The Massachusetts Bay Disposal Site Capping Demonstration Project 1998-2000

Disposal Area Monitoring System DAMOS

DAMOS
DISPOSAL AREA MONITORING SYSTEM

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13. ABSTRACT

Dredging-needs analyses, performed by both federal and state agencies for ports located in the Commonwealth of Massachusetts, indicate that a considerable volume of sediments will need to be dredged in the near future to maintain the viability of many harbor areas. A percentage of the material dredged from the larger, industrialized harbors along the coast of Massachusetts will likely be considered unsuitable for unconfined open water disposal due to elevated levels of environmental contaminants (and classified as unacceptably-contaminated dredged material [UDM]). Subaqueous capping has proven to be an environmentally and economically sound method of managing moderate to large volumes of UDM at the shallow water depths of Long Island Sound (20 m), as well as the moderate water depths of the Portland Disposal Site (65 m) in the Gulf of Maine. However, capping at deeper water disposal sites (>65 m) was an unproven management method due to a variety of factors, including historical difficulties in disposal barge positioning and lack of evidence confirming the formation of distinct UDM and capping layers on the seafloor.

Between 1998 and 2000, a capping demonstration project was conducted at the Massachusetts Bay Disposal Site (MBDS) to evaluate the feasibility of developing a discrete mound of sediment on the seafloor and then effectively adding cap material over the initial deposit at this deep-water (90 m) dredged material disposal site. Sediments considered suitable for unconfined open water disposal dredged from Cohasset Harbor and Chelsea River in Massachusetts were sequentially dredged and disposed within a 0.64 km^2 area of seafloor at MBDS. Monitoring protocols developed through the Disposal Area Monitoring System (DAMOS) Program were utilized to track the formation of the mound at multiple stages of development. Overall, the Massachusetts Bay Disposal Site Capping Demonstration Project showed that dredged material could be effectively placed, capped, and monitored at this deep-water disposal site. Recommendations for improvements to the dredging and disposal operations are provided for future project considerations.

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EXECUTIVE SUMMARY

Sediments from Cohasset Harbor and Chelsea River in Massachusetts, considered suitable for unconfined open water disposal, were sequentially dredged and disposed at the Massachusetts Bay Disposal Site (MBDS) for a capping demonstration project. The objective of this project was to evaluate the feasibility of developing a discrete mound of sediment on the seafloor and then effectively adding cap material over the initial deposit at this deep-water (90 m) dredged material disposal site. Monitoring protocols developed through the Disposal Area Monitoring System (DAMOS) Program were utilized to track the formation of the mound at multiple stages of development. Overall, the Massachusetts Bay Disposal Site Capping Demonstration Project showed that dredged material could be effectively placed, capped, and monitored at this deep-water disposal site. Recommendations for improvements to the dredging and disposal operations are provided for future project considerations.

Dredging-needs analyses, performed by both federal and state agencies for ports located in the Commonwealth of Massachusetts, indicate that a considerable volume of sediments will need to be dredged in the near future to maintain the viability of many harbor areas. A percentage of the material dredged from the larger, industrialized harbors along the coast of Massachusetts will likely be considered unsuitable for unconfined open water disposal due to elevated levels of environmental contaminants (and classified as unacceptably-contaminated dredged material [UDM]). Subaqueous capping has proven to be an environmentally and economically sound method of managing moderate to large volumes of UDM.

Capping dredged material has proven successful in the shallow water depths of Long Island Sound (20 m), as well as the moderate water depths of the Portland Disposal Site (65 m) in the Gulf of Maine. However, capping at deeper water disposal sites (>65 m) was an unproven management method due to a variety of factors, including historical difficulties in disposal barge positioning and lack of evidence confirming the formation of distinct UDM and capping layers on the seafloor. Refinement of dredged material management techniques and the use of differential Global Positioning System (DGPS) to monitor and control disposal and capping operations improved the likelihood of being able to create discrete mounds in deeper water. This tightly controlled, closely monitored deep-water capping project has provided evidence that the technique can be successful at MBDS.

To avoid any potential adverse environmental impacts from such a demonstration, material deemed suitable for unconfined open water disposal from Cohasset Harbor, Cohasset, Massachusetts was used to represent UDM. Capping dredged material (CDM) originated from improvement dredging operations in the Chelsea River as part of the Boston Harbor Navigation Improvement Project (BHNIP). The dredged material originating from these source areas displayed sufficient visual distinction to facilitate identification of source materials after disposal and capping were complete. The capped mound was developed in 86 m of water over a 0.64 km^2 area of featureless seafloor located near the southern boundary of MBDS, away from the active region of the disposal site. This part of the MBDS was designated as the Cohasset Harbor Capping Project (CHCP) area. A series of monitoring surveys were completed over the CHCP Mound during the different phases of capped mound formation.

A Baseline survey was performed over the CHCP study area in September 1998 to evaluate seafloor topography, map the distribution of dredged material from historic disposal events, and develop a basis of comparison for future survey efforts. From December 1998 through February 1999 a total estimated barge volume of 41,250 m^3 of sandy silt and gravel dredged from Cohasset Harbor was transported to the CHCP study area and deposited on the seafloor. A special monitoring survey was performed over the CHCP study area after the first barge load of sediment was deposited to evaluate the effectiveness of various monitoring tools in deep water and to document the distribution of sediment resulting from a single disposal event at these water depths. At the conclusion of UDM disposal, a Precap survey was performed over the CHCP study area, which documented the development of a discrete UDM mound 0.4 m high, with a detectable footprint approximately 600 m wide.

Due to project logistics, the UDM mound was uncapped for a period of nine months on the MBDS seafloor before the next phase of operations commenced, providing consolidation time for the disposal mound. Additionally, before capping operations began, approximately 15,500 m^3 of additional Cohasset Harbor UDM were deposited at CHCP in the Fall of 1999. The UDM deposit was then covered by 154,400 m^3 of cap material consisting of dark silt, sand, gravel, and clumps of Boston Blue Clay, in the Spring of 2000. The Postcap survey completed in the Fall of 2000 determined that the majority of CDM had accumulated within a 100 m radius of the CHCP disposal buoy. The full extent of the CDM apron was over 800 m wide and covered all but a small area of UDM located on the northern fringe of the CHCP Mound.

The results of the single beam bathymetry, side-scan sonar, sediment-profile imaging, and sediment sampling (surface grabs and cores) surveys used to document the development of the CHCP mound agreed well throughout the demonstration project. These data indicated that a layered deposit consisting of distinct sediment strata was developed on the MBDS seafloor. Most cores collected within the CHCP project area consisted of a layer of Chelsea River CDM over a layer Cohasset Harbor UDM over a layer of ambient moist, silty clay, with little to no sediment mixing between layers detected.

1.0 INTRODUCTION

1.1 Background

The coast of Massachusetts has long been recognized as the hub for maritime activity in New England. The Commonwealth has well over 1,800 linear miles of coastline, and throughout its history, many ports and harbors have developed within areas of protected water, supporting commerce, military activity, and recreation (MBP 1996). The coastline of Massachusetts is fairly unique, offering shelter from the open Atlantic Ocean in harbors carved within the exposed bedrock of Cape Ann, to small, shallow embayments tucked behind the sandy barrier spits along Cape Cod.

Each harbor in Massachusetts has evolved over time based upon the type of commerce and trade it supported. In today's economy, the majority of the trade is concentrated in ports capable of providing sufficient infrastructure (larger docks and wharves, maintained channels, and efficient intermodal transfer) to ensure safe operation of large commercial vessels (i.e., Boston and Fall River). The smaller and shallower ports now largely support fleets of commercial fishing vessels and pleasure craft. Natural coastal processes and sedimentation from terrestrial erosion tend to fill harbors and embayments with sediments, gradually reducing water depth and eventually impacting their navigational capacities. Contemporary cargo ships, fishing vessels, and even pleasure boats require controlled depths within inland waterways to ensure unrestricted passage into and out of port. As a result, some ship channels, anchorage areas, and docking facilities require periodic maintenance dredging to create or maintain adequate water depths for vessel operations and ultimately retain the viability of the port. The primary agency responsible for the maintenance of safe, navigable waterways in the United States for the past 200 years has been the U.S. Army Corps of Engineers (USACE).

The New England District (NAE) of the Corps of Engineers regulates all coastal dredging and sediment disposal operations from Eastport, Maine to Byram, Connecticut. Dredging operations in coastal New England most frequently involve the use of a clamshell bucket to extract rock, sand, gravel, mud, and clay from the bottom of waterways. The excavated sediments are then transferred to disposal sites via barges or to on-shore facilities for disposal. A number of alternatives are evaluated for the disposal of dredged material in terrestrial (i.e., upland containment, landfill cap) and aquatic (i.e., subaqueous disposal, beach replenishment, marsh creation) environments. However, the majority of these excess sediments are transported to open water and deposited at predefined dredged material disposal sites (Figure 1-1).

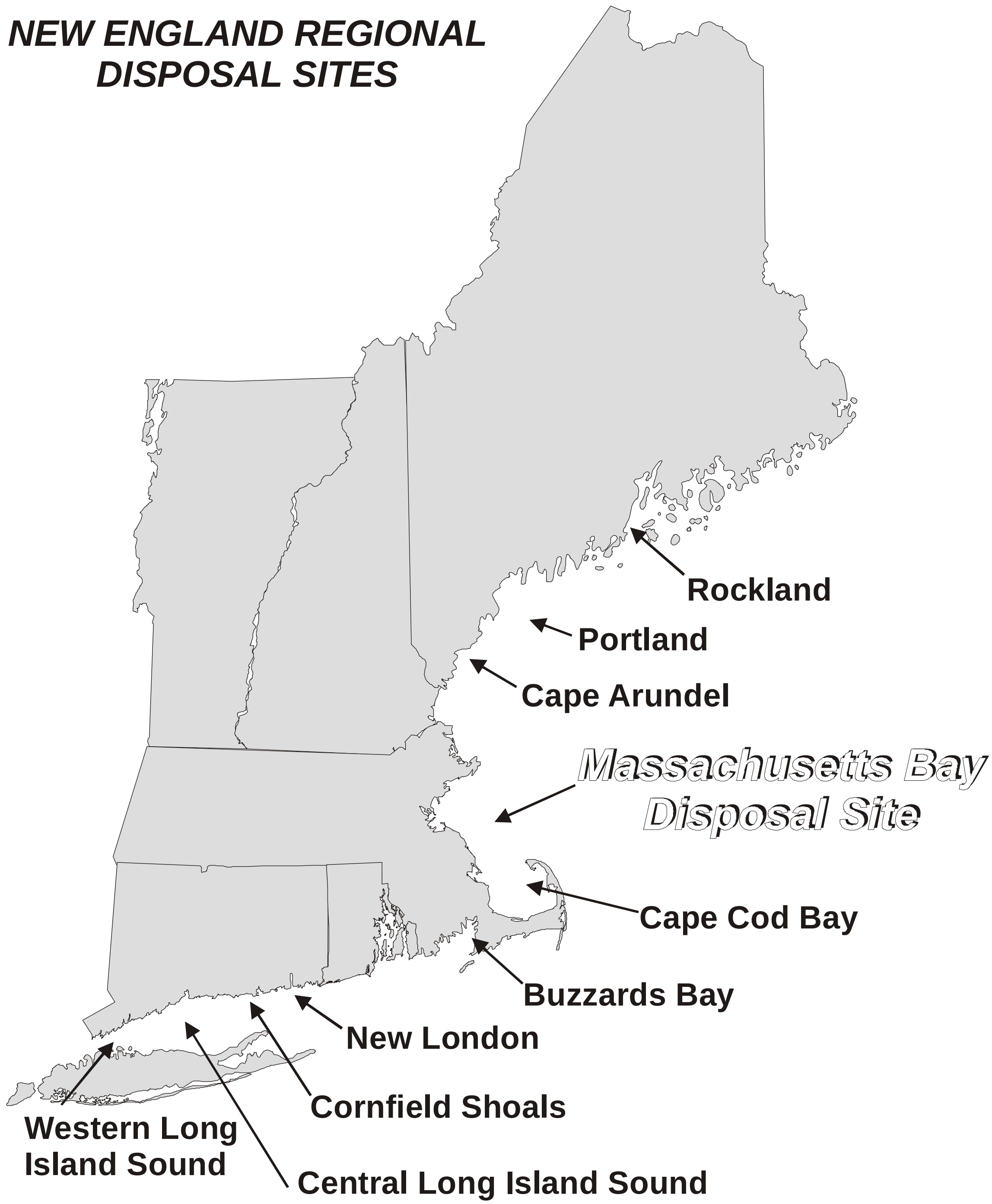


Figure 1-1. Location of the ten regional dredged material disposal sites located in coastal waters of New England and monitored under the DAMOS Program

On occasion, detailed characterization of in-place sediments detects elevated levels of environmental contaminants within the project material. If the sediment does not meet testing criteria, this material is classified as unacceptably-contaminated dredged material (UDM; Fredette 1994). Once removed from the channel or harbor bottom, UDM requires special handling and disposal techniques to ensure the contaminants are isolated from the environment. There are several management options available for large volumes of UDM, with the type and degree of contamination within the sediments affecting what disposal options are feasible.

1) upland confined disposal;
2) bioremediation;
3) confined aquatic disposal; and
4) subaqueous capping.

Upland confined disposal of contaminated sediment is considered extremely expensive due to transportation, land acquisition, and costs associated with construction, dewatering facilities, and long-term site maintenance/management. In addition, the total capacity of upland disposal sites is limited (MBP 1996). Bioremediation is only applicable with sediments when the contaminants are susceptible to organic degradation. Moreover, this method is not very cost-effective and the technology behind the procedure needs improvement (Carey 1998).

Confined Aquatic Disposal (CAD) cells were successfully employed in the Boston Harbor Navigation Improvement Project (BHNIP) to manage contaminated sediment (SAIC 2000; Fredette et al. 2000). However, this alternative can double the cost of the project. In addition, few locations in New England provide basement material conducive to the construction of CAD cells or offer the capacity necessary to handle the volume of UDM.

Over the years, it has been determined that the most cost-effective ***and*** environmentally sound alternative for large volumes of UDM is subaqueous capping. Capping is a containment method that uses sediment determined to be suitable for unconfined open water disposal, or capping dredged material (CDM), to overlay and isolate a UDM deposit from the marine environment (Fredette 1994). Sediment capping was first introduced as a management technique of the DAMOS Program during the 1978/79 disposal season with the development of the Stamford-New Haven mounds (STNH-N and STNH-S) at the Central Long Island Sound Disposal Site (CLDS; SAIC 1995). The CLDS is situated in a low kinetic energy environment, with shallow to moderate water depths (20 to 22 m), and gently sloping, regular bottom topography that provide ideal conditions for refining this management approach. Over the past 18 years, monitoring and management activities regarding subaqueous capping of UDM have evolved within the DAMOS Program, resulting in significant progress in pre-project planning and the development of successful management strategies.

1.2 Massachusetts Dredging Needs and Disposal Options

Environmental managers have projected that an estimated 296 million cubic yards of sediment will be generated from various dredging projects along the coast of Massachusetts over the next 50 years (USACE 1995). Recently, NAE and the Commonwealth of Massachusetts have been compiling information pertaining to anticipated dredged material volumes from various ports in Massachusetts (USACE 1996). The information compiled in 1996 was used to develop a "dredging needs" summary for the next five to ten years, as well as formulate long-term management strategies related to the disposal of project sediments. From this study, it was determined that a significant percentage of the nearly 300 million cubic yards of sediment to be removed from Massachusetts waterways would likely be classified as UDM. Given the forecasted expense and overall practicality of the various management techniques, subaqueous capping would be the preferred method of handling this material.

Of the three regional dredged material disposal sites off the coast of Massachusetts, the Massachusetts Bay Disposal Site (MBDS) is by far the most active disposal site, receiving approximately 245,000 m^3 of material dredged from the ports of Boston, Hingham, Salem, Gloucester, and vicinities annually (Morris 1996). The Massachusetts Bay Disposal Site is an EPA-designated open water dredged material disposal site located 22.2 km (12 nmi) southeast of Gales Point, Manchester, Massachusetts (Figure 1-2). The site is configured as a circle 3.7 km in diameter, centered at 42° 25.106´ N, 70° 34.969´ W (NAD 83). MBDS has water depths ranging from 82 to 92 m, and provides a 10.75 km^2 (3.14 nmi^2) area of seafloor in Massachusetts Bay for the placement of sediment suitable for unconfined open water disposal. Although subaqueous capping has been successful in isolating contaminated sediments from the marine environment at shallower disposal sites in New England, it has yet to be demonstrated in the deeper water of MBDS.

MBDS is located in close proximity to a number of harbors likely to produce UDM in future maintenance or improvement dredging operations. However, the Environmental Impact Statement (EIS) developed as part of the designation process for MBDS excluded the subaqueous disposal and capping of contaminated sediments, based on concerns that the efficacy of this alternative required further study (USEPA 1992). No dredged material disposal site in the region is approved for disposal of UDM, limiting management options. According to the Massachusetts Bays 1996 Comprehensive Conservation and Management Plan (a joint program established by the EPA and Commonwealth of Massachusetts), the lack of suitable disposal alternatives has been and may continue to be a significant obstacle

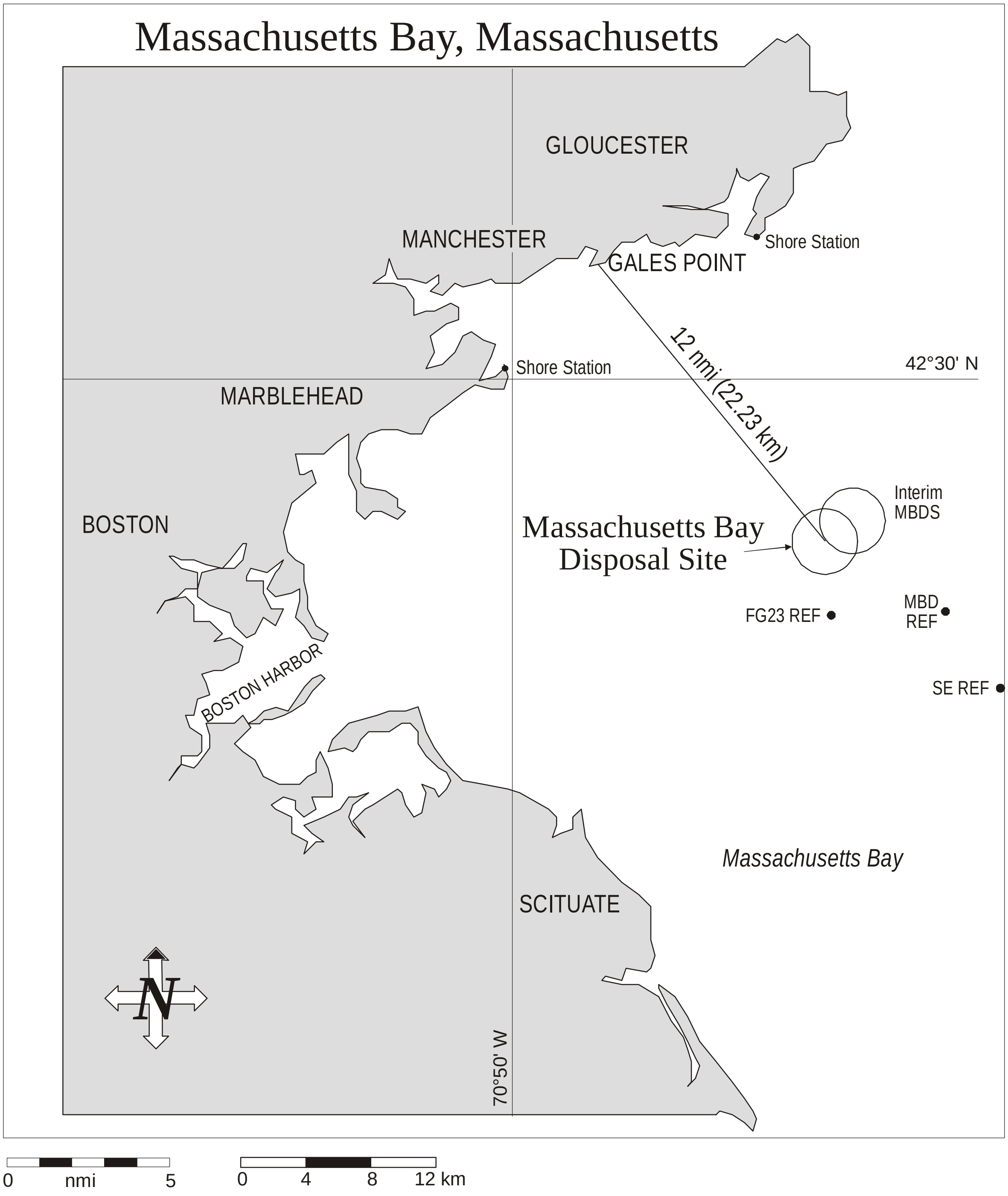


Figure 1-2. Location of the Massachusetts Bay Disposal Site relative to the coastline of Massachusetts

to all port dredging projects in the Massachusetts Bay region (MBP 1996). Therefore, studies on the feasibility and effectiveness of subaqueous capping in the Massachusetts Bay region were considered imperative.

The seafloor within the confines of MBDS is essentially flat with the exception of a historic disposal mound (Mound A) and a naturally occurring bottom depression near the center of the site (Figure 1-3). Although significantly deeper than CLDS, the successful development of capped disposal mounds within the boundaries of MBDS appeared feasible (Morris 1996). In fact, capping operations were conducted at the historic Boston Foul Ground (a.k.a. Interim MBDS) in 1983 in water depths of approximately 90 m (Wiley 1995). However, the limited data collected from these projects did not provide sufficient information on which to base a determination that subaqueous capping could be used as an acceptable deep-water disposal technique.

Increased interest in employing subaqueous capping as a management technique at deep-water disposal sites prompted the completion of a small pilot project at the Portland Disposal Site (PDS) in 1992 (Wiley 1996). The environmental monitoring data collected in support of this project indicated that cap material was evident at the sediment water interface. However, it was also concluded from this effort that difficulties in disposal barge positioning yielded a wider than anticipated dispersal pattern, and resulted in the lack of a discrete UDM mound (Wiley 1996). In addition, lack of evidence confirming the formation of two distinct disposal layers (CDM over UDM) and related concerns with dissipation of fine-grained sediments in the water column presented continued obstacles to using this management strategy at deep water disposal sites (Dolin and Pederson 1991).

Refinement of dredged material management techniques and the implementation of the differential Global Positioning System (DGPS) during disposal and capping operations improved discrete mound development in deeper water. But only a tightly controlled, closely monitored, deep-water capping project would provide insight to the behavior of material on the seafloor. In 1996, a comprehensive capping demonstration project using a relatively small volume of material suitable for unconfined open water disposal was successfully completed on the PDS seafloor at a depth of 65 m (Morris et al. 1998). The Portland Disposal Site Capping Demonstration Project illustrated that dredged material can be effectively placed, capped, and monitored at a deep-water disposal site (Morris et al. 1998). However, the question remained whether UDM could be effectively placed in the deeper coastal water setting (80-95 m) within MBDS in a manner that would yield a discrete mound on the seafloor, which could then be precisely capped. The prospect of the MBDS becoming a potential disposal site for large volumes of sediments that are otherwise unsuitable for ocean disposal would be possible if and when capping in deep water had been demonstrated (MBP 1996).

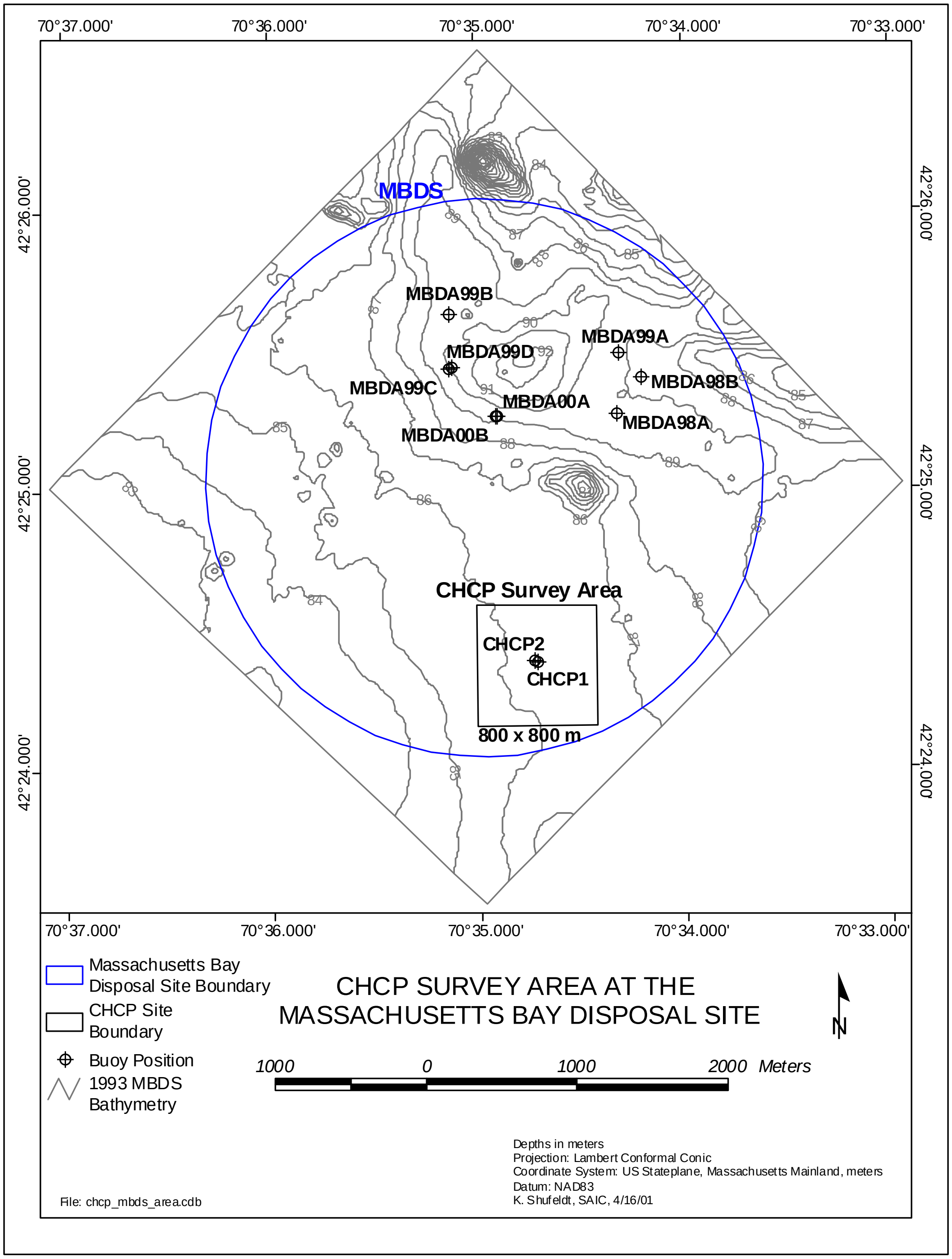


Figure 1-3. Location of the Cohasset Harbor Capping Project Area at the Massachusetts Bay Disposal Site

1.3 Massachusetts Bay Disposal Site Capping Demonstration Project

In support of the DAMOS program, Science Applications International Corporation (SAIC) conducted a comprehensive capping demonstration project at MBDS. This project was initiated to demonstrate and assess the effectiveness of subaqueous capping operations at this deep-water disposal site. All the sediment used in support of this project was deemed suitable for unconfined open water disposal to minimize the impact to the benthic habitat in the event a capped mound could not be constructed at MBDS.

A moderate-sized maintenance dredging project in nearby Cohasset Harbor was identified as the source of suitable sediment. This material was deemed suitable as a proxy for UDM for the capping demonstration based on the volume and variety of suitable material, as well as its location relative to MBDS (Figure 1-4). The material in the harbor was dredged and disposed at the center of the 0.64 km^2 Cohasset Harbor Capping Project (CHCP) study area established within the southern portion of MBDS (Figure 1-3). The Cohasset Harbor material was then covered by CDM removed from the Chelsea River as part of the Boston Harbor Navigation Improvement Project (BHNIP; Figure 1-4). The end result of the project would be the formation of a capped mound on the MBDS seafloor composed of a discrete UDM mound, covered by a distinct capping layer. During the period September 1998 through September 2000, SAIC conducted six separate field efforts in support of this capping demonstration project (Figure 1-5). Detailed pre-dredge sediment characterization studies of the source sediments were performed, in addition to four separate monitoring surveys over the CHCP study area at MBDS.

1.3.1 Baseline Surveys in Cohasset Harbor and the CHCP Study Area

Cohasset Harbor is a complex estuary with an open-ocean influence from Massachusetts Bay and several sources of fresh water run-off from the various brooks, ponds, and swamps in the area. The outer portion of Cohasset Harbor is exposed to the open ocean from the north, but protected from the west and south by the mainland and from the east by Scituate Neck (Figure 1-6). A large tidal flat shaped by wave energy from the north and tidal flow into and out of the harbor extends from the tip of Scituate Neck to White Head. Coastal processes promote the accumulation of sediment (sand and silt) along the southern shoreline, filling Briggs Harbor and allowing the tidal flat to extend well into the center of Cohasset Harbor. A narrow entrance channel through this tidal flat is maintained periodically to allow a fleet of pleasure craft and small fishing vessels home

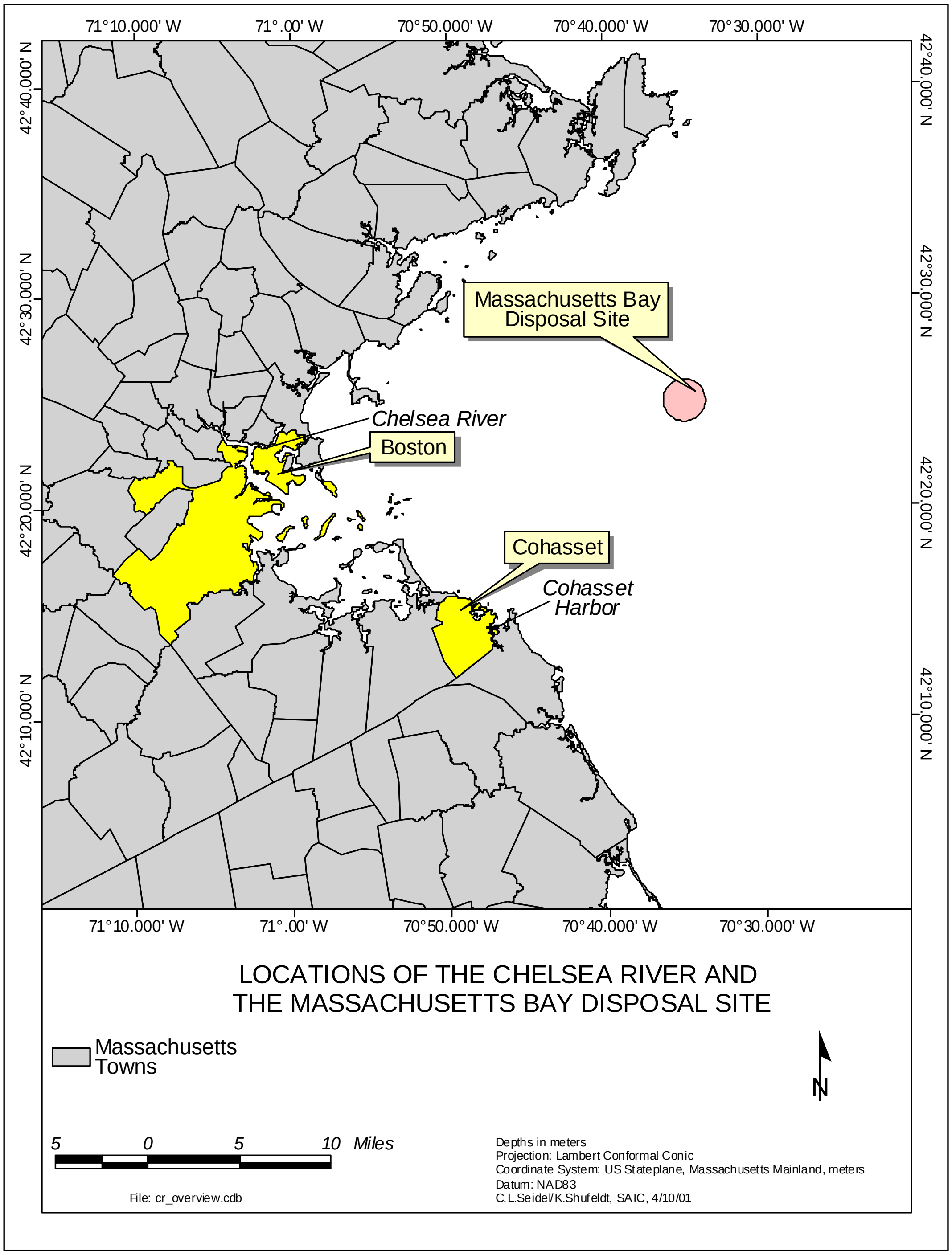


Figure 1-4. Location of the Chelsea River, relative to Cohasset Harbor and the Massachusetts Bay Disposal Site

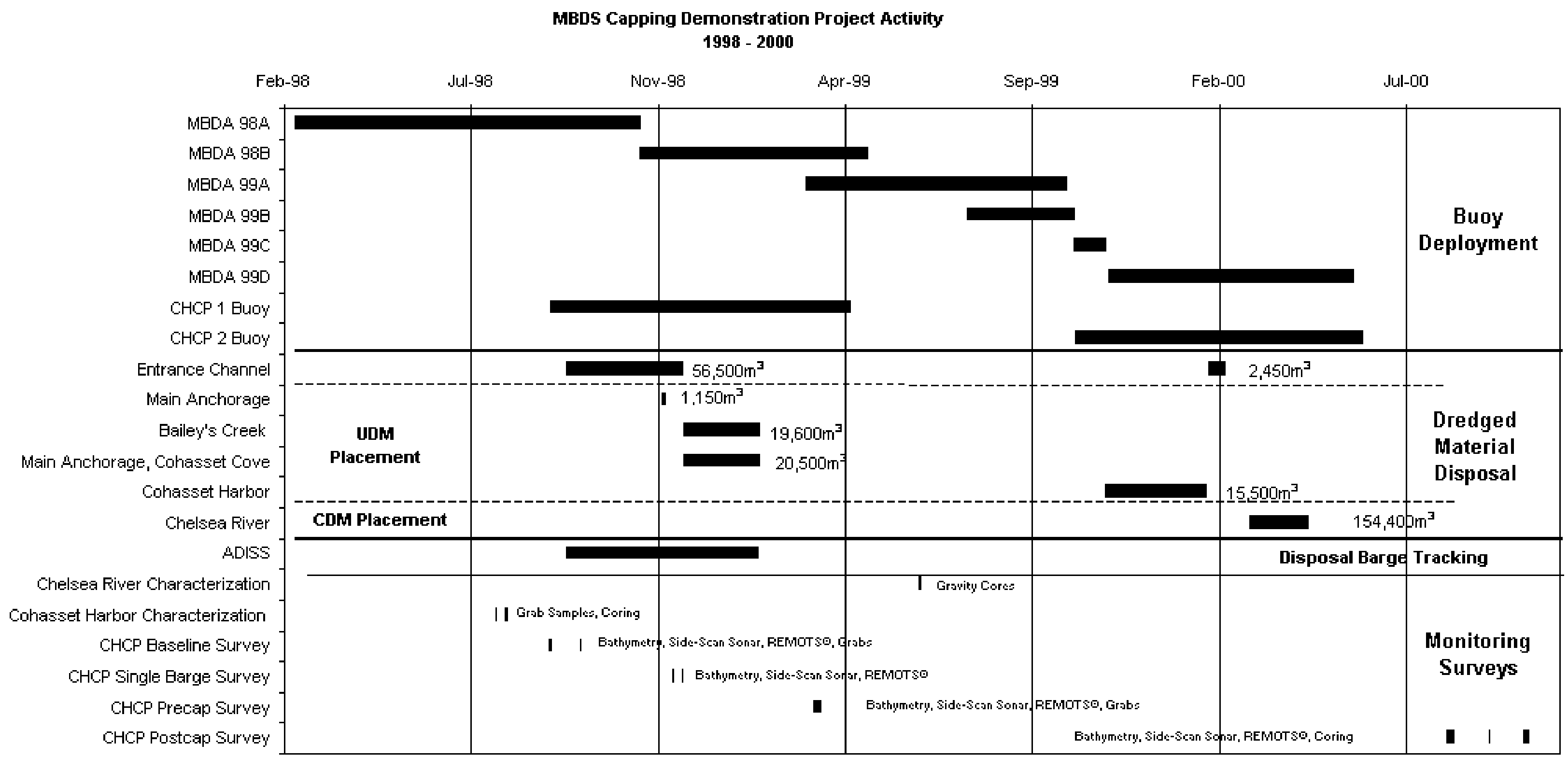


Figure 1-5. Timeline of disposal activity and monitoring studies performed in support of the Massachusetts Bay Disposal Site Capping Demonstration Project

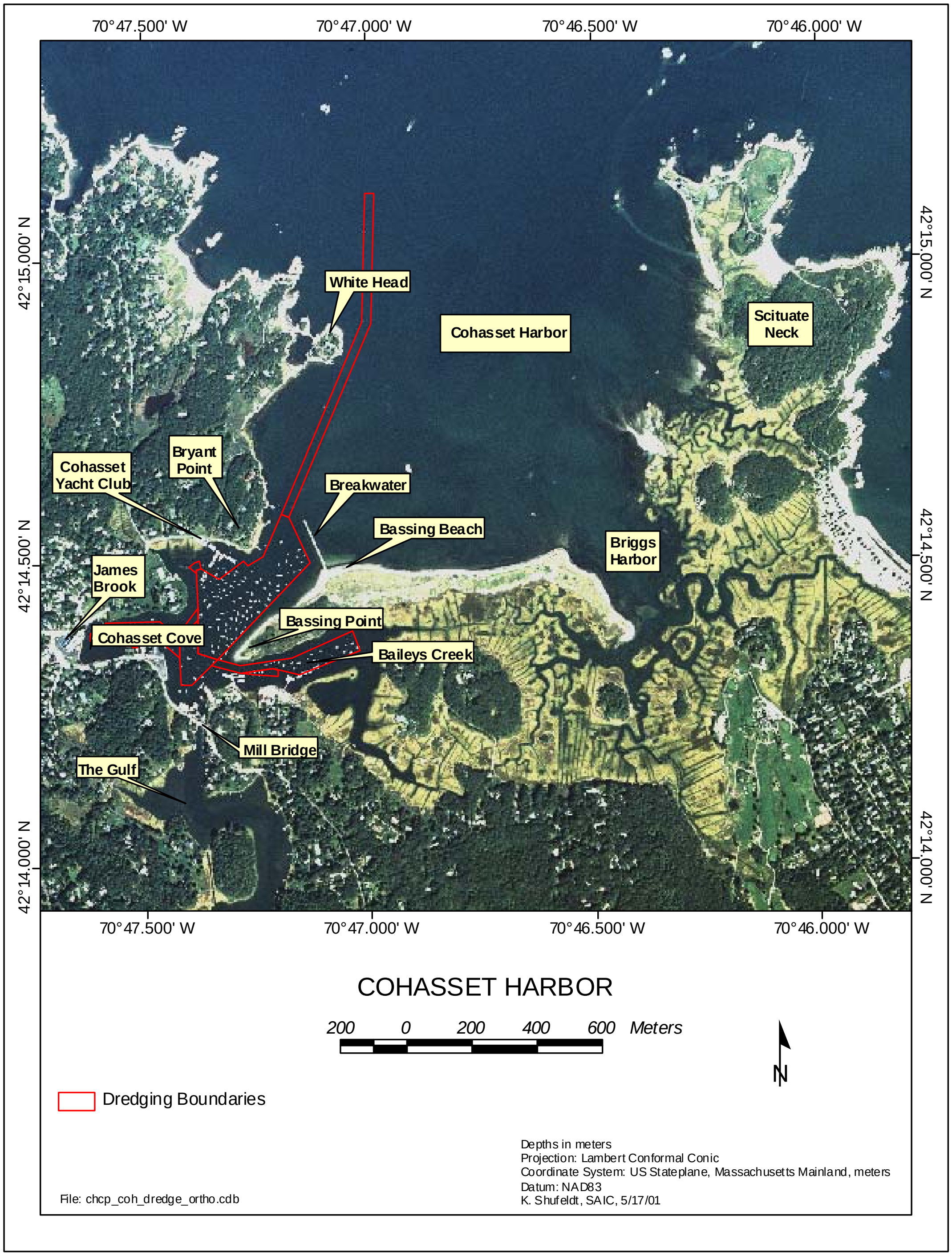


Figure 1-6. Aerial perspective of Cohasset Harbor showing the various landmarks and tributaries

ported in Cohasset Cove to gain access to open water. The majority of the dredging operations were planned for Cohasset Cove to improve navigation within the mooring fields and efficiency of operations at the local marinas.

A detailed sediment characterization study was completed to evaluate the composition of the project sediments within Cohasset Harbor, as well as identify sediment tracers unique to the source area. A series of baseline vibracores and sediment grabs were collected within the confines of the federal project (harbor and entrance channel) before the commencement of dredging operations to characterize the material to be removed.

In order to monitor and assess the progress of the experimental Massachusetts Bay Disposal Site Capping Demonstration Project, a time series of oceanographic surveys were conducted to document the formation the CHCP mound. A Baseline survey was performed over the 800 $\times$ 800 m study area in the Fall of 1998, followed by the deployment of the CHCP buoy at 42° 24.433´N and 70° 34.723´W (Figure 1-3).

1.3.2 UDM Dredging and Disposal Operations

According to the project plan, the sandy material dredged from the entrance channel was placed at the MBDA buoy north of the CHCP project area. The silty areas of Cohasset Cove would serve as UDM for the demonstration project. Dredging operations within the Cohasset Harbor entrance channel commenced on 15 September 1998 and continued through 30 November 1998 (Appendix A). On 2 December 1998, a single-barge load of silty material (approximately 1,150 m^3) representing UDM was dredged from the Main Anchorage and deposited approximately 100 m northwest of the CHCP buoy (Figure 1-5; Table 1-1). Following the first deposit, a Single-Barge survey was conducted over CHCP to document the size and shape of the UDM deposit formed on the MBDS seafloor.

At the conclusion of the Single-Barge survey, the additional UDM (40,100 m^3) was dredged from the designated areas and deposited at the CHCP buoy as part of the second phase of the operation (19 December 1998 through 17 February 1999; Figure 1-5). Dredging operations in Cohasset Harbor were discontinued in mid-February 1999 due to icing within the harbor. A Precap survey was performed over the CHCP study area in March 1999 for the purpose of documenting and characterizing the first layer of the CHCP Mound.

Dredging operations were re-established in the Fall of 1999 with an estimated 15,500 m^3 of material removed from Cohasset Cove and placed over the existing UDM deposit at the CHCP2 buoy position between 21 November 1999 and 10 February 2000 (Figure 1-5; Table 1-1). Because this sediment would be difficult to distinguish from the

Table 1-1. UDM and CDM Dredging Placement Summary for the CHCP Study Area

Project Phase	Dredging Location	Dates	Volume (yd^3)	Volume (m^3)	Buoy
UDM Placement	**Cohasset Harbor (Phase 1)** Main Anchorage (single barge load)	12/01/98	1,500	1,147	CHCP1
	Cohasset Cove Bailey Creek Main Anchorage 8 ft Channel	12/1998 through 02/1999	1,450 25,650 24,650 700	1,109 19,612 18,847 535	
	Total (Phase 1)		**53,950**	**41,250**	
	Cohasset Harbor (Phase 2)	11/21/99 through 2/10/00	20,300	15,500	CHCP2
	Total UDM		**74,250**	**56,750**	
CDM Placement	Chelsea River	3/16/00 through 5/02/00	201,900	154,400	CHCP2
	Total CDM		**201,900**	**154,400**	
	Total Volume of Dredged Material		**257,350**	**196,797**	

sediment deposited in the winter of 1999, this second layer of material would also be considered UDM. As a result, a total volume of UDM dredged from Cohasset Harbor and deposited in the CHCP area was approximately 56,750 m^3 (1 December 1998 through 10 February 2000; Table 1-1). Sediment grabs were taken after the placement of this additional UDM to characterize this layer prior to the start of capping operations.

1.3.3 CDM Dredging and Disposal Operations

Between 16 March 2000 and 2 May 2000, an estimated barge volume of 154,400 m^3 of CDM dredged from Chelsea River was deposited at the CHCP buoy (Appendix A; Figure 1-5; Table 1-1). A Postcap survey was completed in September 2000 to document the distribution of CDM and the successful construction of the capped disposal mound on the MBDS seafloor.

1.4 Objective of the Demonstration Project

The overall objective of the Massachusetts Bay Disposal Site Capping Demonstration Project was to evaluate the effectiveness of subaqueous capping as a dredged material management technique at the deep-water disposal site. An estimated barge volume of 56,750 m^3 of UDM and 154,000 m^3 of CDM were sequentially placed on the relatively flat seafloor within the CHCP study area to develop a capped disposal mound with a CDM to UDM ratio of 2.7 to 1. A series of monitoring surveys were performed to track the development of the capped mound by documenting changes in seafloor topography and composition of material at the sediment-water interface. Each of the four monitoring surveys performed at MBDS was completed to address the following specific objectives.

Baseline: Characterize the ambient seafloor within the 0.64 km^2 CHCP study area to serve as the basis of comparison with future data sets.

Single-Barge: Determine the size and shape of the dredged material footprint formed by a single disposal event (1,150 m^3) in close proximity to the CHCP buoy.

Precap: Document the formation of a discrete UDM mound within the confines of the CHCP study area, as well as map the areal distribution of the Cohasset Harbor material.

Postcap: Determine the morphology of the capped mound, as well as measure CDM thickness and distribution relative to the UDM mound.

2.0 METHODS

In order to fulfill the objectives of the Massachusetts Bay Capping Demonstration Project, multiple marine survey operations were performed within Cohasset Harbor and the CHCP study area of the disposal site. Over a period extending from July 1998 to October 2000, six field surveys were performed under the DAMOS Program to document the success of the capping demonstration project. The survey activity completed in support of this study was based upon the ability to 1) detect and differentiate between layers of sediment deposited in 86 m of water; and 2) accurately map those layers on the MBDS seafloor.

Precision bathymetry, REMOTS® sediment-profile photography, side-scan sonar, grab sampling, and sediment coring were employed at various stages of the project. Figure 1-5 provides a graphical representation showing the timing of the field efforts relative to the 1998-2000 dredged material placement operations. This section summarizes the use of these monitoring techniques to track the development of a capped disposal mound on the MBDS seafloor.

2.1 Cohasset Harbor Sediment Characterization Study

2.1.1 Field Sampling

In Spring of 1998, the maintenance dredging project in Cohasset Harbor was identified by NAE as the source area of sediment to be used for the Massachusetts Bay Disposal Site Capping Demonstration Project. In order to provide a strong scientific foundation for the project, the harbor sediments had to be adequately characterized to facilitate tracking from the source area to a discrete layer on the MBDS seafloor. A series of surface sediment grab samples and vibracores were collected within the confines of the federal project (harbor and entrance channel) before the scheduled start of dredging operations in the Fall of 1998.

On 21 July 1998 a total of 12 reconnaissance grab samples were collected from various locations within the harbor to examine surface sediment composition (Figure 2-1; Table 2-1). A 0.1 m^2 Young-modified van Veen grab sampler was deployed by hand from a small vessel to obtain samples for visual description. Initial sediment characteristics derived from the grab samples were recorded and later utilized in the selection of the stations in support of a comprehensive coring survey.

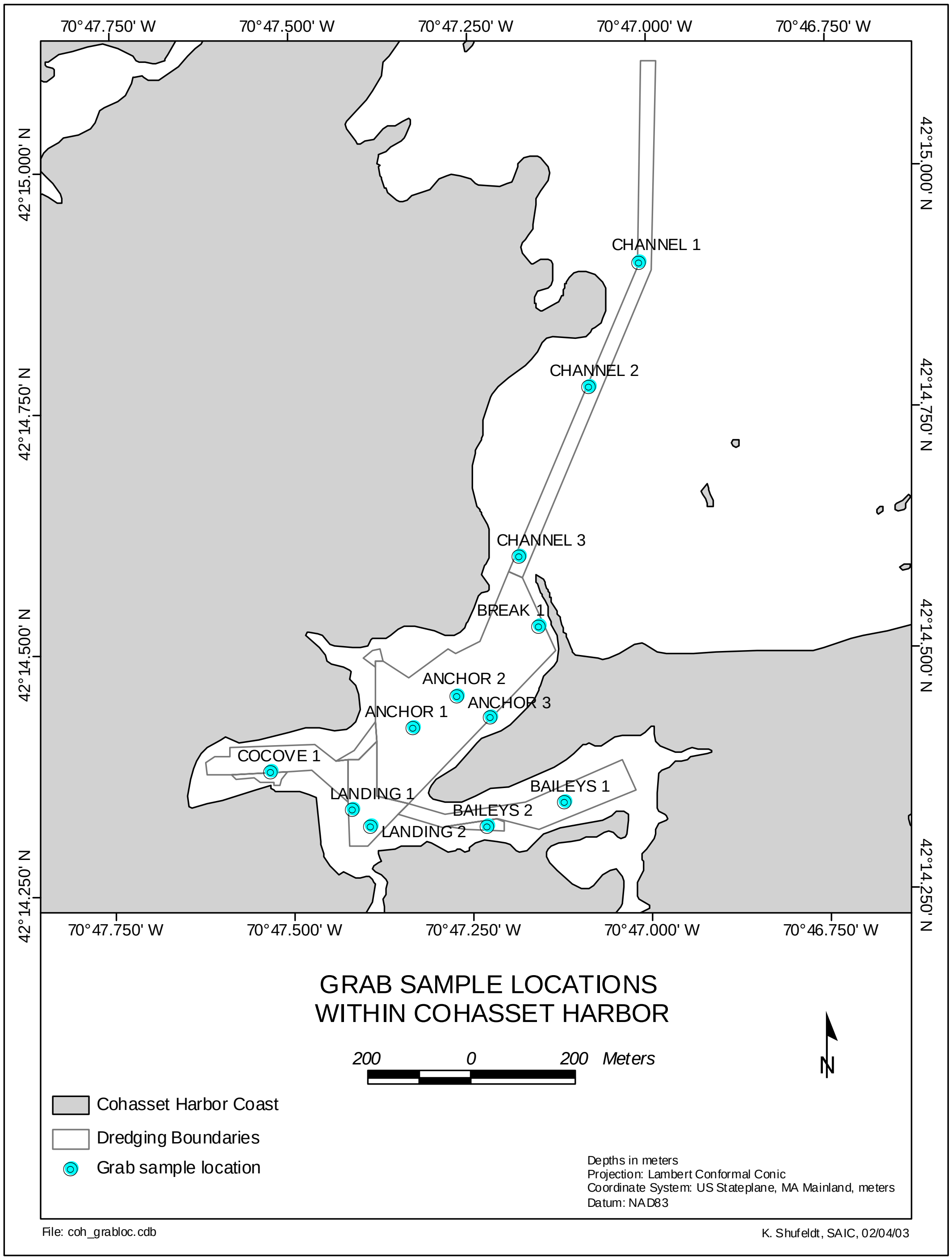


Figure 2-1. Location of surface sediment grab samples obtained from Cohasset Harbor as part of the pre-dredging sediment characterization efforts

Table 2-1. Sediment Grab Sample Locations within Cohasset Harbor and Cohasset Cove

Area	Station	Latitude (NAD 83)	Longitude (NAD 83)
Cohasset Harbor and Cohasset Cove	COCOVE 1	42° 14.421´ N	70° 47.533´ W
	BAILEYS 1	42° 14.386´ N	70° 47.121´ W
	BAILEYS 2	42° 14.362´ N	70° 47.231´ W
	ANCHOR 1	42° 14.464´ N	70° 47.334´ W
	ANCHOR 2	42° 14.498´ N	70° 47.271´ W
	ANCHOR 3	42° 14.475´ N	70° 47.224´ W
	CHANNEL 1	42° 14.946´ N	70° 47.012´ W
	CHANNEL 2	42° 14.817´ N	70° 47.082´ W
	CHANNEL 3	42° 14.641´ N	70° 47.183´ W
	BREAK 1	42° 14.570´ N	70° 47.156´ W
	LANDING 1	42° 14.381´ N	70° 47.419´ W
	LANDING 2	42° 14.363´ N	70° 47.393´ W

Sediment vibracores were collected from the entrance channel and several areas within Cohasset Harbor to provide deep (3 m), cross-sectional samples of the sediments likely to be dredged. A total of 24 vibracores were collected from a series of 32 stations established within the harbor from 27 to 29 July 1998 (Figure 2-2; Table 2-2). Ocean Surveys Incorporated (OSI) of Old Saybrook, CT was contracted to provide the necessary equipment and vessel to extract the core samples from the harbor bottom.

An OSI Model 1500 pneumatic vibracorer was used to collect sediment cores from Cohasset Harbor. The coring device consisted of a compressed air-driven hammer section attached to 3 m (10 ft) steel core barrel (9.5 cm inner diameter). A chemically inert, clear Lexane® liner (8.9 cm inner diameter) was fitted within the core barrel, with stainless steel core cutter and catcher assemblies secured to the end (Figure 2-3).

The pontoon-type coring vessel was positioned directly over each target coring station via a multi-point mooring system. The vibracorer was lowered through the central moon pool of the vessel to the seafloor via a single, steel cable. Air supply and return lines attached to the vibratory head fed air from a deck-mounted compressor to activate the hammer and drive the coring device into the sediments. Exhaust air was then captured and ported to the surface to minimize disturbance of the surface sediments adjacent to the sampling location. Due to the shallow water, penetration was monitored via a tape measure stretching from the top of the vibracore unit to the work deck. Upon attaining an adequate penetration depth, the air supply was cut-off and the corer was extracted from the seafloor using a winch and placed on the deck of the research vessel.

Upon retrieval of the coring device, the internal liner containing the sediment sample was removed from the core barrel. The cores were inspected to ensure that there was a sufficient quantity of material for the intended analyses. The core was then capped with a styrofoam plug and plastic core cap to prevent loss of sediment, labeled with a unique identifier, measured, and stored at 4°C with minimal exposure to sunlight. At the conclusion of this field operation, all cores were transported to the University of Rhode Island Graduate School of Oceanography (GSO) core facility and refrigerated at 4°C until analyzed.

2.1.2 Precision Navigation

Navigation for the Cohasset Harbor sediment characterization survey activities was accomplished with the use of a Trimble 4000 Global Positioning System (GPS) receiver in conjunction with a Differential Corrections Incorporated (DCI) differential beacon receiver modem. The combination produced differentially-corrected GPS information (DGPS) to an accuracy of ± 1 m. Differential satellite corrections were provided by the DCI commercial

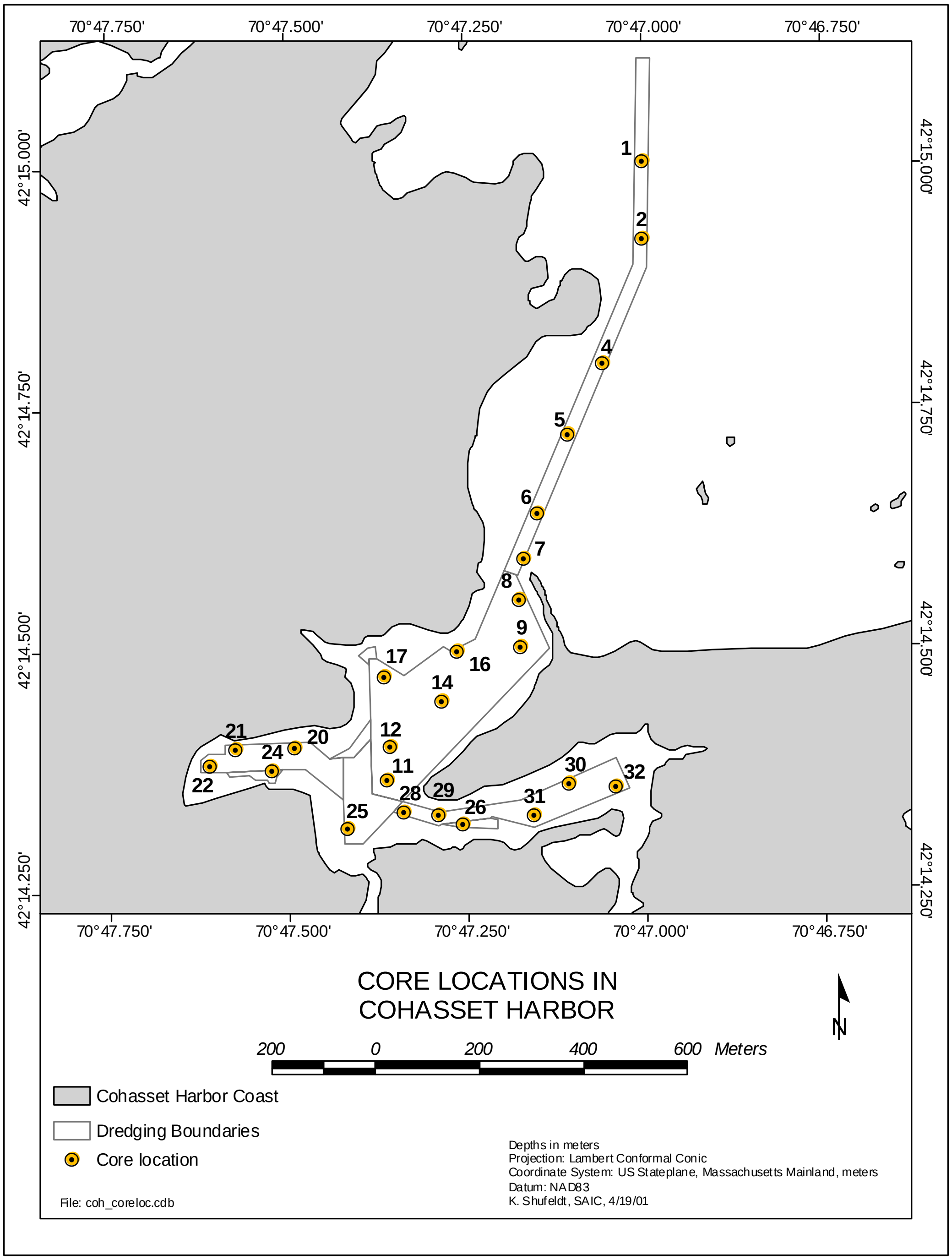


Figure 2-2. Location of sediment vibracore samples obtained from Cohasset Harbor as part of the pre-dredging sediment characterization efforts

Table 2-2. Sediment Vibracore Locations within Cohasset Harbor and Cohasset Cove

Area	Station	Latitude (NAD 83)	Longitude (NAD 83)
Cohasset Harbor and Cohasset Cove	CO-1A	42° 15.049´ N	70° 46.998´ W
	CO-2A	42° 14.965´ N	70° 46.998´ W
	CO-4A	42° 14.839´ N	70° 47.057´ W
	CO-5A	42° 14.766´ N	70° 47.106´ W
	CO-6A	42° 14.684´ N	70° 47.150´ W
	CO-7A	42° 14.637´ N	70° 47.168´ W
	CO-8A	42° 14.595´ N	70° 47.176´ W
	CO-9A	42° 14.546´ N	70° 47.173´ W
	CO-11A	42° 14.408´ N	70° 47.362´ W
	CO-12A	42° 14.443´ N	70° 47.357´ W
	CO-14A	42° 14.490´ N	70° 47.284´ W
	CO-16A	42° 14.542´ N	70° 47.262´ W
	CO-17A	42° 14.515´ N	70° 47.365´ W
	CO-20A	42° 14.443´ N	70° 47.490´ W
	CO-21A	42° 14.441´ N	70° 47.573´ W
	CO-22A	42° 14.424´ N	70° 47.609´ W
	CO-24B	42° 14.419´ N	70° 47.523´ W
	CO-25A	42° 14.358´ N	70° 47.417´ W
	CO-26A	42° 14.362´ N	70° 47.256´ W
	CO-28A	42° 14.375´ N	70° 47.338´ W
	CO-29A	42° 14.372´ N	70° 47.290´ W
	CO-30A	42° 14.404´ N	70° 47.108´ W
	CO-31A	42° 14.371´ N	70° 47.156´ W
	CO-32A	42° 14.400´ N	70° 47.042´ W

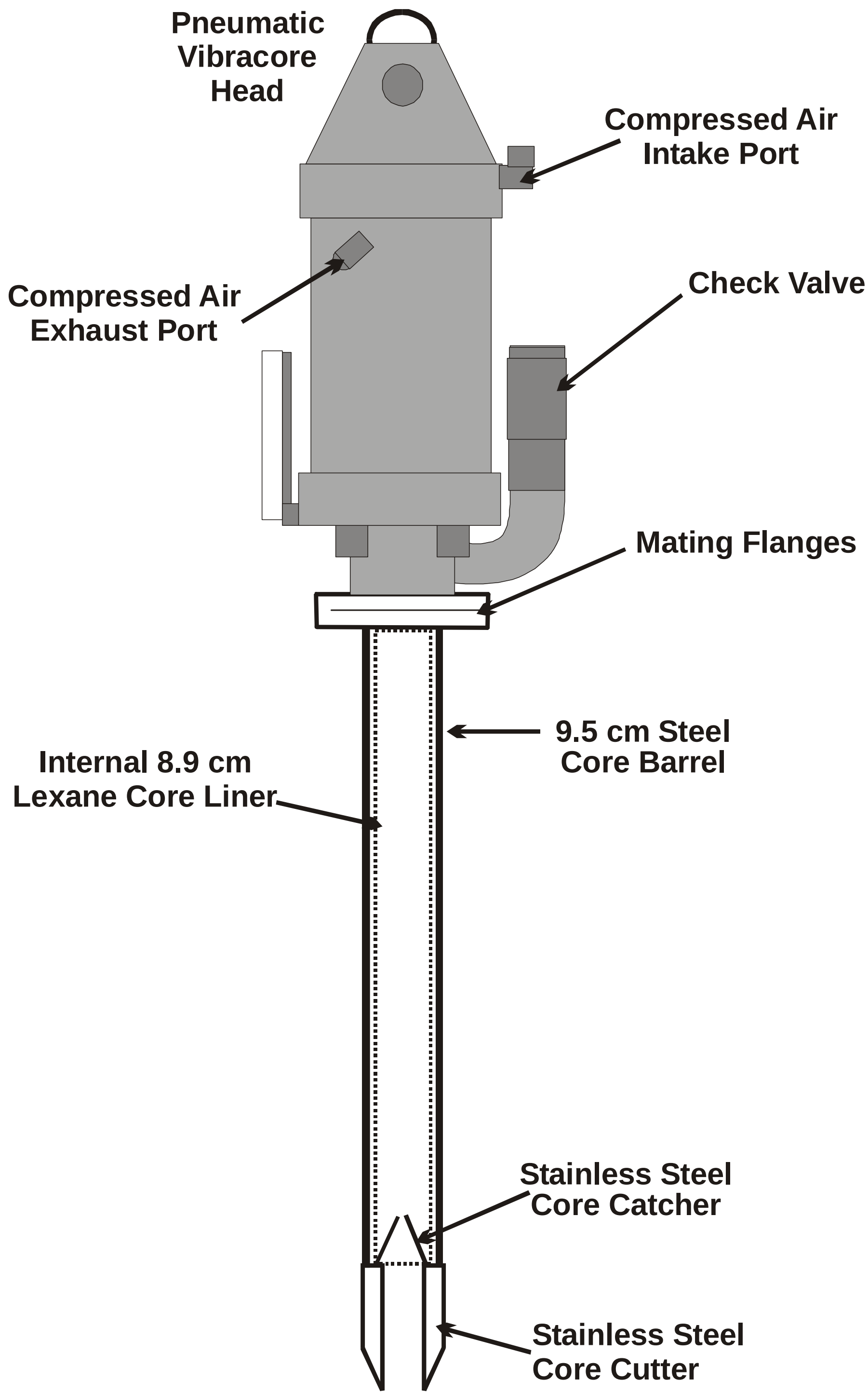


Figure 2-3. Diagram of the pneumatic vibracore device utilized as part of the Cohasset Harbor sediment characterization effort

service broadcasting from Boston, MA. The DGPS positioning data were referenced to the North American Datum of 1983 (NAD 83).

The DGPS data were ported to SAIC's Portable Integrated Navigation Survey System (PINSS) for real-time navigation, data logging, and helm-display. The PINSS navigation software was resident on a Toshiba® 3200XT personal computer (PC) capable of interfacing with many different external sensors. PINSS maintained a project database for the storage of target sampling locations as well as recording actual position and time for individual samples.

2.1.3 Sediment Processing

The vibracores collected from Cohasset Harbor were processed from 31 July through 4 August 1998, at the GSO Rock and Core Laboratory. Core liners were split using a specialized core splitting device. During this process care was taken to cut only the core liner and not the enclosed sediment. The scored liner was then transferred to a laboratory bench where the thin layers of the grooved core Lexane® tube were cut using a pre-cleaned utility knife. Finally, thin piano wire was pulled through to split the sediment axially into two halves. This process eventually yielded two core halves maintained in a natural, undisturbed condition.

After splitting, one half-section of each core was placed in a specially designed cradle labeled with a centimeter scale to determine sampling depth and to provide a linear reference for core sampling and descriptions using standard logging procedures. The standard logging procedures consisted of careful visual core descriptions of each changing section. These were logged in a standardized Excel spreadsheet using Munsell™ color charts and codes. Sediment grain size was visually assessed using the Wentworth grade scale. The other core half was archived under refrigerated conditions for potential future analyses. Complete core descriptions and photographs are provided in Appendix B.

Sixty samples were collected for microscopic and grain size analyses. Samples were collected based on core stratigraphy and proposed dredging depth. Several additional sediment samples were extracted from intervals below the proposed dredging depths and archived. Sediments for both grain size and microscopic analysis were collected from multiple intervals, homogenized, and sub-sampled into appropriate containers and stored for future analysis. Grain size samples were maintained at 4°C until analyzed, while samples collected for microscopic analysis were preserved with a buffered, Rose Bengal/Formalin solution and stored in 250 ml polyethylene containers. Grain size samples were processed by GeoTesting Express Inc. in Boxborough, MA while microscopic analysis was conducted by SAIC, Newport RI.

2.1.4 Sediment Analyses

2.1.4.1 Sediment Grain Size

Grain size analyses were conducted using a modified ASTM (American Society for Testing and Materials) Method D422-63. Samples were sieved into size fractions greater than 0.0625 mm and less than or equal to 0.0625 mm. The gravel and sand fractions were subdivided further by mechanical dry sieving through a graded series of screens. The wet sieve and dry sieve fractions less than 0.0625 mm (silt and clay) were combined for each sample. Grain size results were based on the percent of material passing through sieve series. For the purpose of this study the following grain size distinction was utilized: cobble (>75 mm), gravel (<75–>4.76 mm), coarse sand (<4.76->2.00 mm), medium sand (<2.00–>0.42 mm), fine sand (<0.42–>0.074 mm) and silt and clay (<0.074 mm).

2.1.4.2 Sediment Tracers

A sediment tracer is a unique identifier that allows a layer of sediment placed at a disposal site to be linked back to the source area. Tracers were investigated in this project in the event they were needed to aid in distinguishing between the proxy "UDM" and "CDM" sediments at the disposal site. Sediment tracers can be based on chemistry, grain size, mineralogy, organic load, microorganisms, or a host of other sediment characteristics that permit differentiation between sediment layers. The use of sediment tracers was first introduced to the DAMOS Program in support of the 1995-1997 Portland Disposal Site (PDS) Capping Demonstration Program (Morris et al. 1998). After evaluating several options, the most effective sediment tracer examined as part of the PDS capping demonstration project was determined to be microfossil content. Microorganism populations differ between freshwater, brackish, and saltwater habitats allowing for identification of sediments corresponding to the origin of the microorganism. Because microfossils were found to be a very useful tool in identifying the source of the sediments in the PDS capping demonstration mound, applicability to the MBDS pilot capping project was investigated. The use of this type of tracer required detailed characterization of the project sediments on the microscopic level. Sediments were separated into coarse (>500 μm) and fine sand (63-500 μm) size fractions using sieves, with silts and clays (<63 μm) discarded.

All samples were then dried and archived. A general description of the primary component and secondary components if applicable, were recorded for the samples. The fine sand fraction tends to contain the most useful set of biological tracers. These were examined with microscopy (magnification 40× to 100×) to determine the type and number of microfossils (foraminifera and thecamoebians). While some of these may have been living meiofauna at the time of collection, most microfossils are likely the shells of previously living organisms that have been preserved with the accumulation of sediment since the last dredging operation.

The classification of foraminifera and thecamoebians was based primarily on characteristics of the shell or test. Taxonomic groups were determined using wall composition and structure, chamber shape and arrangement, the shape and position of any apertures, surface ornamentation, and other morphologic features of the shell (Figure 2-4). Species lists and counts were compiled for each sample to determine if suitable tracers were present to track specific dredged material deposits, with the results of this analyses presented in Appendix C.

2.2 Automated Disposal Surveillance

SAIC's Automated Disposal Surveillance System (ADISS) assisted with successful barge positioning during disposal in order to increase the likelihood of forming a discrete disposal mound at the site. This marked the first use of ADISS technology for DAMOS disposal monitoring activities. ADISS is a self-contained disposal barge tracking device that logs the geographic position of individual disposal barges as they are filled with dredged material, transported to an open water disposal site, and dispose of their load.

The system used in this study was DGPS based, comprised of a Trimble ACE-III GPS receiver and a Communication Systems International (CSI) SBX-III differential beacon receiver to monitor the position of the disposal barge to an accuracy of 3 m. The positioning components were interfaced with a programmable data logger and a Micron Instruments pressure sensor, which monitored the barge draft and detected loading and disposal events. All data pertaining to the loading, transit, and disposal were stored on a 10 MB Persistor Flash Memory card. A sub-set of that information pertaining to the disposal event was transmitted directly to SAIC via an ARGOS satellite telemetry link for near-real time analysis.

Two pocket-type disposal barges (743 and 1501) were employed by the dredging contractor (Burnham Associates) for the transport of dredged sediments a distance of approximately 24 km from Cohasset Harbor to MBDS for disposal. A significant increase in barge draft due to the weight of the dredged sediment marked the loading event and prompted ADISS to begin logging position and pressure data at ten minute intervals. Data logging continued at that interval as the barge was towed out of the harbor and headed northeast towards the disposal site. Upon reaching the latitude of 42° 16.800′ N (just north of the harbor entrance channel), the ADISS system increased the

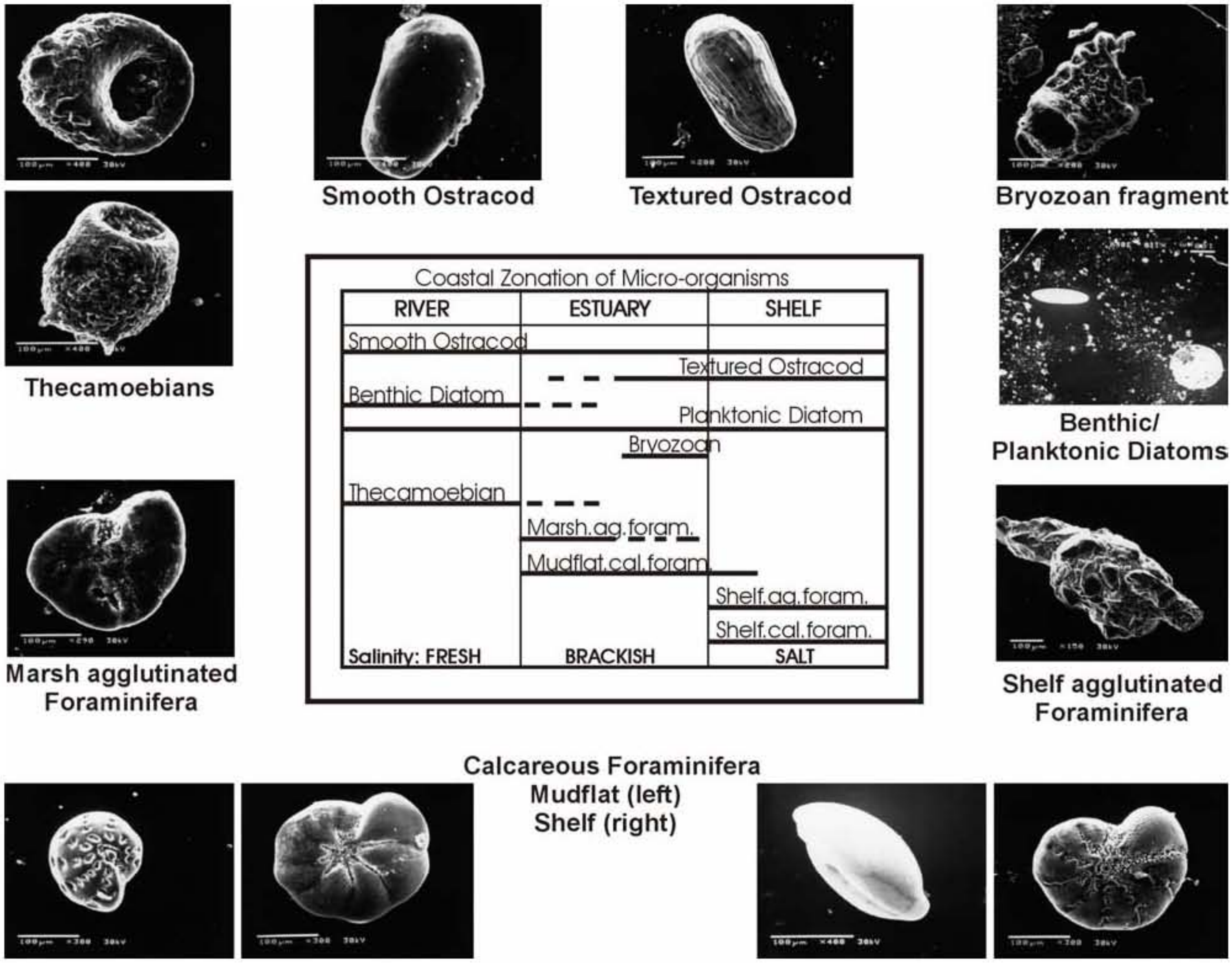


Figure 2-4. Examples of foraminifera and thecamoebian specimens found within the various portions of Cohasset Harbor and the Massachusetts Bay Disposal Site

logging frequency to a one minute interval. As the disposal barge reached a latitude of 42° 22.800´ N (approximately 16 km northeast of the entrance channel), positional fixes were recorded every six seconds until the disposal event occurred.

As the disposal barges deposited their loads at MBDS, the rapid decrease in draft marked the beginning of the disposal event. The geodetic position of the barge was recorded and the position logging continued at a six second interval until the ADISS unit switched into a quiescent state approximately 30 minutes after disposal (Figure 2-5). Load and disposal event files were transmitted via ARGOS® satellite telemetry to a NOAA processing center, which then transmitted abbreviated event files to SAIC's Newport, RI facility. The ARGOS® data provide near-real time data on a point position and time of the events for monitoring the disposal activity and equipment status. The complete data are stored on the internal memory cards in the ADISS unit and downloaded on a weekly basis to display where and when disposal occurred. This information was then incorporated into the Arcview GIS database for storage and display.

The ADISS data collected at MBDS were used to track the progress of dredging activity in Cohasset Harbor as well as the disposal operations at MBDS. As a result, the source area and disposal location for the majority of the sediment removed from the harbor as part of the first phase of operations (December 1998 through February 1999) was well documented. However, due to the limitations of the project, ADISS data were not acquired during the subsequent phases of the capping demonstration project.

2.3 Massachusetts Bay Disposal Site Survey Activity

2.3.1 Capping Demonstration Project Area

In order to maximize the potential for success and the effectiveness of traditional environmental monitoring techniques for this deep-water capping study, the selected site consisted of an area of low relief located away from the active disposal area. A small 800 × 800 m project area in the southern portion of MBDS, centered at 42° 24.449´N and 70° 34.727´W, was identified as a suitable location and designated the CHCP study area. Field operations over the 0.64 km^2 CHCP study area were conducted aboard the M/V *Beavertail*. As described in Section 1. 3 above, SAIC conducted four separate field efforts at the CHCP study area over a two-year period to document the formation of the capped mound at various stages of development (Figure 1-5).

Each comprehensive survey (Baseline, Single-Barge, Precap, and Postcap) included precision bathymetry, REMOTS® sediment-profile photography, side-scan sonar, surface sediment grab sampling, and sediment coring to document the composition and

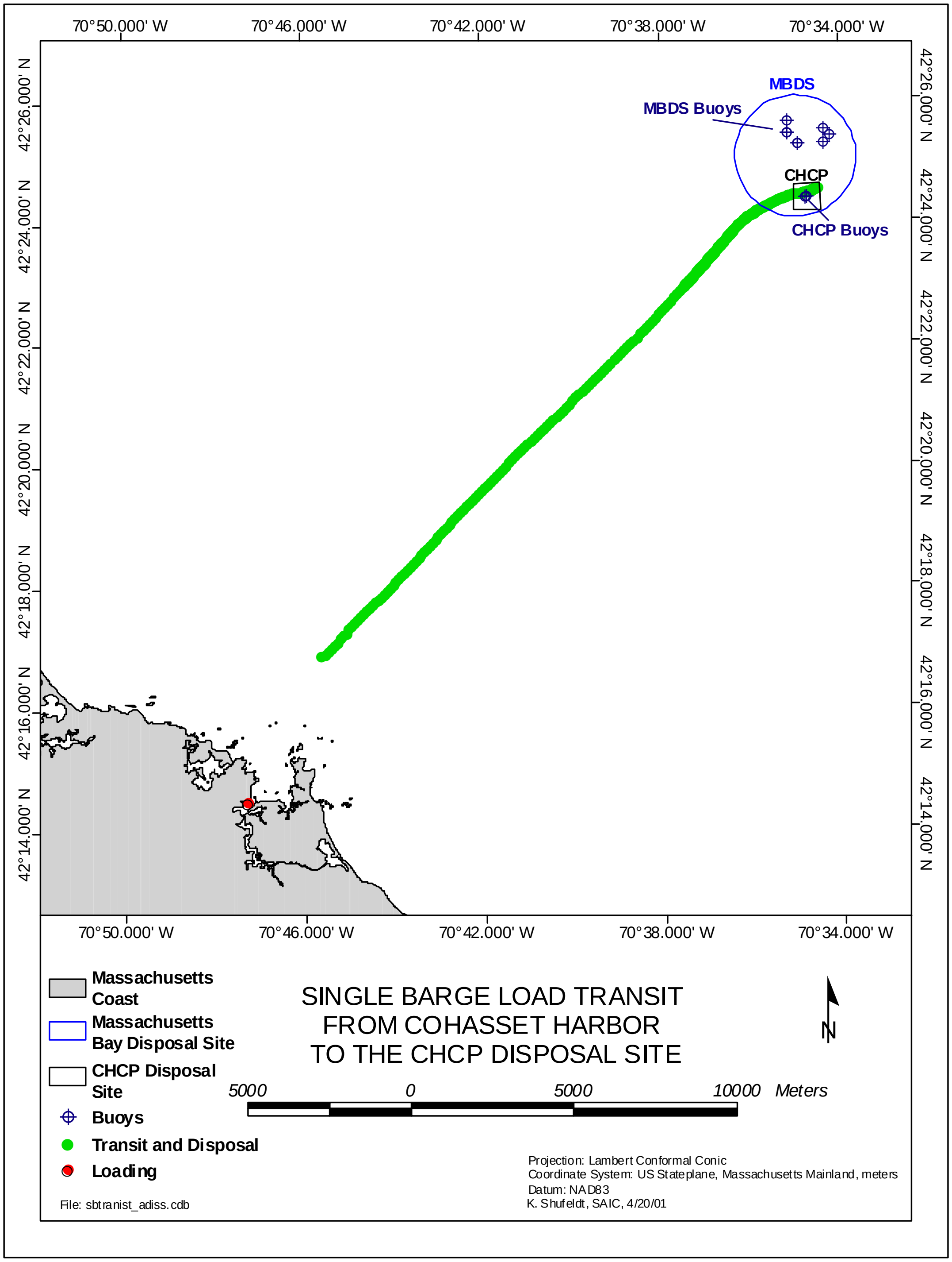


Figure 2-5. A graphical example of a typical ADISS data file documenting an entire trip of a disposal barge transiting from Cohasset Harbor to the CHCP study area

condition of the disposal mound. The Baseline set of surveys characterized the ambient sediments and established the topography prior to disposal activities. For the Single-Barge survey, the ADISS track line data were used to focus the monitoring efforts over the first barge load of material deposited on the seafloor within the CHCP study area. The Precap survey was conducted to document the distribution of UDM material on the seafloor and characterize the first layer of the disposal mound. After the capping operations were completed the Postcap (CDM) survey was conducted to evaluate the capped mound and the formation of two discrete layers of sediment (UDM and CDM), as well as assess the overall effectiveness of capping operations.

2.3.2 Precision Navigation

Navigation for the open water survey work performed at MBDS differed slightly from the methods employed as part of the Cohasset Harbor sediment characterization effort. DGPS was used as the primary position system, but the components were altered to provide better repeatability in positions obtained as part of the sequential survey efforts performed at the offshore work site. A Trimble 7400 RSi Global Positioning System (GPS) receiver in conjunction with a Leica MX41R differential beacon receiver was used to obtain real-time vessel position to an accuracy of ± 3 m in the horizontal control of North American Datum of 1983 (NAD 83). The U.S. Coast Guard beacon broadcasting from Portsmouth, NH (288 kHz) was utilized for differential corrections to satellite information.

During the Baseline, Single-Barge, and Precap surveys, the DGPS positioning data were ported to SAIC's Portable Integrated Navigation Survey System (PINSS) for real-time navigation. This system utilizes a Toshiba DX3200 series computer to provide real-time navigation, data logging, and helm display. PINSS maintains a project database for the storage of target sampling locations as well as recording actual position and time for individual samples. In addition, the navigation software served as a data acquisition system capable of collecting position, depth, and time data for later analysis.

The Postcap survey was initiated in the summer of 2000, when SAIC had transitioned from PINSS to Coastal Oceanographic's HYPACK® navigation software system. The HYPACK® navigation software was resident on a Toshiba® laptop computer and provided real-time navigation, as well as collecting position, depth, and time data for later analysis. HYPACK® offered the same functionality as PINSS, as well as several advantages in survey planning and data collection operations.

2.3.3 Single Beam Bathymetry

Precision bathymetry entails the collection of depth soundings along predetermined survey lanes to map seafloor topography, providing information on depth of the water column and bottom topography. Sequential bathymetric surveys that occupy the same area of seafloor are valuable in detecting and quantifying changes in bottom topography over time. By calculating the changes in depth between two individual bathymetric surveys (depth differencing), accumulation of disposed dredged material or the reduction in mound height due to consolidation or erosion can be measured.

2.3.3.1 Bathymetric Data Collection

The DAMOS Program generally uses single-beam bathymetry, providing precise depth data (±0.05% of overall depth) for the seafloor directly under the survey vessel (Murray and Selvitelli 1996). A 800 × 800 m bathymetric survey grid centered at 42° 24.449´N and 70° 34.727´W, was established over the CHCP study area and occupied to document each stage of capped mound development. A series of thirty-three (33) lanes, oriented in an East-West direction, and spaced at 25 m intervals were used for the completion of the four bathymetric surveys performed over MBDS (Figure 2-6). The raw bathymetric data were later processed to produce contour charts of the seafloor based on water depth. Depth difference plots displaying changes in bottom topography relative to previous surveys were generated by comparing sequential data sets.

Efforts were made to minimize the development of survey artifacts formed by differences in survey vessel track or configuration within the sequential bathymetric surveys. One research vessel, with identical survey configurations, was used to complete the data collection efforts for the September 1998 Baseline survey, as well as the December 1998 Single-Barge, April 1999 Precap, and September 2000 Postcap surveys.

An ODOM DF3200 Echotrac® survey fathometer was employed for the Baseline, Single Barge, and Precap bathymetric surveys completed in support of the capping demonstration project. An Odom Hydrotrac precision survey fathometer was used as part of the Postcap survey. Both units were interfaced with a narrow-beam, 208 kHz transducer capable of measuring 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). Approximately 10 measured depth values were collected, adjusted for transducer depth, and transmitted to the data acquisition and survey system within a one-second interval. The fathometer data were averaged, merged with time and position information, and written to a series of navigation log files at a frequency of 1 Hz. At the

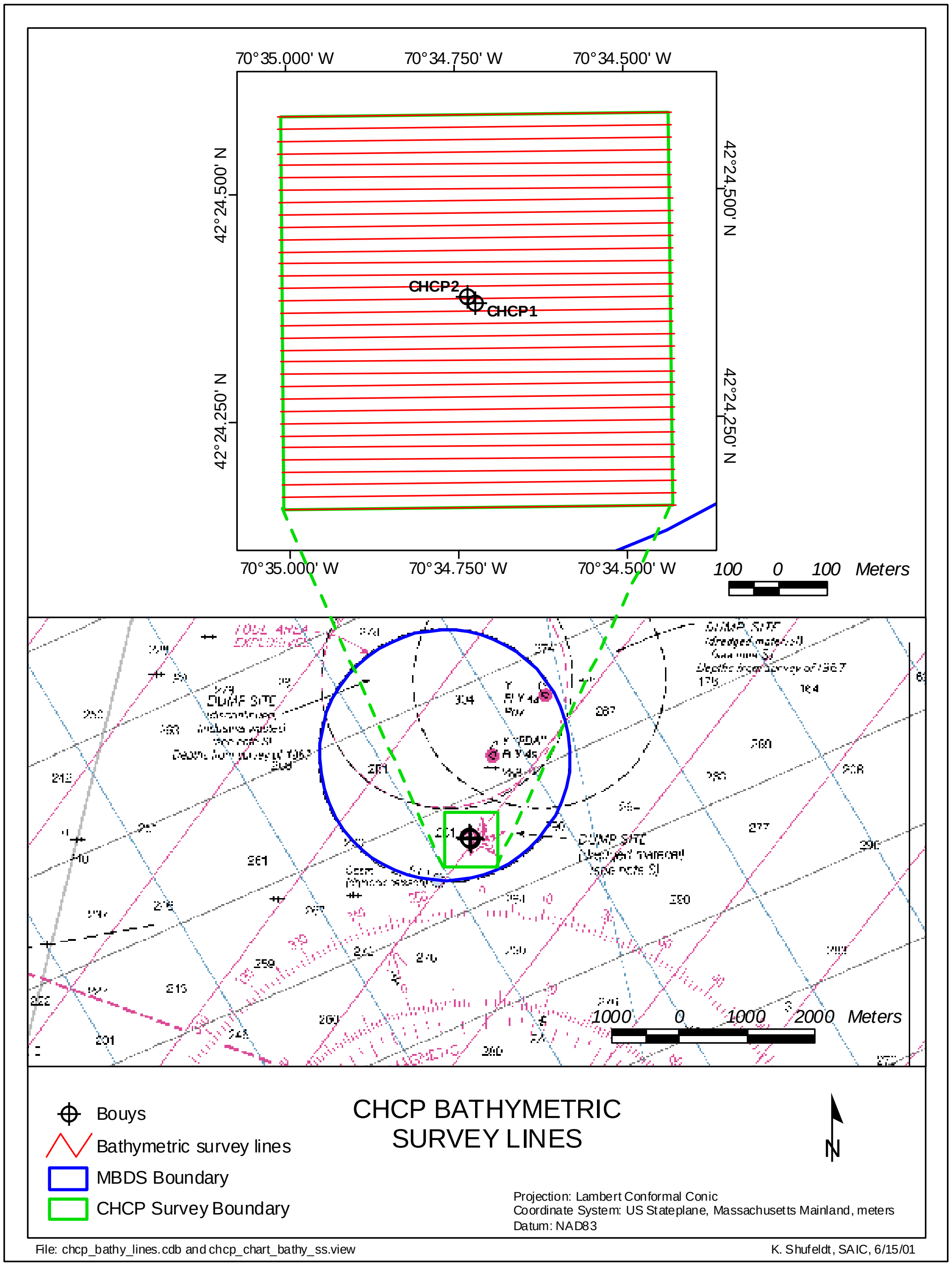


Figure 2-6. Basemap displaying the bathymetric survey lines occupied over the CHCP study area as part of the Baseline, Single-Barge, Precap, and Postcap surveys

conclusion of the survey, raw depth soundings were plotted over the survey lines to re-create vessel track and verify data quality. These data were then stored for future processing and analysis.

In order to adjust the soundings for variation of sound velocity through the water column, a Seabird Instruments, Inc. SEACAT SBE 19-01 Conductivity, Temperature, and Depth (CTD) probe was used to obtain sound velocity profiles at the start, midpoint, and end of each survey. 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 distinct layers within the water column. Sound velocity correction factors were then calculated using the bin-averaged values. A mean sound velocity was calculated for each day from the profile data and was used to develop a depth correction factor based on the ratio of actual sound velocity within the water column to the fathometer setting. This correction factor was applied during the post-processing of the bathymetric data.

2.3.3.2 Bathymetric Data Processing

The first three bathymetric data sets were analyzed using SAIC's Hydrographic Data Analysis System (HDAS), Version 1.03, while the Postcap survey data were analyzed using the HYPACK® data processing modules. Raw bathymetric data were imported into the post-processing packages, corrected for sound velocity, and standardized to Mean Lower Low Water (MLLW) using the National Oceanic and Atmospheric Administration (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).

Observed tidal data were obtained through NOAA’s Ocean and Lake Levels Division’s (OLLD) National Water Level Observation Network. This network is composed of water level stations located throughout the continental United States and abroad that are equipped with the Next Generation Water Level Measurement System tide gauges and satellite transmitters. A large number of these stations have collected and transmitted tide data to the central NOAA facility every six minuets since 1 January 1994. Tidal data are available 1 to 6 hours from the time of collection in station datum or referenced to MLLW and based on Universal Time Coordinate (UTC). The NOAA 6-minute tide data were downloaded in the MLLW datum and corrected for tidal offsets. SAIC utilized the water level data from station (8443970) in Boston Harbor, MA and applied time and height corrections based on the entrance to Gloucester Harbor, MA.

2.3.4 Side-Scan Sonar

Side-scan sonar systems provide an acoustic representation of the seafloor topography, bottom targets, and generalized sediment characteristics by detecting the back-scattered signals emitted from a towed transducer housed in a "towfish." The transducer operates similar to a conventional depth-sounding transducer except that the towfish has a pair of opposing transducers aimed perpendicular to the vessel track. The transducers emit and receive sound waves at specific frequencies typically ranging from 100 to 500 kHz. The transmittal angles of the transducers can be adjusted so that a specific swath of area is covered, such as 75 m or 100 m range scale on both sides of the towfish.

Side-scan data reveal both the size of an object and its horizontal distance from the towfish. Dense objects (e.g., rocks, and firm sediment) reflect strong signals and appear as dark areas on the side-scan records. Conversely, areas characterized by soft features (e.g., muddy sediments), which absorb sonar energy, appear as lighter areas in the side-scan records.

2.3.4.1 Side-Scan Sonar Data Collection

For the Baseline, Single-Barge, and Precap surveys the same side-scan acquisition system and procedures were used. Survey lanes for side-scan were planned using the PINSS survey-planning module to cover the desired survey area. The 800 × 800 m survey area was occupied twice during each field effort, as survey lines were established in both East-West and North-South orientations (Figure 2-7). The position of the towfish was calculated in real-time by PINSS, based on cable scope (layback) and speed of the survey vessel. This information was embedded within the digital side-scan sonar data to allow for the geo-referencing of each acoustic return. For the Postcap survey, these functions were performed by the HYPACK® navigation package.

Sonar data were collected with an EdgeTech DF-1000 side-scan sonar towfish, transmitting at a frequency of 100 kHz. The DF1000 was directly controlled by a topside digital control unit (DCU) which regulated the power output and range scale settings for the side-scan system. The digital data were transmitted from the towfish to the DCU via a double-armored coaxial tow cable. The towfish altitude was controlled to insure 150-200 percent bottom coverage over the CHCP study area. The data were then ported to an EdgeTech 260-TH topside paper recorder to which produce real-time imagery of collected side-scan sonar data. An EdgeTech model 380 recorder was also integrated with an 8 mm tape drive to digitally record the side-scan data onto 8 mm DAT tapes for archive and post processing purposes. After the survey, the side-scan records were replayed through the

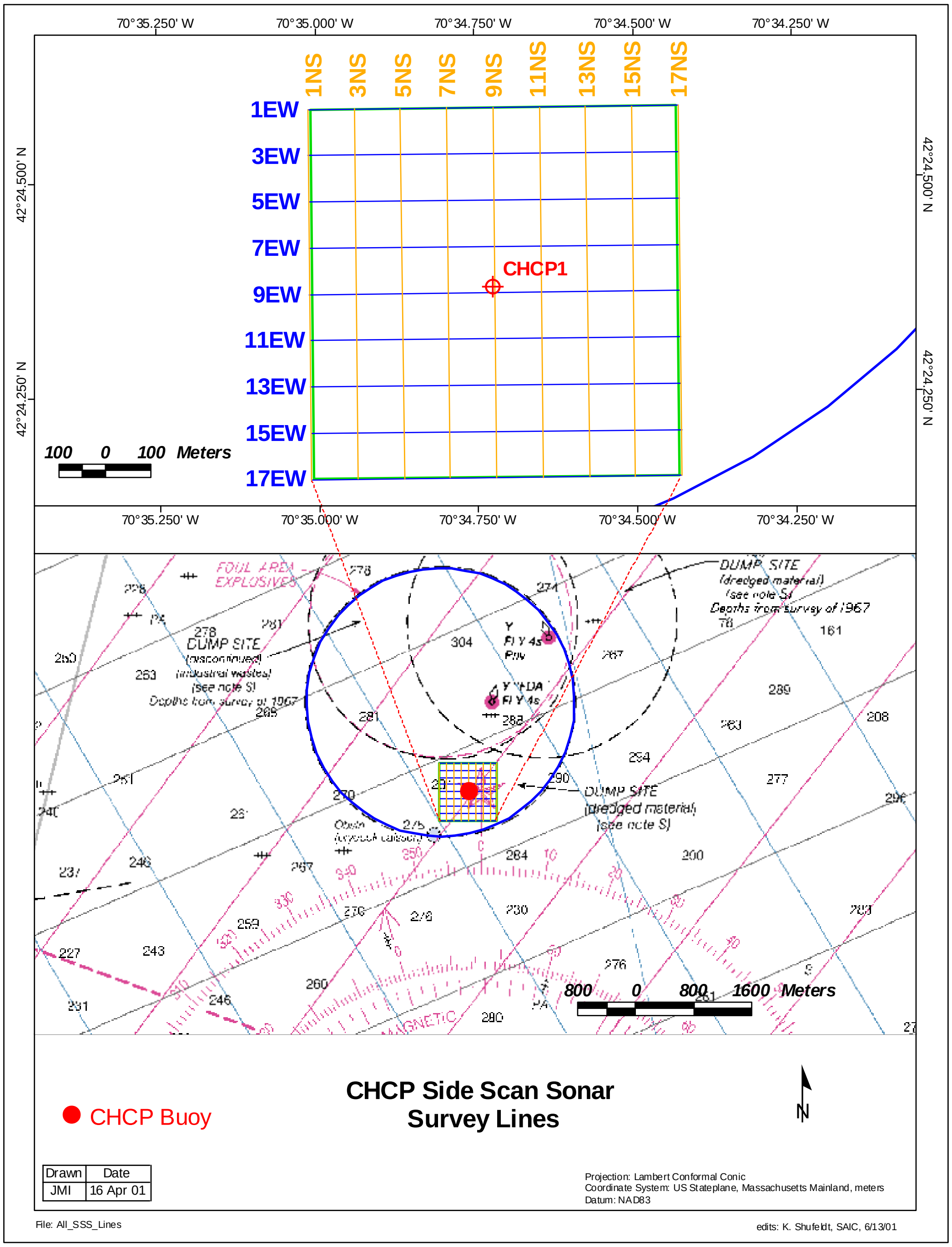


Figure 2-7. Basemap displaying the side-scan sonar survey lines occupied over the CHCP study area as part of the Baseline, Single-Barge, Precap, and Postcap surveys

topside recorder to remove water column artifacts and distortion, providing a better hard copy representation of the MBDS seafloor through side-scan sonar.

The system configuration was modified somewhat for the Postcap side-scan survey. An EdgeTech DF-1000 side-scan sonar towfish was employed for the collection of the sonar data, however, a Triton® Elics ISIS® system was used for data display and storage. The DF-1000 was powered by the EdgeTech Digital Control Interface (DCI), which was integrated within ISIS® and was now capable of collecting data at both a frequency of 100 kHz and 500 kHz simultaneously. The ISIS® system allowed the user to control the power as well as the range scale settings.

The new ISIS® topside data acquisition system was run from a desktop computer, which housed a Magneto Optical (MO) disk drive. All sonar data were backed up at the end of the survey days to MO disks for archiving purposes. One advantage of collecting sonar data with ISIS® is that the data can be easily transformed into a geo-referenced mosaic during post-processing. This capability allowed the side-scan sonar data acquired during the Postcap survey to be illustrated in a very useful way, allowing data analysts to see the entire area of interest. The mosaic also increases the ability for data interpretation of other disciplines such as sediment-profile photography, coring, grab sampling, and bathymetry by serving as a background from which to display the results of these other surveys within a Geographic Information System (GIS).

2.3.4.2 Side-Scan Sonar Data Processing

Using Triton-Elics ISIS® software the sonar data were played back digitally and the water column was removed to produce better quality imaging for mosaic purposes. The "water column" is depicted on the side-scan records as a white gap down the center of each record. This gap corresponds with the time it takes for the acoustic signal to travel from the towfish to the seafloor below and return. As the towfish gains altitude above the seafloor, the amount of time it takes for the signals to reach the seafloor increases, thus increasing the white gap on the side-scan data record.

Each survey line was saved as a separate filename to ease processing procedures. Individual survey lines were played back in ISIS® and converted to a format for use in the Delph Map mosaicing program. Upon playback of the side-scan records adjustments are made to the time-varying-gain (TVG) of the return signal. The TVG adjustments allows the user to alter the gain tracking of the return signal based on the time elapsed since the initial outgoing pulse.

As each line was completed in ISIS® they were imported into Delph Map to check for processing accuracy during the file conversion from one program to the other. Upon processing completion of all of the survey lines, a mosaic was generated in Delph Map to check if any coverage gaps were present between survey lines. After the mosaic was completed it was saved and exported out of Delph Map as a geo-referenced Tiff file. This Tiff image was then imported into a GIS environment as a geo-referenced data source and capable of being compiled with various existing and future data sets from the corresponding area.

2.3.5 REMOTS® Sediment-Profile Imaging

A time series of sediment-profile imaging surveys were collected over the CHCP study area to document changes in surficial sediment layers, and map the distribution of dredged material. Remote Ecological Monitoring of the Seafloor (REMOTS®) sediment-profile photography is a benthic sampling technique used to detect and map the distribution of thin (<20 cm) dredged material layers. The DAMOS Program has used this technique for routine disposal site monitoring for over 20 years.

Measurements obtained from sediment-profile images can be used to characterize sediment types, evaluate benthic habitat conditions, map disturbance gradients over the disposal mound, and follow ecosystem recovery after disturbance abatement. This is a reconnaissance survey technique used for rapid collection, interpretation, and mapping of data on physical and biological seafloor characteristics. REMOTS® utilizes a Benthos® Model 3731 Sediment-Profile Camera, designed to obtain undisturbed, vertical cross-section photographs (*in situ* profiles) of the upper 15 to 20 cm of the seafloor, for analysis and interpretation (Figure 2-8). Computer-aided analysis of each REMOTS® image yields a suite of standard measured parameters, including sediment grain size major mode, camera prism penetration depth (an indirect measure of sediment bearing capacity/density), small-scale surface boundary roughness, depth of the apparent redox potential discontinuity (RPD, a measure of sediment aeration), infaunal successional stage, and Organism-Sediment Index (OSI; a summary parameter reflecting overall benthic habitat conditions). OSI values may range from -10 (azoic with low sediment dissolved oxygen and/or the presence of methane gas in the sediment) to +11 (healthy, aerobic environment with deep RPD depths and advanced successional stages). The OSI values are calculated using values assigned for the apparent RPD depth, successional status, and indicators of methane or low oxygen. Standard REMOTS® image acquisition and analysis methods are described fully in Rhoads and Germano (1982, 1986) and in the recent DAMOS Contribution No. 128 (SAIC 2001).

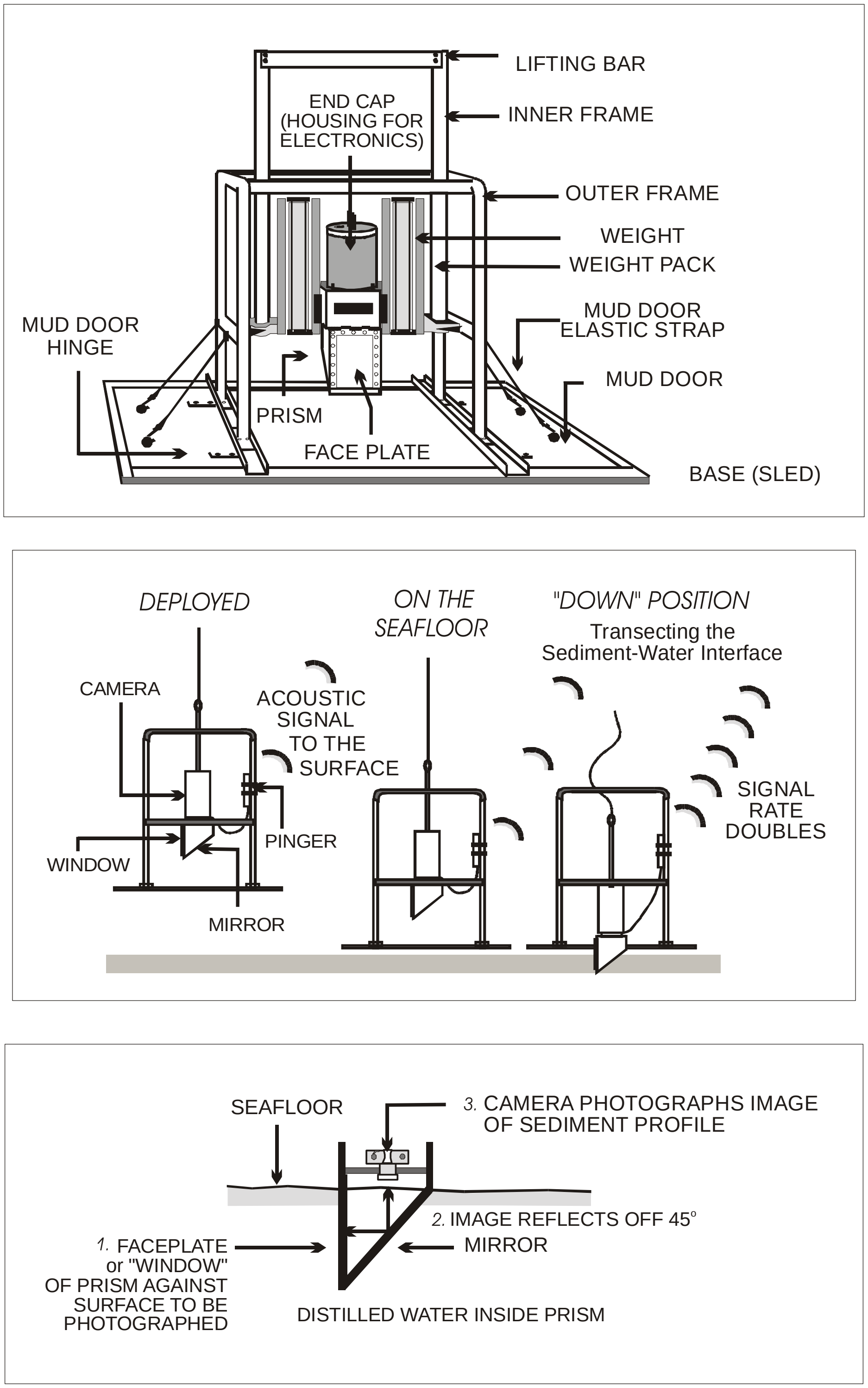


Figure 2-8. Schematic diagram of the Benthos, Inc. Model 3731 REMOTS® sediment-profile camera and sequence

For the Massachusetts Bay Disposal Site Capping Demonstration Project, REMOTS® sediment-profile photography was primarily used to map the areal distribution of dredged material layers within the CHCP area. The individual photographs were used to measure the thin sediment strata as part of the Baseline, Single-Barge, Precap, and Postcap stages of mound development. In addition, the results of the Postcap survey were also analyzed to evaluate benthic recolonization over the capped disposal mound relative to the conditions at three surrounding reference areas (SAIC 2002). A 33-station radial arm grid centered at the CHCP buoy (42° 24.433´ N, 70° 34.723´W) served as the basis of REMOTS® survey activity for the four individual CHCP surveys (September 1998 Baseline, December 1998 Single-Barge, April 1999 Precap, and Fall 2000 Postcap). Stations were distributed over eight radial arms and spaced at 50, 100, 200, and 300 m intervals from the center (Figure 2-9A; Table 2-3).

Two additional survey grids supplemented the primary REMOTS® grid described above during the December 1998 Single-Barge survey to examine two distinct dredged material areas identified in the side-scan sonar survey. The secondary, modified rectangular grid was established over a 250 × 300 m area encompassing the Cohasset Harbor sediment deposit on the northwest side of the buoy (Figure 2-9B; Table 2-4). In addition, the tertiary grid consisting of 24 stations radially distributed around a single, errant deposit (likely 5,350 m^3 of Boston Blue Clay originating from the BHNIP) was occupied. This grid was centered at 42° 24.352´ N, 70° 34.645´ W southeast of the CHCP buoy and consisted of eight radial arms with stations spaced at 80, 120, and 160 m intervals (Figure 2-9B;). Only 25 of the 33 stations from the primary grid were occupied during the Single-Barge survey. The southeast and northwest arms of the primary survey grid were excluded due to overlap with the two supplemental REMOTS® grids.

2.3.6 CHCP Surface Sediment Sampling

Sediment grab samples were collected within the CHCP study area in association with both the Baseline and Precap surveys to characterize the surficial sediments and to examine sediment tracer content. A 0.1 m^2 Young-modified van Veen grab sampler was used to collect samples from thirteen stations, located on the north-south, and east-west axes of the primary REMOTS® survey grid (Figure 2-10; Table 2-3). Ambient sediments within the CHCP study area were sampled in September 1998 as part of the Baseline effort. The same stations were occupied again during the April 1999 Precap survey to examine the surface sediment composition over the mound.

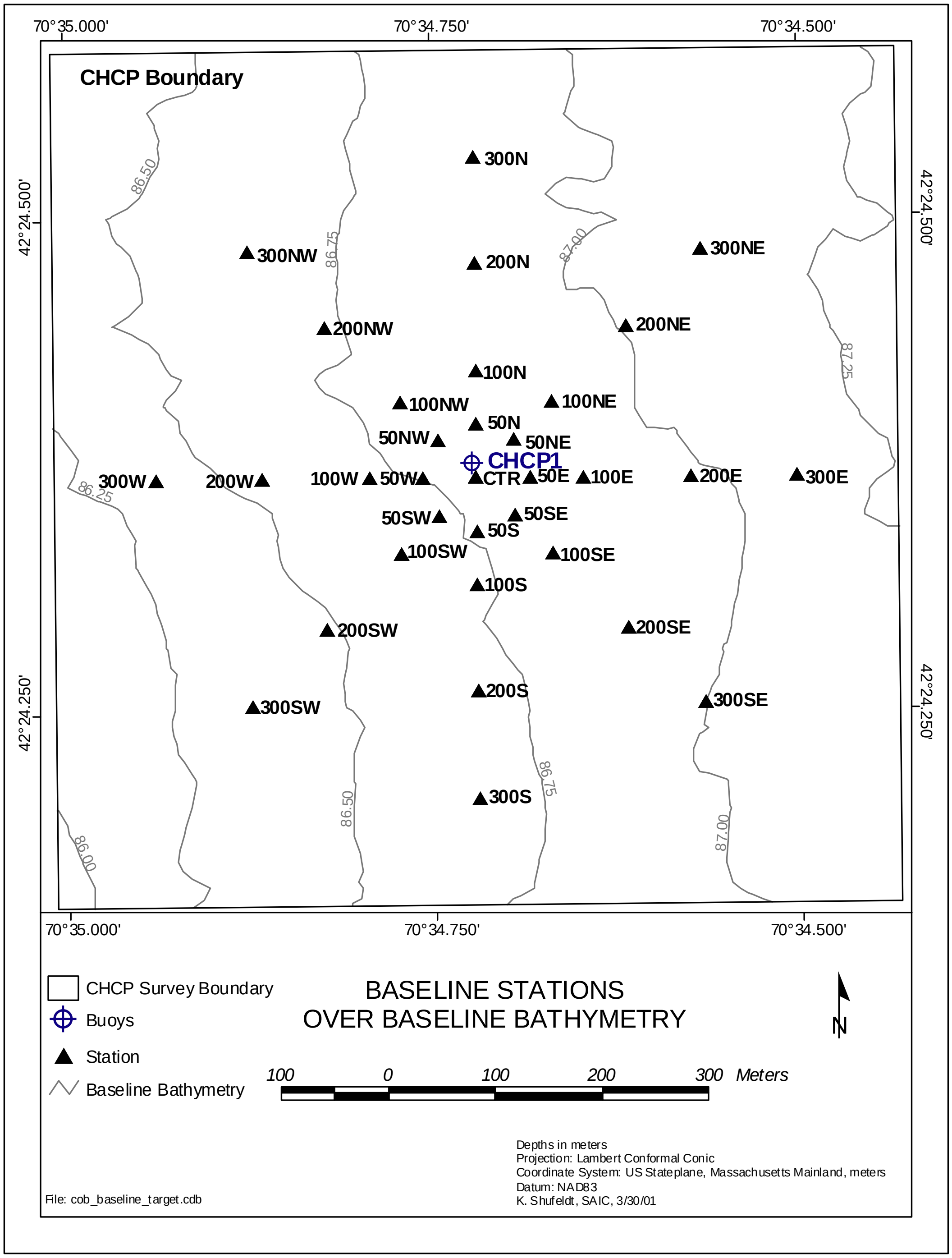


Figure 2-9A. Basemap of the REMOTS® sediment-profile imaging stations occupied over the CHCP study area as part of the Baseline, Precap, and Postcap surveys

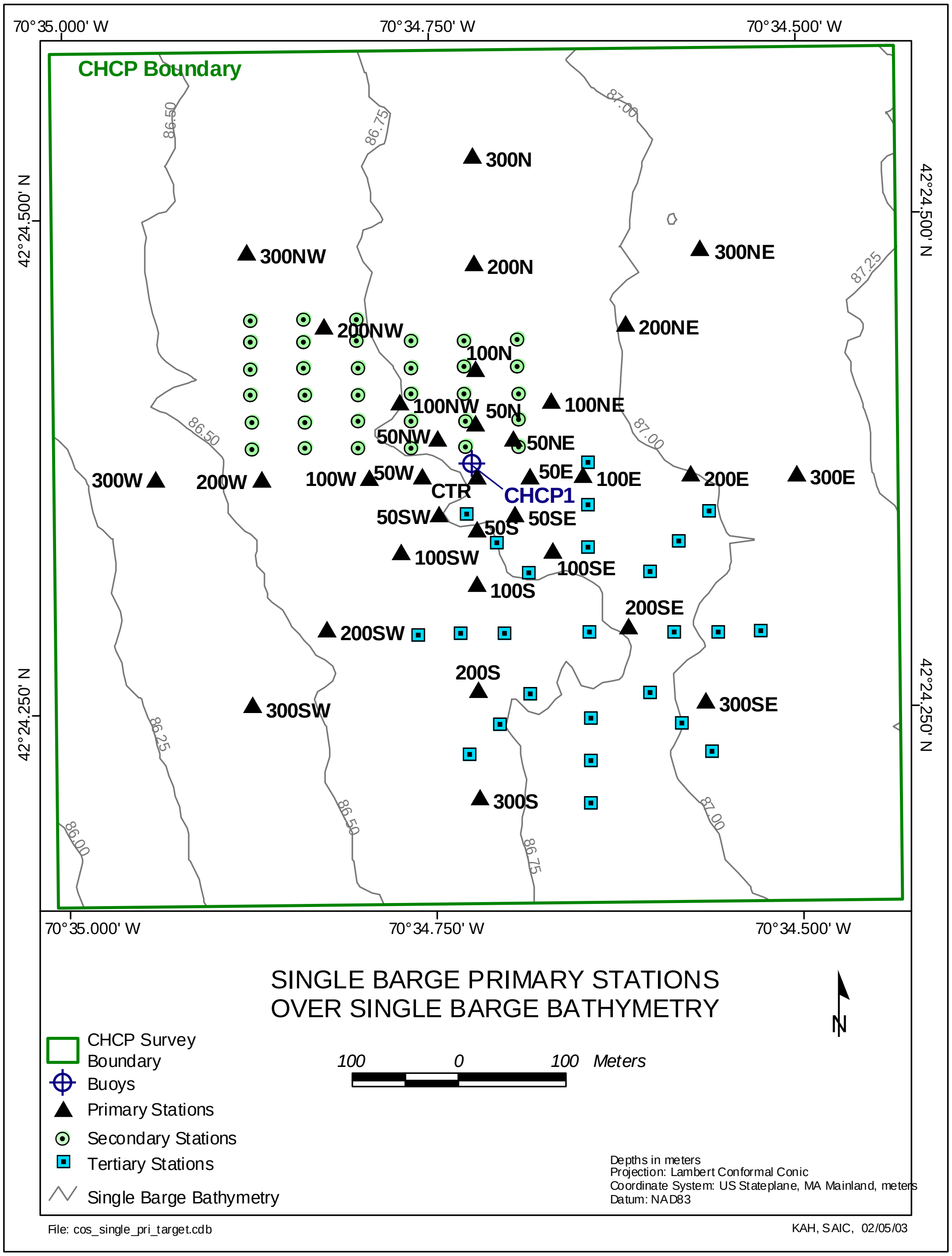


Figure 2-9B. Basemap of the REMOTS® sediment-profile imaging station grids occupied within the CHCP study area as part of the Single-Barge survey

Table 2-3. REMOTS® Sediment-Profile Imaging Stations over the CHCP Study Area, Baseline, Precap, and Postcap Surveys

Area	Station	Latitude (NAD 83)	Longitude (NAD 83)
CHCP Study Area 42° 24.432´ N 70° 34.721´ W	CTR**	42° 24.432´ N	70° 34.721´ W
	50N	42° 24.459´ N	70° 34.721´ W
	100N**	42° 24.486´ N	70° 34.721´ W
	200N**	42° 24.540´ N	70° 34.721´ W
	300N**	42° 24.594´ N	70° 34.721´ W
	50NE	42° 24.451´ N	70° 34.695´ W
	100NE	42° 24.470´ N	70° 34.670´ W
	200NE	42° 24.508´ N	70° 34.618´ W
	300NE	42° 24.547´ N	70° 34.566´ W
	50E	42° 24.432´ N	70° 34.685´ W
	100E**	42° 24.432´ N	70° 34.649´ W
	200E**	42° 24.432´ N	70° 34.576´ W
	300E**	42° 24.432´ N	70° 34.502´ W
	50SE	42° 24.413´ N	70° 34.695´ W
	100SE	42° 24.394´ N	70° 34.670´ W
	200SE	42° 24.356´ N	70° 34.618´ W
	300SE	42° 24.317´ N	70° 34.566´ W
	50S	42° 24.405´ N	70° 34.721´ W
	100S**	42° 24.378´ N	70° 34.721´ W
	200S**	42° 24.324´ N	70° 34.721´ W
	300S**	42° 24.270´ N	70° 34.721´ W
	50SW	42° 24.413´ N	70° 34.747´ W
	100SW	42° 24.394´ N	70° 34.772´ W
	200SW	42° 24.356´ N	70° 34.824´ W
	300SW	42° 24.317´ N	70° 34.876´ W
	50W	42° 24.432´ N	70° 34.757´ W
	100W**	42° 24.432´ N	70° 34.794´ W
	200W**	42° 24.432´ N	70° 34.867´ W
	300W**	42° 24.432´ N	70° 34.940´ W
	50NW	42° 24.451´ N	70° 34.747´ W
	100NW	42° 24.470´ N	70° 34.772´ W
	200NW	42° 24.508´ N	70° 34.824´ W
	300NW	42° 24.547´ N	70° 34.876´ W

** Denotes Sediment Grab Sampling Station (Baseline and Precap Only)

Table 2-4. Supplemental REMOTS® Sediment-Profile Imaging Stations over the CHCP Study Area, Single-Barge Survey

Area	Station	Latitude (NAD 83)	Longitude (NAD 83)
Secondary Survey Grid 42° 24.474´ N 70° 34.873´ W	XCTR	42° 24.474´ N	70° 34.873´ W
	X25N	42° 24.488´ N	70° 34.873´ W
	X50N	42° 24.501´ N	70° 34.873´ W
	X50N	42° 24.501´ N	70° 34.873´ W
	X75N	42° 24.512´ N	70° 34.873´ W
	X25S	42° 24.461´ N	70° 34.873´ W
	X50S	42° 24.447´ N	70° 34.873´ W
	ACTR	42° 24.474´ N	70° 34.837´ W
	A25N	42° 24.488´ N	70° 34.837´ W
	A50N	42° 24.501´ N	70° 34.837´ W
	A75N	42° 24.512´ N	70° 34.837´ W
	A25S	42° 24.461´ N	70° 34.837´ W
	A50S	42° 24.447´ N	70° 34.837´ W
	BCTR	42° 24.474´ N	70° 34.801´ W
	B25N	42° 24.488´ N	70° 34.801´ W
	B50N	42° 24.501´ N	70° 34.801´ W
	B75N	42° 24.512´ N	70° 34.801´ W
	B25S	42° 24.461´ N	70° 34.801´ W
	B50S	42° 24.447´ N	70° 34.801´ W
	CCTR	42° 24.474´ N	70° 34.764´ W
	C25N	42° 24.488´ N	70° 34.764´ W
	C50N	42° 24.501´ N	70° 34.764´ W
	C25S	42° 24.461´ N	70° 34.764´ W
	C50S	42° 24.447´ N	70° 34.764´ W
	DCTR	42° 24.474´ N	70° 34.728´ W
	D25N	42° 24.488´ N	70° 34.728´ W
	D50N	42° 24.501´ N	70° 34.728´ W
	D25S	42° 24.461´ N	70° 34.728´ W
	D50S	42° 24.447´ N	70° 34.728´ W
	ECTR	42° 24.474´ N	70° 34.691´ W
	E25N	42° 24.488´ N	70° 34.691´ W
	E50N	42° 24.501´ N	70° 34.691´ W
	E25S	42° 24.461´ N	70° 34.691´ W
	E50S	42° 24.447´ N	70° 34.691´ W
Tertiary Survey Grid 42° 24.352´ N 70° 34.645´ W	80N	42° 24.395´ N	70° 34.645´ W
	120N	42° 24.417´ N	70° 34.645´ W
	160N	42° 24.438´ N	70° 34.645´ W
	80NE	42° 24.383´ N	70° 34.604´ W
	120NE	42° 24.398´ N	70° 34.583´ W
	160NE	42° 24.413´ N	70° 34.563´ W
	80E	42° 24.352´ N	70° 34.587´ W
	120E	42° 24.352´ N	70° 34.558´ W
	160E	42° 24.352´ N	70° 34.528´ W
	80SE	42° 24.322´ N	70° 34.604´ W
	120SE	42° 24.306´ N	70° 34.583´ W
	160SE	42° 24.291´ N	70° 34.563´ W
	80S	42° 24.309´ N	70° 34.645´ W
	120S	42° 24.287´ N	70° 34.645´ W
	160S	42° 24.266´ N	70° 34.645´ W
	80SW	42° 24.322´ N	70° 34.686´ W
	120SW	42° 24.306´ N	70° 34.707´ W
	160SW	42° 24.291´ N	70° 34.728´ W
	80W	42° 24.352´ N	70° 34.703´ W
	120W	42° 24.352´ N	70° 34.733´ W
	160W	42° 24.352´ N	70° 34.762´ W
	80NW	42° 24.383´ N	70° 34.686´ W
	120NW	42° 24.398´ N	70° 34.707´ W
	160NW	42° 24.413´ N	70° 34.728´ W

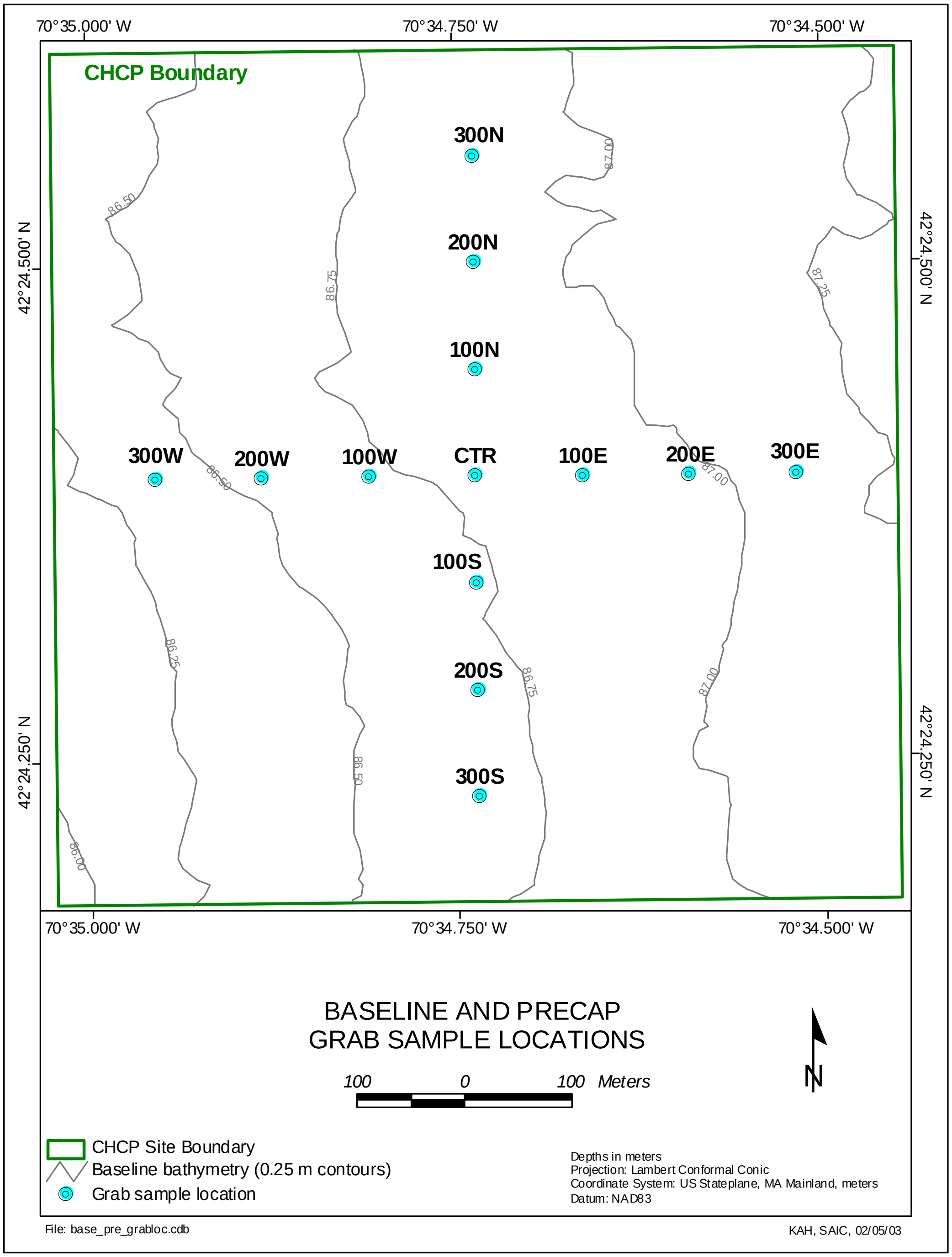


Figure 2-10. Basemap of the sediment grab sampling locations occupied over the CHCP Study Area during the Baseline and Precap surveys

Each grab sample was visually described, sub-sampled, and preserved for microscopic and grain size analyses. The top 15 cm from each sediment grab sample was homogenized, then preserved and processed following the same procedure that was utilized for the Cohasset Harbor vibracore sub-samples (see Section 2.1.3). Samples from the center station (CTR) as well as 200N, 200E, 200S and 200W were selected for grain size analysis. These samples were sent to GeoTesting Express Inc. for grain size analysis utilizing the same analysis method employed for the Cohasset Harbor sediment samples (see Section 2.1.4). The samples not analyzed (eight stations) were archived in the event future analyses are required. Microscopic analysis methods followed the same procedures that were utilized in Cohasset Harbor for sediment characterization and were processed by SAIC technicians in Newport, RI.

2.3.7 Postcap Gravity Coring

2.3.7.1 Core Collection

Gravity cores were collected at the CHCP site in October 2000 as part of the Postcap survey effort. A total of 12 sediment-coring stations were established over the capped mound in an attempt to collect vertical cross-sections of the layered sediment deposit (Figure 2-11; Table 2-5). In addition, one station was selected along the southern margin of the CHCP study area to test penetration of the corer and characterize the ambient sediments. The coring locations were selected based on the results of sequential bathymetric surveys in a manner that would provide an opportunity to penetrate into UDM and potentially ambient sediment.

The coring device consisted of a weighted driver section attached to a 3.0 m (10 ft) steel core barrel (9.5 cm inner diameter). A chemically inert, clear Lexane® liner (8.9 cm inner diameter) was fitted within the core barrel, with a stainless steel core cutter and catcher assembly secured to the end (Figure 2-12). The core was suspended in the water column by the research vessel via a single steel cable attached to a deck winch. Once on station, the gravity corer was allowed to free-fall approximately 20 meters before impacting the bottom. The corer was then retrieved using the winch and placed on the deck of the research vessel.

Upon retrieval of the coring device, the internal liner containing the sediment sample was removed from the core barrel. The cores were inspected to ensure that there was a sufficient quantity of material for the intended analyses. The core was then capped with a styrofoam plug and plastic core cap to prevent loss of sediment, labeled with a unique identifier, measured, and stored at 4°C with minimal exposure to sunlight. Multiple attempts to collect cores greater then 100 cm were made at many of the stations.

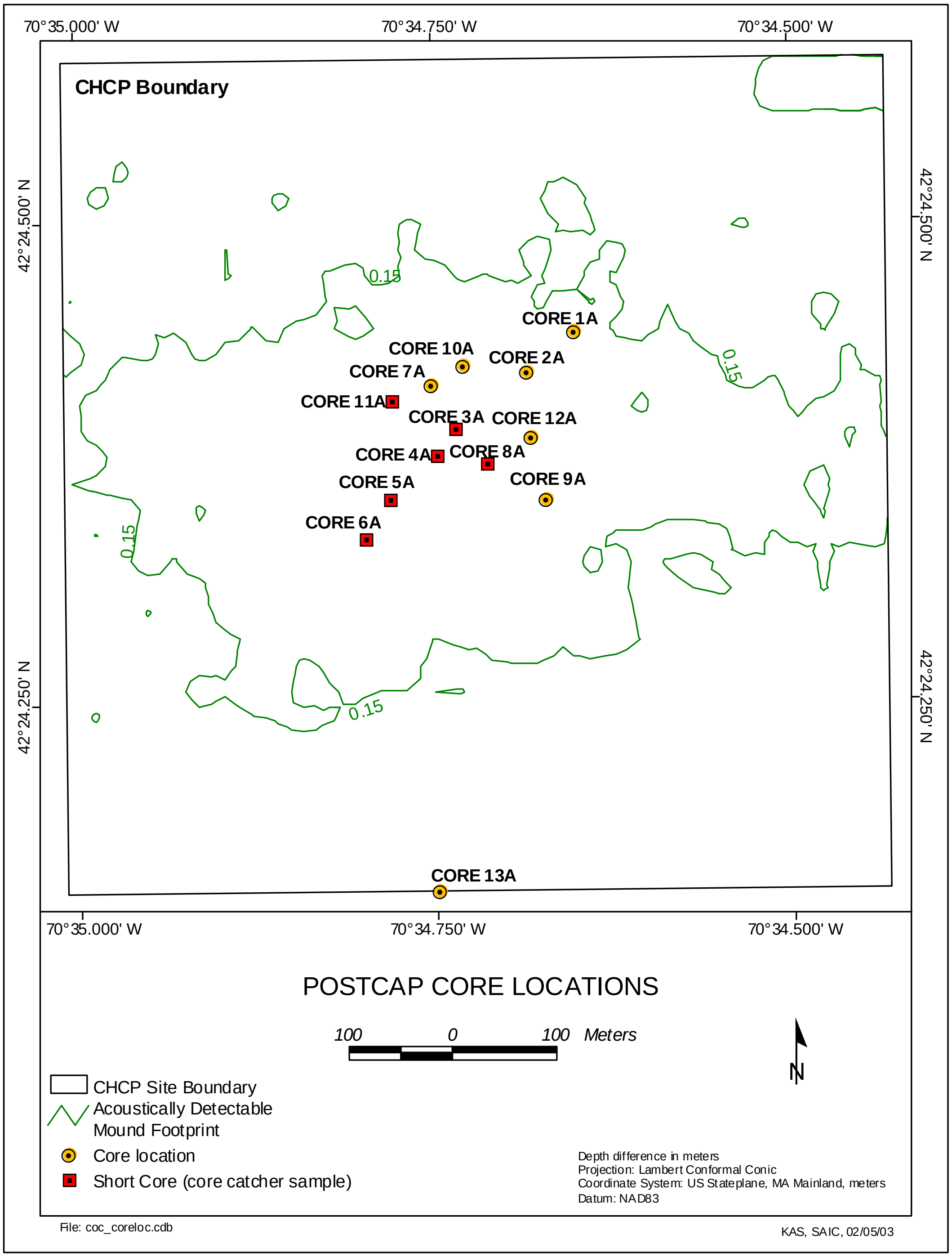


Figure 2-11. Basemap of the gravity coring stations occupied over the CHCP study area during the Postcap survey, relative to the acoustically detectable footprint of the CHCP Mound (green)

Table 2-5. Postcap Gravity Core Locations at the CHCP Study Area

Area	Station	Latitude (NAD 83)	Longitude (NAD 83)
CHCP Study Area	**CHCP 1A**	**42° 24.506´ N**	**70° 34.652´ W**
	CHCP 2A	**42° 24.484´ N**	**70° 34.684´ W**
	CHCP 3A	42° 24.454´ N	70° 34.728´ W
	CHCP 4A	42° 24.434´ N	70° 34.752´ W
	CHCP 5A	42° 24.415´ N	70° 34.776´ W
	CHCP 6A	42° 24.389´ N	70° 34.806´ W
	CHCP 7A	**42° 24.478´ N**	**70° 34.752´ W**
	CHCP 8A	42° 24.445´ N	70° 34.716´ W
	CHCP 9A	**42° 24.419´ N**	**70° 34.671´ W**
	CHCP 10A	**42° 24.488´ N**	**70° 34.729´ W**
	CHCP 11A	42° 24.464´ N	70° 34.782´ W
	CHCP 12A	**42° 24.451´ N**	**70° 34.682´ W**
	CHCP 13A	**42° 24.215´ N**	**70° 34.749´ W**

Bold text denotes long core sample >50 cm

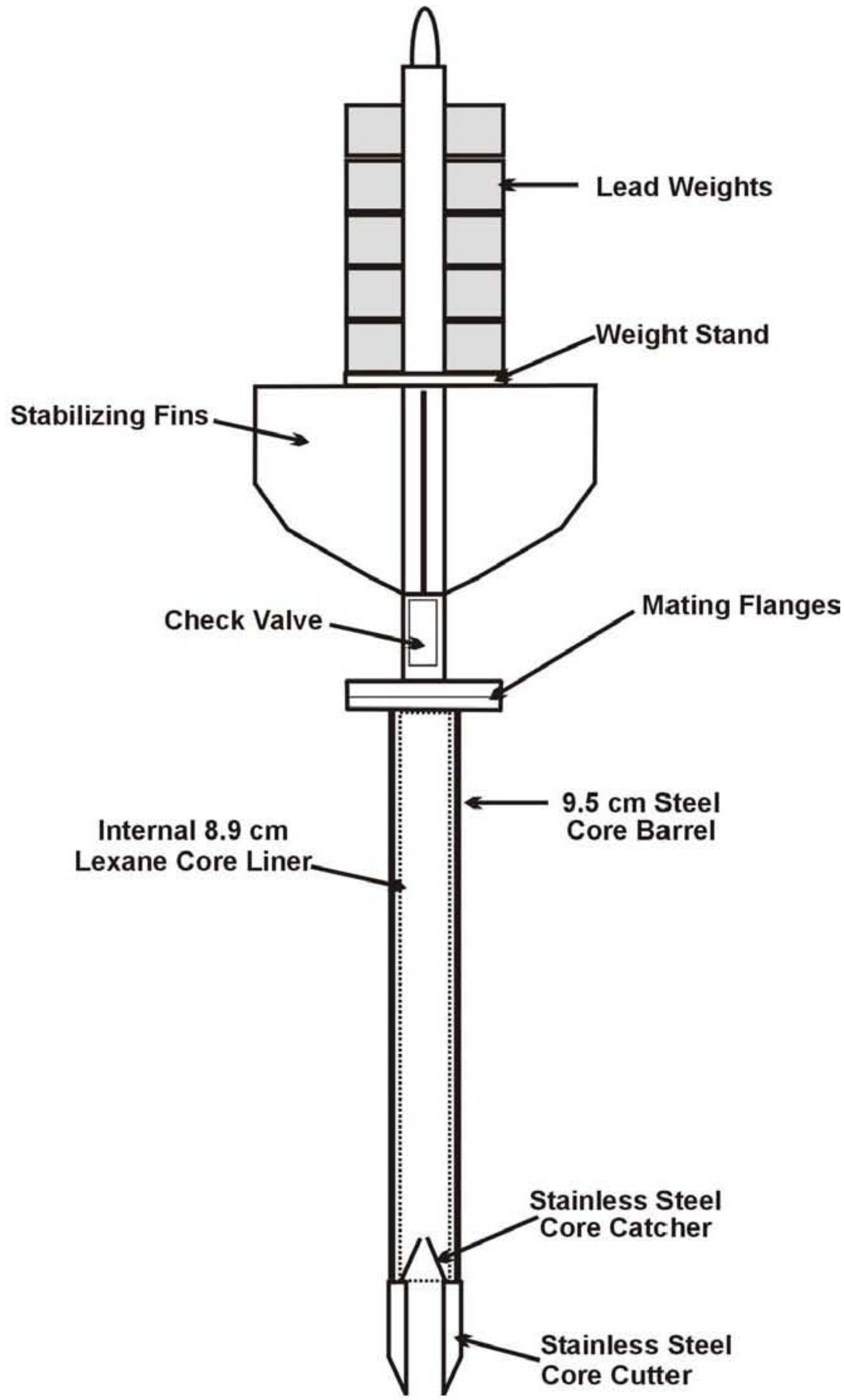


Figure 2-12. Schematic drawing of the SAIC gravity coring device employed as part of the Postcap survey efforts over the CHCP study area

However, penetration was limited over the majority of the mound based on the presence of large clumps of dense, cohesive Boston Blue Clay, as well as a fair amount of sand, gravel, and cobble comprising the cap material. Cores were cut, capped, labeled with the station identifier and stored vertically during field operations. At the conclusion of this field operation, all cores were transported to the GSO core facility and refrigerated at 4°C until analyzed.

2.3.7.2 Sediment Core Processing and Sampling

Postcap cores were processed from October 23 to 24, 2000, at the URI GSO Marine Geological Sampling Laboratory. The same standard operating procedure was utilized for Postcap cores as was described for Cohasset Harbor vibracores. Sub-samples were collected for microscopic and grain size analyses from each gravity core recovered from the CHCP mound. In accordance with the same sampling methods utilized in the processing of the Cohasset Harbor cores (Section 2.1.3), sampling intervals were collected based on core stratigraphy, homogenized and stored in appropriate containers. The microscopic samples were preserved in a buffered formalin solution, while grain size samples were stored at 4°C until analyzed.

2.3.7.3 Sediment Core Sample Analyses

Grain Size Analysis

Grain size analysis was conducted using the same modified ASTM Method D422-63 employed as part of the harbor sediment characterization, Baseline, and Precap surveys, and described in Section 2.1.4. Upon receiving the results, the data were subjected to a qualitative review and evaluation of compatibility with visual descriptions, as well as overall accuracy. Intercomparison between the four data sets (harbor characterization, CHCP Baseline, CHCP Precap, and CHCP Postcap) yielded the anticipated results for each of the respective monitoring surveys and conformed to visual descriptions.

Microscopic Analysis/Sediment Tracers

Sediment samples were collected for microscopic analysis for tracers in the event distinctions between the UDM and CDM were not evident from the other survey methods. Based on the differences in the composition of the project UDM and CDM, the tracer samples from the cores were not analyzed but were archived for possible future use.

2.4 Chelsea River Sediment Characterization

In the spring of 1999, the sediment to be removed in Chelsea River as part of the improvement dredging operations was selected to be the capping material to be used in the Massachusetts Bay Disposal Site Capping Demonstration Project. The lower reaches of the federal channel in the Chelsea River were sampled in June 1999 to characterize the in-place sediments in order to facilitate tracking the CDM deposit in the CHCP study area (Figure 2-13, Table 2-6).

2.4.1 Core Collection

Four gravity cores were collected from five stations established in the Chelsea River using the 3 m, steel core barrel gravity coring device described in Section 2.3.7. The presence of coarse sediment (granule and pebble) over dense, dry Boston Blue Clay prevented deep penetration of the corer into the riverbed, with no measurable sample obtained at one of the stations (CH-5).

Upon retrieval, all cores were allowed to consolidate for two hours before being cut, capped, taped to minimize water loss, and labeled with station name, identification number, and top/bottom descriptors. The cores were stored vertically and relocated to a refrigerated storage facility at GSO for later analysis.

2.4.2 Sediment Core Processing and Sampling

On July 30, 1999, one core from the Chelsea River (CR-1) was split, photographed, and described according to the standard procedures described under core processing (Section 2.1.3). The three short cores, less the 50 cm in length, were split manually. The cores were photographed and described, however the cores where not placed in the standard cradles for digital imagery. The cores were described and sub-sampled for grain size and microscopic analyses according to the same method utilized in the Cohasset Harbor and CHCP site sediment analysis. The sampling method focused on stratigraphy and changes in apparent sediment type. Sub-samples were stored in the event analysis was requested, which could later be used for more quantitative analysis of grain size and sediment tracers if needed. Core halves were wrapped in plastic and archived at the GSO storage facility at 4°C.

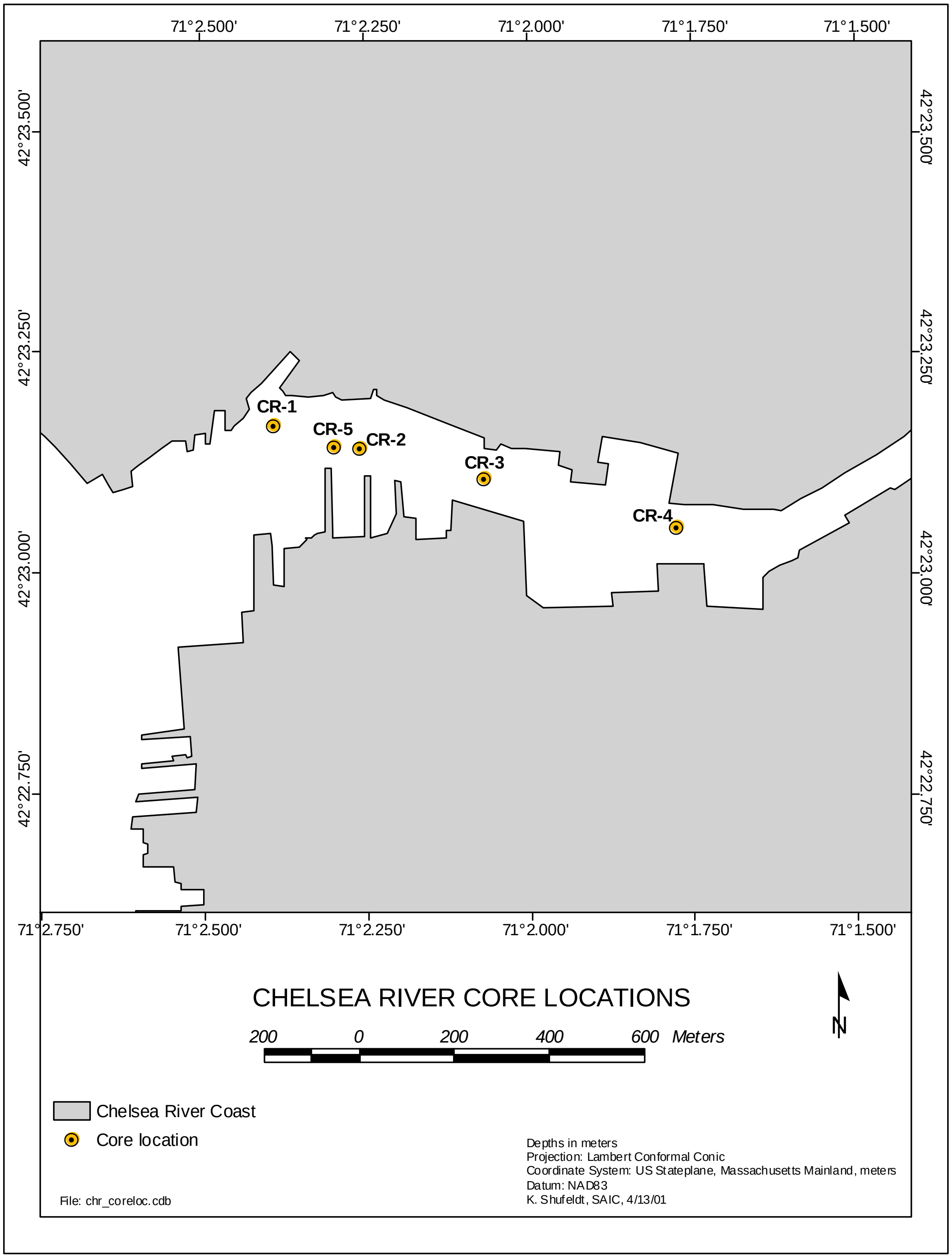


Figure 2-13. Location of gravity core samples obtained from Chelsea River as part of the CDM sediment characterization efforts

Table 2-6. Gravity Core Locations within Chelsea River for CDM Characterization

Area	Station	Latitude (NAD 83)	Longitude (NAD 83)
Chelsea River	CR-1	42° 23.177´ N	71° 02.390´ W
	CR-2	42° 23.150´ N	71° 02.260´ W
	CR-3	42° 23.116´ N	71° 02.069´ W
	CR-4	42° 23.059´ N	71° 01.775´ W
	CR-5	42° 23.153´ N	71° 02.298´ W

3.0 RESULTS

This section summarizes the results of the comprehensive survey program for the Massachusetts Bay Disposal Site Capping Demonstration Project. A total of six survey efforts were completed between July 1998 and Fall 2000 in support of this program. The results of these surveys will be presented as indicated below:

Section 3.1 Cohasset Harbor Sediment Characterization Survey
Section 3.2 September 1998 Baseline Survey
Section 3.3 Single Barge Disposal Survey
Section 3.4 Precap Survey
Section 3.5 Chelsea River (Cap Material) Sediment Characterization Survey
Section 3.6 Postcap Survey

3.1 Cohasset Harbor Sediment Characterization Study

The sediment characterization study within Cohasset Harbor was completed in two phases. A reconnaissance grab sampling survey was conducted to provide an overview of the surficial sediment characteristics and sedimentation processes within Cohasset Harbor. This survey was followed by a comprehensive vibracore collection effort to obtain detailed information regarding sediment grain size and tracer content in the underlying sediments. Visual analysis of both the surface sediment grab and core samples indicated a clear distinction between sandy entrance channel material and the organic-rich silts of Cohasset Cove. A combination of sand and silts was observed behind the breakwater on the eastern side of the main anchorage area and the area extending along Bassing Point Beach. As a result, the material within the interior portions of the harbor was selected to serve as UDM for this project. The sand from the entrance channel was excluded from the study, because the finer-grained material would be more characteristic of UDM. A summary of the geotechnical characterization of the Cohasset Harbor sediments is presented below, while detailed core descriptions have been included in Appendix B. Results pertaining to the sediment tracer analyses are presented in Appendix C.

3.1.1 Cohasset Harbor Sediment Grab Samples

Twelve reconnaissance grab samples were collected using a Young-modified van Veen grab sampler from several different regions within the harbor and entrance channel (Figure 2-1). Grab samples were visually described and sub-samples retained for detailed analysis (Table 3-1). Two grabs (CHANNEL 1 and 2) were collected from the outer reaches of the channel and consisted primarily of sand. The third channel sample (CHANNEL 3),

Table 3-1. Cohasset Harbor Reconnaissance Grab Sample Descriptions

Area	Station	Grain Size	Color	Other	Texture
Cohasset Harbor and Cohasset Cove	COCOVE 1	silty	black	H2S smell, high water content	mud
	BAILEYS 1	silty	blackish	H2S smell, high water content	mud
	BAILEYS 2	sandy silt	black	high water content	mud
	ANCHOR 1	coarser sandy silt	brownish/ olive gray	similar to Baileys 2 but more sandy	mud
	ANCHOR 2	sandy			
	ANCHOR 3	sandy	olive gray,w/ blk		mud
	CHANNEL 1	sand		dense algae mat	
	CHANNEL 2	sandy		hermit crab and some tube worms	
	CHANNEL 3	organic matter	dark	algae, irsh moss, kelp, green crab, hermit crab	very little sediment
	BREAK 1	sandy		less organic matter	less organic matter
	LANDING 1	shell		mussel shells	shell
	LANDING 2	sandy w/ shelly sed	olive gray	shelly silty sand with high water content	shelly mud

collected near the harbor entrance, consisted primarily of organic matter with a minor sand fraction. In general, the Main Anchorage area of the harbor was found to consist of a mix of sand and silt. The sample collected behind the breakwater, but inside the Main Anchorage Area (BREAK 1), indicated the presence of a transition zone where sand was again apparent with some organic matter present. However, the organic material did not dominate the sample as in the Channel 3 sample. The sample collected from Cohasset Cove (COCOVE 1) was dominated by silt with a strong sulfide odor. The surface sediment collected within Bailey's Creek (BAILEYS 1 and 2) was very similar to the cove material, dominated by dark silts with high water content and a strong sulfide odor. The samples collected near the town landing (LANDING 1 and 2) were unique in that they were composed primarily of mussel shells and a small sand fraction.

3.1.2 Cohasset Harbor Sediment Vibracores

Twenty-four cores were collected from various locations within Cohasset Harbor to provide a cross-section of the sediments to be removed as part of the 1998 dredging activity (Figure 2-2). A total of 60 sediment sub-samples were obtained from the cores for both grain size and microscopic analyses. Sub-samples were prepared from material from various depth intervals within the cores that corresponded to approximate depth of dredging and allowable overdepth. Any samples collected below the allowable overdepth were archived in the event future analysis was required. The core descriptions provided below were based on visual analysis corresponding with the collection of sediment sub-samples. The cores contained distinct lithological units, with surface sediments similar to those analyzed in the reconnaissance grab samples collected in July 1998.

The core results are presented in Appendix B with reference to the dredging areas within the harbor as identified by NAE. Overall, each region of the harbor area contained distinct sediment characteristics. The harbor sediments were primarily comprised of fine sand ($<$0.42-0.074 mm) and silt-clay (fine-grained; $<$0.42 mm) with the actual percentages of the sand and silt-clay fractions dependent upon the area in which the sample was collected. Small quantities of medium to coarse sand, gravel, and cobble were also present in the Cohasset Harbor sediment.

3.2 CHCP Baseline Survey

The purpose of the Baseline study was to define the seafloor topography and determine the ambient sediment characteristics in the placement area prior to disposal activities. All survey activity in support of this project was confined to the 0.64 km^2 area of seafloor identified as the CHCP study area within MBDS.

3.2.1 Single Beam Bathymetry

The Baseline bathymetric survey over the 800 × 800 m CHCP study area revealed an even, gently sloping seafloor (Figure 3-1). The depth varied slightly over the survey area, sloping from the west to the east from 86 to 87.5 m. The Baseline survey was later used as the basis for depth difference comparisons between sequential bathymetric surveys completed to document dredged material accumulation and capped mound development.

3.2.2 Side-Scan Sonar

Two side-scan sonar surveys, one oriented east-west and the other north-south, were conducted over the CHCP study area. Both surveys achieved 200% side-scan bottom coverage over the survey area and the sonar images of the seafloor produced by each survey were very similar. Within the 800 × 800 m survey area, weak-sonar return characterized most of the region indicating fine-grained sediments. The side-scan data identified areas of seafloor that displayed distinct grain size differences in contrast to the ambient seafloor. These differences were attributed to a few historic dredged material disposal events within the CHCP study area. Survey lane North-South 13 (Figure 3-2) illustrates a series of disposal material deposits that are oriented to the west and east of the CHCP buoy. This figure also illustrates the presence of what appear to be trawl lines, suggesting the seafloor has been subjected to fishing activities. This same series of sediment deposits appear in Figure 3-3, which is a composite image of East-West lanes 7, 9, and 11. This figure shows that the suspected historical dredged material deposits occur both to the east and west of the CHCP buoy.

3.2.3 REMOTS® Sediment Profile Imaging

The purpose of the Baseline REMOTS® survey was to examine the composition of the surficial sediments within the CHCP study area prior to disposal activities. A complete set of REMOTS® image analysis results appears in Appendix D1. Results for the baseline survey stations at CHCP are summarized in Table 3-2.

The sediments were predominately soft, fine-grained, tan silt with little variation between replicates, indicative of ambient sediments (Figure 3-4). A major modal grain size of >4 phi was calculated for all 33 stations (Table 3-2). Wiper streaks were often present on the prism surface due to the presence of clumps of gray clay, at the sediment surface. The material was unconsolidated, resulting in over-penetration at some stations. Mean camera penetration measurements for the majority of baseline stations reflected the unconsolidated nature of the sediment. Values were relatively high, with the shallowest penetration (13.17 cm) at Station 200S and the deepest penetration (19 cm) at Stations 100N and 100E (average of 16.48 cm; Table 3-2).

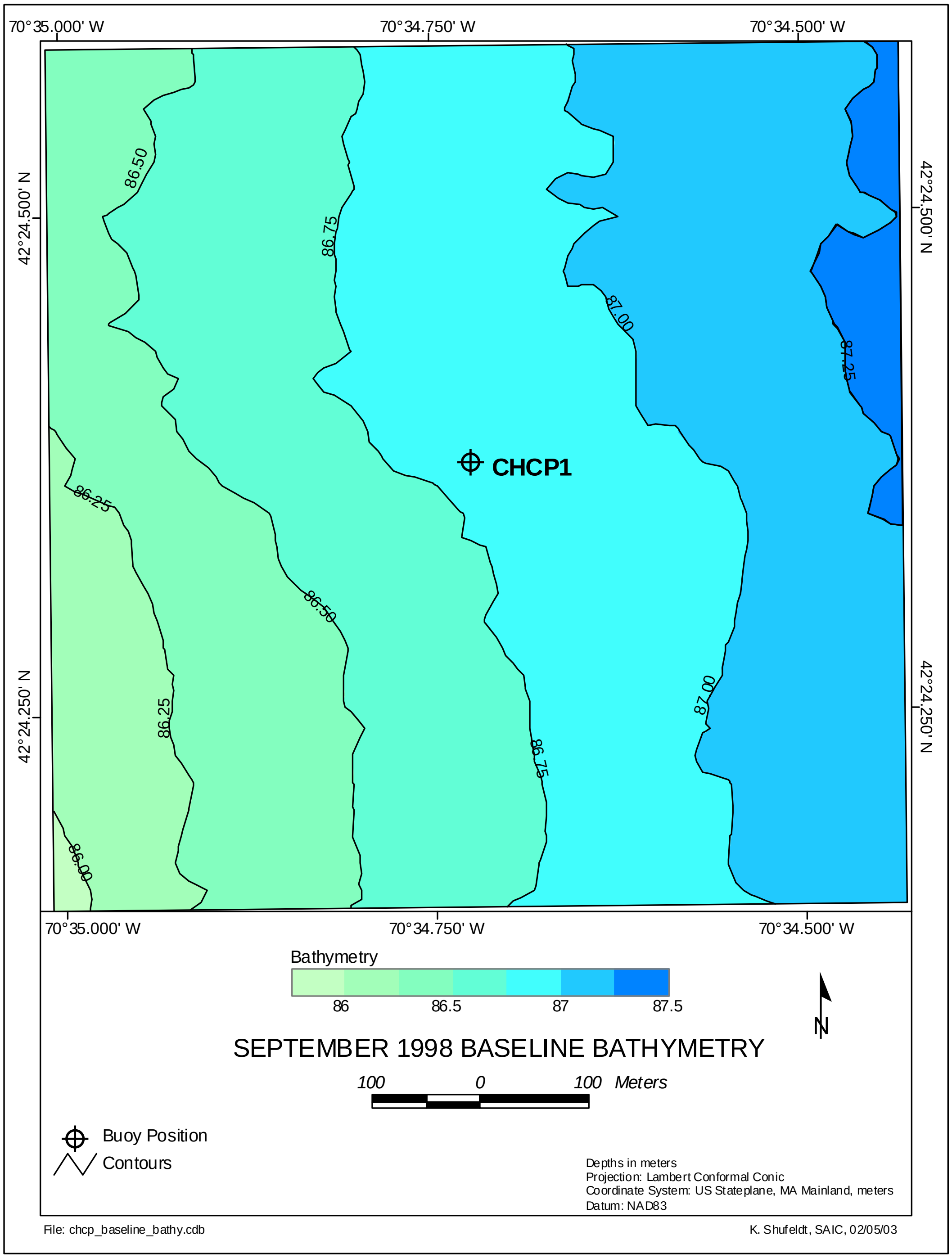


Figure 3-1. Bathymetric chart of the 800 × 800 m CHCP study area during the September 1998 Baseline survey, 0.25 m contour interval

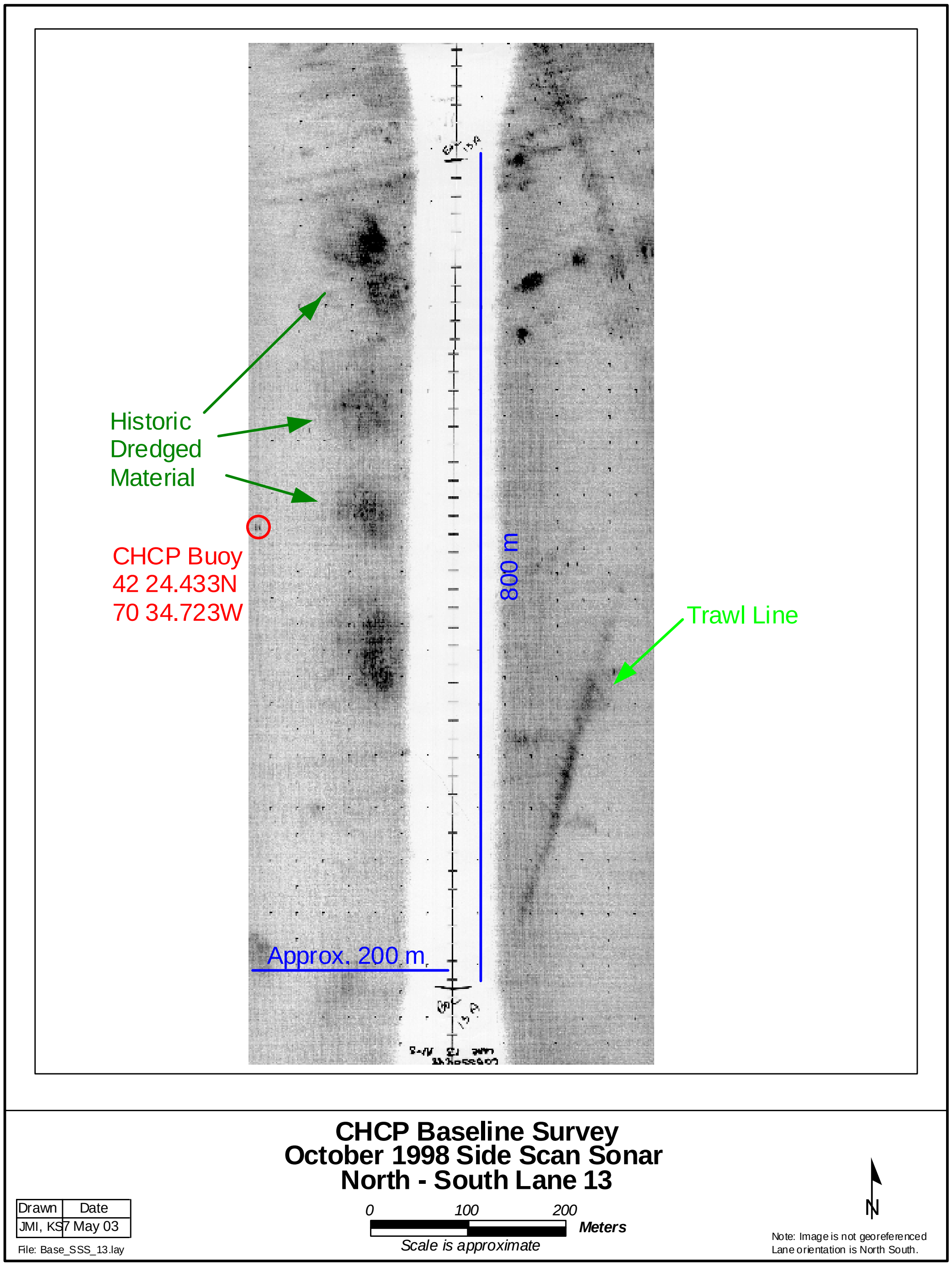


Figure 3-2. Uncorrected side-scan sonar image from North-South Lane 13 during the baseline survey performed over the CHCP study area showing evidence of historic dredged material disposal

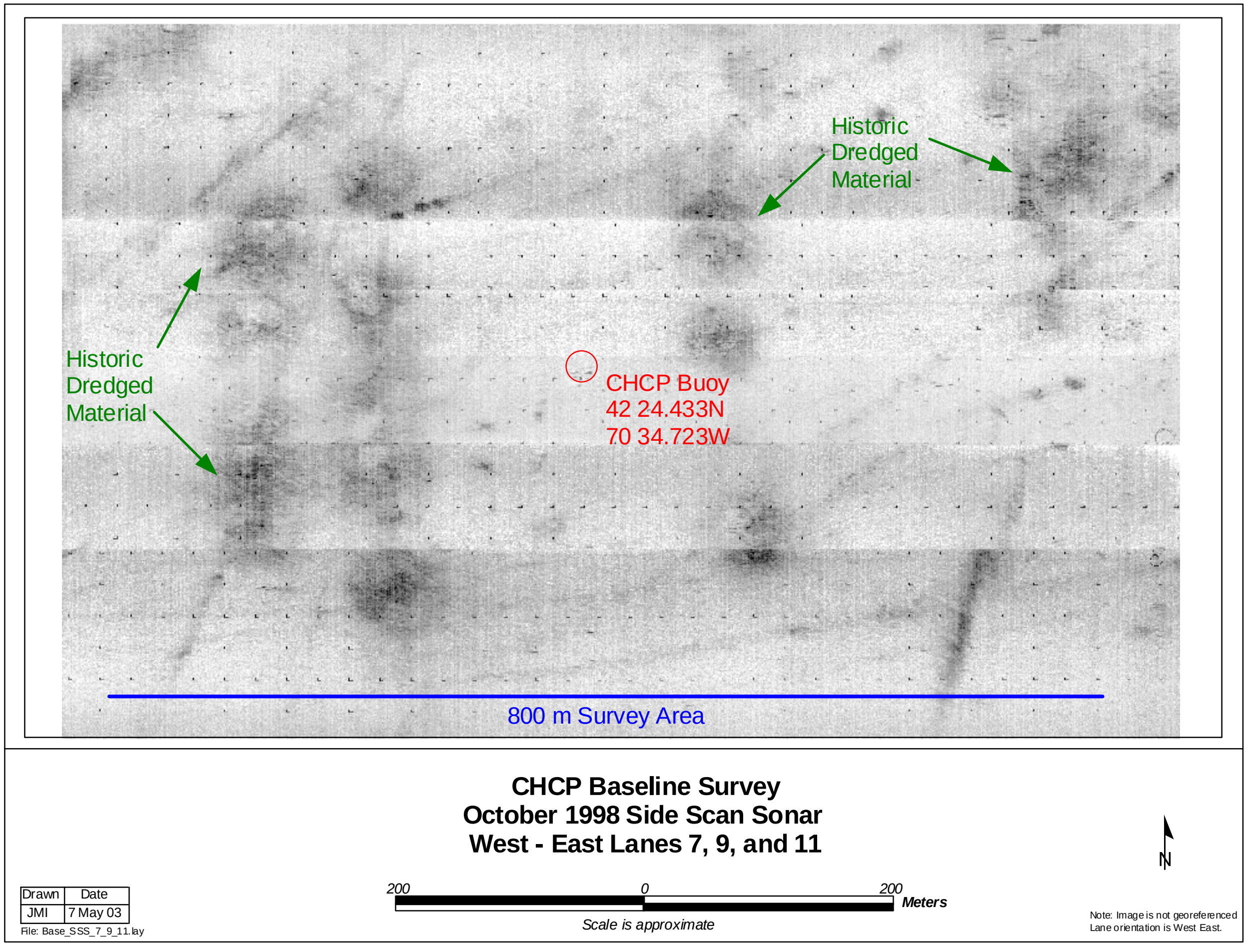


Figure 3-3. Composite image of side-scan sonar data collected from East-West Lanes 7, 9, and 11 over the CHCP study area showing similar results to those of North-South Lane 13 for historic dredged material distribution in the area

Table 3-2. Summary of REMOTS® Results for the Baseline Survey over the CHCP Study Area

Station	Camera Penetration Mean (cm)	Grain Size Major Mode (phi)	Sediment Color	Sediment Description
CTR	17.88	>4	Tan	silt
50N	17.67	>4	Tan	silt
50NE	17.0	>4	Tan	silt
50E	14.67	>4	Tan	silt
50SE	16.17	>4	Tan/Black	silt
50S	13.5	>4	Tan	silt
50SW	18.0	>4	Tan	silt
50W	14.5	>4	Tan	silt
50NW	13.83	>4	Tan	silt
100N	19.0	>4	Tan	silt
100NE	15.5	>4	Tan	silt
100E	19.0	>4	Tan	silt
100SE	15.67	>4	Tan	silt
100S	16.25	>4	Tan	silt
100SW	16.67	>4	Tan	silt
100W	17.33	>4	Tan/Yellowish Tan	silt
100NW	15.17	>4	Tan	silt
200N	14.67	>4	Tan	silt
200NE	17.63	>4	Tan	silt
200E	17.25	>4	Tan	silt
200SE	18.5	>4	Tan	silt
200S	13.17	>4	Tan	silt
200SW	15.33	>4	Tan	silt
200W	13.67	>4	Tan	silt
*200NW	18.5	>4	Tan	silt
300N	18.33	>4	Tan	silt
300NE	17.33	>4	Tan/Grey	silt
300E	16.17	>4	Tan	silt
300SE	16.17	>4	Tan	silt
300S	18.5	>4	Tan	silt
300SW	16.0	>4	Tan	silt
300W	18.0	>4	Tan	silt
*300NW	16.67	>4	Tan	silt

* indicates historic dredged material present

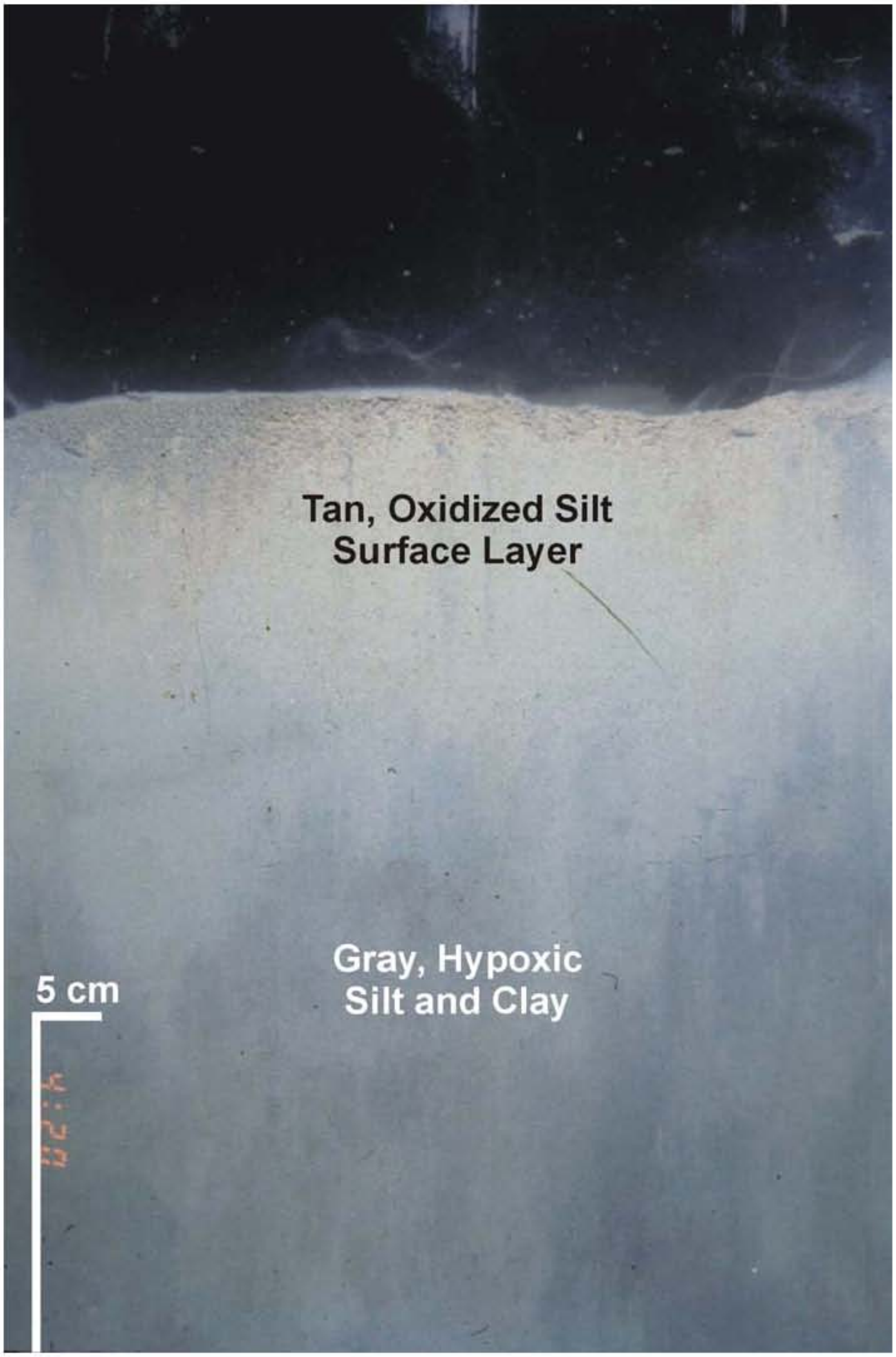


Figure 3-4. REMOTS® image collected from Station 200N during the Baseline survey performed over the CHCP study area showing soft, fine-grained tan silt (>4 phi), which characterized the ambient sediments detected at most stations within the Baseline survey grid

Ambient sediments were detected at the majority of the stations sampled during the Baseline survey. However, historic dredged material was evident in single replicates obtained from Stations 200NW and 300NW (Figure 3-5). The surface sediments in these replicate images displayed chaotic fabric material and the presence of Boston Blue Clay throughout the subsurface sediments (Figure 3-6A). It is likely that the apparent dredged material identified at these stations originated from the historic placement events indicated in the side-scan sonar data. An overlay of the REMOTS® survey stations and side scan sonar mosaic indicates several of the sampling locations were located in close proximity to historic dredged material deposit (200W, 200SW, 200SE, 100E, 100SE), while only Stations 200NW and 300NW displayed visual evidence of dredged material in the surficial sediment layers (Figure 3-5). If dredged material does exist at these other stations, the surface sediments may have been subjected to intense biological reworking by the resident benthos, stripping them of the original organic load, and making them indistinguishable from ambient material through visual inspection (Figures 3-6A & B).

3.2.4 Sediment Grab Samples

Thirteen grab samples were collected using a Young-modified van Veen grab sampler (Figure 2-10). All grabs were described and sub-sampled for grain size and microscopic analyses. Five of the 13 samples were subjected to full analysis while the remaining eight samples were archived in the event future analysis is required.

Ambient material was observed in the Baseline grab samples consisting of soft, wet olive-gray silty clay (Table 3-3). Surface tube mats, worms, and scattered shell fragments were observed in many of the samples. Several grab samples yielded sediment that was mottled in color, ranging from gray-brown to black and contained woodchips, twigs, and plant fibers indicating the possibility of historic dredged material near the survey area.

An overlay of the grab sample results with side-scan sonar indicates that most samples appear to have been collected over areas comprised of ambient sediments, with the possible exception of 200W (Figure 3-7). The spatial data suggests Station 200W was situated in close proximity to the historic dredged material deposit. Although the sediments recovered from 200W displayed the same general composition as those collected from the remaining stations, the presence of a single rock within the sediment matrix may be the only remaining visual evidence of non-ambient sediment input at this station prior to the baseline survey effort (Table 3-3).

Grain size analysis was conducted on five grab samples collected from the CHCP study area (CTR, 200N, 200S, 200E, and 200W). All five samples contained at least 91% fines (silt and clay <0.074 mm). The sand content ranged from 2% to 9%, with the majority

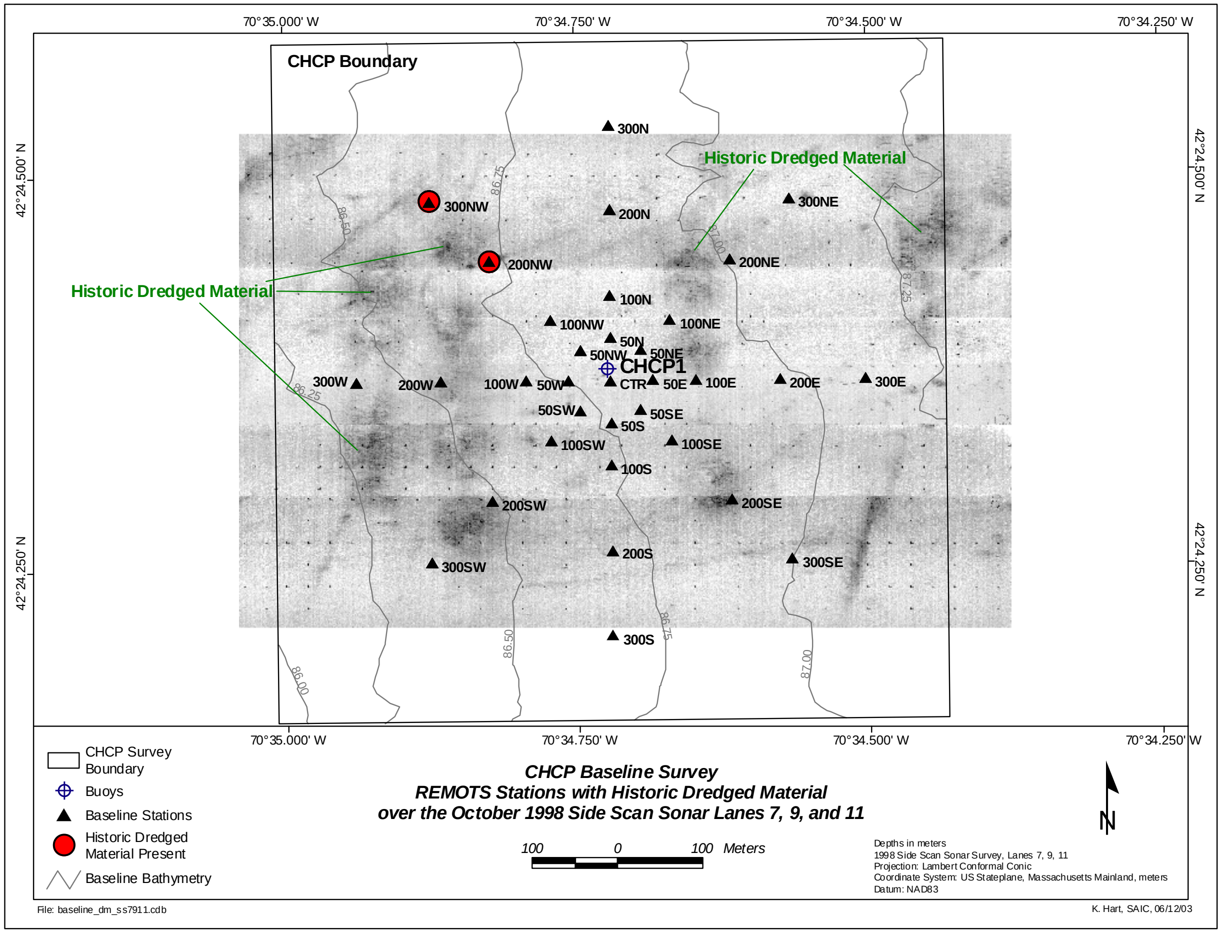
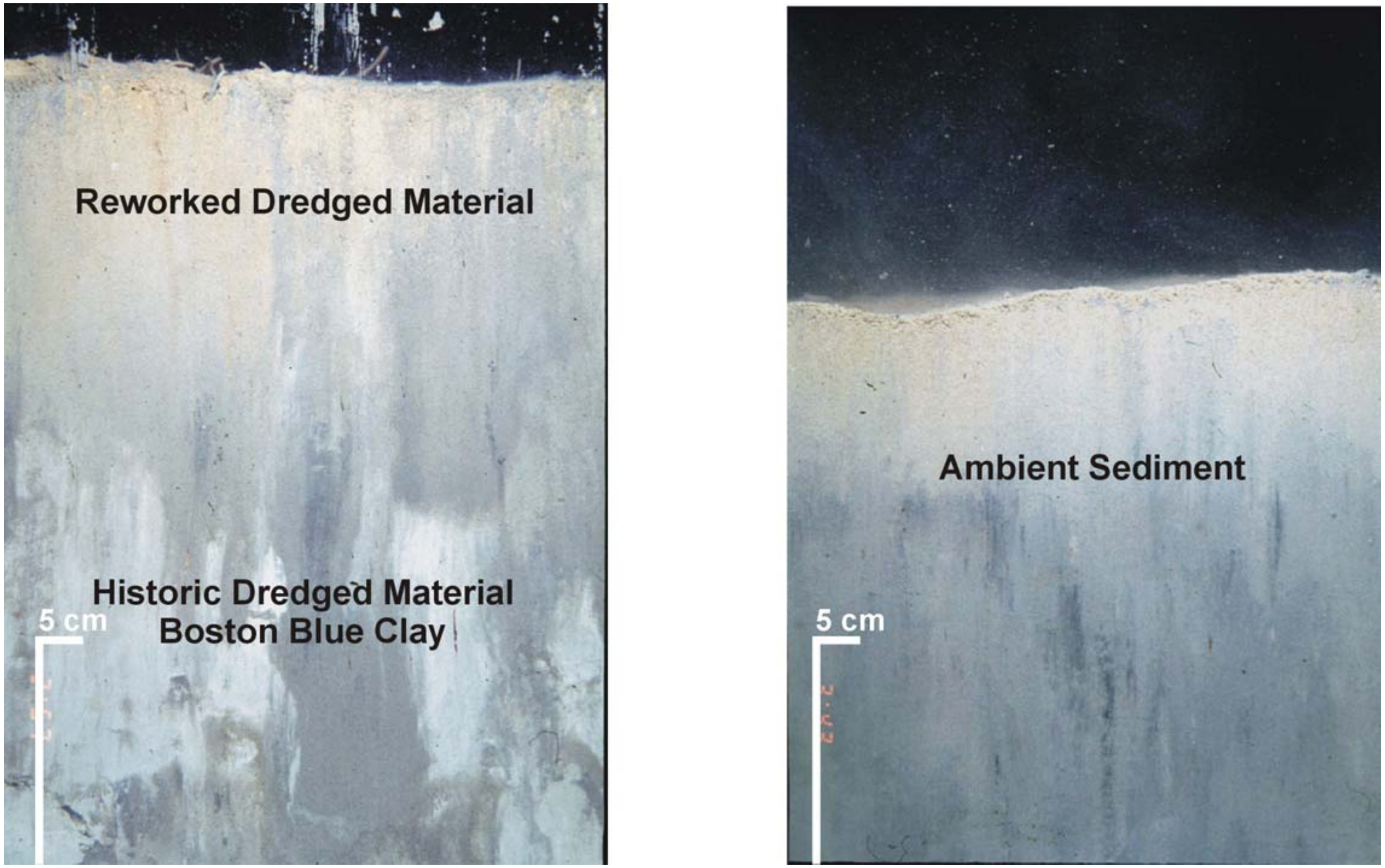


Figure 3-5. Map of the CHCP study area showing the spatial distribution of historic dredged material detected by REMOTS® during the Baseline survey, relative to side scan sonar results



A **B**

Figure 3-6. REMOTS® images collected from Station 300NW (A) displaying characteristics of historic dredged material in contrast to Station 50E (B) with ambient sediment observed during the Baseline survey. Station 300 NW displays historic dredged material in the form of high reflectance clay (Boston Blue Clay) at depth, while Station 50E depicts ambient sediment devoid of dredged material

Table 3-3. Grab Sample Descriptions for the Baseline Survey

Grab Station	Grain Size	Color	Consistency	Other
300N	silty clay	olive gray	wet, soft, smooth	no odor, no rocks
200N	silty clay	olive gray	wet, soft, smooth	stick, worm, starfish
100N	silty clay	olive gray	wet, soft, smooth	worm
CTR	silty clay	olive gray	wet, soft, smooth	tubes, bivalves
100S	silty clay	olive gray-brn	wet, soft, smooth	shell fragments, tubes
200S	silty clay	olive gray;some blk	wet, soft, smooth	worm, tube, woodchip
300S	silty clay	olive gray;w/ blk & brn	wet, soft, smooth	tubemats
300E	silty clay	olive gray	wet, soft, smooth	decomposed brown stuff & tubes
200E	silty clay	olive gray	wet, soft, smooth	tubes, slightly open grab very watery
100E	silty clay	olive gray; blk & brn mottling	wet, soft, smooth	small shell frag. tubes
100W	silty clay	olive gray; blk & brn mottling	wet, soft, smooth	starfish, shell frag, sea cucumber
200W	silty clay	olive gray	wet, soft, smooth	shell fragments, tubes, a rock & worms
300W	silty clay	olive gray	wet, soft, smooth	starfish, tubes

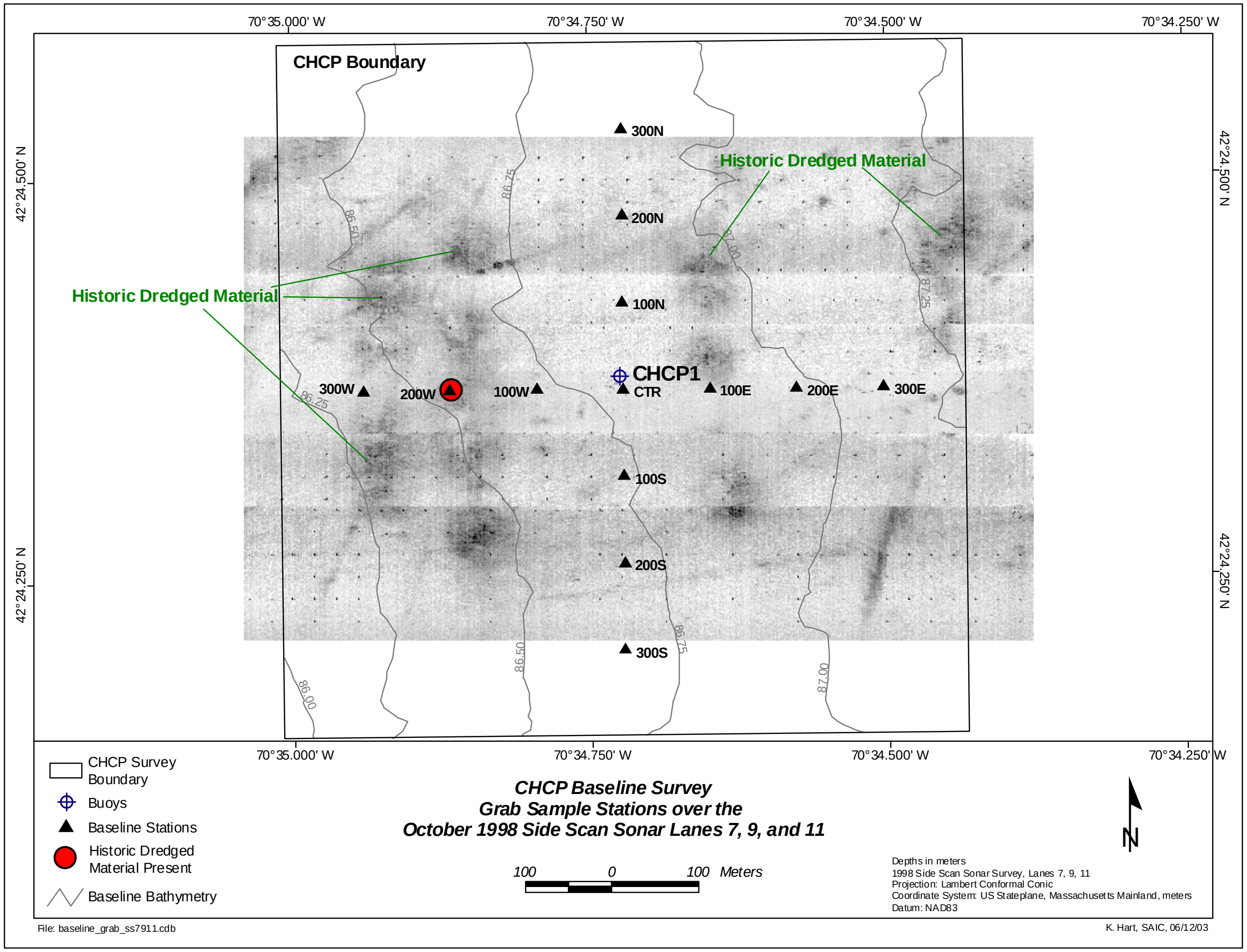


Figure 3-7. Map of the CHCP study area showing the spatial distribution of historic dredged material as detected by sediment grab sampling during the baseline survey, relative to side scan sonar results

of the sand fraction consisting of fine-grained sand (0.42- 0.074 mm). Coarse sand and gravel was not detected in any of the samples (Table 3-4). The total sand content comprised only 4% of the average sample.

The grain size data from Station 200W indicates a minor difference in overall sediment composition relative to the other sediments analyzed. Both medium (2-0.42 mm) and fine (0.42-0.074 mm) content are slightly higher at 200W and may be attributed to the influence of historic dredged material at this station (Table 3-4).

3.3 CHCP Single-Barge Disposal Survey

In order to study the physical processes and behavior of dredged material disposed through 85 to 90 m of water, a series of surveys including precision bathymetry, side-scan sonar, and REMOTS® sediment-profile photography were conducted following the disposal of a single-barge load of sediment on 1 December 1998. The barge contained an estimated volume of 1,150 m^3 (1,500 cy^3) of UDM from Cohasset Harbor, which was deposited approximately 100 m northwest of the CHCP buoy, according to the disposal logs and ADISS data. Using the various monitoring techniques, the fresh dredged material was located and measured to determine the thickness and areal extent of the sediment deposit.

In addition to the CHCP Single-Barge deposit, this survey documented the presence of a second deposit to the south-southeast of the buoy that was not present during the Baseline survey. The results of the Single-Barge survey suggest that this small mound consisted of Boston Blue Clay originating from Boston Harbor. The material was most likely placed by a large ($\sim$5,350 m^3 [7,000 cy]), split-hull barge, and was intended for disposal at the MBDA buoy to the north of CHCP.

3.3.1 Single-Barge Disposal Surveillance Data (ADISS)

The details of the Single-Barge disposal event were documented using ADISS and are depicted in Figure 3-8 (ADISS trip #70). This figure shows the barge transit data and location of the disposal event, indicated by the red triangle northwest of the CHCP buoy. The dredging area inset included in Figure 3-8 also provides the barge loading position within the Main Anchorage dredging area (black triangle). This area of the Main Anchorage was best characterized by Core CO-14, with grain size analysis indicating a sediment type of sandy silt. Survey activity at CHCP study area commenced on 12 December 1998, as dredging of the harbor and channel continued. During the CHCP Single-Barge survey activities, dredged material was sent to the MBDA buoy.

Table 3-4. Grain Size Distribution for Grab Samples Collected as part of the Baseline Survey

Sample ID	% Cobble >75mm	% Gravel <75-4.76mm	% Coarse Sand <4.76-2mm	% Medium Sand <2-0.42mm	% Fine Sand <0.42-0.074mm	Total Sand	% Silt Clay <0.074mm
CTR	0	0	0	1	3	**4**	96
200N	0	0	0	1	2	**3**	97
200E	0	0	0	1	3	**4**	96
200S	0	0	0	1	2	**3**	97
200W	0	0	0	3	6	**9**	91
Average	**0**	**0**	**0**	**1**	**3**	**5**	**95**

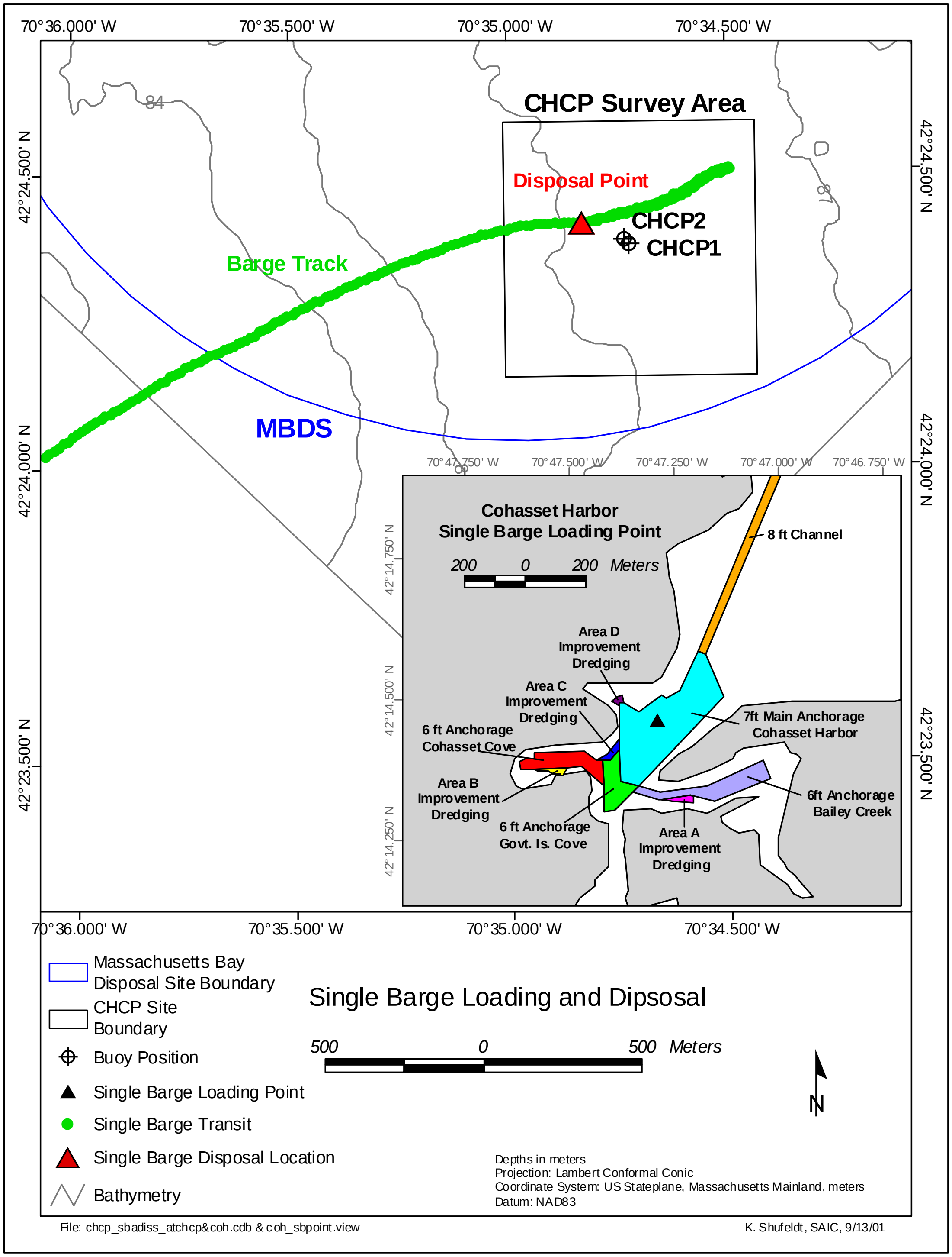


Figure 3-8. Graphic showing the barge track and disposal location of the first load of sediment transported from Cohasset Harbor and deposited at the CHCP buoy

3.3.2 Single Beam Bathymetry

The 800 × 800 m bathymetry survey performed over the CHCP study area in December 1998 indicated a slight change in seafloor topography, relative to the September 1998 Baseline survey (Figure 3-9). Water depths did not reflect any major changes as a minimum depth of 86.0 m was detected along the western margin of the survey area and a maximum depth of 87.25 m was measured along the eastern margin of the survey area. However, the bathymetric data indicated a change in the seafloor morphology occurred southeast of the CHCP buoy position.

Depth difference comparisons with the Baseline survey indicated the presence of a large sediment deposit 150 m south-southeast of the CHCP1 buoy, as well as a smaller accumulation of material approximately 110 m northwest (Figure 3-10). The larger deposit had a mound height of 0.2 m and a diameter 100 m. This bottom feature was likely the result of a single errant disposal of material originating from the BHNIP. The smaller bottom feature, with a maximum height of 0.1 m, corresponds well with the reported disposal position of the Single-Barge load material.

3.3.3 Side-Scan Sonar

The side-scan sonar survey was conducted to determine the spatial extent of the Single-Barge disposal event. The side-scan survey confirmed the presence of two separate sediment deposits within the 0.64 km^2 survey area. The deposits were visible in both the north-south and east-west side-scan records (Figures 3-11 and 3-12). Comparisons of these survey lane images with those from the Baseline survey further suggest that both material mounds were recently placed at the site.

The smaller, less distinct bottom feature was composed of 1,150 m^3 of sandy silt from Cohasset Harbor placed northwest of the buoy. This sediment deposit provided limited contrast with the ambient sediment in the acoustic record, as it consisted of a thin layer ($<$10 cm) of material on the seafloor with similar bulk density to the ambient sediment. The acoustic reflection was relatively weak due to the subtle relief and lack of a significant sediment density gradient (sandy silt versus soft silty clay). Overall, the location of this deposit supported the ADISS disposal location data, as it was detected very close to the reported disposal point.

The second deposit located to the southeast of the buoy had a large ellipsoid shape and appeared rather dark with a clumpy surface texture. The diameter of the second deposit based on the sonar data was about 165 m in the north-south direction and 205 m in

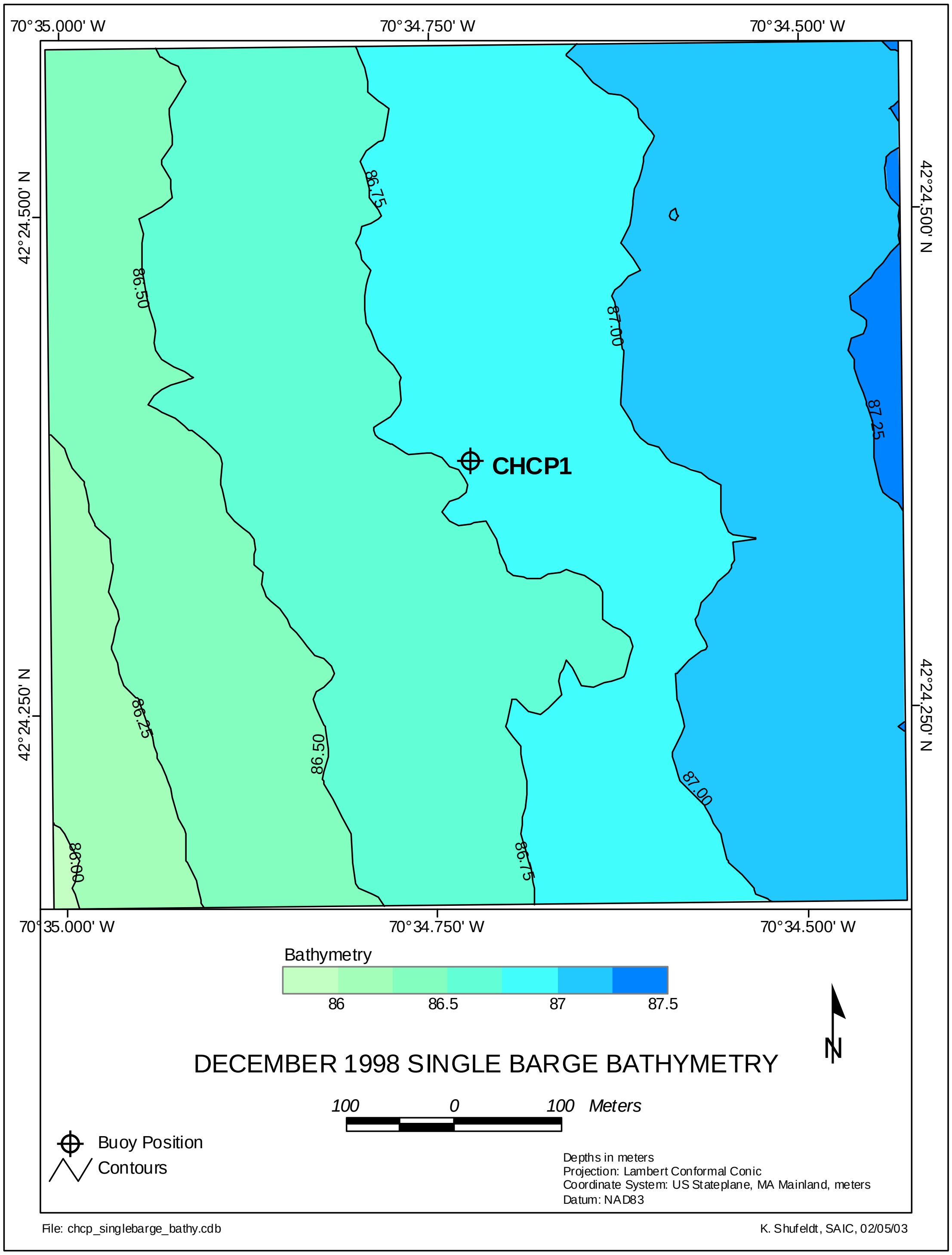


Figure 3-9. Bathymetric chart of the 800 × 800 m CHCP study area during the December 1998 Single-Barge survey, 0.25 m contour interval

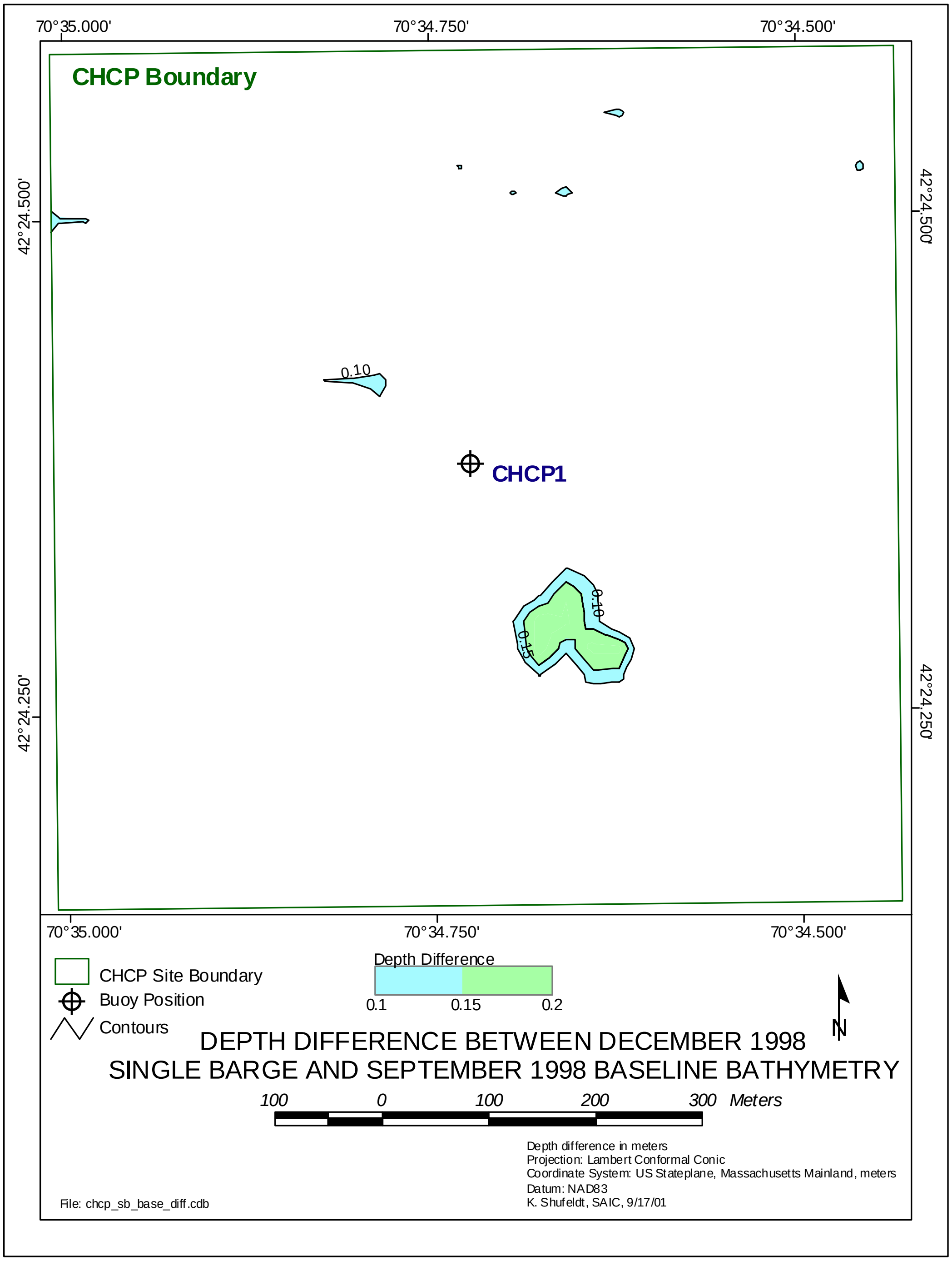


Figure 3-10. Depth difference comparisons between the December 1998 Single-Barge and September 1998 Baseline bathymetric surveys showing the accumulation of dredged material within the CHCP study area

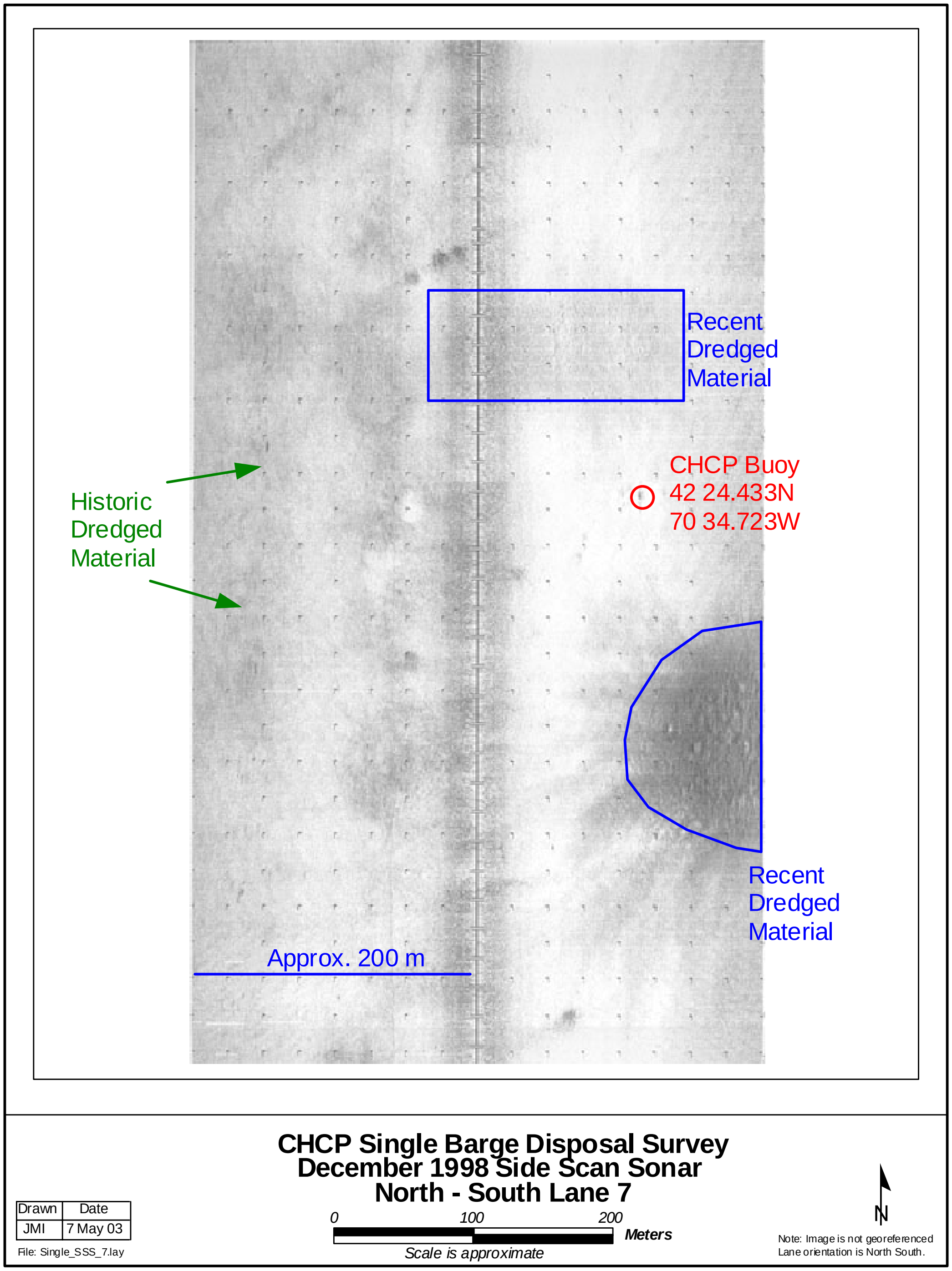


Figure 3-11. Side-scan sonar image collected from North-South Lane 7 during the December 1998 Single-Barge survey showing two areas of recent dredged material placement within the CHCP study area

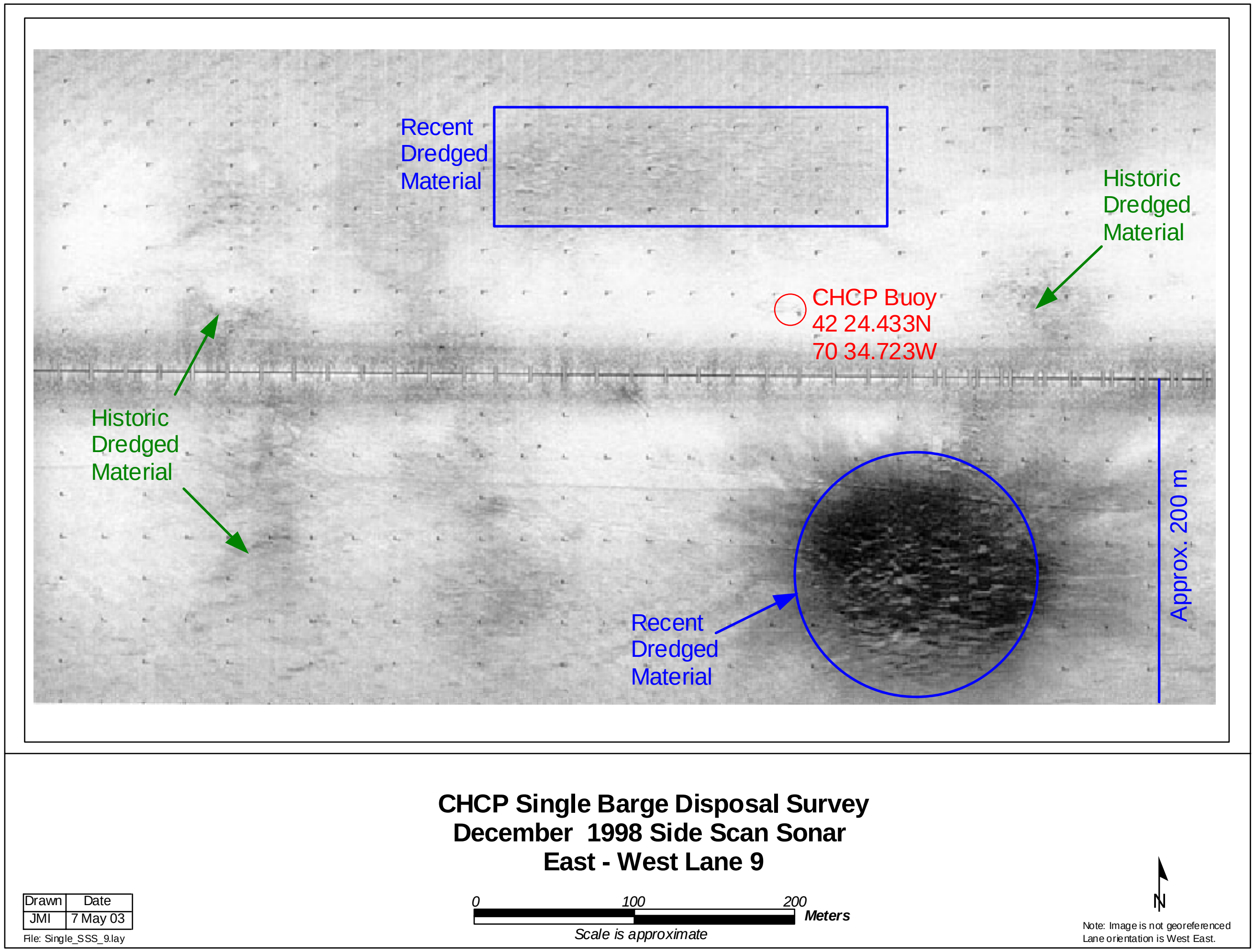


Figure 3-12. Side-scan sonar image collected from East-West Lane 9 during the December 1998 Single-Barge survey showing recent dredged material deposits relative to the CHCP buoy position

the east-west direction. This material was distinct in the side-scan record, suggesting a different composition relative to the ambient material (Figures 3-11 and 3-12). This bottom feature was believed to be the product of a relatively large load (likely from a 5,350 m^3 split-hull barge) of dense Boston Blue Clay, probably originating from improvement dredging operations in Boston Harbor. The disposal was likely intended for the MBDA buoy, but was inadvertently deposited near the CHCP buoy. The shape of the deposit and the thin apron dispersed radially around it suggest that the material was disposed from a split-hull barge as a relatively cohesive mass, swiftly falling through the water column.

3.3.4 REMOTS® Sediment-Profile Imaging

Sediment-profile imaging was used to examine the distribution and thickness of dredged material placed within the boundaries of CHCP. The Baseline primary station grid was revisited during the December 1998 survey to document the thickness and composition of Cohasset Harbor dredged material. In addition, supplemental survey grids were established over both the Single-Barge sediment deposit (secondary) and the suspected Boston Harbor (tertiary) sediment deposit (Figure 2-9B). The results of the Single-Barge survey were compared to the baseline results and served to document changes in surface sediment composition. The complete set of REMOTS® image analysis results for the Single-Barge survey of CHCP is provided in Appendix D2; these results are summarized in Tables 3-5, 3-6, and 3-7.

3.3.4.1 Primary Stations

The results of Single-Barge primary station grid were similar to those of the Baseline survey (Tables 3-2 and 3-5). Physical REMOTS® parameters suggested the surface and near surface sediment layers in the CHCP area were composed of predominately soft, fine-grained sediments (silts). A major modal grain size of >4 phi was observed at all stations as tan silt over gray silt and clay, with the exception of white clay at Stations 100E and 100S (Figure 3-13; Table 3-5). Mean camera penetration values were generally high, ranging from 9.3 cm at Station 100N to 17.5 cm at Station 50NE. These high values were attributed to the soft, unconsolidated nature of the surface sediments.

Dredged material was evident in the REMOTS® images at Stations 100N, 100E, and 100S, with replicate-averaged dredged material thicknesses of 7.7 cm, 6 cm, and 5 cm respectively (Table 3-5). The dredged material observed in Station 100N most likely originated from the Single-Barge load disposal of Cohasset Harbor material that was located to the north and west of the CHCP buoy. This dredged material consisted of tan, oxidized layer of silt on the surface over a darker, reduced silt at depth (Figure 3-14A).

Table 3-5. Summary of REMOTS® Results for the Primary Stations Occupied as part of the Single-Barge Survey over the CHCP Study Area

Station	Camera Penetration Mean (cm)	Grain Size Major Mode (phi)	Sediment Color	Sediment Description	Dredged Material Thickness Mean (cm)
50N	16.67	>4	Tan/Blk	Silt	0
50NE	17.5	>4	Tan/Blk	Silt	0
50E	17.0	>4	Tan/Blk	Silt	0
50S	16.67	>4	Tan/Blk	Silt	0
50SW	16.0	>4	Tan/Blk	Silt	0
50W	14.0	>4	Tan/Blk	Silt	0
100N	9.33	>4	Tan/Blk	Silt	7.67
100NE	17.25	>4	Tan/Blk	Silt	0
100E	12.67	>4	Wht/Tan/Blk	Silt	6.0
100S	16.33	>4	Wht/Tan/Blk	Clay	5.0
100SW	16.5	>4	Tan/Blk	Silt	0
100W	17.0	>4	Tan/Blk	Silt	0
200N	11.33	>4	Tan/Blk	Silt	0
200NE	16.5	>4	Tan/Blk	Silt	0
200E	14.33	>4	Tan/Blk	Silt	0
200S	14.0	>4	Tan/Blk	Silt	0
200SW	14.5	>4	Tan/Blk	Silt	0
200W	14.5	>4	Tan/Blk	Silt	0
300N	15.5	>4	Tan/Blk	Silt	0
300NE	15.0	>4	Tan/Blk	Silt	0
300E	15.83	>4	Tan/Blk	Silt	0
300S	15.83	>4	Tan/Blk	Silt	0
300SW	16.0	>4	Tan/Blk	Silt	0
300W	13.67	>4	Tan/Blk	Silt	0

Table 3-6. Summary of REMOTS® Results for the Secondary Stations Occupied as part of the Single-Barge Survey over the CHCP Study Area

Station	Camera Penetration Mean (cm)	Grain Size Major Mode (phi)	Sediment Color	Sediment Description	Dredged Material Thickness Mean (cm)
XCTR	14.5	>4	Tan/Blk	Silt	0
X25N	13.5	>4	Tan/Blk	Silt	0
X50N	15.25	>4	Tan/Blk	Silt	0
X75N	14.0	>4	Tan/Blk	Silt	0
X25S	14.5	>4	Tan/Blk	Silt	0
X50S	15.75	>4	Tan/Blk	Silt	0
ACTR	13.63	>4	Tan/Blk	Silt	3.0
A25N	15.83	>4	Tan/Blk	Silt	1.0
A50N	14.83	>4	Tan/Blk	Silt	0
A75N	13.0	>4	Tan/Blk	Silt	0
A25S	13.25	>4	Tan/Blk	Silt	0
A50S	15.0	>4	Tan/Blk	Silt	0.5
BCTR	12.33	>4	Chaotic-Tan/Blk	Pulp	>12.33
B25N	13.75	>4	Tan/Blk	Silt	7.75
B50N	14.25	>4	Tan/Blk	Silt	3.5
B75N	14.5	>4	Tan/Blk	Silt	0
B25S	13.5	>4	Tan/Blk	Silt	1.0
B50S	15.25	>4	Tan/Blk	Silt	0
CCTR	11.0	>4	Tan/Blk	Silt	3.0
C25N	6.5	>4	Tan/Blk	Silt	1.33
C50N	16.5	>4	Tan/Blk	Silt	0
C25S	14.5	>4	Tan/Blk	Silt	0.5
C50S	21.0	>4	Tan/Blk	Silt	0
DCTR	9.5	>4	Tan/Blk	Silt	4.25
D25N	13.17	>4	Grey/Tan/Blk	Silt	0.5
D50N	15.33	>4	Tan/Blk	Silt	4.67
D25S	12.5	>4	Tan/Blk	Silt	2.33
D50S	13.0	>4	Tan/Blk	Silt	1.67
ECTR	13.33	>4	Tan/Blk	Silt	0
E25N	13.67	>4	Tan/Blk	Silt	2.33
E50N	12.33	>4	Tan/Blk	Silt	0.33
E25S	14.0	>4	Tan/Blk	Silt	2.67
E50S	14.33	>4	Tan/Blk	Silt	0

Table 3-7. Summary of REMOTS® Results for the Tertiary Stations Occupied as part of the Single-Barge Survey over the CHCP Study Area

Station	Camera Penetration Mean (cm)	Grain Size Major Mode (phi)	Sediment Color	Sediment Description	Dredged Material Thickness Mean (cm)
CTR	11.67	>4	Wht/Tan/Blk	Clay/Silt	>8.50
80N	15.0	>4	Wht/Tan/Blk	Silt	0.67
80NE	14.5	>4	Wht/Tan/Blk	Clay	2.67
80E	15.0	>4	Wht/Tan/Blk	Silt	1.0
80SE	15.67	>4	Wht/Tan/Blk	Silt	1.0
80S	14.67	>4	Wht/Tan/Blk	Silt/Clay	3.67
80SW	12.17	>4	Wht/Tan/Blk	Silt/Clay	3.67
80W	6.33	>4	Wht/Tan/Blk	Clay	>6.33
80NW	14.83	>4	Tan/Blk	Silt	0
120N	15.33	>4	Wht/Tan/Blk	Silt	1.67
120NE	15.17	>4	Tan/Blk	Silt	0
120E	14.17	>4	Tan/Blk	Silt	0.33
120SE	14.83	>4	Tan/Blk	Silt	1.0
120S	15.17	>4	Wht/Tan/Blk	Silt	2.67
120SW	16.33	>4	Wht/Tan/Blk	Silt	1.0
120W	12.67	>4	Wht/Tan/Blk	Clay/Silt	3.33
120NW	13.83	>4	Tan/Blk	Silt	0
160N	13.83	>4	Wht/Tan/Blk	Silt	0
160NE	15.33	>4	Tan/Blk	Silt	1.0
160E	15.5	>4	Tan/Blk	Silt	0
160SE	16.17	>4	Tan/Blk	Silt	0
160S	14.0	>4	Tan/Blk	Silt	0
160SW	15.0	>4	Tan/Blk	Silt	0.67
160W	14.5	>4	Tan/Blk	Silt	0
160NW	12.83	>4	Tan/Blk	Silt	0

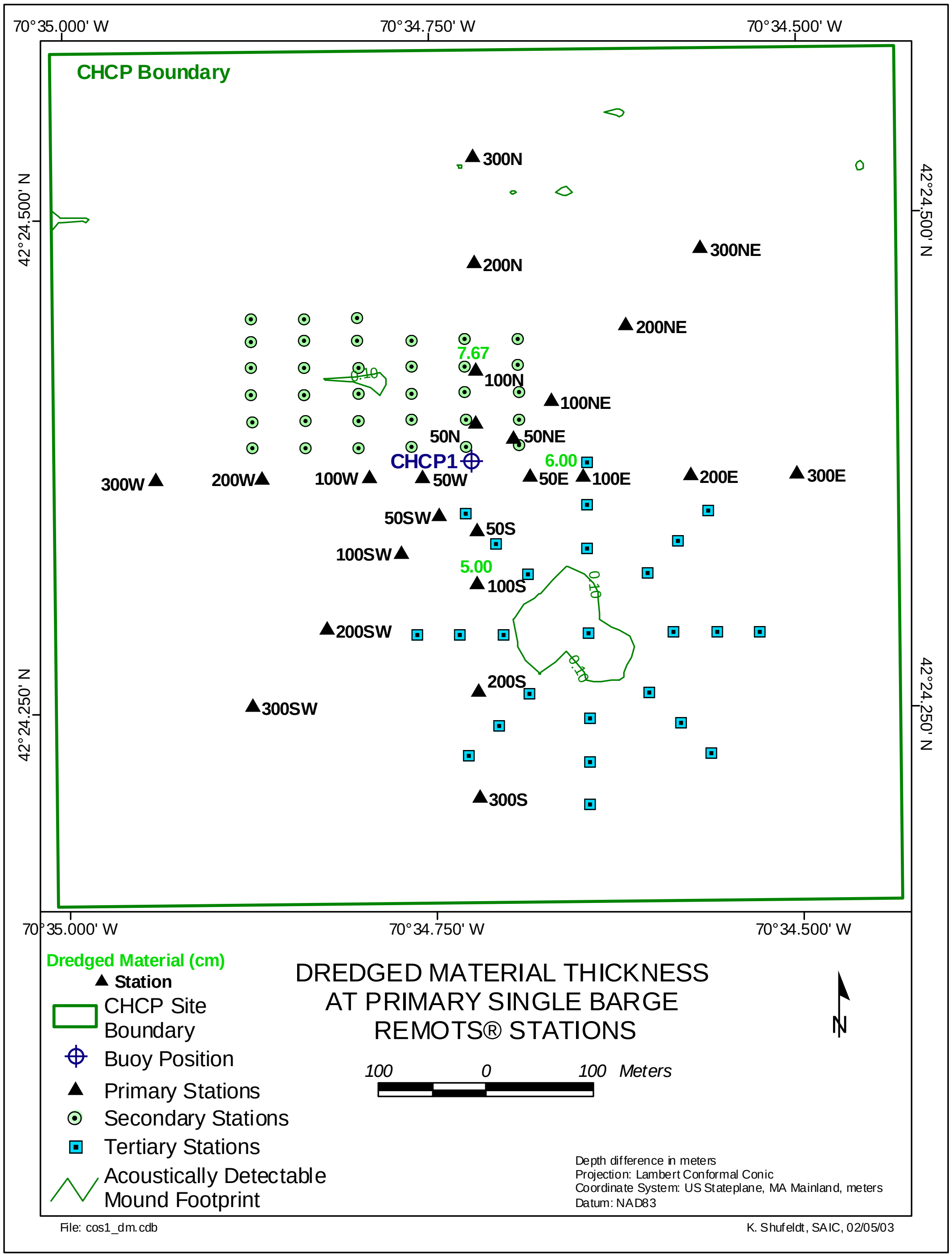
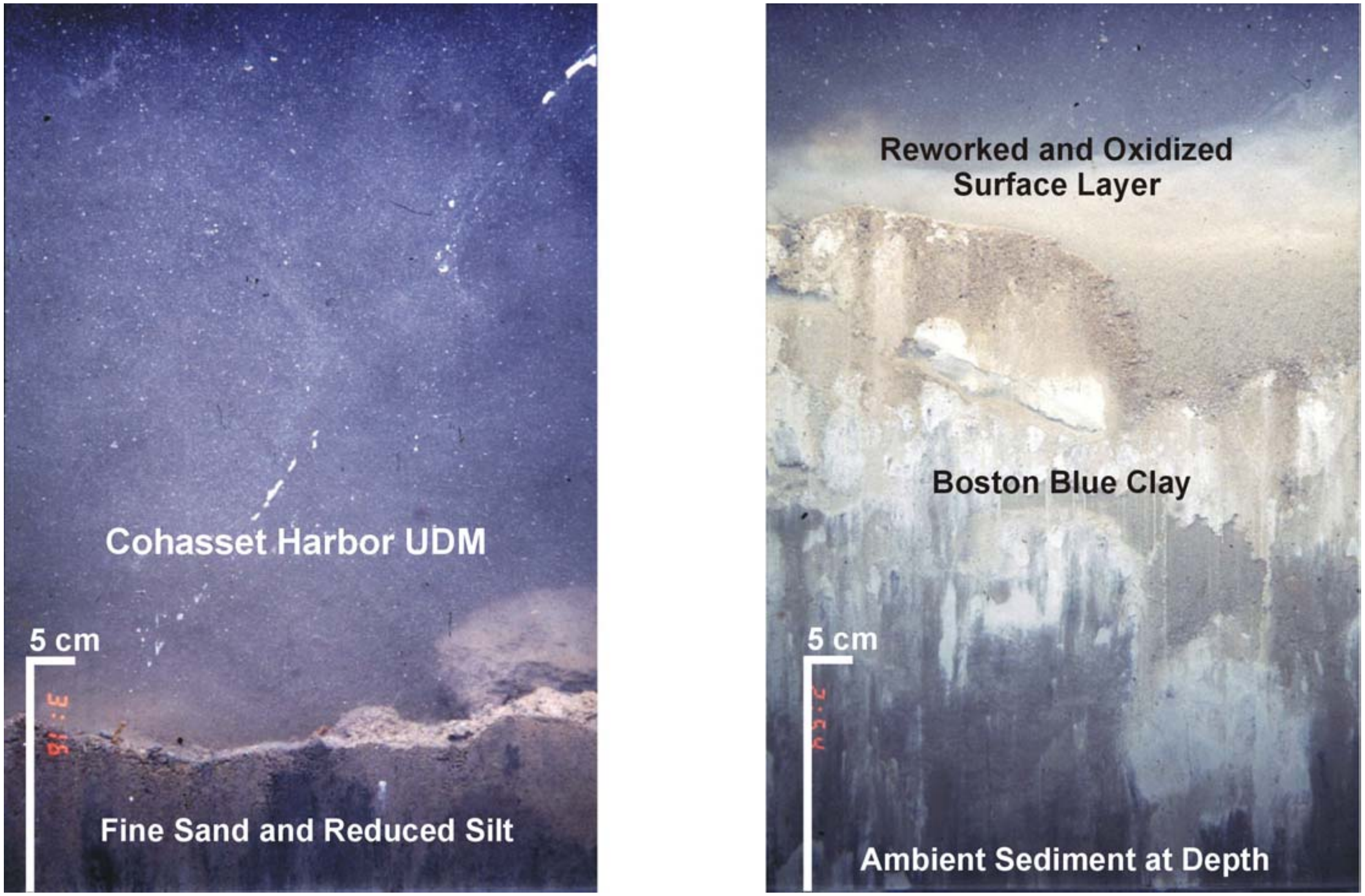


Figure 3-13. Map of the CHCP study area showing the spatial distribution and thickness of dredged material over the primary survey grid during the Single-Barge survey



A B

Figure 3-14. REMOTS® images collected from Stations 100N (A) and 100S (B) of the primary REMOTS® survey grid displaying differences in the composition of dredged material detected during the Single-Barge survey. The image from Station 100N provides an example of Cohasset Harbor UDM, while the image from 100S shows an accumulation of Boston Blue Clay resulting from the errant disposal at the CHCP buoy

The dredged material detected in Stations 100E and 100S was comprised of white clay indicating it most likely originated from the additional deposit of Boston Blue Clay to the south-southeast of the CHCP buoy (Figure 3-14B).

Surface disturbances were classified as physical at all stations with scattered occurrences of biogenic activity in a select few replicates (Appendix D2). Tubicolous, opportunistic polychaetes, densely populated at times, were noted at the sediment-water interface in many of the station replicates. Plant material was also detected in the surface sediment at various stations.

3.3.4.2 Secondary Stations

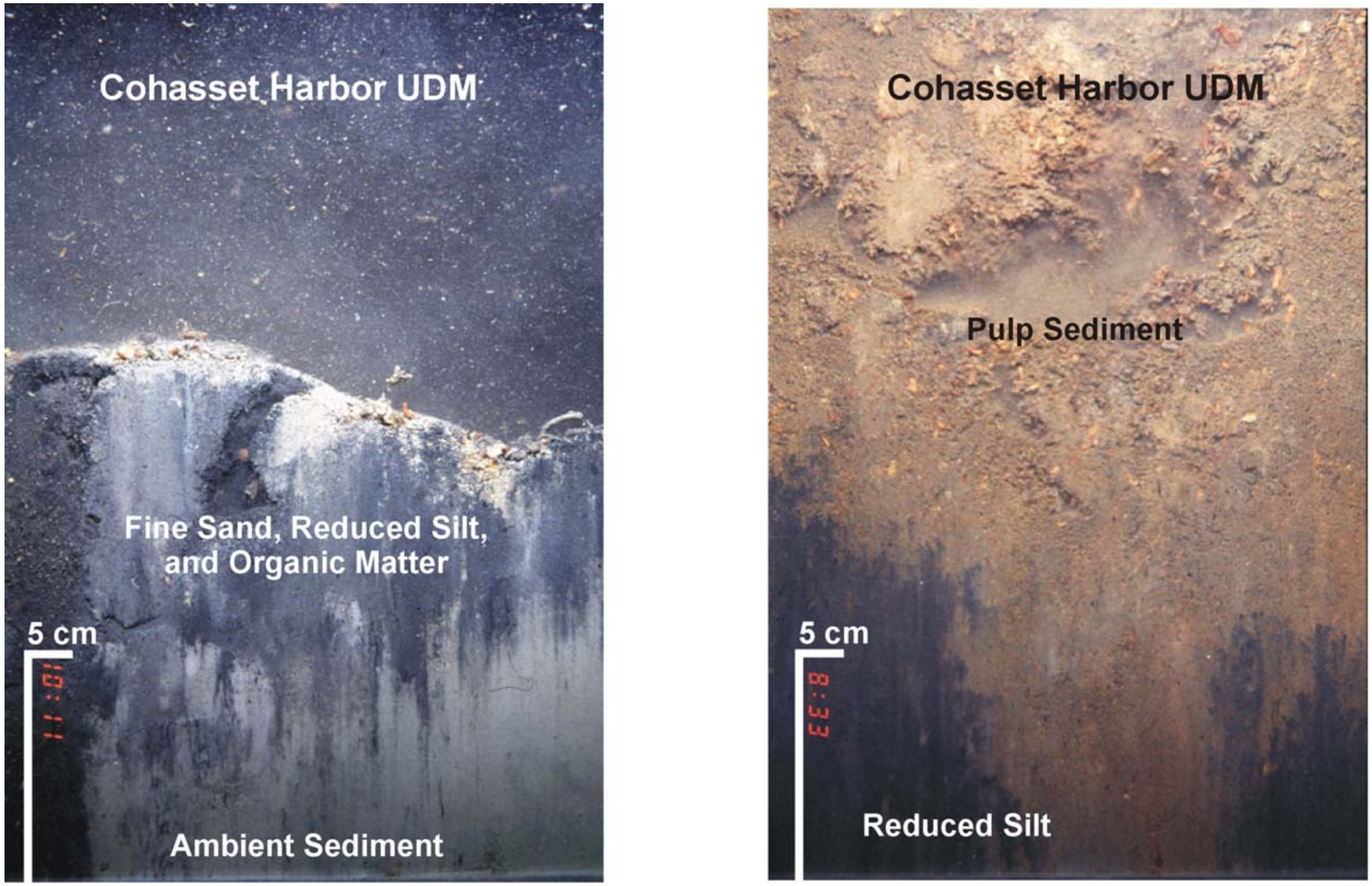
The sediments within the secondary grid were primarily composed of fine-grained silt with tan oxidized silt overlying black silt. A major modal grain size of >4 phi was detected throughout the survey grid (Figure 3-15A; Table 3-6). Mean camera penetration depths ranged from 6.5 cm at Station C25N to 21 cm at Station C50S (Table 3-6). Where detected, dredged material existed as a thin layer over ambient sediments at most stations sampled.

Replicate-averaged dredged material thickness values ranged from 0.5 cm at Stations C25S and D25N to greater than 12.3 cm (camera penetration depth) at Station BCTR (Table 3-6). Dredged material appeared to be concentrated in the center and eastern rows, but demonstrated some variability in composition as several stations displayed clay chips, surface clumps, or chaotic fabric with pulp sediment at the sediment-water interface (Figure 3-15B). The dredged material footprint, as outlined by a thickness greater than 0.5 cm in the REMOTS® images, encompassed an area of approximately 22,800 m^2 (Figure 3-16).

Surface roughness was primarily due to physical disturbance as biogenic surface roughness was detected in only a few replicates. A sloping and irregular surface topography with notable surface clumps was detected at various stations, a feature likely due to recent dredged material deposition.

3.3.4.3 Tertiary Stations

The larger of the two sediment deposits located southeast of the CHCP buoy was investigated with a 25-station radial arm REMOTS® grid. Stations were placed at intervals of 80 m, 120 m, and 160 m from the center position to verify the composition and thickness of the deposited material.



A **B**

Figure 3-15. REMOTS® images obtained from Station CCTR (A) and BCTR (B) displaying the different types of Cohasset Harbor sediments detected in the secondary REMOTS® grid

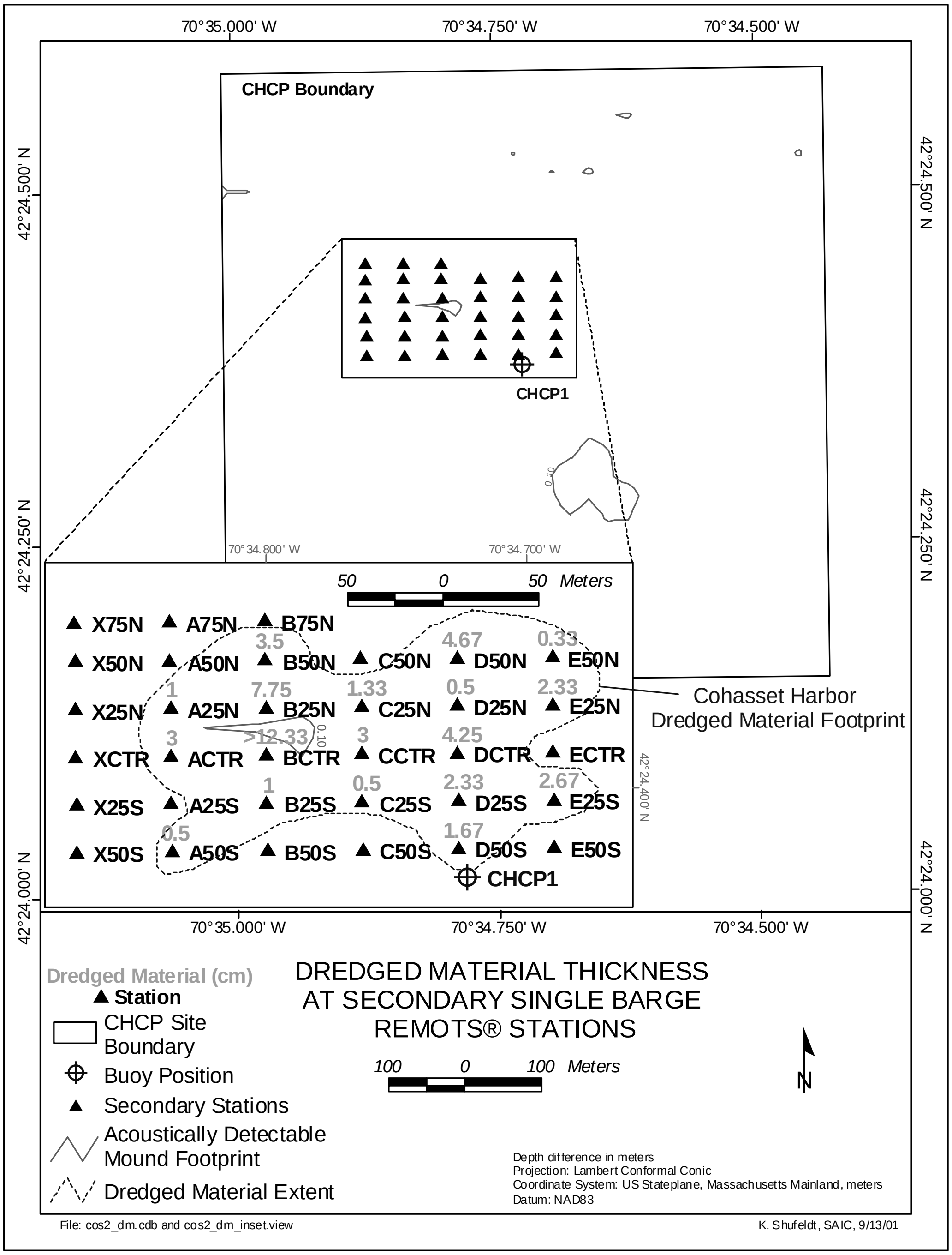


Figure 3-16. Map of the CHCP study area showing the spatial distribution and thickness of dredged material over the secondary survey grid during the Single-Barge survey. The dotted line represents the margins of the dredged material footprint as detected by sediment-profile imaging

Once again, the sediment within this portion of CHCP was composed primarily of silt and clay, as a major modal grain size of >4 phi was observed at all stations (Table 3-7). Mean camera penetration depths for all the tertiary stations ranged between 6.3 cm at Station 80W to 16.3 cm at Station 120SW (Table 3-7). Ambient sediments were detected at most of the stations on the periphery of the survey grid. Dredged material, consisting of Boston Blue Clay, was evident in the REMOTS® images obtained from a number of stations, but tended to be limited to a 120 m radius (Figure 3-17). When present, the thickness of the dredged material ranged from 0.7 cm at Stations 80N and 160SW to dredged material layers exceeding camera penetration depth at Stations CTR and 80W, (>8.5 cm and >6.3 cm respectively; Table 3-7). The footprint of this single dredged material deposit encompassed an area of approximately 50,800 m^2 within the CHCP study area (Figure 3-17).

The surface of the fresh dredged material was highly irregular, which apparently promoted the strong sonar returns noted during the December 1998 side-scan survey. The sediment surface roughness throughout the disposal site was physical in nature for all stations and reflected an irregular topography. The irregular topography was caused by the addition of the Boston Blue Clay dredged material deposit that formed large cohesive clumps at the sediment-water interface.

3.4 CHCP Precap Survey

Upon analyzing the data from the Single-Barge survey, SAIC recommended that disposal activity be directed to the northwest side of the CHCP buoy to form a single, discrete UDM mound on the seafloor. A total estimated barge volume of 41,250 m^3 (53,950 yd^3) of UDM was deposited at the CHCP buoy from 1 December 1998 through 17 February 1999 (Table 1-1). The Precap survey, consisting of single beam bathymetry, side-scan sonar, REMOTS® sediment-profile imaging, and grab sample surveys, was conducted in April 1999 to determine the size and shape of the UDM mound, verify sediment composition, and document the distribution of dredged material within the project area.

3.4.1 Disposal Surveillance Data (ADISS)

Figure 3-18 displays a summary of all the recorded disposal events at the CHCP buoy that contributed to the development of the UDM layer. Most of the disposal occurred within a 150 m radius of the buoy. For each disposal event at the CHCP buoy, a corresponding dredging event was recorded within Cohasset Harbor. The colors of the disposal events at the CHCP buoy correspond to the sediment source areas documented by the positions of the dredging events (Figures 3-18 and 3-19).

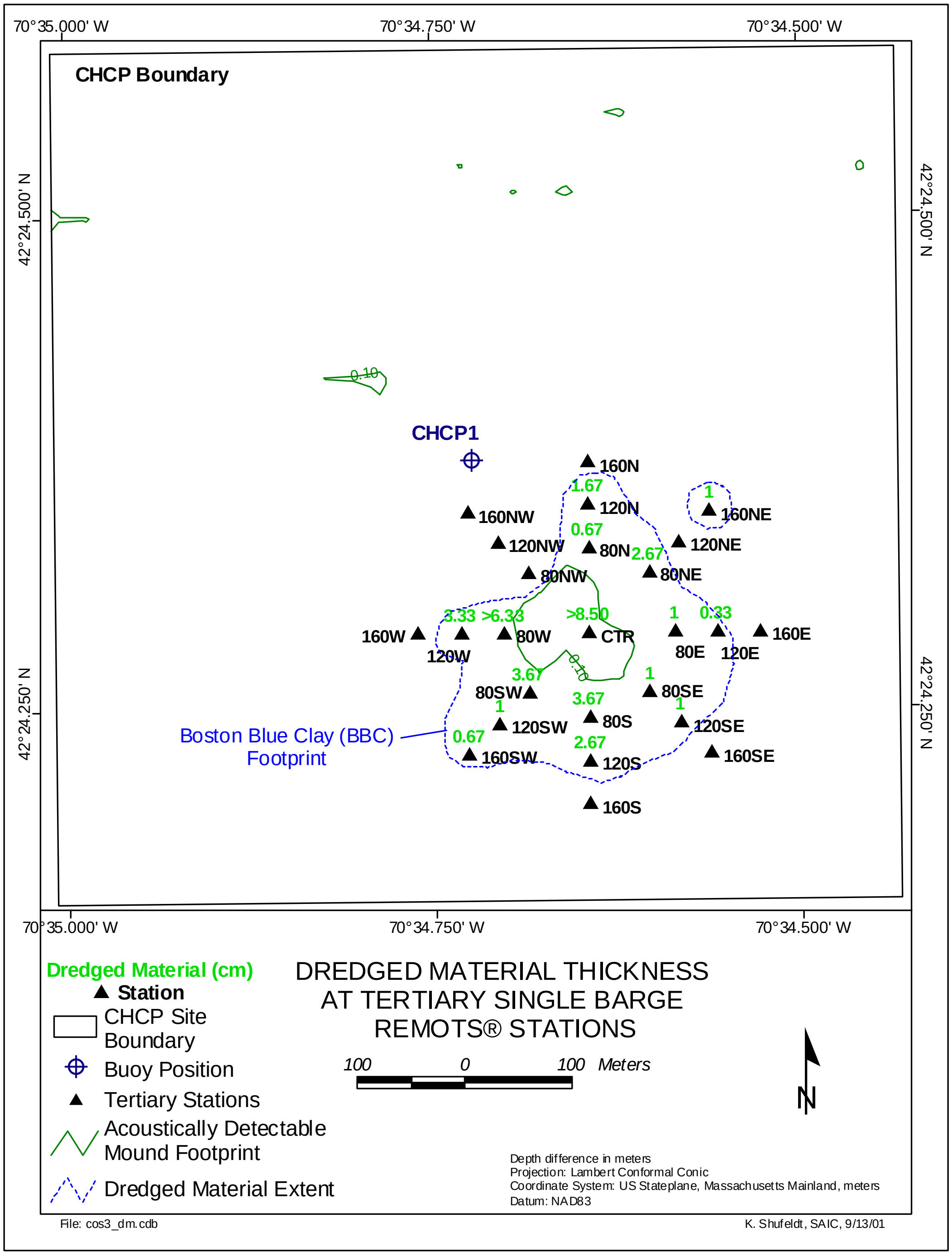


Figure 3-17. Map of the CHCP study area showing the spatial distribution and thickness of dredged material over the tertiary survey grid during the Single-Barge survey

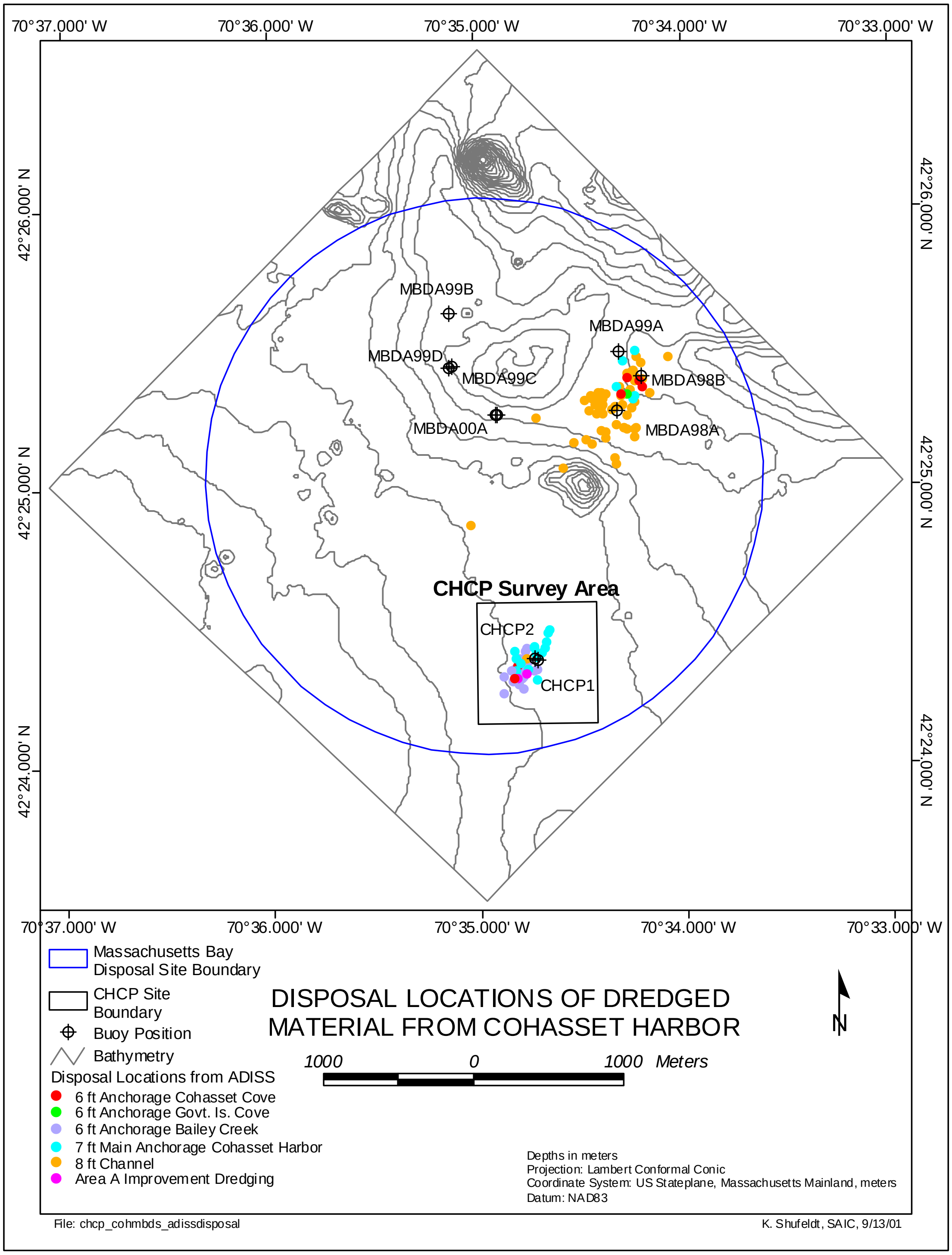


Figure 3-18. Summary of Cohasset Harbor UDM disposal points at the CHCP and MBDA disposal buoys as recorded by ADISS, colors correspond to the dredged material source areas within the harbor

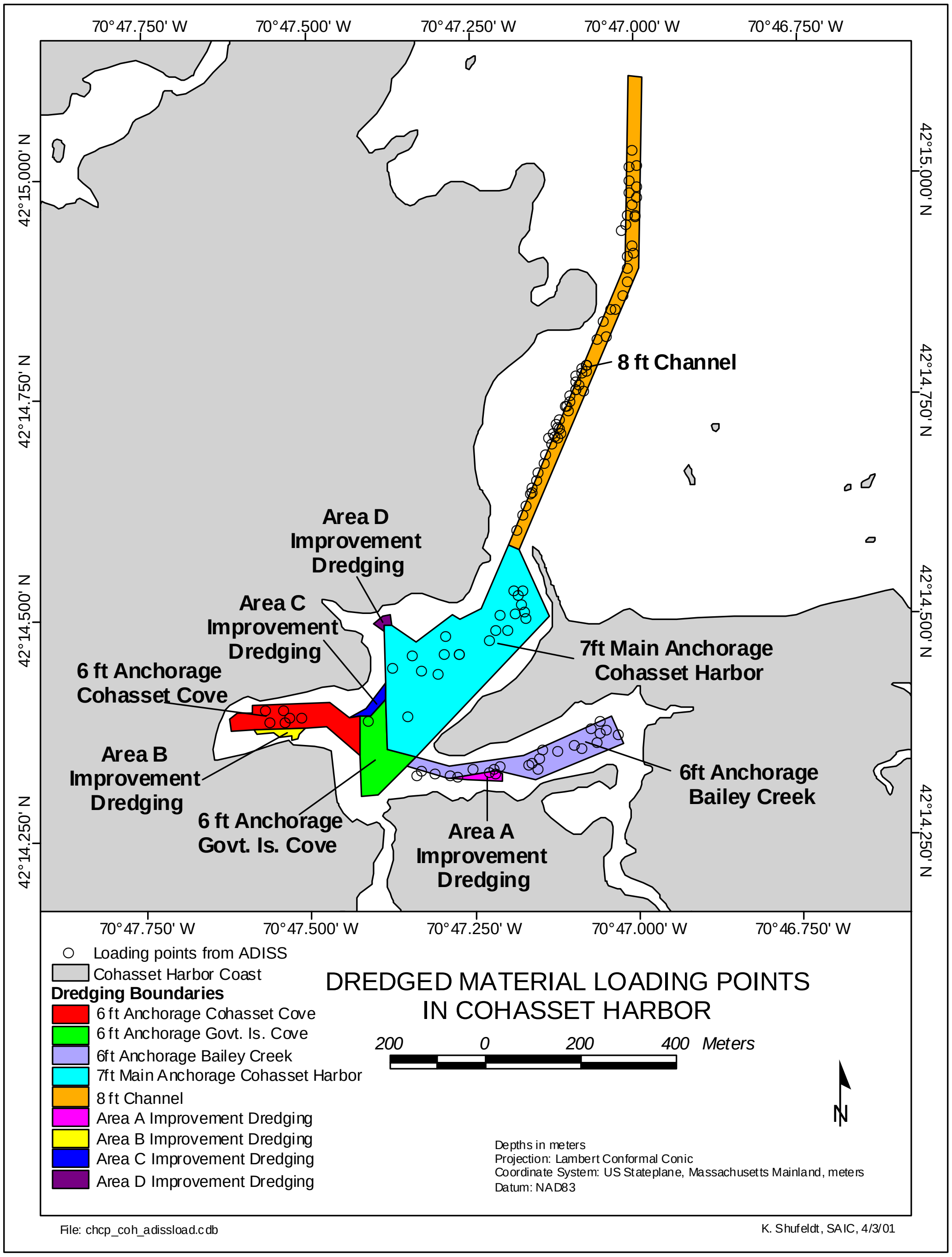


Figure 3-19. Summary of Cohasset Harbor UDM loading positions from the dredged material source areas within Cohasset Harbor as recorded by ADISS

As described in Section 1.3, the majority of the sandy material in the Cohasset Harbor entrance channel (yellow) had been directed to the MBDA buoy north of the CHCP study area at the start of the dredging project (Figure 3-18). Once the dredging contractor had established an adequate depth within the entrance channel, sediment from the interior portions of the harbor were directed to the CHCP Buoy. The Single-Barge load was dredged from the central Main Anchorage (blue), with several subsequent loads of harbor material directed to the MBDA buoy until the Single-Barge survey was completed. Once disposal was redirected to the CHCP buoy, additional sediment from the Main Anchorage Area (blue), Bailey's Creek Cove (purple), Cohasset Cove Anchorage (red), and the improvement project within Area A (pink) was directed to the CHCP study area to form the UDM mound. Only one load of material from Government Island Cove (green) was dredged, and this material was transported to the MBDA buoy for disposal. Contrary to the original dredging plans, no material was removed from improvement dredging areas B, C, or D during the 1998-99 dredging effort (Figure 3-19).

3.4.2 Single Beam Bathymetry

The Precap bathymetric survey was performed in April 1999 following the deposition of UDM within the CHCP study area. The survey area and parameters were identical to those of the Baseline and Single-Barge surveys to facilitate comparisons between the various data sets. In April 1999, water depths within the study area ranged from 86 m in the southwestern corner of the survey area to 87.25 m along the eastern margin (Figure 3-20). There was a noticeably shallower area to the north and west of the CHCP buoy relative to previous surveys.

The depth difference between the Baseline and the Precap surveys indicated two distinct areas of dredged material accumulation (Figure 3-21). Based on disposal logs and automated barge surveillance data, the larger sediment deposit located to the north-northwest of the CHCP buoy represents the UDM mound. The secondary mound, located southeast of the CHCP buoy position, was the same sediment deposit detected during the Single-Barge survey.

The UDM mound at CHCP displayed a height of 0.35 m and a diameter of 250 m along the east-west axis. A fairly wide, 0.15 m thick, dredged material apron was identified in the depth difference comparisons. This apron elongated the UDM mound along the northeast-southwest axis, indicating an acoustically detectable dredged material mound diameter of nearly 400 m (Figure 3-21).

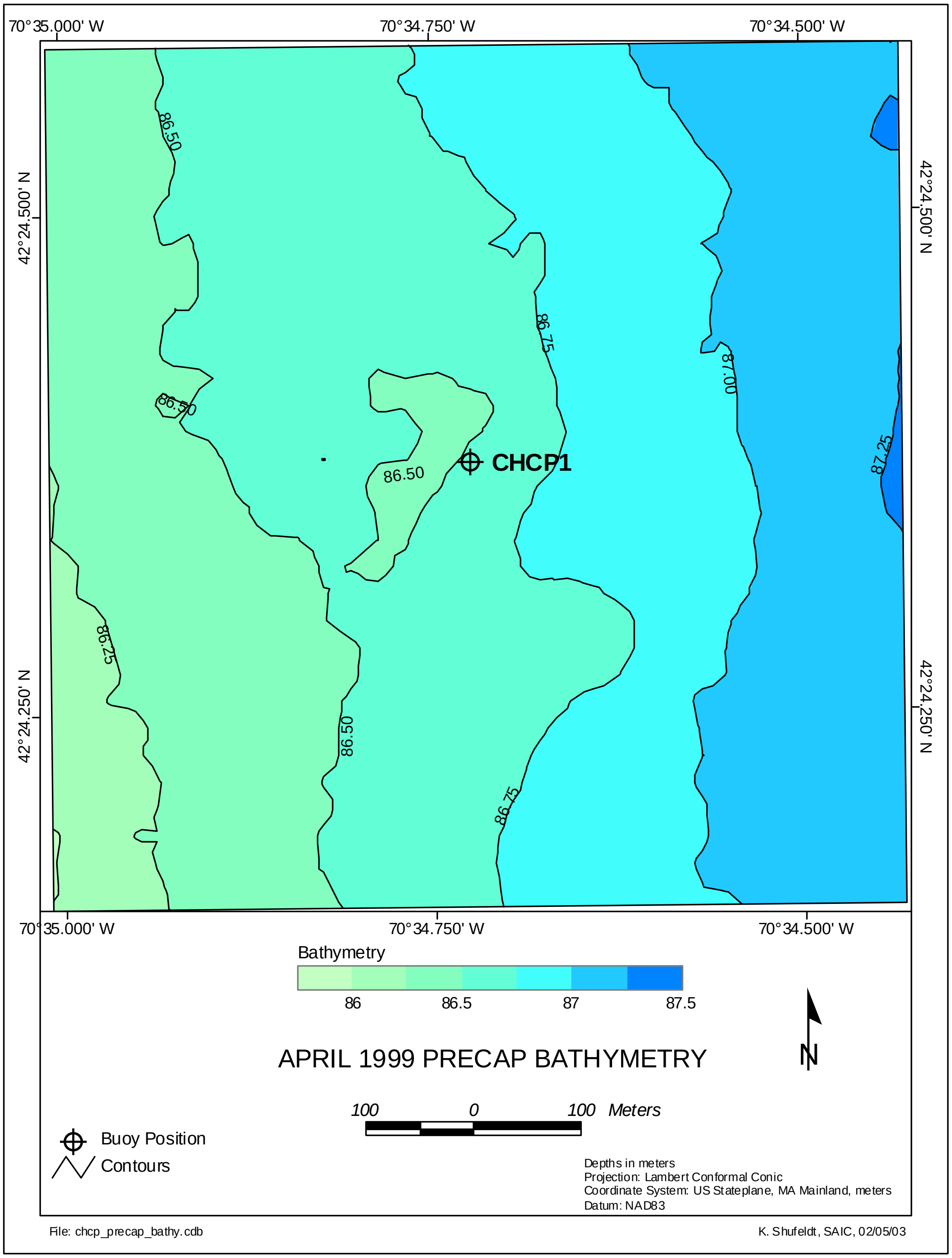


Figure 3-20. Bathymetric chart of the 800 × 800 m CHCP study area during the April 1999 Precap survey, 0.25 m contour interval

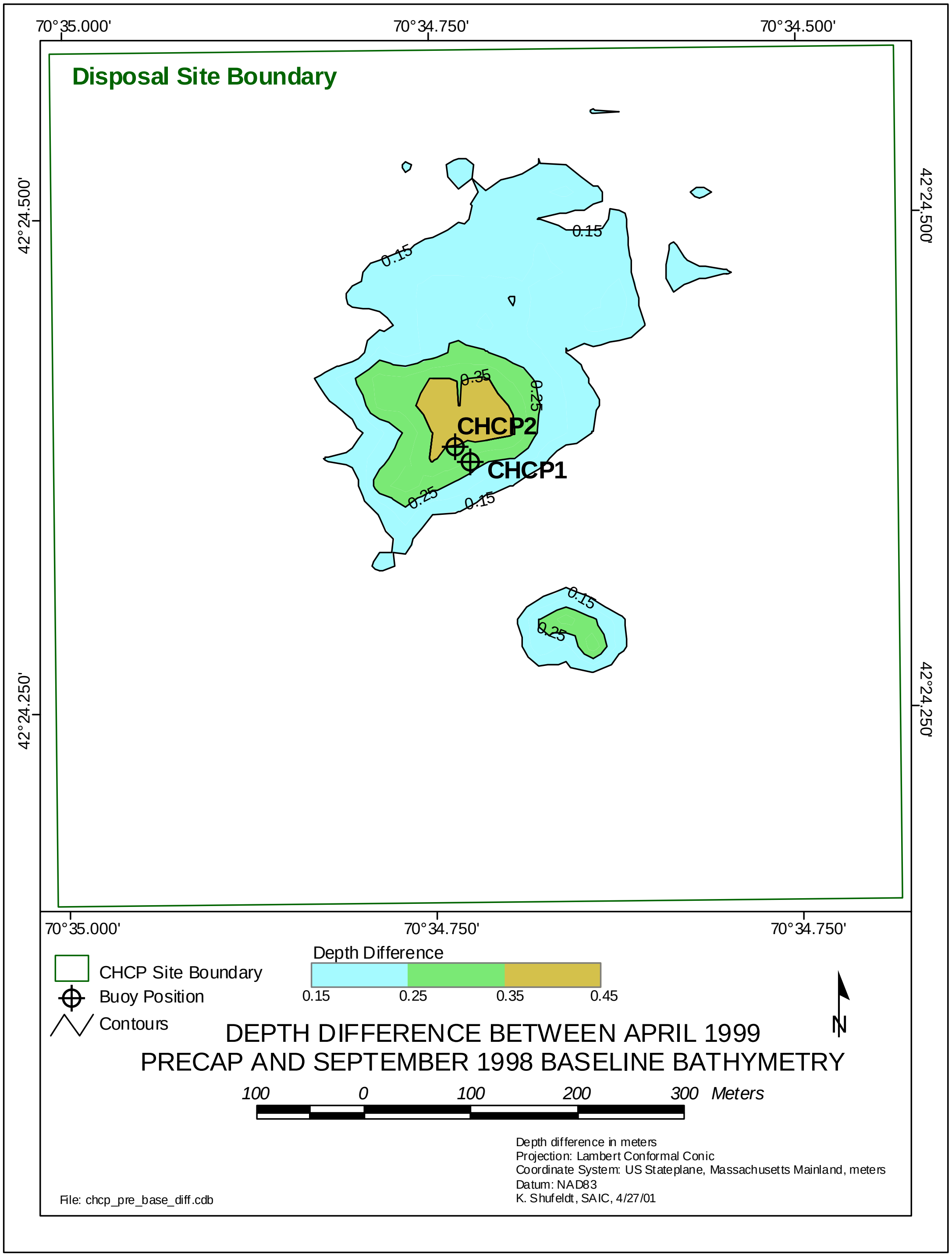


Figure 3-21. Depth difference comparison between the April 1999 Precap and September 1998 Baseline bathymetric surveys showing total accumulation of dredged material within the CHCP study area

3.4.3 Side-Scan Sonar

In contrast to the Single-Barge survey, fresh dredged material was detected over much of the CHCP study area. The dredged material deposits appeared on the side-scan records as dark patches, which extended from the southwestern side of the CHCP buoy to the northeastern region of the survey area (Figure 3-22). This figure also illustrates the ADISS barge tracks referenced over the Precap bathymetry. The ADISS data also corresponded well with the disposal footprints that were visible from the side-scan data. The errant disposal detected during the Single-Barge survey in December 1998 survey was still visible to the southeast of the buoy in the location identified in the Precap bathymetric survey.

Much of the UDM mound was composed of material similar in composition to the Single-Barge deposit and did not form a cohesive mass on the seafloor. The recently deposited material appeared darker in comparison to the ambient seafloor and generally conformed to the margins detected by sequential bathymetric surveys (Figure 3-22). The majority of the apron extended about 300 m to the northeast and some deposits could also be seen directly to the east of the buoy. There were some distinctive, round deposit features detected within the dredged material apron, as well as several areas with isolated sonar reflections. The isolated reflections identified in the sonar data were comparable to the clay deposit to the southeast of the buoy, and may represent large clumps of clay on the surface of the UDM mound. The survey area also included some of the historic dredged material that was present in the Baseline survey. These historic deposits were relatively faint in this precap survey, but were still visible northwest of the buoy.

3.4.4 REMOTS® Sediment-Profile Imaging

Sediment-profile images were instrumental to mapping the footprint of UDM on the seafloor. For the Precap REMOTS® survey, the original 33-station Baseline survey grid was revisited, with the exception of the center station, due to the presence of the CHCP buoy. In addition, no analyzable images were collected from Stations 50E and 100E. A complete set of REMOTS® image analysis results is provided in Appendix D3; these results are summarized in Table 3-8.

The sediments observed during the Precap survey were predominantly tan and black mottled, sandy silt or silty sand with major model grain size of 4 to 3 phi (Figure 3-23; Table 3-8). Replicate-averaged camera penetration for the Precap survey stations was quite variable, with values ranging from 1.6 cm at Station 100SW to 15.4 cm at Station 300E (overall average of 9.9 cm; Table 3-8). These relatively low values reflect the larger overall grain size and firmer bottom conditions (cap material) relative to the earlier

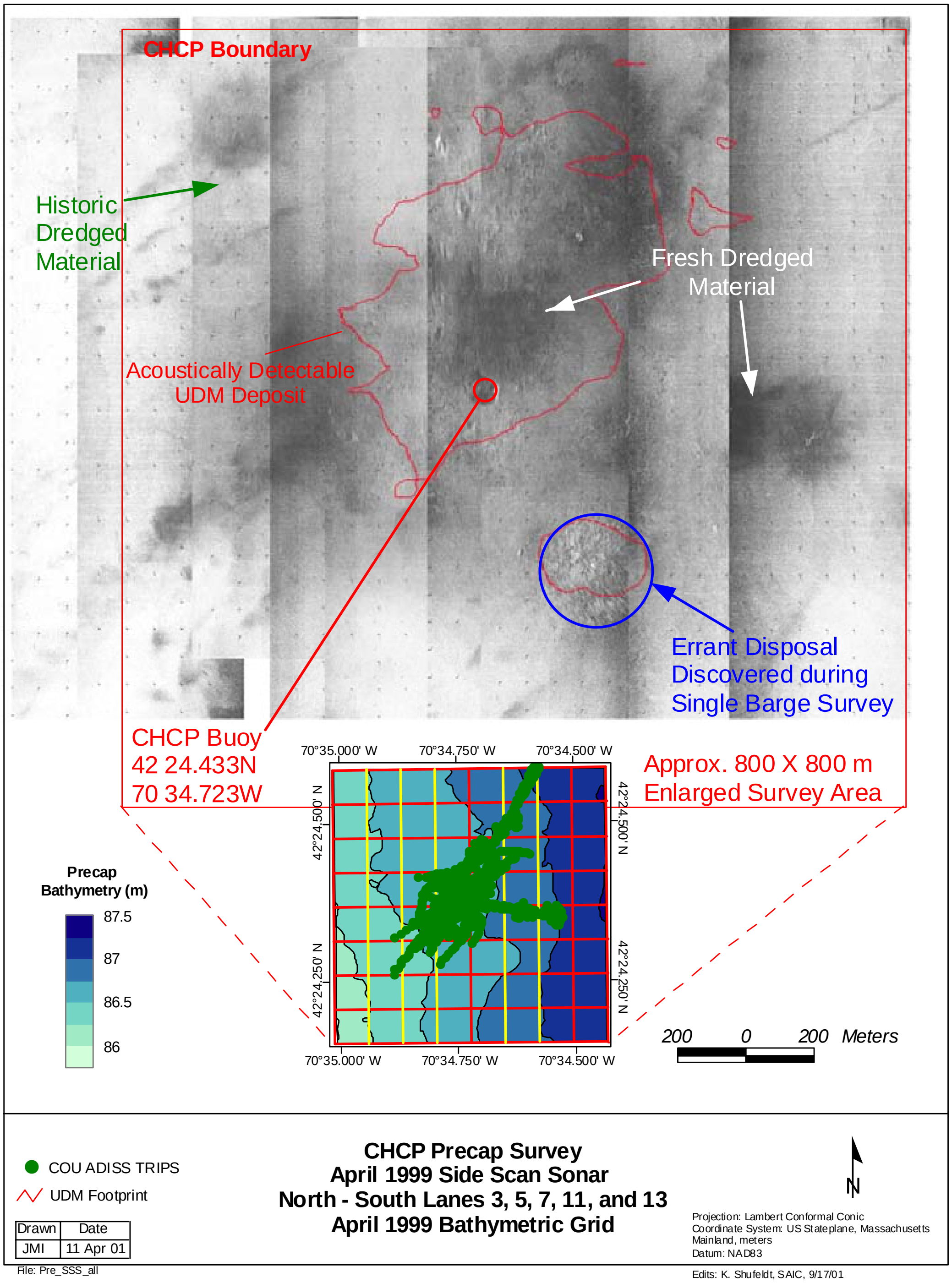


Figure 3-22. Composite side-scan sonar image showing the distribution of UDM within the CHCP study area at the Precap stage of development, relative to the acoustically detectable UDM footprint (red) and disposal barge tracks as documented by ADISS (lower graphic-green)

Table 3-8. Summary of REMOTS® Results for the Precap Survey over the CHCP Study Area

Station	Camera Penetration Mean (cm)	Grain Size Major Mode (phi)	Sediment Color	Sediment Description	Dredged Material Thickness Mean (cm)
50N	2.72	4-3	tan/yellow/blk	sandy silt/clay	>2.72
50NE	5.13	4-3	tan/blk	sandy silt	>5.13
50SE	9.65	4-3	tan/blk	sandy silt	>9.65
50S	6.48	4-3	tan/blk	sandy silt	>6.48
50SW	3.47	4-3	tan/blk	sandy silt/clay	>3.3
50W	10.91	4-3	tan/blk	sandy silt/clay	>10.91
50NW	4.20	4-3	tan/blk/yellow	sandy silt	>4.20
100N	5.75	3	tan/blk	sandy silt	>5.75
100NE	8.26	4-3	tan/blk	sandy silt	>8.26
100SE	13.90	4-3	tan/blk	sandy silt	>13.90
100S	9.43	3-2	tan/blk	fine sand	>8.93
100SW	1.55	4-3	tan	sandy silt	>1.55
100W	11.81	4-3	tan/blk	sandy silt	>11.81
100NW	3.15	3-2	tan/yellow	silty sand/clay	>3.15
200N	8.15	4-3	tan/blk	sandy silt	>8.15
200NE	7.40	3-2	tan/blk	silty sand	>7.40
200E	15.23	4-3	tan/blk/gray	sandy silt	8.0
200SE	10.40	>4	tan/gray/blue clay	silt/clay	>10.40
200S	13.73	4-3	tan	sandy silt	0
200SW	9.73	4-3	tan/gray	sandy silt/silt	4.67
200W	14.97	4-3	blk/gray	sandy silt/silt	5.67
200NW	12.24	4-3	tan/blk/gray	sandy silt/silt	7.88
300N	13.07	4-3	tan	sand/silt	6.0
300NE	12.23	4-3	tan/blk/gray	sandy silt/silt	4.63
300E	15.40	>4	tan/blk/gray	sandy silt/silt	4.33
300SE	13.53	>4	tan	sand/silt	0
300S	12.90	>4	tan	silt	0
300SW	14.63	>4	gray	silt	0
300W	14.93	>4	gray	silt	0
300NW	10.53	>4	tan/gray	sandy silt/silt	3.50

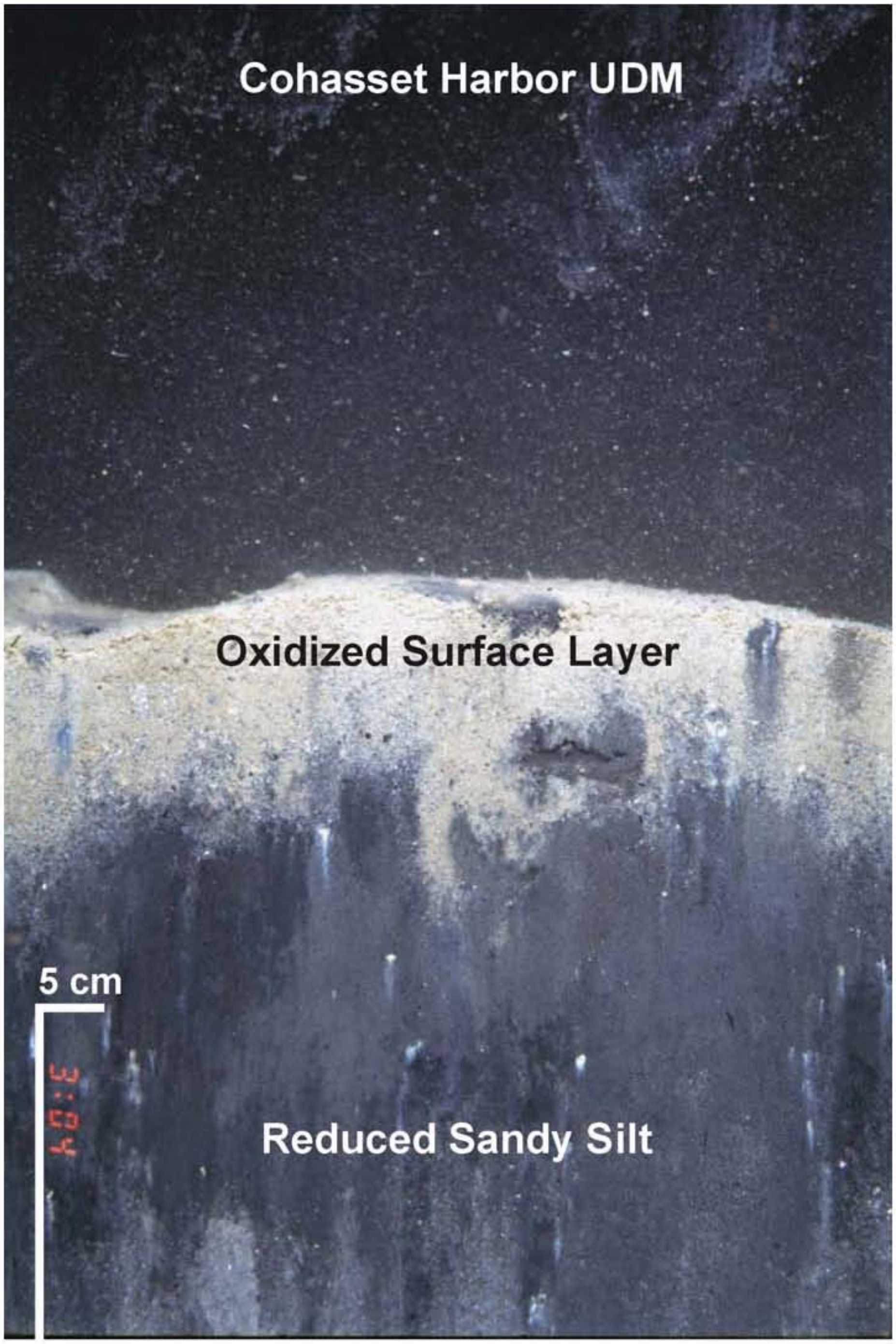


Figure 3-23. REMOTS® image from Precap Survey Station 50W illustrating the tan and black mottled sandy silt (4 to 3 phi) representative of the dredged material observed during the Precap survey. Small blue clay flecks are visible in the surface sediments

surveys (Baseline and Single-Barge surveys of UDM). Stations with an abundance of rocks at the sediment-water interface yielded no penetration (50E and 100E) and thus inhibited the analysis of dredged material thickness.

Dredged material was apparent in all the REMOTS® images at the disposal site with the exception of Stations 200S, 300SE, 300S, 300SW, and 300W (Figure 3-24). The average camera penetration for those stations exhibiting dredged material was 9 cm. All of the stations within a 100 meter radius of the buoy, as well as Stations 200N, 200NE, and 200SE demonstrated mean dredged material thicknesses beyond the penetration of the REMOTS® camera prism (Figure 3-24; Table 3-8). These high mean dredged material depths near the center of the disposal area are expected since the largest amounts of dredged material are typically deposited around the buoy with thin layers spreading out to the periphery of the grid.

Mean dredged material depths for the stations on the periphery of the grid (300 m) ranged from 3.5 cm to 7.9 cm (Figure 3-24; Table 3-8). A large number of these stations displayed distinct layers of dredged material (UDM) over ambient sediment (Figure 3-25). The stations exhibiting ambient material at the sediment water interface showed similar characteristics as the September 1998 Baseline images. Mapping the UDM mound footprint based on thickness of recently deposited Cohasset Harbor sediment detected in the REMOTS® indicated the UDM mound likely occupied an area of 235,900 m^2 on the MBDS seafloor.

The UDM composition was variable throughout the survey grid as multiple lithological units were detected in the replicate REMOTS® images. Sediment in various stations showed sediment characteristics of both yellow and blue clay and thus was influenced by both Cohasset Harbor and the Boston Blue Clay sediment. Yellow clay was present in images to the north and west of the buoy and there was often great variability within the same station with respect to grain size, sediment composition, and dredged material thickness (Figure 3-26).

Alternatively, white and blue clay was noted in images scattered principally in the south and east of the disposal area, in varying sized clumps. This Boston Blue Clay was the result of the single barge load of sediment from Boston Harbor to the area southeast of the CHCP buoy. At station 100S, white/gray clay had been detected in the Single-Barge survey; however, the material observed at 100S in the Precap survey now more closely matched the tan/black Cohasset sandy silt surrounding the CHCP buoy. The Cohasset Harbor UDM now likely overlies the original BHNIP clay deposit at Station 100S (Figures 3-24 and 3-27).

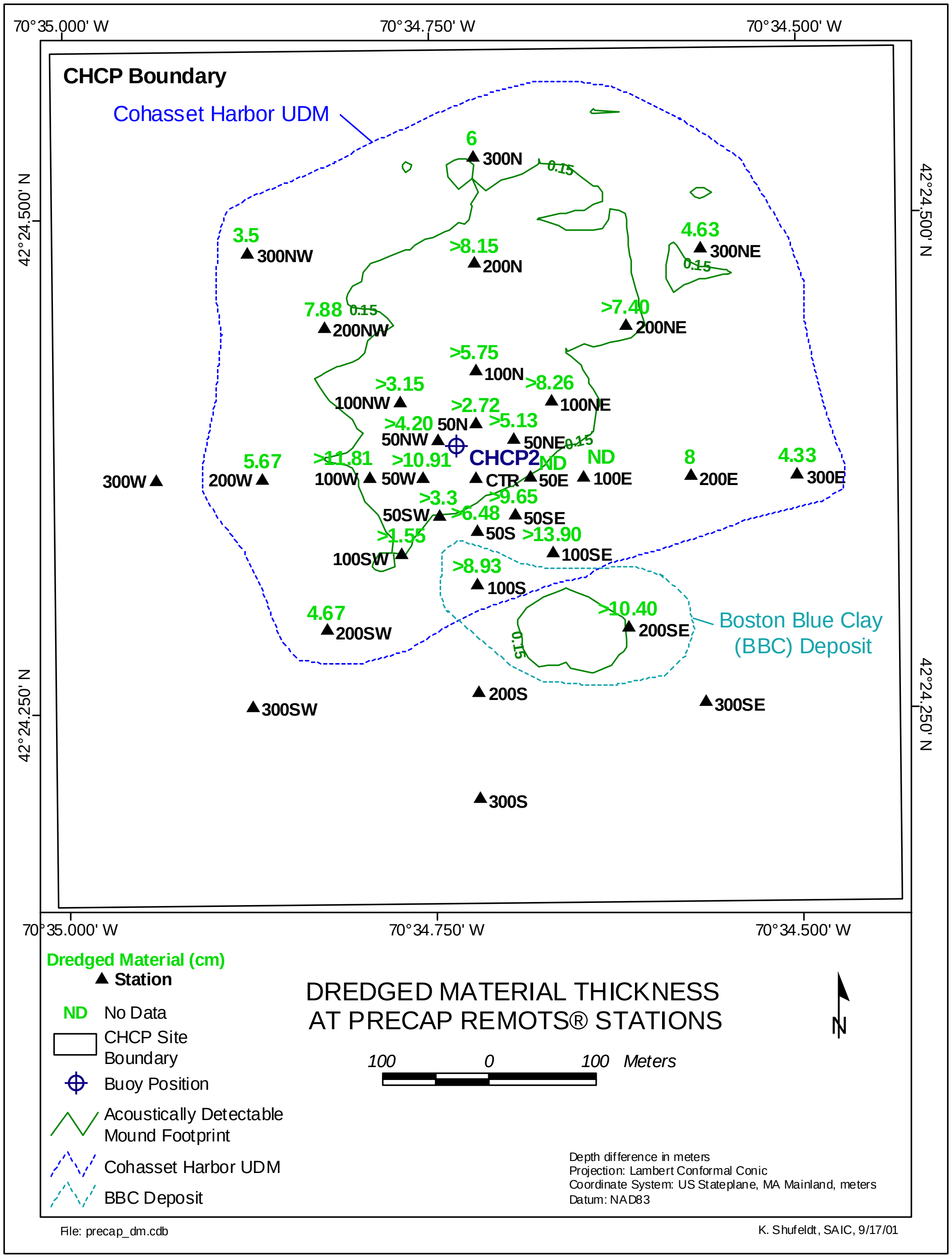
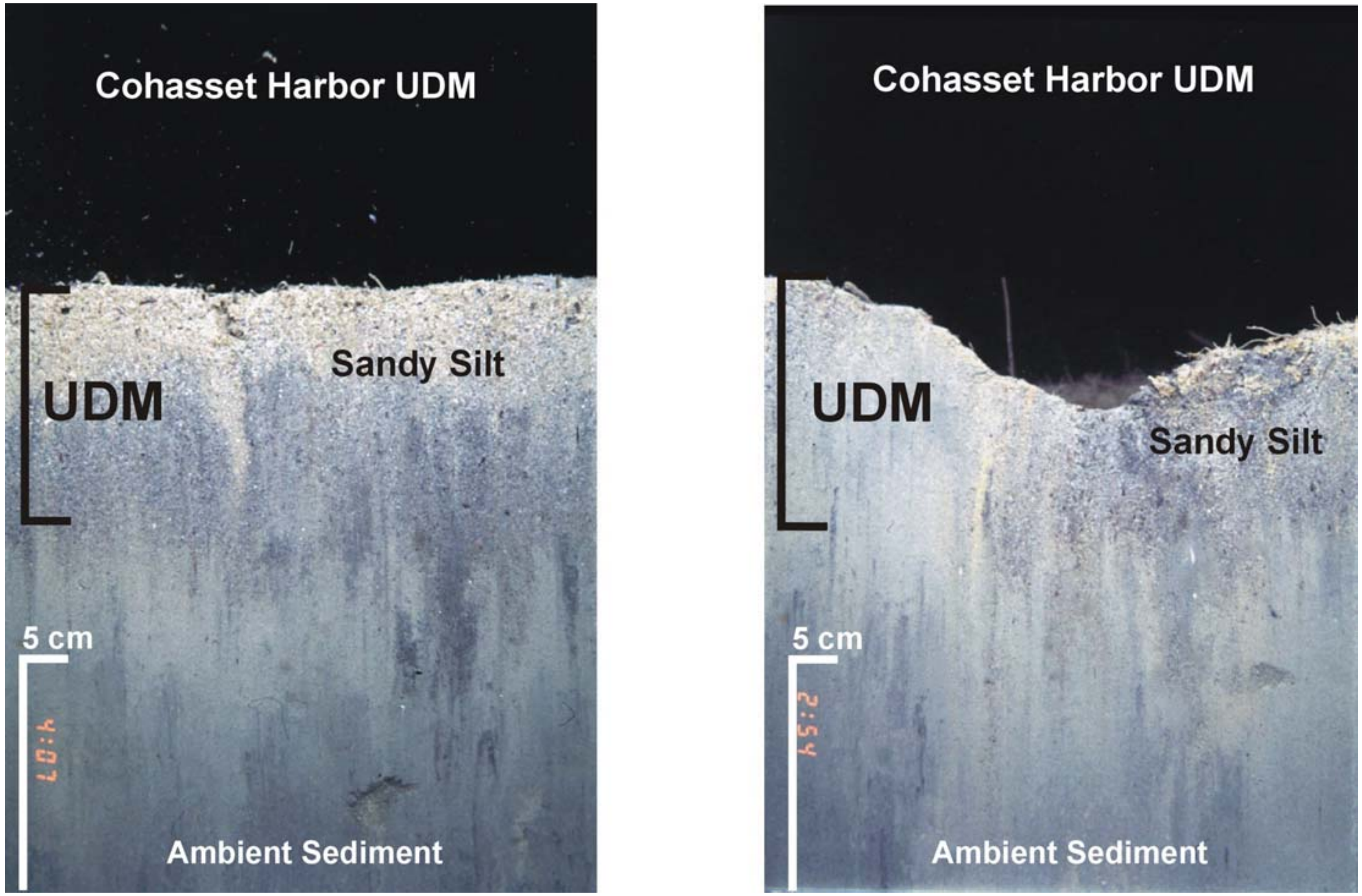
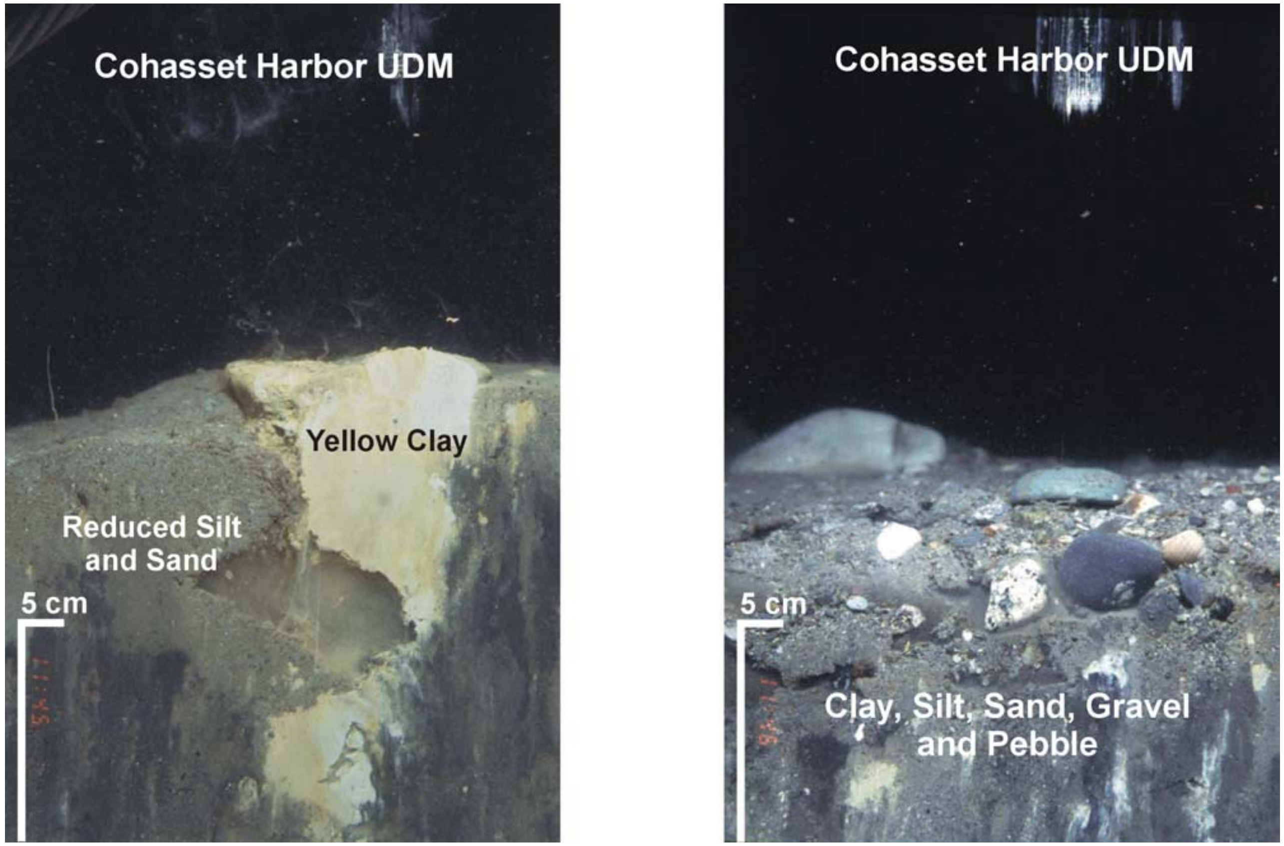


Figure 3-24. Map of the CHCP study area showing the spatial distribution and thickness of Cohasset Harbor UDM within the CHCP study during the Precap survey. The dotted lines represents the margins of the UDM footprint as detected by sediment-profile imaging



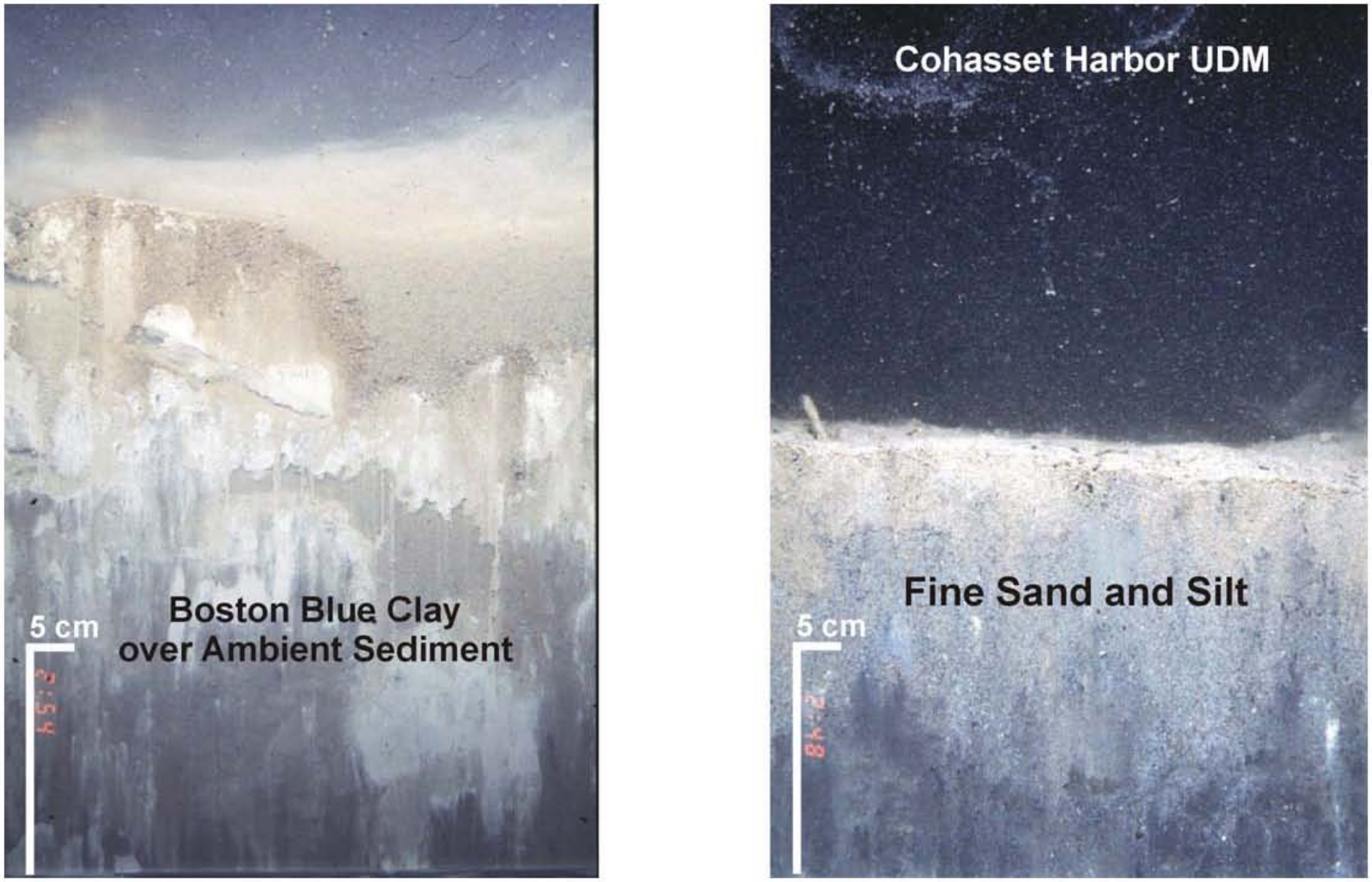
A **B**

Figure 3-25. REMOTS® images collected from Precap Survey Stations 300NE (A) and 200NW (B) displaying layers of Cohasset Harbor UDM material over ambient sediment



A **B**

Figure 3-26. REMOTS® images acquired from Precap Survey Station 100N, replicate E (A) and 100N, replicate F (B) showing variable sediment composition within the sampling radius of the same station. The sediment in the image of replicate E is composed of dredged material in the form of sandy silt and a large pocket of yellow clay (4 to 3 phi). In contrast, replicate F shows dredged material in the form of yellow clay chips and chaotic fabric with medium sand and rocks (3 to 2 phi)



A **B**

Figure 3-27. REMOTS® images acquired from Station 100S as part of the Single-Barge Survey (A) and Precap Survey (B) showing the change in surficial sediment composition at this station resulting from UDM placement

Surface roughness was classified as principally physical in nature in the majority of the replicates. However a significant number of replicates exhibited surface disturbance due to biogenic activity at the sediment-water interface, as dense tubicolous, opportunistic polychaetes were observed in many replicates. Clay clumps, shell fragments, and plant material were also seen at the sediment-water interface and at sediment depth, however pebbles were rare. Stations with ambient sediment commonly displayed a sloping topography, an indication of disturbance other than dredged material deposition.

3.4.5 Sediment Grab Samples

A total of 13 grab samples were collected and described during the Precap survey. Of these samples, five were sub-sampled for grain size and preserved for microscopic analyses, while the remaining eight samples were archived. The general descriptions of the grab samples indicate that the majority of the stations contained either darker sediment than observed in the Baseline survey or some type of organic material similar to that detected in the Cohasset Harbor samples.

Eight of the 13 grabs indicated a visual change in sediment composition in comparison with the Baseline survey (Table 3-9). The color of the sediment was olive gray or a slight variation of olive gray indicating that ambient material was present at Stations 300W, 200W, 300E, 200S and 300S. Stations within 100 meters of the center station, and up to 300 meters north indicated a significant change in sediment color and consistency. All of these stations were darker in color than ambient, ranging from brown-gray to black and had a visually distinct sand component. Grabs collected at 200 and 300 meters east, west, and south of center had minimal changes in sediment characteristics. Very coarse sand as well as gravel and cobble was present at the center station, extending north to station 300N, east to Station 200E and west to Station 100W (Table 3-9). Based on grab sample descriptions the majority of UDM was placed primarily at the center-north region of the CHCP study area.

The five grab samples analyzed for grain size were collected at the same target locations as the Baseline samples analyzed (CTR, 200N, 200S, 200E, and 200W). The grain size data indicated a distinct change in surface sediment composition. The fraction of fine-grained sediment (silt and clay) decreased from an average of 95% to 56% between the Baseline and the Precap surveys, with a corresponding increase in the sand fraction. In addition, there was also a slight increase in the coarseness of the surficial sediments, with a detectable increase in both medium and coarse sand (Table 3-10). The increase in both the sand fraction, as well as the presence of gravel within the CHCP site indicate a distinct change in the type of material at the sediment-water interface.

Table 3-9. Grab Sample Descriptions for the Precap Survey

Grab Station	Grain Size	Color	Consistency	Other
300N	sandy silt	olive gray to black	firm	worm, sulphidic odor
200N	sandy gravel	black to gray	firm	sulphidic odor, gravel, organic material
100N	sandy silty clay	dark gray	firm	sulphidic odor, gravel very hard
CTR	gravel and sand	olive-tan/gray to dark gray	firm	BBC and shells
100S	silty sand	olive brown to tan gray	wet, soft	pebbles, organic material
200S	sandy silt	olive to olive gray	wet, soft, smooth	worm, organic material
300S	silty clay	olive to olive gray	wet, soft, smooth	tubes, plant fragments, seastar
300E	sandy silt	olive to dark gray	wet, firm	tube mats, shells
200E	sandy, clay	tan-gray & dark gray	wet, soft, smooth	brittle star, worm, shell fragments
100E	silty sand	dark tan gray to black gray	wet, soft, smooth	brittle star, worm, shell fragments
100W	sand	light tan gray	firm	shell fragments, BBC
200W	fine sandy silt	olive to tan gray	wet, soft, smooth	shell fragments
300W	fine silty clay	olive to tan gray	wet, soft, smooth	shell fragments

Table 3-10. Grain Size Distribution for Grab Samples Collected as part of the Precap Survey

Sample ID	% Cobble >75mm	% Gravel <75-4.76mm	% Coarse Sand <4.76-2mm	% Medium Sand <2-0.42mm	% Fine Sand <0.42-0.074mm	Total Sand	% Silt Clay <0.074mm
CTR	2	7	6	19	30	55	36
200N	2	0	2	5	43	50	41
200E	0	5	4	9	27	40	55
200S	0	1	1	3	15	19	80
200W	0	0	1	7	26	34	66
Average	**1**	**3**	**3**	**9**	**28**	**40**	**56**

Grain size results from the Precap survey indicated an overall increase in sand content for all stations sampled. Relative to Baseline survey results, total sand content increased from 3 to 19% at Station 200S, 9 to 34% at 200W, 4 to 40% at 200E, and 3 to 50% at 200N at the Precap stage of development (Table 3-10). The center station (CTR) displayed the most significant increase in total sand content (4 to 55%) when compared to Baseline results. In addition, all samples contained a measurable amount of coarse sand (1-6%) in the Precap survey, whereas the results from the Baseline survey did not display the presence of any sediment of this size class (Table 3-10). These findings suggest that UDM was present in the surficial sediments within a 200 m radius from the center of the survey grid prior to CDM placement.

3.5 Chelsea River Sediment Characterization

In Spring 1999, the sediment to be removed from the improvement dredging operations in Chelsea River as part of the BHNIP was identified as the capping material to be used in the Massachusetts Bay Disposal Site Capping Demonstration Project. Four gravity cores were collected from the Chelsea River prior to the removal of maintenance or improvement material in an effort to characterize the sediments to be used as CDM. The proposed dredging sequence within Chelsea River required the removal of the estuarine sediments (maintenance material) and disposal of this sediment within in-channel CAD cells within Boston Harbor, followed by the dredging of a glacially derived clay (improvement material) to increase the overall depth of the navigational channel. Both grain size and microfossil samples were collected and archived. However, due to the distinct difference between Chelsea River sediment and Cohasset Harbor sediment, laboratory analysis was not conducted on the samples. Annotated core images are included in Appendix E.

The sediment in the Chelsea River was extremely hard and difficult to penetrate with the gravity core. The majority of the material was sandy clay mixed with gravel and various sized rocks. Four cores were collected at the five stations, with station CR-5 resulting in material retained in the core catcher located near the opening of the coring device only (Figure 2-12). The material from CR-5 was composed of sand, gravel, rocks and very dry coarse Boston Blue Clay. The Chelsea River cores contained silt, sand, gravel and Boston Blue Clay in various proportions.

Core CR-1, collected near the mouth of the river, was the longest (78 cm) sample obtained during the characterization survey. This core consisted of black- gray, wet, soft clayey silt representing the maintenance material (estuarine sediments) to a penetration depth of 34 cm. From 34-68 cm the sediment was dominated by clayey sand, while 68-78 cm was hard clayey sand and gravel. The material was well mixed and very hard.

Cores CR-2, CR-3, and CR-4 varied in length and contained silty sand in the core liner above a plug of Boston Blue Clay in the core catcher. Core CR-2 was 35 cm long, olive gray in color and firm. While CR-3 only contained 5 cm of silty fine sand in the core liner and 8 cm of Boston Blue Clay in the core catcher.

Core CR-4 was the second longest core at 44 cm, and contained varying sand-sized particles in the upper 32 cm, while from 32-44 cm was gravelly sand and Boston Blue Clay. CR-4 also contained 8.5 cm of Boston Blue Clay in the core catcher.

The material from the Chelsea River cores was distinctly different from the material originating from Cohasset Harbor. The amount of black silt, coarse sand, gravel and Boston Blue Clay detected in the cores indicated that the visual distinction between CDM and UDM would be possible without detailed sediment grain size and sediment tracer analysis.

3.6 CHCP Postcap Survey

The source of CDM for the Massachusetts Bay Disposal Site Capping Demonstration Project was the Chelsea River dredging operation (Figure 1-4). From 16 March 2000 through 2 May 2000, a clamshell bucket dredge supplied approximately 154,400 m^3 of coarse sand, gravel, black silt, and Boston Blue Clay to the CHCP study area to serve as CDM (Figure 1-5). Large, split-hull disposal barges with a capacity in excess of 3,050 m^3 (4,000 yd^3) were used to transport the material to the CHCP2 buoy for disposal. The disposal positions reported in the DAMOS disposal logs completed by on-board inspectors indicate CDM placement was concentrated to the west of the disposal buoy position (Figure 3-28).

As discussed in Section 3.5, the Chelsea River sediment was quite different from the material dredged from Cohasset Harbor, making the CDM layer easily distinguishable from the UDM layer. The sediments with a high percentage of silt and Boston Blue Clay from the outer reaches of the river were the first placed over the UDM mound to provide a distinct indicator of the CDM/UDM boundary. As dredging operations proceeded into the middle and upper reaches of the river, Boston Blue Clay, sand and gravel became the primary component of the CDM.

In the summer of 2000, SAIC initiated a Postcap survey, that included single beam bathymetry, REMOTS® sediment-profile imaging, side-scan sonar, and sediment coring to assess the effectiveness of the capping operations at the deep-water disposal site. Once again, field operations were completed within the 0.64 km^2 CHCP study area located in the southern region of MBDS and served as the final data collection effort in support of this project.

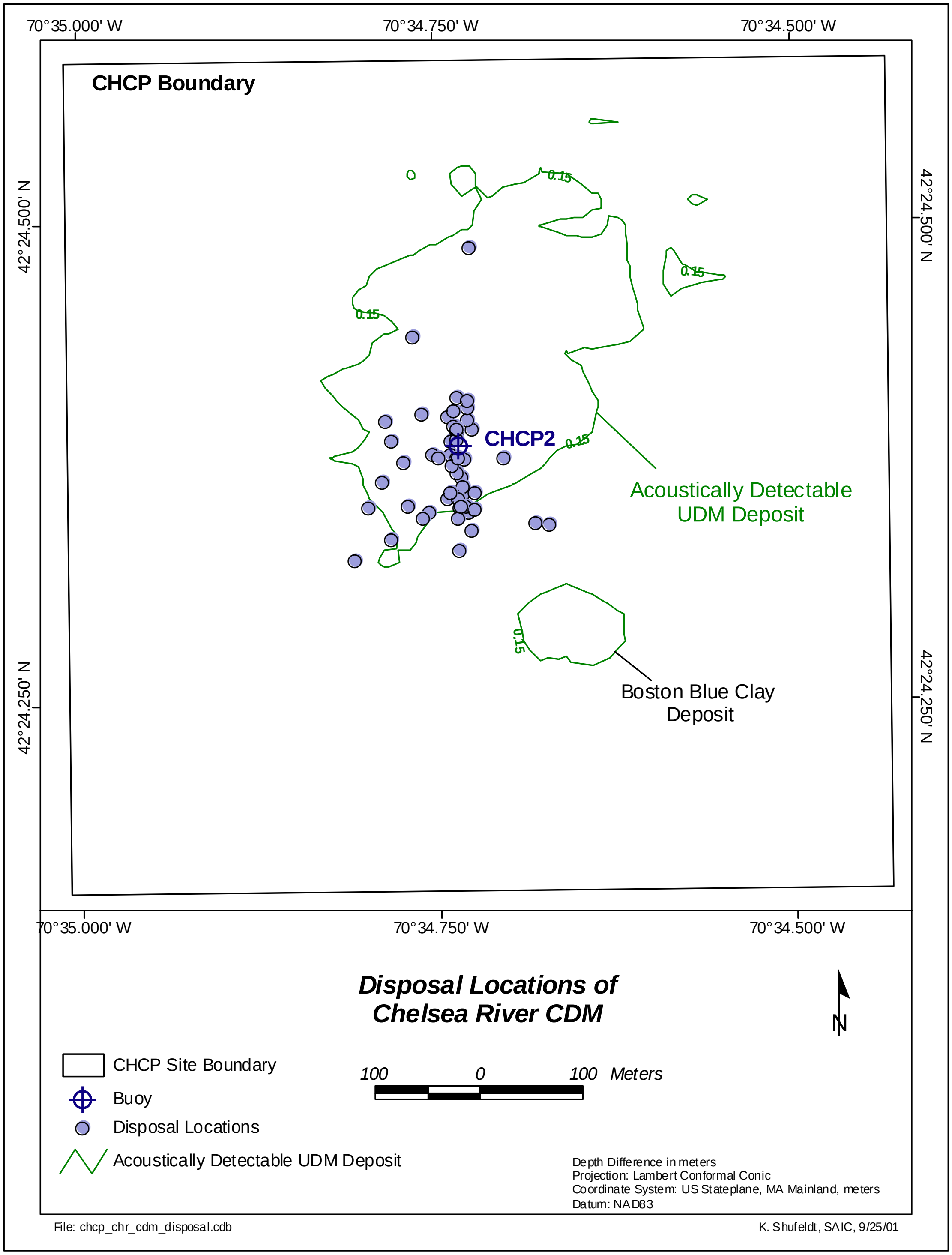


Figure 3-28. Summary of Chelsea River CDM disposal points within the CHCP study area as reported by on-board inspectors

3.6.1 Single Beam Bathymetry

SAIC performed the final bathymetric survey for Cohasset Harbor Capping Project in August 2000. Water depths over the CHCP study area ranged from 85 m at a point approximately 100 m west of the CHCP2 buoy position to 87.25 m in the northeastern corner of the survey area (Figure 3-29). Nearly 212,300 m^3 of dredged material was placed at the CHCP buoy positions over the course of two years (Table 1-1). The change in water depth within the survey area relative to the earlier surveys indicated a substantial change in seafloor topography within the CHCP study area.

Depth difference calculations based on comparisons with the September 1999 Baseline survey displayed a large dredged material disposal mound 1.75 m high and approximately 400 m wide along its north-south axis (Figure 3-30). The mound displayed a diameter of 750 m along the east-west axis, which is likely the result of the disposal pattern used during CDM placement. A survey artifact (or false indication of accumulation) is visible in the northeastern corner of the survey area and is likely the result of small differences between the two bathymetric data processing packages and gridding routines used in support of the demonstration project.

Depth difference comparisons with the April 1999 Precap survey data indicated thickness and distribution of CDM within the CHCP study area. A maximum CDM thickness of 1.75 m was detected over the UDM mound. Based on the similarities in cap material distribution and the morphology of the capped mound, CDM apparently comprised much of the disposal mound (Figure 3-31). The CDM layer displayed a diameter of approximately 380 m along the north-south axis and 750 m along the east-west axis of the mound. The acoustically detectable CDM layer (15 cm thick) covered approximately two-thirds of the original UDM mound, including much of the thin UDM apron that extended east of the CHCP buoy (Figure 3-32).

3.6.2 Side-Scan Sonar

The side-scan sonar data for this survey was used to spatially determine where the footprint of the capped mound existed in relation to the study area. Unlike the side-scan surveys discussed previously, these data were collected using a Triton Elics ISIS® system, which digitally stored the sonar data as geo-referenced files. These files were later post-processed within ISIS® to create a side-scan sonar mosaic of the survey area. The side-scan mosaic is a geo-referenced sonar image that was brought into a GIS system for analysis and graphic generation.

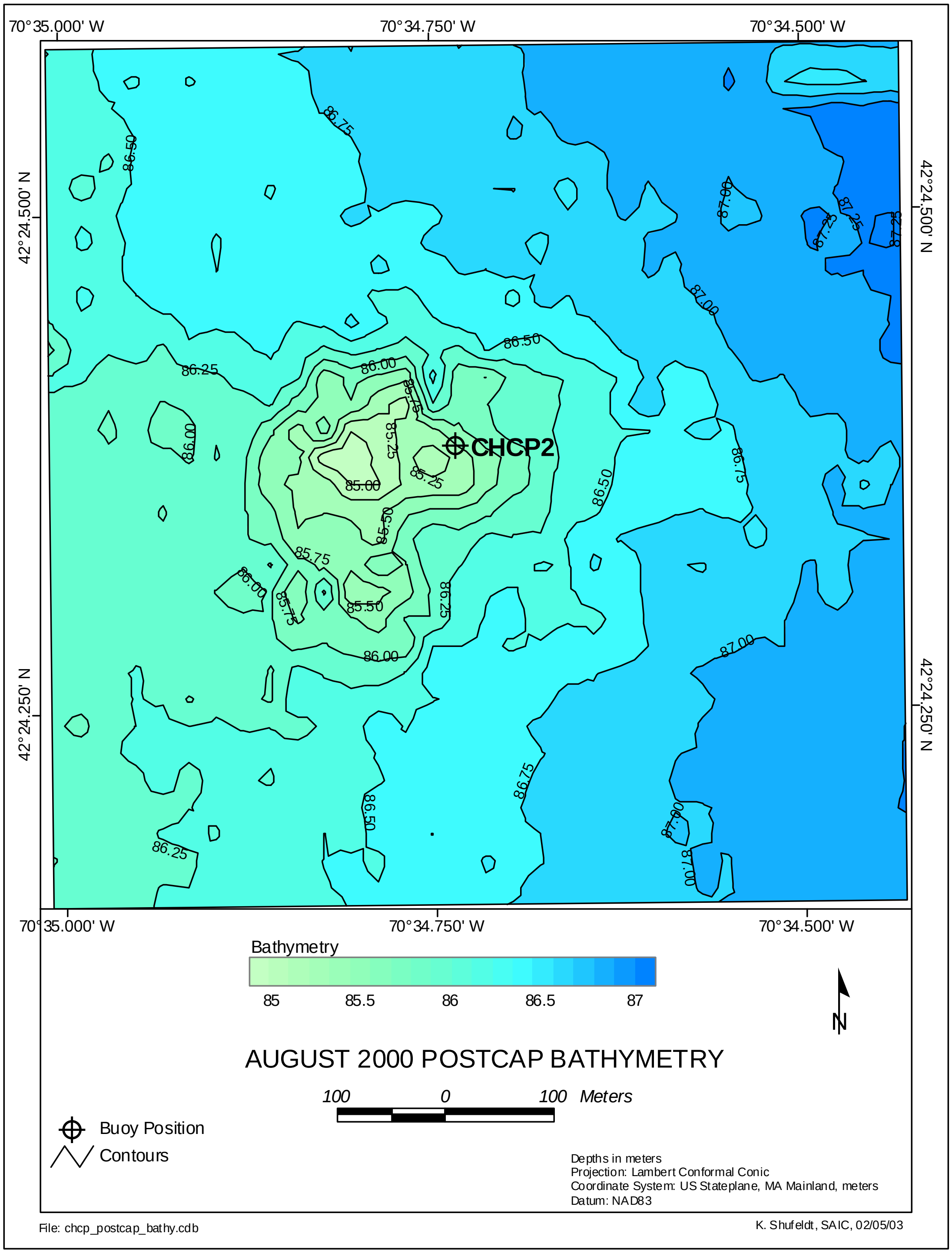


Figure 3-29. Bathymetric chart of the 800 × 800 m CHCP study area during the August 2000 Postcap survey, 0.25 m contour interval

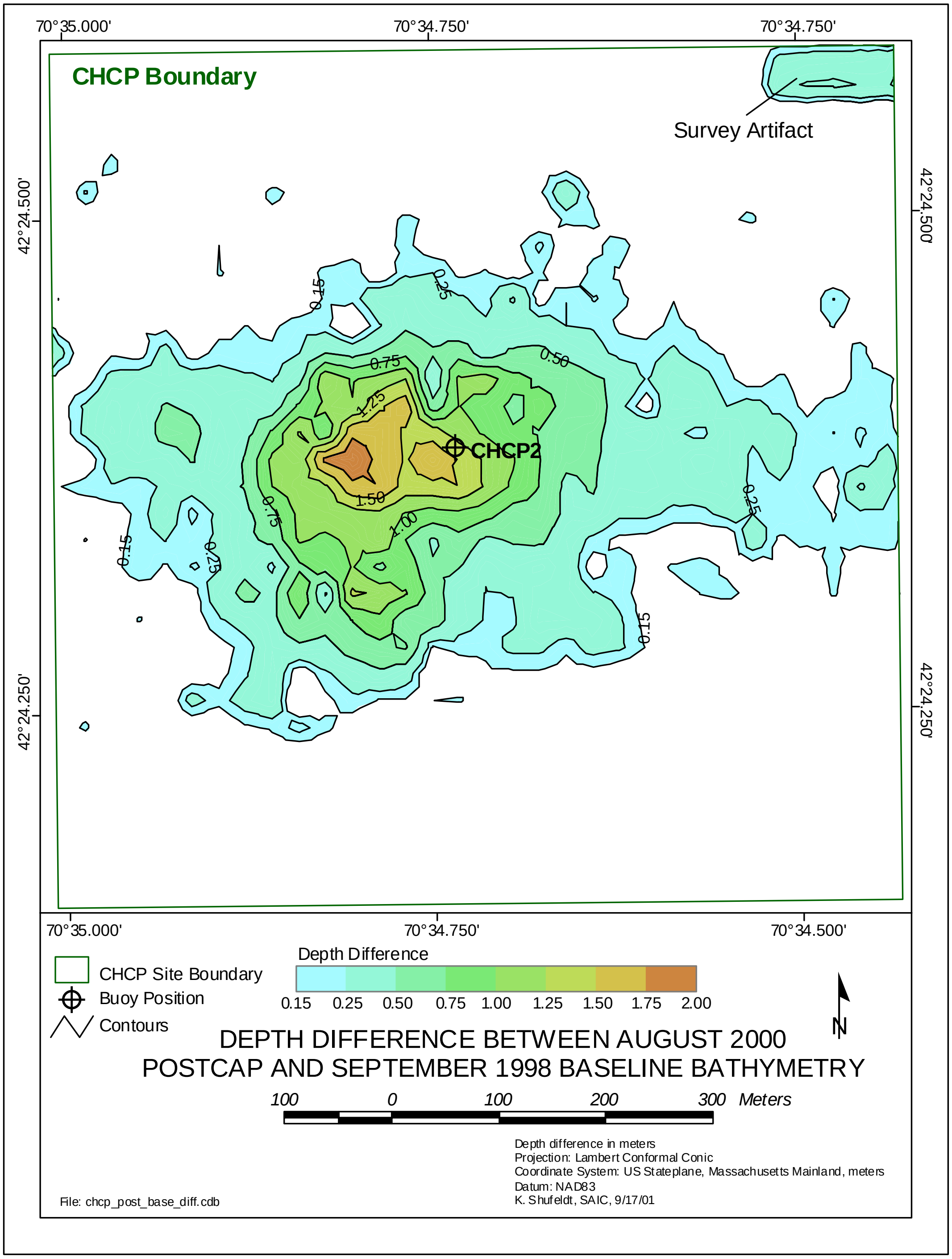


Figure 3-30. Depth difference comparison between the August 2000 Postcap and the September 1998 Baseline bathymetric surveys showing the morphology of the CHCP Mound on the MBDS seafloor, 0.15 m base contour

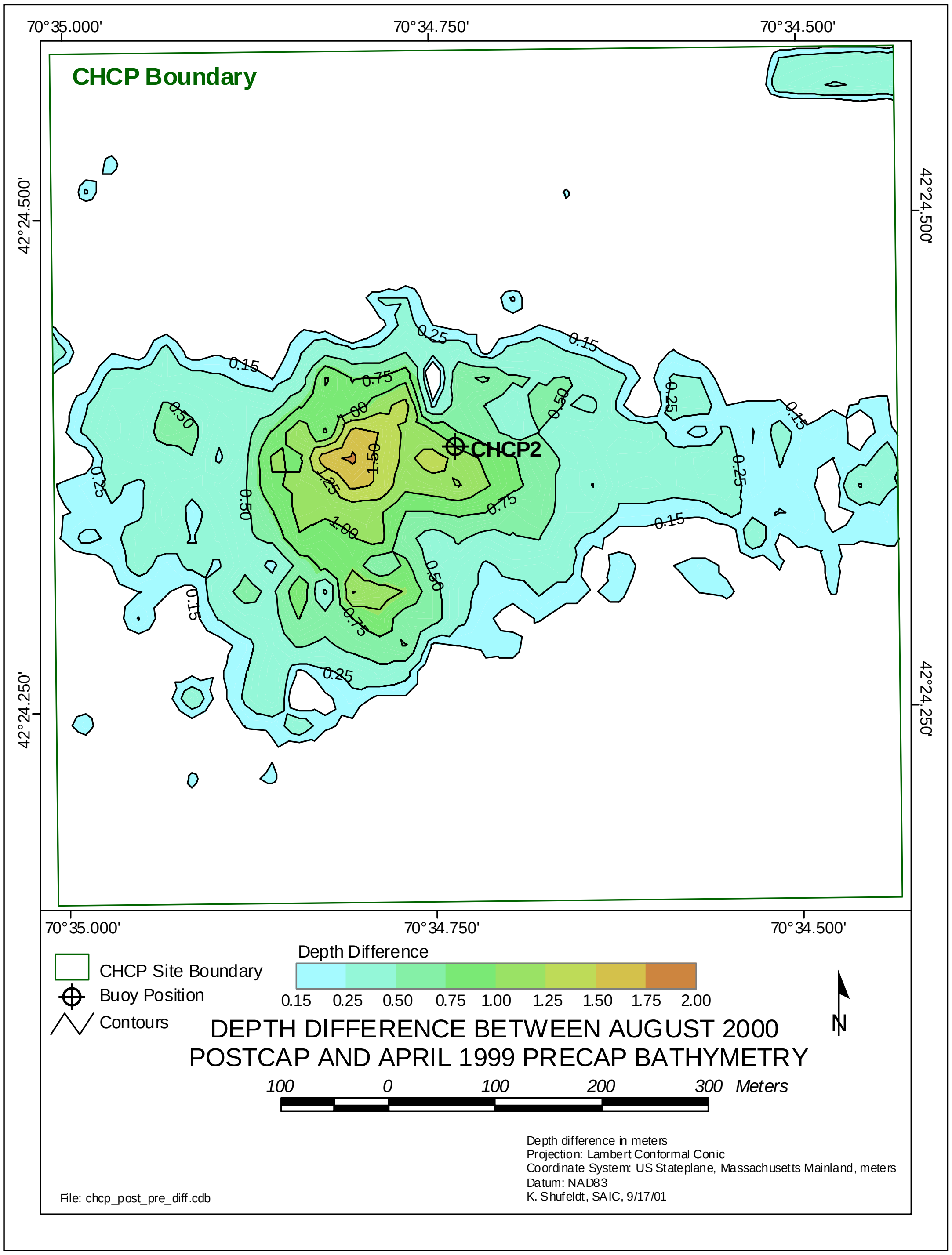


Figure 3-31. Depth difference comparison between the August 2000 Postcap and April 1999 Precap bathymetric surveys showing the distribution and thickness of CDM within the CHCP study area, 0.15 m base contour

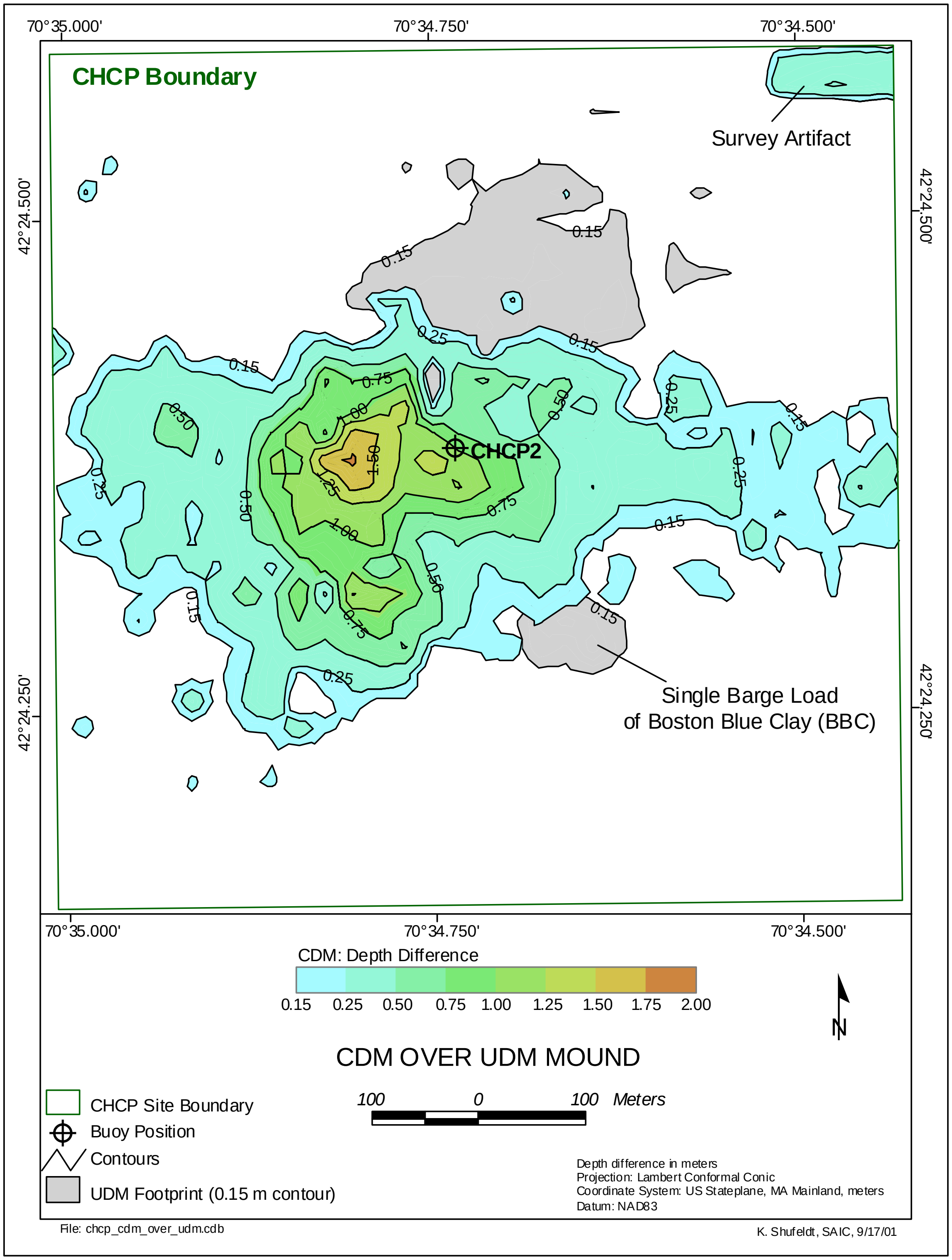


Figure 3-32. Composite map showing the thickness of the CDM layer over the acoustically detectable footprint of the UDM deposit, 0.15 m base contour

Figure 3-33 illustrates the mosaic of the Postcap side-scan survey with the CHCP buoy, as well as the referenced study area and MBDS boundaries. The surface of the cap is mostly comprised of Boston Blue Clay, sand, and mixed gravel. The clay is a very dense material with high cohesive properties often existing in clumps. During disposal, the clumps of Boston Blue Clay maintain their integrity through convective descent through the water column, forming an irregular texture on the seafloor that is evident in certain areas of the side-scan mosaic (Figure 3-34). The coarse sand and granule material is non-cohesive and tends to spread during the convective descent and dynamic collapse phase of disposal, producing the smoother surface seen in other areas of the side-scan mosaic.

The footprint of the capped mound appears to be spread out in a somewhat circular pattern centered on the CHCP buoy position (Figure 3-35). The side-scan data indicate the margins of the mound extend approximately 300 m to both the north and south directions, 380 m to the west, and exceeding 490 m to the east (beyond the data limits). There also appears to be a large extension of cap material to the northeast area of the CHCP site, which also extends past the boundary of the mosaic data limits. In the southeast region of the mosaic a few "trails" of recently deposited dredged material can be seen connecting with individual cap deposits to the north. Similar trails can be seen to the north and northeast, standing out in the areas where they are contrasted against ambient sediment. These types of trails are characteristic of sediment disposals that have taken place while the disposal vessel was still in motion.

3.6.3 REMOTS® Sediment-Profile Imaging

The original 33-station Baseline survey grid was occupied over the capped mound for the Postcap survey in order to determine distribution and thickness of CDM residing in layers too thin to be detected acoustically. As a result, sediment-profile images were key to mapping the footprint of both UDM and CDM on the seafloor. These REMOTS® image analysis results were compared to the results of the UDM characterized in the Precap UDM survey and ambient material characterized in the Baseline survey.

In addition, benthic habitat conditions and recolonization were evaluated over the capped mound during the Postcap survey to verify that the placement of dredged sediment within the CHCP study area had no adverse impacts on the benthos. Three replicate images were obtained at most stations to evaluate within-station variability. Complete REMOTS® results for the Postcap survey are available in Appendix D4; these results are summarized in Tables 3-11 and 3-12.

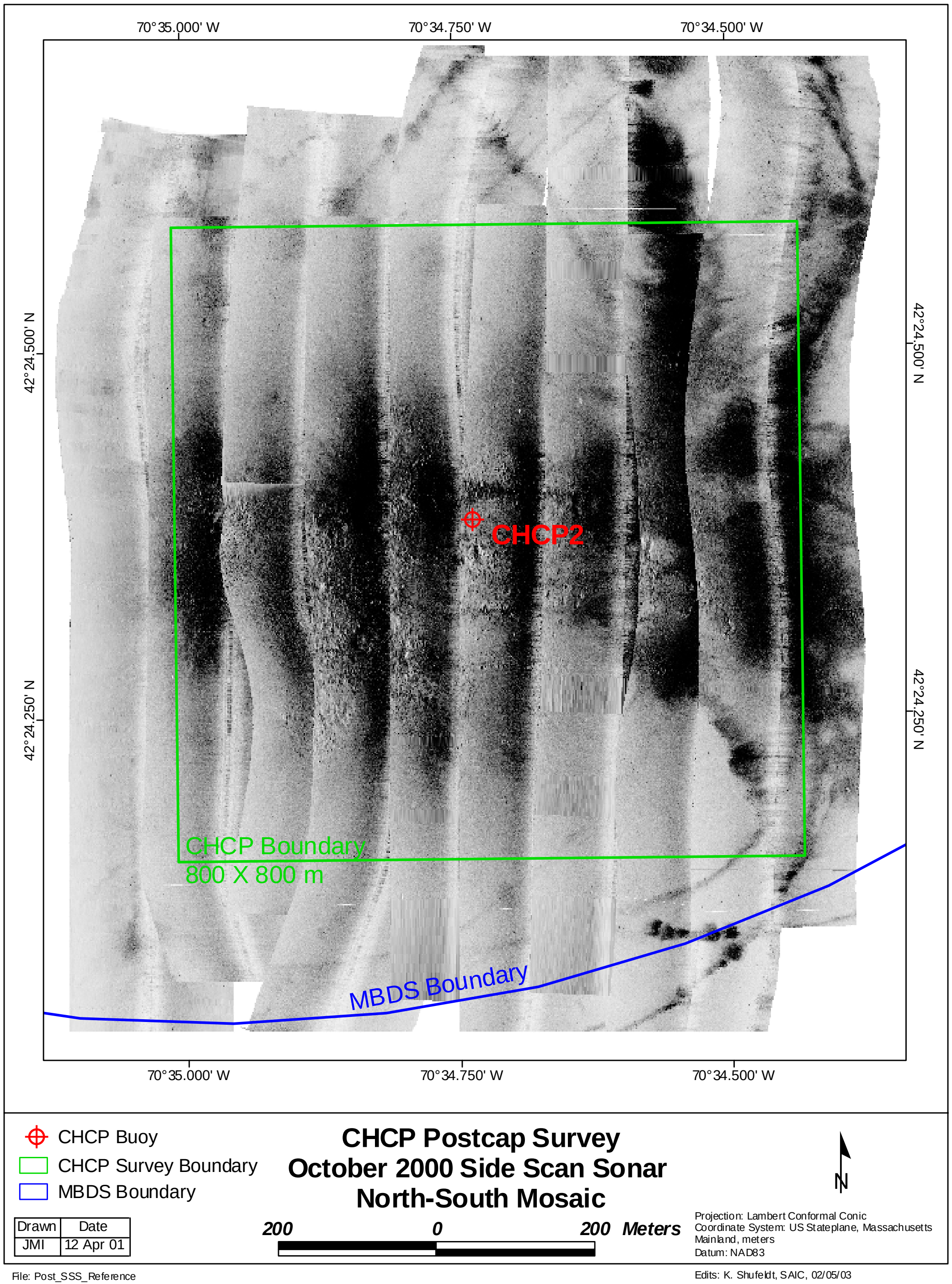


Figure 3-33. Side-scan sonar mosaic of the CHCP study area showing the areal distribution of recently deposited sediments on the seafloor at the Postcap stage of development

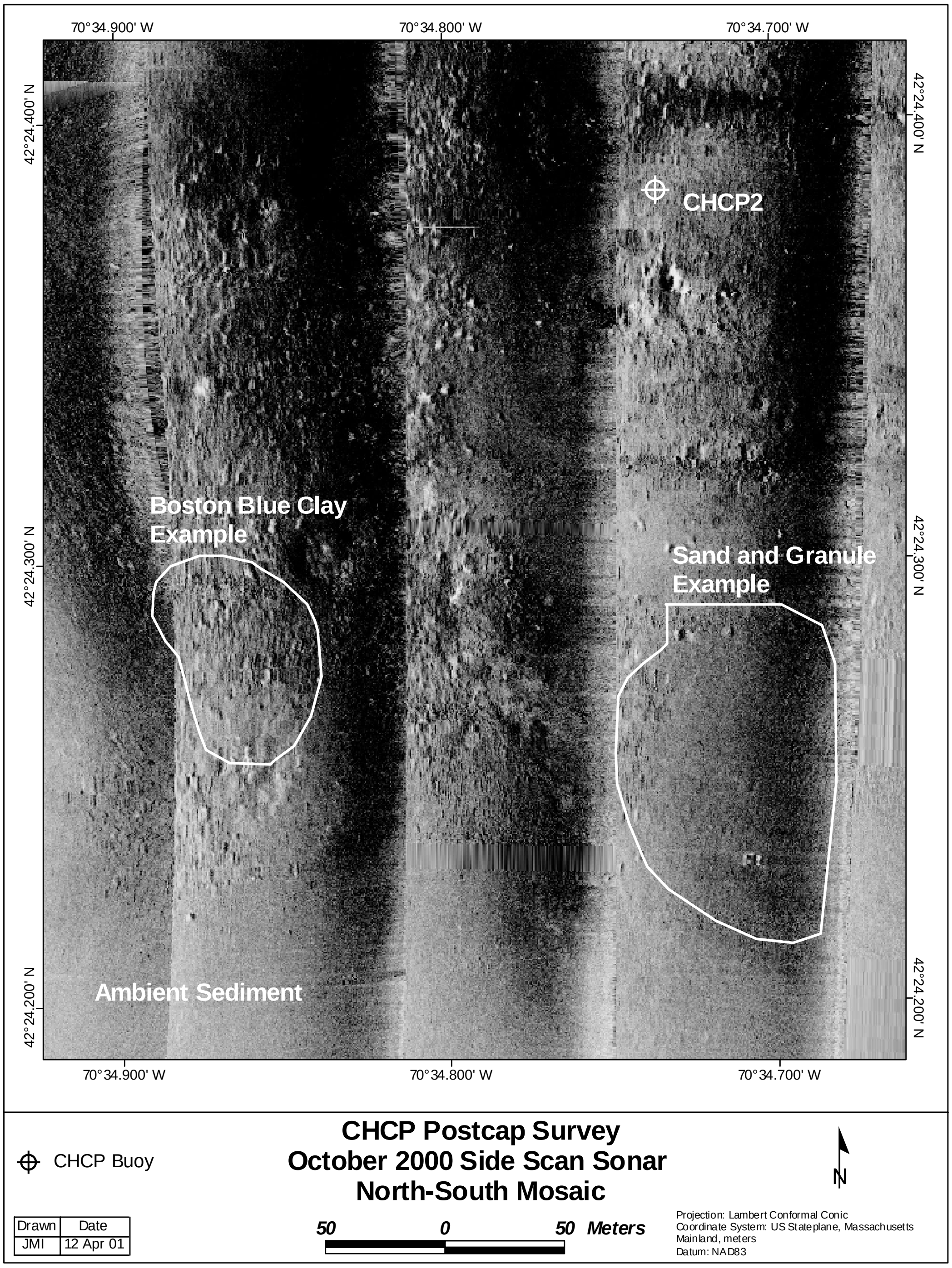


Figure 3-34. Magnified perspective of an area south of the CHCP buoy showing variation in surface sediment texture in close proximity to the disposal point based upon differences in the composition of cap material

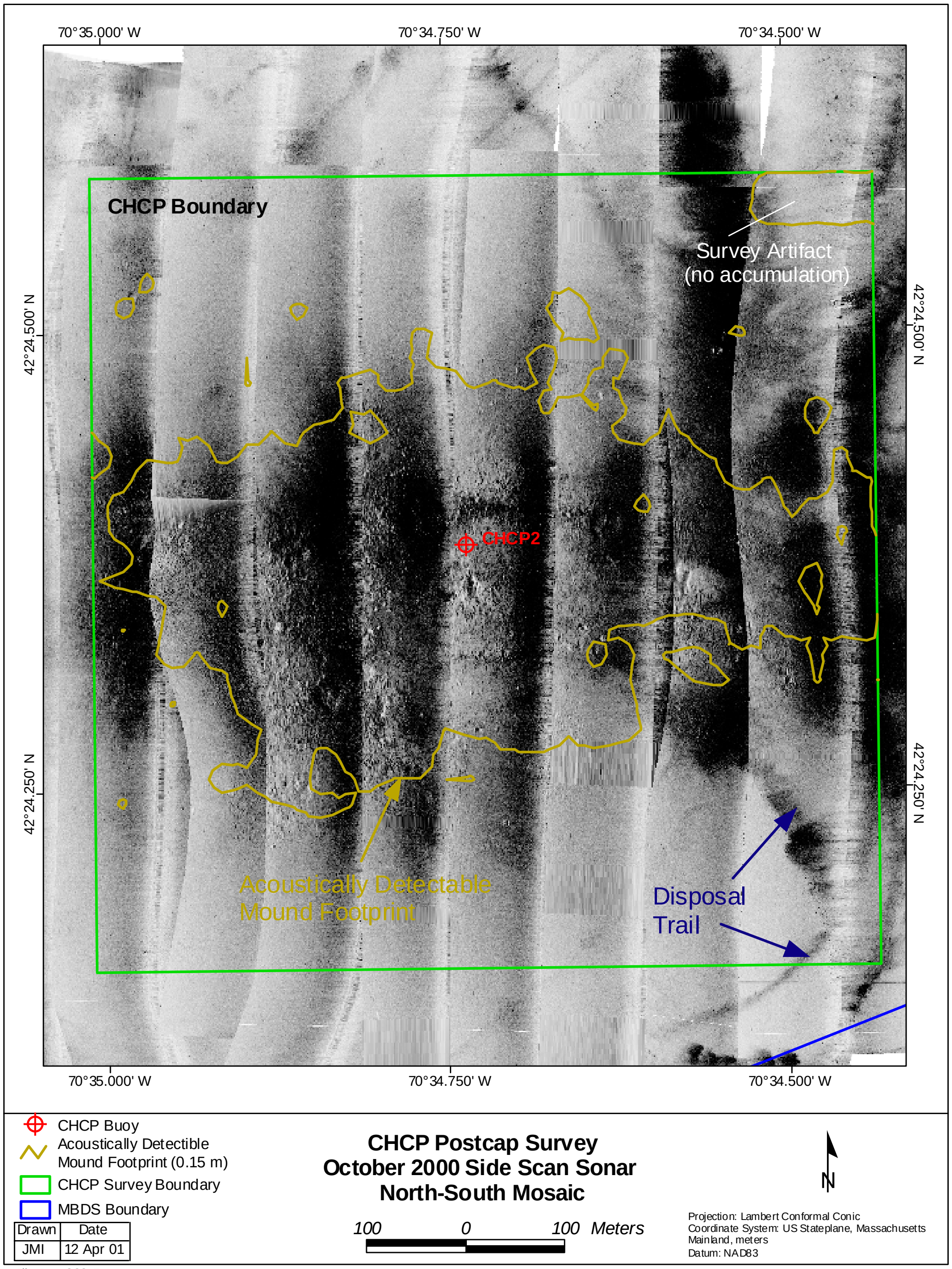


Figure 3-35. Graphic showing the distribution of dredged material within the CHCP study area relative to the acoustically detectable disposal mound footprint at the Postcap stage of development

Table 3-11. Summary of REMOTS® Results for the Postcap Survey over the CHCP Study Area

Station	Camera Penetration Mean (cm)	Grain Size Major Mode (phi)	Sediment Color	Sediment Description	CDM Thickness Mean (cm)
CTR	7.80	>4	Brown	silt/clay	>7.80
50N	10.24	>4	Brown/Blk & Gray	sandy silt/clay	>10.24
50NE	7.63	>4	Brown/Blk & Gray	silt/clay	>7.63
50E	7.20	>4	Brown/Blk & Gray	silt/clay	>7.20
50SE	9.98	>4	Brown/Blk & Gray	silt/clay	>9.98
50S	10.46	>4	Brown/Blk & Gray	silt/clay	>10.46
50SW	14.71	>4	Brown/Blk & Gray	silt/clay	>14.71
50W	12.89	>4	Brown/Blk & Gray	silt/clay	>12.89
50NW	10.97	>4	Brown/Blk & Gray	silt/clay	>10.97
100N	12.72	>4	Brown/Blk & Gray	sandy silt/clay	>12.72
100NE	9.29	>4	Brown/Blk & Gray	silt/clay	>9.29
100E	10.95	>4	Brown/Blk & Gray	sandy silt/clay	>10.95
100SE	11.26	>4	Brown/Blk & Gray	silt/clay	>11.26
100S	12.68	>4	Brown/Blk & Gray	silt/clay	>12.68
100SW	7.88	>4	Brown/Blk & Gray	silt/clay	>7.88
100W	8.88	>4	Brown/Blk & Gray	silt/clay	>8.88
100NW	8.82	>4	Brown/Gray	silt/clay	>8.82
200N	16.40	>4	Brown/Blk & Gray	silt/clay	>16.40
200NE	13.20	>4	Brown/Blk, Gray, & Yellow	silt/clay	>13.20
200E	9.09	>4	Brown/Blk & Gray	sandy silt/clay	>9.09
200SE	11.07	>4	Brown/Black	silt/clay	>11.07
200S	11.98	>4	Brown/Gray	silt/clay	>11.98
200SW	9.78	>4	Brown/Blk & Gray	silt/clay	>9.78
200W	9.73	>4	Brown/Blk & Gray	silt/clay	>9.73
200NW	16.12	>4	Brown/Blk & Gray	silt/clay	>16.12
300N	**17.29**	**>4**	**UDM (6.0 cm)**	**sandy silt**	**0.00**
300NE	12.95	>4	Brown/Gray	silt/clay	>8.58
300E	10.97	>4	Brown/Blk & Gray	silt/clay	>10.97
300SE	15.77	>4	Ambient	silt/clay	0.00
300S	15.68	>4	Brown/Blk & Gray over Ambient	silt/clay	1.73
300SW	17.75	>4	Brown/Blk & Gray	silt/clay	>17.75
300W	8.93	>4	Brown/Blk & Gray	silt/clay	>8.93
300NW	12.65	>4	Brown/Blk & Gray	silt/clay	>12.65

Table 3-12. Summary of Benthic Habitat Assessment Results for the Postcap Survey over the CHCP Study Area

Station	Camera Penetration Mean (cm)	Dredged Material Thickness Mean (cm)	Number of Reps w/ Dredged Material	RPD Mean (cm)	Successional Stages Present	Highest Stage Present	Grain Size Major Mode (phi)	Methane Present	OSI Mean	OSI Median	Boundary Roughness Mean (cm)
CTR	7.80	>7.80	3	2.41	I	ST_I	>4	NO	4.67	4	1.32
50N	10.24	>10.24	3	3.23	I,III	ST_I_ON_III	>4	NO	7.5	7.5	1.72
50NE	7.63	>7.63	3	2.87	I	ST_I	>4	NO	5.33	6	2.02
50E	7.20	>7.20	3	2.47	I	ST_I	>4	NO	4.67	5	3.01
50SE	9.98	>9.98	3	2.76	I	ST_I	>4	NO	5	5	0.89
50S	10.46	>10.46	3	2.09	I	ST_I	>4	NO	4	4	2.20
50SW	14.71	>14.71	3	2.09	I	ST_I	>4	NO	4.33	4	1.06
50W	12.89	>12.89	3	2.83	I	ST_I	>4	NO	5.67	6	2.55
50NW	10.97	>10.97	3	3.07	I	ST_I	>4	NO	5.67	6	1.09
100N	12.72	>12.72	3	1.75	I,III	ST_I_ON_III	>4	NO	6.5	6.5	1.71
100NE	9.29	>9.29	3	2.54	I	ST_I	>4	NO	4.67	5	0.92
100E	10.95	>10.95	3	2.88	I	ST_I	>4	NO	5.33	5	0.68
100SE	11.26	>11.26	3	2.18	I	ST_I	>4	NO	4	4	1.41
100S	12.68	>12.68	3	1.89	I	ST_I	>4	NO	4	5	0.87
100SW	7.88	>7.88	3	2.12	I	ST_I	>4	NO	4	4	0.94
100W	8.88	>8.88	3	2.28	I	ST_I	>4	NO	4.67	5	2.99
100NW	8.82	>8.82	3	3.63	I	ST_I	>4	NO	6	6	2.43
200N	16.40	>16.40	3	2.00	I	ST_I	>4	NO	4	4	0.81
200NE	13.20	>13.20	3	2.70	I,III	ST_I_ON_III	>4	NO	6.33	7	1.71
200E	9.09	>9.09	3	1.97	I	ST_I	>4	NO	4	4	1.76
200SE	11.07	>11.07	2	3.59	I	ST_I	>4	NO	6	6	0.66
200S	11.98	>11.98	3	2.54	I	ST_I	>4	NO	5	5	1.16
200SW	9.78	>9.78	3	2.67	I	ST_I	>4	NO	5	5	1.00
200W	9.73	>9.73	3	2.24	I,III	ST_I_ON_III	>4	NO	5.67	4	3.05
200NW	16.12	>16.12	3	1.15	I	ST_I	>4	NO	3	3	1.77
300N	17.29	0	0	1.20	I	ST_I	>4	NO	2.67	2	0.81
300NE	12.95	>8.58	2	1.59	I,III	ST_I_ON_III	>4	NO	5	5	2.57
300E	10.97	>10.97	3	3.38	I,III	ST_I_ON_III	>4	NO	7.33	6	3.46
300SE	15.77	>15.77	3	1.86	I	ST_I	>4	NO	4	4	1.23
300S	15.68	1.73	3	1.60	I,III	ST_I_ON_III	>4	NO	5	4	1.29
300SW	17.75	>17.75	3	1.53	I	ST_I	>4	NO	3.67	4	2.31
300W	8.93	>8.93	1	3.67	I	ST_I	>4	NO	6	6	1.35
300NW	12.65	>12.65	1	1.70	I	ST_I	>4	NO	4	4	1.47
AVG	12.24	>10.55	2.67	2.32					4.87	4.88	1.60
MAX	17.75	>17.75	3	3.67					7.33	7.5	3.46
MIN	7.88	0	0	1.15					2.67	2	0.66

3.6.3.1 Sediment Composition

Physical REMOTS® parameters indicated the surface and near surface sediment layers at the disposal site were composed primarily of silt and clay with varying sand content. A major modal grain size of >4 phi was observed at all stations as a brown oxidized layer of silt over an often chaotic mixture of black silt and gray mottled clay at depth (Figure 3-36; Table 3-11). In general the CDM detected in the REMOTS® images was characterized by a mixture of black silt and gray clay with varying amounts of granule sand throughout the subsurface layers.

The sediment in certain replicate REMOTS® images was poorly sorted with numerous mud clasts present, both of which are strong indicators of recently placed dredged material (Figure 3-37A and 3-37B). Varying amounts of sand were noted in replicate images collected from multiple stations, which could be attributed to the Chelsea River (Figure 3-37A). The presence of Boston Blue Clay in the REMOTS® photographs also served as an indicator of Chelsea River CDM.

Replicate-averaged camera penetration values over the capped mound ranged from 7.2 cm at Station 50E to 17.8 cm at Station 300SW, with an overall average of 11.6 cm (Table 3-11). The thickness of the CDM layer exceeded the penetration depth of the REMOTS® camera at 30 of the 33 stations (i.e., CDM greater than penetration is denoted by a "greater than" sign in Figure 3-38 and Table 3-11). Ambient sediments were detected on the southern periphery of the survey grid. Station 300S displayed an average dredged material (CDM) thickness of 1.73 cm over ambient sediment, and Station 300SE was classified as ambient material throughout the image (Figure 3-38; Table 3-11). In addition, ambient sediment was detected in one replicate of Station 300NE (Figure 3-39).

As anticipated, the REMOTS® images collected over the center of the CHCP Mound reflected surficial sediment consisting entirely of CDM. The cap material layer was expected to be thicker near the center of the mound due to the higher volume of material reportedly placed in close proximity the CHCP buoy. CDM was also detected at many stations on the periphery of the survey grid, however, none of the REMOTS® images collected at these outer stations displayed an obvious UDM/CDM interface. This suggests a relatively thick layer (10 cm) of CDM extends beyond the acoustically detectable margins of the capped mound.

Mapping the CDM footprint based on thickness of Chelsea River material (reduced black silt and Boston Blue Clay) detected in the REMOTS® images indicated that CDM covered an area of approximately 436,500 m² within the CHCP study area. Only one station within the survey grid (300N) displayed Cohasset Harbor UDM at the sediment-

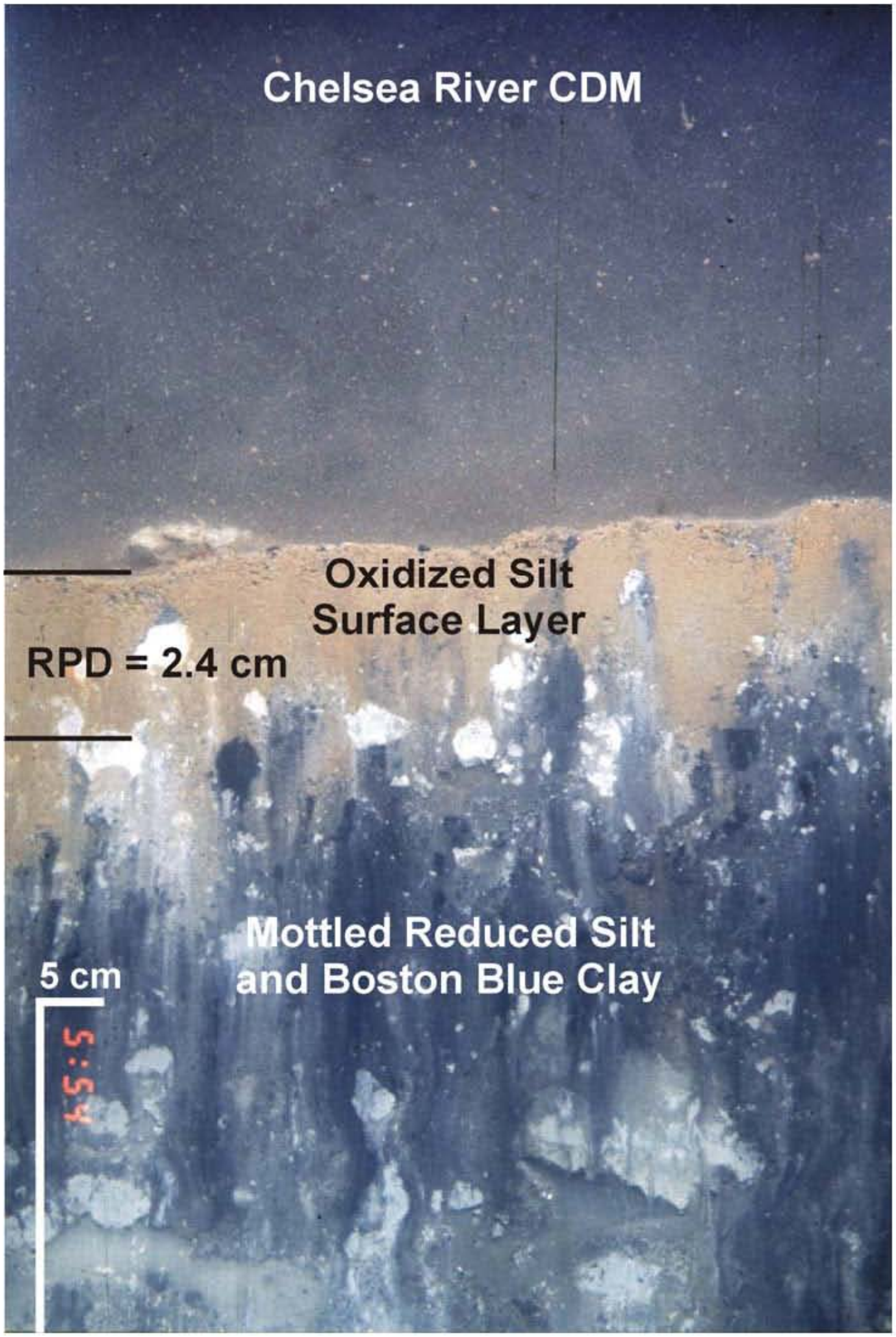
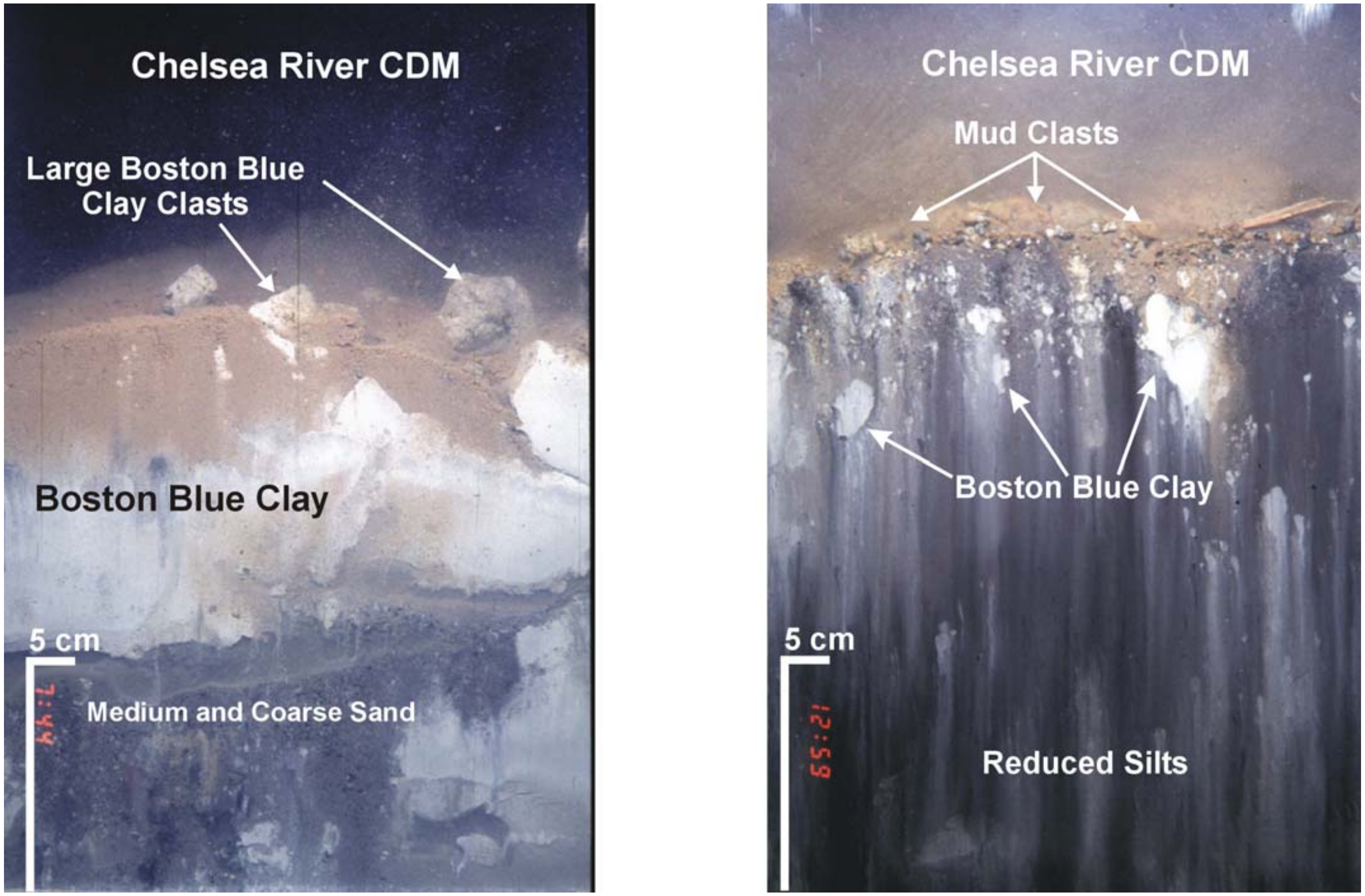


Figure 3-36. REMOTS® image collected from Station 50SW during the Postcap Survey illustrating the characteristic CDM originating from Chelsea River in the form of brown, oxidized silt over black and gray mottled clay (>4 phi)



A **B**

Figure 3-37. REMOTS® images obtained from Postcap Survey Stations 200E (A) and 200NW (B) displaying dredged material indicators such as poorly sorted sediment and surface mud clasts from Chelsea River. Both stations show mud clasts in varying sizes. Poorly sorted gray sandy silt and clay is present below a layer of well-mixed fine-grained sediments (brown silt) at Station 200E.

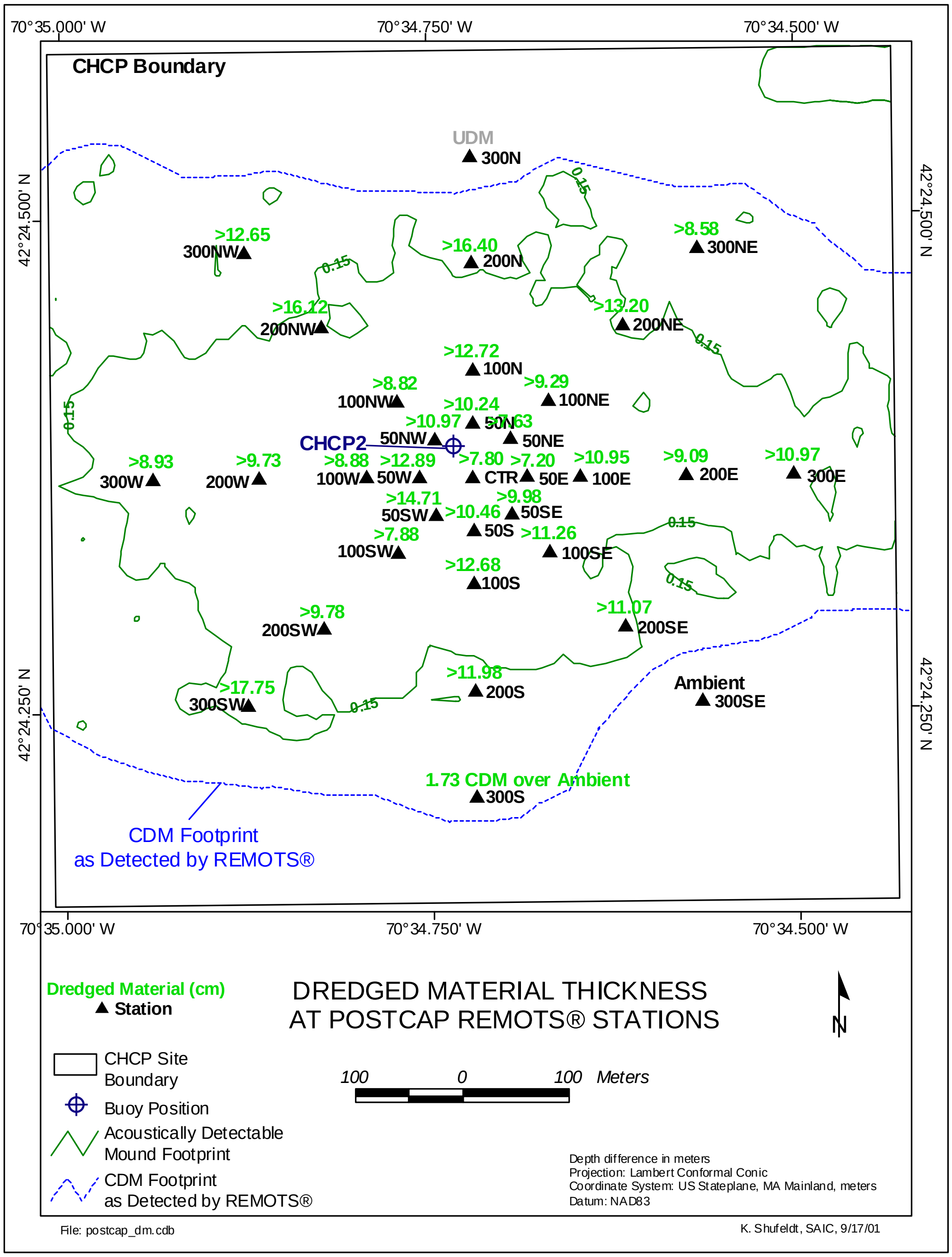


Figure 3-38. Map of the CHCP study area showing the spatial distribution and thickness of CDM within the CHCP study during the Postcap survey. The blue dotted lines represent the margins of the CDM footprint as detected by sediment-profile imaging

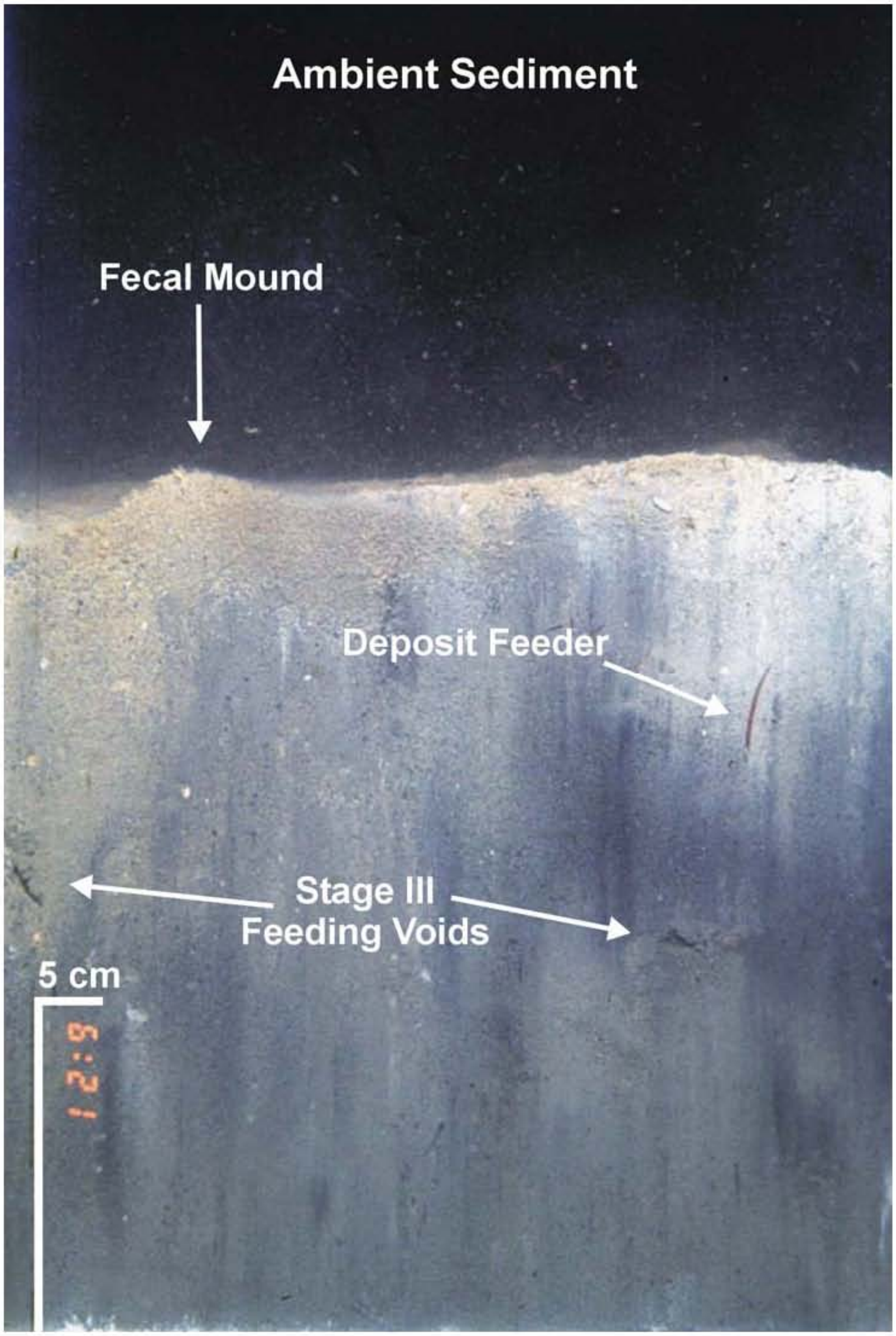


Figure 3-39. REMOTS® image collected from Station 300NE during the Postcap Survey, exhibiting ambient material at the sediment-water interface. Feeding voids, a polychaete worm, and a fecal mound are visible within the ambient sediment

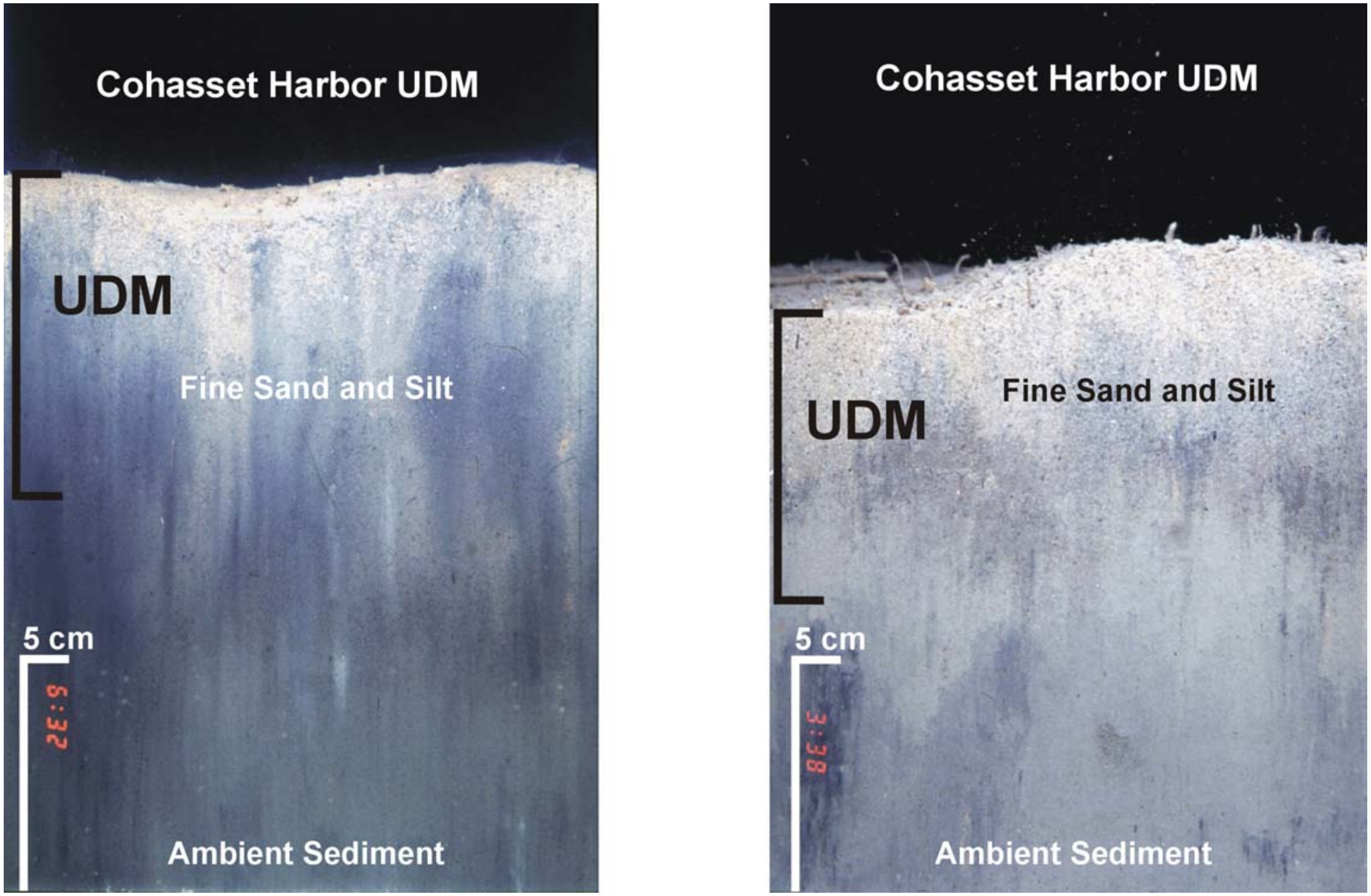
water interface. All three replicate images collected from this station had surface sediment similar in composition to the material detected as part of the Precap survey (Figure 3-40A & B). This finding indicates a lack of CDM coverage over the extreme northern portions of the UDM apron.

As a result of the recent CDM deposition, replicate-averaged boundary roughness values within the disposal site ranged from 0.7 cm at Station 200SE to 3.5 cm at Station 300E (average of 1.6 cm; Table 3-12). There was no obvious spatial pattern of boundary roughness values across the survey area. Surface roughness was attributed to primarily physical disturbance, with only a few occurrences of biogenic surface roughness. The surface of the dredged material was frequently irregular and disturbed. Stiff cohesive clay was often fractured or existing as large clumps at the sediment-water interface.

3.6.3.2 Biological Conditions and Benthic Recolonization

Three parameters were used to assess the benthic recolonization status of the disposal site. The apparent Redox Potential Discontinuity (RPD) depth, Organism-Sediment Index (OSI), and infaunal successional status were mapped on station location plots to outline the biological conditions across the area (Figures 3-41 and 3-42). These data were compared to the results obtained from three reference areas in Massachusetts Bay (FG-23, MBX-REF, SE-REF) sampled as part of the 2000 monitoring survey effort for MBDS (SAIC 2002). A summary of the results pertaining to benthic habitat assessment for the Postcap survey is presented in Table 3-12, with results from the MBDS reference areas summarized in Table 3-13.

The RPD was measured in each image collected over the CHCP Mound to estimate the apparent depth of oxygen in the sediment. The RPD was characterized as a surface layer of oxidized, brown silt over black and gray mottled clay (Figure 3-37A & B). The replicate-averaged RPD depths for the disposal site areas were generally shallow to moderate, ranging from 1.2 cm at Station 200NW to 3.7 cm at Station 300W (average of 2.3 cm; Figure 3-41; Table 3-12). Reference area RPD depths in Fall 2000 were somewhat deeper in comparison to those at the CHCP Mound, with a composite value of 3.9 cm calculated for the three sites (Table 3-13). The measured RPD depths over the mound did not demonstrate any spatial pattern within the survey grid and there was no significant difference between RPD depths for stations surrounding the CHCP buoy or stations on the periphery of the grid. None of the stations at CHCP displayed apparent low dissolved oxygen conditions, visible redox rebounds, or evidence of methane gas entrained within the sediment.



A B

Figure 3-40. REMOTS® images collected from Station 300N during the Postcap (A) and Precap (B) surveys over the CHCP study area displaying similar sediment composition after the placement of CDM over the initial UDM deposit

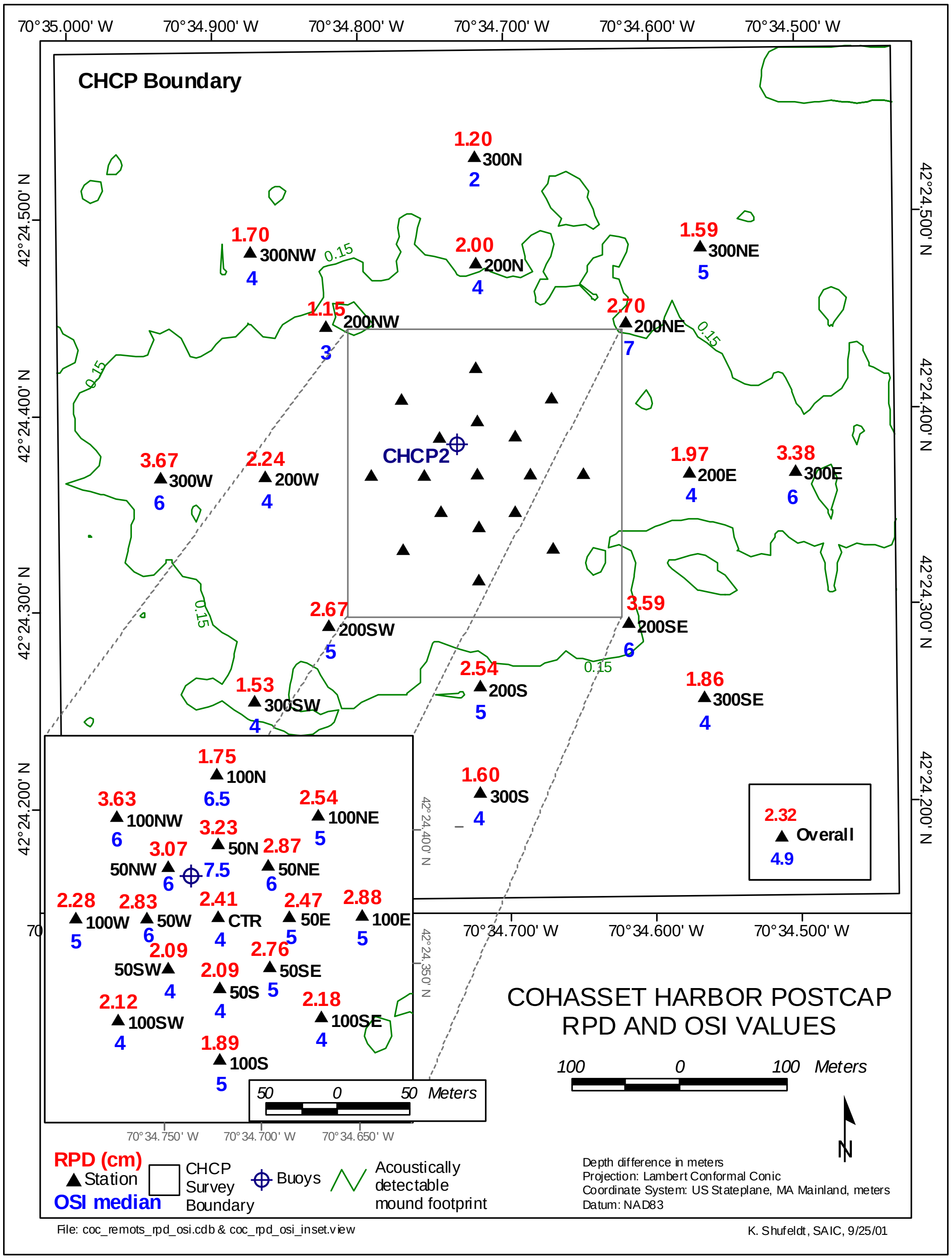


Figure 3-41. Map of mean RPD depth (red) and median OSI values (blue) calculated for the stations over the CHCP Mound during the Fall 2000 Postcap REMOTS® survey, relative to the acoustically detectable mound footprint

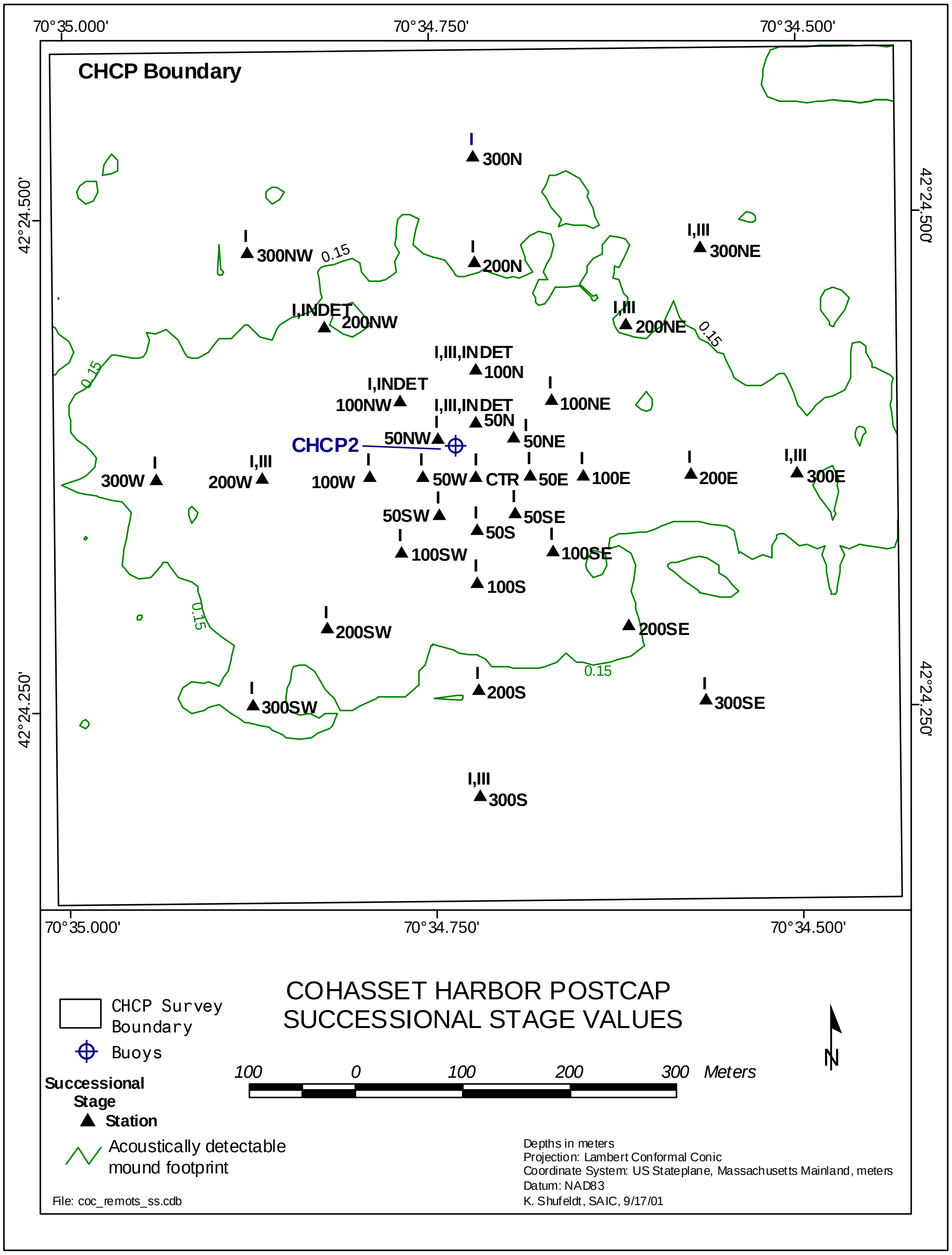


Figure 3-42. Map of the successional stage status for the stations over the CHCP Mound during the Fall 2000 Postcap REMOTS® survey, relative to the acoustically detectable mound footprint

Table 3-13. Summary of Benthic Habitat Assessment Results for the MBDS Reference Areas, Fall 2000

Ref Area	Station	Camera Penetration Mean (cm)	RPD Mean (cm)	Successional Stages Present	Highest Stage Present	Grain Size Major Mode (phi)	OSI Mean	OSI Median	Boundary Roughness Mean (cm)
FG-23	2	14.27	4.02	I,II	ST_II	>4	7.33	7	4.57
FG-23	3	10.02	2.91	I,II	ST_I_TO_II	>4	6	6	3.22
FG-23	4	13.36	3.06	I,III	ST_III	>4	6.67	6	1.98
FG-23	5	12.04	2.71	II,III	ST_II_ON_III	>4	8	8	2.84
FG-23	6	16.92	4.29	I	ST_I	>4	6.67	7	1.95
MBX-REF	1	19.67	5.13	I,III	ST_I_ON_III	>4	8.33	7	1.39
MBX-REF	2	14.24	4.06	III	ST_III	>4	10	10	2.01
MBX-REF	3	11.99	4.55	I,II,III	ST_II_ON_III	>4	9.33	10	1.26
MBX-REF	4	20.39	5.26	I,III	ST_I_ON_III	>4	11	11	0.82
SE-REF	1	12.08	4.17	II,III	ST_II_ON_III	>4	10.33	11	4.07
SE-REF	2	13.05	3.24	II	ST_II	>4	7.67	8	2.79
SE-REF	3	14.63	4.90	I,II,III	ST_III	>4	8.33	7	2.83
SE-REF	4	7.75	2.96	I,II,III	ST_II_ON_III	>4	7	7	1.49
AVG		13.88	3.94				8.21	8.08	2.40
MAX		20.39	5.26				11	11	4.57
MIN		7.75	2.71				6	6	0.82

The successional stage recolonization status at CHCP included principally Stage I pioneering polychaetes at the sediment surface as well as limited progression into Stage III in the subsurface layers (Figure 3-42; Table 3-12). The presence of Stage III taxa (i.e., head-down, deposit-feeding infauna) was detected at seven of the 33 stations, evidenced by active feeding voids at depth or the actual imaging of an errant polychaete worm(s) within the sediment. The stations exhibiting advanced successional stages (Stage III) were predominantly noted in the outer stations of the survey grid (200 m and 300 m) where recent dredged material thickness and impact would be less (Figure 3-42). In general, bioturbation appeared to be limited to the top few centimeters of sediment, confirming that many of the CHCP stations were recently disturbed by the placement of CDM. This finding was anticipated, due to the large amounts of cohesive clay detected in the majority of the sediment-profile images. Cohesive clays at the sediment-water interface tend to slow benthic recolonization as the dense sediment impedes the burrowing activity of advanced successional seres. In addition, the glacial clay deposits are usually devoid of organic matter that deposit-feeding invertebrates normally exploit as a food source. Therefore fresh clay deposits cannot support a dense population of Stage III organisms.

In response to the limited presence of Stage III activity and relatively shallow RPD depths, replicate-averaged median OSI values for the disposal site stations ranged from +2 to +7.5. As anticipated due to the recent disposal-related disturbance to the seafloor within the CHCP study area, the average OSI value for the CHCP mound (+4.9) was somewhat lower than the composite OSI for the MBDS reference areas (+8.1; Tables 3-12 and 3-13). Relatively shallow RPD depths and Stage I activity served to limit the median OSI values for Station 300N (+2) and Station 200NW (+3) (Figure 3-41). Conversely, deeper RPD depths and the presence of Stage III individuals elevated the OSI values for Stations 50N (+7.5) and 200NE (+7; Table 3-12). Overall, the lower median OSI values determined for the CHCP study area stations suggest a relatively disturbed benthic environment that is in the initial stages of benthic recolonization following recent capping activities.

3.6.4 Postcap Gravity Coring

The Postcap survey effort consisted of 12 sediment coring stations established over the capped mound in an attempt to collect vertical cross-sections of the layered sediment deposit (Figure 3-43; Table 2-5). The coring locations were selected based on the results of sequential bathymetric surveys and targeted those areas that would provide an opportunity to view the sediment interfaces between the CDM, UDM, and ambient sediment horizons.

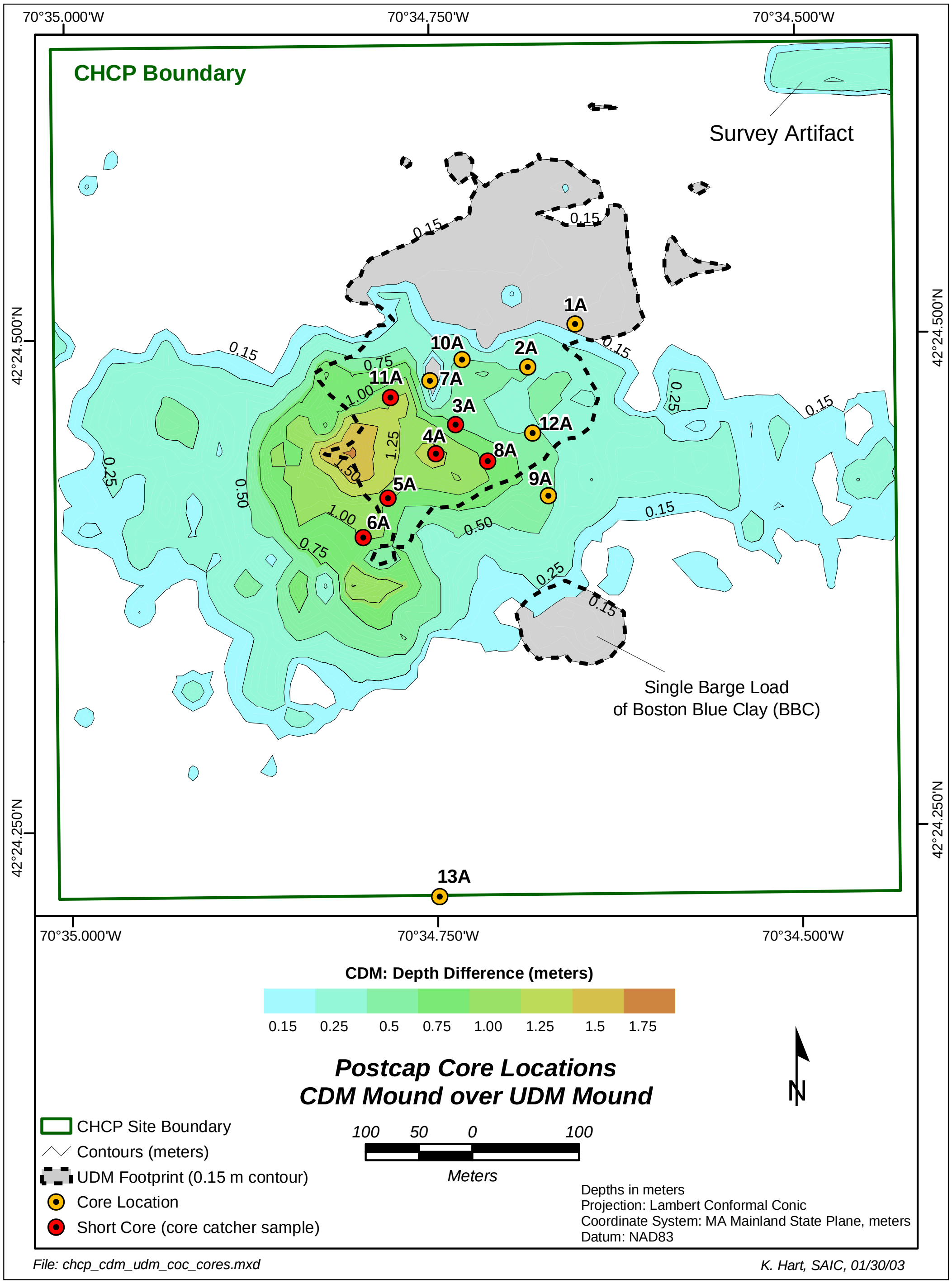


Figure 3-43. Location of the long (yellow) and short (red) cores collected from the surface of the CHCP Mound during the summer 2000 Postcap survey, relative to the acoustically detectable margins of the UDM and CDM deposits

In addition, a thirteenth core was collected along the southern margin of the CHCP study area (CHCP 13) to test the coring device and characterize the ambient sediments. This core penetrated 112 cm into the seafloor and consisted entirely of dark greenish gray, moist, soft-firm clay with 98% fine-grained sediment (Table 3-14). Water content within the ambient sediment was generally high with values in excess of 100% detected in all three horizons sampled. Because the water content of sediments composed of fine-grained material has a tendency to be higher than coarser material, this parameter was useful in differentiating between ambient and deposited sediments.

The Chelsea River CDM was distinctly different from the sediments originating from Cohasset Harbor. In general, the Chelsea River material contained a significant amount of Boston Blue Clay, as well as coarse sand, gravel and cobble, while the Cohasset Harbor UDM primarily consisted of sandy silt with varying amounts of organic matter and larger grain size sediment. Due to the dense nature of the Chelsea River CDM layer over the CHCP Mound, only eight cores successfully collected more than 50 cm of core length including the reference core (CHCP 13). The seven cores varied in length as well as material type present. Coring efforts at Stations 3, 4, 5, 6, and 8 resulted in no more than 25 cm of material recovered from the seafloor, while the sample obtained from Station 11 was 41 cm in length and consisted entirely of dense clay. All the shorter cores were attempted near the central portion of the CDM deposit where cap material thickness in excess of 0.75 cm was detected through bathymetric depth difference comparisons (Figure 3- 43). This relatively thick layer of consolidated and cohesive material was resistant to shearing action of a fully-weighted (400 lbs) gravity coring device, resulting in shallow penetration and low sediment yield at these stations. Core catcher material was collected and described for the both the longer and shorter cores (Table 3-15). The majority of material collected in the core catcher of the short cores consisted of a consolidated, very hard aggregate of clay, gravel and/or rock, similar to the material collected in the Chelsea River. Annotated core images and core logs for the CHCP Postcap cores are included in Appendix F.

Most of the long Postcap cores displayed a distinct stratification in sediment grain size with depth. The presence of ambient sediment was indicated by a high (>90%) silt and clay content, presence of shell fragments, and water content >100%. The CDM was characterized by an interval with a significant Boston Blue Clay component, as well as a mix of gravel and medium to coarse sand (24%). Most of the long cores collected contained what appeared to be ambient material at depth, indicating that cores penetrated through both the CDM and the UDM material. Core 10 was the exception in that it captured the CDM/UDM interface, but did not penetrate into ambient sediment.

Table 3-14. Sediment Grain Size Distributions for the Sub-samples Collected from the Postcap Cores

ID	depth interval	wet wt.	dry wt.	Water Content	% cobble	% gravel	% sand			% fines	
							coarse	medium	fine	silt	clay
		g/cc	g/cc	%	>3"	<3"-#4	#10	#20-#40	#60-#200	0.074-0.005mm	<0.005mm
CHCP1A1	4.5-10	2.21	1.87	18	0	30.26	6.99	18.91	36.35	3.88	3.6
CHCP1A2	20-25	1.43	0.68	110	0	0	0.64	2.33	3.51	46.53	47
CHCP 2A1	6-16	2.14	1.75	22	0	24.3	8.31	20.9	20.91	9.58	16
CHCP 2A2	56-66	1.9	1.42	33	0	7.4	2.61	15.63	50.27	12.09	12
CHCP 2A3	66-76	1.44	0.71	104	0	0	0.02	1.88	4.04	39.06	55
CHCP 2A4	140-150	1.45	0.73	100	0	0	0.01	0.04	0.54	37.41	62
CHCP 7A1	12-25	2.01	1.52	32	0	22.57	4.93	8.98	12.73	14.79	36
CHCP 7A2	27-37	2.02	1.57	29	0	18.42	4.15	7.67	11.08	18.69	40
CHCP 7A3	38-48	1.93	1.44	34	0	41.74	8.42	8.89	6.53	13.43	21
CHCP 7A4	141	1.46	0.7	107	0	0	0.15	0.18	0.81	41.86	57
CHCP 9A1	13-20	2.36	2.08	13	0	49.39	10.86	17.26	13.36	3.13	6
CHCP 9A2	40	1.47	0.7	109	0	0	0.46	0.66	1.83	49.04	48
CHCP 10A1	7-13	2.12	1.76	21	0	0.42	2.07	40.5	37.77	6.26	13
CHCP 10A2	16-22	2.04	1.62	26	0	28.42	14.04	14.09	13.56	7.9	22
CHCP 10A3	60-68	1.55	0.87	77	0	12.59	4.43	6.56	5.59	22.82	48
CHCP 12A1	10-20	2.15	1.79	20	0	44.55	11.39	17.78	11.82	4.46	10
CHCP 12A2	20-30	1.56	0.87	80	0	7.11	2.77	7.73	12.68	27.71	42
CHCP 12A3	75-85	1.45	0.72	100	0	0	0.05	0.02	0.4	39.52	60
CHCP 13A1	5-10	1.46	0.67	117	0	0	0.51	1.14	1.98	46.37	50
CHCP 13A2	12-17	1.41	0.64	121	0	0	0	0.08	1.29	53.63	45
CHCP 13A3	25-30	1.47	0.72	105	0	0	0	0.04	0.78	52.18	47

Table 3-15. Description of the Sediment Retained in the Core Catcher Assembly during the Postcap Survey over the CHCP Mound

Core Station	Rep.	Description of Core Catcher Material
1	A	10.5cm; BBC
2	A	15cm; BBC
3	A	5cm; greenish-gray, organic odor, moist, firm, CLAY (BBC)& shells & large pebbles
3	B	21cm; BBC/gravel
4	A	15cm; greenish-gray, moist, firm, BBC, 55% rock, with petrolium vein
5	A	8cm; greenish-gray, moist, firm, CLAY (BBC)
6	A	19cm; dark dgreenish-gray, moist, firm, CLAY (BBC) w/gravel at depth (stop penentration)
6	B	less than 1m material Bagged as top & bottom, w/ bottom BBC plug that stopped corer
7	A	17cm; greenish-gray, organic, moist,firm, CLAY
8	A	25cm; mottled black & greenish-gray, petrolium, moist-wet, firm-hard (moderate cementation), CLAY & GRAVEL (coarse sand-7cm rock)
9	A	17.5cm; dark greenish-gray, organic, moist, firm, CLAY, shell
11	A	16cm; mottled black & greenish-gray, petrolium, moist, firm-hard, sandy CLAY (BBC), rock @2cm & rock@5cm
12	A	14cm; dark greenish-gray, organic,moist, soft, CLAY w/ shell frags
13	A	17cm; dark greenish-gray, organic,moist, soft, CLAY w/ shell frags

Core 1A was collected within the acoustically detectable UDM mound and just outside the 15 cm CDM contour (Figure 3-43). This core was 103 cm in length and contained ambient material below a penetration depth of 17 cm. The surface material (5-12 cm) was greenish-black, hard silty sand over a narrow (5 cm) band of greenish-black, soft silty clay. Although Core 1A did not contain Boston Blue Clay, the thin surface interval likely represented material dredged from the upper reaches of Chelsea River. The second interval, described as a 5 cm band of silty clay, may be attributable to the placement of Cohasset Harbor UDM. Grain size data was collected from two intervals within Core 1A (surface and 20-25 cm of penetration). The surface material contained 82% sand and gravel, while the lower sample horizon contained 8%. The silt and clay components were significantly higher in the 20-25 cm sample, comparable to the values detected in Core 13, indicating the presence of ambient sediments. In addition, water content data confirmed the visual descriptions and grain size results, as the sandy surface material had a water content of 18% versus 110% in the fine-grained sediments from 20-25 cm interval (Table 3-14). Overall, the data confirm the interval above the 17 cm horizon represents deposited sediments with thin layers of both UDM and CDM captured; however, no visually distinct interface existed between the two deposits.

Core 2A was 169 cm long and contained ambient material (97% silt/clay) below a penetration depth of 67 cm. This core was collected approximately 60 m southwest of Core 1A in an area with overlapping UDM and CDM aprons (Figure 3-43). From a penetration depth of 6 cm to 20 cm the core had a strong petroleum odor and contained greenish-gray, firm-hard silty, sandy clay and gravel, indicative of CDM. A large pocket of Boston Blue Clay was present from 20-56 cm, again indicative of Chelsea River CDM. At 56 cm, a layer of greenish-gray clay and sandy silts (UDM) that continued 11 cm down core until ambient sediments were detected at a penetration depth of 67 cm. From 67-169 cm ambient sediment dominated by silt and clay (94-99%) was present. Two sub-samples were collected for grain size and water content analysis above 67 cm; both of these samples indicated silt content below 12% and clay content below 16% (Table 3-14). Furthermore, both of these samples also had low water content (22 and 33%) when compared to the finer-grained sediment (100-104%) deeper in the core, which correlated well with both the visual description information and grain-size data.

The target locations for Cores 3A through 6A were established over CHCP to complete a northeast-southwest transect over the capped mound (Figure 3-43). Despite the use of a fully weighted coring device, the depth of penetration for these four samples was below 25 cm primarily due to the thickness of the cap material (in excess of 75 cm) in conjunction with consolidated and cohesive nature of the CDM. Any material recovered from the multiple coring attempts at each station was retained for visual description only (Table 3-15). The surface sediments at all four stations were characterized as dense Boston

Blue Clay and gravel, indicative of Chelsea River CDM. Due to the shallow penetration, no visually distinct horizons between UDM and CDM were apparent.

Core 7A was collected in an area of the mound that would provide an opportunity to examine the UDM/CDM interface, as well as the UDM/ambient interface (Figure 3-43). The surface interval of this core contained a mix of Boston Blue Clay, 15% silt, 27% sand and 22% pebbles at the surface and a water content of 32%, which is indicative of Chelsea River CDM (Table 3-14). A firm, greenish-gray clay (40%) dominated from 26-38 cm of penetration and appeared to represent CDM as well. This middle horizon of Core 7A also contained a mix of sand, silt and gravel. The interval from 38-49 cm consisted of a greenish-gray colored material, containing 21% clay, 24% sand and 14% silt with a high gravel content (41%), likely indicative of Cohasset Harbor sediment. The sediment from 49-156 cm was likely ambient material with 98% silt/clay and a water content of 107%. The samples collected above 49 cm had lower water contents ranging from 29-32%, confirming the presence of Cohasset Harbor and Chelsea River dredged material in the upper layers.

Multiple coring attempts at Station 8 over the CHCP Mound yielded rock and gravel within a silty clay matrix. This sample was collected over an area that had apparently received a substantial amount of sediment from Chelsea River to form a CDM layer nearly 1 m thick (Figure 3-43). Although this sample did not provide any information regarding the formation of distinct sediment layers within the capped mound,the results confirm the presence of a highly armored CDM layer over this portion of the mound.

The surface of Core 9A was quite similar to the surface sediments detected at Station 8, however, this sample penetrated 109 cm into the disposal mound. Core 9 was collected outside the acoustically detectable margin of the UDM mound and likely contained only a thin horizon of UDM from the mound apron, which may have been subjected to limited mixing with the overlying CDM and underlying ambient material (Figure 3-43). The top 20 cm of the core was indicative of CDM as it was dominated (50%) by rock and gravel surrounded by silty clay and sand matrix (9% fines; Table 3-13). A narrow band (5 to 10 cm) of slightly darker and finer material (sandy gravel with shell) was noted below the surface horizon of rock and gravel, which may represent Cohasset Harbor material. A clear distinction was visible between the deposited material and the greenish-gray ambient sediment (97% silt/clay) at depth. The water content of the surface sample was 13% due to the abundance of large sediment grains, while that of the 40 cm sample was 109% indicating ambient sediments.

Core 10A was another sample collected in an area of the mound that would provide an opportunity to examine the UDM/CDM interface, and potentially the UDM/ambient interface (Figure 3-43). This core was 72 cm in length and contained 56 cm of very hard, sandy clay with gravel and Boston Blue Clay, which is indicative of Chelsea River CDM. Two sub-samples were collected for water content and grain size above 56 cm; both had a water content less then 26% and a silt/clay component less than 29%. The interval below 56 cm was described as a greenish-gray, firm silty clay (potentially Cohasset Harbor material). The sediment sub-sample collected from 60-68 cm displayed higher water content (77%) and a high silt/clay component (70%) relative to the surface interval (Table 3-13). Although the sediment was greenish-gray in color, the material in the bottom of Core 10 was not believed to be ambient material because the grain size data indicated fine-grained sediments comprised less then 90% of the sediment and the water content was less than 100%.

The sample obtained from Station 11 consisted of homogenous greenish-gray clay to a depth of 41 cm (Table 3-15). Based on the location of the core relative to the UDM and CDM footprint, this sample likely represents Chelsea River CDM. No detailed analyses were performed on this sample to confirm its origin.

Core 12A was collected in close proximity to Cores 8A and 9A, and yielded very similar results. Core 12A was 98 cm in length and contained at least 22 cm of CDM consisting primarily of firm-hard sandy clayey gravel (45%). The water content of this sediment was 20% (Table 3-13). There were distinct patches of Boston Blue Clay within the top 22 cm, indicative of Chelsea River material. The sediment below 22 cm consisted primarily of greenish-gray silty clay. Cohasset Harbor material likely exists from a penetration depth of 22-36.5 cm due to the presence of plant material, noticeably greater water content (80%), and a greater fine-grained (silt/clay) component (69%). From 75-85 cm the water content of the sediment was 100% and the silt/clay component was 99.5%, which is indicative of ambient material (Table 3-13).

4.0 DISCUSSION

4.1 Capped Mound Development

The Massachusetts Bay Capping Demonstration Project successfully demonstrated the ability to create a capped disposal mound in 90 m water depths. The overall success of the study was based on the ability to develop a layered dredged material deposit at this deep-water disposal site, as well as accurately detect the changes in seafloor topography and surface sediment composition over time using conventional monitoring techniques. The results of the four comprehensive surveys performed over the CHCP study area confirmed that a capped mound was constructed at MBDS.

One of the major concerns regarding the use of subaqueous capping as a dredged material management technique at MBDS pertains to the ability to develop a discrete UDM deposit in 86 m of water using only a small to moderate volume of sediment. When a barge-load of sediment is deposited at an open-water disposal site, the dredged material goes through multiple phases of descent as it settles to the seafloor: convective descent, dynamic collapse, and passive dispersion (SAIC 1988; Figure 4-1). Convective descent refers to the vertical transport of dredged material falling though the water column to the seafloor. As the dredged material reaches the bottom it enters the dynamic collapse phase of descent, with the vertical falling motion translated into horizontal spreading over the seafloor. Once the kinetic energy from the disposal event dissipates, the deposited sediments settle to the bottom and are subject to passive dispersion through exposure to natural seafloor processes.

The behavior of the deposited sediment during the convective descent and dynamic collapse phases is directly related to the depth of water at the disposal site and the geotechnical properties of the dredged material. Oftentimes, UDM is composed of fine-grained, estuarine sediments (silt and clay) that are non-cohesive in nature. The Cohasset Harbor material that was designated as UDM for the purposes of the demonstration project had many of the same physical properties (fine-grained, non-cohesive). However, this material was classified as suitable for unconfined open water disposal (i.e., low to undetectable contaminant levels) to minimize any adverse environmental impacts.

Due to the dynamics associated with placement of this type of dredged material at deep-water disposal sites, each individual barge load of this material tends to form a low relief sediment deposit on the seafloor with a relatively wide apron. Without tight control over disposal operations, the placement of true UDM at MBDS could lead to widespread distribution of contaminated sediments within the disposal site, complicating capping

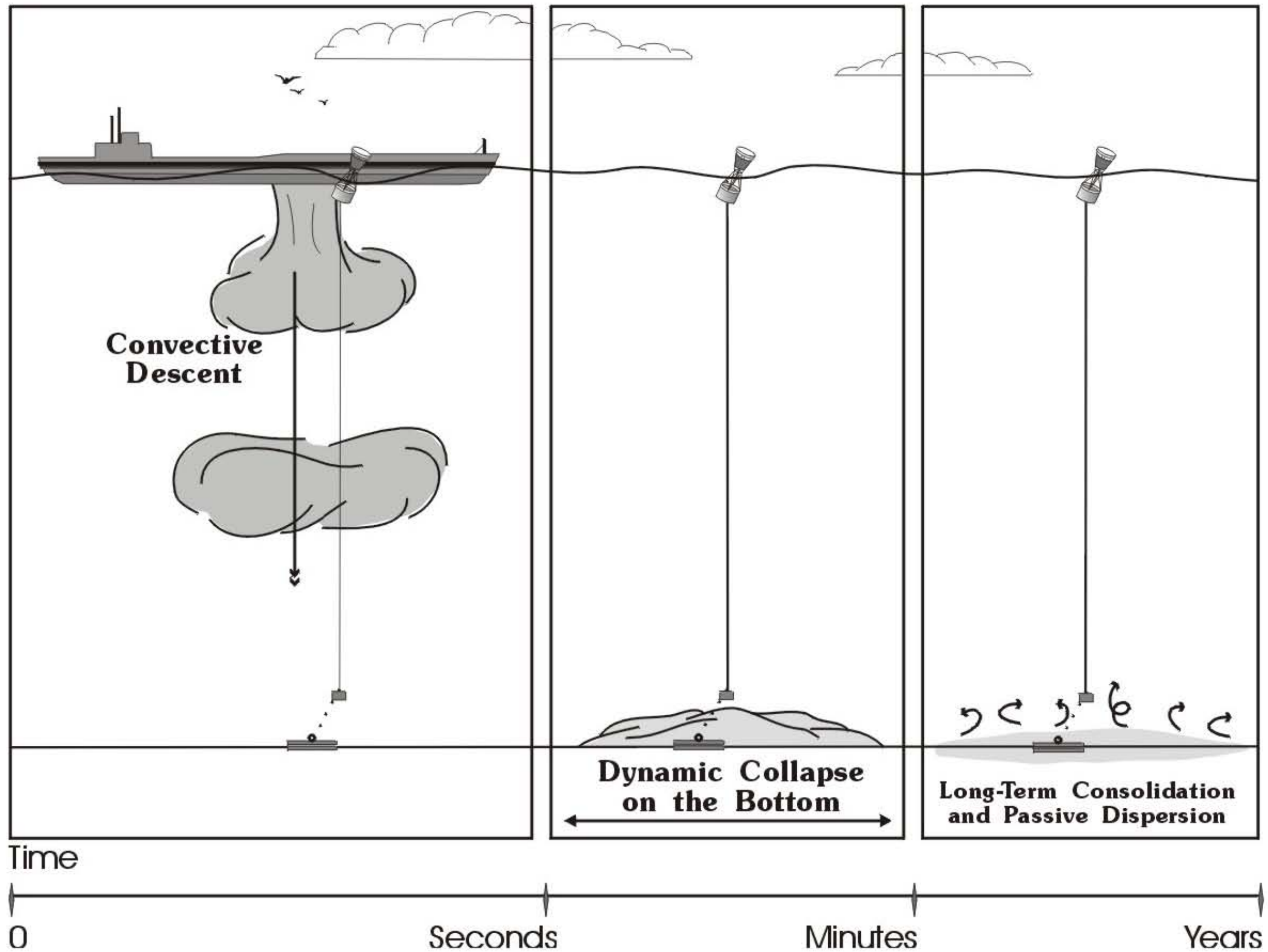


Figure 4-1. Schematic diagram of the three phases of descent encountered during a dredged material disposal event

operations (SAIC 1984). As a result, a major objective of this study was to verify the development of a discrete and relatively compact UDM mound within the CHCP study area using material deemed suitable for unconfined open water disposal.

The development of a discrete and compact UDM mound on the seafloor is critical to the overall success of any capping project. Maintenance dredging operations in industrialized harbors do not often yield large volumes of sediment suitable for use as CDM. Therefore, the formation of a single, small UDM mound limits the volume of CDM required to completely cover the contaminated sediment and isolate it from the marine environment. In accordance with standard management practices, a taut-wire disposal buoy (CHCP) with a restricted watch circle was deployed in the center of the study area to mark the disposal point and foster the development of a discrete and compact UDM mound by preventing widespread distribution of sediment.

The DAMOS Capping Model is a tool used to predict the approximate size of a single barge load of sediment or an entire mound on the seafloor based on point disposal of dredged material at a given water depth (SAIC 1995). The capping model indicated a single barge load of sediment consisting of 1,150 m^3 sandy silt (similar to the composition of the Cohasset Harbor material) would form a 260 m wide detectable dredged material deposit ranging in thickness from 0.5 cm to 3 cm. The model also predicted that this single barge load of UDM would occupy an area of 53,100 m^2 on the flat MBDS seafloor.

The comprehensive examination of the single barge load of sediment deposited to the northwest of the CHCP buoy allowed comparison of the model output to actual field results. This relatively small sediment deposit was detectable using a variety of conventional monitoring techniques (bathymetry, side-scan sonar, and REMOTS® sediment-profile imaging). The sediment deposit was found to be irregular in shape, with the distribution of dredged material on the seafloor consistent with the pattern of disposal associated with a drifting disposal barge (Figure 3-16). Based on the extent of dredged material detected by REMOTS®, this single dredged material deposit occupied an area of 22,800 m^2 within the CHCP study area. At the stations where Cohasset Harbor dredged material was detected, thicknesses ranged between 0.5 cm and in excess of 12.3 cm. This suggests a much more concentrated sediment deposit was actually formed on the seafloor relative to model predictions.

The DAMOS Capping Model was also used to predict the size of the mound if 41,250 m^3 of UDM were deposited within a close radius to the central disposal point. In this scenario, the model indicated that the individual sediment deposits would overlay each other, forming a conical mound with a height of nearly 1 m and an overall width approaching 500 m. The model also estimated that the area impacted by UDM at a thickness of 0.5 cm or greater would be constrained to 196,400 m^2 or approximately 31% of the 0.64 km^2 study area.

A total of 49 individual barge loads of Cohasset Harbor sediment designated as UDM were transported to CHCP during the first phase of disposal. Once again, a comprehensive monitoring survey conducted after placement allowed comparisons between the model output and the observed field results. Bathymetric depth difference calculations using the Baseline and Precap survey data indicated the majority of the UDM was deposited in close proximity to the buoy forming a sediment mound with a height of nearly 0.4 m (Figure 3-21). The ADISS information compiled for the UDM phase of the dredging project and side-scan sonar imagery generally confirmed this finding (Figure 3-22). However, several loads of dredged material were placed up to 200 m north and east of the CHCP buoy, resulting in the development of an enlarged disposal mound apron. In addition, the lateral spread of the deposited sediment during the dynamic collapse phase of each UDM disposal event was unrestricted on the flat MBDS seafloor. Based on the REMOTS® data, the extent of the Cohasset Harbor UDM deposit covered an area of 235,900 m^2, approximately 37% of the CHCP study area (Figure 4-2). The somewhat larger UDM footprint indicated in the field results versus the model predictions (37% versus 31%) is primarily attributed to the dispersion of placement events around the buoy, rather than at a single location. However, considering the differences in dredged material placement locations, these findings indicate a rather strong agreement between model results and field observations.

Throughout the demonstration project, the composition of the surface of the CHCP Mound reflected the source of the sediments. The Baseline sediment samples determined the ambient sediment was composed of olive gray, silty clay. Grain size analysis for the ambient sediments within the CHCP study area indicated that the surface material was comprised primarily (95%) of silts and clays (<0.074 mm) (Figure 4-3). Water content and REMOTS® camera penetration depths during the Baseline survey confirmed that this material was fairly soft, low-density sediment. As expected, sediment tracer analysis indicated the meiofaunal populations were composed of shelf species of foraminifera.

The Precap survey grain size results indicated the presence of a new deposit within the CHCP study area relative to the baseline survey. The UDM material was generally coarser than the ambient sediment and could be detected geotechnically as well as visually in sediment profile images and grab samples. The average value for cobble (>75 mm), and gravel (75-4.76 mm) displayed small increases over the surface of the mound during the precap survey relative to the baseline assessment. In addition, coarse (4.76-2 mm), medium (2-0.42 mm), and fine sand (0.43-0.074 mm) content was noticeably higher in

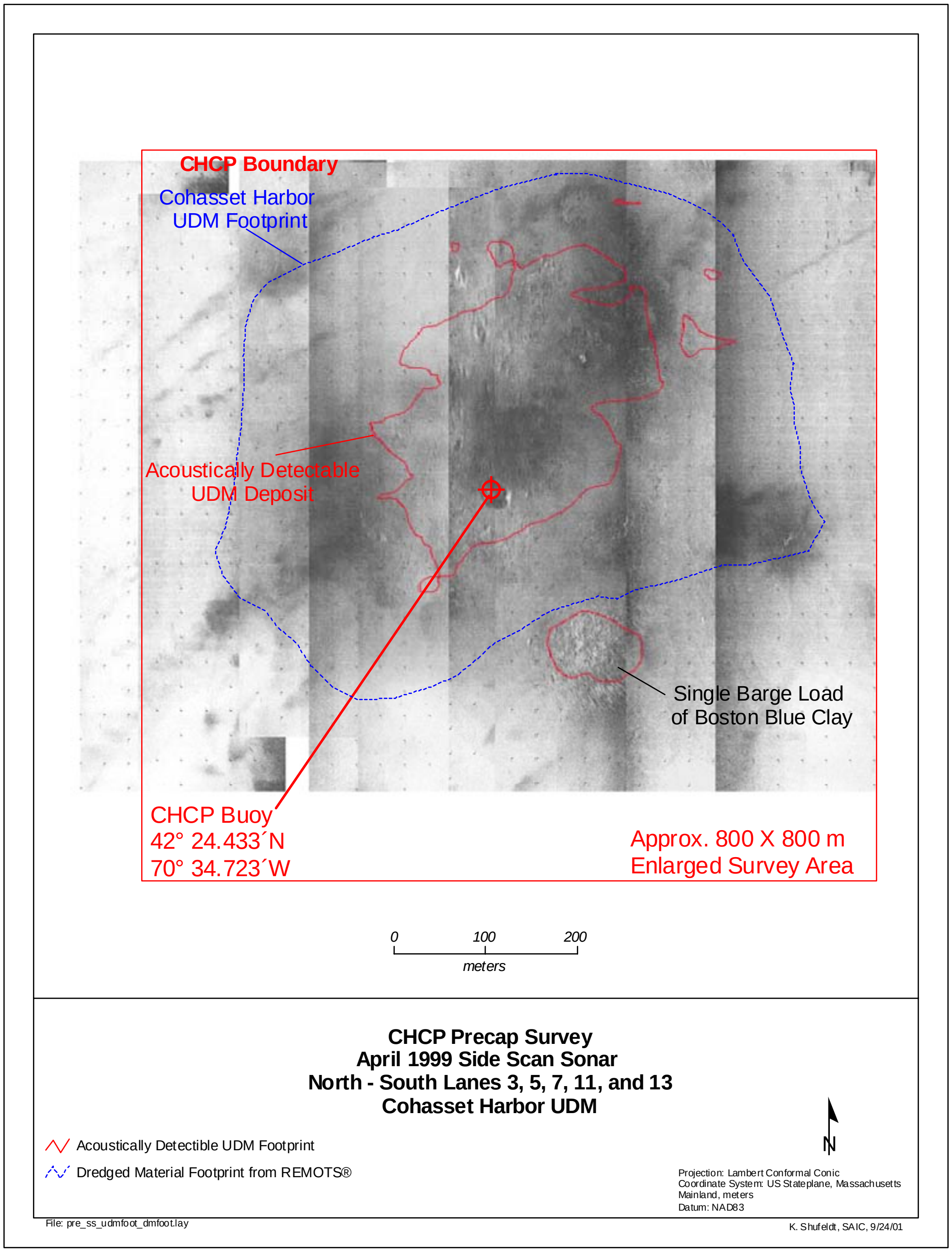


Figure 4-2. Composite figure showing the distribution of UDM within the CHCP study area as detected by bathymetric depth difference comparison, REMOTS® sediment-profile imaging, and side-scan sonar data collected as part of the Precap survey effort

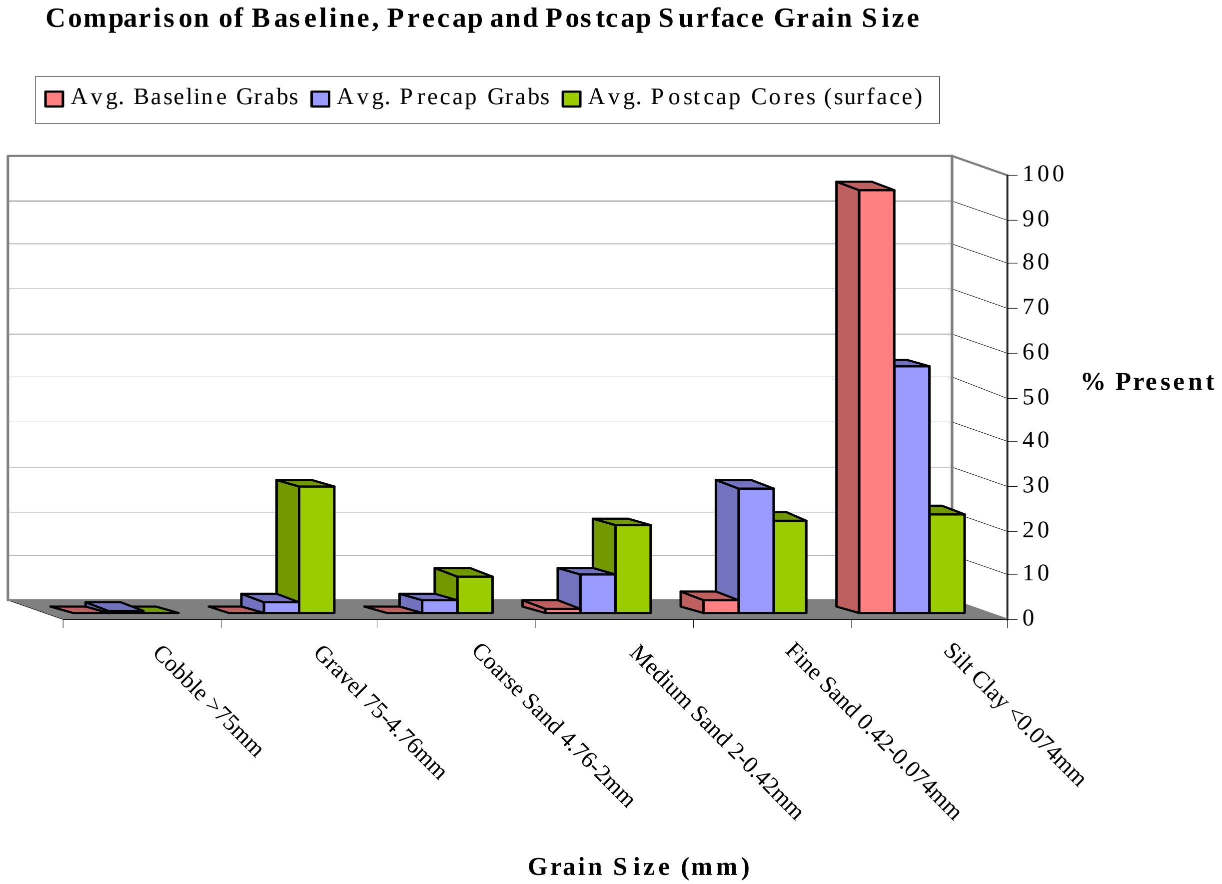


Figure 4-3. Histogram of average surface grain size values for the Baseline (pink) and Precap (blue) grab samples, as well as the surface sediment interval in the Postcap Cores (green) displaying a trend of surface sediment coarsening over time resulting from the disposal of UDM and placement of CDM

comparison to the baseline results (Figure 4-3). Sediment tracer analysis provided further evidence of this change in sediment composition as an abundance of inland species was detected at all stations sampled, confirming the presence of estuarine sediments at the sediment water interface.

In response to changes in project logistics, the disposal of UDM at the CHCP study area was completed in two distinct phases that were separated by a period of nine months. In the Fall and Winter of 1999-2000, approximately 15,500 m^3 of supplemental UDM originating from Cohasset Harbor was placed over the pre-existing UDM mound (formed between December 1998 to February 1999). This material was then covered by an estimated barge volume of 154,400 m^3 of CDM emanating from Chelsea River in Spring 2000 (Figure 1-5). The supplemental Cohasset Harbor UDM was the product of dredging activity that was postponed due to heavy icing within the harbor. The distinct characteristics of the Chelsea River dredged material used as cap material (high reflectance, cohesive, Boston Blue Clay, as well as sand and gravel) provided sufficient contrast with the UDM, allowing relatively straightforward interpretations of sediment layering at the capped mound.

Comparisons between the Baseline and Postcap bathymetric surveys indicated that a broad, stable bottom feature was constructed on the MBDS seafloor by the placement of a total barge volume of 211,250 m^3 within the CHCP study area (Figure 3-30). Depth difference comparisons between the Precap and Postcap bathymetric surveys displayed the thickness and distribution of CDM residing in layers greater than 15 cm. A layer of CDM ranging in thickness from 15 cm to 1.75 m was detected over the southern two-thirds of the detectable UDM mound (Figure 3-31). The results of the Postcap REMOTS® sediment-profile imaging and side-scan sonar surveys indicated that CDM also existed in thinner layers covering nearly 436,500 m^2 of seafloor (approximately 68% of the study area), and extended well beyond the margins detected by depth difference comparisons (Figure 4-4).

Though grain size analysis was not conducted specifically on the in-place Chelsea River sediment, a detectable difference in surface sediment composition between the Precap and Postcap surveys indicated the presence of a new deposit at the sediment-water interface. The Chelsea River material residing on the surface of the central portion of the CHCP Mound was distinctly coarser than the Cohasset Harbor UDM. Gravel (75-4.76 mm) was determined to comprise a much larger percentage of the surficial sediments within the CHCP study area after the deposition of CDM (Figure 4-3). Coarse sand (4.76-2 mm) and medium sand (2-0.42 mm) contents were higher in comparison to the earlier surveys, while fine sand and silt/clay content were notably lower. As a result of the relatively high gravel, coarse sand, and medium sand percentages in the CDM, the fine fraction comprised only 21% of the sediment within the surface interval of the Postcap

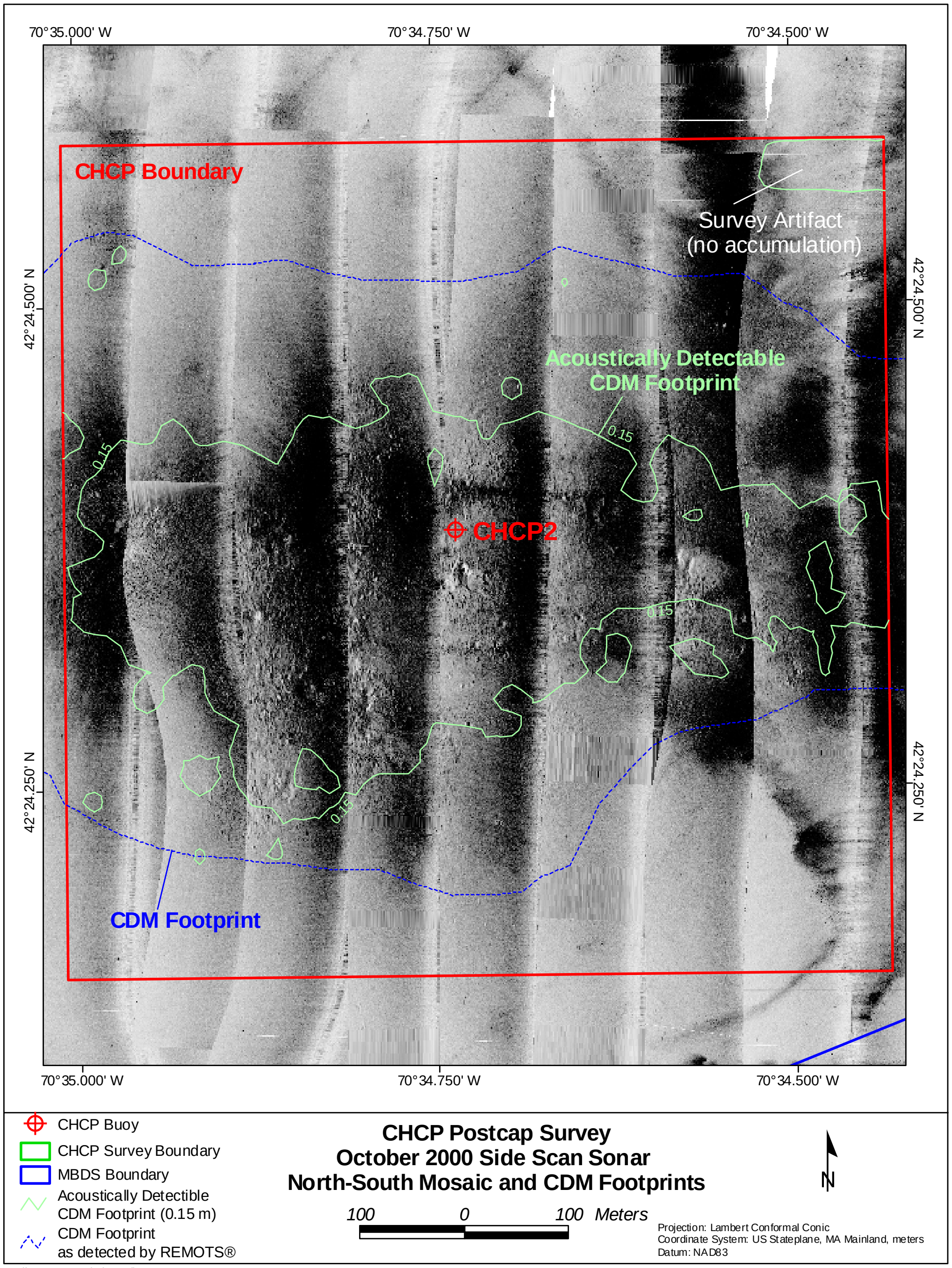


Figure 4-4. Composite figure showing the distribution of CDM within the CHCP study area as detected by bathymetric depth difference comparison, REMOTS® sediment-profile imaging, and side-scan sonar data collected as part of the Postcap survey effort

cores (Figure 4-3). Due to the distinct visual and geotechnical differences in the UDM and CDM for this project, no sediment tracer analyses were conducted on the Postcap cores to confirm these results.

Stratification of the sediment and differentiation between the ambient material, UDM, and CDM was noted in several of the Postcap cores. The establishment of horizons of sediment forming measurable layers was apparent in the six cores successfully collected over the CHCP Mound. The distinction between the Cohasset Harbor sediment, Chelsea River sediment and ambient Massachusetts Bay sediment was evident through a combination of visual description, as well as grain size and water content analyses (Figure 4-5). Overall, the visual appearance and grain size data indicated that Chelsea River material was present over Cohasset Harbor material at the CHCP study area.

By overlaying the various dredged material footprints (both acoustically detectable and image-based) it appears that nearly 90% of the UDM mound, including the thin apron extending beyond the acoustically detectable margins to the south, east, and west was covered with some measurable thickness of CDM (Figure 4-6). The exception to this was found along the northern boundary of study area, as approximately 26,000 m^2 of the 235,900 m^2 areal extent of the UDM deposit remained exposed at the sediment-water interface. The lack of cap material on the northern apron of the UDM mound posed no environmental risk, as all materials used in support of the demonstration project were classified as suitable for unconfined open water disposal.

The lack of CDM over this portion of the study area was likely the result of differences in the patterns of UDM disposal and CDM placement, as well as the spread of material during the dynamic collapse phase of descent. The ADISS records and DAMOS disposal logs indicate that most of the Cohasset Harbor UDM was placed in close proximity to the CHCP buoy or northeast of the buoy position. Although the CHCP buoy was moved to the northwest in order to mark the apex of the mound prior to the beginning of the Fall 1999 capping operations, the adjustment was insufficient to promote the complete coverage of the UDM mound apron. During the capping phase of the project, DAMOS disposal logs indicated the majority of the CDM was deposited in close proximity to the CHCP buoy. Depth difference plots indicated that CDM deposition appeared to be concentrated west of the buoy, as an accumulation of cap material nearly 2 m high was detected approximately 100 m from the buoy (Figure 3-32). Similar to the UDM apron, the CDM apron was found to be fairly widespread over the CHCP study area. REMOTS® images collected on the peripheral stations as part of the Postcap survey detected a significant amount of reduced silts with small clumps of Boston Blue Clay at the sediment-water interface. This material originated from the lower reaches of the Chelsea River and was likely the initial material disposed during the capping effort. Side-scan sonar and

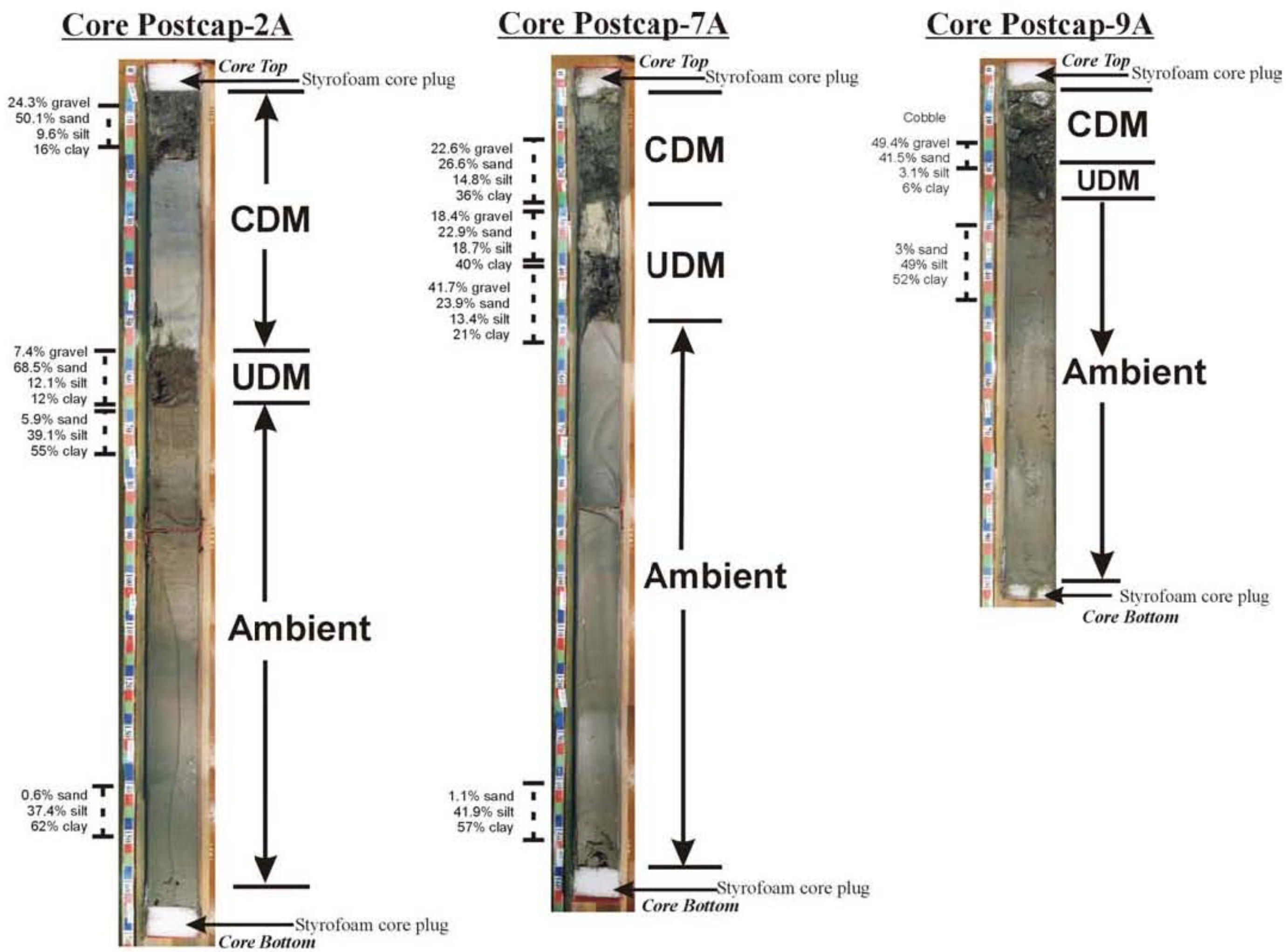


Figure 4-5. Annotated images of Postcap Cores 2A, 7A, and 9A as examples showing layering of CDM, UDM, and ambient sediments based on visual appearance, sediment grain size and grain size distribution

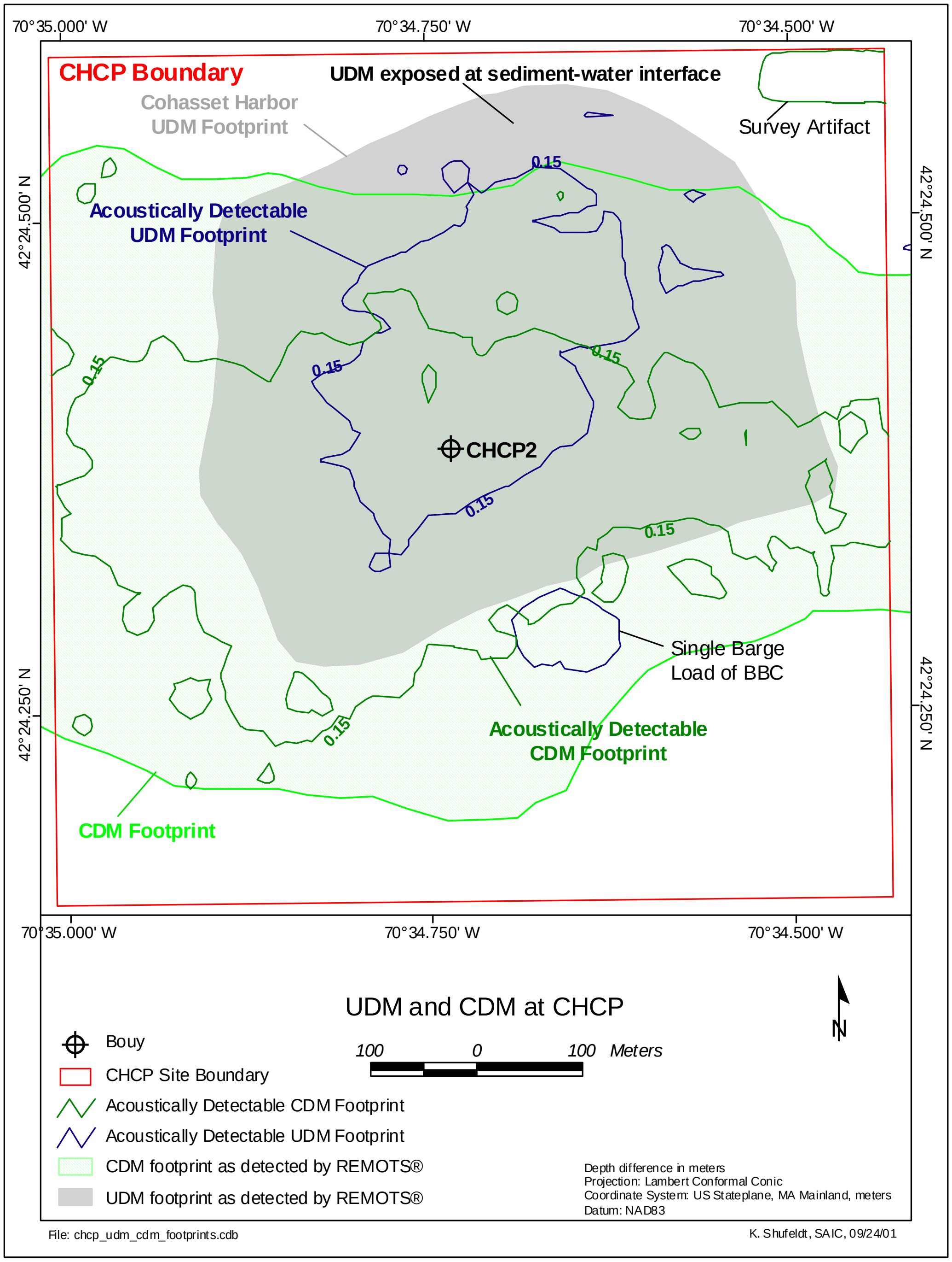


Figure 4-6. Interpretive map illustrating the extent of CDM coverage (green) as detected by bathymetry (solid) and REMOTS® sediment-profile imaging (hatched) relative to the acoustically detectable UDM mound (blue), and the UDM apron (gray)

Postcap coring results suggest much of this silt layer near the central portion of the mound was likely covered over by large clumps of cohesive Boston Blue Clay, sand, and gravel from the upper reaches of Chelsea River during the later stages of the capping effort.

The DAMOS Capping Model indicated that each individual CDM placement event composed primarily of silt and clay that was deposited from a 3,100 m^3 (4,000 yd^3) split-hull barge would likely form a detectable cap material deposit 440 m wide. A single deposit over a low relief UDM mound would spread to cover an area of 152,100 m^2 of UDM to a thickness ranging from 0.5 cm to 4 cm. Assuming approximately 50% of the cap material volume (77,250 m^3) was composed of this silt/clay mixture, the model predicts the first layer of cap material would promote the coverage of 636,200 m^2 of seafloor. If properly placed, this layer of CDM would have been sufficient to completely overlay the UDM mound footprint (235,900 m^2) with the thin apron of cap material extending over ambient sediment. However, a significant volume of additional CDM would be required to develop a cap material layer to the desired cap thickness (generally 0.5 m) that would be required to completely isolate the UDM from the marine environment.

Due to project logistics, no interim bathymetric or REMOTS® sediment-profile imaging surveys were completed over the area during the capping phase of this study. Interim surveys, as conducted on large actual capping projects, allow for early identification of areas lacking CDM coverage or demonstrating insufficient cap thickness. Once identified, these areas can then be specifically targeted for additional CDM deposition during subsequent placement events. Based on the findings of the Postcap survey, the area of exposed UDM could be completely covered with the placement of two to five additional barge loads of CDM specifically targeting the northern margin of the CHCP study area.

Another method of promoting efficient capping of a UDM mound would be the development of specific capping points within the project area to precisely target and control disposal operations. Capping points are specific locations over the UDM mound other than the taut-wire buoy that a disposal barge can target for CDM placement. Figure 4-7 illustrates cap material placement locations over the UDM mound that could have been employed as part of the Massachusetts Bay Capping Demonstration Project to direct barges to strategic areas over the UDM mound and apron. By using this type of control measure in support of capping operations at MBDS, the volumes of CDM strategically placed at these locations would facilitate a better distribution of CDM and the gradual development of an even cap to a desired thickness (usually ranging from 0.5 to 1 m) over the UDM.

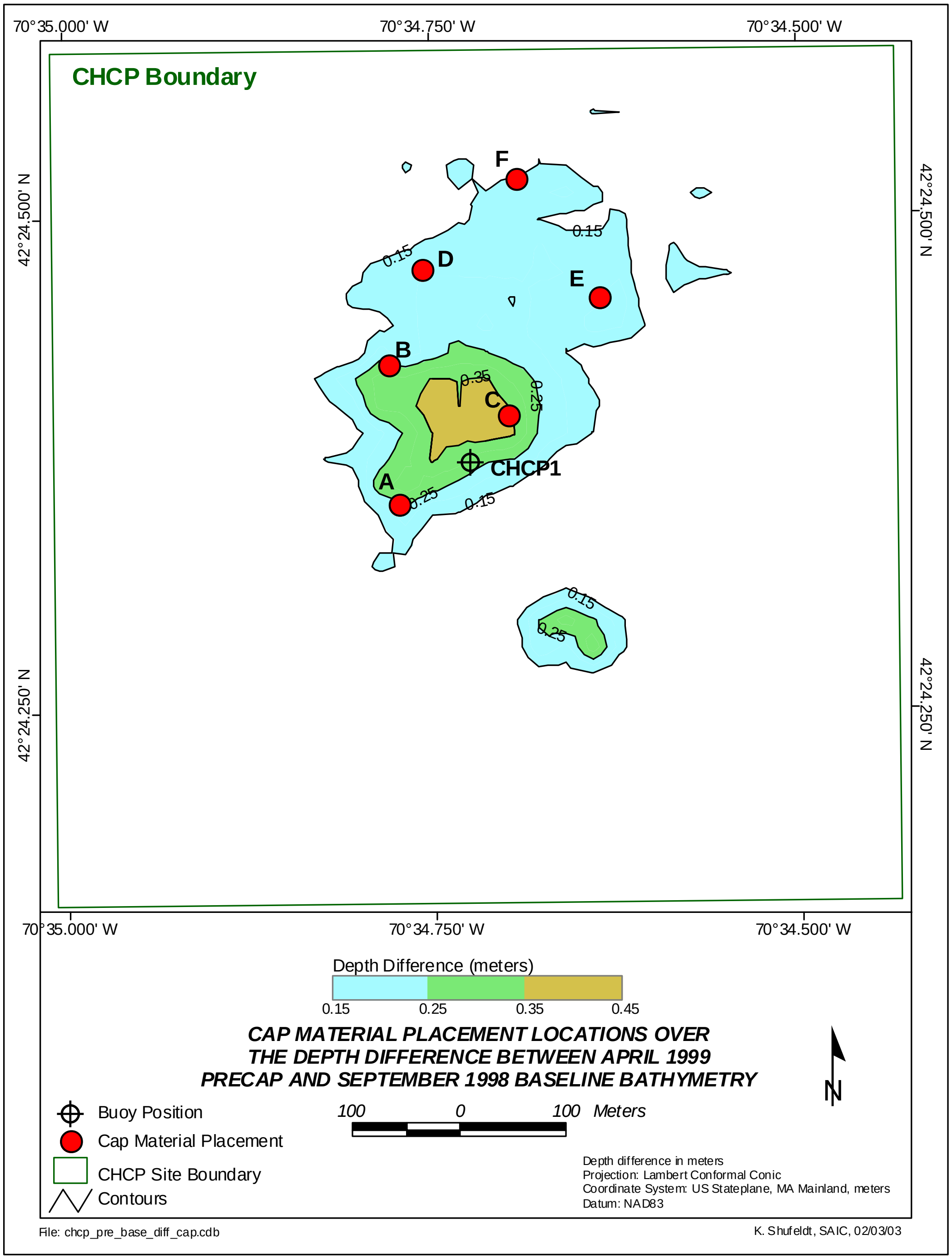


Figure 4-7. Graphic illustrating the potential location of capping points over the UDM mound for the placement of CDM to facilitate the development of an even sediment cap to a desired thickness

The deposition of dredged material in the southern portion of MBDS does not appear likely to have long-term impacts on the benthic community, as surface sediments displayed the expected patterns of recolonization over the majority of the mound. A stable Stage I community is present over the entire surface of CHCP with advancement to Stage I on III at some stations. A moderately deep average RPD of 2.3 cm was calculated for the CHCP mound. However, this RPD was shallower than the composite value for the MBDS reference areas. Benthic habitat quality as represented by median OSI values indicated the disposal mound is still moderately disturbed, but recovering as anticipated.

Coincidently, the lowest median OSI value (+2) was detected at Station 300N, which displayed no apparent accumulation of CDM in the Postcap survey. The low median OSI value was primarily due to shallow RPD depths in two replicates despite the presence of a stable Stage I community. The lower OSI values were not a function of poor sediment quality or contaminants, as all the sediments placed at the CHCP buoy during the demonstration project were deemed suitable for unconfined open water disposal to minimize environmental impacts.

4.2 Evaluation of Tools

4.2.1 Precision Bathymetry

Single-beam bathymetry has been a tool used by the DAMOS Program for the past twenty years to track changes in seafloor topography resulting from dredged material deposition or disposal mound consolidation. Depth difference comparisons based on the various precision bathymetric surveys were quite effective at tracking the development of the capped mound within the CHCP study area during the Massachusetts Bay Disposal Site Capping Demonstration Project. The bathymetry data were used to document changes in mound height with minimal noise or survey artifacts due to the generally flat, featureless seafloor.

For the purposes of this study, the highest confidence was placed in the data showing changes in depth of 15 cm or greater. Changes in seafloor topography less than 15 cm were considered undetectable due to the accumulation of small errors originating from the motion of the survey vessel, as well as the various correctors (i.e., tides, sound velocity) applied to the raw data. Other types of data were relied upon to measure the thickness of dredged material along the margins of the mound in layers too thin to be detected acoustically (i.e., REMOTS® and sediment sampling).

4.2.2 Side-Scan Sonar

Side-scan sonar is a traditional monitoring tool used periodically over the years to support DAMOS survey objectives related to determining the areal distribution of deposited sediments. Based on differences in sediment density and surface texture, side-scan sonar was used to provide an image of the entire seafloor within the CHCP study area and identify the areas of sediment accumulation. By contrasting the strong returns from recently deposited sediment to the weaker sonar reflections from the ambient seafloor an areal perspective of dredged material distribution (UDM and CDM) was provided.

In the past, the use of analog side-scan data in seafloor maps was limited, as the information could not be readily combined with other forms of data (i.e., bathymetry) for display. However, the development and implementation of digital side-scan sonar has allowed the incorporation of geo-referenced side-scan sonar mosaics into a GIS framework for the production of accurate seafloor maps and for use as a data layer to support other forms of spatial information (Figures 4-2 and 4-4). For the purposes of the Massachusetts Bay Disposal Site Capping Demonstration Project, the side-scan sonar data were used to reinforce the results of precision bathymetry and REMOTS® sediment-profile imaging collected over CHCP as part of each survey effort.

4.2.3 REMOTS® Sediment-Profile Imaging

The DAMOS Program has used REMOTS® sediment-profile imaging for many years as a method of detecting the distribution of dredged material, as well as mapping benthic disturbance gradients and monitoring infauna recolonization status. As in previous capping projects, REMOTS® sediment-profile imaging was instrumental in differentiating and measuring thin layers (<15 cm) of sediment deposited on the seafloor that are generally undetectable by bathymetry.

The REMOTS® images collected in support of the Massachusetts Bay Disposal Site Capping Demonstration Project provided a very strong time series data set capable of tracking changes in surface sediment composition over the course of the project (Figures 4-8, 4-9, and 4-10; Table 4-1). Due to the limitations of the bathymetric and side-scan sonar data collected in support of this capping study, REMOTS® data were critical in identifying the distribution of cap material on the periphery of the CHCP Mound.

A　　B　　C

Figure 4-8. REMOTS® images illustrating the transition of surface sediment composition at the interior portions of the CHCP Mound (Station 50SW) from ambient fine-grained silt (A-Baseline), to organic UDM with yellow and blue clay influenced by Cohasset Harbor sediment (B-Precap), to CDM consisting of mottled black silt and white clay originating from Chelsea River (C-Postcap)

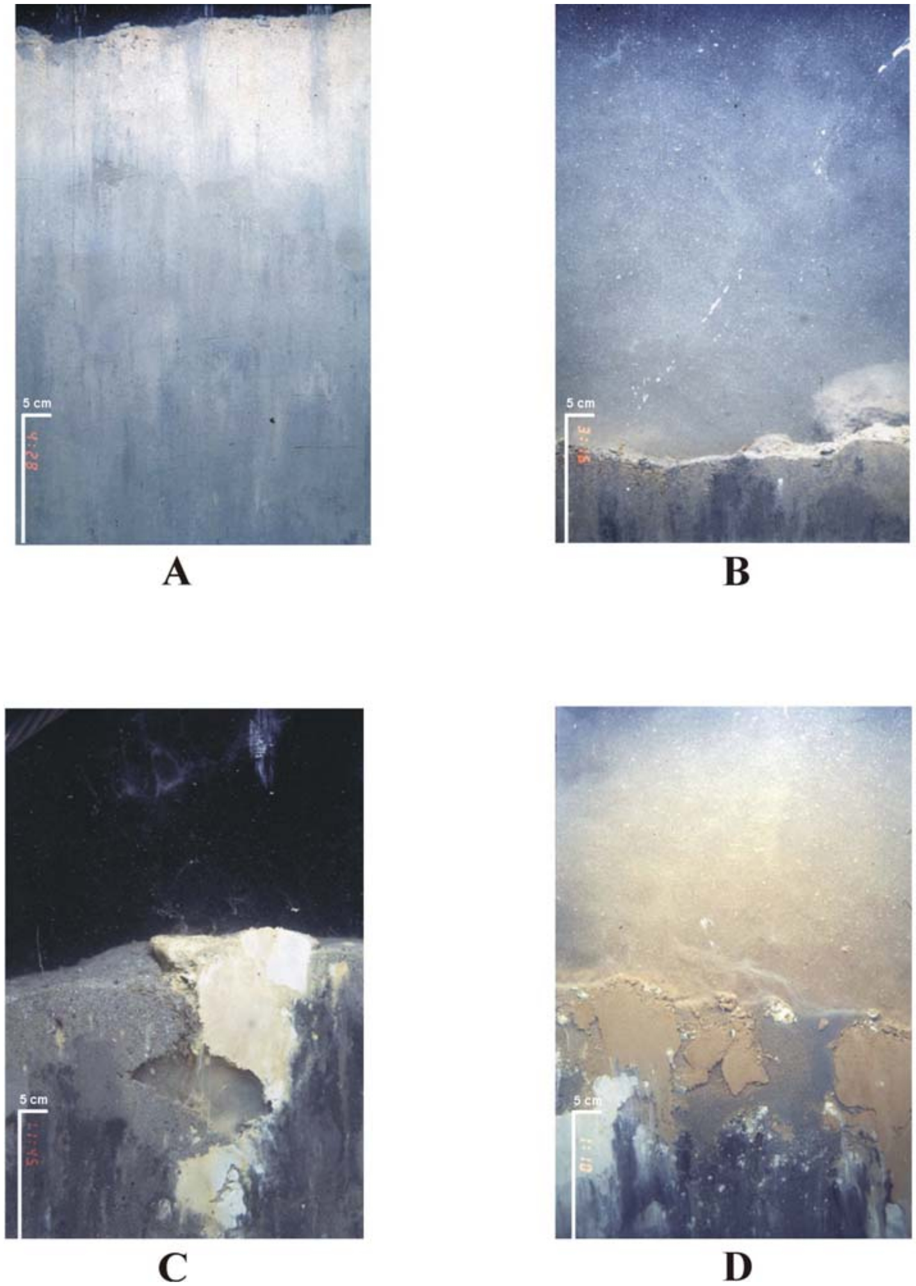


Figure 4-9. REMOTS® images collected at Station 100N documenting the development of a capped mound on the seafloor of MBDS. Ambient sediment present during the Baseline survey (A) was covered by UDM in the form of black reduced silt and sand from Cohasset Harbor (B-Single-Barge survey), as well as yellow clay/sand and black silt detected in the Precap Survey (C). A discrete layer of CDM consisting of mottled black and gray clay was visible at this station in the Postcap survey (D)

A B C

Figure 4-10. REMOTS® images illustrating the transition in surface sediment composition away from the central portion of the CHCP Mound (Station 200NE). Ambient sediment in the form of silt and clay visible in the Baseline survey (A) is replaced by black silt and sand comprising the UDM detectable during the Precap Survey (B). The final layer of CDM in the form of reduced silt and clumps of Boston Blue Clay from the Chelsea River was visible in the images collected as part of the Postcap survey (C)

Table 4-1. Summary of CHCP REMOTS® Data Documenting Changes in Dredged Material Thickness and Composition 1998-2000

Station	Baseline Survey September 1998		Single Barge Survey December 1998		Precap Survey April 1999		Postcap Survey August 2000	
	Dredged Material Thickness (cm)	Dredged Material Description	UDM Thickness (cm)	Dredged Material Description	UDM Thickness (cm)	Dredged Material Description	CDM Thickness (cm)	Dredged Material Description
CTR	0	N/A	**				>7.80	black/gray/white mottled clay
50N	0	N/A	0	N/A	>2.72	yellow clay	>10.24	black/gray/white mottled clay
50NE	0	N/A	0	N/A	>5.13	yellow and blue clay	>7.63	black/gray/white mottled clay
50E	0	N/A	0	N/A	NO DATA	NO DATA	>7.20	black/gray/white mottled clay
50SE	0	N/A			>9.65	yellow and blue clay	>9.98	black/gray/white mottled clay
50S	0	N/A	0	N/A	>6.48	dk brown silt, blue clay	>10.46	black/gray/white mottled clay
50SW	0	N/A	0	N/A	>3.3	organic, yellow and blue clay	>14.71	black/gray/white mottled clay
50W	0	N/A	0	N/A	>10.91	black silt, blue clay	>12.89	black/gray/white mottled clay
50NW	0	N/A			>4.20	black silt, yellow clay	>10.97	black/gray/white mottled clay
100N	0	N/A	7.67	tan/black silt and clay	>5.75	black silt, yellow clay	>12.72	black/gray mottled clay
100NE	0	N/A	0	N/A	>8.26	organic, yellow and blue clay	>9.29	black/gray mottled clay
100E	0	N/A	0.0	6.0 cm white clay	NO DATA	NO DATA	>10.95	black/gray mottled clay
100SE	0	N/A			>13.90	black silt, blue clay	>11.26	black/gray mottled clay
100S	0	N/A	0.0	5.0 cm white clay	>8.93	black silt, blue clay	>12.68	black/gray/white mottled clay
100SW	0	N/A	0	N/A	>1.55	tan and black silt	>7.88	black/gray mottled clay
100W	0	N/A	0	N/A	>11.81	black silt, yellow and blue clay	>8.88	black/gray mottled clay
100NW	0	N/A			>3.15	chaotic fabric, yellow clay	>8.82	gray clay
200N	0	N/A	0	N/A	>8.15	black silt, blue clay	>16.40	black/gray mottled clay
200NE	0	N/A	0	N/A	>7.40	black silt, blue clay	>13.20	black/gray/yellow mottled clay
200E	0	N/A	0	N/A	8.0	brown/black silt, yellow clay	>9.09	black/gray/white mottled clay
200SE	0	N/A			>10.40	dk brown silt, blue clay	>11.07	black silt and clay
200S	0	N/A	0	N/A	0	N/A (ambient)	>11.98	gray and white clay
200SW	0	N/A	0	N/A	4.67	brown/gray silt, white clay	>9.78	black/gray/white mottled clay
200W	0	N/A	0	N/A	5.67	dk brown/gray silt	>9.73	black/gray mottled clay
200NW	Historic DM*	white clay chips			7.88	black/brown silt, blue clay	>16.12	black/gray mottled clay
300N	0	N/A	0	N/A	6.0	tan/gray silt, organic	**0**	**6.0 cm UDM**
300NE	0	N/A	0	N/A	4.63	dk brown silt, white clay	>8.58	black silt and gray clay
300E	0	N/A	0	N/A	4.33	brown/gray silt	>10.97	black/gray mottled clay
300SE	0	N/A			0	N/A (ambient)	0	ambient
300S	0	N/A	0	N/A	0	N/A (ambient)	1.73	black/gray clay and silt
300SW	0	N/A	0	N/A	0	N/A (ambient)	>17.75	black/gray mottled clay
300W	0	N/A	0	N/A	0	N/A (ambient)	>8.93	black/gray/white mottled clay
300NW	Historic DM*	white clay chips			3.50	brown/gray silt, white clay	>12.65	black/gray/white mottled clay

4.2.4 Sediment Sampling and Analyses

Intended to serve as a principal method of evaluating the effectiveness of capping operations at the deep-water disposal site, comprehensive sediment analyses (i.e., sediment tracers) played a lesser role in the capping demonstration project than originally planned. The changes in project design reduced the importance of sediment tracers, and promoted the use of physical sediment characteristics as a method of confirming the findings of the other data products. Sediment grab sampling appeared effective at documenting the different sediment composition within the CHCP study area, confirming both the bathymetric depth difference and REMOTS® sediment profile imaging data. In addition to providing information pertaining to surficial sediments, the Postcap coring results at CHCP confirmed the presence of multiple distinct layers (CDM, UDM and ambient) at several stations and showed that these layers remained intact during the disposal operations (i.e., no large scale mixing). Although considered a useful tool, detailed sediment tracer analysis was discontinued in the final phase of the capping project, because sediment grain size and visual descriptions were sufficient to confirm the results of other data sets.

4.3 Future Capping Operations at MBDS

The Massachusetts Bay Disposal Site Capping Demonstration Project marks the first documented formation of a capped mound at this deep-water disposal site. The abundance of data collected in support of the program indicated that a layered dredged material deposit was successfully constructed on the MBDS seafloor. A discrete UDM mound was developed within the confines of the CHCP study area and subsequently covered by a layer of cap material. As a result, the use of subaqueous capping appears to be a viable approach to manage volumes of UDM dredged from the ports and harbors along the Atlantic Coast of Massachusetts.

Limited control procedures (to avoid increased costs to the dredging projects) were utilized during cap placement operations within the CHCP study area resulting in significant volume of cap material placed to the south and west of the CHCP 2 buoy location (Figure 3-34). However, the Postcap survey results indicated approximately 90% of the UDM mound and apron were covered by a measurable thickness of CDM suggesting some variation in cap material placement patterns. If implemented as a dredged material management practice at MBDS in the future, subaqueous capping operations will require specific cap placement conditions to allow adjustments that were not part of the demonstration project.

As with any capping project, the primary objective should focus on controlled UDM placement to minimize the lateral spread of the UDM mound and sediment apron, thereby simplifying the capping operations and reducing the required volume of CDM to adequately isolate the environmental contaminants of concern from the marine environment. This can be accomplished over a flat seafloor by restricting UDM placement to a 30 meter radius of the taut-wire disposal buoy and providing increased oversight during disposal operations. In addition, the lateral spread of the deposited dredged material can also be reduced by constructing and utilizing artificial containment cells on the seafloor (Morris et al. 1996). The first artificial containment cell at MBDS is currently under construction around a sizable seafloor depression located in the northeast quadrant of the disposal site. Once complete, this cell will offer a dredged material capacity well in excess of one million cubic meters (Figure 4-11; SAIC 2002). However, the formation of smaller containment cells could be used to facilitate efficient completion of smaller-scale capping operations.

The four monitoring surveys performed over the CHCP study area were crucial to documenting the successful development of a capped mound at MBDS. However, interim bathymetric and sediment-profile photography surveys are recommended during both the disposal and capping phases of any subsequent capping projects. The data collected as part of these additional monitoring surveys will allow the evaluation of UDM and/or CDM distribution and thickness within the project area and permit the refinement of target placement locations before disposal or capping operations are complete.

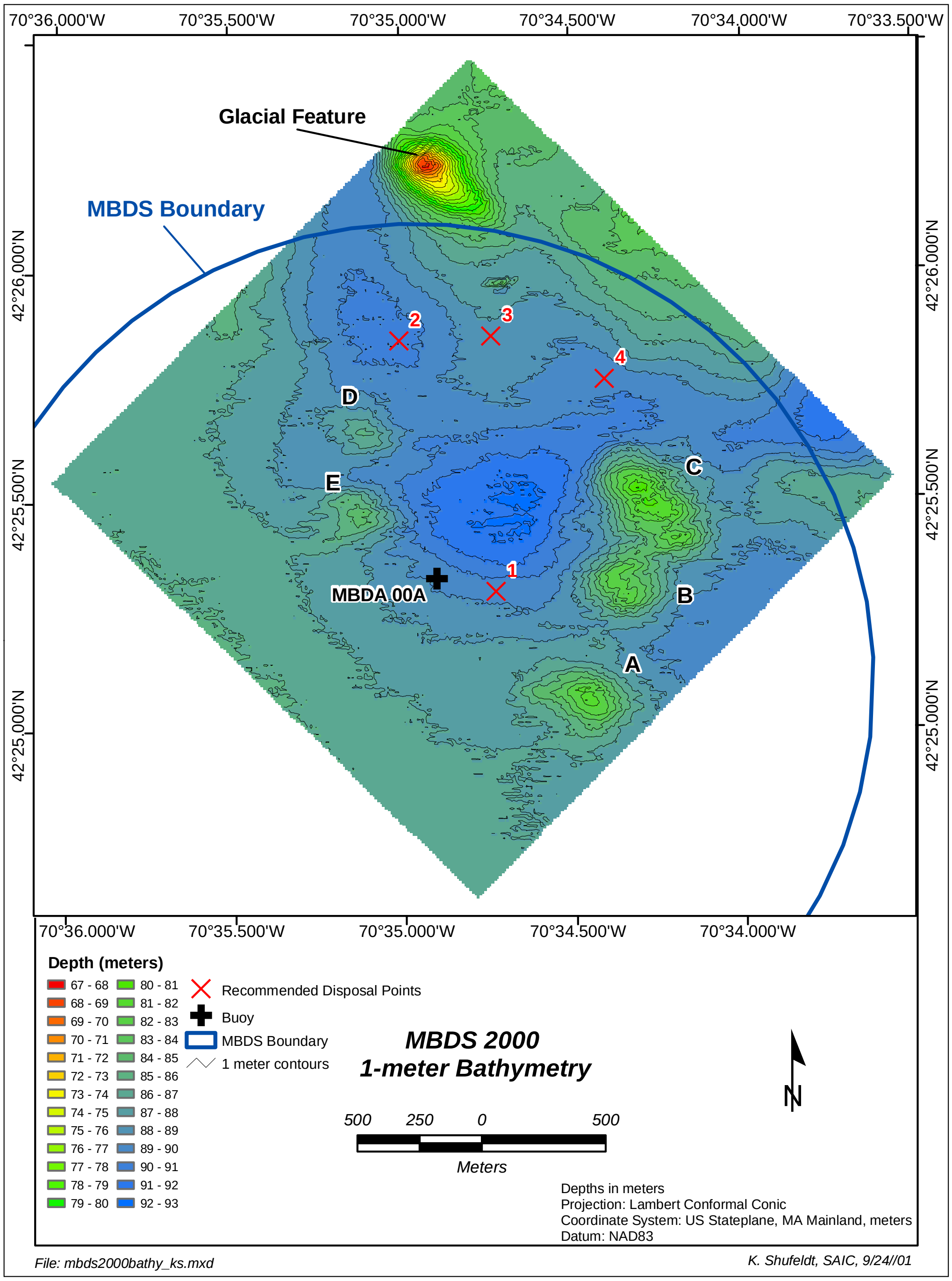


Figure 4-11. Bathymetric chart of the northeastern quadrant of MBDS showing disposal mounds A through E, the current MBDA buoy location (MBDA 00A), as well as future recommended disposal points (1-4) to complete the first artificial containment cell on the MBDS seafloor

5.0 CONCLUSIONS

- A discrete capped dredged material mound was created and detected on the seafloor of the Massachusetts Bay Disposal Site within the CHCP study area. Analysis of precision bathymetry, side-scan sonar, sediment-profile images, and grain size data confirmed the formation of a layered deposit consisting of Chelsea River CDM over Cohasset Harbor UDM over ambient sediment.

- The monitoring techniques employed as part of the Massachusetts Bay Disposal Site Capping Demonstration Project were successful at documenting the various stages of capped mound development. In addition, the combination of survey tools employed as part of the Massachusetts Bay Disposal Site Capping Demonstration Project appeared to be appropriate for use at this deep-water disposal site.

- A single dredged material barge load consisting of approximately 1,150 m^3 of Cohasset Harbor sediment was detected and mapped on the MBDS seafloor by precision bathymetry, side-scan sonar imagery, and REMOTS® sediment-profile imaging. This survey was conducted to evaluate the resolution of the remote sensors used to document the development of a capped mound in nearly 90 m of water, as well as determine the thickness and areal extent of a single dredged material deposit on the MBDS seafloor.

- An accumulation of UDM consisting of 41,250 m^3 of Cohasset Harbor sediment was detected on the flat MBDS seafloor immediately surrounding the CHCP buoy position, as well as extending 250 m to the north-northeast. The placement of several barge loads of sediment up to 200 m north and east of the buoy caused the development of a relatively wide, thin apron of UDM on the seafloor.

- Approximately 90% of the UDM mound was covered by the placement of 154,400 m^3 of CDM capping material originating from the Chelsea River. Depth difference comparisons between the Precap and Postcap bathymetric surveys indicated the majority of the CDM was placed in close proximity to the CHCP buoy. However, a layer of silt with small clumps of Boston Blue Clay was widely distributed within the CHCP study area and found in thicknesses exceeding REMOTS® camera penetration depths at most stations sampled.

- The results of the Postcap REMOTS® sediment-profile imaging survey indicated nearly 10% of the UDM mound located along the northern boundary of the CHCP study area remained exposed at the sediment-water interface. This uncapped area was likely the result in differences in barge disposal patterns between the Cohasset

Harbor and Chelsea River projects. The exposed UDM could be easily covered in the future by the placement of two to five additional barge loads of CDM specifically targeting this portion of the CHCP study area. All material utilized by this demonstration project was classified as suitable for unconfined open water disposal. As a result, the presence of a small amount of Cohasset Harbor dredged material at the sediment-water interface poses no environmental risk.

- The surface of the CHCP Mound appears to be recovering as anticipated from the deposition of dredged material as a stable Stage I benthic community was detected at every station occupied as part of the Postcap survey, with some advancement to Stage I on III at some stations.

- Overall, the Massachusetts Bay Disposal Site Capping Demonstration Project demonstrated that dredged material can be effectively placed, capped, and monitored at a deep-water disposal site. As with all capping projects, the primary objective of future capping operations at MBDS should pertain to restricting the lateral spread of the UDM mound. The size of the UDM mound can be minimized by restricting disposal activity to within a tight radius (30 m) of a taut-wire buoy and tightly controlling the disposal operations. In addition, the creation and use of artificial containment cells on the flat MBDS seafloor will aid in controlling the lateral spread of UDM and also facilitate efficient capping operations. In addition, the development and use of cap placement locations over the UDM mound will promote the formation of an even cap material layer of the desired thickness.

- Interim surveys are recommended during both the disposal and capping phases of future dredged material capping projects at MBDS. The data collected as part of these additional monitoring surveys will allow the evaluation of UDM and/or CDM distribution and thickness and permit the refinement of target placement locations before disposal or capping operations are complete.

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