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	06-Feb-96	0	26545	43996.1	0	41	8.677	72	53.051	950
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	07-Feb-96	0	26544.9	43996.1	0	41	8.679	72	53.039	950
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	08-Feb-96	0	26545.1	43996.2	0	41	8.687	72	53.059	950
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	13-Feb-96	0	26545	43996.3	0	41	8.702	72	53.043	925
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	15-Feb-96	0	26545	43996.1	0	41	8.677	72	53.051	975
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	15-Feb-96	0	26545	43996.3	0	41	8.702	72	53.043	975
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	22-Feb-96	0	26545	43996	0	41	8.664	72	53.055	1000
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	23-Feb-96	0	26545	43996.1	0	41	8.677	72	53.051	1000
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	27-Feb-96	0	26545.1	43996	0	41	8.661	72	53.067	1000
ASSOC AT THE GUILFORD YC	WEST RIVER	CLIS	04-Mar-96	0	26545	43996.2	0	41	8.689	72	53.047	950
											Total CDM yd^3	65500
											Total CDM m^3	50081.3