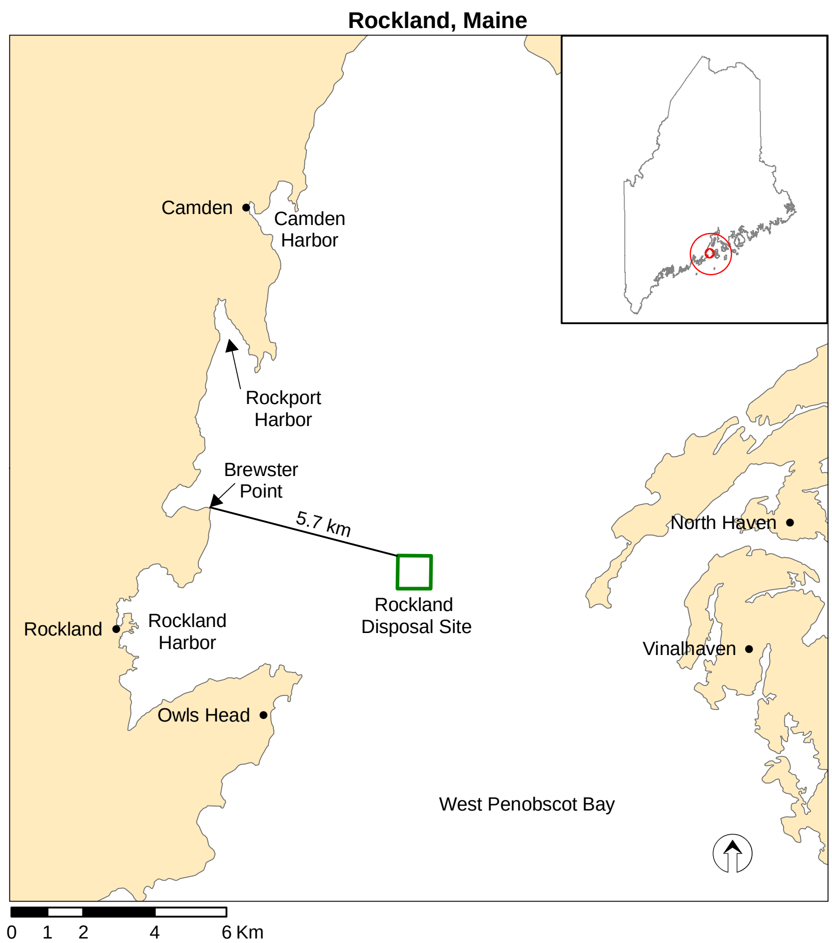
Monitoring Survey at the Rockland Disposal Site
September 2003

Disposal Area Monitoring System DAMOS

DISPOSAL AREA MONITORING SYSTEM

Contribution 156
August 2004

US Army Corps of Engineers®
New England District



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13. ABSTRACT

The Rockland Disposal Site (RDS) was monitored as part of the US Army Corps of Engineers New England District Disposal Area Monitoring System (DAMOS) on 5-6 September 2003 and 22-26 September. The 2003 field effort included bathymetric, side-scan sonar and sediment-profile imaging (SPI) surveys designed to document changes in seafloor topography, evaluate the physical distribution of dredged material and assess the benthic recolonization status associated with recent dredged material disposal activity. Disposal site data were compared with nearby reference area data and historical data from the September 2000 RDS survey.

Prior to the September 2000 survey, there was limited dredged material disposal at RDS, and the September 2000 survey characterized baseline conditions at RDS. Between the September 2000 and the September 2003 surveys, approximately 263,000 m^3 of dredged material was placed at RDS. Depth difference results between the 2000 and the 2003 bathymetric surveys indicated the formation of a single disposal mound with an approximate height of 4 m. The mound had a circular footprint with an approximate diameter of 900 m detectable in the side-scan sonar images. The size and location of this disposal mound was consistent with the volume and placement of dredged material since the 2000 survey. The SPI images revealed a diverse benthic community dominated by Stage I and Stage III organisms and indicated a high level of benthic recovery. Benthic habitat at RDS is recovering as expected following dredged material disposal.

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EXECUTIVE SUMMARY

A monitoring survey was conducted at the Rockland Disposal Site (RDS), as part of the Disposal Area Monitoring System (DAMOS), from 5 to 26 September 2003. The September 2003 field effort consisted of bathymetric, side-scan sonar, and sediment-profile imaging (SPI) surveys designed to document changes in seafloor topography, evaluate the physical distribution of dredged material, and assess benthic recolonization status associated with recent dredged material disposal activity.

Approximately 263,000 m^3 of dredged material was deposited at RDS since the last bathymetric and sediment-profile imaging survey (September 2000). This dredged material disposal volume is large relative to the prior 10 years of disposal activity at this site. A recently formed disposal mound was found at the present location of the disposal buoy. The mound had a maximum height of approximately 4 m and an approximate diameter of 220 m based on comparison of bathymetric data from the previous (2000) and present (2003) surveys. Side-scan sonar and SPI data collected in 2003 are consistent with the bathymetric data, revealing a single mound centered at the disposal buoy. These more sensitive measurement techniques revealed a thin layer of dredged material extending farther from the disposal buoy with a diameter of approximately 900 m. This single mound detected in 2003 appears to have replaced the two smaller mounds observed during the previous (2000-2001) RDS monitoring survey. The location and extent of the single mound at the active disposal buoy was entirely consistent with dredged material disposal activities conducted over the past three years.

Advanced benthic recolonization was found at RDS. The sediment-profile imaging survey found evidence of a diverse benthic community comprised of both surface-dwelling polychaetes (Stage I) and sub-surface deposit-feeders (Stage III) at a very high percentage of locations throughout RDS. Overall median Organism-Sediment Index (OSI) values at RDS stations indicated a high level of recovery within the sediment deposit from the physical disturbance associated with both past and present dredged material placement.

1.0 INTRODUCTION

A monitoring survey was conducted at the Rockland Disposal Site in September 2003 as part of the U.S. Army Corps of Engineers (USACE) New England District (NAE) Disposal Area Monitoring System (DAMOS). DAMOS is a comprehensive monitoring and management program designed and conducted to ensure environmental protection of open water dredged material disposal sites throughout the New England region. An introduction to the DAMOS Program and the Rockland Disposal Site, including a brief description of previous dredged material disposal activities and previous monitoring surveys at this site, is provided below.

Disposal site boundaries are established to provide a management area for placement of dredged material on the seafloor. Barge operators are given specific coordinates (and often visible lighted buoys) within these disposal boundaries to navigate to and release their cargo of dredged material. In practice, it is expected that disposal will occur in a cluster around these target coordinates (or buoys) and that some dredged material is lost in the water column during release. The Clean Water Act Section (404)(b)(1) provides guidelines for the discharge of dredged material and defines the "discharge point" as the point within the disposal site (including both the bottom surface area and any overlying volume of water) at which the dredged material is released. The Marine Protection, Research, and Sanctuaries Act Section 102 defines the release zone as a locus of points 100 m around the barge from beginning to end of the discharge (40 CFR Section 227.28). Monitoring objectives recognize that the site boundary is a target area for release at the water's surface, and that during descent and placement some dredged material may extend across the boundary on the seafloor.

1.1 Overview of the DAMOS Program

For over 25 years, the USACE NAE has collected and evaluated disposal site data throughout New England. Patterns of physical, chemical, and biological responses of seafloor environments to dredged material disposal activity have been documented based on these data. The DAMOS Program grew out of these studies and features a tiered management protocol designed to ensure that any potential adverse environmental impacts associated with dredged material disposal activities are promptly identified and addressed (Germano et al. 1994). Monitoring surveys are designed to collect data that will allow evaluation of the environmental status of each disposal site, relative both to conditions at the site after recent disposal of dredged material and to conditions observed in nearby reference areas unaffected by disposal activities. The results of each monitoring survey are evaluated to determine the next step in the process of managing each specific disposal site.

DAMOS monitoring surveys are designed to test hypotheses related to established site response patterns. Two primary goals of DAMOS monitoring surveys have been to document the physical location and evaluate the environmental impact of dredged material placed on the seafloor at disposal sites. Sequential bathymetric measurements are performed to determine the location and buildup or loss of dredged material placed at sites, and sediment-profile imaging (SPI) is performed after disposal to support evaluation of seafloor (benthic) habitat conditions. Each type of data collection activity is conducted periodically, and the response of the animal-sediment system is evaluated. For example, periodic surveys have been conducted to document recovery rates of benthic communities (i.e., the time required for affected benthic communities to return to conditions similar to those at nearby reference areas). The conditions found after a specific disposal operation are compared to an expected recovery sequence and rate to qualify observed benthic conditions (Germano et al., 1994). DAMOS monitoring surveys may also feature additional types of data collection activities, such as side-scan sonar and sediment coring, as deemed appropriate to achieve specific survey objectives.

1.2 Introduction to the Rockland Disposal Site

The Rockland Disposal Site (RDS) is a regional dredged material disposal site located in the waters of central coastal Maine (Figure 1-1). RDS is situated in West Penobscot Bay, approximately 5 km east of Rockland Harbor and approximately 4 km west of Vinalhaven Island, and is exposed to the Gulf of Maine to the south. RDS is defined as a 930 x 930 m area on the seafloor centered at coordinates 44° 07.105' N, 69° 00.269' W (NAD 83).

Water depths within RDS range from 66 to 72 m, except for a deeper trough situated within the northeastern quadrant, where water depth reaches 80 m (Figure 1-2). Water depths in the area immediately surrounding RDS generally increase both to the south and within the trough to the north. To the east and west, water depths in areas immediately adjacent to RDS are generally similar to depths within the site (i.e., 66-72 m), except for a rock outcrop to the west (minimum depth of 56 m).

Two dredged material disposal mounds have been identified previously within RDS (SAIC 2001) and are designated as Mound A and Mound B (Figure 1-2). A brief description of the origin of the RDS mounds is provided below. One buoy, the US Coast Guard, Class-A Special Purposes buoy designated “DG”, was located at RDS prior to and during the September 2003 survey period (Figure 1-2).

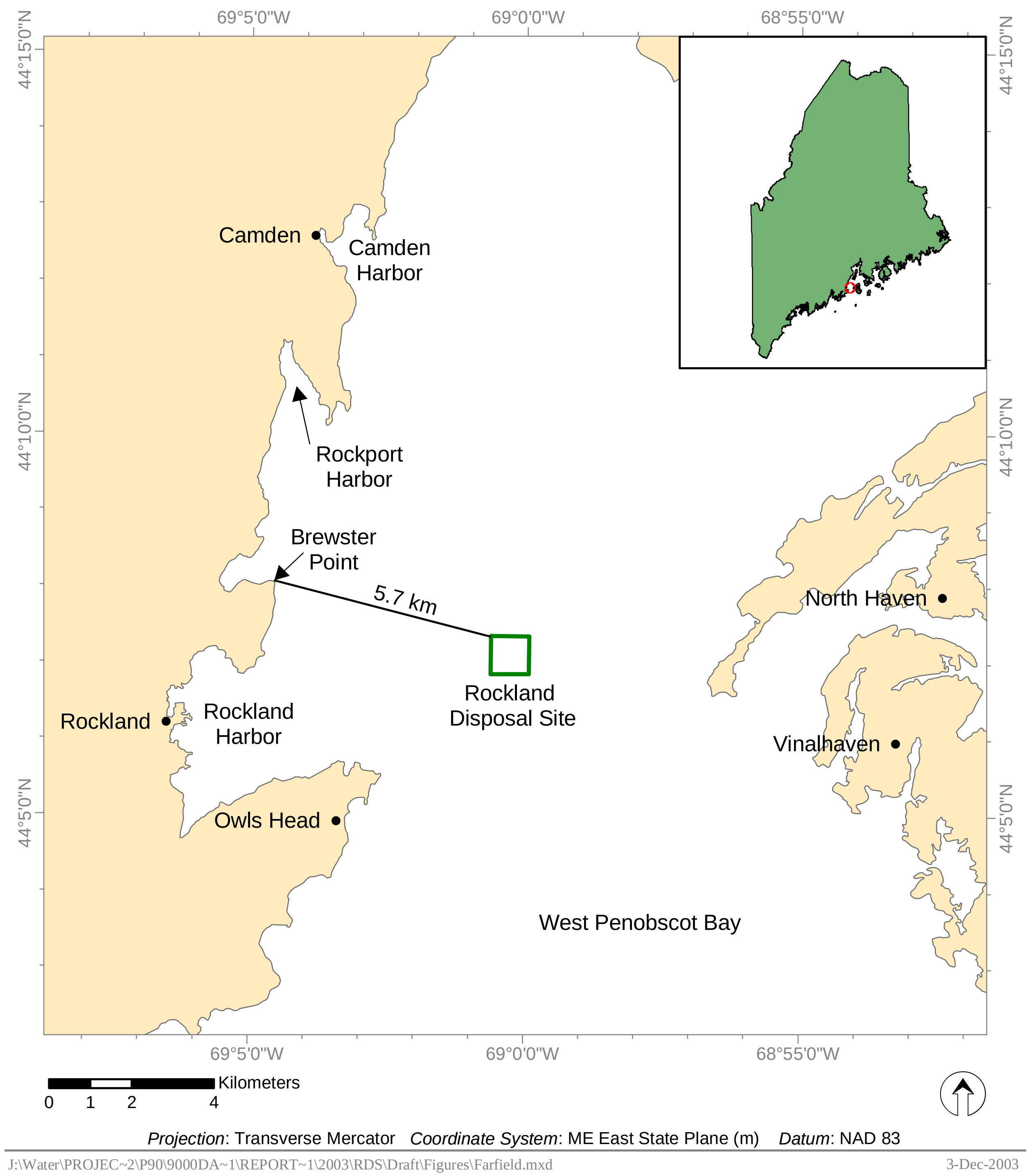

Figure 1-1. Location of the Rockland Disposal Site in central, coastal Maine

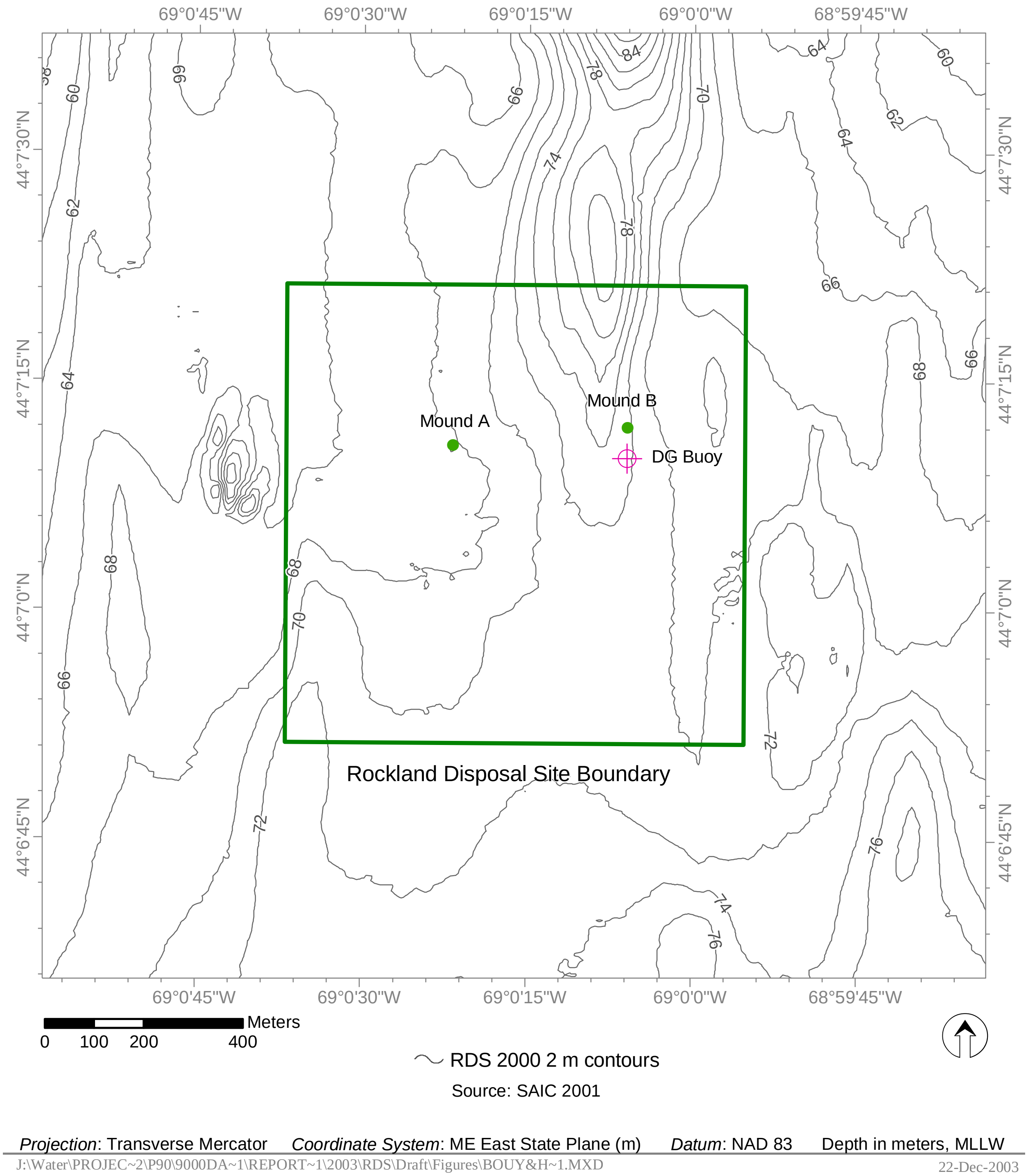

Figure 1-2. RDS with disposal mounds and buoys indicated

1.3 Historic Dredged Material Disposal Activity

Dredged material disposal activity at RDS prior to May 2000 is outlined below. RDS was first used in 1973 when it received approximately 69,000 m^3 of dredged material from Rockland Harbor. In 1984 and 1985, approximately 275,000 m^3 of dredged material from Searsport was placed at this site (SAIC 1988). From May 1985 to June 1989, it is estimated that 430,000 m^3 of dredged material was deposited at RDS (SAIC 1992). RDS was little used during the 1990s; specifically, from April 1990 to May 2000, an estimated total barge volume of only 27,000 m^3 was placed at RDS (SAIC 2001). All of this dredged material was deposited near Mound A (Figure 1-2).

1.4 Historic RDS Monitoring Events

RDS was previously surveyed in September 1984, May 1985, June 1989, September 2000, May 2001, and August 2001. The September 2000 survey included bathymetric, sediment-profile imaging, and drop video surveys and was reported together with the May 2001 side-scan sonar survey (SAIC 2001). The August 2001 survey focused on physical oceanographic characterization through measurement of water velocity and turbidity (SAIC 2003).

The September 2000 survey followed a period of minimal dredged material disposal at RDS and preceded several significant dredging projects. The objective of this survey was to establish an updated baseline characterization of RDS, primarily through bathymetric and sediment-profile imaging investigations. The survey was designed to provide an assessment of conditions in September 2000 and to provide a basis for comparison following dredged material disposal activities anticipated during the 2001 through 2003 time period.

The September 2000 survey revealed that the bathymetry of RDS changed relatively little during the 1989 to 2000 time period. Comparison between the 1989 and 2000 surveys indicated changes in elevation of less than 0.5 m throughout the site. Dredged material was observed at several stations located outside of the site boundary. The occurrence of dredged material outside of the site boundary is not unexpected, given the water depth and relatively small size of the disposal site. Based on the 2000 survey, it appeared that no significant dredged material mounds were formed at RDS between 1989 and 2000. A sediment-profile imaging and drop video survey conducted at RDS in 2000 concluded that the seafloor of RDS was at or near ambient benthic habitat conditions (SAIC 2001).

The August 2001 physical oceanographic survey was conducted to provide a characterization of ambient currents in the disposal area and to collect data required to support mathematical modeling of dredged material transport during disposal events. This survey featured deployment of a suite of instruments for a period of one month. The instrument suite included an acoustic Doppler current profiler to collect water velocity measurements throughout the water column and a fixed-point acoustic Doppler current meter and turbidity meter to collect near-bottom measurements.

The physical oceanographic survey found that ambient currents at RDS are primarily driven by tidal forcings. Typical peak tidal currents ranged from 10 to 30 cm/s, with stronger currents in the middle of the water column and weaker currents near the bottom. Maximum ambient water velocity measurements of 45 cm/s at mid-depth and 26 cm/s at near-bottom were observed during the one-month deployment period. Ambient currents were observed to be oriented with the main channel of West Penobscot Bay flowing north and south with the flooding and ebbing tide, respectively.

1.5 Recent Dredged Material Disposal Activity

Recent dredged material disposal activity at RDS is defined as activity conducted after the most recent previous survey until the present survey, i.e., from September 2000 to September 2003. During this period, an estimated 263,000 m^3 of dredged material was deposited at RDS (Table 1-1). The dredged material disposed at RDS originated primarily from the Belfast Harbor, Mack Point, Rockland Federal Navigation Channel, and Camden Federal Navigation Channel projects. Several relatively smaller projects (Tenants Harbor, Lassell Island, and Camden Harbor) also contributed to the total (Table 1-1). Disposal records indicate that all of this dredged material was placed in the vicinity of the "DG" buoy marking the active mound (Mound B) in the northeast section of RDS (Figure 1-3). A detailed record of barge disposal activity at RDS for the September 2000 to September 2003 period is provided in Appendix A.

1.6 Survey Objectives

The September 2003 survey was designed to characterize potential impacts associated with recent dredged material disposal activity. Survey objectives included documentation of changes in seafloor topography and an assessment of benthic recolonization status in response to disposal operations. Sediment characterization objectives included comparison of RDS benthic habitat conditions to those at reference areas.

Table 1-1.

Overview of Recent RDS Disposal Activity

Source Project	Estimated Scow Volume Disposed (m^3)
Belfast Harbor	122,902
Camden Federal Navigation Channel	18,988
Camden Harbor	1,674
Lassell Island	3,268
Mack Point	54,742
Rockland FEF Navigation	46,222
Rockland Harbor, MA	10,352
Tenants Harbor	4,821
Total	262,969

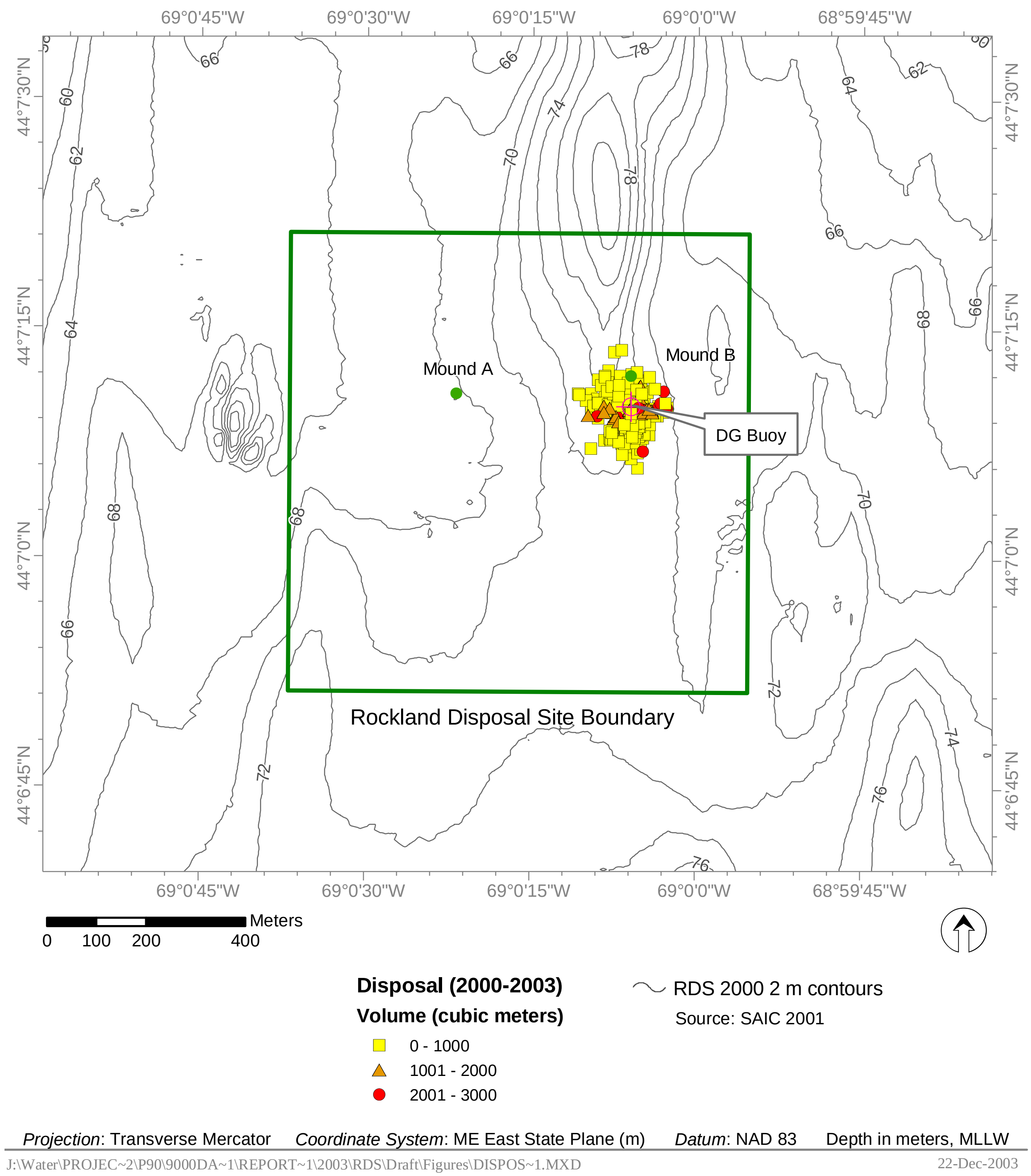

Figure 1-3. RDS with recent dredged material disposal locations indicated

2.0 METHODS

The September 2003 Rockland Disposal Site survey was conducted by a team of investigators from ENSR International, CR Environmental, and Germano & Associates. The survey was performed 5-6 and 22-26 September 2003 and included bathymetry, side-scan sonar, and sediment-profile imaging (SPI). Field activities are summarized in Table 2-1, and an overview of the methods used to collect the survey data as well as methods used to process and analyze the data is provided below. A detailed description of SPI methodology and related terminology is in Appendix B.

2.1 Navigation and On-Board Data Acquisition

Positional data, comprised of horizontal positioning (x- and y-dimensional data) and time (t-dimensional data), were collected using a Trimble AG 132 Differential Global Position System (DGPS). This system received and processed satellite and land-based beacon data and provided real-time vessel position, typically to sub-meter accuracy. Coastal Oceanographics', Inc. HYPACK® hydrographic survey software was used to acquire, integrate, and store all positional data from the DGPS as well as bathymetric and station data. The HYPACK® software also displayed real-time vessel position, bathymetric data, and SPI stations over an electronic chart of the study area, thus enabling survey scientists to review and evaluate survey data on a real-time basis (Figure 2-1).

2.2 Bathymetry

Bathymetry surveys provide measurements of water depth that, when processed, can be used to map the seafloor topography. The processed data can also be compared with previous surveys to track changes in the size and location of seafloor features. This technique is the primary tool in the DAMOS Program for mapping the distribution of dredged material at disposal sites.

2.2.1 Bathymetric Data Acquisition

The 2003 bathymetric survey was conducted over a 2100 x 2100 m area duplicating the baseline survey effort conducted in September 2000 (SAIC 2001). A total of 85 survey lines, each 25 m apart, were occupied (Figure 2-2). In addition, several perpendicular and diagonal cross-tie lines were occupied to provide quality control. The bathymetric survey was conducted on 22-26 September 2003 aboard the R/V *Cyprinodon.*

Table 2-1.

September 2003 RDS Field Activities Summary

Survey Type	Date	Summary
Bathymetry	22-26 Sep. 2003	Area: 2100 x 2100 m Lines: 85 Spacing: 25 m
Side-Scan Sonar	22-26 Sep. 2003	Area: 2100 x 2100 m Lines: 11 Spacing: 200 m
Sediment-Profile Imaging	5-6 Sep. 2003	Stations: 55 30 inner 12 outer 13 reference

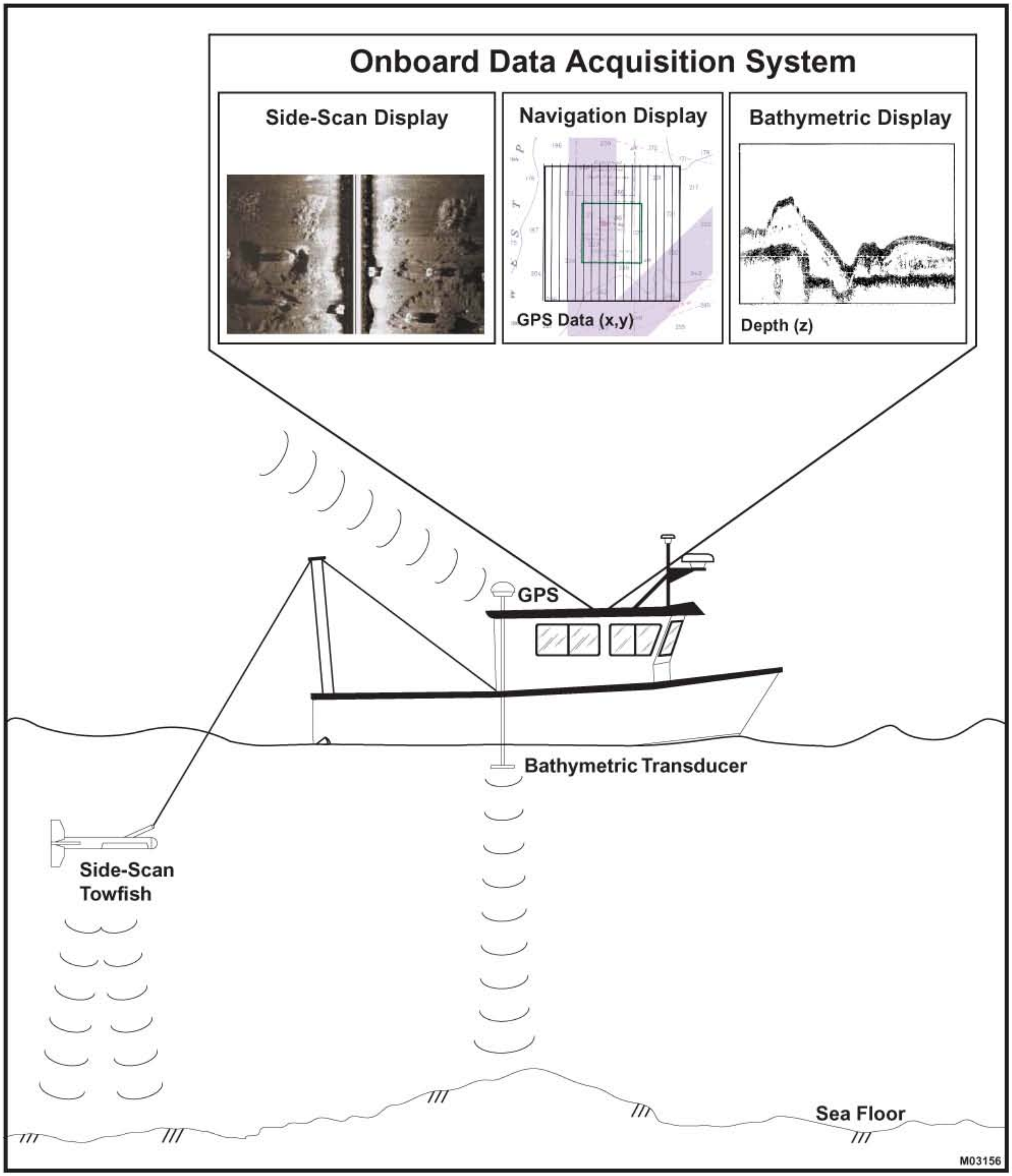

Figure 2-1. Schematic diagram of on-board data acquisition system

Figure 2-2. RDS 2003 bathymetry and side-scan sonar lines

The bathymetric survey was conducted using an Ocean Data Equipment Corporation (ODEC) MF500 precision echo sounder outfitted with a narrow beam (3°), 200-kHz transducer. The accuracy of the bathymetric system used in this survey was approximately 0.1% of the water depth, approximately 7 cm in the waters of RDS. The system was calibrated at the dock prior to each survey day. In addition, local measurements of salinity and temperature were taken *in-situ* using a Seabird SEACAT-19 CTD. Local tidal water level data were recorded at a project benchmark established by a Maine Registered Land Surveyor in Rockland Harbor using a pressure transducer (InSitu, Inc. Mini-Troll®). These ancillary measurements were used to process the bathymetric data.

2.2.2 Bathymetric Data Processing

The bathymetric data were processed using the HYPACK® software program and included corrections for tidal conditions, local speed of sound, acquisition system latency, and spurious data points. Tidal correction consisted of transforming the raw measurements of depth below the transducer to seafloor elevation measurements relative to Mean Lower Low Water (MLLW) using the locally collected tidal elevation data. The speed of sound during performance of the survey was calculated from local temperature and salinity measurements and used to correct the bathymetric data. Corrections were applied for acquisition system latency to account for positional errors related to small time delays between the actual DGPS and echo sounder measurements and the digital recording. The bathymetric data were also reviewed for spurious data points (clearly unrealistic measurements resulting from signal interference), and these points were removed.

2.2.3 Bathymetric Data Analysis

Bathymetric data were analyzed to gain a better understanding of the existing conditions at the site and for comparison with previous surveys to document changes in seafloor topography. For this survey, the corrected bathymetric data were analyzed using a combination of the contouring and surface plotting software program, Surfer® 8.0 and the GIS-based software package ArcView® 8.3. Using Surfer®, the processed RDS 2003 data were gridded to a cell size of 25 m^2, consistent with the bathymetric grid created for the previous (September 2000) survey (SAIC 2001). Once gridded, bathymetric contour lines were displayed using ArcView®.

Surfer® was also used to calculate a depth difference grid based on the September 2000 and the September 2003 bathymetric data sets. This grid was calculated by subtracting interpolated depth estimates of September 2003 from the September 2000 depth estimates at each point throughout the grid. The resulting depth differences were contoured and displayed using ArcView®.

2.3 Side-Scan Sonar

Side-scan sonar measurements characterize the reflective properties of the seafloor beneath and to each side of the transiting survey vessel. Following processing, a map of seafloor reflectivity can be generated to help infer seafloor topography and surficial sediment characteristics. This technique is used in the DAMOS Program to provide reconnaissance-level characterization of near-surface seafloor materials and identification of seafloor features associated with disposal activities.

2.3.1 Side-Scan Sonar Data Acquisition

The 2003 side-scan sonar survey was conducted over a 2100 x 2100 m area duplicating the baseline survey effort conducted in September 2000 (SAIC 2001). Every eighth bathymetric survey line was surveyed using the side-scan system, resulting in 200 m spacing between survey lines. The side-scan sonar range was set to ensure sufficient overlap between survey lines. The side-scan sonar survey was conducted concurrently with the bathymetric survey on 22-26 September 2003 aboard the R/V *Cyprinodon*.

Side-scan sonar measurements were collected using an Edgetech, Inc. TD272 dual-frequency transducer array with the following settings: 1° signal horizontal beam angle, 30° tilt angle, and 50° beam width angle. A sonar frequency of 100-kHz was used with a range of 150 m, resulting in a total swath width of 300 m. The towfish was deployed using a hydraulic oceanographic winch and incoming acoustic return arrived as analog sonar signals ("pings") and were converted to digital data within the on-board data acquisition package. These digital signals were recorded and displayed in real-time using Chesapeake Technology, Inc.'s SonarWiz data acquisition software.

2.3.2 Side-Scan Sonar Data Processing

Raw side-scan sonar data were processed using Chesapeake Technology, Inc.'s SonarWeb software to correct for layback and signal attenuation (related to swath width), and to georeference sonar imagery. Data processing also included corrections for variations of the sonar beam angle of incidence relative to the seafloor (beam angle corrections) and signal attenuation with distance (time varied gain corrections). These corrections were made through an iterative review of survey lane data. Once corrected, data from each survey lane were merged to create a single georeferenced mosaic of the survey area with a resolution of 0.25-meters per pixel.

Side-scan images are typically depicted in a range of shades or colors that correspond to the strength of the returning signal used to infer bottom type and topography. The 2003 RDS side-scan images were depicted in both a brown color scale and the traditional gray scale. The inverted, colorized scale was developed to optimize data analysis and target recognition. This scale is often recommended because the eye can perceive a wider range of color shades than gray shades, and is most sensitive to the color scales' longer wavelengths (Fish and Carr 2001). A key to the inverted brown color scale recommended for viewing the RDS side-scan sonar survey results is provided in Figure 2-3.

2.3.3 Side-Scan Sonar Data Analysis

Side-scan sonar data was analyzed to identify seafloor features (e.g., trawl scours and historic disposal artifacts) and to approximate the extent of the dredged material distribution. Analysis was performed on the georeferenced mosaic displayed in the inverted brown color scale. In general, weak signal returns corresponded to smooth seafloor substrates (e.g., fine sediments with little micro-topography), soft materials that absorb the signal, or seabed sloping away from the signal source. These features appeared medium to dark brown in the inverted brown color scale and lighter gray in the conventional scale. Strong signal returns corresponded to rough seabed substrates (e.g., gravel, cobble), highly reflective materials, or to a seabed sloping towards the signal source. These features appeared as lighter shades of brown and orange in the inverted brown color scale and dark gray to black in the conventional scale. Features that rose above the seabed (e.g., boulders) reflected more of the sonar energy than the surrounding substrate resulting in strong signal returns due to decreased angle of incidence. These features often prevented insonification of the area opposite the signal source, resulting in a sonar "shadow" (dark brown to black in the inverted scale and white in the conventional scale). The 2003 side-scan sonar image was visually compared with the 2001 image to infer changes in sediment distribution.

2.4 Sediment-Profile Imaging

Sediment-profile imaging (SPI) is a monitoring technique used to provide data on the physical characteristics of the seafloor as well as the status of the benthic biological community. The technique involves an underwater frame/camera system that can photograph a cross section of the sediment-water interface. Computer-aided analysis of the resulting images provides a set of standard measurements that can be compared between different locations and different surveys. A detailed description of SPI methodology and terminology is provided in Appendix B. The DAMOS Program has

Figure 2-3. Side-scan sonar reflection: inverted brown color and conventional gray scales

successfully used this technique for over 20 years to map the distribution of disposed dredged material and to monitor benthic recolonization at disposal sites.

2.4.1 SPI Data Acquisition

The 2003 SPI survey design included 55 station designated as inner, outer, and reference stations relative to RDS (Table 2-2; Figure 2-4). Inner sampling stations consisted of a 30-station square grid within the 930 x 930 m disposal site boundary. Outer sampling stations consisted of 12 stations distributed immediately outside the disposal site boundary (Figure 2-4 and Table 2-2). Reference samples were collected in three previously established reference areas located approximately 1.5 km to the north, east, and south of the disposal site. Four stations each were located at the East Reference (ER) and South Reference (SR) areas, and five stations were located at the North Reference (NR) area (Figure 2-4). Within each reference area, specific reference stations were located randomly within a 300-m radius of the center.

The SPI survey was conducted on 5-6 September 2003 aboard the F/V *Susan and Caitlyn*. At each station, the vessel was positioned at the target coordinates, and images were collected within a defined station tolerance of 10 m. Three replicate sediment-profile images were collected at each of the 55 stations for characterization of small-scale variability. Due to the extremely soft sediment at some RDS survey stations, the SPI frame was outfitted with mud doors, which enabled optimal sampling.

The SPI system hardware for the 2003 survey included a metal frame, a Benthos Model 3731 pressure housing, a prism chamber, a digital camera, and a Benthos Model 2216 Deep Sea Pinger. The camera was mounted inside the pressure housing and sat atop a wedge-shaped prism with a front faceplate and a back mirror mounted at a 45-degree angle to reflect the profile of the sediment-water interface. The pinger was attached to the camera and output a constant 12-kHz signal of one ping per second. Upon discharge of the camera strobe, the ping rate doubled for 10 seconds. Sound from the pinger was audible on-deck and provided scientists with confirmation that a successful image has been obtained.

2.4.2 SPI Data Analysis

Computer-aided analysis of each SPI image provided measurement of the following standard set of parameters:

Table 2-2.

RDS Inner, Outer, and Reference SPI Sampling Locations, September 2003

Area	Station	Latitude (N)	Longitude (W)	Area	Station	Latitude (N)	Longitude (W)
Inner	I1	44° 07.152'	69° 00.269'	Outer	O1	44° 07.512'	69° 00.836'
	I2	44° 07.250'	69° 00.269'		O2	44° 07.512'	69° 00.457'
	I3	44° 07.055'	69° 00.269'		O3	44° 07.512'	69° 00.080'
	I4	44° 06.959'	69° 00.269'		O4	44° 07.512'	68° 59.701'
	I5	44° 07.250'	69° 00.134'		O5	44° 07.240'	69° 00.835'
	I6	44° 07.249'	68° 59.999'		O6	44° 06.967'	69° 00.835'
	I7	44° 07.250'	69° 00.539'		O7	44° 06.695'	69° 00.836'
	I8	44° 07.249'	69° 00.404'		O8	44° 06.695'	69° 00.458'
	I9	44° 07.153'	69° 00.539'		O9	44° 06.695'	69° 00.079'
	I10	44° 07.055'	69° 00.539'		O10	44° 06.696'	68° 59.701'
	I11	44° 06.958'	69° 00.539'		O11	44° 06.968'	68° 59.701'
	I12	44° 07.153'	69° 00.403'		O12	44° 07.240'	68° 59.701'
	I13	44° 07.056'	69° 00.404'				
	I14	44° 06.958'	69° 00.403'	Reference	ER-1	44° 07.164'	68° 58.789'
	I15	44° 07.153'	69° 00.133'		ER-2	44° 07.219'	68° 58.647'
	I16	44° 07.055'	69° 00.134'		ER-3	44° 07.062'	68° 58.691'
	I17	44° 06.958'	69° 00.134'		ER-4	44° 07.036'	68° 58.481'
	I18	44° 07.152'	68° 59.999'		NR-1	44° 08.225'	69° 00.289'
	I19	44° 07.056'	68° 59.998'		NR-2	44° 08.322'	69° 00.207'
	I20	44° 06.959'	68° 59.998'		NR-3	44° 08.159'	69° 00.348'
	I21	44° 07.348'	69° 00.538'		NR-4	44° 08.030'	69° 00.280'
	I22	44° 07.347'	69° 00.404'		NR-5	44° 08.107'	69° 00.085'
	I23	44° 07.348'	69° 00.268'		SR-1	44° 06.109'	69° 00.304'
	I24	44° 07.348'	69° 00.133'		SR-2	44° 06.109'	69° 00.207'
	I25	44° 07.348'	68° 59.999'		SR-3	44° 05.979'	69° 00.423'
	I26	44° 06.862'	69° 00.539'		SR-4	44° 05.926'	69° 00.115'
	I27	44° 06.862'	69° 00.404'				
	I28	44° 06.862'	69° 00.268'				
	I29	44° 06.862'	69° 00.133'				
	I30	44° 06.861'	68° 59.998'				

Note: All coordinates NAD83.

Figure 2-4. RDS 2003 SPI sampling stations

Sediment Type—The sediment grain size major mode and range were estimated visually from the images using a grain-size comparator at a similar scale. Results were reported using the phi scale; a conversion to other grain size scales is provided in Appendix B. The presence and thickness of disposed dredged material was also assessed by inspection of the images.

Penetration Depth—The depth to which the camera penetrates into the seafloor was measured to provide an indication of the sediment density or bearing capacity.

Surface Boundary Roughness—Surface boundary roughness is a measure of the vertical relief of features at the sediment-water interface in the sediment-profile image. Computer image-analysis software was used to calculate the roughness measure. Analysis also included interpretation of the source (biological or physical) of the roughness.

Apparent Redox Potential Discontinuity (RPD) Depth—RPD provides a measure of the oxygen conditions within sediment pore waters. The RPD depth was measured by assessing color and reflectance boundaries within the images.

Infaunal Successional Stage—Infaunal successional stage is a measure of the biological community inhabiting the seafloor. Current theory holds that organism-sediment interactions in fine-grained sediments follow a predictable sequence of development after a major disturbance (such as dredged material disposal), and this sequence has been divided subjectively into three stages (Rhoads and Germano 1982, 1986). Successional stage was assigned by assessing what types of species or organism-related activities were apparent in the images.

Organism-Sediment Index (OSI)—OSI is a summary parameter incorporating the apparent mean RPD depth, successional stage, and presence of methane or low oxygen. This index is a convenient summary statistic to map disturbance gradients in benthic habitats (Revelas et at. 1987; Table 2-3).

Additional components of the SPI analysis included calculation of means and ranges for the parameters listed above and mapping individual values.

Table 2-3.

Organism-Sediment Index (OSI) Terms and Formulation

Parameter	Index Value
A. Mean RPD Depth (choose one)	
0.00 cm	0
0.01 – 0.75 cm	1
0.76 – 1.50 cm	2
1.51 – 2.25 cm	3
2.26 – 3.00 cm	4
3.01 – 3.75 cm	5
> 3.75 cm	6
B. Successional Stage (choose one)	
Azoic	-4
Stage I	1
Stage I – II	2
Stage II	3
Stage II – III	4
Stage III	5
Stage I on III	5
Stage II on III	5
C. Chemical Parameters (choose all that apply)	
Methane Present	-2
No/Low Dissolved Oxygen	-4
Calculation of Organism-Sediment Index (OSI)	
OSI = Total of above indices (A+B+C)	
Range of possible OSI values is -10 to +11	

3.0 RESULTS

3.1 Bathymetry

3.1.1 Existing Bathymetry

The September 2003 bathymetry of RDS and the 2100 x 2100 m surrounding study area was plotted at 2-m contour intervals (Figure 3-1). Water depths ranged from 60 to 76 m over most of the survey area. A north-south trough was present in the north-central portion of the survey area, where water depths increase up to 90 m. A rock outcrop was evident to the west of the disposal site boundary, protruding upwards approximately 9 m from the surrounding sea floor. Within RDS, water depth ranged from 66 to 78 m, with the greatest depths located along the northern boundary in the deep trough.

3.1.2 Comparison to Previous Bathymetric Survey

The bathymetry of a smaller area, extending to just beyond the RDS boundary, was plotted at 1-m contour intervals for both the September 2003 (Figure 3-2) and September 2000 (Figure 3-3) surveys for comparison. The 2003 RDS bathymetric features were generally similar to those observed in the 2000 survey. The most noticeable differences were observed at the southern end of the trough near the DG buoy (Mound B). Water depths at this location were shallower in the 2003 survey by 2 to 4 m compared to the 2000 survey. In the 2000 RDS plot, regularly spaced contours from 70 to 72 m in the DG buoy area indicated a slope to the west toward the axis of the trough (Figure 3-3). In the 2003 RDS plot, the contours have flattened near the DG buoy, and a low mound with a minimum depth of 67 m was distinguishable (Figure 3-2).

A depth difference contour plot for the study area with a 1-m contour interval shows the difference in water depth between the 2000 and 2003 RDS bathymetric surveys (Figure 3-4). Positive values represent decreases in water depth (shallower water) and negative values represent increases in water depth (deeper water). The most prominent feature identified by the depth difference plot is the mound that formed at the location of the DG buoy in the northeast quadrant of RDS where dredged material disposal has been focused since the September 2000 survey (Figure 3-4).

The depth difference between the 2000 and 2003 surveys was plotted for a smaller area at 0.5-meter contour intervals to better characterize the mound (Figure 3-5). The disposal mound was roughly conical in shape, with a maximum height of approximately 4 m and an approximate diameter of 220 m (Figure 3-5). The average slope of the mound was 3%, with a maximum slope near the top of 6%.

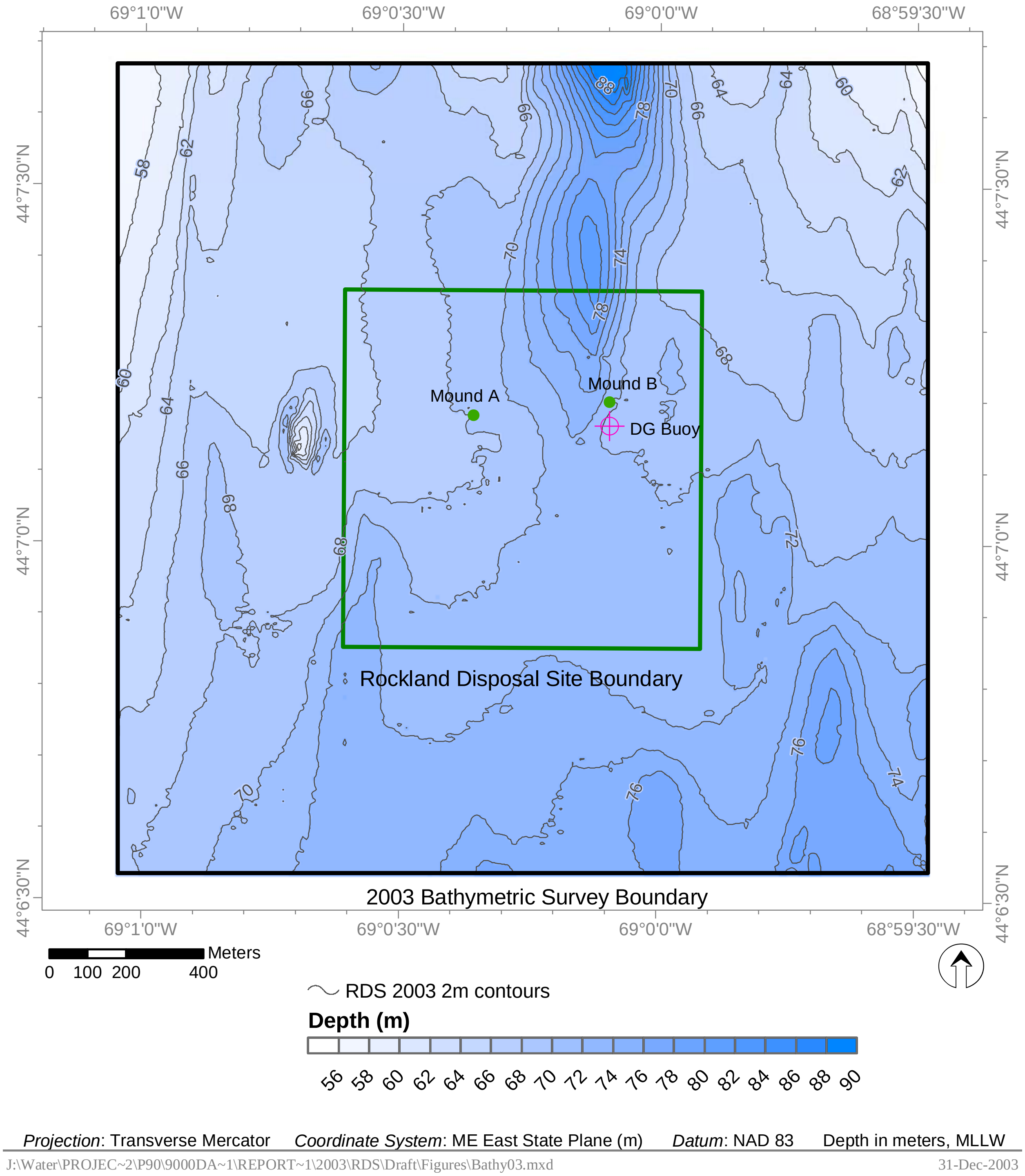

Figure 3-1. Bathymetric contour chart of the RDS September 2003 survey area (at 2 m contour interval)

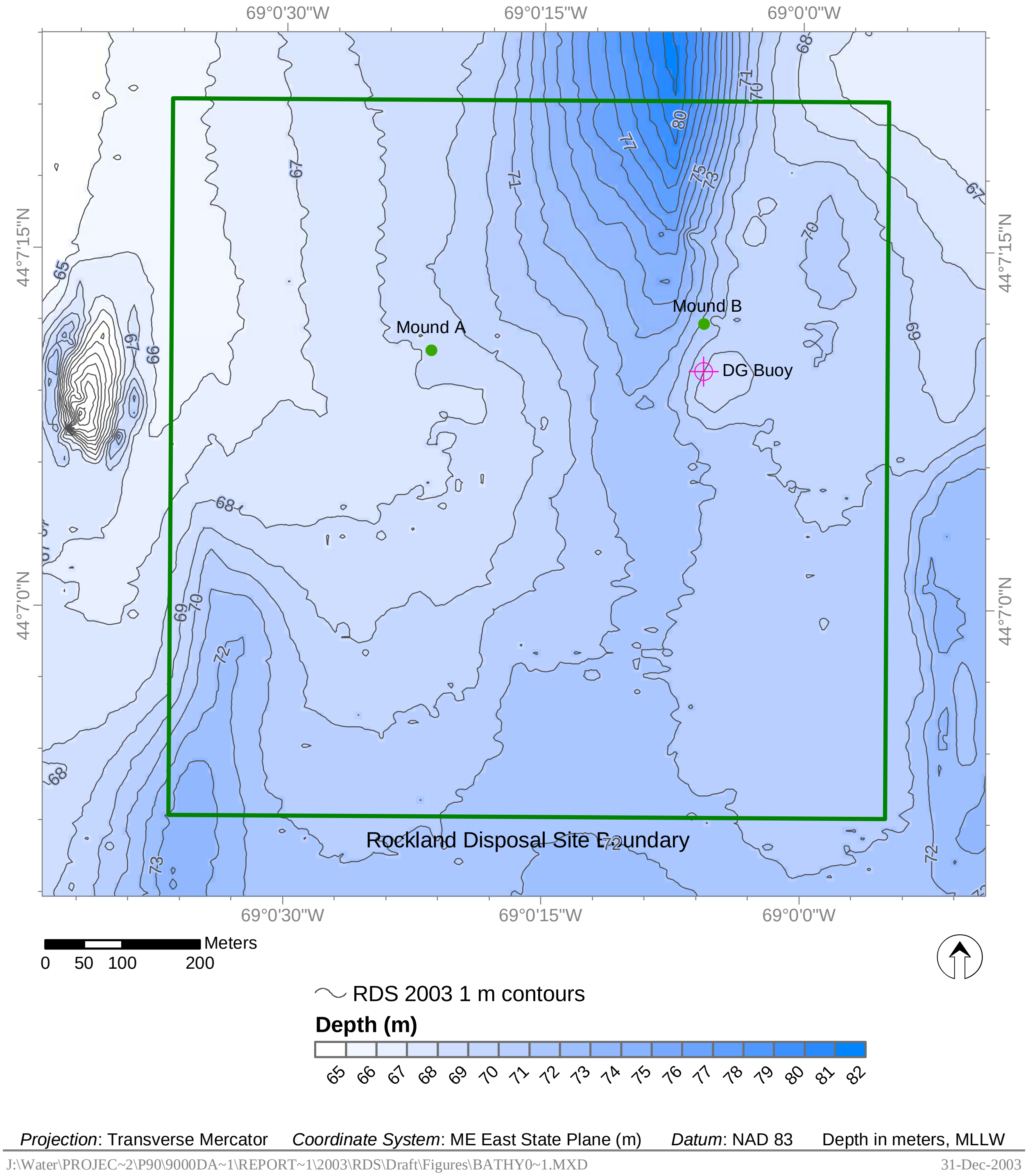

Figure 3-2. Bathymetric contour chart of the RDS September 2003 survey area (at 1 m contour interval)

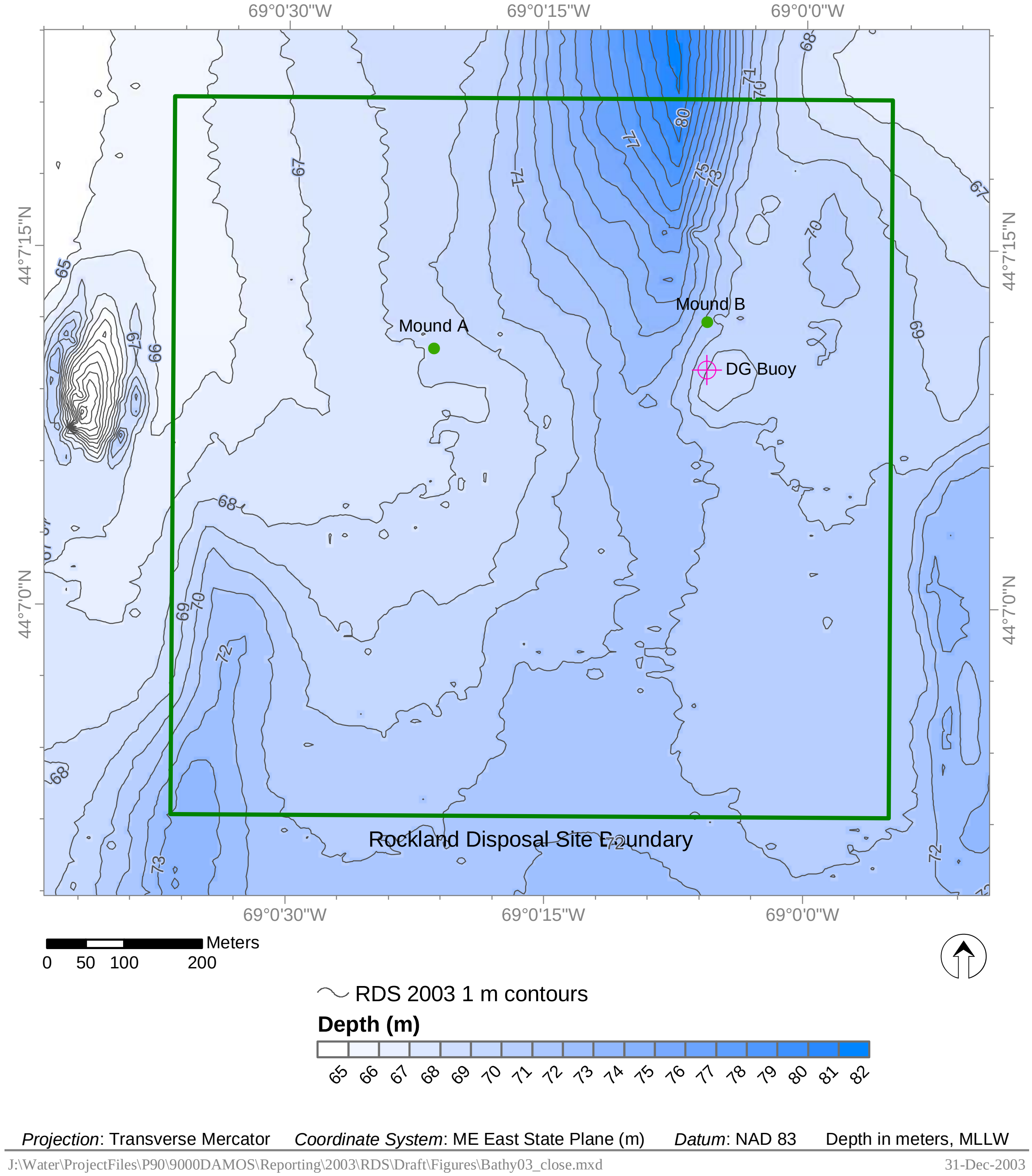

Figure 3-3. Bathymetric contour chart of the RDS September 2000 survey area based on SAIC (2001) data (at 1 m contour interval)

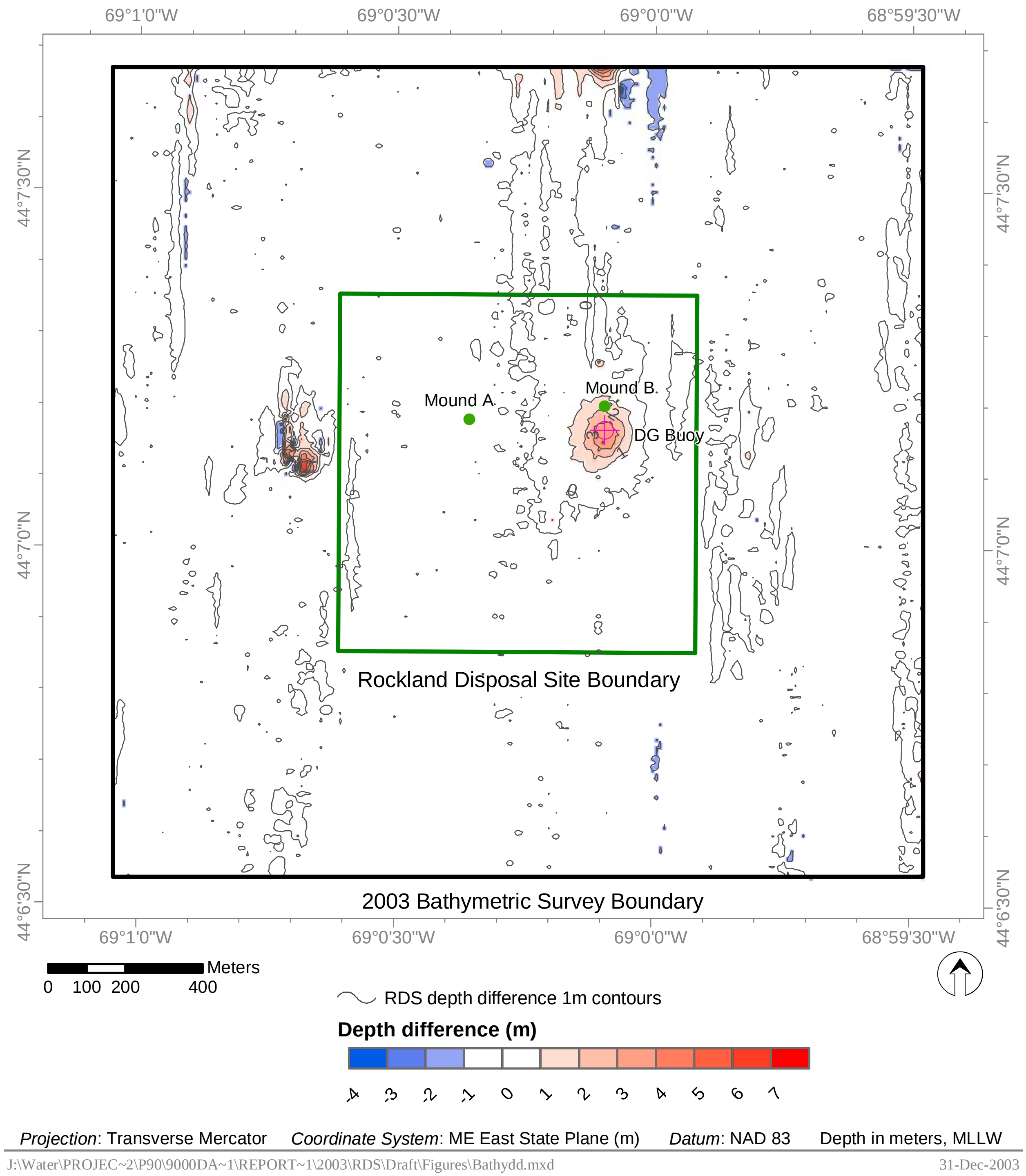

Figure 3-4. Depth difference contour chart: September 2000 vs. September 2003 survey results (at 1 m contour interval)

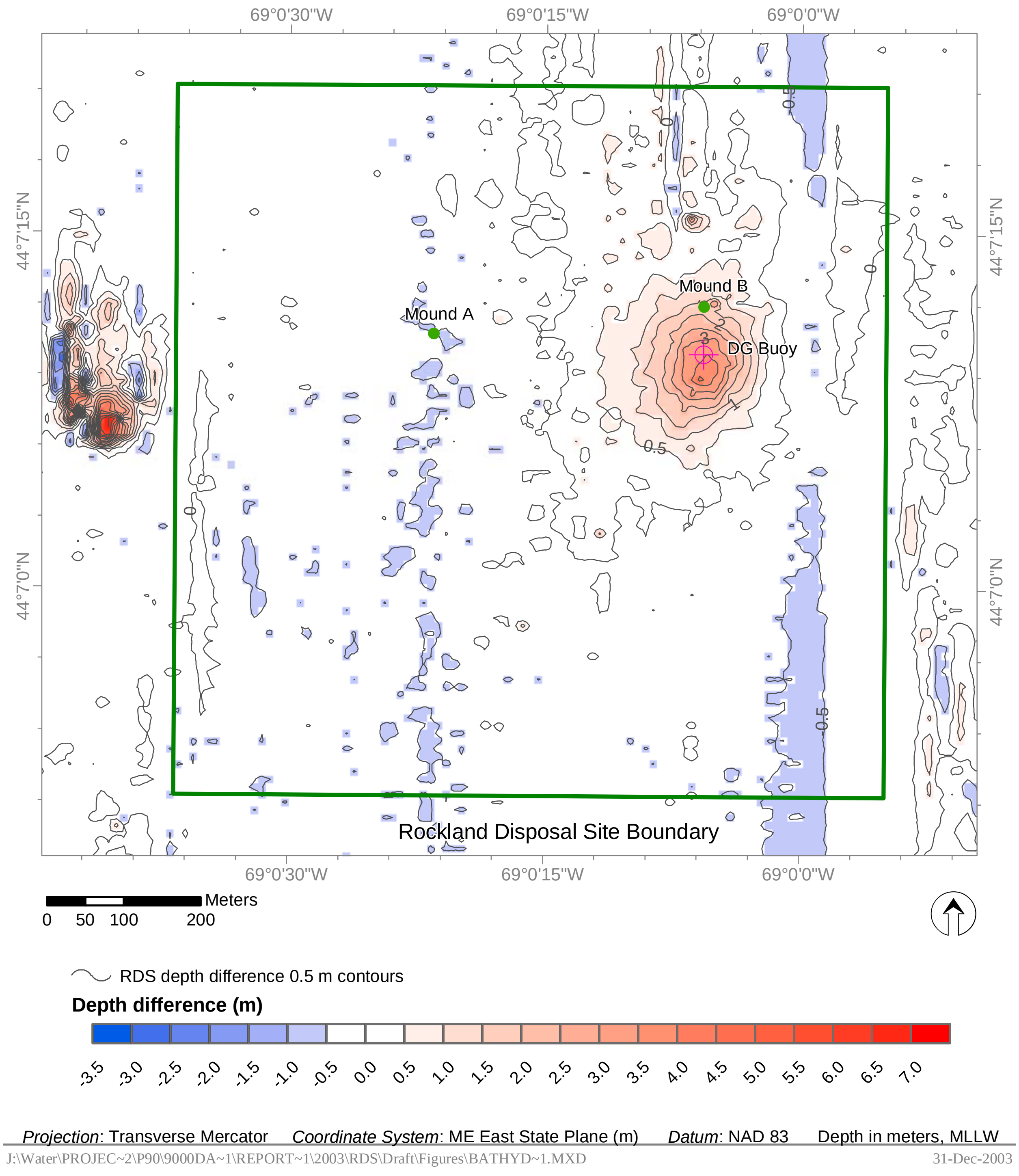

Figure 3-5. Depth difference contour chart: September 2000 vs. September 2003 survey results (at 0.5 m contour interval)

Other features that were apparent in the depth difference plots include apparent changes in the area of the rock outcrop to the west of RDS, in the deepest portion of the trough at the northern edge of the study area, and in a series of north-south trending features across the study area (Figures 3-4 and 3-5). These differences are likely measurement and processing artifacts, rather than actual bathymetric differences between the two surveys. We attribute the apparent differences to several factors including accuracy limitations of single-beam bathymetry in areas of steep slope (e.g., near the rock outcrop to the west and the trough to the north) and differences in bathymetric data processing methodology (e.g., the 2003 survey data set utilized a local tidal correction, whereas the 2000 survey utilized NOAA tidal measurements at Portland, ME).

3.2 Side-Scan Sonar

3.2.1 Existing Side-Scan Sonar

A mosaic image of the seafloor, based on the September 2003 RDS side-scan sonar survey, was generated and is presented in the inverted color scheme (Figure 3-6). A large, nearly circular region of high reflectance was clearly visible (delineated by the red contour line) and was centered at the RDS DG buoy location. This high reflectance region was approximately 900 m in diameter and covered an area of approximately 0.6 km^2, extending north and east of the RDS boundary. Because recently deposited dredged material is, in general, more reflective than ambient sediments (due primarily to the roughness of the surface), the region of high reflectance likely delineates the extent of dredged material on the seafloor.

The side-scan sonar mosaic identified numerous topographic details throughout the survey area, including rock outcroppings, likely historic disposal artifacts, and trawl scours. The side-scan survey was conducted at sufficient resolution to allow enlargement and viewing of smaller scale features. For example, the rock outcropping situated to the west of the RDS boundary was better distinguished in the close-up, in which the outcrop ledge, the sandy slope, and the backside shadow of this topographic feature were clearly identifiable (compare Figure 3-6 and Figure 3-7). An enlargement of the southeastern portion of RDS highlighted several features including likely disposal artifacts, trawl scours and the area of high reflectance in the area of recent disposal activity (Figure 3-8).

3.2.2 Comparison to Previous Side-Scan Sonar Survey

The 2001 RDS side-scan mosaic image (SAIC 2001) was presented in gray-scale format and is reproduced in Figure 3-9. The 2001 side-scan survey identified two distinct high reflectance areas (denoted as dark gray in Figure 3-9) in the central portion of RDS that corresponded with Mound A and Mound B locations. Each of these high

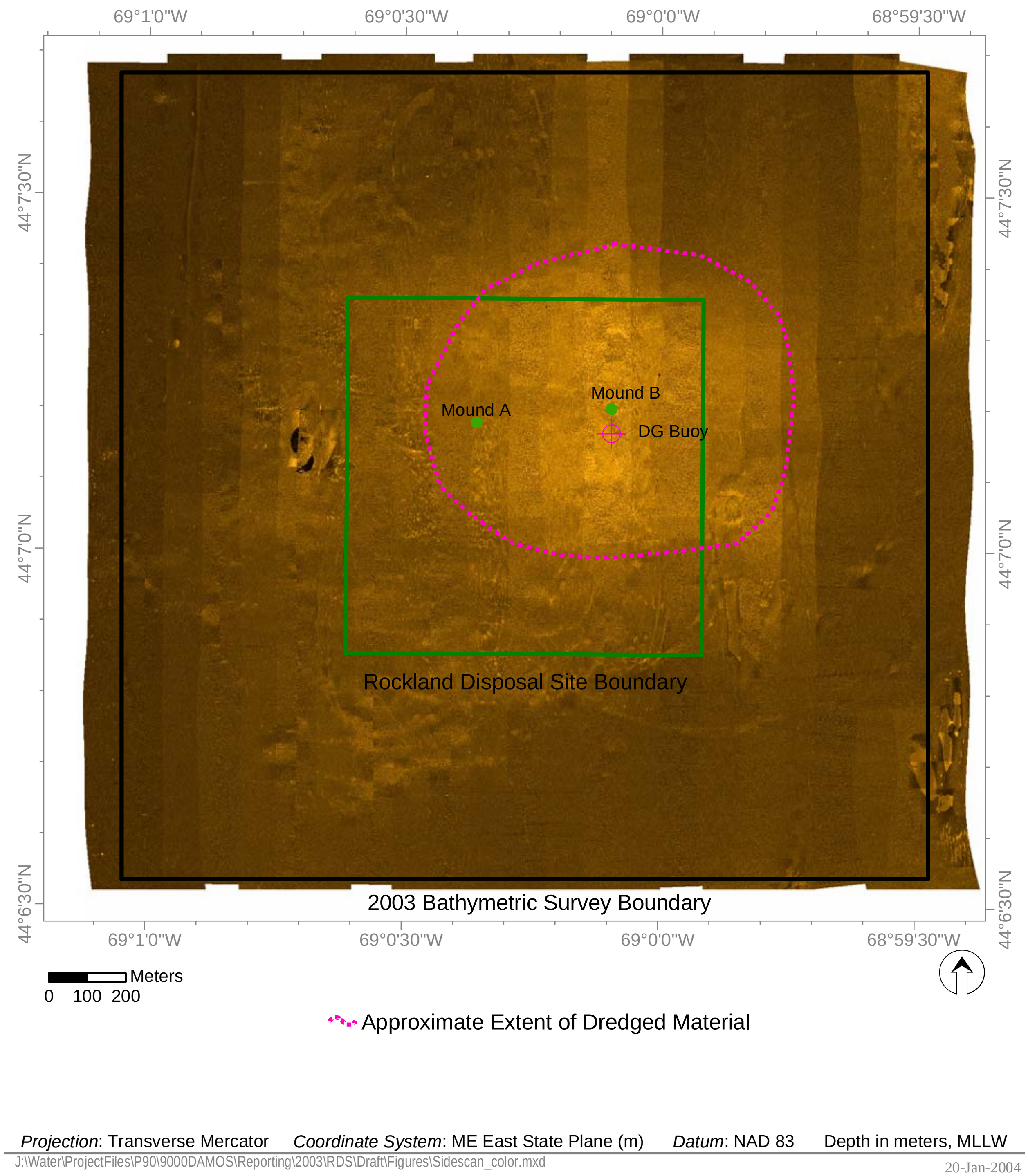

Figure 3-6. Side-scan sonar mosaic image of the RDS September 2003 survey area (inverted color scale)

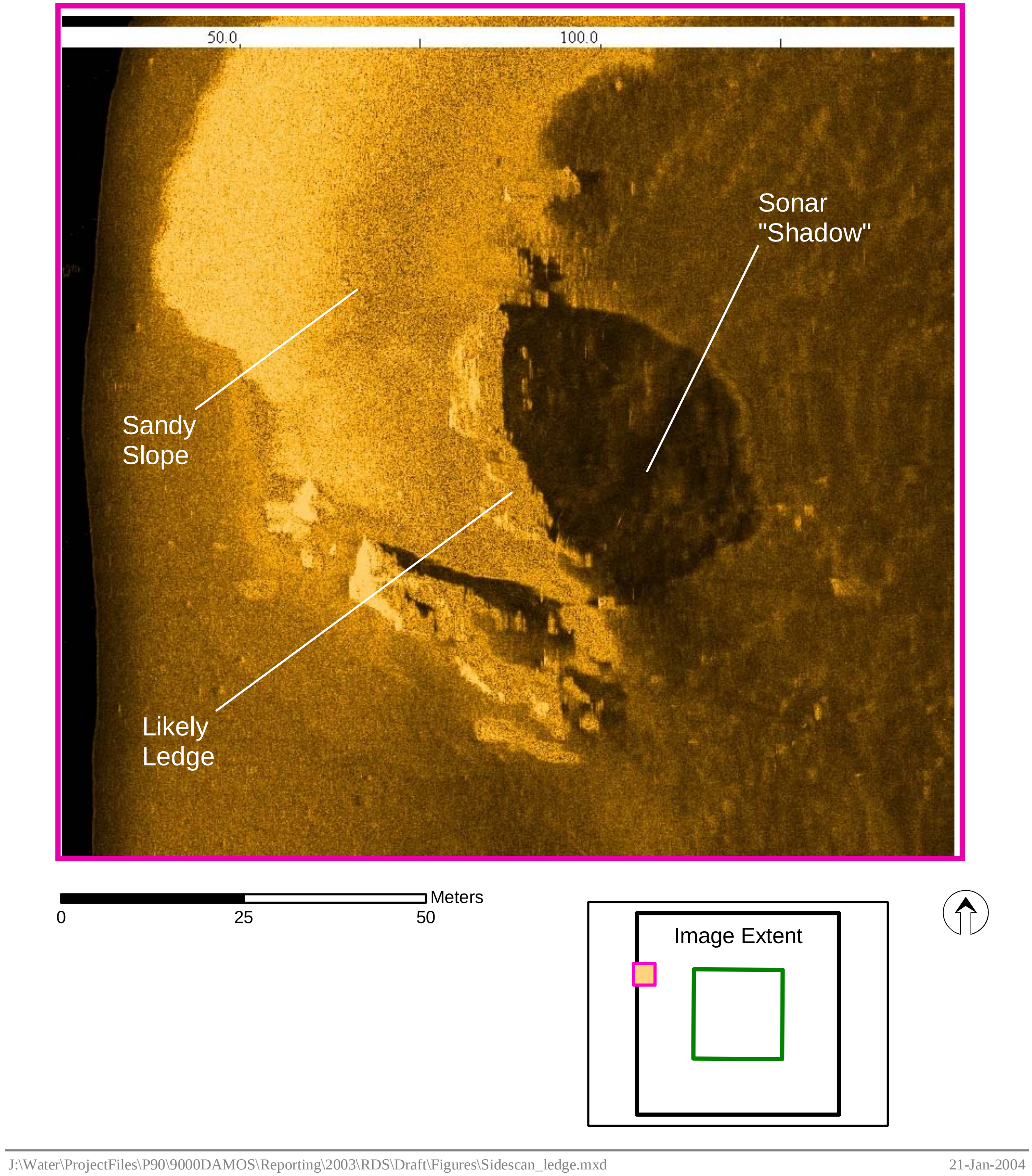

Figure 3-7. Side-scan sonar sub-area chart of the rock outcrop to the west of RDS

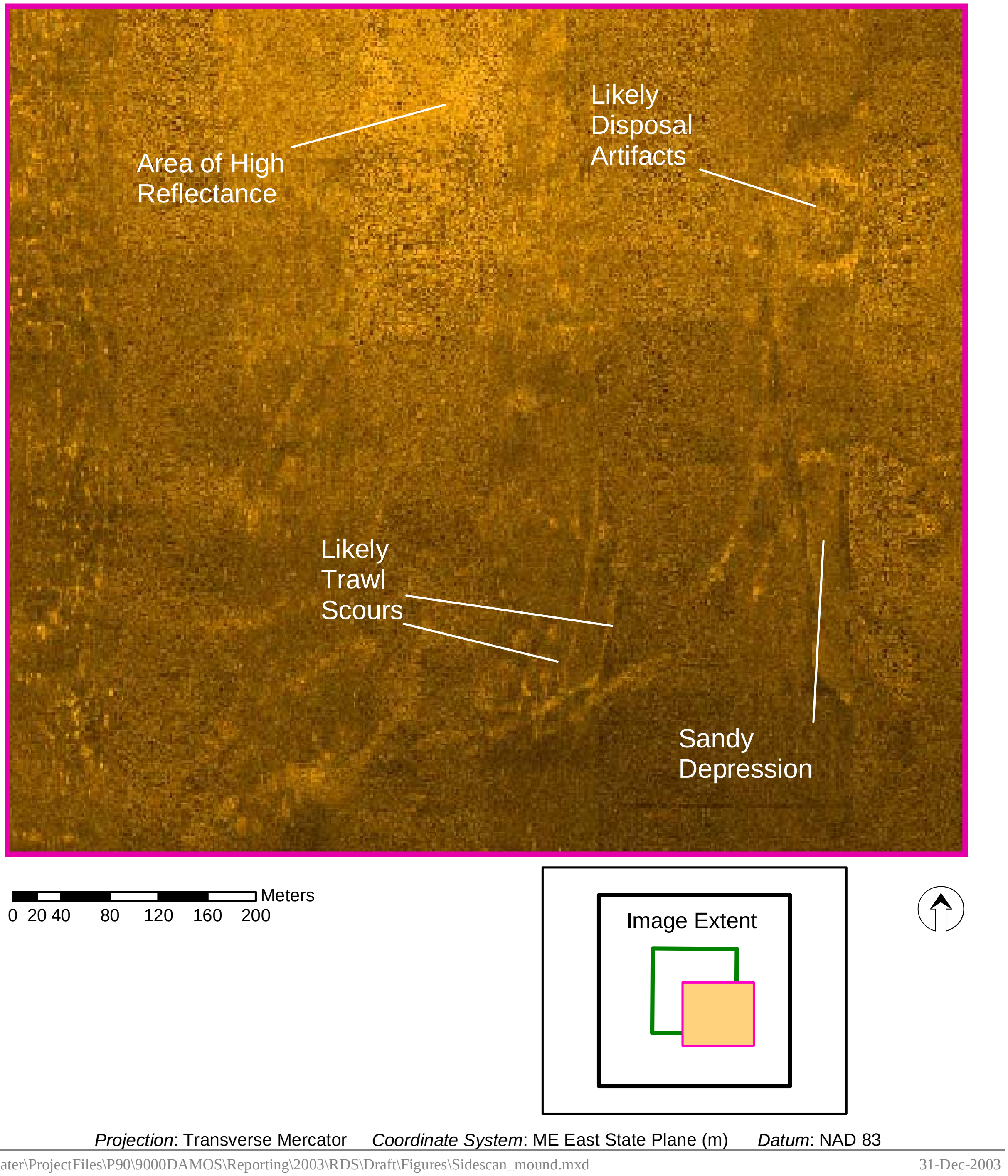

Figure 3-8. Side-scan sonar sub-area in the southeastern portion of the RDS study area

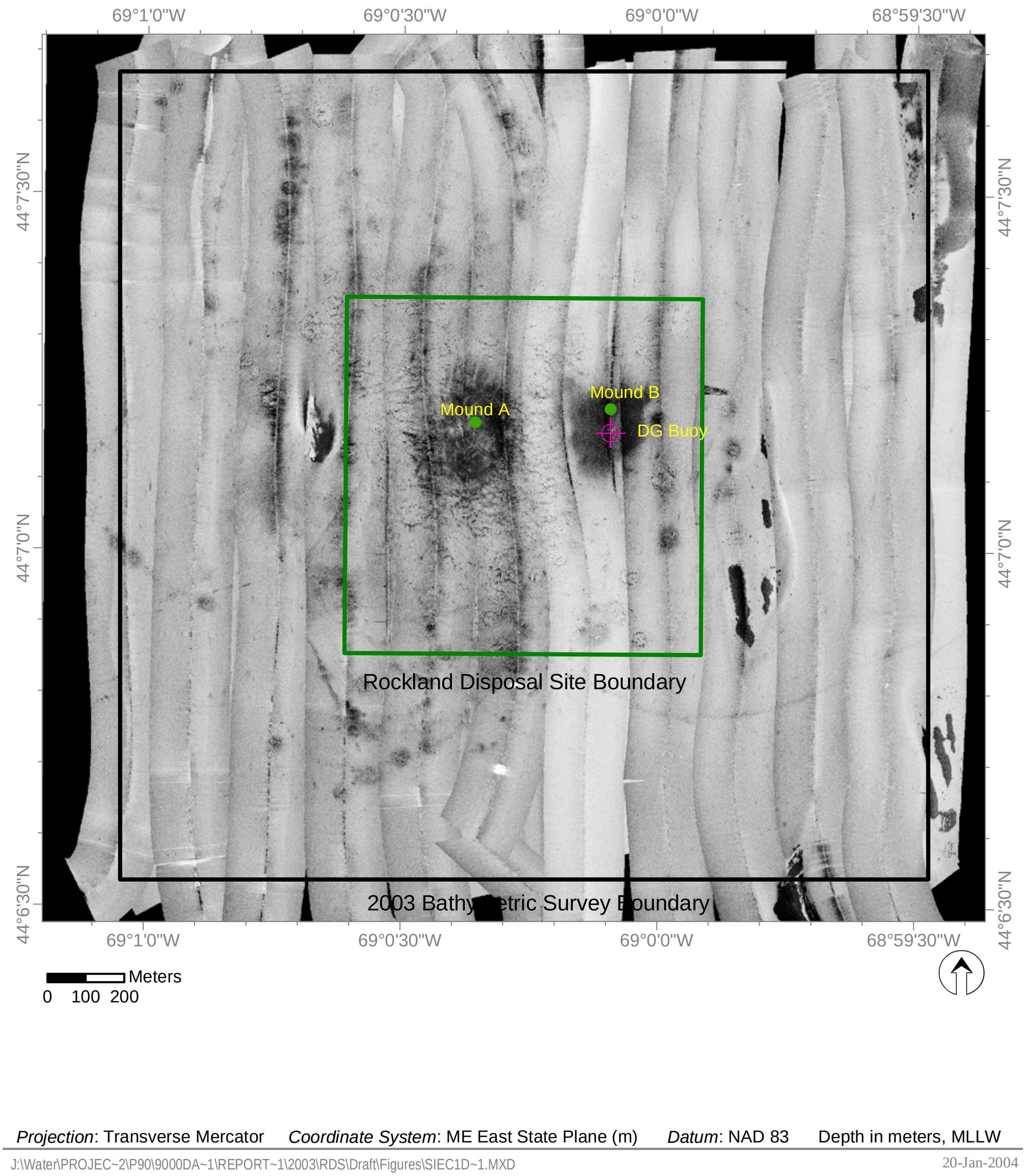

Figure 3-9. Side-scan sonar mosaic image of the RDS May 2001 survey (gray scale) from SAIC (2001)

reflectance areas was nearly circular with an approximately diameter of 200 m and was consistent with the location of historical dredged material disposal activity.

The 2003 RDS mosaic image was also processed in gray-scale format to allow comparison with the 2001 survey (Figure 3-10). The 2003 RDS side-scan imagery illustrated a change from the two smaller, distinct areas of high reflectance, shown in the 2001 RDS results, to one larger region of high reflectance material centered at the DG buoy location.

3.3 Sediment-Profile Imaging

Three replicate SPI images were successfully obtained and analyzed at each of the 55 sampling locations (RDS inner, outer, and reference), except for inner Station I15. At Station I15, only two replicate images were suitable for analysis; rocks prevented adequate penetration of the sediment-profile camera despite repeated attempts by the field crew to obtain a third replicate image. Full analysis results for each replicate image are presented in Appendix C, Tables C-2 through C-4. Summary results for the reference areas are presented in Section 3.3.1 below, followed by a presentation of the results for the RDS inner and outer stations in Section 3.3.2. Section 3.3.3 provides a comparison of the conditions observed in and around RDS in September 2003 versus those at the reference areas, while Section 3.3.4 compares the September 2003 results with those of the previous SPI survey of September 2000.

3.3.1 Reference Areas

Sediment Physical Characteristics

Surface sediments in the three reference areas were uniformly muddy; the grain size major mode at each reference area station was >4 phi (i.e., silt/clay; Table 3-1 and Figure 3-11). The oxidized surface of the mud typically was brown or tan in appearance, and the underlying reduced sediment was various shades of gray or black (Figure 3-11).

The overall average boundary roughness at the reference area stations of 1.1 cm indicated an absence of significant small-scale vertical relief in the muddy sediments at these stations. The observed minor surface roughness was primarily of biological origin (e.g., fecal mounds, burrow openings, feeding pits).

The majority of images showed typical ambient muddy sediments at the RDS reference areas. At the North Reference Area, however, one of the three replicate images at Station NR1, and two of the three replicates at Stations NR2, NR4 and NR5,

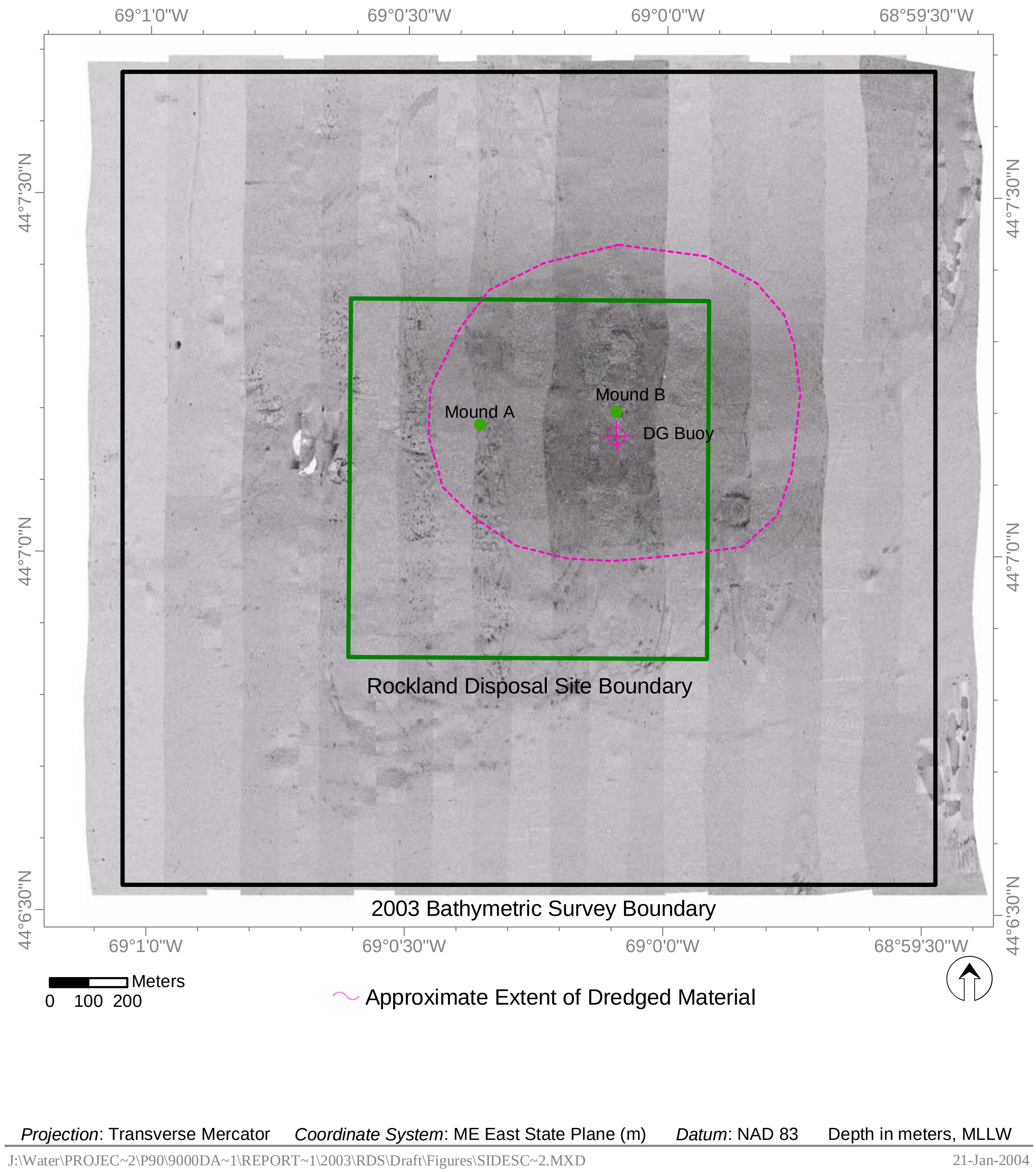

Figure 3-10. Side-scan sonar mosaic image of the RDS September 2003 survey (gray scale)

Table 3-1.

Summary of SPI Results for RDS Reference Area Stations

Area	Station	Grain Size Major Mode (phi)	Mean Prism Penetration Depth (cm)	Mean RPD Depth (cm)	Successional Stages Present (no. of replicates)	Median OSI
East-Ref	ER-1	>4	12.5	4.6	I on III (3)	11
East-Ref	ER-2	>4	11.5	3.1	I on III (3)	10
East-Ref	ER-3	>4	11.4	3.9	I on III (3)	11
East-Ref	ER-4	>4	12.2	4.9	I on III (3)	11
North-Ref	NR-1	>4	18.0	5.5	I on III (3)	11
North-Ref	NR-2	>4	19.1	5.1	I on III (2), III (1)	11
North-Ref	NR-3	>4	16.0	5.4	I on III (3)	11
North-Ref	NR-4	>4	16.9	4.1	I on III (3)	10
North-Ref	NR-5	>4	15.1	3.4	II (1), II to III (1), I on III (1)	8
South-Ref	SR-1	>4	9.9	3.1	I on III (2), III (1)	10
South-Ref	SR-2	>4	9.1	3.1	I on III (3)	11
South-Ref	SR-3	>4	10.7	4.3	I on III (3)	11
South-Ref	SR-4	>4	10.1	3.5	I on III (3)	10
Average			13.3	3.5		NA
Median			NA	NA		11
Minimum			9.1	3.1		8
Maximum			19.1	5.5		11

NA=Not applicable

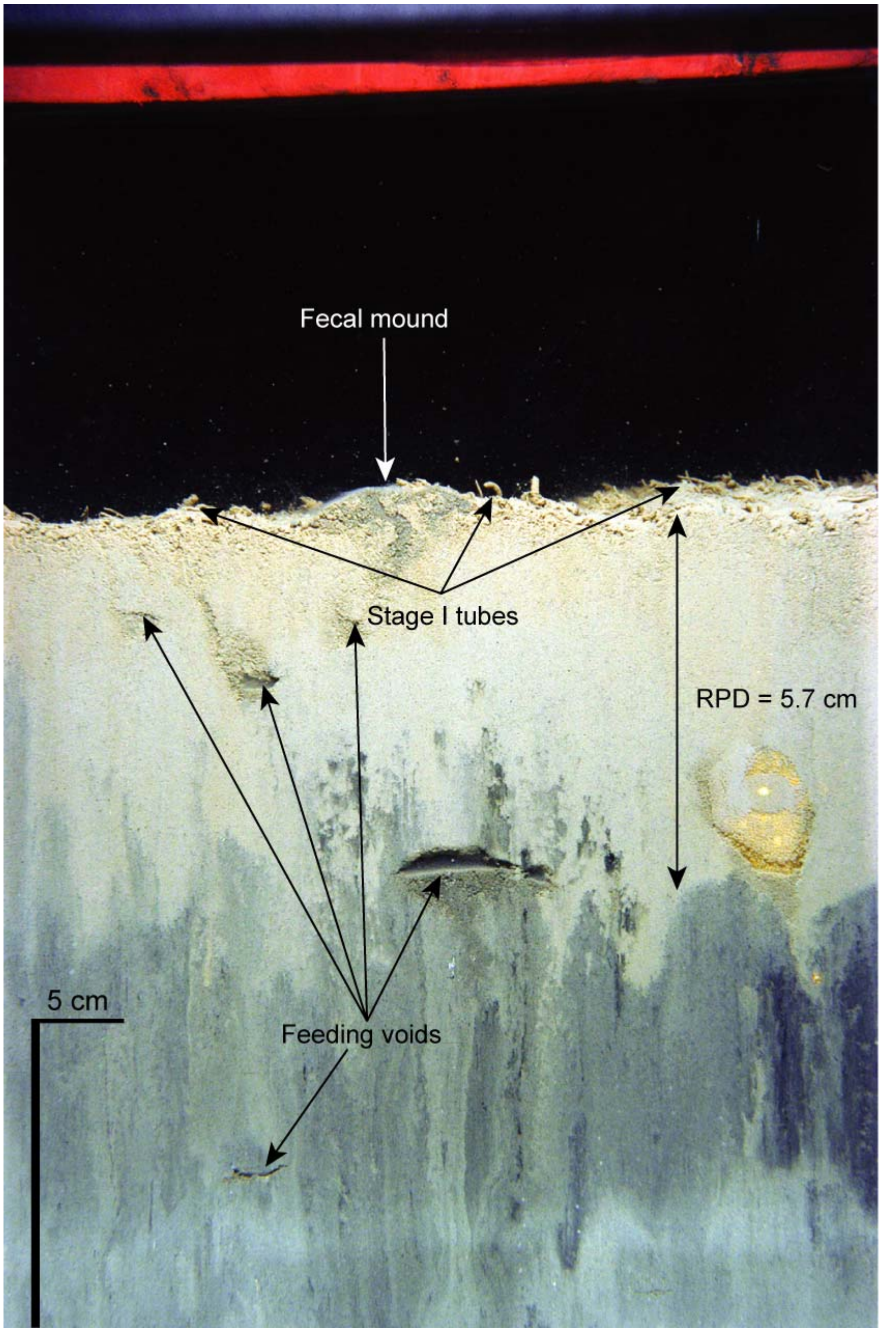

Figure 3-11. SPI image from East Reference Area Station ER-1 illustrating the soft, muddy sediment that typified all three RDS reference areas. The sediment is uniformly silt-clay (grain size major mode >4 phi), with the well-oxidized surface layer appearing light brown or tan in color, and the underlying reduced sediments appearing gray to black. Both the numerous small polychaete tubes visible at the sediment surface as well as several feeding voids at depth indicate a relatively diverse benthic community

had characteristics consistent with a layer of old or historic dredged material. These characteristics were faint patches of reduced black sediment occurring in a discontinuous band at depth within the sediment profile (Figure 3-12). Similarly, a single replicate image obtained at South Reference Area Station SR1 showed a subsurface layer of gray clay that also indicated the possible presence of historic dredged material.

Surface sediments at all of the reference area stations were well-oxidized; the average RPD depth was > 3 cm at each reference area station, with an overall average of 3.5 cm for all of the reference stations combined (Table 3-1 and Figure 3-13). The greatest RPD depths (>5 cm) occurred consistently in the very soft mud observed at several of the North Reference Area stations (Table 3-1; Figures 3-13 and 3-14).

Biological Conditions

All of the replicate images collected at the three reference areas showed an advanced successional status consisting of either Stage III or Stage I on III (Table 3-1 and Figure 3-15), with the exception of Station NR-5, where two replicate images were assigned a Stage II successional stage. Evidence of Stage I on III at the reference area stations included abundant surface tubes, fecal mounds, subsurface feeding voids, and burrows (e.g., Figures 3-11 and 3-13). Reflecting the well-developed RPD depths and the consistent presence of Stage III or I on III, median OSI values at all of the reference area stations were high (+10 or +11) at every station except NR-5, where the median OSI value of +8 was due to the occurrence of intermediate successional stages (Stage II or II advancing to III) in two replicate images (Table 3-1; Figures 3-11, 3-13, and 3-16). The overall median OSI value for all three of the reference areas combined was +11 (Table 3-1). These maximum OSI values are indicative of the undisturbed benthic habitat conditions and mature soft-bottom benthic assemblages found at every reference area station sampled in the September 2003 SPI survey.

3.3.2 Rockland Disposal Site

Sediment Physical Characteristics

<u>Inner Stations</u>

Surface sediments at all of the inner stations were fine-grained. Silt-clay (>4 phi) occurred at 26 of the 30 inner stations, very fine sand (4-3 phi) was observed at three stations (Stations I5, I6 and I16) and pebble- to cobble-sized rocks (< -1 phi) were found at Station I15 (Table 3-2). The silt-clay sediments were both naturally-occurring (i.e., ambient sediments) and the result of dredged material placement, while the presence of

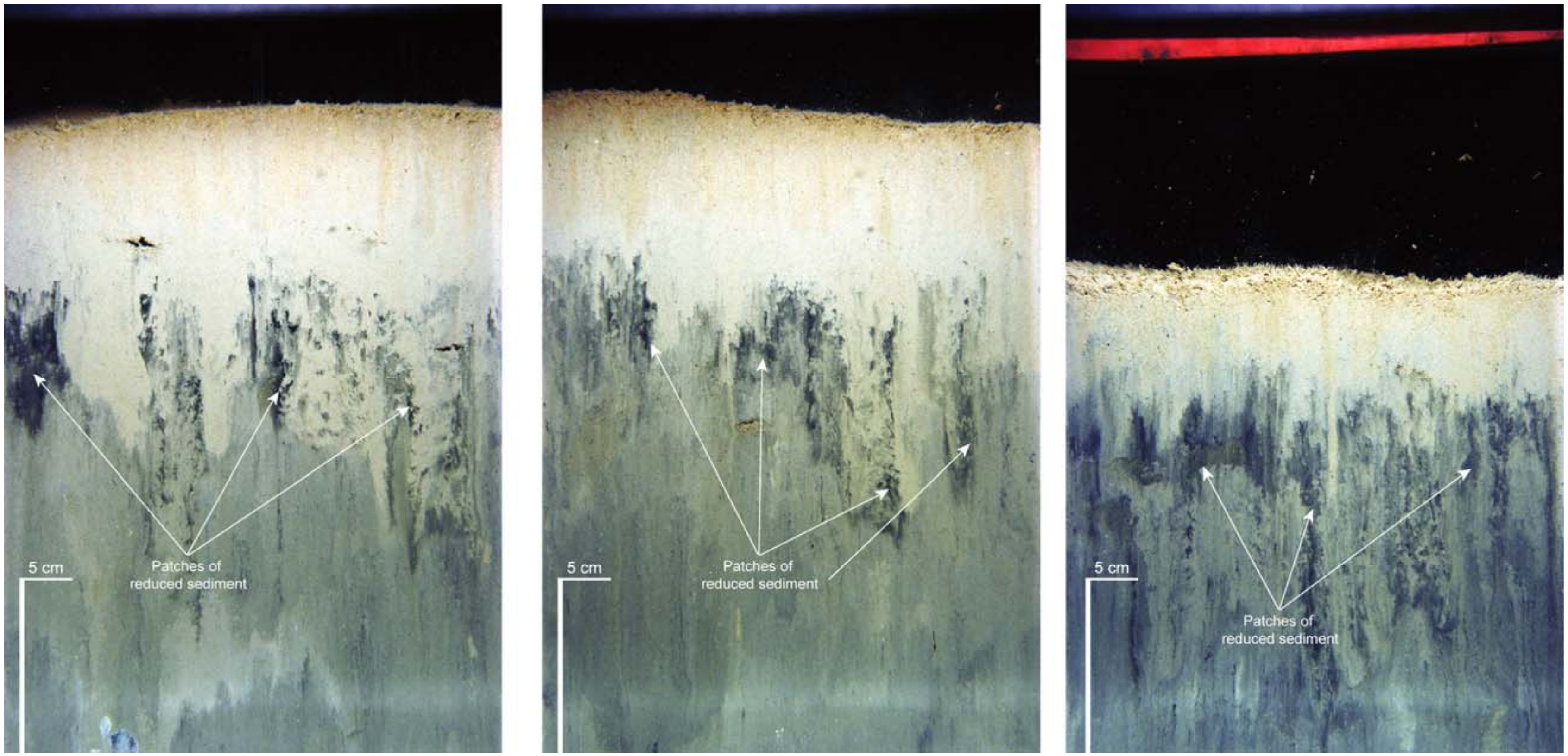

Figure 3-12. SPI images from Stations NR-1, NR-2, I21 showing patches of reduced sediment. Left and center are from North Reference Area Stations NR-1 and NR-2, respectively. Both images show faint, discontinuous patches of reduced, black sediment at depth that is characteristic of an historic, weathered dredged material layer. The image at right from Station I21 within RDS shows a surface layer of more-recent dredged material overlying historic dredged material. Note the similarity in the appearance of all three images.

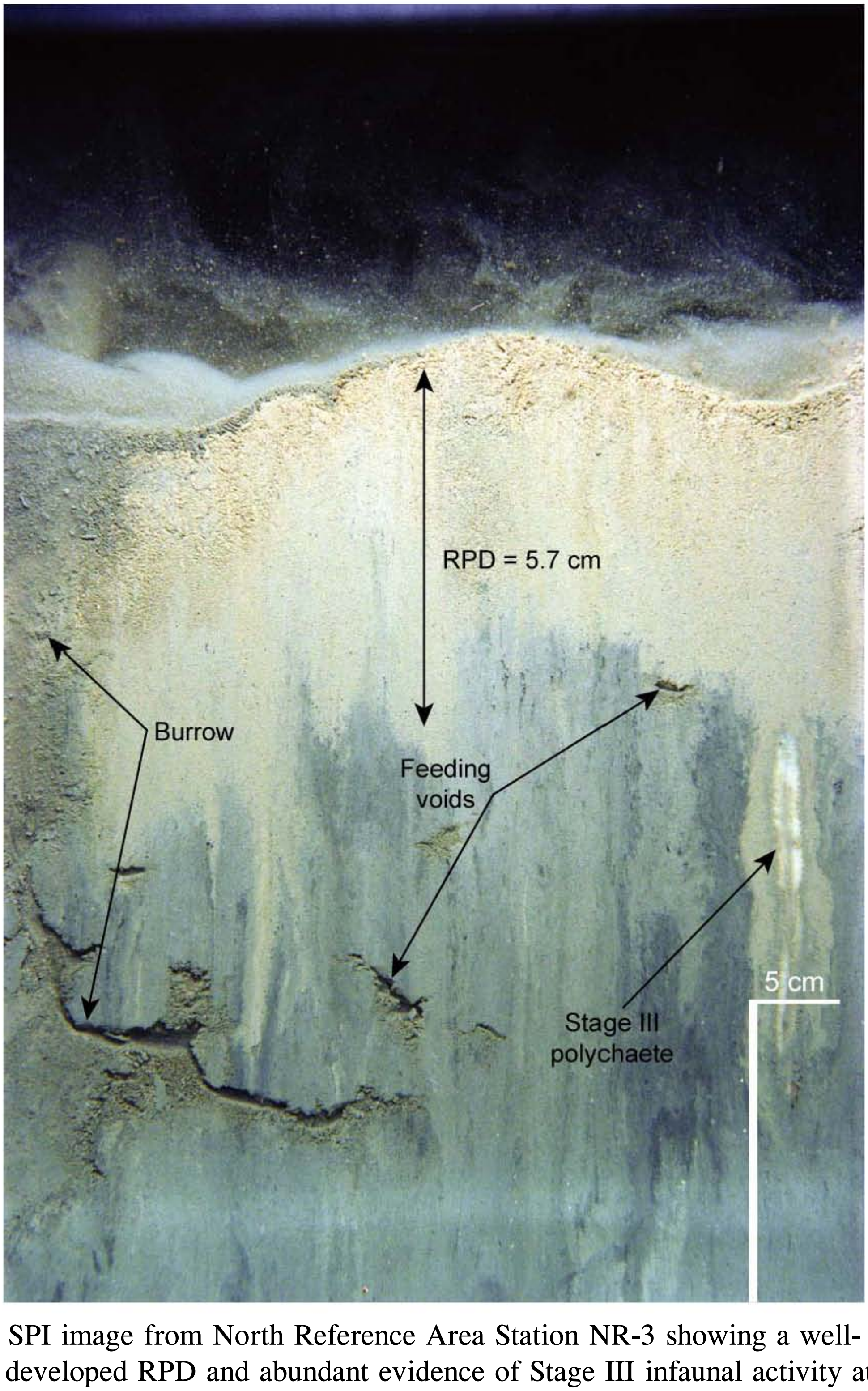

Figure 3-13. SPI image from North Reference Area Station NR-3 showing a well-developed RPD and abundant evidence of Stage III infaunal activity at depth (e.g., feeding voids, a burrow and a large errant polychaete).

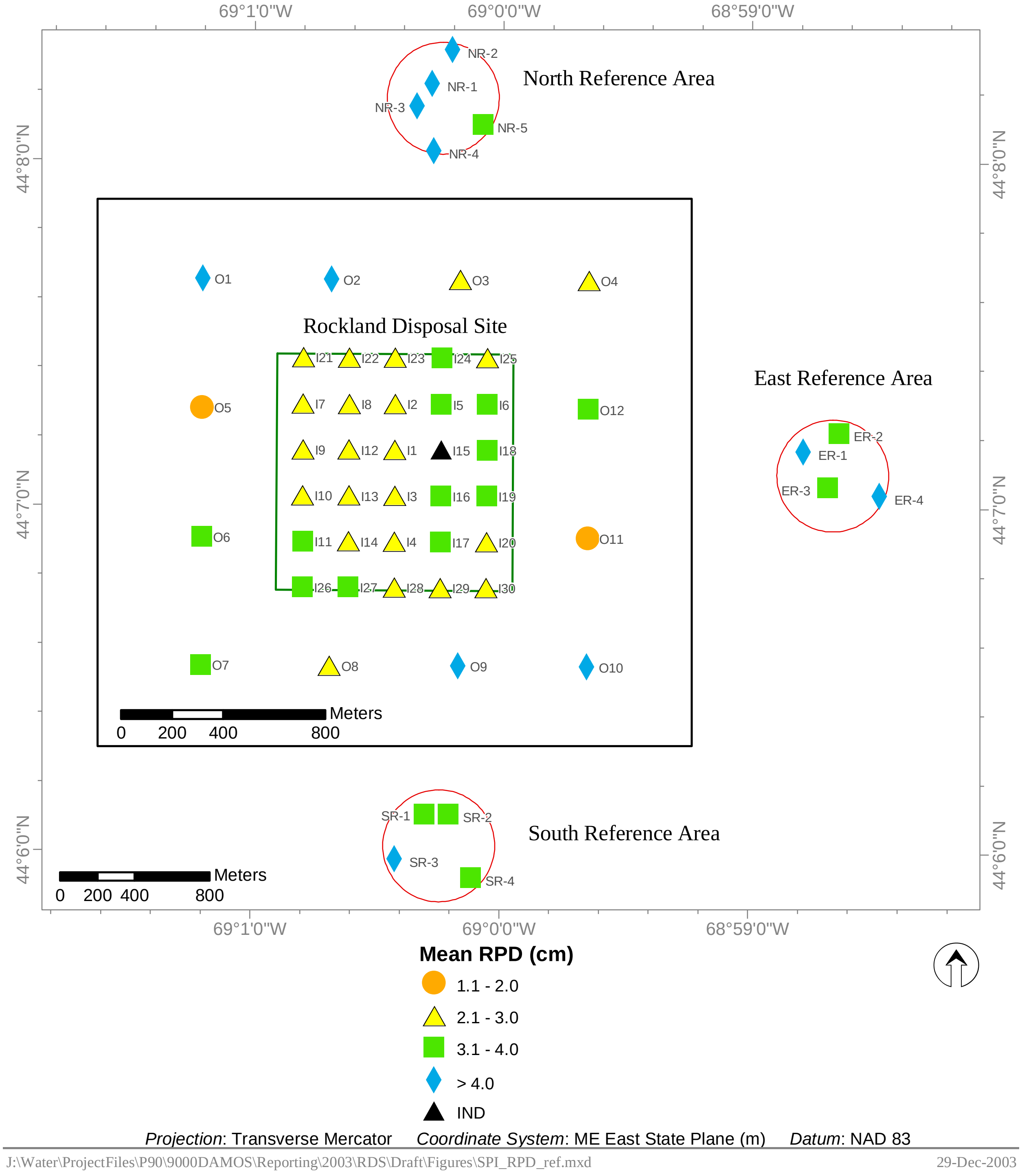

Figure 3-14. Map of mean RPD depths at the inner, outer and reference area SPI stations at RDS

Figure 3-15. Map of infaunal successional stages at the inner, outer and reference Area SPI stations at RDS

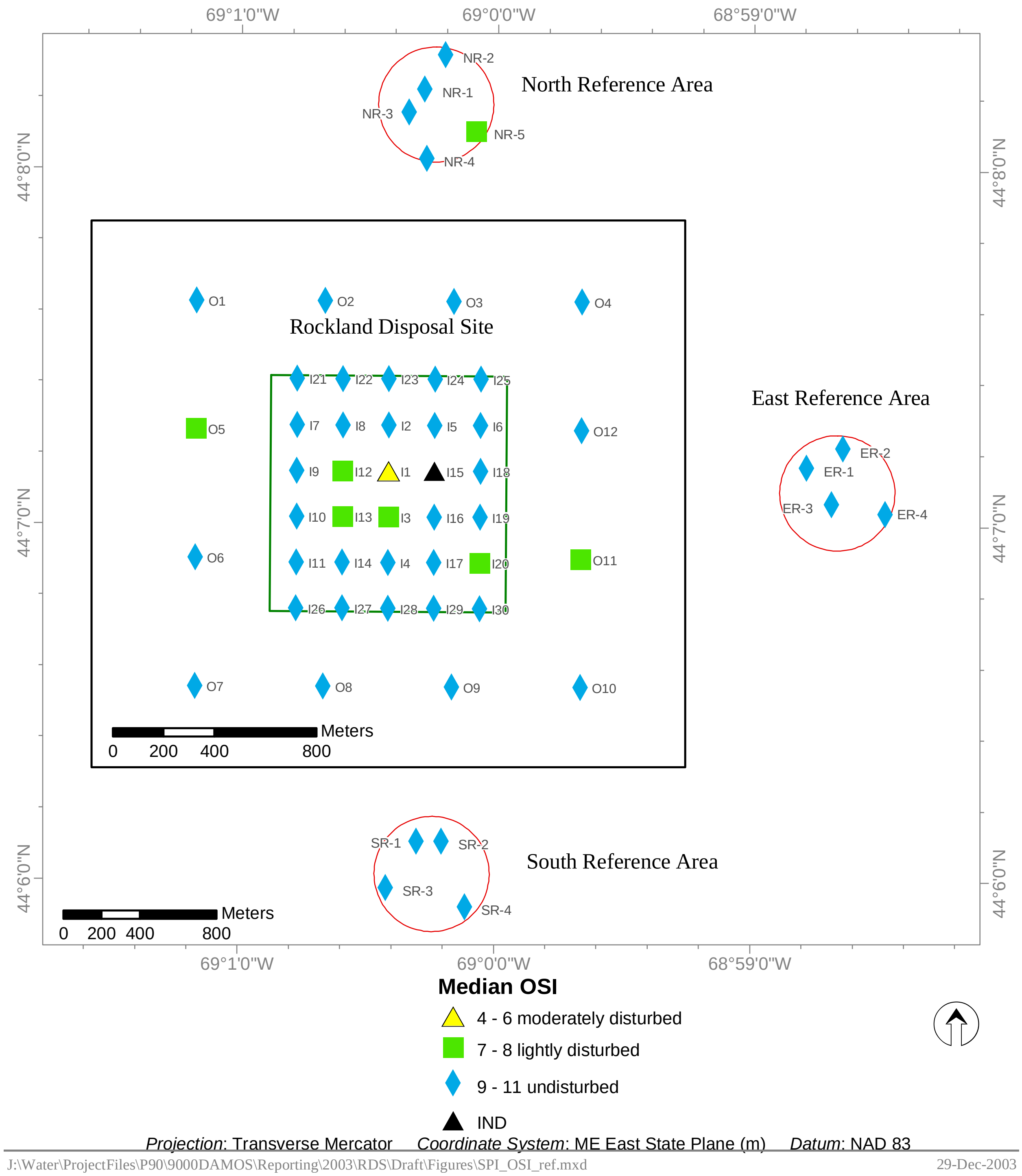

Figure 3-16. Map of median OSI values at the inner, outer and reference area SPI stations at RDS

Table 3-2.

Summary of SPI Results for the Inner Stations at RDS

Area	Station	Grain Size Major Mode (phi)	Mean Prism Penetration Depth (cm)	Mean RPD Depth (cm)	Successional Stages present (no. of replicates)	Median OSI	Mean Total DM Thickness (cm)	Mean Recent DM Thickness (cm)
Inner	I-1	>4	7.0	2.4	I (1), II (1), I on III (1)	6	>7.0	>7.0
Inner	I-2	>4	9.2	3.0	I on III (3)	10	>9.2	>9.2
Inner	I-3	>4	9.1	2.1	I on III (3)	8	>9.1	>9.1
Inner	I-4	>4	11.0	2.9	I on III (3)	9	>11.0	4.7
Inner	I-5	4-3	9.4	3.4	I on III (3)	10	>9.4	>9.4
Inner	I-6	4-3	8.3	3.6	I on III (3)	10	>8.3	>8.3
Inner	I-7	>4	10.1	2.7	I on III (3)	9	0	0
Inner	I-8	>4	10.1	2.6	I on III (3)	9	5.2	5.2
Inner	I-9	>4	12.2	2.7	I on III (3)	9	0	0
Inner	I-10	>4	10.4	2.5	I to II (1), I on III (2)	9	0	0
Inner	I-11	>4	10.1	3.9	I on III (3)	11	0	0
Inner	I-12	>4	8.9	2.3	II (1), I on III (2)	8	4.1	4.1
Inner	I-13	>4	11.9	2.2	III (1), I on III (2)	8	3.9	3.9
Inner	I-14	>4	12.1	2.4	I on III (3)	9	>12.1	0
Inner	I-15	<-1	0.5	IND	IND	IND	>0.5	>0.5
Inner	I-16	4-3	7.6	3.3	I on III (3)	10	>7.6	>7.6
Inner	I-17	>4	10.2	3.2	II to III (1), I on III (2)	10	>10.2	7.3
Inner	I-18	>4	6.1	3.1	I on III (2), IND (1)	10	>6.1	>6.1

Table 3-2. (continued)

Summary of SPI Results for the Inner Stations at RDS

Area	Station	Grain Size Major Mode (phi)	Mean Prism Penetration Depth (cm)	Mean RPD Depth (cm)	Successional Stages present (no. of replicates)	Median OSI	Mean Total DM Thickness (cm)	Mean Recent DM Thickness (cm)
Inner	I-19	>4	9.6	3.4	I on III	10	>9.6	6.6
Inner	I-20	>4	11.6	2.3	I on III (3)	8	4.9	4.9
Inner	I-21	>4	11.9	2.6	I on III (3)	9	>9.6	5.5
Inner	I-22	>4	10.4	2.9	I on III (3)	9	4.6	4.6
Inner	I-23	>4	9.2	3.0	II to III (1), I on III (2)	9	7.1	7.1
Inner	I-24	>4	8.8	3.5	I (1), I on III (2)	10	>8.8	>8.8
Inner	I-25	>4	9.9	2.7	I (1), I on III (2)	9	>9.9	6.8
Inner	I-26	>4	9.4	3.4	I on III (3)	10	0	0
Inner	I-27	>4	11.1	3.2	I on III (3)	10	0	0
Inner	I-28	>4	11.2	2.5	I on III (3)	9	6.1	6.1
Inner	I-29	>4	11.1	2.3	I on III (3)	9	0	0
Inner	I-30	>4	11.7	2.9	I on III (3)	9	5.2	0
Avg			9.7	2.9		NA		
Median			NA	NA		9		
Min			0.5	2.1		6		
Max			12.2	3.9		11		

NA=Not applicable

very fine sand and rocks was strictly due to the relatively recent (i.e., since the September 2000 DAMOS survey at RDS) dredged material placement (Figure 3-17). The average prism penetration depth of 9.7 cm for the inner stations suggested moderately soft sediments; except for the exceptionally low value of 0.5 cm which reflected the presence of rocks at Station I15, the average prism penetration values at the inner stations fell in the 6.1-12.2 cm range (Table 3-2).

Dredged material layers were observed in the SPI images at 23 of the 30 inner stations. Most the observed dredged material was considered to be of recent origin (i.e., deposited since the September 2000 survey), and at nine stations, this material extended from the sediment surface to below the imaging depth of the sediment-profile camera (e.g., Figures 3-17 [right image] and 3-18). At 12 stations, the recent dredged material was visible as a thinner, discrete surface layer overlying either an older dredged material layer or ambient sediment (Figure 3-19). The average total dredged material thickness shown in Table 3-2 and mapped in Figure 3-20 represents the combined thickness of both recent and any older dredged material layers observed at each station. The distribution of recent dredged material only is shown in Figure 3-21. Because most of the dredged material observed at each station was considered to be recent, the spatial distributions depicted in Figures 3-20 and 3-21 are similar.

The thickest layers of recent dredged material (i.e., greater than 8 cm and exceeding the camera's imaging depth) occurred at the group of stations immediately surrounding the central dredged material deposit located at the DG buoy (Figure 3-21). Rocks were observed at Station I15 located near the highest point of this central deposit (Figure 3-17), but elsewhere the dredged material consisted of fine-grained sediment (silt-clay or very fine sand). The thinner, discrete surface layers of recent dredged material (i.e., consistently less than 8 cm) were observed at stations located approximately 400 to 700 m from the central mound apex (Figure 3-21). The total footprint of the recent dredged material deposit delineated by the outer contour (broken line) in Figure 3-21 was roughly elliptical, with a diameter ranging from about 800 to 1200 m. The accuracy of this contour is somewhat limited by the distance between the inner and outer stations, particularly along the eastern boundary of the disposal site.

<u>Outer Stations</u>

Fine-grained sediments having a major mode of >4 phi (silt-clay) occurred at all of the RDS outer stations (Table 3-3). The sediment at most of these stations appeared to be ambient soft mud, similar to that found at the nearby reference areas. Dredged material was observed at 3 of the 12 outer stations: O3, O11, and O12 (Figures 3-20 and 3-21). At Stations O11 and O12, the signature of dredged material in the SPI images was

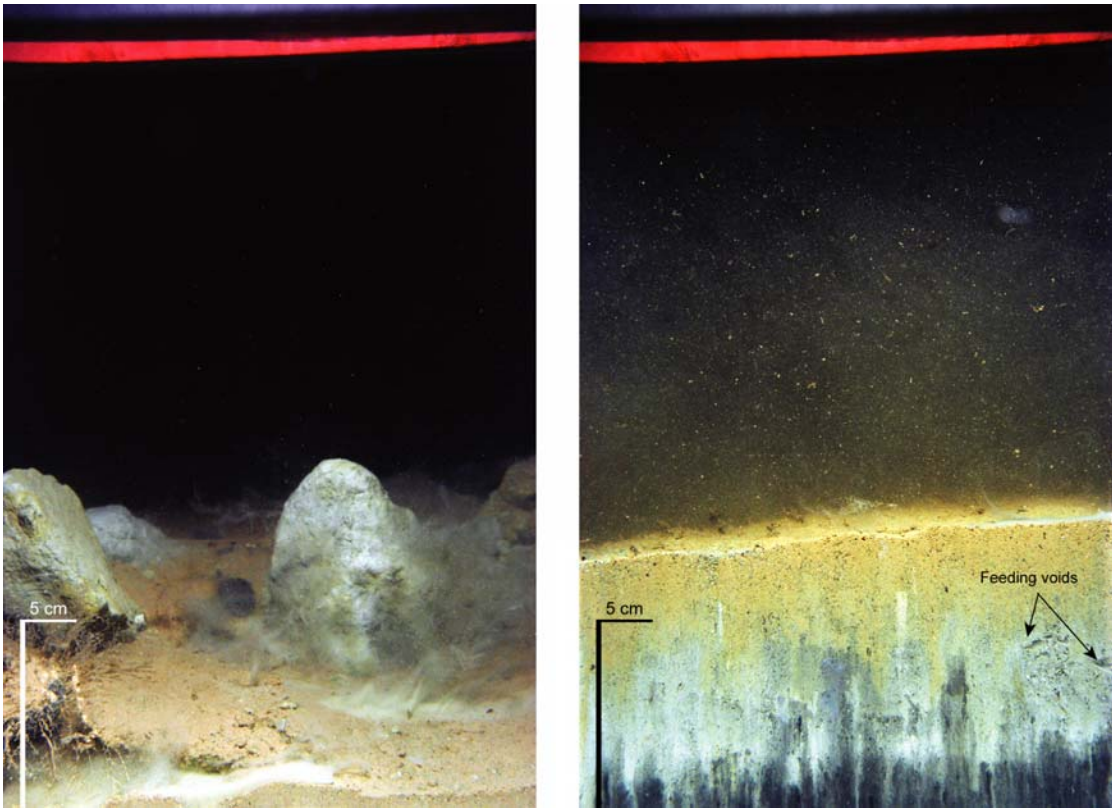

Figure 3-17. SPI images illustrating two types of recent dredged material observed at the inner stations. The left image shows pebble- to cobble-sized rocks at Station I15, while the right image shows muddy sediment with a significant component of very fine sand (major mode of 4-3 phi) at Station I16. Because the layer of recent dredged material in the right image extends from the sediment surface to below the imaging depth of the sediment-profile camera, its measured thickness is expressed as >7.2 cm (i.e., greater than the camera penetration depth). Two feeding voids also are visible within the dredged material in the right image.

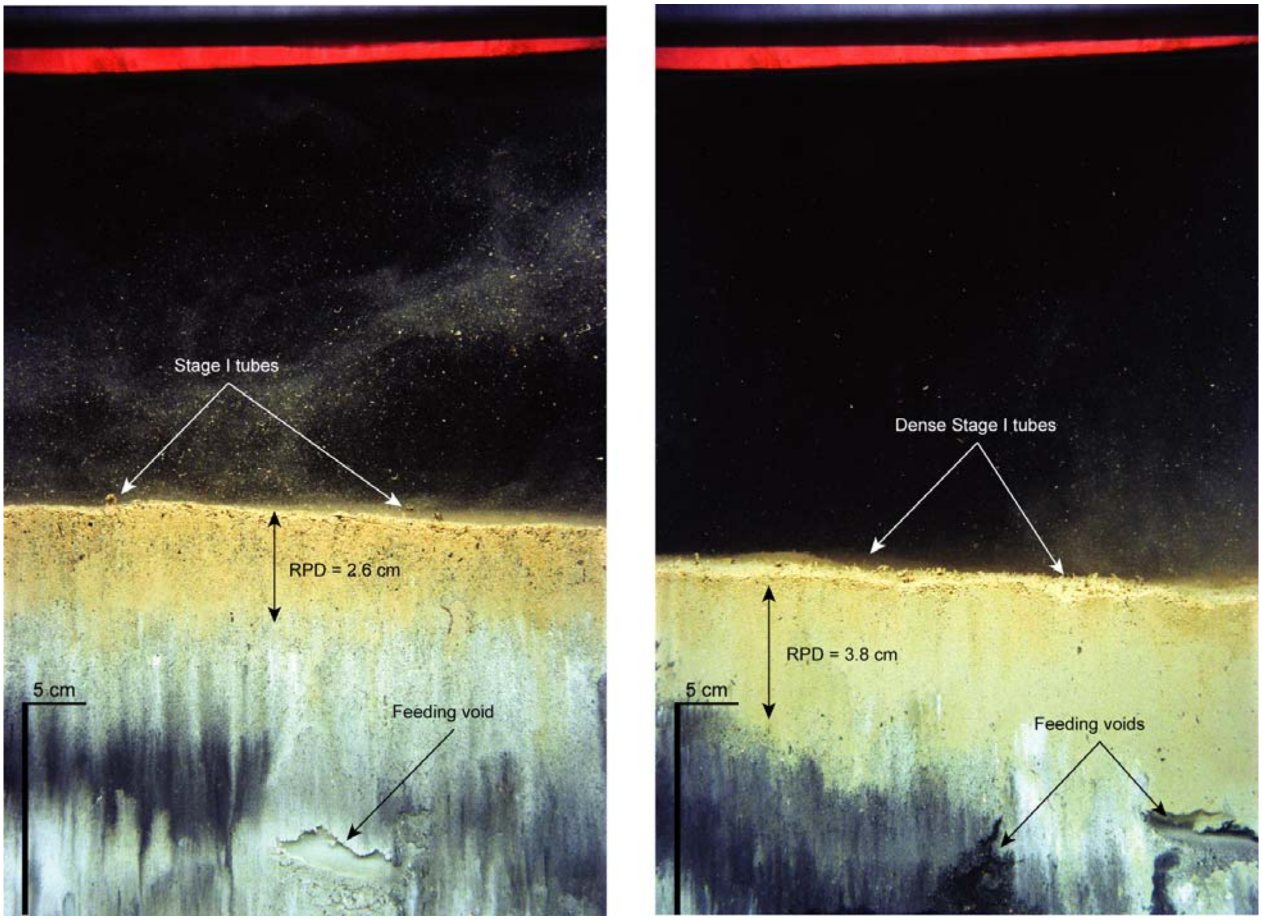

Figure 3-18 Example SPI images from Stations I2 (left) and I18 (right) showing recent dredged material extending from the sediment surface to below the camera's imaging depth. The surface of the dredged material has become oxidized since its placement, and the material also has become colonized by both surface-dwelling Stage I and deeper-dwelling Stage III taxa.

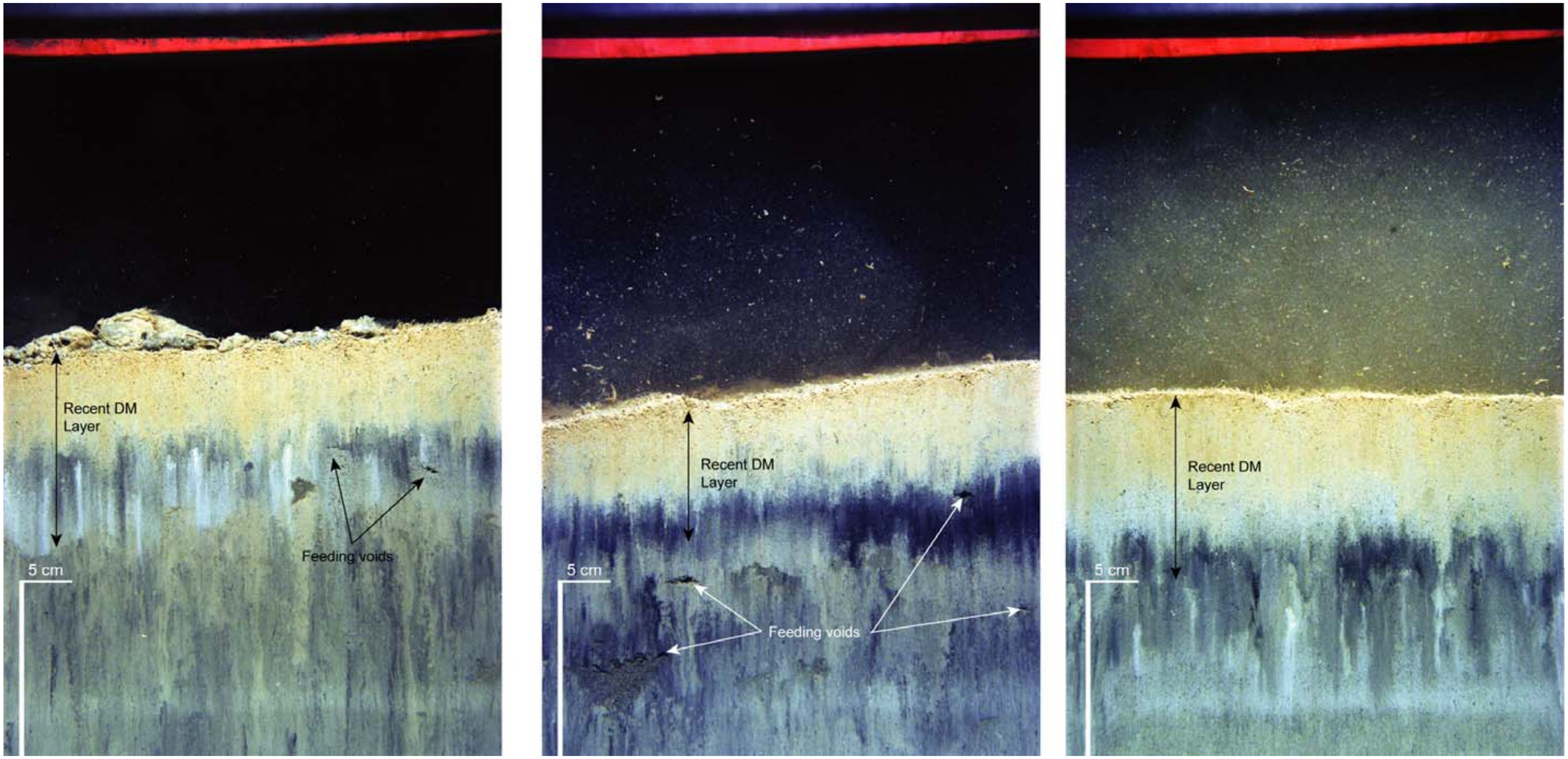

Figure 3-19 SPI images from Stations I8 (left), I12 (center) and I23 (right) illustrating discrete layers of recent dredged material (DM) overlying either ambient sediment or older dredged material. In all three images, the surface of the recent DM layer has become oxidized and therefore appears significantly lighter in color compared to the underlying horizon of gray/black DM that marks the bottom of the layer. Stage I tubes occur at the sediment surface in all three images, and several feeding voids (evidence of Stage III) are visible at depth in the left and center images.

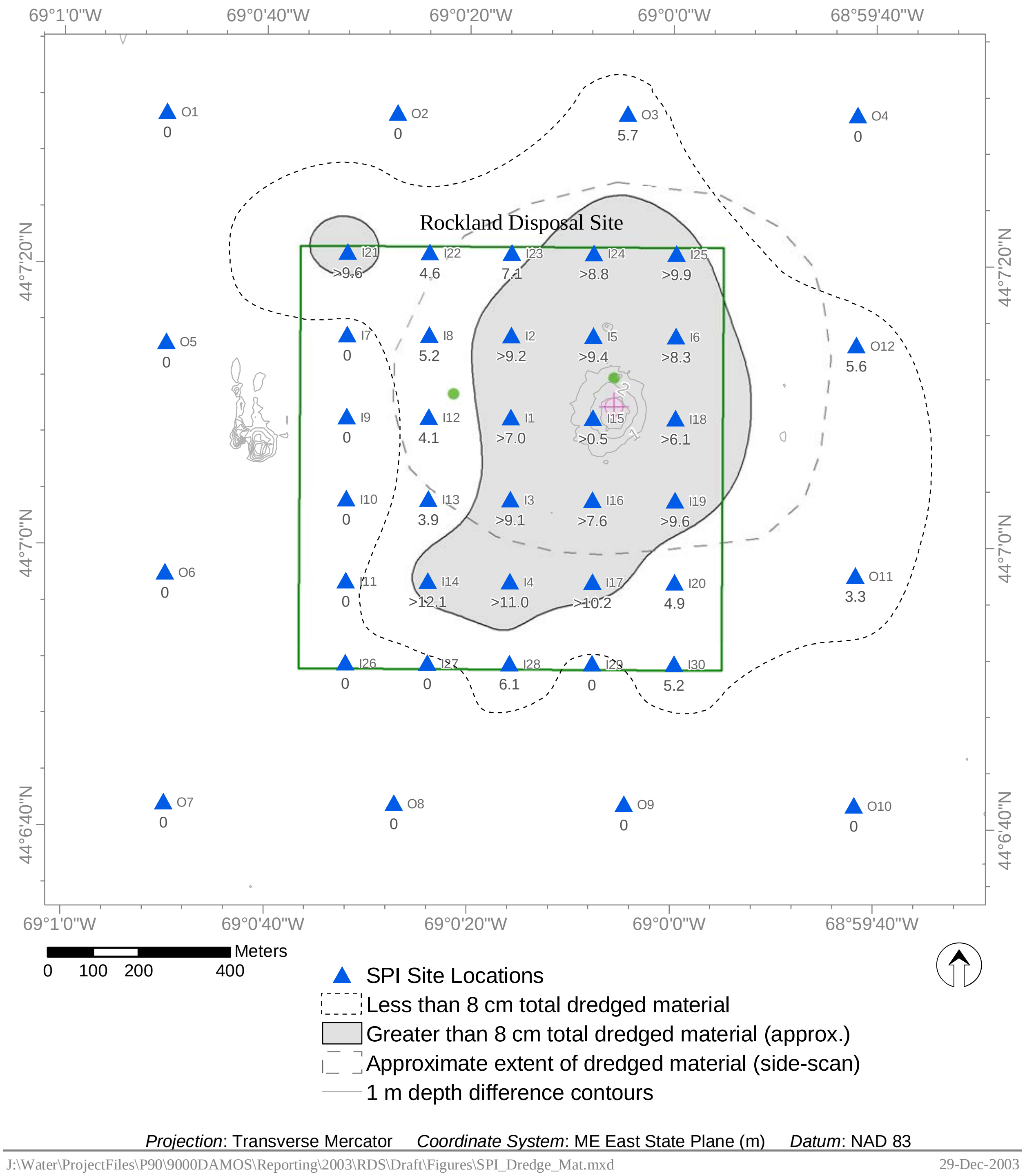

Figure 3-20. Map showing the average total thickness of dredged material layers (both recent and old) observed in SPI images at the RDS inner and outer stations

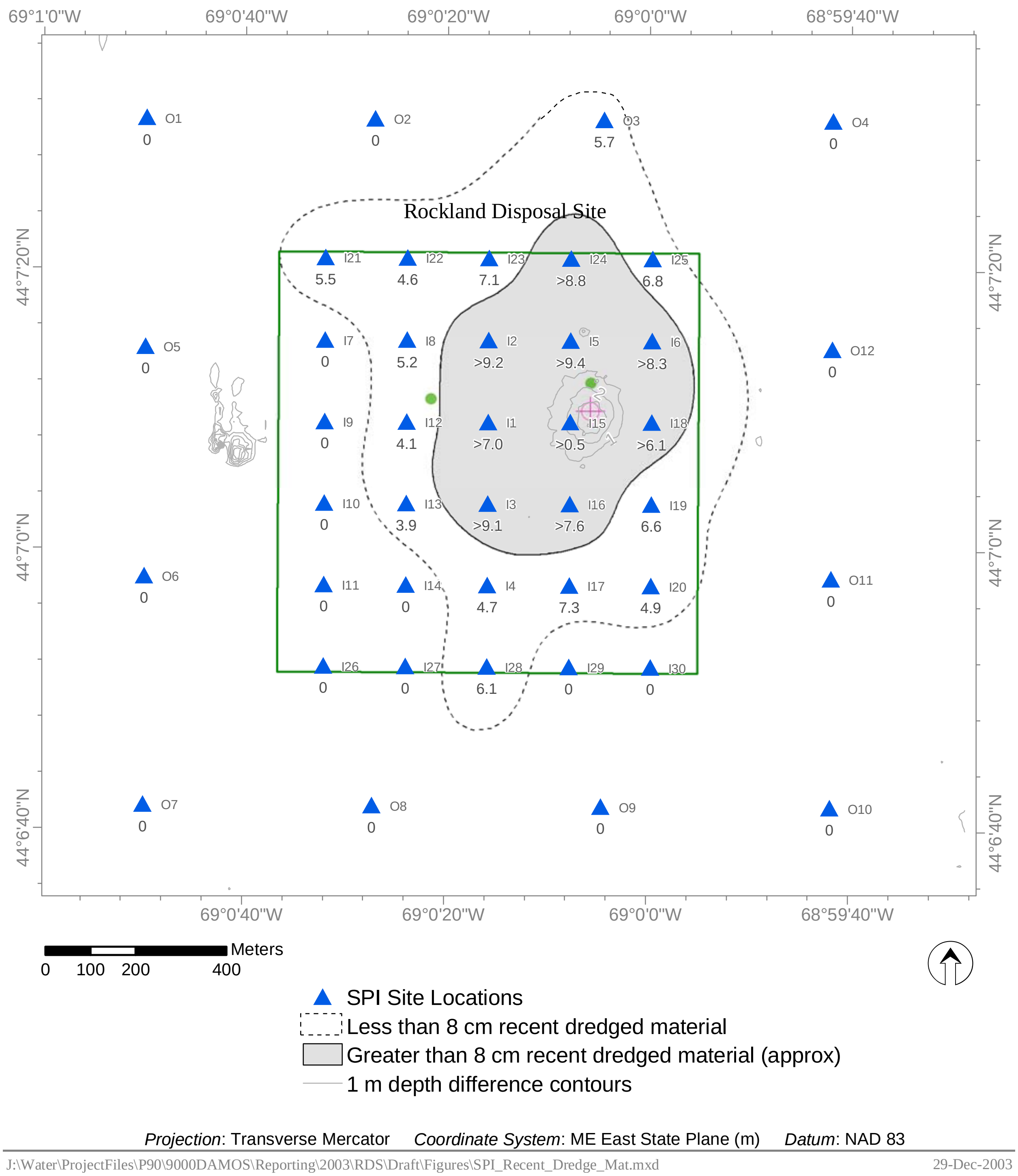

Figure 3-21. Map showing the average thickness of recent dredged material layers observed in SPI images at the RDS inner and outer stations

Table 3-3.

Summary of SPI Results for the Outer Stations at RDS

Area	Station	Grain Size Major Mode (phi)	Mean Prism Penetration Depth (cm)	Mean RPD Depth (cm)	Successional Stages present (no. of replicates)	Median OSI	Mean Total DM Thickness (cm)	Mean Recent DM Thickness (cm)
Outer	O-1	>4	14.3	5.1	I on III (3)	11	0	0
Outer	O-2	>4	12.0	4.5	I on III (3)	11	0	0
Outer	O-3	>4	10.5	2.7	I on III (3)	9	5.7	5.7
Outer	O-4	>4	12.7	2.5	I on III (3)	9	0	0
Outer	O-5	>4	10.8	1.7	I on III (3)	8	0	0
Outer	O-6	>4	12.8	3.4	II to III (1), I on III (2)	10	0	0
Outer	O-7	>4	12.2	3.5	I on III (3)	10	0	0
Outer	O-8	>4	11.0	3.0	II to III (1), I on III (2)	9	0	0
Outer	O-9	>4	12.1	4.1	III (1), I on III (2)	11	0	0
Outer	O-10	>4	12.5	4.7	I on III (3)	11	0	0
Outer	O-11	>4	10.6	1.7	III (1), I on III (2)	8	3.3	0
Outer	O-12	>4	12.7	3.7	III (1), I on III (2)	11	5.6	0
Outer	O-13	>4	8.4	2.2	III (1)	8	4.6	0
Avg			11.8	3.3		NA		
Median			NA	NA		10		
Min			8.4	1.7		8		
Max			14.3	5.1		11		

NA=Not Applicable

subtle and faint, consisting of discontinuous patches of reduced sediment at depth suggestive of older, weathered dredged material (Figure 3-22, left image). At Station O3, a distinct surface depositional layer of recent dredged material was present (Figure 3-22, right image).

Biological Conditions and Benthic Recolonization Status

Inner Stations

Despite the presence of recent dredged material layers at the majority of inner stations, RPD depths were fairly well developed (e.g., Figures 3-18 and 3-19). Mean RPD depths ranged from 2.1 to 3.9 cm and averaged 2.9 cm for the inner stations as a group (Table 3-2). There did not appear to be any significant spatial patterns in the distribution of RPD values among the inner stations; similar ranges of values occurred at stations having dredged material and those having ambient sediment (Figure 3-23). The RPD could not be measured at Station I15 due to the presence of rocks.

Stage I on III was present in at least one replicate SPI image, and often in all three replicates, at each of the inner stations (Table 3-2). Dense assemblages of small, tube-dwelling polychaetes living at the sediment surface (Stage I) were widespread across the disposal site, and there was abundant evidence of Stage III organisms in the form of sub-surface feeding voids and burrows (e.g., Figures 3-17 through 3-19). Except for the “indeterminate” status due to the presence of rocks at Station I15, Stage III was the highest successional stage at each of the inner stations (Figure 3-15), indicating advanced recolonization of both recent and older dredged material had occurred by the time of the September 2003 survey.

Reflecting the advanced successional status and moderately well-developed RPD depths, median OSI values at the inner stations were uniformly high, ranging from +6 to +11 (Table 3-2). OSI values falling at the lower end of this range (+6 to +8) indicate a moderate to slight degree of disturbance and were found at just five of the inner stations, all of which exhibited recent dredged material (Figure 3-24). The OSI values greater than +8 at the remaining 25 inner stations, as well as the overall median OSI of +9 for the inner stations as a group, indicate almost complete recovery of the seafloor within the disposal site from the physical disturbance associated with past and recent dredged material disposal activities.

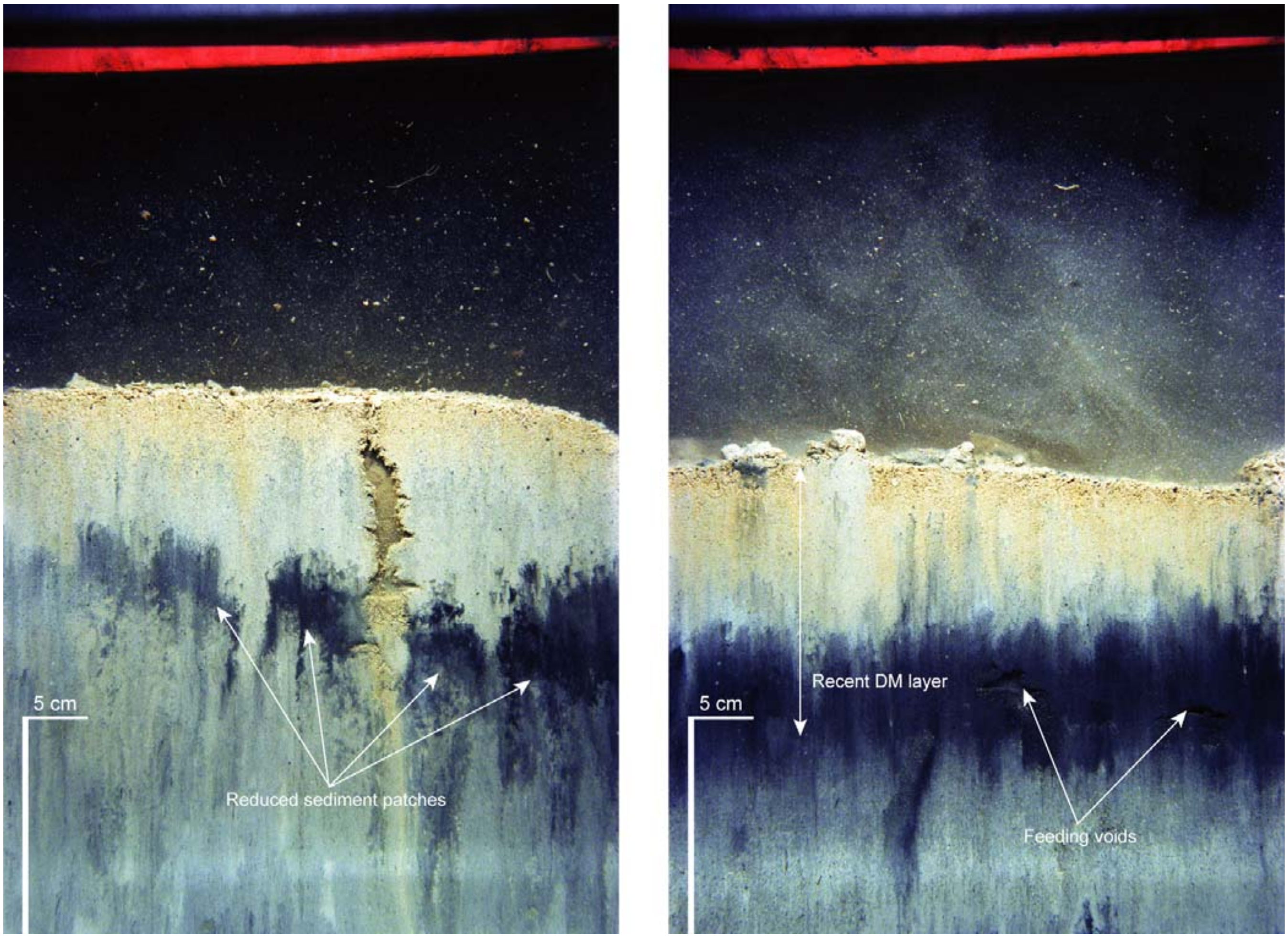

Figure 3-22. The SPI image at left from Station O12 shows discontinuous patches of black, reduced sediment at depth, suggestive of older dredged material. The image at right from Station O3 shows a distinct surface depositional layer of recent dredged material.

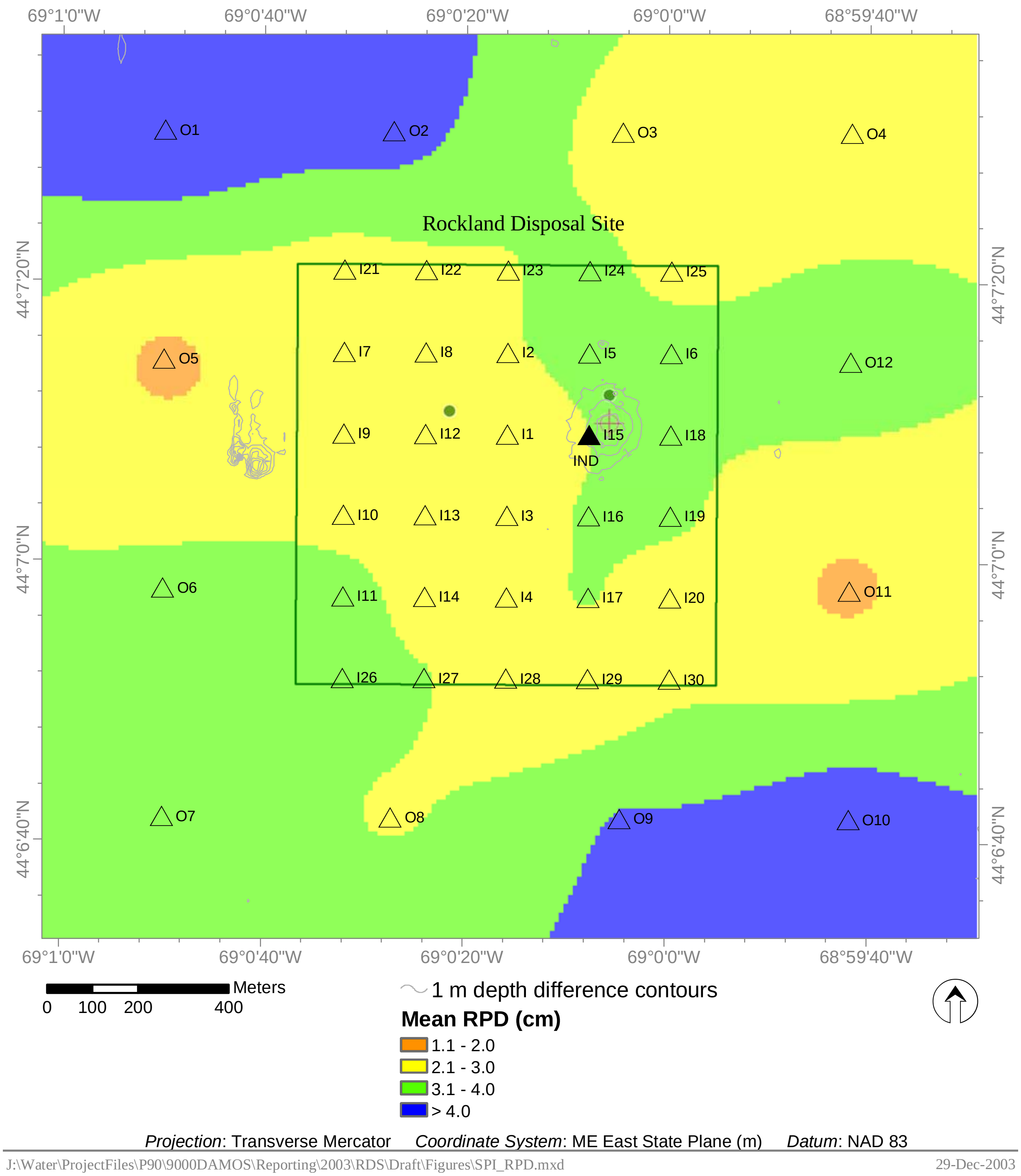

Figure 3-23. Contour map of average RPD depths at the inner and outer SPI stations at RDS

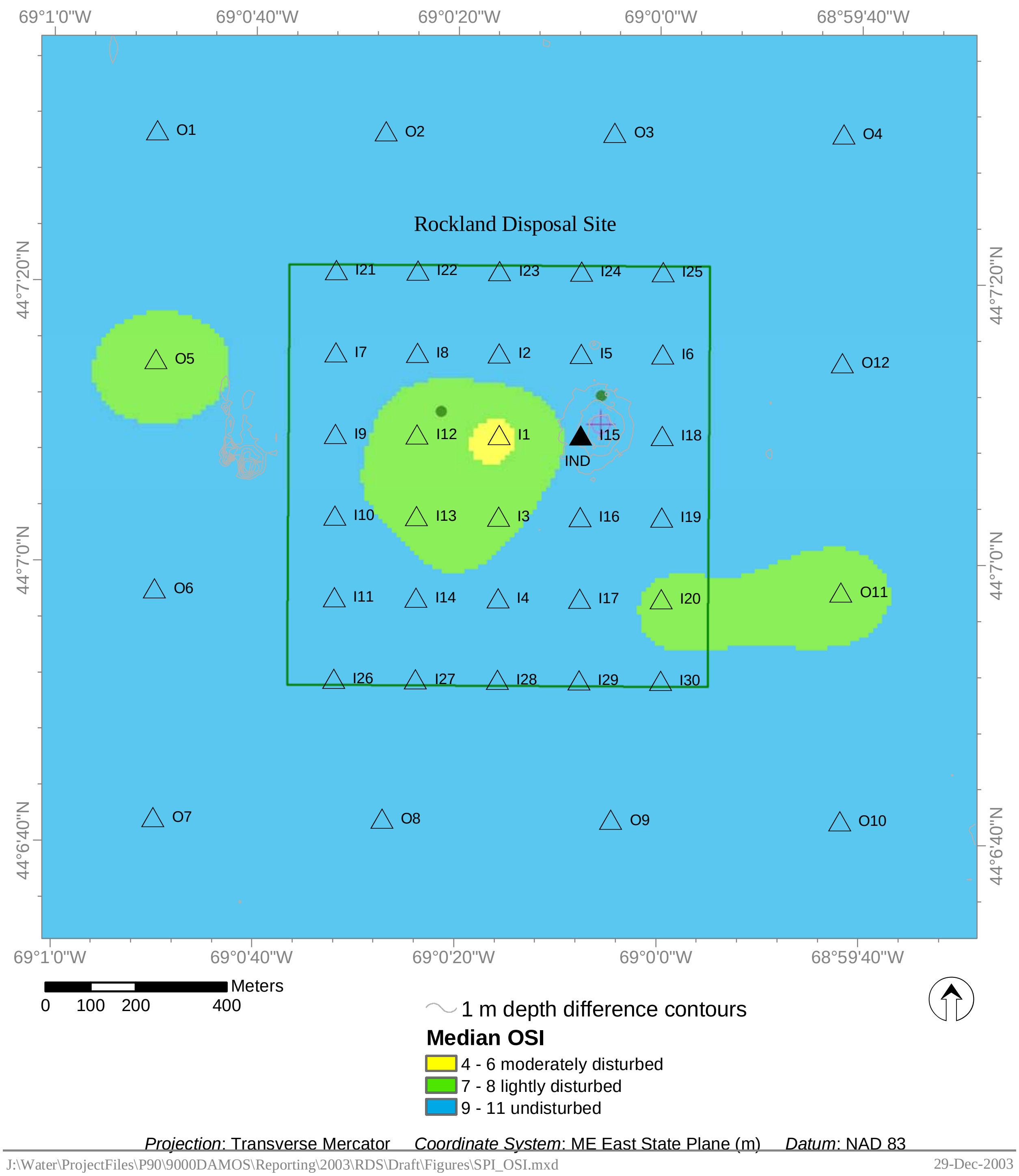

Figure 3-24. Contour map of median OSI values at the inner and outer SPI stations at RDS

Outer Stations

Similar to the inner stations, average RPD depths were well developed at most of the outer stations, ranging from 1.7 to 5.1 cm and averaging 3.4 cm (Table 3-3). Relatively shallow average RPD depths of 1.7 cm were observed at Stations O5 and O11 (Figure 3-23). Advanced Stage III or Stage I on III successional stages were present at every outer station (Table 3-3 and Figure 3-15), resulting in uniformly high OSI values ranging from +8 to +11 (overall median of +10; Table 3-3 and Figure 3-24).

3.3.3 Comparison of RDS and Reference Area Conditions

Despite the presence of dredged material at all but seven of the RDS inner stations, the sediment grain-size major mode was fairly uniform throughout the site and at the reference stations (mostly fine-grained, soft muds in both areas). A few of the inner stations had a grain-size major mode of very fine sand (4-3 phi) due to the heterogeneity of the dredged material placed at the site, but with the exception of Station I15 near the disposal point center where rocks were found, this slight variation in sediment grain-size as well as the physical disturbance from dredged material disposal operations, did not appear to impair faunal recolonization of the site.

Sediment biological conditions, as reflected in the RPD depth, successional stage, and OSI measurements, were roughly comparable among the inner, outer, and reference stations (Table 3-4 and Figures 3-14 to 3-16). The very high OSI values at both the outer and reference area stations indicated undisturbed benthic habitat conditions in the ambient mud or old, weathered dredged material found in these areas. Slightly shallower average RPD depths and a slightly lower percentage of replicate images with evidence of advanced Stage III infauna resulted in somewhat lower median OSI values at the inner stations compared to the outer and reference area stations (Table 3-4 and Figure 3-16). These values were nevertheless indicative of either undisturbed or only slightly disturbed conditions at the inner stations at the time of the September 2003 survey.

3.3.4 Comparisons to Previous Survey

Similar fine-grained sediments were observed in all three areas in both the 2000 and 2003 surveys. Average RPD depths at the reference and outer stations were about 1 cm deeper in 2003 compared to 2000, while average RPD depths at the inner stations were somewhat shallower in 2003 (Table 3-5). Considerably more of the replicate SPI images showed evidence of Stage III in 2003 compared to 2000, particularly at the reference and outer stations (Table 3-5). As a result of this difference in Stage III

Table 3-4.

Summary of RDS 2003 Sediment Biological Conditions for Inner, Outer, and Reference Stations

Area	Average RPD, in cm (range)	Percentage of replicate images with Stage III	Median OSI value (range)
Reference	3.5 (3.1 to 5.5)	95%	+11 (+8 to +11)
RDS Inner	2.9 (2.1 to 3.9)	91%	+9 (+6 to +11)
RDS Outer	3.4 (1.7 to 5.1)	94%	+10 (+8 to +11)

Table 3-5.

Comparison of RDS 2000 and RDS 2003 Sediment Biological Conditions for Inner, Outer, and Reference Stations

Area	Year	Average RPD, in cm (range)	Percentage of replicate images with Stage III	Median OSI (range)
Reference	2000	2.6 (1.8 to 3.5)	15%	+6 (+4 to +9)
	2003	3.5 (3.1 to 5.5)	95%	+11 (+8 to +11)
RDS Inner	2000	3.3 (1.9 to 6.0)	42%	+8 (+4 to +11)
	2003	2.9 (2.1 to 3.9)	91%	+9 (+6 to +11)
RDS Outer	2000	2.4 (1.9 to 3.5)	28%	+7 (+4 to +9)
	2003	3.4 (1.7 to 5.1)	94%	+10 (+8 to +11)

RDS 2000 data from SAIC (2001)

frequency, median OSI values were higher at the inner, outer and reference area stations in 2003 compared to 2000 (Table 3-5).

There were differences between the 2000 and 2003 surveys in the mapped distribution of dredged material, both within and outside RDS. In September 2000, all of the inner stations were found to have dredged material, in layers thicker than the imaging depth of the sediment-profile camera. In 2003, dredged material classified as either recent or old was mapped at only 23 of the 30 inner stations (Figure 3-20), while surface sediment at the remaining seven stations was considered to be ambient.

Dredged material layers exceeding the camera's imaging depth also were observed at five outer stations (Stations O1, O5, O6, O8 and O10) in the 2000 survey, but in 2003 no dredged material was found at these stations. Relatively thin layers of old dredged material were observed at outer stations O11 and O12 in 2003; this material had not been observed in 2000. There was no dredged material found at any of the reference area stations in the September 2000 survey. In September 2003, there was evidence of old, weathered dredged material layers at a few of the North Reference Area stations (Stations NR1, NR2, NR4 and NR5), as well as potentially at South Reference Area Station SR1.

4.0 DISCUSSION

The September 2003 DAMOS survey at RDS was designed to characterize potential impacts associated with dredged material disposal activity conducted since the September 2000 survey. The two primary objectives were to evaluate dredged material distribution and to assess benthic recolonization status. The findings of the RDS 2003 monitoring survey are discussed below.

4.1 Dredged Material Distribution

In the 10 years prior to the September 2000 survey at RDS, an estimated 27,000 m^3 of dredged material was placed at RDS. Between September 2000 and September 2003, disposal at the site increased significantly and an estimated 263,000 m^3 of dredged material was placed at RDS. As part of the September 2003 survey, three separate activities (bathymetry, side-scan sonar, and SPI) were performed to independently map the distribution of this recently placed dredged material. Changes in bathymetry detected between the September surveys of 2000 and 2003 showed that the thickest accumulations of dredged material occurred in the immediate vicinity of the DG buoy location (Figure 3-5), coincident with the recorded disposal locations (Figure 1-3). The bathymetric changes revealed a mound with a maximum height of approximately 4 m and an approximate diameter of 220 m.

The 2003 side-scan sonar results were entirely consistent with the bathymetry results and showed a more extensive area of dredged material disposal, centered at the DG buoy, with an approximate diameter of 900 m (Figure 3-6). This expanded disposal footprint compared to the bathymetry is expected given the increased sensitivity of the side-scan imaging. The 2003 side-scan sonar results differed from those of the previous May 2001 survey. The previous survey revealed two distinct dredged material areas, each having an approximate diameter of 200 m. Due to the comparatively greater amount of disposal activity concentrated in a single location between May 2001 and September 2003, the September 2003 side scan sonar survey revealed only one dredged material area with a wider footprint.

The SPI results were also in excellent agreement with the bathymetry and side-scan sonar results, showing the thickest accumulations of recent dredged material at the stations immediately surrounding the DG buoy location (Figure 3-21). At the SPI stations located at greater distances from the DG buoy, the recent dredged material was detected in discrete surface layers less than 8 cm thick (Figure 3-21).

The dredged material placed at RDS between September 2000 and 2003 thus appears to have formed a distinct mound on the seafloor. The thickest accumulations of dredged material, comprising the mound center, were detected by bathymetric, side-scan sonar, and SPI methods, while thinner layers comprising the mound apron were detected by side-scan sonar and SPI only. As indicated by the contour lines in Figures 3-6 and 3-21, most of the recent disposed dredged material was found within the RDS boundary, with relatively thin layers extending beyond the RDS boundary in the downgradient direction to the north and east. Dredged material outside of the site boundaries is not unexpected, given the relatively small size of the site.

Differences were noted between the September 2000 and September 2003 SPI surveys in the distribution of dredged material in and around RDS. The 2003 survey indicated an absence of any dredged material (i.e., only ambient sediment was observed) at seven inner stations (Stations I7, I9, I10, I11, I26, I27, and I29) and five outer stations (Stations O1, O5, O6, O8 and O10) where dredged material had been found in 2000 (Figure 3-20). The main reason for this apparent discrepancy is the difficulty experienced in 2000 in distinguishing between old, weathered dredged material and ambient sediment at a number of stations. At the time of the 2000 survey, much of the dredged material present at RDS had been in place on the seafloor for over 10 years. The 2000 survey report notes that, "at some of the inner stations, it was difficult to distinguish clearly and definitely between older, fine-grained dredged material versus ambient fine-grained sediment" and further acknowledged that apparent dredged material identified at some of the inner stations in the southwest corner of RDS actually may have been naturally occurring, ambient sediment (SAIC 2001).

The 2003 SPI survey results therefore suggest two possibilities: (1) due to the acknowledged difficulties of distinguishing between the two types of sediments, ambient sediment was incorrectly identified as old dredged material at some of the inner and outer stations in 2000, or (2) old dredged material layers that were correctly identified as such in 2000 have continued weathering to the point of becoming indistinguishable from ambient sediments. Regarding this second possibility, selected images from Station I7 help to illustrate how old dredged material at some stations has weathered to the point of becoming indistinguishable from ambient sediment (Figure 4-1).

In 2003, sediments with the appearance of old dredged material were observed in the SPI images at a few of the outer and reference area stations (e.g., Figures 3-12 and 3-22). There had been no evidence of such material at these stations in the 2000 survey. It is possible that old dredged material exists in relatively small patches at these stations as a result of either past disposal outside the site boundary or leakage from scows transiting to or from the site. Regardless of whether the sediment observed at these

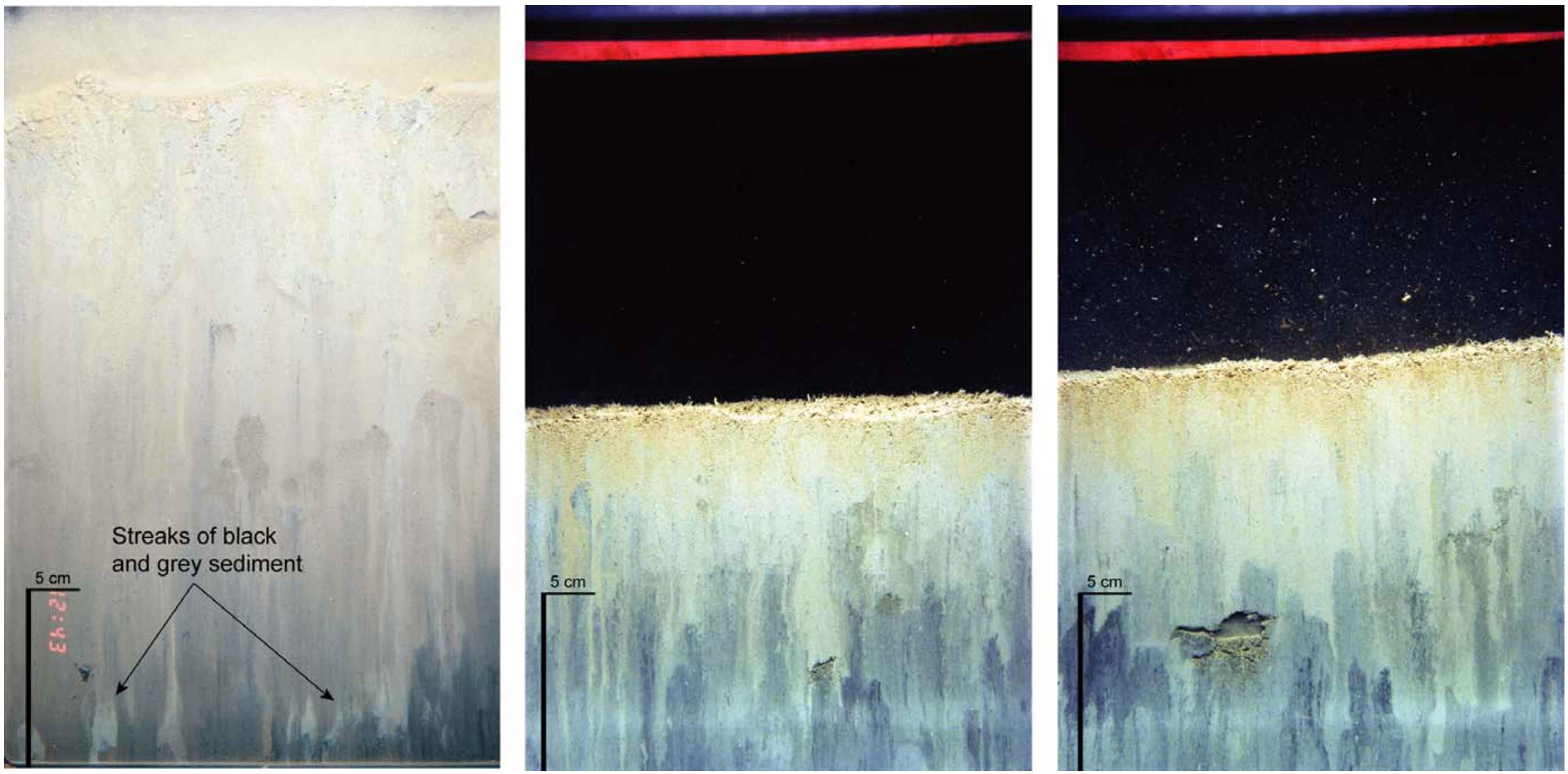

Figure 4-1. SPI images obtained at Station I7 in the September surveys of 2000 and 2003 compared to East Reference Area Station ER2. Deeper penetration of the SPI camera in 2000 (left) revealed streaks of black and gray sediment at depth that were interpreted as evidence of an old dredged material layer exceeding the camera's imaging depth. Such evidence was not observed in the 2003 survey; the sediment at Station I7 (center) appeared similar to the ambient sediment at the reference area (right).

stations was naturally occurring or was influenced by dredged material deposition at some time in the past, all of the outer and reference area stations had very high OSI values in September 2003, indicative of undisturbed habitat conditions. If, in fact, there was some dredged material from past errant disposal events present at these stations, the September 2003 results do not indicate any evidence of lasting negative environmental impacts.

4.2 Biological Conditions and Benthic Recolonization Status

A very high percentage of the SPI images obtained at the inner, outer, and reference area stations showed evidence of a diverse benthic community comprised of both surface-dwelling polychaetes (Stage I) and subsurface deposit-feeders (Stage III), resulting in a Stage I on III successional designation at the majority of stations (e.g., Figures 3-11 and 3-13). In particular, the images from the RDS inner stations provide abundant evidence of Stage III feeding voids occurring within both recent and older dredged material layers (e.g., Figures 3-17 to 3-19). The high frequency of Stage III clearly indicates that recolonization of recent and older dredged material deposits by benthic organisms was advanced at both inner and outer stations at the time of the September 2003 survey.

Average OSI values at the inner and outer stations were high and comparable to those found at the reference area stations. A few of the inner stations had OSI values in the range +6 to +8, indicative of a slight degree of disturbance associated with recent dredged material placement. At these stations, RPD depths were moderately well developed but not quite as uniformly deep as those at the reference areas. Continued reworking of the dredged material by the resident Stage III community can be expected to result in deepening of the oxidized surface layer at these stations over time. Regardless, the OSI values at both the inner and outer stations reflect the advanced recolonization status and indicate a high level of recovery within RDS from the physical disturbance associated with both past and recent dredged material placement.

Compared to the 2000 survey, a much higher percentage of the images obtained in the 2003 survey at the inner, outer and reference area stations showed evidence of larger, deposit-feeding (Stage III) taxa (Table 3-4). This resulted in uniformly higher OSI values in 2003 compared to 2000. The increased frequency of Stage III assemblages at both the disposal site and reference area stations may be the result of seasonal or inter-annual differences in infaunal recruitment patterns across the region, with particular Stage III species achieving much higher recruitment success in 2003 compared to 2000. In a significant number of the images from the 2000 survey, small, light-colored bivalves (probably *Nucula* sp.) were visible at and near the sediment-water interface, indicating there had been a relatively successful recruitment event for this organism at some time prior to this survey. The relative absence of these bivalves from the 2003 images is one example of the inter-annual variability in benthic community patterns that can be experienced at RDS and other nearshore disposal sites. Similar temporal differences in recruitment and growth patterns would result in the observed differences in the occurrence of Stage III organisms between the 2000 and 2003 SPI surveys at RDS.

5.0 CONCLUSIONS

The previous survey at the Rockland Disposal Site (RDS) in 2000-2001 (SAIC 2001) was performed following a 10-year period of limited dredged material disposal at the site. Between September 2000 and September 2003, approximately 263,000 m^3 of dredged material was placed at RDS. The physical distribution of dredged material observed during the September 2003 RDS monitoring survey was entirely consistent with expectations based on this recent dredged material disposal activity. The monitoring survey found that dredged material, placed at RDS's DG buoy position, had formed a mound extending to approximately 4 m above the seafloor with thickest accumulations of dredged material over an approximately 220-m diameter area (Figure 3-5). The mound appeared to be relatively stable with an average slope of 3% and a maximum slope near the top of 6%. A thinner layer of dredged material extended outward to form an apron around the mound center with an approximate diameter of 900 m (Figure 3-21 and 3-6). The observations of each of the three separate survey activities (bathymetry, side-scan sonar, and SPI) were consistent, strengthening conclusions regarding physical distribution of dredged material at RDS.

In terms of benthic recolonization status, data from the RDS September 2003 survey indicates that the benthic community has achieved a high level of recovery. This conclusion is based on observations of a diverse benthic community and advanced recolonization at nearly all of the sampling locations throughout RDS (Figures 3-14 to 3-16). Benthic community status within RDS was observed to be similar to that of reference sites at nearly all locations.

In summary, dredged material is distributed as expected and no evidence of lasting negative environmental impacts to the benthic community were observable, based on RDS September 2003 survey results.

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Appendix A

Disposal Barge Log Summary for RDS
September 2000 to September 2003

Project Name: BELFAST HARBOR
Permittee: COE-Belfast Federal Project
Permit Number: 2002C0027

Disposal Date	Volume Disposed (yd3)	Volume Disposed (m3)	Disposal Latitude	Disposal Longitude	Distance From Buoy	Direction from Buoy
11/25/2002	1,200	917	44.11938	-69.00170	52ft	E
11/26/2002	1,200	917	44.11938	-69.00170	50ft	
12/2/2002	1,505	1,151	44.11938	-69.00170	75	E
12/3/2002	1,500	1,147	44.11938	-69.00170	100	S
12/4/2002	1,500	1,147	44.11938	-69.00170	100	W
12/5/2002	1,500	1,147	44.11938	-69.00170	75	W
12/5/2002	1,500	1,147	44.11938	-69.00170	25	E
12/6/2002	1,500	1,147	44.11938	-69.00170	75	NW
12/6/2002	1,500	1,147	44.11938	-69.00170	100	E
12/7/2002	1,500	1,147	44.11938	-69.00170	75	NW
12/7/2002	1,500	1,147	44.11938	-69.00170	100	E
12/8/2002	1,500	1,147	44.11938	-69.00170	75	SE
12/9/2002	1,500	1,147	44.11938	-69.00170	25	E
12/10/2002	1,500	1,147	44.11938	-69.00170	25	SW
12/10/2002	1,500	1,147	44.11938	-69.00170	50	NE
12/11/2002	1,500	1,147	44.11938	-69.00170	25	W
12/11/2002	1,500	1,147	44.11938	-69.00170	25	N
12/12/2002	1,500	1,147	44.11938	-69.00170	50	S
12/12/2002	1,250	956	44.11938	-69.00170	50	NE
12/13/2002	1,500	1,147	44.11938	-69.00170	50	W
12/13/2002	1,500	1,147	44.11938	-69.00170	75	N
12/14/2002	1,500	1,147	44.11938	-69.00170	75	E
12/14/2002	1,500	1,147	44.11938	-69.00170	100	W
12/15/2002	1,500	1,147	44.11938	-69.00170	100	W
12/16/2002	1,500	1,147	44.11938	-69.00170	25	N
12/16/2002	1,500	1,147	44.11938	-69.00170	100	W
12/17/2002	1,500	1,147	44.11938	-69.00170	15	NW
12/17/2002	1,500	1,147	44.11938	-69.00170	100	S
12/18/2002	1,500	1,147	44.11938	-69.00170	115	NW
12/18/2002	1,500	1,147	44.11938	-69.00170	15	E
12/19/2002	1,500	1,147	44.11938	-69.00170	50	E
12/19/2002	1,500	1,147	44.11938	-69.00170	15	NW
12/20/2002	1,500	1,147	44.11938	-69.00170	75	N
12/20/2002	1,500	1,147	44.11938	-69.00170	100	W
12/21/2002	1,400	1,070	44.11938	-69.00170	75	N
12/21/2002	1,500	1,147	44.11938	-69.00170	50	E
12/31/2002	1,500	1,147	44.11938	-69.00170	75 ft	W
12/31/2002	1,500	1,147	44.11938	-69.00170	75	W
12/31/2002	1,500	1,147	44.11938	-69.00170	100	NE
1/1/2003	1,500	1,147	44.11938	-69.00170	50	E
1/2/2003	1,500	1,147	44.11938	-69.00170	100	NW
1/2/2003	1,500	1,147	44.11938	-69.00170	100	W
1/5/2003	860	658	44.11938	-69.00170	25	E
1/7/2003	1,500	1,147	44.11938	-69.00170	100	N
1/8/2003	1,500	1,147	44.11938	-69.00170	100	E

Project Name: BELFAST HARBOR (Continued)
Permittee: COE-Belfast Federal Project
Permit Number: 2002C0027

Disposal Date	Volume Disposed (yd3)	Volume Disposed (m3)	Disposal Latitude	Disposal Longitude	Distance From Buoy	Direction from Buoy
1/8/2003	1,500	1,147	44.11938	-69.00170	100	N
1/9/2003	1,500	1,147	44.11938	-69.00170	50 ft	N
1/9/2003	1,500	1,147	44.11938	-69.00170	100	N
1/10/2003	1,500	1,147	44.11938	-69.00170	10	E
1/10/2003	1,500	1,147	44.11938	-69.00170	100	N
1/11/2003	1,500	1,147	44.11938	-69.00170	25	E
1/11/2003	1,500	1,147	44.11938	-69.00170	100	NW
1/12/2003	1,500	1,147	44.11938	-69.00170	100	S
1/14/2003	1,500	1,147	44.11938	-69.00170	75	N
1/14/2003	1,500	1,147	44.11938	-69.00170	100	N
1/15/2003	1,500	1,147	44.11938	-69.00170	100	N
1/16/2003	1,385	1,059	44.11938	-69.00170	50	W
1/17/2003	1,500	1,147	44.11938	-69.00170	100	N
1/17/2003	1,500	1,147	44.11938	-69.00170	50	W
1/18/2003	1,500	1,147	44.11938	-69.00170	25	W
1/19/2003	1,500	1,147	44.11938	-69.00170	50	W
1/19/2003	1,500	1,147	44.11938	-69.00170	100	N
1/20/2003	1,500	1,147	44.11938	-69.00170	50	E
1/23/2003	1,500	1,147	44.11938	-69.00170	100	E
1/23/2003	1,500	1,147	44.11938	-69.00170	100	N
1/25/2003	1,500	1,147	44.11938	-69.00170	100	E
1/25/2003	1,500	1,147	44.11938	-69.00170	100	
1/26/2003	1,500	1,147	44.11938	-69.00170	100	N
1/27/2003	1,500	1,147	44.11938	-69.00170	100	S
1/28/2003	1,500	1,147	44.11938	-69.00170	25	NW
1/29/2003	1,500	1,147	44.11938	-69.00170	50	E
1/29/2003	1,500	1,147	44.11938	-69.00170	100	NW
1/30/2003	1,200	917	44.11938	-69.00170	100	N
1/30/2003	1,500	1,147	44.11938	-69.00170	25	NE
1/31/2003	1,500	1,147	44.11938	-69.00170	50	N
2/1/2003	1,500	1,147	44.11938	-69.00170	100	N
2/1/2003	1,500	1,147	44.11938	-69.00170	25	NE
2/3/2003	1,500	1,147	44.11938	-69.00170	100	E
2/3/2003	1,500	1,147	44.11938	-69.00170	10	NW
2/4/2003	1,500	1,147	44.11938	-69.00170	100	N
2/5/2003	1,500	1,147	44.11938	-69.00170	50	W
2/5/2003	1,500	1,147	44.11938	-69.00170	100	W
2/6/2003	1,500	1,147	44.11938	-69.00170	100	S
2/7/2003	750	573	44.11950	-69.00170	100	N
2/7/2003	1,500	1,147	44.11938	-69.00170	50	E
2/8/2003	1,500	1,147	44.11938	-69.00170	100-25 ft	N-W
2/10/2003	1,500	1,147	44.11938	-69.00170	50	NW
2/12/2003	1,500	1,147	44.11938	-69.00170	50	NW
2/13/2003	1,500	1,147	44.11938	-69.00170	100	E
2/16/2003	1,500	1,147	44.11938	-69.00170	100	N

Project Name: BELFAST HARBOR (Continued)
Permittee: COE-Belfast Federal Project
Permit Number: 2002C0027

Disposal Date	Volume Disposed (yd3)	Volume Disposed (m3)	Disposal Latitude	Disposal Longitude	Distance From Buoy	Direction from Buoy
2/18/2003	1,500	1,147	44.11938	-69.00170	50	SW
2/19/2003	1,500	1,147	44.11938	-69.00170	50	W
2/20/2003	1,500	1,147	44.11938	-69.00170	50	W
2/21/2003	1,500	1,147	44.11938	-69.00170	75	NW
2/22/2003	1,500	1,147	44.11938	-69.00170	50	N
2/24/2003	1,500	1,147	44.11938	-69.00170	50	N
2/26/2003	1,500	1,147	44.11938	-69.00170	100	N
2/27/2003	1,500	1,147	44.11938	-69.00170	100	N
3/4/2003	1,500	1,147	44.11938	-69.00170	75	N
3/14/2003	1,500	1,147	44.11938	-69.00170	100	N
3/16/2003	1,500	1,147	44.11938	-69.00170	25	N
3/16/2003	1,500	1,147	44.11938	-69.00170	75	N
3/17/2003	1,500	1,147	44.11938	-69.00170	50	NW
3/18/2003	1,500	1,147	44.11938	-69.00170	50	NW
3/22/2003	1,500	1,147	44.11938	-69.00170	100	N
3/29/2003	1,500	1,147	44.11938	-69.00170	100	NW
3/30/2003	1,500	1,147	44.11938	-69.00170	50	W
4/1/2003	1,500	1,147	44.11938	-69.00170	75 ft	W
4/2/2003	1,500	1,147	44.11938	-69.00170	75 ft	NW
Total Dredged Matieral Volume	**160,750**	**122,902**				

Project Name: CAMDEN FED NAV
Permittee: COE-Camden Federal Navigation
Permit Number: 2002C0026A

Disposal Date	Volume Disposed (yd3)	Volume Disposed (m3)	Disposal Latitude	Disposal Longitude	Distance From Buoy	Direction from Buoy
11/18/2002	450	344	44.11860	-69.00150	50ft	SE
11/19/2002	450	344	44.11937	-69.00134	60	E
11/19/2002	500	382	44.11930	-69.00187	50	W
11/19/2002	425	325	44.11968	-69.00162	20	N
11/20/2002	575	440	44.11958	-69.00253	25ft	W
11/20/2002	500	382	44.11972	-69.00140	15	SE
11/20/2002	550	421	44.11988	-69.00225	28	NE
11/21/2002	500	382	44.11963	-69.00207	50ft	NW
11/22/2002	600	459	44.11877	-69.00190	50ft	E
11/22/2002	450	344	44.11973	-69.00134	50ft	NE
11/25/2002	500	382	44.12010	-69.00224	25ft	N
11/26/2002	575	440	44.11993	-69.00250	20ft	W
11/26/2002	500	382	44.11985	-69.00169	25ft	N
11/27/2002	550	421	44.11967	-69.00233	50ft	W
11/27/2002	500	382	44.11955	-69.00280	25ft	SW
11/27/2002	575	440	44.12043	-69.00210	25	N
12/2/2002	475	363	44.11983	-69.00242	20	NE
12/2/2002	600	459	44.11978	-69.00170	10	E
12/3/2002	475	363	44.11895	-69.00134	50	E
12/3/2002	600	459	44.11923	-69.00250	80	W
12/4/2002	450	344	44.12000	-69.00195	30	NW
12/4/2002	500	382	44.12003	-69.00166	30	N
12/5/2002	500	382	44.11857	-69.00188	50	SW
12/5/2002	600	459	44.11960	-69.00215	10	N
12/5/2002	410	313	44.11955	-69.00170	20	NE
12/6/2002	600	459	44.11950	-69.00250	30	W
12/6/2002	500	382	44.11992	-69.00142	20	NE
12/6/2002	600	459	44.11953	-69.00183	10	E
12/9/2002	500	382	44.11990	-69.00150	20	E
12/9/2002	575	440	44.11975	-69.00142	20	ESE
12/10/2002	500	382	44.11880	-69.00190	70	SE
12/10/2002	500	382	44.11943	-69.00172	5	E
12/11/2002	500	382	44.11963	-69.00187	30	NE
12/11/2002	600	459	44.11937	-69.00235	25	E
12/12/2002	500	382	44.12000	-69.00233	60	NW
12/12/2002	600	459	44.11913	-69.00183	50	S
12/12/2002	500	382	44.11934	-69.00183	10	E
12/13/2002	575	440	44.11934	-69.00237	20	W
12/13/2002	500	382	44.11946	-69.00262	35	W
12/13/2002	600	459	44.11948	-69.00213	5 ft	N
12/16/2002	400	306	44.11867	-69.00142	70 ft	SE
12/17/2002	475	363	44.11887	-69.00220	5 ft	SW
12/17/2002	350	268	44.11962	-69.00177	5 ft	NE
12/18/2002	300	229	44.11967	-69.00210	10 ft	N
12/19/2002	475	363	44.11938	-69.00245	20 ft	NW

Project Name: CAMDEN FED NAV (Continued)
Permittee: COE-Camden Federal Navigation
Permit Number: 2002C0026A

Disposal Date	Volume Disposed (yd3)	Volume Disposed (m3)	Disposal Latitude	Disposal Longitude	Distance From Buoy	Direction from Buoy
12/19/2002	500	382	44.11933	-69.00177	5 ft	NE
12/24/2002	425	325	44.11997	-69.00233	50	NW
12/24/2002	450	344	44.11917	-69.00166	30	SE
1/6/2003	450	344	44.11950	-69.00250	25	NE
1/8/2003	50	38	44.11950	-69.00134	20	E
Total Dredged Material Volume	**24,835**	**18,988**				

Project Name: CAMDEN HARBOR
Permittee: Nancy Symington & Analine Corp.
Permit Number: 200103133

Disposal Date	Volume Disposed (yd3)	Volume Disposed (m3)	Disposal Latitude	Disposal Longitude	Distance From Buoy	Direction from Buoy
1/6/2003	90	69	44.11950	-69.00250	25	NE
1/7/2003	340	260	44.11958	-69.00175	10	N
3/4/2003	400	306	44.11946	-69.00201	15	SW
Total Dredged Material Volume	**830**	**635**				

Project Name: CAMDEN HARBOR
Permittee: Harbor Square Partners
Permit Number: 200201727

Disposal Date	Volume Disposed (yd3)	Volume Disposed (m3)	Disposal Latitude	Disposal Longitude	Distance From Buoy	Direction from Buoy
1/3/2003	400	306	44.11950	-69.00150	20	E
1/7/2003	160	122	44.11958	-69.00175	10	N
Total Dredged Material Volume	**560**	**428**				

Project Name: CAMDEN HARBOR
Permittee: Harbor Square Assoc.
Permit Number: 200202324

Disposal Date	Volume Disposed (yd3)	Volume Disposed (m3)	Disposal Latitude	Disposal Longitude	Distance From Buoy	Direction from Buoy
3/4/2003	200	153	44.11946	-69.00201	15	SW
3/5/2003	300	229	44.11977	-69.00180	5	NE
Total Dredged Material Volume	**500**	**382**				

Project Name: CAMDEN HARBOR
Permittee: Bayview Landing
Permit Number: 200202433

Disposal Date	Volume Disposed (yd3)	Volume Disposed (m3)	Disposal Latitude	Disposal Longitude	Distance From Buoy	Direction from Buoy
3/5/2003	300	229	44.11977	-69.00180	5	NE
Total Dredged Material Volume	**300**	**229**				

Project Name: LASSELL ISLAND
Permittee: Christopher Page
Permit Number: 200103135

Disposal Date	Volume Disposed (yd3)	Volume Disposed (m3)	Disposal Latitude	Disposal Longitude	Distance From Buoy	Direction from Buoy
3/25/2003	275	210	44.12007	-69.00153	25	N
3/27/2003	300	229	44.11998	-69.00120	25	NE
3/28/2003	325	248	44.11987	-69.00175	20	N
3/28/2003	100	76	44.12047	-69.00191	30	NW
4/1/2003	310	237	44.11977	-69.00107	25	NE
4/2/2003	350	268	44.11946	-69.00155	15	SE
4/3/2003	350	268	44.11912	-69.00183	25	N
4/4/2003	325	248	44.11972	-69.00227	20	NW
4/7/2003	325	248	44.11980	-69.00215	25 ft	N
4/8/2003	300	229	44.11963	-69.00198	20 ft	NW
4/9/2003	300	229	44.11965	-69.00297	30 ft	NW
4/10/2003	350	268	44.11975	-69.00153	10 ft	N
4/11/2003	290	222	44.11983	-69.00197	20 ft	NW
4/14/2003	375	287	44.11967	-69.00140	35 ft	N
Total Dredged Material Volume	**4,275**	**3,268**				

Project Name: MACK POINT
Permittee: ME DOT & Sprague Energy
Permit Number: 200000269

Disposal Date	Volume Disposed (yd3)	Volume Disposed (m3)	Disposal Latitude	Disposal Longitude	Distance From Buoy	Direction from Buoy
2/19/2003	2,800	2,141	44.11863	-69.00137	140	ESE
2/20/2003	2,000	1,529	44.11946	-69.00235	80	W
2/21/2003	3,100	2,370	44.11972	-69.00085	100	ENE
2/25/2003	3,400	2,599	44.11940	-69.00143	45	E
2/26/2003	1,800	1,376	44.11953	-69.00148	50	ENE
2/27/2003	3,000	2,294	44.11943	-69.00097	30	E
2/28/2003	1,900	1,453	44.11980	-69.00146	75	NNE
3/3/2003	2,700	2,064	44.11925	-69.00200	50	NW
3/4/2003	1,400	1,070	44.11960	-69.00146	35	NNE
3/5/2003	2,800	2,141	44.11942	-69.00076	60	E
3/6/2003	1,700	1,300	44.11942	-69.00083	60	E
3/7/2003	2,800	2,141	44.11950	-69.00093	45	E
3/8/2003	2,000	1,529	44.11913	-69.00200	30	SW
3/9/2003	2,600	1,988	44.11923	-69.00210	90	WSW
3/10/2003	2,500	1,911	44.11938	-69.00115	40	E
3/11/2003	3,200	2,447	44.11942	-69.00080	90	E
3/11/2003	1,900	1,453	44.11982	-69.00143	80	NNE
3/12/2003	2,600	1,988	44.11927	-69.00205	35	WSW
3/13/2003	1,900	1,453	44.11935	-69.00146	45	E
3/14/2003	1,700	1,300	44.11932	-69.00143	30	E
3/14/2003	1,800	1,376	44.11940	-69.00127	75	E
3/17/2003	3,200	2,447	44.11927	-69.00252	100	W
3/17/2003	1,900	1,453	44.11928	-69.00275	75	W
3/19/2003	2,300	1,758	44.11935	-69.00135	45	E
3/20/2003	1,500	1,147	44.11942	-69.00220	45	W
3/21/2003	2,300	1,758	44.11934	-69.00235	50	W
3/22/2003	2,200	1,682	44.11934	-69.00114	50	E
3/23/2003	2,500	1,911	44.11940	-69.00121	30	E
3/24/2003	1,600	1,223	44.11917	-69.00198	35	SW
4/4/2003	2,800	2,141	44.11942	-69.00148	15	E
4/5/2003	1,200	917	44.11932	-69.00166	10	E
4/10/2003	500	382	44.11950	-69.00080	65	E
Total Dredged Material Volume	**71,600**	**54,742**				

Project Name: ROCKLAND Fed. Nav.
Permittee: COE Rockland Federal Navigation
Permit Number: 2002C0026B

Disposal Date	Volume Disposed (yd3)	Volume Disposed (m3)	Disposal Latitude	Disposal Longitude	Distance From Buoy	Direction from Buoy
1/9/2003	600	459	44.11945	-69.00097	10	NE
1/9/2003	564	431	44.11932	-69.00172	20	S
1/9/2003	600	459	44.11946	-69.00165	20	N
1/10/2003	600	459	44.11910	-69.00179	20	S
1/10/2003	564	431	44.11934	-69.00173	10	S
1/10/2003	475	363	44.11885	-69.00217	25	W
1/10/2003	600	459	44.11930	-69.00163	10	S
1/10/2003	564	431	44.11923	-69.00155	10	SE
1/13/2003	500	382	44.11953	-69.00183	20	N
1/13/2003	312	239	44.11900	-69.00165	20	S
1/14/2003	555	424	44.11948	-69.00175	5	N
1/14/2003	284	217	44.11878	-69.00159	50	S
1/14/2003	564	431	44.11960	-69.00159	25	N
1/14/2003	312	239	44.11930	-69.00163	25	S
1/15/2003	564	431	44.11915	-69.00182	75	S
1/15/2003	312	239	44.11948	-69.00224	50	NW
1/15/2003	564	431	44.11970	-69.00125	30	E
1/15/2003	312	239	44.11932	-69.00148	25	S
1/15/2003	564	431	44.11905	-69.00163	30	S
1/16/2003	423	323	44.11955	-69.00183	50	N
1/16/2003	312	239	44.11955	-69.00166	30	E
1/16/2003	564	431	44.11932	-69.00217	40	W
1/16/2003	312	239	44.11950	-69.00153	10	NE
1/17/2003	564	431	44.11930	-69.00170	10	S
1/17/2003	312	239	44.11952	-69.00164	20	
1/17/2003	564	431	44.11930	-69.00163	30	S
1/17/2003	312	239	44.11927	-69.00166	20	E
1/20/2003	550	421	44.11940	-69.00163	30	N
1/20/2003	304	232	44.11893	-69.00121	50	SE
1/20/2003	550	421	44.11938	-69.00166	10	E
1/20/2003	312	239	44.11942	-69.00166	50	E
1/23/2003	550	421	44.11937	-69.00170	20	E
1/23/2003	312	239	44.11922	-69.00195	20	W
1/23/2003	550	421	44.11902	-69.00163	10	E
1/23/2003	312	239	44.11892	-69.00145	20	E
1/23/2003	550	421	44.11925	-69.00197	30	W
1/24/2003	550	421	44.11907	-69.00210	50	E
1/24/2003	300	229	44.11907	-69.00205	50	E
1/24/2003	550	421	44.11927	-69.00183	50	W
1/24/2003	300	229	44.11890	-69.00148	5	E
1/24/2003	550	421	44.11895	-69.00133	50	E
1/25/2003	312	239	44.11940	-69.00120	20	E
1/25/2003	550	421	44.11887	-69.00158	10	E
1/25/2003	312	239	44.11895	-69.00170	2	E
1/25/2003	550	421	44.11938	-69.00166	5	E

Project Name: ROCKLAND Fed. Nav. (Continued)
Permittee: COE Rockland Federal Navigation
Permit Number: 2002C0026B

Disposal Date	Volume Disposed (yd3)	Volume Disposed (m3)	Disposal Latitude	Disposal Longitude	Distance From Buoy	Direction from Buoy
1/25/2003	312	239	44.11920	-69.00182	2	N
1/26/2003	550	421	44.11885	-69.00211	20	E
1/26/2003	300	229	44.11934	-69.00211	20	NW
1/28/2003	420	321	44.11897	-69.00152	25	E
1/28/2003	312	239	44.11900	-69.00152	1	S
1/28/2003	575	440	44.11912	-69.00120	50	NE
1/28/2003	312	239	44.11892	-69.00183	1	W
1/28/2003	600	459	44.11922	-69.00133	20	S
1/29/2003	312	239	44.11897	-69.00155	20	E
1/29/2003	540	413	44.11927	-69.00100	10	N
1/29/2003	312	239	44.11903	-69.00182	10	S
1/29/2003	600	459	44.11946	-69.00163	1	S
1/29/2003	312	239	44.11912	-69.00155	1	W
1/30/2003	600	459	44.11918	-69.00179	1	W
1/30/2003	260	199	44.11927	-69.00172	1	W
1/30/2003	540	413	44.11903	-69.00180	1	W
1/30/2003	312	239	44.11923	-69.00150	1	W
1/31/2003	600	459	44.11900	-69.00169	1	W
1/31/2003	312	239	44.11928	-69.00182	1	W
1/31/2003	600	459	44.11905	-69.00153	1	W
1/31/2003	312	239	44.11897	-69.00169	20	SW
1/31/2003	500	382	44.11917	-69.00155	1	W
1/31/2003	312	239	44.11938	-69.00170	0	
2/3/2003	280	214	44.11950	-69.00163	100	E
2/3/2003	400	306	44.11922	-69.00170	5	S
2/4/2003	312	239	44.11905	-69.00172	30	S
2/4/2003	312	239	44.11913	-69.00173	100	S
2/5/2003	480	367	44.11908	-69.00145	0	SE
2/5/2003	292	223	44.11908	-69.00148	0	SE
2/6/2003	550	421	44.11943	-69.00075	100	E
2/6/2003	312	239	44.11918	-69.00138	50	S
2/6/2003	600	459	44.11934	-69.00170	5	W
2/6/2003	307	235	44.11938	-69.00170	0	
2/6/2003	600	459	44.11927	-69.00107	30	E
2/6/2003	312	239	44.11940	-69.00170	5	W
2/7/2003	600	459	44.11920	-69.00165	75	E
2/7/2003	600	459	44.11923	-69.00172	5	W
2/7/2003	600	459	44.11945	-69.00138	20	E
2/7/2003	312	239	44.11913	-69.00183	50	S
2/10/2003	600	459	44.11967	-69.00159	100	N
2/10/2003	312	239	44.11957	-69.00156	50	N
2/10/2003	600	459	44.11952	-69.00188	20	N
2/10/2003	312	239	44.11923	-69.00172	20	S
2/11/2003	600	459	44.11952	-69.00173	100	N
2/11/2003	312	239	44.11946	-69.00182	20	N

Project Name: ROCKLAND Fed. Nav. (Continued)
Permittee: COE Rockland Federal Navigation
Permit Number: 2002C0026B

Disposal Date	Volume Disposed (yd3)	Volume Disposed (m3)	Disposal Latitude	Disposal Longitude	Distance From Buoy	Direction from Buoy
2/11/2003	600	459	44.11907	-69.00180	100	N
2/11/2003	312	239	44.11937	-69.00115	50	E
2/11/2003	600	459	44.11952	-69.00156	20	N
2/11/2003	312	239	44.11958	-69.00163	20	N
2/11/2003	600	459	44.11915	-69.00173	20	S
2/12/2003	312	239	44.11930	-69.00172	10	S
2/12/2003	600	459	44.11927	-69.00173	100	E
2/12/2003	312	239	44.11927	-69.00163	40	E
2/12/2003	600	459	44.11920	-69.00163	30	S
2/12/2003	312	239	44.11945	-69.00172	5	N
2/13/2003	600	459	44.11913	-69.00155	100	E
2/13/2003	302	231	44.11932	-69.00163	50	E
2/13/2003	470	359	44.11925	-69.00153	50	S
2/14/2003	470	359	44.11938	-69.00170	0	
2/18/2003	376	287	44.11920	-69.00170	100	E
2/18/2003	234	179	44.11920	-69.00170	100	E
2/19/2003	534	408	44.11967	-69.00179	50	N
2/19/2003	312	239	44.11920	-69.00163	30	S
2/20/2003	307	235	44.11930	-69.00179	30	N
2/20/2003	564	431	44.11958	-69.00170	50	N
2/20/2003	312	239	44.11928	-69.00170	50	S
2/20/2003	564	431	44.11963	-69.00170	50	N
2/21/2003	312	239	44.11953	-69.00170	30	N
2/21/2003	564	431	44.11943	-69.00156	20	E
2/21/2003	300	229	44.11928	-69.00172	20	W
2/21/2003	376	287	44.11934	-69.00163	25	E
2/24/2003	564	431	44.11943	-69.00179	20	E
2/25/2003	292	223	44.11950	-69.00148	100	E
2/25/2003	564	431	44.11946	-69.00182	0	
2/25/2003	297	227	44.11915	-69.00182	50	S
2/25/2003	564	431	44.11932	-69.00201	100	W
2/25/2003	312	239	44.11930	-69.00198	50	W
2/26/2003	564	431	44.11920	-69.00148	50	E
2/26/2003	312	239	44.11928	-69.00188	10	N
2/26/2003	564	431	44.11915	-69.00156	40	S
2/27/2003	312	239	44.11932	-69.00198	20	S
2/28/2003	564	431	44.11958	-69.00182	50	N
2/28/2003	312	239	44.11927	-69.00170	25	S
3/4/2003	550	421	44.11889	-69.00163	10	W
3/6/2003	550	421	44.11917	-69.00132	20	E
3/10/2003	550	421	44.11915	-69.00146	25	NE
3/11/2003	480	367	44.11973	-69.00198	20	W
3/13/2003	500	382	44.11900	-69.00220	10	W
3/18/2003	425	325	44.11897	-69.00215	25	S
3/27/2003	312	239	44.11910	-69.00162	10	E
3/27/2003	564	431	44.11925	-69.00169	20	SE
Total Dredged Material Volume	**60,456**	**46,222**				

Project Name: ROCKLAND HARBOR, ME
Permittee: 200001733
Permit Number: ATLANTIC CHALLENGE

Disposal Date	Volume Disposed (yd3)	Volume Disposed (m3)	Disposal Latitude	Disposal Longitude	Distance From Buoy	Direction from Buoy
3/1/2001	300	229	44.11833	-69.00150	15ft	W
3/29/2001	325	248	44.11950	-69.00150	50ft	NW
3/29/2001	500	382	44.11933	-69.00167	50ft	W
3/30/2001	350	268	44.11950	-69.00150	75ft	NW
4/2/2001	400	306	44.11900	-69.00166	50	SW
4/3/2001	300	229	44.11900	-69.00150	50	S
4/3/2001	360	275	44.11883	-69.00200	30	SW
4/4/2001	300	229	44.11867	-69.00183	50	S
4/5/2001	360	275	44.11867	-69.00166	75	SW
4/5/2001	300	229	44.11850	-69.00166	75	SW
4/9/2001	500	382	44.11967	-69.00300	50ft	W
4/9/2001	320	245	44.11967	-69.00267	75	NW
4/10/2001	400	306	44.11967	-69.00183	70	NW
4/10/2001	300	229	44.11934	-69.00267	90	W
4/11/2001	400	306	44.11967	-69.00183	25	NNW
4/11/2001	300	229	44.11934	-69.00083	75	E
4/12/2001	400	306	44.11934	-69.00166	15	N
4/13/2001	250	191	44.11967	-69.00166	25	NNE
4/13/2001	400	306	44.11967	-69.00183	15	SW
4/13/2001	300	229	44.11883	-69.00233	20	SW
4/16/2001	375	287	44.11900	-69.00200	20	S
4/16/2001	275	210	44.11883	-69.00217	25	S
4/17/2001	400	306	44.11900	-69.00217	30	SSW
4/17/2001	325	248	44.11900	-69.00217	20	SSW
4/19/2001	400	306	44.11967	-69.00150	30	S
4/19/2001	275	210	44.11950	-69.00200	30	S
4/19/2001	400	306	44.11900	-69.00200	30	S
4/19/2001	250	191	44.11967	-69.00200	35	SW
4/20/2001	450	344	44.11934	-69.00166	30	NW
4/20/2001	200	153	44.11950	-69.00200	30	NNW
4/23/2001	450	344	44.11900	-69.00183	30	SW
4/23/2001	300	229	44.11917	-69.00183	40	SW
4/24/2001	450	344	44.11883	-69.00183	75	S
4/24/2001	300	229	44.11967	-69.00217	75	n
4/25/2001	400	306	44.11934	-69.00267	45	WNW
4/25/2001	300	229	44.11867	-69.00267	15	SW
4/26/2001	475	363	44.11900	-69.00134	40	SE
4/26/2001	250	191	44.11867	-69.00150	50	SE
4/27/2001	200	153	44.11900	-69.00217	25	SW
Total Dredged Material Volume	**13,540**	**10,352**				

Project Name: TENANTS HARBOR
Permittee: Hales Miller d/b/a Cod End
Permit Number: 200102505

Disposal Date	Volume Disposed (yd3)	Volume Disposed (m3)	Disposal Latitude	Disposal Longitude	Distance From Buoy	Direction from Buoy
1/2/2003	500	382	44.11880	-69.00175	5	S
1/6/2003	500	382	44.11887	-69.00137	10	SE
1/7/2003	475	363	44.11972	-69.00190	20	SW
1/11/2003	500	382	44.11900	-69.00188	20	S
1/13/2003	400	306	44.11900	-69.00148	25	SE
1/15/2003	605	463	44.11902	-69.00173	10	S
1/16/2003	600	459	44.11912	-69.00146	75	SW
1/20/2003	600	459	44.11967	-69.00211	20	W
1/23/2003	600	459	44.11917	-69.00150	20	E
1/25/2003	600	459	44.11887	-69.00180	10	E
1/29/2003	450	344	44.11877	-69.00183	10	SW
1/31/2003	475	363	44.11880	-69.00198	20	SE
Total Dredged Material Volume	**6,305**	**4,821**				

Appendix B

SEDIMENT-PROFILE IMAGING METHODOLOGY

1.0 INTRODUCTION

Sediment-profile imaging (SPI) is a benthic sampling technique that enables investigators to evaluate the thickness and distribution of thin dredged material layers, delineate benthic disturbance gradients, and monitor the process of benthic recolonization following seafloor disturbance. SPI surveys obtain undisturbed, vertical cross-sectional images of the upper 15 to 20 cm of the seafloor. Each image is analyzed for a suite of standard parameters, including sediment grain size, penetration depth, surface boundary roughness, depth of apparent redox potential discontinuity (RPD), infaunal successional stage and Organism-Sediment Index (OSI).

2.0 SPI DATA ACQUISITION

Standard SPI system hardware includes a metal frame, pressure housing, a prism chamber, and a camera (Figure B-1). The hardware may also include a deep sea pinger or a video feed. The camera is mounted inside the pressure housing and sits atop a wedge-shaped prism with a front faceplate and a back mirror mounted at a 45-degree angle to reflect the profile of the sediment-water interface.

The frame is lowered through the water column in a controlled manner and, once on the bottom, the prism penetrates the seafloor (Figure B-2). A passive hydraulic piston ensures that the prism enters the bottom slowly (approximately 6 cm/sec) to minimize disturbance of the sediment-water interface. As the prism penetrates the seafloor, a trigger activates a time delay circuit that fires the internal strobe twice with each lowering to obtain two cross-sectional images of the upper 20 cm of the sediment column. After the two replicate images are obtained at the first location, the camera is raised about 2 or 3 m off the bottom to reposition it nearby and to allow the strobe to recharge. The strobe recharges within 5 seconds, and the camera is lowered again for another two images.

Three camera lowerings (six replicate images) are performed at each station. If a deep sea pinger is attached to the camera, a constant 12 kHz signal of one ping per second is output. Upon discharge of the camera strobe, the ping rate doubles for 10 seconds (Figure B-2). Sound from the pinger is audible on-deck and provides scientists with confirmation that a successful image has been obtained. If the system is equipped with a video feed, real-time plan view observation of the frame on the seafloor is performed concurrent with image collection.

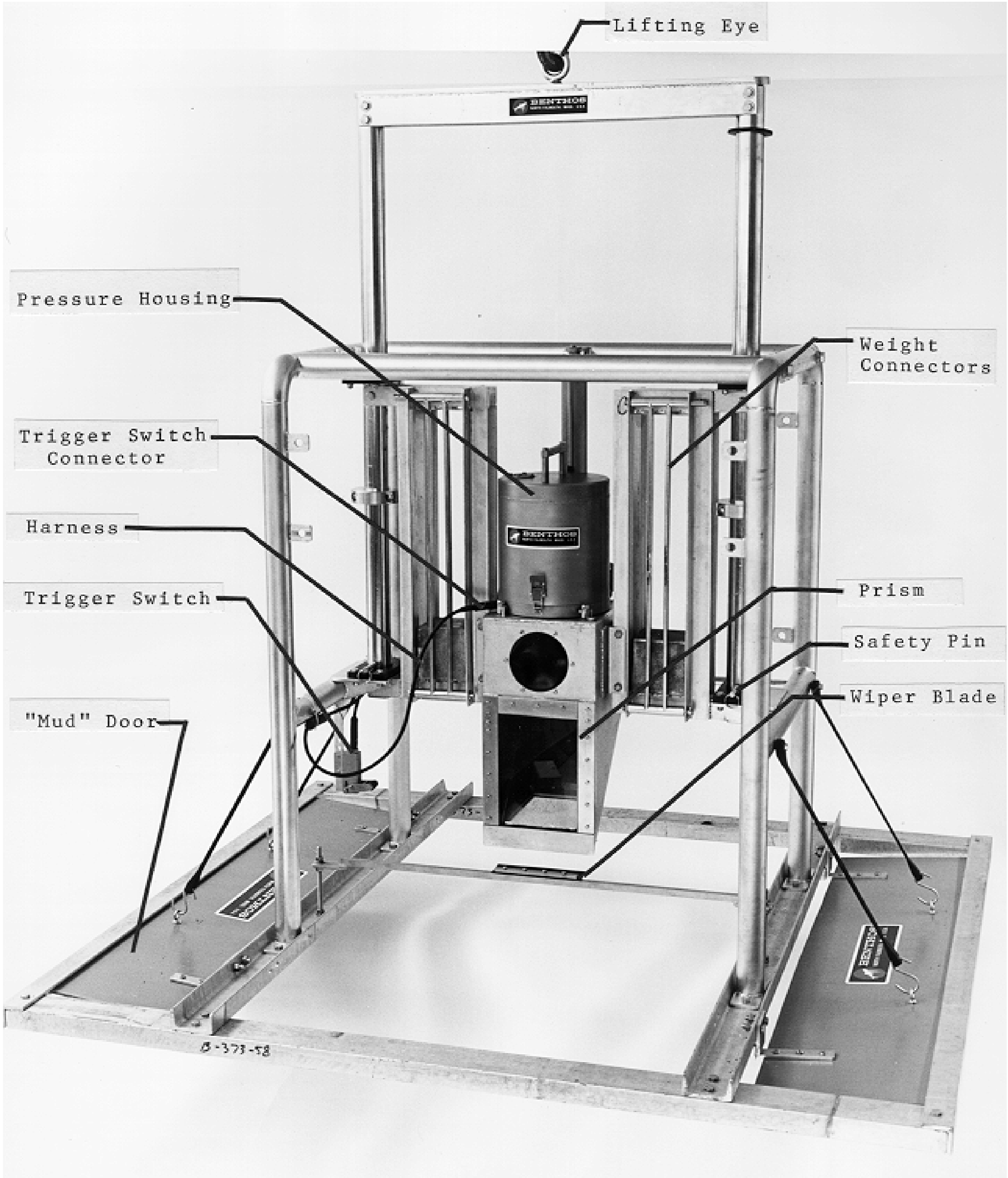

Figure B-1. Photograph of the SPI system

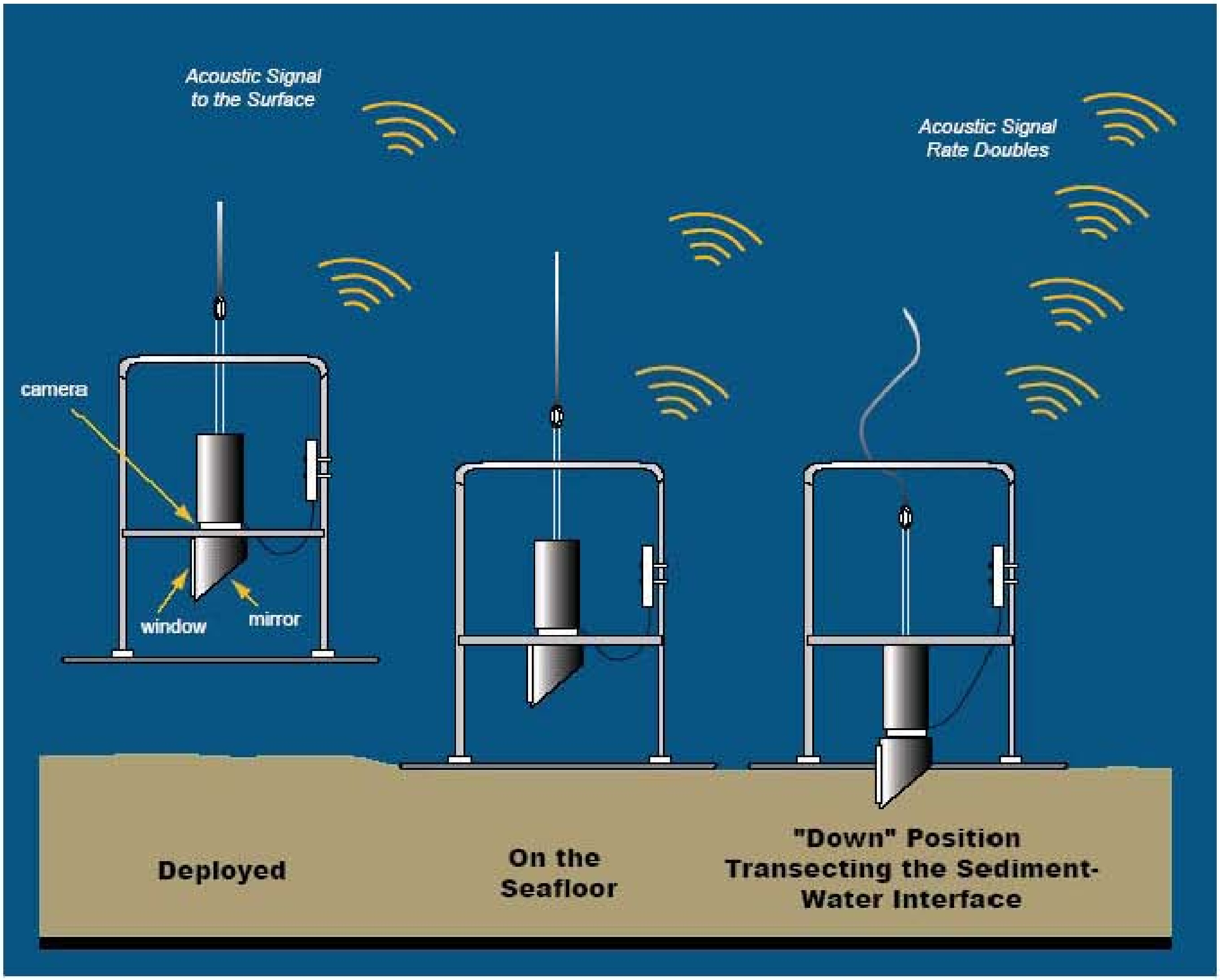

Figure B-2. Schematic diagrams of the SPI system in operation

After deployment of the camera at each station, the frame counter is checked to make sure that the proper number of images has been taken. In addition, a prism penetration depth indicator on the camera frame is checked to verify that the prism penetrated the bottom to a depth sufficient to acquire a profile image. In the event that penetration depth is insufficient, (e.g., if hard packed bottom is encountered), additional weight is added to the SPI hardware frame, and the system is re-deployed. In the event that extremely soft sediment is encountered and the prism over-penetrates, the frame is outfitted with a set of mud doors (Figure B-1). Mud doors increase the surface area and distribute the weight of the camera system over the soft sediment preventing the sediment-water interface from being obscured due to over-penetration of the window.

3.0 SPI DATA ANALYSIS

In general, three replicate camera images are analyzed from each sampling location, allowing for characterization of variability in benthic habitat conditions that may exist at small spatial scales. One image from each of the three lowerings is selected based on image clarity and quality. Computer-aided analysis of each image yields a suite of standard measured parameters. For mapping purposes, the measured values for the three replicate images at each station are averaged in order to characterize the larger-scale spatial patterns in seafloor conditions existing within each surveyed area. Each of the SPI analysis parameters is described below.

3.1 Sediment Type

The sediment grain size major mode and range are estimated visually from the camera images using a grain-size comparator at a similar scale. The phi (Φ) scale is typically used for this measurement, where phi is a unitless measure of grain size:

$$\Phi = -\log_2(g/g_0);$$

where g is the grain size in mm and g_0 is defined as 1 mm. The lower limit of optical resolution for humans is approximately 62 microns (0.062 mm), allowing recognition of grain sizes equal to or greater than coarse silt (≥ 4 phi). Seven grain size classes are identified: silt/clay (>4 phi), very fine sand (4 to 3 phi), fine sand (3 to 2 phi), medium sand (2 to 1 phi), coarse sand (1 to 0 phi), very coarse sand (0 to –1 phi), and granules or larger (<-1 phi) (Table B-1). During analysis, the major modal grain size that is assigned to an image is the dominant grain size as estimated by area within the imaged sediment column.

Table B-1.

Grain Size Scale for Sediments

Phi (Φ) size	Size range (mm)	Size class (Wentworth class)
< -1	> 2	Gravel
0 to –1	1 to 2	Very coarse sand
1 to 0	0.5 to 1	Coarse sand
2 to 1	0.25 to 0.5	Medium sand
3 to 2	0.125 to 0.25	Fine sand
4 to 3	0.0625 to 0.125	Very fine sand
> 4	< 0.0625	Silt/clay

3.2 Penetration Depth

The penetration depth into the seafloor depends on the force exerted by the prism and the bearing strength of the sediment. If the weight of the frame is held constant, the change in penetration depth over a surveyed site will reflect changes in the geotechnical properties of the bottom. The prism penetration depth is measured from the bottom of the image to the sediment-water interface. The average penetration depth is determined by measuring across the entire cross-sectional image so that differences in height across the sediment-water interface are taken into account. The depth of penetration of the prism can be used to map gradients in the bearing strength (hardness) of seafloor sediments. Sediments that are older and highly bioturbated and/or comprised primarily of silts and clay tend to be soft and allow deeper penetration than sediments that are overconsolidated/relic deposits and/or with a higher sand content, which tend to create resistance to prism penetration. Bioturbation is defined as the exchange of particles and porewater at the seafloor as the result of biological activity.

3.3 Surface Boundary Roughness

Small-scale surface boundary roughness is a measure of vertical relief of features in the sediment-profile image; it is calculated by the computer image analysis software. This parameter is defined as the vertical measurement from the highest point at the sediment-water interface to the lowest point across the image. Typical values measured over the horizontal 15-cm span of the image range from near zero to 4 cm. In most cases, the source of the roughness is either biogenic (mounds and depressions formed by bioturbation or foraging activity) or relief formed by physical processes (ripples, scour depressions, rip-ups, mud clasts, etc.).

3.4 Apparent Redox Potential Discontinuity Depth

Aerobic near-surface marine sediments typically have higher reflectance values relative to underlying hypoxic or anoxic sediments. Sand also has higher optical reflectance than mud. These differences in optical reflectance are readily apparent in sediment-profile images; the oxidized surface sediment contains particles that are coated with ferric hydroxide (an olive color when associated with particles), while reduced and muddy sediments below this oxygenated layer are darker, generally gray to black. The optical reflectance boundary between the colored ferric hydroxide surface sediment and underlying gray to black sediment is called the apparent redox potential discontinuity (RPD). The depth of the apparent RPD in the sediment column is an important indicator of dissolved oxygen conditions over time within sediment pore waters.

In the absence of bioturbating organisms, the high reflectance layer (in muds) will typically reach a thickness of 2 mm (Rhoads 1974). This depth is related to the supply rate of molecular oxygen by diffusion from the overlying water into the bottom sediments and the consumption of that oxygen by the sediment and associated microflora. In sediments that have very high sediment-oxygen demand, the sediment may lack a high reflectance layer even when the overlying water column is aerobic. In the presence of bioturbating organisms, the thickness of the high reflectance layer may be several centimeters.

The apparent RPD is mapped as a mean value across the image. The actual boundary separating the oxidized sediment from the underlying reduced sediment can be determined accurately only with microelectrodes. In general, the depth of the actual boundary will be either equal to or slightly shallower than the depth of the optical reflectance boundary. As a result, the apparent mean RPD depth can be used as an estimate of the depth of porewater exchange.

The depression and rebound of the apparent RPD within the sediment is relatively slow, and measurable changes can typically be detected over a period of one or two months. Hence, this parameter is used effectively to document changes (or gradients) which develop over a seasonal or yearly cycle related to water temperature effects on bioturbation rates, seasonal hypoxia, sediment oxygen demand, and infaunal recruitment. Time-series RPD measurements following a disturbance can be a critical diagnostic element in monitoring the degree of recolonization in an area by the ambient benthos (Rhoads and Germano 1986).

Another important characteristic of the apparent RPD is the contrast in reflectance values at this boundary. This contrast is related to interactions among the degree of organic-loading, the bioturbational activity in the sediment, and bottom-water dissolved oxygen level in a given area. High inputs of labile organic material increase sediment oxygen demand and, subsequently, sulfate reduction rates (and the abundance of sulfide end products). This results in more highly reduced (lower reflectance) sediments at depth and higher RPD contrasts. In a region of generally low RPD contrasts, images with high RPD contrasts indicate localized sites of relatively high past inputs of organic-rich material (e.g., organic or phytoplankton detritus, dredged material, sewage sludge, etc.).

3.5 Methane

SPI images are analyzed for the presence of methane, which is readily visible as gas bubbles with the sediment voids. These bubbles are generally circular in shape and glossy in appearance due to the reflectance of the camera strobe light. The presence of methane indicates highly enriched organic sediments and significant microbial activity.

3.6 Infaunal Successional Stage

The mapping of successional stages is based on the theory that organism-sediment interactions in fine-grained sediments follow a predictable sequence after a major seafloor perturbation (e.g., passage of a storm, disturbance by bottom trawling, dredged material deposition, hypoxia). The theory states that primary succession results in "the predictable appearance of macrobenthic invertebrates belonging to specific functional types following a benthic disturbance. These invertebrates interact with sediment in specific ways. Because functional types are the biological units of interest, our definition does not demand a sequential appearance of particular invertebrate species or genera" (Rhoads and Boyer 1982).

The continuum of change in animal communities after a disturbance has been divided subjectively into three stages. Pioneering or Stage I assemblages may appear shortly after the disturbance and eventually consist of dense aggregations of near-surface living, tube-dwelling polychaetes. These functional types are usually associated with a shallow redox boundary and shallow bioturbation depths, and are characterized by high rates of recruitment and high ontogenic growth rates. These animals feed at or near the sediment-water interface and physically stabilize the sediment surface by building tubes that incorporate sediment particles bound with mucous.

In the absence of further disturbance, infaunal deposit feeders eventually replace these early successional assemblages; the start of this process is designated as Stage II. Typical Stage II species are shallow dwelling bivalves or, as is common in New England waters, tubiculous amphipods. Stage III taxa, in turn, represent higher successional stages typically found in low disturbance areas. Many feed at depth in a head-down orientation; this activity results in distinctive excavations called feeding voids. Diagnostic features of these feeding structures include a generally semicircular shape with a flat bottom and arched roof and a distinct change in the sediment particles overlying the floor of the structure. This change is caused by the accumulation of coarse particles that are rejected by the animals feeding selectively on fine-grained material. The bioturbational activities of these deposit-feeders are responsible for aerating the sediment and causing the redox horizon to be located several centimeters below the sediment-water interface.

It is possible for Stage I polychaetes or Stage II tubiculous amphipods to be present at the sediment surface, while at the same time, Stage III organisms are present at depth within the sediment. In those instances where two types of assemblages are visible in a sediment-profile image, the image is designated as having either a Stage I on Stage III (I-III) or Stage II on Stage III (II-III) successional state.

Infaunal successional stages apply only to soft-bottom habitats, where the camera is able to penetrate into the sediment. In hard bottom environments (i.e., sand, cobble, or rocky substrata), camera penetration is prevented and the infaunal successional stage is identified as "indeterminate." Although hard-bottom areas can support abundant and diverse epibenthic communities and therefore may represent habitat that is biologically productive, the faunal status of hard-bottom habitats is not reflected in the successional stage designation.

3.7 Organism-Sediment Index (OSI)

The multi-parameter Organism-Sediment Index (OSI) has been constructed to characterize disturbance gradients in soft-bottom benthic environments. The OSI is calculated on the basis of four independently measured sediment-profile imaging parameters: apparent mean RPD depth, presence of methane gas, dissolved oxygen content at the sediment-water interface, and infaunal succession stage (Table B-2). Habitat quality as measured by the OSI ranges from –10 to +11. The lowest value (-10) is given to those bottoms that have low or no dissolved oxygen in the overlying bottom water, no apparent macrofaunal life, and methane gas present in the sediment (Rhoads and Germano 1982, 1986). The highest possible OSI value is +11 and reflects a mature benthic community in relatively undisturbed conditions. These conditions are characterized by an aerobic bottom with a deep RPD, evidence of a mature macrofaunal assemblage, and no apparent methane gas bubbles at depth. An OSI of greater than +6 is considered indicative of undisturbed benthic conditions and/or a recovered benthic community. The index has proven to be a useful parameter for mapping disturbance gradients in an area and documenting ecosystem recovery after disturbance (Germano and Rhoads 1984; Revelas et al. 1987; Valente et al. 1992).

The OSI may change seasonally because the mean apparent RPD depths vary as a result of temperature-controlled changes in bioturbation rates and sediment oxygen demand. Furthermore, the successional status of a station may change over the course of a season due to recruitment and mortality patterns or the disturbance history of the bottom. Stage III communities tend to persist over periods of several years unless they are eliminated by increased organic loading, extended periods of hypoxia, or burial by thick layers of dredged material. The recovery of Stage III communities following such a disturbance may take several years due to their relatively conservative rates of recruitment, intrinsic population increases, and ontogenic growth rates (Germano et al. 1994).

Table B-2.

Organism-Sediment Index (OSI) Terms and Formulation

Parameter	Index Value
A. Mean RPD Depth (choose one)	
0.00 cm	0
0.01 – 0.75 cm	1
0.76 – 1.50 cm	2
1.51 – 2.25 cm	3
2.26 – 3.00 cm	4
3.01 – 3.75 cm	5
> 3.75 cm	6
B. Successional Stage (choose one)	
Azoic	-4
Stage I	1
Stage I – II	2
Stage II	3
Stage II – III	4
Stage III	5
Stage I on III	5
Stage II on III	5
C. Chemical Parameters (choose all that apply)	
Methane Present	-2
No/Low Dissolved Oxygen	-4
Calculation of Organism-Sediment Index (OSI)	
OSI = Total of above indices (A+B+C)	
Range of possible OSI values is -10 to +11	

The Organism-Sediment Index is useful for characterizing benthic habitat quality and making comparisons among soft-bottom areas, where the sediment-profile imaging camera is able to penetrate into the sediment. In hard bottom environments (i.e., rocky substrates), camera penetration is prevented and the standard suite of measurements cannot be made.

3.8 Sediment Thickness

Sediment-profile imaging can be used to detect the thickness of depositional and dredged material. Recently deposited material is usually evident because of its unique optical reflectance and/or color relative to the underlying material representing the pre-disposal surface. In most cases, the point of contact between the two layers is clearly visible as a textural change in sediment composition, facilitating measurement of the thickness of the newly deposited layer. Layers ranging in thickness from approximately 1 mm to 20 cm (height of the optical window) can be measured. The thickness of newly deposited layers can be determined by measuring the linear distance between the pre- and post-disposal sediment-water interface.

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Appendix C

Sediment-Profile Image Results for RDS
September 2003 Survey

Table C-1
Sediment-Profile Image Results for Inner Stations at RDS

Station	Rep	Date	Time	GrnSize Major Mode (phi)	GrnSize Range	Min Pen (cm)	Max Pen (cm)	Avg Pen (cm)	RPD Area	RPD Mean (cm)	RPD min (cm)	RPD max (cm)	No. Mudclasts	MC Avg Diam (cm)	Methane?	Boundary Roughness (cm)	BR Process (phys/bio)	Low DO?	No. Feeding Voids	Feeding Void Min. Depth (cm)	Feeding Void Max. Depth (cm)	Feeding Void Avg. Depth (cm)	Successional Stage	OSI	DM present?	Thickness of Total DM Layer (cm)	Thickness of Recent DM Layer (cm)	COMMENT
I-1	A2	9/5/2003	2:44 PM	>4	>4 to 1	5.92	6.57	6.2	32.1	2.2	1.45	3.38	0		N	0.7	B	N	0			0.00	Stage II	6	Y	>pen		DM>pen; dm=silt-clay w/ some sand; red sed@depth
I-1	B2	9/5/2003	2:45 PM	>4	>4 to 1	7.44	8.08	7.8	32.6	2.3	1.9	2.66	0		N	0.6	B	N	1	5.69	5.69	5.69	Stage I on III	9	Y	>pen		DM>pen; dm-silt-clay w/ fine sand; reduced@depth; void@depth
I-1	C2	9/5/2003	2:48 PM	>4	>4 to 1	6.34	7.48	6.9	37.9	2.6	1.59	3.77	2	0.69	N	1.1	P	N	0			0.00	Stage I	5	Y	>pen		DM>pen; reduced@depth; silt-clay with fine sand component
I-2	A2	9/5/2003	1:05 PM	>4	>4 to 1	8.99	10.1	9.5	47.3	3.3	2.59	3.99	0		N	1.1	B	N	3	0.69	8.05	4.37	Stage I on III	10	Y	>pen		DM>pen; reduced@depth; silt-clay w/ fine sand; surface burrow
I-2	B2	9/5/2003	1:07 PM	>4	>4 to 1	8.32	8.77	8.5	45.7	3.2	1.83	4.9	0		N	0.4	B	N	1	7.96	7.96	7.96	Stage I on III	10	Y	>pen		DM>pen; reduced@depth; burrow/void at depth; silt-clay w/ significant fine sand
I-2	C2	9/5/2003	1:31 PM	>4	>4 to 1	9.22	9.75	9.5	36.8	2.6	1.9	2.93	0		N	0.5	B	N	1	7.97	7.97	7.97	Stage I on III	9	Y	>pen		DM>pen; dm has reduced sed band; void@depth; substantial fine sand component
I-3	A2	9/5/2003	3:38 PM	>4	>4 to 1	6.49	9.53	8.0	23.6	1.6	0.16	3.77	0		N	3.0	B	N	1	4.52	4.52	4.52	Stage I on III	8	Y	>pen		DM>pen; dm is silt-clay with sand; reduced patches@depth; patchy RPD; thin void but large mound with reduced pellets around opening
I-3	B2	9/5/2003	3:41 PM	>4	>4 to 1	10	10.9	10.4	35	2.4	1.9	2.58	0		N	0.8	B	N	1	8.12	8.12	8.12	Stage I on III	9	Y	>pen		DM>pen; dm=silt-clay with fine sand; band of red sed@depth; small ; multiple DM layers
I-3	C2	9/5/2003	3:42 PM	>4	>4 to 1	8.31	9.3	8.8	31.1	2.2	1.18	3.04	0		N	1.0	B	N	1	4.67	4.67	4.67	Stage I on III	8	Y	>pen	6	DM>pen; dm=silt-clay with fine sand; band of red sed@depth; small ; multiple DM layers
I-4	A1	9/5/2003	4:45 PM	>4	>4 to 2	11	12.1	11.6	36.9	2.6	1.98	3.84	0		N	1.1	B	N	1	6.76	6.76	6.76	Stage I on III	9	Y	>pen	4.3	DM>pen; newer DM lyr/relic dm; new lyr=4.3 cm; band of red sed=bottom of new dm layer; small void
I-4	B2	9/5/2003	4:57 PM	>4	>4 to 2	9.87	10.7	10.3	46.4	3.2	1.7	5.3	0		N	0.9	B	N	4	3.88	7.25	5.57	Stage I on III	10	Y	>pen	4.9	DM>pen; new dm lyr/relic; red sed band; voids @ z
I-4	C2	9/5/2003	4:58 PM	>4	>4 to 2	11	11.3	11.2	42.1	2.9	2.09	4.11	0		N	0.3	B	N	0			0.00	Stage I on III	9	Y	>pen	4.86	DM>pen; newer dm lyr/relic; red sed band=bottom of new dm lyr; burrow opening, fecal mound
I-5	D2	9/6/2003	8:31 AM	4-3	>4 to 1	10.1	10.6	10.4	49.6	3.5	1.6	5.81	1	0.83	N	0.5	P	N	0			0.00	Stage I on III	10	Y	>pen		recent DM>pen; sandy dm with grey clay; poorly sorted; burrows
I-5	E2	9/6/2003	8:32 AM	4-3	>4 to 1	9.95	10.5	10.2	59	4.1	2.75	5.44	0		N	0.5	B	N	0			0.00	Stage I on III	11	Y	>pen		recent DM>pen; sandy dm with grey clay; well-developed RPD; extensive subsurface burrows
I-5	H2	9/6/2003	#######	4-3	>4 to 1	6.65	8.85	7.8	39.4	2.7	1.8	3.76	2	0.37	N	2.2	P	N	0			0.00	Stage I on III	9	Y	>pen		recent DM>pen; sandy dm with grey clay; chaotic fabric; burrows
I-6	A2	9/5/2003	#######	4-3	>4 to 1	7.4	8.01	7.7	46.9	3.3	1.87	5.9	1	0.52	N	0.6	B	N	2	2.43	4.1	3.27	Stage I on III	10	Y	>pen		recent DM>pen; sandy grey clay w/ brown RPD; voids/burrows at depth
I-6	D2	9/6/2003	8:38 AM	4-3	>4 to 1	7.67	8.77	8.2	58.8	4.1	3	5.28	0		N	1.1	B	N	4	3.38	7.85	5.62	Stage I on III	11	Y	>pen		recent DM>pen; brown RPD over sandy grey clay; extensive void/burrow subsurface network

Table C-1
Sediment-Profile Image Results for Inner Stations at RDS

Station	Rep	Date	Time	GrnSize Major Mode (phi)	GrnSize Range	Min Pen (cm)	Max Pen (cm)	Avg Pen (cm)	RPD Area	RPD Mean (cm)	RPD min (cm)	RPD max (cm)	No. Mudclasts	MC Avg Diam (cm)	Methane?	Boundary Roughness (cm)	BR Process (phys/bio)	Low DO?	No. Feeding Voids	Feeding Void Min. Depth (cm)	Feeding Void Max. Depth (cm)	Feeding Void Avg. Depth (cm)	Successional Stage	OSI	DM present?	Thickness of Total DM Layer (cm)	Thickness of Recent DM Layer (cm)	COMMENT
I-6	E2	9/6/2003	8:39 AM	>4	>4 to 2	8.5	9.45	9.0	47	3.3	1.75	4.29	6	0.3	N	0.9	B	N	1	4.9	4.9	4.90	Stage I on III	10	Y	>pen		DM>pen; brown RPD over grey clay; prominent void
I-7	A2	9/5/2003	1:47 PM	>4	>4 to 2	9.87	10.3	10.1	43.4	3.0	1.72	6.26	0		N	0.4	B	N	1	7.17	7.17	7.17	Stage I on III	10	N			ambient muddy sed>pen; small void; possibly very old dm ?
I-7	B2	9/5/2003	1:49 PM	>4	>4 to 2	9.64	11	10.3	35.5	2.5	1.41	3.57	0		N	1.4	B	N	2	3.12	5.24	4.18	Stage I on III	9	N			ambient muddy sed>pen; prominent burrow+void; fecal mound
I-7	C2	9/5/2003	1:51 PM	>4	>4 to 2	9.71	10.1	9.9	37.8	2.6	1.45	4.52	0		N	0.4	B	N	1	5.43	5.43	5.43	Stage I on III	9	N			ambient muddy sed>pen
I-8	A2	9/5/2003	1:38 PM	>4	>4 to 2	11.2	12.7	11.9	39.3	2.7	1.83	3.42	5	0.61	N	1.5	P	N	2	4.03	4.55	4.29	Stage I on III	9	Y	4.71	4.71	newer DM lyr over ambient sediment or possibly relic DM; relic RPD, small void
I-8	B2	9/5/2003	1:39 PM	>4	>4 to 2	9.56	10.4	10.0	40.3	2.8	1.15	4.22	0		N	0.9	B	N	5	3.73	9.63	6.68	Stage I on III	9	Y	5.7		newer DM lyr over ambient sediment or possibly relic DM; relic RPD, small voids
I-8	C2	9/5/2003	1:42 PM	>4	>4 to 2	8.13	8.54	8.3	31.2	2.2	0.81	3.27	0		N	0.4	B	N	1	6.6	6.6	6.60	Stage I on III	8	Y	5.16	5.16	newer DM lyr over ambient sediment or possibly relic DM; relic RPD, large void & polychaete
I-9	A2	9/5/2003	2:26 PM	>4	>4 to 2	10.4	11	10.7	41	2.9	1.75	3.61	0		N	0.6	B	N	0			0.00	Stage I on III	9	N			ambient muddy sed>pen; possibly old or weathered dm?; burrows
I-9	B2	9/5/2003	2:28 PM	>4	>4 to 2	14.3	15	14.6	37.4	2.6	0.77	6.91	0		N	0.7	B	N	7	4.44	10.1	7.28	Stage I on III	9	N			ambient muddy sed>pen; possibly old dm? multiple voids; dense Stg 1 tubes
I-9	C2	9/5/2003	2:29 PM	>4	>4 to 2	10.6	12	11.3	39.5	2.8	1.49	4.67	0		N	1.3	B	N	2	3.68	5.76	4.72	Stage I on III	9	N			ambient muddy sed>pen; possibly old dm? biological surface reworking; voids
I-10	A2	9/5/2003	3:59 PM	>4	>4 to 2	11.2	12	11.6	39	2.7	1.29	3.62	0		N	0.8	B	N	2	5.73	6.5	6.12	Stage I on III	9	N			ambient muddy sed>pen; trace of old dm in upper 5 cm; small void
I-10	B2	9/5/2003	4:00 PM	>4	>4 to 2	7.63	9.38	8.5	28	2.0	0.66	3.8	0		N	1.8	P	N	0			0.00	Stage I -> II	5	N			potentially relic DM, but looks more like ambient sediment
I-10	C2	9/5/2003	4:02 PM	>4	>4 to 2	10.9	11.3	11.1	38.7	2.7	0.84	4.6	0		N	0.5	B	N	3	3.04	5.84	4.44	Stage I on III	9	N			potentially relic DM, but looks more like ambient sediment; fecal mounds; voids
I-11	B2	9/5/2003	4:25 PM	>4	>4 to 2	9.98	10.9	10.4	55.8	3.9	1.82	7.14	0		N	0.9	B	N	4	2.7	8.57	5.64	Stage I on III	11	N			potentially relic DM, but looks more like ambient sediment; small voids, dense Stage 1 tubes
I-11	C2	9/5/2003	4:26 PM	>4	>4 to 2	10.4	10.7	10.5	67	4.7	2.63	5.88	0		N	0.3	B	N	2	5.39	6.07	5.73	Stage I on III	11	N			most likely ambient sediment -- prominent voids; fecal mound
I-11	D2	9/5/2003	4:29 PM	>4	>4 to 2	8.85	9.71	9.3	42.8	3.0	1.45	5.2	0		N	0.9	B	N	5	2.48	7.85	5.17	Stage I on III	9	N			potentially relic DM, but looks more like ambient sediment; numerous small voids
I-12	A2	9/5/2003	2:35 PM	>4	>4 to 2	9.53	11.3	10.4	35.8	2.5	1.22	3.12	0		N	1.8	P	N	4	4.98	7.77	6.38	Stage I on III	9	Y	4.18	4.18	newer DM lyr over potentially relic DM; red sed band@depth=bottom of new lyr; voids
I-12	B2	9/5/2003	2:36 PM	>4	>4 to 2	7.02	7.97	7.5	29.6	2.1	0.77	5.01	0		N	1.0	P	N	0			0.00	Stage II	6	Y	4.22	4.22	newer DM lyr over potentially relic DM; indistinct red sed band@depth
I-12	C2	9/5/2003	2:38 PM	>4	>4 to 2	8.12	9.15	8.6	31.8	2.2	1.26	4.07	0		N	1.0	B	N	1	8.46	8.46	8.46	Stage I on III	8	Y	4.03	4.03	newer DM lyr over potentially relic DM; red sed band@depth=bottom of new lyr
I-13	D1	9/5/2003	3:53 PM	>4	>4 to 2	7.93	8.92	8.4	32.8	2.3	1.03	2.89	0		N	1.0	B	N	3	3.26	4.37	3.82	Stage I on III	9	Y	3.57	3.57	newer DM lyr over potentially relic DM; red sed band@depth; several voids and polychaete=Nephtys?

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Station	Rep	Date	Time	GrnSize Major Mode (phi)	GrnSize Range	Min Pen (cm)	Max Pen (cm)	Avg Pen (cm)	RPD Area	RPD Mean (cm)	RPD min (cm)	RPD max (cm)	No. Mudclasts	MC Avg Diam (cm)	Methane?	Boundary Roughness (cm)	BR Process (phys/bio)	Low DO?	No. Feeding Voids	Feeding Void Min. Depth (cm)	Feeding Void Max. Depth (cm)	Feeding Void Avg. Depth (cm)	Successional Stage	OSI	DM present?	Thickness of Total DM Layer (cm)	Thickness of Recent DM Layer (cm)	COMMENT
I-13	**E2**	9/6/2003	8:18 AM	>4	>4 to 2	12.6	15.1	13.9	31	2.2	0.2	2.85	0		N	2.4	B	N	1	11.9	11.9	11.87	Stage III	8	Y	>pen		muddy DM>pen; some fine sand mixed w/ mud; RPD indistinct; large burrow/void@z
I-13	**F2**	9/6/2003	8:24 AM	>4	>4 to 2	12.9	13.9	13.4	31	2.2	0.8	3.45	0		N	0.9	B	N	1	6.11	6.11	6.11	Stage I on III	8	Y	4.2		newer DM lyr over potentially relic DM
I-14	**A2**	9/5/2003	4:38 PM	>4	>4 to 2	9.64	10.4	10.0	27.5	1.9	0.88	2.51	0		N	0.8	B	N	2	5.66	9.71	7.69	Stage I on III	8	Y	>pen		older (relic) muddy DM>pen; faint grey clay band below RPD
I-14	**B2**	9/5/2003	4:39 PM	>4	>4 to 2	14.6	15	14.8	34.1	2.4	1.07	3.95	0		N	0.4	B	N	4	3.04	7.51	5.28	Stage I on III	9	Y	>pen		older (relic) muddy DM>pen; red sed@z; multiple feeding voids
I-14	**C2**	9/5/2003	4:41 PM	>4	>4 to 2	10.4	12.6	11.5	39.8	2.8	0	4.49	0		N	2.1	P	N	1	1.79	1.79	1.79	Stage I on III	9	Y	>pen		older (relic) muddy DM>pen; redsed@z; red sed@surface; patchy RPD
I-15	**A1**	9/5/2003	2:53 PM	<-1	>4 to <-1	0	1.56	0.8	IND	IND	IND	IND	0		N	1.6	P	N	NA			0.00	IND	IND	Y	>pen		underpenetration; angular rock = DM; rock on top of brown muddy substrate; clay clasts
I-15	**B1**	9/5/2003	2:54 PM	<-1	>4 to <-1	0	0.61	0.3	IND	IND	IND	IND	0		N	0.6	P	N	NA			0.00	IND	IND	Y	>pen		underpenetration; several rocks = DM; rock on top of brown muddy substrate
I-16	**A2**	9/5/2003	3:26 PM	4-3	>4 to 2	8.2	8.96	8.6	43.9	3.1	1.75	3.92	0		N	0.8	P	N	2	5.46	6.38	5.92	Stage I on III	10	Y	>pen		recent DM>pen; muddy dm with significant fine sand component; reduced@depth; voids
I-16	**B2**	9/5/2003	3:28 PM	4-3	>4 to 1	6.8	7.48	7.1	61.2	4.3	3.24	6.04	0		N	0.7	P	N	0			0.00	Stage I on III	11	Y	>pen		recent DM>pen; muddy dm with significant fine sand component; reduced@depth; burrows
I-16	**C2**	9/5/2003	3:31 PM	4-3	>4 to 1	6.57	7.75	7.2	36.9	2.6	1.19	4.42	0		N	1.2	P	N	2	3.16	3.72	3.44	Stage I on III	9	Y	>pen		recent DM>pen; muddy with significant fine sand; reduced@depth; voids on right
I-17	**A2**	9/5/2003	5:04 PM	>4	>4 to 2	9.38	9.87	9.6	50.9	3.5	2.21	4.67	7	0.68	N	0.5	P	N	3	2.66	4.37	3.52	Stage I on III	10	Y	>pen	7.14	DM>pen; possible layering newer DM over older; red sed band@depth; mud clasts
I-17	**B2**	9/5/2003	5:06 PM	>4	>4 to 2	10.2	11.2	10.7	42.2	2.9	2.24	4.52	0		N	1.0	B	N	0			0.00	Stage II -> III	8	Y	>pen		newer DM lyr over relic DM>pen; red sed band@z=bottom of newer layer; burrows
I-17	**C2**	9/5/2003	5:10 PM	>4	>4 to 2	10.3	10.5	10.4	44.7	3.1	2.29	4.07	0		N	0.2	B	N	4	3.68	9.38	6.53	Stage I on III	10	Y	>pen	7.52	newer DM lyr over older DM or ambient>pen; void@z; distinct red sed band; relic RPD@z?
I-18	**A2**	9/5/2003	3:00 PM	>4	>4 to 2	1.8	3.76	2.8	38.7	2.7	1.72	3.8	0		N	2.0	P	N	0			0.00	IND	IND	Y	>pen		muddy DM>pen; underpen; RPD>pen
I-18	**B2**	9/5/2003	3:01 PM	>4	>4 to 2	7.48	8.16	7.8	54.2	3.8	2.21	5.24	0		N	0.7	P	N	2	5.43	6.65	6.04	Stage I on III	11	Y	>pen		recent DM>pen; muddy DM reduced@depth; grey streaks; prominent feeding void lwr right
I-18	**C2**	9/5/2003	3:02 PM	4-3	>4 to 1	6.69	8.5	7.6	38.6	2.7	1.3	3.5	0		N	1.8	P	N	0			0.00	Stage I on III	9	Y	>pen		recent DM>pen; muddy fine sand; reduced@depth, grey streaks; distinct Stg 3 tubes; burrows
I-19	**A2**	9/5/2003	3:17 PM	>4	>4 to 2	9.11	9.3	9.2	40.9	2.9	2.06	3.42	0		N	0.2	B	N	2	5.96	7.4	6.68	Stage I on III	9	Y	>pen	6.42	newer DM over older DM>pen; relic RPD; band of reduced sed@depth=bottom of new lyr; small voids (?); minor sand component in muddy DM

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Station	Rep	Date	Time	GrnSize Major Mode (phi)	GrnSize Range	Min Pen (cm)	Max Pen (cm)	Avg Pen (cm)	RPD Area	RPD Mean (cm)	RPD min (cm)	RPD max (cm)	No. Mudclasts	MC Avg Diam (cm)	Methane?	Boundary Roughness (cm)	BR Process (phys/bio)	Low DO?	No. Feeding Voids	Feeding Void Min. Depth (cm)	Feeding Void Max. Depth (cm)	Feeding Void Avg. Depth (cm)	Successional Stage	OSI	DM present?	Thickness of Total DM Layer (cm)	Thickness of Recent DM Layer (cm)	COMMENT
I-19	**B2**	9/5/2003	3:18 PM	>4	>4 to 2	9.07	10.4	9.7	53.9	3.8	2.48	7.1	0		N	1.3	P	N	5	3.76	8.69	6.23	Stage I on III	11	Y	>pen	5.96	newer DM over older DM>pen; faint relic RPD; red sed banding; some sand; multiple voids, oxidized burrow
I-19	**C2**	9/5/2003	3:20 PM	>4	>4 to 2	9.72	10	9.9	49.5	3.5	1.76	5.32	0		N	0.3	P	N	4	1.61	6.41	4.01	Stage I on III	10	Y	>pen	7.59	newer DM over older DM>pen; faint relic RPD; red sed banding; some sand; multiple voids, oxidized burrow
I-20	**A2**	9/5/2003	5:17 PM	>4	>4 to 2	13.8	15.4	14.6	38.8	2.7	1.83	3.89	0		N	1.6	P	N	0			0.00	Stage I on III	9	Y	4.7	4.83	newer DM over older DM or ambient>pen; red sed banding; some sand; dense Stg 1 tubes; burrows
I-20	**B2**	9/5/2003	5:19 PM	>4	>4 to 2	8.5	11.8	10.1	30.5	2.1	0.39	4.03	0		N	3.3	P	N	1	4.9	4.9	4.90	Stage I on III	8	Y	5.2		newer DM over older DM or ambient>pen; large burrow opening with plume showing boundary layer flow
I-20	**C2**	9/5/2003	5:20 PM	>4	>4 to 2	9.95	10.4	10.2	29.4	2.1	0.8	3.04	0		N	0.5	B	N	3	5.77	6.3	6.04	Stage I on III	8	Y	trace		trace of recent DM on either older DM or ambient sediment -
I-21	**A2**	9/5/2003	#######	>4	>4 to 2	13.3	13.9	13.6	43.1	3.0	1.3	5.78	0		N	0.6	B	N	0			0.00	Stage I on III	9	Y	5.5		dense Stg 1 tubes, reduced "cake-batter" texture appears to be recent DM layer that has been rapidly recolonized by opportunists; burrows
I-21	**B2**	9/5/2003	#######	>4	>4 to 2	12.2	12.5	12.4	37.5	2.6	1.15	3.61	0		N	0.3	B	N	1	2.28	2.28	2.28	Stage I on III	9	Y	trace		trace of organic-rich layering in surface; small void at left
I-21	**G2**	9/5/2003	#######	>4	>4 to 2	8.85	10.4	9.6	32.9	2.3	0.77	3.95	0		N	1.6	P	N	0			0.00	Stage I on III	9	Y	>pen		newer DM>pen; possible layering new over old; band of reduced sed@depth; burrows
I-22	**A2**	9/5/2003	#######	>4	>4 to 2	11.2	13.1	12.1	49.2	3.4	2.33	4.41	0		N	1.9	P	N	3	5.39	8.95	7.17	Stage I on III	10	Y	>pen		older (relic) DM>pen; possible ambient sediment; band of reduced sed@depth; voids
I-22	**B2**	9/5/2003	#######	>4	>4 to 2	10.1	10.5	10.3	38.2	2.7	1.18	3.69	0		N	0.5	B	N	4	3.19	5.91	4.55	Stage I on III	9	Y	4.7	4.71	newer DM layer over older DM or ambient>pen; grey band=bottom of new lyr; multiple voids
I-22	**C2**	9/5/2003	#######	>4	>4 to 2	8.35	9.11	8.7	35.6	2.5	1.22	3.72	0		N	0.8	B	N	1	4.17	4.17	4.17	Stage I on III	9	Y	4.5		newer DM layer over older DM or ambient>pen; reduced banding shows horizon of old SWI
I-23	**A2**	9/5/2003	#######	>4	>4 to 2	10.1	10.5	10.3	43.8	3.1	2.29	4.41	0		N	0.5	B	N	0			0.00	Stage II -> III	9	Y	7.78	7.78	newer DM lyr over older DM or ambient sediment; burrows
I-23	**B2**	9/5/2003	#######	>4	>4 to 2	8.65	9.11	8.9	42.3	3.0	1.83	3.61	0		N	0.5	B	N	1	5.54	5.54	5.54	Stage I on III	9	Y	7.03	7.03	newer DM lyr over older DM or ambient sediment;void/burrow on right
I-23	**C2**	9/5/2003	#######	>4	>4 to 2	7.93	8.73	8.3	43.1	3.0	1.86	5.25	0		N	0.8	B	N	1	5.77	5.77	5.77	Stage I on III	9	Y	6.56	6.56	newer DM lyr over older DM or ambient sediment; large void in center
I-24	**A2**	9/5/2003	#######	>4	>4 to 2	7.86	8.08	8.0	45	3.2	1.65	4.14	5	1.01	N	0.2	P	N	0			0.00	Stage I	6	Y	>pen		DM>pen; mud clasts; back-filled voids, probably Stage 3 present; brown rpd transition to grey to black

Table C-1
Sediment-Profile Image Results for Inner Stations at RDS

Station	Rep	Date	Time	GrnSize Major Mode (phi)	GrnSize Range	Min Pen (cm)	Max Pen (cm)	Avg Pen (cm)	RPD Area	RPD Mean (cm)	RPD min (cm)	RPD max (cm)	No. Mudclasts	MC Avg Diam (cm)	Methane?	Boundary Roughness (cm)	BR Process (phys/bio)	Low DO?	No. Feeding Voids	Feeding Void Min. Depth (cm)	Feeding Void Max. Depth (cm)	Feeding Void Avg. Depth (cm)	Successional Stage	OSI	DM present?	Thickness of Total DM Layer (cm)	Thickness of Recent DM Layer (cm)	COMMENT
I-24	**C2**	9/5/2003	#######	>4	>4 to 2	7.21	8.16	7.7	49.5	3.5	2.28	4.56	0		N	1.0	P	N	2	3.91	4.48	4.20	Stage I on III	10	Y	>pen		DM>pen; appears recent; distinct grey banding@depth transitioning to black; voids
I-24	**F2**	9/6/2003	8:47 AM	>4	>4 to 2	10.3	11.1	10.7	55.7	3.9	1.94	5.01	0		N	0.8	P	N	1	5.2	5.2	5.20	Stage I on III	11	Y	>pen		DM>pen; appears recent; distinct color changes - brown rpd to grey to black; voids
I-25	**A2**	9/5/2003	#######	>4	>4 to 2	10.2	11.7	11.0	44.7	3.1	2.13	4.42	0		N	1.5	B	N	3	4.1	5.58	4.84	Stage I on III	10	Y	>pen	6.68	newer DM lyr over older DM; band of reduced sed@depth; prominent feeding void; polychaete
I-25	**B2**	9/5/2003	#######	>4	>4 to 2	9.04	10.2	9.6	35.3	2.5	1.84	4	0		N	1.2	B	N	0			0.00	Stage I	5	Y	6.58	6.58	newer DM lyr over older DM or ambient; band of reduced sed@depth; grey streaks
I-25	**C2**	9/5/2003	#######	>4	>4 to 2	8.65	9.61	9.1	35.3	2.5	1.29	3.08	0		N	1.0	B	N	2	2.39	7.74	5.07	Stage I on III	9	Y	>pen	7.21	newer DM>pen; distinct black and grey streaks=DM; multiple depositional layers
I-26	**A2**	9/6/2003	9:36 AM	>4	>4 to 2	9.91	10.5	10.2	43.6	3.1	1.67	4.3	0		N	0.6	P	N	2	3.65	5.54	4.60	Stage I on III	10	N			ambient muddy sed>pen; feeding void; no black sed @ depth
I-26	**B2**	9/6/2003	9:38 AM	>4	>4 to 2	8.84	10.7	9.8	48.3	3.4	1.83	5.43	0		N	1.8	P	N	1	5.35	5.35	5.35	Stage I on III	10	N			ambient muddy sed>pen; large burrow/feeding void; stick amphipod
I-26	**C1**	9/6/2003	9:38 AM	>4	>4 to 2	7.97	8.69	8.3	54.8	3.8	2.03	6.57	0		N	0.7	B	N	0			0.00	Stage I on III	11	N			ambient muddy sed>pen; dense brittlestars (Amphiurids)
I-27	**A2**	9/6/2003	9:28 AM	>4	>4 to 1	10.7	11.6	11.2	43.3	3.0	1.9	3.75	0		N	0.8	B	N	4	4.47	7.55	6.01	Stage I on III	10	N			ambient muddy sed>pen; low RPD contrast; minor fine sand component; multiple feeding voids
I-27	**B2**	9/6/2003	9:29 AM	>4	>4 to 2	9.95	11.3	10.6	47.1	3.3	1.26	5.06	0		N	1.4	P	N	1	4.44	4.44	4.44	Stage I on III	10	N			ambient muddy sed>pen; low RPD contrast; one void/burrow
I-27	**C2**	9/6/2003	9:30 AM	>4	>4 to 2	11.2	11.8	11.5	48.5	3.4	1.6	5.06	0		N	0.6	P	N	1	9.15	9.15	9.15	Stage I on III	10	N			ambient muddy sed>pen; low RPD contrast; one void; burrow opening/fecal deposit on right?
I-28	**A2**	9/6/2003	9:22 AM	>4	>4 to 2	11.2	11.8	11.5	18.2	1.3	0	2.51	6	0.33	N	0.6	P	N	0			0.00	Stage I on III	7	Y	3.2		reduced sed near surface; thin/patchy RPD; red sed patches@z; mud clasts; burrows
I-28	**B2**	9/6/2003	9:22 AM	4-3	>4 to 1	9.26	10.7	10.0	48.5	3.4	2.09	4.37	0		N	1.4	P	N	3	3.83	6.3	5.07	Stage I on III	10	Y	trace		trace of reduced sed/DM in surface layer; sandier near surface and silt-clay@z; small and indistinct feeding voids
I-28	**C2**	9/6/2003	9:23 AM	>4	>4 to 2	11.5	13	12.2	40	2.8	0.77	4.49	0		N	1.6	P	N	2	3.04	7.82	5.43	Stage I on III	9	Y	9.1		newer DM over potentially reclic or more likely ambient sediment; silt-clay with reduced patches@depth; patchy RPD; feeding voids
I-29	**A2**	9/6/2003	9:15 AM	>4	>4 to 2	11	11.3	11.2	38.7	2.7	1.87	3.88	4	0.4	N	0.4	P	N	2	5.01	6.41	5.71	Stage I on III	9	N			ambient muddy sed>pen; possible old DM but very weathered; mud clasts=possible farfield DM influence
I-29	**B2**	9/6/2003	9:16 AM	>4	>4 to 2	11.3	11.8	11.5	33	2.3	0.88	3.92	0		N	0.5	B	N	3	5.5	6.83	6.17	Stage I on III	9	N			ambient muddy sed>pen; possible old DM but very weathered; fecal layer

Table C-1
Sediment-Profile Image Results for Inner Stations at RDS

Station	Rep	Date	Time	GrnSize Major Mode (phi)	GrnSize Range	Min Pen (cm)	Max Pen (cm)	Avg Pen (cm)	RPD Area	RPD Mean (cm)	RPD min (cm)	RPD max (cm)	No. Mudclasts	MC Avg Diam (cm)	Methane?	Boundary Roughness (cm)	BR Process (phys/bio)	Low DO?	No. Feeding Voids	Feeding Void Min. Depth (cm)	Feeding Void Max. Depth (cm)	Feeding Void Avg. Depth (cm)	Successional Stage	OSI	DM present?	Thickness of Total DM Layer (cm)	Thickness of Recent DM Layer (cm)	COMMENT
I-29	**C2**	9/6/2003	9:17 AM	>4	>4 to 2	9.45	11.5	10.5	26.4	1.8	0.81	2.89	0		N	2.1	B	N	2	3.12	3.73	3.43	Stage I on III	8	N			ambient muddy sed>pen; possible old DM but very weathered; fecal layer & biogenic mound left
I-30	**A2**	9/5/2003	5:37 PM	>4	>4 to 2	12.3	13.1	12.7	37.8	2.6	1.18	4.56	1	1.3	N	0.8	P	N	3	5.66	9.78	7.72	Stage I on III	9	N			ambient muddy sed>pen; possible old DM but very weathered; prominent feeding voids
I-30	**B2**	9/5/2003	5:39 PM	>4	>4 to 2	10.1	11.2	10.7	40.1	2.8	1.86	3.69	0		N	1.1	P	N	1	10.2	10.2	10.17	Stage I on III	9	N			ambient muddy sed>pen;possible old DM but weathered; feeding void lower center
I-30	**C2**	9/5/2003	5:41 PM	>4	>4 to 2	11.1	12.1	11.6	47	3.3	1.9	4.82	0		N	1.0	P	N	5	6.07	9.94	8.01	Stage I on III	10	Y	5.2		Multiple feeding voids -- looks like layer of dredged material at this one replicate due to highly reduced band of sediment

Table C-2
Sediment-Profile Image Results for Outer Stations at RDS

Station	Rep	Date	Time	GrnSize Major Mode (phi)	GrnSize Range	Min Pen (cm)	Max Pen (cm)	Avg Pen (cm)	RPD Area	RPD Mean (cm)	RPD min (cm)	RPD max (cm)	No. Mudclasts	MC Avg Diam (cm)	Methane?	Boundary Roughness (cm)	BR Process (phys/bio)	Low DO?	No. Feeding Voids	Feeding Void Min. Depth (cm)	Feeding Void Max. Depth (cm)	Feeding Void Avg. Depth (cm)	Successional Stage	OSI	DM present?	Thickness of Total DM Layer (cm)	Thickness of Recent DM Layer (cm)	COMMENT
O-1	**A2**	9/5/2003	10:59 AM	>4	>4 to 3	16.4	17.3	16.8	82.9	5.8	3.84	8.2	0		N	0.9	B	N	2	2.7	9.29	6.00	Stage I on III	11	N			ambient soft mud>pen; low RPD contrast; two prominent feeding voids; deep RPD
O-1	**B2**	9/5/2003	11:00 AM	>4	>4 to 3	12.5	13.4	12.9	70.5	4.9	3.23	6.11	0		N	0.9	P	N	0			0.00	Stage I on III	11	N			ambient soft mud>pen; low RPD contrast; deep RPD; burrows
O-1	**C2**	9/5/2003	11:03 AM	>4	>4 to 3	12.3	14.3	13.3	63.5	4.4	2.66	7.23	2	0.59	N	2.0	P	N	2	12.7	12.9	12.80	Stage I on III	11	N			ambient soft mud>pen; low RPD contrast; very small feeding voids lower left
O-2	**A2**	9/5/2003	10:50 AM	>4	>4 to 3	11.5	12	11.8	61.1	4.3	3.15	6.91	0		N	0.4	P	N	5	3.95	7.51	5.73	Stage I on III	11	N			ambient soft mud>pen; patches of reduced sed below RPD; multiple feeding voids
O-2	**B2**	9/5/2003	10:51 AM	>4	>4 to 2	12.2	13.1	12.6	79.4	5.5	3.16	7.59	2	0.3	N	0.9	P	N	3	4.63	6.07	5.35	Stage I on III	11	N			ambient mud>pen; deep RPD; two feeding voids; vertical oxidized burrows
O-2	**C2**	9/5/2003	10:52 AM	>4	>4 to 3	11.2	11.9	11.5	53.5	3.7	1.64	5.89	0		N	0.7	B	N	1	5.35	5.35	5.35	Stage I on III	10	N			ambient mud>pen; low contrast RPD; prominent void and visible polychaete@depth
O-3	**A2**	9/5/2003	10:39 AM	>4	>4 to 2	9.53	10.5	10.0	36.9	2.6	1.64	2.45	0		N	0.9	B	N	5	4.55	8.19	6.37	Stage I on III	9	Y	5.39		DM surface depositional layer over ambient sed or relic DM; band of reduced sed=bottom of DM lyr; mutiple feeding voids
O-3	**B2**	9/5/2003	10:40 AM	>4	>4 to 2	10.2	11.6	10.9	41.9	2.9	1.83	3.61	0		N	1.4	P	N	2	4.59	6.26	5.43	Stage I on III	9	Y	4.48		DM depositional layer over ambient sed or relic DM (?); band of reduced sed=bottom of DM lyr; large void on right
O-3	**C2**	9/5/2003	10:42 AM	>4	>4 to 2	10.3	11.1	10.7	35.6	2.5	0.5	3.95	8	0.68	N	0.8	P	N	2	4.97	5.18	5.08	Stage I on III	9	Y	7.26		DM depositional lyr over ambient sed or relic DM (?); distinct band of reduced sed=bottom of DM lyr; numerous small mud clasts
O-4	**A2**	9/5/2003	10:21 AM	>4	>4 to 3	14.5	15.4	14.9	28.1	2.0	1.03	2.74	0		N	0.9	B	N	0			0.00	Stage I on III	8	N			ambient muddy sed>pen; low RPD contrast; dense surface tubes; shallow feeding void
O-4	**D2**	9/5/2003	10:29 AM	>4	>4 to 2	9.98	11.3	10.7	34.4	2.4	1.45	3	0		N	1.4	B	N	1	4.94	4.94	4.94	Stage I on III	9	N			ambient muddy sed>pen; low contrast RPD=very diffuse; prominent void right; biogenic roughness
O-4	**E2**	9/5/2003	10:31 AM	>4	>4 to 3	12	12.9	12.5	43.5	3.0	0.31	4.1	0		N	0.9	B	N	2	4.37	9.11	6.74	Stage I on III	10	N			ambient muddy sed>pen; biogenic surface roughness; low contrast RPD; small voids; dense Stage 1 tubes
O-5	**B2**	9/5/2003	2:16 PM	>4	>4 to 3	10.6	11.4	11.0	10.1	0.7	0	2.32	0		N	0.8	B	N	0			0.00	Stage I on III	6	N			ambient muddy sed>pen; shallow RPD; red sed present near surface; dense Stage 1 tubes & burrow/pellets in middle of picture
O-5	**C2**	9/5/2003	2:17 PM	>4	>4 to 2	10.9	11.7	11.3	25.6	1.8	0.77	3.42	0		N	0.8	B	N	0			0.00	Stage I on III	8	N			ambient muddy sed>pen; thin and patchy RPD; burrow opening left (?); low RPD contrast

Table C-2
Sediment-Profile Image Results for Outer Stations at RDS

Station	Rep	Date	Time	GrnSize Major Mode (phi)	GrnSize Range	Min Pen (cm)	Max Pen (cm)	Avg Pen (cm)	RPD Area	RPD Mean (cm)	RPD min (cm)	RPD max (cm)	No. Mudclasts	MC Avg Diam (cm)	Methane?	Boundary Roughness (cm)	BR Process (phys/bio)	Low DO?	No. Feeding Voids	Feeding Void Min. Depth (cm)	Feeding Void Max. Depth (cm)	Feeding Void Avg. Depth (cm)	Successional Stage	OSI	DM present?	Thickness of Total DM Layer (cm)	Thickness of Recent DM Layer (cm)	COMMENT
O-5	**D2**	9/5/2003	2:18 PM	>4	>4 to 2	10	10.3	10.1	36.5	2.5	0.24	3.95	0		N	0.2	B	N	2	4.4	5.13	4.77	Stage I on III	9	N			ambient muddy sed>pen; low RPD contrast; small feeding voids; dense Stg 1 tubes
O-6	**A2**	9/5/2003	4:10 PM	>4	>4 to 3	12.8	13.4	13.1	51.9	3.6	2.21	4.79	0		N	0.6	B	N	2	8.39	12.1	10.26	Stage I on III	10	N			ambient muddy sed>pen; prominent burrow opening; dense Stg 1 tubes; red sed@depth
O-6	**C2**	9/5/2003	4:14 PM	>4	>4 to 3	12.5	13.8	13.1	51.1	3.6	2.32	6.04	0		N	1.3	P	N	1	5.39	5.39	5.39	Stage I on III	10	N			ambient muddy sed>pen; feeding void right; red sed patch@depth
O-6	**D2**	9/5/2003	4:15 PM	>4	>4 to 3	11.5	13	12.2	44.6	3.1	0.96	4.53	0		N	1.5	P	N	0			0.00	Stage II -> III	9	N			ambient muddy sed>pen; reduced sed@depth; burrows
O-7	**A2**	9/6/2003	9:44 AM	>4	>4 to 3	12.2	13.1	12.7	46.7	3.3	1.79	5.66	0		N	0.9	B	N	2	9.95	12	10.97	Stage I on III	10	N			ambient muddy sed>pen; band of reduced sed below RPD; small feeding voids@depth
O-7	**B2**	9/6/2003	9:45 AM	>4	>4 to 2	12.3	12.9	12.6	48.1	3.4	2.09	5.24	0		N	0.6	B	N	2	4.48	5.06	4.77	Stage I on III	10	N			ambient muddy sed>pen; low RPD contrast=subtle transition; small feeding voids; dense Stg 1 tubes
O-7	**C2**	9/6/2003	9:47 AM	>4	>4 to 2	11.1	11.9	11.5	55.4	3.9	2.36	6.3	0		N	0.8	P	N	5	2.88	9.26	6.07	Stage I on III	11	N			ambient muddy sed>pen; reduced sed below RPD=strong contrast; multiple feeding voids
O-8	**A2**	9/6/2003	9:52 AM	>4	>4 to 2	10.8	11.6	11.2	41	2.9	1.33	4.45	0		N	0.8	P	N	3	2.63	9.37	6.00	Stage I on III	9	N			ambient muddy sed>pen; multiple feeding voids; moderate RPD contrast
O-8	**B2**	9/6/2003	9:53 AM	>4	>4 to 2	10.2	11.2	10.7	39.8	2.8	1.59	4.21	0		N	1.0	P	N	2	2.97	5.36	4.17	Stage I on III	9	N			ambient muddy sed>pen; several small feeding voids; low RPD contrast
O-8	**C2**	9/6/2003	9:55 AM	>4	>4 to 2	10.7	11.6	11.2	49.7	3.5	1.75	4.94	0		N	0.9	P	N	0			0.00	Stage II -> III	9	N			ambient muddy sed>pen; intermediate RPD contrast; burrows
O-9	**A2**	9/6/2003	10:17 AM	>4	>4 to 1	12.5	14	13.3	76.5	5.3	3.5	7.1	0		N	1.5	P	N	2	5.17	5.81	5.49	Stage I on III	11	N			ambient muddy sed>pen; some very fine sand present; low RPD contrast; prominent feeding void
O-9	**B2**	9/6/2003	10:18 AM	>4	>4 to 1	12	12.5	12.2	57.9	4.0	2.55	4.98	0		N	0.5	B	N	2	1.56	5.35	3.46	Stage III	11	N			ambient muddy sed>pen; some very fine sand present; low RPD contrast; several prominent feeding voids
O-9	**C2**	9/6/2003	10:21 AM	>4	>4 to 1	10.7	11	10.9	40.4	2.8	1.83	4.07	0		N	0.3	B	N	3	1.9	6.73	4.32	Stage I on III	9	N			ambient muddy sed>pen; some fine sand present; red sed@depth; burrow opening/fecal layer; feeding void
O-10	**A2**	9/6/2003	10:35 AM	>4	>4 to 3	12.7	13.2	12.9	74.3	5.2	3.61	6.91	0		N	0.5	B	N	3	2.93	8.58	5.76	Stage I on III	11	N			ambient muddy sed>pen; deep RPD; red sed@z=strong RPD contrast; multiple voids
O-10	**B2**	9/6/2003	10:36 AM	>4	>4 to 2	10.9	11.7	11.3	63.7	4.4	2.47	5.39	0		N	0.8	B	N	3	3.35	8.26	5.81	Stage I on III	11	N			ambient muddy sed>pen; low RPD contrast=subtle transition; several small feeding voids

Table C-2
Sediment-Profile Image Results for Outer Stations at RDS

Station	Rep	Date	Time	GrnSize Major Mode (phi)	GrnSize Range	Min Pen (cm)	Max Pen (cm)	Avg Pen (cm)	RPD Area	RPD Mean (cm)	RPD min (cm)	RPD max (cm)	No. Mudclasts	MC Avg Diam (cm)	Methane?	Boundary Roughness (cm)	BR Process (phys/bio)	Low DO?	No. Feeding Voids	Feeding Void Min. Depth (cm)	Feeding Void Max. Depth (cm)	Feeding Void Avg. Depth (cm)	Successional Stage	OSI	DM present?	Thickness of Total DM Layer (cm)	Thickness of Recent DM Layer (cm)	COMMENT
O-10	**C2**	9/6/2003	10:38 AM	>4	>4 to 2	13	13.6	13.3	66.1	4.6	3.08	5.73	0		N	0.6	B	N	2	9.89	12.2	11.04	Stage I on III	11	N			ambient muddy sed>pen; deep RPD w/ intermediate contrast; sparse Stg 1; one feeding void
O-11	**A2**	9/5/2003	5:26 PM	>4	>4 to 1	11.5	11.6	11.5	33.4	2.3	1.3	3.46	0		N	0.1	B	N	4	4.6	7.81	6.21	Stage I on III	9	Y	3.6		mostly ambient muddy sed w/ fine sand component>pen; low RPD contrast; band of grey sed below RPD=DM layer; several feeding voids
O-11	**B2**	9/5/2003	5:29 PM	4-3	>4 to 1	8.08	9.49	8.8	12.5	0.9	0	1.75	0		N	1.4	P	N	1	6.04	6.04	6.04	Stage III	7	N			ambient muddy fine sand>pen; thin RPD w/ red sed@surface; Stg 3 polychaete@z
O-11	**C2**	9/5/2003	5:30 PM	>4	>4 to 2	11	12	11.5	27.4	1.9	0.61	3.35	0		N	1.0	P	N	0			0.00	Stage I on III	8	Y	2.9		Mostly ambient muddy sed>pen; some fine sand; band of grey sed below RPD=DM layer; red sed patches@z; burrows
O-12	**A2**	9/5/2003	12:28 PM	>4	>4 to 2	12.2	14.2	13.2	60.2	4.2	2.52	5.05	0		N	2.1	P	N	3	3.12	5.96	4.54	Stage I on III	11	Y	5.8		ambient muddy sed>pen; some fine sand present; subtle band of grey sed below RPD interpreted as surface DM layer; low RPD contrast; one feeding void
O-12	**B2**	9/5/2003	12:30 PM	>4	>4 to 2	11	14.4	12.7	45.3	3.2	1.03	9.99	0		N	3.4	B	N	3	5.81	12.1	8.98	Stage III	10	Y	5.6		ambient muddy sed>pen; reduced sed patches@z= most likely relic DM; oxidized vertical burrow; feeding voids
O-12	**C2**	9/5/2003	12:32 PM	>4	>4 to 2	11.6	12.7	12.1	54.9	3.8	2.48	5.16	0		N	1.1	B	N	0			0.00	Stage I on III	11	Y	5.4		ambient muddy sed>pen; band of reduced sed below RPD interpreted as DM influence; oxidized vertical burrow=Stg 3
O-13	**D2**	9/5/2003	3:53 PM	>4	>4 to 2	7.97	8.92	8.4	32.1	2.2	1.07	3.12	0		N	1.0	P	N	3	3.31	4.4	3.86	Stage III	8	Y	4.6		ambient muddy sed>pen; band of reduced sed below RPD=DM layer; 3 voids and Stg 3 polychaete

Table C-3
Sediment-Profile Image Results for Reference Stations at RDS

Station	Rep	Date	Time	GrnSize Major Mode (phi)	GrnSize Range	Min Pen (cm)	Max Pen (cm)	Avg Pen (cm)	RPD Area	RPD Mean (cm)	RPD min (cm)	RPD max (cm)	No. Mudclasts	MC Avg Diam (cm)	Methane?	Boundary Roughness (cm)	BR Process (phys/bio)	Low DO?	No. Feeding Voids	Feeding Void Min. Depth (cm)	Feeding Void Max. Depth (cm)	Feeding Void Avg. Depth (cm)	Successional Stage	OSI	DM present?	Thickness of Total DM Layer (cm)	Thickness of Recent DM Layer (cm)	COMMENT
ER-1	**A2**	9/5/2003	9:39 AM	>4	>4 to 2	12.2	12.7	12.4	54.9	3.8	1.64	5.93	0		N	0.5	B	N	2	5.73	8.2	6.97	Stage I on III	11	N			Ambient mud>pen; reduced patches@depth; vertical burrow and void
ER-1	**B2**	9/5/2003	9:42 AM	>4	>4 to 2	10.8	12.4	11.6	60.6	4.2	3.12	6.04	0		N	1.6	B	N	3	3.41	4.74	4.08	Stage I on III	11	N			Ambient mud>pen, small void on left
ER-1	**C2**	9/5/2003	9:43 AM	>4	>4 to 2	13.1	13.6	13.3	82.1	5.7	3.53	7.67	0		N	0.5	B	N	5	1.56	10.6	6.09	Stage I on III	11	N			Ambient mud>pen ; prominent void; fecal mound; sea cucumber? good example Stg. 1 on 3
ER-2	**A2**	9/5/2003	9:29 AM	>4	>4 to 2	10.9	11.2	11.1	45.1	3.1	1.86	5.32	0		N	0.4	B	N	1	5.47	5.47	5.47	Stage I on III	10	N			Ambient mud>pen; small void below RPD; amphipod stalk left
ER-2	**B2**	9/5/2003	9:32 AM	>4	>4 to 2	11	12.2	11.6	67.2	4.7	2.44	6.91	0		N	1.2	B	N	2	7.1	7.1	7.10	Stage I on III	11	N			Ambient mud>pen; prominent void@RPD; red patches@z
ER-2	**C2**	9/5/2003	9:34 AM	>4	>4 to 2	10.6	12.8	11.7	20.8	1.5	0.66	3.38	0		N	2.2	B	N	3	3.01	5.62	4.32	Stage I on III	7	N			Ambient mud>pen; red sed patches@z; voids left; RPD somewhat shallow
ER-3	**A2**	9/5/2003	9:49 AM	>4	>4 to 2	10.4	12.1	11.3	76.3	5.3	3.27	8.05	0		N	1.6	B	N	1	6.12	6.12	6.12	Stage I on III	11	N			Ambient mud>pen; void; reduced sed patches@z
ER-3	**B2**	9/5/2003	9:52 AM	>4	>4 to 2	8.73	10.9	9.8	32.1	2.2	0.5	4.34	1	0.35	N	2.2	P	N	2	4.63	5.4	5.02	Stage I on III	8	N			Ambient mud>pen; void
ER-3	**C2**	9/5/2003	9:54 AM	>4	>4 to 2	12.7	13.4	13.1	59.9	4.2	2.33	6.5	0		N	0.8	B	N	2	2.05	6.45	4.25	Stage I on III	11	N			Ambient mud>pen; voids; burrow opening near surface; red sed patch@z
ER-4	**A2**	9/5/2003	10:02 AM	>4	>4 to 2	10.4	12.5	11.4	53.3	3.7	2.62	6	0		N	2.1	P	N	3	2.43	7.09	4.76	Stage I on III	10	N			Ambient mud>pen; several voids; dense Stg 1 tubes; reduced sediment layer below RPD
ER-4	**B2**	9/5/2003	10:04 AM	>4	>4 to 2	12.3	12.9	12.6	81.2	5.7	2.74	8.7	5	0.32	N	0.6	B	N	3	3.84	5.84	4.84	Stage I on III	11	N			Ambient mud>pen; several small voids; red sed@depth
ER-4	**C2**	9/5/2003	10:06 AM	>4	>4 to 2	12.6	12.9	12.7	74.5	5.2	2.36	7.59	0		N	0.3	B	N	3	3.8	11.6	7.72	Stage I on III	11	N			Ambient mud>pen; prominent void left; dense Stg 1 tubes
NR-1	**A2**	9/5/2003	8:54 AM	>4	>4 to 3	17.7	18.8	18.3	94	6.5	4.75	9.99	0		N	1.1	B	N	3	4.94	6.34	5.64	Stage I on III	11	N			ambient soft mud>pen; deep RPD with low RPD contrast;
NR-1	**B2**	9/5/2003	8:54 AM	>4	>4 to 3	17.3	17.6	17.5	59.9	4.2	1.26	7.67	0		N	0.3	B	N	2	4.86	7.89	6.38	Stage I on III	11	N			ambient soft mud>pen; deep RPD with low RPD contrast; prominent feeding void
NR-1	**C2**	9/5/2003	8:56 AM	>4	>4 to 3	17.9	18.8	18.3	84.2	5.9	4.18	9.26	0		N	0.9	B	N	2	3.65	6.79	5.22	Stage I on III	11	N			patches of reduced sed below RPD & cake batter texture appears to be layer of DM input (similar to I21-A2),but unlikely
NR-2	**A2**	9/5/2003	9:03 AM	>4	>4 to 3	18.1	19.1	18.6	79.2	5.5	4.14	7.56	0		N	0.9	B	N	1	9.19	9.19	9.19	Stage I on III	11	N			similar to last image with highly reduced surface layer - also looks like dredged material layer
NR-2	**B2**	9/5/2003	9:06 AM	>4	>4 to 3	21.6	21.6	21.6	IND	IND	IND	IND	0		N	0.0	IND	N	3	5.66	17.1	11.40	Stage III	IND	N			overpenetration=sediment-water interface obscured, but reduced band also looks like an older DM layer
NR-2	**C2**	9/5/2003	9:07 AM	>4	>4 to 3	15.4	19.1	17.2	68.2	4.7	3.04	6.49	0		N	3.7	B	N	2	6	15.2	10.60	Stage I on III	11	N			ambient soft mud>pen; low contrast RPD; fecal mound/burrow opening=biogenic roughness; feeding voids

Table C-3
Sediment-Profile Image Results for Reference Stations at RDS

Station	Rep	Date	Time	GrnSize Major Mode (phi)	GrnSize Range	Min Pen (cm)	Max Pen (cm)	Avg Pen (cm)	RPD Area	RPD Mean (cm)	RPD min (cm)	RPD max (cm)	No. Mudclasts	MC Avg Diam (cm)	Methane?	Boundary Roughness (cm)	BR Process (phys/bio)	Low DO?	No. Feeding Voids	Feeding Void Min. Depth (cm)	Feeding Void Max. Depth (cm)	Feeding Void Avg. Depth (cm)	Successional Stage	OSI	DM present?	Thickness of Total DM Layer (cm)	Thickness of Recent DM Layer (cm)	COMMENT
NR-3	**A2**	9/5/2003	8:43 AM	>4	>4 to 3	13.9	14.7	14.3	86.5	6.0	2.4	8.66	0		N	0.8	B	N	2	4.45	13.1	8.77	Stage I on III	11	N			trace of highly reduced sediment at depth with banding pattern; deep RPD with low RPD contrast; prominent feeding void on left
NR-3	**B2**	9/5/2003	8:45 AM	>4	>4 to 3	18.3	18.7	18.5	65.2	4.6	3.12	7.06	0		N	0.4	B	N	0			0.00	Stage I on III	11	N			soft mud; deep RPD; low contrast RPD with reduced sed patches; subsurface burrows evident, Stage 3 present
NR-3	**C2**	9/5/2003	8:46 AM	>4	>4 to 3	14.5	16.2	15.3	82	5.7	4.44	8.58	0		N	1.7	B	N	3	4.86	10.6	7.74	Stage I on III	11	N			ambient soft mud>pen; deep RPD w/ low contrast; fecal layer/burrow opening; multiple voids+polychaete
NR-4	**A2**	9/5/2003	8:32 AM	>4	>4 to 3	18.1	18.5	18.3	48.9	3.4	1.57	4.86	0		N	0.4	B	N	3	2.96	4.34	3.65	Stage I on III	10	N			surface layer appears to be old DM input; black reduced sed@depth=strong RPD contrast; small feeding voids
NR-4	**B2**	9/5/2003	8:33 AM	>4	>4 to 3	14.7	15.4	15.0	74.6	5.2	2.85	7.51	0		N	0.7	B	N	2	2.51	5.16	3.84	Stage I on III	11	N			ambient soft mud>pen; deep RPD with low RPD contrast; two feeding voids
NR-4	**C2**	9/5/2003	8:34 AM	>4	>4 to 3	16.8	18	17.4	53.3	3.7	1.94	5.89	0		N	1.2	B	N	3	5.09	15.9	10.49	Stage I on III	10	N			surface layer appears to be old DM input; band of reduced sed below RPD; deep feeding voids
NR-5	**A2**	9/5/2003	8:18 AM	>4	>4 to 3	16.2	17.3	16.8	57.3	4.0	2.66	4.82	0		N	1.1	B	N	3	0.73	5.66	3.20	Stage I on III	11	N			surface layer appears to have trace of DM; patches of red sed below RPD; shallow feeding voids
NR-5	**B2**	9/5/2003	8:22 AM	>4	>4 to 3	11.8	15	13.4	47.5	3.3	0	6.41	0		N	3.2	B	N	0			0.00	Stage II	8	N			ambient soft mud>pen; reduced sed near surface= burrow opening
NR-5	**C2**	9/5/2003	8:24 AM	>4	>4 to 3	14.3	16	15.2	39.9	2.8	0.96	5.54	0		N	1.7	B	N	0			0.00	Stage II -> III	8	N			surface layer appears to be old DM input; reduced sed below RPD; burrows
SR-1	**A2**	9/6/2003	10:55 AM	>4	>4 to 2	11	12.7	11.9	50.9	3.5	2.02	5.21	8	0.91	N	1.7	P	N	3	3.53	9.26	6.40	Stage III	10	N			ambient muddy sed>pen; many reduced mud clasts@surface=phys. disturbance?; two feeding voids
SR-1	**B2**	9/6/2003	10:57 AM	>4	>4 to 1	7.97	8.89	8.4	33.7	2.4	1.08	3.61	0		N	0.9	P	N	1	6.68	6.68	6.68	Stage I on III	9	Y	> pen (historical)		grey clay@depth= historic DM signature -- DM from mis-dump?; one feeding void
SR-1	**C2**	9/6/2003	10:58 AM	>4	>4 to 2	9.04	9.95	9.5	48.9	3.4	2.13	3.61	0		N	0.9	P	N	1	7.94	7.94	7.94	Stage I on III	10	N			ambient muddy sed>pen; minor sand component; low contrast RPD; dense Stg 1 tubes; thin voids
SR-2	**A2**	9/6/2003	10:48 AM	>4	>4 to 2	9.64	10.7	10.2	57.5	4.0	3.16	5.36	0		N	1.1	P	N	2	3.46	6.98	5.22	Stage I on III	11	N			ambient muddy sed>pen; red sed patch@depth; reduced fecal pellets around mound opening at right
SR-2	**B2**	9/6/2003	10:49 AM	4-3	>4 to 1	7.06	8.2	7.6	9.15	0.6	0	1.68	0		N	1.1	P	N	1	7.78	7.78	7.78	Stage I on III	6	N			ambient muddy fine sand>pen; shallow RPD; low RPD contrast

Table C-3
Sediment-Profile Image Results for Reference Stations at RDS

Station	Rep	Date	Time	GrnSize Major Mode (phi)	GrnSize Range	Min Pen (cm)	Max Pen (cm)	Avg Pen (cm)	RPD Area	RPD Mean (cm)	RPD min (cm)	RPD max (cm)	No. Mudclasts	MC Avg Diam (cm)	Methane?	Boundary Roughness (cm)	BR Process (phys/bio)	Low DO?	No. Feeding Voids	Feeding Void Min. Depth (cm)	Feeding Void Max. Depth (cm)	Feeding Void Avg. Depth (cm)	Successional Stage	OSI	DM present?	Thickness of Total DM Layer (cm)	Thickness of Recent DM Layer (cm)	COMMENT
SR-2	**C2**	9/6/2003	10:50 AM	>4	>4 to 2	9.3	9.61	9.5	67	4.7	3.08	7.71	0		N	0.3	P	N	0			0.00	Stage I on III	11	N			ambient muddy sed>pen; deep RPD with low contrast; dense Stg 1 tubes; burrows
SR-3	**A2**	9/6/2003	11:02 AM	>4	>4 to 2	11.5	11.8	11.6	60.9	4.3	2.82	5.77	0		N	0.3	P	N	1	6.52	6.52	6.52	Stage I on III	11	N			ambient muddy sed>pen; few Stage 1 tubes; deep RPD with low contrast (subtle transition)
SR-3	**B2**	9/6/2003	11:04 AM	>4	>4 to 2	9.45	10.6	10.0	65.2	4.6	2.66	6	2	0.49	N	1.1	P	N	3	3.84	8.73	6.29	Stage I on III	11	N			ambient muddy sed>pen; sand component near surface; small feeding voids@center; red sed@depth=strong RPD contrast
SR-3	**C2**	9/6/2003	11:04 AM	>4	>4 to 2	9.68	11.2	10.4	60.5	4.2	1.67	6.27	0		N	1.5	B	N	4	1.03	6.9	3.97	Stage I on III	11	N			ambient muddy sed>pen; sand component near surface; two small voids; burrow opening?
SR-4	**B1**	9/6/2003	11:12 AM	>4	>4 to 2	8.39	9.04	8.7	56.9	4.0	1.83	6.96	0		N	0.6	B	N	1	8.31	8.31	8.31	Stage I on III	11	N			ambient muddy sed>pen; near surface sand component?; feeding void lwr left; low RPD contrast
SR-4	**C2**	9/6/2003	11:13 AM	>4	>4 to 2	8.96	9.26	9.1	41.5	2.9	1.37	5.63	0		N	0.3	P	N	2	5.52	7.51	6.52	Stage I on III	9	N			ambient muddy sed>pen; prominent feeding void; low RPD contrast=subtle transition
SR-4	**D2**	9/6/2003	11:31 AM	>4	>4 to 2	12.1	12.9	12.5	52.1	3.6	1.91	4.89	0		N	0.8	B	N	3	6.53	11.8	9.18	Stage I on III	10	N			ambient muddy sed>pen; several voids and vertical burrow opening; only a few Stg 1 tubes; low RPD contrast=subtle transition