MONITORING
OF
1998/1999 DREDGED MATERIAL PLACEMENT
AT POOLES ISLAND
OPEN-WATER PLACEMENT SITE 92

Final
COMPREHENSIVE MONITORING REPORT

September 2002

Prepared for:

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Prepared by:
Maryland Environmental Service

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EXECUTIVE SUMMARY

Monitoring of environmental conditions prior to and after the first year of subaqueous placement of dredged material was performed in the Site 92 designated dredged material placement area in the upper Chesapeake Bay. This report contains a summary of the 1998/1999 monitoring studies and is submitted to the Maryland Department of the Environment (MDE) by the Maryland Environmental Service (MES) to fulfill the requirements of Water Quality Certification 98-WQ-0003. MES manages the comprehensive environmental monitoring and produces the comprehensive monitoring report under contract to the U.S. Army Corps of Engineers, Philadelphia District (CENAP) and the Maryland Port Administration (MPA). The monitoring elements consisted of site management of the placement area; placement, consolidation and erosion studies; and a pre-placement benthic community evaluation. Project management, technical support and technical integration tasks were also performed.

Site management, site placement, and consolidation and erosion studies found that the sediment berm placed in the northernmost section of the site had been placed within the authorized time constraints and according to the specifications in the Site Management Plan and Water Quality Certification issued by MDE. The sediment berm was created to form an enclosed basin within the site that would minimize the potential for sediment migration out of the site during any subsequent placement operations. The tracking results indicated that the scow loads were placed within site boundaries. A later survey performed by the Maryland Geological Survey (MGS) indicated that 4,600 cy ± 3,000 cy of the placed sediment had settled beyond the site boundary at the completion of placement, extending a maximum of 330 ft to the east of the site boundary and covering an area of 28,000 yd^2. The MGS determined that sediment placed at the top of the berm during the latter weeks of the placement period likely moved downslope of the berm's steep east embankment and came to rest at the base of the slope. MGS further determined that the bottom characteristics did not change as a result of deposition in these areas and that there was no significant impact to the benthic environment in the vicinity of the placement area. The MGS study recommended greater setbacks and shallower slopes in the future to minimize the potential spread of placed sediment.

An assessment of the benthic community in and around Site 92 was conducted by the Maryland Department of the Environment (MDE) to establish the baseline conditions at Site 92 prior to placement of dredged material. The study found that Site 92 had a typical benthic community when compared to nearby reference stations. *Marenzelleria viridis* and *Rangia cuneata* were the dominant species. The Benthic Index of Biotic Integrity (B-IBI) values at all stations exceeded the Chesapeake Bay Restoration Goal of 3.0 during July and September, indicating the presence of unstressed benthic communities. The minimum B-IBI score at any station was 3.5; the maximum was 4.5. The study recommended that a post-placement study be conducted at least 18 months after all placement activity has ceased in the Pooles Island area. At that time, results between the pre- and post- placement studies will be compared to verify restoration of the benthic community within the placement area.

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GLOSSARY OF TERMS

BATHYMETRY: depth measurement and bottom characterization of waterbodies.

BENTHIC: living in, on or in close association with, the bottom of a body of water.

BERM: a protective ridge.

B-IBI: the Benthic Index of Biotic Integrity. A system that allows comparison of a benthic community against a reference range that represents an established restoration goal for a given area.

CENAP: US Army Corps of Engineers, Philadelphia District

CONTROLLED BOTTOM PLACEMENT: the practice of placing dredged material using bottom release scows.

CY: cubic yards

DGPS: Differential Global Positioning System

DO: Dissolved Oxygen

ISOPACH: contour lines drawn through points of equal thickness.

MCY: Million cubic yards

MDE: Maryland Department of the Environment

MES: Maryland Environmental Service

MESOHALINE: Salinity of 5.0 – 18.0 parts per thousand

MGS: Maryland Geological Survey, Department of Natural Resources

MLLW: mean low-low water; mean low water (MLW) is the average of all low tides in a diurnal tide system. MLLW is the average of the lower half of the low tides calculated for MLW.

MPA: Maryland Port Administration

NUTRIENT: inorganic compound of nitrogen, phosphorus or silica used as food by organisms, specifically plants.

OLIGOHALINE: Salinity of 0.5 – 5.0 parts per thousand

RESTORATION GOALS INDEX (RGI): A combined measure of the number of taxa, abundance and number of each species present in a benthic sample. This is a general measure of the health of a benthic community, developed as part of the Chesapeake Bay Program. An RGI of 3 in the summer is the target for benthic communities in the Bay.

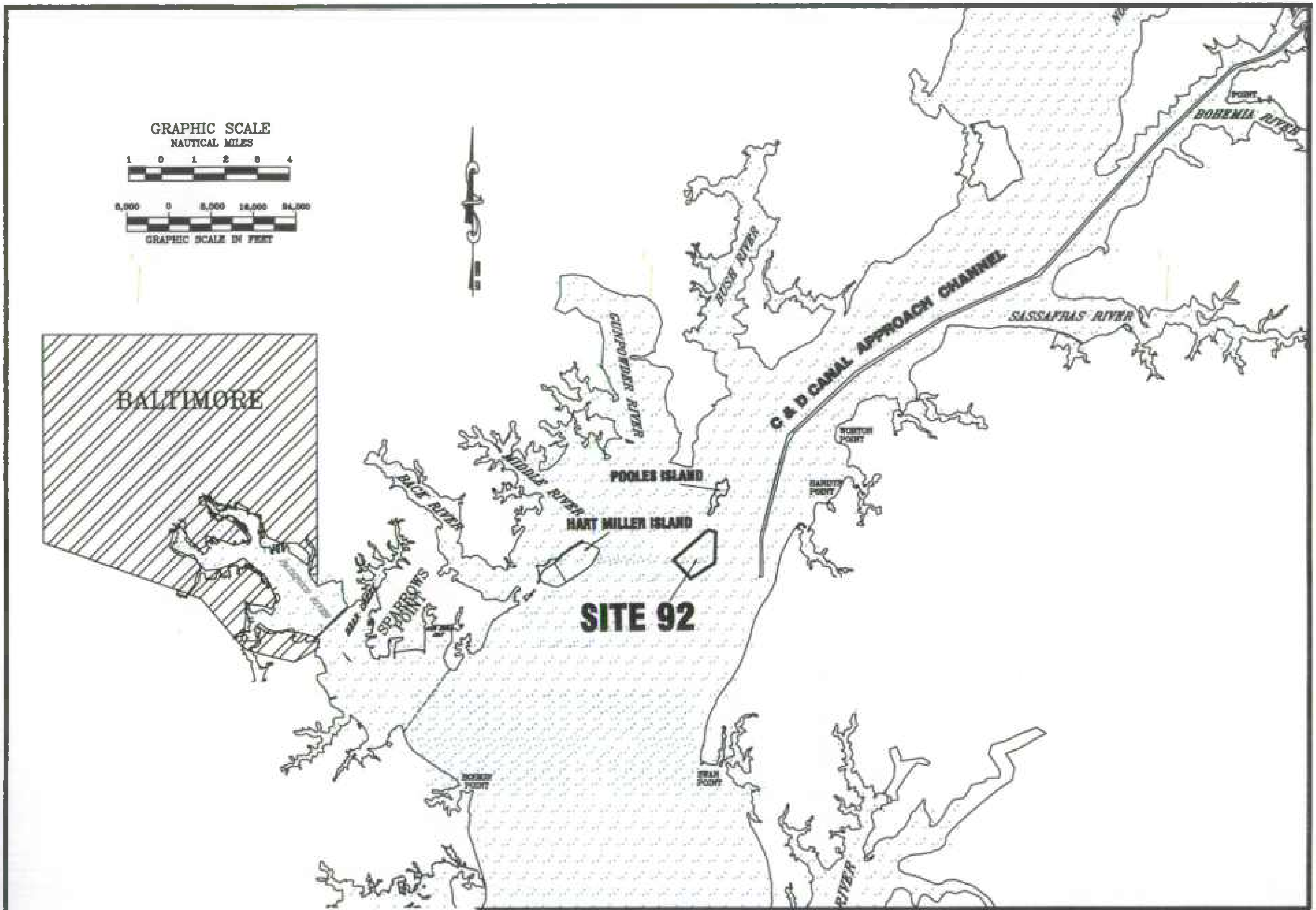
1. INTRODUCTION

The U.S. Army Corps of Engineers, Philadelphia District (CENAP), and the Maryland Port Administration (MPA) share responsibility for developing placement options for dredged material removed from federal navigation channels leading to the Chesapeake and Delaware (C&D) Canal. Channel maintenance and improvement to the C&D Canal northern approach channels, located in the upper Chesapeake Bay, requires the removal of up to 1.5 million cubic yards (mcy) of material annually. The Site 92 placement area (Site 92) was studied and developed as a designated open-water placement site for this purpose in 1997 (MES 1997).

Site 92 is located immediately south of Pooles Island in the northern portion of the upper Chesapeake Bay (Figure 1). One of the former Pooles Island sites, also known as Area G, was initially divided into G-Central, G-North, and G-South; G-West was added in the mid 1990's. Placement in the original Area G sites and in the other Pooles Island sites, Areas D, E, and F, occurred from 1981 until 1997. G-West was utilized for placement beginning in 1994 and continued through 1997.

In 1996, expansion of the Pooles Island area to include G-East and/or Site 92 was under consideration due to a need for increased capacity (Figure 1). Both G-East and Site 92 were selected as potential sites because of the extensive data already available on the Pooles Island area, including ongoing environmental documentation and monitoring of G-West and G-South. Prior studies included sediment transport studies; sediment quality studies; sediment oxygen and nutrient exchange studies; water quality studies; fish abundance, size and species composition studies; fishing activity studies; and benthic studies. These studies did not reveal any regional water quality impacts from the placement of dredged material. Studies showed that a change in water depth as a result of placement likely eliminates habitat for some fish species during certain times of the year, whereas it improves habitat or is not a factor in determining habitat use for other fish species. Historic benthic studies suggested that recolonization of a benthic community typical of stable habitat conditions will occur within two to three years after placement (MES 1999). Evaluations of the area south of G-West following placement at that site during 1997-1998 indicated that the effect of sediment deposition is localized and short term (MES 2000).

The proximity of G-West to Site 92 permitted results of prior environmental studies to be applied to determine the suitability of Site 92 for dredged material placement. Site 92, which is south of G-Central and includes part of G-South, was found to be outside of areas screened by state and federal resource agencies as having significant habitat value, and so was selected as a new dredged placement site to meet needs for increased capacity (MES 1997). In order to obtain the required environmental permits for placement, environmental data collection of the Site 92 placement area was performed, and a joint Environmental Assessment (EA) of the two proposed open-water placement areas, G-East and Site 92, was prepared. The final EA, titled *Environmental Assessment - Designation of Aquatic Dredged Material Placement Areas G-East and Site 92 for Maintenance Dredging, Inland Waterway Delaware River to Chesapeake Bay,*



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SITE 92
VICINITY MAP
FIGURE 1

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Delaware and Maryland Northern Approach Channel, was issued in July 1997, and a Finding of No Significant Impact was issued for both sites in August 1997.

Site 92 is approximately 934 acres in size and, prior to its initial use, was estimated to provide approximately 7.0 mcy of capacity up to elevation -14 feet MLLW. Site 92 surrounds a shallow elongated basin, oriented in a northeast to southwest direction. The pre-placement depths at Site 92 ranged from about –15 ft (-4.5 m) MLLW along the northwest side of the site to a maximum depth of about –26 ft (-8 m) MLLW in the north. In the central section of the basin, the depth averaged around –23 ft (-7 m) MLLW (Halka *et al.* 1996).

In accordance with the Water Quality Certification (WQC) #98-WQ-0003, dredged material was placed by controlled bottom release scow into the Site 92 area, in the upper Chesapeake Bay, from December 23, 1998 to March 31, 1999 (Figure 2). This placement action in Site 92 totaled approximately 1.09 mcy, according to the dredging contractor. The first stage of development of the site (Phase I) was to create an underwater berm along the northeastern corner of the designated area to create a basin for future placement activities. This includes placement along the northern and eastern edges of the site inward. Phase II included placement of material behind the berm within the main placement area.

This report documents the findings of the first full year of placement monitoring in the Site 92 area in the upper Chesapeake Bay. The activities described in this report include pre-placement benthic sampling, pre- and post placement sediment core sampling, bathymetric surveys, and monitoring of the placement of material to create the berm in the northeastern section of the site, as well as placement of material within the basin of the site. The format of this report is to present a synopsis of each major study element, with full copies of the completed studies attached as appendices C, D and E. Also attached are copies of the Water Quality Certification (Appendix A) and the Monitoring Plan (Appendix B). The agencies responsible for performing the studies are listed in Table 1.

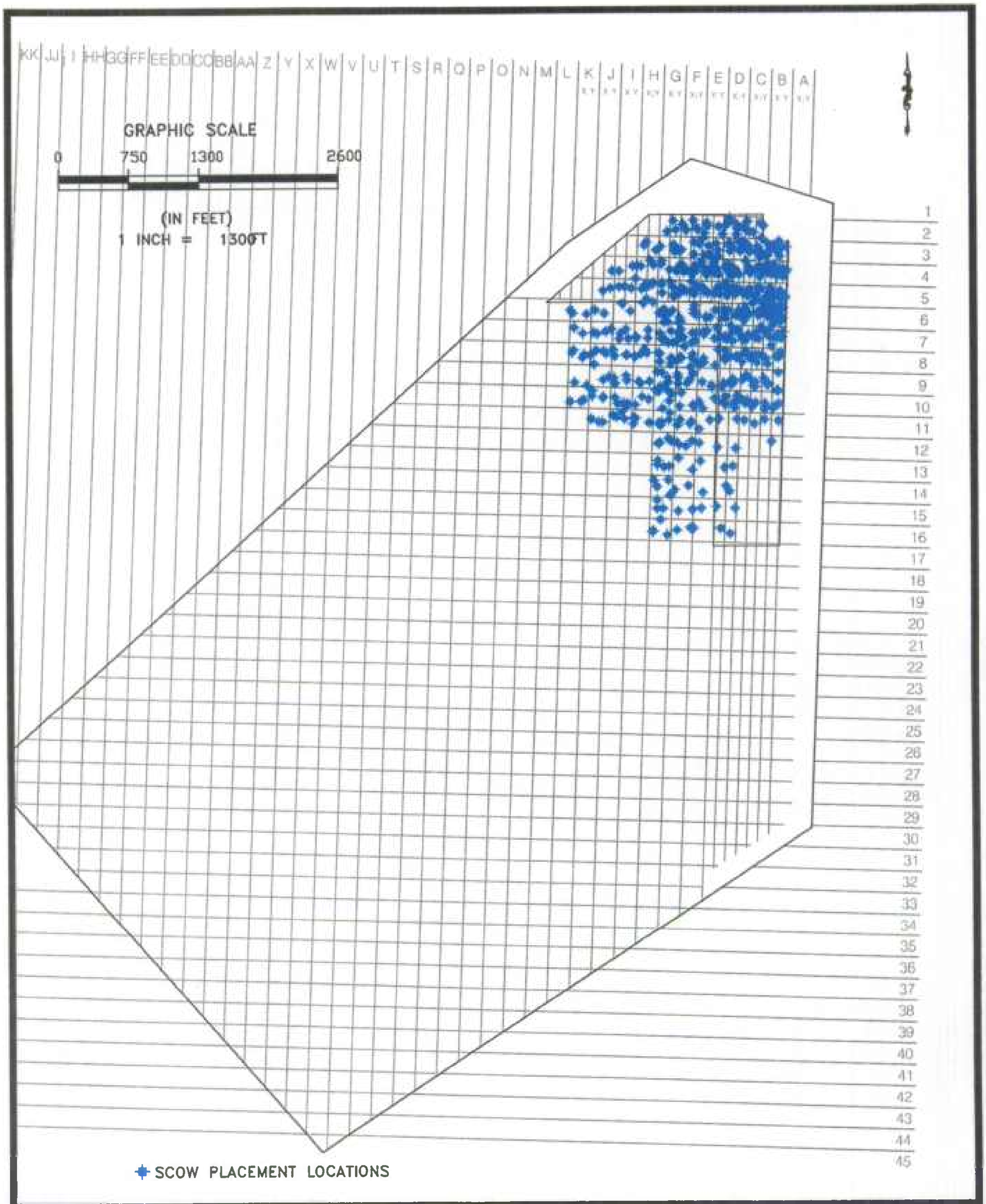
Table 1. Site 92 Monitoring; 1998-1999 Study Elements

Study Element	Agency
Site Management	Maryland Environmental Service
Placement, Consolidation & Erosion	Maryland Geological Survey
Turbidity Plume Studies	Maryland Geological Survey
Technical Support	Maryland Department of the Environment
Technical Integration	Maryland Environmental Service
Project Management	Maryland Environmental Service

(MES 2001, Appendix B)

2. SITE MANAGEMENT

2.1 Placement Operations



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SITE 92 SCOW PLACEMENT
12/23/98–3/31/99
FIGURE 2

Dredging was accomplished using a clamshell bucket dredge with placement occurring by controlled bottom release scows within the basin of Site 92. Dredged material was placed in the northern portion of the site from December 23, 1998 to March 31, 1999 (Figure 2). The estimates for the quantity of material placed at Site 92 are based on daily reports of operations (DRO's) submitted by the contractor. Contractor's estimates for the quantity of material dredged for placement at Site 92 totaled 1,090,367 cubic yards (cy). Of this material, an estimated 657,068 cubic yards (cy) was used to construct the berm and the remaining estimated 433,299 cy was placed inside the site contiguous to the berm. A total of 640 scows were placed during the 1998/1999 placement season (December 23, 1998 to March 31, 1999) averaging 6.4 scows a day over a 99-day placement window. Because of equipment problems and weather related issues, 95% of the project was achieved in less than 30 days.

2.2 Extent of Fill

2.2.1 Berm Dimensions and Placement Depth

The creation of the berm at Site 92 provides closure on the northern and eastern sides of a discrete underwater basin used for dredged material placement. The placed sediments formed a berm approximately 4,300 ft long and an average of 2,100 ft wide with a top crest elevation of between -15 and -16 feet MLW.

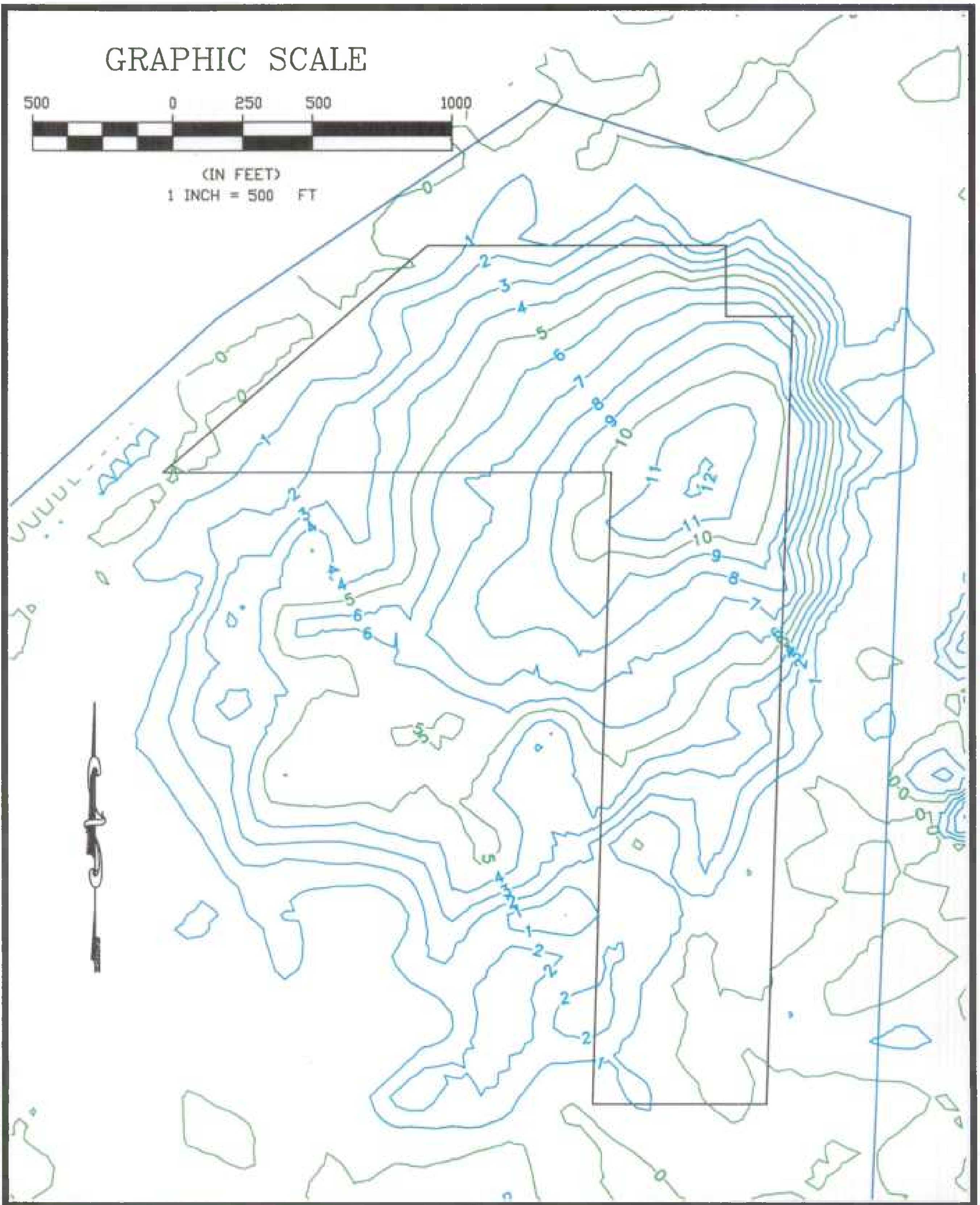
The lateral extent and thickness of the newly placed material were determined from the MGS and CENAP pre- and post placement surveys to be concentrated in the northeastern half of the Site 92 basin area (Figure 3).

2.2.2 Basin Area

The scow tracking information compiled by MES from data submitted by the contractor to CENAP indicates that all material was placed within the Site 92 boundaries as required in the WQC (Appendix A). While tracking results indicated that the scow loads were placed within site boundaries, the April 1999 0-100% isopach drawing based on the 100% post-placement survey conducted by CENAP showed a small anomalous projection ranging in thickness from 1.6-8.2 ft off the northeast side of the placement area (Appendix C; Figure F-7). The tidally uncorrected MGS post-placement bathymetry survey, which was performed on April 7-9, 1999, did not show this projection. Because the April 100% completion surveys did not correlate, CENAP and MGS repeated the surveys between October 27 and November 9, 1999, approximately 6 months after placement ceased. The new surveys correlated. The anomalous projection was investigated and is discussed further in the MGS Placement, Consolidation, and Erosion report and is summarized in Section 3.4 (Appendix D).

2.3 Conclusions

Analysis of the data collected for the site management monitoring phase of this project is provided below. Overall project evaluation and conclusions are also provided.



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SITE 92 BATHYMETRY
0 – 100% ISOPACH
Performed April 7–9, 1999
FIGURE 3

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Dredged material placement by controlled bottom release scow occurred within the authorized time constraints and according to the specifications in the Site Management Plan and WQC. Contractor's estimates for the quantity of material dredged for placement at Site 92 totaled 1,090,367 cy. Of this material, an estimated 657,068 cy was used to construct the berm and the remaining estimated 433,299 cy was placed inside the berm.

2.4 Summary

A review of the placement activities, quantities and locations of material placed and the surveys of the basin area and newly constructed berm indicate that the project met the objectives stated in the Site Management Plan. Because of equipment problems and weather related issues, 95% of the project was achieved in less than 30 days. Communication and coordination between all parties were accomplished in such a manner that even with the weather delays, the project was successfully completed within the tight time frame.

2.5 Recommendations

Based on the experience gained on this project, the following recommendations are offered:

- For future placement activities, it is recommended that every effort be made to use the full window for dredging operations (October 1 – March 31). During this project, starting sooner in the allowed window could have resulted in placement during less harsh weather conditions.

- Close coordination, frequent meetings, and active communication between the State and Federal agencies and the Contractor were key factors in enabling the positive outcome. This type of project coordination and communication is recommended for future placement activities.

- During the 1998/1999 placement season, the Contractor daily reports were received by MES in a timely fashion for daily tracking of information. This allowed the technical team enough time for review of information and the ability to recommend operation changes when necessary. This allowed continual site monitoring of placement activities that ultimately led to the overall success of the placement season. This type of monitoring is recommended for future placement activities.

- Continue investigation of anomalous projection off the northeast corner of Site 92 through follow up surveys of the site by the MGS.

3. PLACEMENT, CONSOLIDATION AND EROSION

3.1 Background

The MGS has studied the placement, consolidation and erosion of dredged material in the upper Chesapeake Bay for over 15 years. These studies have documented the configuration and occupied volume of dredged material that was placed using different techniques. The studies have also found that subsequent to placement, deposited sediments may be subjected to volume changes due to two processes. First, resuspension and erosion may remove sediment particles from the site. Second, consolidation of deposited sediment and the underlying foundation will result in a change in volume and height of the deposit. Consolidation processes result in a change in the elevation of the deposit without the removal of sediment particles.

During the 1998/1999 placement season, an underwater sediment berm was constructed along the northeast corner of Site 92 using controlled bottom release scow placement techniques. This study measures and documents the effects of resuspension, erosion, and consolidation on the sediments placed at Site 92. The study also is used to determine capacity for the following placement year.

3.2 Objectives

The objectives of the placement, consolidation, and erosion study were to gather data and report on the following elements:

- To evaluate pre-placement conditions at the designated placement site;
- To determine the placement location, thickness, and spatial extent of the deposited dredged sediment and changes in these characteristics through time;
- To sample the dredged sediments to determine their physical and bulk properties in the channel and at the placement site;
- To evaluate foundation settlement underlying the placed sediments during the placement and post-placement periods;
- To evaluate the quantity of dredged sediment present at the placement site soon after the completion of dredging and placement operations;
- To evaluate consolidation and erosion of the placed sediments; and,
- To develop a total sediment mass budget for the placement and post-placement periods.

3.3 Methods

The methods used to gather data for the study objectives came from several sources. Bathymetric surveys of the Site 92 placement area were conducted by MGS, sediment core samples were collected and analyzed by MGS, and information on the dredged volumes were obtained from CENAP and the contractor's daily report of operations. These were the main data sources used for determining the pre-placement conditions and the subsequent post-placement consolidation of the berm and foundation sediments. Material loss during dredging, placement, sediment resuspension, and erosion after placement were then calculated from these sources of data.

Placement and sampling activities for the Site 92 placement area over the 1998/1999 placement season are presented in Table 2. The proposed schedule called for bathymetric surveys prior to placement, at the completion of placement, and at one, three, six, and nine months after placement, and bottom sediment coring prior to, at completion of, and nine months after placement. However, inclement weather and/or vessel scheduling conflicts resulted in a modified schedule. Coring cruises were actually performed at one month and eleven months following the completion of placement. An additional bathymetric survey was conducted at eleven months to coincide with bottom sediment coring.

Bottom sediment cores were collected from the channel maintenance sediments and the Site 92 placement area prior to dredging and placement. After placement, cores were taken from the Site 92 placement area. These samples were analyzed for grain size and water content. From the water content, bulk density, porosity and void ratios were calculated. Based on changes in porosity, the amount of consolidation in the berm and foundation sediment was determined. From bathymetric surveys, cross sections were developed illustrating the changes in the sediment elevation over time. Core sample locations in the placement area are indicated in Figure 4.

3.4 Discussion of Findings

Table 2. Chronology of placement and study activities in Site 92

Date	Study Activity
October 19, 1998	Bottom sediment coring prior to sediment placement
October 30, 1998	Bathymetric survey prior to sediment placement
December 23, 1998	Scow placement commences
January 11, 1999	Additional bottom sediment coring prior to sediment placement
March 31, 1999	Scow placement completed
April 7, 1999	Bathymetric data for completion survey
April 28, 1999	Bottom sediment coring for completion survey
May 6, 1999	Bathymetric data for one month survey
July 12, 1999	Bathymetric data for three month survey
September 29, 1999	Bathymetric data for six month survey
January 6, 2000	Bathymetric data for nine month survey
February 21, 2000	Bathymetric data for eleven month survey
February 22, 2000	Bottom sediment coring for eleven month survey

(MGS 2001, Appendix D)

3.4.1 Bathymetric Changes

The contractor reported that 1,090,367 cy of material had been dredged from the C & D Canal approach channel with the intention of being placed in the Site 92 placement area over the study period. CENAP reported a lesser volume of 759,534 cy of sediment dredged. The difference between the two is that the contractor's dredged volume was based on the quantity of sediment placed per scow load and CENAP's

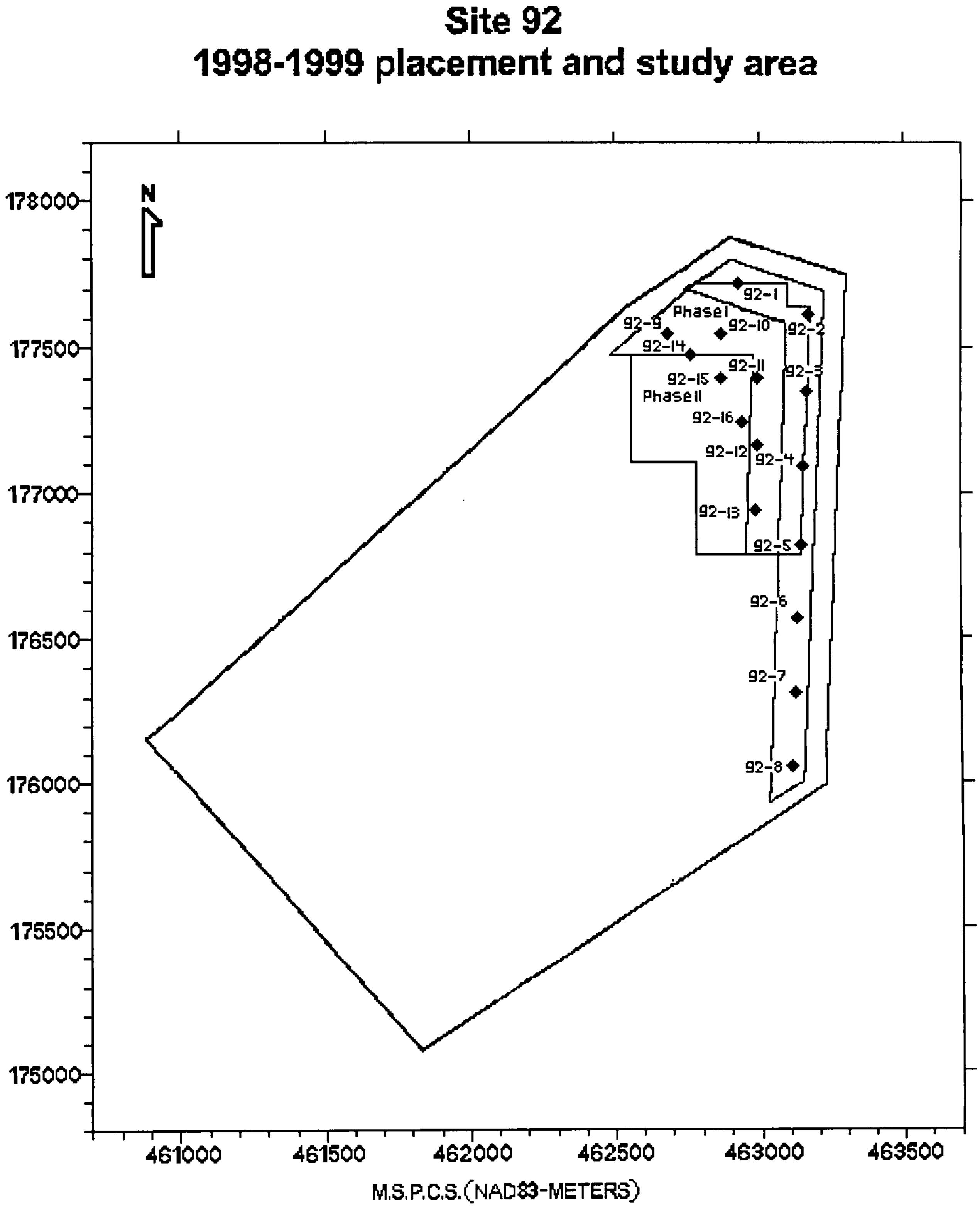

Figure 4. Foundation, Consolidation and Erosion Sampling Locations in Site 92, 1998-1999 Placement Monitoring

dredged volume was based on the change between pre- and post-dredging bathymetric surveys in the channel and calculated as a pay volume to the allowable -41 ft depth. For this report, the contractor's cut value is reported as the actual cut volume placed at the site. Placement of dredged sediment in the northeast section of Site 92 resulted in a berm that filled the northeast end of the West Sailing Course tug channel that traverses the site.

Although all sediments were placed within the site boundaries, a small amount of the placed sediment extended beyond the northeast site boundary at the completion of placement operations. This sediment extended a maximum distance of 330 ft to the east of the site boundary and had an estimated volume of 4,600 cy ± 3,000 cy. This represents less than one-half of one percent (0.4%) of the placed sediment identified at the site and of the volume reportedly placed by the contractor. Sediment that was placed at the top of the berm during the latter weeks of the placement period likely moved downslope of the berm's east steep embankment and came to rest at the base of the slope in the deeper portion of the trough to the northeast. In addition, tidal currents may have spread some of the less consolidated sediments beyond the site boundaries. The sediment deposits that had initially spread to the northeast of the site were relatively thin; upon completion of placement they were approximately 0.5 ft thick at the site boundary and thinned to the north and to the east.

Due to redistribution of sediment, one month after placement the sediment mass immediately outside of the Site 92 boundary was between 6.6 and 8.2 ft thick and thinned in a northeast direction to a thickness of less than 1.6 ft. By the three month survey the sediment mass outside of the Site 92 boundary had been largely eroded away and was no longer apparent beyond the site boundary. By the nine month survey the sediments that spread into the peripheral areas were no longer identifiable. The sediments were deposited in areas where the existing bottom sediments had similar grain size and bulk properties. Cores were not taken outside of the Site 92 boundary to the north and east, only on the boundary itself and within the Site. Coring was conducted prior to the placement, as well as during the one month and eleven month surveys. The figures that depict the sediment that had moved outside of the Site 92 boundary are bathymetric surveys. Bottom characteristics did not change as a result of deposition in these areas.

Survey history: CENAP performed six bathymetric surveys of Site 92. The first was a pre-placement survey that was performed on December 9-12, 1998. Throughout the placement period, 25%, 50% and 75% placement surveys were conducted on February 1,1999, February 23, 1999 and March 17, 1999, respectively. A 100% survey was conducted between April 7th and April 9th, 1999. The 100% survey was conducted a second time between October 27 and November 9, 1999 due to discrepancies between the initial 100% surveys conducted by CENAP and MGS. MGS conducted a total of seven bathymetric surveys of Site 92. The first survey was a pre-placement survey on October 30, 1998. Upon completion of placement, a survey was conducted on April 7, 1999. Five additional surveys were conducted one month, three months, six months, nine months and eleven months following completion of placement. MGS also took bottom sediment cores of Site 92 twice prior to placement, following completion of placement, and during the eleven month survey.

3.5 Consolidation and Erosion

The berm underwent elevation and volume changes over the eleven-month post-placement study period, as expected. Redistribution of sediment within three months of placement resulted in the area of the placed sediments increasing by two-thirds to approximately 1,432,000 square yards but did not result in a measurable change in the total volume. The redistribution included slumping of sediment to a short distance beyond the site boundary within a month after completion of placement. Sediment appeared to have moved over the peripheral areas of the berm and deposited as a thin layer in the tug channel to the northeast and in the basin within the site to the southwest. Between three and six-months after placement, a reduction in the elevation of the berm and thinning of the sediments in the peripheral areas resulted in an 11% volume reduction. Between six and nine-months after placement, the sediments that had previously spread into the peripheral areas were largely eroded, contributing to an additional 20% volume reduction. Between nine and eleven-months after placement, there was an additional 2% volume reduction. The net area covered by the berm sediments was reduced to approximately 637,000 square yards or three-quarters of the original footprint. The maximum elevation of the placed berm decreased by 2 ft since completion to -10.2 ft MLLW at eleven months.

3.6 Placement Capacity

Theoretical capacity estimates were calculated by MGS allowing for up to 10 years of placement at Site 92 at a final elevation of –14 feet MLW. The theoretical estimate of total capacity at Site 92 is 7.0 mcy. This total capacity is based upon an estimated cut volume of approximately 1 mcy per year placed at Site 92 with a 30% volume reduction of the material due to consolidation and erosion between placement years.

During the 1998/1999 season, the cut volume of the material placed at Site 92 was approximately 1 mcy. Monitoring found an estimated volume reduction of 30%, resulting in 0.7 mcy of capacity used. Therefore, the remaining capacity of Site 92 after the 1998/1999 placement season is 6.30 mcy.

3.7 Conclusions

The eleven-month survey of the placed sediments, performed in February 2000, indicated that 67% of the original sediment volume was accounted for. Bulk property data indicated that one-third of the volume change, approximately 12% of the originally placed volume, was attributed to dewatering and consolidation. The remaining two-thirds of the volume change, representing 21% of the original volume, was attributed to erosion of sediment from the surface of the deposit. In past studies of clamshell-dredged and scow-placed sediments, it has been found that one-third to two-thirds of the total volumetric reduction could be attributed to either consolidation or erosion. The sediments placed in this operation exhibited similar amounts of consolidation and erosion as those placed in previous years in the northern Chesapeake Bay and the findings are consistent with those described in the Site 92 Environmental Assessment (MES, 1997).

3.8 Recommendations

The following recommendations are offered:

- Continue the placement, consolidation and erosion studies.
- Avoid developing an accumulation of sediment of thickness and slopes (<50H:1V [0.0200]) in deep areas similar to those in the 1998/1999 placement year. Shallower slopes should be anticipated and a greater setback from the site boundary identified for scow drops to minimize the spread of sediment outside of the site boundary.
- Continue close coordination between CENAP, the dredging contractor, MES, and MGS during the development of a suitable site management plan.
- The time between the pre-placement bathymetric survey (October 30th) and the commencement of scow placement (December 23rd) is almost two months. In the interest of collecting the best possible scientific information, the pre-placement surveys should be conducted as close as possible to the commencement of scow placement, particularly since this is a high energy area where sediment moves around quite a bit.

4. BENTHIC COMMUNITY MONITORING

4.1 Background

Benthic macroinvertebrates are organisms that live on or in bottom substrates for all or part of their lives (Versar 1992). Benthic species are an important link in the ecology of the Chesapeake Bay because they are secondary consumers of detritus and bacteria from the bottom and are in turn an important food source for fish, crustaceans, and waterfowl. Benthic macroinvertebrate species diversity and distribution are reduced in the upper Bay compared to areas further south due to salinity and temperature fluctuations (Rogers and Rogers 1986; Diaz and Schaffner 1990; Ruddy 1990). In addition, diversity of benthic communities (number of species present) is theoretically lowest in environments with salinities of approximately 7 ppt; diversity increases progressively at salinities above and below 7ppt. (Gosner 1971). Salinity in the Pooles Island area, based on data collected from the Chesapeake Bay Monitoring Program, Chesapeake Bay Mainstem water quality monitoring station MCB 3.1, ranges from the oligohaline (0.5 – 5.0 ppt) to the low mesohaline (5.0 – 18.0 ppt) regimes. Oligohaline is the predominant salinity regime between February and July (MES 1997). Studies in the upper Bay have shown that benthic species diversity is typically highest in spring and fall (MDE 1996a).

The substrate in the upper Bay is predominantly silty clay, to clayey silt (mud) (MDE 1996a; MDE 1996b; MDNR 1996). Because of this, the upper Bay is dominated by macroinvertebrates that prefer mud substrates and that can survive in a low-mesohaline to oligohaline environment with wide fluctuation in salinity and temperature.

The benthic macroinvertebrate component of the biota was selected as a study element for the Site 92 comprehensive monitoring program because benthic macroinvertebrate communities are good indicators of estuarine ecological conditions, due to their sedentary nature and other life-history characteristics.

An assessment of the benthic community in and around Site 92 was conducted by the MDE to establish the baseline conditions at Site 92 prior to placement of dredged material. The methods and results of this baseline study are discussed in the following sections.

4.2 Methods

Benthic cruises were performed on May 6, July 31, and September 28, 1998, to establish baseline conditions in and around the Site 92 area prior to dredged material placement. Eleven benthic stations (S92-1 through S92-7, S92-R1, S92-R2, MDE-R1, and MDE-R2) were sampled for several habitat quality parameters and aspects of the benthic community structure. Station locations are shown in Figure 5. Stations S92-1 through S92-7 lie within the boundary of the site and provide information on the pre-placement conditions within Site 92. Following the May sampling cruise, stations S92-3 and S92-4 were found to lie outside the Site 92 boundary. These two stations were relocated a short distance to the northeast inside the boundary of the site and renamed stations S92-3A and S92-4A, respectively, for the remainder of the study. Stations S92-R1 and S92-R2 serve as reference stations for Site 92. These reference stations were selected based on their locations outside Site 92. Stations MDE-R1, in the area designated G-South, and MDE-R2, just north of the area designated as G-East, were also sampled by MDE.

The monitoring stations (S92-1 through S92-7) ranged in depth from –16.1 to –24.6 feet MLLW, the reference stations (S92-R1 and S92-R2) ranged from –15.4 to –19.0 feet MLLW, and the G-South (MDE-R1) and northeast (MDE-R2) stations were –15.1 and –14.8 ft MLLW, respectively. The station locations were verified using a Differential Global Positioning System (DGPS) navigation unit.

Water quality monitoring was also performed for the following parameters: temperature, depth, salinity, pH, conductivity, dissolved oxygen and turbidity. Monitoring was performed approximately 1.6 feet (0.5 m) from the surface, 3.3 ft (1.0 m) from the bottom, and at 6.6 ft (2.0 m) intervals from the bottom measurement to develop a vertical profile of water quality at each station (MDE 2000).

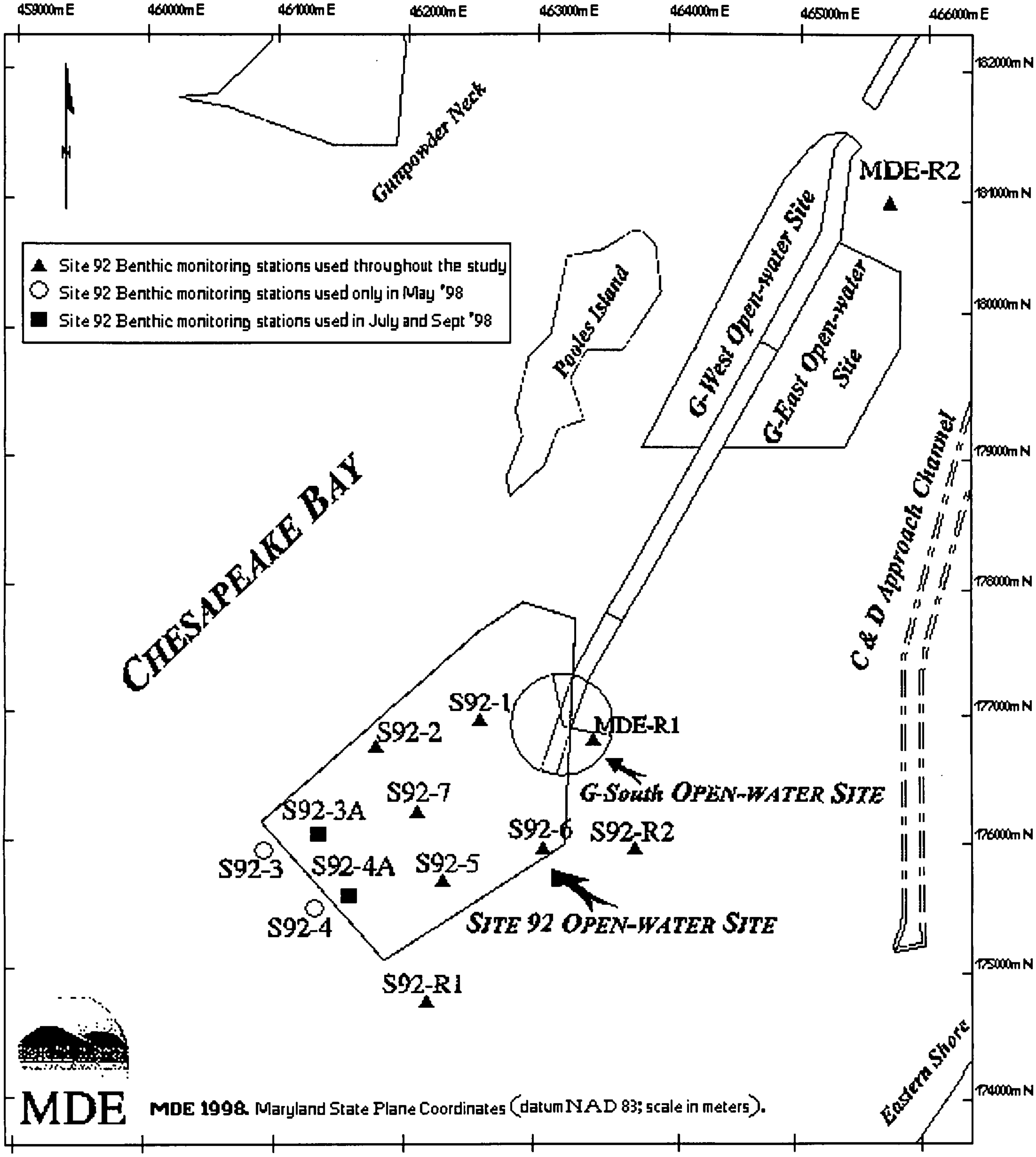

Figure 5. Benthic Monitoring Station Locations in and around Site 92, 1998 Pre Placement Benthic Studies

Benthic and sediment samples were collected with a Van Veen grab sampler. Benthic samples were sieved, preserved, and sorted and organisms were identified to the lowest practical taxon. Only infaunal macroinvertebrates (i.e., those organisms actually living in the sediments, as opposed to epifaunal, or those living on top of the sediments) were used in the analysis, as epifaunal macroinvertebrates are mobile and are thus not as good indicators of in-situ condiditons. Surface sediment was refrigerated and analyzed for grain-size and water content.

The Chesapeake Bay Benthic Index of Biotic Integrity (B-IBI) is an index used to measure the health and the biological completeness of the infaunal benthic communities in the Chesapeake Bay. The B-IBI was developed to identify the degree to which the benthic assemblage meets the Chesapeake Bay Program's Community Restoration Goals (Weisberg et al. 1997). It provides a uniform scale for comparing the quality of the benthic assemblages across varying habitats (Weisberg et al. 1997). During the Site 92 benthic sampling, the following attributes were measured: total abundance, relative abundance of pollution-indicative taxa, relative abundance of pollution-sensitive taxa, and the Shannon Weiner diversity index. Each parameter measured was assigned a score. The score was used to calculate the B-IBI. Taxa richness was also measured, but it was not used to calculate the B-IBI. The Shannon Weiner Diversity Index was used to assess the benthic community in and around the Site 92 area. The Shannon Weiner Index is a measure of biodiversity. It combines two quantifiable measures: the species richness (the number of species in the community) and the species equitability (how even are the numbers of individuals of each species).

The B-IBI is scored on a scale of 0 to 5; 0 being severely degraded and 5 being pristine. For the July and September samples, analysis was performed in the context of the Chesapeake Bay Program's Benthic Community Restoration Goals using the Benthic Index of Biotic Integrity (Weisberg et al. 1997). B-IBI scores of 3 or greater were considered to meet the Chesapeake Bay Restoration Goal. A restoration goal and B-IBI have not been developed for spring, so B-IBI's were not calculated for the May samples. However, the May, July, and September samples were evaluated in terms of the benthic attributes that comprise the B-IBI for this area's salinity regime. Additional information about the methods can be found in the MDE benthic report located in Appendix E.

4.3 Discussion of Findings

The monitoring (S92-1 through S92-7) and reference (S92-R1 and S92-R2) sampling stations for Site 92 had similar benthic communities throughout the study. Differences between the stations could be attributed to the abundance of the clam *Rangia cuneata* and the worm *Marenzelleria viridis*. The Chesapeake Bay Benthic Index of Biotic Integrity was calculated for July and September 1998 sampling events. All sampling stations (S92-1 through S92-7; S92-R1 and S92-R2; MDE-R1 and MDE-R2) exceeded the Chesapeake Bay Restoration Goal (3.0) during both seasons, indicating healthy benthic communities (See tables 5a, 5b, and 5c from MDE report located in Appendix E). The number of taxa was similar among all sampling stations as well.

Generally there were anywhere from 9 to 15 taxa per station during each sampling event. The Shannon-Wiener Diversity Index values were highly variable.

Sediments at all of the monitoring stations, excluding S92-5, the reference stations and the G-South station (MDE-R1) were mostly silt/clay for all sampling events. At station S92-5, sediment consisted of mostly silt/clay during the May sampling event and mostly gravel during the July and September sampling events. At the northeast station (MDE-R2), above placement area G-East, the sediments consisted mostly of gravel with silt/clay during all sampling events. Salinity and temperature data followed normal seasonal variations for the upper Bay region. Dissolved oxygen (DO) concentrations decreased from May highs of 8.6 to 9.5 parts per million (ppm) to July lows of 6.2 to 7.2 ppm and rebounded slightly in September (6.9 to 8.2 ppm). Overall, the DO concentrations remained above the level considered stressful to aquatic life.

4.4 Conclusions

Water quality values were very similar among stations during each season and were similar to values found in previous studies. Seasonal fluctuations occurred as expected with temperatures warming from spring through mid-summer, then declining toward the end of summer. Seasonal fluctuations in temperature, dissolved oxygen, and salinity were important in determining the composition of the benthic community. *Marenzelleria viridis* and *Rangia cuneata* were the dominant species. B-IBI values at all stations exceeded the Chesapeake Bay Restoration Goal of 3.0 during July and September indicating the presence of unstressed benthic communities. The minimum B-IBI score at any station was 3.5; the maximum was 4.5.

In a post-placement study of benthic organism recovery rates in Area G-West sediments, Scott (2001) determined that full recovery of the benthic community occurred within nine to twenty-one months of deposition. Similarly, post-placement studies of Areas G-Central and G-South indicated that the benthic community recovered to its original species composition and biomass within eight to eleven months (Versar, 1994). Studies of benthic recovery rates in Area G-West by Dalal (1996) found that the original community may completely recover within twelve to twenty-four months. Although no data on benthic organisms was collected during this monitoring effort, these earlier studies suggest that benthic community recovery should have been well underway between the six and nine month surveys. By the nine month survey, when the spread sediment was no longer apparent due to its removal from and/or consolidation into the existing bottom, recovery was likely complete or nearly complete. Thus, it is likely that the deposition of these sediments had no significant impact to the benthic environment in the vicinity of the placement area.

4.5 Recommendations

A post-placement study in the Pooles Island area will be conducted at least 18 months after all placement activity has ceased. At that time, results between the pre- and post- placement studies will be compared to verify restoration of the benthic community within the placement area.

5. SPECIAL NOTE/EPILOGUE

Site Management operations have improved in response to the lessons learned from the "anomalous projection" identified during the first placement season at Site 92 in 1998/1999. Following the recommendations made in the 1998/1999 Site Management Report (Appendix C), close coordination, frequent meetings and active communication between the State and Federal agencies and the contractor have continued. In addition, the implementation of guidelines for a greater setback and managing placement to ensure development of shallower slopes has contributed to successful placement seasons for the three subsequent years at Site 92.

Measures have been taken to more closely follow the placement of dredged material at Site 92, including daily scow tracking and data reporting. Consistent delivery of and access to information throughout the placement process each year has allowed the technical team enough time for review of information and enabled the team members to recommend operation changes when necessary. Continual site monitoring of placement activities have resulted in the overall success of placement during the 1999/2000, 2000/2001, and 2001/2002 seasons.

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7. LIST OF PREPARERS

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APPENDIX A

Site 92 1998/1999 Water Quality Certification

TARSA Fax:410-631-[illegible]

Visty

MDE

MARYLAND DEPARTMENT OF THE ENVIRONMENT
2500 Broening Highway • Baltimore Maryland 21224
(410) 631-3000 • 1-800-633-6101 • http://www.mde.state.md.us

Parris N. Glendening
Governor

Jane T. Nishida
Secretary

SEP 14 1998

To Tammy Banta MES

From – Visty Dalal MDE

Mr. Thomas M. Schina, P.E.
Assistant Chief, Operations Division
Philadelphia District, Corps of Engineers
Wanamaker Building, 100 Penn Square East
Philadelphia, Pennsylvania 19107-3390

Dear Mr. Schina:

The Maryland Department of the Environment (MDE) has completed its review of the proposed maintenance dredging for the Chesapeake and Delaware Canal and its approach channel for calendar year 1998. Please find enclosed Water Quality Certification 98-WQ-0003 for the proposed maintenance dredging activities.

I want to direct your attention to Condition #23 which requires that a pilot project be undertaken at the Courthouse Point upland disposal site. The pilot effort entails amending a portion of the dredged material in order to minimize the potential for groundwater deterioration. If successful, it may be possible to implement such a measure at the Pearce Creek upland disposal site to prevent further deterioration of groundwater in that area. MDE staff will be in contact with your office to discuss the technical details of the pilot project.

If you have any questions, please contact me at (410) 631-3567 or Elder Ghigiarelli, Jr. of my staff at (410) 631-8093.

Sincerely,

J.L. Hearn /ssa

J.L. Hearn
Director
Water Management Administration

JLH:EAGJr:cma

cc: Secretary Jane T. Nishida
Mike Haire

MDE
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Parris N. Glendening
Governor

Jane T. Nishida
Secretary

WATER QUALITY CERTIFICATION

NAPOP

CERTIFICATION 98-WQ-0003

PUBLIC NOTICE DATE July 16, 1998

TO: Philadelphia District, Corps of Engineers
Wanamaker Building, 100 Penn Square East
Philadelphia, Pennsylvania 19107-3391

RE: 1998 Maintenance Dredging of the
Chesapeake and Delaware Canal

This water quality certification is issued under authority of Section 401 of the Federal Water Pollution Control Act and its Amendments and the Environment Article, Sections 9-313 - 9-323, inclusive, Annotated Code of Maryland. A copy of this required certification has been sent to the Corps of Engineers. This certification does not relieve the applicant of responsibility for obtaining any other approvals, licenses or permits in accordance with federal, State, or local requirements and does not authorize commencement of the proposed project. The Maryland Department of the Environment has determined from a review of the plans that the construction of this facility and its subsequent operation as noted herein will not violate Maryland's water quality standards, provided that the following conditions are satisfied.

The applicant shall comply with the conditions marked (X) below:

(X) (1) The proposed project shall be constructed in a manner which will not violate Maryland's Water Quality Standards as set forth in COMAR 26.08.02. The applicant is to notify this department ten (10) days prior to commencing work. Verbal notification is to be followed by written notice within ten (10) days.

(X) (2) The proposed project shall be constructed in accordance with the plan and its revisions as approved by the:

(X) (a) Corps of Engineers
(X) (b) Water Management Administration

(X) (3) All fill and construction materials not used in the project shall be removed and disposed of in a manner which will prevent their entry into waters of this State.

(X) (4) The applicant shall notify this Department upon transferring this ownership or responsibility for compliance with these conditions to another person. The new owner/operator shall request transfer of this water quality certification to his/her name.

(X) (5) The certification holder shall allow the Maryland Department of the Environment or its representative to inspect the project area at reasonable times and to inspect records regarding this project.

Page Two Water Quality Certification

( ) (6) Construction of any bulkhead shall be completed prior to filling behind the bulkhead. The bulkhead shall be constructed in such a manner so as to prevent the loss of fill material to waters of this State. Only clean fill, which is free of organic, metallic, toxic or deleterious materials shall be used.

( ) (7) The disturbance of the bottom of the water and sediment transport into the adjacent State waters shall be minimized. The applicant shall obtain and certify compliance with a grading and sediment control plan which has been approved by the:

( ) (a) ____________________ Soil Conservation District or
( ) (b) Erosion and Control Representative, Division of Environmental Services, Bureau of Highways, Department of Public Works of the City of Baltimore or
( ) (c) The Department of the Environment, Water Management Administration or
( ) (d) Montgomery County Department of Environmental Protection.

The approved plan shall be available at the project site during all phases of construction.

(X) (8) The spoil disposal area(s), including dikes where applicable, shall be constructed to limit the suspended solids content in the discharge to the waters of this State to four hundred (400) parts per million or less.

(X) (9) Dredging shall be done only in the period specified in Condition 21.

( ) (10) Stormwater runoff from impervious surfaces shall be controlled to prevent the washing of debris into the waterway. The natural vegetation shall be maintained and restored when disturbed or eroded. Stormwater drainage facilities shall be designed, implemented, operated and maintained in accordance with the requirements of the applicable approving authority.

( ) (11) ____ shall provide to the Water Management Administration a stormwater management plan including cross-sections which incorporates effective pollutant removal strategies in uplands to treat a minimum of the first one-half inch of runoff from impervious surfaces prior to release of stormwater into State waters or wetlands. There shall be no discharge of untreated stormwater to State waters or wetlands. The plan shall be provided by __________________ and shall be implemented by ____________________.

( ) (12) ____ shall provide to the Water Management Administration a mitigation plan for the construction of ________________ acre(s) of ________________________ wetland for review and approval by ____________________________. The plan shall be implemented by ________________________. The plan shall show:

- the source of hydrology for the constructed wetland
- the source and amount of soil to be used in constructing the wetland
- the species, size and density of vegetation to be planted in the constructed wetland and a planting schedule.
- a monitoring/maintenance plan.

( ) (13) ____ shall monitor the mitigation site for a period of five years and shall determine whether the wetland construction has been successful. A successful mitigation project shall result in: _____ plants/acre and 85% survivability of plants in forested and scrub/shrub wetlands and plants covering 85% of the area for emergent wetlands. If these standards are not met, ______________________________ shall determine the reason(s) for failure, the problem(s) shall be corrected, and the area(s) shall be replanted and monitored.

( ) (14) The mitigation site shall be constructed in accordance with the plan.
dated ____________________.

( ) (15) ______________________________ shall provide a ______________________________ plan for review and approval by ____________________ ______________________________.
This plan shall be implemented by ______________________________.

( ) (16) At least one culvert in every stream crossing shall be depressed at least one foot below existing stream bottom under the low flow condition. A low flow channel shall be provided through any riprap structures. The culvert shall be constructed and any riprap placed so as not to obstruct the movement of aquatic species.

( ) (17) Stormwater discharges from ponds, stormwater management outfalls, and stormwater facilities shall have a velocity no greater than four feet per second for the two year storm in order to prevent erosion in the receiving waterway or wetland.

( ) (18) Future stormwater discharges to certified pond(s) are prohibited unless the first one half inch of stormwater runoff from impervious surfaces is managed in uplands for effective pollutant removal.

( ) (19) Authorized stormwater detention ponds shall have a maximum detention time of ____________________ hours.

( ) (20) ______________________________ shall restore and revegetate all temporarily disturbed waters and wetlands to original contours upon completion of construction.

(X) (21) Dredging with placement in the Site 92 open water placement site shall be done only during the period October 1, 1998 through March 31, 1999. Dredging with upland disposal may be done during the period June 16, 1998 through March 31, 1999.

(X) (22) Pooles Island to Sassafras River - approximately 1.5 million cubic yards of material will be removed. The maintenance dredging will be performed by bucket dredge and will be deposited by controlled bottom placement scows in the proposed open water placement site known as Site 92 in the Governor's Dredged Material Management Plan. Placement will begin by berm creation as described in the Environmental Assessment for this site with the remainder of the material to be placed within the site boundaries not exceeding depths of -14 feet..

(X) (23) Sassafras River to Courthouse Point - approximately 500,000 cubic yards of material will be removed by bucket, hopper or hydraulic pipeline dredges. The material will be placed in the previously used upland banked disposal area at Courthouse Point. In a pilot effort, approximately 50,000 cubic yards of the material shall be treated with slurried calcite while placing the dredged material in a test plot at the Courthouse Point upland disposal site. Technical details on this condition will be forthcoming in a separate document from the Maryland Department of the Environment.

Page Four Water Quality Certification

(X) (24) Courthouse Point to Maryland State line within Canal - approximately 100,000 cubic yards of material to be removed by bucket, hopper or hydraulic pipeline dredges. The material will be placed in the previously used upland banked disposal areas at Chesapeake City and Bethel along the Chesapeake and Delaware Canal proper.

(X) (25) The Philadelphia District Corps of Engineers shall submit a monitoring plan for Site 92 to the Maryland Department of the Environment before placement operations begin.

(X) (26) The Philadelphia District Corps of Engineers shall submit a Site Management Plan for Site 92 to the Maryland Department of the Environment for review and approval prior to commencement of disposal operations. The plan shall depict the sequence and locations of dumping operations.

Failure to comply with these conditions shall constitute reason for suspension or revocation of the Water Quality Certification and legal proceedings may be instituted against the applicant in accordance with the Annotated Code of Maryland. In granting this certification, the Department reserves the right to inspect the operations and records regarding this project at anytime.

CERTIFICATION APPROVED

Water Management Administration

Sept. 15 1999

Expiration Date

APPENDIX B

Site 92 1998/1999 Monitoring Plan

SITE 92 OPEN-WATER PLACEMENT MONITORING PLAN

1998/1999 Monitoring (1st Year) - Controlled Bottom Placement

GENERAL SUMMARY

This document is the Monitoring Plan for the first year of open-water placement of dredged material at Site 92, which will occur over the 1998/1999 dredging season. The placement method utilized in the first year will be controlled bottom placement. This Monitoring Plan is prepared for submittal by the Maryland Environmental Service to the Maryland Department of the Environment on behalf of the Philadelphia District, U.S Army Corps of Engineers (CENAP) and the Maryland Port Administration (MPA).

Site 92 is an open-water dredged material placement area located immediately south of Pooles Island in the Chesapeake Bay. The site is approximately 934 acres in size and is estimated to provide 7.0 mcy of capacity when brought to elevation -14 feet MLLW. A berm will be placed within the site along the northeastern edge. Material will also be placed by bottom release scow along the northern edge of the site and at necessary areas along the site boundaries to raise the elevations to -14 ft MLLW.

In order to initially obtain the required environmental permits for placement, environmental data collection of the Site 92 placement area was performed, and a joint Environmental Assessment (EA) of two proposed open-water placement areas, G-East and Site 92, was prepared. The final EA, entitled *Environmental Assessment - Designation of Aquatic Dredged Material Placement Areas G-East and Site 92 for Maintenance Dredging, Inland Waterway Delaware River to Chesapeake Bay, Delaware and Maryland Northern Approach Channel,* was issued in July 1997, and a Finding of No Significant Impact was issued for both sites in August 1997.

The CENAP submitted a Water Quality Certification (WQC) request to MDE in June 1998 for the use of Site 92 in addition to the Courthouse Point, Bethel and Chesapeake City upland disposal areas. This Monitoring Plan is submitted in accordance with Certification Number 98-WQ-0003 issued by the Maryland Department of the Environment to CENAP.

The main objective of the monitoring at Site 92 is to determine if the predicted impacts presented in the EA are the same as the actual impacts associated with placement of dredged material. Results of the monitoring will be submitted to the Maryland Department of the Environment for use in evaluating future dredged material placement at this site.

The Site 92 Open Water Placement Monitoring Plan is a multi-agency, multi-disciplinary, multi-year study. The objectives of the study are to assess the accuracy of predictions of the extent to which placement activities at Site 92 affect the physical, biological, and water quality characteristics of the immediate area and adjacent aquatic habitats. Another objective is to collect data to continue to evaluate the capacity of Site 92 and the environmental acceptability of the current configuration and operation of the site. Monitoring will continue during and after construction of the berm in Fall 1998 and controlled bottom placement of dredged material during the 1998/1999 placement season.

The activities described in this plan include pre-placement benthic sampling, pre- and post-placement core sampling and bathymetric surveys of Site 92, and monitoring of the placement of material to create the Site 92 berm, as well as placement of material within the Site 92 basin area.

Monitoring will begin with pre-placement activities before the initiation of placement at Site 92. As stated in Certificate Number 98-WQ-0003, placement is planned to start in October, 1998 and end by March, 1999. Monitoring activities will then continue until December, 1999. This year, studies will include: site management; consolidation and resuspension studies; benthic community evaluation, technical support, technical integration and project management. All phases of the Site 92 monitoring plan will be conducted under the direction of the Maryland Environmental Service, in cooperation with the Maryland Geological Survey of the Department of Natural Resources, the Maryland Department of the Environment, the Maryland Port Administration and the Philadelphia District of the Corps of Engineers. Plan elements and parties with project responsibility are as follows:

SITE 92 MONITORING PLAN

1998/1999 Monitoring (1st Year) - Controlled Bottom Placement

	STUDY ELEMENT	PRINCIPAL INVESTIGATOR
I.	Site Management	Maryland Environmental Service
II.	Consolidation & Resuspension	Maryland Geological Survey
III.	Benthic Community Evaluation	Maryland Department of the Environment
IV.	Technical Support	Maryland Department of the Environment
V.	Technical Integration	Maryland Environmental Service
VI.	Project Management	Maryland Environmental Service

The consolidation and resuspension and benthic studies are included in this plan with stated endpoints. It is not the intent of the monitoring to continue studies when the finding of no significant impact from the EA is borne out through repeated monitoring. At the point when there are repeated findings of the short-term near-field impacts which were predicted in the EA, the monitoring can safely be stopped. Prior to eliminating any monitoring elements, a meeting shall be convened with the DNPOP Upper Bay working group and the Site 92 principal investigators. At this meeting, the working group members shall make recommendations to the MDE for their approval to discontinue the monitoring elements.

Final reports will be produced for the site management, consolidation and resuspension, and benthics tasks upon completion of the studies. A comprehensive 1998/1999 placement monitoring final report will also be generated. The draft final comprehensive report will be issued by June 30, 2000 presenting an interpretation and synthesis of findings of the consolidation and erosion, the site management studies, and the benthic pre-placement evaluation.

A draft report of site management activities will be produced within 12 weeks of final placement at Site 92. This report will detail survey and volume information and verify the sediment locations, the shape and slopes of the berm as well as the controlled bottom placement volume and location.

The following sections of this Plan present study design details for each element of the monitoring plan:

I. SITE MANAGEMENT

STUDY ENDPOINT - The last placement action at Site 92.

OBJECTIVES

It is anticipated that controlled bottom placement of up to 1.5 mcy (cut) of dredged material will take place at the Site 92 placement area from around October 1, 1998 to March 31, 1999. A berm will be created along the northeastern side of the site to prevent material movement. Material will also be strategically placed along the northernmost portion of the site. Pre-placement surveys will be performed by MGS to verify capacity of dredged material in the Site 92 area and will also be performed to characterize the bathymetry of the adjacent high relief area to the northeast. During placement, data will be collected by MES on the volume of material placed in the area, the duration of placement, and the location of the scows as they place material. After placement, MES will review the most recent post-placement surveys of the placement areas by MGS and CENAP and will produce a site management report on the dredging activities, including capacity evaluations.

To ensure coordination of all parties involved, MDE has required under condition 26 of WQC 98-MD-0003, that CENAP submit a finalized Site Management Plan to MDE and obtain approval for its use prior to commencement of any placement activity at Site 92. MES shall create and submit this plan to MDE on behalf of CENAP.

METHODOLOGY

1. Dredged quantity and placement location

The location and quantity of material placed at the site will be reviewed on a regular basis after transmittal from CENAP to MES and for consistency, will be compared to the Site Management Plan. A map of the site will be produced with the scow locations plotted. This will enable review of placement operations and the movement of controlled bottom placed material within the placement area. The total quantity of material placed in the area will be tabulated in an Excel spreadsheet. This information will be transmitted via fax or electronic mail on a weekly basis to MGS, MDE, MPA and CENAP for review.

2. Hydrographic surveys

A pre-placement survey of the Site 92 area will be performed by the Maryland Geologic Survey and/or CENAP before placement activities begin in Site 92. Surveys will be performed immediately after placement has ceased in Site 92 and afterward in order to determine the placed volume and remaining capacity. A contour map of each survey will be developed and analyzed by MES.

3. Data analysis and site management

Surveys at Site 92 will be conducted by CENAP during the placement operation at the following intervals 25%, 50%, 75% and 100%. Each survey will be compared against previous surveys and the volume of placed material and remaining capacity will be calculated. This volume will then be compared with the dredged quantity to determine volumetric changes during dredging and placement. Cross sections will be developed from surveys to monitor the berm and placement areas. The dredged material quantity and placement locations will be compared with previous survey maps and checked for developing trends. Surveys will also be checked to determine the limits and distribution of placed material and to ensure that the material is remaining within the designated placement area.

DELIVERABLES

A Site Management Plan shall be submitted to MDE by MES, on behalf of CENAP, prior to the commencement of any placement action at Site 92. The Site Management Plan will include placement capacity estimates from MGS and the designated grid area in which all placement will occur. This shall include the sequence of placement with location and volume information. The operations plan submitted by the contractor for dredged material placement at Site 92 shall also be appended to the Site Management Plan.

A Site Management Draft Report will be submitted by MES to MPA, CENAP, MDE and MGS for review within twelve weeks of conclusion of placement activities. This report will consist of a summary of placement activities. The quantity of material placed in each area and the remaining capacity will be documented graphically and in a tabular format. The report will also include copies of all hydrographic surveys performed to date and the cross sections developed by MES.

II. CONSOLIDATION AND RESUSPENSION

NULL HYPOTHESIS - Dredged sediment is subject to predictable forces after placement which result in fairly standard rates of consolidation and erosion, based on the type of material, the type of placement and the placement location. Placement of dredged material will not deviate from these expected conditions.

STUDY ENDPOINT - Monitoring will be performed each year that placement occurs within the Site 92 area, and for up to one year after placement is completed to document consolidation and erosion of materials.

OBJECTIVES

- To measure and evaluate changes in the placed material within the placement area and nearby areas due to erosion and consolidation of sediments.
- To determine capacity of the Site 92 berm and interior areas before and after placement of dredged material.
- To evaluate the results of the study and suggest modifications as necessary in the study design, and site management.
- To verify whether changes are occurring in the high relief areas to the northeast of Site 92 resulting from placement activities.

BACKGROUND

The MGS has studied the placement, consolidation and erosion of dredged material in the Upper Bay for over 15 years. These studies have documented the configuration and occupied volume of dredged material placed using different techniques. The studies have also found that subsequent to placement, deposited sediments may be subjected to volume changes due to two processes. First, resuspension and erosion may remove sediment particles from the site. Second, consolidation of deposited sediment and the underlying foundation will result in a change in volume and height of the deposit. The consolidation processes result in a change in the elevation of the deposit without the removal of sediment particles. This study will measure and document the effects of these processes on the berm and the controlled bottom placed sediments at Site 92. This study will also attempt to define when the observed placement, erosion and consolidation processes are within expected parameters. This study will also identify when these processes exceed expected parameters and what the potential reasons are for variation from expectations.

Observations of consolidation and erosion in the Site 92 Area will be determined though field work, laboratory analysis and data processing and synthesis. Sediments will be collected and analyzed before dredging and placement operations begin in Site 92 and in the channel. A hydrographic survey of the placement area will also be performed prior to placement to enable later measurement of the changes in the berm height and configuration and changes in capacity of the placement area. At the conclusion of the placement activities and at the end of the monitoring period, core samples will be collected from the placement area to determine the changing state of the deposited sediments over time. Selected samples will be subjected to grain size and bulk property analyses. This data will be analyzed to determine volumetric changes due to consolidation of the berm and foundation sediments. The amount of material which is resuspended from the surface of the berm will be estimated from a comparison between the calculated change in volume due to consolidation and the total observed change measured from the hydrographic surveys.

METHODOLOGY

1. Preplacement activities - Site 92

Prior to dredging and placement activities, core samples will be taken from the Site 92 placement area and the channel. These samples will be analyzed for grain size and water content. From the water content, bulk density, porosity and void ratios will be calculated. This information will then be available to calculate foundation consolidation of existing sediments before placement of material. A detailed hydrographic survey of the site will also be performed and a contour map of the site will be developed.

2. Material lost during placement

It is anticipated that some percentage of sediments will be lost due to suspended sediment dispersion during placement activities. To estimate the quantity of suspended sediment lost as a turbidity plume at the placement location(s), 5 core samples will be collected from the channel maintenance sediments prior to dredging and analyzed for bulk properties. At the conclusion of placement, 8 core samples will be collected of the placed sediment and also analyzed for bulk properties. In addition, a hydrographic survey of the site will be conducted and the volume occupied by the placed sediment calculated. This data will be utilized to estimate the total volume of sediment lost during the placement process.

3. Consolidation of the placement area sediments

Consolidation of the placed sediments will alter the remaining capacity of the designated placement area. Calculation of the remaining capacity is necessary to determine an appropriate volume for placement in the next dredging operation. To accomplish the analysis of consolidation over time, a maximum of 6 bathymetric surveys of the placement area will be conducted, pre-placement, post-placement and at the 1, 3, 6 and 9 month points after the completion of placement. In addition, sediment cores will be collected at eight sites in the placement area at three points in time - pre-, post and either 6 or 9 months following placement (depending on the following year's dredging schedule).

4. Sediment resuspension and erosion after placement

Based on previous studies that have been conducted in the vicinity of Pooles Island it is expected that some controlled bottom placed sediment may be resuspended and eroded from the area over time. The rate of erosion is anticipated to decrease over time as the sediments consolidate making individual particles less susceptible to erosion, and as the surface becomes armored with slightly coarser particles left behind by the erosion process. This study will estimate the erosion of the placed sediment during a six to nine month period following placement. The amount of material eroded from the placement area will be estimated by further analysis of the sediment bulk properties and volume data. The water content changes in the sediments will be converted to a volume change attributable to consolidation. The difference between the volume change and the total observed change will yield the volume of material estimated removed due to erosion.

DATA BASE MANAGEMENT

Survey data shall be collected in digital format and transmitted to the MES. Electronic data shall be transmitted in a form suitable for incorporation in AutoCAD files.

DELIVERABLES

Progress reports will be submitted monthly, on the last day of the month. The progress reports shall document progress on work tasks, findings to date and any unusual circumstances or problems that have arisen since the last report.

An interim report with remaining capacity calculations for Site 92 will be produced six months after the completion of placement, and again prior to the initiation of the next year's placement activities (tentatively scheduled for October, 1999).

The final report will be produced six months following the completion of the last survey (approximately March 2000). It will document the lateral extent and thickness of the deposited sediments and the elevation and volumetric changes that the sediment has undergone during the study period. The report will contain a consolidation history of the placed sediments through analysis of the hydrographic surveys and the change in bulk properties of sediment in the collected core samples. The report will also document the estimated loss during dredging and placement, the remaining capacity of the placement area, and the sediment resuspension and erosion estimate for Site 92. The results of consolidation and resuspension study shall be incorporated, as a separate chapter, in the overall placement effects assessment report.

III. BENTHIC COMMUNITY EVALUATION

NULL HYPOTHESIS - There is no long term loss of the benthic community in terms of the multi-metric Benthic Index of Biotic Integrity (B-IBI) after placement of dredged material has ceased.

STUDY ENDPOINT - This study will be performed during the Spring, Summer and Fall of 1998 (May, July and October 1998) before dredged material placement in Site 92. Then, at least 18 months after all placement has ceased at Site 92, this study will be repeated within the Site 92 placement area.

OBJECTIVES

The objectives of this study are:

- To assess the benthic community at Site 92 to determine baseline conditions and to verify the re-establishment of a healthy benthic community more than eighteen months after completion of dredged material placement at the site.
- To compare the results of sampling with established Chesapeake Bay benchmarks, including the B-IBI, to evaluate the benthic community conditions at Site 92.
- To compare seasonal baseline data for Site 92 with other open-water and contained dredged material disposal placement sites.
- To assess Site 92 benthic populations to determine the possible effects of the placement of dredged material at open-water sites in the Pooles Island complex.

METHODOLOGY

Baseline benthic species abundance data will be collected from seven locations in Site 92. Two reference stations will be used for comparison purposes. The reference stations have been selected based on their location away from the proposed Site 92 and the conditions affecting this area. In addition, two background stations will provide supplemental information for comparison purposes.

1. Sampling Locations

Seven assessment stations have been selected in the Site 92 area (In May 1998, five assessment stations were selected in Site 92). Additionally, two reference and two background stations have been selected in adjacent waters (In May 1998, six assessment stations were selected outside of Site 92). The two reference stations were selected in representative areas of varying depths and salinity regimes. One background station is located in G-South and the other is located northeast of G-East. Three samples will be collected from each station. The latitude and longitude of each sampling location shall be recorded.

2. Sampling Schedule

The seven assessment stations, two reference stations, and two background stations shall be sampled in May, July and October 1998 before placement has occurred.

3. Sampling Methods

During each sampling cruise, triplicate samples shall be collected at each sample station. A physical description of the sediments will be recorded from each location for bottom sediment substrate characterization. Water quality parameters (including salinity, temperature, dissolved oxygen concentration, turbidity, and pH) of surface and bottom waters shall be measured at each location.

4. Laboratory Processing

Benthic samples shall be sorted and all organisms identified, to the lowest practical taxonomic level, and enumerated. All sample processing shall be subject to quality assurance and quality control procedures described in the Contractor's Laboratory Manual.

5. Data Management

Data shall be entered and edited using approved procedures to ensure accuracy. The data will be analyzed statistically using SAS and other methodologically appropriate software. All data sets will be stored on the Chesapeake Bay Program's VAX computer system.

6. Data Analysis

Benthic assemblage differences among the placement area and reference sites shall be identified and evaluated using appropriate ecological, statistical and graphical techniques.

DELIVERABLES

Data collected for the Site 92 benthic study shall be prepared by the Maryland Department of the Environment as fully documented SAS Data Sets in DEC VAX/VMS format. The draft report for this study element will be submitted to MES by January 31, 1999 (90 days after last cruise). The results of the benthic evaluation shall be incorporated, as a separate chapter, in the overall placement effects assessment report. This also includes attendance at site management and project status meetings.

V. TECHNICAL SUPPORT

The Maryland Department of the Environment Technical and Regulatory Services Administration (TARSA) staff shall provide technical and regulatory support and advice to the Maryland Port Administration, the Philadelphia District of the U.S. Army Corps of Engineers and the Maryland Environmental Service, throughout the year. This includes coordination of the Water Quality Certification (WQC) request for dredged material placement, coordination of time of year restrictions and possible extensions of the WQC.

VI. TECHNICAL INTEGRATION

For the Site 92 Monitoring Plan, the Technical Integrator shall have responsibility for coordination of program activities by all participants, the integration of findings from all program elements, and the preparation of interim and final reports that address the overall program objectives stated earlier.

OBJECTIVES

The technical objectives of this element are:

- To ensure that all elements of the data collection program are conducted in a coordinated and mutually beneficial manner.
- To provide overall program QA/QC to ensure that program elements are meeting stated technical objectives.
- To conduct overall impact assessments and prepare program assessment reports.

The management objectives of this study are:

- To determine from an analysis of the study findings, the magnitude and extent of impacts resulting from placement activity.

METHODOLOGY

1. Coordinate studies and principal investigators to maximize efficiencies and exchange information during the study period.
2. Conduct periodic meetings of principal investigators.
3. Verify and track cruises, deliverables and findings.
4. Produce final comprehensive monitoring report.

5. Produce monitoring plan for 99/00 placement activities.

6. Coordinate monitoring activities with dredging operations.

7. Provide overall program QA/QC to ensure that project elements are meeting stated technical objectives.

8. To provide technical support to MPA and CENAP on future placement actions and monitoring plans in the Pooles Island area.

DATA BASE MANAGEMENT

All data submitted from all program elements shall be assembled in an electronic format and stored in an acceptable, archivable format.

DELIVERABLES

A final comprehensive report of monitoring activities from the Site 92 monitoring program will be prepared. Interim technical reports shall also be prepared as necessary. Interim reports will be structured around specific issues that have been raised about the project and augmented to address all additional issues which have been identified as a result of input received during the recent project approval process.

The 1998/1999 draft placement monitoring report shall be prepared in June 2000 and shall include a description of findings of the baseline monitoring. The report shall include an assessment of physical impacts resulting from placement, an evaluation of the ability for prediction of impacts from additional placement events and an assessment of potential impacts from additional placement at Site 92. Such an evaluation shall include identification of information gaps and needs, and the delineation of information areas for which data of greater precision may be required.

A 1999/2000 monitoring plan shall be prepared for MPA and CENAP approval, if necessary and submitted to MDE before planned placement actions at Site 92 or elsewhere in the Pooles Island area.

VII. PROJECT MANAGEMENT

OBJECTIVES

- To manage the contract and subcontractors in a timely manner within the allowed budget and schedule.
- To provide management support to the MPA and CENAP for dredged material placement in the Pooles Island area.

- To provide administrative support to MPA and CENAP for the purposes of budgeting and scheduling future placement actions and preparing monitoring plans for the Pooles Island Area.

METHODOLOGY

1. Prepare detailed schedules and work plans to ensure timely completion of assessment report.
2. Coordinate routine activities between all parties involved including MPA and CENAP.
3. Monitor progress on work tasks.
4. Prepare and conduct 4 meetings if necessary for relevant committees and the general public.
5. Prepare and conduct periodic coordination meetings for the clients and MES staff as necessary.
6. Budget tracking and invoice payment.
7. Monthly progress reports to client.
8. Prepare fiscal year budgets and schedule as required by MPA and CENAP.
9. Conduct budget reviews and projections as required by MPA and CENAP.
10. Prepare scopes and agreements for monitoring plan elements.

DELIVERABLES

1. Monthly progress reports to the clients.
2. Detailed schedules and budgets as requested by the client.

APPENDIX C

Site 92 1998/1999 Site Management Report

FINAL

MONITORING
OF
1998/1999 DREDGED MATERIAL PLACEMENT AT POOLES ISLAND OPEN-WATER PLACEMENT SITE 92

SITE MANAGEMENT REPORT

July 2001

Prepared for:

The Maryland Port Administration
MPA Contract #: 599910
PIN #: 600106-H

MARYLAND
PORT
ADMINISTRATION

and

U.S. Army Corps of Engineers,
Philadelphia District
Contract #: DACW61-00-C-0015

US Army Corps
of Engineers
Philadelphia District

Prepared by:
Maryland Environmental Service

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EXECUTIVE SUMMARY

Controlled bottom release scow placement of dredged material to Pooles Island area Site 92 occurred during the 1998/1999 placement season. Site 92 is a designated open-water dredged material placement site in the upper Chesapeake Bay (Figure 1). Site 92 is a subaqueous basin that was developed as a concept in 1996 to provide placement capacity for dredged material (MES 1997). The material placed in Site 92 is generated from federal navigation dredging projects associated with the maintenance of the northern approach channels to the Chesapeake and Delaware (C&D) Canal in the Chesapeake Bay. Maintenance of these federal channels is the responsibility of the U.S. Army Corps of Engineers, Philadelphia District (CENAP). The Maryland Port Administration (MPA) shares responsibility for identifying placement options for the dredged material.

This report is submitted to the Maryland Department of the Environment (MDE) by the Maryland Environmental Service (MES) to fulfill requirements of the Water Quality Certification (WQC) (98-WQ-0003) (Appendix A). MES manages the comprehensive environmental monitoring and produces a site management report under contract to CENAP and the MPA per the 1998/1999 Site 92 Monitoring Plan (Appendix B).

A total of approximately 1.09 million cubic yards (mcy) was placed at Site 92 during this reporting period. Placement occurred between December 23, 1998 and March 31, 1999. The objectives this year were to perform controlled bottom placement of up to 1.5 mcy into the designated Site 92 area in such a manner as to complete placement within the authorized time constraints, within site boundaries and authorized elevations and without negative impact to nearby habitat areas. These objectives were met. Placement was completed by the March 31, 1999 deadline and the material was placed as required within the site boundaries and within the authorized elevation of –14 ft MLW. While tracking results indicated that the scow loads were placed within site boundaries, the 0-100% isopach drawing showed a small anomalous projection off the northeast side of the placement area (Figure F-7). This projection is investigated and discussed further in the Maryland Geological Survey (MGS) Placement, Consolidation, and Erosion report (Panageotou 2001).

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APPENDICES

1 INTRODUCTION

Controlled bottom release scow placement of dredged material was performed at the Site 92 designated placement site in the upper Chesapeake Bay from December 23, 1998 to March 31, 1999 (Figure 1). In accordance with Water Quality Certification (WQC) 98-WQ-0003, this Site Management Report is one of several monitoring requirements for the project (Appendix A). This report describes the dredged material placement activities, provides an analysis of the site management data gathered before, during and after placement, and provides recommendations for future open-water placement activities.

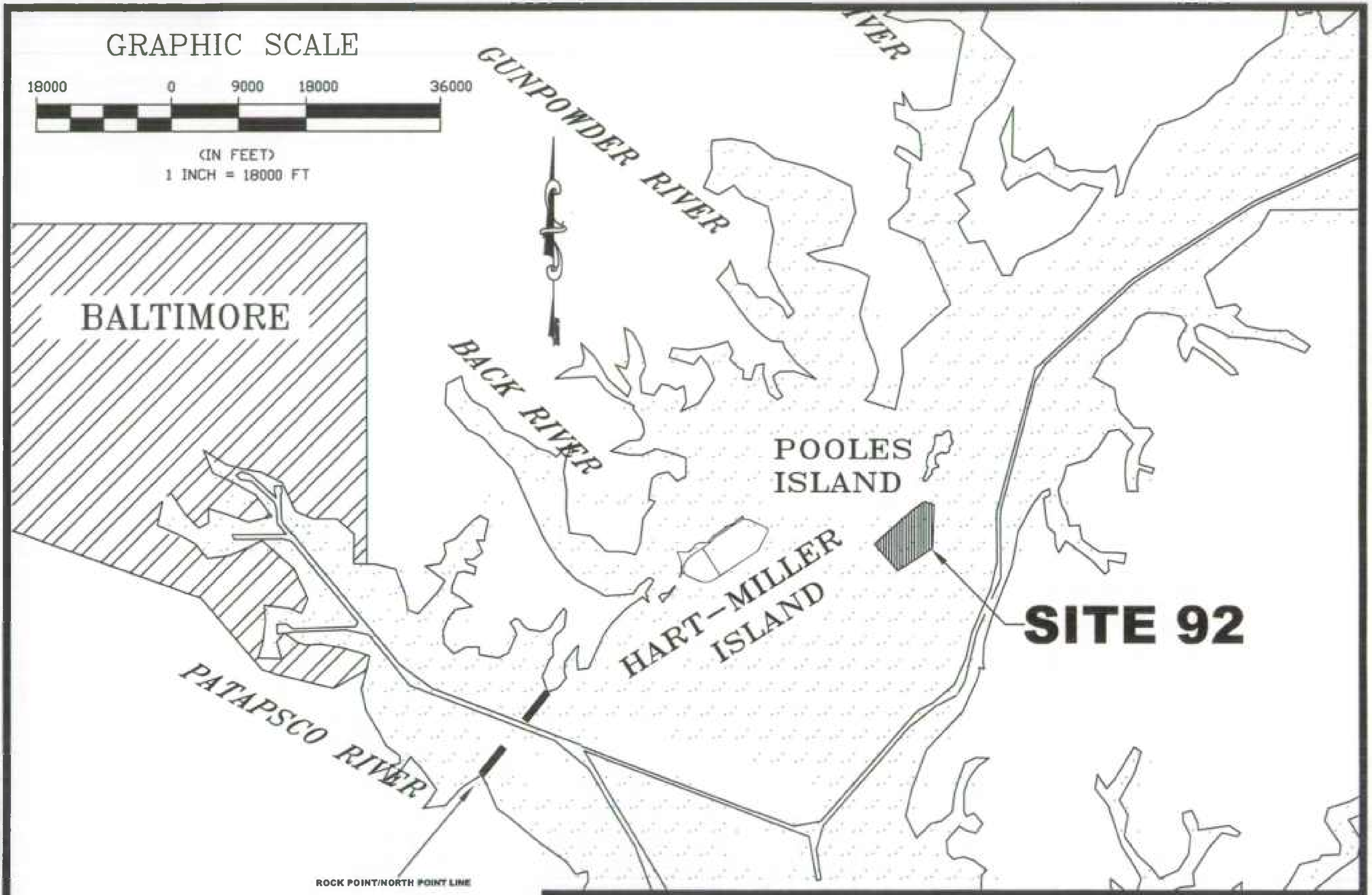
2 SITE DESCRIPTION

Site 92 is an open-water dredged material placement area located immediately south of Pooles Island in the northern portion of the upper Chesapeake Bay (Figure 1). The site is approximately 934 acres in area (MES 1997) and when brought to –14 feet Mean Low Water (MLW) is estimated to provide at least 7.0 million cubic yards (mcy) of capacity. Site 92 surrounds a shallow elongated basin, oriented in a northeast to southwest direction. The coordinates (Geographic NAD 83 U.S. Foot) for Site 92 are presented below.

Beginning at the western-most point at 39 15 05.07N, 076 17 40.37W,
Running thence to 39 15 52.89N, 076 16 30.76W,
Running thence to the northern-most point at 39 16 00.35N, 076 16 16.10W,
Running thence to 39 15 56.19N, 076 15 59.30W,
Running thence to 39 14 59.24N, 076 16 02.88W,
Running thence to the southern-most point at 39 14 29.95N, 076 17 01.16W,
and running thence to the point of beginning.

3 BACKGROUND

The U.S. Army Corps of Engineers, Philadelphia District (CENAP) and the Maryland Port Administration (MPA) share responsibility for developing placement options for dredged material removed from the federal navigation channels leading to the Chesapeake & Delaware (C&D) Canal. In order to initially obtain the required environmental permits for placement, environmental data collection of the Site 92 placement area was performed, and a joint Environmental Assessment (EA) of two proposed open-water placement areas, G-East and Site 92, was prepared. The final EA, entitled *Environmental Assessment – Designation of Aquatic Dredged Material Placement Areas G-East and Site 92 for Maintenance Dredging, Inland Waterway Delaware River to Chesapeake Bay, Delaware and Maryland Northern Approach Channel,* was issued in July 1997, and a Finding of No Significant Impact was issued for both sites in August 1997.



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SITE 92 VICINITY MAP
FIGURE 1

J:\SITE92\REPORTFIGUREC1.DWG

The CENAP requested a WQC from the Maryland Department of the Environment (MDE) in spring 1998 for the placement of up to 1.5 mcy of dredged material in Site 92. The WQC (98-WQ-003) was issued by MDE on September 14, 1998 (Appendix A). The WQC identified the volume of material to be dredged and the timeframe for dredging and placement. The schedule for placement was specified to provide the least impact to fish spawning and recreational fishing in the project area.

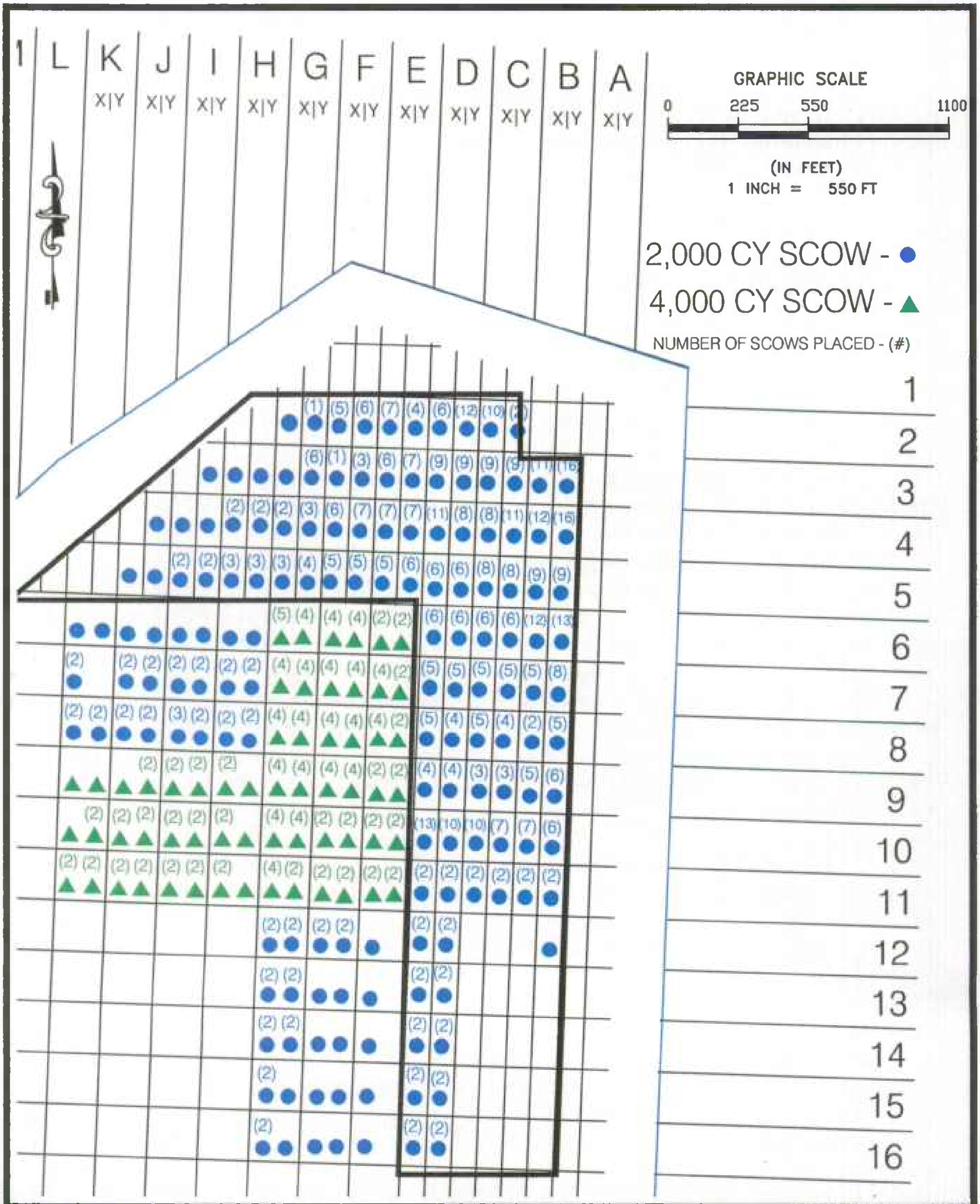
The WQC also specified that a Monitoring Plan (Appendix B) and Site Management Plan (Appendix C) be submitted and approved prior to placement. The Site Management Plan was required to include the sequence and location of placement operations. Both plans were prepared and submitted to MDE by the Maryland Environmental Service (MES) in advance of placement at the site. The Monitoring Plan was approved on December 16, 1998 and the Site Management Plan was approved on December 21, 1998.

The CENAP developed contract plans and specifications for bottom release scow placement of 1.5 mcy of material in specified locations within Site 92 to address the requirements of the WQC. The scow drop zone within the berm was specified based on material slopes of 30H: 1V, with all slopes (including the toe of the dike) to be within site boundaries. Fill elevations for the top of the berm were specified to be –14 feet MLW. Upon fulfilling these requirements, the contractor was required to place any remaining material within the site at a previously agreed upon location, not to exceed the restricted –14 feet MLW elevation.

Numerous other controls were stipulated in the plans and specifications to ensure proper berm creation and material placement, including the requirement for the contractor to submit a disposal operations plan for approval prior to dredging. The dredging and placement contract was competitively bid by CENAP and the contract was awarded on November 16, 1998 to Weeks Marine, Inc (Weeks).

On December 15, 1998, a contractor meeting was held with representatives from CENAP, MPA, MES, MDE, MGS, and Weeks to discuss the dredging operations plan for Site 92 proposed by Weeks. This work plan was enveloped into the Site Management Plan submitted to MDE by MES on behalf of CENAP and MPA.

On December 18, 1998, Weeks submitted the initial Dredging Operations Plan for Site 92 (Appendix C; Appendix I). This plan included a description of the order of dredge excavation and material placement, the tug positioning systems, access to and from the placement area, placement area marking, a gridded layout of the placement area for proposed scow placement, and a table which designated the order of work. This plan was updated as necessary throughout the placement season. The plan and revisions to the plan are located in Appendix D. The final placement plan is presented in Figure 2.



MARYLAND ENVIRONMENTAL SERVICE

SITE 92 BERM
PLACEMENT PLAN
(REVISED 3/24/99)
FIGURE 2

J:\SITE92\92DROP-NEW2.DWG

4 OBJECTIVES

4.1 Monitoring Objectives

The principal study elements of the Pooles Island Site 92 Monitoring Plan (Appendix B) for controlled bottom placement, during the 1998/1999 dredging season, are outlined in Table 1. These elements are required by MDE to be reported for evaluation of the project impacts as part of the WQC. All phases of the Site 92 Monitoring Plan are conducted under the direction of the MES, in cooperation with the MPA, CENAP, MGS, and MDE.

Table 1. 1998/1999 Placement Monitoring Elements

Study Element	Responsible Agency
Site Management	Maryland Environmental Service
Foundation, Consolidation and Erosion	Maryland Geological Survey
Benthic Community Evaluation	Maryland Department of the Environment
Technical Support	Maryland Department of the Environment
Technical Integration	Maryland Environmental Service
Project Management	Maryland Environmental Service

5 SITE MANAGEMENT

Site management activities were required to be conducted in accordance with the Monitoring Plan submitted by MES and approved by MDE (Appendix B). The site management objectives and monitoring methodology as specified in the 1998/1999 Site 92 Monitoring Plan and Site Management Plan are provided below.

5.1 Site Management Objectives

The main objectives of site management at Site 92 are:

- *To describe the dredged material placement activities;*
- *To ensure that all required information is collected before, during, and after placement;*
- *To assure timely transmittal, analysis, and reporting of information;*
- *To provide for a review process; and*
- *To provide recommendations for future open-water placement activities.*

It is anticipated that controlled bottom release scow placement of up to 1.5 mcy (cut) of dredged material will take place at the Site 92 placement area from October 1, 1998 to March 31, 1999. A berm will be created along the northeastern side of the site to prevent material movement. Material will also be strategically placed along the northern most portion of the site. Pre-placement surveys will be performed by MGS to verify capacity of dredged material in the

Site 92 area and will also be performed to characterize the bathymetry of the adjacent high relief area to the northeast. During placement, data will be collected by MES on the volume of material placed in the area, the duration of placement, and the location of scows as they place material. After placement, MES will review post-placement surveys of the placement areas by MGS and CENAP and will produce a site management report on the dredging activities, including capacity evaluations.

5.2 Site Management Methodology

5.2.1 Dredged quantity and placement location

The location and quantity of material placed at the site will be reviewed on a regular basis after transmittal from CENAP and MES. A map of the site will be produced with the scow locations plotted. This will enable review of placement operations and the movement of controlled bottom placed material within the placement area. The total quantity of material placed in the area will be tabulated in an Excel spreadsheet.

5.2.2 Hydrographic surveys

The MGS and/or CENAP will perform a pre-placement survey of the Site 92 area before placement activities begin in Site 92. Nearby high relief areas will also be surveyed. Surveys will be performed immediately after placement has ceased in Site 92 and afterward in order to determine the placed volume and remaining capacity, as well as the continued observation of the berm. A contour map of each survey will be developed and analyzed by MES.

5.2.3 Data analysis and site management

Each survey will be compared against previous surveys and the volume of placed material and remaining capacity will be calculated. This volume will then be compared with the dredged quantity to determine volumetric changes during dredging and placement. Cross sections will be developed from surveys to monitor the berm and placement areas. The dredged material quantity and placement locations will be compared with previous survey maps and checked for developing trends. Surveys will also be checked to determine the limits and distribution of placed material and to ensure that the material is remaining within the designated placement areas.

6 PLACEMENT OPERATIONS

6.1 Overview

Operations that directly affected site management at Site 92 are documented below. This section includes procedures used by the contractor for placement of dredged material within Site

92. Dredging started on December 23, 1998, with controlled bottom placement by scows in the designated berm construction area of Site 92. Dredged material placement ended in Site 92 on March 31, 1999. Table 2 presents a summary of the primary placement activities that occurred at Site 92. An analysis of the operations is included in Section 8.

6.2 Data Collection and Transfer

The contractor submitted a scow discharge report and a report of operations to CENAP on a daily basis. These reports included the scow and trip number, estimated quantity of material in the scow, and the exact Differential Global Positioning System (DGPS) coordinates of each placement. CENAP forwarded this information to MES on a daily basis. MES determined the position of the scow placements from these reports and created a spreadsheet compiling the quantity and placement location information. This spreadsheet was used to keep a running total of material placed (Appendix E). Maps of Site 92 were also generated from these reports, showing the pre-placement bathymetry overlain by the scow placement locations. This information was compared to the contractor's work and placement plan to determine compliance. The spreadsheet and the scow placement map were distributed on a weekly basis to MPA, CENAP, MDE, and MGS.

Site management meetings were held on a regular basis before, during, and immediately after the placement activity at Site 92 (Table 2). Once placement began in December, meetings were usually held on a bi-weekly basis. The site management meetings included the contractor, MES, CENAP, MPA, MDE, and MGS. Summaries from the previous site management meeting were distributed at the next meeting for review and comment. These meetings proved useful in communicating information and coordination between all involved parties.

7 MONITORING RESULTS

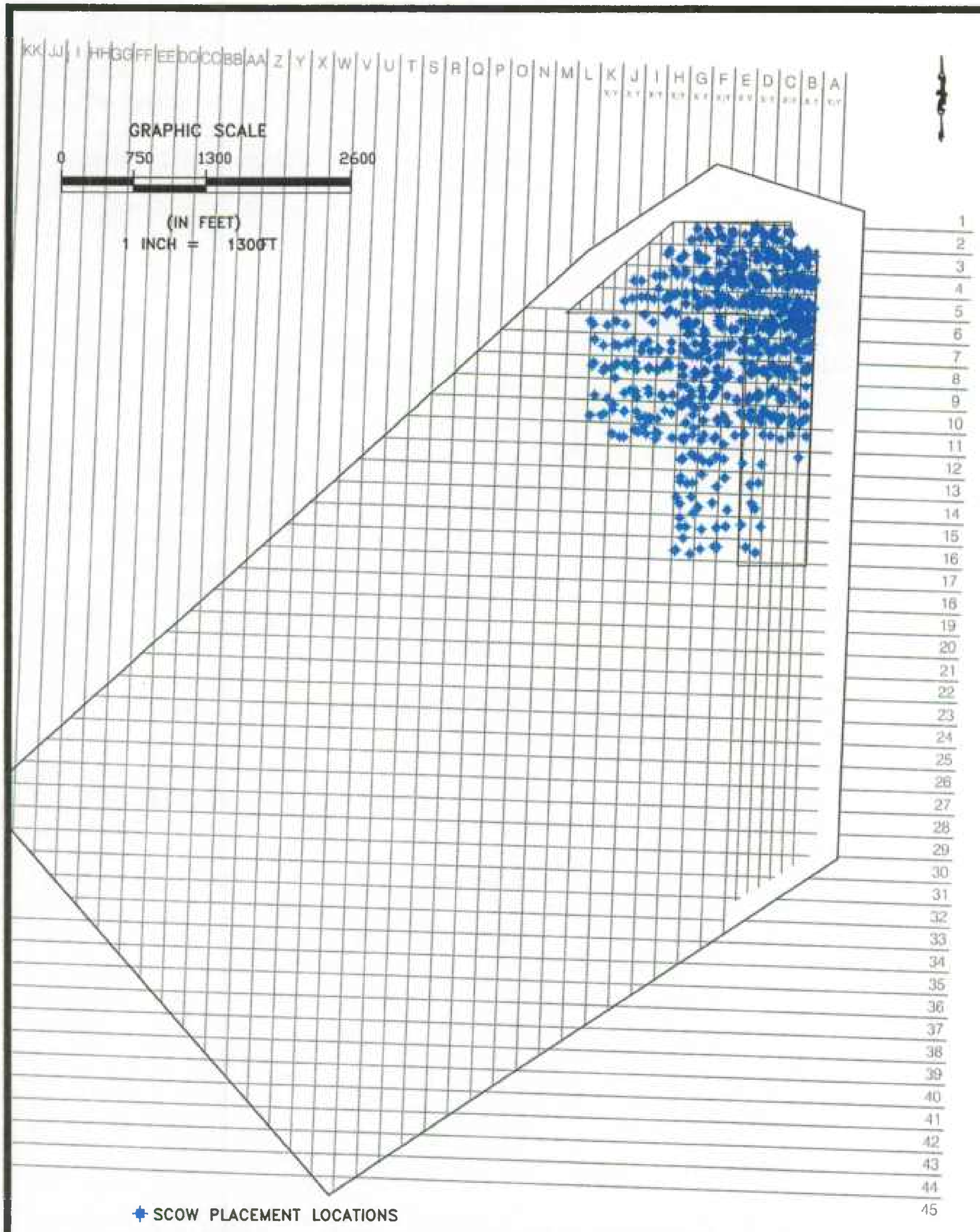
A summary and description of the placement locations and quantity placed are given below. Data analysis and conclusions are presented in Section 8.

7.1 Material Quantity and Placement Location

Figure 3 depicts the grid area that was overlaid on the Site 92 boundaries to determine the locations for material placement. The material drop zone area was designated as column areas B through L, running east to west and rows 1-16, running north to south. Column area A was removed from the placement zone, as suggested by MGS, to increase the setback from the edge of the site. Within the drop zone, cells were created for material placement using the column and row designations. The placement cells were further divided into sub-cells with x and y designations.

Table 2. Summary of 1998/1999 Placement Activities - Pooles Island Site 92

Date	Activity
September 4, 1998	CENAP issued invitation for bids for maintenance dredging.
December 9-12, 1998	CENAP performs pre-placement survey at Site 92.
December 15, 1998	Pre-construction meeting held at CENAP.
December 18, 1999	Contractor submits work plan for 2,000 cy scow placement within northern and eastern berm areas (loads 1-240).
December 21, 1999	Site Management Plan submitted by MES and approved by MDE.
December 23, 1998	Contractor began controlled bottom placement along northern end of berm area.
January 5, 1999	Principal investigator and contractor meetings held at Chesapeake City. Study team requests revised work plan.
January 5, 1999	Contractor submits revised work plan for 2,000 cy scow placement within northern and eastern berm areas (loads 1-224).
January 27, 1999	Contractor meeting at Chesapeake City.
February 1, 1999	CENAP performs 25% survey of Site 92 area.
February 14, 1999	Contractor submits revised work plan for 2,000 cy scow placement within northern berm area and northern portion of eastern berm area (loads 225-276).
February 17, 1999	Contractor meeting at Chesapeake City. Study team approves February 14, 1999 revised placement plan.
February 19, 1999	Contractor submits revised work plan for 2,000 cy scow placement along northern berm and northern and lower portion of eastern berm (loads 225-307).
February 23, 1999	CENAP performs 50% survey of Site 92 area.
March 2, 1999	Contractor submits revised work plan for 2,000 cy scow placement using more realistic scow estimates per MGS request. Placement along northern and eastern berm areas (loads 260-348).
March 3, 1999	March 2, 1999 work plan approved by study team.
March 5, 1999	Contractor submits work plan for 4,000 cy scow placement inside the site contiguous to the berm (loads 1-57).
March 9, 1999	Contractor Meeting at Chesapeake City. Study team approves March 5, 1999 revised placement plan.
March 11, 1999	Contractor submits revised work plan for 2,000 cy scow placement in northern berm area (loads 349-394).
March 12, 1999	March 11, 1999 work plan approved by study team.
March 15, 1999	Contractor submits revised work plan for 2,000 cy scow placement in northern berm area and the 4,000 cy scow placement inside the site contiguous to the berm (loads 395-431, 58-115).
March 16, 1999	March 15, 1999 work plan approved by study team. Contractor submits revised work plan for 4,000 cy scow placement inside site, including revised scow yardage estimates (loads 37-114).
March 17, 1999	CENAP performs 75% survey of Site 92 area.
March 22, 1999	Contractor submits revised work plan for 2,000 cy scow placement (loads 421-495) inside site for use until 75% surveys are completed. Study team requests revised work plan.
March 23, 1999	Contractor meeting at Chesapeake City. Contractor submits revised work plan for 2,000 cy scow placement (loads 422-495) and 4,000 cy scow placement (loads 115-155) inside the site to left of berm. March 23, 1999 work plan approved by study team.
March 31, 1999	Contractor finishes controlled bottom placement at Site 92.
April 6, 1999	Principal Investigator and Site Management meetings at Chesapeake City.
April 7, 1999	MGS performs completion survey of scow placement at Site 92.
April 7-9, 1999	CENAP performs 100% survey of the Site 92 area.
October 27 - November 9, 1999	MGS and CENAP perform 6-month post placement survey of the Site 92 area to correlate surveys.



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SITE 92 SCOW PLACEMENT
12/23/98–3/31/99
FIGURE 3

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The contractor provided information daily on the scow drop locations and estimated quantities of material placed. The scow drop locations for the 1998/1999 placement action were plotted over the grid area and are depicted in blue in Figure 3. Scow placement was also tracked by cell/grid location for quality control and evaluation purposes (Appendix E). The data was evaluated daily to ensure that material was placed according to the revised plan and within the designated drop zone.

7.2 Hydrographic Surveys

Five hydrographic surveys of Site 92 and surrounding areas were performed by CENAP as part of the placement activities (Appendix F). The pre-placement survey was performed on December 9-12, 1998, just prior to material placement in Site 92 (Appendix F; Figures F-1 and F-2). Three condition surveys were also performed on February 1, 23, and March 17, 1999 at approximately 25%, 50% and 75% completion of the project (Appendix F; Figures F-3, F-4 and F-5). These surveys were used to verify the scow tracking information and to determine the exact placement and development of the berm. CENAP performed the 100% post-placement survey, between April 7-9, 1999 (Appendix F; Figure F-6). While tracking results indicated that the scow loads were placed within site boundaries, the 0-100% isopach drawing showed a small anomalous projection off the northeast side of the placement area (Appendix F; Figure F-7). The MGS post-placement bathymetry survey, which was performed on April 7-9, 1999, did not show this projection. This survey was uncorrected for secondary alignments. Because the 100% completion surveys did not correlate, CENAP and MGS repeated the surveys between October 27 through November 9, 1999, approximately 6 months after placement ceased. The new surveys correlated. The anomalous projection is investigated and discussed further in the MGS report entitled *Placement, consolidation, and erosion studies of sediments dredged from the approach channel to the Chesapeake and Delaware Canal* (Panageotou 2001).

The condition surveys have been used to evaluate the site conditions for this report. Figures F-1 (0%), F-3 (25%), F-4 (50%), F-5 (75%), and F-6 (100%) show the condition surveys as bathymetric contour drawings. Figure F-2 (0%) shows the pre-placement condition survey as bathymetric color contours. The change in elevation from pre-placement to post-placement is shown in Figure F-7 (0 – 100% isopach). Figure F-8 illustrates the bathymetric cross sections of the placement area at 0%, 25%, 50%, 75% and 100% intervals. All condition surveys are included in Appendix F.

8 DATA ANALYSIS AND CONCLUSIONS

Analysis of the data collected for the site management-monitoring phase of this project is provided below. Overall project evaluation and conclusions are also provided.

8.1 Placement Operations

Dredged material placement by controlled bottom release scow occurred within the authorized time constraints and according to the specifications in the Site Management Plan and WQC. A review of the site management records combined with the post-placement survey found that scow placement met the objective of being placed within the site and within the authorized elevation of -14 ft MLW. As mentioned in Section 7.2, the 0-100% isopach drawing showed a small anomalous projection off the northeast side of the placement area (Appendix F; Figure F-7). A discussion of this projection can be found in the MGS report entitled *Placement, consolidation, and erosion studies of sediments dredged from the approach channel to the Chesapeake and Delaware Canal* (Panageotou 2001).

Contractor's estimates for the quantity of material dredged for placement at Site 92 totaled 1,090,367 cubic yards. Of this material, an estimated 657,068 cubic yards was used to construct the berm and the remaining estimated 433,299 cubic yards was placed inside the berm. A total of 640 scows were placed during the 1998/1999 placement season averaging 6.4 scows a day over a 99-day placement window. Because of equipment problems and weather related issues, 95% of the project was achieved in less than 30 days.

8.2 Berm Length

The creation of the berm at Site 92 provides closure on the northern and eastern sides of a discrete underwater basin used for dredged material placement. The placed sediments formed a berm approximately 4,300 ft long and an average of 2,100 ft wide.

8.3 Berm Height

The surveys show the progressive development of a berm average width of 2,100 feet wide with a crest top elevation of between -15 and -16 feet MLW by the 100% survey (Appendix F, Figure F-8).

8.4 Extent of Fill

A comparison of the pre- and post-placement surveys is presented in Figure F-7 in Appendix F. This figure shows the lateral extent and thickness of the newly placed material. The lateral extent and the thickness of the layer of placed material was determined from the surveys to be concentrated in the northeastern half of the Site 92 basin area. The scow tracking information indicates that all material was placed within the Site 92 boundaries as required in the WQC. As mentioned previously, the 100% isopach drawing showed a small anomalous projection off the northeast side of the placement area (Appendix F; Figure F-7). This projection is investigated and discussed further in the MGS report entitled *Placement, consolidation, and* *erosion studies of sediments dredged from the approach channel to the Chesapeake and Delaware Canal* (Panageotou 2001).

8.5 Theoretical Capacity Estimates

Theoretical estimates of capacity were provided by MGS allowing for up to 10 years of placement at Site 92 at a final elevation of –14 feet MLLW. The theoretical estimate of total capacity at Site 92 over the 10 year period is 7.0 mcy. This total capacity estimate is based upon an estimated cut volume of approximately 1 mcy per year for year 1, 0.5 mcy for year 2, and 1 mcy per year for years 3 through 10. The theoretical estimate assumes that in the year following placement, a 30% volume reduction will occur due to consolidation and erosion.

During the 1998/1999 season (year 1), the contractor's reported cut volume of the dredged sediment was 1.09 mcy. MGS identified 1.04 mcy after completion of placement at Site 92. MGS estimated that the placed sediment had a volume reduction of 33% (0.34 mcy) over the year following placement. Two-thirds of this volume reduction was attributed to erosion and one-third attributed to consolidation. This resulted in 0.69 mcy of capacity being used. Therefore, the remaining capacity of Site 92 one year after the 1998/1999 placement season is 6.31 mcy.

8.6 Summary

A review of the placement activities, quantities and locations of material placed and the surveys of the basin area and newly constructed berm indicate that the project met the objectives stated in the Site Management Plan. Because of equipment problems and weather-related issues, 95% of the project was achieved in less than 30 days. Communications and coordination between all parties were accomplished in such a manner that even with the weather delays, the project was successfully completed within the tight time frame.

9 RECOMMENDATIONS

Based on the experience gained on this project, the following recommendations are offered:

- For future placement activities, it is recommended that every effort be made to use the full window for dredging operations (October 1 – March 31). During this project, starting sooner in the allowed window could have resulted in placement during the less harsh environmental conditions.
- Close coordination, frequent meetings, and active communication between the State and Federal agencies and the contractor was a key factor in enabling the positive outcome. This type of project coordination and communication is recommended for future placement activities.

- During the 1998/1999 placement season, the contractor daily reports were received by MES in a timely enough fashion for effective tracking of information. This allowed the technical team enough time for review of information and the ability to recommend operation changes when necessary. This allowed continual site monitoring of placement activities that ultimately lead to the overall success of the placement season. This type of monitoring is recommended for future placement activities.

- Continue investigation of anomalous projection off the northeast corner of Site 92 through follow up surveys of the site by the MGS.

10 REFERENCES

Maryland Environmental Service. 1997. Environmental Assessment – Designation of Aquatic Dredged Material Placement Areas G-East and Site 92 for Maintenance Dredging, Inland Waterway Delaware River to Chesapeake Bay, Delaware and Maryland Northern Approach Channel.

Panageotou, William. 2001. Placement, consolidation, and erosion studies of sediments dredged from the approach channel to the Chesapeake and Delaware Canal December 1998 – March 1999. Performed by the Maryland Geological Survey, Coastal and Estuarine Geology, File Report No. 01-1. 2001.

11 LIST OF PREPARERS

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APPENDIX A

1998/1999 PLACEMENT MONITORING

WATER QUALITY CERTIFICATION

Visty

MDE

MARYLAND DEPARTMENT OF THE ENVIRONMENT
2500 Broening Highway • Baltimore Maryland 21224
(410) 631-3000 • 1-800-633-6101 • http://www.mde.state.md.us

Parris N. Glendening
Governor

Jane T. Nishida
Secretary

SEP 14 1998

To Tammy Banta, MES
From:- Visty Dalal MDE

Mr. Thomas M. Schina, P.E.
Assistant Chief, Operations Division
Philadelphia District, Corps of Engineers
Wanamaker Building, 100 Penn Square East
Philadelphia, Pennsylvania 19107-3390

Dear Mr. Schina:

The Maryland Department of the Environment (MDE) has completed its review of the proposed maintenance dredging for the Chesapeake and Delaware Canal and its approach channel for calendar year 1998. Please find enclosed Water Quality Certification 98-WQ-0003 for the proposed maintenance dredging activities.

I want to direct your attention to Condition #23 which requires that a pilot project be undertaken at the Courthouse Point upland disposal site. The pilot effort entails amending a portion of the dredged material in order to minimize the potential for groundwater deterioration. If successful, it may be possible to implement such a measure at the Pearce Creek upland disposal site to prevent further deterioration of groundwater in that area. MDE staff will be in contact with your office to discuss the technical details of the pilot project.

If you have any questions, please contact me at (410) 631-3567 or Elder Ghigiarelli, Jr. of my staff at (410) 631-8093.

Sincerely,

J.L. Hearn
Director
Water Management Administration

JLH:EAGJr:cma

cc: Secretary Jane T. Nishida
Mike Haire

MDE

MARYLAND DEPARTMENT OF THE ENVIRONMENT
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Parris N. Glendening
Governor

Jane T. Nishida
Secretary

WATER QUALITY CERTIFICATION

NAPOP

CERTIFICATION 98-WQ-0003

PUBLIC NOTICE DATE July 16, 1998

TO: Philadelphia District, Corps of Engineers
Wanamaker Building, 100 Penn Square East
Philadelphia, Pennsylvania 19107-3391

RE: 1998 Maintenance Dredging of the
Chesapeake and Delaware Canal

This water quality certification is issued under authority of Section 401 of the Federal Water Pollution Control Act and its Amendments and the Environment Article, Sections 9-313 - 9-323, inclusive, Annotated Code of Maryland. A copy of this required certification has been sent to the Corps of Engineers. This certification does not relieve the applicant of responsibility for obtaining any other approvals, licenses or permits in accordance with federal, State, or local requirements and does not authorize commencement of the proposed project. The Maryland Department of the Environment has determined from a review of the plans that the construction of this facility and its subsequent operation as noted herein will not violate Maryland's water quality standards, provided that the following conditions are satisfied.

The applicant shall comply with the conditions marked (X) below:

(X) (1) The proposed project shall be constructed in a manner which will not violate Maryland's Water Quality Standards as set forth in COMAR 26.08.02. The applicant is to notify this department ten (10) days prior to commencing work. Verbal notification is to be followed by written notice within ten (10) days.

(X) (2) The proposed project shall be constructed in accordance with the plan and its revisions as approved by the:

- (X) (a) Corps of Engineers
- (X) (b) Water Management Administration

(X) (3) All fill and construction materials not used in the project shall be removed and disposed of in a manner which will prevent their entry into waters of this State.

(X) (4) The applicant shall notify this Department upon transferring this ownership or responsibility for compliance with these conditions to another person. The new owner/operator shall request transfer of this water quality certification to his/her name.

(X) (5) The certification holder shall allow the Maryland Department of the Environment or its representative to inspect the project area at reasonable times and to inspect records regarding this project.

Page Two Water Quality Certification

( ) (6) Construction of any bulkhead shall be completed prior to filling behind the bulkhead. The bulkhead shall be constructed in such a manner so as to prevent the loss of fill material to waters of this State. Only clean fill, which is free of organic, metallic, toxic or deleterious materials shall be used.

( ) (7) The disturbance of the bottom of the water and sediment transport into the adjacent State waters shall be minimized. The applicant shall obtain and certify compliance with a grading and sediment control plan which has been approved by the:

( ) (a) ______________________ Soil Conservation District or
( ) (b) Erosion and Control Representative, Division of Environmental Services, Bureau of Highways, Department of Public Works of the City of Baltimore or
( ) (c) The Department of the Environment, Water Management Administration or
( ) (d) Montgomery County Department of Environmental Protection.
The approved plan shall be available at the project site during all phases of construction.

(X) (8) The spoil disposal area(s), including dikes where applicable, shall be constructed to limit the suspended solids content in the discharge to the waters of this State to four hundred (400) parts per million or less.

(X) (9) Dredging shall be done only in the period specified in Condition 21.

( ) (10) Stormwater runoff from impervious surfaces shall be controlled to prevent the washing of debris into the waterway. The natural vegetation shall be maintained and restored when disturbed or eroded. Stormwater drainage facilities shall be designed, implemented, operated and maintained in accordance with the requirements of the applicable approving authority.

( ) (11) ____ shall provide to the Water Management Administration a stormwater management plan including cross-sections which incorporates effective pollutant removal strategies in uplands to treat a minimum of the first one-half inch of runoff from impervious surfaces prior to release of stormwater into State waters or wetlands. There shall be no discharge of untreated stormwater to State waters or wetlands. The plan shall be provided by __________________ and shall be implemented by ______________________.

( ) (12) ____ shall provide to the Water Management Administration a mitigation plan for the construction of __________________ acre(s) of ______________________________ wetland for review and approval by ____________________________________. The plan shall be implemented by ______________________________. The plan shall show:

- the source of hydrology for the constructed wetland
- the source and amount of soil to be used in constructing the wetland
- the species, size and density of vegetation to be planted in the constructed wetland and a planting schedule.
- a monitoring/maintenance plan.

( ) (13) ____ shall monitor the mitigation site for a period of five years and shall determine whether the wetland construction has been successful. A successful mitigation project shall result in: _____ plants/acre and 85% survivability of plants in forested and scrub/shrub wetlands and plants covering 85% of the area for emergent wetlands. If these standards are not met, ______________________ shall determine the reason(s) for failure, the problem(s) shall be corrected, and the area(s) shall be replanted and monitored.

( ) (14) The mitigation site shall be constructed in accordance with the plan, dated__________________.

( ) (15) ______________________________ shall provide a ______________________ plan for review and approval by ______________________. This plan shall be implemented by ______________________.

( ) (16) At least one culvert in every stream crossing shall be depressed at least one foot below existing stream bottom under the low flow condition. A low flow channel shall be provided through any riprap structures. The culvert shall be constructed and any riprap placed so as not to obstruct the movement of aquatic species.

( ) (17) Stormwater discharges from ponds, stormwater management outfalls, and stormwater facilities shall have a velocity no greater than four feet per second for the two year storm in order to prevent erosion in the receiving waterway or wetland.

( ) (18) Future stormwater discharges to certified pond(s) are prohibited unless the first one half inch of stormwater runoff from impervious surfaces is managed in uplands for effective pollutant removal.

( ) (19) Authorized stormwater detention ponds shall have a maximum detention time of __________________ hours.

( ) (20) ______________________ shall restore and revegetate all temporarily disturbed waters and wetlands to original contours upon completion of construction.

(X) (21) Dredging with placement in the Site 92 open water placement site shall be done only during the period October 1, 1998 through March 31, 1999. Dredging with upland disposal may be done during the period June 16, 1998 through March 31, 1999.

(X) (22) Pooles Island to Sassafras River - approximately 1.5 million cubic yards of material will be removed. The maintenance dredging will be performed by bucket dredge and will be deposited by controlled bottom placement scows in the proposed open water placement site known as Site 92 in the Governor's Dredged Material Management Plan. Placement will begin by berm creation as described in the Environmental Assessment for this site with the remainder of the material to be placed within the site boundaries not exceeding depths of -14 feet..

(X) (23) Sassafras River to Courthouse Point - approximately 500,000 cubic yards of material will be removed by bucket, hopper or hydraulic pipeline dredges. The material will be placed in the previously used upland banked disposal area at Courthouse Point. In a pilot effort, approximately 50,000 cubic yards of the material shall be treated with slurried calcite while placing the dredged material in a test plot at the Courthouse Point upland disposal site. Technical details on this condition will be forthcoming in a separate document from the Maryland Department of the Environment.

Page Four Water Quality Certification

(X) (24) Courthouse Point to Maryland State line within Canal - approximately 100,000 cubic yards of material to be removed by bucket, hopper or hydraulic pipeline dredges. The material will be placed in the previously used upland banked disposal areas at Chesapeake City and Bethel along the Chesapeake and Delaware Canal proper.

(X) (25) The Philadelphia District Corps of Engineers shall submit a monitoring plan for Site 92 to the Maryland Department of the Environment before placement operations begin.

(X) (26) The Philadelphia District Corps of Engineers shall submit a Site Management Plan for Site 92 to the Maryland Department of the Environment for review and approval prior to commencement of disposal operations. The plan shall depict the sequence and locations of dumping operations.

Failure to comply with these conditions shall constitute reason for suspension or revocation of the Water Quality Certification and legal proceedings may be instituted against the applicant in accordance with the Annotated Code of Maryland. In granting this certification, the Department reserves the right to inspect the operations and records regarding this project at anytime.

CERTIFICATION APPROVED

Water Management Administration

Sept. 15, 1999
Expiration Date

APPENDIX B

1998/1999 PLACEMENT MONITORING

MONITORING PLAN

SITE 92 OPEN-WATER PLACEMENT MONITORING PLAN

1998/1999 Monitoring (1st Year) - Controlled Bottom Placement

GENERAL SUMMARY

This document is the Monitoring Plan for the first year of open-water placement of dredged material at Site 92, which will occur over the 1998/1999 dredging season. The placement method utilized in the first year will be controlled bottom placement. This Monitoring Plan is prepared for submittal by the Maryland Environmental Service to the Maryland Department of the Environment on behalf of the Philadelphia District, U.S Army Corps of Engineers (CENAP) and the Maryland Port Administration (MPA).

Site 92 is an open-water dredged material placement area located immediately south of Pooles Island in the Chesapeake Bay. The site is approximately 934 acres in size and is estimated to provide 7.0 mcy of capacity when brought to elevation -14 feet MLLW. A berm will be placed within the site along the northeastern edge. Material will also be placed by bottom release scow along the northern edge of the site and at necessary areas along the site boundaries to raise the elevations to -14 ft MLLW.

In order to initially obtain the required environmental permits for placement, environmental data collection of the Site 92 placement area was performed, and a joint Environmental Assessment (EA) of two proposed open-water placement areas, G-East and Site 92, was prepared. The final EA, entitled *Environmental Assessment - Designation of Aquatic Dredged Material Placement Areas G-East and Site 92 for Maintenance Dredging, Inland Waterway Delaware River to Chesapeake Bay, Delaware and Maryland Northern Approach Channel,* was issued in July 1997, and a Finding of No Significant Impact was issued for both sites in August 1997.

The CENAP submitted a Water Quality Certification (WQC) request to MDE in June 1998 for the use of Site 92 in addition to the Courthouse Point, Bethel and Chesapeake City upland disposal areas. This Monitoring Plan is submitted in accordance with Certification Number 98-WQ-0003 issued by the Maryland Department of the Environment to CENAP.

The main objective of the monitoring at Site 92 is to determine if the predicted impacts presented in the EA are the same as the actual impacts associated with placement of dredged material. Results of the monitoring will be submitted to the Maryland Department of the Environment for use in evaluating future dredged material placement at this site.

The Site 92 Open Water Placement Monitoring Plan is a multi-agency, multi-disciplinary, multi-year study. The objectives of the study are to assess the accuracy of predictions of the extent to which placement activities at Site 92 affect the physical, biological, and water quality characteristics of the immediate area and adjacent aquatic habitats. Another objective is to collect data to continue to evaluate the capacity of Site 92 and the environmental acceptability of the current configuration and operation of the site. Monitoring will continue during and after construction of the berm in Fall 1998 and controlled bottom placement of dredged material during the 1998/1999 placement season.

The activities described in this plan include pre-placement benthic sampling, pre- and post-placement core sampling and bathymetric surveys of Site 92, and monitoring of the placement of material to create the Site 92 berm, as well as placement of material within the Site 92 basin area.

Monitoring will begin with pre-placement activities before the initiation of placement at Site 92. As stated in Certificate Number 98-WQ-0003, placement is planned to start in October, 1998 and end by March, 1999. Monitoring activities will then continue until December, 1999. This year, studies will include: site management; consolidation and resuspension studies; benthic community evaluation, technical support, technical integration and project management. All phases of the Site 92 monitoring plan will be conducted under the direction of the Maryland Environmental Service, in cooperation with the Maryland Geological Survey of the Department of Natural Resources, the Maryland Department of the Environment, the Maryland Port Administration and the Philadelphia District of the Corps of Engineers. Plan elements and parties with project responsibility are as follows:

SITE 92 MONITORING PLAN

1998/1999 Monitoring (1st Year) - Controlled Bottom Placement

	STUDY ELEMENT	PRINCIPAL INVESTIGATOR
I.	Site Management	Maryland Environmental Service
II.	Consolidation & Resuspension	Maryland Geological Survey
III.	Benthic Community Evaluation	Maryland Department of the Environment
IV.	Technical Support	Maryland Department of the Environment
V.	Technical Integration	Maryland Environmental Service
VI.	Project Management	Maryland Environmental Service

The consolidation and resuspension and benthic studies are included in this plan with stated endpoints. It is not the intent of the monitoring to continue studies when the finding of no significant impact from the EA is borne out through repeated monitoring. At the point when there are repeated findings of the short-term near-field impacts which were predicted in the EA, the monitoring can safely be stopped. Prior to eliminating any monitoring elements, a meeting shall be convened with the DNPOP Upper Bay working group and the Site 92 principal investigators. At this meeting, the working group members shall make recommendations to the MDE for their approval to discontinue the monitoring elements.

Final reports will be produced for the site management, consolidation and resuspension, and benthics tasks upon completion of the studies. A comprehensive 1998/1999 placement monitoring final report will also be generated. The draft final comprehensive report will be issued by June 30, 2000 presenting an interpretation and synthesis of findings of the consolidation and erosion, the site management studies, and the benthic pre-placement evaluation.

A draft report of site management activities will be produced within 12 weeks of final placement at Site 92. This report will detail survey and volume information and verify the sediment locations, the shape and slopes of the berm as well as the controlled bottom placement volume and location.

The following sections of this Plan present study design details for each element of the monitoring plan:

I. SITE MANAGEMENT

STUDY ENDPOINT - The last placement action at Site 92.

OBJECTIVES

It is anticipated that controlled bottom placement of up to 1.5 mcy (cut) of dredged material will take place at the Site 92 placement area from around October 1, 1998 to March 31, 1999. A berm will be created along the northeastern side of the site to prevent material movement. Material will also be strategically placed along the northernmost portion of the site. Pre-placement surveys will be performed by MGS to verify capacity of dredged material in the Site 92 area and will also be performed to characterize the bathymetry of the adjacent high relief area to the northeast. During placement, data will be collected by MES on the volume of material placed in the area, the duration of placement, and the location of the scows as they place material. After placement, MES will review the most recent post-placement surveys of the placement areas by MGS and CENAP and will produce a site management report on the dredging activities, including capacity evaluations.

To ensure coordination of all parties involved, MDE has required under condition 26 of WQC 98-MD-0003, that CENAP submit a finalized Site Management Plan to MDE and obtain approval for its use prior to commencement of any placement activity at Site 92. MES shall create and submit this plan to MDE on behalf of CENAP.

METHODOLOGY

1. Dredged quantity and placement location

The location and quantity of material placed at the site will be reviewed on a regular basis after transmittal from CENAP to MES and for consistency, will be compared to the Site Management Plan. A map of the site will be produced with the scow locations plotted. This will enable review of placement operations and the movement of controlled bottom placed material within the placement area. The total quantity of material placed in the area will be tabulated in an Excel spreadsheet. This information will be transmitted via fax or electronic mail on a weekly basis to MGS, MDE, MPA and CENAP for review.

2. Hydrographic surveys

A pre-placement survey of the Site 92 area will be performed by the Maryland Geologic Survey and/or CENAP before placement activities begin in Site 92. Surveys will be performed immediately after placement has ceased in Site 92 and afterward in order to determine the placed volume and remaining capacity. A contour map of each survey will be developed and analyzed by MES.

3. Data analysis and site management

Surveys at Site 92 will be conducted by CENAP during the placement operation at the following intervals 25%, 50%, 75% and 100%. Each survey will be compared against previous surveys and the volume of placed material and remaining capacity will be calculated. This volume will then be compared with the dredged quantity to determine volumetric changes during dredging and placement. Cross sections will be developed from surveys to monitor the berm and placement areas. The dredged material quantity and placement locations will be compared with previous survey maps and checked for developing trends. Surveys will also be checked to determine the limits and distribution of placed material and to ensure that the material is remaining within the designated placement area.

DELIVERABLES

A Site Management Plan shall be submitted to MDE by MES, on behalf of CENAP, prior to the commencement of any placement action at Site 92. The Site Management Plan will include placement capacity estimates from MGS and the designated grid area in which all placement will occur. This shall include the sequence of placement with location and volume information. The operations plan submitted by the contractor for dredged material placement at Site 92 shall also be appended to the Site Management Plan.

A Site Management Draft Report will be submitted by MES to MPA, CENAP, MDE and MGS for review within twelve weeks of conclusion of placement activities. This report will consist of a summary of placement activities. The quantity of material placed in each area and the remaining capacity will be documented graphically and in a tabular format. The report will also include copies of all hydrographic surveys performed to date and the cross sections developed by MES.

II. CONSOLIDATION AND RESUSPENSION

NULL HYPOTHESIS - Dredged sediment is subject to predictable forces after placement which result in fairly standard rates of consolidation and erosion, based on the type of material, the type of placement and the placement location. Placement of dredged material will not deviate from these expected conditions.

STUDY ENDPOINT - Monitoring will be performed each year that placement occurs within the Site 92 area, and for up to one year after placement is completed to document consolidation and erosion of materials.

OBJECTIVES

- To measure and evaluate changes in the placed material within the placement area and nearby areas due to erosion and consolidation of sediments.
- To determine capacity of the Site 92 berm and interior areas before and after placement of dredged material.
- To evaluate the results of the study and suggest modifications as necessary in the study design, and site management.
- To verify whether changes are occurring in the high relief areas to the northeast of Site 92 resulting from placement activities.

BACKGROUND

The MGS has studied the placement, consolidation and erosion of dredged material in the Upper Bay for over 15 years. These studies have documented the configuration and occupied volume of dredged material placed using different techniques. The studies have also found that subsequent to placement, deposited sediments may be subjected to volume changes due to two processes. First, resuspension and erosion may remove sediment particles from the site. Second, consolidation of deposited sediment and the underlying foundation will result in a change in volume and height of the deposit. The consolidation processes result in a change in the elevation of the deposit without the removal of sediment particles. This study will measure and document the effects of these processes on the berm and the controlled bottom placed sediments at Site 92. This study will also attempt to define when the observed placement, erosion and consolidation processes are within expected parameters. This study will also identify when these processes exceed expected parameters and what the potential reasons are for variation from expectations.

Observations of consolidation and erosion in the Site 92 Area will be determined though field work, laboratory analysis and data processing and synthesis. Sediments will be collected and analyzed before dredging and placement operations begin in Site 92 and in the channel. A hydrographic survey of the placement area will also be performed prior to placement to enable later measurement of the changes in the berm height and configuration and changes in capacity of the placement area. At the conclusion of the placement activities and at the end of the monitoring period, core samples will be collected from the placement area to determine the changing state of the deposited sediments over time. Selected samples will be subjected to grain size and bulk property analyses. This data will be analyzed to determine volumetric changes due to consolidation of the berm and foundation sediments. The amount of material which is resuspended from the surface of the berm will be estimated from a comparison between the calculated change in volume due to consolidation and the total observed change measured from the hydrographic surveys.

METHODOLOGY

1. Preplacement activities - Site 92

Prior to dredging and placement activities, core samples will be taken from the Site 92 placement area and the channel. These samples will be analyzed for grain size and water content. From the water content, bulk density, porosity and void ratios will be calculated. This information will then be available to calculate foundation consolidation of existing sediments before placement of material. A detailed hydrographic survey of the site will also be performed and a contour map of the site will be developed.

2. Material lost during placement

It is anticipated that some percentage of sediments will be lost due to suspended sediment dispersion during placement activities. To estimate the quantity of suspended sediment lost as a turbidity plume at the placement location(s), 5 core samples will be collected from the channel maintenance sediments prior to dredging and analyzed for bulk properties. At the conclusion of placement, 8 core samples will be collected of the placed sediment and also analyzed for bulk properties. In addition, a hydrographic survey of the site will be conducted and the volume occupied by the placed sediment calculated. This data will be utilized to estimate the total volume of sediment lost during the placement process.

3. Consolidation of the placement area sediments

Consolidation of the placed sediments will alter the remaining capacity of the designated placement area. Calculation of the remaining capacity is necessary to determine an appropriate volume for placement in the next dredging operation. To accomplish the analysis of consolidation over time, a maximum of 6 bathymetric surveys of the placement area will be conducted, pre-placement, post-placement and at the 1, 3, 6 and 9 month points after the completion of placement. In addition, sediment cores will be collected at eight sites in the placement area at three points in time - pre-, post and either 6 or 9 months following placement (depending on the following year's dredging schedule).

4. Sediment resuspension and erosion after placement

Based on previous studies that have been conducted in the vicinity of Pooles Island it is expected that some controlled bottom placed sediment may be resuspended and eroded from the area over time. The rate of erosion is anticipated to decrease over time as the sediments consolidate making individual particles less susceptible to erosion, and as the surface becomes armored with slightly coarser particles left behind by the erosion process. This study will estimate the erosion of the placed sediment during a six to nine month period following placement. The amount of material eroded from the placement area will be estimated by further analysis of the sediment bulk properties and volume data. The water content changes in the sediments will be converted to a volume change attributable to consolidation. The difference between the volume change and the total observed change will yield the volume of material estimated removed due to erosion.

DATA BASE MANAGEMENT

Survey data shall be collected in digital format and transmitted to the MES. Electronic data shall be transmitted in a form suitable for incorporation in AutoCAD files.

DELIVERABLES

Progress reports will be submitted monthly, on the last day of the month. The progress reports shall document progress on work tasks, findings to date and any unusual circumstances or problems that have arisen since the last report.

An interim report with remaining capacity calculations for Site 92 will be produced six months after the completion of placement, and again prior to the initiation of the next year's placement activities (tentatively scheduled for October, 1999).

The final report will be produced six months following the completion of the last survey (approximately March 2000). It will document the lateral extent and thickness of the deposited sediments and the elevation and volumetric changes that the sediment has undergone during the study period. The report will contain a consolidation history of the placed sediments through analysis of the hydrographic surveys and the change in bulk properties of sediment in the collected core samples. The report will also document the estimated loss during dredging and placement, the remaining capacity of the placement area, and the sediment resuspension and erosion estimate for Site 92. The results of consolidation and resuspension study shall be incorporated, as a separate chapter, in the overall placement effects assessment report.

III. BENTHIC COMMUNITY EVALUATION

NULL HYPOTHESIS - There is no long term loss of the benthic community in terms of the multi-metric Benthic Index of Biotic Integrity (B-IBI) after placement of dredged material has ceased.

STUDY ENDPOINT - This study will be performed during the Spring, Summer and Fall of 1998 (May, July and October 1998) before dredged material placement in Site 92. Then, at least 18 months after all placement has ceased at Site 92, this study will be repeated within the Site 92 placement area.

OBJECTIVES

The objectives of this study are:

- To assess the benthic community at Site 92 to determine baseline conditions and to verify the re-establishment of a healthy benthic community more than eighteen months after completion of dredged material placement at the site.

- To compare the results of sampling with established Chesapeake Bay benchmarks, including the B-IBI, to evaluate the benthic community conditions at Site 92.

- To compare seasonal baseline data for Site 92 with other open-water and contained dredged material disposal placement sites.

- To assess Site 92 benthic populations to determine the possible effects of the placement of dredged material at open-water sites in the Pooles Island complex.

METHODOLOGY

Baseline benthic species abundance data will be collected from seven locations in Site 92. Two reference stations will be used for comparison purposes. The reference stations have been selected based on their location away from the proposed Site 92 and the conditions affecting this area. In addition, two background stations will provide supplemental information for comparison purposes.

1. Sampling Locations

Seven assessment stations have been selected in the Site 92 area (In May 1998, five assessment stations were selected in Site 92). Additionally, two reference and two background stations have been selected in adjacent waters (In May 1998, six assessment stations were selected outside of Site 92). The two reference stations were selected in representative areas of varying depths and salinity regimes. One background station is located in G-South and the other is located northeast of G-East. Three samples will be collected from each station. The latitude and longitude of each sampling location shall be recorded.

2. Sampling Schedule

The seven assessment stations, two reference stations, and two background stations shall be sampled in May, July and October 1998 before placement has occurred.

3. Sampling Methods

During each sampling cruise, triplicate samples shall be collected at each sample station. A physical description of the sediments will be recorded from each location for bottom sediment substrate characterization. Water quality parameters (including salinity, temperature, dissolved oxygen concentration, turbidity, and pH) of surface and bottom waters shall be measured at each location.

4. Laboratory Processing

Benthic samples shall be sorted and all organisms identified, to the lowest practical taxonomic level, and enumerated. All sample processing shall be subject to quality assurance and quality control procedures described in the Contractor's Laboratory Manual.

5. Data Management

Data shall be entered and edited using approved procedures to ensure accuracy. The data will be analyzed statistically using SAS and other methodologically appropriate software. All data sets will be stored on the Chesapeake Bay Program's VAX computer system.

6. Data Analysis

Benthic assemblage differences among the placement area and reference sites shall be identified and evaluated using appropriate ecological, statistical and graphical techniques.

DELIVERABLES

Data collected for the Site 92 benthic study shall be prepared by the Maryland Department of the Environment as fully documented SAS Data Sets in DEC VAX/VMS format. The draft report for this study element will be submitted to MES by January 31, 1999 (90 days after last cruise). The results of the benthic evaluation shall be incorporated, as a separate chapter, in the overall placement effects assessment report. This also includes attendance at site management and project status meetings.

V. TECHNICAL SUPPORT

The Maryland Department of the Environment Technical and Regulatory Services Administration (TARSA) staff shall provide technical and regulatory support and advice to the Maryland Port Administration, the Philadelphia District of the U.S. Army Corps of Engineers and the Maryland Environmental Service, throughout the year. This includes coordination of the Water Quality Certification (WQC) request for dredged material placement, coordination of time of year restrictions and possible extensions of the WQC.

VI. TECHNICAL INTEGRATION

For the Site 92 Monitoring Plan, the Technical Integrator shall have responsibility for coordination of program activities by all participants, the integration of findings from all program elements, and the preparation of interim and final reports that address the overall program objectives stated earlier.

OBJECTIVES

The technical objectives of this element are:

- To ensure that all elements of the data collection program are conducted in a coordinated and mutually beneficial manner.
- To provide overall program QA/QC to ensure that program elements are meeting stated technical objectives.
- To conduct overall impact assessments and prepare program assessment reports.

The management objectives of this study are:

- To determine from an analysis of the study findings, the magnitude and extent of impacts resulting from placement activity.

METHODOLOGY

1. Coordinate studies and principal investigators to maximize efficiencies and exchange information during the study period.
2. Conduct periodic meetings of principal investigators.
3. Verify and track cruises, deliverables and findings.
4. Produce final comprehensive monitoring report.

5. Produce monitoring plan for 99/00 placement activities.

6. Coordinate monitoring activities with dredging operations.

7. Provide overall program QA/QC to ensure that project elements are meeting stated technical objectives.

8. To provide technical support to MPA and CENAP on future placement actions and monitoring plans in the Pooles Island area.

DATA BASE MANAGEMENT

All data submitted from all program elements shall be assembled in an electronic format and stored in an acceptable, archivable format.

DELIVERABLES

A final comprehensive report of monitoring activities from the Site 92 monitoring program will be prepared. Interim technical reports shall also be prepared as necessary. Interim reports will be structured around specific issues that have been raised about the project and augmented to address all additional issues which have been identified as a result of input received during the recent project approval process.

The 1998/1999 draft placement monitoring report shall be prepared in June 2000 and shall include a description of findings of the baseline monitoring. The report shall include an assessment of physical impacts resulting from placement, an evaluation of the ability for prediction of impacts from additional placement events and an assessment of potential impacts from additional placement at Site 92. Such an evaluation shall include identification of information gaps and needs, and the delineation of information areas for which data of greater precision may be required.

A 1999/2000 monitoring plan shall be prepared for MPA and CENAP approval, if necessary and submitted to MDE before planned placement actions at Site 92 or elsewhere in the Pooles Island area.

VII. PROJECT MANAGEMENT

OBJECTIVES

- To manage the contract and subcontractors in a timely manner within the allowed budget and schedule.
- To provide management support to the MPA and CENAP for dredged material placement in the Pooles Island area.

- To provide administrative support to MPA and CENAP for the purposes of budgeting and scheduling future placement actions and preparing monitoring plans for the Pooles Island Area.

METHODOLOGY

1. Prepare detailed schedules and work plans to ensure timely completion of assessment report.
2. Coordinate routine activities between all parties involved including MPA and CENAP.
3. Monitor progress on work tasks.
4. Prepare and conduct 4 meetings if necessary for relevant committees and the general public.
5. Prepare and conduct periodic coordination meetings for the clients and MES staff as necessary.
6. Budget tracking and invoice payment.
7. Monthly progress reports to client.
8. Prepare fiscal year budgets and schedule as required by MPA and CENAP.
9. Conduct budget reviews and projections as required by MPA and CENAP.
10. Prepare scopes and agreements for monitoring plan elements.

DELIVERABLES

1. Monthly progress reports to the clients.
2. Detailed schedules and budgets as requested by the client.

APPENDIX C

1998/1999 PLACEMENT MONITORING

SITE MANAGEMENT PLAN

SITE 92 OPEN-WATER PLACEMENT
SITE MANAGEMENT PLAN
1998/1999 Monitoring (1st Year) - Controlled Bottom Placement

INTRODUCTION & PURPOSE:

This document is the Site Management Plan for the first year of open-water placement of dredged material at Site 92, which will occur around December 18, 1998 to March 31, 1999. The placement method utilized in the first year will be controlled bottom release scow placement. This Site Management Plan is prepared for submittal by the Maryland Environmental Service (MES) to the Maryland Department of the Environment (MDE) on behalf of the Philadelphia District, U.S Army Corps of Engineers (CENAP) and the Maryland Port Administration (MPA) in compliance with Water Quality Certificate number 98-WQ-0003.

The purpose of this Site Management Plan is to monitor placement activities, assure timely transmittal, analysis and reporting of information, and to recommend operational changes, if necessary.

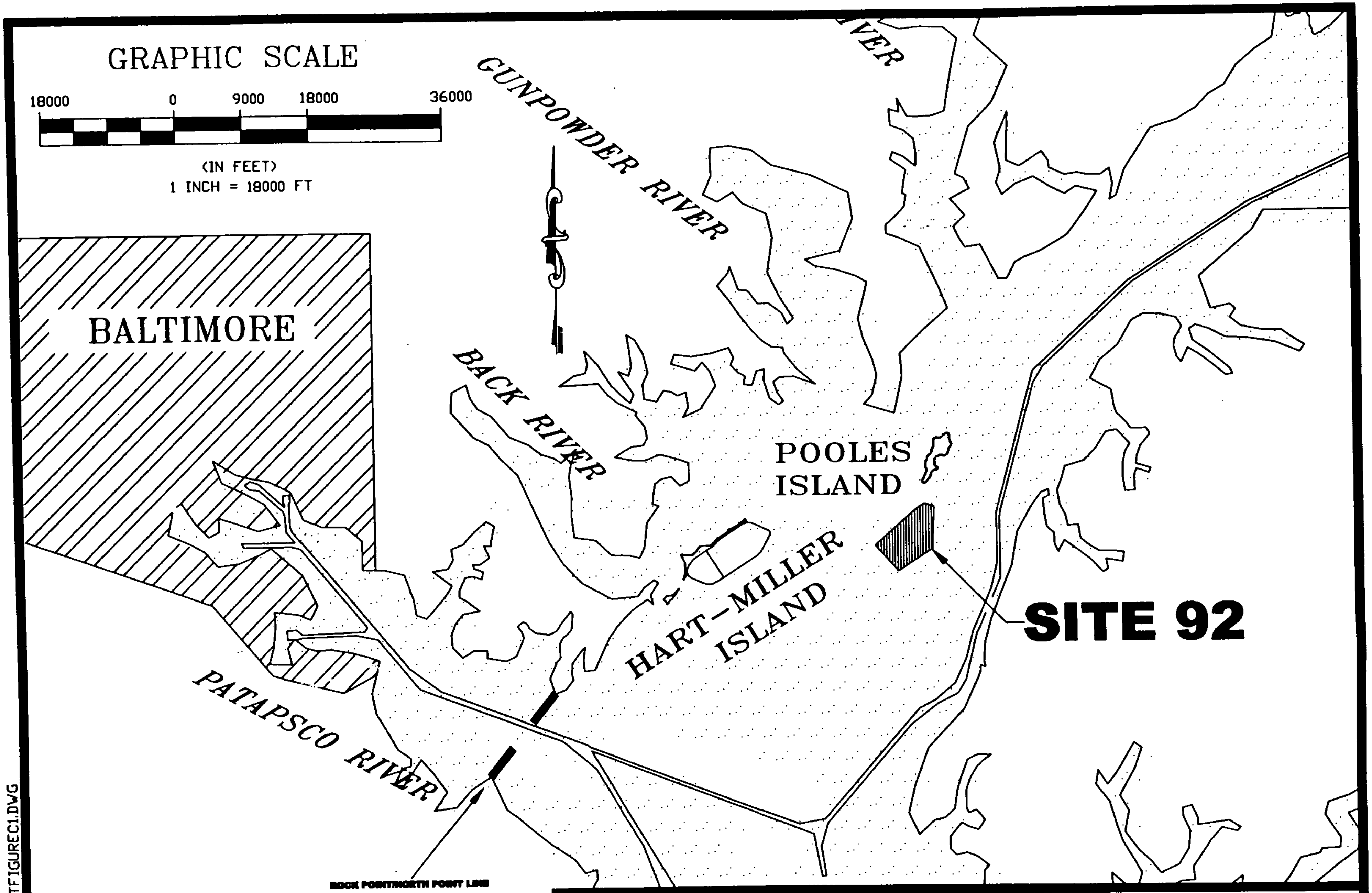
SITE DESCRIPTION:

Site 92 is an open-water dredged material placement area located immediately south of Pooles Island in the Chesapeake Bay (Figure C-1). The site is approximately 934 acres in size and is estimated to provide 3.7 mcy of capacity when brought to elevation -14 feet MLLW. Site 92 surrounds a shallow, elongated basin, oriented in a northeast to southwest direction. A berm will be placed within Site 92 (Figure C-2), along the north and eastern edge to minimize the potential for material migration.

The boundaries of Site 92 are as follows (NAD 27 coordinates):
Beginning at the western-most point at 39 15 05.07 N, 076 17 40.37 W,
Running thence to 39 15 52.89 N, 076 16 30.76W,
Running thence to the northern-most point at 39 16 00.35N, 076 16 16.10W,
Running thence to 39 15 56.19N, 076 15 59.30W,
Running thence to 39 14 59.24 N, 076 16 02. 88 W,
Running thence to the southern-most point at 39 14 29.95N, 076 17 01.16W,
and running thence to the point of beginning.

BACKGROUND:

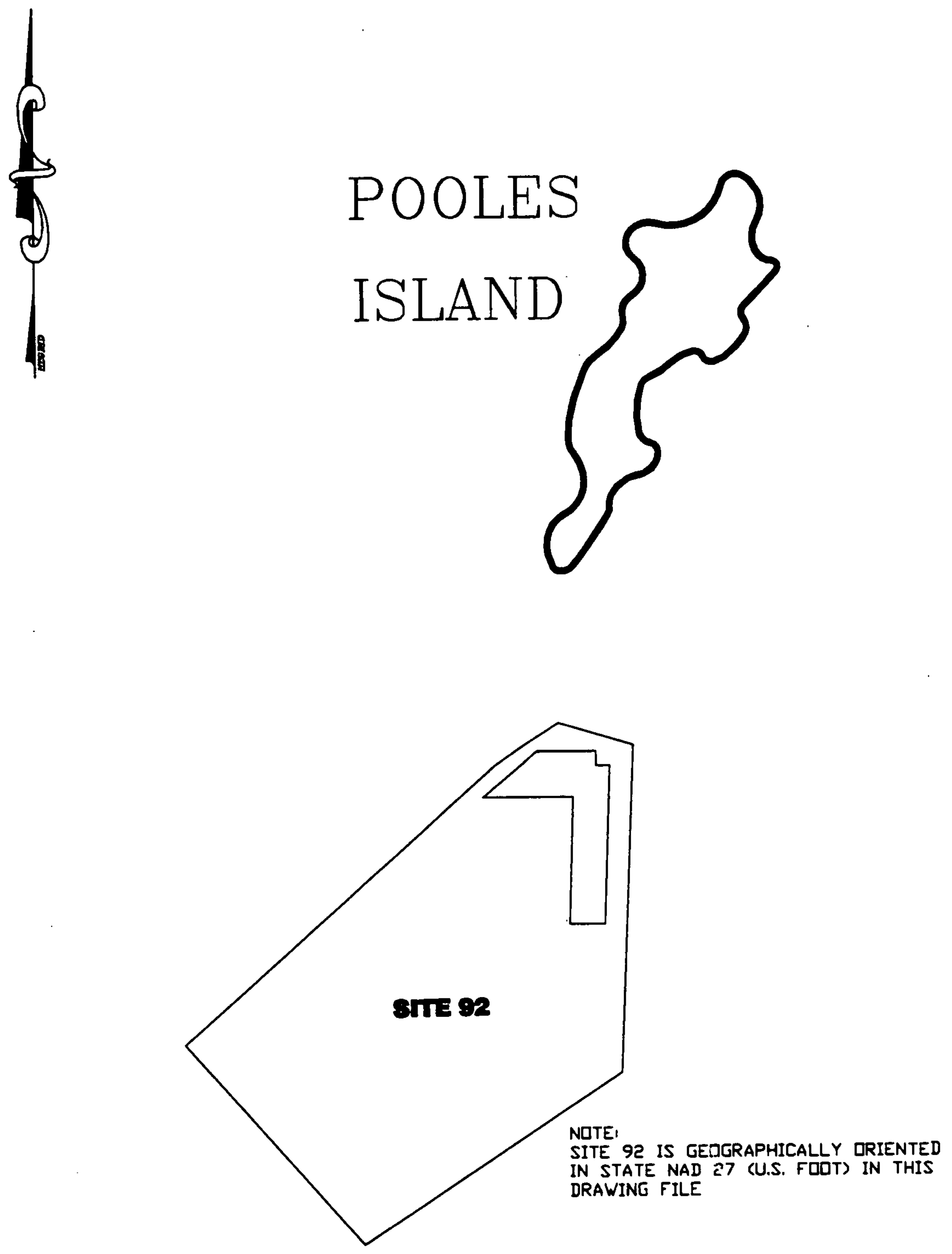
In order to initially obtain the required environmental permits for placement, environmental data collection of the Site 92 placement area was performed, and a joint Environmental Assessment (EA) of two proposed open-water placement



MARYLAND ENVIRONMENTAL SERVICE

SITE 92 VICINITY MAP
FIGURE C-1

J:\SITE92\REPORTFIGUREC1.DWG



MARYLAND
ENVIRONMENTAL
SERVICE

SITE 92 & BERM
FIGURE C-2

J:SITE92/NEWBERM.DWG

areas, G-East and Site 92, was prepared. The final EA, entitled *Environmental Assessment - Designation of Aquatic Dredged Material Placement Areas G-East and Site 92 for Maintenance Dredging, Inland Waterway Delaware River to Chesapeake Bay, Delaware and Maryland Northern Approach Channel,* was issued in July 1997, and a Finding of No Significant Impact was issued for both sites in August 1997.

A Water Quality Certification (WQC) (98-WQ-0003) was issued by MDE on September 14, 1998 for the use of Site 92 in addition to the Courthouse Point, Bethel and Chesapeake City upland placement areas. On November 16, 1998, CENAP awarded the dredging contract to Weeks Marine, Inc. On December 15, 1998, a Contractor/Team Meeting was held with representatives from CENAP, MPA, MES, MDE, Maryland Geological Survey (MGS), and Weeks Marine, Inc. to discuss the dredging operations plan for Site 92 proposed by Weeks Marine, Inc. This work plan would be enveloped into the Site Management Plan submitted to MDE by MES on behalf of CENAP and MPA. On December 18, 1998, Weeks submitted the Dredging Operations Plan for Site 92 (Appendix I). This plan includes a description of the order of dredge excavation and material placement, the tug positioning systems, access to and from the placement area, placement area marking, a gridded layout of the placement area for proposed scow placement, and a table which designates the order of work.

Site Management will begin with pre-placement activities (meetings and surveys) before the initiation of placement at Site 92. Site Management is required to be conducted in accordance with the monitoring plan that was submitted for Site 92 to MDE in December 1998. The Site Management objectives, dredging operations, placement operations, data collection and transfer, meeting plans, and deliverables are discussed below:

OBJECTIVES:

The main objectives of site management at Site 92 are:

- to describe the dredged material placement activities;
- to ensure that all required information is collected before, during and after placement;
- to assure timely transmittal, analysis and reporting of information;
- to provide for a review process; and
- to provide recommendations for future open-water placement activities.

Monitoring of dredged material placement is used to detect trends in material movement and site elevations to allow for appropriate adjustments to operations.

DREDGING OPERATIONS:

The dredge will commence work in Acceptance Section 2 of the channel. Acceptance Section 1 was eliminated from the contract due to lack of available material. The dredge will be supported by one tugboat and two scows. The dredge will progress in a southerly direction. The dredge may at any time move into more southerly sections of the channels in order to facilitate the construction of the southern half of the underwater berm.

The total estimated quantity of material necessary to be removed from the channels is as follows:

Acceptance Section	Estimated Quantity (cy)
2	25,698
3	76,962
4	91,572
5	127,561
6	182,682
7	140,908
8	24,585
9	38,009
10	37,803
11	15,250
12	20,668
13	103,779
Total	**885,497**

Shortnose Sturgeon Observer:

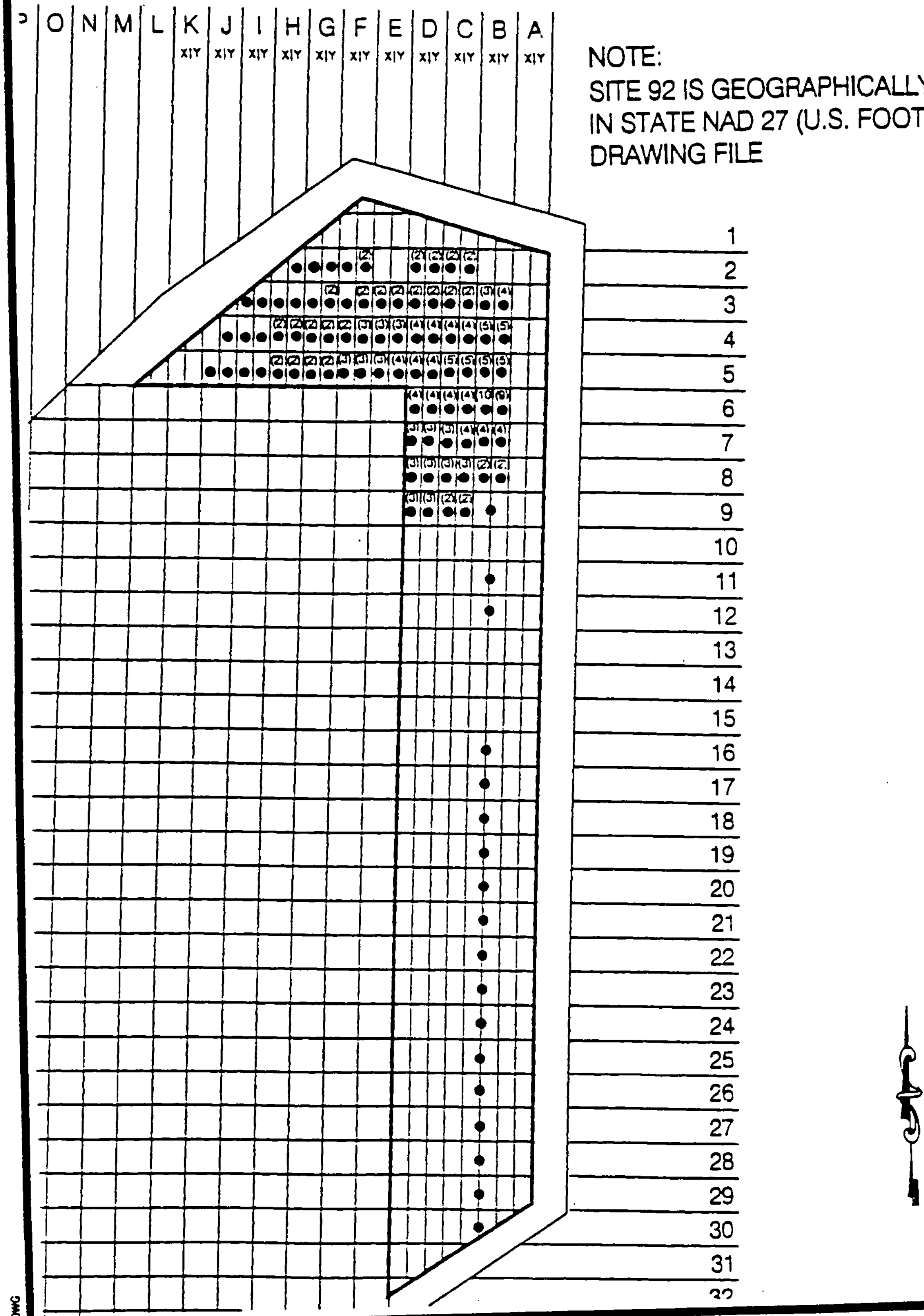
Observations for shortnose sturgeon will be performed on a daily basis by CENAP inspection personnel. Coordination with the appropriate agencies, including the National Marine Fisheries Service, will take place immediately upon the observation of a shortnose sturgeon in the dredge.

PLACEMENT OPERATIONS:

Phase I - Berm Creation:

The first phase of placement at Site 92 (Phase I) is to create the underwater berm (Figure C-3). A minimum of 300,000 cy of dredged material will be needed to construct the northern and eastern portion of the berm. Placement of material is restricted to -14 feet MLLW and below.

Weeks Marine, Inc. will start Phase I of the placement at the northern end of the underwater berm in the manner depicted in the attached berm construction and dumping schedule location (Appendix 1: pages 5-7). The drop zone for the berm construction is divided into cells 100' by 200' in area as seen in Figure C-3. Each cell is labeled and the approximate number of scow drops are included in



NOTE:
SITE 92 IS GEOGRAPHICALLY ORIENTED IN STATE NAD 27 (U.S. FOOT) IN THIS DRAWING FILE

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Disposal Grid
Phase I (Berm Creation)
Figure C-3

parenthesis. Material will then be placed in the southern section of the eastern berm. After completion, the berm is designed to have a 30H:1V slope with all slopes contained within the site boundaries. The top of the berm is designed to have a final constant elevation along the entire length of -14 feet MLLW. The towing tugboats will place each load in a predetermined cell.

Prior to placement, the scow equipped with a Differential Global Positioning System (DGPS) will be brought to a complete stop and the exact location of the scow and the approximate quantity of material to be placed will be recorded. The limits of Site 92 will be delineated with approved markers.

Phase II- Remaining Material:

Following the satisfactory construction of the berm, which will be determined by analyzing CENAP survey data, Weeks Marine, Inc. will commence placement of material behind the berm within the main placement area (Phase II). This area is divided into cells 200 by 200 feet in area. An official placement schedule and location table will be developed by Weeks Marine, Inc. during the berm construction process. A suggested placement area will be discussed during the Site Management meeting scheduled on January 5, 1998. Upon submission of the official placement schedule and location table and agreement by CENAP, MPA, MDE, MES and MGS that the berm was satisfactorily constructed, Weeks Marine, Inc. will place the remaining material within site boundaries according to the Site Operations Plan.

DATA COLLECTION & TRANSFER:

Tug Positioning:

Each scow will be equipped with a DGPS and pressure differential gages. The DGPS will indicate the position of the dredge and each placement scow. The DGPS will be interfaced with a computer to run HYPACK computer software. This system will record the tugboats position on computer disk and on the computer monitor. This minimizes any margin of error in horizontal control for placing material in the chosen cell. The towing tugboat will utilize the DGPS tracking system to follow a predetermined route from the Upper Chesapeake Bay into Site 92. The same route will be followed each trip.

Data Collection:

Records of the overboard placement operations will be recorded on disk every 15 minutes. The position of the scow shall automatically be recorded when the scow discharges material. Scow drop locations and estimated quantity of material placed at Site 92 will be submitted to CENAP on a daily basis.

Weeks Marine, Inc. will prepare a Daily Report of Operations form and a Scow Discharge Report, which will be submitted to CENAP daily for approval. CENAP will forward this data to MES on a daily basis.

Data forwarded to MES from CENAP will be analyzed for volume of material placed in the area, the duration of placement, and the location of the scows material is placed. Quantity and placement information will be compiled by MES in Excel format and will be represented graphically. Data will be used to generate a map of the site showing scow placement locations overlain upon the pre-placement bathymetry. After being analyzed and quality controlled, the data (compiled in the excel format) and a scow placement map will be forwarded to MPA, MGS, CENAP and MDE for review on a weekly basis. All parties will review the information promptly and will report back to MES should they find any discrepancies with the data. MES will then contact CENAP for verification of the information.

Dredged Quantity and Placement Location:

Upon receipt of information from CENAP, MES will review the location and quantity of material placed at the site on a regular basis. This data will be compared to the Site Management Plan for consistency. A map of the site will be produced with the scow locations plotted. This will enable review of operations and the placement of controlled bottom placed material within the placement area. This information will be transmitted via fax or electronic mail on a weekly basis to MGS, MDE, MPA and CENAP for review. All parties will review the information promptly and will report back to MES should they find any discrepancies with the data. MES will then contact CENAP for verification of the information.

HYDROGRAPHIC SURVEYS:

Surveys of Site 92 will be performed by CENAP prior to, during and at the conclusion of placement operations in order to determine placement location and changes in bathymetry. A pre-placement survey of the Site 92 area will be performed before placement activities begin in Site 92. The pre-placement survey is used to verify capacity and bathymetry of the Site 92 area.

Intermediate surveys will be performed at 25%, 50% and 75% of the total estimated quantity of material to be dredged. Each intermediate survey will be compared against previous surveys and the volume of placed material and remaining capacity will be calculated. This volume will then be compared with the dredged quantity to determine volumetric changes during dredging and placement. Cross sections will be developed from surveys to monitor the berm and placement areas. The dredged material quantity and placement locations will be compared with previous survey maps and checked for developing trends. Surveys will also be checked to determine the limits and distribution of placed material and to ensure that the material is remaining within the designated placement area.

Prior to completion of placement, Weeks Marine, Inc. will notify CENAP approximately two weeks prior to the last placement. CENAP will then notify MGS. This will allow MGS and CENAP to complete their final surveys.

All surveys upon completion will promptly be forwarded to MGS, MDE, MPA and CENAP for review.

SITE MANAGEMENT MEETINGS:

Status update meetings will be held between the contractor, CENAP, MES, MGS, and MDE approximately every other week to discuss placement activities, proposed changes to the work plan and overall progress. If necessary, meetings will be scheduled more frequently. The first meeting will take place on January 5, 1999.

DELIVERABLES:

Daily Deliverables:

Placement data (Daily Operating Reports) will be forwarded to MES from CENAP daily. This data will be analyzed for volume of material placed in the area, the duration of placement, and the location of the scows as material is placed. Quantity and placement information will be compiled in Excel format and will be represented graphically. Data will be used to generate a map of the site showing scow placement locations overlain upon the pre-placement bathymetry.

Weekly Deliverables:

After the placement data has been analyzed and quality controlled MES will forward the data in tabular format and a scow placement map to MPA, MGS, CENAP and MDE for review on a weekly basis.

25%, 50% and 75% Surveys:

MES will compare the 25% survey performed by CENAP against the pre-placement survey and the volume of placed material and remaining capacity will be calculated. The 50% and 75% surveys will be compared against other surveys and the volume of placed material and remaining capacity will be calculated. This volume will then be compared with the dredged quantity to determine volumetric changes during dredging and placement. Cross sections will be developed from this survey to monitor the berm to ensure that the material is remaining within the designated placement area. After completion, the 25% survey will be forwarded to CENAP, MPA, MGS and MDE for review.

Post Placement Surveys:

MES will review the most recent post-placement surveys performed by MGS and will produce a Site Management Report on the dredging activities, including capacity evaluations.

Site Management Report:

A Site Management Draft Report will be submitted by MES to MPA, CENAP, MDE and MGS for review within twelve weeks of conclusion of placement activities. This report will consist of a summary of placement activities. The quantity of material placed in each area and the remaining capacity will be documented graphically and in a tabular format. The report will also include copies of all hydrographic surveys performed to date and the cross sections developed by MES.

APPENDIX I

WEEKS MARINE, INC.
MARINE CONTRACTORS – EQUIPMENT RENTALS
DREDGING DIVISION, 901 BEACH STREET, CAMDEN, NJ 08102 (609) 963-0963 FAX: (609) 963-0773 or (609) 963-3294

DISPOSAL OPERATIONS PLAN
Disposal Site #92
Maintenance Dredging
Station 162-308 to 250-440
Inland Waterway, Delaware River to Upper Chesapeake Bay
Contract #DACW61-99-C-0001
Revised December 18, 1998

Order of Dredge Excavation

The dredge #549 will commence work in Acceptance Section 1 at Station 201-200 and continue dredging southward through the next sequential Acceptance Sections. At the start of the work, the dredge #549 will be supported by one towing tugboat, two scows and a crewboat. Additional plant and equipment may be added to the project as required to meet the completion schedule.

In conjunction with what was discussed at the December 15, 1998 Site #92 Contractor/Team Meeting, the dredge may jump ahead to perform work in some of the more southern Acceptance Sections in order to facilitate the construction of the southern half of the underwater berm.

Order of Disposal

1.) Berm Construction

The first order of disposal is to construct the northern end of the underwater berm. The dumping schedule and location plan to perform this task is attached. The 'drop' zone for the berm construction will be divided into cells 100' x 200' in area. Each cell has a specific label. The baseline for the cell labelling system will start at the centerline of the berm. A plan view of the grid system layout is also attached.

2.) Post Berm Dumping

Following the satisfactory construction of the berm, which will be determined by analyzing survey data, we will commence dumping behind the berm within the main disposal area. This area is divided into cells 200' x 200' in area. Dumping will commence in the north quadrants and progress west to east, continually moving southward. Cells L6 to E6 would be filled than cells M7 to E7 and so on. An official dumping schedule and loaction table will be developed during the berm construction process. This is neccessary because a review of progress surveys may indicate variations need to be made to insure the integrity of the berm.

The towing tugboat(s) will be directed to dump each load in a predetermined cell. Regular hydrographic surveys will be performed to monitor cell construction progress. From these surveys it can be determined how many loads can be placed in any given cell. All dumping efforts will be coordinated to eliminate the possibility of material exceeding the disposal area limits.

As discussed at the December 15, 1998 Team Meeting, our dumping activities will be designed and coordinated to, at the very least, minimize the use of a drag bar to obtain the desired berm elevations. Proper notification will be given prior to the potential use of a drag bar within this area.

Tug Positioning Systems

All towing tugboats will be equipped with DGPS Differential Global Positioning Systems. The DGPS will be interfaced with a computer to run HYPACK computer software. The use of HYPACK enables us to record the tugboat's position on computer disk and, as importantly, enables the tugboat to have a real time position displayed on a computer monitor in the wheelhouse, both in coordinate form and plan view. This minimizes any margin of error in horizontal control for dumping in the right cell. In addition, the scow is secured directly to the towing tugboat for accurate horizontal control during the dumping operation.

As contractually required, records of the overboard disposal operations will be recorded on disk every 15 minutes. The disk will be submitted to the Corps Of Engineers. A Scow Discharge Report will be filled out for each scow load of material. A copy of this report is attached.

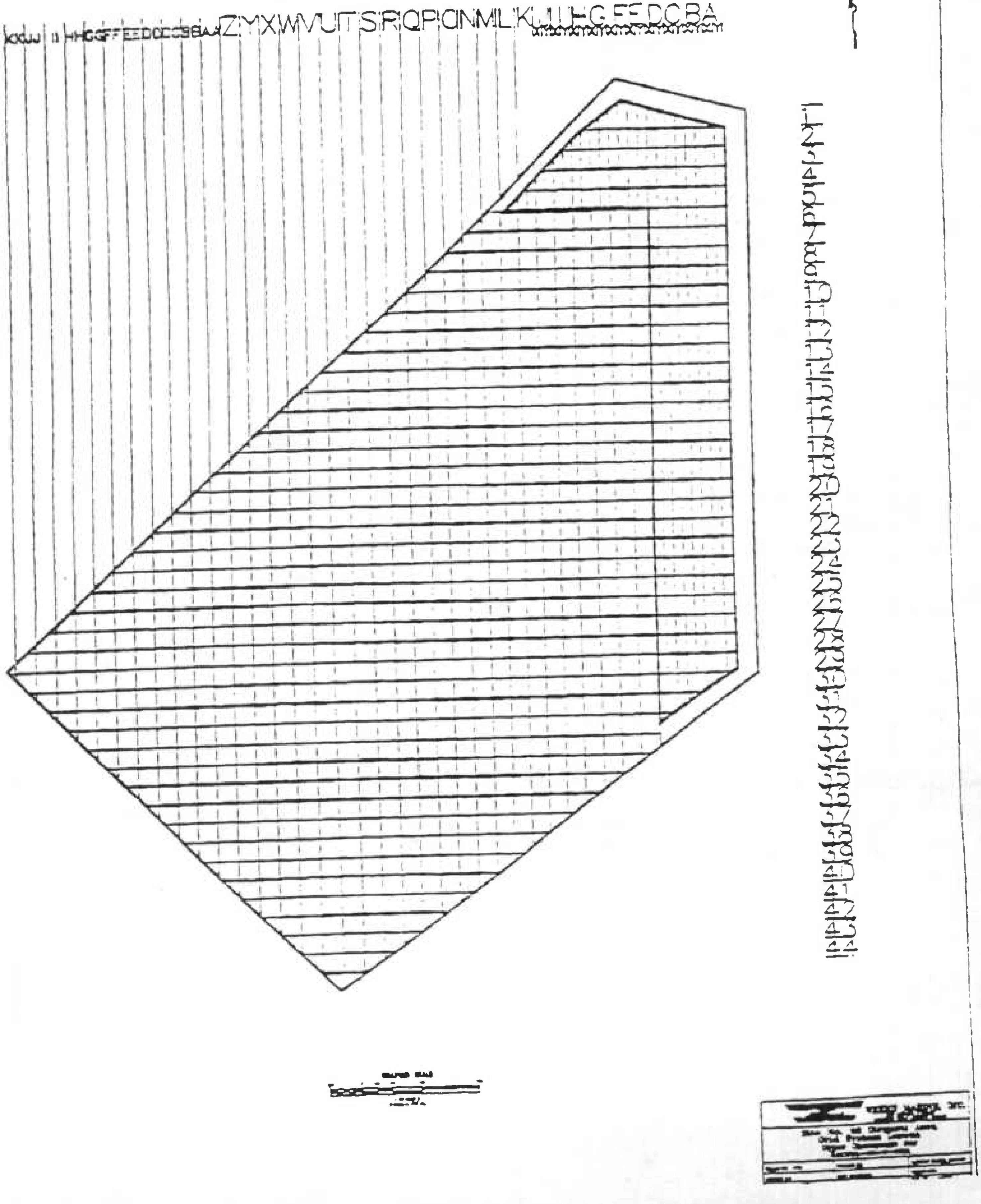
Access To and From the Disposal Area

The towing tugboat will utilize the DGPS tracking system to follow a predetermined route from the Upper Chesapeake range into Site #92 Disposal Area. The same route will be followed for ingress and egress transit.

Disposal Area Marking

Weeks Marine, as contractually required, will delineate the boundaries of the berm area with buoys. The buoys will be accurately placed with the use of DGPS. They will also be lighted with United States Coast Guard approved lights.

SITE NO. 92 DISPOSAL AREA – GRID SYSTEM



SITE #92 BERM CONSTRUCTION
DUMPING SCHEDULE and LOCATION

Revised 12/18/98

Load #	Cell #	Volume Cy/Load	Cumulative Volume
1	GX2	2,000	2,000
2	GY2	2,000	4,000
3	FX2	2,000	6,000
4	FY2	2,000	8,000
5	FY2	2,000	10,000
6	~~E3~~	2,000	12,000
7	DX2	2,000	14,000
8	DX2	2,000	16,000
9	DY2	2,000	18,000
10	DY2	2,000	20,000
11	DX3	2,000	22,000
12	DX3	2,000	24,000
13	DY3	2,000	26,000
14	DY3	2,000	28,000
15	CX2	2,000	30,000
16	CX2	2,000	32,000
17	CY2	2,000	34,000
18	CY2	2,000	36,000
19	CX3	2,000	38,000
20	CX3	2,000	40,000
21	CY3	2,000	42,000
22	CY3	2,000	44,000
23	BX3	2,000	46,000
24	BX3	2,000	48,000
25	BX3	2,000	50,000
26	BY3	2,000	52,000
27	BY3	2,000	54,000
28	BY3	2,000	56,000
29	BY3	2,000	58,000
30	BX4	2,000	60,000
31	BX4	2,000	62,000
32	BX4	2,000	64,000
33	BX4	2,000	66,000
34	BX4	2,000	68,000
35	BY4	2,000	70,000
36	BY4	2,000	72,000
37	BY4	2,000	74,000
38	BY4	2,000	76,000
39	BY4	2,000	78,000
40	BX5	2,000	80,000
41	BX5	2,000	82,000
42	BX5	2,000	84,000
43	BX5	2,000	86,000
44	BX5	2,000	88,000
45	BY5	2,000	90,000
46	BY5	2,000	92,000
47	BY5	2,000	94,000
48	BY5	2,000	96,000
49	BY5	2,000	98,000
50	BX6	2,000	100,000
51	BX6	2,000	102,000
52	BX6	2,000	104,000
53	BX6	2,000	106,000
54	BX6	2,000	108,000
55	BY6	2,000	110,000
56	BY6	2,000	112,000
57	BY6	2,000	114,000
58	BY6	2,000	116,000
59	BY6	2,000	118,000
60	B30	1,800	119,800
61	B29	1,800	121,600
62	B28	1,800	123,400
63	B27	1,800	125,200
64	B26	1,800	127,000
65	B25	1,800	128,800
66	B24	1,800	130,600
67	B23	1,800	132,400
68	B22	1,800	134,200
69	B21	1,800	136,000
70	B20	1,800	137,600
71	B19	1,800	139,600
72	B18	1,800	141,400
73	B17	1,800	143,200
74	B16	1,800	145,000
75	BX6	2,000	147,000
76	BX6	2,000	149,000
77	BX6	2,000	151,000
78	BX6	2,000	153,000
79	BX6	2,000	155,000
80	BY6	2,000	157,000
81	BY6	2,000	159,000
82	BY6	2,000	161,000
83	BY6	2,000	163,000
84	BX7	2,000	165,000
85	BX7	2,000	167,000
86	BX7	2,000	169,000
87	BX7	2,000	171,000
88	BY7	2,000	173,000
89	BY7	2,000	175,000
90	BY7	2,000	177,000

Load #	Cell #	Volume Cy/Load	Cumulative Volume
91	BY7	2,000	179,000
92	BX8	2,000	181,000
93	BX8	2,000	183,000
94	BY8	2,000	185,000
95	BY8	2,000	187,000
96	B9	2,000	189,000
97	B10	2,000	191,000
98	B11	2,000	193,000
99	B12	2,000	195,000
100	H2	2,000	197,000
101	EY3	2,000	199,000
102	EY3	2,000	201,000
103	EX3	2,000	203,000
104	EX3	2,000	205,000
105	FY3	2,000	207,000
106	FY3	2,000	209,000
107	FX3	2,000	211,000
108	GY3	2,000	213,000
109	GY3	2,000	215,000
110	GX3	2,000	217,000
111	HY3	2,000	219,000
112	HX3	2,000	221,000
113	IY3	2,000	223,000
114	CY4	2,000	225,000
115	CY4	2,000	227,000
116	CY4	2,000	229,000
117	CY4	2,000	231,000
118	CX4	2,000	233,000
119	CX4	2,000	235,000
120	CX4	2,000	237,000
121	CX4	2,000	239,000
122	DY4	2,000	241,000
123	DY4	2,000	243,000
124	DY4	2,000	245,000
125	DY4	2,000	247,000
126	DX4	2,000	247,000
127	DX4	2,000	249,000
128	DX4	2,000	251,000
129	DX4	2,000	253,000
130	EY4	2,000	255,000
131	EY4	2,000	257,000
132	EY4	2,000	259,000
133	EX4	2,000	261,000
134	EX4	2,000	263,000
135	EX4	2,000	265,000
136	FY4	2,000	267,000
137	FY4	2,000	269,000
138	FY4	2,000	271,000
139	FX4	2,000	273,000
140	FX4	2,000	275,000
141	GY4	2,000	277,000
142	GY4	2,000	279,000
143	GX4	2,000	281,000
144	GX4	2,000	283,000
145	HY4	2,000	285,000
146	HY4	2,000	287,000
147	HX4	2,000	289,000
148	HX4	2,000	291,000
149	IY4	2,000	293,000
150	IX4	2,000	295,000
151	JY4	2,000	297,000
152	CY5	2,000	299,000
153	CY5	2,000	301,000
154	CY5	2,000	303,000
155	CY5	2,000	305,000
156	CY5	2,000	307,000
157	CX5	2,000	309,000
158	CX5	2,000	311,000
159	CX5	2,000	313,000
160	CX5	2,000	315,000

Load #	Cell #	Volume Cy/Load	Cumulative Volume
161	CX5	2,000	317,000
162	DY5	2,000	319,000
163	DY5	2,000	321,000
164	DY5	2,000	323,000
165	DY5	2,000	325,000
166	DX5	2,000	327,000
167	DX5	2,000	329,000
168	DX5	2,000	331,000
169	DX5	2,000	333,000
170	EY5	2,000	335,000
171	EY5	2,000	337,000
172	EY5	2,000	339,000
173	EY5	2,000	341,000
174	EX5	2,000	343,000
175	EX5	2,000	345,000
176	EX5	2,000	347,000
177	FY5	2,000	349,000
178	FY5	2,000	351,000
179	FY5	2,000	353,000
180	FX5	2,000	355,000
181	FX5	2,000	357,000
182	FX5	2,000	359,000
183	GY5	2,000	361,000
184	GY5	2,000	363,000
185	GX5	2,000	365,000
186	GX5	2,000	367,000
187	HY5	2,000	369,000
188	HY5	2,000	371,000
189	HX5	2,000	373,000
190	HX5	2,000	375,000
191	IY5	2,000	377,000
192	IX5	2,000	379,000
193	JY5	2,000	381,000
194	JX5	2,000	383,000
195	CY6	2,000	385,000
196	CY6	2,000	387,000
197	CY6	2,000	389,000
198	CY5	2,000	391,000
199	CX6	2,000	393,000
200	CX6	2,000	395,000
201	CX6	2,000	397,000
202	CX6	2,000	399,000
203	DY6	2,000	401,000
204	DY6	2,000	403,000
205	DY6	2,000	405,000
201	DY6	2,000	407,000
202	DX6	2,000	409,000
203	DX6	2,000	411,000
204	DX6	2,000	413,000
205	DX6	2,000	415,000
206	CY7	2,000	417,000
207	CY7	2,000	419,000
208	CY7	2,000	421,000
209	CY7	2,000	423,000
210	CX7	2,000	425,000
211	CX7	2,000	427,000
212	CX7	2,000	429,000
213	DY7	2,000	431,000
214	DY7	2,000	433,000
215	DY7	2,000	435,000
216	DX7	2,000	437,000
217	DX7	2,000	439,000
218	DX7	2,000	441,000
219	CY8	2,000	443,000
220	CY8	2,000	445,000
221	CY8	2,000	447,000
222	CX8	2,000	449,000
223	CX8	2,000	451,000
224	CX8	2,000	453,000
225	DY8	2,000	455,000
226	DY8	2,000	457,000
227	DY8	2,000	459,000
228	DX8	2,000	461,000
229	DX8	2,000	463,000
230	DX8	2,000	465,000
231	CY9	2,000	467,000
232	CY9	2,000	469,000
233	CX9	2,000	471,000
234	CX9	2,000	473,000
235	DY9	2,000	475,000
236	DY9	2,000	477,000
237	DY9	2,000	479,000
238	DX9	2,000	481,000
239	DX9	2,000	483,000
240	DX9	2,000	485,000

APPENDIX D

1998/1999 PLACEMENT MONITORING

OPERATIONS PLAN AND PLAN REVISIONS

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
PHILADELPHIA DISTRICT
WANAMAKER BUILDING
100 PENN SQUARE EAST
PHILADELPHIA, PA. 19107-3390

REPLY TO
ATTENTION OF

DATE: 12/18/98

PLEASE DELIVER THE FOLLOWING PAGES TO:

Name: TAMATY BOSTA

Location: MES

Phone Number: 410-974-7261

Name of Sender: CHIP [illegible] CENAP-OP

Sender's Phone Number: 215-656-6882

Comments: NEW REVISED WORK PLAN BY [illegible].
CHIP

NUMBER OF PAGES: 7 (INCLUDING COVER SHEET)

OUR FAX NUMBER IS : (215) 656 - 6742

If the transaction is not completed or any other difficulties arise, please contact the sender as noted above.

WEEKS MARINE, INC.
MARINE CONTRACTORS – EQUIPMENT RENTALS

DREDGING DIVISION, 901 BEACH STREET, CAMDEN, NJ 08102 (609) 963-0963 FAX: (609) 963-0773 or (609) 963-3294

DISPOSAL OPERATIONS PLAN
Disposal Site #92
Maintenance Dredging
Station 162+308 to 250+440
Inland Waterway, Delaware River to Upper Chesapeake Bay
Contract #DACW61-99-C-0001
Revised December 18, 1998

Order of Dredge Excavation

The dredge #549 will commence work in Acceptance Section 1 at Station 201+200 and continue dredging southward through the next sequential Acceptance Sections. At the start of the work, the dredge #549 will be supported by one towing tugboat, two scows and a crewboat. Additional plant and equipment may be added to the project as required to meet the completion schedule.

In conjunction with what was discussed at the December 15, 1998 Site #92 Contractor/Team Meeting, the dredge may jump ahead to perform work in some of the more southern Acceptance Sections in order to facilitate the construction of the southern half of the underwater berm.

Order of Disposal

1.) Berm Construction

The first order of disposal is to construct the northern end of the underwater berm. The dumping schedule and location plan to perform this task is attached. The 'drop' zone for the berm construction will be divided into cells 100' x 200' in area. Each cell has a specific label. The baseline for the cell labelling system will start at the centerline of the berm. A plan view of the grid system layout is also attached.

2.) Post Berm Dumping

Following the satisfactory construction of the berm, which will be determined by analyzing survey data, we will commence dumping behind the berm within the main disposal area. This area is divided into cells 200' x 200' in area. Dumping will commence in the north quadrants and progress west to east, continually moving southward. Cells L6 to E6 would be filled than cells M7 to E7 and so on. An official dumping schedule and loaction table will be developed during the berm construction process. This is neccessary because a review of progress surveys may indicate variations need to be made to insure the integrity of the berm.

The towing tugboat(s) will be directed to dump each load in a predetermined cell. Regular hydrographic surveys will be performed to monitor cell construction progress. From these surveys it can be determined how many loads can be placed in any given cell. All dumping efforts will be coordinated to eliminate the possibility of material exceeding the disposal area limits.

As discussed at the December 15, 1998 Team Meeting, our dumping activities will be designed and coordinated to, at the very least, minimize the use of a drag bar to obtain the desired berm elevations. Proper notification will be given prior to the potential use of a drag bar within this area.

Tug Positioning Systems

All towing tugboats will be equipped with DGPS Differential Global Positioning Systems. The DGPS will be interfaced with a computer to run HYPACK computer software. The use of HYPACK enables us to record the tugboat's position on computer disk and, as importantly, enables the tugboat to have a real time position displayed on a computer monitor in the wheelhouse, both in coordinate form and plan view. This minimizes any margin of error in horizontal control for dumping in the right cell. In addition, the scow is secured directly to the towing tugboat for accurate horizontal control during the dumping operation.

As contractually required, records of the overboard disposal operations will be recorded on disk every 15 minutes. The disk will be submitted to the Corps Of Engineers. A Scow Discharge Report will be filled out for each scow load of material. A copy of this report is attached.

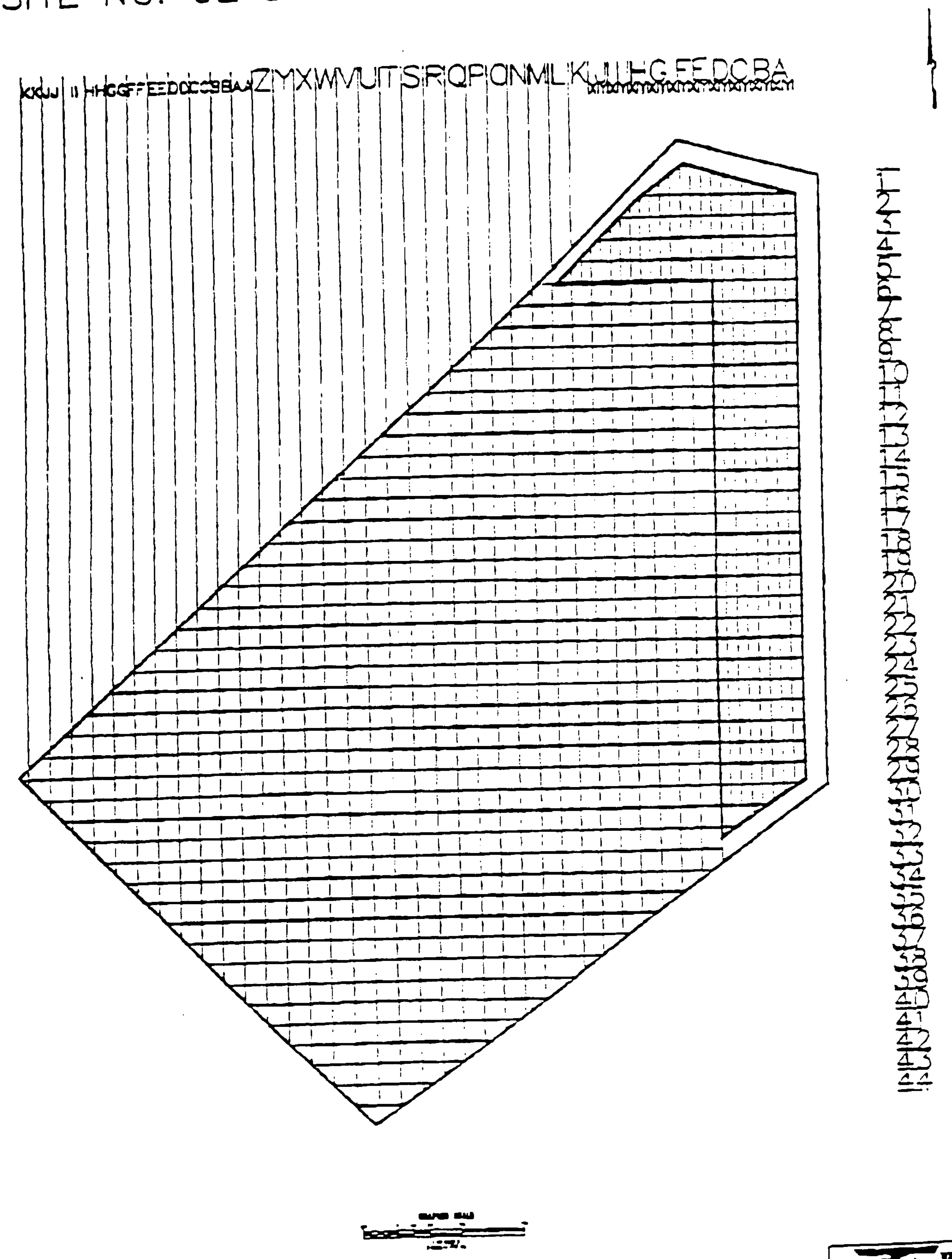
Access To and From the Disposal Area

The towing tugboat will utilize the DGPS tracking system to follow a predetermined route from the Upper Chesapeake range into Site #92 Disposal Area. The same route will be followed for ingress and egress transit.

Disposal Area Marking

Weeks Marine, as contractually required, will delineate the boundaries of the berm area with buoys. The buoys will be accurately placed with the use of DGPS. They will also be lighted with United States Coast Guard approved lights.

SITE NO. 92 DISPOSAL AREA - GRID SYSTEM



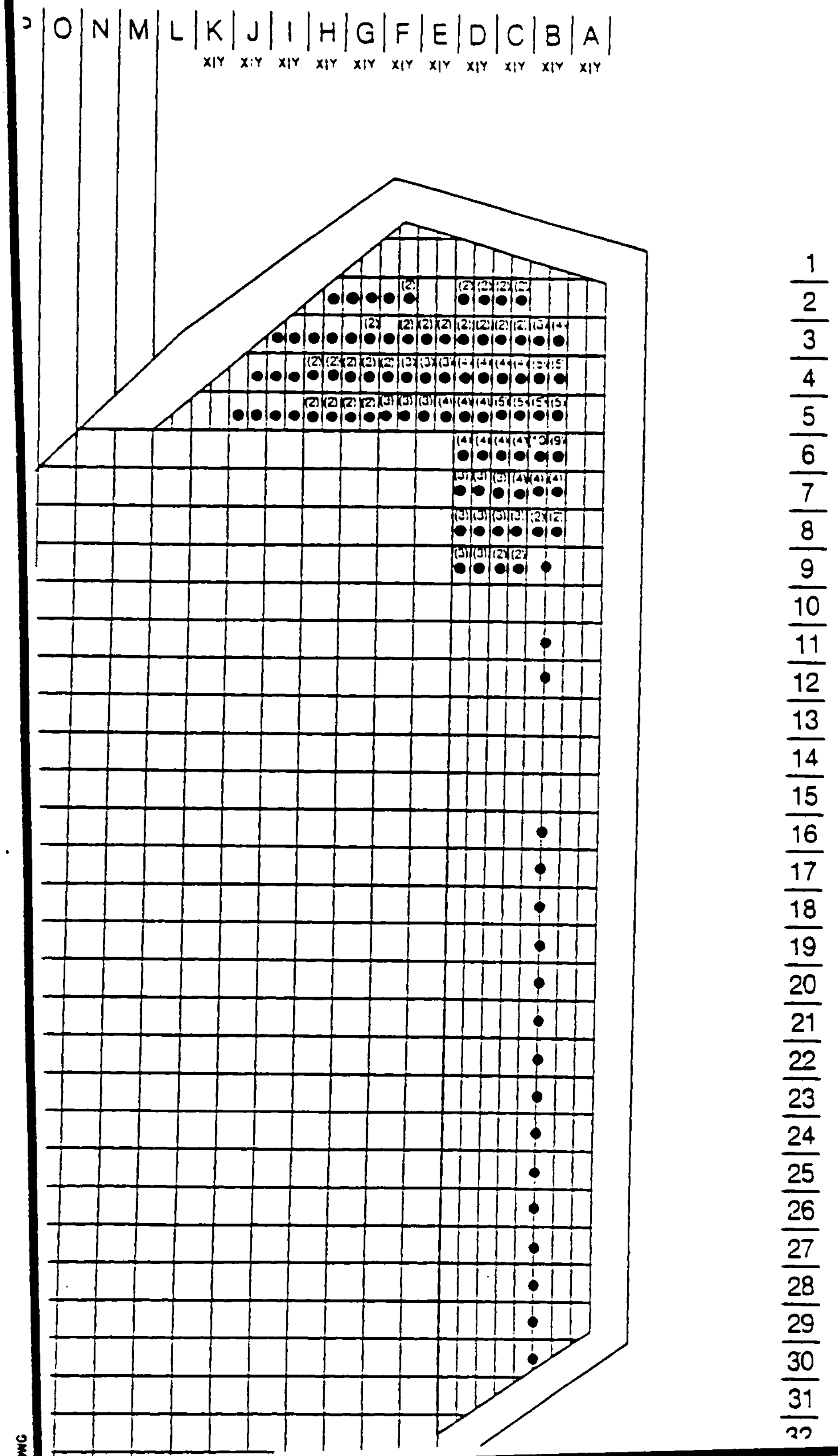
SITE #92 BERM CONSTRUCTION DUMPING SCHEDULE and LOCATION

Revised 12/18/98*

Load #	Cell #	Volume Cy/Load	Cumulative Volume
1	GX2	2,000	2,000
2	GY2	2,000	4,000
3	FX2	2,000	6,000
4	FY2	2,000	8,000
5	FY2	2,000	10,000
6	~~E3~~	2,000	12,000
7	DX2	2,000	14,000
8	DX2	2,000	16,000
9	DY2	2,000	18,000
10	DY2	2,000	20,000
11	DX3	2,000	22,000
12	DX3	2,000	24,000
13	DY3	2,000	26,000
14	DY3	2,000	28,000
15	CX2	2,000	30,000
16	CX2	2,000	32,000
17	CY2	2,000	34,000
18	CY2	2,000	36,000
19	CX3	2,000	38,000
20	CX3	2,000	40,000
21	CY3	2,000	42,000
22	CY3	2,000	44,000
23	BX3	2,000	46,000
24	BX3	2,000	48,000
25	BX3	2,000	50,000
26	BY3	2,000	52,000
27	BY3	2,000	54,000
28	BY3	2,000	56,000
29	BY3	2,000	58,000
30	BX4	2,000	60,000
31	BX4	2,000	62,000
32	BX4	2,000	64,000
33	BX4	2,000	66,000
34	BX4	2,000	68,000
35	BY4	2,000	70,000
36	BY4	2,000	72,000
37	BY4	2,000	74,000
38	BY4	2,000	76,000
39	BY4	2,000	78,000
40	BX5	2,000	80,000
41	BX5	2,000	82,000
42	BX5	2,000	84,000
43	BX5	2,000	86,000
44	BX5	2,000	88,000
45	BY5	2,000	90,000
46	BY5	2,000	92,000
47	BY5	2,000	94,000
48	BY5	2,000	96,000
49	BY5	2,000	98,000
50	BX6	2,000	100,000
51	BX6	2,000	102,000
52	BX6	2,000	104,000
53	BX6	2,000	106,000
54	BX6	2,000	108,000
55	BY6	2,000	110,000
56	BY6	2,000	112,000
57	BY6	2,000	114,000
58	BY6	2,000	116,000
59	BY6	2,000	118,000
60	B30	1,800	119,800
61	B29	1,800	121,600
62	B28	1,800	123,400
63	B27	1,800	125,200
64	B26	1,800	127,000
65	B25	1,800	128,800
66	B24	1,800	130,600
67	B23	1,800	132,400
68	B22	1,800	134,200
69	B21	1,800	136,000
70	B20	1,800	137,800
71	B19	1,800	139,600
72	B18	1,800	141,400
73	B17	1,800	143,200
74	B16	1,800	145,000
75	BX6	2,000	147,000
76	BX6	2,000	149,000
77	BX6	2,000	151,000
78	BX6	2,000	153,000
79	BX6	2,000	155,000
80	BY6	2,000	157,000
81	BY6	2,000	159,000
82	BY6	2,000	161,000
83	BY6	2,000	163,000
84	BX7	2,000	165,000
85	BX7	2,000	167,000
86	BX7	2,000	169,000
87	BX7	2,000	171,000
88	BY7	2,000	173,000
89	BY7	2,000	175,000
90	BY7	2,000	177,000

Load #	Cell #	Volume Cy/Load	Cumulative Volume
91	BY7	2,000	179,000
92	BX8	2,000	181,000
93	BX8	2,000	183,000
94	BY8	2,000	185,000
95	BY8	2,000	187,000
96	B9	2,000	189,000
97	B10	2,000	191,000
98	B11	2,000	193,000
99	B12	2,000	195,000
100	H2	2,000	197,000
101	EY3	2,000	199,000
102	EY3	2,000	201,000
103	EX3	2,000	203,000
104	EX3	2,000	205,000
105	FY3	2,000	207,000
106	FY3	2,000	209,000
107	FX3	2,000	211,000
108	GY3	2,000	213,000
109	GY3	2,000	215,000
110	GX3	2,000	217,000
111	HY3	2,000	219,000
112	HX3	2,000	221,000
113	IY3	2,000	223,000
114	CY4	2,000	225,000
115	CY4	2,000	227,000
116	CY4	2,000	229,000
117	CY4	2,000	231,000
118	CX4	2,000	233,000
119	CX4	2,000	235,000
120	CX4	2,000	237,000
121	CX4	2,000	239,000
122	DY4	2,000	241,000
123	DY4	2,000	243,000
124	DY4	2,000	245,000
125	DY4	2,000	247,000
126	DX4	2,000	247,000
127	DX4	2,000	249,000
128	DX4	2,000	251,000
129	DX4	2,000	253,000
130	EY4	2,000	255,000
131	EY4	2,000	257,000
132	EY4	2,000	259,000
133	EX4	2,000	261,000
134	EX4	2,000	263,000
135	EX4	2,000	265,000
136	FY4	2,000	267,000
137	FY4	2,000	269,000
138	FY4	2,000	271,000
139	FX4	2,000	273,000
140	FX4	2,000	275,000
141	GY4	2,000	277,000
142	GY4	2,000	279,000
143	GX4	2,000	281,000
144	GX4	2,000	283,000
145	HY4	2,000	285,000
146	HY4	2,000	287,000
147	HX4	2,000	289,000
148	HX4	2,000	291,000
149	IY4	2,000	293,000
150	IX4	2,000	295,000
151	JY4	2,000	297,000
152	CY5	2,000	299,000
153	CY5	2,000	301,000
154	CY5	2,000	303,000
155	CY5	2,000	305,000
156	CY5	2,000	307,000
157	CX5	2,000	309,000
158	CX5	2,000	311,000
159	CX5	2,000	313,000
160	CX5	2,000	315,000

Load #	Cell #	Volume Cy/Load	Cumulative Volume
161	CX5	2,000	317,000
162	DY5	2,000	319,000
163	DY5	2,000	321,000
164	DY5	2,000	323,000
165	DY5	2,000	325,000
166	DX5	2,000	327,000
167	DX5	2,000	329,000
168	DX5	2,000	331,000
169	DX5	2,000	333,000
170	EY5	2,000	335,000
171	EY5	2,000	337,000
172	EY5	2,000	339,000
173	EY5	2,000	341,000
174	EX5	2,000	343,000
175	EX5	2,000	345,000
176	EX5	2,000	347,000
177	FY5	2,000	349,000
178	FY5	2,000	351,000
179	FY5	2,000	353,000
180	FX5	2,000	355,000
181	FX5	2,000	357,000
182	FX5	2,000	359,000
183	GY5	2,000	361,000
184	GY5	2,000	363,000
185	GX5	2,000	365,000
186	GX5	2,000	367,000
187	HY5	2,000	369,000
188	HY5	2,000	371,000
189	HX5	2,000	373,000
190	HX5	2,000	375,000
191	IY5	2,000	377,000
192	IX5	2,000	379,000
193	JY5	2,000	381,000
194	JX5	2,000	383,000
195	CY6	2,000	385,000
196	CY6	2,000	387,000
197	CY6	2,000	389,000
198	CY6	2,000	391,000
199	CX6	2,000	393,000
200	CX6	2,000	395,000
201	CX6	2,000	397,000
202	CX6	2,000	399,000
203	DY6	2,000	401,000
204	DY6	2,000	403,000
205	DY6	2,000	405,000
201	DY6	2,000	407,000
202	DX6	2,000	409,000
203	DX6	2,000	411,000
204	DX6	2,000	413,000
205	DX6	2,000	415,000
206	CY7	2,000	417,000
207	CY7	2,000	419,000
208	CY7	2,000	421,000
209	CY7	2,000	423,000
210	CX7	2,000	425,000
211	CX7	2,000	427,000
212	CX7	2,000	429,000
213	DY7	2,000	431,000
214	DY7	2,000	433,000
215	DY7	2,000	435,000
216	DX7	2,000	437,000
217	DX7	2,000	439,000
218	DX7	2,000	441,000
219	CY8	2,000	443,000
220	CY8	2,000	445,000
221	CY8	2,000	447,000
222	CX8	2,000	449,000
223	CX8	2,000	451,000
224	CX8	2,000	453,000
225	DY8	2,000	455,000
226	DY8	2,000	457,000
227	DY8	2,000	459,000
228	DX8	2,000	461,000
229	DX8	2,000	463,000
230	DX8	2,000	465,000
231	CY9	2,000	467,000
232	CY9	2,000	469,000
233	CX9	2,000	471,000
234	CX9	2,000	473,000
235	DY9	2,000	475,000
236	DY9	2,000	477,000
237	DY9	2,000	479,000
238	DX9	2,000	481,000
239	DX9	2,000	483,000
240	DX9	2,000	485,000



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MARYLAND
ENVIRONMENTAL
SERVICE

Disposal Grid
Phase I (Berm Creation)
Figure 3. 12/18/98

Note: submitted to group with distribution of Site Management Plan.

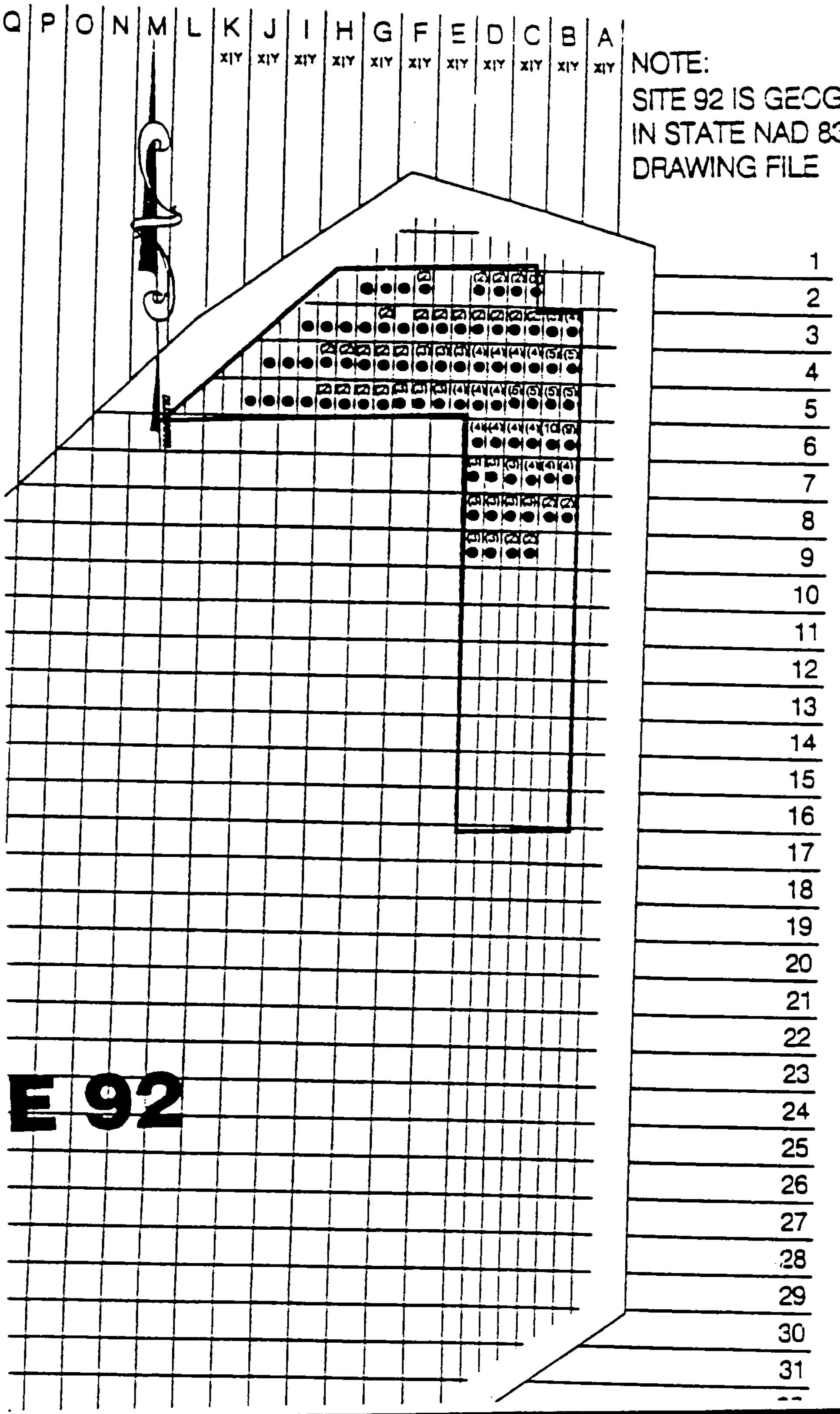
SITE #92 BERM CONSTRUCTION DUMPING SCHEDULE and LOCATION

Revised 12/18/98*

Load #	Cell #	Volume Cy/Load	Cumulative Volume
1	GX2	2,000	2,000
2	GY2	2,000	4,000
3	FX2	2,000	6,000
4	FY2	2,000	8,000
5	FY2	2,000	10,000
6	E3	2,000	12,000
7	DX2	2,000	14,000
8	DX2	2,000	16,000
9	DY2	2,000	18,000
10	DY2	2,000	20,000
11	DX3	2,000	22,000
12	DX3	2,000	24,000
13	DY3	2,000	26,000
14	DY3	2,000	28,000
15	CX2	2,000	30,000
16	CX2	2,000	32,000
17	CY2	2,000	34,000
18	CY2	2,000	36,000
19	CX3	2,000	38,000
20	CX3	2,000	40,000
21	CY3	2,000	42,000
22	CY3	2,000	44,000
23	BX2	2,000	46,000
24	BX2	2,000	48,000
25	BX2	2,000	50,000
26	AX2	2,000	52,000
27	AX2	2,000	54,000
28	AX2	2,000	56,000
29	AY2	2,000	58,000
30	AY2	2,000	60,000
31	AY2	2,000	62,000
32	AY2	2,000	64,000
33	AY2	2,000	66,000
34	BX3	2,000	68,000
35	BX3	2,000	70,000
36	BX3	2,000	72,000
37	BY3	2,000	74,000
38	BY3	2,000	76,000
39	BY3	2,000	78,000
40	BY3	2,000	80,000
41	AX3	2,000	82,000
42	AX3	2,000	84,000
43	AX3	2,000	86,000
44	AX3	2,000	88,000
45	AY3	2,000	90,000
46	AY3	2,000	92,000
47	AY3	2,000	94,000
48	BX4	2,000	96,000
49	BX4	2,000	98,000
50	BX4	2,000	100,000
51	BX4	2,000	102,000
52	BX4	2,000	104,000
53	BY4	2,000	106,000
54	BY4	2,000	108,000
55	BY4	2,000	110,000
56	BY4	2,000	112,000
57	BY4	2,000	114,000
58	AX4	2,000	116,000
59	AX4	2,000	118,000
60	AX4	2,000	120,000
61	AY4	2,000	122,000
62	AY4	2,000	124,000
63	BX5	2,000	126,000
64	BX5	2,000	128,000
65	BX5	2,000	130,000
66	BX5	2,000	132,000
67	BX5	2,000	134,000
68	BY5	2,000	136,000
69	BY5	2,000	138,000
70	BY5	2,000	140,000
71	BY5	2,000	142,000
72	BY5	2,000	144,000
73	AX5	2,000	146,000
74	AX5	2,000	148,000
75	AX5	2,000	150,000
76	AY5	2,000	152,000
77	AY5	2,000	154,000
78	BX6	2,000	156,000
79	BX6	2,000	158,000
80	BX6	2,000	160,000
81	BX6	2,000	162,000
82	BX6	2,000	164,000
83	BY6	2,000	166,000
84	BY6	2,000	168,000
85	BY5	2,000	170,000
86	BY6	2,000	172,000
87	BY6	2,000	174,000
88	B30	1,800	175,800
89	B29	1,800	177,600
90	B28	1,800	179,400

Load #	Cell #	Volume Cy/Load	Cumulative Volume
91	B27	1,800	181,200
92	B26	1,800	183,000
93	B25	1,800	184,800
94	B24	1,800	186,600
95	B23	1,800	188,400
96	B22	1,800	190,200
97	B21	1,800	192,000
98	B20	1,800	193,800
99	B19	1,800	195,600
100	B18	1,800	197,400
101	B17	1,800	199,200
102	B16	1,800	201,000
103	BX6	2,000	203,000
104	BX6	2,000	205,000
105	BX6	2,000	207,000
106	BX6	2,000	209,000
107	BX6	2,000	211,000
108	BY6	2,000	213,000
109	BY6	2,000	215,000
110	BY6	2,000	217,000
111	BY6	2,000	219,000
112	AX6	2,000	221,000
113	AX6	2,000	223,000
114	AX6	2,000	225,000
115	AY6	2,000	227,000
116	AY6	2,000	229,000
117	BX7	2,000	231,000
118	BX7	2,000	233,000
119	BX7	2,000	235,000
120	BX7	2,000	237,000
121	BY7	2,000	239,000
122	BY7	2,000	241,000
123	BY7	2,000	243,000
124	BY7	2,000	245,000
125	AX7	2,000	247,000
126	AX7	2,000	247,000
127	AY7	2,000	249,000
128	BX8	2,000	251,000
129	BX8	2,000	253,000
130	BY8	2,000	255,000
131	BY8	2,000	257,000
132	AX8	2,000	259,000
133	AY8	2,000	261,000
134	B9	2,000	263,000
135	A9	2,000	265,000
136	B10	2,000	267,000
137	A9	2,000	269,000
138	B11	2,000	271,000
139	A11	2,000	273,000
140	B12	2,000	275,000

*This schedule does not include the deposition of material in row 1.



NOTE:
SITE 92 IS GEOGRAPHICALLY ORIENTED IN STATE NAD 83 (U.S. FOOT) IN THIS DRAWING FILE

MARYLAND
ENVIRONMENTAL
SERVICE

SITE 92 BERM PLACEMENT PLAN

revised: 1/5/99

C:\[illegible]\HC\DRWG\040793.DWG

* received on 1/26/99 - submitted to group on 1/27/99

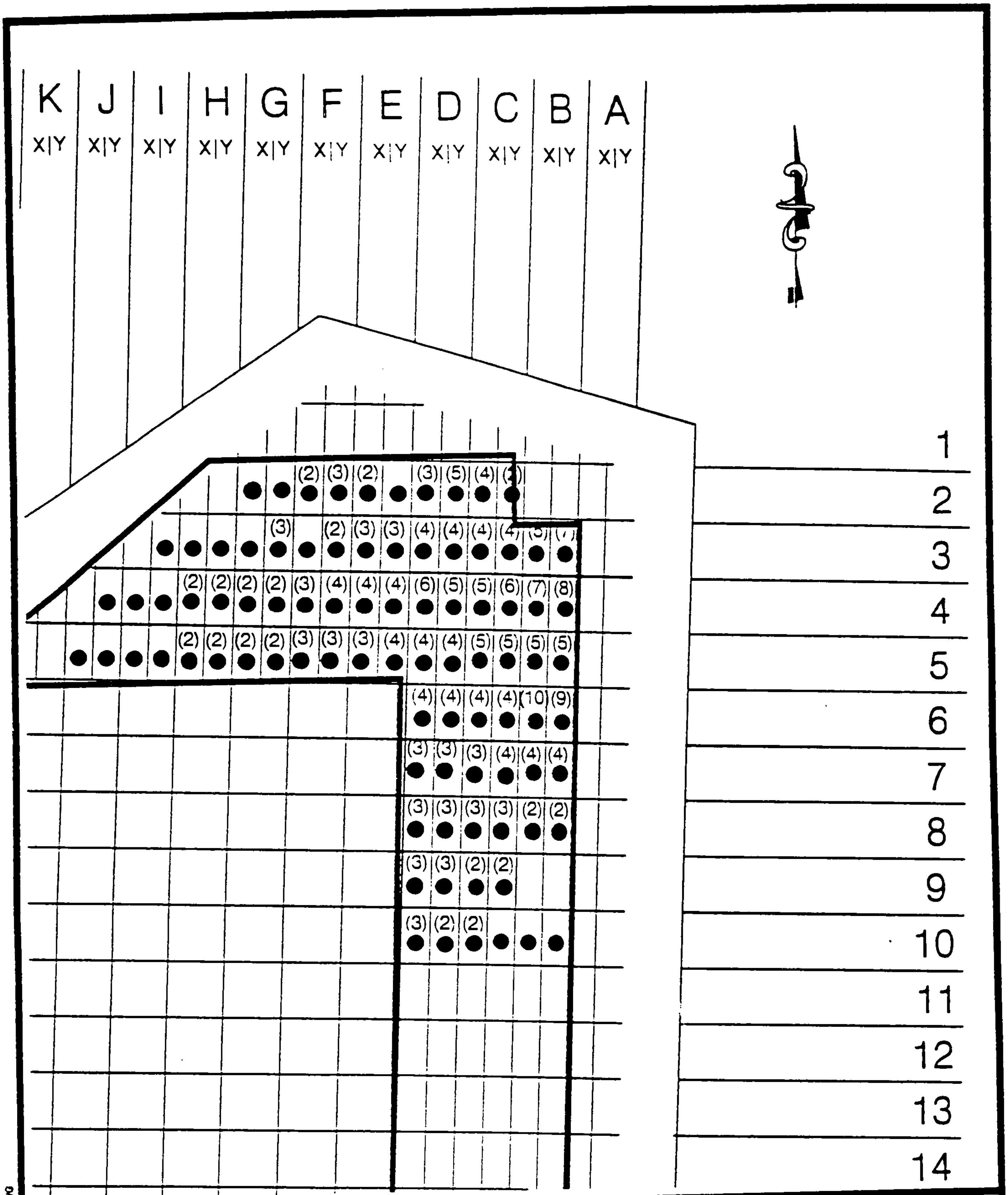
SITE #92 BERM CONSTRUCTION
DUMPING SCHEDULE and LOCATION

Revised 1/5/99

Load #	Cell #	Volume Cy/Load	Cumulative Volume
1	GX2	2,000	2,000
2	GY2	2,000	4,000
3	FX2	2,000	6,000
4	FY2	2,000	8,000
5	FY2	2,000	10,000
6	DX2	2,000	12,000
7	DX2	2,000	14,000
8	DY2	2,000	16,000
9	DY2	2,000	18,000
10	DX3	2,000	20,000
11	DX3	2,000	22,000
12	DY3	2,000	24,000
13	DY3	2,000	26,000
14	CX2	2,000	28,000
15	CX2	2,000	30,000
16	CY2	2,000	32,000
17	CY2	2,000	34,000
18	CX3	2,000	36,000
19	CX3	2,000	38,000
20	CY3	2,000	40,000
21	CY3	2,000	42,000
22	BX3	2,000	44,000
23	BX3	2,000	46,000
24	BX3	2,000	48,000
25	BY3	2,000	50,000
26	BY3	2,000	52,000
27	BY3	2,000	54,000
28	BY3	2,000	56,000
29	BX4	2,000	58,000
30	BX4	2,000	60,000
31	BX4	2,000	62,000
32	BX4	2,000	64,000
33	BX4	2,000	66,000
34	BY4	2,000	68,000
35	BY4	2,000	70,000
36	BY4	2,000	72,000
37	BY4	2,000	74,000
38	BY4	2,000	76,000
39	BX5	2,000	78,000
40	BX5	2,000	80,000
41	BX5	2,000	82,000
42	BX5	2,000	84,000
43	BX5	2,000	86,000
44	BY5	2,000	88,000
45	BY5	2,000	90000
46	BY5	2,000	92,000
47	BY5	2,000	94,000
48	BY5	2,000	96,000
49	BX6	2,000	98,000
50	BX6	2,000	100,000
51	BX6	2,000	102,000
52	BX6	2,000	104,000
53	BX6	2,000	106,000
54	BY6	2,000	108,000
55	BY6	2,000	110,000
56	BY5	2,000	112,000
57	BY6	2,000	114,000
58	BY6	2,000	116,000
59	BX5	2,000	118,000
60	BX6	2,000	120,000
61	BX6	2,000	122,000
62	BX6	2,000	124,000
63	BX6	2,000	126,000
64	BY6	2,000	128,000
65	BY6	2,000	130,000
66	BY6	2,000	132,000
67	BY6	2,000	134,000
68	BX7	2,000	136,000
69	BX7	2,000	138,000
70	BX7	2,000	140,000
71	BX7	2,000	142,000
72	BY7	2,000	144,000
73	BY7	2,000	146,000
74	BY7	2,000	148,000

Load #	Cell #	Volume Cy/Load	Cumulative Volume
75	BY7	2,000	150,000
76	BX8	2,000	152,000
77	BX8	2,000	154,000
78	BY8	2,000	156,000
79	BY8	2,000	158,000
80	EY3	2,000	160,000
81	EY3	2,000	162,000
82	EX3	2,000	164,000
83	EX3	2,000	166,000
84	FY3	2,000	168,000
85	FY3	2,000	170,000
86	FX3	2,000	172,000
87	GY3	2,000	174,000
88	GY3	2,000	176,000
89	GX3	2,000	178,000
90	HY3	2,000	180,000
91	HX3	2,000	182,000
92	IY3	2,000	184,000
93	CY4	2,000	186,000
94	CY4	2,000	188,000
95	CY4	2,000	190,000
96	CY4	2,000	192,000
97	CX4	2,000	194,000
98	CX4	2,000	196,000
99	CX4	2,000	198,000
100	CX4	2,000	200,000
101	DY4	2,000	202,000
102	DY4	2,000	204,000
103	DY4	2,000	206,000
104	DY4	2,000	208,000
105	DX4	2,000	210,000
106	DX4	2,000	212,000
107	DX4	2,000	214,000
108	DX4	2,000	216,000
109	EY4	2,000	218,000
110	EY4	2,000	220,000
111	EY4	2,000	222,000
112	EX4	2,000	224,000
113	EX4	2,000	226,000
114	EX4	2,000	228,000
115	FY4	2,000	230,000
116	FY4	2,000	232,000
117	FY4	2,000	234,000
118	FX4	2,000	236,000
119	FX4	2,000	238,000
120	GY4	2,000	240,000
121	GY4	2,000	242,000
122	GX4	2,000	244,000
123	GX4	2,000	246,000
124	HY4	2,000	248,000
125	HY4	2,000	250,000
126	HX4	2,000	252,000
127	HX4	2,000	254,000
128	IY4	2,000	256,000
129	IX4	2,000	258,000
130	JY4	2,000	260,000
131	CY5	2,000	262,000
132	CY5	2,000	264,000
133	CY5	2,000	266,000
134	CY5	2,000	268,000
135	CY5	2,000	270,000
136	CX5	2,000	272,000
137	CX5	2,000	274,000
138	CX5	2,000	276,000
139	CX5	2,000	278,000

Load #	Cell #	Volume Cy/Load	Cumulative Volume
140	CX5	2,000	280,000
141	DY5	2,000	282,000
142	DY5	2,000	284,000
143	DY5	2,000	286,000
144	DY5	2,000	288,000
145	DX5	2,000	290,000
146	DX5	2,000	292,000
147	DX5	2,000	294,000
148	DX5	2,000	296,000
149	EY5	2,000	298,000
150	EY5	2,000	300,000
151	EY5	2,000	302,000
152	EY5	2,000	304,000
153	EX5	2,000	306,000
154	EX5	2,000	308,000
155	EX5	2,000	310,000
156	FY5	2,000	312,000
157	FY5	2,000	314,000
158	FY5	2,000	316,000
159	FX5	2,000	318,000
160	FX5	2,000	320,000
161	FX5	2,000	322,000
162	GY5	2,000	324,000
163	GY5	2,000	326,000
164	GX5	2,000	328,000
165	GX5	2,000	330,000
166	HY5	2,000	332,000
167	HY5	2,000	334,000
168	HX5	2,000	336,000
169	HX5	2,000	338,000
170	IY5	2,000	340,000
171	IX5	2,000	342,000
172	JY5	2,000	344,000
173	JX5	2,000	346,000
174	CY6	2,000	348,000
175	CY6	2,000	350,000
176	CY6	2,000	352,000
177	CY6	2,000	354,000
178	CX6	2,000	356,000
179	CX6	2,000	358,000
180	CX6	2,000	360,000
181	CX6	2,000	362,000
182	DY6	2,000	364,000
183	DY6	2,000	366,000
184	DY6	2,000	368,000
185	DY6	2,000	370,000
186	DX6	2,000	372,000
187	DX6	2,000	374,000
188	DX6	2,000	376,000
189	DX6	2,000	378,000
190	CY7	2,000	380,000
191	CY7	2,000	382,000
192	CY7	2,000	384,000
193	CY7	2,000	386,000
194	CX7	2,000	388,000
195	CX7	2,000	390,000
196	CX7	2,000	392,000
197	DY7	2,000	394,000
198	DY7	2,000	396,000
199	DY7	2,000	398,000
200	DX7	2,000	400,000
201	DX7	2,000	402,000
202	DX7	2,000	404,000
203	CY8	2,000	406,000
204	CY8	2,000	408,000
205	CY8	2,000	410,000
206	CX8	2,000	412,000
207	CX8	2,000	414,000
208	CX8	2,000	416,000
209	DY8	2,000	418,000
210	DY8	2,000	420,000
211	DY8	2,000	422,000
212	DX8	2,000	424,000
213	DX8	2,000	426,000
214	DX8	2,000	428,000
215	CY9	2,000	430,000
216	CY9	2,000	432,000
217	CX9	2,000	434,000
218	CX9	2,000	436,000
219	DY9	2,000	438,000
220	DY9	2,000	440,000
221	DY9	2,000	442,000
222	DX9	2,000	444,000
223	DX9	2,000	446,000
224	DX9	2,000	448,000



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MARYLAND
ENVIRONMENTAL
SERVICE

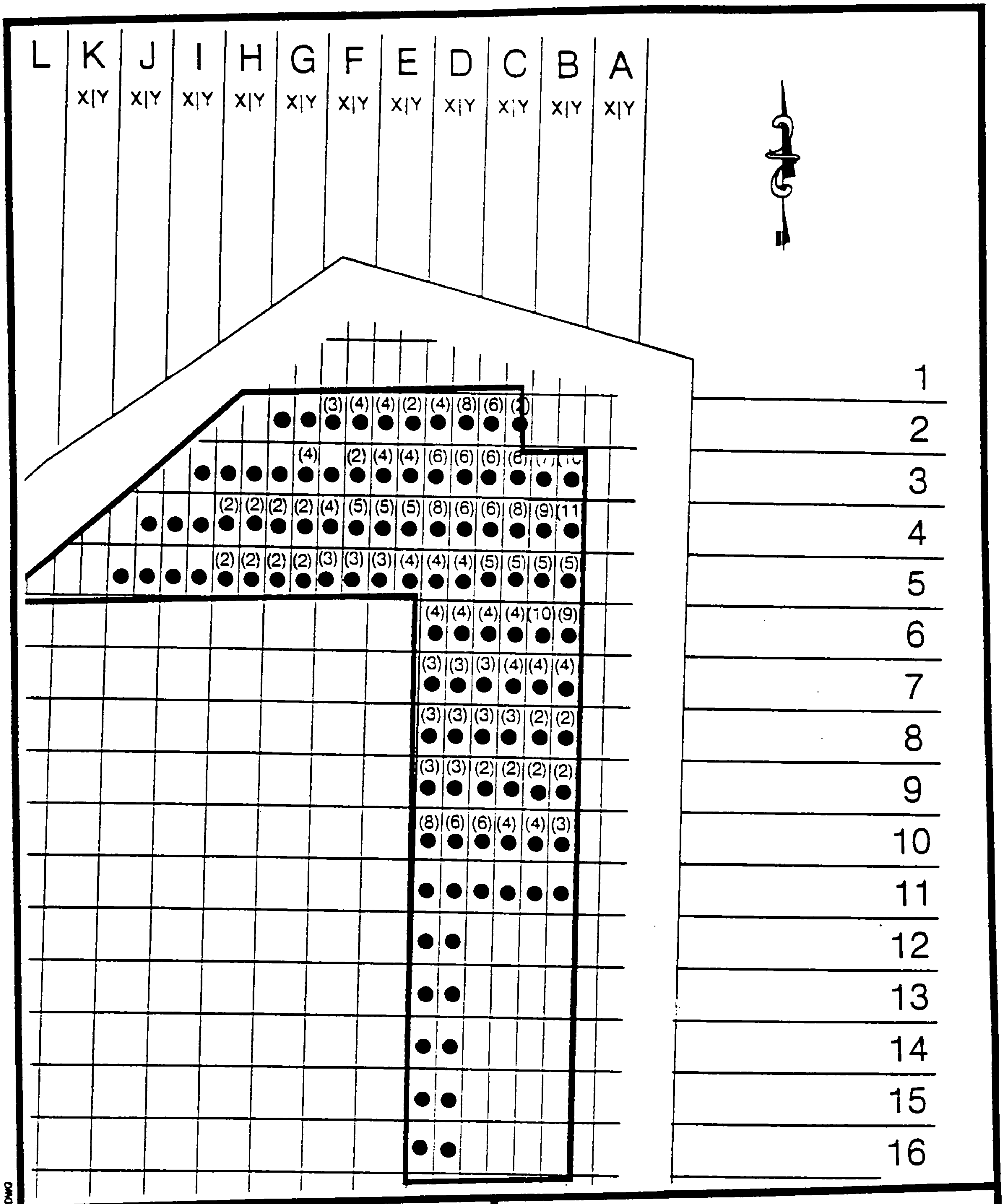
SITE 92 BERM PLACEMENT PLAN

2.14.99 - Revised

mitted to group on 2/17/99

REVISED: 14-Feb-99

Load #	Cell #	Volume Cy/Load	Cumulative Volume
225	BY10	2,000	450,000
226	BX10	2,000	452.000
227	CY10	2,000	454,000
228	CX10	2,000	456,000
229	CX10	2,000	458,000
230	DY10	2,000	460,000
231	DY10	2,000	462,000
232	DX10	2,000	464,000
233	DX10	2,000	466,000
234	DX10	2,000	468,000
235	CX2	2,000	470,000
236	CX2	2,000	472,000
237	DY2	2,000	474,000
238	DY2	2,000	476,000
239	DY2	2,000	478,000
240	DX2	2,000	480,000
241	EY2	2,000	482,000
242	EX2	2,000	484,000
243	EX2	2,000	486,000
244	FY2	2,000	488,000
245	FX2	2,000	490,000
246	BY3	2,000	492,000
247	BY3	2,000	494,000
248	BY3	2,000	496,000
249	BX3	2,000	498,000
250	BX3	2,000	500,000
251	CY3	2,000	502,000
252	CY3	2,000	504,000
253	CX3	2,000	506,000
254	CX3	2,000	508,000
255	DY3	2,000	510,000
256	DY3	2,000	512,000
257	DX3	2,000	514,000
258	DX3	2,000	516,000
259	EY3	2,000	518,000
260	EX3	2,000	520,000
261	GY3	2,000	522,000
262	BY4	2,000	524,000
263	BY4	2,000	526,000
264	BY4	2,000	528,000
265	BX4	2,000	530,000
266	BX4	2,000	532,000
267	CY4	2,000	534,000
268	CY4	2,000	536,000
269	CX4	2,000	538,000
270	DY4	2,000	540,000
271	DX4	2,000	542,000
272	DX4	2,000	544,000
273	EY4	2,000	546,000
274	EX4	2,000	548,000
275	FY4	2,000	550,000
276	FX4	2,000	552,000
277		2,000	554,000
278		2,000	556,000
279		2,000	558,000
280		2,000	560,000
281		2,000	562,000
282		2,000	564,000
283		2,000	566,000
284		2,000	568,000
285		2,000	570,000
286		2,000	572,000
287		2,000	574,000
288		2,000	576,000
289		2,000	578,000
290		2,000	580,000
291		2,000	582,000
292		2,000	584,000
293		2,000	586,000
294		2,000	588,000
295		2,000	590,000
296		2,000	592,000
297		2,000	594,000
298		2,000	596,000
299		2,000	598,000
300		2,000	600,000
301		2,000	602,000
302		2,000	604,000
303		2,000	606,000
304		2,000	608,000
305		2,000	610,000
306		2,000	612,000
307		2,000	614,000
308		2,000	616,000
309		2,000	618,000
310		2,000	620,000
311		2,000	622,000
312		2,000	624,000
313		2,000	626,000
314		2,000	628,000



MARYLAND ENVIRONMENTAL SERVICE

SITE 92 BERM
PLACEMENT PLAN
(REVISED 2/19/99)

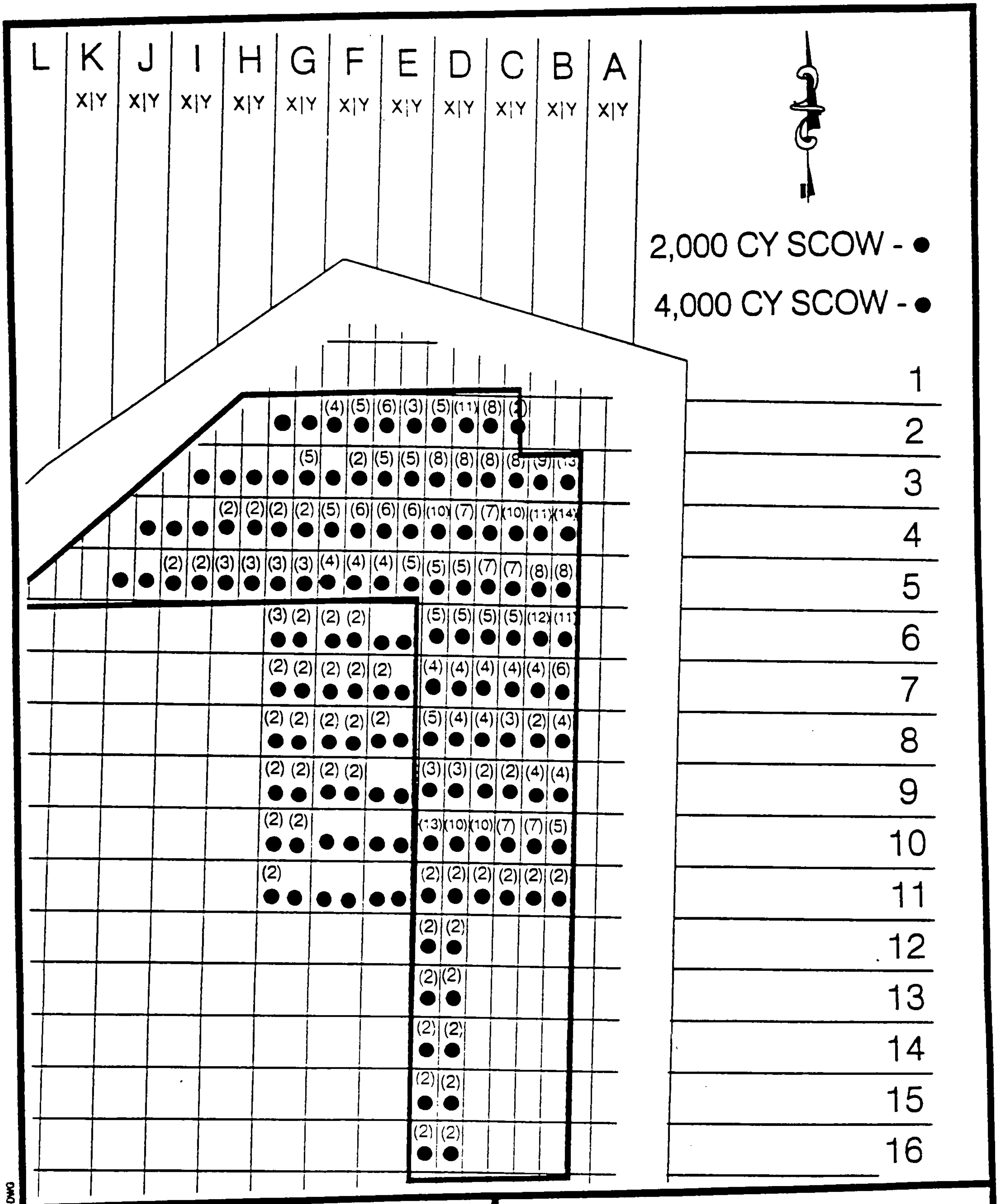
J:\SITE92\92DROP-NEW2.DWG

REVISED: 19-Feb-99

Load #	Cell #	Volume Cy/Load	Cumulative Volume	Load #	Cell #	Volume Cy/Load	Cumulative Volume
225	BY10	2,000	450,000	270	DY4	2,000	540,000
226	BX10	2,000	452,000	271	DX4	2,000	542,000
227	CY10	2,000	454,000	272	DX4	2,000	544,000
228	CX10	2,000	456,000	273	EY4	2,000	546,000
229	CX10	2,000	458,000	274	EX4	2,000	548,000
230	DY10	2,000	460,000	275	FY4	2,000	550,000
231	DY10	2,000	462,000	276	FX4	2,000	552,000
232	DX10	2,000	464,000	277	BY9	2,000	554,000
233	DX10	2,000	466,000	278	BY9	2,000	556,000
234	DX10	2,000	468,000	279	BX9	2,000	558,000
235	CX2	2,000	470,000	280	BX9	2,000	560,000
236	CX2	2,000	472,000	281	BY10	2,000	562,000
237	DY2	2,000	474,000	282	BX10	2,000	564,000
238	DY2	2,000	476,000	283	BX10	2,000	566,000
239	DY2	2,000	478,000	284	CY10	2,000	568,000
240	DX2	2,000	480,000	285	CY10	2,000	570,000
241	EY2	2,000	482,000	286	CX10	2,000	572,000
242	EX2	2,000	484,000	287	CX10	2,000	574,000
243	EX2	2,000	486,000	288	DY10	2,000	576,000
244	FY2	2,000	488,000	289	DY10	2,000	578,000
245	FX2	2,000	490,000	290	DX10	2,000	580,000
246	BY3	2,000	492,000	291	DX10	2,000	582,000
247	BY3	2,000	494,000	292	BY11	2,000	584,000
248	BY3	2,000	496,000	293	BX11	2,000	586,000
249	BX3	2,000	498,000	294	CY11	2,000	588,000
250	BX3	2,000	500,000	295	CX11	2,000	590,000
251	CY3	2,000	502,000	296	DY11	2,000	592,000
252	CY3	2,000	504,000	297	DX11	2,000	594,000
253	CX3	2,000	506,000	298	DY12	2,000	596,000
254	CX3	2,000	508,000	299	DX12	2,000	598,000
255	DY3	2,000	510,000	300	DY13	2,000	600,000
256	DY3	2,000	512,000	301	DX13	2,000	602,000
257	DX3	2,000	514,000	302	DY14	2,000	604,000
258	DX3	2,000	516,000	303	DX14	2,000	606,000
259	EY3	2,000	518,000	304	DY15	2,000	608,000
260	EX3	2,000	520,000	305	DX15	2,000	610,000
261	GY3	2,000	522,000	306	DY16	2,000	612,000
262	BY4	2,000	524,000	307	DX16	2,000	614,000
263	BY4	2,000	526,000	308		2,000	616,000
264	BY4	2,000	528,000	309		2,000	618,000
265	BX4	2,000	530,000	310		2,000	620,000
266	BX4	2,000	532,000	311		2,000	622,000
267	CY4	2,000	534,000	312		2,000	624,000
268	CY4	2,000	536,000	313		2,000	626,000
269	CX4	2,000	538,000	314		2,000	628,000

REVISED: 14-Feb-99

Load #	Cell #	Volume Cy/Load	Cumulative Volume
225	BY10 -	2,000	460,000
226	BX10	2,000	452,000
227	CY10	2,000	454,000
228	CX10	2,000	456,000
229	CX10	2,000	458,000
230	DY10	2,000	460,000
231	DY10	2,000	462,000
232	DX10	2,000	464,000
233	DX10	2,000	466,000
234	DX10	2,000	468,000
235	CX2	2,000	470,000
236	CX2	2,000	472,000
237	DY2	2,000	474,000
238	DY2	2,000	476,000
239	DY2	2,000	478,000
240	DX2	2,000	480,000
241	EY2	2,000	482,000
242	EX2	2,000	484,000
243	EX2	2,000	486,000
244	FY2	2,000	488,000
245	FX2	2,000	490,000
246	BY3	2,000	492,000
247	BY3	2,000	494,000
248	BY3	2,000	496,000
249	BX3	2,000	498,000
250	BX3	2,000	500,000
251	CY3	2,000	502,000
252	CY3	2,000	504,000
253	CX3	2,000	506,000
254	CX3	2,000	508,000
255	DY3	2,000	510,000
256	DY3	2,000	512,000
257	DX3	2,000	514,000
258	DX3	2,000	516,000
259	EY3	2,000	518,000
260	EX3	2,000	520,000
261	GY3	2,000	522,000
262	BY4	2,000	524,000
263	BY4	2,000	526,000
264	BY4	2,000	528,000
265	BX4	2,000	530,000
266	BX4	2,000	532,000
267	CY4	2,000	534,000
268	CY4	2,000	536,000
269	CX4	2,000	538,000
270	DY4	2,000	540,000
271	DX4	2,000	542,000
272	DX4	2,000	544,000
273	EY4	2,000	546,000
274	EX4	2,000	548,000
275	FY4	2,000	550,000
276	FX4	2,000	552,000
277		2,000	554,000
278		2,000	556,000
279		2,000	558,000
280		2,000	560,000
281		2,000	562,000
282		2,000	564,000
283		2,000	566,000
284		2,000	568,000
285		2,000	570,000
286		2,000	572,000
287		2,000	574,000
288		2,000	576,000
289		2,000	578,000
290		2,000	580,000
291		2,000	582,000
292		2,000	584,000
293		2,000	586,000
294		2,000	588,000
295		2,000	590,000
296		2,000	592,000
297		2,000	594,000
298		2,000	596,000
299		2,000	598,000
300		2,000	600,000
301		2,000	602,000
302		2,000	604,000
303		2,000	606,000
304		2,000	608,000
305		2,000	610,000
306		2,000	612,000
307		2,000	614,000
308		2,000	616,000
309		2,000	618,000
310		2,000	620,000
311		2,000	622,000
312		2,000	624,000
313		2,000	626,000
314		2,000	628,000



MARYLAND ENVIRONMENTAL SERVICE

SITE 92 BERM PLACEMENT PLAN

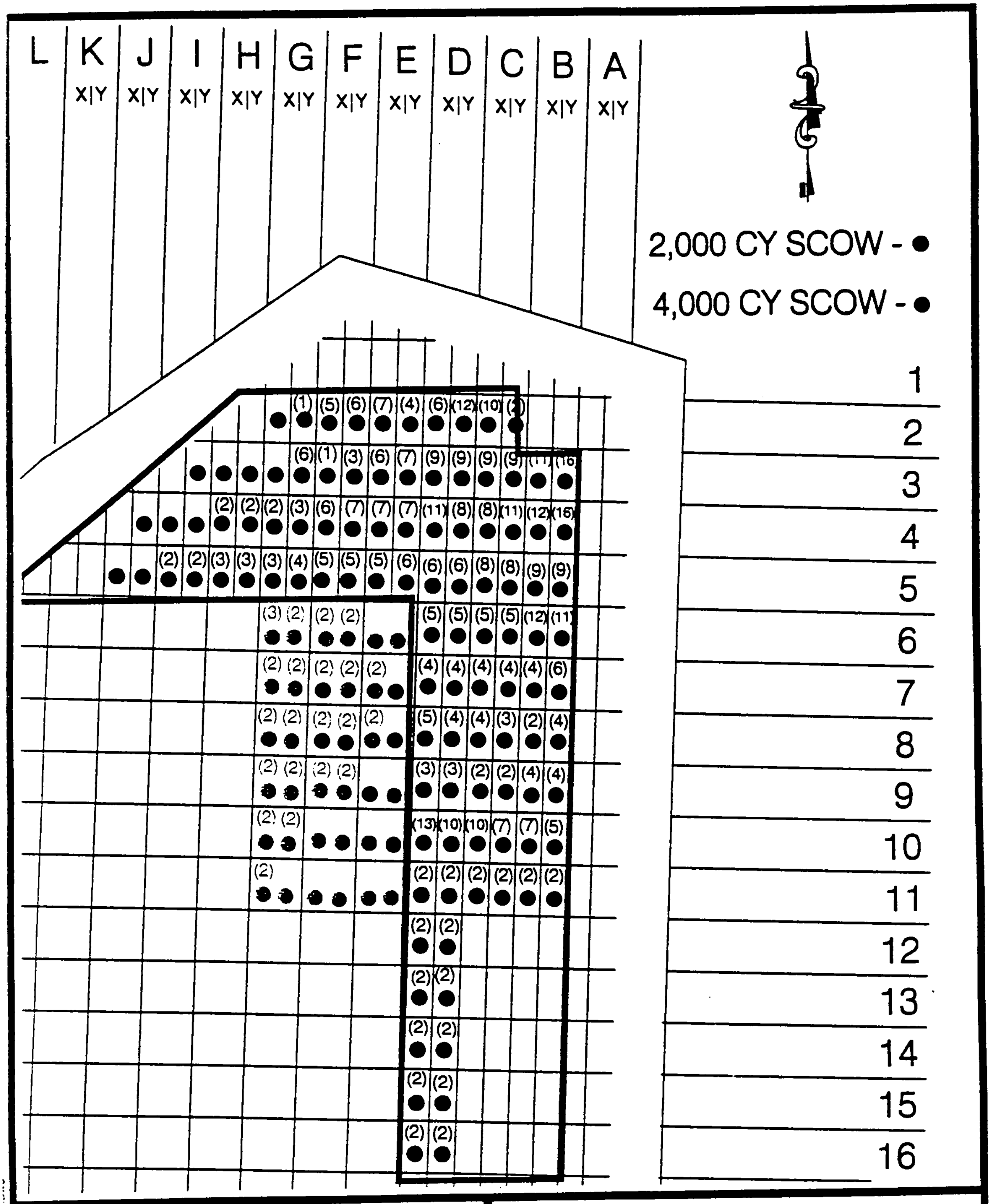
(REVISED 3/5/99)

J:\SITE92\92DROP-NEW2.DWG

4,000 yds SCOW DUMP PLAN

REVISED: 05-Mar-99

Load #	Cell #	Volume Cy/Load	Cumulative Volume	Load #	Cell #	Volume Cy/Load	Cumulative Volume
1	EY6	3,200	3,200	46	FX10	3,200	147,200
2	EX6	3,200	6,400	47	GY10	3,200	150,400
3	FY6	3,200	9,600	48	GY10	3,200	153,600
4	FY6	3,200	12,800	49	GX10	3,200	156,800
5	FX6	3,200	16,000	50	GX10	3,200	160,000
6	FX6	3,200	19,200	51	EY11	3,200	163,200
7	GY6	3,200	22,400	52	EX11	3,200	166,400
8	GY6	3,200	25,600	53	FY11	3,200	169,600
9	GX6	3,200	28,800	54	FX11	3,200	172,800
10	GX6	3,200	32,000	55	GY11	3,200	176,000
11	EY7	3,200	35,200	56	GX11	3,200	179,200
12	EX7	3,200	38,400	57	GX11	3,200	182,400
13	EX7	3,200	41,600	58		3,200	185,600
14	FY7	3,200	44,800	59		3,200	188,800
15	FY7	3,200	48,000	60		3,200	192,000
16	FX7	3,200	51,200	61		3,200	195,200
17	FX7	3,200	54,400	62		3,200	198,400
18	GY7	3,200	57,600	63		3,200	201,600
19	GY7	3,200	60,800	64		3,200	204,800
20	GX7	3,200	64,000	65		3,200	208,000
21	GX7	3,200	67,200	66		3,200	211,200
22	EY8	3,200	70,400	67		3,200	214,400
23	EX8	3,200	73,600	68		3,200	217,600
24	EX8	3,200	76,800	69		3,200	220,800
25	FY8	3,200	80,000	70		3,200	224,000
26	FY8	3,200	83,200	71		3,200	227,200
27	FX8	3,200	86,400	72		3,200	230,400
28	FX8	3,200	89,600	73		3,200	233,600
29	GY8	3,200	92,800	74		3,200	236,800
30	GY8	3,200	96,000	75		3,200	240,000
31	GX8	3,200	99,200	76		3,200	243,200
32	GX8	3,200	102,400	77		3,200	246,400
33	EY9	3,200	105,600	78		3,200	249,600
34	EX9	3,200	108,800	79		3,200	252,800
35	FY9	3,200	112,000	80		3,200	256,000
36	FY9	3,200	115,200	81		3,200	259,200
37	FX9	3,200	118,400	82		3,200	262,400
38	FX9	3,200	121,600	83		3,200	265,600
39	GY9	3,200	124,800	84		3,200	268,800
40	GY9	3,200	128,000	85		3,200	272,000
41	GX9	3,200	131,200	86		3,200	275,200
42	GX9	3,200	134,400	87		3,200	278,400
43	EY10	3,200	137,600	88		3,200	281,600
44	EX10	3,200	140,800	89		3,200	284,800
45	FY10	3,200	144,000	90		3,200	288,000



MARYLAND
ENVIRONMENTAL
SERVICE

SITE 92 BERM PLACEMENT PLAN

(REVISED 3/11/99)

REVISED: 11-Mar-99

Load #	Cell #	Volume Cy/Load	Cumulative Volume	Load #	Cell #	Volume Cy/Load	Cumulative Volume
315	CY5	1,850	468,038	360	BY3	1,850	551,288
316	CX5	1,850	469,888	361	BX3	1,850	553,138
317	CX5	1,850	471,738	362	BX3	1,850	554,988
318	DY5	1,850	473,588	363	CY3	1,850	556,838
319	DX5	1,850	475,438	364	CX3	1,850	558,688
320	EY5	1,850	477,288	365	DY3	1,850	560,538
321	EX5	1,850	479,138	366	DX3	1,850	562,388
322	FY5	1,850	480,988	367	EY3	1,850	564,238
323	FX5	1,850	482,838	368	EX3	1,850	566,088
324	GY5	1,850	484,688	369	FY3	1,850	567,938
325	GX5	1,850	486,538	370	FX3	1,850	569,788
326	HY5	1,850	488,388	371	GY3	1,850	571,638
327	HX5	1,850	490,238	372	BY4	1,850	573,488
328	IY5	1,850	492,088	373	BY4	1,850	575,338
329	IX5	1,850	493,938	374	BX4	1,850	577,188
330	BY6	1,850	495,788	375	CY4	1,850	579,038
331	BY6	1,850	497,638	376	CX4	1,850	580,888
332	BX6	1,850	499,488	377	DY4	1,850	582,738
333	BX6	1,850	501,338	378	DX4	1,850	584,588
334	CY6	1,850	503,188	379	EY4	1,850	586,438
335	CX6	1,850	505,038	380	EX4	1,850	588,288
336	DY6	1,850	506,888	381	FY4	1,850	590,138
337	DX6	1,850	508,738	382	FX4	1,850	591,988
338	BY7	1,850	510,588	383	GY4	1,850	593,838
339	BY7	1,850	512,438	384	BY5	1,850	595,688
340	CX7	1,850	514,288	385	BX5	1,850	597,538
341	DY7	1,850	516,138	386	CY5	1,850	599,388
342	DX7	1,850	517,988	387	CX5	1,850	601,238
343	BY8	1,850	519,838	388	DY5	1,850	603,088
344	BY8	1,850	521,688	389	DX5	1,850	604,938
345	CX8	1,850	523,538	390	EY5	1,850	606,788
346	DY8	1,850	525,388	391	EX5	1,850	608,638
347	DX8	1,850	527,238	392	FY5	1,850	610,488
348	DX8	1,850	529,088	393	FX5	1,850	612,338
349	CX2	1,850	530,938	394	GY5	1,850	614,188
350	CX2	1,850	532,788	395		1,850	616,038
351	DY2	1,850	534,638	396		1,850	617,888
352	DX2	1,850	536,488	397		1,850	619,738
353	EY2	1,850	538,338	398		1,850	621,588
354	EX2	1,850	540,188	399		1,850	623,438
355	FY2	1,850	542,038	400		1,850	625,288
356	FX2	1,850	543,888	401		1,850	627,138
357	GY2	1,850	545,738	402		1,850	628,988
358	BY3	1,850	547,588	403		1,850	630,838
359	BY3	1,850	549,438	404		1,850	632,688

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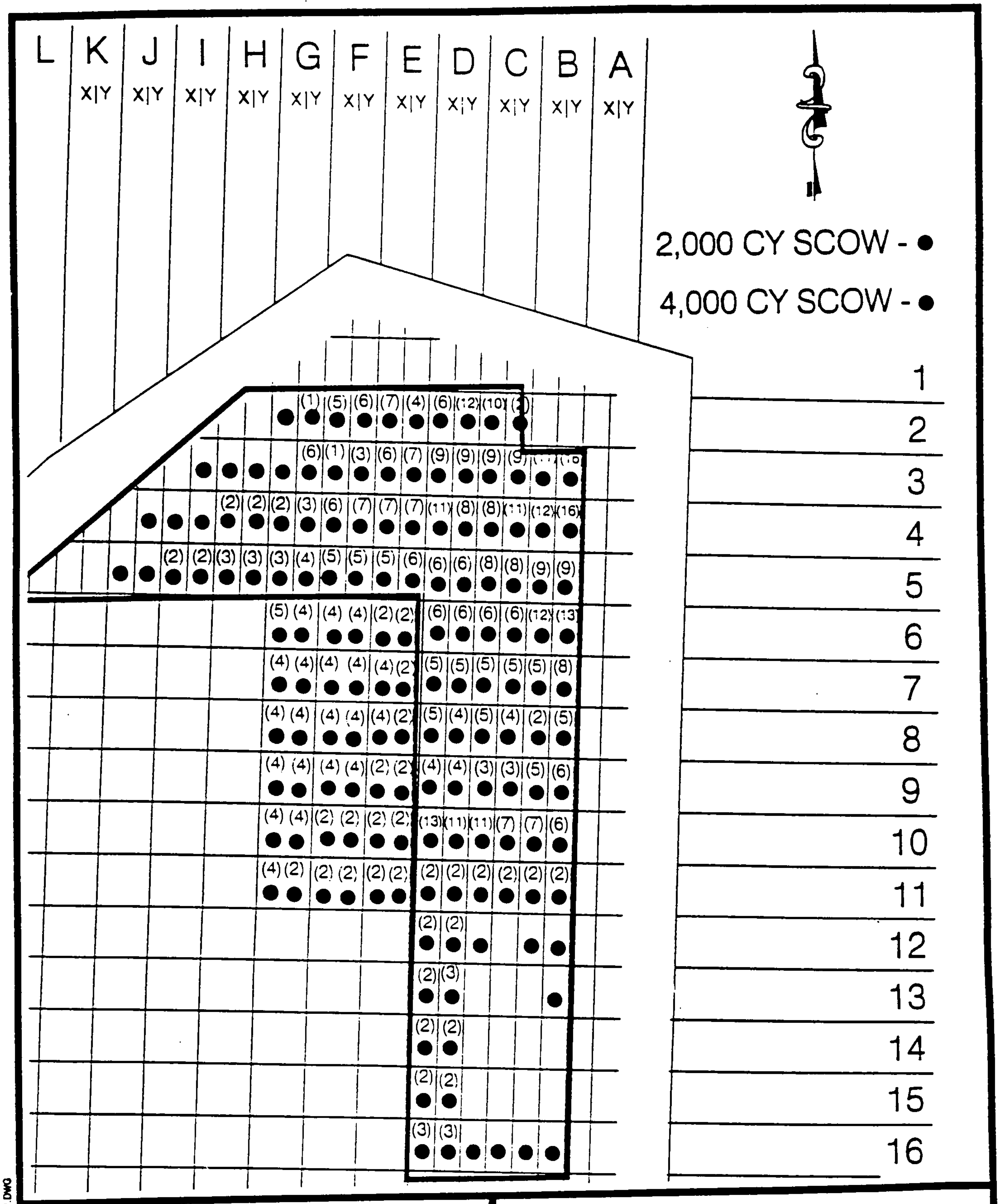

MARYLAND ENVIRONMENTAL SERVICE

SITE 92 BERM PLACEMENT PLAN

(REVISED 3/15/99)

J:\SITE92\92DROP-NEW2.DWG

①

4,000 yds SCOW DUMP PLAN

REVISED: 15-Mar-99

Load #	Cell #	Volume Cy/Load	Cumulative Volume	Load #	Cell #	Volume Cy/Load	Cumulative Volume
1	EY6	3,200	3,200	46	FX10	3,200	147,200
2	EX6	3,200	6,400	47	GY10	3,200	150,400
3	FY6	3,200	9,600	48	GY10	3,200	153,600
4	FY6	3,200	12,800	49	GX10	3,200	156,800
5	FX6	3,200	16,000	50	GX10	3,200	160,000
6	FX6	3,200	19,200	51	EY11	3,200	163,200
7	GY6	3,200	22,400	52	EX11	3,200	166,400
8	GY6	3,200	25,600	53	FY11	3,200	169,600
9	GX6	3,200	28,800	54	FX11	3,200	172,800
10	GX6	3,200	32,000	55	GY11	3,200	176,000
11	EY7	3,200	35,200	56	GX11	3,200	179,200
12	EX7	3,200	38,400	57	GX11	3,200	182,400
13	EX7	3,200	41,600	58	EY6	3,200	185,600
14	FY7	3,200	44,800	59	EX6	3,200	188,800
15	FY7	3,200	48,000	60	FY6	3,200	192,000
16	FX7	3,200	51,200	61	FY6	3,200	195,200
17	FX7	3,200	54,400	62	FX6	3,200	198,400
18	GY7	3,200	57,600	63	FX6	3,200	201,600
19	GY7	3,200	60,800	64	GY6	3,200	204,800
20	GX7	3,200	64,000	65	GY6	3,200	208,000
21	GX7	3,200	67,200	66	GX6	3,200	211,200
22	EY8	3,200	70,400	67	GX6	3,200	214,400
23	EX8	3,200	73,600	68	EY7	3,200	217,600
24	EX8	3,200	76,800	69	EX7	3,200	220,800
25	FY8	3,200	80,000	70	EX7	3,200	224,000
26	FY8	3,200	83,200	71	FY7	3,200	227,200
27	FX8	3,200	86,400	72	FY7	3,200	230,400
28	FX8	3,200	89,600	73	FX7	3,200	233,600
29	GY8	3,200	92,800	74	FX7	3,200	236,800
30	GY8	3,200	96,000	75	GY7	3,200	240,000
31	GX8	3,200	99,200	76	GY7	3,200	243,200
32	GX8	3,200	102,400	77	GX7	3,200	246,400
33	EY9	3,200	105,600	78	GX7	3,200	249,600
34	EX9	3,200	108,800	79	EY8	3,200	252,800
35	FY9	3,200	112,000	80	EX8	3,200	256,000
36	FY9	3,200	115,200	81	EX8	3,200	259,200
37	FX9	3,200	118,400	82	FY8	3,200	262,400
38	FX9	3,200	121,600	83	FY8	3,200	265,600
39	GY9	3,200	124,800	84	FX8	3,200	268,800
40	GY9	3,200	128,000	85	FX8	3,200	272,000
41	GX9	3,200	131,200	86	GY8	3,200	275,200
42	GX9	3,200	134,400	87	GY8	3,200	278,400
43	EY10	3,200	137,600	88	GX8	3,200	281,600
44	EX10	3,200	140,800	89	GX8	3,200	284,800
45	FY10	3,200	144,000	90	EY9	3,200	288,000

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4,000 yds SCOW DUMP PLAN

REVISED: 15-Mar-99

Load #	Cell #	Volume Cy/Load	Cumulative Volume
91	EX9	3,200	275,200
92	FY9	3,200	278,400
93	FY9	3,200	281,600
94	FX9	3,200	284,800
95	FX9	3,200	288,000
96	GY9	3,200	291,200
97	GY9	3,200	294,400
98	GX9	3,200	297,600
99	GX9	3,200	300,800
100	EY10	3,200	304,000
101	EX10	3,200	307,200
102	FY10	3,200	310,400
103	FX10	3,200	313,600
104	GY10	3,200	316,800
105	GY10	3,200	320,000
106	GX10	3,200	323,200
107	GX10	3,200	326,400
108	EY11	3,200	329,600
109	EX11	3,200	332,800
110	FY11	3,200	336,000
111	FX11	3,200	339,200
112	GY11	3,200	342,400
113	GX11	3,200	345,600
114	GX11	3,200	348,800
115		3,200	352,000
116		3,200	355,200
117		3,200	358,400
118		3,200	361,600
119		3,200	364,800
120		3,200	368,000
121		3,200	371,200
122		3,200	374,400
123		3,200	377,600
124		3,200	380,800
125		3,200	384,000
126		3,200	387,200
127		3,200	390,400
128		3,200	393,600
129		3,200	396,800
130		3,200	400,000
131		3,200	403,200
132		3,200	406,400
133		3,200	409,600
134		3,200	412,800
135		3,200	416,000
136		3,200	419,200
137		3,200	422,400
138		3,200	425,600
139		3,200	428,800
140		3,200	432,000
141		3,200	435,200
142		3,200	438,400
143		3,200	441,600
144		3,200	444,800
145		3,200	448,000
146		3,200	451,200
147		3,200	454,400
148		3,200	457,600
149		3,200	460,800
150		3,200	464,000
151		3,200	467,200
152		3,200	470,400
153		3,200	473,600
154		3,200	476,800
155		3,200	480,000
156		3,200	483,200
157		3,200	486,400
158		3,200	489,600
159		3,200	492,800
160		3,200	496,000
161		3,200	499,200
162		3,200	502,400
163		3,200	505,600
164		3,200	508,800
165		3,200	512,000
166		3,200	515,200
167		3,200	518,400
168		3,200	521,600
169		3,200	524,800
170		3,200	528,000
171		3,200	531,200
172		3,200	534,400
173		3,200	537,600
174		3,200	540,800
175		3,200	544,000
176		3,200	547,200
177		3,200	550,400
178		3,200	553,600
179		3,200	556,800
180		3,200	560,000

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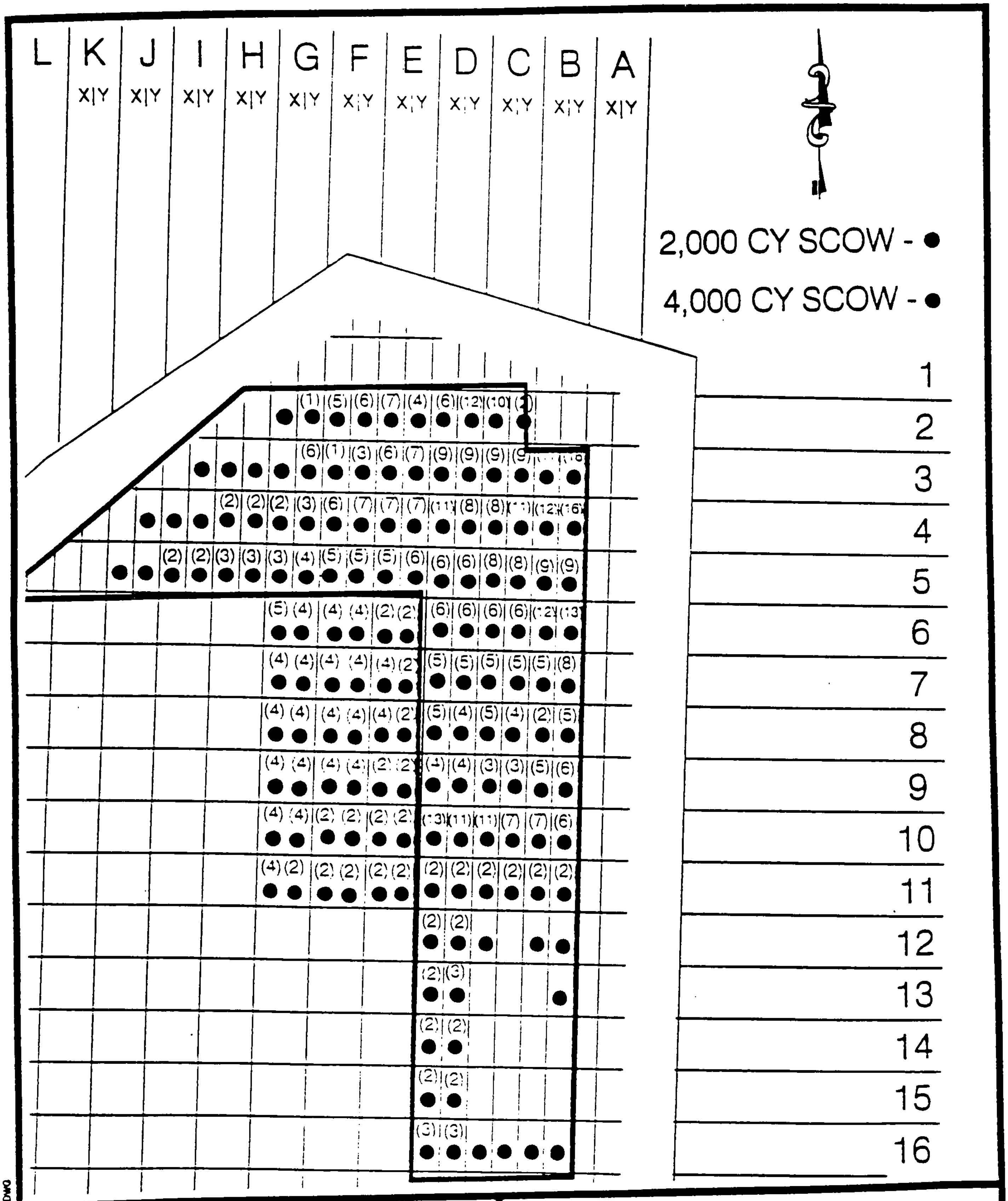
REVISED: **15-Mar-99**

Load #	Cell #	Volume Cy/Load	Cumulative Volume
315	CY5	1,850	468,038
316	CX5	1,850	469,888
317	CX5	1,850	471,738
318	DY5	1,850	473,588
319	DX5	1,850	475,438
320	EY5	1,850	477,288
321	EX5	1,850	479,138
322	FY5	1,850	480,988
323	FX5	1,850	482,838
324	GY5	1,850	484,688
325	GX5	1,850	486,538
326	HY5	1,850	488,388
327	HX5	1,850	490,238
328	IY5	1,850	492,088
329	IX5	1,850	493,938
330	BY6	1,850	495,788
331	BY6	1,850	497,638
332	BX6	1,850	499,488
333	BX6	1,850	501,338
334	CY6	1,850	503,188
335	CX6	1,850	505,038
336	DY6	1,850	506,888
337	DX6	1,850	508,738
338	BY7	1,850	510,588
339	BY7	1,850	512,438
340	CX7	1,850	514,288
341	DY7	1,850	516,138
342	DX7	1,850	517,988
343	BY8	1,850	519,838
344	BY8	1,850	521,688
345	CX8	1,850	523,538
346	DY8	1,850	525,388
347	DX8	1,850	527,238
348	DX8	1,850	529,088
349	CX2	1,850	530,938
350	CX2	1,850	532,788
351	DY2	1,850	534,638
352	DX2	1,850	536,488
353	EY2	1,850	538,338
354	EX2	1,850	540,188
355	FY2	1,850	542,038
356	FX2	1,850	543,888
357	GY2	1,850	545,738
358	BY3	1,850	547,588
359	BY3	1,850	549,438
360	BY3	1,850	551,288
361	BX3	1,850	553,138
362	BX3	1,850	554,988
363	CY3	1,850	556,838
364	CX3	1,850	558,688
365	DY3	1,850	560,538
366	DX3	1,850	562,388
367	EY3	1,850	564,238
368	EX3	1,850	566,088
369	FY3	1,850	567,938
370	FX3	1,850	569,788
371	GY3	1,850	571,638
372	BY4	1,850	573,488
373	BY4	1,850	575,338
374	BX4	1,850	577,188
375	CY4	1,850	579,038
376	CX4	1,850	580,888
377	DY4	1,850	582,738
378	DX4	1,850	584,588
379	EY4	1,850	586,438
380	EX4	1,850	588,288
381	FY4	1,850	590,138
382	FX4	1,850	591,988
383	GY4	1,850	593,838
384	BY5	1,850	595,688
385	BX5	1,850	597,538
386	CY5	1,850	599,388
387	CX5	1,850	601,238
388	DY5	1,850	603,088
389	DX5	1,850	604,938
390	EY5	1,850	606,788
391	EX5	1,850	608,638
392	FY5	1,850	610,488
393	FX5	1,850	612,338
394	GY5	1,850	614,188
395	BY6	1,850	616,038
396	BY6	1,850	617,888
397	CY6	1,850	619,738
398	CX6	1,850	621,588
399	DY6	1,850	623,438
400	DX6	1,850	625,288
401	BY7	1,850	627,138
402	BY7	1,850	628,988
403	BX7	1,850	630,838
404	CY7	1,850	632,688

REVISED: 15-Mar-99

Load #	Cell #	Volume Cy/Load	Cumulative Volume	Load #	Cell #	Volume Cy/Load	Cumulative Volume
405	CX7	1,850	623,438	450		1,850	706,688
406	DY7	1,850	625,288	451		1,850	708,538
407	DX7	1,850	627,138	452		1,850	710,388
408	BY8	1,850	628,988	453		1,850	712,238
409	CY8	1,850	630,838	454		1,850	714,088
410.	CX8	1,850	632,688	455		1,850	715,938
411	BY9	1,850	634,538	456		1,850	717,788
412	BY9	1,850	636,388	457		1,850	719,638
413	BX9	1,860	638,238	458		1,850	721,488
414	CY9	1,850	640,088	459		1,850	723,338
415	CX9	1,850	641,938	460		1,850	725,188
416	DY9	1,850	643,788	461		1,850	727,038
417	DX9	1,850	645,638	462		1,850	728,888
418	BY10	1,850	647,488	463		1,850	730,738
419	CX10	1,850	649,338	464		1,850	732,588
420	DY10	1,850	651,188	465		1,850	734,438
421	BY12	1,850	653,038	466		1,850	736,288
422	BX12	1,850	654,888	467		1,850	738,138
423	CX12	1,850	656,738	468		1,850	739,988
424	BY13	1,850	658,588	469		1,850	741,838
425	DY13	1,850	660,438	470		1,850	743,688
426	BY16	1,850	662,288	471		1,850	745,538
427	BX16	1,850	664,138	472		1,850	747,388
428	CY16	1,850	665,988	473		1,850	749,238
429	CX16	1,850	667,838	474		1,850	751,088
430	DY16	1,850	669,588	475		1,850	752,938
431	DX16	1,850	671,538	476		1,850	754,788
432		1,850	673,388	477		1,850	756,638
433		1,850	675,238	478		1,850	758,488
434		1,850	677,088	479		1,850	760,338
435		1,850	678,938	480		1,850	762,188
436		1,850	680,788	481		1,850	764,038
437		1,850	682,638	482		1,850	765,888
438		1,850	684,488	483		1,850	767,738
439		1,850	686,338	484		1,850	769,588
440		1,850	688,188	485		1,850	771,438
441		1,850	690,038	486		1,850	773,288
442		1,850	691,888	487		1,850	775,138
443		1,850	693,738	488		1,850	776,988
444		1,850	695,588	489		1,850	778,838
445		1,850	697,438	490		1,850	780,688
446		1,850	699,288	491		1,850	782,538
447		1,850	701,138	492		1,850	784,388
448		1,850	702,988	493		1,850	786,238
449		1,850	704,838	494		1,850	788,088



MARYLAND
ENVIRONMENTAL
SERVICE

SITE 92 BERM PLACEMENT PLAN

(REVISED 3/16/99)

J:\SITE92\92DROP-NEW2.DWG

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4,000 yds SCOW DUMP PLAN

REVISED: 16-Mar-99

Load #	Cell #	Volume Cy/Load	Cumulative Volume
1	EY6	3,200	3,200
2	EX6	3,200	6,400
3	FY6	3,200	9,600
4	FY6	3,200	12,800
5	FX6	3,200	16,000
6	FX6	3,200	19,200
7	GY6	3,200	22,400
8	GY6	3,200	25,600
9	GX6	3,200	28,800
10	GX6	3,200	32,000
11	EY7	3,200	35,200
12	EX7	3,200	38,400
13	EX7	3,200	41,600
14	FY7	3,200	44,800
15	FY7	3,200	48,000
16	FX7	3,200	51,200
17	FX7	3,200	54,400
18	GY7	3,200	57,600
19	GY7	3,200	60,800
20	GX7	3,200	64,000
21	GX7	3,200	67,200
22	EY8	3,200	70,400
23	EX8	3,200	73,600
24	EX8	3,200	76,800
25	FY8	3,200	80,000
26	FY8	3,200	83,200
27	FX8	3,200	86,400
28	FX8	3,200	89,600
29	GY8	3,200	92,800
30	GY8	3,200	96,000
31	GX8	3,200	99,200
32	GX8	3,200	102,400
33	EY9	3,200	105,600
34	EX9	3,200	108,800
35	FY9	3,200	112,000
36	FY9	3,200	78,000
37	FX9	2,300	80,300
38	FX9	2,300	82,600
39	GY9	2,300	84,900
40	GY9	2,300	87,200
41	GX9	2,300	89,500
42	GX9	2,300	91,800
43	EY10	2,300	94,100
44	EX10	2,300	96,400
45	FY10	2,300	98,700
46	FX10	2,300	101,000
47	GY10	2,300	103,300
48	GY10	2,300	105,600
49	GX10	2,300	107,900
50	GX10	2,300	110,200
51	EY11	2,300	112,500
52	EX11	2,300	114,800
53	FY11	2,300	117,100
54	FX11	2,300	119,400
55	GY11	2,300	121,700
56	GX11	2,300	124,000
57	GX11	2,300	126,300
58	EY6	2,300	128,600
59	EX6	2,300	130,900
60	FY6	2,300	133,200
61	FY6	2,300	135,500
62	FX6	2,300	137,800
63	FX6	2,300	140,100
64	GY6	2,300	142,400
65	GY6	2,300	144,700
66	GX6	2,300	147,000
67	GX6	2,300	149,300
68	EY7	2,300	151,600
69	EX7	2,300	153,900
70	EX7	2,300	156,200
71	FY7	2,300	158,500
72	FY7	2,300	160,800
73	FX7	2,300	163,100
74	FX7	2,300	165,400
75	GY7	2,300	167,700
76	GY7	2,300	170,000
77	GX7	2,300	172,300
78	GX7	2,300	174,600
79	EY8	2,300	176,900
80	EX8	2,300	179,200
81	EX8	2,300	181,500
82	FY8	2,300	183,800
83	FY8	2,300	186,100
84	FX8	2,300	188,400
85	FX8	2,300	190,700
86	GY8	2,300	193,000
87	GY8	2,300	195,300
88	GX8	2,300	197,600
89	GX8	2,300	199,900
90	EY9	2,300	202,200

* DUMP36 CUMMULATIVE TOTAL WAS CHANGED TO REFLECT THE ACTUAL TOTAL FROM DAILY REPORT FROM 3/14/99 AS PER CORPS INSTRUCTION. ALSO INDIVIDUAL SCOW YARDAGE WAS CHANGED TO REFLECT MORE ACTUAL CONDITIONS.

2

4,000 yds SCOW DUMP PLAN

REVISED: 16-Mar-99

Load #	Cell #	Volume Cy/Load	Cumulative Volume
91	EX9	2,300	193,000
92	FY9	2,300	195,300
93	FY9	2,300	197,600
94	FX9	2,300	199,900
95	FX9	2,300	202,200
96	GY9	2,300	204,500
97	GY9	2,300	206,800
98	GX9	2,300	209,100
99	GX9	2,300	211,400
100	EY10	2,300	213,700
101	EX10	2,300	216,000
102	FY10	2,300	218,300
103	FX10	2,300	220,600
104	GY10	2,300	222,900
105	GY10	2,300	225,200
106	GX10	2,300	227,500
107	GX10	2,300	229,800
108	EY11	2,300	232,100
109	EX11	2,300	234,400
110	FY11	2,300	236,700
111	FX11	2,300	239,000
112	GY11	2,300	241,300
113	GX11	2,300	243,600
114	GX11	2,300	245,900
115		2,300	248,200
116		2,300	250,500
117		2,300	252,800
118		2,300	255,100
119		2,300	257,400
120		2,300	259,700
121		2,300	262,000
122		2,300	264,300
123		2,300	266,600
124		2,300	268,900
125		2,300	271,200
126		2,300	273,500
127		2,300	275,800
128		2,300	278,100
129		2,300	280,400
130		2,300	282,700
131		2,300	285,000
132		2,300	287,300
133		2,300	289,600
134		2,300	291,900
135		2,300	294,200
136		2,300	296,500
137		2,300	298,800
138		2,300	301,100
139		2,300	303,400
140		2,300	305,700
141		2,300	308,000
142		2,300	310,300
143		2,300	312,600
144		2,300	314,900
145		2,300	317,200
146		2,300	319,500
147		2,300	321,800
148		2,300	324,100
149		2,300	326,400
150		2,300	328,700
151		2,300	331,000
152		2,300	333,300
153		2,300	335,600
154		2,300	337,900
155		2,300	340,200
156		2,300	342,500
157		2,300	344,800
158		2,300	347,100
159		2,300	349,400
160		2,300	351,700
161		2,300	354,000
162		2,300	356,300
163		2,300	358,600
164		2,300	360,900
165		2,300	363,200
166		2,300	365,500
167		2,300	367,800
168		2,300	370,100
169		2,300	372,400
170		2,300	374,700
171		2,300	377,000
172		2,300	379,300
173		2,300	381,600
174		2,300	383,900
175		2,300	386,200
176		2,300	388,500
177		2,300	390,800
178		2,300	393,100
179		2,300	395,400
180		2,300	397,700

2,000 cy Scow

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REVISED: 15-Mar-99

Load #	Cell #	Volume Cy/Load	Cumulative Volume	Load #	Cell #	Volume Cy/Load	Cumulative Volume
315	CY5	1,850	468,038	360	BY3	1,850	551,288
316	CX5	1,850	469,888	361	BX3	1,850	553,138
317	CX5	1,850	471,738	362	BX3	1,850	554,988
318	DY5	1,850	473,588	363	CY3	1,850	556,838
319	DX5	1,850	475,438	364	CX3	1,850	558,688
320	EY5	1,850	477,288	365	DY3	1,850	560,538
321	EX5	1,850	479,138	366	DX3	1,850	562,388
322	FY5	1,850	480,988	367	EY3	1,850	564,238
323	FX5	1,850	482,838	368	EX3	1,850	566,088
324	GY5	1,850	484,888	369	FY3	1,850	567,938
325	GX5	1,850	486,538	370	FX3	1,850	569,788
326	HY5	1,850	488,388	371	GY3	1,850	571,638
327	HX5	1,850	490,238	372	BY4	1,850	573,488
328	IY5	1,850	492,088	373	BY4	1,850	575,338
329	IX5	1,850	493,938	374	BX4	1,850	577,188
330	BY5	1,850	495,788	375	CY4	1,850	579,038
331	BY6	1,850	497,638	376	CX4	1,850	580,888
332	BX6	1,850	499,488	377	DY4	1,850	582,738
333	BX6	1,850	501,338	378	DX4	1,850	584,588
334	CY6	1,850	503,188	379	EY4	1,850	586,438
335	CX6	1,850	505,038	380	EX4	1,850	588,288
336	DY6	1,850	506,888	381	FY4	1,850	590,138
337	DX6	1,850	508,738	382	FX4	1,850	591,988
338	BY7	1,850	510,588	383	GY4	1,850	593,838
339	BY7	1,850	512,438	384	BY5	1,850	595,688
340	CX7	1,850	514,288	385	BX5	1,850	597,538
341	DY7	1,850	516,138	386	CY5	1,850	599,388
342	DX7	1,850	517,988	387	CX5	1,850	601,238
343	BY8	1,850	519,838	388	DY5	1,850	603,088
344	EY8	1,850	521,688	389	DX5	1,850	604,938
345	CX8	1,850	523,538	390	EY5	1,850	606,788
346	DY8	1,850	525,388	391	EX5	1,850	608,638
347	DX8	1,850	527,238	392	FY5	1,850	610,488
348	DX8	1,850	529,088	393	FX5	1,850	612,338
349	CX2	1,850	530,938	394	GY5	1,850	614,188
350	CX2	1,850	532,788	395	BY6	1,850	616,038
351	DY2	1,850	534,638	396	BY6	1,850	617,888
352	DX2	1,850	536,488	397	CY6	1,850	619,738
353	EY2	1,850	538,338	398	CX6	1,850	621,588
354	EX2	1,850	540,188	399	DY6	1,850	623,438
355	FY2	1,850	542,038	400	DX6	1,850	625,288
356	FX2	1,850	543,888	401	BY7	1,850	627,138
357	GY2	1,850	545,738	402	BY7	1,850	628,988
358	BY3	1,850	547,588	403	BX7	1,850	630,838
359	BY3	1,850	549,438	404	CY7	1,850	632,688

2,000 cy scow

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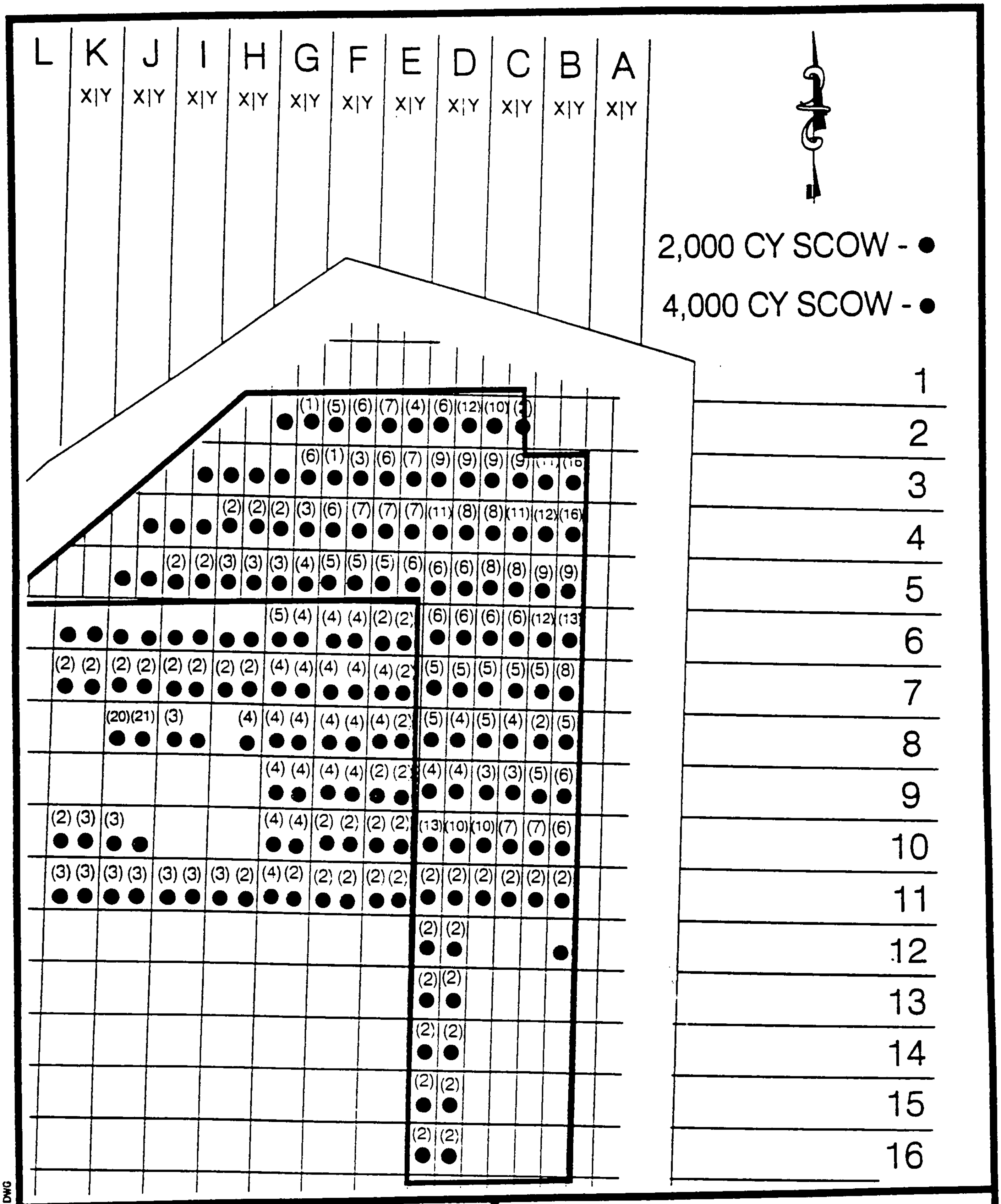
REVISED: **15-Mar-99**

Load #	Cell #	Volume Cy/Load	Cumulative Volume	Load #	Cell #	Volume Cy/Load	Cumulative Volume
405	CX7	1,850	623,438	450		1,850	706,688
406	DY7	1,850	625,288	451		1,850	708,538
407	DX7	1,850	627,138	452		1,850	710,388
408	BY8	1,850	628,988	453		1,850	712,238
409	CY8	1,850	630,838	454		1,850	714,088
410	CX8	1,850	632,688	455		1,850	715,938
411	BY9	1,850	634,538	456		1,850	717,788
412	BY9	1,850	636,388	457		1,850	719,638
413	BX9	1,850	638,238	458		1,850	721,488
414	CY9	1,850	640,088	459		1,850	723,338
415	CX9	1,850	641,938	460		1,850	725,188
416	DY9	1,850	643,788	461		1,850	727,038
417	DX9	1,850	645,638	462		1,850	728,888
418	BY10	1,850	647,488	463		1,850	730,738
419	CX10	1,850	649,338	464		1,850	732,588
420	DY10	1,850	651,188	465		1,850	734,438
421	BY12	1,850	653,038	466		1,850	736,288
422	BX12	1,850	654,888	467		1,850	738,138
423	CX12	1,850	656,738	468		1,850	739,988
424	BY13	1,850	658,588	469		1,850	741,838
425	DY13	1,850	660,438	470		1,850	743,688
426	BY16	1,850	662,288	471		1,850	745,538
427	BX16	1,850	664,138	472		1,850	747,388
428	CY16	1,850	665,988	473		1,850	749,238
429	CX16	1,850	667,838	474		1,850	751,088
430	DY16	1,850	669,688	475		1,850	752,938
431	DX16	1,850	671,538	476		1,850	754,788
432		1,850	673,388	477		1,850	756,638
433		1,850	675,238	478		1,850	758,488
434		1,850	677,088	479		1,850	760,338
435		1,850	678,938	480		1,850	762,188
436		1,850	680,788	481		1,850	764,038
437		1,850	682,638	482		1,850	765,888
438		1,850	684,488	483		1,850	767,738
439		1,850	686,338	484		1,850	769,588
440		1,850	688,188	485		1,850	771,438
441		1,850	690,038	486		1,850	773,288
442		1,850	691,888	487		1,850	775,138
443		1,850	693,738	488		1,850	776,988
444		1,850	695,588	489		1,850	778,838
445		1,850	697,438	490		1,850	780,688
446		1,850	699,288	491		1,850	782,538
447		1,850	701,138	492		1,850	784,388
448		1,850	702,988	493		1,850	786,238
449		1,850	704,838	494		1,850	788,088



MARYLAND
ENVIRONMENTAL
SERVICE

SITE 92 BERM
PLACEMENT PLAN

(REVISED 3/22/99)

J:\SITE92\92DROP-NEW2.DWG

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REVISED: 22-Mar-99

Load #	Cell #	Volume Cy/Load	Cumulative Volume	Load #	Cell #	Volume Cy/Load	Cumulative Volume
405	CX7	1,850	623,438	450	IY8	1,850	702,988
406	DY7	1,850	625,288	451	IX8	1,850	704,838
407	DX7	1,850	627,138	452	IX8	1,850	706,688
408	BY8	1,850	628,988	453	IX8	1,850	708,538
409	CY8	1,850	630,838	454	JY8	1,850	710,388
410	CX8	1,850	632,688	455	JY8	1,850	712,238
411	BY9	1,850	634,538	456	JX8	1,850	714,088
412	BY9	1,850	636,388	457	JX8	1,850	715,938
413	BX9	1,850	638,238	458	JY8	1,850	717,788
414	CY9	1,850	640,088	459	JY8	1,850	719,638
415	CX9	1,850	641,938	460	JX8	1,850	721,488
416	DY9	1,850	643,788	461	JX8	1,850	723,338
417	DX9	1,850	645,638	462	JY8	1,850	725,188
418	BY10	1,850	647,488	463	JY8	1,850	727,038
419	SKIP	0	647,488	464	JX8	1,850	728,888
420	SKIP	0	647,488	465	JX8	1,850	730,738
421	BY12	1,850	649,338	466	JY8	1,850	732,588
422	HY6	1,850	651,188	467	JY8	1,850	734,438
423	HX6	1,850	653,038	468	JX8	1,850	736,288
424	IY6	1,850	654,888	469	JX8	1,850	738,138
425	IX6	1,850	656,738	470	JY8	1,850	739,988
426	JY6	1,850	658,588	471	JY8	1,850	741,838
427	JX6	1,850	660,438	472	JX8	1,850	743,688
428	KY6	1,850	662,288	473	JX8	1,850	745,538
429	KX6	1,850	664,138	474	JY8	1,850	747,388
430	HY7	1,850	665,988	475	JY8	1,850	749,238
431	HY7	1,850	667,838	476	JX8	1,850	751,088
432	HX7	1,850	669,688	477	JX8	1,850	752,938
433	HX7	1,850	671,538	478	JY8	1,850	754,788
434	IY7	1,850	673,388	479	JY8	1,850	756,638
435	IY7	1,850	675,238	480	JX8	1,850	758,488
436	IX7	1,850	677,088	481	JX8	1,850	760,338
437	IX7	1,850	678,938	482	JY8	1,850	762,188
438	JY7	1,850	680,788	483	JY8	1,850	764,038
439	JY7	1,850	682,638	484	JX8	1,850	765,888
440	JX7	1,850	684,488	485	JX8	1,850	767,738
441	JX7	1,850	686,338	486	JY8	1,850	769,588
442	KY7	1,850	688,188	487	JY8	1,850	771,438
443	KX7	1,850	690,038	488	JX8	1,850	773,288
444	HY8	1,850	691,888	489	JX8	1,850	775,138
445	HY8	1,850	693,738	490	JY8	1,850	776,988
446	KY7	1,850	695,588	491	JY8	1,850	778,838
447	KX7	1,850	697,438	492	JX8	1,850	780,688
448	HY8	1,850	699,288	493	JX8	1,850	782,538
449	HY8	1,850	701,138	494	JY8	1,850	784,388

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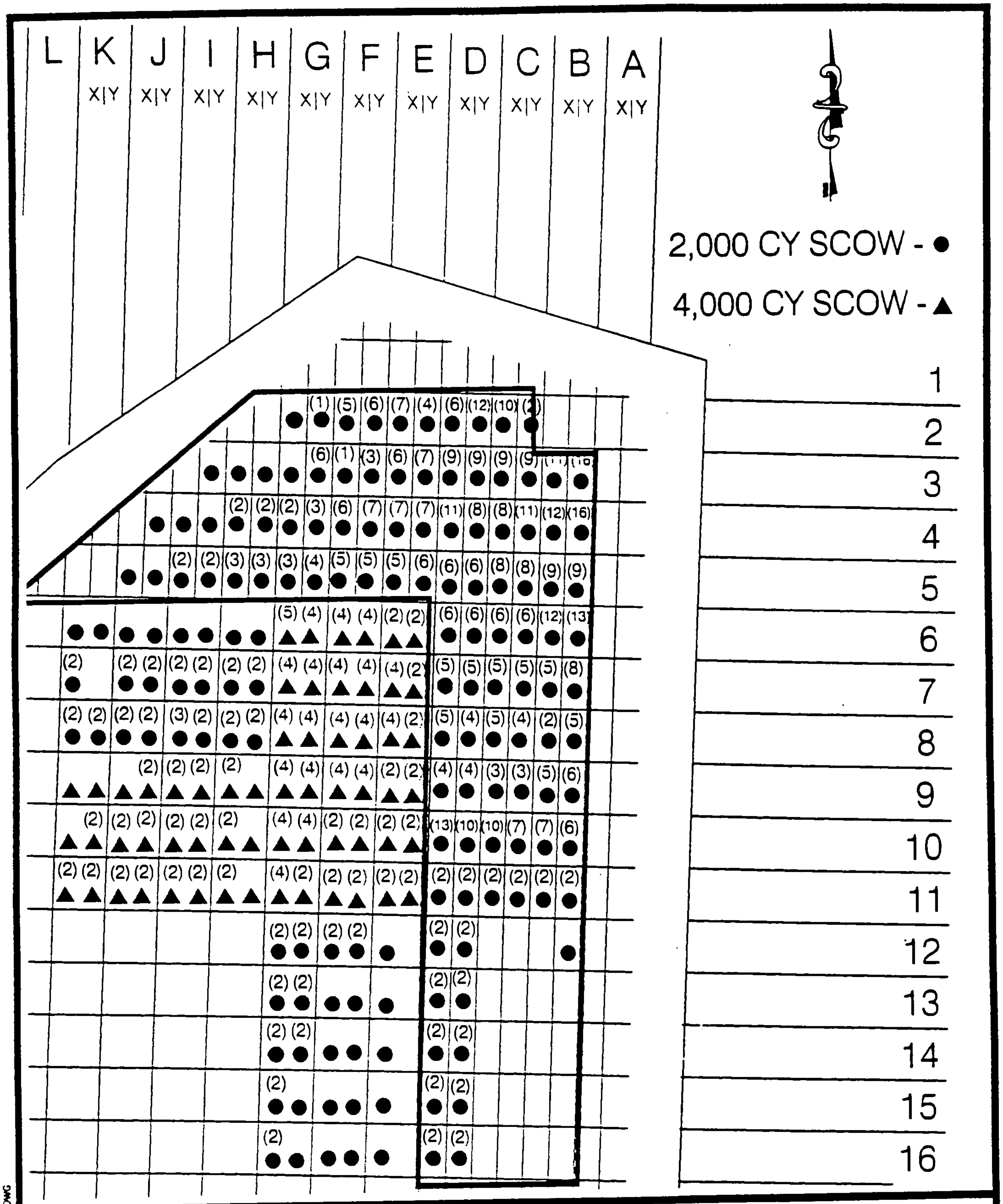
REVISED: 22-Mar-99

Load #	Cell #	Volume Cy/Load	Cumulative Volume	Load #	Cell #	Volume Cy/Load	Cumulative Volume
495	JY10	1,850	775,138	540		1,850	858,388
496	JX10	1,850	776,988	541		1,850	860,238
497	JX10	1,850	778,838	542		1,850	862,088
498	JX10	1,850	780,688	543		1,850	863,938
499	KY10	1,850	782,538	544		1,850	865,788
500	KY10	1,850	784,388	545		1,850	867,638
501	KY10	1,850	786,238	546		1,850	869,488
502	KX10	1,850	788,088	547		1,850	871,338
503	KX10	1,850	789,938	548		1,850	873,188
504	HY11	1,850	791,788	549		1,850	875,038
505	HY11	1,850	793,638	550		1,850	876,888
506	HX11	1,850	795,488	551		1,850	878,738
507	HX11	1,850	797,338	552		1,850	880,588
508	HX11	1,850	799,188	553		1,850	882,438
509	IY11	1,850	801,038	554		1,850	884,288
510	IY11	1,850	802,888	555		1,850	886,138
511	IY11	1,850	804,738	556		1,850	887,988
512	IX11	1,850	806,588	557		1,850	889,838
513	IX11	1,850	808,438	558		1,850	891,688
514	IX11	1,850	810,288	559		1,850	893,538
515	JY11	1,850	812,138	560		1,850	895,388
516	JY11	1,850	813,988	561		1,850	897,238
517	JY11	1,850	815,838	562		1,850	899,088
518	JX11	1,850	817,688	563		1,850	900,938
519	JX11	1,850	819,538	564		1,850	902,788
520	JX11	1,850	821,388	565		1,850	904,638
521	KY11	1,850	823,238	566		1,850	906,488
522	KY11	1,850	825,088	567		1,850	908,338
523	KY11	1,850	826,938	568		1,850	910,188
524	KX11	1,850	828,788	569		1,850	912,038
525	KX11	1,850	830,638	570		1,850	913,888
526	KX11	1,850	832,488	571		1,850	915,738
527		1,850	834,338	572		1,850	917,588
528		1,850	836,188	573		1,850	919,438
529		1,850	838,038	574		1,850	921,288
530		1,850	839,888	575		1,850	923,138
531		1,850	841,738	576		1,850	924,988
532		1,850	843,588	577		1,850	926,838
533		1,850	845,438	578		1,850	928,688
534		1,850	847,288	579		1,850	930,538
535		1,850	849,138	580		1,850	932,388
536		1,850	850,988	581		1,850	934,238
537		1,850	852,838	582		1,850	936,088
538		1,850	854,688	583		1,850	937,938
539		1,850	856,538	584		1,850	939,788



MARYLAND
ENVIRONMENTAL
SERVICE

SITE 92 BERM PLACEMENT PLAN

(REVISED 3/24/99)

J:\SITE92\92DROP-NEW2.DWG

4,000 yds SCOW DUMP PLAN

REVISED: 23-Mar-99

Load #	Cell #	Volume Cy/Load	Cumulative Volume	Load #	Cell #	Volume Cy/Load	Cumulative Volume
1	EY6	3,200	3,200	46	FX10	2,300	101,000
2	EX6	3,200	6,400	47	GY10	2,300	103,300
3	FY6	3,200	9,600	48	GY10	2,300	105,600
4	FY6	3,200	12,800	49	GX10	2,300	107,900
5	FX6	3,200	16,000	50	GX10	2,300	110,200
6	FX6	3,200	19,200	51	EY11	2,300	112,500
7	GY6	3,200	22,400	52	EX11	2,300	114,800
8	GY6	3,200	25,600	53	FY11	2,300	117,100
9	GX6	3,200	28,800	54	FX11	2,300	119,400
10	GX6	3,200	32,000	55	GY11	2,300	121,700
11	EY7	3,200	35,200	56	GX11	2,300	124,000
12	EX7	3,200	38,400	57	GX11	2,300	126,300
13	EX7	3,200	41,600	58	EY6	2,300	128,600
14	FY7	3,200	44,800	59	EX6	2,300	130,900
15	FY7	3,200	48,000	60	FY6	2,300	133,200
16	FX7	3,200	51,200	61	FY6	2,300	135,500
17	FX7	3,200	54,400	62	FX6	2,300	137,800
18	GY7	3,200	57,600	63	FX6	2,300	140,100
19	GY7	3,200	60,800	64	GY6	2,300	142,400
20	GX7	3,200	64,000	65	GY6	2,300	144,700
21	GX7	3,200	67,200	66	GX6	2,300	147,000
22	EY8	3,200	70,400	67	GX6	2,300	149,300
23	EX8	3,200	73,600	68	EY7	2,300	151,600
24	EX8	3,200	76,800	69	EX7	2,300	153,900
25	FY8	3,200	80,000	70	EX7	2,300	156,200
26	FY8	3,200	83,200	71	FY7	2,300	158,500
27	FX8	3,200	86,400	72	FY7	2,300	160,800
28	FX8	3,200	89,600	73	FX7	2,300	163,100
29	GY8	3,200	92,800	74	FX7	2,300	165,400
30	GY8	3,200	96,000	75	GY7	2,300	167,700
31	GX8	3,200	99,200	76	GY7	2,300	170,000
32	GX8	3,200	102,400	77	GX7	2,300	172,300
33	EY9	3,200	105,600	78	GX7	2,300	174,600
34	EX9	3,200	108,800	79	EY8	2,300	176,900
35	FY9	3,200	112,000	80	EX8	2,300	179,200
36	FY9	3,200	78,000	81	EX8	2,300	181,500
37	FX9	2,300	80,300	82	FY8	2,300	183,800
38	FX9	2,300	82,600	83	FY8	2,300	186,100
39	GY9	2,300	84,900	84	FX8	2,300	188,400
40	GY9	2,300	87,200	85	FX8	2,300	190,700
41	GX9	2,300	89,500	86	GY8	2,300	193,000
42	GX9	2,300	91,800	87	GY8	2,300	195,300
43	EY10	2,300	94,100	88	GX8	2,300	197,600
44	EX10	2,300	96,400	89	GX8	2,300	199,900
45	FY10	2,300	98,700	90	EY9	2,300	202,200

* DUMP36 CUMMULATIVE TOTAL WAS CHANGED TO REFLECT THE ACTUAL TOTAL FROM DAILY REPORT FROM 3/14/99 AS PER CORPS INSTRUCTION, ALSO INDIVIDUAL SCOW YARDAGE WAS CHANGED TO REFLECT MORE ACTUAL CONDITIONS.

4,000 yds SCOW DUMP PLAN

REVISED: 23-Mar-99

Load #	Cell #	Volume Cy/Load	Cumulative Volume	Load #	Cell #	Volume Cy/Load	Cumulative Volume
91	EX9	2,300	193,000	136	JX10	2,300	296,500
92	FY9	2,300	195,300	137	JX10	2,300	298,800
93	FY9	2,300	197,600	138	KY10	2,300	301,100
94	FX9	2,300	199,900	139	KY10	2,300	303,400
95	FX9	2,300	202,200	140	KX10	2,300	305,700
96	GY9	2,300	204,500	141	HY11	2,300	308,000
97	GY9	2,300	206,800	142	HX11	2,300	310,300
98	GX9	2,300	209,100	143	HX11	2,300	312,600
99	GX9	2,300	211,400	144	IY11	2,300	314,900
100	EY10	2,300	213,700	145	IY11	2,300	317,200
101	EX10	2,300	216,000	146	IX11	2,300	319,500
102	FY10	2,300	218,300	147	IX11	2,300	321,800
103	FX10	2,300	220,600	148	JY11	2,300	324,100
104	GY10	2,300	222,900	149	JY11	2,300	326,400
105	GY10	2,300	225,200	150	JX11	2,300	328,700
106	GX10	2,300	227,500	151	JX11	2,300	331,000
107	GX10	2,300	229,800	152	KY11	2,300	333,300
108	EY11	2,300	232,100	153	KY11	2,300	335,600
109	EX11	2,300	234,400	154	KX11	2,300	337,900
110	FY11	2,300	236,700	155	KX11	2,300	340,200
111	FX11	2,300	239,000	156		2,300	342,500
112	GY11	2,300	241,300	157		2,300	344,800
113	GX11	2,300	243,600	158		2,300	347,100
114	GX11	2,300	245,900	159		2,300	349,400
115	HY9	2,300	248,200	160		2,300	351,700
116	HX9	2,300	250,500	161		2,300	354,000
117	HX9	2,300	252,800	162		2,300	356,300
118	IY9	2,300	255,100	163		2,300	358,600
119	IY9	2,300	257,400	164		2,300	360,900
120	IX9	2,300	259,700	165		2,300	363,200
121	IX9	2,300	262,000	166		2,300	365,500
122	JY9	2,300	264,300	167		2,300	367,800
123	JY9	2,300	266,600	168		2,300	370,100
124	JX9	2,300	268,900	169		2,300	372,400
125	KY9	2,300	271,200	170		2,300	374,700
126	KX9	2,300	273,500	171		2,300	377,000
127	HY10	2,300	275,800	172		2,300	379,300
128	HX10	2,300	278,100	173		2,300	381,600
129	HX10	2,300	280,400	174		2,300	383,900
130	IY10	2,300	282,700	175		2,300	386,200
131	IY10	2,300	285,000	176		2,300	388,500
132	IX10	2,300	287,300	177		2,300	390,800
133	IX10	2,300	289,600	178		2,300	393,100
134	JY10	2,300	291,900	179		2,300	395,400
135	JY10	2,300	294,200	180		2,300	397,700

REVISED: **23-Mar-99**

Load #	Cell #	Volume Cy/Load	Cumulative Volume
405	CX7	1,850	623,438
406	DY7	1,850	625,288
407	DX7	1,850	627,138
408	BY8	1,850	628,988
409	CY8	1,850	630,838
410	CX8	1,850	632,688
411	BY9	1,850	634,538
412	BY9	1,850	636,388
413	BX9	1,850	638,238
414	CY9	1,850	640,088
415	CX9	1,850	641,938
416	DY9	1,850	643,788
417	DX9	1,850	645,638
418	BY10	1,850	647,488
419	SKIP	0	647,488
420	SKIP	0	647,488
421	BY12	1,850	649,338
422	EX12	1,850	651,188
423	FY12	1,850	653,038
424	FY12	1,850	654,888
425	FX12	1,850	656,738
426	FX12	1,850	658,588
427	GY12	1,850	660,438
428	GY12	1,850	662,288
429	GX12	1,850	664,138
430	GX12	1,850	665,988
431	EX13	1,850	667,838
432	FY13	1,850	669,688
433	FX13	1,850	671,538
434	GY13	1,850	673,388
435	GY13	1,850	675,238
436	GX13	1,850	677,088
437	GX13	1,850	678,938
438	EX14	1,850	680,788
439	FY14	1,850	682,638
440	FX14	1,850	684,488
441	GY14	1,850	686,338
442	GY14	1,850	688,188
443	GX14	1,850	690,038
444	GX14	1,850	691,888
445	EX15	1,850	693,738
446	FY15	1,850	695,588
447	FX15	1,850	697,438
448	GY15	1,850	699,288
449	GX15	1,850	701,138
450	GX15	1,850	702,988
451	EX16	1,850	704,838
452	FY16	1,850	706,688
453	FX16	1,850	708,538
454	GY16	1,850	710,388
455	GX16	1,850	712,238
456	GX16	1,850	714,088
457	HY6	1,850	715,938
458	HX6	1,850	717,788
459	IY6	1,850	719,638
460	IX6	1,850	721,488
461	JY6	1,850	723,338
462	JX6	1,850	725,188
463	KY6	1,850	727,038
464	KX6	1,850	728,888
465	HY7	1,850	730,738
466	HY7	1,850	732,588
467	HX7	1,850	734,438
468	HX7	1,850	736,288
469	IY7	1,850	738,138
470	IY7	1,850	739,988
471	IX7	1,850	741,838
472	IX7	1,850	743,688
473	JY7	1,850	745,538
474	JY7	1,850	747,388
475	JX7	1,850	749,238
476	JX7	1,850	751,088
477	KY7	1,850	752,938
478	KX7	1,850	754,788
479	HY8	1,850	756,638
480	HY8	1,850	758,488
481	HX8	1,850	760,338
482	HX8	1,850	762,188
483	IY8	1,850	764,038
484	IY8	1,850	765,888
485	IX8	1,850	767,738
486	IX8	1,850	769,588
487	IX8	1,850	771,438
488	JY8	1,850	773,288
489	JY8	1,850	775,138
490	JX8	1,850	776,988
491	JX8	1,850	778,838
492	KY8	1,850	780,688
493	KY8	1,850	782,538
494	KX8	1,850	784,388

REVISED: 23-Mar-99

Load #	Cell #	Volume Cy/Load	Cumulative Volume	Load #	Cell #	Volume Cy/Load	Cumulative Volume
495	KX8+	1,850	775,138	540		1,850	858,388
496		1,850	776,988	541		1,850	860,238
497		1,850	778,838	542		1,850	862,088
498		1,850	780,688	543		1,850	863,938
499		1,850	782,538	544		1,850	865,788
500		1,850	784,388	545		1,850	867,638
501		1,850	786,238	546		1,850	869,488
502		1,850	788,088	547		1,850	871,338
503		1,850	789,938	548		1,850	873,188
504		1,850	791,788	549		1,850	875,038
505		1,850	793,638	550		1,850	876,888
506		1,850	795,488	551		1,850	878,738
507		1,850	797,338	552		1,850	880,588
508		1,850	799,188	553		1,850	882,438
509		1,850	801,038	554		1,850	884,288
510		1,850	802,888	555		1,850	886,138
511		1,850	804,738	556		1,850	887,988
512		1,850	806,588	557		1,850	889,838
513		1,850	808,438	558		1,850	891,688
514		1,850	810,288	559		1,850	893,538
515		1,850	812,138	560		1,850	895,388
516		1,850	813,988	561		1,850	897,238
517		1,850	815,838	562		1,850	899,088
518		1,850	817,688	563		1,850	900,938
519		1,850	819,538	564		1,850	902,788
520		1,850	821,388	565		1,850	904,638
521		1,850	823,238	566		1,850	906,488
522		1,850	825,088	567		1,850	908,338
523		1,850	826,938	568		1,850	910,188
524		1,850	828,788	569		1,850	912,038
525		1,850	830,638	570		1,850	913,888
526		1,850	832,488	571		1,850	915,738
527		1,850	834,338	572		1,850	917,588
528		1,850	836,188	573		1,850	919,438
529		1,850	838,038	574		1,850	921,288
530		1,850	839,888	575		1,850	923,138
531		1,850	841,738	576		1,850	924,988
532		1,850	843,588	577		1,850	926,838
533		1,850	845,438	578		1,850	928,688
534		1,850	847,288	579		1,850	930,538
535		1,850	849,138	580		1,850	932,388
536		1,850	850,988	581		1,850	934,238
537		1,850	852,838	582		1,850	936,088
538		1,850	854,688	583		1,850	937,938
539		1,850	856,538	584		1,850	939,788

APPENDIX E

1998/1999 PLACEMENT MONITORING

SCOW PLACEMENT DATA

Table 3 Scow drop locations and estimated quantity of material placed daily.

Date	Load#	Scow#	Est.Scow Quant./cy	Location MD Grid		Location in Drop Zone
				X	Y	
12/23/98	1	250	1100	1518469	582895	Gx2
12/24/98	2	139	1100	1518525	582995	Gy2
12/25/98		NO ACTIVITY				
12/26/98	3	250	820	1518647	582906	Fx2
12/26/98	4	250	1200	1518747	582929	Fy2
12/26/98	5	139	1500	1518801	582829	Fy2
12/27/98	6	139	1500	1519018	582953	Dx2
12/27/98	7	139	1420	1519054	583021	Dx2
12/27/98	8	251	1420	1519123	582954	Dy2
12/28/98	9	139	1550	1519122	582929	Dy2
12/28/98	10	251	1500	1519052	582750	Dx3
12/28/98	11	139	1550	1519049	582776	Dx3
12/29/98	12	251	1200	1519146	582728	Dy3
12/29/98	13	139	1250	1519158	582746	Dy3
12/29/98	14	251	1200	1519209	582921	Cx2
12/29/98	15	139	1150	1519237	582891	Cx2
12/30/98	16	251	1500	1519340	582966	Cy2
12/30/98	17	139	1450	1519369	582948	Cy2
12/31/98	18	251	1350	1519193	582795	Cx3
12/31/98	19	139	1400	1519242	582710	Cx3
1/1/99		NO ACTIVITY				
1/2/99		NO ACTIVITY				
1/3/99		NO ACTIVITY				
1/4/99		NO ACTIVITY				
1/5/99		NO ACTIVITY				
1/6/99	20	251	1400	1519348	582833	Cy3
1/7/99	21	139	1400	1519303	582755	Cy3
1/7/99	22	251	1500	1519459	582762	Bx3
1/7/99	23	139	1500	1519422	582761	Bx3
1/7/99	24	251	1500	1519440	582735	Bx3
1/7/99	25	139	1500	1519508	582725	By3
1/8/99	26	251	1450	1519550	582761	By3
1/8/99	27	139	1450	1519526	582773	By3
1/8/99	28	251	1450	1519512	582737	By3
1/8/99	29	139	1450	1519447	582521	Bx4
1/8/99	30	251	1450	1519464	582592	Bx4
1/9/99	31	139	1465	1519456	582559	Bx4
1/9/99	32	251	1624	1519439	582499	Bx4
1/9/99	33	139	1624	1519442	582512	Bx4
1/9/99	34	251	1624	1519585	582513	By4
1/9/99	35	139	1624	1519556	582537	By4
1/10/99	36	251	1503	1519548	582476	By4
1/10/99	37	139	1381	1519557	582518	By4
1/10/99	38	251	1381	1519519	582549	By4
1/10/99	39	139	1381	1519450	582269	Bx5
1/10/99	40	251	1381	1519421	582293	Bx5
1/11/99	41	139	1418	1519402	582293	Bx5

Date	Load#	Scow#	Est.Scow Quant./cy	Location MD Grid		Location in Drop Zone
				X	Y	
1/11/99	42	251	1417	1519355	582244	Bx5
1/11/99	43	139	1417	1519445	582275	Bx5
1/11/99	44	251	1417	1519563	582300	By5
1/11/99	45	139	1417	1519525	582282	By5
1/11/99	46	251	1418	1519525	582225	By5
1/12/99	47	139	1200	1519519	582351	By5
1/12/99	48	251	1300	1519451	582348	By5
1/12/99	49	139	1300	1519414	592175	Bx6
1/12/99	50	251	1350	1519428	582111	Bx6
1/12/99	51	139	1300	1519418	582123	Bx6
1/13/99	52	251	1150	1519422	582159	Bx6
1/13/99	53	139	1150	1519437	582153	Bx6
1/13/99	54	251	1150	1519545	582186	By6
1/13/99	55	139	1150	1519526	582189	By6
1/14/99	56	251	1330	1519480	582075	By6
1/14/99	57	139	1330	1519112	582112	By6
1/14/99	58	251	1330	1519479	582166	By6
1/14/99	59	139	1330	1519418	582203	Bx6
1/14/99	60	251	1330	1519390	582204	Bx6
1/15/99	61	139	1200	1519399	582123	Bx6
1/15/99	62	251	1150	1519399	582111	Bx6
1/15/99	63	139	1200	1519399	582111	Bx6
1/16/99	64	241	1350	1519503	582166	By6
1/16/99	65	139	1400	1519541	582094	By6
1/16/99	66	251	1400	1519512	582111	By6
1/16/99	67	139	1350	1519518	582063	By6
1/16/99	68	251	1450	1519433	581917	Bx7
1/17/99	69	139	1278	1519410	581982	Bx7
1/17/99	70	251	1278	1519391	581953	Bx7
1/17/99	71	139	1278	1519401	581947	Bx7
1/17/99	72	251	1278	1519500	581947	By7
1/17/99	73	139	1278	1519504	581941	By7
1/17/99	74	251	1278	1519538	581923	By7
1/17/99	75	139	1278	1519481	581941	By7
1/18/99	76	251	1600	1519387	581725	Bx8
1/18/99	77	139	1600	1519398	581673	Bx8
1/18/99	78	251	1600	1519525	581778	By8
1/18/99	79	139	1600	1519478	581745	By8
1/18/99	80	251	1600	1518942	582659	Ey3
1/18/99	81	139	1600	1518913	582639	Ey3
1/18/99	82	251	1600	1518863	582669	Ex3
1/18/99	83	139	1600	1518860	582689	Ex3
1/19/99	84	251	1800	1518720	582688	Fy3
1/19/99	85	139	1800	1518766	582779	Fy3
1/19/99	86	251	1800	1518601	582729	Fx3
1/19/99	87	139	1800	1518540	582729	Gy3

Date	Load#	Scow#	Est.Scow Quant./cy	Location	MD Grid	Location in Drop Zone
				X	Y	
1/19/99	88	251	1800	1518530	582776	Gy3
1/19/99	89	139	1800	1518408	582758	Gx3
1/19/99	90	251	1800	1518366	582727	Hy3
1/20/99	91	139	1400	1518257	582769	Hx3
1/20/99	92	251	1300	1518275	582800	Hx3
1/20/99	93	139	1350	1519298	582546	Cy4
1/20/99	94	251	1300	1519348	582553	Cy4
1/21/99		NO ACTIVITY				
1/22/99	95	139	1400	1519287	582522	Cy4
1/22/99	96	251	1450	1519361	582523	Cy4
1/23/99	97	139	1400	1519230	582564	Cx4
1/23/99	98	251	1450	1519240	582504	Cx4
1/23/99	99	139	1500	1519235	582565	Cx4
1/23/99	100	251	1500	1519223	582535	Cx4
1/23/99	101	139	1500	1519092	582549	Dy4
1/23/99	102	251	1500	1519098	582551	Dy4
1/24/99	103	139	1450	1519099	582509	Dy4
1/24/99	104	251	1450	1519132	582502	Dy4
1/25/99	105	139	1600	1519027	582581	Dx4
1/25/99	106	251	1650	1519060	582575	Dx4
1/25/99	107	139	1600	1519041	582579	Dx4
1/25/99	108	251	1650	1519053	582500	Dx4
1/25/99	109	139	1600	1518900	582604	Ey4
1/25/99	110	251	1650	1518892	582577	Ey4
1/25/99	111	139	1600	1518905	582509	Ey4
1/25/99	112	251	1650	1518811	582531	Ex4
1/26/99	113	139	1500	1518835	582492	Ex4
1/26/99	114	251	1350	1518820	582561	Ex4
1/26/99	115	139	1350	1518730	582524	Fy4
1/26/99	116	251	1350	1518726	582584	Fy4
1/26/99	117	139	1350	1518763	582589	Fy4
1/26/99	118	251	1350	1518656	582541	Fx4
1/27/99	119	139	1500	1518621	582525	Fx4
1/27/99	120	251	1500	1518555	582529	Gy4
1/27/99	121	139	1500	1518491	582546	Gy4
1/27/99	122	251	1500	1518418	582625	Gx4
1/27/99	123	139	1500	1518412	582595	Gx4
1/27/99	124	251	1500	1518310	582630	Hy4
1/27/99	125	139	1500	1518344	582588	Hy4
1/28/99	126	251	1600	1518192	582581	Hx4
1/29/99	127	139	1200	1518225	582578	Hx4
1/29/99	128	251	1200	1518148	582579	Iy4
1/29/99	129	251	1200	1518022	582534	Ix4
1/29/99	130	139	1200	1517957	582536	Jy4
1/29/99	131	251	1600	1519261	582237	Cy5
1/30/99	132	139	1600	1519336	582371	Cy5
1/30/99	133	251	1600	1519304	582268	Cy5
1/30/99	134	139	1600	1519312	582377	Cy5

Date	Load#	Scow#	Est.Scow Quant./cy	Location MD Grid		Location in Drop Zone
				X	Y	
1/30/99	135	251	1600	1519288	582285	Cy5
1/30/99	136	139	1600	1519228	582316	Cx5
1/30/99	137	251	1600	1519202	582340	Cx5
1/30/99	138	139	1600	1519204	582321	Cx5
1/31/99	139	251	1600	1519209	582315	Cx5
1/31/99	140	139	1600	1519237	582370	Cx5
1/31/99	141	251	1600	1519166	582327	Dy5
1/31/99	142	139	1600	1519142	582363	Dy5
2/1/99		NO ACTIVITY				
2/2/99		NO ACTIVITY				
2/3/99		NO ACTIVITY				
2/4/99		NO ACTIVITY				
2/5/99		NO ACTIVITY				
2/6/99		NO ACTIVITY				
2/7/99	142A	251	1600	1519100	582314	Dy5
2/7/99	143	139	1600	1519100	582364	Dy5
2/7/99	144	251	1600	1519081	582383	Dy5
2/7/99	145	139	1600	1519034	582369	Dx5
2/8/99	146	251	1600	1519019	582390	Dx5
2/8/99	147	139	1600	1519029	582363	Dx5
2/8/99	148	251	1600	1519024	582338	Dx5
2/8/99	149	139	1700	1518907	582319	Ey5
2/8/99	150	251	1700	1518961	582386	Ey5
2/8/99	151	139	1700	1518925	582350	Ey5
2/8/99	152	251	1700	1518959	582319	Ey5
2/9/99	153	139	1825	1518803	582343	Ex5
2/9/99	154	251	1825	1518845	582331	Ex5
2/9/99	155	139	1825	1518845	582337	Ex5
2/9/99	156	251	1825	1518708	582360	Fy5
2/9/99	157	139	1825	1518751	582366	Fy5
2/9/99	158	251	1825	1518718	582318	Fy5
2/9/99	159	139	1825	1518604	582377	Fx5
2/10/99	160	251	1800	1518628	582353	Fx5
2/10/99	161	260	1800	1518581	582332	Fx5
2/10/99	162	139	1800	1518529	582298	Gy5
2/10/99	163	260	1800	1518524	582383	Gy5
2/10/99	164	139	1800	1518421	582333	Gx5
2/10/99	165	260	1800	1518415	582406	Gx5
2/10/99	166	139	1800	1518275	582278	Hy5
2/10/99	167	260	1800	1518344	582423	Hy5
2/11/99	168	139	1800	1518264	582410	Hx5
2/11/99	169	260	1800	1518231	582368	Hx5
2/11/99	170	139	1800	1518133	582376	Iy5
2/11/99	171	260	1800	1518022	582391	Ix5
2/11/99	172	139	1800	1517939	582378	Jy5
2/11/99	173	260	1800	1517873	582356	Jx5
2/11/99	174	139	1800	1519322	582146	Cy6

Date	Load#	Scow#	Est.Scow Quant./cy	Location MD Grid		Location in Drop Zone
				X	Y	
2/12/99	175	260	1800	1519314	582122	Cy6
2/12/99	176	139	1800	1519300	582150	Cy6
2/12/99	177	260	1800	1519338	582135	Cy6
2/13/99	178	139	1700	1519192	582097	Cx6
2/13/99	179	139	1700	1519234	582136	Cx6
2/13/99	180	260	1700	1519182	582075	Cx6
2/14/99	181	139	1700	1519196	582170	Cx6
2/14/99	182	260	1700	1519130	582169	Dy6
2/14/99	183	139	1700	1519119	582128	Dy6
2/14/99	184	260	1700	1519107	582120	Dy6
2/14/99	185	139	1700	1519158	582133	Dy6
2/14/99	186	260	1700	1519002	582180	Dx6
2/15/99	187	261	1800	1518970	582095	Dx6
2/15/99	188	260	1800	1519040	582168	Dx6
2/15/99	189	261	1800	1519012	582095	Dx6
2/15/99	190	260	1800	1519273	581927	Cy7
2/15/99	191	261	1800	1519297	581964	Cy7
2/15/99	192	260	1800	1519316	581910	Cy7
2/15/99	193	261	1800	1519292	581920	Cy7
2/16/99	194	260	1400	1519170	581898	Cx7
2/16/99	195	261	1400	1519188	581913	Cx7
2/16/99	196	260	1400	1519198	581897	Cx7
2/16/99	197	261	1400	1519080	581889	Dy7
2/16/99	198	260	1400	1519059	582026	Dx7
2/16/99	199	261	1400	1519150	581933	Dy7
2/16/99	200	260	1400	1519009	581931	Dx7
2/16/99	201	261	1400	1519056	581956	Dx7
2/17/99	202	260	1800	1518957	581925	Dx7
2/17/99	203	261	1800	1519317	581758	Cy8
2/17/99	204	260	1800	1519341	581752	Cy8
2/17/99	205	261	1800	1519287	581764	Cy8
2/17/99	206	260	1800	1519246	581739	Cx8
2/17/99	207	261	1800	1519294	581775	Cx8
2/17/99	208	260	1800	1519242	581721	Cx8
2/17/99	209	261	1800	1519100	581741	Dy8
2/18/99	210	260	1500	1519133	581742	Dy8
2/18/99	211	261	1500	1519115	581714	Dy8
2/18/99	212	260	1500	1519010	581792	Dx8
2/18/99	213	261	1500	1519001	581737	Dx8
2/18/99	214	260	1500	1519006	581713	Dx8
2/18/99	215	261	1500	1519286	581509	Cy9
2/18/99	216	260	1500	1519282	581466	Cy9
2/18/99	217	261	1500	1519165	581532	Cx9
2/19/99	218	260	1500	1519234	581539	Cx9
2/19/99	219	261	1500	1519050	581507	Dy9
2/19/99	220	260	1500	1519083	581507	Dy9
2/19/99	221	261	1500	1519064	581495	Dy9

Date	Load#	Scow#	Est.Scow Quant./cy	Location MD Grid		Location in Drop Zone
				X	Y	
2/19/99	222	260	1500	1518994	581488	Dx9
2/20/99	223	261	1500	1518989	581500	Dx9
2/20/99	224	260	1500	1518980	581478	Dx9
2/20/99	225	261	1500	1519504	581310	By10
2/20/99	226	260	1500	1519373	581260	Bx10
2/20/99	227	261	1500	1519250	581308	Cy10
2/20/99	228	260	1500	1519207	581344	Cx10
2/21/99	229	261	1500	1519189	581314	Cx10
2/21/99	230	260	1500	1519103	581343	Dy10
2/21/99	231	261	1500	1519117	581380	Dy10
2/21/99	232	260	1500	1519005	581306	Dx10
2/21/99	233	261	1500	1519000	581300	Dx10
2/21/99	234	260	1500	1518981	581324	Dx10
2/22/99	235	261	1800	1519218	581910	Cx2
2/22/99	236	260	1800	1519220	582983	Cx2
2/23/99	237	261	1800	1519184	582929	Cx2
2/23/99	238	260	1800	1519115	582867	Dy2
2/23/99	239	261	1800	1519180	582934	Dy2
2/23/99	240	260	1800	1519095	582975	Dx2
2/23/99	241	261	1800	1518987	582866	Ey2
2/23/99	242	260	1800	1518816	582877	Ex2
2/23/99	243	261	1800	1518845	582944	Ex2
2/23/99	244	260	1800	1518751	582913	Fy2
2/24/99	245	261	1800	1518614	582960	Fx2
2/24/99	246	260	1800	1519496	582700	By3
2/24/99	247	261	1800	1519543	582786	By3
2/24/99	248	260	1800	1519512	582804	By3
2/24/99	249	261	1800	1519403	582784	Bx3
2/24/99	250	260	1800	1519400	582663	Bx3
2/24/99	251	261	1800	1519305	582705	Cy3
2/24/99	252	260	1800	1519333	582717	Cy3
2/25/99	253	261	1400	1519224	582765	Cx3
2/25/99	254	260	1400	1519234	582728	Cx3
2/25/99	255	261	1400	1519139	582794	Dy3
2/25/99	256	260	1400	1519167	582807	Dy3
2/25/99	257	261	1400	1519048	582788	Dx3
2/25/99	258	260	1400	1519054	582712	Dx3
2/25/99	259	261	1400	1518927	582781	Ey3
2/26/99	260	260	1677	1518856	582762	Ex3
2/26/99	261	261	1677	1518540	582711	Gy3
2/26/99	262	260	1677	1519533	582518	By4
2/26/99	263	261	1677	1519473	582510	Bx4
2/26/99	264	260	1677	1519570	582519	By4
2/26/99	265	261	1677	1519410	582523	Bx4
2/27/99		NO ACTIVITY				
2/28/99		NO ACTIVITY				
3/1/99		NO ACTIVITY				

Date	Load#	Scow#	Est.Scow Quant./cy	Location MD Grid		Location in Drop Zone
				X	Y	
3/2/99	266	260	1000	1519405	582590	Bx4
3/3/99	267	260	1700	1519381	582578	Cy4
3/3/99	268	261	1700	1519325	582577	Cy4
3/3/99	269	260	1700	1519245	582534	Cx4
3/3/99	270	261	1700	1519117	582527	Dy4
3/3/99	271	260	1700	1519004	582575	Dx4
3/3/99	272	261	1700	1519023	582545	Dx4
3/4/99		NO ACTIVITY				
3/5/99	273	261	1500	1518934	582459	Ey4
3/5/99	274	260	1500	1518870	582537	Ex4
3/5/99	275	261	1500	1518716	582542	Fy4
3/5/99	276	260	1500	1518607	582590	Fx4
3/5/99	277	261	1500	1519498	581595	By9
3/5/99	278	260	1500	1519499	581431	By9
3/5/99	279	261	1500	1519409	581491	Bx9
3/5/99	280	260	1500	1519361	581546	Bx9
3/6/99	281	261	1500	1519448	581273	By10
3/6/99	282	260	1500	1519382	581279	Bx10
3/6/99	283	261	1500	1519373	581315	Bx10
3/6/99	284	260	1500	1519288	581320	Cy10
3/6/99	285	261	1500	1519250	581284	Cy10
3/6/99	286	260	1500	1519150	581356	Cx10
3/6/99	287	261	1500	1519179	581332	Cx10
3/6/99	288	260	1500	1519080	581307	Dy10
3/6/99	289	261	1500	1519090	581276	Dy10
3/6/99	290	260	1500	1519003	581376	Dx10
3/6/99	291	261	1500	1519115	581386	Dy10
3/6/99	292	260	1500	1519497	581152	By11
3/7/99		NO ACTIVITY				
3/8/99	293	260	1525	1519369	581163	Bx11
3/8/99	294	261	1525	1519275	581126	Cy11
3/8/99	295	260	1525	1519180	581156	Cx11
3/9/99	296	261	1700	1519110	581167	Dy11
3/9/99	297	260	1700	1518944	581172	Dx11
3/9/99	298	261	1700	1519097	580899	Dy12
3/9/99	299	260	1700	1518927	580911	Dx12
3/9/99	300	261	1700	1519070	580736	Dy13
3/9/99	301	260	1700	1518995	580723	Dx13
3/9/99	302	261	1700	1519039	580506	Dy14
3/9/99	303	260	1700	1519006	580554	Dx14
3/9/99	304	261	1700	1519088	580348	Dy15
3/9/99	305	260	1700	1518913	580365	Dx15
3/9/99	306	261	1700	1519042	580117	Dy16
3/9/99	307	260	1700	1518952	580164	Dx16
3/10/99	308	261	1800	1519529	582330	By5
3/10/99	309	260	1800	1519497	582300	By5
3/10/99	310	261	1800	1519511	582312	By5
3/10/99	311	260	1800	1519407	582305	Bx5

Date	Load#	Scow#	Est.Scow Quant./cy	Location MD Grid		Location in Drop Zone
				X	Y	
3/10/99	312	261	1800	1519421	582341	Bx5
3/10/99	313	260	1800	1519425	582378	Bx5
3/10/99	314	261	1800	1519299	582310	Cy5
3/10/99	315	260	1800	1519308	582341	Cy5
3/10/99	316	261	1800	1519209	582315	Cx5
3/10/99	317	260	1800	1519209	582309	Cx5
3/10/99	318	261	1800	1519123	582369	Dy5
3/10/99	319	260	1800	1519019	582429	Dx5
3/10/99	1	254	2300	1518865	582109	Ex6
3/10/99	2	255	2300	1518829	582100	Ex6
3/10/99	3	254	2300	1518741	582127	Fy6
3/10/99	4	255	2300	1518720	582217	Fy6
3/10/99	5	254	2300	1518587	582075	Fx6
3/10/99	6	255	2300	1518583	582060	Fx6
3/10/99	7	254	2300	1518471	582066	Gy6
3/10/99	8	255	2300	1518438	582065	Gx6
3/11/99	320	261	1700	1518939	582360	Ey5
3/11/99	321	260	1700	1518798	582385	Ex5
3/11/99	322	261	1700	1518699	582432	Fy5
3/11/99	323	260	1700	1518595	582341	Fx5
3/11/99	324	261	1700	1518500	582431	Gy5
3/11/99	325	260	1700	1518420	582430	Gx5
3/11/99	326	261	1700	1518321	582411	Hy5
3/11/99	327	260	1700	1518274	582381	Hx5
3/11/99	328	261	1700	1518173	582465	Iy4
3/11/99	329	260	1700	1518072	582392	Ix5
3/11/99	330	261	1700	1519517	582130	Bx5
3/11/99	331	260	1700	1519484	582184	Bx6
3/11/99	9	254	2550	1518453	582147	Gx6
3/11/99	10	255	2550	1518390	582148	Gx6
3/11/99	11	254	2550	1518926	582009	Ey7
3/11/99	12	255	2550	1518835	581983	Ex7
3/11/99	13	254	2550	1518809	581960	Ex7
3/12/99	14	255	2261	1518693	581875	Fy7
3/12/99	15	254	2261	1518699	581963	Fy7
3/12/99	16	255	2261	1518566	581962	Fx7
3/12/99	17	254	2261	1518614	581922	Fx7
3/12/99	18	255	2261	1518501	581980	Gy7
3/12/99	19	254	2261	1518479	581873	Gy7
3/12/99	20	255	2261	1518412	581917	Gx7
3/12/99	21	254	2261	1518416	581906	Gx7
3/12/99	22	255	2261	1518909	581663	Ey8
3/12/99	332	261	1477	1519423	582153	Bx6
3/12/99	333	260	1477	1519395	582171	Bx6
3/12/99	334	261	1477	1519340	582176	Cy6
3/12/99	335	260	1477	1519196	582194	Cx6
3/12/99	336	261	1477	1519135	582175	Dy6

Date	Load#	Scow#	Est.Scow Quant./cy	Location	MD Grid	Location in Drop Zone
				X	Y	
3/12/99	337	260	1477	1519001	582154	Dx6
3/12/99	338	261	1477	1519543	581970	By7
3/12/99	339	260	1477	1519519	581917	By7
3/12/99	340	261	1477	1519221	581951	Cx7
3/13/99	23	254	2200	1518802	581729	Ex8
3/13/99	24	254	2200	1518804	581691	Ex8
3/13/99	25	255	2200	1518702	581768	Fy8
3/13/99	26	254	2200	1518678	581646	Fy8
3/13/99	27	255	2200	1518581	581738	Fx8
3/13/99	28	254	2200	1518598	581733	Fx8
3/13/99	29	255	2200	1518494	581679	Gy8
3/13/99	341	260	1353	1519127	581993	Dy7
3/13/99	342	261	1353	1518990	581921	Dx7
3/13/99	343	260	1353	1519506	581747	By8
3/13/99	344	261	1353	1519496	581759	By8
3/13/99	345	260	1353	1519199	581793	Cx8
3/13/99	346	261	1353	1519058	581744	Dy8
3/13/99	347	260	1353	1519010	581719	Dx8
3/14/99	348	261	1291	1519001	581713	Dx8
3/14/99	349	260	1291	1519213	582983	Cx2
3/14/99	350	261	1291	1519275	582886	Cx2
3/14/99	351	260	1291	1519128	582916	Dy2
3/14/99	352	261	1291	1519052	582988	Dx2
3/14/99	353	260	1291	1518949	582939	Ey2
3/14/99	354	261	1291	1518840	582974	Ex2
3/14/99	355	260	1291	1518713	582997	Fy2
3/14/99	356	261	1291	1518642	582918	Fx2
3/14/99	30	254	2200	1518500	581724	Gy8
3/14/99	31	255	2200	1518384	581785	Gx8
3/14/99	32	254	2200	1518397	581698	Gx8
3/14/99	33	255	2200	1518876	581479	Ey9
3/14/99	34	254	2200	1518790	581511	Ex9
3/14/99	35	255	2200	1518647	581500	Fy9
3/15/99	357	260	1500	1518552	582911	Gy2
3/15/99	358	261	1500	1519531	582743	By3
3/15/99	36	254	2200	1518670	581531	Fy9
3/16/99	359	260	1500	1519581	582749	By3
3/16/99	360	261	1500	1519522	582664	By3
3/16/99	361	260	1500	1519380	582681	Cy3
3/16/99	362	261	1500	1519432	582730	Bx3
3/16/99	363	260	1500	1519336	582656	Cy3
3/16/99	364	261	1500	1519224	582716	Cx3
3/16/99	365	260	1500	1519149	582709	Dy3
3/16/99	366	261	1500	1519078	582745	Dx3
3/16/99	367	260	1500	1518941	582720	Ey3
3/16/99	368	261	1500	1518809	582677	Ex3
3/17/99	369	260	1400	1518719	582797	Fy3

Date	Load#	Scow#	Est.Scow Quant./cy	Location MD Grid X	Location MD Grid Y	Location in Drop Zone
3/17/99	370	261	1400	1518583	582717	Gy3
3/17/99	371	260	1400	1518531	582759	Gy3
3/17/99	372	261	1400	1519547	582555	By4
3/17/99	373	260	1400	1519490	582482	By4
3/17/99	374	261	1400	1519400	582516	Bx4
3/17/99	375	260	1400	1519330	582474	Cy4
3/17/99	376	261	1400	1519206	582619	Cx4
3/17/99	377	260	1400	1519141	582495	Dy4
3/17/99	378	261	1400	1519066	582490	Dx4
3/17/99	379	260	1400	1518944	582499	Ey4
3/18/99	380	261	1825	1518792	582615	Ex4
3/18/99	381	260	1825	1518698	582499	Fy4
3/18/99	382	261	1825	1518626	582548	Fx4
3/18/99	383	260	1825	1518574	582571	Gy4
3/18/99	384	261	1825	1519567	582285	By5
3/19/99	385	260	1600	1519407	582329	Bx5
3/19/99	386	261	1600	1519351	582256	Cy5
3/19/99	387	260	1600	1519227	582322	Cx5
3/19/99	388	261	1600	1519100	582327	Dy5
3/19/99	389	260	1600	1519025	582302	Dx5
3/19/99	390	261	1600	1518935	582380	Ey5
3/19/99	391	260	1600	1518831	582343	Ex5
3/19/99	392	261	1600	1518746	582409	Fy5
3/19/99	393	260	1600	1518652	582348	Fx5
3/19/99	394	261	1600	1518529	582316	Gy5
3/20/99	395	260	1900	1519479	582209	By6
3/20/99	396	261	1900	1519447	582044	Bx6
3/20/99	397	260	1900	1519338	582019	Cy6
3/20/99	398	261	1900	1519234	582136	Cx6
3/20/99	399	260	1900	1519144	582115	Dy6
3/20/99	400	261	1900	1519007	582150	Dx6
3/20/99	401	260	1900	1519509	581935	By7
3/20/99	402	261	1900	1519486	581911	By7
3/20/99	403	260	1900	1519436	581844	Bx7
3/20/99	404	261	1900	1519358	581995	Cy7
3/20/99	405	260	1900	1519164	581932	Cx7
3/20/99	37	254	2000	1518569	581497	Fx9
3/21/99	406	261	1900	1519103	581980	Dy7
3/21/99	407	260	1900	1519022	581901	Dx7
3/21/99	408	261	1900	1519501	581735	By8
3/21/99	409	260	1900	1519299	581685	Cy8
3/21/99	410	261	1900	1519162	581694	Cx8
3/21/99	411	260	1900	1519480	581431	By9
3/21/99	412	NO ACTIVITY				
3/21/99	413	260	1900	1519390	581485	Bx9
3/21/99	414	261	1900	1519267	581478	Cy9
3/21/99	415	260	1900	1519267	581478	Cx9

Date	Load#	Scow#	Est.Scow Quant./cy	Location MD Grid		Location in Drop Zone
				X	Y	
3/21/99	38	254	1300	1518559	581582	Fx9
3/21/99	39	139	1300	1518472	581514	Gy9
3/21/99	40	254	1300	1518469	581551	Gy9
3/22/99	41	139	1600	1518374	581604	Gx9
3/22/99	42	254	1600	1518399	581471	Gx9
3/22/99	43	261	1750	1518900	581360	Ey10
3/22/99	44	139	1600	1518759	581328	Ex10
3/22/99	45	260	1750	1518698	581298	Fy10
3/22/99	46	254	1600	1518593	581412	Fx10
3/22/99	47	261	1750	1518504	581399	Gy10
3/22/99	48	260	1750	1518466	581434	Gy10
3/22/99	49	139	1600	1518357	581434	Gx10
3/22/99	50	261	1750	1518381	581422	Gx10
3/22/99	416	261	1750	1519073	581537	Dy9
3/22/99	417	260	1750	1518970	581464	Dx9
3/22/99	418	261	1750	1519481	581298	By10
	419	NO ACTIVITY				
	420	NO ACTIVITY				
3/22/99	421	260	1750	1519432	580963	By12
3/23/99	51	255	2500	1518859	581159	Ey11
3/23/99	52	254	2500	1518756	581079	Ex11
3/23/99	53	261	1825	1518671	581127	Fy11
3/23/99	54	260	1825	1518581	581163	Fx11
3/23/99	55	255	2300	1518478	581161	Gy11
3/23/99	56	254	2400	1518411	581143	Gx11
3/23/99	57	261	1800	1518397	581113	Gx11
3/23/99	58	260	1800	1518913	582173	Ey6
3/23/99	59	255	2300	1518829	582115	Ex6
3/23/99	60	261	1800	1518710	582178	Fy6
3/23/99	61	254	2300	1518712	582144	Fy6
3/23/99	62	260	1800	1518579	582106	Fx6
3/23/99	63	255	2300	1518729	582148	Fy6
3/23/99	64	261	1800	1518474	582133	Gy6
3/24/99	65	260	1400	1518516	582170	Gy6
3/24/99	66	254	2500	1518422	582133	Gx6
3/24/99	67	261	1500	1518436	582182	Gx6
3/24/99	68	255	2500	1518905	581912	Ey7
3/24/99	69	260	1500	1518806	581948	Ex7
3/24/99	70	261	1500	1518796	581972	Ex7
3/24/99	71	254	2500	1518739	581966	Fy7
3/24/99	72	255	2500	1518721	581887	Fy7
3/24/99	73	260	1800	1518593	581992	Fx7
3/24/99	74	254	2500	1518588	581928	Fx7
3/24/99	75	261	1800	1518552	581885	Gy7
3/24/99	76	255	2500	1518519	581873	Gy7
3/24/99	422	260	1800	1518758	580949	Ex12
3/24/99	423	261	1800	1518635	580921	Fy12

Date	Load#	Scow#	Est.Scow Quant./cy	Location MD Grid		Location in Drop Zone
				X	Y	
3/24/99	424	260	1800	1518691	580970	Fy12
3/25/99	77	254	2500	1518400	581963	Gx7
3/25/99	78	255	2500	1518434	581913	Gx7
3/25/99	79	254	2500	1518939	581809	Ey8
3/25/99	80	255	2500	1518754	581674	Ex8
3/25/99	81	254	2500	1518770	581668	Ex8
3/25/99	82	255	2500	1518694	581735	Fy8
3/25/99	425	261	1800	1518573	580932	Fx12
3/25/99	426	260	1800	1518550	580956	Fx12
3/25/99	427	261	1800	1518497	580968	Gy12
3/25/99	428	260	1800	1518469	580992	Gy12
3/25/99	429	261	1800	1518389	580955	Gx12
3/25/99	430	260	1800	1518380	580943	Gx12
3/25/99	431	261	1800	1518768	580782	Ex13
3/25/99	432	260	1800	1518693	580703	Fy13
3/25/99	433	261	1800	1518565	580811	Fx13
3/25/99	434	260	1800	1518429	580731	Gy13
3/25/99	435	261	1800	1518478	580737	Gy13
3/26/99	436	260	1800	1518370	580750	Gx13
3/26/99	437	261	1800	1518372	580789	Gx13
3/26/99	438	261	1800	1518789	580497	Ex14
3/26/99	439	260	1800	1518656	580559	Fy14
3/26/99	440	261	1800	1518529	580519	Fx14
3/26/99	441	260	1800	1518483	580470	Gy14
3/26/99	442	261	1800	1518467	580610	Gy14
3/26/99	443	260	1800	1518364	580550	Gx14
3/26/99	444	261	1800	1518335	580609	Gx14
3/26/99	445	260	1800	1518774	580351	Ex15
3/26/99	83	254	3000	1518732	581692	Fy8
3/26/99	84	255	3000	1518627	581837	Fx8
3/26/99	85	254	3000	1518553	581703	Gy8
3/26/99	86	255	3000	1518501	581733	Gy8
3/26/99	87	NO ACTIVITY				
3/26/99	88	254	3000	1518392	581770	Gx8
3/26/99	89	NO ACTIVITY				
3/26/99	90	255	3000	1518881	581463	Ey9
3/26/99	91	NO ACTIVITY				
3/26/99	92	NO ACTIVITY				
3/26/99	93	254	3000	1518705	581589	Fy9
3/26/99	94	255	3000	1518568	581551	Fx9
3/26/99	95	NO ACTIVITY				
3/26/99	96	254	3000	1518460	581496	Gy9
3/27/99	446	260	1300	1518691	580338	Fy15
3/27/99	447	261	1300	1518559	580325	Fx15
3/27/99	448	260	1300	1518418	580348	Gy15
3/27/99	449	261	1300	1518365	580348	Gx15
3/27/99	450	260	1300	1518365	580427	Gx15

Date	Load#	Scow#	Est.Scow Quant./cy	Location MD Grid X	Y	Location in Drop Zone
3/27/99	451	261	1300	1518702	580168	Ex16
3/27/99	452	260	1300	1518457	580106	Gy16
3/27/99	453	261	1300	1518546	580149	Fx16
3/27/99	454	260	1300	1518395	580245	Gx16
3/27/99	455	261	1300	1518329	580141	Gx16
3/27/99	456	260	1300	1518320	580135	Gx16
3/27/99	97	NO ACTIVITY				
3/27/99	98	255	3100	1518417	581599	Gx9
3/27/99	99	NO ACTIVITY				
3/27/99	100	NO ACTIVITY				
3/27/99	101	254	3100	1518792	581268	Ex10
3/27/99	102	255	3100	1518712	581290	Fy10
3/27/99	103	254	3100	1518578	581290	Fx10
3/27/99	104	255	3100	1518480	581338	Gy10
3/27/99	105	NO ACTIVITY				
3/27/99	106	106	3100	1518418	581271	Gx10
3/27/99	107	NO ACTIVITY				
3/27/99	108	NO ACTIVITY				
3/27/99	109	NO ACTIVITY				
3/27/99	110	255	3100	1518686	581146	Fy11
3/27/99	111	254	3100	1518557	581114	Fx11
3/28/99	459	261	1900	1518125	582167	Iy6
3/28/99	460	260	1900	1518052	582233	Ix6
3/28/99	461	261	1900	1517884	582147	Jy6
3/28/99	462	260	1900	1517799	582178	Jx6
3/28/99	463	261	1900	1517719	582140	Ky6
3/28/99	464	260	1900	1517591	582151	Kx6
3/28/99	452	261	1900	1518670	580170	Fy16
3/28/99	457	260	1900	1518336	582248	Hy5
3/28/99	458	261	1900	1518247	582235	Hx6
3/28/99	464a	260	1900	1517572	582181	Kx6
3/28/99	465	261	1900	1518291	581992	Hy7
3/28/99	112	255	3200	1518487	581226	Gy11
3/28/99	113	254	3200	1518383	581133	Gx11
3/28/99	114	NO ACTIVITY				
3/28/99	115	255	3200	1518300	581519	Hy9
3/28/99	116	254	3200	1518201	581518	Hx9
3/28/99	117	255	3200	1518218	581500	Hx9
3/28/99	118	254	3200	1518089	581528	Iy9
3/28/99	119	255	3200	1518082	581572	Iy9
3/28/99	120	254	3200	1517983	581498	Ix9
3/29/99	466	260	1300	1518286	581917	Hy7
3/29/99	467	261	1300	1518174	581931	Hx7
3/29/99	468	260	1300	1518182	581922	Hx7
3/29/99	469	261	1300	1518103	581912	Iy7
3/29/99	470	260	1300	1518083	581999	Iy7
3/29/99	471	261	1300	1518023	581911	Ix7

Date	Load#	Scow#	Est.Scow Quant./cy	Location MD Grid		Location in Drop Zone
				X	Y	
3/29/99	472	260	1300	1518032	581960	Ix7
3/29/99	473	261	1300	1517947	582002	Jy7
3/29/99	474	260	1300	1517895	581977	Jy7
3/29/99	475	261	1300	1517819	581958	Jx7
3/29/99	476	260	1300	1517786	581970	Jx7
3/29/99	477	261	1300	1517683	581963	Ky7
3/29/99	121	255	2400	1517959	581552	Ix9
3/29/99	122	254	2400	1517870	581534	Jy9
3/29/99	123	255	2400	1517921	581558	Jy9
3/29/99	124	254	2400	1517788	581677	Jx9
3/29/99	125	255	2400	1517718	581484	Ky9
3/29/99	126	254	2400	1517606	581513	Kx9
3/29/99	127	255	2400	1518291	581355	Hy10
3/29/99	128	254	2400	1518164	581305	Hx10
3/30/99	478	260	1200	1517607	582017	Kx7
3/30/99	479	261	1200	1518255	581816	Hy8
3/30/99	480	260	1200	1518279	581780	Hy8
3/30/99	481	261	1200	1518222	581773	Hx8
3/30/99	482	260	1200	1518166	581743	Hx8
3/30/99	483	261	1200	1518085	581760	Iy8
3/30/99	484	260	1200	1518090	581766	Iy8
3/30/99	485	260	1200	1517962	581802	Ix8
3/30/99	486	261	1200	1517962	581814	Ix8
3/30/99	487	260	1200	1517977	581753	Ix8
3/30/99	488	261	1200	1517896	581777	Jy8
3/30/99	489	260	1200	1517873	581795	Jy8
3/30/99	490	260	1200	1517807	581806	Jx8
3/30/99	491	261	1200	1517760	581764	Jx8
3/30/99	492	260	1200	1517680	581739	Ky8
3/30/99	129	255	3000	1518230	581379	Hx10
3/30/99	130	254	3000	1518057	581321	Iy10
3/30/99	131	255	3000	1518098	581317	Iy10
3/30/99	132	254	3000	1518003	581316	Ix10
3/30/99	133	255	3000	1517980	581371	Ix10
3/30/99	134	254	3000	1517871	581376	Jy10
3/30/99	135	255	3000	1517866	581370	Jy10
3/31/99	493	261	1500	1517698	581769	Ky8
3/31/99	494	260	1500	1517585	581786	Kx8
3/31/99	495	361	1500	1517599	581811	Kx8
3/31/99	136	254	2000	1517772	581436	Jx10
3/31/99	137	255	2000	1517767	581387	Jx10
3/31/99	138	260	1500	1517664	581338	Ky10
3/31/99	139	255	2000	1517690	581349	Ky10
3/31/99	140	261	1500	1517565	581337	Kx10
3/31/99	141	255	2000	1518293	581137	Hy11
3/31/99	142	260	1500	1518151	581184	Hx11
3/31/99	143	261	1500	1518147	581129	Hx11

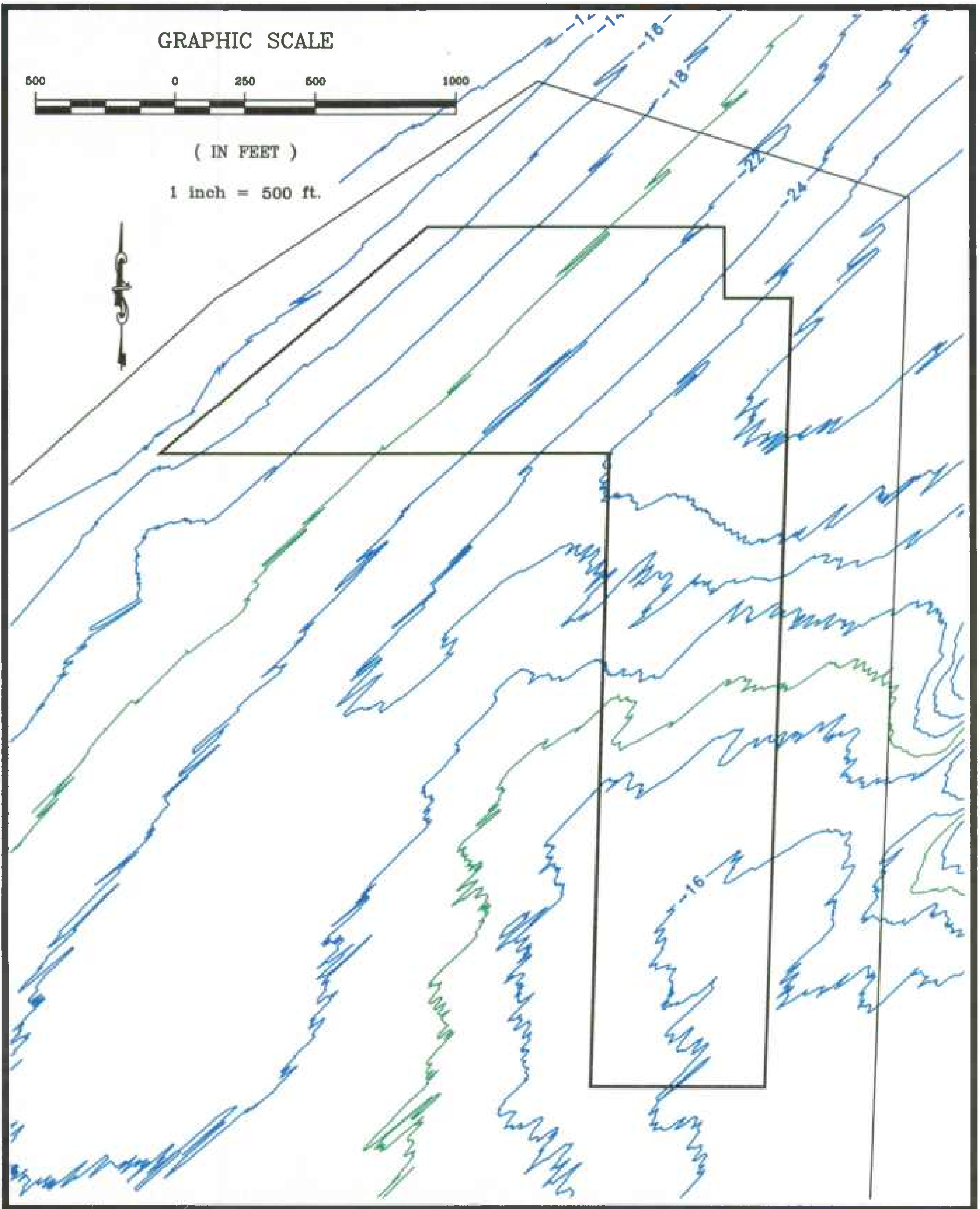
Date	Load#	Scow#	Est.Scow Quant./cy	Location MD Grid X	Location MD Grid Y	Location in Drop Zone
3/31/99	144	254	2000	1518042	581238	Iy11
3/31/99	145	260	1500	1518066	581171	Iy11
3/31/99	146	261	1500	1517962	581207	Ix11
3/31/99	147	260	1500	1517991	581189	Ix11
3/31/99	148	255	2000	1517864	581145	Jy11
3/31/99	149	261	1500	1517826	581145	Jx11
3/31/99	150	260	1500	1517760	581173	Jx11
	Total:	645	1090367			

Site 92 Scow Placement Totals	
CY Berm Construction	657068
CY Placed inside of Berm	433299
Total CY	1090367

APPENDIX F

1998/1999 PLACEMENT MONITORING

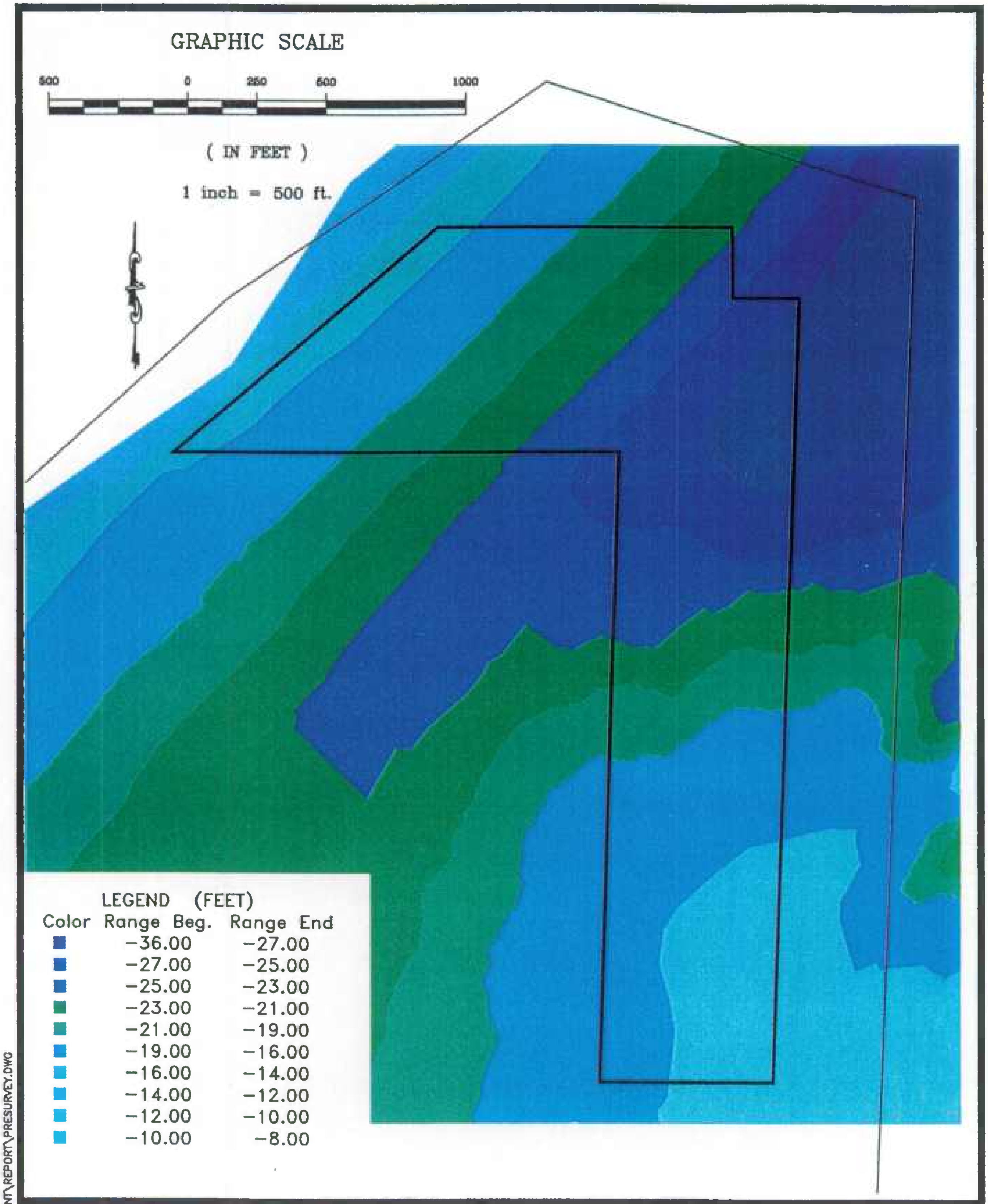
CONDITION SURVEYS



MARYLAND
ENVIRONMENTAL
SERVICE

SITE 92 BATHYMETRY
PRE-PLACEMENT CENAP SURVEY
PERFORMED: DEC 9-12, 1998
FIGURE F-1

J:\SITE92\9899PLACEMENT\REPORT\PRESURVEY.DWG



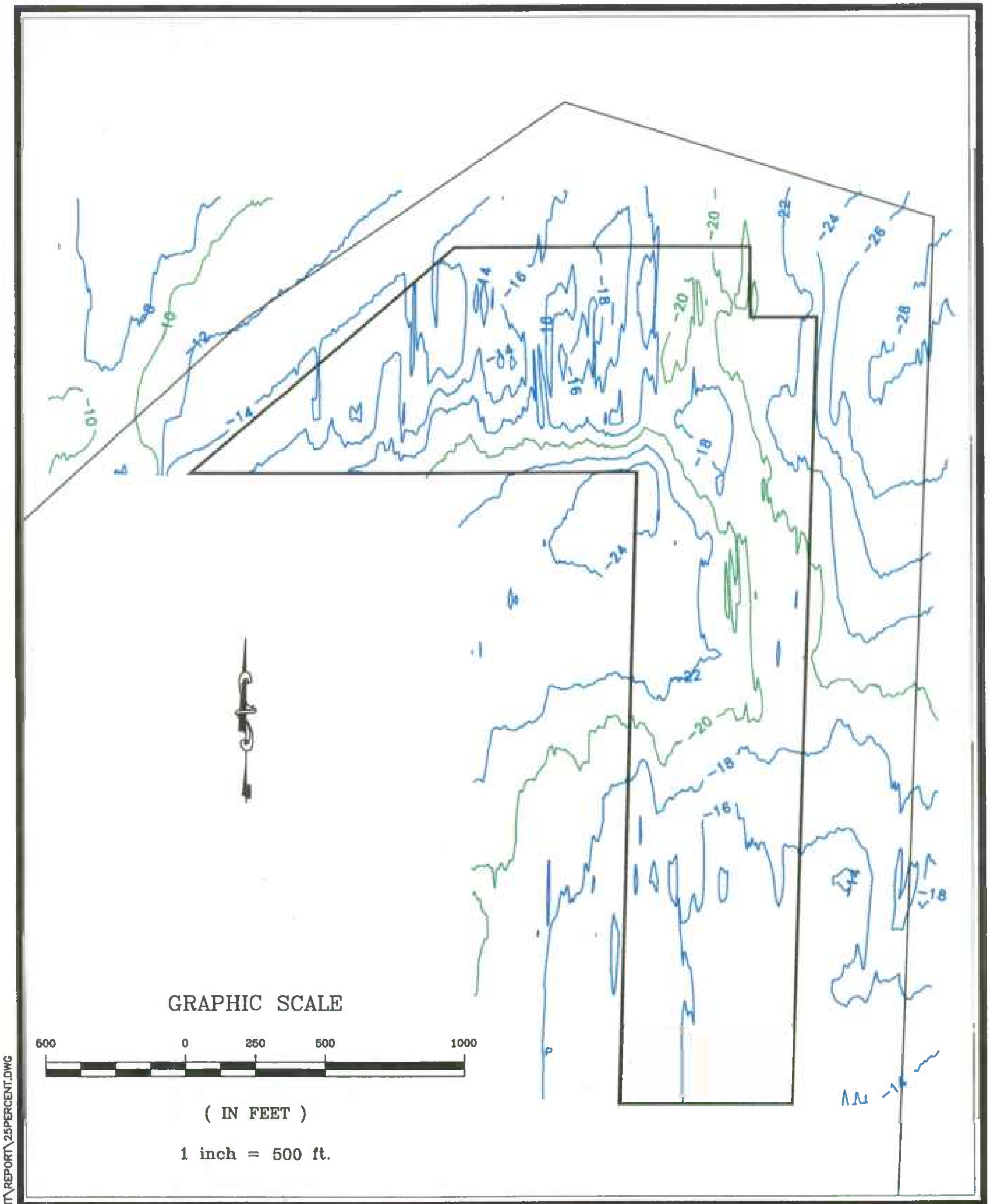
LEGEND (FEET)

Color	Range Beg.	Range End
🟦	−36.00	−27.00
🟦	−27.00	−25.00
🟦	−25.00	−23.00
🟩	−23.00	−21.00
🟩	−21.00	−19.00
🟦	−19.00	−16.00
🟦	−16.00	−14.00
🟦	−14.00	−12.00
🟦	−12.00	−10.00
🟦	−10.00	−8.00

MARYLAND
ENVIRONMENTAL
SERVICE

SITE 92 BATHYMETRY
PRE−PLACEMENT CENAP SURVEY
PERFORMED: DEC 9−12, 1998
FIGURE F−2

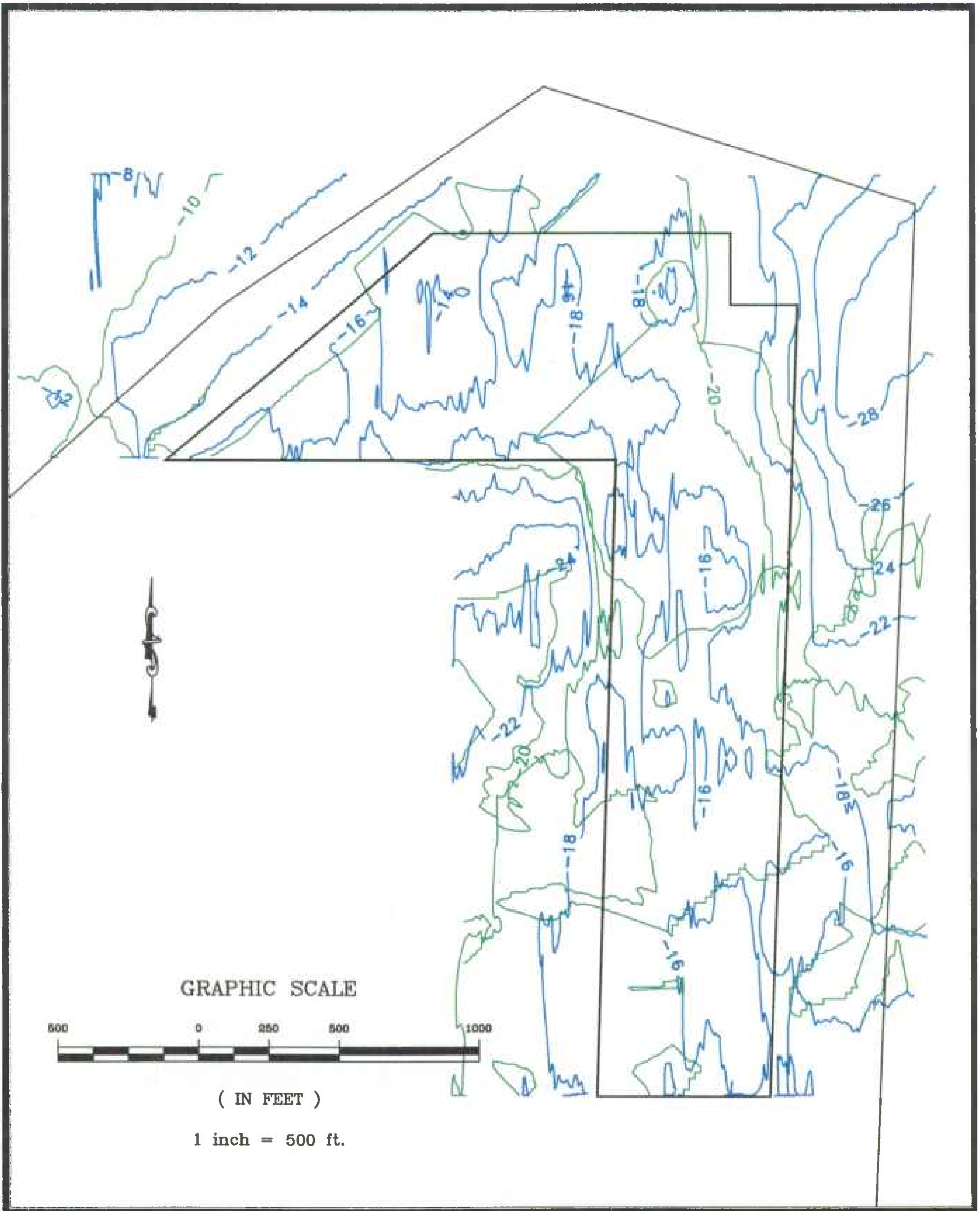
J:\SITE92\9899PLACEMENT\REPORT\PRESURVEY.DWG



MARYLAND
ENVIRONMENTAL
SERVICE

SITE 92 BATHYMETRY
25% CENAP SURVEY
PERFORMED: FEB 1, 1999
FIGURE F-3

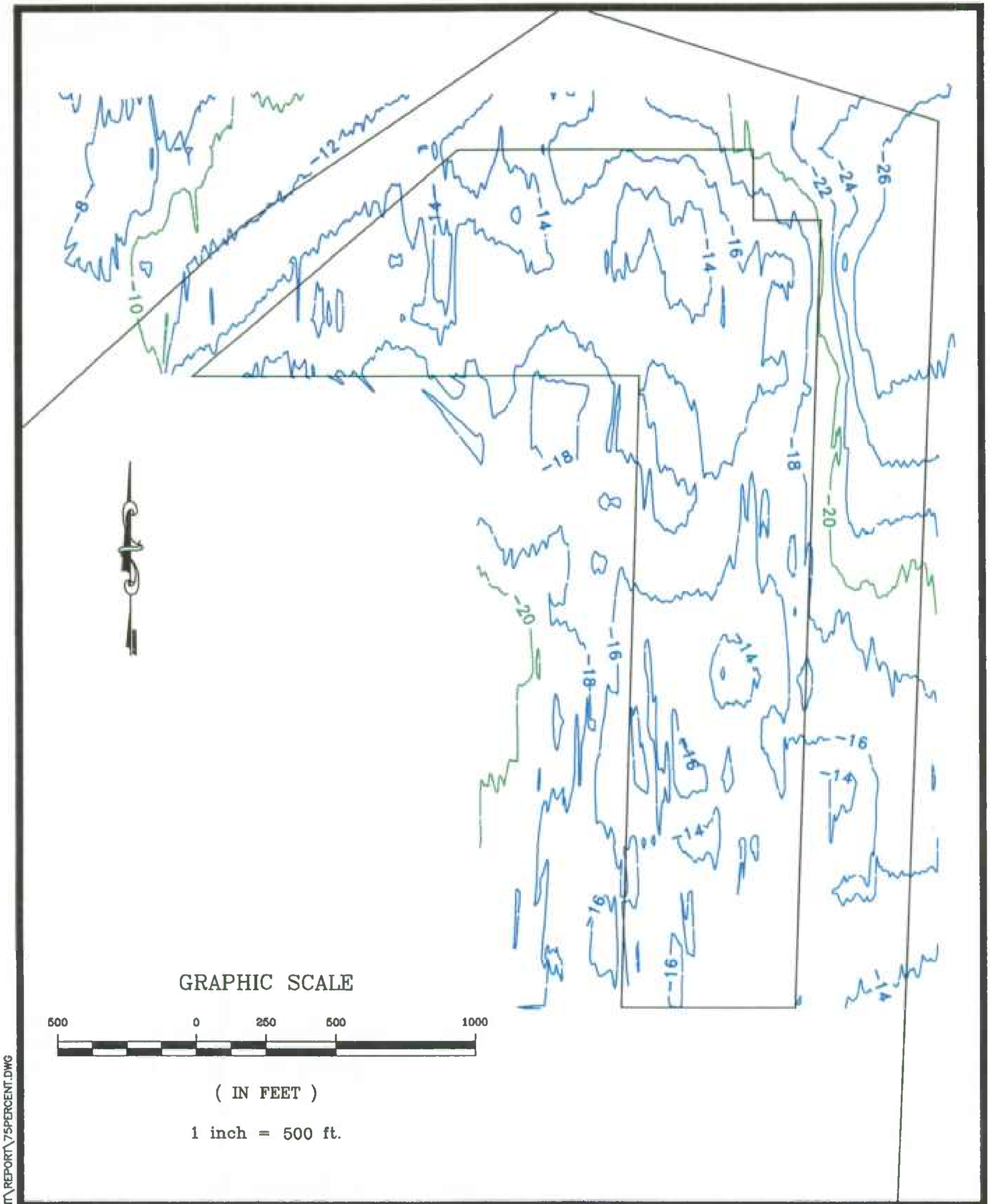
J:\SITE92\9899PLACEMENT\REPORT\25PERCENT.DWG



J:\SITE92\9899PLACEMENT\REPORT\50PERCENT.DWG

MARYLAND
ENVIRONMENTAL
SERVICE

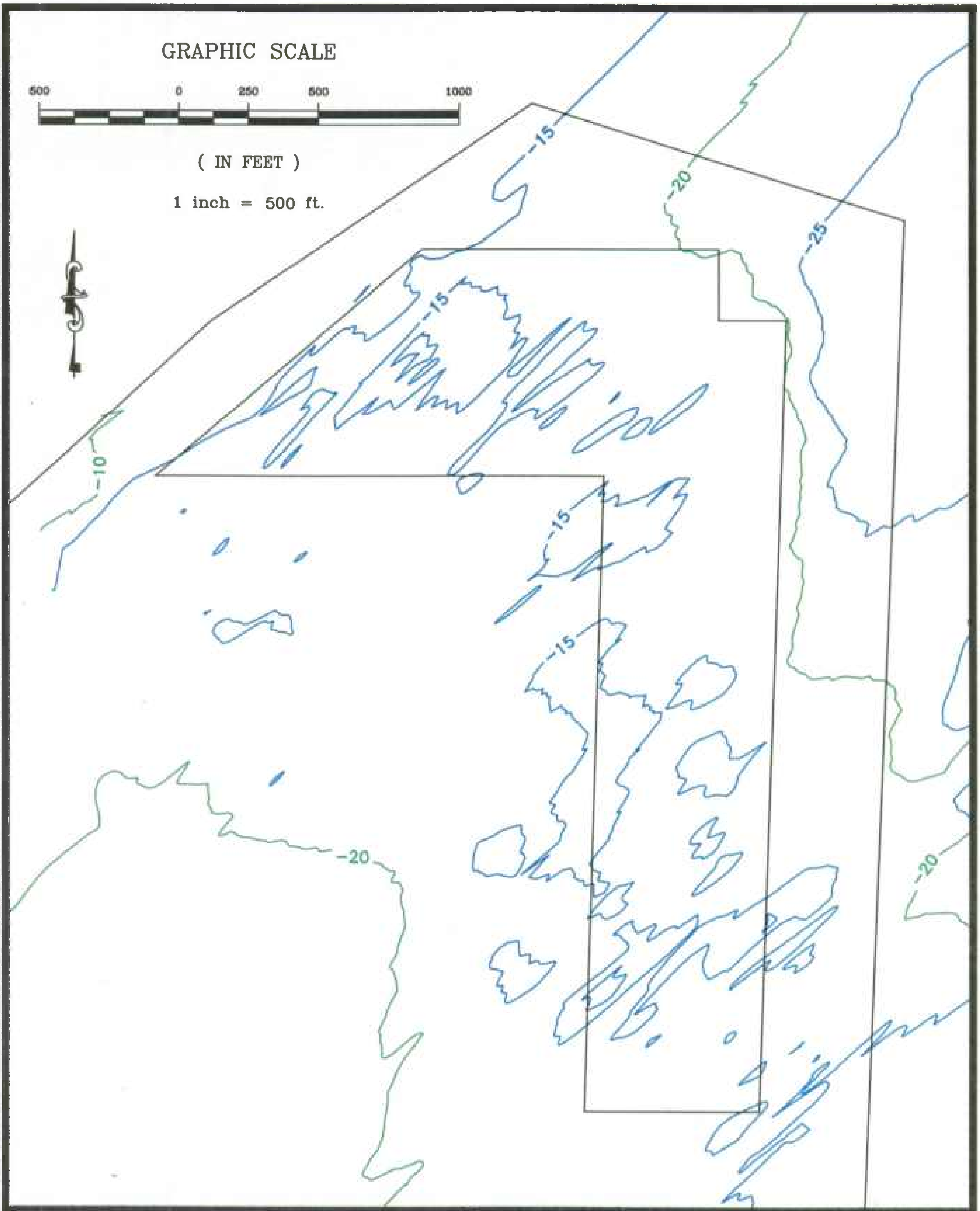
SITE 92 BATHYMETRY
50% CENAP SURVEY
PERFORMED: FEB 23, 1999
FIGURE F-4



MARYLAND
ENVIRONMENTAL
SERVICE

SITE 92 BATHYMETRY
75% CENAP SURVEY
PERFORMED: MARCH 17, 1999
FIGURE F-5

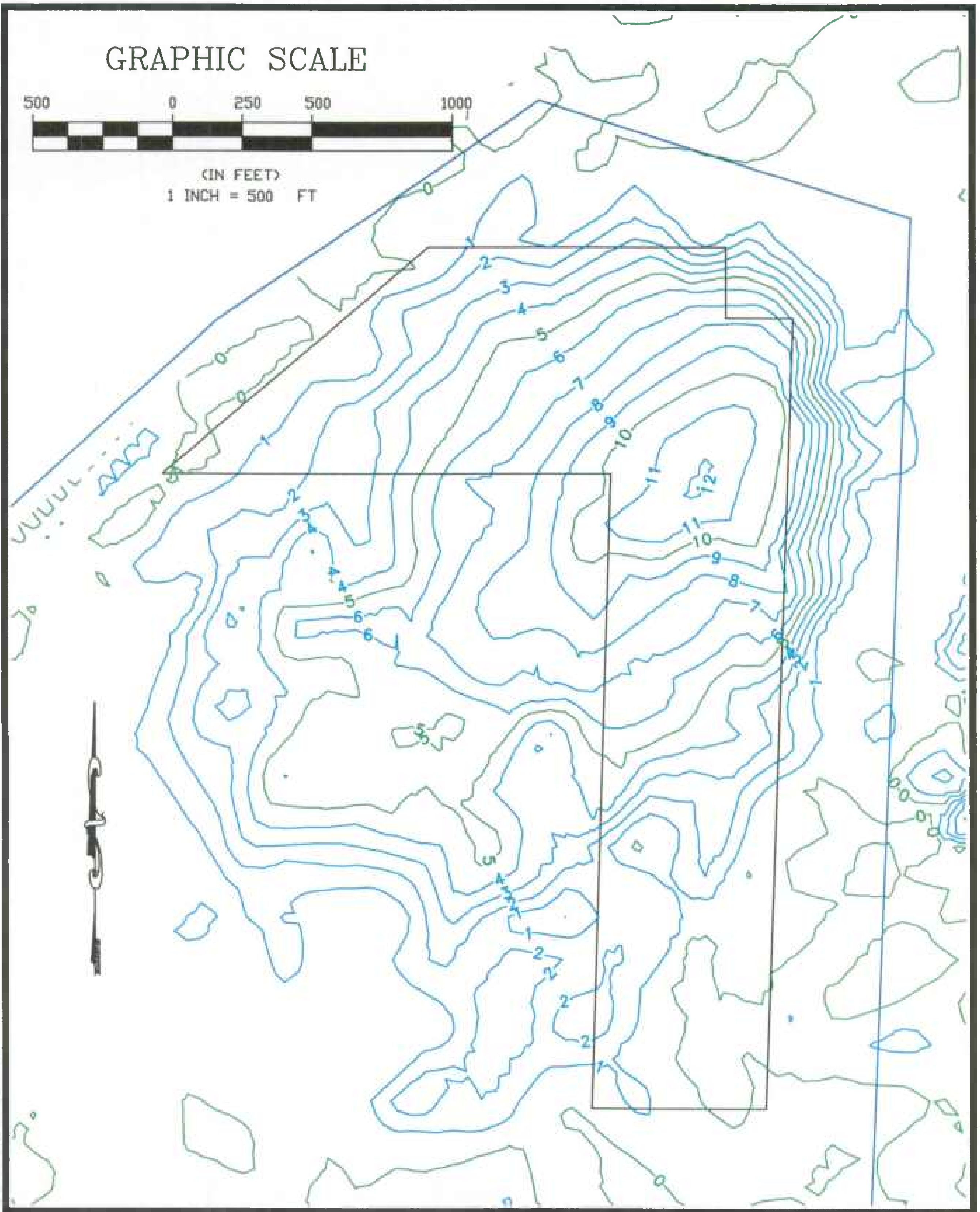
J:\SITE92\9899PLACEMENT\REPORT\75PERCENT.DWG



MARYLAND ENVIRONMENTAL SERVICE

SITE 92 BATHYMETRY
100% CENAP SURVEY
PERFORMED: APRIL 7- 9, 1999
FIGURE F-6

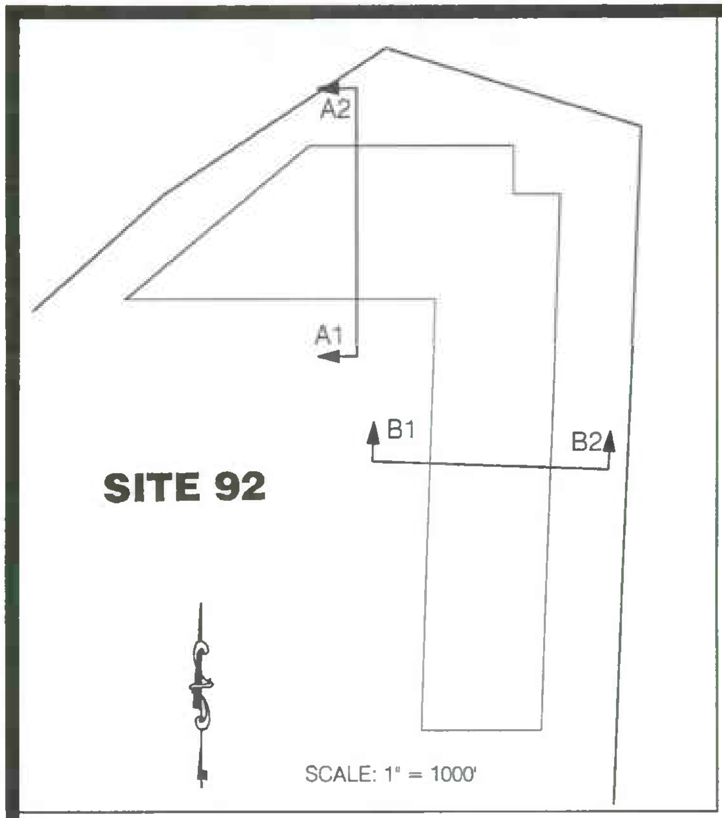
J:\SITE92\9899PLACEMENT\REPORT\100PERCENT.DWG

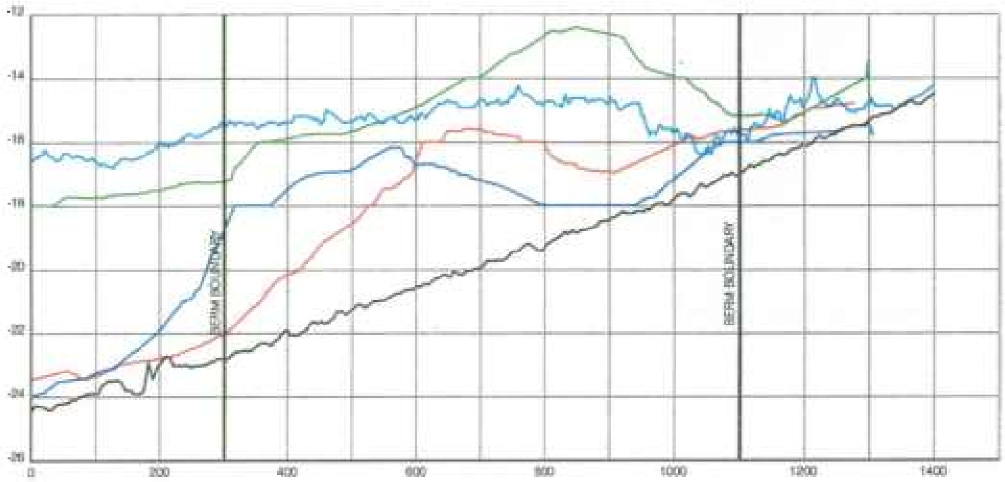


MARYLAND
ENVIRONMENTAL
SERVICE

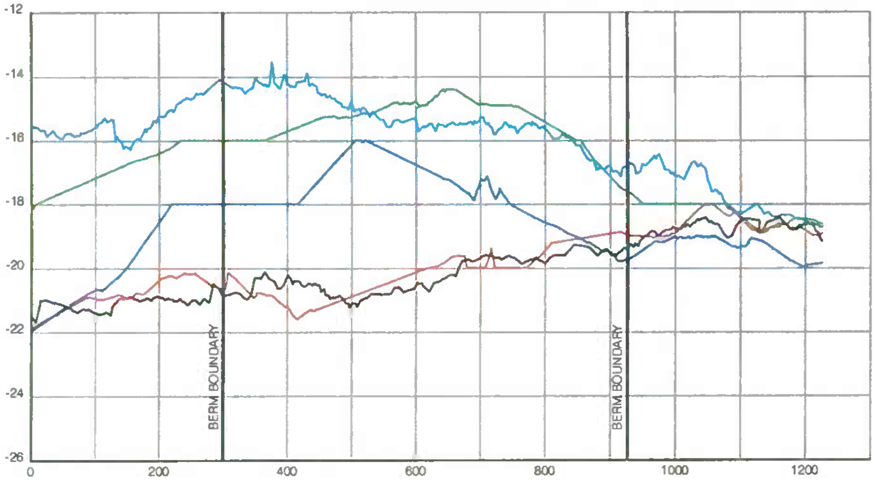
SITE 92 BATHYMETRY
0 – 100% ISOPACH
Performed April 7-9, 1999
FIGURE F-7

J:SITE92\9899PLACEMENT\REPORT\COMPLETEISO3.DWG





A1-A2



B1-B2

SCALE: HORIZ: = 1" = 300'
VERT: 1" = 6'

LEGEND

- — 100% SURVEY
- — 75% SURVEY
- — 50% SURVEY
- — 25% SURVEY
- — PRE-PLACEMENT

MARYLAND ENVIRONMENTAL SERVICE

SITE 92 BATHYMETRY
CROSS SECTIONS
1998/1999 PLACEMENT
FIGURE F-8

J:\SITE92\9899PLACEMENT\REPORT\SECTIONS.DWG

APPENDIX D

Site 92 1998/1999 Placement, Consolidation, and Erosion Study

Department of Natural Resources
Resource Assessment Service
MARYLAND GEOLOGICAL SURVEY
Emery T. Cleaves, Director

COASTAL AND ESTUARINE GEOLOGY

FILE REPORT NO. 01-1

Placement, consolidation, and erosion studies at open-water placement Site 92
1998 - 1999

by

William Panageotou

Prepared For:
The Maryland Port Administration
(Contract # 599910, PIN # 600106-H)
and
U.S. Army Corps of Engineers, Philadelphia District
(Contract # DACW61-99-C-0008 and DACW61-00-C-0015)

Under Contract To:
Maryland Environmental Service
(Contract # 99-07-35)

April 2001

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ABSTRACT

A clamshell bucket dredge was used to excavate clayey silt sediment from the Chesapeake & Delaware Canal approach channel between December 23, 1998 and March 31, 1999. The volume of sediment dredged was reported as 833,695 m^3 [1,090,367 yd^3] by the contractor, Weeks Marine Inc., and 580,740 m^3 [759,534 yd^3] by the U.S. Army Corps of Engineers, Philadelphia District (CENAP). The reported volumes typically differ because of the different methodologies used to determine the quantities dredged from the channel. The sediment was placed via bottom-release scows into the northernmost section of Site 92, in the tug channel, known as the West Sailing Course, that traverses the placement site. Placement was designed to create a sediment berm, not to exceed an elevation of 4.27 m [14 ft] below mean low water (MLW), in the northernmost section of the site. This would form an enclosed basin within the site that would minimize the potential for sediment migration out of the site during any subsequent placement operations.

Studies are routinely conducted by Maryland Geological Survey (MGS) on the dredged sediments to monitor their placement locations, elevation changes, physical characteristics, volumes occupied, and the changes in these attributes over time. The studies showed that placement resulted in a berm that filled the tug channel in the northern section of Site 92. The contract specification of 4.27 m [14 feet] below MLW was confirmed over the site. The 30H:1V [0.0333] sediment slope that was used in planning site management and for determining the set-back from the boundary was not achieved during this placement operation. The steepest slopes identified along the northeast side of the placement area fell between 35H:1V [0.0286] and 50H:1V [0.0200].

The initial area of the completed berm was approximately 719,000 m^2 [860,000 yd^2]. The volume of placed sediment identified by MGS at Site 92 after the completion of placement was 792,000 m^3 ±73,000 m^3 [1,035,500 yd^3 ±95,000 yd^3]. This represents an excess of 211,500 m^3 [276,000 yd^3] or 36% more than the CENAP reported dredged volume and a deficit of 41,500 m^3 [55,000 yd^3] or 5% less than the contractor's reported dredged volume. Based on the total volume of sediment identified and discussions with CENAP personnel, the volume that CENAP reported dredged is pay yardage removed by the contractor and an underestimate of the gross quantity removed from the channel.

Although all sediments were placed within the site boundaries, a small amount of the placed sediment extended beyond the northeast site boundary at the completion of placement operations. This sediment extended a maximum distance of 100 m [330 ft] to the east of the site boundary and had an estimated volume of 3,500 m^3 ±2,300 m^3 [4,600 yd^3 ±3,000 yd^3]. This represents less than one-half of one percent (0.4%) of the placed sediment identified at the site and of the volume reportedly placed by the contractor. Sediment that was placed at the top of the berm during the latter weeks of the placement period likely moved downslope on the berm's east steep embankment and came to rest at the base of the slope in the deeper portion of the trough to the northeast. In addition, tidal currents may have spread some of the less consolidated sediments beyond the drop zones.

Over the eleven month post-placement study period, as expected the berm underwent elevation and volume changes. Redistribution of sediment within three months after completion of placement resulted in the area of the placed sediments increasing by two-thirds to approximately 1,200,000 m^2 [1,432,000 yd^2] but did not result in a measurable change in the total volume. The redistribution included slumping of sediment to a short distance beyond the site boundary, within a month after completion of placement. Sediment appeared to have moved over the peripheral areas of the berm and deposited as a thin layer in the tug channel to the northeast and in the basin within the site to the southwest. Between three and six months after placement, a reduction in the elevation of the berm and thinning of the sediments in the peripheral areas resulted in an 11% volume reduction. Between six and nine months after placement, the sediments that had previously spread into the peripheral areas were largely eroded, contributing to an overall 20% volume reduction. Between nine and eleven months after placement, there was an additional 2% volume reduction. The net area covered by the berm sediments was reduced to approximately 533,000 m^2 [637,000 yd^2] or three-quarters of the original footprint. The maximum elevation of the placed berm decreased by 0.6 m [2 ft] since completion to 3.1 m [10.2 ft] at eleven months.

At the end of the eleven month post-placement period, 67% of the original sediment volume was identified at Site 92 with a net decrease of 263,500 m^3 [344,500 yd^3], or 33% less than the volume identified on the completion survey. Bulk property data indicated that one-third of the volume change, approximately 12% of the originally placed volume, was due to dewatering and consolidation. The remaining two-thirds of the volume change, representing 21% of the original volume, was attributed to erosion of sediment from the surface of the deposit. In past studies of clamshell dredged and scow placed sediments, it has been found that one-third to two thirds of the total volumetric reduction could be attributed to either consolidation or erosion. The sediments placed in this operation exhibited similar amounts of consolidation and erosion as those placed in previous years in the northern Chesapeake Bay.

It is recommended that future placement near site boundaries should avoid developing a sediment pile (lift) of similar thickness and slopes (<50H:1V [0.0200]) as those in this year's placement operation in deep areas such as this. Shallower slopes should be anticipated and a greater set-back from the site boundary identified for scow drops to minimize the potential spread of sediment outside of the site boundary. However, it is unlikely that any future operations in Site 92 will result in these conditions occurring given the bathymetry at the site. Close coordination between CENAP, the dredging contractor, Maryland Environmental Service (MES), and MGS and development of a suitable site management plan will minimize the potential for spread of sediment outside of the site boundary and slumping events in future placement operations.

PROJECT DESCRIPTION

Dredging of shipping channels in the northern Chesapeake Bay is routinely required to maintain navigational access to the Port of Baltimore. Portions of the sediment dredged from these operations are placed overboard, on the Bay bottom, in designated sites adjacent to the shipping channels. Figure 1 is a location map of the upper Chesapeake Bay showing the dredged navigation channels and the designated open-water placement sites. The designated sites are located south and east of Pooles Island, just to the west of the lower reach of the Chesapeake and Delaware (C&D) Canal approach channel.

Maintenance dredging of sediment from the C&D Canal approach channel was conducted during the winter of 1998-1999 under contract from the U.S. Army Corps of Engineers, Philadelphia District (CENAP) to Weeks Marine, Inc. (Invitation For Bid No. DACW61-98-B-0013; Contract No. DACW61-99-C-0001). Sediments were removed from the channel by clamshell bucket dredge and transported and placed within a designated portion of Site 92 via bottom-release scows. Site 92 straddles a channel known as the West Sailing Course which is used principally by tugs running without barges and tugs with empty or light-loaded barges. Placement was designed to create a sediment berm along the northeastern corner of the site within this channel to minimize the potential for the spread of sediment deposited in subsequent placement operations (Maryland Environmental Service, 1997). The final elevations for the placed sediment berm was not to exceed 4.27 m [14 ft] below mean low water (MLW) to allow for continued access by the tugs.

The drop zone for berm construction was modified from the design presented in the Final Environmental Assessment (Maryland Environmental Service, 1997) and the original bid specifications (U.S. Army Corps of Engineers, Philadelphia District, 1998, chart number 58081). Based on the October 30, 1998 bathymetry, and discussions between CENAP, the contractor, and Maryland Geological Survey (MGS), the originally proposed drop zone was reduced in length and the setback from the Site 92 boundary was increased. This change was brought about in an effort to ensure that the berm's footprint, with anticipated side slopes of 30H:1V [0.0333], would remain within the site boundary (Figure 1, inset; Figure 2). The approved placement plan called for the initial construction of the berm in the reconfigured zone designated as phase I. Following satisfactory construction of the berm, placement was to occur directly behind the berm within the adjoining area designated as phase II. The disposal operation plan as well as the location and quantity of each scow placement, or drop, is presented in the Site Management Report (Maryland Environmental Service, 2001).

The contractor reported on their Daily Report of Operations (DRO) that a sediment volume of 833,695 m^3 [1,090,367 yd^3] was removed from the channel between December 23, 1998, and March 31, 1999, and placed within the designated drop zone. CENAP reported that a sediment volume of 580,740 m^3 [759,534 yd^3] was removed from the channel. The contractor's dredged volume was based on the quantity of sediment placed per scow load. CENAP's dredged volume was based on the change between pre- and post-dredging bathymetric surveys in the channel and calculated as a pay volume to the authorized -41 ft depth.

Location Map

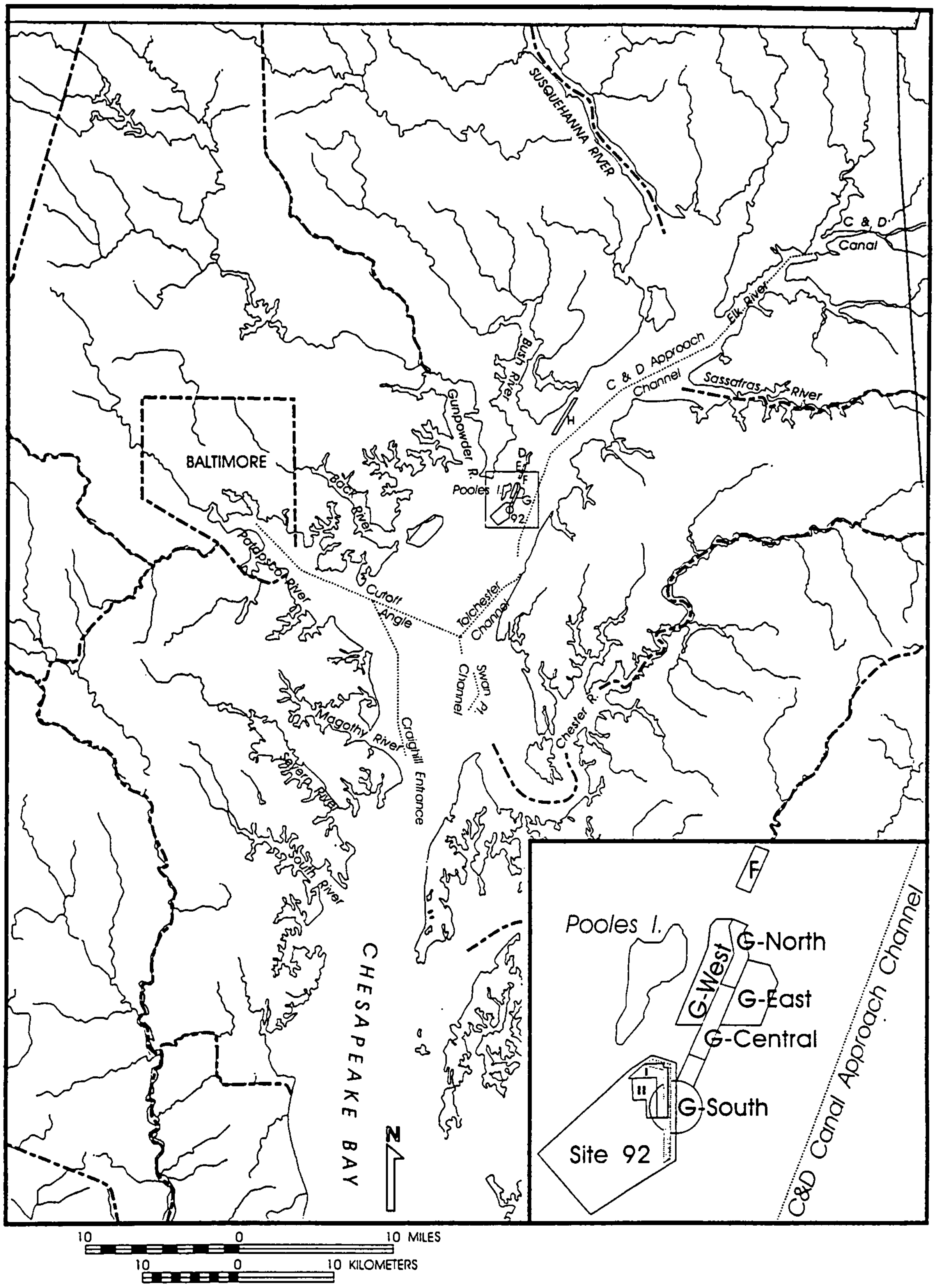
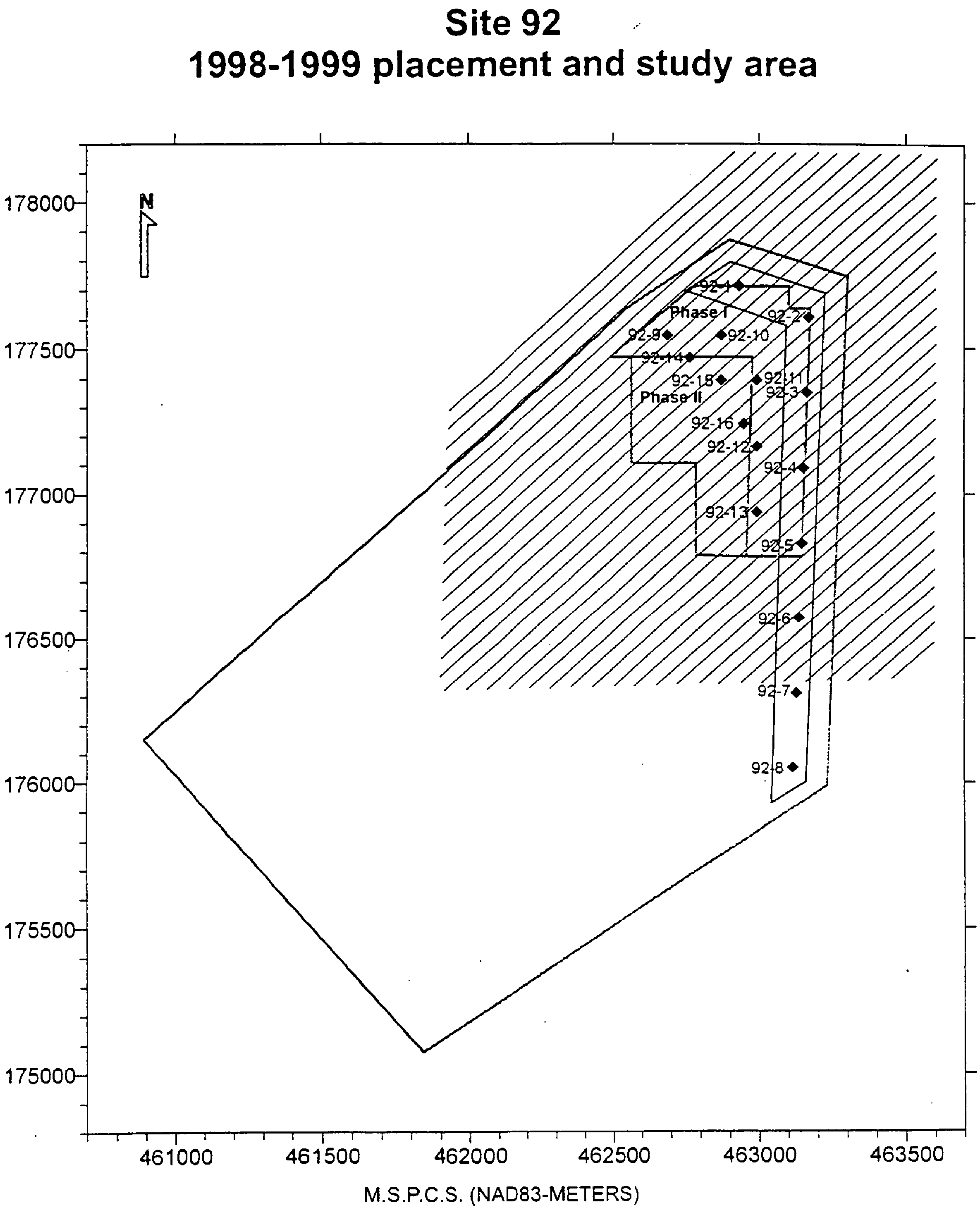


Figure 1. Location of overboard disposal areas in the northern Chesapeake Bay. Site 92 was utilized for placement. Original drop zone is shaded. Reconfigured drop zones are designated as I and II. Light dotted lines indicate position of dredged shipping channels. In this operation, sediments were taken from the C&D Canal approach channel.



Site 92
1998-1999 placement and study area

Figure 2. Location map showing designated drop zones, bathymetric tracklines, and bottom sediment coring sites. Original drop zone is shaded. Reconfigured drop zones are designated as phase I and phase II.

Studies are routinely conducted on the dredged sediments to monitor their placement locations, elevation changes, physical characteristics, volumes occupied, and the changes in these attributes over time. This document reports the studies conducted by MGS on the overboard placement of sediment dredged from the approach channel to the C&D Canal during the winter of 1998-1999. The studies were funded by the Maryland Port Administration (MPA) and CENAP and administered through a contract with the Maryland Environmental Service (MES). The specific objectives of the studies conducted by MGS were:

(1) to evaluate pre-placement conditions at the designated placement site;
(2) to determine the placement location, thickness, and spatial extent of the deposited dredged sediment and changes in these characteristics through time;
(3) to sample the dredged sediments to determine their physical and bulk properties in the channel and at the placement site;
(4) to evaluate foundation settlement underlying the placed sediments during the placement and post-placement periods;
(5) to evaluate the quantity of dredged sediment present at the placement site soon after the completion of dredging and placement operations;
(6) to evaluate consolidation and erosion of the placed sediments; and,
(7) to develop a total sediment mass budget for the placement and post-placement periods.

On site monitoring activities were conducted aboard the Maryland Department of Natural Resources' Research Vessel *Kerhin*. Field work included bathymetric surveys of the placement site and surrounding areas and bottom sediment sampling (Figure 2). Eleven cruises were required to accomplish the stated objectives. The chronology of placement and study activities are described in greater detail in the Methods section.

METHODS

Table I lists the chronology of placement and scheduled study activities. The proposed schedule called for bathymetric surveys prior to placement, at the completion of scow placement, and at one, three, six, and nine months after placement and bottom sediment coring prior to, at completion of, and nine months after placement. Inclement weather, ice in northern Bay, or vessel scheduling conflicts delayed the completion and nine month bottom sediment coring cruises until one month and eleven months after placement, respectively. An additional bathymetric survey was conducted at eleven months to coincide with bottom sediment coring.

Table I. Chronology of placement and study activities in Site 92.

October 19, 1998	bottom sediment coring prior to sediment placement
October 30, 1998	bathymetric survey prior to sediment placement
January 11, 1999	additional bottom sediment coring prior to sediment placement
December 23, 1998	scow placement commences
March 31, 1999	scow placement completed
April 7, 1999	bathymetric data for completion survey
April 28, 1999	bottom sediment coring for completion survey
May 6, 1999	bathymetric data for one month survey
July 12, 1999	bathymetric data for three month survey
September 29, 1999	bathymetric data for six month survey
January 6, 2000	bathymetric data for nine month survey
February 21, 2000	bathymetric data for eleven month survey
February 22, 2000	bottom sediment coring for eleven month survey

BATHYMETRIC SURVEYING

Data Collection

Tracklines running northeast to southwest were established for bathymetric surveying in a wide area surrounding the designated drop zones (Figure 2). The spacing between tracklines was 45 m [150 ft]. All tracklines were surveyed prior to the placement operations in order to establish a baseline record of the bottom depths, and as soon as possible after placement operations were completed in order to establish the initial spatial extent, thickness, and volume of the placed dredged sediment (Table I). Surveys were repeated on five other occasions to evaluate the bathymetric and volumetric changes of the deposit through time.

Bathymetric data were collected using a Magnavox 300 survey-grade Differential Global Positioning System (DGPS) and a Furuno FCV-800 echosounder. DGPS differential corrections broadcast by the United States Coast Guard provided a horizontal accuracy of 2 to 5 m [7 to 16 ft]. Horizontal position was recorded in Maryland State Plane Coordinate System (MSPCS) in meters based upon the North American Datum of 1983 (NAD 83). The echosounder generated repetitive acoustic pulses, ten soundings per second, at 198 kHz for bottom recognition. The acoustic wave reflected off the density gradient separating the water column from the bottom sediment. The reflections were then filtered and integrated within the echosounder to produce an accurate measurement from the transducer to the water/sediment interface every two seconds. A data point was collected approximately every 6 m [20 ft] along the survey tracklines. Bathymetry and positioning data were logged to a personal computer at a rate of one point every two seconds. Both the DGPS and the echosounder were checked against known horizontal and vertical measurements before and after each survey.

The depth data were referenced to mean lower low water (MLLW) at the Tolchester Beach location for 1960-1978 National Tidal Datum Epoch. This station is maintained by National Oceanic and Atmospheric Administration/ National Ocean Service (NOAA/NOS). MLLW is 7 cm [2.8 in] below mean low water (MLW) at Tolchester. The depth data were adjusted by using tide data from the tide station, recorded at six minute intervals, and subtracting the tide level from the bathymetric data collected during the same time interval. Incorporated into the tidal adjustments was a +20 minute offset from Tolchester Beach to Site 92. Quality Assurance/Quality Control (QA/QC) analyses indicated that the practical resolution of the post-processed bathymetric data is ± 2.5 cm [1 in].

Bathymetric Interpretation and Volumetric Calculations

Bathymetric data were interpreted with Surfer, a commercially available contouring software package (product of Golden Software, Golden, CO). The raw data was processed using the Surfer's Triangulation with linear interpolation method. This method is based on the works of Lawson (1977), Lee and Schachter (1980), and Guibas and Stolfi (1985). A 25 m [82 ft] regularly spaced grid was calculated from the bathymetric data. After the regularly-spaced grids were created, volumes and thicknesses of the placed dredged sediments could be calculated between upper and lower surfaces by comparison. The vertical resolution of the isopach maps showing bottom elevation changes was estimated to be 0.1 m ±0.05 m [4 in ±2 in]. This resolution produces a range of uncertainty in the volume calculations that is a function of the area covered by placed sediments. Ground-truthing the isopach maps showing bottom elevation changes was accomplished by collecting gravity cores both within and outside the area of the placed sediments.

BOTTOM SEDIMENT SAMPLING

Bottom sediment sampling occurred prior to placement and at one month and eleven months after completion of placement. The sampling sites are shown in Figure 2. Bottom sediments were collected in 6.7 cm [2.6 in] diameter cellulose acetate butyrate (CAB) core liners inserted into either a Benthos open-barrel gravity corer, model 2171 or a Benthos piston corer, model 2450. The recovered cores were trimmed at the sediment-water interface, capped, and returned to the laboratory for bulk property and granulometric analyses.

In the laboratory, the sediment cores were first X-rayed in their liners using a TORR-MED medical X-ray unit. Prints of the X-ray images were developed using a Xerox 125 xeroradiograph processor. X-rays of cores facilitated recognition of small-scale internal structures, such as clam and worm burrows or tubes, shells, and gas voids. These observations were used to evaluate benthic activity and identify the pre-placement bottom. On a negative xeroradiographic print, less dense material, such as burrows or gas voids, appear darker as compared to denser material, such as shells or sand, which appear lighter.

After the cores were X-rayed, the sediment was extruded from the core liner, split along the axis, photographed, and described. The core was then carefully examined to identify the pre- and post-placement sedimentary units. Each sedimentary unit was subsequently sub-sampled in equal 10 cm [3.9 in] interval volumes along the entire length, homogenized into a single representative sample, and analyzed for water content and grain size. Analyses were conducted according to MGS standard techniques as outlined in Kerhin and others (1988). Samples used for water content analysis were divided into 15 to 20 g portions, dried at 65°C, and then reweighed. Water content was calculated as the percentage of water weight to the total weight of wet sediment:

$$\% H_2O = (\frac{W_w}{W_t})\_100 \qquad (1)$$

where W_w is the weight of water, and W_t is the weight of wet sediment. The water content, as sub-sampled from the homogenized intervals, was assumed to represent the mean water content present down-core in each pre- and post-placement sedimentary unit (MGS, unpublished data).

The water content may be underestimated because of water being lost from the sediment during the time interval between collection and extrusion of the core. Recently placed sediments, contained within the core liner, exhibit a measurable amount of dewatering between the time of collection and analysis, resulting in compaction. The amount of water expressed from the sediment subsequent to collection can be calculated by measuring the change in core length prior to extrusion. Water contents calculated in the laboratory were corrected by assuming that this compaction occurred evenly throughout the thickness of the most recently placed sediment layer. The percent water contents reported for the samples represent corrected values.

During collection of fine-grained sediments via open-barrel gravity coring, a significant but generally variable and indeterminable amount of compression (core shortening) also occurs in the sediment due to frictional forces against the inner wall core liner. The shortening of the collected sediment results from a physical thinning caused by lateral extrusion in front of the core (Weaver and Schultheiss, 1983; Blomqvist, 1988). Lateral thinning of sediment ahead of the retained sediments in the corer does not alter the water content (Halka and Panageotou, 1993).

The precision of water content measurements was determined by calculating the relative standard deviation from replicate measurements made on fine-grained sediments collected at disposal Areas D and F in 1991 (Figure 1). For sediment samples collected and analyzed in this manner, the relative standard deviation for percent water content was determined to be 4.46% (Halka and Panageotou, 1993). The standard deviation (σ) for any particular water content may be calculated as:

$$\sigma H_2O = \frac{\% H_2O}{100} \_ \ 4.46 \qquad (2)$$

This function yields a plus or minus value (±) indicating the range of variability possible in water content for each sediment sample.

Bulk density (ρ_b), porosity (P), and void ratio (e) were calculated from water content utilizing equations (3), (4), and (5) by assuming an average grain density (ρ_s) of 2.65 g/cm^3 and saturation of voids with water of density $\rho_w = 1.0$ g/cm^3. This method was adopted from the work of Bennet and Lambert (1971):

$$\rho_b = \frac{W_t}{W_d \ / 2.65 + W_w} \qquad (3)$$

where W_d is the weight of dry sediment.

$$P = \rho_s \frac{\% H_2O}{\rho_s \ \% H_2O + \rho_w (1 - \% H_2O)} \qquad (4)$$

$$e = \frac{V_v}{V_s} \qquad (5)$$

where V_v is the volume of voids, and V_s is the volume of solids.

A statistically verifiable change in mean water content over time can be used to definitively quantify volumetric change through time. Using a t-test, two water contents can be compared at a certain confidence level to determine if the values are statistically different (Davis, 1973; Ott and others, 1978). If the water content values are determined to be statistically different, then the percent volume change over a specified time interval can be calculated at the specified confidence level.

The percentage of volumetric change (V_Δ) attributable to either bulking (water-loading during dredging and placement) or *in situ* consolidation (dewatering of foundation sediments and post-placement sediments) was determined from the change in porosity over time. Percent volume change can be calculated utilizing equation (6):

$$V_\Delta = \frac{1 - P_i}{1 - P_f}\_100 \qquad (6)$$

where P_i is the initial porosity at time one, and P_f is the final porosity at time two. The amount of erosion in placed sediments can subsequently be estimated by first calculating the total sediment volume change from the bathymetric analyses, and then subtracting the volume due to *in situ* consolidation.

Grain size analysis involved cleaning 40 g samples in solutions of 10 percent hydrochloric acid and 15 percent hydrogen peroxide and subsequent rinsing with deionized water. This process removes soluble salts, carbonates, and organic matter that could interfere with the disaggregation of the individual grains. The samples were then treated with a 0.26 percent solution of the dispersant sodium hexametaphosphate ($(NaPO_3)_6$) to ensure that individual grains did not reaggregate during analysis.

The separation of sand and mud portions of the sample was accomplished by wet-sieving through a 4-phi mesh sieve (0.0625 mm, U.S. Standard Sieve #230). The sand fraction was dried and weighed. The finer silt and clay sized particles were suspended in a 1000 ml cylinder in a solution of 0.26 percent sodium hexametaphosphate. The suspension was agitated, and at specified times thereafter, 20 ml pipette withdrawals were made (Carver, 1971; Folk, 1974). The rationale behind this process is that larger particles settle faster than smaller ones. By calculating the settling velocities for different sized particles, times for withdrawal can be determined at which all particles of a specified size will have settled out past the point of withdrawal. Sampling times were calculated to permit the determination of the amount of silt (4 phi) and clay sized (8 phi) particles in the suspension. Withdrawn samples were dried at 60°C and weighed. From these data, the dry weight percentages of sand, silt, and clay were calculated for each sample and classified according to Shepard's (1954) nomenclature (Figure 3).

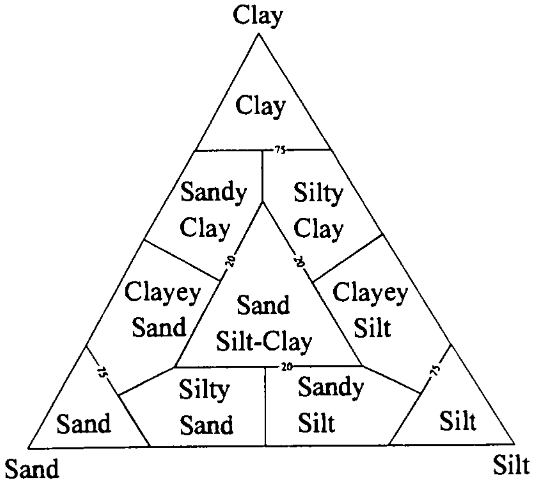


Figure 3. Shepard's (1954) classification of sediment types.

RESULTS

APPROACH CHANNEL SEDIMENT PROPERTIES

Table II summarizes the physical properties of the C&D Canal approach channel sediments collected on October 19, 1998, prior to any dredging. Five sediment cores were collected in designated maintenance areas (acceptance sections) to specified dredging depths, based on the bid specifications (U.S. Army Corps of Engineers, Philadelphia District, 1998). The cores were labeled by the acceptance section (AS) in which they were collected. The locations of the acceptance sections are found on the soundings chart numbers 58077, 58078, and 58079, dated September 4, 1998 (U.S. Army Corps of Engineers, Philadelphia District, 1998).

Table II. Physical properties of C&D approach channel sediments (10/19/98).

Core location	AS-3	AS-5	AS-6	AS-7	AS-13
Sediment thickness in core (m)	1.04	1.13	1.11	1.18	1.04
Sand/silt/clay fraction (%)	3/55/42	3/57/40	4/58/38	4/59/37	1/57/42
Shepard's (1954) classification	clayey silt	clayey silt	clayey silt	clayey silt	clayey silt
Water content (%)	54.1 ±2.4	58.9 ±2.6	56.0 ±2.5	55.9 ±2.5	57.3 ±2.6
Bulk density (g/cm^3)	1.40 ±0.03	1.34 ±0.03	1.38 ±0.03	1.38 ±0.03	1.36 ±0.03
Porosity	0.758 ±0.018	0.792 ±0.018	0.771 ±0.018	0.771 ±0.018	0.780 ±0.018
Void ratio	3.1 ±0.3	3.8 ±0.4	3.4 ±0.4	3.4 ±0.4	3.6 ±0.4

All five sediment cores were primarily an olive gray clayey silt mud (Shepard's 1954 classification, Figure 3). There was relatively little variation in the sand/silt/clay fractions. The sand content ranged from 1 to 4%, silt from 55 to 59%, and clay from 37 to 42%. Mean water content ranged from 54.1 to 58.9%, a range of 4.8%. The average of the mean water content values, 56.4%, was utilized to calculate a bulking factor for the placed sediments at the disposal site (see Tables X and XI in section: Volumetric Analyses - Dredged and Placement Amounts). The bulk property values are consistent with clayey silt muds sampled in previous years. The water content for dredged maintenance sediments from previous years' sampling ranged between 53 and 62%. The average of the water content values in any given year (1991 through 1997) was between 56 and 59%. This variation is due to the location of the designated maintenance areas (acceptance sections) dredged. The long term average of all maintenance dredged sediment cores collected to date is 57.4%.

Higher water content values are generally found in the upper reaches of the navigation channel and lower values in the lower reaches. This trend may be due to a greater shoaling rate in the lower reaches of the channel than the upper reaches during the spring freshet. During the latter months of the year, shoaling occurs at greater rates in the upper reaches as the fresh water flow decreases and the turbidity maximum shifts northward. Thus, the accumulated sediment in the lower reaches has an opportunity to dewater over a relatively longer period of time prior to collection than does the sediment in the upper reaches. Channel bathymetric surveys conducted by CENAP commonly indicate that shoaling occurs first in the lower reaches, supporting this hypothesis (W. DePrefontaine, oral commun., 1999).

PRE-PLACEMENT CONDITIONS

Bathymetry

Site 92 is approximately 934 acres in size (Maryland Environmental Service, 1997). The site straddles a trough known as the West Sailing Course channel between Buoy R "6" to the south and Buoy G "7" to the north. The western portion of former placement Area G-South is included within the site (Figure 1). The West Sailing Course channel is used principally by tugs running without barges and tugs with empty or light-loaded barges. The trough is oriented in a northeast to southwest direction and extends beyond the site boundary both to the northeast into deeper water and to the southwest into shallower water. In the northeast direction, the trough opens to variable bottom topography referred to as the high relief area.

A pre-placement bathymetric survey of Site 92 was conducted on October 30, 1998 (Figure 4). Pre-placement water depths throughout Site 92 ranged from 3.0 to 9.0 m [9.8 to 29.5 ft]. Relatively shallower water depths, less than 5.0 m [16.4 ft], were located along the margins of the northwest and southeast boundary. From the northwest and southeast margins, the bottom sloped into the West Sailing Course channel that runs through the center of the site. Depths within the West Sailing Course tug channel ranged from 5.8 m [19 ft] in the southwest to 9.0 m [29.5 ft] in the northeast.

Water depths in the northern half of the site, within the designated drop zone, were between 5.0 to 8.5 m [16.4 to 27.9 ft]. The variable topography within the northeast sector, characterized by irregular semi-circular contours, resulted from scow placement of up to 2.0 m [6.6 ft] of dredged sediment into Area G-South in 1997 (Panageotou and others, 1998). The southern end of the high relief area is located immediately east of this sector of the site. Water depths vary in the high relief area from 3.5 to 12.0 m [11.5 to 39.4 ft] over very short distances.

Sediment Properties

Bottom sediment coring occurred on two dates: October 19, 1998 and January 11, 1999 in order to characterize the pre-placement bottom sediment and establish bulk property data to evaluate subsequent foundation consolidation. The bottom sediments were sampled to a depth of 0.5 m [1.6 ft] at sixteen locations throughout the northern half of the placement area (Figure 2). Cores 92-1 through 92-8 were collected on the former date along the center line in the originally configured drop zone. These sites were located along the northern and eastern margins of Site 92. Cores 92-9 through 92-13 were collected on the latter date in the phase I drop zone. Cores 92-14 through 92-16 were collected on the latter date in the phase II drop zone. Tables III and IV summarize the sediment physical properties in the upper 0.5 m [1.6 ft] of each core.

Site 92
bathymetry prior to placement
October 30, 1998

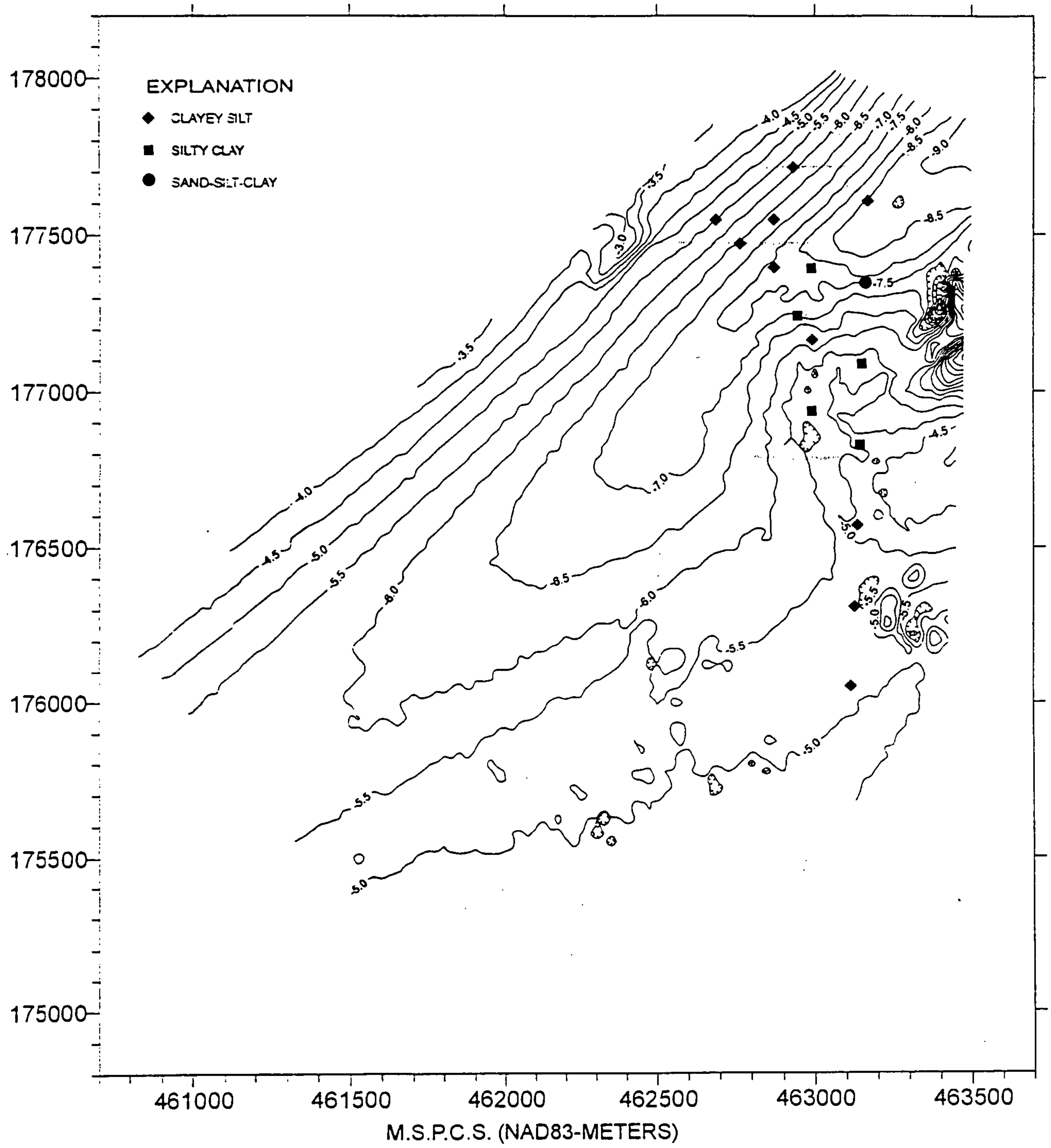


Figure 4. Bathymetry on October 30, 1998, prior to sediment placement. Depths in meters (contour interval 0.5 m). Grain size distribution for foundation sediments collected on October 19, 1998 and January 11, 1999 is indicated. Refer to Figure 2 for identification of sediment core sites.

Table III. Physical properties of foundation sediments prior to placement in the original drop zone (10/19/98).

Core location	92-1	92-2	92-3	92-4
Sediment thickness in core (m)	0.50	0.50	0.50	0.50
Sand/silt/clay fraction (%)	2/57/41	8/53/39	25/26/49	4/36/60
Shepard's (1954) classification	clayey silt	clayey silt	sand silt clay	silty clay
Water content (%)	58.0 ±2.6	57.6 ±2.6	57.3 ±2.6	55.4 ±2.5
Bulk density (g/cm^3)	1.35 ±0.03	1.36 ±0.03	1.36 ±0.03	1.39 ±0.03
Porosity	0.785 ±0.018	0.783 ±0.018	0.780 ±0.018	0.767 ±0.018
Void ratio	3.7 ±0.4	3.6 ±0.4	3.6 ±0.4	3.3 ±0.3

~~Core location~~	~~92-5~~	~~92-6~~	~~92-7~~	~~92-8~~
Sediment thickness in core (m)	0.50	0.50	0.50	0.50
Sand/silt/clay fraction (%)	3/44/53	15/53/32	5/52/43	4/52/44
Shepard's (1954) classification	silty clay	clayey silt	clayey silt	clayey silt
Water content (%)	56.9 ±2.5	48.3 ±2.2	53.7 ±2.4	54.1 ±2.4
Bulk density (g/cm^3)	1.37 ±0.03	1.47 ±0.03	1.41 ±0.03	1.40 ±0.03
Porosity	0.778 ±0.018	0.713 ±0.018	0.754 ±0.018	0.758 ±0.018
Void ratio	3.5 ±0.4	2.5 ±0.2	3.1 ±0.3	3.1 ±0.3

Table IV. Physical properties of foundation sediments prior to placement in phase I and II drop zones (1/11/99).

Core location	92-9	92-10	92-11	92-12
Sediment thickness in core (m)	0.50	0.50	0.50	0.50
Sand/silt/clay fraction (%)	2/54/44	3/55/42	8/32/60	1/57/42
Shepard's (1954) classification	clayey silt	clayey silt	silty clay	clayey silt
Water content (%)	59.6 ±2.7	57.8 ±2.6	61.6 ±2.7	48.5 ±2.2
Bulk density (g/cm^3)	1.34 ±0.03	1.36 ±0.03	1.31 ±0.03	1.47 ±0.03
Porosity	0.796 ±0.018	0.784 ±0.018	0.810 ±0.018	0.714 ±0.018
Void ratio	3.9 ±0.5	3.6 ±0.4	4.2 ±0.5	2.5 ±0.2

~~Core location~~	~~92-13~~	~~92-14~~	~~92-15~~	~~92-16~~
Sediment thickness in core (m)	0.50	0.50	0.50	0.50
Sand/silt/clay fraction (%)	2/30/68	2/53/45	9/46/45	8/34/58
Shepard's (1954) classification	silty clay	clayey silt	clayey silt	silty clay
Water content (%)	56.3 ±2.5	57.6 ±2.6	57.7 ±2.6	56.9 ±2.5
Bulk density (g/cm^3)	1.37 ±0.03	1.36 ±0.03	1.36 ±0.03	1.37 ±0.03
Porosity	0.774 ±0.018	0.783 ±0.018	0.783 ±0.018	0.778 ±0.018
Void ratio	3.4 ±0.4	3.6 ±0.4	3.6 ±0.4	3.5 ±0.4

The foundation sediments were predominantly banded grayish black, dark gray, or olive gray muddy sediments that fell into one of three categories (Shepard's 1954 classification, Figure 3). Of the sixteen sites sampled, ten were clayey silts, five were silty clays, and one was sand-silt-clay (Figure 4). The natural foundation sediments in Site 92 are the clayey silt muds (Halka and others, 1996). For clayey silts, the sand fraction ranged from 1 to 15%, silt fraction from 46 to 57%, and clay fraction from 32 to 45%. Water contents ranged from 48.3 to 59.6%. The silty clays resulted from the placement of sediments dredged from the Cutoff Angle, Swan Point, and Craighill Entrance channels and placed into former Area G-South in 1992-93 (Panageotou and Halka, 1994b). The silty clays had a sand fraction that ranged from 2 to 8%, silt fraction from 30 to 44%, and clay fraction from 53 to 68%. Water contents ranged from 55.4 to 61.6%. The sand-silt-clay had a sand fraction of 25%, silt fraction of 26% and clay fraction of 49%; water content was 57.3%. The average of the water contents at all 16 sites was 56.1%.

POST-PLACEMENT CONDITIONS

Bathymetric Changes

Figures 5 through 10 depict the post-placement bathymetry over the study period. These figures are presented in metric units with the contours labeled in meters. The figures are presented again in Appendix I in standard English units with the contours labeled in feet. The proposed work called for surveys to be conducted prior to placement, at the completion of placement, and at one, three, six, and nine months after placement. All the scheduled surveys were conducted; however, in addition to the scheduled nine month survey on January 6, 2000, an additional survey was conducted on February 21, 2000. Inclement weather and vessel scheduling conflicts delayed the nine month bottom sediment coring cruise until February 21, 2000. The final bathymetric survey, referred to as the eleven month survey, coincided with the final bottom sediment collection date.

The bathymetry at the completion of placement (April 7, 1999) is presented in Figure 5. The placed sediments formed a berm that filled the northeast end of the trough (tug channel) within Site 92. This created a basin near the center of placement site. Water depths throughout the phase I drop zone averaged 5.0 m [16.4 ft] and ranged from a minimum of 4.6 m [15.1 ft] to a maximum of 5.3 m [17.4 ft]. Water depths decreased since the pre-placement survey by as much as 3.7 m [12.1 ft] across the area of the placed berm. The lower southeast corner of the phase I drop zone, where the pre-placement water depth averaged 5.0 m [16.4 ft], was not affected by placement. Water depths throughout the phase II drop zone were more variable than in the phase I drop zone, averaging 5.5 m [18 ft] and ranging from 4.7 to 6.0 m [15.4 to 19.7 ft]. Water depths in the phase II zone decreased since the pre-placement survey by 0.1 to 3.0 m [0.3 to 9.8 ft].

Along the outside edge of the phase I drop zone, the placed sediments generally sloped to the north and east at an average gradient of 100H:1V [0.0100]. In one section, in the vicinity of northing 177,500, steeper gradients were present. In this area slopes ranged from 35H:1V [0.0286] to 50H:1V [0.0200]. As discussed in the Project Description section, the original plan for determining the phase I placement area utilized a bottom slope of 30H:1V [0.0333] for

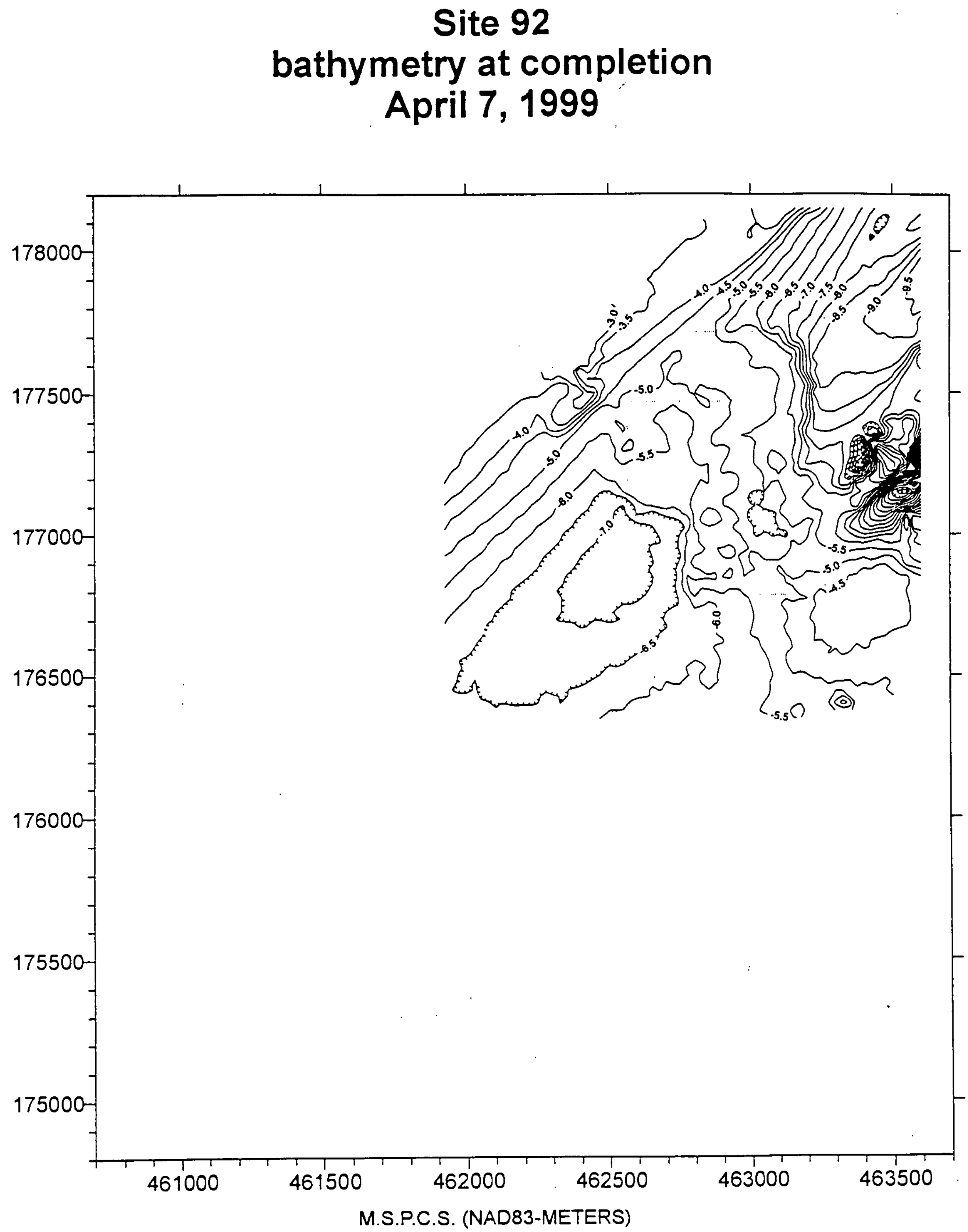

Site 92
bathymetry at completion
April 7, 1999

Figure 5. Bathymetry on April 7 1999, after completion of sediment placement. Depths in meters (contour interval 0.5 m).

Site 92
bathymetry at one month
May 6, 1999

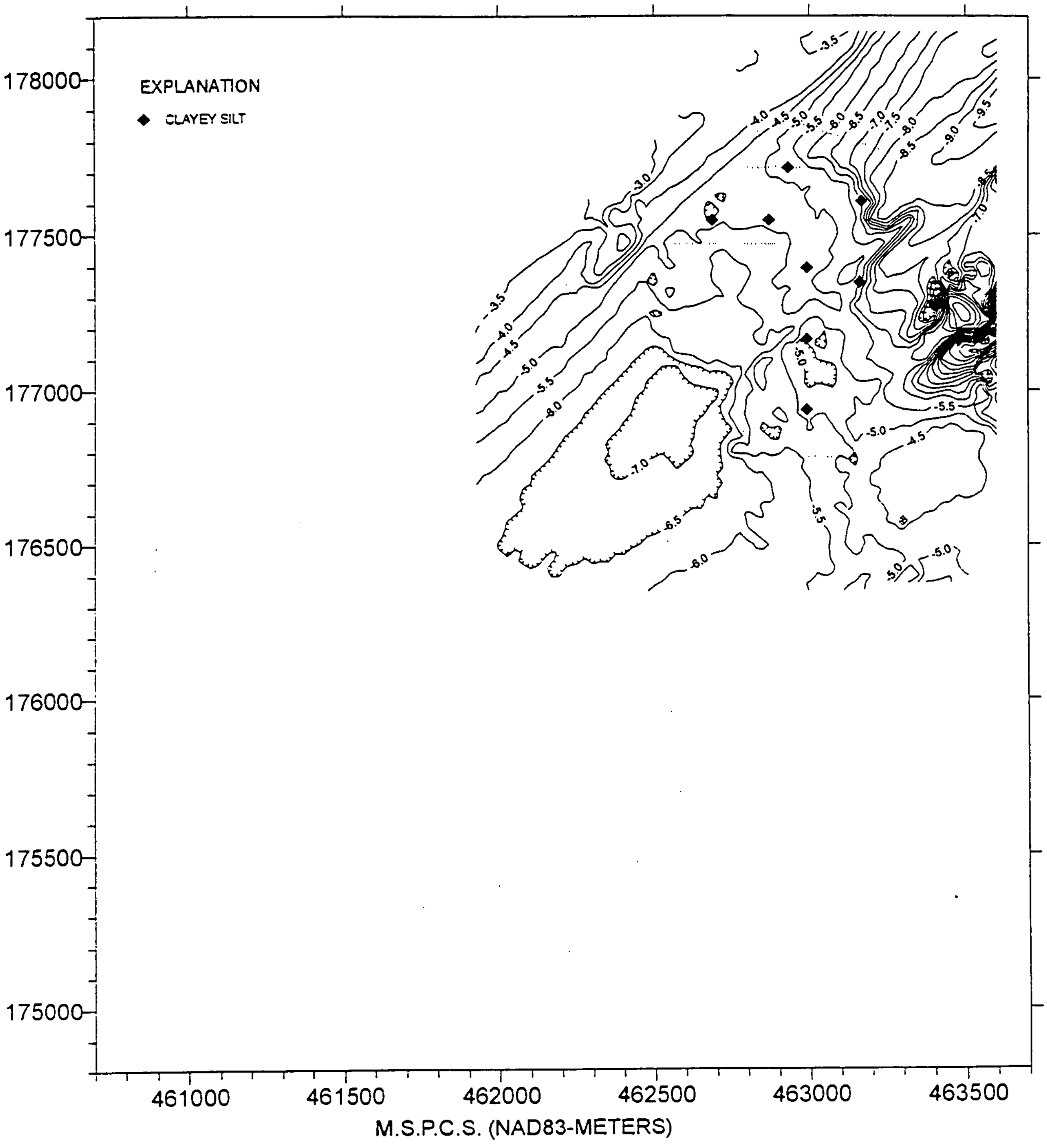


Figure 6. Bathymetry on May 6, 1999, one month after completion of sediment placement. Depths in meters (contour interval 0.5 m). Grain size distribution for placed sediments collected on April 28, 1999 is indicated. Refer to Figure 2 for identification of sediment core sites.

Site 92
bathymetry at three months
July 12, 1999

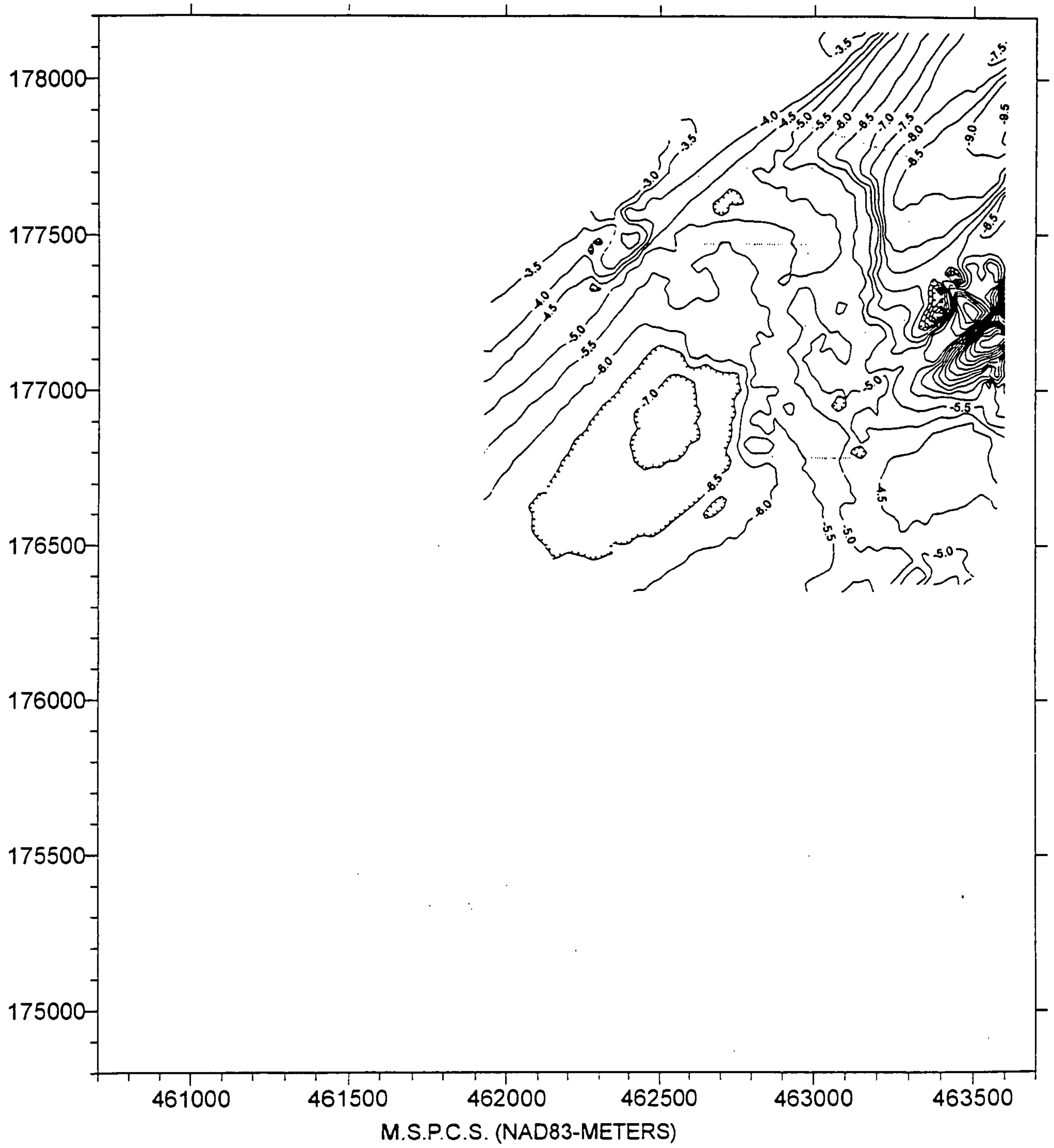


Figure 7. Bathymetry on July 12, 1999, three months after completion of sediment placement. Depths in meters (contour interval 0.5 m).

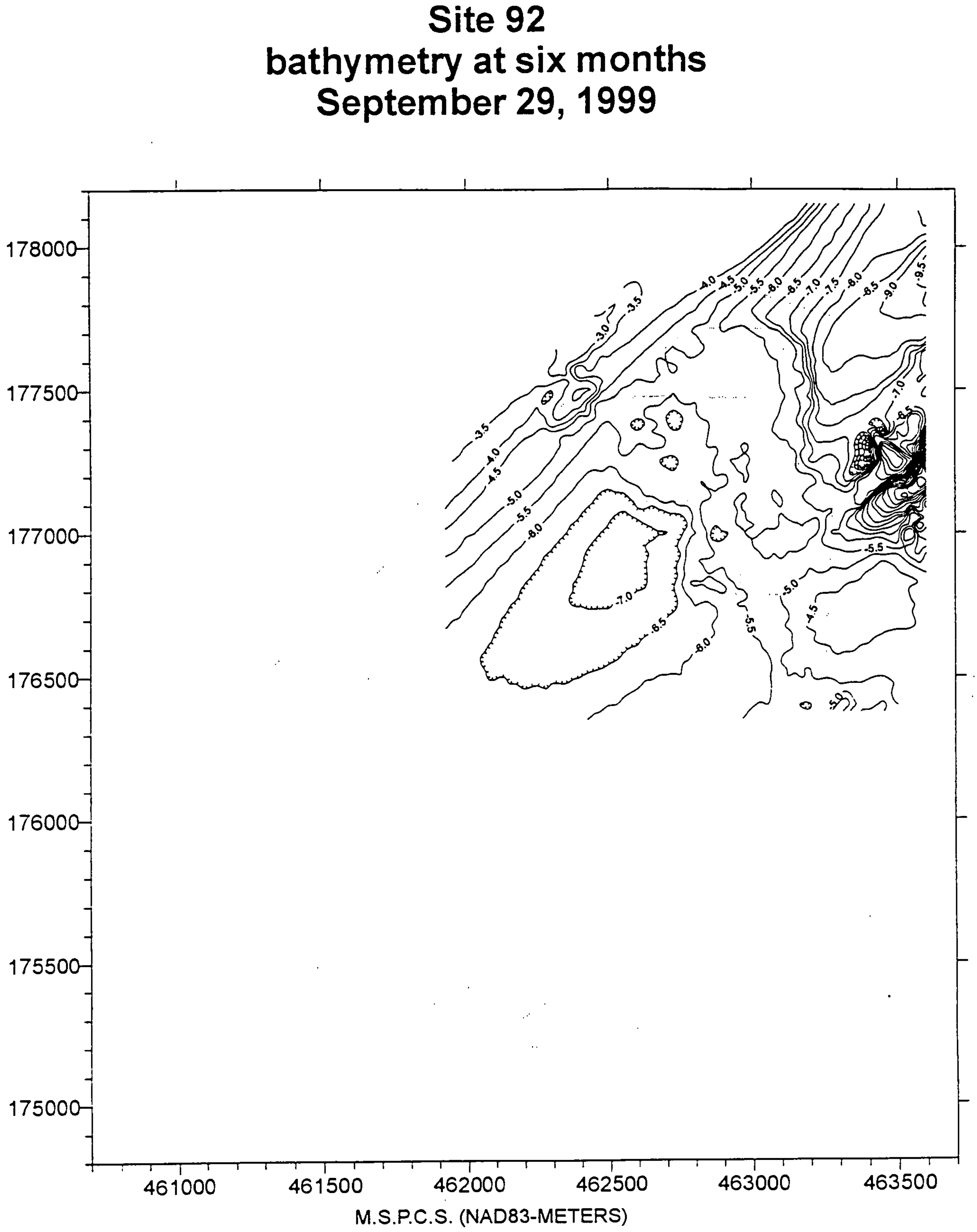


Figure 8. Bathymetry on September 29, 1999, six months after completion of sediment placement. Depths in meters (contour interval 0.5 m).

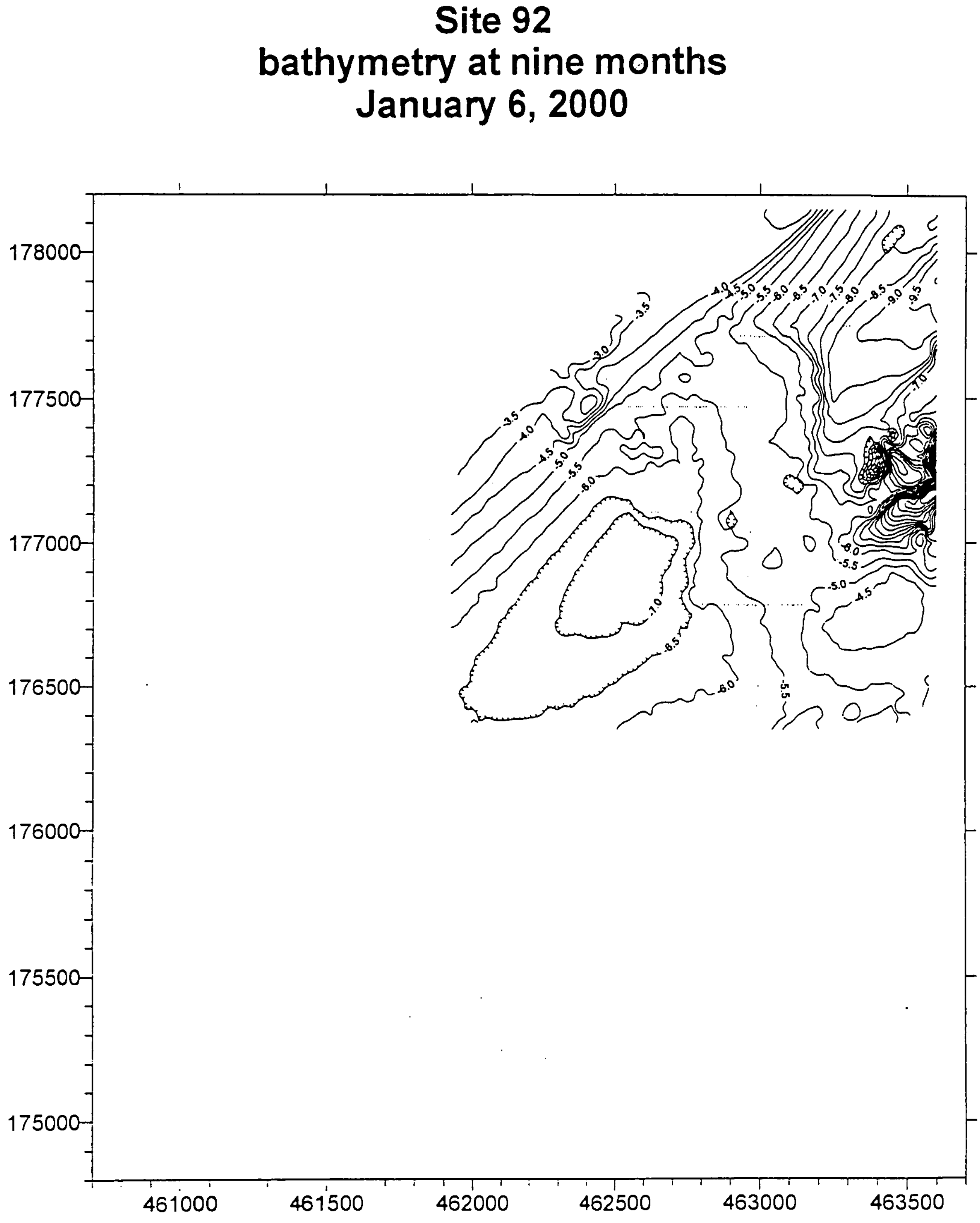

Site 92
bathymetry at nine months
January 6, 2000

Figure 9. Bathymetry on January 6, 2000, nine months after completion of sediment placement. Depths in meters (contour interval 0.5 m).

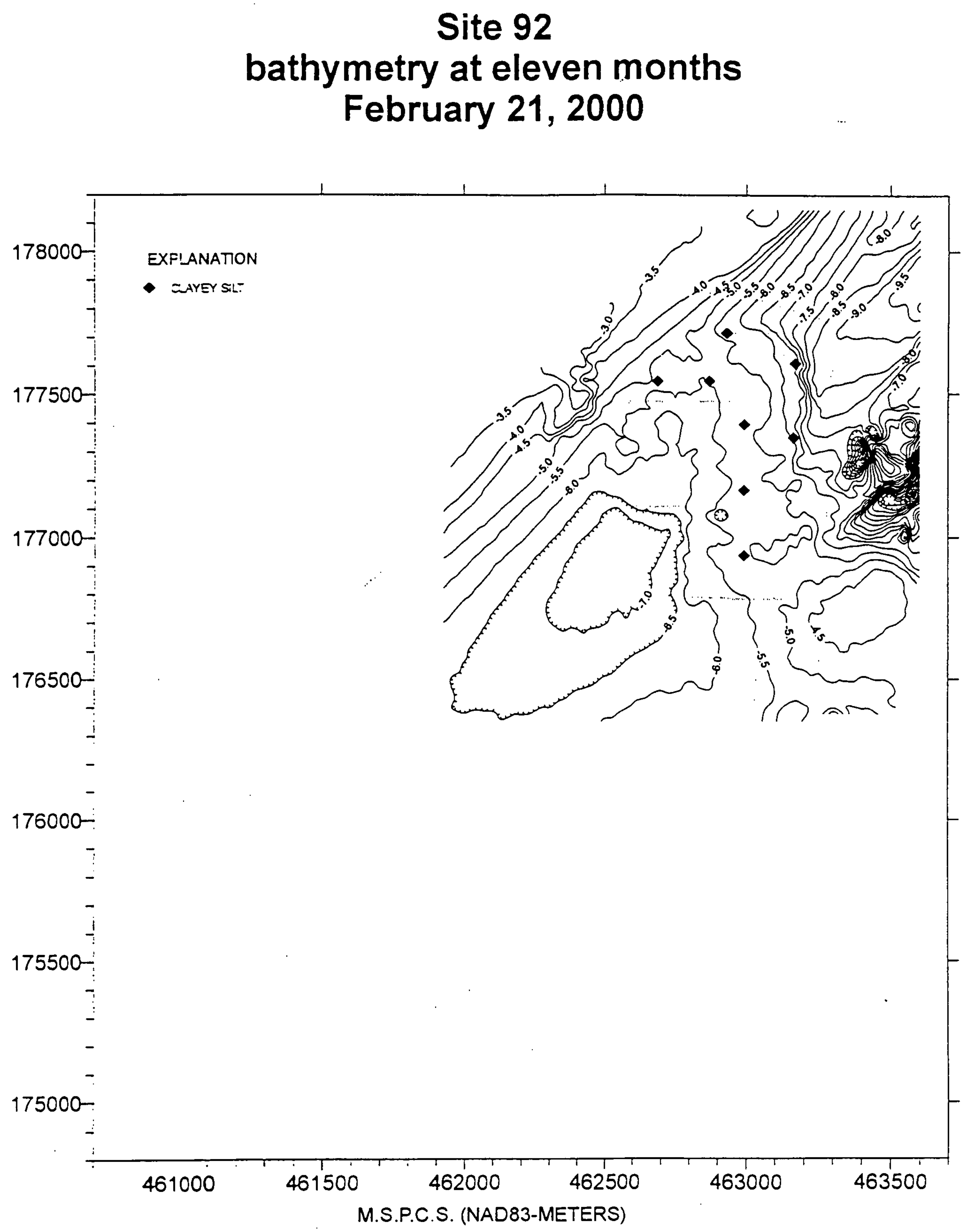


Figure 10. Bathymetry on February 21, 2000, eleven months after completion of sediment placement. Depths in meters (contour interval 0.5 m). Grain size distribution for placed sediments collected on February 22. 2000 is indicated. Refer to Figure 2 for identification of sediment core sites.

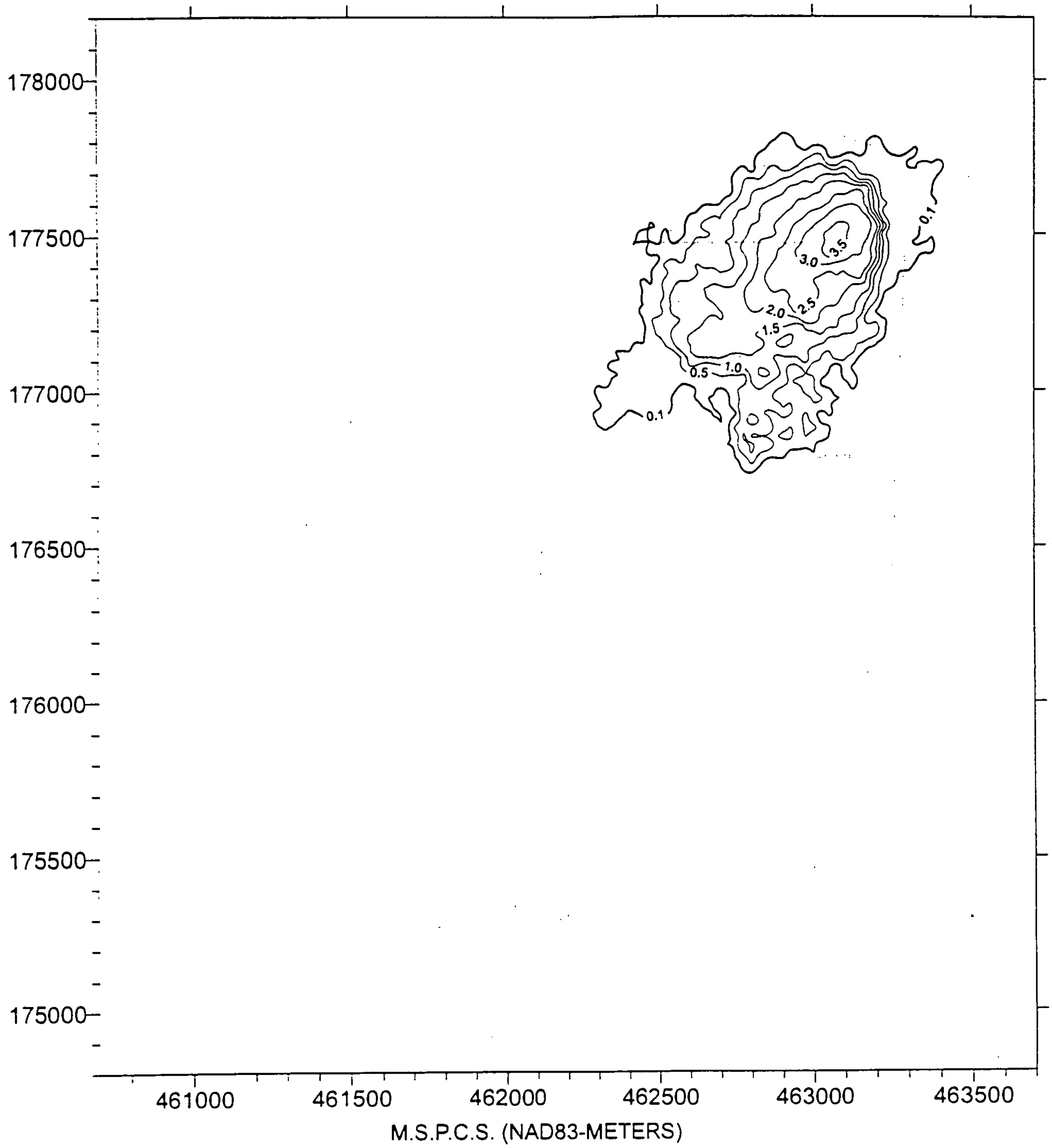
calculating the set-back from the site boundary. The 30H:1V [0.0333] estimated slope was based on the berm design proposed in the Final Environmental Assessment (Maryland Environmental Service, 1997). However, slopes of this magnitude were not achieved in this placement operation. In the phase II drop zone the placed sediment sloped to the southwest into deeper water in Site 92 at a lower gradient of 200H to 300H:1V [0.0050 to 0.0033]. The shallower slope in the phase II drop zone resulted from the wider distribution of the individual scow drops by the contractor. The completion survey indicated that the autoerized depth of4.27 m [14 ft] MLW depth was maintained over the entire placement area.

The bathymetric surveys over the eleven month post-placement period showed, in general, a gradual deepening over both the phase I and II drop zones (Figures 6 through 10). The greatest increases in water depth took place over the thicker sediment deposits of the berm in the phase I placement area. Depths over much of the berm top were 5.0 m [16.4 ft] at the completion of placement (Figure 5). The 5.0 m [16.4 ft] depth contour over the berm top showed a decrease in size on both the one month (Figure 6) and three month (Figure 7) surveys. By the six month survey most of the top of the berm had a depth between 5.0 m [16.4 ft] and 5.5 m [18 ft] (Figure 8), and the berm top remained at near this depth on both the nine and eleven month surveys (Figures 9 and 10). In the phase II placement area, where the deposited sediments were generally thinner, relatively smaller depth changes took place over the study period. Depths within this area largely remained between 5.5 m [18 ft] and 6.0 m [19.7 ft] on all the survey dates.

An obvious localized change occurred on the northeast periphery of the berm between the completion survey (Figure 5) and the one month survey (Figure 6). The one month survey showed a finger-like projection of the contour lines along the steep northeast slope (at approximately northing 177,500 - easting 463,200). This projection extended to the northeast approximately 150 m [500 ft] from the original base of the berm, and protruded as far as 100 m [330 ft] outside the site boundary. Apparently, sediment had slumped down the berm slope where the initial gradient was a relatively steep 50H:1V [0.0200] and had come to rest at a lower gradient of 80H:1V [0.0125] sometime between the completion and the one month survey. By the three month survey, these projecting contours were no longer evident (Figure 7).

The six month survey showed a continued increase in water depth over the top of the berm and minor changes in bathymetry over the northeast-southwest peripheral areas of the berm since the three month survey (Figure 8). The nine and eleven month surveys exhibited nearly identical bathymetries (Figures 9 and 10). Over the eleven month study period, water depths gradually increased over the berm by an average of 0.5 m [1.6 ft] (compare Figures 5 and 10). Eleven months following placement the average water depth in the phase I drop zone was 5.5 m [18 ft] and 6.0 m [19.7 ft] in the phase II drop zone. The resultant berm sloped to the northeast at a gradient of approximately 150H:1V [0.0067]. The placed sediments in the phase II drop zone sloped to the southwest at a gradient of 375H:1V [0.0027].

The extent of bathymetry changes over the study period can also be depicted as isopach maps created from the bathymetric data. Figures 11 through 16 depict bottom elevation changes that occurred between the pre-placement and each of the post-placement surveys (completion, one, three, six, nine, and eleven months). In these figures it is easier to delimit the areal extent of the bathymetric changes as well as the thicknesses of the deposited sediment. The 0.1 m [0.3 ft]



Site 92
change in elevation between pre-placement
and completion of placement

Figure 11. Isopach map showing change in elevation (in meters) between pre-placement (October 30, 1998) and completion of placement (April 7, 1999).

Site 92
change in elevation between
pre-placement and one month

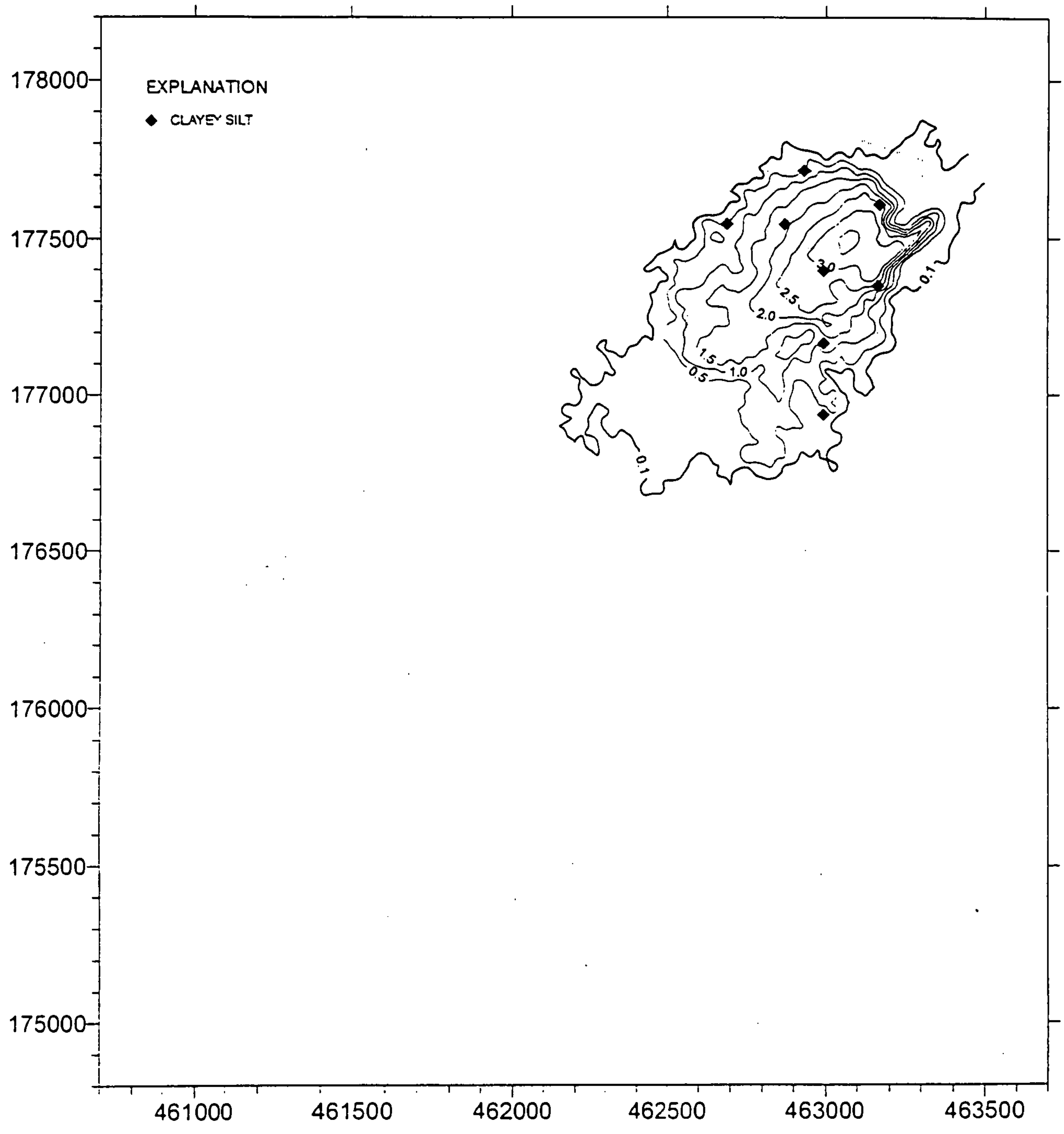
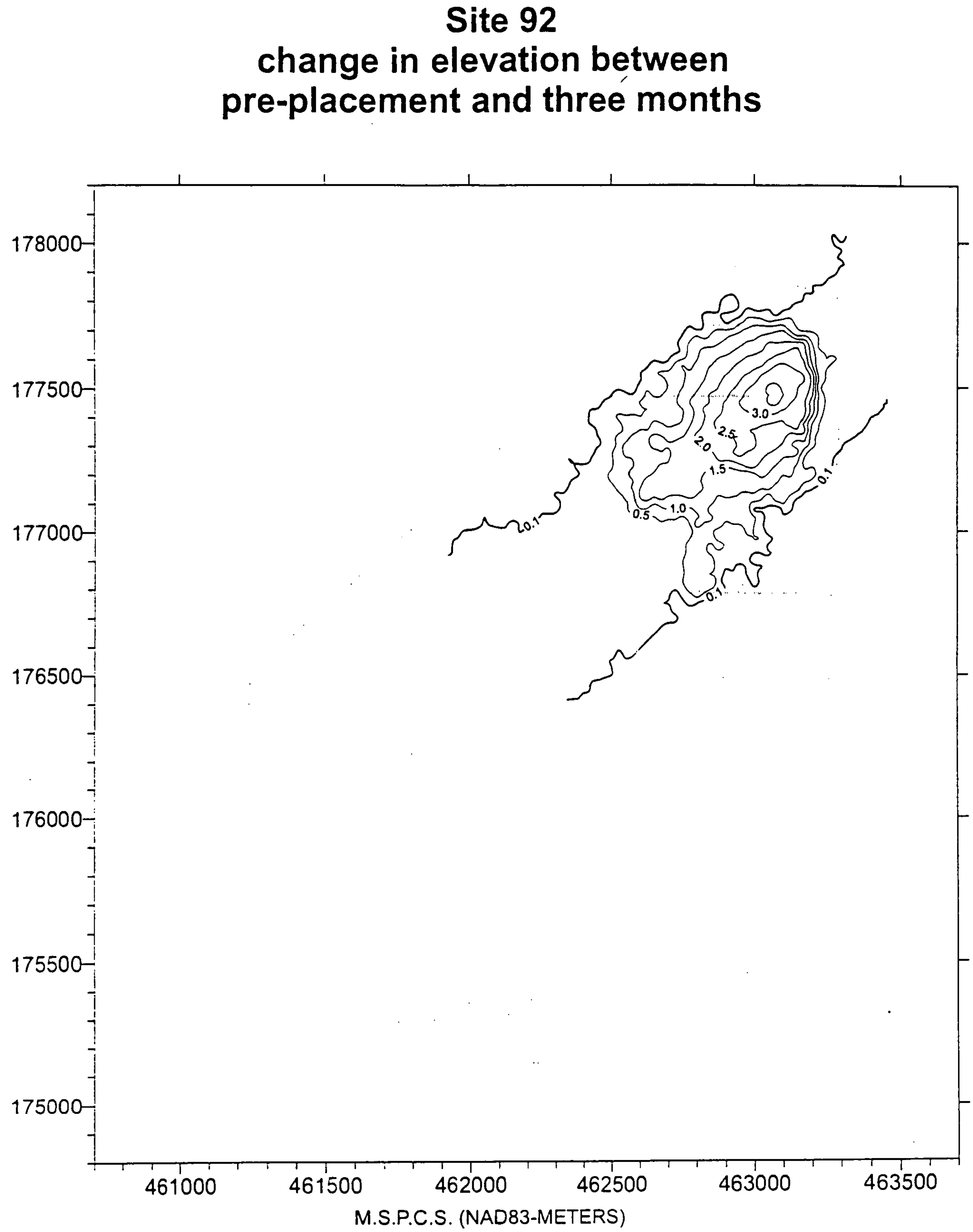


Figure 12. Isopach map showing increase in elevation (in meters) between pre-placement (October 30, 1998) and one month (May 6, 1999). Refer to Figure 2 for identification of sediment core sites.



Site 92
change in elevation between
pre-placement and three months

Figure 13. Isopach map showing increase in elevation (in meters) between pre-placement (October 30, 1998) and three months (July 12, 1999).

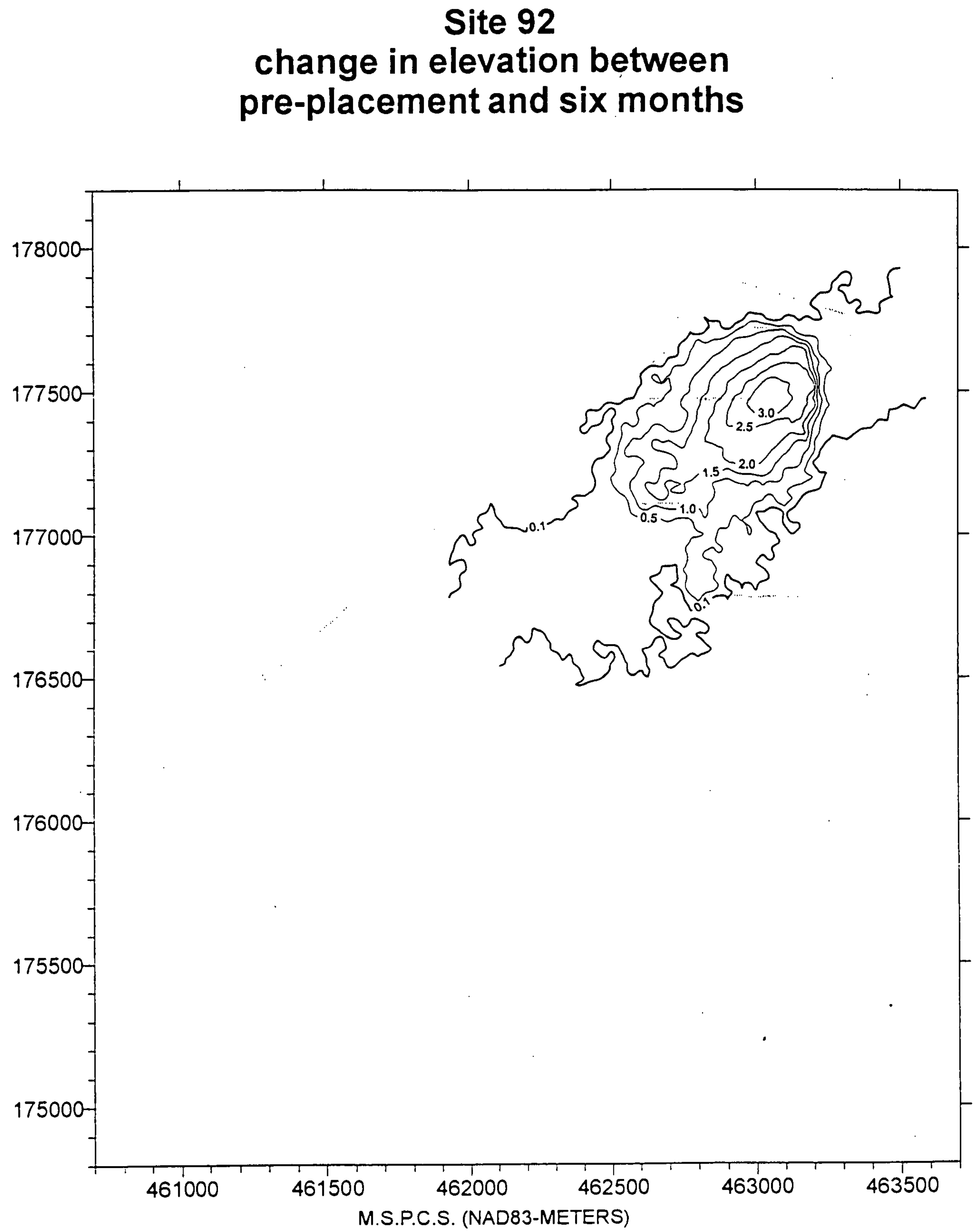


Figure 14. Isopach map showing increase in elevation (in meters) between pre-placement (October 30, 1998) and six months (September 29, 1999).

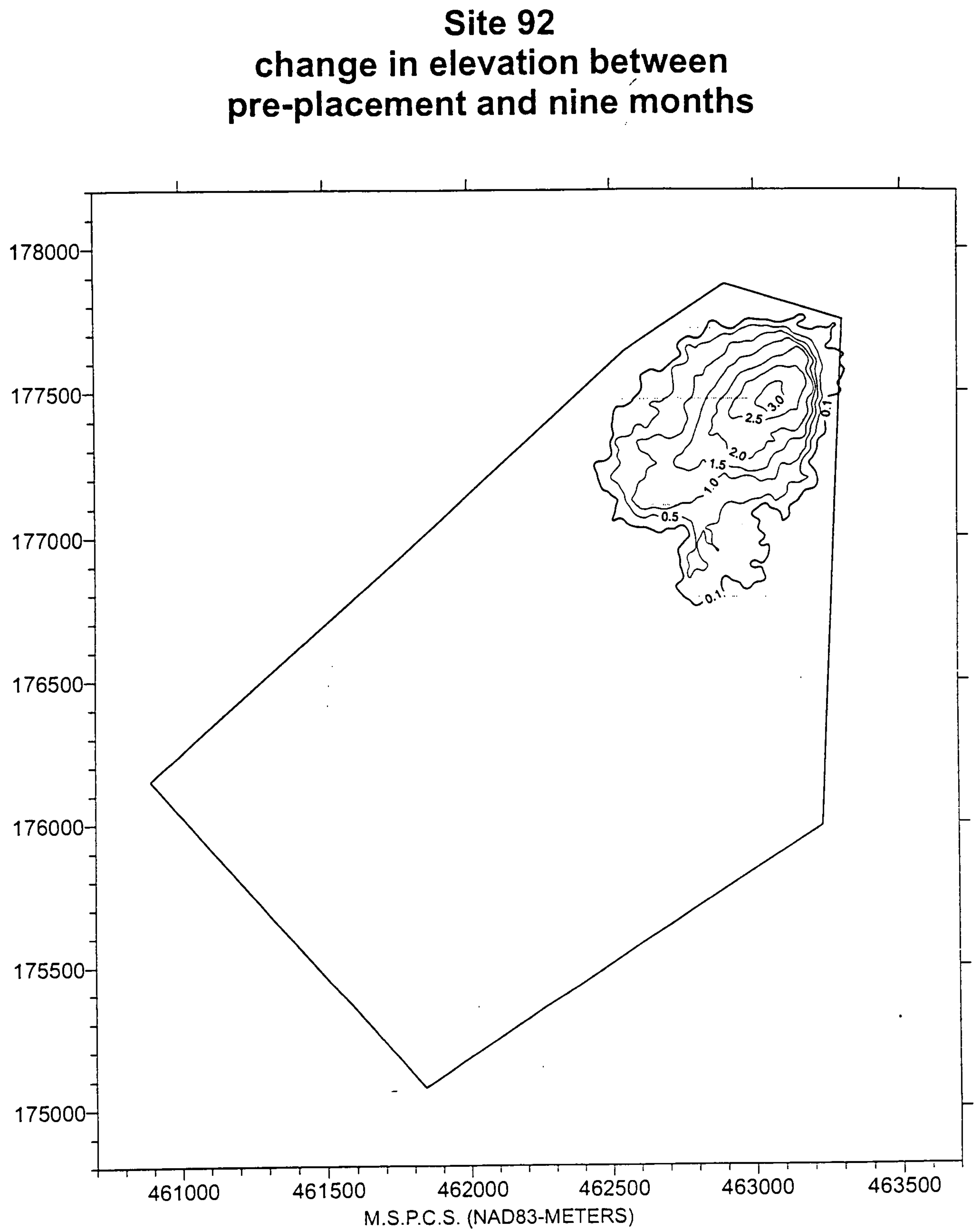

Site 92
change in elevation between
pre-placement and nine months

Figure 15. Isopach map showing increase in elevation (in meters) between pre-placement (October 30, 1998) and nine months (January 6, 2000).

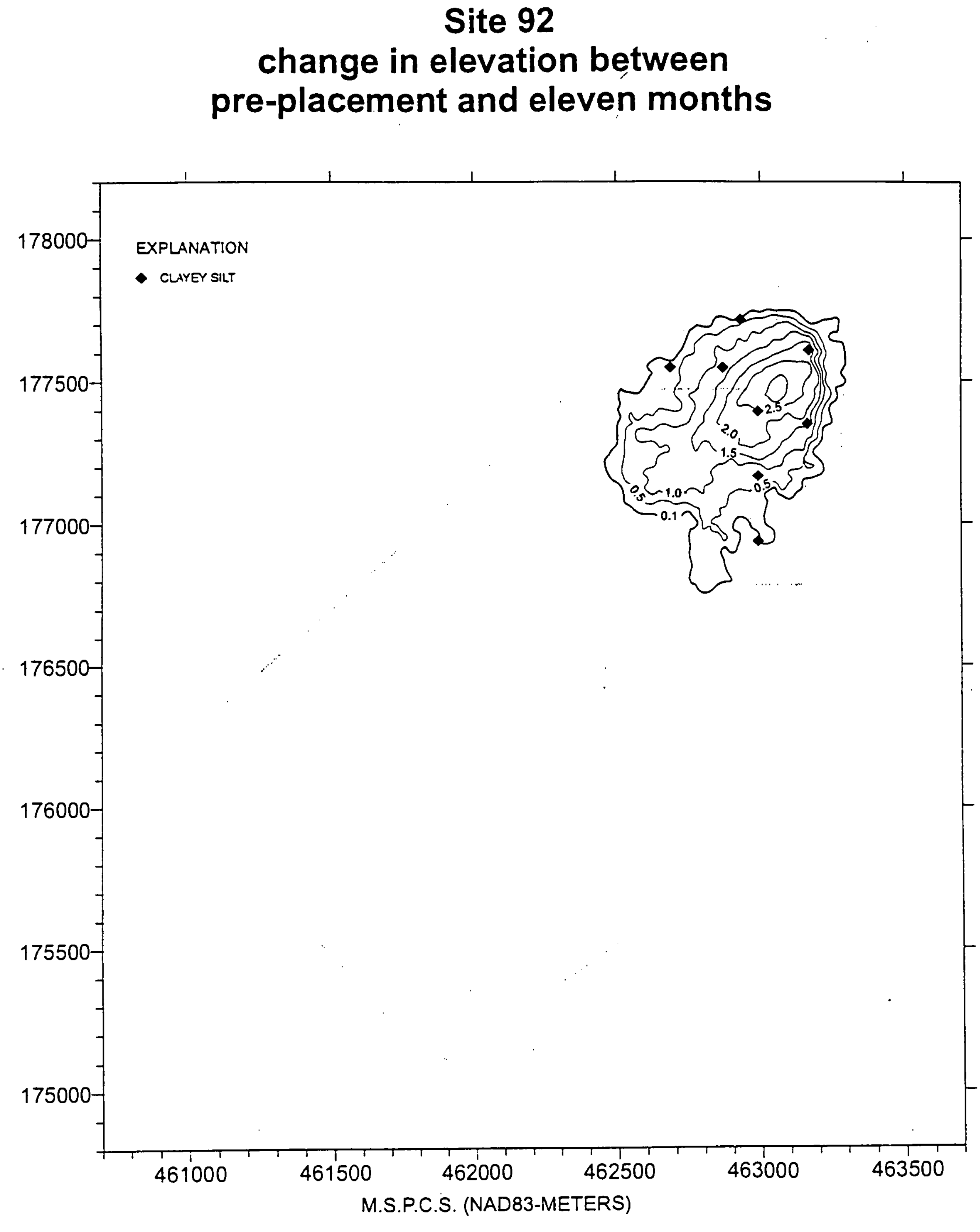


Figure 16. Isopach map showing increase in elevation (in meters) between pre-placement (October 30, 1998) and eleven months (February 22, 2000). Refer to Figure 2 for identification of sediment core sites.

contour is presented as a bold line and delineates the minimum elevation change discernable from the bathymetric data. The figures are presented again in Appendix II in standard English units with the contours labeled in feet.

Figure 11 presents the isopach of sediment thickness that resulted from the initial placement in the phase I and phase II drop zones. Sediment placement in the adjoining drop zones resulted in a thick contiguous deposit at the northeast end of Site 92. The initial area of placed sediments covered approximately 719,000 m^2 [860,000 yd^2]. The placed sediments formed a berm 1,300 m [4,300 ft] long and an average of 650 m [2,100 ft] wide. A comparison of Figure 11 with Figure 4 indicates that the thicker sediments were located along an axis stretching in a northeast-southwest direction in the center of the trough that had existed in the area prior to placement. The maximum deposited sediment thickness was 3.7 m [12.1 ft] in the phase I drop zone between northing 176,750 and 177,800, at the northeast corner of the berm. The placed sediments also exhibited maximum slopes at that location as indicated on Figure 5. Approximately 44% of the total area of placement, 315,000 m^2 [377,000 yd^2], had a deposited sediment thickness of 1.0 m [3.3 ft] or greater.

The extension of the 0.1 m [0.3 ft] contour in both a northeast and southwest direction from the defined placement areas suggests that tidal currents may have spread some of the less consolidated sediments beyond the drop zones (Figure 11). In addition, the thick sediment pile (lift) created at the edge of the placement area may have contributed to the movement of sediment to the northeast, beyond the site boundary. As indicated in the Site Management Report (Maryland Environmental Service, 2001), multiple scow drops were made within the northeast corner of the phase I drop zone. The maximum water depths prior to placement were 8.5 m [27.9 ft], and the bottom was elevated by as much as 3.7 m [12.1 ft] in the vicinity of northing 177,500 creating a steep slope on the east side of berm. Sediment that was deposited during the latter weeks of the placement period at this location likely moved downslope on the steep embankment and came to rest at the base of the slope, in water depths of 8.0 to 8.8 m [26.2 to 28.9 ft], thus pushing the 0.1 m [0.3 ft] contour to the northeast beyond the site boundary. The resultant 0.1 m [0.3 ft] contour line extended a maximum distance of 100 m [330 ft] in a northeast direction. At the site boundary, this sediment was approximately 0.15 m [0.5 ft] thick and thinned to the north and east. The sediment located outside of the boundary covered an area of 23,000 m^2 [28,000 yd^2] and had an approximate volume of 3,500 m^3 ±2,300 m^3 [4,600 yd^3 ±3,000 yd^3]. This represented less than one-half of one percent (0.4%) of the placed sediment identified at the site and of the volume reportedly placed by the contractor.

One month after placement, minimal elevation changes occurred over the top of the berm; however, some redistribution of sediment occurred on the periphery (Figure 12). As discussed above, sediment along the relatively steep northeast slope had slumped northeastward appearing in this figure as a finger-like projection. Immediately outside of the Site 92 boundary this sediment mass was between 2.0 and 2.5 m [6.6 and 8.2 ft] thick, but thinned rapidly in a northeast direction to less than 0.5 m [1.6 ft]. In addition, some additional sediment accumulated as a thin layer to the northeast and southwest of the center of the deposit. This area of sediment accumulation was revealed by the extension of the 0.1 m [0.3 ft] isopach contour when compared to the completion survey one month earlier (Figure 11). Apparently, some of the less consolidated and easily eroded surficial sediments were transported by tidal currents and deposited in the basin/tug channel located to the northeast and the southwest of the berm. The total area of the deposited sediment increased by one-fifth to 871,500 m^2 [1,042,000 yd^2] one month after placement due to this redistribution of material.

Three months following placement, sediments swept from the berm top decreased its thickness somewhat and appeared to be deposited as a thin, broad deposit, less than 0.25 m [0.8 ft] thick, in the deeper portion of the basin/tug channel (Figure 13). To the northeast, this deposit was present to the limits of the surveyed area and probably spread a short distance beyond. This accumulation covered an additional area of 400,000 m^2 [478,000 yd^2] in the deepest area of Site 92. The total area covered by the placed sediments increased above that identified on the completion survey by two-thirds to approximately 1,200,000 m^2 [1,432,000 yd^2]. However, by this date the slumped sediment mass observed on the one month survey had been largely eroded away and were no longer apparent beyond the site boundary.

The six month survey showed a continued reduction in the elevation of the berm to a maximum thickness of 3.4 m [11.2 ft] and some thinning of the sediments in the peripheral areas to the northeast and southwest (Figure 14). By the nine month survey, the sediments that had previously spread into the peripheral areas were no longer identifiable (Figure 15). By eleven months, the net area of the berm was reduced to approximately 533,000 m^2 [637,000 yd^2] or three-quarters of the original footprint (Figure 16). Approximately 44% of the total area of placement had a thickness of 1.0 m [3.3 ft] or greater. This was the same proportion as that identified at the completion of placement. The maximum thickness was reduced by 0.6 m [2 ft] since completion to 3.1 m [10.2 ft] at eleven months.

The sediment that spread to the northeast portion of the tug channel between the completion and three month surveys was located on similar, fine-grained bottom sediment (Figure 13). In a post-placement study of benthic organism recovery rates in Area G-West sediments, Scott (2000) determined that full recovery of the benthic community occurred within nine to twenty-one months of deposition. Similarly, post-placement studies of Areas G-Central and G-South indicated that the benthic community recovered to its original species composition and biomass within eight to eleven months (Versar, 1994). Studies of benthic recovery rates in Area G-West by Dalal (1996) found that the original community may completely recover within twelve to twenty-four months. Although no data on benthic organisms were collected during this monitoring effort, these earlier studies suggest that benthic community recovery should have been well underway between the six and nine month surveys. By the nine month survey, when the spread sediment was no longer apparent due to its removal and consolidation into the existing bottom, recovery was likely complete or nearly complete (Figure 15).

Sediment Properties

Sediment cores were scheduled for collection at completion of placement and nine months after placement. However as discussed in the Methods section, collection occurred on April 28, 1999 and February 22, 2000, approximately one month and eleven months, respectively, after the completion of placement. Of the sixteen sites selected for sampling prior to placement (Figure 2), only eleven were covered by placed sediments. Eight of the covered sites were selected for evaluation based on a range of sediment thicknesses (Table V). Three additional sites (92-4, 92-5, 92-6) were sampled for ground-truthing the bathymetric surveys. The bathymetry surveys indicated that these sites were not covered by placed sediments. The absence of placed sediments within the respective cores confirmed the bathymetric data.

In addition to sampling the placed sediments, these cores re-sampled the underlying foundation sediments to evaluate foundation consolidation due to the weight of the overburden. Tables V and VI summarize the physical properties of the placed sediments at the one month and eleven month collection dates. Figures 6, 10, 12, and 16 show the core locations on the bathymetric and isopach maps. Figure 17 exhibits cross-section profiles at the core locations depicting the bathymetry and the *in situ* placed sediment thickness at completion, one month, and eleven months. The sediment thicknesses listed in the tables are less than the *in situ* thickness due to core shortening (refer to Methods section). The discussion concerning bulk properties focuses on the results of the mean water content analyses. The other properties (bulk density, porosity, and void ratio), calculated from the water content, are included in the tables for completeness.

The grain size classification at the eight sites sampled was clayey silt (Shepard's 1954 classification, Figure 3). The placed sediments were primarily olive gray in color. The sand content ranged from 2 to 6%, silt from 51 to 54%, and clay from 40 to 46%. Water content ranged from 53.9 to 58.8%, a 4.9% variation. This variation is primarily related to the time lapse in the chronology of scow placement. The average of the mean water content values, 56.5%, was utilized to calculate a bulking factor for the placed sediments at the disposal site and for post-placement consolidation/erosion calculations (see Tables X and XI in section: Volumetric Analyses - Dredged and Placement Amounts and Table XIV in section: Volumetric Analyses After Placement - Consolidation and Erosion). The average placed sediment water content was 0.1 percent greater than that of the channel sediments. Clamshell dredged sediments in the Bay typically undergo a volume increase of approximately 10 to 15% because of water-loading when placed in scows (J. Martin and R. Jackson, Great lakes Dredge & Dock Company; D. Nelson, Weeks Marine, Inc., personal communication). However, dewatering of the sediments during placement and over the one month period following placement reduced the placed sediment water content to nearly that measured in the channel sediments prior to dredging.

At the time of the eleven month survey, the grain size classification at all eight sites was clayey silt (Table VI). The sand/silt/clay fractions were within a few percent of those collected at one month following placement. The placed sediments exhibited a 6.6% water content variation, from 50.4 to 57.0%. The sediments dewatered by an average of 2.9% over the post-placement study period to an average 53.6%. This value was utilized for consolidation/erosion calculations (see Table XIV in section: Volumetric Analyses After Placement - Consolidation and Erosion).

Site 92
cross-section profiles at core locations

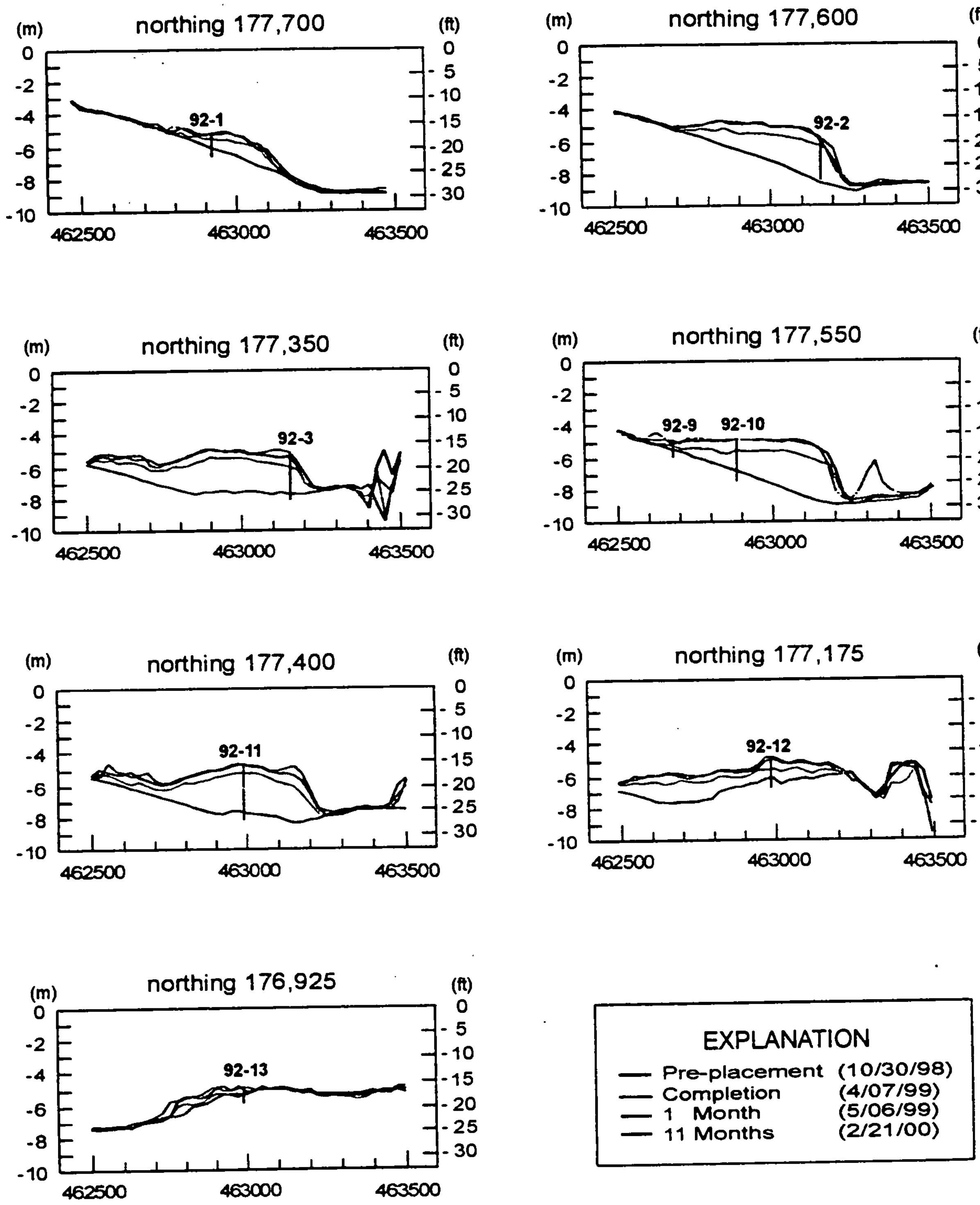


Figure 17. West to east cross-section profiles at core locations depicting bathymetry through time and *in situ* sediment thickness at times of collection. Refer to Figure 2 for core locations. Horizontal coordinates are S.P.C.S., NAD 83- meters. Elevation below MLLW is in meters on left axis and feet on right axis. Vertical exaggeration is 50x.

Table V. Physical properties of placed sediments one month after completion of placement (4/28/99).

Core location	92-1	92-2	92-3	92-9
Sediment thickness in core (m)	0.80	2.75+	2.40	0.52
Sand/silt/clay fraction (%)	4/51/45	3/52/45	5/51/44	3/52/45
Shepard's (1954) classification	clayey silt	clayey silt	clayey silt	clayey silt
Water content (%)	55.1 ±2.5	55.1 ±2.5	53.9 ±2.4	58.3 ±2.6
Bulk density (g/cm^3)	1.39 ±0.03	1.39 ±0.03	1.40 ±0.03	1.35 ±0.03
Porosity	0.765 ±0.018	0.765 ±0.018	0.756 ±0.018	0.787 ±0.018
Void ratio	3.3 ±0.3	3.3 ±0.3	3.1 ±0.3	3.7 ±0.4

~~Core location~~	~~92-10~~	~~92-11~~	~~92-12~~	~~92-13~~
Sediment thickness in core (m)	1.54	2.80	0.70	0.47
Sand/silt/clay fraction (%)	3/53/44	6/54/40	3/51/46	2/53/45
Shepard's (1954) classification	clayey silt	clayey silt	clayey silt	clayey silt
Water content (%)	57.0 ±2.5	55.5 ±2.5	58.8 ±2.6	58.5 ±2.6
Bulk density (g/cm^3)	1.37 ±0.03	1.38 ±0.03	1.35 ±0.03	1.35 ±0.03
Porosity	0.779 ±0.018	0.767 ±0.018	0.791 ±0.018	0.789 ±0.018
Void ratio	3.5 ±0.4	3.3 ±0.3	3.8 ±0.4	3.7 ±0.4

+ Site 92-2 did not penetrate the full thickness of the placed sediments

Table VI. Physical properties of placed sediments eleven months after completion of placement (2/22/00).

Core location	92-1	92-2	92-3	92-9
Sediment thickness in core (m)	0.38	2.33	2.11	0.27
Sand/silt/clay fraction (%)	4/51/45	3/52/45	4/51/44	3/52/45
Shepard's (1954) classification	clayey silt	clayey silt	clayey silt	clayey silt
Water content (%)	54.3 ±2.4	53.2 ±2.4	50.4 ±2.2	56.7 ±2.5
Bulk density (g/cm^3)	1.40 ±0.03	1.41 ±0.03	1.45 ±0.03	1.37 ±0.03
Porosity	0.759 ±0.018	0.751 ±0.018	0.729 ±0.018	0.776 ±0.018
Void ratio	3.1 ±0.3	3.0 ±0.3	2.7 ±0.3	3.5 ±0.4

~~Core location~~	~~92-10~~	~~92-11~~	~~92-12~~	~~92-13~~
Sediment thickness in core (m)	1.12	2.03	0.83	0.38
Sand/silt/clay fraction (%)	4/53/43	6/54/40	3/51/46	2/53/45
Shepard's (1954) classification	clayey silt	clayey silt	clayey silt	clayey silt
Water content (%)	53.4 ±2.4	52.6 ±2.3	51.0 ±2.3	57.0 ±2.5
Bulk density (g/cm^3)	1.41 ±0.03	1.42 ±0.03	1.44 ±0.03	1.37 ±0.03
Porosity	0.752 ±0.018	0.746 ±0.018	0.734 ±0.018	0.779 ±0.018
Void ratio	3.0 ±0.3	2.9 ±0.3	2.8 ±0.3	3.5 ±0.4

DISCUSSION

Consolidation of Foundation Sediments

Dewatering of the foundation sediments is expected to occur through time and result in some consolidation after placement. Without accounting for foundation consolidation, the placed sediment volumes determined through the bathymetric surveys may be underestimated. Therefore, foundation consolidation was evaluated and included in the calculations to derive the most accurate volumes possible.

The depth to which foundation consolidation is affected by the overburden of placed sediments is unknown. This study evaluated the upper 0.5 m [1.6 ft] foundation layer because this was the estimated maximum thickness that the coring device could penetrate through placed sediments and recover pre-placement foundation sediments. Poindexter-Rollings (1990) determined that foundation consolidation should be greatest in the upper portion of the underlying sediment column. Based on that research, it was assumed that if minimal foundation consolidation was identified in the upper 0.5 m [1.6 ft] layer, then it was likely consolidation was negligible below this level.

Tables III and IV list the physical properties of the foundation sediments within Site 92 sampled prior to placement. Tables VII and VIII list the properties of the foundation sediments at one month and eleven months after completion of placement. At coring location 92-2, the placed sediments were not fully penetrated during post-placement sampling; therefore, foundation sediments were not recovered. Table IX summarizes the change in mean water content values over the three sampling periods at the remaining seven sites affected by the overburden of placed sediments.

Table VII. Physical properties of foundation sediments one month after completion of placement (4/28/99).

Core location	92-1	92-2	92-3	92-9
Sediment thickness in core (m)	0.50	n/a	0.50	0.50
Sand/silt/clay fraction (%)	2/53/45		12/28/60	1/50/49
Shepard's (1954) classification	clayey silt		silty clay	clayey silt
Water content (%)	56.1 ±2.5		57.8 ±2.6	57.7 ±2.6
Bulk density (g/cm^3)	1.38 ±0.03		1.36 ±0.03	1.37 ±0.03
Porosity	0.772 ±0.018		0.784 ±0.018	0.783 ±0.018
Void ratio	3.4 ±0.4		3.6 ±0.4	3.6 ±0.4

Table VII continued. Physical properties of foundation sediments one month after completion of placement).

Core location	92-10	92-11	92-12	92-13
Sediment thickness in core (m)	0.50	0.50	0.50	0.50
Sand/silt/clay fraction (%)	4/53/43	5/45/50	1/58/41	1/50/49
Shepard's (1954) classification	clayey silt	silty clay	clayey silt	clayey silt
Water content (%)	53.6 ±2.4	50.3 ±2.2	50.2 ±2.2	49.3 ±2.2
Bulk density (g/cm^3)	1.42 ±0.03	1.46 ±0.03	1.46 ±0.03	1.47 ±0.03
Porosity	0.754 ±0.018	0.729 ±0.018	0.727 ±0.018	0.720 ±0.018
Void ratio	3.1 ±0.3	2.7 ±0.3	2.7 ±0.2	2.6 ±0.2

Table VIII. Physical properties of foundation sediments at eleven months (2/22/00).

Core location	92-1	92-2	92-3	92-9
Sediment thickness in core (m)	0.50	n/a	0.50	0.50
Sand/silt/clay fraction (%)	3/58/39		17/29/54	5/51/44
Shepard's (1954) classification	clayey silt		silty clay	clayey silt
Water content (%)	57.8 ±2.6		58.4 ±2.6	56.7 ±2.5
Bulk density (g/cm^3)	1.36 ±0.03		1.35 ±0.03	1.37 ±0.03
Porosity	0.784 ±0.018		0.788 ±0.018	0.776 ±0.018
Void ratio	3.6 ±0.4		3.7 ±0.4	3.5 ±0.4

~~Core location~~	~~92-10~~	~~92-11~~	~~92-12~~	~~92-13~~
Sediment thickness in core (m)	0.50	0.50	0.50	0.50
Sand/silt/clay fraction (%)	4/53/43	5/51/44	2/50/48	3/43/54
Shepard's (1954) classification	clayey silt	clayey silt	clayey silt	silty clay
Water content (%)	55.4 ±2.5	54.2 ±2.4	50.8 ±2.3	52.7 ±2.3
Bulk density (g/cm^3)	1.38 ±0.03	1.40 ±0.03	1.44 ±0.03	1.42 ±0.03
Porosity	0.767 ±0.018	0.758 ±0.018	0.733 ±0.018	0.747 ±0.018
Void ratio	3.3 ±0.3	3.1 ±0.3	2.7 ±0.3	2.9 ±0.3

Table IX. Change in foundation sediment water content values through time [1].

	site 92-1	**site 92-2**	**site 92-3**	**site 92-9**
placement period change in water content between pre-placement (10/19/98 & 1/11/99) and one month after placement (4/28/99)	-1.9	n/a	+0.5	-1.9
	site 92-10	**site 92-11**	**site 92-12**	**site 92-13**
	-4.2	-11.3	+1.7	-7.0
post-placement period change in water content between one month after placement (4/28/99) and eleven months after placement (2/22/00)	**site 92-1**	**site 92-2**	**site 92-3**	**site 92-9**
	+1.7	n/a	+0.6	-1.0
	site 92-10	**site 92-11**	**site 92-12**	**site 92-13**
	+1.8	+3.9	+0.6	+3.4

[1] Positive values indicate an increase in water content. Negative values indicate a decrease in water content.

No trend was immediately evident from the data. The change in foundation sediment water content values over the sampling periods varied significantly from site to site (Table IX). In most cases, the change in the mean water content values fell within the uncertainty range of the water content measurements. The variations resulted from factors including the overlying thickness of the placed sediments, the porosity and permeability of the foundation sediments, and sampling and analytical errors.

An average of the mean water content measurements from the multiple cores was calculated at pre-placement, at one month after completion, and at eleven months. The average of the foundation sediment water content prior to placement was 57.0% ±3.8%. At one month after completion of placement, the average water content was to 53.6% ±3.4%. A reduction of 3.4% occurred between pre-placement and one month after placement. At eleven months after placement, the average water content was to 55.1% ±2.6%, an increase of 1.5% over the post-placement period.

Statistical analyses were run on the data (t-test) to determine if the change in foundation sediment water content values over the sampling periods was definitively quantifiable. The first test demonstrated that change in foundation sediment water content values between pre-placement and one month was statistically significant (at 90% confidence level). Therefore, foundation consolidation occurred over this period. The 3.4% decrease in the average water content values over the placement period equated to a 10% volumetric reduction in the foundation sediments throughout the area. Assuming uniform settling throughout the 0.5 m [1.6 ft] foundation, 5 cm [2 in] of sediment consolidation occurred. A change of this magnitude increased the calculated volume of placed sediment by 36,000 m^3 [47,000 yd^3]. A second test demonstrated that the change in foundation sediment water content values between one month and eleven months was not statistically significant (at 99% confidence level). Therefore, no quantifiable consolidation occurred after one month of completion of placement.

In three previous studies of foundation consolidation at Area G-West, a 4 and 5% volumetric change occurred in the foundation sediments over the placement period, and a 2 and 4% volumetric change occurred over the post-placement period (Panageotou and others, 1997, 1998; Panageotou, 1999). The relatively greater amount of foundation consolidation during placement at Site 92 may be due to a much thicker pile (lift) of placed sediments in this operation. In Area G-West, maximum thicknesses of placed sediments were generally between 1.5 and 2 m [5 and 6.5 ft] in comparison to 3.5 m [11 ft] at Site 92. Another factor may be the one month delay in collecting the Site 92 completion cores. This would have the effect of reducing the volume change over the post-placement period by adding that amount into the placement period calculations.

Volumetric Analyses - Dredged and Placement Amounts

The study evaluated the quantity of dredged sediment present at the placement site soon after the completion of dredging and placement operations. CENAP and the contractor both provided estimates of the quantity of dredged sediment. In this year's operation, there were differences in the reported quantity dredged. This is not unusual given the variations in measurement techniques for large volumes of sediment and water. CENAP reported a "pay yardage" sediment volume of 580,740 m^3 [759,534 yd^3] was dredged from the channel. The contractor reported on their Daily Report of Operations (DRO) that a sediment volume of 833,695 m^3 [1,090,367 yd^3] was dredged from the channel. The contractor's dredged volume was 252,955 m^3 [330,833 yd^3] or 44% more than CENAP.

The reported dredged volumes in conjunction with bulk property and bathymetric data collected by MGS were used to estimate the change in sediment volume at completion of placement operations. During mechanical excavation, scow loading, and bottom placement operations, dredged sediment is initially bulked to a greater volume than the in *situ* volume due to water-loading (Dortch and others, 1990, Poindexter-Rollings, 1990, Palermo and others, 1990). However, deficit of sediment is expected at completion of placement operations. This deficit results from the following processes: (1) consolidation of the placed sediment during the placement period, (2) suspended sediment loss in primary turbidity plumes during dredging and placement, and (3) erosion of placed sediment during the placement period. The completion bathymetric survey was conducted seven days after the final day of placement. Additional consolidation and erosion occurred in the seven day interval between the completion of placement and the completion survey.

The volumetric analyses is presented in both cubic meters (Table X) and cubic yards (Table XI). The expected volume at the placement site (column *e*) was determined by multiplying a derived bulking ratio (column *d*) by the reported volume of dredged sediments (column *a*). The expected volume (column *e*) was rounded off to the nearest 500 m^3 [500 yd^3]. The bulking ratio is a function of the change in porosities (equation 6, Methods section) which are calculated from the mean water contents of the dredged channel sediments (column *b*) and the placed sediments (column *c*). The percent water content of the C&D Canal approach channel sediments (column *b*) was the calculated average of five sediment cores collected on October 19, 1998 in areas where maintenance dredging was to occur (Table II). The percent water content of the placed sediments in Site 92 (column *c*) was the calculated average of eight cores collected on April 28, 1999, one month after completion of placement (Table V). The standard deviation (σ) for each water content average is shown as the ± component of the water content in columns *b* and *c*. The volume of sediment identified at the placement site (column *f*) was calculated on the basis of bathymetric measurements. The ± component in column *f* reflects the possible range in the volume of sediment identified. The ranges are shown for completeness.

Table X. Comparison of bulk property and volumetric data in cubic meters using CENAP's and contractor's (DRO) reported volume dredged.

(*a*) reported volume dredged (m^3)		(*b*) % water content of channel sediment [range]	(*c*) % water content of placed sediment [range]	(*d*) bulking ratio from water content data [range]	(*e*) expected volume of sediment at placement site (m^3) [range]	(*f*) volume of sediment identified at placement site (m^3) [range]	(*g*) volume difference identified at placement site (m^3) [range]	(*h*) volume difference identified at placement site (%) [range]
CENAP	**580,740**	**56.4 ±1.6** [54.8 to 58.0]	**56.5 ±1.6** [54.9 to 58.1]	**1.00** [0.91 to 1.11]	**580,500** [528,500 to 644,500]	**792,000 ±73,000** [719,000 to 865,000]	**+211,500** [+74,500 to +336,500]	**+36** [+12 to +64]
DRO	**833,695**				**833,500** [758,500 to 925,500]		**-41,500** [-206,500 to +106,500]	**-5** [-22 to +14]

Table XI. Comparison of bulk property and volumetric in cubic yards data using CENAP's and contractor's (DRO) reported volume dredged.

(*a*) reported volume dredged (yd^3)		(*b*) % water content of channel sediment [range]	(*c*) % water content of placed sediment [range]	(*d*) bulking ratio from water content data [range]	(*e*) expected volume of sediment at placement site (yd^3 [range]	(*f*) volume of sediment identified at placement site (yd^3) [range]	(*g*) volume difference identified at placement site (yd^3) [range]	(*h*) volume difference identified at placement site (%) [range]
CENAP	**759,534**	**56.4 ±1.6** [54.8 to 58.0]	**56.5 ±1.6** [54.9 to 58.1]	**1.00** [0.91 to 1.11]	**759,500** [691,000 to 843,000]	**1,035,500 ±95,000** [940,500 to 1,130,500]	**+276,000** [+97,500 to +439,500]	**+36** [+12 to +64]
DRO	**1,090,367**				**1,090,500** [992,000 to 1,210,500]		**-55,000** [-270,000 to +138,500]	**-5** [-22 to +14]

After the completion of placement, the volume of placed sediment identified at Site 92 was 792,500 m^3 ±73,000 m^3 [1,035,500 yd^3 ±95,000 yd^3]. This represented an excess of 211,500 m^3 [276,000 yd^3] or 36% utilizing the CENAP reported dredged volume, and a deficit of 41,500 m^3 [55,000 yd^3] or 5% using the contractor's reported volume. Based on the total volume of sediment identified and discussions with CENAP personnel, the volume that CENAP reported dredged may be an underestimate. It was reported that the CENAP volume was calculated as a pay yardage volume to the -41 ft depth (W. DePrefontaine, oral commun., 2000). The volume that the contractor reports is a gross quantity that often includes dredging below the -41 ft depth, and thus is probably a more valid volume. The volumetric deficit of 41,500 m^3 [55,000 yd^3] or 5%, calculated from the volume the contractor reported dredged, is a reasonable approximation of the sediment loss from scow placement in Site 92.

It should be noted that because of the lapse in time between the completion survey (seven days) and the collection of the cores (one month), the effect of consolidation on the sediment volume change could only be roughly estimated. The bulking ratio of 1.00 (Tables X and XI, column *d*), is lower than typically determined in sediment cores collected within one week of completion of placement. In order to more accurately estimate the effect of consolidation on the volume change near the time of completion , a bulking ratio of 1.04 could be used (Panageotou, 1999). This bulking ratio, calculated from cores collected three days after placement from last year's scow placement study, would yield a volumetric deficit of 9% near the time of completion of placement rather than 5%. This loss is in line with previous studies of scow placed sediments in the Pooles Island area. There was an estimated 3 to 8% sediment volume loss for the berm construction at Area G-West in 1994 (Halka and others, 1995). In 1996-97, there was a 6% loss for the berm maintenance at Area G-West and an 11% loss from placement in Area G-South (Panageotou and others, 1998). In 1997, there was a 14% loss from scow placement in Area G-West (Panageotou, 1999).

Consolidation of Placed Sediments

The study evaluated dewatering and consolidation trends within the placed sediments during the post-placement period. Mean water content was determined for the entire placed sediment column and for every 10 cm [3.9 in] interval in the collected cores. The mean water content data for the 10 cm [3.9 in] intervals were averaged and grouped into four equal quarter intervals: upper, upper middle, lower middle, and lower. The mean water content measurements for each core and the corresponding percent volume changes through time due to dewatering and consolidation are presented in Table XII.

Table XII. Percent mean water content and corresponding percent volume change through time at each site.

core location	section of placed sediments		one month		eleven months		percent volume change	
92-1	upper	entire sediment column	56.7	55.1	56.7	54.3	0	-2
	upper middle		55.4		53.8		-2	
	lower middle		57.0		53.5		-10	
	lower		56.8		52.2		-13	
92-2	upper	entire sediment column	56.6	55.1	54.3	53.2	-7	-6
	upper middle		56.9		53.0		-11	
	lower middle		55.0		52.6		-7	
	lower		52.0		52.0		0	
92-3	upper	entire sediment column	58.1	53.9	51.2	50.4	-19	-10
	upper middle		56.4		50.5		-16	
	lower middle		53.3		48.1		-14	
	lower		51.9		49.5		-7	
92-9	upper	entire sediment column	59.0	58 .3	56.4	56.7	-8	-5
	upper middle		58.1		56.4		-5	
	lower middle		57.6		56.4		-4	
	lower		57.4		55.8		-5	
92-10	upper	entire sediment column	58.7	57.0	52.8	53.4	-17	-11
	upper middle		57.7		50.0		-21	
	lower middle		55.3		51.1		-12	
	lower		54.6		52.7		-6	
92-11	upper	entire sediment column	57.7	55.5	53.7	52.6	-12	-8
	upper middle		57.1		53.3		-11	
	lower middle		53.3		53.6		+1	
	lower		51.6		51.9		+1	
92-12	upper	entire sediment column	62.8	58.8	52.3	51.0	-29	-21
	upper middle		60.2		51.5		-24	
	lower middle		54.4		49.0		-15	
	lower		55.6		48.6		-19	
92-13	upper	entire sediment column	61.2	58.5	59.7	57.0	-5	-5
	upper middle		57.9		57.5		-1	
	lower middle		57.1		56.0		-3	
	lower		56.4		54.6		-5	

At seven of the eight sites, mean water contents measured for the entire sediment column over the post-placement period decreased by 0.8 to 3.6%. The corresponding volume reductions attributed to dewatering ranged from 2 to 11%. At core location 92-12, a large decrease in water content over the post-placement period (7.8%) was recorded, with a correspondingly large decrease in volume (21%). The site to site variations at the other locations are related to the initial sediment thicknesses (Table V). In locations where the initial thickness was less than 1 m [3.3 ft] (92-1, 92-9, 92-13), the volume reduction from dewatering ranged from 2 to 5%. In locations where the initial thickness was 1 to 3 m [3.3 to 9.8 ft] (92-2, 92-3, 92-10, 92-11), the volume reduction from dewatering ranged from 6 to 11%. It is believed that the water content decrease at core location 92-12 is anomalous because a change this great has not been documented in previous studies of scow placed sediments in the northern Chesapeake Bay (Panageotou and others, 1998; Panageotou, 1999) and is inconsistent with the changes observed in the other core locations during this study.

Water contents measured for the quarter intervals over the post-placement period exhibited much variation from site to site. The corresponding volume reductions attributed to dewatering through time did not demonstrate a clear trend. At each site, the interval water content data generally decreased with depth at both sampling periods. The placed sediments at one month generally exhibited a greater range in water content between the upper and lower intervals than at eleven months. At one month, the upper two intervals had an average water content that was 3.2% greater than the lower two intervals. At eleven months, the difference was 1.5%. The data demonstrated that consolidation occurred rapidly within the lower most sediments during the placement period because of the initial applied overburden and self-weight consolidation. During the post-placement period, further dewatering and volumetric reduction occurred at a relatively greater rate in the upper most sediments.

The average of the mean water contents and corresponding volumetric changes through time, for the entire sediment column and the quarter sections, is listed in Table XIII. The site to site variations in Table XII are smoothed out when averaged. Averaging the data provides the best estimate of dewatering and consolidation trends over the post-placement period.

Table XIII. Average of the mean water contents and corresponding volumetric changes through time for entire sediment column and quarter sections.

section of placed sediments		averaged % water content at one month		averaged % water content at eleven months		averaged % volume change	
upper	entire sediment column	58.9 ±1.9	56.5 ±1.7	54.6 ±2.5	53.6 ±2.1	-13	-9
upper middle		57.5 ±1.2		53.3 ±2.3		-12	
lower middle		55.4 ±1.5		52.5 ±2.7		-8	
lower		54.5 ±2.1		52.2 ±2.1		-6	

The average of the mean water content data one month after completion was 56.5% for the entire placed sediment column and 58.9, 57.5, 55.4, and 54.5%, respectively, for the down core quarter sections. Clayey silt sediments with water contents of approximately 55 to 60% typically have a consistency of slightly soft to slightly firm mud. The average of the mean water content data at eleven months was 53.6% for the entire placed sediment column and 54.6, 53.3, 52.5, and 52.2% for the down core quarter sections. Sediments with water contents in the 50 to 55% range typically have a consistency of slightly firm to firm mud. The change in the average of the mean water content values over the post-placement period was -3.0% for the entire placed sediment column and -4.3, -4.2, -2.9, and -2.0% for the down core quarter sections.

A t-test was used to determine if a change in placed sediment water content values occurred over the post-placement period. The test demonstrated that change in placed sediment water content values between one month and eleven months, in the quarter intervals and the entire placed sediment column, was statistically significant at 95% confidence level. Therefore, consolidation occurred over this period. The 3% decrease in the average water content values over the placement period equated to a 9% volumetric reduction in the placed sediments throughout the area.

The measured change in water content values equated to a 9% volumetric reduction for the entire placed sediment column and 13, 12, 8, and 6% for the down core quarter sections. This data suggests that consolidation occurs initially in the lower half during the placement period and subsequently in the upper half during the post-placement period.

Clayey silt sediments previously placed in Area G West, both hydraulically and from scows, generally had water contents that ranged from approximately 50 to 55%, six months to a year after placement (Halka and others, 1995, Panageotou and others, 1996, 1997, 1998, Panageotou, 1999). These and previous studies at nearby sites determined that placed sediments consolidate at a relatively rapid rate during the first two months after completion, at a more gradual rate between two and six months, and even more gradually thereafter (Panageotou and Halka, 1989, 1994b). In some cases, these sediments served as the foundation for subsequent placements. Recent foundation consolidation studies at G-West demonstrated that additional consolidation occurred due to the overburden of placed sediments (Panageotou and others, 1997, 1998, Panageotou, 1999). After burial, foundation sediment water contents were in the upper 40% to lower 50% range. The additional consolidation resulted in further volume reductions of 6 to 9%.

Naturally deposited, clayey silt bottom sediments in nearby areas of non-placement, such as the southeast section of Area G-East, exhibited water contents in the upper 40% range (Halka and others, 1996). Placed sediments dewatering to this degree either require burial or a time frame that exceeds the monitoring studies. A sediment core collected four years after placement in Area F had a mean water content of 51% (MGS, unpublished data). The buried sediments with water contents in the upper 40% range have always been gas-charged. Salem and Krizek (1973) determined that gas-charged sediments may counteract further consolidation; therefore, water contents in this range represent the limit of consolidation at depths encountered in these studies.

Volumetric Analyses After Placement - Consolidation and Erosion

The volumetric reductions that occur after placement result from both consolidation due to dewatering and erosion of sediment from the surface of the deposit. The reduction in sediment volume due to consolidation can be estimated from changes in the water content over time. The amount of erosion can be estimated by first calculating the total sediment volume change from the bathymetric data and then subtracting the volume change determined to be due to consolidation.

Table XIV, columns *a-d*, summarize the mean volumes estimated to be present at the completion of placement and at one, three, six, nine, and eleven months after placement. Column *e* is the percent cumulative volume change over time adjusted for foundation consolidation. The associated volumetric changes attributed to consolidation and erosion were estimated from the sediment core data collected on the one month and eleven month after completion survey dates and are presented in columns *f-j*.

Table XIV. Volumetric analyses of placed sediments through time.

Bathymetric analyses and associated volumetric changes.

(*a*) survey	(*b*) survey date	(*c*) measured volume present (yd³)	(*d*) measured volume present (m³)	(*e*) cumulative volume change (%)
completion	4/7/99	1,035,500±95,000	792,000±73,000	0
one month	5/6/99	1,048,500±115,500	802,000±88,500	+1
three month	7/12/99	1,045,500±158,000	799,500±120,500	+1
six month	9/29/99	922,500±145,500	705,000±111,500	-11
nine months	1/6/00	717,000±73,000	548,000±56,000	-31
eleven months	2/21/00	691,000±72,500	528,500±55,500	-33

Water content analyses and associated volumetric changes.

(*f*) survey	(*g*) sampling date	(*h*) average % water content	(*i*) % mean volume change due to consolidation [range]	(*j*) % mean volume change due to erosion [range]
one month	4/28/99	56.5±1.7	0	0
eleven months	2/22/00	53.6±2.1	-9 [0 to -9]	-24 [-14 to -33]

The underlying assumption in estimating consolidation and erosion is that the recovered sediment accurately reflects the water content of the *in situ* sediment. Water makes up a relatively large proportion of the bottom sediments by volume, and relatively small differences in the calculated water contents can result in large volume differences. This can affect the analyses in two ways. First, in recently placed sediments, water contents are at their highest and dewatering occurs very rapidly. Because the water contents are at their highest levels, the effect of small water content variations on the volumetric change analyses is greatly magnified in the early stages of dewatering. Calculating dewatering rates over periods of less than approximately three months has yielded ambiguous results in previous studies conducted by MGS (Panageotou and Halka, 1994a; 1994b). Secondly, there exists variability in the water content values over the site. The standard deviation (σ) of mean water content measurements is shown as the ± component of the water contents reported in column *h*. The values reported for consolidation (column *i*) and erosion (column *j*) in brackets indicate the possible range in the volumetric analyses. The mean water content value represents the best approximation of the consolidation changes occurring in the sediments over the longer term.

The volumes calculated for the one month and three month surveys are 1% greater than the volume calculated to be in place on the completion survey. The six month survey showed a net decrease in sediment volume of 87,000 m^3 [113,000 yd^3] or 11% less than the volume calculated to be in place on the completion survey. The nine and eleven month surveys showed a net decrease in volume of 244,000 m^3 [318,500 yd^3] or 31% and 263,500 m^3 [344,500 yd^3] or 33%, respectively.

In general, it is expected that the placed sediment volume should decrease through time; however, the volume remained relatively constant over the three month period following placement. The 1% increase in the calculated volumes, 10,000 m^3 [13,000 yd^3] at one month and 7,500 m^3 [10,000 yd^3] at three months are within the uncertainty range of the bathymetric calculations. Two past studies of scow placed sediments in Area G-West indicated a decrease in sediment volume over this time-frame. Panageotou and others (1998) calculated a 10% volume reduction after three months in the G-West berm maintenance operation in 1996-97 and Panageotou (1999) calculated a 10% volume reduction after one month for scow placed sediment in 1997-98. In contrast, Halka and others (1995) found that the sediment volume of the G-West berm constructed in 1994 remained constant over the first four months following placement. Given that the sediment volume is anticipated to decrease over time, but did not during the first three months following placement, the thickness and extent of the sediment spread to the northeast and southwest that are shown on Figure 13 is questionable. The material shown in these areas would have contributed to the total volume calculated from the bathymetric comparisons, and may have resulted in the 1% increase in volume. By three months after placement, the area of the placed sediments increased by two-thirds, as shown on Figure 13, primarily as a relatively thin layer of sediment (<0.25 m [0.8 ft]). It is possible that during the spring months after placement, currents enhanced by the spring freshet and storm events promoted erosion from the newly deposited berm with deposition to the northeast or southwest in the trough depending on tidal current direction. However, the volume increase suggests that this result may be slightly overstated.

Between three and six month after placement, a reduction in the elevation of the berm and thinning of the sediments in the peripheral areas resulted in an 11% volume reduction. During these summer months, (July through September), relatively quiescent flow and weather conditions resulted in little redistribution of the sediment. Between six and nine months after placement, the sediments that apparently had spread into the peripheral areas were eroded or reduced in thickness below the limits of bathymetric resolution. This resulted in the greatest volumetric reduction during the study period, an additional 20%. The area covered by dredged sediments was reduced to approximately 75% of the original footprint. This period coincided with the fall and winter months when strong wind generated currents from storms, such as northeasters, are common and the erosion potential is at its greatest.

At the end of the eleven month post-placement period, 67% of the original sediment volume remained was identified with a net decrease of 263,500 m^3 [344,500 yd^3], or 33% less than the volume identified on the completion survey. During the period between one and eleven months after placement, the average sediment water content decreased 2.9%, from 56.5 to 53.6% (Table XIII). This equated to a 9% volume reduction due to dewatering and consolidation. The remainder of the volume change, 24%, was attributed to erosion. Thus, approximately one-quarter of the mean volumetric reduction was from consolidation and three-quarters from erosion. However, as noted above, there was a lapse in time between the completion survey (seven days) and the collection of the cores (one month) for the completion survey. Due to this lapse in time, dewatering and consolidation of the sediments in the month following completion resulted in some of the volume deficit being erroneously attributed to erosion. Using the average water content from last year's scow placement, 57.8%, from sediment cores collected three days after placement (Panageotou, 1999), there would be a volumetric reduction due to dewatering and consolidation of 12%. Thus, erosion would account for 21%. In this case, one-third of the mean volumetric change was from consolidation and two-thirds from erosion. This scenario is more probable. In past studies of clamshell dredged and scow placed sediments, it has been found that one-third to two thirds of the total volumetric reduction could be attributed to either consolidation or erosion. (Panageotou and Halka,1993, 1994a, 1994b, Panageotou and others, 1998).

Sediment Mass Budget

A sediment mass budget estimates the movement of sediment mass from the placement site during the placement and post-placement periods, which can be recorded as a loss of material. Sediment loss occurs due to transport of suspended sediment in turbidity plumes during placement and resuspension and erosion of the deposited sediments after placement. The effects of consolidation and interstitial water loss are not included in the analysis. Whereas volumetric data (cubic meters or cubic yards) allows for site capacity calculations and provides ready comparison to the reported channel sediment volumes dredged, sediment mass calculations (metric tons or tonnes) allow for comparison with sediment input information available from other studies conducted in the Chesapeake Bay. Primary sources of sediment input into the upper Bay are from the Susquehanna River and shoreline erosion. A discussion of sediment input into the upper Bay in relation to a sediment mass budget resulting from the 1994-95 dredging and placement operations was presented in Panageotou and others (1996).

Sediment mass is calculated by multiplying the weight of the solids determined from the bulk property analysis by the volume of placed sediment. A metric ton (tonne) is equal to 1,000 kilograms (2,205 pounds). Table XV summarizes the sediment mass calculated from the reported volumes dredged and the sediment mass identified at the completion and eleven month bathymetric surveys. The sources of the sediment mass values are listed. As discussed earlier, there was a difference in the dredged volume reported by CENAP and the contractor in this year's operation. Therefore, both of the reported volumes were used and compared to determine the sediment mass dredged from the channel. Also, as noted above, there was a lapse in time between the completion survey (seven days) and the collection of cores (one month) for the completion survey. Due to this lapse in time, it is necessary to back calculate the bulk property for the completion cores. This was done using the average water content from last year's scow placement as discussed in the Volumetric Analyses After Placement - Consolidation and Erosion section.

TableXV. Sediment mass for dredging and placement operations and post-placement period.

	source	metric tonnes
sediment mass dredged	CENAP	347,300
	contractor	498,600
sediment mass identified at completion	MGS	452,900
sediment mass identified at eleven months	MGS	345,100

Table XVI presents the differences in sediment mass between the reported tonnes dredged and the tonnes identified at Site 92 on the completion survey, for the interval between the completion and eleven month surveys, and for the eleven month survey. The loss of sediment mass at eleven months accounts for sediment transported as suspended material from Site 92 during both the placement and post-placement period.

Table XVI. Deficit/surplus in sediment mass in tonnes and percentage.

	source	CENAP	contractor
at completion	reported dredged/MGS	+105,600 (+30%)	-45,700 (-9%)
completion to eleven months	MGS	-107,800 (-24%)	
at eleven months	reported dredged/MGS	-2,200 (-1%)	-153,500 (-31%)

At the completion survey, there was a 9% deficit of sediment mass (-45,700 tonnes) identified at the site using the contractor's dredged volume and a 30% surplus (+105,600 tonnes) using the CENAP dredged volume. Over the post-placement period, MGS calculated an additional 24% loss (-107,800 tonnes) from resuspension and erosion processes. Over both the placement and post-placement periods, there was an overall 31% reduction of sediment mass (-153,500 tonnes) identified at site using the contractor's dredged volume and a 1% reduction (-2,200 tonnes) using the CENAP dredged volume. As previously noted, the pay yardage volume that CENAP reported dredged is underestimated, and the gross yardage volume that the contractor reported is probably more valid.

The average annual input of fine-grained sediment from shoreline erosion and the Susquehanna River to the upper Bay (during years without major floods) has been estimated at

1,446,000 tonnes (see Panageotou and others, 1996). This year's dredging operation involved the movement of 498,600 tonnes of sediment mass from the C&D approach channel to Site 92. By the end of the monitoring period, 153,500 tonnes were estimated to have been transported from Site 92 and dispersed by prevailing currents over the upper Bay. The sediment mass dispersed over the upper Bay represents 11% of the average annual input of fine-grained sediment from shoreline erosion and the Susquehanna River. Spread evenly over the area covered by fine-grained sediment north of Tolchester (174 km^2) [67 mi^2], a thickness of 0.2 cm [0.08 in] would result from the mass of sediment transported from the Site 92 during this monitoring period. These results are similar to the reduction of sediment mass from other Pooles Island placement sites. There was a 28% reduction of sediment mass from the 1994-95 G-West hydraulic placement operation and a 20% reduction from the 1996-97 G-West/G-South scow placement operation (Panageotou and others, 1996, 1998). The amount of sediment moved from these sites represented 12% of the average annual input of fine-grained sediment from shoreline erosion and the Susquehanna River.

CONCLUSIONS

The volume of clayey silt sediment dredged from the C&D Canal approach channel during the winter of 1998-1999 was reported as 833,695 m^3 [1,090,367 yd^3] by the contractor and 580,740 m^3 [759,534 yd^3] by CENAP. The reported volumes typically differ because of the different methodologies used to determine the quantities dredged from the channel. The contractor's dredged volume was based on the quantity of sediment placed per scow load. CENAP's dredged volume was calculated as a pay yardage volume and based on the change between pre- and post-dredging bathymetric surveys in the channel to the -41 ft depth. The volume that the contractor reports likely included some sediment that was dredged from below the -41 ft dredging depth. After the completion of placement, the volume of placed sediment identified by MGS was 792,000 m^3 ±73,000 m^3 [1,035,500 yd^3 ±95,000 yd^3]. This represented an excess of 211,500 m^3 [276,000 yd^3] or 36% utilizing the CENAP reported dredged volume, and a deficit of 41,500 m^3 [55,000 yd^3] or 5% using the contractor's reported volume. Based on the total volume of sediment identified and discussions with CENAP personnel, the pay yardage volume that CENAP reported dredged is likely an underestimate and the contractor's reported dredged volume is more valid.

The deficit of sediment identified at completion of placement operations is the result of: (1) consolidation of the sediment during placement and in the interval between the completion of placement and the completion survey, (2) suspended sediment loss in primary turbidity plumes during dredging and placement, and (3) erosion of sediment both during placement and in the interval between the completion of placement and the completion survey. Due to the lapse in time between the completion survey (seven days) and the collection of the completion sediment cores (one month), the effects of consolidation on volume could not be completely determined. The estimated 5% sediment loss may be as much as 9% when consolidation is accounted for this lapse in time in data collection.

Placement of dredged sediment in the northeast section of Site 92 resulted in a berm that filled the northeast end of the West Sailing Course tug channel that traverses the site. The initial area of the completed berm was approximately 719,000 m^2 [860,000 yd^2]. The berm had a length of 1,300 m [4,300 ft] and an average width of 650 m [2,100 ft]. The maximum increase in bottom elevation was 3.7 m [12.1 ft] near the northeastern corner of the placement area. Water depths at completion of placement in the designated drop zones ranged from 4.6 to 6.0 m [15 to 20 ft]. The contract specification for maintenance of a minimum 4.2 m [14 feet] depth below MLW was confirmed over the site. The 30H:1V [0.0333] sediment slope that was used in planning site management and for determining the set-back from the boundary was not achieved during this placement operation. The steepest slopes identified along the northeast side of the placement area fell between 35H:1V [0.0286] and 50H:1V [0.0200].

A small amount of the placed sediment extended beyond the site boundary at the completion of placement operations. This sediment extended a maximum distance of 100 m [330 ft] to the east of the site boundary and had an estimated volume of 3,500 m^3 ±2,300 m^3 [4,600 yd^3 ±3,000 yd^3]. This represents less than one-half of one percent (0.4%) of the placed sediment identified at the site and of the volume reportedly placed by the contractor. Sediment that was placed at the top of the berm during the latter weeks of the placement period likely moved downslope of the berm's east steep embankment and came to rest at the base of the slope in the deeper portion of the trough to the northeast. In addition, tidal currents may have spread some of the less consolidated sediments beyond the drop zones.

Over the post-placement period, the berm underwent elevation and volumetric changes. Redistribution of sediment within three months after completion of placement resulted in the area of the placed sediments increasing by two-thirds to approximately 1,200,000 m^2 [1,432,000 yd^2]. Between the completion and one-month surveys, a mass of sediment apparently slumped down a portion of the steepest sediment deposit and came to rest approximately 100 m [330 ft] beyond the site boundary. The thick deposit of sediment in this area coupled with the relatively steep slopes resulted in a mass movement along a failure plane in the sediment deposit. In addition, sediment eroded from the top of the deposits was also swept over the northeast-southwest peripheral areas of the berm. These sediments were deposited as a thin layer to the southwest, in the deepest area of site, and to the northeast in the tug channel, probably a short distance beyond the limits of the surveyed area. However, volume calculations indicate that the extent of the spread may be slightly overstated. These sediment deposits were relatively thin and were deposited in areas where the existing bottom sediments had a similar grain size and bulk properties. Thus the bottom characteristics did not change as a result of deposition in these areas. Sediments were also apparent in these areas six months following the completion of placement operations. Normal tidal erosion and consolidation of these sediments beyond the periphery of the placed berm resulted in their removal or incorporation into the normal bottom sediments by the time of the nine month post-placement survey. Thus, the deposition of these sediments should have resulted in no significant impact to the benthic environment in the vicinity of the placement area.

The redistribution of the sediments did not result in any measurable volume change over the three month period following placement. Between three and six months after placement, a reduction in the elevation of the berm and thinning of the sediments in the peripheral areas resulted in a 11% volume reduction. Between six and nine month after placement, the sediments that had previously spread into the peripheral areas were largely eroded resulting in a 20% volume reduction. Between nine and eleven months after placement, there was an additional 2% volume reduction. The net area covered by the berm sediments was reduced to approximately 533,000 m^2 [637,000 yd^2] or three-quarters of the original footprint. The maximum elevation of the placed berm decreased by 0.6 m [2 ft] since completion to 3.1 m [10.2 ft] at eleven months.

At the end of the eleven month post-placement period, 67% of the original sediment volume was identified with a net decrease of 263,500 m^3 [344,500 yd^3], or 33% less than the volume identified on the completion survey. Bulk property data indicated that one-third of the volume change, approximately 12% of the originally placed volume, was due to dewatering and consolidation. The remaining two-thirds of the volume change, representing 21% of the original volume, was attributed to erosion of sediment from the surface of the deposit. In past studies of clamshell dredged and scow placed sediments, it has been found that one-third to two thirds of the total volumetric reduction could be attributed to either consolidation or erosion. The sediments placed in this operation exhibited similar amounts of consolidation and erosion as those placed in previous years in the northern Chesapeake Bay.

Consolidation occurred rapidly within the lower most sediments during the placement period because of the initial applied overburden and self-weight consolidation. During the post-placement period, further dewatering and consolidation occurred at a relatively greater rate in the upper most sediments. In areas where the placed sediments were 1 to 3 m [3.3 to 9.8 ft] thick, the volume reduction from dewatering and consolidation was at least 2 times greater than in areas where the initial thickness was less than 1 m [3.3 ft].

This year's dredging operation involved the movement of 498,600 tonnes of sediment from the C&D approach channel to Site 92. During the placement and post-placement period, 153,500 tonnes were estimated to have been transported from Site 92 as suspended sediment and dispersed by prevailing currents over the upper Bay. The sediment mass dispersed over the upper Bay represents 11% of the average annual input of fine-grained sediment from shoreline erosion and the Susquehanna River. Spread evenly over the area covered by fine-grained sediment north of Tolchester (174 km^2) [67 mi^2], a thickness of 0.2 cm [0.08 in] would result from the mass of sediment transported from Site 92.

It is recommended that future placement near site boundaries should avoid developing a sediment pile (lift) of similar thickness and slopes (<50H:1V [0.0200]) as those in this year's placement operation in deep areas such as this. Shallower slopes should be anticipated and a greater set-back from the site boundary identified for scow drops to minimize the spread of sediment outside of the site boundary. However, it is unlikely that any future operations in Site 92 will result in these conditions occurring given the bathymetry at the site. Close coordination between CENAP, the dredging contractor, MES, and MGS and development of a suitable site management plan will minimize the potential for spread of sediment outside of the site boundary and slumping events in future placement operations.

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APPENDIX I

Bathymetric maps labeled in feet

Site 92
bathymetry prior to placement
October 30, 1998

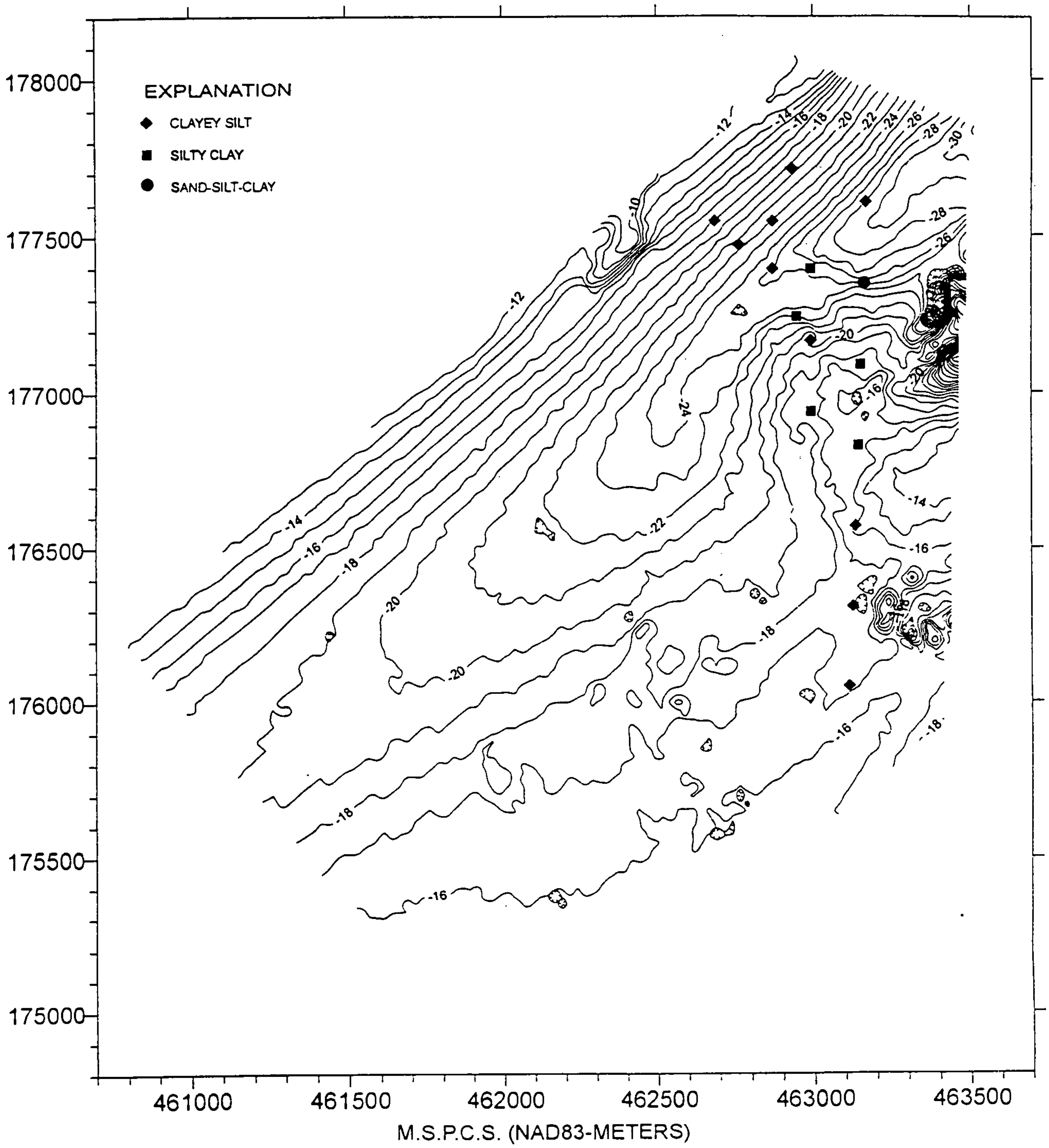


Figure 4. Bathymetry on October 30, 1998, prior to sediment placement. Depths in feet (contour interval 1 ft). Grain size distribution for foundation sediments collected on October 19, 1998 and January 11, 1999 is indicated. Refer to Figure 2 for identification of sediment core sites.

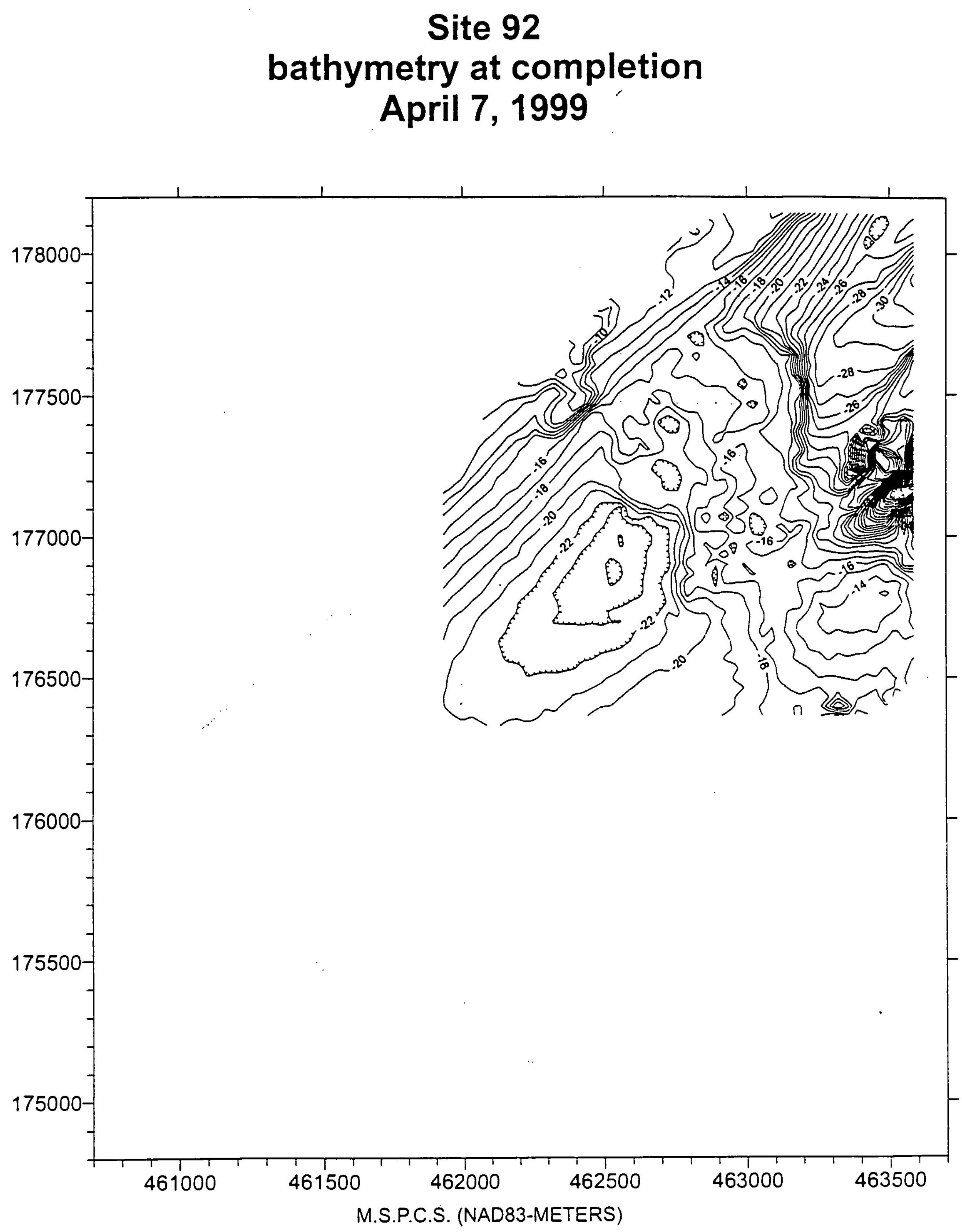
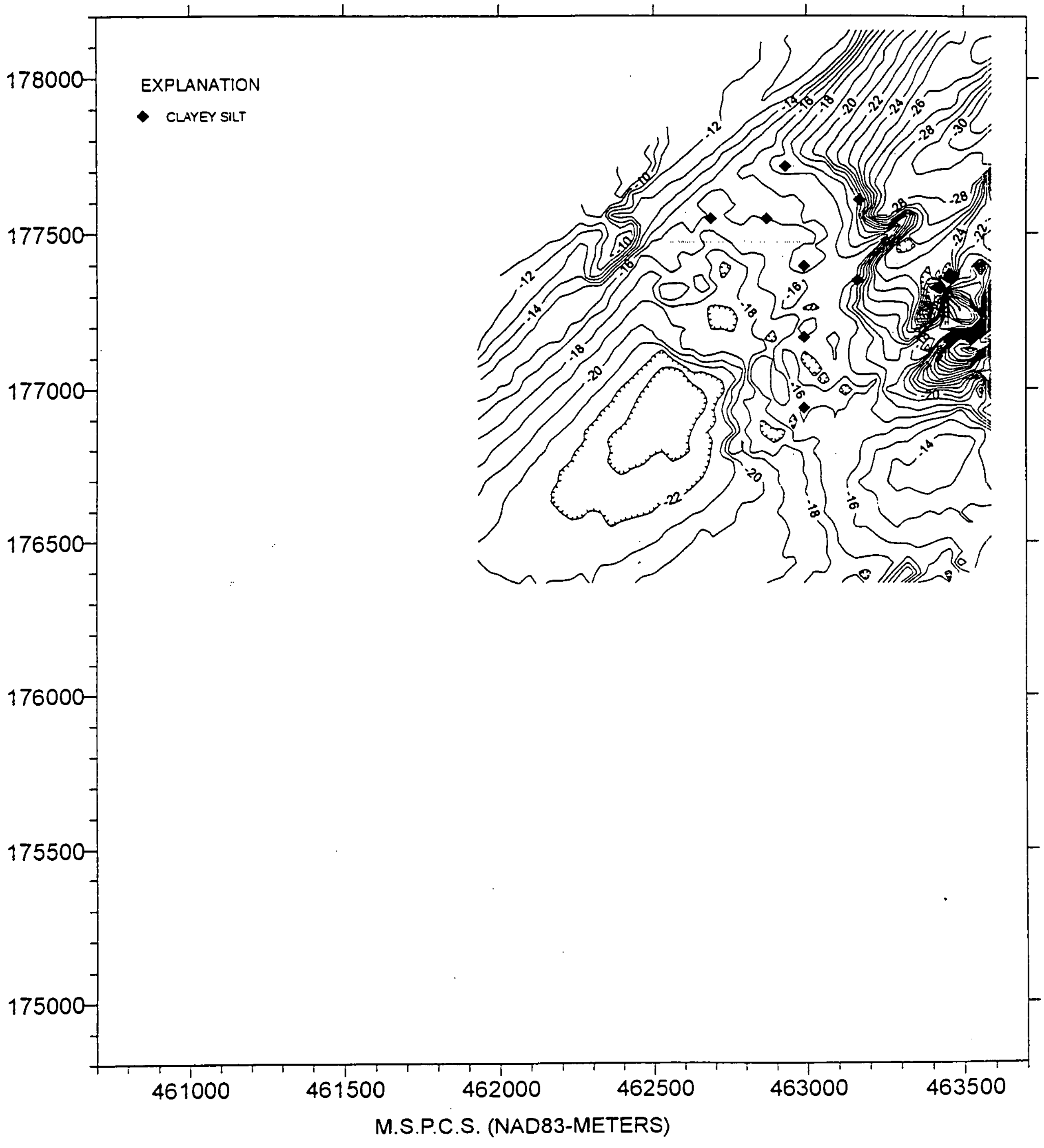
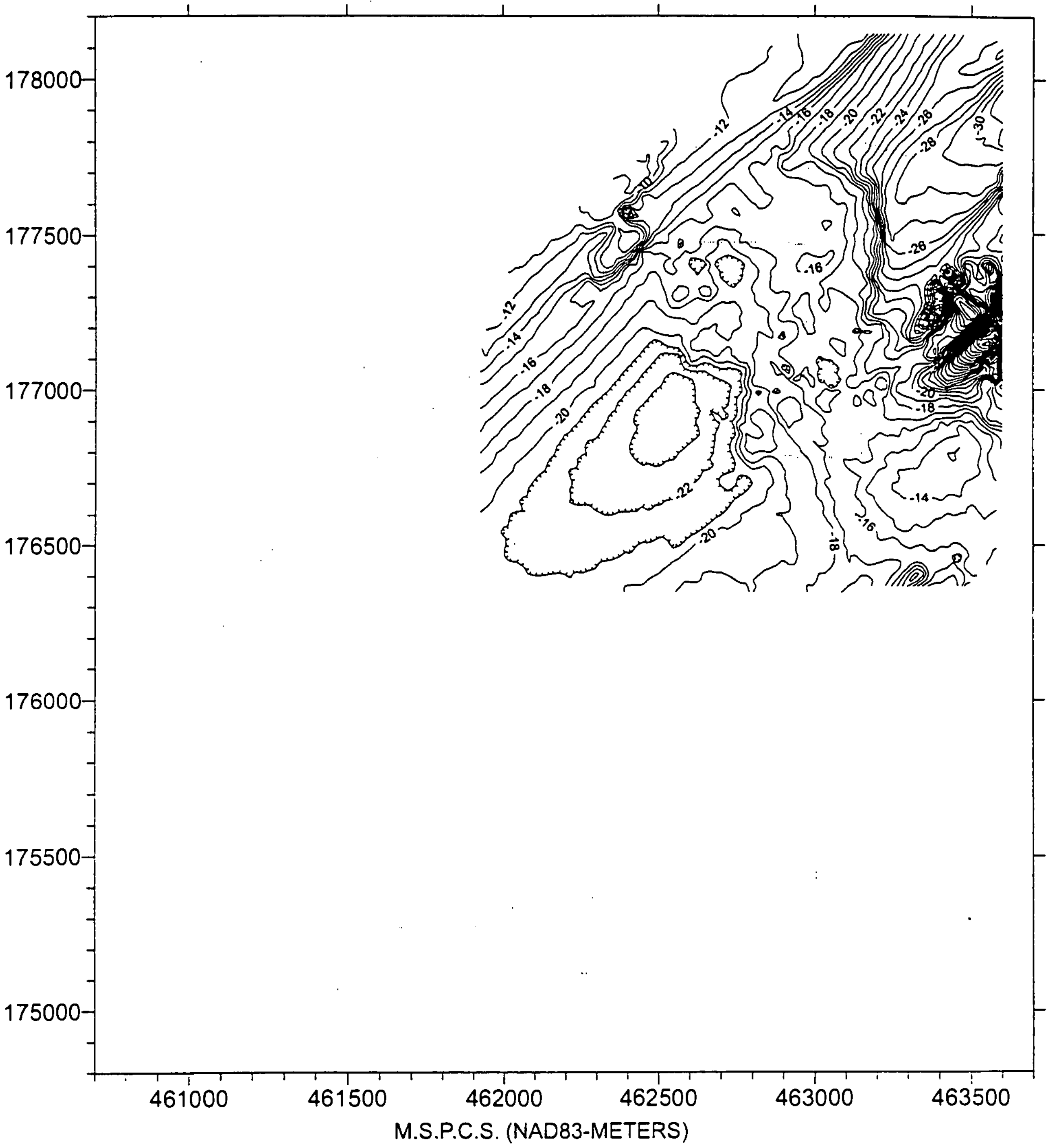

Site 92
bathymetry at completion
April 7, 1999

Figure 5. Bathymetry on April 7 1999, after completion of sediment placement. Depths in feet (contour interval 1 ft).



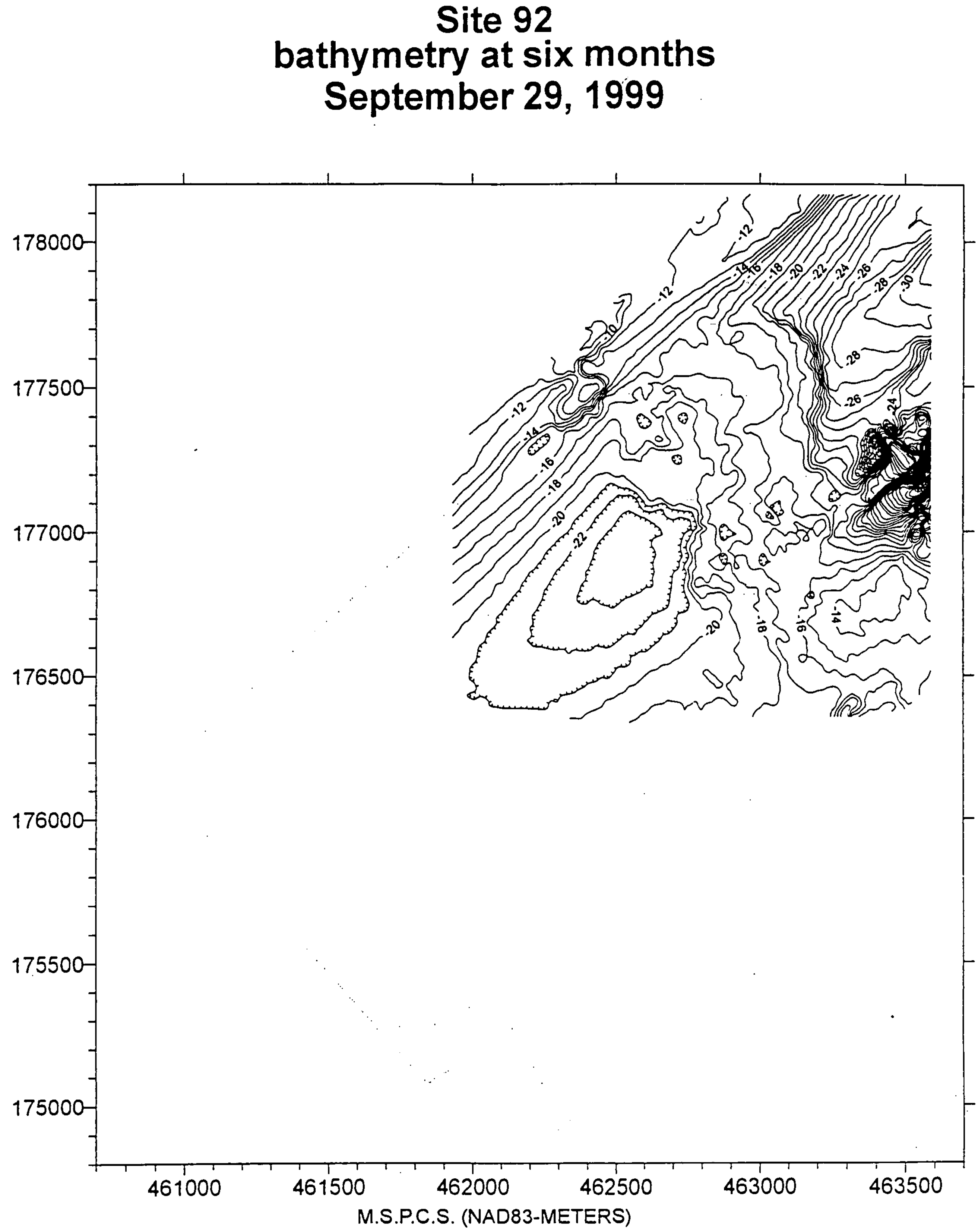
Site 92
bathymetry at one month
May 6, 1999

Figure 6. Bathymetry on May 6, 1999, one month after completion of sediment placement. Depths in feet (contour interval 1ft). Grain size distribution for placed sediments collected on April 28, 1999 is indicated. Refer to Figure 2 for identification of sediment core sites.



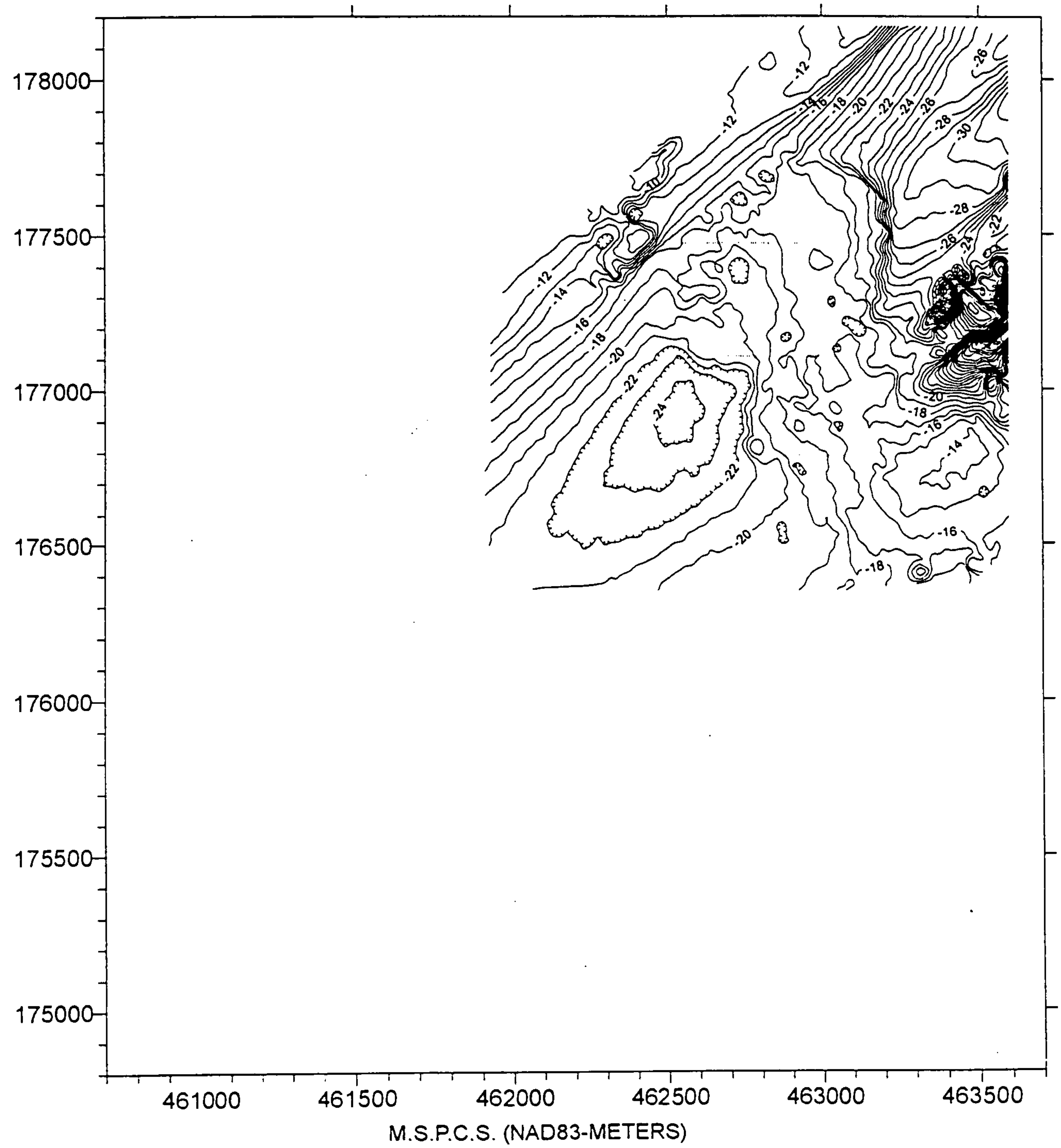
Site 92
bathymetry at three months
July 12, 1999

Figure 7. Bathymetry on July 12, 1999, three months after completion of sediment placement. Depths in feet (contour interval 1 ft).



Site 92
bathymetry at six months
September 29, 1999

Figure 8. Bathymetry on September 29, 1999, six months after completion of sediment placement. Depths in feet (contour interval 1 ft).



Site 92
bathymetry at nine months
January 6, 2000

Figure 9. Bathymetry on January 6, 2000, nine months after completion of sediment placement. Depths in feet (contour interval 1ft).

Site 92
bathymetry at eleven months
February 21, 2000

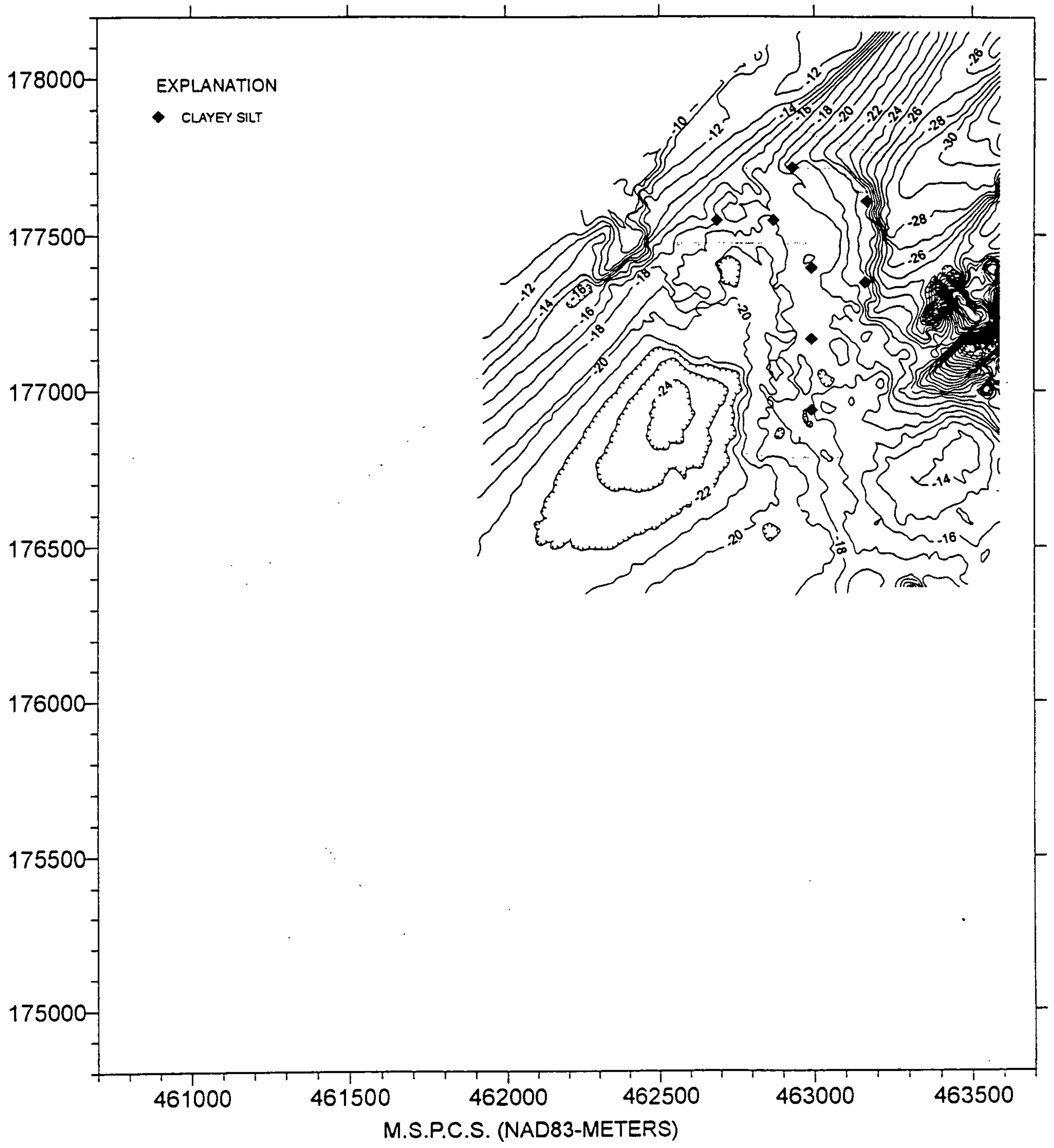
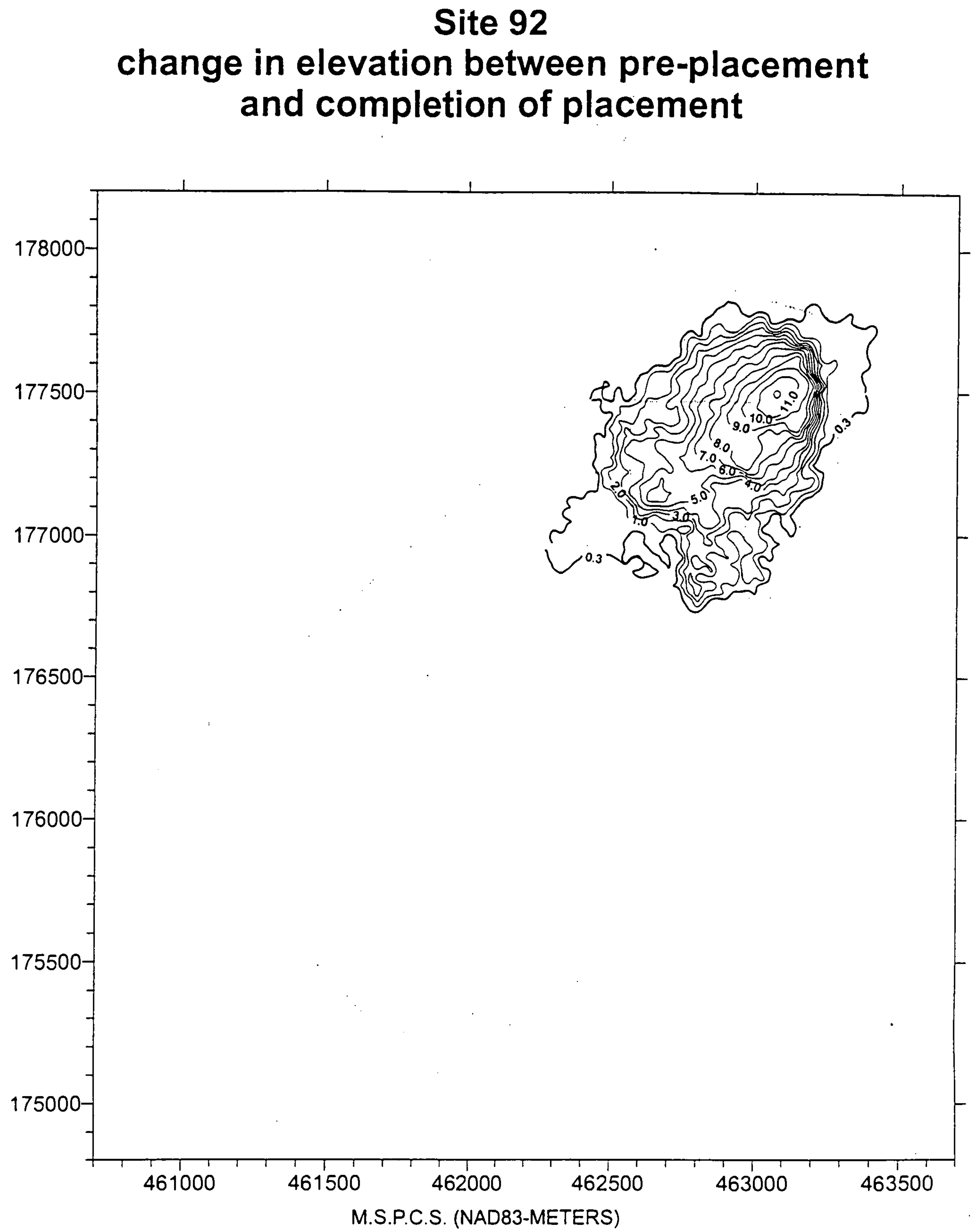


Figure 10. Bathymetry on February 21, 2000, eleven months after completion of sediment placement. Depths in feet (contour interval 1 ft). Grain size distribution for placed sediments collected on February 22, 2000 is indicated. Refer to Figure 2 for identification of sediment core sites.

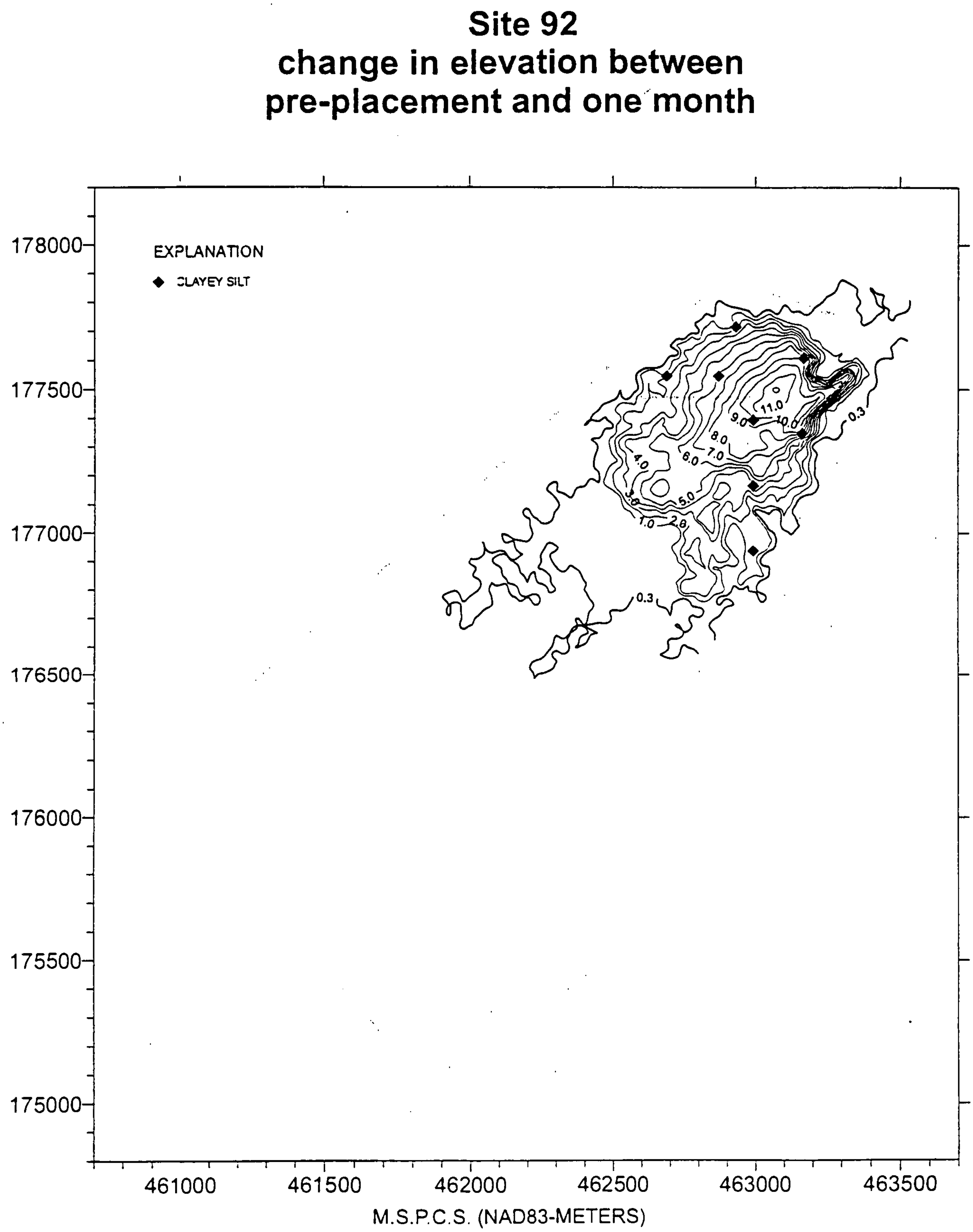
APPENDIX II

Isopach maps labeled in feet



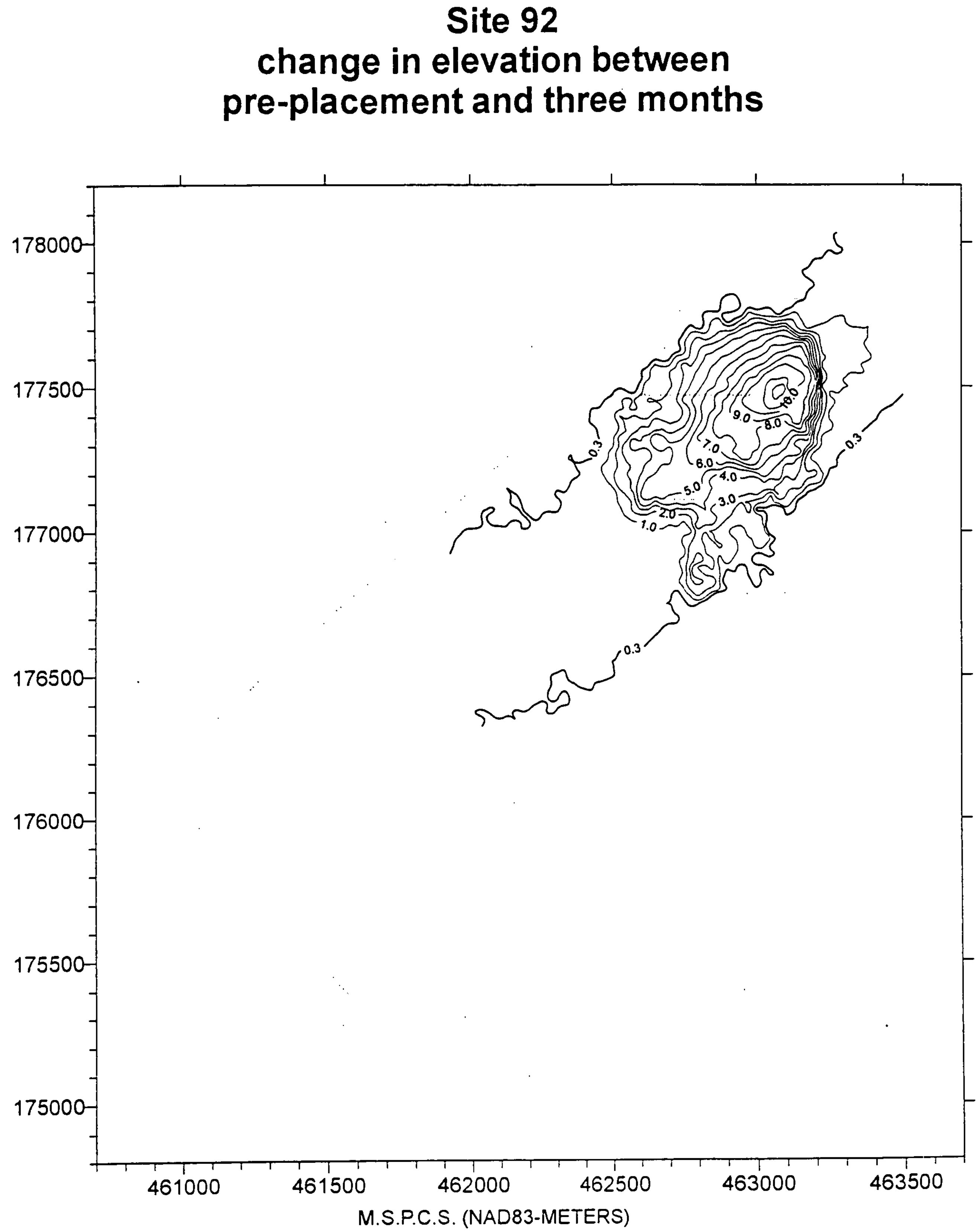
Site 92
change in elevation between pre-placement
and completion of placement

Figure 11. Isopach map showing change in elevation (in feet) between pre-placement (October 30, 1998) and completion of placement (April 7, 1999).



Site 92
change in elevation between
pre-placement and one month

Figure 12. Isopach map showing increase in elevation (in feet) between pre-placement (October 30, 1998) and one month (May 6, 1999). Refer to Figure 2 for identification of sediment core sites.



Site 92
change in elevation between
pre-placement and three months

Figure 13. Isopach map showing increase in elevation (in feet) between pre-placement (October 30, 1998) and three months (July 12, 1999).

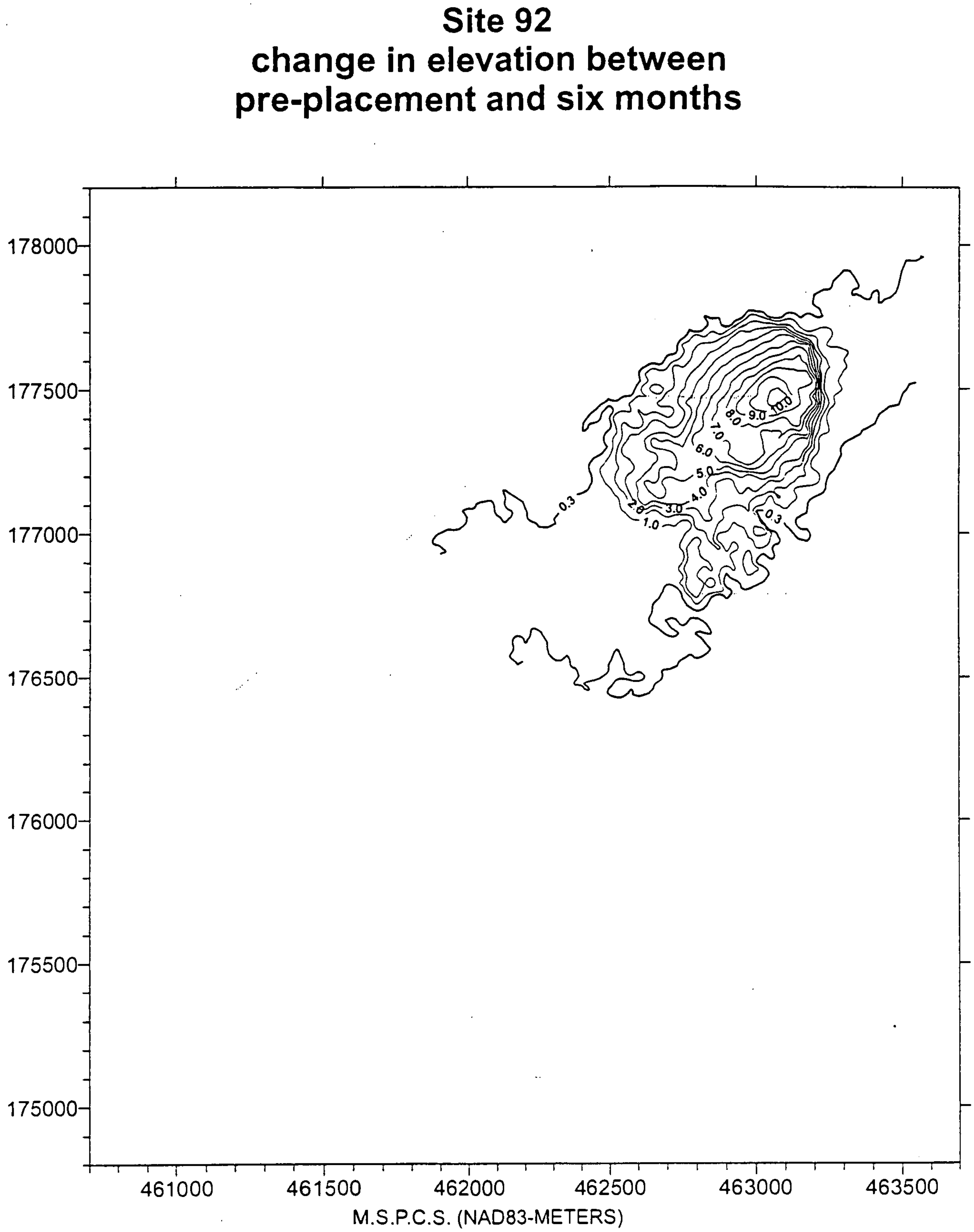
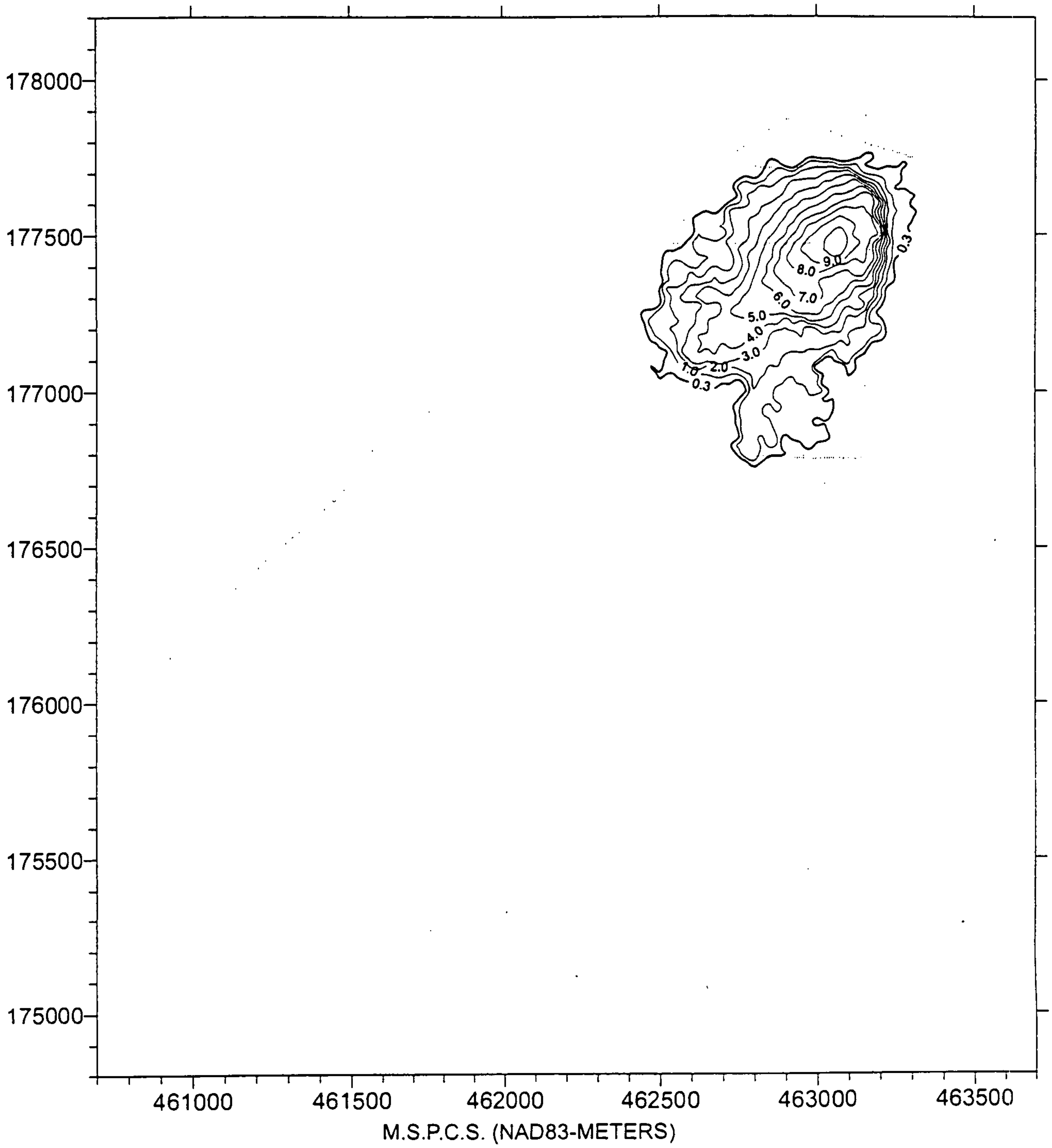
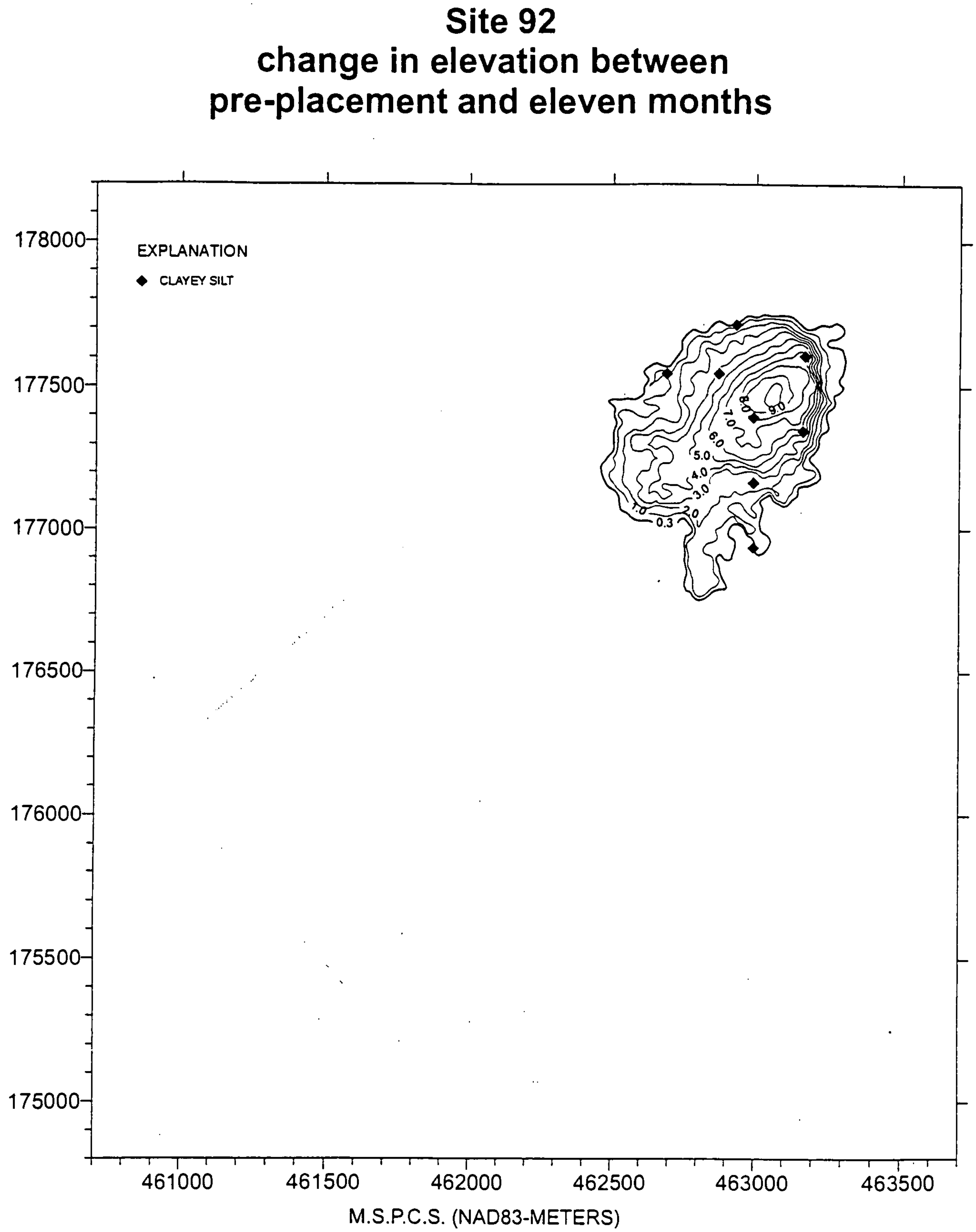


Figure 14. Isopach map showing increase in elevation (in feet) between pre-placement (October 30, 1998) and six months (September 29, 1999).



Site 92
change in elevation between
pre-placement and nine months

Figure 15. Isopach map showing increase in elevation (in feet) between pre-placement (October 30, 1998) and nine months (January 6, 2000).



Site 92
change in elevation between
pre-placement and eleven months

Figure 16. Isopach map showing increase in elevation (in feet) between pre-placement (October 30, 1998) and eleven months (February 22, 2000). Refer to Figure 2 for identification of sediment core sites.

APPENDIX E

Site 92 1998/1999 Benthic Community Assessment Report

Pre-Placement Benthic Community Assessment At Site 92 Open-Water Dredged Material Placement Site, Pooles Island Complex, Maryland

Submitted to
Maryland Port Administration
Maryland Environmental Service
&
United States Army Corps of Engineers,
Philadelphia District

January 2000

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Technical and Regulatory Services Administration
Maryland Department of the Environment

MDE

MDE/TARSA Technical Report No: 99-01

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Thanks are also given to Mr. Visty Dalal, Mr. Nathaniel Brown, Mr. Matthew Rowe, Ms. Karen Eason and Dr. Richard Eskin for their valuable comments and guidance. Mr. Michael Haire, Past Director, Dr. Robert Summers, Director, and Mr. Narendra Panday, Technical Coordinator, Technical and Regulatory Services Administration, provided suggestions and leadership throughout this project.

EXECUTIVE SUMMARY

Site 92 is an open-water placement site located south-southwest of Pooles Island in the Upper Chesapeake Bay. The site comprises 934 acres and has an estimated placement capacity of 3.7 million cubic yards (mcy), giving the site a useful life of approximately 2 to 3 years. Site 92 will be used for the placement of uncontaminated material dredged from the shipping channels leading to the Port of Baltimore. The deposition of material began in December 1998.

The Maryland Department of the Environment's Dredging Coordination and Assessment Division (MDE/DCAD) conducted baseline benthic community monitoring studies for Site 92. The benthic cruises were conducted in May, July and September 1998, in order to establish baseline conditions prior to dredged material placement. As part of this baseline study, MDE evaluated seasonal effects on the benthic macroinvertebrate community in and around the site. Each of the three cruises included *in-situ* water quality measurements and collection of samples for benthic macroinvertebrate community and sediment grain-size analyses. This report provides the results of the baseline benthic community and sedimentary analyses. Benthic and sediment samples were also collected in area G-South and at a station north of proposed area G-East for comparison to previous studies in these areas. Results of these comparisons are also presented in this report.

Benthic community assessment stations are grouped into four categories based on their locations. Seven stations are located within Site 92; these stations are referred to as *Inner* stations (S92-1 through S92-7). Stations S92-R1 and S92-R2 lie close to but not within the boundary of the site and are included as *Reference* stations. Two additional stations were surveyed as a cost-share for comparison with previous work (Dalal et al. 1996a; Dalal et al. 1996b; Ranasinghe and Richkus 1993). One of these stations, referred to as the *G-South* station (MDE-R1), was located in the G-South area. The other, referred to as the *Northeast* station (MDE-R2), was located north of the proposed G-East open-water placement area.

Salinity increased markedly from May (spring) lows of 0.1 to 0.5 parts per thousand (‰) to September (late summer/early fall) highs of 8.0 to 9.5 ‰. Temperatures increased from an average of 16.6 °C in May to an average of 26.7 °C in July. Temperatures decreased slightly in September to an average of 22.8 °C. Changes in dissolved oxygen (DO) concentrations were inversely related to changes in the temperature. Dissolved oxygen (DO) decreased from May highs of 8.6 to 9.5 parts per million (ppm) to July lows of 6.2 to 7.2 ppm; concentrations remained above the level considered to be stressful to aquatic life. Dissolved oxygen concentrations rebounded slightly in September (6.9 to 8.2 ppm) but did not reach the high levels seen in May.

Benthic communities at *Inner* and *Reference* stations were similar throughout the study. Differences between the two station groups could be attributed to differences in the abundance of the clam *Rangia cuneata* and the worm *Marenzelleria viridis*. The Chesapeake Bay Benthic Index of Biotic Integrity (B-IBI) was calculated for the July and September 1998 sampling events. All *Inner* and *Reference* stations exceeded the Chesapeake Bay Restoration Goal (3.0) during both seasons indicating healthy benthic communities.

Seasonal variation was seen in most benthic parameters. Total infaunal abundance was highest at most stations in May due to spring recruitment. Shannon-Wiener Diversity Index values were highly variable. Diversity was highest at the *Reference* stations in July and at most *Inner* stations during May. Abundance of pollution-sensitive taxa was highest at most *Inner* stations during May or July, and at the *Reference* stations during May. Total abundance, the Shannon-Wiener Diversity Index, and the relative abundance of pollution-sensitive taxa were largely determined by the abundance of the clam *Rangia cuneata* and the polychaete worm *Marenzelleria viridis*. These two species are considered pollution-sensitive in the Chesapeake Bay (Weisberg et al. 1997). Either or both of these species were the dominant taxa in the communities of all *Inner* and *Reference* stations in May and most stations in July and September. Abundance of pollution-indicative taxa was low during all seasons.

The B-IBI scores for the G-South and Northeast stations exceeded the Chesapeake Bay Restoration Goal (3.0) during July and September, indicating that benthic communities in both areas were not stressed during the summer of 1998. Diversity was highest at the *G-South* and *Northeast* stations during September. Abundance of pollution-sensitive taxa was highest at these stations during May due to high seasonal recruitment of *Marenzelleria viridis*.

In May, higher abundance of *M. viridis* resulted in higher total abundance, lower diversity, and higher relative abundance of pollution-sensitive taxa at the *G-South* station than at the *Reference* stations. The benthic community at the *G-South* station was similar to *Reference* stations during July and September 1998. The benthic community present in September 1998 was similar to the pre-placement community found in August 1991 except that *Marenzelleria viridis* has replaced *Rangia cuneata* as the dominant taxon in G-South. The benthic community found at the *G-South* station was somewhat different from the community present in September 1996, two years after placement had ceased. Total abundance and diversity were lower in 1998 than in 1996. Placement of dredged material in a portion of G-South during January and February 1997, may have contributed to the differences seen in the benthic communities of 1996 and 1998.

The *Northeast* station was similar to *Reference* stations during May and July 1998. Abundance was severely depressed at this station during September 1998. This change may have been the result of habitat disturbance caused by nearby Langenfelder fossil oyster shell dredging that was occurring at the time of the September collection. The benthic community present at the*Northeast* station during 1998 was not significantly different from the community present in the vicinity of G-East during the 1995 study, except that total infaunal abundance was much lower in 1998.

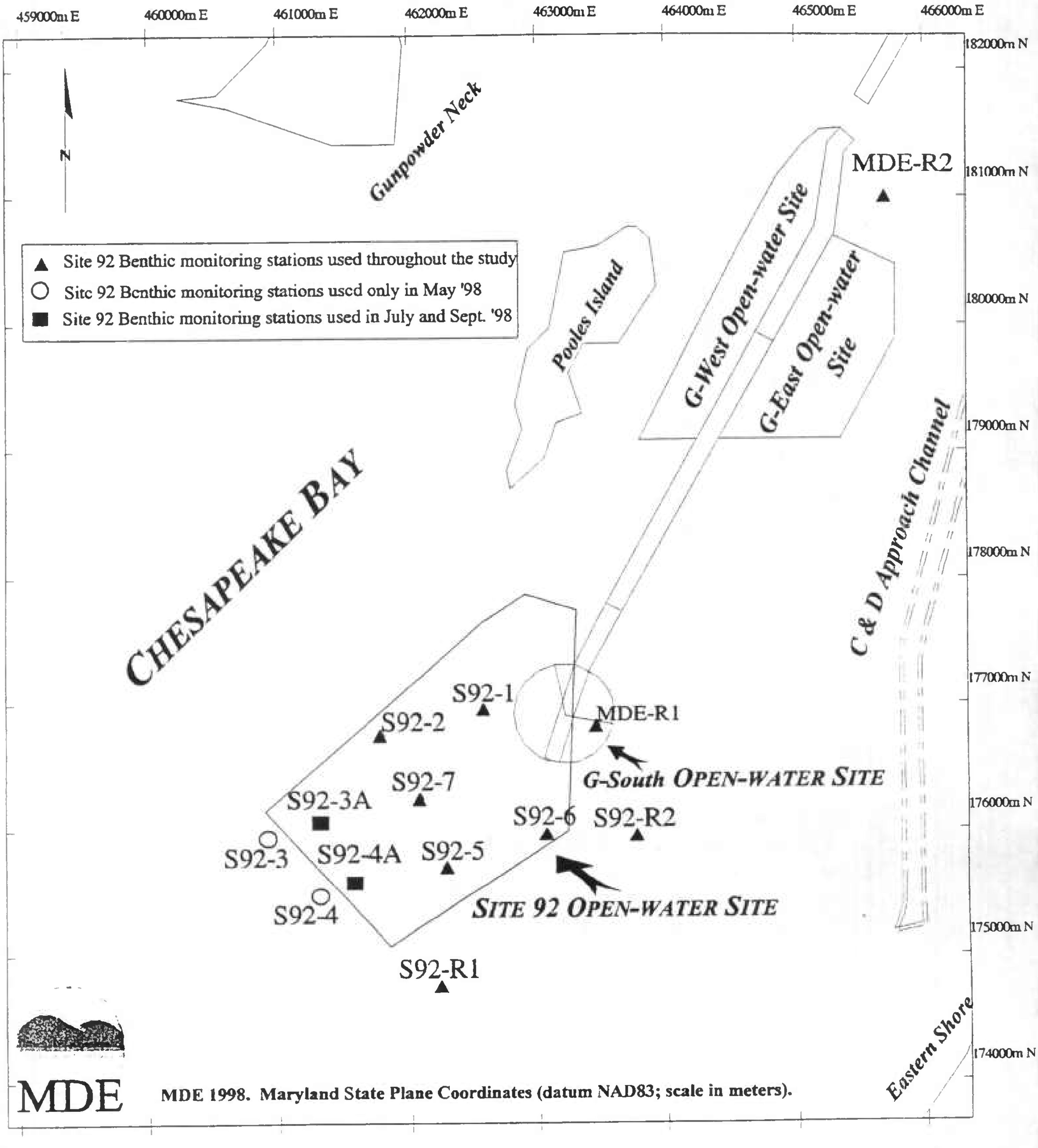
INTRODUCTION

Site 92 is an open-water dredged material placement site in the vicinity of Pooles Island. This subaqueous site in the Upper Chesapeake Bay has been designated for the placement of uncontaminated material dredged from the shipping channels leading to the Port of Baltimore. Site 92 comprises 934 acres and will provide a placement capacity of approximately 3.7 million cubic yards (mcy) with a useful life of approximately 2 to 3 years. Berm construction on the northeast end of the site began in December 1998. A thorough baseline assessment of the benthic community in and around Site 92 was conducted from May through September 1998. The purpose of this assessment was to establish baseline conditions and to determine whether placement of dredged material at adjacent open-water sites in the Pooles Island complex (G-West, G-West berm, G-North, G-Central, and G-South) has affected this area. Baseline characterization of the existing benthic community will also permit statistical comparison with conditions after placement at Site 92 has been completed.

Three seasonal baseline sampling cruises (May, July and September 1998) were conducted to assess the condition of the benthic community in relation to seasonal fluctuations in water quality parameters and recruitment potential. Sampling was conducted in May (spring) to examine the extent of spring recruitment. Samples were collected in July (early summer) because the summer months typically have the highest temperatures and lowest dissolved oxygen levels. Late September sampling was conducted to evaluate the late summer/early fall conditions of warm temperatures and higher salinity. July and September also fall within the index period for which the Chesapeake Bay Benthic Index of Biotic Integrity (B-IBI) has been calibrated.

This report contains the analysis and interpretation of data from the complete Site 92 baseline benthic community study. Raw data, the cruise report, spreadsheets, and other documentation from the September cruise are attached as appendices to this document. Raw data, cruise reports, spreadsheets, and other documentation from the May and July cruises are found in Dalal et al. (1998a and 1998b, respectively).

Summaries of benthic community data from past studies (Ranasinghe and Richkus 1993; Dalal et al. 1996a; Dalal et al. 1996b) in the Pooles Island Complex are included as Appendix VIII of this report. These studies were carried out at the adjacent G-South area and in the vicinity of the proposed G-East open-water placement area. The benthic community found at station *Northeast* during 1998 was compared to the benthic community found in the vicinity of the proposed area G-East in 1995 (Dalal et al. 1996a). Conditions in G-South during 1998 have been compared to present reference conditions in the Pooles Island area to determine whether the benthic community at this former placement site is significantly different from present reference conditions. Results of the present G-South study have also been compared to results of pre- and post-placement studies in G-South (Ranasinghe and Richkus 1993; Dalal et al. 1996b). These comparisons will help MDE develop expectations for post-placement benthic community recovery in Site 92.



MDE 1998. Maryland State Plane Coordinates (datum NAD83; scale in meters).

Figure 1. Site 92 Open-Water Placement Location and Benthic Monitoring Stations.

SITE DESCRIPTION

Site 92 lies in the Upper Chesapeake Bay northeast of Baltimore, Maryland. Site 92 is located south of Pooles Island and southwest of open-water placement site G-West. Site 92 encompasses a portion of area G-South (Figure 1). Salinity in the Pooles Island area varies seasonally and typically ranges from tidal freshwater (0-0.5 parts per thousand [‰]) or oligohaline (0.5-5 ‰) in the spring to low mesohaline (5-12 ‰) in the summer and fall.

METHODS

A. Sampling Design

Eleven benthic stations in and around the Site 92 area were assessed for several habitat quality parameters and aspects of the benthic community structure on May 6, July 31, and September 28, 1998. Station locations are shown in Figure 1; latitude and longitude (in degrees decimal minutes) for each station are provided in Table 1. Stations designated S92-1 through S92-7 lie within the boundary of the site and provide information on the conditions existing within Site 92. Following the May sampling cruise, stations S92-3 and S92-4 were found to lie outside the Site 92 boundary. These two stations were relocated a short distance to the northeast inside the boundary of the site and renamed stations S92-3A and S92-4A, respectively, for the remainder of the study. Stations S92-R1, to the south of Site 92, and S92-R2, to the east, serve as reference stations for Site 92. These reference stations were selected based on their locations outside of Site 92. Stations MDE-R1, in the area designated G-South, and MDE-R2, just north of the proposed G-East area, were sampled by MDE as a cost-share effort for comparison to reference conditions in the Pooles Island area and to previous studies in the Pooles Island Complex.

B. Field Sampling Techniques

Station locations were verified using a Differential Global Positioning System (DGPS) navigation unit. Latitudes, longitudes, and total depth at each station during all three benthic cruises are provided in Table 1. Standard U.S. EPA biological sampling protocols were followed during field collections and subsequent laboratory identifications of benthic macroinvertebrates (Klemm et al. 1990).

1. Water Quality Measurements

In May and September, temperature, depth, salinity, pH, conductivity and dissolved oxygen were measured *in-situ* using a Hydrolab Surveyor II, calibrated based on the manufacturer's instructions prior to sampling (Hydrolab 1994). In July, a Yellow Springs Instrument (YSI) water quality meter, calibrated based on the manufacturer's instructions prior to the sampling event (YSI 1998), was used to measure temperature, depth, salinity, pH, conductivity and dissolved oxygen. The YSI meter was also used to measure turbidity throughout the water column in July and in the bottom water layer in September. Water quality parameters were measured at approximately 1.6 ft (0.5 m) from the surface, 3.3 ft (1.0 m) from the bottom, and at 6.6 ft (2.0 m) intervals from the bottom measurement to develop a vertical profile of water quality at each station. These data and other field observations (e.g., weather conditions, sediment composition estimates) were recorded on Benthic Community Field Data Sheets. These data were archived electronically using Microsoft *Word* (September, Appendix I; May and July, Appendix I in Dalal et al. 1998a and 1998b, respectively). This information was used to generate the cruise report (September, Appendix II; May and July, Appendix II in Dalal et al. 1998a and 1998b, respectively).

Station Designation	**Latitude (Degrees Decimal Minutes)**	**Longitude (Degrees Decimal Minutes)**	**Total Depth (ft)**		
			May	**July**	**Sept**
Inner Stations					
S92-1	39°15.5232	76°16.5192	24.6	23.3	23.6
S92-2	39°15.4182	76°17.0766	16.4	13.8	14.8
S92-3	39°14.9898	76°17.7060	18.0	*	*
S92-3A	39°15.0762	76°17.4918	*	18.4	17.4
S92-4	39°14.6976	76°17.4468	17.4	*	*
S92-4A	39°14.8314	76°17.2578	*	18.0	18.0
S92-5	39°14.8488	76°16.7352	17.1	16.4	16.4
S92-6	39°14.9802	76°16.1772	16.1	17.7	16.4
S92-7	39°15.1464	76°16.8702	20.7	20.7	20.3
Reference Stations					
S92-R1	39°14.3352	76°16.7754	15.4	14.8	14.4
S92-R2	39°14.9772	76°15.6906	19.0	18.4	18.0
G-South Station					
MDE-R1	39°15.4542	76°15.9054	15.1	11.5	13.4
Northeast Station					
MDE-R2	39°17.6706	76°14.3070	14.8	15.4	13.1

Table 1. Station designations, locations (latitude and longitude in degrees decimal minutes), and total depth (feet) of Site 92 *Inner*, *Reference*, *G-South*, and *Northeast* stations, in May, July, and September 1998. *Stations S92-3 and S92-4 were moved a short distance after the May sampling cruise and renamed as stations S92-3A and S92-4A, respectively.

2. Benthic Community Sampling

Semi-quantitative benthic samples were collected using a Van Veen grab sampler, which collects 1.1 ft^2 (0.1 m^2) of bottom substrate. Three replicate benthic grab samples were collected from each station for statistical analysis. Collection efforts were standardized to assure reproducible volumes in each replicate sample. Grab samples in which the Van Veen sampler was at least 90% filled with sediment were considered acceptable. Samples were rinsed through a standard No. #30 (0.5 mm) sieve on the vessel to remove fine sediment particles. Organisms small enough to pass through this mesh were not considered macroinvertebrates (Klemm et al. 1990). The remaining material from each replicate was condensed, flushed into a container, and preserved in a solution of 10% formalin and bay water. A paper label with station and date information was placed inside the sample container. Station and date information were also written on the lid of the container to ensure proper sample identification. Upon return from the field, a chain-of-custody form was completed indicating the transfer of the benthic samples from the vessel to the laboratory (September, Appendix III; May and July, Appendix III in Dalal et al. 1998a and 1998b, respectively).

3. Sediment Sampling

During the July and September cruises, a fourth grab sample was collected at each station for sediment analysis using the Van Veen grab sampler. A small subsample of the sediment in this grab sample, approximately 100 to 400 grams, was collected using a plastic scoop and placed into a labeled plastic bag for storage and transport to the laboratory. During the May cruise, a subsample of approximately 200 to 400 grams of sediment was removed from the third benthic community replicate sample using a plastic coring device. The subsample was placed into a labeled plastic bag for storage and transport to the laboratory. Subjective estimates (nearest 5%) of the percent contributions of gravel, shell, sand, and silt/clay (mud) were made in the field by the senior scientist and recorded on field data sheets. All sediment subsamples were transferred to MDE's Benthos Lab and refrigerated pending grain-size and water content analysis in the laboratory. A chain-of-custody form was completed for the transfer of sediments to the laboratory (September, Appendix III; May and July, Appendix III in Dalal et al. 1998a and 1998b, respectively).

C. Laboratory Processing Techniques

1. Benthos

Replicate samples were recorded in the Maryland Department of the Environment's Benthic Log Book upon transfer to the MDE Technical and Regulatory Services Administration (TARSA) Benthos Laboratory in Baltimore. Each replicate was given a log number for reference purposes. In the laboratory, each sample was placed into a 0.5-mm sieve and rinsed with tap water to remove fine sediments and the field preservative. A small quantity of the sample was then placed into a shallow white pan with a small amount of water to facilitate removal of the organisms, which were extracted from the remaining debris using forceps. Periodic checks were made by senior lab personnel to assure that at least 95% of the organisms present in the sample were recovered. Organisms were separated into vials by major taxonomic groups and preserved in 70% ethanol for subsequent identification and enumeration.

Large organisms were identified to the lowest practical taxon, usually species, using a stereo dissecting microscope. Members of the insect family Chironomidae and some annelid worms were mounted on microscope slides, cleared and stained using a mixture of CMCP-10 and CMCP-9AF. Mounted organisms were identified using a binocular compound microscope. Identifications were based on available taxonomic keys and in-house reference specimens. Identifications and enumerations were recorded in the taxonomists' bench notebooks/bench sheets and later transcribed onto MDE's Taxa Inventory Sheets (September, Appendix IV; May and July, Appendix IV in Dalal et al. 1998a and 1998b, respectively). Routine Quality Assurance/Quality Control (QA/QC) examination by senior personnel was performed to ensure proper identification. In addition, organisms from one of every ten samples identified was sent to an independent consultant for confirmation or identified by a second MDE taxonomist as part of the QA/QC protocol (September, Appendix V; May and July, Appendix V in Dalal et al. 1998a and 1998b, respectively).

2. Sediments

Standard Operating Procedures (SOP's) established by MDE/DCAD were followed during all laboratory sedimentological analyses. A single sediment sample was used for both water content and size fractionation. Three size fractions were obtained by this method: gravel particles (≥2.00 mm), sand (<2.00 mm to >63 μm), and silt/clay (≤63 μm). In preparation for determining both water content and sediment size-fraction, the sample was removed from the refrigerator, allowed to warm to room temperature, and thoroughly homogenized by massaging the zip-lock bag in which the sediment was stored.

For sediment size-fraction analysis, two brass sieves (2.00 mm and 63 μm) were stacked over a solid brass collection pan and placed on a sieve-shaker with the 2.00-mm sieve on top. Approximately 50 grams of wet sediment were randomly scooped from the sediment sample bag, added to a pre-weighed aluminum pan, and weighed on an analytical balance. Wet sediment weight was calculated as the difference between the weight of the wet sediment sample in the pan and the weight of the aluminum pan. After weighing, the sediment was rinsed from the aluminum pan into a small beaker. Care was taken to ensure that all the sediment was washed from the pan into the beaker. Approximately 80 milliliters of water were added to the beaker and the resulting sediment slurry was stirred to break up the mud. The slurry was then poured onto the 2.00-mm sieve. A gentle stream of water from a wash bottle was used to rinse the beaker to ensure that all of the sediment was transferred to the sieve stack. The sample was rinsed to remove fine particles that adhered to the coarse fraction. In some instances, a small brush was used along with the water to remove mud that adhered to shell fragments. A cover was then placed onto the top sieve and the stack was shaken by the sieve-shaker for 5 minutes. The coarse fraction was then rinsed to remove any remaining fine particles, removed from the sieve, and placed into a pre-weighed aluminum weigh pan. The weigh pan with the coarse particles was placed into a convection oven at 150°C until completely dry. After the coarse fraction was removed, the 2.00-mm sieve was rinsed briefly to remove any finer particles that may have adhered to it and removed from the stack. The contents of the 63 μm sieve were then rinsed to help separate the mud from the sand. A small brush was used to help break up any small clumps of mud and to help move the material through the sieve. After the brush was rinsed, the lid was placed back onto the sieve and the stack was shaken for 5 minutes. The lid was then removed, the sand fraction brushed and rinsed, and the lid replaced. The sieves were then shaken for an additional 5 minutes. This procedure was repeated one or two more times, if necessary, to help separate the sand and mud fractions. After separation was complete, the sand fraction was washed into a pre-weighed aluminum weigh pan, placed into the oven, and allowed to dry completely. The contents of the bottom brass pan (i.e., mud fraction) were then rinsed into one or two large beakers depending on the amount of water present. The sediment was allowed to settle undisturbed for at least 48 hours, after which excess water was removed using a syringe, and the beaker was placed into the oven at 150 °C until the sediment was nearly dry. The silt/clay fraction then was transferred to a pre-weighed aluminum weigh pan and allowed to dry completely. After drying was complete, pans and their contents were allowed to cool to room temperature prior to being weighed to the nearest milligram on the analytical balance.

The weights of the various size fractions were calculated as the difference between the weights of the empty pans and the pans plus their contents. Total dry weight was determined by summing the weights of the various size fractions. Each fraction was also expressed as a percentage of the total dry weight. Water weight was determined as the difference between the wet sediment weight and the total dry sediment weight. Water content was also expressed as a percentage of the wet sediment weight.

All information was recorded on the Dredging Coordination and Assessment Division's (DCAD) Sediment Grain Size and Water Content Analysis Sheets (September, Appendix VI; May and July, Appendix VI in Dalal et al. 1998a and 1998b, respectively). As part of MDE's QA/QC protocol, one randomly selected subsample out of every ten analyzed was duplicated to ensure accuracy. The analysis of the first sample was accepted if the standard deviation of the two samples was $\leq$ 5 % for each fraction and for the water content. If the standard deviation was > 5 % for any fraction or for the water content, then a third sample was analyzed and an average of the three samples was used.

D. Data Management Methods

Information from Taxa Inventory Sheets was transferred to the spreadsheet program *Excel* to generate benthic community spreadsheets (September, Appendix VII; May and July, Appendix VII in Dalal et al. 1998a and 1998b, respectively). These spreadsheets were evaluated by a senior scientist to confirm that the data were accurately transferred from the inventory sheets to the computer database. Data from the sediment analyses were also entered into an *Excel* spreadsheet. Data from the Benthic Field Data sheets were archived into Microsoft *Word*.

E. Analytical Methods

Sediment size-fraction data were compared graphically using Microsoft *Excel*. Water quality data were also entered into an *Excel* spreadsheet and used in statistical analyses.

Five main measures of benthic community condition were examined: total abundance, relative abundance of pollution-indicative taxa, relative abundance of pollution-sensitive taxa, the Shannon-Wiener diversity index, and taxa richness. The first four of these measures were used to calculate the Chesapeake Bay Benthic Index of Biotic Integrity (B-IBI; Weisberg et al. 1997) for both the July and September sampling events. The benthic community measures were calculated using formulas in the benthic community spreadsheets. All measures were calculated based solely on the presence of the infaunal taxa because the B-IBI is based only on infaunal taxa (Ranasinghe personal communication 1998; Ranasinghe et al. 1994). Taxa richness was also based solely on the infaunal taxa because of its relationship to the Shannon-Wiener diversity index. Seasonal fluctuations in the abundance of the three dominant infaunal taxa were also examined.

Abundance measures were calculated based on the average abundance of infaunal taxa in the three replicate samples at each station. Total Abundance was calculated as the total number of organisms per square meter (m^2). Pollution-Sensitive Taxa Abundance was calculated as the percentage of total abundance represented by pollution-sensitive taxa. The pollution-sensitive taxa found during the Site 92 sampling cruises were the clams *Macoma balthica* and *Rangia cuneata,* the worm *Marenzelleria viridis,* and the isopod *Cyathura polita.* Pollution-Indicative Taxa Abundance was calculated as the percentage of total abundance represented by pollution-indicative taxa. Pollution-indicative taxa tend to reproduce rapidly and often dominate disturbed habitats. The pollution-indicative taxa found during the Site 92 sampling were the midges (Insecta: Chironomidae) *Coelotanypus* sp. and *Procladius* sp., and the polychaete worms *Streblospio benedicti* and *Hypereteone heteropoda.* Taxa were designated as pollution-indicative or pollution-sensitive according to Weisberg et al. (1997)[1].

The Shannon-Wiener Diversity Index (H′) is a theoretical measure of community diversity based on a combination of taxa richness (total taxa found in all replicates) and the evenness of distribution of individuals among the taxa. This index was estimated using the standard formula:

$$H' = \Sigma(\frac{n_i}{N})\log_2(\frac{n_i}{N})$$

where n_i = number of individuals in a given taxon and N = total number of individuals in the sample. Calculations were made in *Excel* using the machine formula provided in Weber (1993). Because this diversity index represents the theoretical total diversity found in an area, the value for each station was calculated based on the total numbers of individuals in each infaunal taxon for all replicates (i.e., the composite average). Taxa richness (number of taxa) was calculated for each station as the total number of infaunal taxa found in all replicates.

Chesapeake Bay Benthic Index of Biological Integrity (B-IBI) scores were calculated for the July and September sampling events. The B-IBI was not calculated for May samples because

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[1] The terms "pollution-indicative" and "pollution-sensitive" have replaced the terms "opportunistic" and "equilibrium", respectively, used in previous documents (Dalal et al. 1998a and 1998b).

the B-IBI has been calibrated only for the summer index period – July 15 through September 30 (Ranasinghe personal communication 1998; Weisberg et al. 1997). Calculation of the B-IBI requires scoring individual measures (attributes) of the benthic community according to criteria provided by Weisberg et al. (1997). The scores of the individual measures are then averaged to yield the B-IBI score. Selection of measures to be used depends on the bottom salinity and sediment composition (silt/clay content) present at the site during sampling. Summer salinity in the Pooles Island area ranged from 3.6 ‰ at station S92-2 in July (average July salinity at all stations = 4.3 ‰) to 9.5 ‰ at station S92-R1 in September (average September salinity at all stations = 8.9 ‰). The average salinity at all stations over the summer index period was 6.6 ‰. Therefore, the area was classified as "low mesohaline" (salinity ≥ 5 to 12 ‰) for the purposes of calculating the B-IBI. No distinction is made between sand and silt/clay sediments in mesohaline environments (Weisberg et al. 1997). Measures appropriate to the B-IBI in low mesohaline environments are total abundance, relative abundance of pollution-indicative taxa, relative abundance of pollution-sensitive taxa, and the Shannon-Wiener Diversity Index.

Threshold limits for the B-IBI were 1.7 - 2.5 for the diversity index[2], 10-20% for the abundance of pollution-indicative taxa, and 5-25% for the pollution-sensitive taxa abundance. Values within the threshold ranges are given a score of 3. Diversity and pollution-sensitive taxa abundance increase with improved habitat conditions. Values above threshold for diversity and pollution-sensitive taxa abundance are, therefore, considered optimal and given a score of 5. Pollution-indicative taxa abundance decreases as habitat conditions improve. Therefore, values lower than threshold for pollution-indicative taxa abundance are considered optimal and given a score of 5. Values below threshold for diversity and pollution-sensitive taxa abundance, or above threshold for pollution-indicative taxa abundance, are assigned a score of 1. Total abundance was scored bimodally because the response of the benthic community to organic pollution varies with the amount of enrichment (Pearson and Rosenberg 1978; Dauer and Conner 1980; Ferraro et al. 1991). Stations were given a score of 3 if abundance was between 500 and 1,500 **or** between 2,500 and 6,000 organisms per square meter. Abundances between 1,500 and 2,500 organisms per square meter were considered ideal and scored as five. All other values were given a score of one. The scores for each of these four measures were then averaged to determine the B-IBI. B-IBI scores of 3 or greater were considered to meet the Chesapeake Bay Restoration Goal (Ranasinghe et al. 1994). Scoring criteria for the four measures (metrics) used in this study are provided in Table 2.

Several taxa found during the study have been noted on the benthic community spreadsheets but excluded from calculations of individual measures, because these taxa are not included in the B-IBI (Ranasinghe, personal communication 1998; Ranasinghe et al. 1994). The B-IBI is based solely on the condition of the benthic **infaunal** community (organisms that live within the sediments). The taxa that were excluded are members of the **epifaunal** community (organisms that live *on* rather than *in* the sediment). The excluded taxa were snails in the family Hydrobiidae, the mussel *Mytilopsis leucophaeata*, the amphipods *Melita nitida* and *Apocorophium lacustre*, the crab *Rhithropanopeus harrisii*, the barnacle *Balanus improvisus*, and the isopod *Edotea triloba*. Members of the phyla Bryozoa (bryozoans) and Porifera (sponges)

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[2] This range was incorrectly reported as 1.9 – 2.5 in Dalal et al. 1998b.

were excluded from the Taxa Inventory Sheets and spreadsheets, as well as the calculations, because these groups are not only epifaunal but were only qualitatively sampled.

Measure	Score		
	5	3	1
Shannon Diversity Index (H')	≥ 2.5	1.7 - 2.5	< 1.7
Total Abundance (individuals per square meter)	≥ 1,500 – 2,500	500-1,500 **or** ≥ 2,500- 6,000	< 500 **or** ≥ 6,000
% Pollution-sensitive Taxa	≥ 25%	5-25%	< 5%
% Pollution-indicative Taxa	≤ 10%	10-20%	> 20%

Table 2. Scoring Criteria for Measures Used in Calculating the Chesapeake Bay Benthic Index of Biological Integrity (B-IBI)

F. Statistical Analysis

Multiple correlation analysis was applied separately to the *in-situ* habitat data, a combination of *in-situ* habitat data and certain measures of the benthic community, and to certain measures of the benthic community in order to determine whether any significant relationships existed among variables. Significant ($p < 0.05$) strong ($r \geq 0.75$), moderately strong ($r = 0.50$ to 0.74), and weak ($r < 0.50$) correlations were found between several parameters.

T-tests were performed to determine whether significant differences existed 1) between *Inner* and *Reference* stations during each season; 2) between *G-South* and *Reference* stations; 3) between *Northeast* and *Reference* stations; 4) between present conditions at the *Northeast* station and conditions in the vicinity of G-East during September 1995; and 5) between present conditions in G-South and conditions during previous studies of G-South in the early 1990's and 1996. These tests were performed using the statistical software package *Statistica*. Results of both the t-tests and correlation analysis are found in Appendix IX.

RESULTS AND DISCUSSION[3]

Stations were separated into categories based on their location inside or outside Site 92, or in G-South or in the vicinity of G-East. Stations S92-1 through S92-7, which lie within Site 92, were designated as *Inner* stations. Stations S92-R1 and S92-R2, which lie outside Site 92, are referred to as *Reference* stations. Stations MDE-R1 and MDE-R2 are designated as the *G-South* and *Northeast* stations because they lie within area G-South and north of area G-East, respectively.

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[3] **EDITOR'S NOTE:** After the May and July 1998 data were published, the data were re-examined and a number of minor discrepancies were found. Corrections have been made and the data that appear in this report are correct. Conclusions of the earlier reports are unchanged. An addendum to the May report (Dalal et al. 1998a) and revised copies of the July seasonal report (Dalal et al. 1998b) are available on request from MDE.

A. Habitat Parameters

Data from *in-situ* surface and bottom measurements of water quality parameters are provided in Tables 3a-c. Water quality measurements at other depths are included in the Benthic Field Data Sheets [September, Appendix I; May and July, Appendix I in Dalal et al. (1998a and 1998b, respectively)]. Results of sedimentological analysis are found in Table 4.

1. *In-Situ* Water Quality, May, July and September 1998

Salinity, conductivity, dissolved oxygen, pH and temperature were measured at all stations at 1.6 feet (0.5 m) below the surface, at 3.3 feet (1.0 m) from the bottom, and at 6.6 feet (2 m) intervals from the bottom measurement during each of the three cruises in 1998. Turbidity was measured at 3.3 feet (1.0 m) from the bottom during July and September. Secchi depth was measured during all seasons. Little variation in measurement values was seen throughout the water column indicating that no vertical stratification was occurring. Little spatial variation was seen in any water quality parameter within each season. Therefore, the following discussion focuses on seasonal variation within the bottom waters.

Salinity. Seasonal variation in salinity during 1998 was typical for this region of the Bay. Salinity increased from May to September in the Pooles Island Area. In May 1998, salinity was very low and fell within the "tidal freshwater" range (0.1-0.5 ‰; Weisberg et al. 1997). May salinity values ranged from 0.1 ‰ to 0.5 ‰ (Table 3a; average = 0.3 ± 0.1‰) with the lowest salinity found at the northern-most station, MDE-R2. Low salinity in May was attributed to high freshwater influx, mainly from the Susquehanna River. By July, salinity had climbed into the oligohaline range (≥ 0.5-5 ‰; Weisberg et al. 1997) with a range of 3.6 to 4.9 ‰ (Table 3b; average = 4.3 ± 0.5 ‰) due to a decrease in freshwater influx. Salinity continued to increase over the summer due to low freshwater influx. By September, bottom salinity in the Pooles Island area averaged 8.9 ± 0.4 ‰ with a range of 8.0 to 9.5 ‰ (Table 3c), placing it within the "low mesohaline" classification (≥ 5 – 12 ‰; Weisberg et al. 1997). This was a large increase over the salinity values recorded in May, as well as July, and is likely to have affected the benthos in the Pooles Island Area. Average summer salinity based on July and September data was 6.6 ‰. Salinity at the *Northeast* station, MDE-R2, was typically lower than average due to its location closer to the head of the Bay and freshwater influx from the Susquehanna River. No other spatial patterns were present during any season examined.

Temperature. Water temperatures in May (Table 3a) were cool (average = 16.6 ± 0.2 °C; range = 16.4 to 17.0 °C). By July (Table 3b), water temperatures had risen by 50% to an average of 26.7 ± 0.1 °C (range = 26.5 °C to 26.9 °C). Water temperatures were slightly cooler, though still warm, in September (Table 3c; average = 22.9 ± 0.1 °C; range = 22.8° C to 23.0° C).

Secchi Depth. Secchi depth was lowest at all stations in May (Table 3a; average = 2.5 ± 0.7 ft; range = 1.6 to 3.9 ft). Secchi depth increased at most stations in July (Table 3b; average 4.3 ± 0.5 ft; range = 3.9 to 5.2 ft). A slight increase in secchi depth was seen at most stations in September (Table 3c; average = 5.2 ± 0.7 ft; range = 3.6 to 6.0 ft).

Station \ Layer		Depth (ft)	Temp. (°C)	pH	Dissolved O_2 (mg/l)	Conductivity (µmhos /cm)	Salinity (ppt)	Secchi Depth (ft)
Inner Stations								
S92-1	Surface	1.6	17.1	7.4	8.5	361	0.2	3.9
	Bottom	21.3	16.5	7.3	8.6	980	0.5	
S92-2	Surface	1.6	17.0	7.4	8.5	348	0.2	2.3
	Bottom	13.1	16.6	7.5	8.6	907	0.5	
S92-3	Surface	1.6	16.8	7.4	8.5	621	0.3	1.6
	Bottom	14.8	16.9	7.5	8.7	576	0.3	
S92-4	Surface	1.6	16.6	7.5	8.5	857	0.5	2.0
	Bottom	14.1	16.6	7.5	8.6	848	0.4	
S92-5	Surface	1.6	16.6	7.4	8.8	807	0.4	3.3
	Bottom	13.8	16.4	7.6	8.7	863	0.5	
S92-6	Surface	1.6	16.5	7.3	8.9	742	0.4	2.0
	Bottom	12.8	16.4	7.7	8.9	749	0.4	
S92-7	Surface	1.6	16.9	7.6	8.8	374	0.2	2.6
	Bottom	17.4	16.6	7.7	8.7	451	0.2	
Reference Stations								
S92-R1	Surface	1.6	16.8	7.7	8.9	804	0.4	2.6
	Bottom	12.1	16.5	7.6	9.3	815	0.4	
S92-R2	Surface	1.6	17.0	7.8	9.2	493	0.3	2.0
	Bottom	16.4	16.5	7.8	9.1	585	0.3	
G-South Station								
MDE-R1	Surface	1.6	17.2	7.9	9.2	301	0.2	2.3
	Bottom	11.8	16.6	7.7	9.4	372	0.2	
Northeast Station								
MDE-R2	Surface	1.6	17.2	8.0	9.5	167	0.1	2.6
	Bottom	11.5	17.0	8.0	9.5	166	0.1	

Table 3a. Water Quality Parameters Measured at Site 92 *Inner, Reference*, *G-South* and *Northeast* Stations During the May 1998 Cruise. *In-situ* measurements were taken at approximately 1.6 ft (0.5 m) from the surface and 3.3 ft (1.0 m) from the bottom.

Station \ Layer		Depth (ft)	Temp. (°C)	pH	Dissolved O_2 (mg/l)	Conductivity (µmhos/cm)	Salinity (ppt)	Turbidity (NTU)	Secchi Depth (ft)
Inner Stations									
S92-1	Surface	1.6	26.8	7.4	6.9	5980	3.2	11.2	3.9
	Bottom	19.7	26.8	7.4	6.4	7010	3.8	11.0	
S92-2	Surface	1.6	26.8	7.4	7.0	6600	3.6	10.9	3.9
	Bottom	9.8	26.8	7.4	7.0	6640	3.6	34.4	
S92-3A	Surface	1.6	26.7	7.4	7.0	6690	3.6	10.2	4.6
	Bottom	15.1	26.8	7.3	6.9	7600	4.2	8.4	
S92-4A	Surface	1.6	26.7	7.3	6.7	7608	4.2	8.2	4.6
	Bottom	14.8	26.8	7.3	6.6	7815	4.3	8.2	
S92-5	Surface	1.6	26.6	7.4	6.8	7700	4.2	8.2	4.6
	Bottom	13.1	26.6	7.3	6.2	8097	4.5	8.7	
S92-6	Surface	1.6	26.9	7.3	7.0	8054	4.5	6.8	4.6
	Bottom	14.4	26.5	7.3	6.3	8538	4.7	4.2	
S92-7	Surface	1.6	26.9	7.5	7.3	7437	4.1	6.2	4.6
	Bottom	17.4	26.8	7.3	7.1	8030	4.4	8.3	
Reference Stations									
S92-R1	Surface	1.6	26.7	7.2	7.2	8715	4.8	11.5	3.6
	Bottom	11.5	26.7	7.2	7.2	8719	4.9	16.5	
S92-R2	Surface	1.6	27.0	7.8	8.1	7180	3.9	9.9	3.6
	Bottom	15.1	26.5	7.4	6.6	8700	4.9	11.4	
G-South Station									
MDE-R1	Surface	1.6	27.0	7.5	7.7	7680	4.2	6.0	5.2
	Bottom	8.2	26.6	7.3	6.5	8220	4.5	6.1	
Northeast Station									
MDE-R2	Surface	1.6	26.9	7.4	6.5	6730	3.7	8.0	3.9
	Bottom	12.1	26.8	7.4	6.6	6740	3.7	10.0	

Table 3b. Water Quality Parameters Measured at Site 92 *Inner, Reference, G-South* and *Northeast* Stations During the July 1998 Cruise. *In-situ* measurements were taken at approximately 1.6 ft (0.5 m) from the surface and 3.3 ft (1.0 m) from the bottom.

Station \ Layer		Depth (ft)	Temp. (°C)	pH	Dissolved O_2 (mg/l)	Conductivity (µmhos/cm)	Salinity (ppt)	Turbidity (NTU)	Secchi Depth (ft)
Inner Stations									
S92-1	Surface	1.5	23.2	7.5	8.7	15,000	8.5	NR	5.2
	Bottom	19.7	23.0	7.3	8.1	15.700	9.0	7.4	
S92-2	Surface	1.5	23.2	7.6	8.8	15,200	8.6	NR	5.2
	Bottom	13.1	22.9	7.2	7.6	15.600	8.8	7.4	
S92-3A	Surface	1.5	23.1	7.5	9.0	15,100	8.6	NR	5.2
	Bottom	14.8	23.0	7.1	8.2	15,800	9.0	4.7	
S92-4A	Surface	1.5	22.9	7.1	7.4	15,600	8.8	NR	4.6
	Bottom	14.8	22.8	7.0	7.8	15.600	8.9	7.2	
S92-5	Surface	1.5	22.8	7.1	7.1	15.600	8.8	NR	5.2
	Bottom	14.8	22.8	6.9	7.1	16,100	9.0	15.1	
S92-6	Surface	1.5	22.9	7.1	7.3	14,580	8.2	NR	5.2
	Bottom	14.8	22.8	7.0	7.1	16.100	9.0	4.7	
S92-7	Surface	1.5	23.0	7.0	7.6	14,450	8.1	NR	4.9
	Bottom	18.7	22.9	6.8	7.6	15,800	9.0	12.4	
Reference Stations									
S92-R1	Surface	1.5	22.8	7.3	7.5	16,240	9.5	NR	3.9
	Bottom	12.5	22.8	7.2	7.7	16,230	9.5	10.9	
S92-R2	Surface	1.5	23.1	7.0	7.1	13,770	7.7	NR	4.6
	Bottom	16.4	22.8	6.9	6.9	15.700	9.0	4.4	
G-South Station									
MDE-R1	Surface	1.5	23.3	7.5	8.3	14,590	8.2	NR	5.9
	Bottom	10.8	22.9	7.3	7.1	15,600	8.8	3.5	
Northeast Station									
MDE-R2	Surface	1.5	23.4	7.3	7.8	13,410	7.3	NR	6.6
	Bottom	10.5	23.0	7.2	7.1	14,230	8.0	4.7	

Table 3c. Water Quality Parameters Measured at Site 92 *Inner, Reference, G-South* and *Northeast* Stations During the September 1998 Cruise. *In-situ* measurements were taken at approximately 1.6 ft (0.5 m) from the surface and 3.3 ft (1.0 m) from the bottom. Turbidity was not recorded (NR) at the surface during September due to low battery in the YSI water quality meter.

Turbidity. In July (Table 3b), turbidity averaged 11.5 Nephlometric Turbidity Units (NTU) and ranged from 4.2 to 34.4 NTU. The moderately high turbidity seen at station S92-2 in July (34.4 NTU) may have been caused by use of the Van Veen grab sampler at about the same time the reading was taken. Turbidity was low (< 17 NTU) at all stations during September (Table 3c). The range in September was from a low of 3.5 NTU (MDE-R1) to a high of 15.1 NTU (S92-5) with an average of 7.5 NTU.

Dissolved Oxygen. Dissolved oxygen (DO) concentrations were highest in May (Table 3a; average = 8.9 ± 0.3 ppm; range = 8.6 to 9.5 ppm) when the water temperature was lowest and freshwater influx was highest. DO concentrations were slightly higher at *Reference* stations (average = 9.3 ± 0.2 ppm) than at *Inner* stations (average = 8.6 ± 0.1 ppm). This difference was not ecologically important as all stations were well above the level at which low DO becomes a stressor. By July (Table 3b), DO concentrations had dropped to an average of 6.7 ± 0.3 ppm; average values at *Inner* stations were similar to values at *Reference* stations. Changes in DO concentration were significantly correlated with temperature (r = -0.93; Table IX-1). Therefore, the decrease in average DO concentration has been attributed primarily to increases in temperature. July DO concentrations were still above the level considered stressful to aquatic life. Dissolved oxygen concentrations increased in September (Table 3c; average = 7.5 ± 0.4 ppm) when water temperature was lower, but did not reach the level of May DO concentrations.

pH. No significant variation was seen in pH either among stations within a season or among seasons. In most cases, pH was near or only slightly above neutral. In May (Table 3a), pH ranged from 7.3 to 8.0 (average 7.6 ± 0.2 pH units). In July (Table 3b), a very slight decrease (0.1 to 0.6 pH units) was seen at all stations, except at S92-1, where pH increased very slightly (0.1 pH units). July pH values averaged 7.3 ± 0.1 and ranged from 7.2 to 7.4. Another very slight decrease (0.1 to 0.5 pH units) was seen at many stations in September (Table 3c). September pH values averaged 7.1 ± 0.2 and ranged from 6.9 to 7.3.

Correlation Analysis. Significant relationships ($p < 0.05$) were found among a number of *in-situ* water quality parameters (Appendix IX, Table IX-1). Some of these significant correlations were strong ($r > 0.75$); other correlations were moderately strong ($r = 0.50$ to 0.74) or weak ($r < 0.50$). Many of these correlations can be explained as similar seasonal responses by both parameters. For example, salinity was moderately correlated with temperature (r = 0.58). Both are expected to increase from spring through summer (temperature as solar radiation increases, salinity as freshwater influx decreases). Other correlations may suggest the existence of cause-and-effect relationships.

A strong negative correlation was found between temperature and dissolved oxygen concentration (r = -0.93). The effect of temperature on the saturation of dissolved gasses has been well documented in the literature. There was also a moderate negative correlation between temperature and pH (r = -0.55); pH, in turn, was positively correlated with DO (r = 0.60). This supports the hypothesis that temperature not only affects DO concentrations directly, but also indirectly by increasing benthic metabolism. Increasing benthic metabolism would cause an increase in carbon dioxide leading to decreased pH. There was a moderate negative correlation between DO and salinity (r = -0.55). Salinity is also known to affect DO saturation (Reid and

Wood 1976). However, given the stronger correlation between temperature and DO, and the relatively low salinity in the Pooles Island area, it is unlikely that salinity played a major role in determining DO concentration during 1998.

There were moderately strong negative correlations between Secchi depth and bottom pH (r = -0.74) and bottom dissolved oxygen (r = -0.68). There was a weak positive correlation between Secchi depth and bottom turbidity (r = 0.37). This suggests that the increase in Secchi depth may have been due to settling of organic material, resulting in slightly increased bottom turbidity and benthic metabolism.

2. Comparisons of Site 92 *In-Situ* Water Quality with Previous Studies in the Pooles Island Area

Water quality has been measured in the Pooles Island area as part of previous studies (Appendix VIII, Table VIII-1). Temperature varies seasonally, increasing from spring lows in the teens to highs in the mid to upper 20's (degrees Celsius) in July or August. Temperatures recorded in May, July and September 1998 were similar to those measured by Versar in the early 1990's (Ranasinghe and Richkus 1993) and by MDE in 1995 and 1996 (Dalal et al. 1996a and Dalal et al. 1996b).

Dissolved oxygen concentrations generally remain above 5.0 ppm, because the water around Pooles Island is shallow in depth. DO concentrations vary from season to season with higher values seen in the spring when the water is cooler and lower in salinity. Lowest values are typically seen in July and August due to increased temperatures and decreased freshwater influx. DO concentrations typically increase in September or October as water temperatures decline. DO concentrations recorded in May, July and September 1998 were similar to those reported by Versar in the early 1990's (Ranasinghe and Richkus 1993) and by MDE in 1995 and 1996 (Dalal et al. 1996a and Dalal et al. 1996b).

Rainfall in the Upper Chesapeake Bay drainage plays a major role in determining the salinity of the waters around Pooles Island. Typically, salinity is lowest in spring when freshets introduce large volumes of freshwater from the Susquehanna River and other rivers of the Upper Bay. Salinity values are often in the oligohaline range (> 0.5 to 5.0 ‰) and may even drop into the "tidal freshwater" range (0.1 to 0.5 ‰) if spring precipitation is heavy as it was in the spring of 1998. Salinity is lower than normal in years with greater than average rainfall and higher than normal in years with less than average rainfall. Average salinity recorded in May 1998 (0.3 ‰) was slightly lower than the average value recorded in May 1993 (1.6 ‰). Salinity climbs into the low mesohaline range (> 5.0 to 12.0 ‰) during summer as the amount of freshwater entering the Bay declines. Typically, July and August salinity values are in the lower end of this range (5.0 to 7 ‰). Average values recorded in July 1998 (4.3 ‰) were slightly higher than the average salinity recorded in August 1992 (2.5 ‰). During dry summers, such as 1991 and 1993, salinity may become even higher. Average salinity in August 1991 was 9.3 ‰; average salinity in July 1993, 10.6 ‰. During especially wet years, salinity may remain low even through September; for example, the average salinity in September 1996 was 5.5 ‰. During other years, the salinity has been higher in September. For example, average September salinity was 10.0 ‰

in 1995 and 8.9 ‰ in 1998.

3. Sediment Composition

Laboratory sediment analyses were performed to improve upon the accuracy of the field estimates. Sediments at stations S92-1, S92-2, S92-6, S92-7, S92-R2 and MDE-R1 consisted of over 60% silt/clay (dry weight) during all seasons (Figure 2 and Table 4). Sediments at S92-1 and S92-2 consisted of over 85% silt/clay with little or no gravel material (< 5%). Silt/clay accounted for over 90% of the dry sediment weight at MDE-R1 in the G-South placement area during all seasons; the ratio of sand to silt/clay at MDE-R1 is similar to that found at other stations. Gravel accounted for less than 1% of the sediment at this station. Numbers of *Rangia cuneata*, whose shells comprise most of the "gravel" fraction at other stations, have generally been low at MDE-R1 since 1992 (except in July 1993). Thus, it is not surprising that little "gravel" is found at MDE-R1.

Silt/clay was the dominate sediment type at Stations S92-4 and S92-4A (> 70%), and S92-3 and S92-3A (> 83% in each season). S92-3, sampled only in May, had a lower relative amount of silt/clay (52.22%) and a higher gravel fraction (36.81%). S92-6 and S92-7 had high silt/clay contents in May and September. The silt/clay content at stations S92-6 and S92-7 was lower in July due to a higher gravel (shell) content (24.20% and 30.57%, respectively). In contrast, silt/clay accounted for less than 51% of the dry weight at *Inner* station S92-5 and *Northeast* station MDE-R2 during all seasons. Silt/clay content was less than 61% at *Reference* station S92-R1 during May and July. The relative contribution of silt/clay increased at S92-R1 during September due to a decrease in the gravel (shell) fraction.

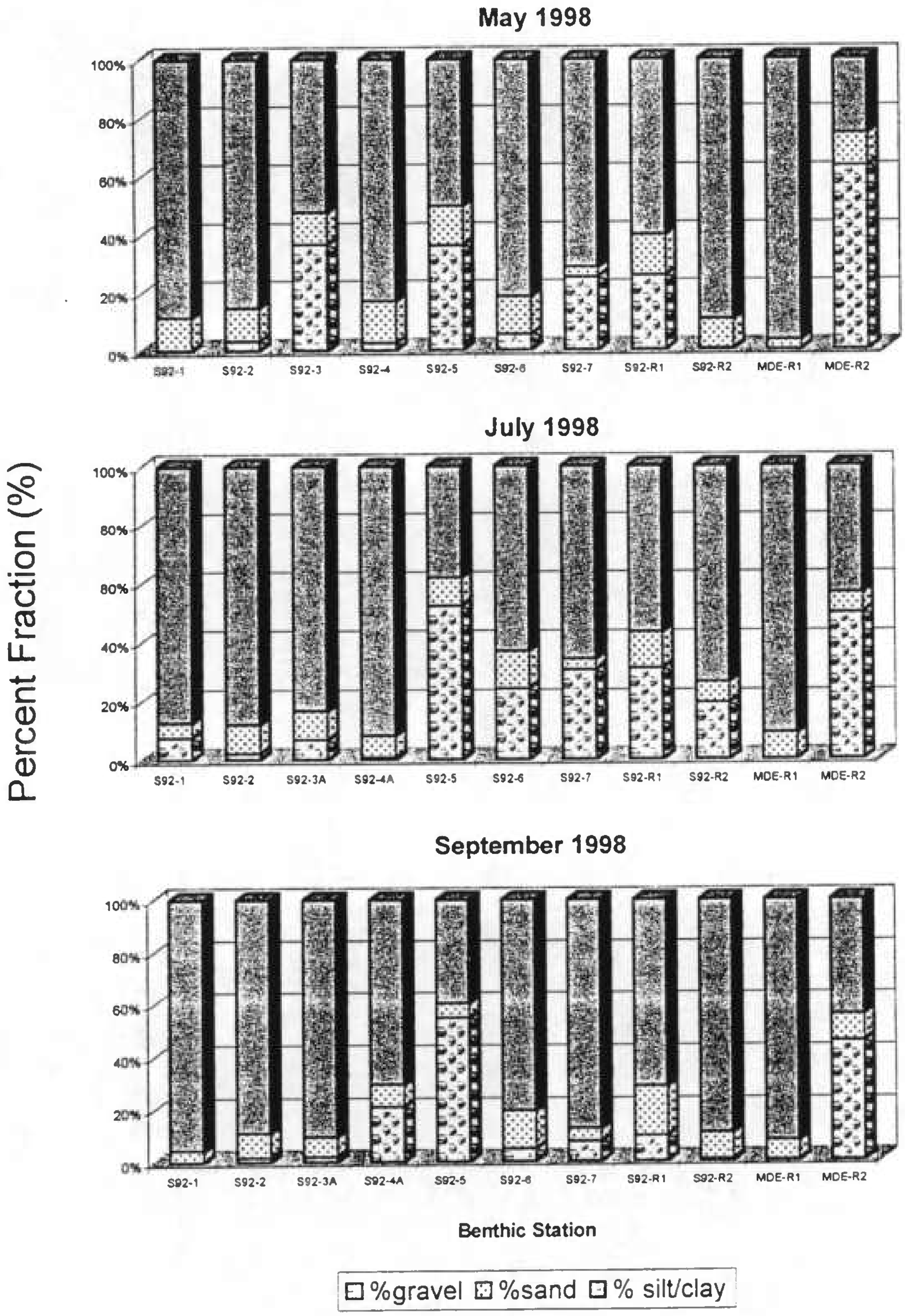
Sand accounted for an average of 11.16% of the dry sediment weight at *Inner* stations in May (range = 3.47 to 14.47 %), 8.19 % in July (range = 3.47 to 12.56%), and 7.84% in September (range = 4.32 to 14.44 %). Average sand content at *Reference* stations was slightly higher than at *Inner* stations (12.13%, 9.62%, and 14.45% in May, July and September, respectively). S92-R1 had slightly higher than average sand content during all three seasons.

The gravel fraction was composed almost exclusively of shell fragments from bivalves, primarily *Rangia cuneata*, at all stations during all seasons. Stations S92-5 and MDE-R2 were composed of over 36% gravel during all seasons. Station S92-3, sampled only in May, also had a relatively high gravel content (36.81%). S92-R1 and S92-7 had comparatively high gravel contents in May and July (> 25%), but lower gravel contents in September (< 10%). Other stations averaged less than 25% gravel during any season.

B. Benthic Community

Stations were separated into categories based on their locations around Pooles Island. Stations S92-1 through S92-7 are *Inner* stations lying within Site 92. Station S92-R1 and S92-R2 are *Reference* stations located outside Site 92. Station MDE-R1, located in area G-South, and station MDE-R2, located north of the proposed area G-East, were designated as the *G-South* and *Northeast* stations, respectively.

Figure 2. Sediment Grain Size Distribution at Site 92
Inner, *Reference*, *G-South* and *Northeast* Stations, 1998



Station	May 1998			July 1998			September 1998		
	% gravel	% sand	% silt/clay	% gravel	% sand	% silt/clay	% gravel	% sand	% silt/clay
Inner Stations									
S92-1	0.37	11.30	88.33	7.92	4.86	87.22	0.01	4.32	95.67
S92-2	3.40	11.30	85.30	2.13	10.00	87.87	1.69	9.37	88.94
S92-3	36.81	10.98	52.22						
S92-3A				7.13	9.39	83.48	1.83	7.80	90.37
S92-4	2.53	14.47	83.00						
S92-4A				0.90	7.47	91.64	20.78	8.60	70.62
S92-5	36.17	13.54	50.29	52.37	9.58	38.05	54.79	5.42	39.79
S92-6	5.40	13.07	81.53	24.20	12.56	63.25	4.91	14.44	80.66
S92-7	25.07	3.47	71.45	30.57	3.47	65.96	7.62	4.93	87.46
Reference Stations									
S92-R1	25.63	14.06	60.31	31.06	12.16	56.78	9.86	18.67	71.47
S92-R2	0.24	10.19	89.58	19.20	7.09	73.72	0.62	10.20	89.18
G-South Station									
MDE-R1	0.00	3.44	96.56	0.03	9.04	90.93	0.13	7.61	92.26
Northeast Station									
MDE-R2	63.09	11.10	25.81	49.73	6.74	43.52	45.67	10.16	44.17

Table 4. Sediment Composition at Site 92 *Inner, Reference, G-South* and *Northeast* Stations Based on Laboratory Analysis, May, July and September 1998. The gravel fraction was composed almost entirely of shell in each case.

1. Seasonal and Spatial Comparisons of Site 92 Stations

Values of the measures used to describe the benthic communities at Site 92 *Inner* and *Reference* stations are presented in Tables 5a-c. The measures used were Total Abundance, Pollution-Indicative Taxa Abundance (%), Pollution-Sensitive Taxa Abundance (%), the Shannon-Wiener Diversity Index, Taxa Richness, and the Chesapeake Bay Benthic Index of Biotic Integrity (B-IBI), which was not calculated for May. Seasonal changes at each station were examined using bar graphs.

Three additional characteristics of the benthic community were examined: the relative abundance of the three most common taxa at each station during each season (Table 6; Figures 9, 10 and 11), the abundance of the polychaete worm *Marenzelleria viridis* (Figure 12; Appendix X, Tables X-1, X-2 and X-3); and the abundance of the clam *Rangia cuneata* (Figure 13; Appendix X, Tables X-1, X-2 and X-3).

Correlation analysis was performed to determine whether relationships existed between benthic community and habitat parameters and among the benthic community parameters themselves. Significant correlations ($p < 0.05$) were found between several of the benthic parameters and certain habitat parameters (Appendix IX, Table IX-2). Significant correlations were also found between several benthic community parameters (Appendix IX, Table IX-3). Some of these correlations were moderately strong (r = 0.50 to 0.74); others were weaker (r = 0.35 to 0.49). T-tests were performed to determine whether significant differences ($p < 0.05$) existed between station types (e.g., *Reference* versus *Inner* stations) for certain benthic community parameters (Appendix IX, Table IX-4).

Total Abundance. Average total abundance (Figure 3) was highly variable among stations and within station groups. Moderate, but significant ($p < 0.05$), correlations were found between total abundance and the abiotic parameters temperature, salinity, DO, and pH (Appendix IX, Table IX-2). Total abundance was higher when salinity and temperature were lower. Increased temperature would be expected to affect benthic organisms' metabolic rates and oxygen consumption, as well as have a direct effect on DO concentrations. DO and pH were positively correlated with total abundance. Total abundance was moderately influenced by the relatively high abundance of the clam *Rangia cuneata* and more strongly by the abundance of the polychaete worm *Marenzelleria viridis* (Appendix IX, Table IX-3). Abundances of *R. cuneata* and *M. viridis* were negatively affected by increased temperature and salinity (Appendix IX, Table IX-2). The effects of increased temperature could not be separated from the effects of increased salinity. There were no significant differences in total abundance between *Reference* and *Inner* stations during the study (Appendix IX, Table IX-4).

Station	Average Total Abundance (#/m^2)	Pollution-Indicative Taxa Abundance (%)*	Pollution-Sensitive Taxa Abundance (%)*	Shannon-Wiener Diversity Index	Taxa Richness
Inner Stations					
S92-1	1633	0.80	74.76	2.19	13
S92-2	4390	0.21	97.77	1.25	11
S92-3	4090	0.00	89.60	1.36	11
S92-4	870	0.00	83.87	2.12	10
S92-5	3840	0.00	95.40	1.52	9
S92-6	940	0.00	79.74	2.10	9
S92-7	3183	0.18	90.54	1.57	12
Reference Stations					
S92-R1	3690	0.00	95.23	1.52	9
S92-R2	2173	0.10	92.72	1.13	10
G-South Station					
MDE-R1	5847	0.00	97.67	0.62	10
Northeast Station					
MDE-R2	1630	0.63	86.42	1.35	15

Table 5a. Values of Measures Used to Assess Infaunal Benthic Community Condition at Site 92 *Inner, Reference, G-South* and *Northeast* Stations, May 1998.
***Differences from 100% for the two tolerance categories combined are due to the presence of taxa not classified as pollution-sensitive or pollution-indicative.**

Total abundance was highest in May at seven of the eleven stations sampled (Figure 3; Table 5a). Average May abundance for *Inner* stations at Site 92 was 2.707 ± 1.522 individuals/m^2 and ranged from 870 (S92-4) to 4.390 individuals/m^2 (S92-2). Site 92 *Reference* stations averaged 2,932 ± 1,072 individuals/m^2 and ranged from 2,173 individuals/m^2 (S92-R2) to 3,690 individuals/m^2 (S92-R2). *Northeast* station MDE-R2 averaged 1,630 individuals/m^2. There was no significant difference between *Reference* stations and *Inner* stations or between *Reference* stations and the *Northeast* station (MDE-R2). The greatest abundance observed during May was at the *G-South* station MDE-R1, which averaged 5,847 individuals/m^2. Abundance at MDE-R1 was more than twice the average of the other stations and was significantly higher than at *Reference* stations (p = 0.0138; Table IX-4). This was attributed to the very high abundance of the pollution-sensitive worm *M. viridis* at MDE-R1.

Station	Average Total Abundance (#/m^2)	Pollution-Indicative Taxa Abundance (%)*	Pollution-Sensitive Taxa Abundance (%)*	Shannon-Wiener Diversity Index	Taxa Richness	B-IBI
Inner Stations						
S92-1	2617	0.11	94.39	1.00	13	3.5
S92-2	2253	0.00	95.59	1.11	9	4.0
S92-3A	1227	0.73	95.13	1.27	11	3.5
S92-4A	1490	1.00	89.34	1.79	12	4.0
S92-5	1073	6.70	66.58	2.94	16	4.5
S92-6	1637	0.56	89.20	1.74	13	4.5
S92-7	1993	0.14	96.11	1.17	12	4.0
Reference Stations						
S92-R1	2463	3.35	67.95	2.12	17	4.5
S92-R2	510	1.37	72.04	2.62	12	4.0
G-South Station						
MDE-R1	1597	0.00	88.57	1.39	13	4.5
Northeast Station						
MDE-R2	3500	1.29	79.83	1.31	13	3.5

Table 5b. Values of Measures Used to Assess Infaunal Benthic Community Condition at Site 92 *Inner, Reference, G-South* and *Northeast* Stations, July 1998. *Differences from 100% for the two tolerance categories combined are due to the presence of taxa not classified as either pollution-sensitive or pollution-indicative.

In July (Table 5b), average total abundance for *Inner* stations at Site 92 was 1,756 ± 559 individuals/m^2 and ranged from 1,073 (S92-5) to 2,617 individuals/m^2 (S92-1). Total abundance was very different between the two Site 92 *Reference* stations. Total abundance at S92-R1 was 2,463 individuals/m^2, similar to abundances seen at *Inner* stations S92-1 and S92-2. Total abundance at S92-R2 was very low, only 510 individuals/m^2, or less than half the abundance at any other station. The decrease at *Reference* station S92-R2 was due to a large decrease in the abundance of *M. viridis* at this station compared to May. Total abundance at MDE-R1 was 1,597 individuals/m^2, similar to the average total abundance at *Inner* stations and not significantly different from *Reference* stations. Abundance at the *Northeast* station MDE-R2 was 3,500 individuals/m^2. High total abundance at this station resulted from the large number of *R. cuneata* (700 individuals) found in the third 0.1 m^2 (1.1 ft^2) grab sample. The vast majority of the clams were juveniles less than 15 mm in length. The average of the other two replicates from MDE-R2 was 1,310 individuals/m^2, similar to the *Reference* station average of 1,486 individuals/m^2.

Station	Average Total Abundance (#/m^2)	Pollution-indicative Taxa Abundance (%)*	Pollution-sensitive Taxa Abundance (%)*	Shannon-Wiener Diversity Index	Taxa Richness	B-IBI
Inner Stations						
S92-1	927	5.48	77.32	2.28	11	4.0
S92-2	1140	6.04	83.46	1.70	11	4.0
S92-3	1387	0.72	92.36	0.99	8	3.5
S92-4	1430	0.65	88.97	1.28	11	3.5
S92-5	1673	2.28	78.34	1.81	13	4.5
S92-6	1610	2.49	67.99	1.95	12	4.5
S92-7	2060	1.07	94.63	0.84	10	4.0
Reference Stations						
S92-R1	2230	0.64	81.38	1.36	12	4.0
S92-R2	940	7.09	23.23	2.27	15	3.5
G-South Station						
MDE-R1	1543	1.43	84.76	1.93	12	4.5
Northeast Station						
MDE-R2	453	8.00	29.49	2.66	9	3.5

Table 5c. Values of Measures Used to Assess Infaunal Benthic Community Condition at Site 92 *Inner, Reference, G-South* and *Northeast* Stations, September 1998. *Differences from 100% for the two tolerance categories combined are due to the presence of taxa not classified as either pollution-sensitive or pollution-indicative.

In September (Table 5c), average abundance for *Inner* stations at Site 92 was 1,461 ± 370 individuals/m^2, with a range from 927 individuals/m^2 (S92-1) to 2,060 individuals/m^2 (S92-7). *Reference* stations averaged 1,538 individuals/m^2, with 940 individuals/m^2 at S92-R2 and 2,230 individuals/m^2 at S92-R1, which had the highest total abundance of any station. There was no significant difference in total abundance between *Inner* and *Reference* stations. Little change in total abundance was seen at four stations (S92-3, S92-4, S927, MDE-R1) between July and September. Decreases in abundance of the polychaete worm *Marenzelleria viridis* were offset by increases in the abundance of the clam *Rangia cuneata* at these four stations. Large decreases in total abundance were seen at *Inner* stations S92-1 and S92-2. At station S92-1, decreases in *R. cuneata* contributed to decreases in total abundance. The decrease at S92-2 was due to a decrease in the abundance of *M. viridis*. Total abundance also decreased slightly at *Reference* station S92-R1, although the change could not be attributed to declines in any one taxon. Total abundance nearly doubled at *Reference* station S92-R2 due to increases in several taxa, most notably the polychaete worm *Neanthes succinea*. Total abundance at station S92-5 also increased from July to September. The increase at S92-5 was due to increased abundance of *R. cuneata*. Total abundance at *G-South* station MDE-R1 was 1,543 individuals/m^2, similar to *Reference* stations during September. The lowest total abundance was seen at the *Northeast* station (MDE-R2) in September (453 individuals/m^2). Abundance at MDE-R2 was significantly lower than at *Reference* stations (p = 0.0299). The maximum abundance based on any replicate at MDE-R2 in September (550 individuals/m^2) was less than half of the minimum abundance found in July (1,280 individuals/m^2; Appendix IX, Figure IX-1). Low abundance at MDE-R2 was due to loss of individuals from all taxa, particularly the isopods and amphipods (Appendix X, Table X-3). Fossil oyster shell dredging was occurring in the area around MDE-R2 in September and a 2-5 cm layer of light gray material was observed on the top of the sediments.

Abundance of Pollution-Indicative Taxa. Abundance of pollution-indicative taxa is expressed as a percentage of the total abundance. Pollution-indicative taxa found during the Site 92 baseline study were the polychaete worms *Hypereteone heteropoda* and *Streblospio benedicti*, and the midges (Insecta: Chironomidae) *Coelotanypus* sp. and *Procladius* sp. Statistically significant correlations were found between the relative abundance of pollution-indicative taxa and DO, pH and salinity (Appendix IX, Table IX-2). Relative abundance of pollution-indicative taxa increased as DO and pH decreased and salinity increased. These changes were due to both numeric increases in pollution-indicative taxa and to decreased abundance of pollution-sensitive taxa such as *Marenzelleria viridis* and *Rangia cuneata*. A strong negative correlation (r = -0.86) was found between pollution-indicative taxa abundance and pollution-sensitive taxa abundance. This is expected because pollution-indicative taxa are tolerant of environmental conditions that lead to decreased abundance of pollution-sensitive taxa.

The relative abundance of pollution-indicative taxa was less than 10% throughout the study (Figure 4). Pollution-indicative taxa abundance was very low (< 1%) at all stations in May (Table 5a). Slight increases in pollution-indicative taxa abundance occurred at most stations by July (Table 5b). In July, average pollution-indicative taxa abundance at *Inner* stations was 1.32%; at *Reference* stations, 2.36%. *G-South* station MDE-R1 and *Northeast* station MDE-R2 had pollution-indicative taxa abundances of 0% and 1.29%, respectively. Pollution-indicative taxa abundance increased again, but remained below 10%, at many stations in September due to the addition of *H. heteropoda* and slight increases in the numbers of other pollution-indicative taxa.

Abundance of Pollution-Sensitive Taxa. Abundance of pollution-sensitive taxa is also expressed as a percentage of the total abundance. Four pollution-sensitive taxa were found during the Site 92 baseline study. These were the clams *Macoma balthica* and *Rangia cuneata*, the isopod *Cyathura polita*, and the polychaete worm *Marenzelleria viridis*. Stations with high abundance of *M. viridis* or *R. cuneata* also had high pollution-sensitive taxa abundance. Pollution-sensitive taxa abundance was weakly correlated with the numeric and relative abundance of *R. cuneata* and numeric abundance of *M. viridis* (Appendix IX, Table IX-3). Lack of stronger correlations with either of these taxa individually is not surprising because two stations had few *R. cuneata* but many *M. viridis.* Pollution-sensitive taxa abundance was strongly correlated with the combined abundance of these two taxa (r = 0.96). Pollution-sensitive taxa abundance was also weakly correlated with pH and salinity (Appendix IX, Table IX-2). Increased salinity can cause stress to sensitive organisms.

In May (Appendix X, Table X-1), many samples were dominated by *R. cuneata* or *M. viridis,* with total numbers often more than 1,000 individuals per square meter. Average abundance of pollution-sensitive taxa was 87.38% (range = 74.76% to 97.77%) for *Inner* stations, 93.98% for *Reference* stations (range = 92.72% to 95.23%), and 86.42% for the *Northeast* station (Table 5a, Figure 5). Relative abundance of pollution-sensitive taxa was significantly higher at the *G-South* station (97.67%) than at the *Reference* stations in May (Appendix IX, Table IX-4) due to large numbers of *M. viridis* in G-South. The highest percentage of pollution-sensitive taxa in May was 97.77% at *Inner* station S92-2 where *R. cuneata* and *M. viridis* accounted for nearly 96% of all individuals. *Inner* station S92-1 had the lowest abundance of pollution-sensitive taxa, 74.76%. This was most likely due to a combination of lower relative abundance of *R. cuneata* and *M. viridis* coupled with the higher abundance of the amphipod *Leptocheirus plumulosus* found at this station.

In July (Table 5b), average abundance of pollution-sensitive taxa for *Inner* stations was slightly higher (average = 89.48%; range = 66.58% to 96.11%). The increased pollution-sensitive taxa abundance at S92-1 was largely due to an increase in the abundance of *Rangia cuneata.* Relative abundance of pollution-sensitive taxa decreased at *Inner* station S92-5 where *C. polita* replaced *M. viridis* as second-most dominant taxon. Pollution-sensitive taxa abundance at S92-2 also decreased due to a decrease in the number of *R. cuneata*, *M. viridis*, and *C. polita.* Decreases in the numeric abundance of *R. cuneata* and *M. viridis* at the Site 92 *Reference* stations, coupled with increases in other taxa, resulted in a significant decrease in the abundance of pollution-sensitive taxa at these stations (see Appendix X, Tables X-1 and X-2). The average pollution-sensitive taxa abundance for Site 92 *Reference* stations was 70.00% (range: 67.95% to 72.04%) in July. Pollution-sensitive taxa abundance was significantly lower at *Reference* stations than at *Inner* stations in July (Appendix IX, Table IX-4). This was due to the lower abundance of *Rangia* at the *Reference* stations. Pollution-sensitive taxa abundance at the *G-South* station (MDE-R1) was 88.57%, lower than the abundance in May (97.67%), due to a decrease in the abundance of *M. viridis.* Pollution-sensitive taxa abundance at the *G-South* station was significantly higher than at *Reference* stations (Appendix IX, Table IX-4) due to the higher abundance of *M. viridis* in G-South. Pollution-sensitive taxa abundance for the *Northeast* station decreased (from 86.42% to 80.63%), again due to a decrease in the abundance of *M. viridis*.

Abundance of pollution-sensitive taxa decreased from July to September at all *Inner* stations except S92-5 (Figure 5). Average abundance of pollution-sensitive taxa was 83.30% (range: 67.99% to 94.63%) at *Inner* stations in September (Table 5c). Average pollution-sensitive taxa abundance was 52.30% at *Reference* stations. This was significantly lower than abundance of these organisms at *Inner* stations (Appendix IX, Table IX-4). *G-South* station MDE-R1 had a high pollution-sensitive taxa abundance (84.43%) due to the large number of *M. viridis* present at this station in September. Pollution-sensitive taxa abundance at *Northeast* station MDE-R2 was greatly depressed (29.49%) compared to July, due to decreases in *M. viridis*, *R. cuneata*, and *C. polita*, and increases in the oligochaete worm *Tubificoides* sp. These changes may have been due to disturbance of the habitat by nearby fossil oyster shell dredging.

Shannon-Wiener Diversity Index. The Shannon-Wiener Diversity Index is affected primarily by taxa richness and distribution of individuals among the species (Weber 1973). Diversity was below the B-IBI threshold value for low mesohaline environments at most stations during each season. Significant negative correlations were found between diversity and total abundance, abundance of pollution-sensitive taxa, and numeric abundance of *Rangia cuneata* and *Marenzelleria viridis* (Appendix IX, Table IX-3). Significant positive correlations were found between diversity and taxa richness and pollution-indicative taxa abundance (Appendix IX, Table IX-3). Relative abundance of *R. cuneata* and *M. viridis* combined was also an important factor influencing diversity (Appendix IX, Figure IX-3). When combined relative abundance of these two taxa was greater than 71%, the diversity index was less than 1.7, which is below the threshold value used in calculating the B-IBI. At combined relative abundances between 51% and 71%, the Shannon-Wiener diversity index values were higher, but still not in the optimal range. Only when the combined abundance of *R. cuneata* and *M. viridis* was less than 51% did the diversity index value climb into the optimal range (i.e., above 2.5).

Clear trends in diversity were seen at only four stations: S92-3/3A, S92-4/4A, S92-7, and MDE-R1 (Figure 6). Diversity decreased throughout the study at S92-3, S92-4, and S92-7. The relative abundance of the clam *Rangia cuneata* increased at these three stations over the study period primarily due to the loss of individuals in other taxa, especially the amphipods (Amphipoda). Diversity increased throughout the study at MDE-R1 as both relative and numeric abundance of the polychaete worm *Marenzelleria viridis* decreased and additional taxa were found. Changes in diversity at other stations showed no regular pattern but were often tied to the abundance of *R. cuneata.*

Diversity values for *Inner* stations were low (average = 1.73; range = 1.25 to 2.19) in May (Table 5a). *Reference* stations averaged slightly lower diversity (average = 1.33; range = 1.13 to 1.52) due to larger numbers of *R. cuneata* and *M. viridis* at these stations. Diversity at the *G-South* station (0.62) was significantly lower than at *Reference* stations (Table IX-4) due to the large number of *M. viridis* at this station. Diversity for the *Northeast* station was 1.35.

In July (Table 5b), large numbers of *R. cuneata*, coupled with decreases in the number of individuals of *M. viridis* and other taxa, resulted in slightly lower diversity values for most *Inner* stations compared to May values. Overall, diversity values for *Inner* stations were low (average = 1.42; range: 1.00 to 2.94). Diversity increased at *Inner* station S92-5 where the number of both *R. cuneata* and *M. viridis* decreased. Diversity at *Reference* stations (average = 2.37; range: 2.12 to 2.62) was higher than in May and significantly higher than at *Inner* stations (Table IX-4). Increased diversity at the *Reference* stations was the result of decreases in the number of *R.*

cuneata and *M. viridis* and the addition of taxa not present in the May samples. Diversity at the *G-South* station (MDE-R1) increased compared to May, primarily due to a decrease in the number of *M. viridis* and the addition of several taxa not found in the May samples. Diversity for the *Northeast* station (MDE-R2) was 1.30, which is very similar to the May value of 1.35.

For seven of the eleven stations sampled, diversity values for September were very similar to those of July (Table 5). Diversity was higher at S92-1 due to a decrease in the abundance of *Rangia cuneata*. Diversity was lower at station S92-5 due to increased abundance of *R. cuneata* and decreased taxa richness. Increased abundance of *R. cuneata* and decreased abundance of *Marenzelleria viridis* resulted in lower diversity at S92-4. The lowest diversity, 0.84, occurred at *Inner* station S92-7. Average diversity at the *Inner* stations in September (1.33 ± 0.51) was slightly lower than the July average (1.57 ± 0.68). However, diversity at *Inner* stations was similar to the average diversity at *Reference* stations (average = 1.82 ± 0.55). A decrease in taxa richness at *Reference* station S92-R1 resulted in lower diversity at this station.

Chesapeake Bay Benthic Index of Biotic Integrity (B-IBI). B-IBI values were calculated based on total abundance, pollution-indicative taxa abundance, pollution-sensitive taxa abundance, and the Shannon-Wiener Diversity Index. Individual metrics were scored according to Table 2 [based on Weisberg et al. (1997)]. All stations met or exceeded the Chesapeake Bay Restoration Goal of 3.0 in July and September (Figure 7) indicating that the benthic communities in the Pooles Island area were healthy. During July (Table 5b), the average B-IBI score for *Inner* stations was 4.1; the *Reference* station average was 4.0. The average B-IBI scores for *Inner* stations in September was 4.0; for *Reference* stations, 3.8. The *G-South* station had B-IBI scores of 4.0 and 4.5 in July and September, respectively. The *Northeast* station had a B-IBI score of 3.5 in both July and September.

Taxa Richness. Taxa richness (Figure 8) was calculated as the total number of **infaunal** taxa found in all replicates at a station. As with other measures of the benthic community condition, epifaunal taxa were excluded from calculation of taxa richness because these taxa are excluded from the B-IBI. Only minor changes (increases or decreases of 1 or 2 taxa) were seen at most stations between seasons. Larger changes (3 or more taxa) occurred between May and July at stations S92-5, S92-6, S92-R1, and MDE-R1, and between July and September at stations S92-3A, S92-5, S92-R1, S92-R2 and MDE-R2. Taxa richness was significantly correlated with temperature and dissolved oxygen (Appendix IX, Table IX-3). Taxa richness was also affected by the number of pollution-indicative taxa present, which increased as environmental conditions became less favorable. Taxa richness was generally similar among stations.

In May, taxa richness ranged from 9 taxa (S92-5, S92-6, and S92-R1) to 15 taxa (MDE-R2). Average taxa richness for *Inner* stations was 11. Average taxa richness for *Reference* stations was 10. The *G-South* station, MDE-R1, was represented by 10 taxa; the *Northeast* station, MDE-R2, by 15.

In July, taxa richness ranged from 9 taxa (S92-2) to 17 taxa (S92-R1). Average taxa richness for *Inner* stations was 12; average taxa richness for *Reference* stations was 15. The *G-South* station, MDE-R1, was represented by 13 taxa; the *Northeast* station, MDE-R2, by 13.

Increases in taxa richness at stations S92-6, S92-7, and MDE-R1 from May to July were due to increases in the number of polychaete worm taxa. The most dramatic increases in taxa richness occurred at *Inner* station S92-5 and *Reference* station S92-R1 due to an increase in the number of polychaete worm taxa and the addition of three genera of midges (Insecta: Chironomidae). The slight decrease in taxa richness at MDE-R2 was due primarily to loss of midge taxa.

In September, taxa richness ranged from 8 (S92-3) to 15 (S92-R2). Average taxa richness for *Inner* stations was 11; average taxa richness for *Reference* stations was 14. The *G-South* station was represented by 12 taxa. The *Northeast* station, MDE-R2, was represented by only nine taxa, a large decrease compared to May (15 taxa) and July (13 taxa). The lost taxa at MDE-R2 were primarily amphipods (Amphipoda) and midges (Insecta: Chironomidae). A 2 to 5 cm layer of light gray sediment was seen during September at MDE-R2. This sediment layer, not seen in May or July, may have resulted from fossil oyster shell dredging activity that was taking place in close proximity to the station and may have caused the resultant loss of taxa.

Abundance of the Three Most Dominant Infaunal Taxa. The three most abundant infaunal taxa at each station are listed in Table 6 in order of abundance. Abundances of other taxa are provided in Tables X-1, X-2 and X-3 (Appendix X). The clam *Rangia cuneata* and the polychaete worm *Marenzelleria viridis* were the two numerically dominant taxa at the *Inner* stations in May 1998 (Figure 9a). The isopod *Cyathura polita* alternated with the amphipod *Leptocheirus plumulosus* as the third most abundant taxon at *Inner* stations. In July (Figure 10a), *Rangia cuneata* and the polychaete worm *Marenzelleria viridis* were again the two numerically dominant taxa at *Inner* stations. An exception occurred at station S92-5 where the *C. polita* was the second most abundant taxon after *R. cuneata* and *M. viridis* was third most abundant. *C. polita* was the third most abundant taxon at other *Inner* stations. Fewer *L. plumulosus* were seen at any *Inner* station in July than had been seen in May (Appendix X, Table X-2); *L. plumulosus* was not among the three most dominant taxa at any *Inner* station during July. *R. cuneata*, *M. viridis*, and *C. polita* were again the three most abundant taxa at *Inner* stations S92-1, S92-2, S92-4 and S92-7 in September (Figure 11a). Increases in abundance of the clam worm, *Neanthes succinea*, made it one of the three dominant taxa at the other three *Inner* stations where it replaced either *M. viridis* or *C. polita*.

At *Reference* stations S92-R1 and S92-R2, the clam *R. cuneata*, the polychaete worm *M. viridis*, and the isopod *C. polita* were the three most abundant taxa in May (Figure 9b). *M. viridis* and *C. polita* were the two most abundant taxa at both the *G-South* (MDE-R1) and *Northeast* (MDE-R2) stations in May. The oligochaete worm *Tubificoides* spp. was third most abundant at MDE-R1, whereas the clam worm *Neanthes succinea* was third most abundant at MDE-R2. In July (Figure 10b), *Rangia cuneata* was among the three most abundant taxa at both *Reference* stations and at MDE-R2. The abundance of *Rangia* had increased at stations MDE-R1 and MDE-R2 but decreased at stations S92-R1 and S92-R2 compared to May values (Appendix X, Tables X-1 and X-2). Increased abundance of the polychaete worm *Polydora cornuta* resulted in its being one of the three most abundant taxa at S92-R1 and MDE-R2 in July. Relatively high numbers of *P. cornuta* were also present at *Inner* stations S92-4A and S92-5 where it was the fourth most common taxon. *P. cornuta* had not been found in any of the May samples. The oligochaete worm *Tubificoides* spp. was the third most abundant taxon at S92-R1 in July. The polychaete worm *Neanthes succinea* was among the three most abundant taxa at the two *Reference* stations, the *G-South* station and the *Northeast* station in September (Table 6; Figure 11b). Most of the *N. succinea* present were young and small (<15 mm in length). *C. polita* was also among the three most abundant taxa at both *Reference* stations and the *G-South* station MDE-R1. The oligochaete worm *Tubificoides* spp. was among the three most abundant taxa at S92-R2 and the *Northeast* station, MDE-R2. The polychaete worm *Marenzelleria viridis* was among the three most abundant taxa only at the *G-South* station. This station usually had a high abundance of *M. viridis* even when other stations have not.

Abundance of *Rangia cuneata* and *Marenzelleria viridis*. The abundance of the clam *Rangia cuneata* and the polychaete worm *Marenzelleria viridis* are important factors influencing the B-IBI and its component metrics in the Pooles Island area. Both of these taxa have been designated as "pollution-sensitive" in the Chesapeake Bay (Weisberg et al. 1997). High numbers of either of these species resulted in low diversity and low relative abundance of pollution-indicative taxa. High abundance of these taxa also results in high total abundance and high relative abundance of pollution-sensitive taxa.

Rangia cuneata and *Marenzelleria viridis* were the two most abundant taxa at all *Inner* stations and both *Reference* stations in May (Table 6; Appendix X, Table X-1). Relative abundance of these two species combined ranged from 67% to almost 96% at these stations. *R. cuneata* was significantly more abundant at *Inner* stations than at *Reference* stations (Appendix IX, Table IX-3). *M. viridis* was significantly less abundant at *Inner* stations than at *Reference* stations. *R. cuneata* was rare at the *G-South* and *Northeast* stations. *M. viridis* was very abundant at these two stations, comprising over 78% of the individuals.

By July, numeric abundance of *M. viridis* had decreased at all stations (Figure 12). *M. viridis* continued to comprise more than 75% of the individuals at the *G-South* station. Numeric abundance of *Rangia* fluctuated at many stations, increasing at some stations and decreasing at others (Figure 13); however, *Rangia* was the most abundant taxon at all *Inner* stations and at S92-R1 (Appendix X, Table X-2). Relative abundance of *Rangia* increased at all *Inner* stations and at S92-R1. Although numeric abundance of *Rangia* decreased at *Reference* station S92-R2, relative abundance increased slightly due to decreases in abundance of other taxa. *Rangia* continued to be rare at the *G-South* station. Abundance of *Rangia* at the *Northeast* station increased dramatically compared to May due in part to very high abundance (700 individuals) in the third replicate sample taken at MDE-R2 in July.

By September, numeric and relative abundance of *M. viridis* continued to decline at all stations except *Inner* station S92-1 where both numeric and relative abundance increased. *M. viridis* comprised less than 6% of individuals at all stations except *Inner* station S92-1 and *G-South* MDE-R2, where it comprised over 57% of all individuals. Again, populations of *Rangia cuneata* were more variable. *Rangia* continued to comprise more than 59% of the individuals at all *Inner* stations except S92-1 (7.6% *Rangia*). *Rangia* also continued to dominate *Reference* station S92-R1 (74.2% *Rangia*). *Rangia* continued to occur in low numbers at *Reference* station S92-R2 (30 individuals/m^2), the *G-South* station (70 individuals/m^2) and the *Northeast* station (60 individuals/m^2).

Station	Season		
	May	July	September
		Inner Stations	
S92-1	*Rangia cuneata* *Marenzelleria viridis* *Leptocheirus plumulosus*	*Rangia cuneata* *Marenzelleria viridis* *Cyathura polita*	*Marenzelleria viridis* *Cyathura polita* *Rangia cuneata*
S92-2	*Rangia cuneata* *Marenzelleria viridis* *Cyathura polita*	*Rangia cuneata* *Marenzelleria viridis* *Cyathura polita*	*Rangia cuneata* *Cyathura polita* *Marenzelleria viridis*
S92-3/3A	*Rangia cuneata* *Marenzelleria viridis* *Leptocheirus plumulosus*	*Rangia cuneata* *Marenzelleria viridis* *Cyathura polita*	*Rangia cuneata* *Marenzelleria viridis* *Neanthes succinea*
S92-4/4A	*Marenzelleria viridis* *Rangia cuneata* *Cyathura polita*	*Rangia cuneata* *Marenzelleria viridis* *Cyathura polita*	*Rangia cuneata* *Cyathura polita* *Neanthes succinea*
S92-5	*Rangia cuneata* *Marenzelleria viridis* *Leptocheirus plumulosus*	*Rangia cuneata* *Cyathura polita* *Marenzelleria viridis*	*Rangia cuneata* *Neanthes succinea* *Marenzelleria viridis*
S92-6	*Marenzelleria viridis* *Rangia cuneata* *Leptocheirus plumulosus*	*Rangia cuneata* *Marenzelleria viridis* *Cyathura polita*	*Rangia cuneata* *Neanthes succinea* *Cyathura polita*
S92-7	*Marenzelleria viridis* *Rangia cuneata* *Leptocheirus plumulosus*	*Rangia cuneata* *Marenzelleria viridis* *Cyathura polita*	*Rangia cuneata* *Cyathura polita* *Marenzelleria viridis*
		Reference Stations	
S92-R1	*Rangia cuneata* *Marenzelleria viridis* *Cyathura polita*	*Rangia cuneata* *Polydora cornuta* *Tubificoides* sp.	*Rangia cuneata* *Neanthes succinea* *Cyathura polita*
S92-R2	*Marenzelleria viridis* *Rangia cuneata* *Cyathura polita*	*Marenzelleria viridis* *Cyathura polita* *Rangia cuneata*	*Neanthes succinea* *Cyathura polita* *Tubificoides* sp.
		G-South Station	
MDE-R1	*Marenzelleria viridis* *Cyathura polita* *Tubificoides* sp.	*Marenzelleria viridis* *Cyathura polita* *Leptocheirus plumulosus*	*Marenzelleria viridis* *Cyathura polita* *Rangia cuneata*
		Northeast Station	
MDE-R2	*Marenzelleria viridis* *Cyathura polita* *Neanthes succinea*	*Rangia cuneata* *Marenzelleria viridis* *Polydora cornuta*	*Neanthes succinea* *Tubificoides* sp. *Rangia cuneata*

Table 6. Three Most Numerically Abundant Infaunal Taxa at Site 92 *Inner, Reference, G-South* and *Northeast* Stations, May, July and September 1998. Taxa are listed in decreasing order of abundance.

2. Comparison of the 1998 *G-South* Station with Previous Studies in G-South

Studies of the Pooles Island area were conducted by Versar, Inc. during the early 1990's (Ranasinghe and Richkus 1993). Included among these studies were a baseline study of the G-South area and studies to determine the early effects of placement activities on the benthic community. Cruises were conducted in June 1991 and August 1991 prior to placement. The first post-placement studies were conducted in August 1992, October 1992, May 1993, June 1993, and July 1993. Results of the August 1991/August 1992, May 1993, and July 1993 cruises have been compared with the September 1998, May 1998 and July 1998 data, respectively. Table VIII-2 (Appendix VIII) summarizes the benthic community data from the 1991 through 1993 studies. In addition, MDE studied the recovery of the benthic community at G-South during September 1996 (Dalal et al. 1996b). Table VIII-3 (Appendix VIII) summarizes the benthic community data from MDE's 1996 study. The results of the present study have also been compared with the results of the 1996 study. Total abundance, Shannon-Wiener diversity index values, relative abundance of *Rangia cuneata* and *Marenzelleria viridis*, relative abundance of pollution-sensitive taxa, and B-IBI values were compared. T-tests were used to determine whether total abundance, relative abundance of *Rangia cuneata* and *Marenzelleria viridis*, and relative abundance of pollution-sensitive taxa differed between selected study periods (Appendix IX, Table IX-5). B-IBI and Shannon-Wiener diversity index values were not included in the t-tests.

B-IBI values were above the threshold (3.0) established as part of the Chesapeake Bay Restoration Goals during all sampling periods for which they were applicable (August 1991, August 1992, July 1993, September 1996, July 1998 and September 1998). A significant decrease in the abundance of the clam *Rangia cuneata* occurred between pre-placement in August 1991 and the first year after placement, August 1992. No other significant differences were found between these two dates. The decrease in abundance of *Rangia* has persisted through September 1998. Total abundance was also significantly lower in September 1998 than in August 1991 or August 1992. Abundance of the worm *Marenzelleria viridis* was significantly higher in September 1998 than in August 1991.

Values for the Shannon-Wiener diversity index, the relative abundance of pollution-sensitive taxa, and the relative abundance of *M. viridis* in May 1998 were different from values for May 1993, less than one-half year after dredged material placement. The numeric and relative abundance of *M. viridis* was higher in May 1998 than in May 1993. Because this species has been classified as pollution-sensitive (Weisberg et al. 1997), the relative abundance of pollution-sensitive taxa also increased. *M. viridis* comprised almost 90% of the individuals collected in May 1998 resulting in a low diversity value. Other measures were similar between the two years.

The benthic community found in July 1993 was somewhat different in regard to the measures examined from the community that was found in July 1998. Total abundance and diversity were higher in July 1993 than in July 1998, as was the abundance of *Rangia*. The relative abundance of *M. viridis* increased from July 1993 to July 1998, although the numeric abundance decreased (see Appendix VIII, Table VIII-2 and Appendix X, Table X-2).

Dominance by *M. viridis* lead to an increase in relative abundance of pollution-sensitive taxa and a decrease in the Shannon-Wiener diversity index in 1998.

Total abundance and diversity were significantly higher in September 1996 than in September 1998 (Appendix IX, Table IX-5). Relative abundance of *M. viridis* and relative abundance of pollution-sensitive taxa were not significantly different between the two years. The relative abundance of *Rangia cuneata* was statistically significantly higher in 1998 than in 1996, although the actual difference was small (Appendix IX, Table IX-5). *Rangia* still accounted for less than 5% of the total individuals in G-South in 1998.

Additional placement of dredged material occurred in a limited portion of G-South during January and February 1997. The benthic community residing in G-South during 1998 was likely still recovering from the effects of placement during 1997, slightly more than one year prior to sampling. This might have contributed to the differences between the community seen in 1993 and the community seen in 1998.

3. Comparison of the *Northeast* Station with the 1996 G-East Baseline Study

No statistically significant differences were found between the benthic community that was sampled in the vicinity of G-East in 1996 and the community sampled in 1998 (see Appendix IX, Table IX-6). Total abundance was much lower in 1998 (453 individuals/m^2) than in 1996 (4,297 individuals/m^2). This was not a statistically significant difference at $p < 0.05$ due to the variability seen in the September 1996 data. However, the average number of individuals found in 1998 (Appendix X, Table X-3) was less than half the lowest value found in 1996 (Appendix VIII, Table VIII-4). In 1996, the community was dominated by the clams *Rangia cuneata* and *Macoma balthica*, with an average of over 1,000 individuals of each per square meter. The third most abundant taxon in 1996 was the isopod *Cyathura polita*. No *Macoma* were found at the *Northeast* station (MDE-R2) in 1998. In addition, the average number of *Rangia* per square meter was less than 100 in 1998, although *Rangia* was still the third most abundant taxon. The relative abundance of *Rangia* was not significantly different between the two years (Appendix IX, Table IX-6). The benthic community at MDE-R2 was dominated by the polychaete worm *Neanthes succinea* and by the oligochaete worm *Tubificoides* spp. in 1998. Shannon-Wiener diversity was slightly higher in 1998 (2.66) than in 1996 (2.45) most likely due to the greater evenness with which the individuals were divided among taxa. Fewer taxa (9) were found in 1998 than were found in 1996 (16). Most notable was the absence of the clam species *Macoma balthica* and *Macoma mitchelli,* which were found in 1996 but not 1998. The abundance of pollution-indicative taxa was slightly higher in 1998 (8.0 %) than in 1996 (1.2 %) due to a higher abundance of the oligochaete worm *Tubificoides* spp. in 1998. The abundance of pollution-sensitive taxa was slightly higher in 1996 (51.0 %) than in 1998 (29.5 %) due to the lower abundance of *Rangia* and the absence of *Macoma* in 1998. Decreases in overall abundance and the abundance of sensitive organisms, such as *Rangia* and *Macoma*, may have been related to Langenfelder fossil oyster shell dredging that occurred in the vicinity of the *Northeast* station during September 1998.

Figure 3. Total Abundance of Infaunal Taxa at Inner, Reference, G-South and Northeast Stations, May, July and September 1998

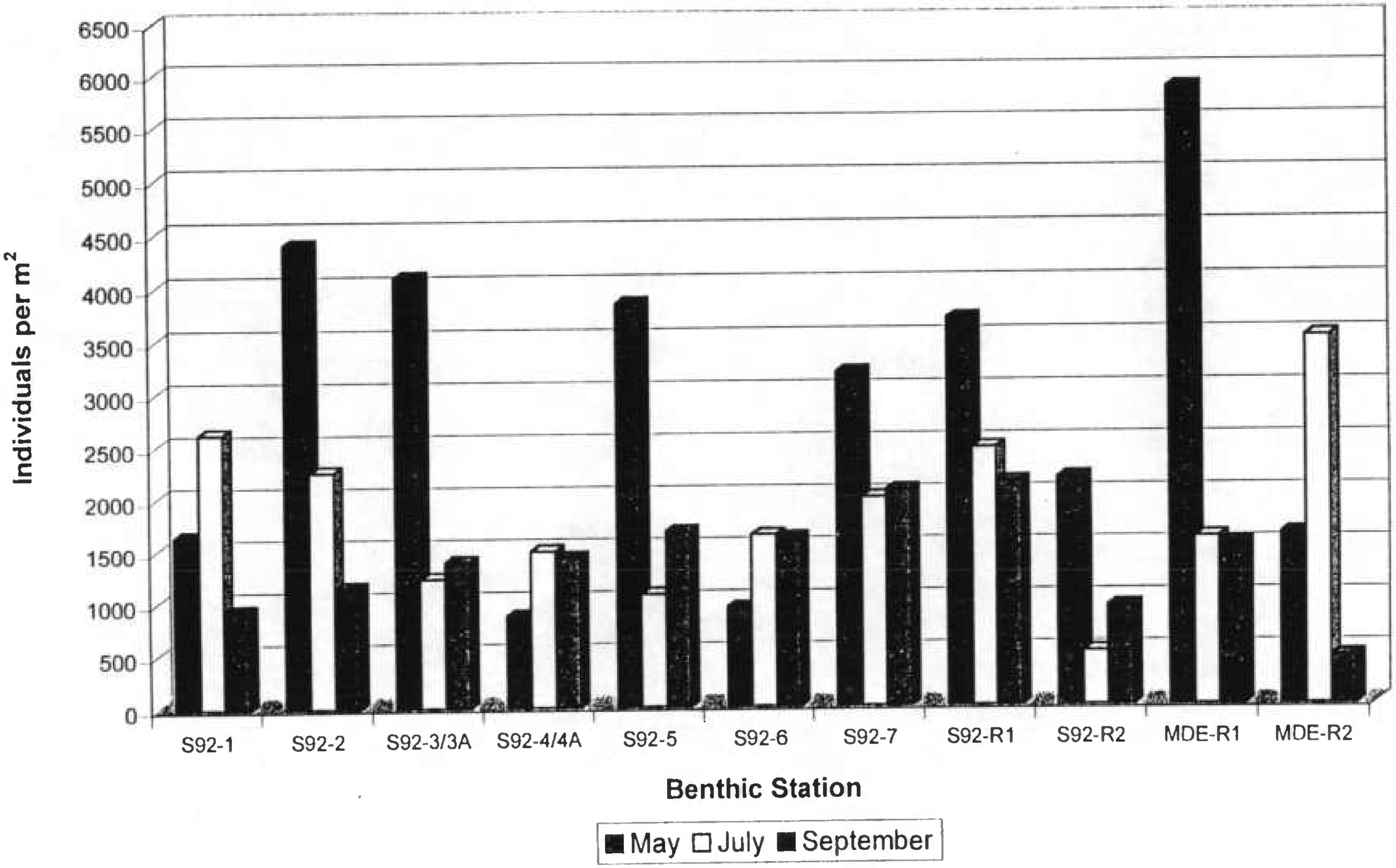


Figure 4. Relative Abundance of Pollution-Indicative Infaunal Taxa at Inner, Reference, G-South and Northeast Stations, May, July and September 1998

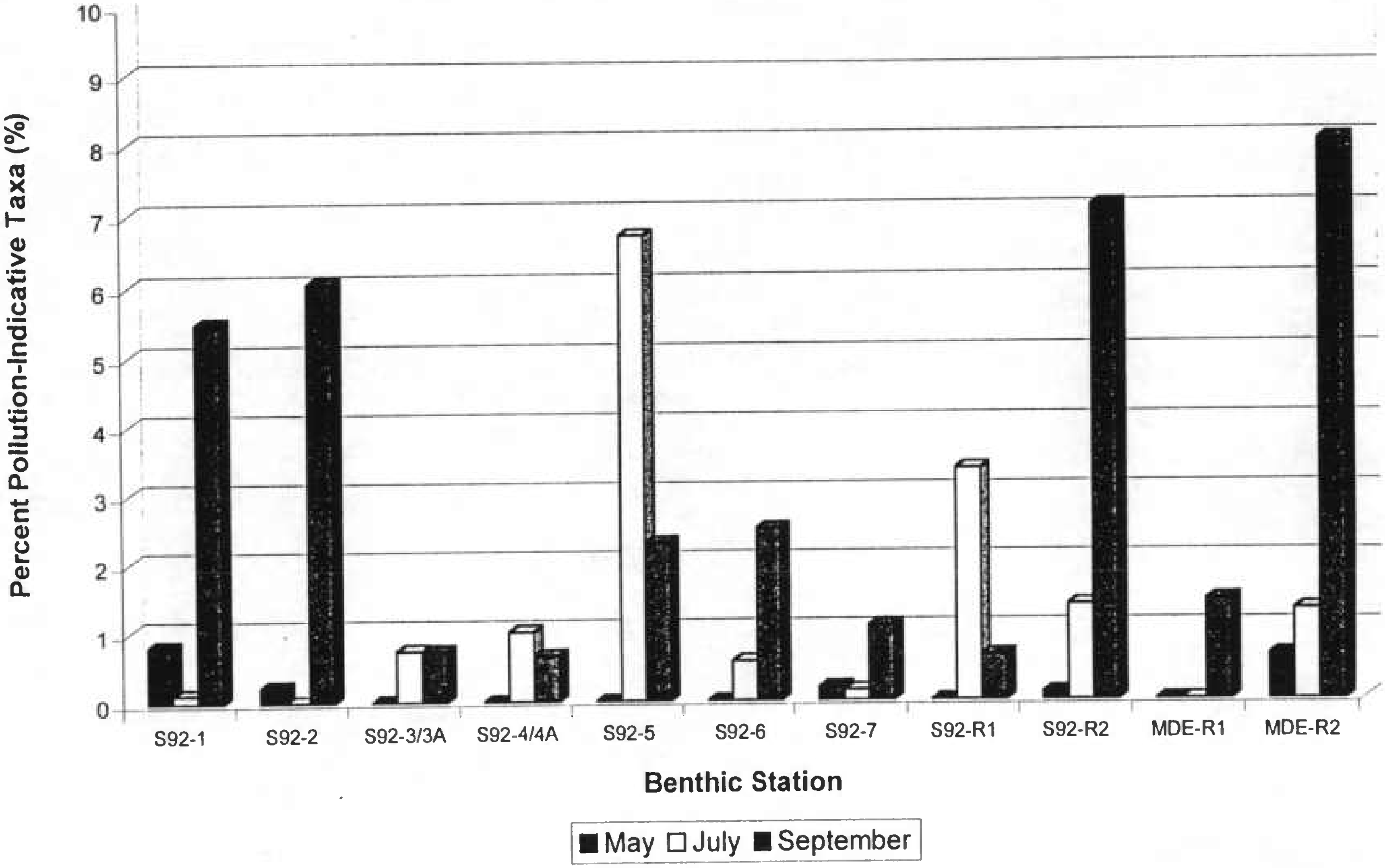


Figure 5. Relative Abundance of Pollution-Sensitive Infaunal Taxa at Inner, Reference, G-South and Northeast Stations, May, July and September 1998

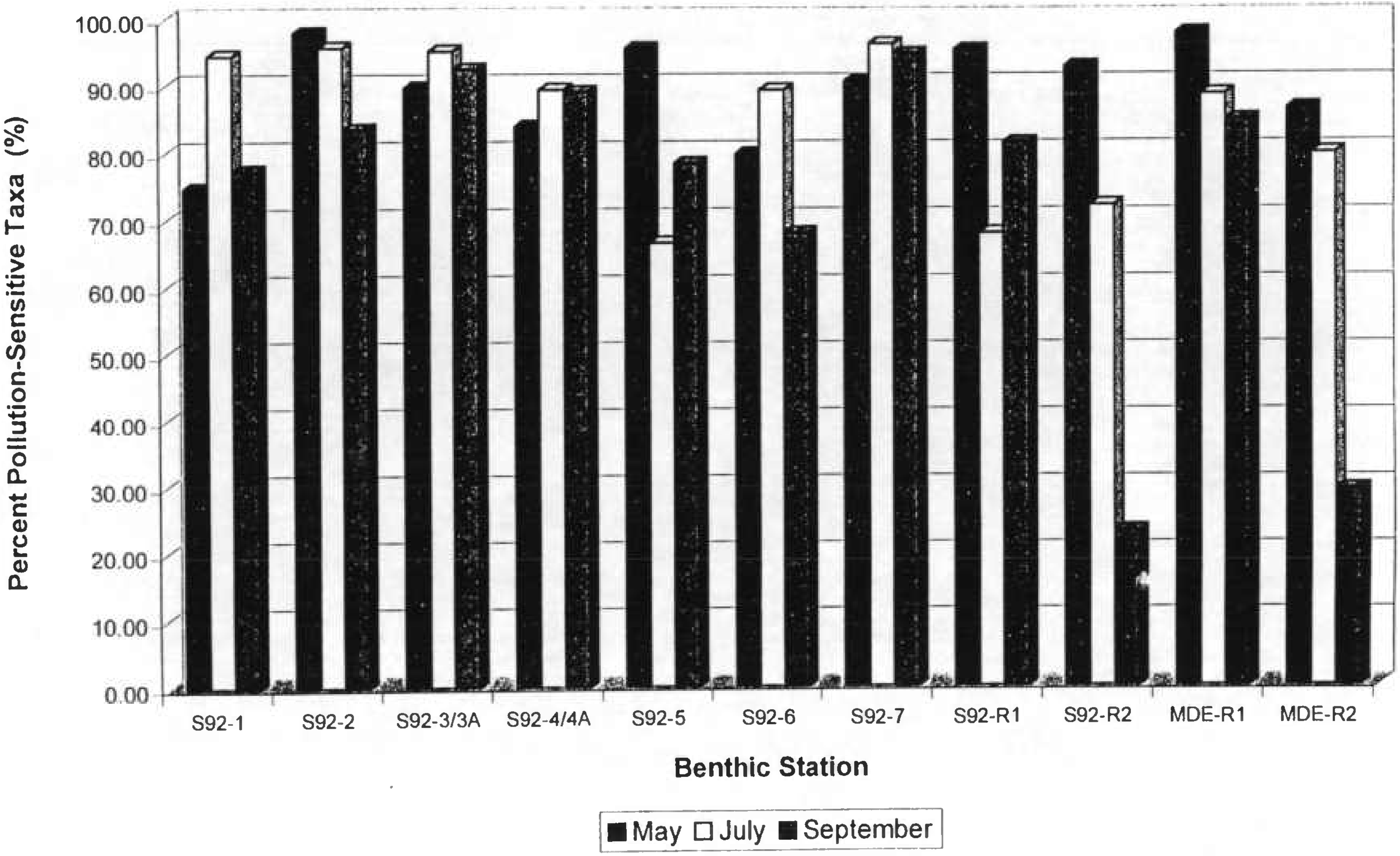


Figure 6. Shannon-Wiener Diversity Index at Inner, Reference, G-South and Northeast Stations, May, July and September 1998

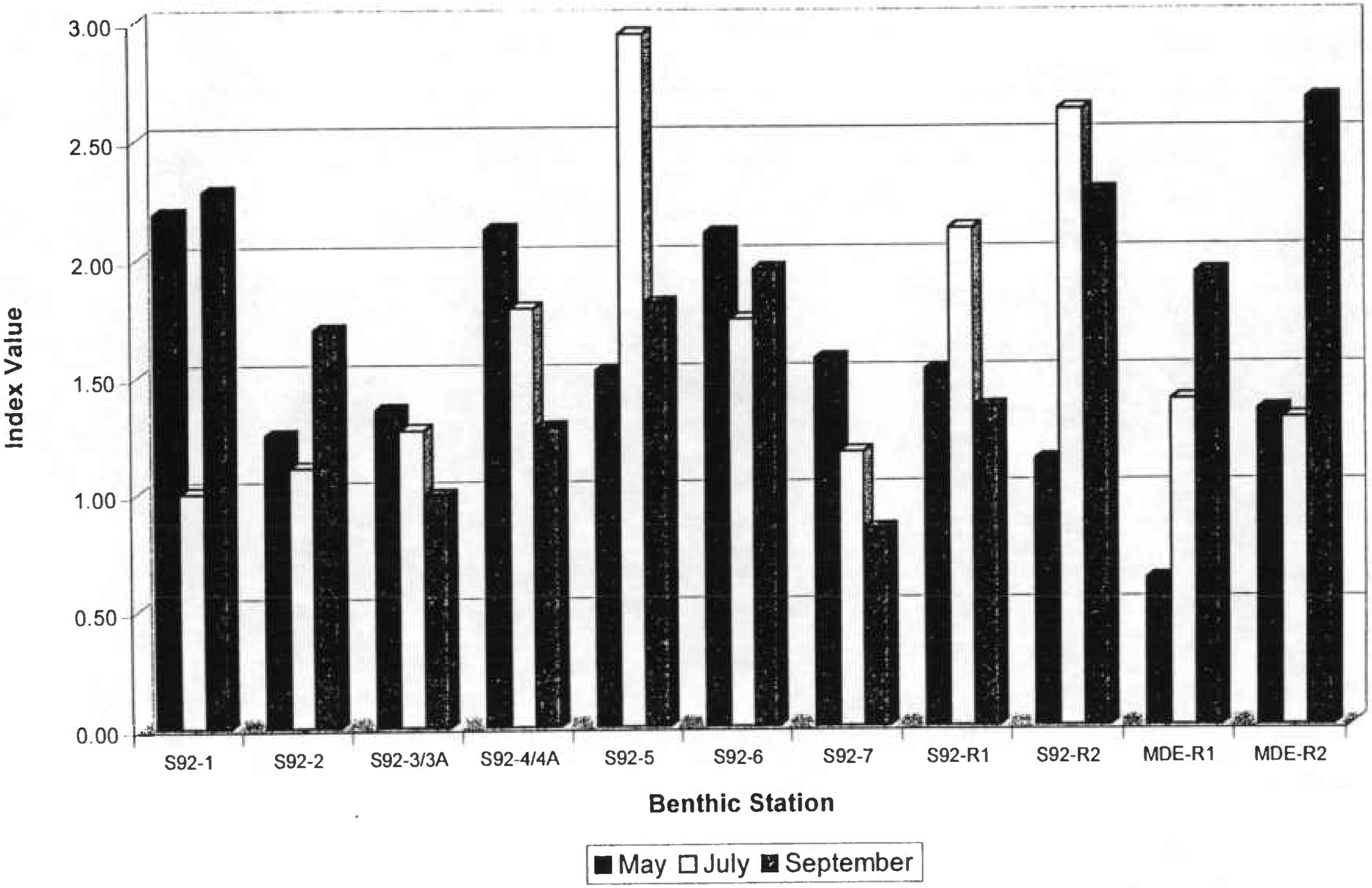


Figure 7. Benthic Index of Biotic Integrity at Inner, Reference, G-South and Northeast Stations, May, July and September 1998

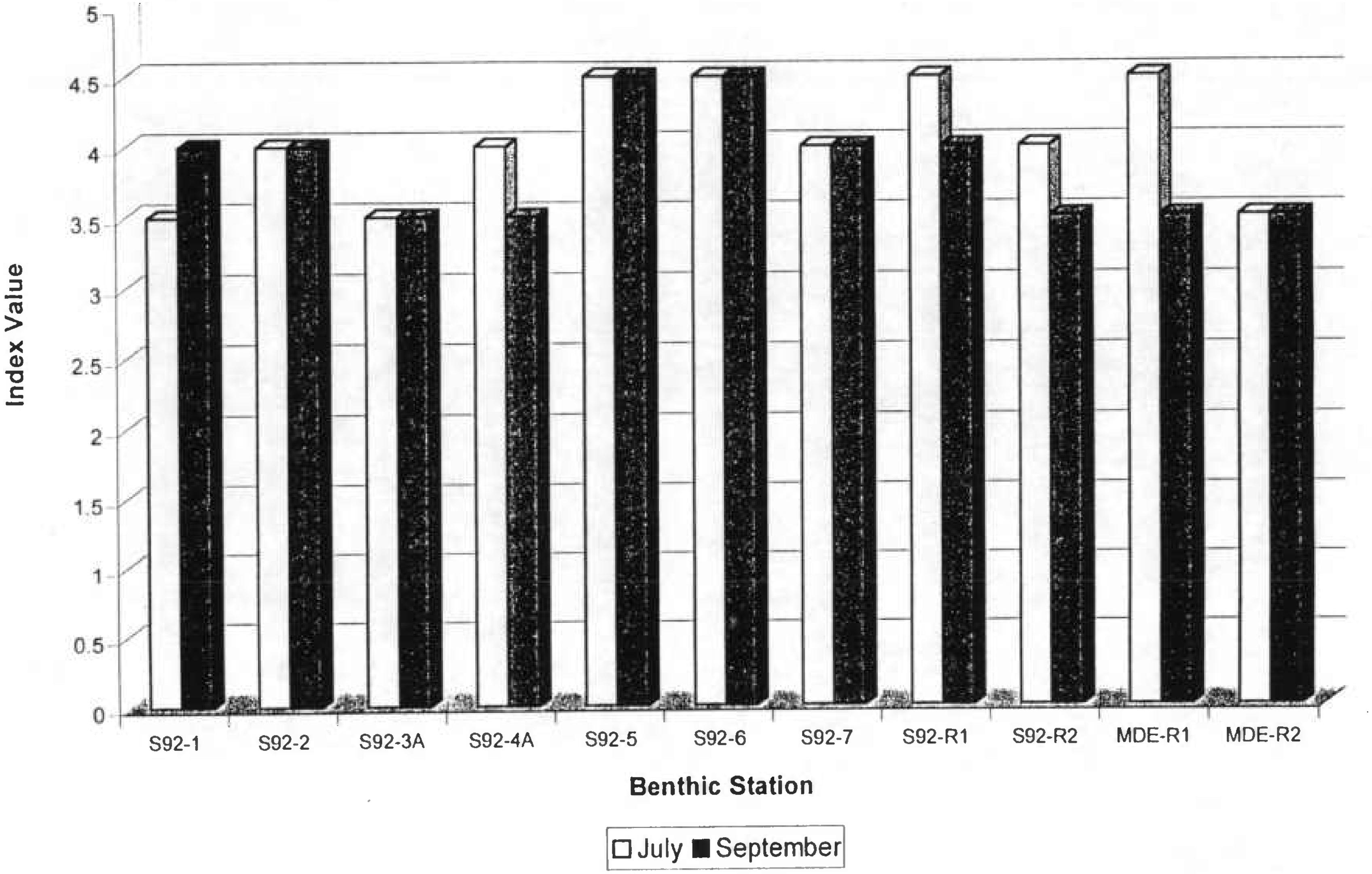


Figure 8. Infaunal Taxa Richness at Inner, Reference, G-South and Northeast Stations, May, July and September 1998

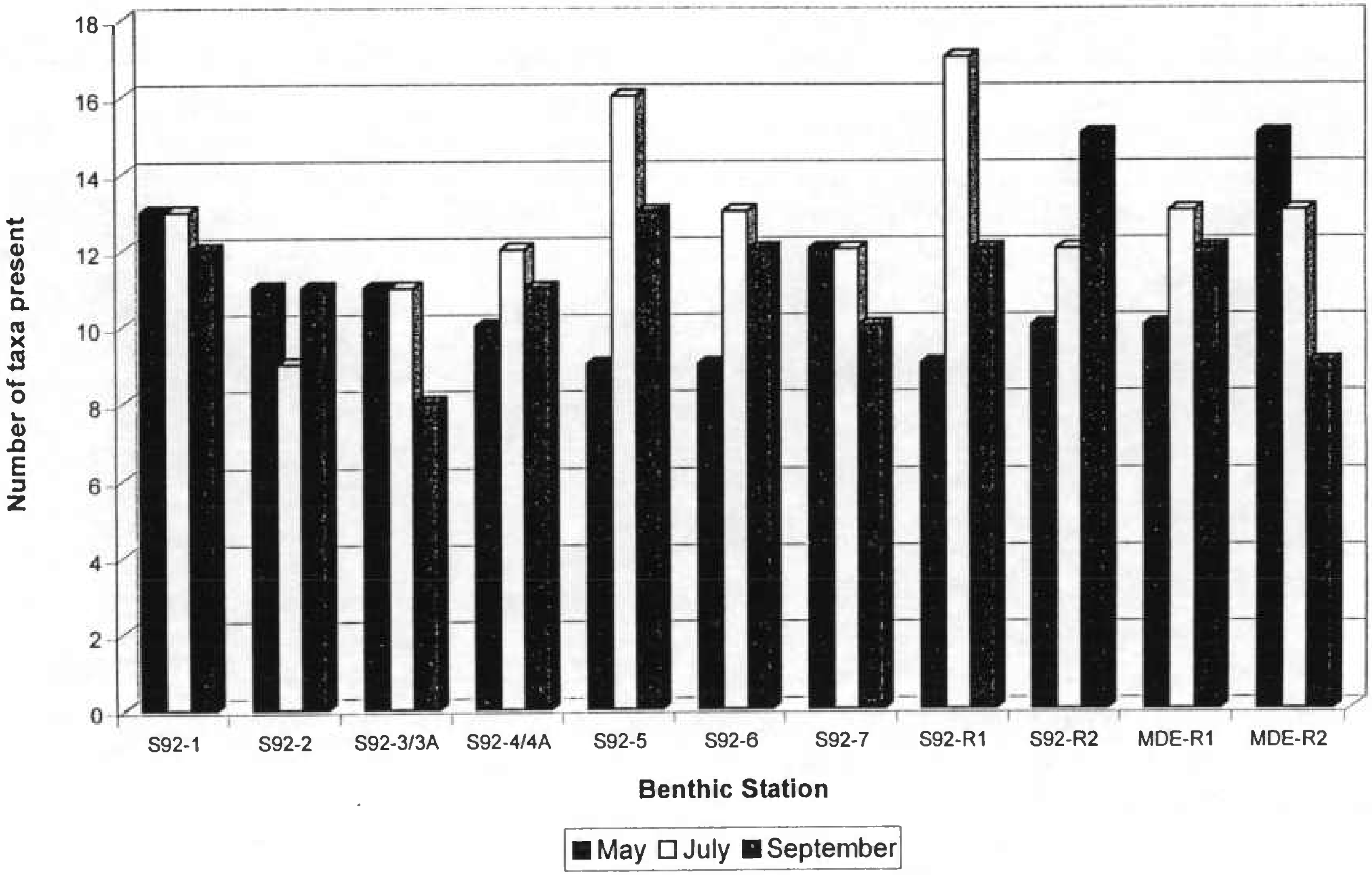


Figure 9a. Relative Abundance of the Three Most Dominant Infaunal Taxa at Site 92 Inner Stations, May 1998

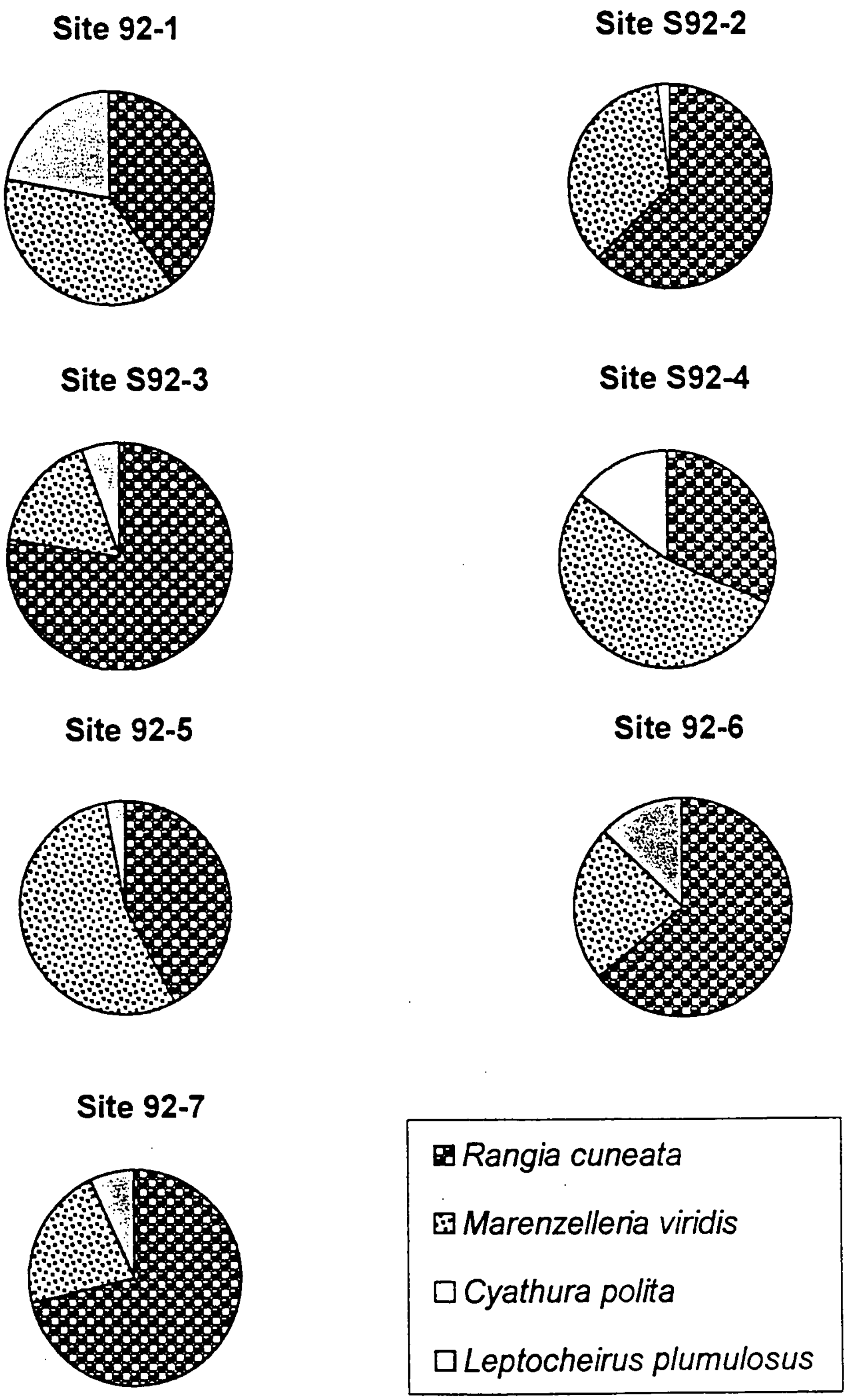


Figure 9b. Relative Abundance of the Three Most Dominant Infaunal Taxa at Site 92 Reference, G-South and Northeast Stations, May 1998

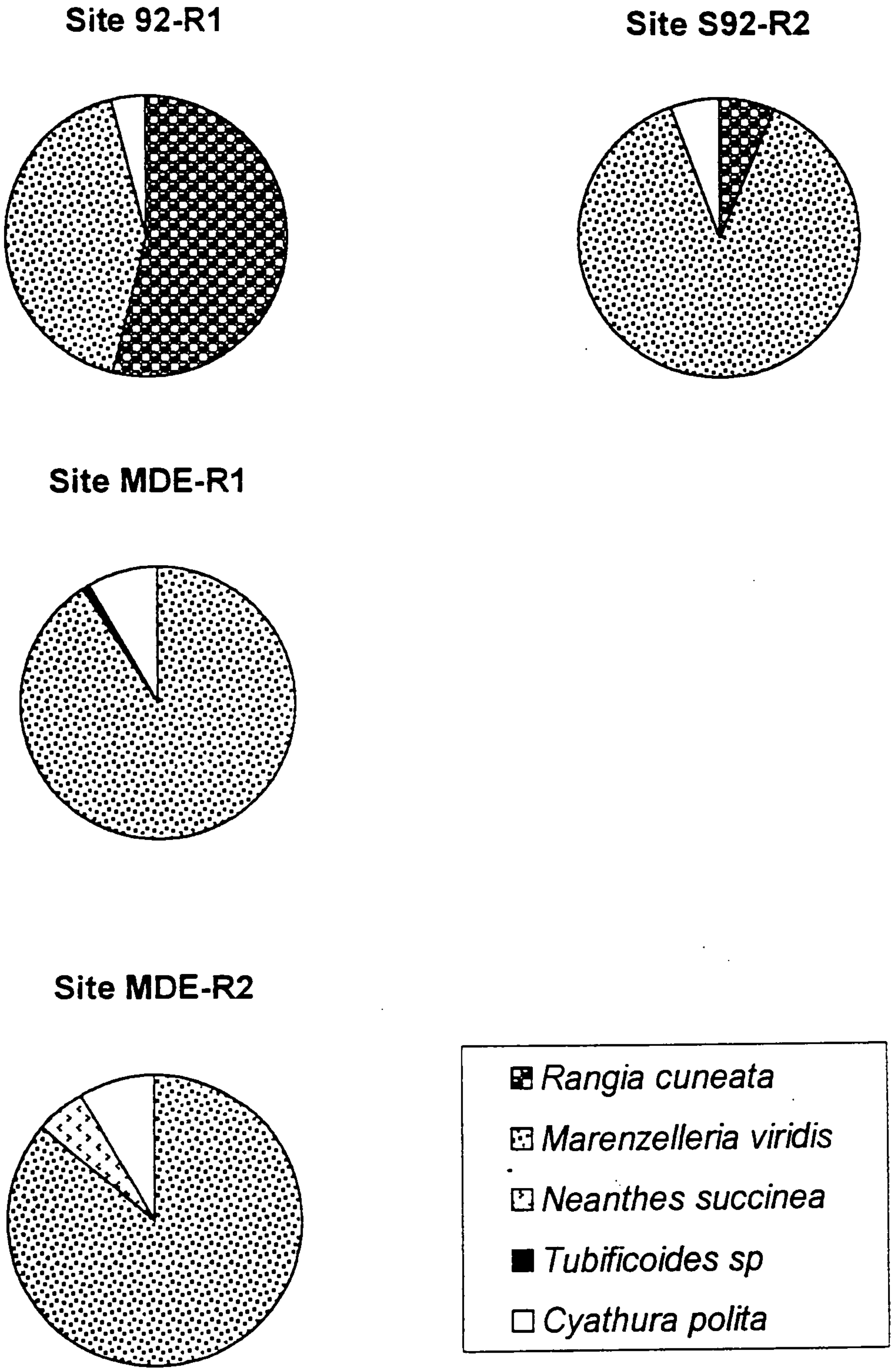


Figure 10a. Relative Abundance of the Three Most Dominant Infaunal Taxa at Site 92 Inner Stations, July 1998

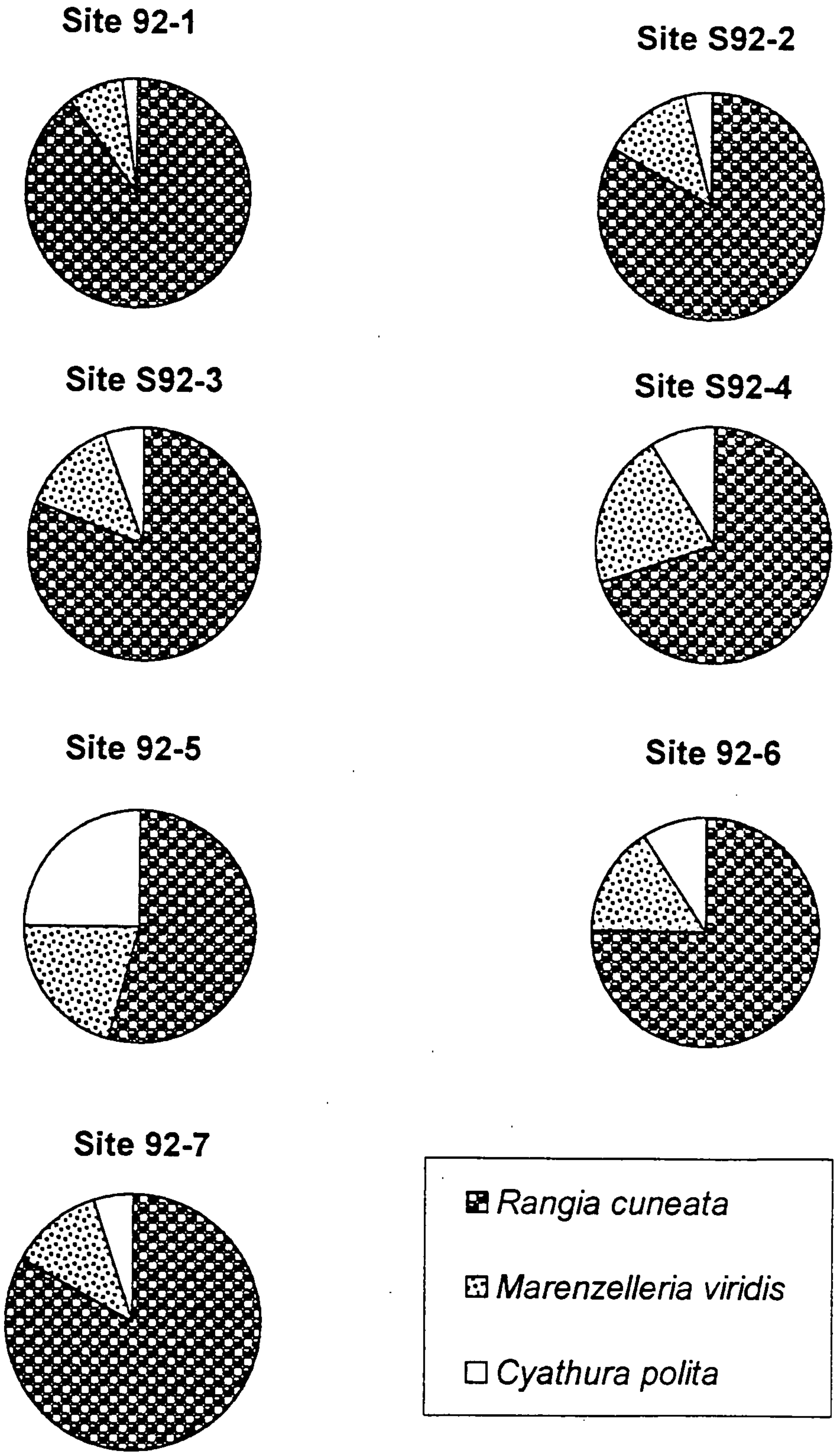
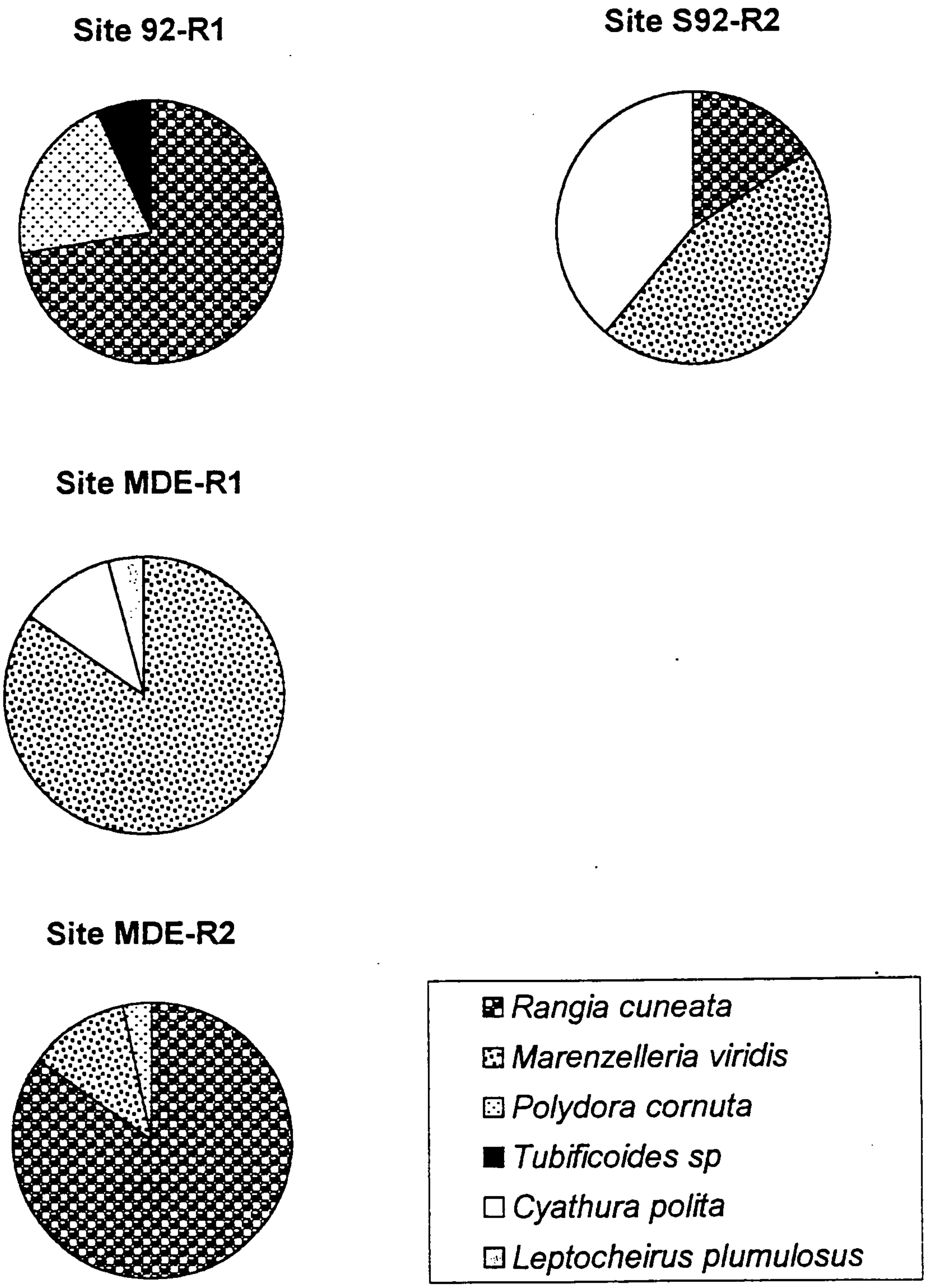


Figure 10b. Relative Abundance of the Three Most Dominant Infaunal Taxa at Site 92 Reference, and G-South and Northeast Stations, July 1998


Site 92-R1

Site S92-R2

Site MDE-R1

Site MDE-R2

Figure 11a. Relative Abundance of the Three Most Dominant Infaunal Taxa at Site 92 Inner Stations, September 1998

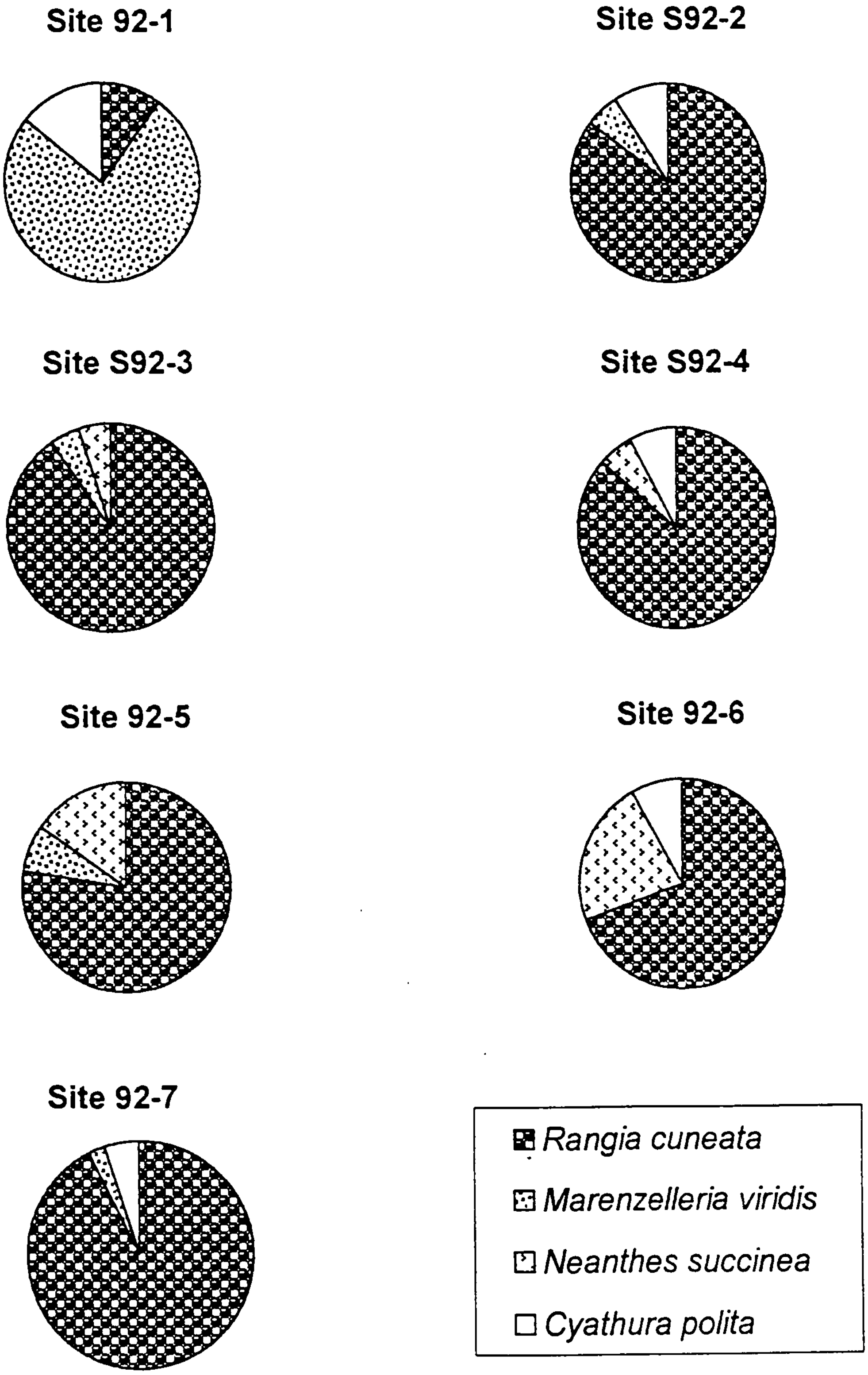


Figure 11b. Relative Abundance of the Three Most Dominant Infaunal Taxa at Site 92 Reference, and G-South and Northeast Stations, September 1998

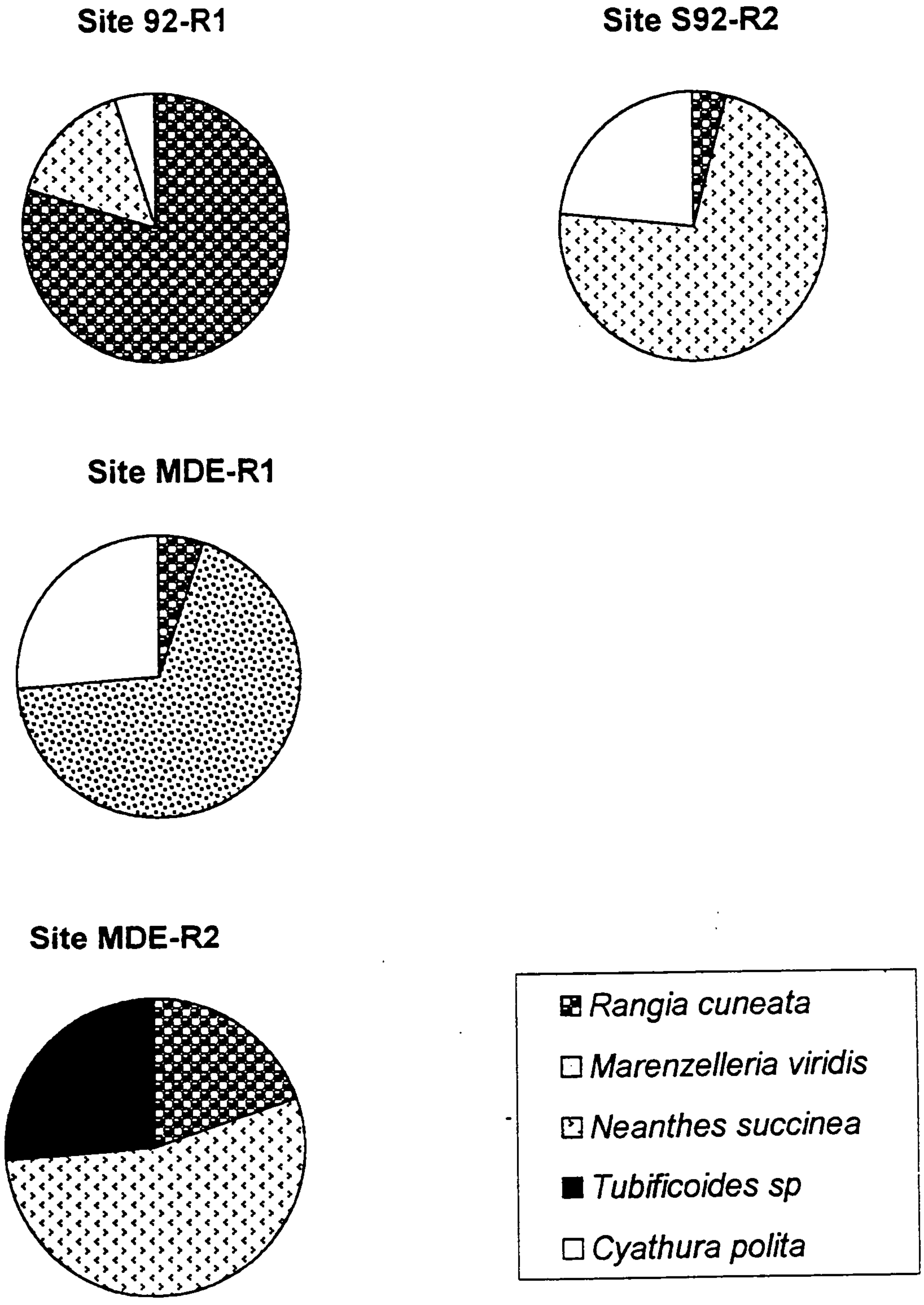


Figure 12. Numeric and Relative Abundance of *Marenzelleria viridis* at Inner, Reference, G-South and Northeast Stations, May, July and September 1998

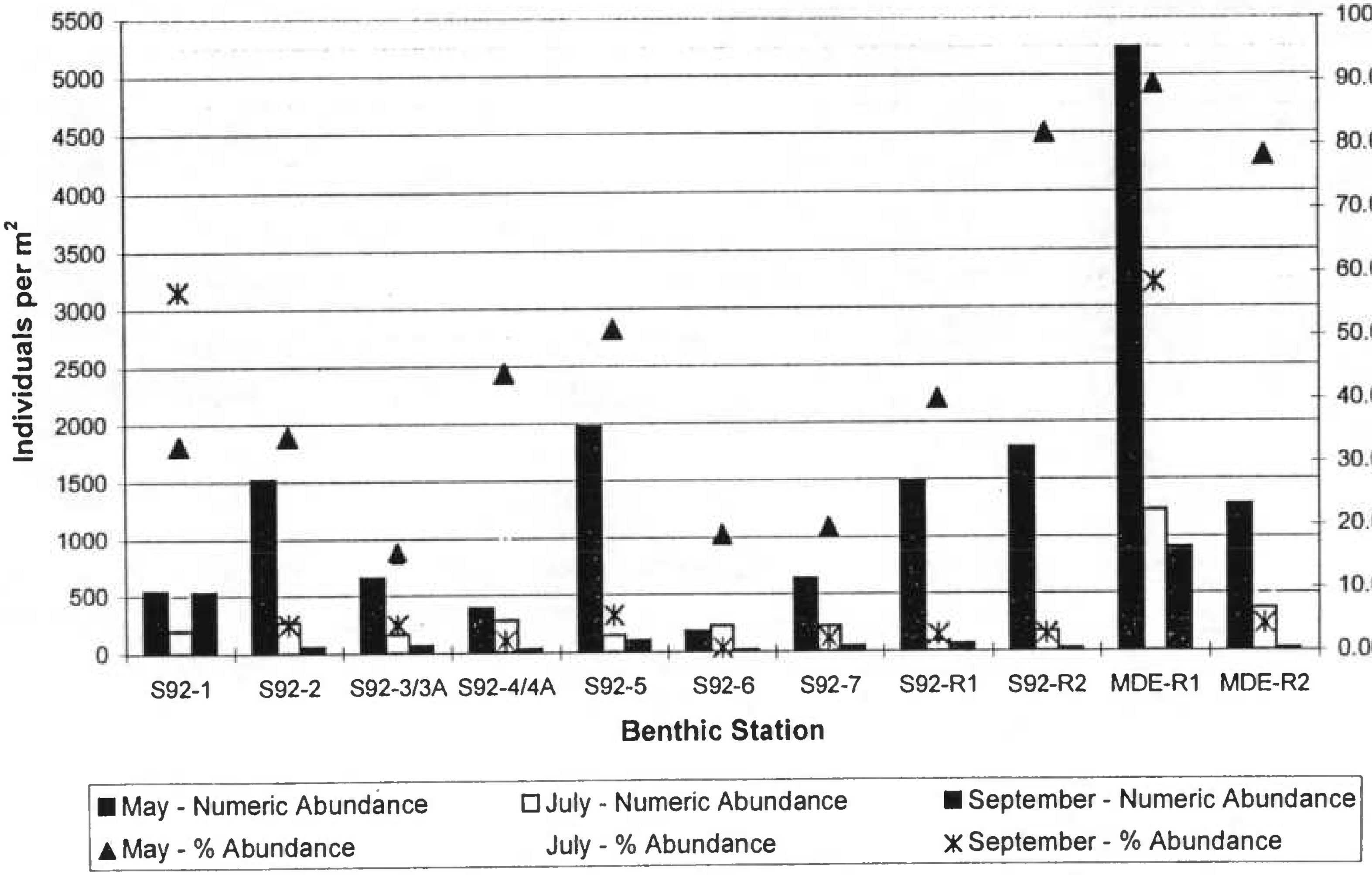
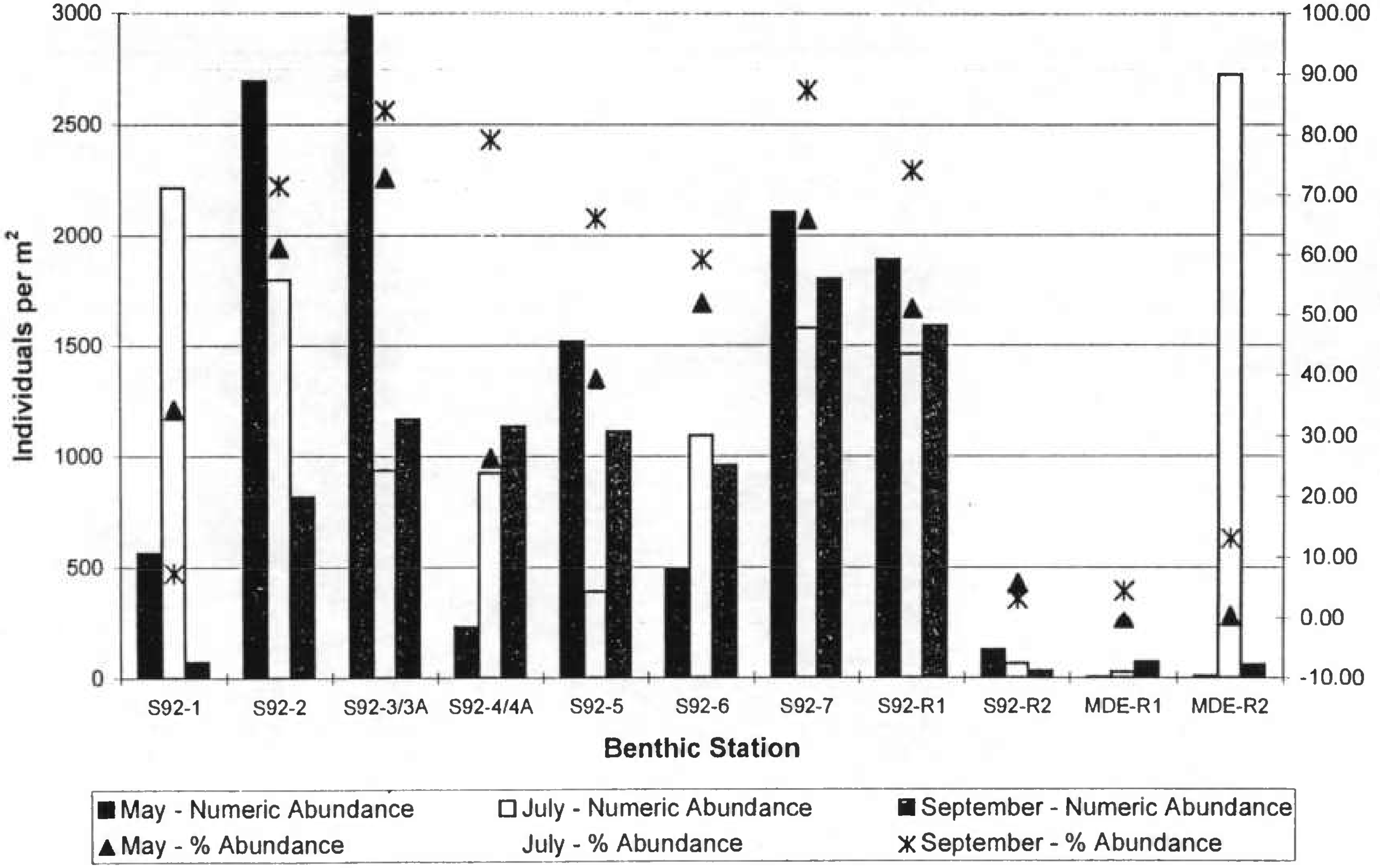


Figure 13. Numeric and Relative Abundance of *Rangia cuneata* at Inner, Reference, G-South and Northeast Stations, May, July and September 1998



CONCLUSIONS

A baseline study was conducted at Site 92 to assess the existing benthic community during the spring recruitment and summer index periods. Data were gathered during cruises on May 6, July 31, and September 28, 1998. Placement of dredged material at Site 92 began in December 1998. A post-placement study will be conducted 18-20 months after all placement activity has ceased. At that time, results between the pre- and post-placement studies will be compared to determine the effects placement of dredged material has had on the benthic macroinvertebrate communities in and around Site 92.

Water quality values were very similar among stations during each season and were similar to values found in previous studies in the Pooles Island area. Seasonal fluctuations occurred as expected with temperatures warming from spring through mid-summer, then declining toward the end of summer. Dissolved oxygen concentrations closely followed the temperature changes, decreasing through mid-summer then increasing toward the end of summer as temperatures declined. Salinity increased throughout the course of the study as freshwater influx declined. Sediment composition varied, but most stations were dominated by the silt/clay fraction. During this study, sediment composition played only a minor role, if any, in determining the abundance and diversity of the benthic infauna.

Seasonal fluctuations in temperature, dissolved oxygen and salinity were important in determining the composition of the benthic community around Pooles Island. Increases in the abundance of pollution-indicative taxa paralleled increases in salinity and temperature, and the associated decreases in dissolved oxygen. Increases in salinity and temperature and decreases in dissolved oxygen were also associated with decreases in the abundance of pollution-sensitive taxa, particularly the polychaete worm *Marenzelleria viridis*.

Differences among station types (*Inner*, *Reference*, *G-South* and *Northeast*) were primarily related to differences in the abundance of *M. viridis* or the clam *Rangia cuneata*. These two taxa had a major influence on species diversity (Shannon-Wiener diversity index) and the relative abundance of pollution-sensitive taxa.

Total abundance was not significantly different between *Inner* and *Reference* stations during any month sampled. There was no significant difference between *Inner* and *Reference* stations in regard to diversity or relative abundance of pollution-sensitive taxa in May. However, abundance of *Rangia* was generally higher at *Inner* stations than at *Reference* stations in July and September, resulting in higher pollution-sensitive taxa abundance and lower diversity at *Inner* stations.

Total abundance was significantly different between *Reference* stations and the *G-South* station during May but not during July or September. Higher abundance of *M. viridis* at the *G-South* station resulted in lower diversity than at *Reference* stations in May and July. Abundance of *M. viridis* was also significantly higher at *G-South* station than at the *Reference* stations during September. The *Northeast* station was generally very similar to the *Reference* except that total abundance was significantly depressed at this station in September. This depression may have been related to Langenfelder fossil oyster shell dredging that was occurring near the station in September 1998.

Benthic Index of Biotic Integrity (B-IBI) values were calculated based on infaunal taxa found in July and September. B-IBI values at all stations exceeded the Chesapeake Bay Restoration Goal of 3.0 during both months indicating the presence of unstressed benthic communities. The minimum score at any station was 3.5; the maximum, 4.5.

The benthic community in the G-South area has changed since pre-placement in 1991. The most notable change has been the decrease in the abundance of the clam *Rangia cuneata* that occurred between August 1991 (pre-placement) and August 1992 (post-placement). Concurrent with the decline of *Rangia* has been an increase in the abundance of the worm *Marenzelleria viridis*, which now dominates the benthic community. Total abundance and the abundance of *Rangia cuneata* were significantly lower in September 1998 compared to August 1991. Abundance of *Marenzelleria viridis* was significantly higher in September 1998 compared to August 1991. Other measures of the benthic community condition remain largely unchanged between pre-placement conditions in August 1991 and post-placement conditions in September 1998. The benthic community found in September 1998 was slightly different from that found in September 1996. Placement of dredged material in a portion of G-South during January and February 1997 may have contributed to the differences seen. Benthic Index of Biotic Integrity values indicate that the community in G-South is not currently stressed.

No statistically significant differences were found between the *Northeast* station sampled in September 1998 and baseline conditions found in the vicinity of G-East during September 1995 due to the large variation in the September 1995 data. However, the abundance in September 1998 was less than half the minimum abundance found at any station in the vicinity of G-East during September 1995.

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APPENDIX I

Benthic Community Field Data Sheets
September 1998

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION

Benthic Field Data Sheet

Survey Site 92 Collector Evans, Lathrop, Lookingland, Rasmussen Station S92-1

Lat.[1] 3 9 1 5 5 2 3 2 Long.[1] 7 6 1 6 5 1 9 2 MD Code X I G 5 8 2 5

Date Collected (YR MO DY)	Time Coll.	Gear	Tide	Total Depth Meters	Total Depth Feet
9 8 0 9 2 8	1 3 0 5	0 4	F	7.2	23.6

No. Reps.[2]	Submitter Code	Data Category	Equip. Set Unit#	Sample Size	Field Fixative	Secchi Depth (m)
0 3	6 0	B C	C* R	0.1	0 2	1.6

Wave Height	Wind Direction	Wind Speed (knots) Min	Wind Speed (knots) Max	Air Temp. (°C)	Weather Code Past 24 hrs	Weather Code Today	% Cloud Cover
0.3	N N W	1 5	2 0	28.0	1 0	1 0	1 0

Observed Bottom Sediment

% SiltClay	% Sand	% Shell	% Gravel	% Detritus
9 5		5		

Comments

[1] Latitude and Longitude are in degrees, decimal minutes.
[2] 4th grab taken and used for sediment sample only.

*C – used for bottom turbidity only

Sample Depth (m)	Water Temp. (°C)	Field pH	D.O. (mg/l)	Conductivity µmhos/cm	Salinity (ppt, ‰)	Turbidity (NTU)
0.5	23.2	7.5	8.7	15,000	8.5	
2.0	23.2	7.5	8.4	15,000	8.5	
4.0	23.0	7.3	8.1	15,800	9.0	
6.0	23.0	7.3	8.1	15,700	9.0	7.4

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION

Benthic Field Data Sheet

Survey Site 92 Collector Evans, Lathrop, Lookingland, Rasmussen Station S92-2

Lat.[1] 3 9 1 5 4 1 8 2 Long.[1] 7 6 1 7 0 7 6 6 MD Code X I G 5 7 1 6

Date Collected YR	MO	DY	Time Coll.	Gear	Tide	Total Depth Meters	Feet
9 8	0 9	2 8	1 2 3 0	0 4	F	4 . 5	1 4 . 8

No. Reps.[2]	Submitter Code	Data Category	Equip. Set Unit#	Sample Size	Field Fixative	Secchi Depth (m)
0 3	6 0	B C	C* R	0 . 1	0 2	1 . 6

Wave Height (m)	Wind Direction	Wind Speed (knots) Min	Max	Air Temp. (°C)	Weather Code Past 24 hrs	Today	% Cloud Cover
0 . 3	N N W	1 5	2 0	27.0	1 0	1 0	1 0

Observed Bottom Sediment

% SiltClay	**% Sand**	**% Shell**	**% Gravel**	**% Detritus**
9 5		5		

Comments

[1] Latitude and Longitude are in degrees, decimal minutes.

[2] 4th grab taken and used for sediment sample only.

*C – used for bottom turbidity only

Sample Depth (m)	Water Temp. (°C)	Field pH	D.O. (mg/l)	Conductivity µmhos/cm	Salinity (ppt, ‰)	Turbidity (NTU)
0.5	23.2	7.6	8.8	15,200	8.6	
2.0	23.1	7.4	8.5	15,300	8.6	
4.0	22.9	7.2	7.6	15,600	8.8	7.4

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION

Benthic Field Data Sheet

Survey Site 92 Collector Evans, Lathrop, Lookingland, Rasmussen Station S92-3A

Lat.[1]	Long.[1]	MD Code
3 9 1 5 0 7 6 2	7 6 1 7 4 9 1 8	X I G 4 9 0 6

Date Collected YR	MO	DY	Time Coll.	Gear	Tide	Total Depth Meters	Feet
9 8	0 9	2 8	1 1 4 0	0 4	F	5 . 3	1 7 . 4

No. Reps.[2]	Submitter Code	Data Category	Equip. Set Unit#	Sample Size	Field Fixative	Secchi Depth (m)
0 3	6 0	B C	C* R	0 . 1	0 2	1 . 6

Wave Height (m)	Wind Direction	Wind Speed (knots) Min	Max	Air Temp. (°C)	Weather Code Past 24 hrs	Today	% Cloud Cover
0 . 2	N N W	1 5	2 0	26.0	1 0	1 0	1 0

Observed Bottom Sediment

% SiltClay	**% Sand**	**% Shell**	**% Gravel**	**% Detritus**
9 5		5		

Comments

[1] Latitude and Longitude are in degrees, decimal minutes.

[2] 4th grab taken and used for sediment sample only.

*C – used for bottom turbidity only

Sample Depth (m)	Water Temp. (°C)	Field pH	D.O. (mg/l)	Conductivity µmhos/cm	Salinity (ppt, ‰)	Turbidity (NTU)
0.5	23.1	7.5	9.0	15,100	8.6	
2.5	23.0	7.2	8.3	15,500	8.8	
4.5	23.0	7.1	8.2	15,800	9.0	4.7

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION

Benthic Field Data Sheet

Survey Site 92 Collector Evans, Lathrop, Lookingland, Rasmussen Station S92-4A

Lat.[1]	Long.[1]	MD Code
3 9 1 4 8 3 1 4	7 6 1 7 2 5 7 8	X I G 4 4 1 0

Date Collected YR	Date Collected MO	Date Collected DY	Time Coll.	Gear	Tide	Total Depth Meters	Total Depth Feet
9 8	0 9	2 8	0 8 5 0	0 4	F	5 . 5	1 8 . 0

No. Reps.[2]	Submitter Code	Data Category	Equip. Set Unit#	Sample Size	Field Fixative	Secchi Depth (m)
0 3	6 0	B C	C* R	0 . 1	0 2	1 . 4

Wave Height (m)	Wind Direction	Wind Speed (knots) Min	Wind Speed (knots) Max	Air Temp. (°C)	Weather Code Past 24 hrs	Weather Code Today	% Cloud Cover
0 . 1	N N W	5	1 0	24.5	1 0	1 0	0

Observed Bottom Sediment

% SiltClay	**% Sand**	**% Shell**	**% Gravel**	**% Detritus**
9 5		5		

Comments

[1] Latitude and Longitude are in degrees, decimal minutes.

[2] 4th grab taken and used for sediment sample only.

*C – used for bottom turbidity only

Sample Depth (m)	Water Temp. (°C)	Field pH	D.O. (mg/l)	Conductivity µmhos/cm	Salinity (ppt, ‰)	Turbidity (NTU)
0.5	22.9	7.1	7.4	15,600	8.8	
2.5	22.9	7.1	7.3	15,600	8.8	
4.5	22.8	7.0	7.8	15,600	8.9	7.2

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION

Benthic Field Data Sheet

Survey Site 92 Collector Evans, Lathrop, Lookingland, Rasmussen Station S92-5

Lat.[1] 3 9 1 4 8 4 8 8 Long.[1] 7 6 1 6 7 3 5 2 MD Code X I G 4 7 2 2

Date Collected YR	MO	DY	Time Coll.	Gear	Tide	Total Depth Meters	Feet
9 8	0 9	2 8	0 9 1 5	0 4	F	5 . 0	1 6 . 4

No. Reps.[2]	Submitter Code	Data Category	Equip. Set Unit#	Sample Size	Field Fixative	Secchi Depth (m)
0 3	6 0	B C	C* R	0 . 1	0 2	1 . 6

Wave Height (m)	Wind Direction	Wind Speed (knots) Min	Max	Air Temp. (°C)	Weather Code Past 24 hrs	Today	% Cloud Cover
0 . 1	N N W	5	1 0	24.5	1 0	1 0	0

Observed Bottom Sediment

% SiltClay	% Sand	% Shell	% Gravel	% Detritus
9 5		5		

Comments

[1]Latitude and Longitude are in degrees, decimal minutes.
[2]4th grab taken and used for sediment sample only.

*C – used for bottom turbidity only

Sample Depth (m)	Water Temp. (°C)	Field pH	D.O. (mg/l)	Conductivity µmhos/cm	Salinity (ppt, ‰)	Turbidity (NTU)
0.5	22.8	7.1	7.1	15,600	8.8	
2.5	22.8	7.0	7.0	15,700	9.0	
4.5	22.8	6.9	7.1	16,100	9.0	15.1

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION

Benthic Field Data Sheet

Survey Site 92 Collector Evans, Lathrop, Lookingland, Rasmussen Station S92-6

Lat.[1] 3 9 1 4 9 8 0 2 Long.[1] 7 6 1 6 1 7 7 2 MD Code X I G 4 9 3 1

Date Collected YR	MO	DY	Time Coll.	Gear	Tide	Total Depth Meters	Feet
98	09	28	0945	04	F	5.0	16.4

No. Reps.[2]	Submitter Code	Data Category	Equip. Set Unit#	Sample Size	Field Fixative	Secchi Depth (m)
03	60	BC	C* R	0.1	02	1.6

Wave Height (m)	Wind Direction	Wind Speed (knots) Min	Max	Air Temp. (°C)	Weather Code Past 24 hrs	Today	% Cloud Cover
0.1	NNW	5	10	24.5	10	10	0

Observed Bottom Sediment

% SiltClay	% Sand	% Shell	% Gravel	% Detritus
85	10	5		

Comments

[1] Latitude and Longitude are in degrees, decimal minutes.

[2] 4th grab taken and used for sediment sample only.

*C – used for bottom turbidity only

Sample Depth (m)	Water Temp. (°C)	Field pH	D.O. (mg/l)	Conductivity μmhos/cm	Salinity (ppt, ‰)	Turbidity (NTU)
0.5	22.9	7.1	7.3	14,580	8.2	
2.5	22.8	7.1	7.0	15,000	8.5	
4.5	22.8	7.0	7.1	16,100	9.0	4.7

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION

Benthic Field Data Sheet

Survey Site 92 Collector Evans, Lathrop, Lookingland, Rasmussen Station S92-7

Lat.[1] 3 9 1 5 1 4 6 4 Long.[1] 7 6 1 6 8 7 0 2 MD Code X I G 5 2 2 0

Date Collected							Time Coll.	Gear	Tide	Total Depth	
	YR		MO		DY					Meters	Feet
	9	8	0	9	2	8	1 0 .5 5	0 4	F	6 . 2	2 0 . 3

No. Reps.[2]	Submitter Code	Data Category	Equip. Set Unit#	Sample Size	Field Fixative	Secchi Depth (m)
0 3	6 0	B C	C* R	0 . 1	0 2	1 . 5

Wave Height (m)	Wind Direction	Wind Speed (knots) Min	Wind Speed (knots) Max	Air Temp. (°C)	Weather Code Past 24 hrs	Weather Code Today	% Cloud Cover
0 . 3	N N W	1 5	2 0	25.0	1 0	1 0	1 0

Observed Bottom Sediment

% SiltClay	% Sand	% Shell	% Gravel	% Detritus
9 5		5		

Comments

[1]Latitude and Longitude are in degrees, decimal minutes.
[2]4th grab taken and used for sediment sample only.

*C – used for bottom turbidity only

Sample Depth (m)	Water Temp. (°C)	Field pH	D.O. (mg/l)	Conductivity µmhos/cm	Salinity (ppt, ‰)	Turbidity (NTU)
0.5	23.0	7.0	7.6	14,450	8.1	
1.7	22.9	7.0	7.3	14,800	8.4	
3.7	22.9	6.9	7.4	15,600	8.9	
5.7	22.9	6.8	7.6	15,800	9.0	12.4

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION

Benthic Field Data Sheet

Survey Site 92 Collector Evans, Lathrop, Lookingland, Rasmussen Station S92-R1

Lat.[1] 3 9 1 4 3 3 5 2 Long.[1] 7 6 1 6 7 7 5 4 MD Code X I G 3 9 2 1

Date Collected YR 9 8 MO 0 9 DY 2 8

Time Coll. 0 8 1 7

Gear 0 4

Tide LS

Total Depth Meters 4 . 4 Feet 1 4 . 5

No. Reps.[2] 0 3

Submitter Code 6 0

Data Category B C

Equip. Set Unit# C

Sample Size 0 . 1

Field Fixative 0 2

Secchi Depth (m) 1 . 2

Wave Height (m) 0 . 1

Wind Direction N N W

Wind Speed (knots) Min 5 Max 1 0

Air Temp. (°C) 24.0

Weather Code Past 24 hrs 1 0 Today 1 0

% Cloud Cover 0

Observed Bottom Sediment

% SiltClay 7 0

% Sand 1 5

% Shell 1 5

% Gravel

% Detritus

Comments

[1] Latitude and Longitude are in degrees, decimal minutes.

[2] 4th grab taken and used for sediment sample only.

Sample Depth (m)	Water Temp. (°C)	Field pH	D.O. (mg/l)	Conductivity µmhos/cm	Salinity (ppt, ‰)	Turbidity (NTU)
0.5	22.8	7.3	7.5	16,240	9.5	6.4
1.8	22.8	7.3	7.7	16,250	9.5	6.3
3.8	22.8	7.2	7.7	16,230	9.5	.10.9

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION

Benthic Field Data Sheet

Survey Site 92 Collector Evans, Lathrop, Lookingland, Rasmussen Station S92-R2

Lat.[1] 3 9 1 4 9 7 7 2 Long.[1] 7 6 1 5 6 9 0 6 MD Code X I G 4 9 3 9

Date Collected			Time Coll.	Gear	Tide	Total Depth	
YR	MO	DY				Meters	Feet
9 8	0 9	2 8	1 0 2 0	0 4	F	5 . 5	1 8 . 0

No. Reps.[2]	Submitter Code	Data Category	Equip. Set Unit#	Sample Size	Field Fixative	Secchi Depth (m)
0 3	6 0	B C	C* R	0 . 1	0 2	1 . 4

Wave Height (m)	Wind Direction	Wind Speed (knots)		Air Temp. (°C)	Weather Code		% Cloud Cover
		Min	Max		Past 24 hrs	Today	
0 . 3	N N W	1 5	2 0	25.0	1 0	1 0	2 0

Observed Bottom Sediment

% SiltClay	% Sand	% Shell	% Gravel	% Detritus
8 0	1 0	1 0		

Comments

[1]Latitude and Longitude are in degrees, decimal minutes.
[2]4th grab taken and used for sediment sample only.

*C – used for bottom turbidity only

Sample Depth (m)	Water Temp. (°C)	Field pH	D.O. (mg/l)	Conductivity µmhos/cm	Salinity (ppt, ‰)	Turbidity (NTU)
0.5	23.1	7.0	7.1	13,770	7.7	
1.0	23.1	7.0	7.0	13,800	7.7	
3.0	22.9	7.0	6.7	15,100	8.5	
5.0	22.8	6.9	6.9	15,700	9.0	4.4

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION

Benthic Field Data Sheet

Survey Site 92 Collector Evans, Lathrop, Lookingland, Rasmussen Station MDE-R1

Lat.[1] 3 9 1 5 4 5 4 2 Long.[1] 7 6 1 5 9 0 5 4 MD Code X I G 5 7 3 6

Date Collected			Time Coll.	Gear	Tide	Total Depth	
YR	MO	DY				Meters	Feet
9 8	0 9	2 8	1 3 5 0	0 4	E	4 . 1	1 3 . 4

No. Reps.[2]	Submitter Code	Data Category	Equip. Set Unit#	Sample Size	Field Fixative	Secchi Depth (m)
0 3	6 0	B C	C* R	0 . 1	0 2	1 . 8

Wave Height (m)	Wind Direction	Wind Speed (knots)		Air Temp. (°C)	Weather Code		% Cloud Cover
		Min	Max		Past 24 hrs	Today	
0 . 2	N N W	1 0	1 5	NR	1 0	1 0	1 0

Observed Bottom Sediment

% SiltClay	% Sand	% Shell	% Gravel	% Detritus
1 0 0				

Comments

[1]Latitude and Longitude are in degrees, decimal minutes.
[2]4th grab taken and used for sediment sample only.

*C – used for bottom turbidity only

Sample Depth (m)	Water Temp. (°C)	Field pH	D.O. (mg/l)	Conductivity µmhos/cm	Salinity (ppt, ‰)	Turbidity (NTU)
0.5	23.3	7.5	8.3	14,590	8.2	
1.3	23.3	7.5	8.2	14,580	8.2	
3.3	22.9	7.3	7.1	15,600	8.8	3.5

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION

Benthic Field Data Sheet

Survey Site 92 Collector Evans, Lathrop, Lookingland, Rasmussen Station MDE-R2

Lat.[1]	39176706
Long.[1]	76143070
MD Code	XIG9462
Date Collected YR	98
Date Collected MO	09
Date Collected DY	28
Time Coll.	1430
Gear	04
Tide	E
Total Depth Meters	4.0
Total Depth Feet	13.1
No. Reps.[2]	03
Submitter Code	60
Data Category	BC
Equip. Set Unit#	C* R
Sample Size	0.1
Field Fixative	02
Secchi Depth (m)	2.0
Wave Height	0.3
Wind Direction	NNW
Wind Speed (knots) Min	15
Wind Speed (knots) Max	20
Air Temp. (°C)	28.0
Weather Code Past 24 hrs	10
Weather Code Today	10
% Cloud Cover	5

Observed Bottom Sediment

% SiltClay	% Sand	% Shell	% Gravel	% Detritus
90		10		

Comments

[1]Latitude and Longitude are in degrees, decimal minutes.

[2]4th grab taken and used for sediment sample only.

*C – used for bottom turbidity only

Rep. #3 and sediment rep. light gray in color – appeared fresh; barge with gray material (gravel or shell?) within 100 m of station, appeared to be depositing material

Sample Depth (m)	Water Temp. (°C)	Field pH	D.O. (mg/l)	Conductivity µmhos/cm	Salinity (ppt, ‰)	Turbidity (NTU)
0.5	23.4	7.3	7.8	13,410	7.3	
1.2	23.4	7.3	7.7	13,480	7.6	
3.2	23.0	7.2	7.1	14,230	8.0	4.7

APPENDIX II

Benthic Cruise Report
September 1998

MDE

MARYLAND DEPARTMENT OF THE ENVIRONMENT

TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
Field Operations Program

TO: Visty Dalal

FROM: William Evans

CC: Ellen Lathrop-Davis

DATE: September 30, 1998

SUBJECT: Site 92 Benthic Cruise Report

On September 28, 1998, MDE personnel William Evans, Ellen Lathrop-Davis, Gilbert Lookingland, Dennis Rasmussen conducted the third of three benthic sampling events at the open-water placement area Site 92. Sampling consisted of a collection of four subsamples at eleven stations (S92-1 through S92-7, S92-R1, S92-R2, MDE-R1 and MDE-R2) using a Van Veen bottom grab sampler. The fourth subsample was collected from the Van Veen using a plastic scoop and stored in labeled plastic bags for future grain size analysis. Triplicate samples were sifted in the field through a 0.5 mm screen. Remaining material was put into ½ gallon buckets and preserved with 10% formalin and bay water. All samples were transported to the MDE Benthos Laboratory in Baltimore. Sampling sites were verified using a Differential Global Positioning System (DGPS) Navigation Unit.

The research vessel R/V *Hopkins* left Dundee Creek, located within Gunpowder State Park, at 0700 and returned at 1600 hours. Wave height averaged 2-3 feet with variable winds ranging from 5-20 knots. Tides were flooding during the morning sampling and later ebbing in the afternoon.

Bottom salinity levels ranged from 8.8 ppt (S92-2 and MDE-R1) to 9.5 ppt (S92-R1). Bottom dissolved oxygen levels ranged from 6.9 mg/l (S92-R2) to 8.2 mg/l (S92-3A). Due to a low battery level in the YSI unit, turbidity levels were only taken at the bottom. Lowest bottom turbidity levels were observed at station MDE-R1 (3.5 NTU's) and maximum levels at S92-5 (15.1 NTU's).

When sampling station MDE-R2, oyster shell dredging was observed in close proximity of the station. As a result, a thin layer of grayish, newly deposited material was viewed in the first one to two inches of the sediment. Any effects that this may have on the benthos will be determined once the September 1998 samples are analyzed.

APPENDIX III

Standard Chain of Custody Forms for the Transfer of Benthic and Sediment Samples
September 1998

Standard Chain-of-Custody Form

MDE-TARSA
Annapolis Field Office
Chain of Custody

Collector/ Phone # W. Evans/(410)631-3611 Signature/Initials William M. Evans/

Sample Collection Date: September 28, 1998

Sample Source: Chesapeake Bay

Project Name: Site 92

Sample Number: 33 subsamples

Media Sampled: Benthics

Date Sample sent to Laboratory: 9/29/98

Sample Preservation Method:

Frozen - 10% Formalin
Refrigerated -

Holding Time: N/A

Analysis Requested: Identification

Chain of Custody sample possession: In house

Samples Iced?

From Vessel/8:30am/9/29 to Balt. Benthos Lab/11:00am/9/29 Y [✓ N]
Name/Time/Date Name/Time/Date

From _____ to _____ Y N
Name/Time/Date Name/Time/Date

From _____ to _____ Y N
Name/Time/Date Name/Time/Date

From _____ to _____ Y N
Name/Time/Date Name/Time/Date

Standard Chain-of-Custody Form

MDE-TARSA
Annapolis Field Office
Chain of Custody

Collector/ Phone # W. Evans/(410)631-3611 Signature/Initials William M. Evans Jr./w.

Sample Collection Date: September 28, 1998

Sample Source: Chesapeake Bay

Project Name: Site 92

Sample Number: 11

Media Sampled: Sediment

Date Sample sent to Laboratory: 9/28/98

Sample Preservation Method:

Frozen -
Refrigerated - NA

Holding Time: NA

Analysis Requested: Sediment grain-size analysis

Chain of Custody sample possession: In house

				Samples Iced?
From	Vessel/4:00pm/9/28 Name/Time/Date	to	Balt. Benthos Lab/5:00pm/9/28 Name/Time/Date	Y [✓ N]
From	Name/Time/Date	to	Name/Time/Date	Y N
From	Name/Time/Date	to	Name/Time/Date	Y N
From	Name/Time/Date	to	Name/Time/Date	Y N

APPENDIX IV

Benthic Taxa Inventory Sheets
September 1998

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION

Taxa Inventory Sheet

Survey Site 92 Collector Evans, Lathrop-Davis, Lookingland Station S92-1

Lat.[1] 3 9 1 5 5 2 3 2 Long.[1] 7 6 1 6 5 1 9 2 MD Code X I G 5 8 2 5

[1]Latitude and Longitude are in degrees, decimal minutes.

Date Collected	YR	MO	DY	Time Coll.	Gear	Tide	Water Depth	Meters	Feet
	9 8	0 9	2 8	1 3 0 5	0 4	F		7 . 2	2 3 . 6

Temp.[2] °C	pH[2]	DO[2] mg/l	Salinity[2] ppt. ‰	Conductivity[2] µmhos/cm	Turbidity[2] NTU
2 3 . 0	7 . 3	8 . 1	9 . 0	1 5 7 0 0	7 . 4

[2]Water quality measurements are from the bottom layer.

Samp. Size 0 . 1 0 Samp. Type B E N Field Fixative 0 2

Grab#	Log Number	ID By	YR	MO	DY	QC By	YR	MO	DY
1	9 8 0 0 1 1 7	J E L	9 8	1 2	2 2				
2	9 8 0 0 1 1 8	J E L	9 8	1 2	2 4				
3	9 8 0 0 1 1 9	J E L	9 8	1 2	2 4				

PPSP CODE	DNR CODE	VALUE FOR GRAB			TAXON
		1	2	3	
1 2 4 0		3		3	*Carinoma tremaphoros*
	4 9 0 4 0 1 9				*Hydrobia* sp.
0 6 8 6	4 9 0 5 0 1 1				*Mytilopsis leucophaeata*
0 5 2 0	4 9 0 5 0 0 9			2	*Macoma balthica*
0 5 2 6	4 9 0 5 0 0 8	3	13	5	*Rangia cuneata*
0 6 6 9			2	2	*Hobsonia florida*
0 4 1 6	4 8 0 1 0 0 3				*Heteromastus filiformis*
0 4 1 1	4 8 0 1 0 1 7				*Hypereteone heteropoda*
0 4 3 0	4 8 0 1 0 0 5	43	44	73	*Marenzelleria viridis*
0 4 2 0	4 8 0 1 0 0 4	4	2	8	*Neanthes succinea*
0 4 2 6	4 8 0 1 0 5 7				*Polydora cornuta*
0 4 3 3	4 8 0 1 0 1 8	2	2	3	*Streblospio benedicti*
1 0 3 9	4 8 0 2 0 2 3		1	3	*Tubificoides* sp.
	5 3 0 7 0 1 1				*Balanus improvisus*
0 1 0 3	5 3 1 9 0 1 4				*Rhithropanopeus harrisii*
0 1 0 8					*Neomysis americana*
0 4 9 7	5 3 1 6 0 1 2	9	7	14	*Cyathura polita*
0 6 2 5	5 3 1 6 0 2 1				*Chiridotea almyra*
0 4 9 8	5 3 1 6 0 2 4	1	4	5	*Edotea triloba*
0 4 6 8	5 3 1 7 0 2 5		1	4	*Ameroculodes* spp.complex
0 6 3 5	5 3 1 7 0 1 3				*Apocorophium lacustre*
0 4 6 4	5 3 1 7 0 0 1				*Gammarus* sp.
0 4 6 6	5 3 1 7 0 1 6	8		10	*Leptocheirus plumulosus*
0 4 6 7	5 3 1 7 0 2 2				*Melita nitida*
0 3 0 1	5 4 2 4 0 4 6	2	4	1	*Coelotanypus* sp.
0 5 6 4	5 4 2 4 0 4 7				*Procladius* sp.
0 6 3 8	5 4 2 4 0 4 9				*Cryptochironomus* sp.
0 2 9 5	5 4 2 4 0 5 1				*Polypedilum* sp.

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Taxa Inventory Sheet

Survey Site 92 Collector Evans, Lathrop, Lookingland Station S92-2

Lat.[1] 3 9 1 5 4 1 8 2 Long.[1] 7 6 1 7 0 7 6 6 MD Code X I G 5 7 1 6

[1]Latitude and Longitude are in degrees, decimal minutes.

Date Collected			Time Coll.	Gear	Tide	Water Depth	
YR	MO	DY				Meters	Feet
9 8	0 9	2 8	1 2 3 0	0 4	F	4 . 5	1 4 . 8

Temp.[2]	pH[2]	DO[2]	Salinity[2]	Conductivity[2]	Turbidity[2]
°C		mg/l	ppt, ‰	μmhos/cm	NTU
2 2 . 9	7 . 2	7 . 6	8 . 8	1 5 6 0 0	7 . 4

[2]Water quality measurements are from the bottom layer.

Samp. Size 0 . 1 0 Samp. Type B E N Field Fixative 0 2

Grab#	Log Number	ID By	YR	MO	DY	QC By	YR	MO	DY
1	9 8 0 0 1 2 0	J E L	9 8	1 2	2 8				
2	9 8 0 0 1 2 1	J E L	9 9	0 1	2 5				
3	9 8 0 0 1 2 2	J E L	9 9	0 1	2 5				

PPSP CODE	DNR CODE	VALUE FOR GRAB			TAXON
		1	2	3	
1 2 4 0		4	1	5	*Carinoma tremaphoros*
	4 9 0 4 0 1 9				*Hydrobia* sp.
0 6 8 6	4 9 0 5 0 1 1				*Mytilopsis leucophaeata*
0 5 2 0	4 9 0 5 0 0 9				*Macoma balthica*
0 5 2 6	4 9 0 5 0 0 8	100	80	65	*Rangia cuneata*
0 4 1 6	4 8 0 1 0 0 3				*Heteromastus filiformis*
0 6 6 9					*Hobsonia florida*
0 4 1 1	4 8 0 1 0 1 7			2	*Hypereteone heteropoda*
0 4 3 0	4 8 0 1 0 0 5	6	6	4	*Marenzelleria viridis*
0 4 2 0	4 8 0 1 0 0 4	2	4	4	*Neanthes succinea*
0 4 2 6	4 8 0 1 0 5 7				*Polydora cornuta*
0 4 3 3	4 8 0 1 0 1 8		8	5	*Streblospio benedicti*
1 0 3 9	4 8 0 2 0 2 3		6	3	*Tubificoides* sp.
	5 3 0 7 0 1 1				*Balanus improvisus*
0 1 0 3	5 3 1 9 0 1 4				*Rhithropanopeus harrisii*
0 1 0 8					*Neomysis americana*
0 4 9 7	5 3 1 6 0 1 2	6	14	6	*Cyathura polita*
0 6 2 5	5 3 1 6 0 2 1				*Chiridotea almyra*
0 4 9 8	5 3 1 6 0 2 4		1	1	*Edotea triloba*
0 4 6 8	5 3 1 7 0 2 5		1	4	*Ameroculodes* spp.complex
0 6 3 5	5 3 1 7 0 1 3				*Apocorophium lacustre*
0 4 6 4	5 3 1 7 0 0 1				*Gammarus* sp.
0 4 6 6	5 3 1 7 0 1 6			1	*Leptocheirus plumulosus*
0 4 6 7	5 3 1 7 0 2 2				*Melita nitida*
0 3 0 1	5 4 2 4 0 4 6		1	4	*Coelotanypus* sp.
0 5 6 4	5 4 2 4 0 4 7				*Procladius* sp.
0 6 3 8	5 4 2 4 0 4 9				*Cryptochironomus* sp.
0 2 9 5	5 4 2 4 0 5 1				*Polypedilum* sp.

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Taxa Inventory Sheet

Survey Site 92 Collector Evans, Lathrop, Lookingland Station S92-3A

Lat.[1] 3 9 1 5 0 7 6 2 Long.[1] 7 6 1 7 4 9 1 8 MD Code X I G 4 9 0 6

[1]Latitude and Longitude are in degrees, decimal minutes.

	Date Collected YR	MO	DY	Time Coll.	Gear	Tide	Water Depth Meters	Feet
	9 8	0 9	2 8	1 1 4 0	0 4	F	5 . 3	1 7 . 4

Temp.[2] °C	pH[2]	DO[2] mg/l	Salinity[2] ppt, ‰	Conductivity[2] µmhos/cm	Turbidity[2] NTU
2 3 . 0	7 . 1	8 . 2	9 . 0	1 5 8 0 0	4 . 7

[2]Water quality measurements are from the bottom layer.

Samp. Size 0 . 1 0 Samp. Type B E N Field Fixative 0 2

Grab#	Log Number	ID By	YR	MO	DY	QC By	YR	MO	DY
1	9 8 0 0 1 2 3	J E L	9 8	1 2	2 8				
2	9 8 0 0 1 2 4	J E L	9 8	1 2	2 9				
3	9 8 0 0 1 2 5	J E L	9 8	1 2	3 0				

PPSP CODE	DNR CODE	VALUE FOR GRAB 1	2	3	TAXON
1 2 4 0		3	2	2	*Carinoma tremaphoros*
	4 9 0 4 0 1 9				*Hydrobia* sp.
0 6 8 6	4 9 0 5 0 1 1			1	*Mytilopsis leucophaeata*
0 5 2 0	4 9 0 5 0 0 9				*Macoma balthica*
0 5 2 6	4 9 0 5 0 0 8	118	131	101	*Rangia cuneata*
0 6 6 9					*Hobsonia florida*
0 4 1 6	4 8 0 1 0 0 3				*Heteromastus filiformis*
0 4 1 1	4 8 0 1 0 1 7			1	*Hypereteone heteropoda*
0 4 3 0	4 8 0 1 0 0 5	7	4	8	*Marenzelleria viridis*
0 4 2 0	4 8 0 1 0 0 4	6	3	10	*Neanthes succinea*
0 4 2 6	4 8 0 1 0 5 7				*Polydora cornuta*
0 4 3 3	4 8 0 1 0 1 8				*Streblospio benedicti*
1 0 3 9	4 8 0 2 0 2 3				*Tubificoides* sp.
	5 3 0 7 0 1 1				*Balanus improvisus*
0 1 0 3	5 3 1 9 0 1 4		1		*Rhithropanopeus harrisii*
0 1 0 8					*Neomysis americana*
0 4 9 7	5 3 1 6 0 1 2	6	7	3	*Cyathura polita*
0 6 2 5	5 3 1 6 0 2 1				*Chiridotea almyra*
0 4 9 8	5 3 1 6 0 2 4	1	1	1	*Edotea triloba*
0 4 6 8	5 3 1 7 0 2 5	1		1	*Ameroculodes* spp.complex
0 6 3 5	5 3 1 7 0 1 3				*Apocorophium lacustre*
0 6 5 8	5 3 1 7 0 3 3				*Gammarus* sp.
0 4 6 6	5 3 1 7 0 1 6				*Leptocheirus plumulosus*
0 4 6 7	5 3 1 7 0 2 2				*Melita nitida*
0 3 0 1	5 4 2 4 0 4 6	1	1		*Coelotanypus* sp.
0 5 6 4	5 4 2 4 0 4 7				*Procladius* sp.
0 6 3 8	5 4 2 4 0 4 9				*Cryptochironomus* sp.
0 2 9 5	5 4 2 4 0 5 1				*Polypedilum* sp.

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Taxa Inventory Sheet

Survey Site 92 Collector Evans, Lathrop, Lookingland Station S92-4A

Lat.[1] 3 9 1 4 8 3 1 4 Long.[1] 7 6 1 7 2 5 7 8 MD Code X 1 G 4 4 1 0

[1]Latitude and Longitude are in degrees, decimal minutes.

Date Collected			Time Coll.	Gear	Tide	Water Depth	
YR	MO	DY				Meters	Feet
9 8	0 9	2 8	0 8 5 0	0 4	F	5 . 5	1 8 . 0

Temp.[2]	pH[2]	DO[2]	Salinity[2]	Conductivity[2]	Turbidity[2]
°C		mg/l	ppt, ‰	µmhos/cm	NTU
2 2 . 8	7 . 0	7 . 8	8 . 9	1 5 6 0 0	7 . 2

[2]Water quality measurements are from the bottom layer.

Samp. Size 0 . 1 0 Samp. Type B E N Field Fixative 0 2

Grab#	Log Number	ID By	YR	MO	DY	QC By	YR	MO	DY
1	9 8 0 0 1 2 6	J E L	9 8	0 1	2 7				
2	9 8 0 0 1 2 7	J E L	9 9	0 1	2 8				
3	9 8 0 0 1 2 8	J E L	9 9	0 1	2 8				

PPSP CODE	DNR CODE	VALUE FOR GRAB			TAXON
		1	2	3	
1 2 4 0		2	3	4	*Carinoma tremaphoros*
	4 9 0 4 0 1 9				*Hydrobia* sp.
0 6 8 6	4 9 0 5 0 1 1			3	*Mytilopsis leucophaeata*
0 5 2 0	4 9 0 5 0 0 9		1		*Macoma balthica*
0 5 2 1	4 9 0 5 0 1 0	1	2		*Macoma mitchelli*
0 5 2 6	4 9 0 5 0 0 8	105	106	128	*Rangia cuneata*
0 6 6 9					*Hobsonia florida*
0 4 1 6	4 8 0 1 0 0 3				*Heteromastus filiformis*
0 4 1 1	4 8 0 1 0 1 7				*Hypereteone heteropoda*
0 4 3 0	4 8 0 1 0 0 5	2	3	4	*Marenzelleria viridis*
0 4 2 0	4 8 0 1 0 0 4	4	11	7	*Neanthes succinea*
0 4 2 6	4 8 0 1 0 5 7				*Polydora cornuta*
0 4 3 3	4 8 0 1 0 1 8		1		*Streblospio benedicti*
1 0 3 9	4 8 0 2 0 2 3				*Tubificoides* sp.
	5 3 0 7 0 1 1				*Balanus improvisus*
0 1 0 3	5 3 1 9 0 1 4				*Rhithropanopeus harrisii*
0 1 0 8					*Neomysis americana*
0 4 9 7	5 3 1 6 0 1 2	10	10	11	*Cyathura polita*
0 6 2 5	5 3 1 6 0 2 1				*Chiridotea almyra*
0 4 9 8	5 3 1 6 0 2 4	1			*Edotea triloba*
0 4 6 8	5 3 1 7 0 2 5	1	1	1	*Ameroculodes* spp.complex
0 6 3 5	5 3 1 7 0 1 3				*Apocorophium lacustre*
0 4 6 4	5 3 1 7 0 0 1				*Gammarus* sp.
0 4 6 6	5 3 1 7 0 1 6	1	2	5	*Leptocheirus plumulosus*
0 4 6 7	5 3 1 7 0 2 2				*Melita nitida*
0 3 0 1	5 4 2 4 0 4 6			2	*Coelotanypus sp.*
0 5 6 4	5 4 2 4 0 4 7				*Procladius sp.*
0 6 3 8	5 4 2 4 0 4 9				*Cryptochironomus sp.*
0 2 9 5	5 4 2 4 0 5 1				*Polypedilum sp.*

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Taxa Inventory Sheet

Survey Site 92 Collector Evans, Lathrop, Lookingland Station S92-5

Lat.[1] 39148488 Long.[1] 76167352 MD Code XIG4722

[1]Latitude and Longitude are in degrees. decimal minutes.

Date Collected			Time Coll.	Gear	Tide	Water Depth	
YR	MO	DY				Meters	Feet
98	09	28	0915	04	F	5.0	16.4

Temp.[2]	pH[2]	DO[2]	Salinity[2]	Conductivity[2]	Turbidity[2]
°C		mg/l	ppt, ‰	µmhos/cm	NTU
22.8	6.9	7.1	9.0	16100	15.1

[2]Water quality measurements are from the bottom layer.

Samp. Size 0.10 Samp. Type BEN Field Fixative 02

Grab#	Log Number	ID By	YR	MO	DY	QC By	YR	MO	DY
1	9800129	JEL	98	12	31				
2	9800130	JEL	99	01	04	NKM	99	02	22
3	9800131	JEL	99	01	19				

PPSP CODE	DNR CODE	VALUE FOR GRAB			TAXON
		1	2	3	
1240		1	1	3	*Carinoma tremaphoros*
	4904019				*Hydrobia* sp.
0686	4905011				*Mytilopsis leucophaeata*
0520	4905009				*Macoma balthica*
0521	4905010		2		*Macoma mitchelli*
0526	4905008	99	107	127	*Rangia cuneata*
0669					*Hobsonia florida*
0416	4801003				*Hetercmastus filiformis*
0411	4801017	2	3		*Hypereteone heteropoda*
0430	4801005	5	23	2	*Marenzelleria viridis*
0420	4801004	15	30	21	*Neanthes succinea*
0426	4801057				*Polydora cornuta*
0433	4801018		3		*Streblospio benedicti*
1039	4802023		2		*Tubificoides sp.*
	5307011				*Balanus improvisus*
0103	5319014	1			*Rhithropanopeus harrisii*
0108			1		*Neomysis americana*
0497	5316012	9	10	7	*Cyathura polita*
0625	5316021				*Chiridotea almyra*
0498	5316024	2	1	1	*Edotea triloba*
0468	5317025	1	6	5	*Ameroculodes* spp.complex
0635	5317013				*Apocorophium lacustre*
0464	5317001				*Gammarus* sp.
0463	5317045		1		*Gammarus mucronatus*
0466	5317016	4	8	2	*Leptocheirus plumulosus*
0467	5317022				*Melita nitida*
0301	5424046	1	2	1	*Coelotanypus* sp.
0564	5424047				*Procladius* sp.
0638	5424049				*Cryptochironomus* sp.
0295	5424051				*Polypedilum* sp.

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Taxa Inventory Sheet

Survey Site 92 Collector Evans, Lathrop, Lookingland Station S92-6

Lat.[1] 3 9 1 4 9 8 0 2 Long.[1] 7 6 1 6 1 7 7 2 MD Code X I G 4 9 3 1

[1]Latitude and Longitude are in degrees, decimal minutes.

Date Collected			Time Coll.	Gear	Tide	Water Depth	
YR	MO	DY				Meters	Feet
98	09	28	0945	04	F	5.0	16.4

Temp.[2]	pH[2]	DO[2]	Salinity[2]	Conductivity[2]	Turbidity[2]
°C		mg/l	ppt, ‰	umhos/cm	NTU
22.8	7.0	7.1	9.0	16100	4.7

[2]Water quality measurements are from the bottom layer.

Samp. Size 0.10 Samp. Type BEN Field Fixative 02

Grab#	Log Number	ID By	YR	MO	DY	QC By	YR	MO	DY
1	9800132	JEL	99	01	29				
2	9800133	JEL	99	01	29				
3	9800134	JEL	99	01	29				

PPSP CODE	DNR CODE	VALUE FOR GRAB			TAXON
		1	2	3	
1240		1	3	2	*Carinoma tremaphoros*
	4904019				*Hydrobia* sp.
0686	4905011			2	*Mytilopsis leucophaeata*
0520	4905009				*Macoma balthica*
0526	4905008	98	84	105	*Rangia cuneata*
0669					*Hobsonia florida*
0416	4801003		1		*Heteromastus filiformis*
0411	4801017	1		1	*Hypereteone heteropoda*
0430	4801005	1		3	*Marenzelleria viridis*
0420	4801004	21	23	50	*Neanthes succinea*
0426	4801057				*Polydora cornuta*
0433	4801018	4	1	5	*Streblospio benedicti*
1039	4802023	6	3	8	*Tubificoides* sp.
	5307011	10	5	10	*Balanus improvisus*
0103	5319014		1		*Rhithropanopeus harrisii*
0108					*Neomysis americana*
0497	5316012	15	4	14	*Cyathura polita*
0625	5316021				*Chiridotea almyra*
0498	5316024	5	1	4	*Edotea triloba*
0468	5317025	7	2	12	*Ameroculodes* spp.complex
0635	5317013				*Apocorophium lacustre*
0464	5317001				*Gammarus* sp.
0466	5317016	3	3	1	*Leptocheirus plumulosus*
0467	5317022				*Melita nitida*
0301	5424046			1	*Coelotanypus* sp.
0564	5424047				*Procladius* sp.
0638	5424049				*Cryptochironomus* sp.
0295	5424051				*Polypedilum* sp.

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Taxa Inventory Sheet

Survey Site 92 Collector Evans, Lathrop, Lookingland Station S92-7

Lat.[1] 3 9 1 5 1 4 6 4 Long.[1] 7 6 1 6 8 7 0 2 MD Code X I G 5 2 2 0

[1]Latitude and Longitude are in degrees, decimal minutes.

Date Collected			Time Coll.	Gear	Tide	Water Depth	
YR	MO	DY				Meters	Feet
9 8	0 9	2 8	1 0 5 5	0 4	F	6 . 2	2 0 . 3

Temp.[2]	pH[2]	DO[2]	Salinity[2]	Conductivity[2]	Turbidity[2]
°C		mg/l	ppt, ‰	umhos/cm	NTU
2 2 . 9	6 . 8	7 . 6	9 . 0	1 5 8 0 0	1 2 . 4

[2]Water quality measurements are from the bottom layer.

Samp. Size 0 . 1 0 Samp. Type B E N Field Fixative 0 2

Grab#	Log Number	ID By	YR	MO	DY	QC By	YR	MO	DY
1	9 8 0 0 1 3 5	J E L	9 9	0 2	0 1				
2	9 8 0 0 1 3 6	J E L	9 9	0 2	0 1				
3	9 8 0 0 1 3 7	J E L	9 9	0 2	0 1				

PPSP CODE	DNR CODE	VALUE FOR GRAB			TAXON
		1	2	3	
1 2 4 0		3	5	1	*Carinoma tremaphoros*
	4 9 0 4 0 1 9				*Hydrobia sp.*
0 6 8 6	4 9 0 5 0 1 1				*Mytilopsis leucophaeata*
0 5 2 0	4 9 0 5 0 0 9			1	*Macoma balthica*
0 5 2 6	4 9 0 5 0 0 8	233	165	143	*Rangia cuneata*
0 6 6 9					*Hobsonia florida*
0 4 1 6	4 8 0 1 0 0 3			1	*Heteromastus filiformis*
0 4 1 1	4 8 0 1 0 1 7				*Hypereteone heteropoda*
0 4 3 0	4 8 0 1 0 0 5	6	3	5	*Marenzelleria viridis*
0 4 2 0	4 8 0 1 0 0 4	5	4	5	*Neanthes succinea*
0 4 2 6	4 8 0 1 0 5 7				*Polydora cornuta*
0 4 3 3	4 8 0 1 0 1 8	1			*Streblospio benedicti*
1 0 3 9	4 8 0 2 0 2 3				*Tubificoides sp.*
	5 3 0 7 0 1 1				*Balanus improvisus*
0 1 0 3	5 3 1 9 0 1 4				*Rhithropanopeus harrisii*
0 1 0 8					*Neomysis americana*
0 4 9 7	5 3 1 6 0 1 2	11	9	10	*Cyathura polita*
0 6 2 5	5 3 1 6 0 2 1				*Chiridotea almyra*
0 4 9 8	5 3 1 6 0 2 4	1			*Edotea triloba*
0 4 6 8	5 3 1 7 0 2 5	1	1		*Ameroculodes* spp.complex
0 6 3 5	5 3 1 7 0 1 3		1		*Apocorophium lacustre*
0 4 6 4	5 3 1 7 0 0 1				*Gammarus* sp.
0 4 6 6	5 3 1 7 0 1 6				*Leptocheirus plumulosus*
0 4 6 7	5 3 1 7 0 2 2				*Melita nitida*
0 3 0 1	5 4 2 4 0 4 6		2	3	*Coelotanypus* sp.
0 5 6 4	5 4 2 4 0 4 7				*Procladius* sp.
0 6 3 8	5 4 2 4 0 4 9				*Cryptochironomus* sp.
0 2 9 5	5 4 2 4 0 5 1				*Polypedilum* sp.

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Taxa Inventory Sheet

Survey Site 92 Collector Evans. Lathrop. Lookingland Station S92-R1

Lat.[1] 39143352 Long.[1] 76167754 MD Code XIG3921

[1]Latitude and Longitude are in degrees. decimal minutes.

Date Collected YR	MO	DY	Time Coll.	Gear	Tide	Water Depth Meters	Feet
98	09	28	0817	04	LS	4.4	14.5

Temp.[2] °C	pH[2]	DO[2] mg/l	Salinity[2] ppt, ‰	Conductivity[2] µmhos/cm	Turbidity[2] NTU
22.8	7.2	7.7	9.5	16230	10.9

[2]Water quality measurements are from the bottom layer.

Samp. Size 0.10 Samp. Type BEN Field Fixative 02

Grab#	Log Number	ID By	YR	MO	DY	QC By	YR	MO	DY
1	9800138	JEL	99	02	02				
2	9800139	JEL	99	02	02				
3	9800140	JEL	99	02	03	NKM	99	02	22

PPSP CODE	DNR CODE	VALUE FOR GRAB			TAXON
		1	2	3	
1240		3	4	1	*Carinoma tremaphorus*
	4904019				*Hydrobia* sp.
0686	4905011	2	1		*Mytilopsis leucophaeata*
0520	4905009				*Macoma balthica*
0526	4905008	142	165	169	*Rangia cuneata*
0669					*Hobsonia florida*
0416	4801003			2	*Heteromastus filiformis*
0411	4801017	1			*Hypereteone heteropoda*
0430	4801005	6	4	8	*Marenzelleria viridis*
0420	4801004	36	23	34	*Neanthes succinea*
0426	4801057				*Polydora cornuta*
0433	4801018	1		1	*Streblospio benedicti*
1039	4802023	1			*Tubificoides* sp.
	5307011				*Balanus improvisus*
0103	5319014				*Rhithropanopeus harrisii*
0108					*Neomysis americana*
0497	5316012	10	13	5	*Cyathura polita*
0625	5316021				*Chiridotea almyra*
0498	5316024	2	1	1	*Edotea triloba*
0468	5317025	2	3	2	*Ameroculodes* spp.complex
0635	5317013	1		3	*Apocorophium lacustre*
0464	5317001				*Gammarus* sp.
0466	5317016	2	1	1	*Leptocheirus plumulosus*
0467	5317022				*Melita nitida*
0301	5424046	1			*Coelotanypus* sp.
0564	5424047				*Procladius* sp.
0638	5424049				*Cryptochironomus* sp.
0295	5424051				*Polypedilum* sp.

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION

Taxa Inventory Sheet

Survey Site 92 Collector Evans, Lathrop, Lookingland Station S92-R2

Lat.[1] 3 9 1 4 9 7 7 2 Long.[1] 7 6 1 5 6 9 0 6 MD Code X I G 4 9 3 9

[1]Latitude and Longitude are in degrees, decimal minutes.

Date Collected YR 9 8 MO 0 9 DY 2 8

Time Coll. 1 0 2 0

Gear 0 4

Tide F

Water Depth Meters 5 . 5 Feet 1 8 . 0

Temp.[2] °C 2 2 . 8

pH[2] 6 . 9

DO[2] mg/l 6 . 9

Salinity[2] ppt, ‰ 9 . 0

Conductivity[2] µmhos/cm 1 5 7 0 0

Turbidity[2] NTU 4 . 4

[2]Water quality measurements are from the bottom layer.

Samp. Size 0 . 1 0 Samp. Type B E N Field Fixative 0 2

Grab#	Log Number	ID By	YR	MO	DY	QC By	YR	MO	DY
1	9800141	JEL	99	01	22				
2	9800142	JEL	99	01	22				
3	9800143	JEL	99	01	25				

PPSP CODE	DNR CODE	VALUE FOR GRAB			TAXON
		1	2	3	
1240		2	2	3	*Carinoma tremaphoros*
	4904019				*Hydrobia sp.*
0686	4905011		1	1	*Mytilopsis leucophaeata*
0520	4905009	1			*Macoma balthica*
0521	4905010	1			*Macoma mitchelli*
0526	4905008	4	3	2	*Rangia cuneata*
0669		1			*Hobsonia florida*
0416	4801003	1			*Heteromastus filiformis*
0411	4801017		1	1	*Hypereteone heteropoda*
0430	4801005	1	7		*Marenzelleria viridis*
0420	4801004	48	44	61	*Neanthes succinea*
0426	4801057				*Polydora cornuta*
0433	4801018	6	12		*Streblospio benedicti*
1039	4802023	15	7		*Tubificoides sp.*
	5307011	7	7	19	*Balanus improvisus*
0103	5319014	3	6	3	*Rhithropanopeus harrisii*
0108					*Neomysis americana*
0497	5316012	18	21	10	*Cyathura polita*
0625	5316021				*Chiridotea almyra*
0498	5316024	3			*Edotea triloba*
0468	5317025		1	6	*Ameroculodes spp.complex*
0635	5317013				*Apocorophium lacustre*
0464	5317001				*Gammarus sp.*
0466	5317016	1	1		*Leptocheirus plumulosus*
0467	5317022		3	2	*Melita nitida*
0301	5424046		1		*Coelotanypus sp.*
0564	5424047				*Procladius sp.*
0638	5424049				*Cryptochironomus sp.*
0295	5424051				*Polypedilum sp.*

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION

Taxa Inventory Sheet

Survey Site 92 Collector Evans, Lathrop, Lookingland Station MDE-R1

Lat.[1] 3 9 1 5 4 5 4 2 Long.[1] 7 6 1 5 9 0 5 4 MD Code X I G 5 7 3 6

[1]Latitude and Longitude are in degrees, decimal minutes.

Date Collected YR	MO	DY	Time Coll.	Gear	Tide	Water Depth Meters	Feet
9 8	0 9	2 8	1 3 5 0	0 4	E	4 . 1	1 3 . 4

Temp.[2] °C	pH[2]	DO[2] mg/l	Salinity[2] ppt, ‰	Conductivity[2] umhos/cm	Turbidity[2] NTU
2 2 . 9	7 . 3	7 . 1	8 . 8	1 5 6 0 0	3 . 5

[2]Water quality measurements are from the bottom layer.

Samp. Size 0 . 1 0 Samp. Type B E N Field Fixative 0 2

Grab#	Log Number	ID By	YR	MO	DY	QC By	YR	MO	DY
1	9 8 0 0 1 4 4	J E L	9 9	0 1	2 1				
2	9 8 0 0 1 4 5	J E L	9 9	0 1	2 1	N M K	9 9	0 2	2 2 2
3	9 8 0 0 1 4 6	J E L	9 9	0 1	2 2				

PPSP CODE	DNR CODE	VALUE FOR GRAB			TAXON
		1	2	3	
1 2 4 0		7	3	5	*Carinoma tremaphorus*
	4 9 0 4 0 1 9				*Hydrobia sp.*
0 6 8 6	4 9 0 5 0 1 1		1		*Mytilopsis leucophaeata*
0 5 2 0	4 9 0 5 0 0 9				*Macoma balthica*
0 5 2 6	4 9 0 5 0 0 8	9	6	6	*Rangia cuneata*
0 6 6 9		1	2	6	*Hobsonia florida*
0 4 1 6	4 8 0 1 0 0 3				*Heteromastus filiformis*
0 4 1 1	4 8 0 1 0 1 7	1			*Hypereteone heteropoda*
0 4 3 0	4 8 0 1 0 0 5	80	135	56	*Marenzelleria viridis*
0 4 2 0	4 8 0 1 0 0 4	6	6	4	*Neanthes succinea*
0 4 2 6	4 8 0 1 0 5 7				*Polydora cornuta*
0 4 3 3	4 8 0 1 0 1 8	1	1	3	*Streblospio benedicti*
1 0 3 9	4 8 0 2 0 2 3				*Tubificoides sp.*
	5 3 0 7 0 1 1		1		*Balanus improvisus*
0 1 0 3	5 3 1 9 0 1 4		1		*Rhithropanopeus harrisii*
0 1 0 8					*Neomysis americana*
0 4 9 7	5 3 1 6 0 1 2	37	31	36	*Cyathura polita*
0 6 2 5	5 3 1 6 0 2 1		1		*Chiridotea almyra*
0 4 9 8	5 3 1 6 0 2 4	12	10	5	*Edotea triloba*
0 4 6 8	5 3 1 7 0 2 5	2	2	4	*Ameroculodes spp.complex*
0 6 3 5	5 3 1 7 0 1 3				*Apocorophium lacustre*
0 4 6 4	5 3 1 7 0 0 1	1			*Gammarus sp.*
0 4 6 6	5 3 1 7 0 1 6	1	5	5	*Leptocheirus plumulosus*
0 4 6 7	5 3 1 7 0 2 2				*Melita nitida*
0 3 0 1	5 4 2 4 0 4 6				*Coelotanypus sp.*
0 5 6 4	5 4 2 4 0 4 7				*Procladius sp.*
0 6 3 8	5 4 2 4 0 4 9				*Cryptochironomus sp.*
0 2 9 5	5 4 2 4 0 5 1				*Polypedilum sp.*

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION

Taxa Inventory Sheet

Survey Site 92 Collector Evans, Lathrop, Lookingland Station MDE-R2

Lat.[1] 3 9 1 7 6 7 0 6 Long.[1] 7 6 1 4 3 0 7 0 MD Code X I G 9 4 6 2

[1]Latitude and Longitude are in degrees, decimal minutes.

Date Collected	YR	MO	DY	Time Coll.	Gear	Tide	Water Depth	Meters	Feet
	9 8	0 9	2 8	1 4 3 0	0 4	E		4 . 0	1 3 . 1

Temp.[2] °C	pH[2]	DO[2] mg/l	Salinity[2] ppt. ‰	Conductivity[2] µmhos/cm	Turbidity[2] NTU
2 3 . 0	7 . 2	7 . 1	8 . 0	1 4 2 3 0	4 . 7

[2]Water quality measurements are from the bottom layer.

Samp. Size 0 . 1 0 Samp. Type B E N Field Fixative 0 2

Grab#	Log Number	ID By	YR	MO	DY	QC By	YR	MO	DY
1	9 8 0 0 1 4 7	J E L	9 9	0 1	2 6				
2	9 8 0 0 1 4 8	J E L	9 9	0 1	2 7				
3	9 8 0 0 1 4 9	J E L	9 9	0 1	2 7				

PPSP CODE	DNR CODE	VALUE FOR GRAB			TAXON
		1	2	3	
1 2 4 0		4	1	4	*Carinoma tremaphorus*
	4 9 0 4 0 1 9				*Hydrobia* sp.
0 6 8 6	4 9 0 5 0 1 1			1	*Mytilopsis leucophaeata*
0 5 2 0	4 9 0 5 0 0 9				*Macoma balthica*
0 5 2 6	4 9 0 5 0 0 8	8	4	6	*Rangia cuneata*
0 6 6 9					*Hobsonia florida*
0 4 1 6	4 8 0 1 0 0 3				*Heteromastus filiformis*
0 4 1 1	4 8 0 1 0 1 7		1		*Hypereteone heteropoda*
0 4 3 0	4 8 0 1 0 0 5	2	2	2	*Marenzelleria viridis*
0 4 2 0	4 8 0 1 0 0 4	8	7	34	*Neanthes succinea*
0 4 2 6	4 8 0 1 0 5 7				*Polydora cornuta*
0 4 3 3	4 8 0 1 0 1 8	5	2	2	*Streblospio benedicti*
1 0 3 9	4 8 0 2 0 2 3	16	5	3	*Tubificoides* sp.
	5 3 0 7 0 1 1	15	14	12	*Balanus improvisus*
0 1 0 3	5 3 1 9 0 1 4				*Rhithropanopeus harrisii*
0 1 0 8					*Neomysis americana*
0 4 9 7	5 3 1 6 0 1 2	6	4	4	*Cyathura polita*
0 6 2 5	5 3 1 6 0 2 1				*Chiridotea almyra*
0 4 9 8	5 3 1 6 0 2 4				*Edotea triloba*
0 4 6 8	5 3 1 7 0 2 5	5	1		*Ameroculodes* spp.complex
0 6 3 5	5 3 1 7 0 1 3				*Apocorophium lacustre*
0 4 6 4	5 3 1 7 0 0 1				*Gammarus* sp.
0 4 6 6	5 3 1 7 0 1 6				*Leptocheirus plumulosus*
0 4 6 7	5 3 1 7 0 2 2				*Melita nitida*
0 3 0 1	5 4 2 4 0 4 6				*Coelotanypus* sp.
0 6 3 8	5 4 2 4 0 4 9				*Cryptochironomus* sp.
0 2 9 5	5 4 2 4 0 5 1				*Polypedilum* sp.

APPENDIX V

External Quality Assurance/Quality Control (QA/QC) of Identified Benthic Macroinvertebrate Samples
September 1998

External Quality Assurance/Quality Control of Taxonomic Identifications, Site 92 September 1998 Samples

Vial No.	Taxon	Count	Comments
Station S92-5 #2 of 3 9/28/1998			
1	*Carinoma tremaphoros*	1	Identification confirmed by Nancy K. Mountford 22FEB99.
2	*Rangia cuneata*	2	Identification confirmed by Nancy K. Mountford 22FEB99.
3	*Macoma mitchelli*	1	This is *Macoma balthica;* corrected by Nancy Mountford 22 Feb 99
4	*Macoma mitchelli*	1	Identification confirmed by Nancy K. Mountford 22FEB99.
5	*Marenzelleria viridis*	5	Identification confirmed by Nancy K. Mountford 22FEB99.
6	*Neanthes succinea*	5	Identification confirmed by Nancy K. Mountford 22FEB99.
7	*Hypereteone heteropoda*	3	Identification confirmed by Nancy K. Mountford 22FEB99.
8	*Streblospio benedicti*	3	Identification confirmed by Nancy K. Mountford 22FEB99.
9	*Tubificoides* sp.	2	Identification confirmed by Nancy K. Mountford 22FEB99.
10	*Cyathura polita*	5	Identification confirmed by Nancy K. Mountford 22FEB99.
11	*Edotea triloba*	1	Identification confirmed by Nancy K. Mountford 22FEB99.
12	*Ameroculodes* spp. complex	6	Identification confirmed by Nancy K. Mountford 22FEB99.
13	*Leptocheirus plumulosus*	5	Identification confirmed by Nancy K. Mountford 22FEB99.
14	*Gammarus mucronatus*	1	Identification confirmed by Nancy K. Mountford 22FEB99.
15	*Neomysis americana*	1	Identification confirmed by Nancy K. Mountford 22FEB99.
16	*Membranipora tenuis*	colony	Identification confirmed by Nancy K. Mountford 22FEB99.
Site 92-R1 #3 of 3 9/28/1998			
17	*Carinoma tremaphoros*	1	Identification confirmed by Nancy K. Mountford 22FEB99.
18	*Rangia cuneata*	2	Identification confirmed by Nancy K. Mountford 22FEB99.
19	*Marenzelleria viridis*	8	Identification confirmed by Nancy K. Mountford 22FEB99.
20	*Neanthes succinea*	5	Identification confirmed by Nancy K. Mountford 22FEB99.
21	*Streblospio benedicti*	1	Identification confirmed by Nancy K. Mountford 22FEB99.
22	*Heteromastus filiformis*	2	Identification confirmed by Nancy K. Mountford 22FEB99.
23	*Cyathura polita*	5	Identification confirmed by Nancy K. Mountford 22FEB99.
24	*Edotea triloba*	1	Identification confirmed by Nancy K. Mountford 22FEB99.
25	*Ameroculodes* spp. complex	2	Identification confirmed by Nancy K. Mountford 22FEB99.
26	*Leptocheirus plumulosus*	1	Identification confirmed by Nancy K. Mountford 22FEB99.
27	*Apocorophium lacustre*	3	Identification confirmed by Nancy K. Mountford 22FEB99.

MDE-R1 #2 of 3 9/28/1998			
28	*Mytilopsis leucophaeata*	1	Identification confirmed by Nancy K. Mountford 22FEB99.
29	*Carinoma tremaphoros*	3	Identification confirmed by Nancy K. Mountford 22FEB99.
30	*Rangia cuneata*	6	Identification confirmed by Nancy K. Mountford 22FEB99.
31	*Marenzelleria viridis*	5	Identification confirmed by Nancy K. Mountford 22FEB99.
32	*Neanthes succinea*	6	Identification confirmed by Nancy K. Mountford 22FEB99.
33	*Hobsonia florida*	2	Identification confirmed by Nancy K. Mountford 22FEB99.
34	*Streblospio benedicti*	1	Identification confirmed by Nancy K. Mountford 22FEB99.
35	*Cyathura polita*	5	Identification confirmed by Nancy K. Mountford 22FEB99.
36	*Chiridotea almyra*	1	Identification confirmed by Nancy K. Mountford 22FEB99.
37	*Edotea triloba*	5	Identification confirmed by Nancy K. Mountford 22FEB99.
38	*Ameroculodes* spp. complex	2	Identification confirmed by Nancy K. Mountford 22FEB99.
39	*Leptocheirus plumulosus*	5	Identification confirmed by Nancy K. Mountford 22FEB99.
40	*Rhithropanopeus harrisii*	1	Identification confirmed by C. Timothy Morris 23FEB99.
41	*Balanus improvisus*	1	Identification confirmed by C. Timothy Morris 23FEB99.
S92-7 # 3 of 3 9/28/1998			
42	*Macoma balthica*	4	Identification confirmed by Nancy K. Mountford 22FEB99.
S92-R2 #2 of 3 9/28/1998			
43	*Melita nitida*	3	Identification confirmed by Nancy K. Mountford 22FEB99.
44	*Balanus improvisus*	5	Identification confirmed by Nancy K. Mountford 22FEB99.
S92-R2 #3 of 3 9/28/1998			
45	*Mytilopsis leucophaeata*	1	Identification confirmed by Nancy K. Mountford 22FEB99.
S92-3A #1 of 3 9/28/1998			
46	*Neomysis americana*	1	Identification not confirmed. Incomplete specimen with posterior end missing. C. Timothy Morris 23FEB99.

NOTE: Confirmations of taxonomic identifications were performed by Nancy K. Mountford and C. Timothy Morris of Cove Corporation, Lusby, Maryland

APPENDIX VI

Sediment Grain Size and Water Content Analysis Sheets September 1998

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION
Sediment Grain Size and Water Content Analysis Sheet

Survey Site 92 Collector Evans, Lathrop-Davis, Kamens Station S92-1

Lat.[1] 3 9 1 5 5 2 3 2 Long.[1] 7 6 1 6 5 1 9 2 MD Code X I G 5 8 2 5

[1]Latitude and Longitude are in degrees, decimal minutes.

Date Collected			Time Coll.	Gear	Tide	Water Depth	
YR	MO	DY				Meters	Feet
9 8	0 9	2 8	1 3 0 5	0 4	F	7 . 2	2 3 . 6

Temp.[2]	pH[2]	DO[2]	Salinity[2]	Conductivity[2]	Turbidity[2]
°C		mg/l	ppt, ‰	µmhos/cm	NTU
2 3 . 0	7 . 3	8 . 1	9 . 0	1 5 7 0 0	7 . 4

[2]Water quality measurements are from the bottom layer.

Date Completed			Analyzed By	QA/QC By	QA/QC Date		
YR	MO	DY			YR	MO	DY
9 9	0 1	2 7	C E B				

I. Water Content Analysis

Weight of Pan (a)	Weight of Pan + Wet Sediment (b)	Weight of Wet Sediment (c = b-a)	Weight of Dry Sediment (d)	Water Weight (e = c-d)	Percent Water (f = [e/c]*100)
15.655	69.209	53.554	23.462	30.092	56.19

II. Grain Size Analysis

	Weight of Pan (g)	Weight of Pan + Fraction (h)	Weight of Fraction (i = h-g)	Percent of Total (j = [i/d]*100)
Dry Weight, Sieve # 10 (2.00 mm; gravel)	2.704	2.707	0.003	0.01
Dry Weight, Sieve # 230 (63 µm; sand)	1.699	2.712	1.013	4.32
Dry Weight, Pan (silt/clay)	2.704	25.150	22.446	95.67
Total Dry Weight (d)			23.462	

Note 1: Latitude and Longitude are in degrees, decimal minutes.
Note 2: The water quality parameters DO, Salinity, Temperature, Conductivity, and pH are bottom measurements.
Note 3: All weights are in grams.

III. Comments

"Gravel" consisted of no shell fragments, only organic detritus.

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION

Sediment Grain Size and Water Content Analysis Sheet

Survey Site 92 Collector Evans, Lathrop-Davis, Kamens Station S92-2

Lat.[1] 3 9 1 5 4 1 8 2 Long.[1] 7 6 1 7 0 7 6 6 MD Code X I G 5 7 1 6

[1]Latitude and Longitude are in degrees, decimal minutes.

Date Collected

YR	MO	DY
9 8	0 9	2 8

Time Coll. 1 2 3 0 Gear 0 4 Tide F

Water Depth

Meters	Feet
4 . 5	1 4 . 8

Temp.[2]	pH[2]	DO[2]	Salinity[2]	Conductivity[2]	Turbidity[2]
°C		mg/l	ppt, ‰	µmhos/cm	NTU
2 2 . 9	7 . 2	7 . 6	8 . 8	1 5 6 0 0	7 . 4

[2]Water quality measurements are from the bottom layer.

Date Completed

YR	MO	DY
9 9	0 1	1 8

Analyzed By C E B

QA/QC By C E B

QA/QC Date

YR	MO	DY
9 9	0 2	0 3

I. Water Content Analysis

Weight of Pan (a)	Weight of Pan + Wet Sediment (b)	Weight of Wet Sediment (c = b-a)	Weight of Dry Sediment (d)	Water Weight (e = c-d)	Percent Water (f = [e/c]*100)
15.690	66.316	50.626	35.861	14.765	29.16

II. Grain Size Analysis

	Weight of Pan (g)	Weight of Pan + Fraction (h)	Weight of Fraction (i = h-g)	Percent of Total (j = [i/d]*100)
Dry Weight, Sieve # 10 (2.00 mm; gravel)	2.703	4.215	1.512	4.22
Dry Weight, Sieve # 230 (63 µm; sand)	2.673	4.853	2.180	6.08
Dry Weight, Pan (silt/clay)	2.697	34.866	32.169	89.70
Total Dry Weight (d)			35.861	

Note 1: Latitude and Longitude are in degrees, decimal minutes.

Note 2: The water quality parameters DO, Salinity, Temperature, Conductivity, and pH are bottom measurements.

Note 3: All weights are in grams.

III. Comments

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION
Sediment Grain Size and Water Content Analysis Sheet

Survey Site 92 Collector Evans, Lathrop-Davis, Kamens Station S92-3A

Lat.[1]	3	9	1	5	0	7	6	2
Long.[1]	7	6	1	7	4	9	1	8
MD Code	X	I	G	4	9	0	6	

[1]Latitude and Longitude are in degrees, decimal minutes.

	YR		MO		DY	
Date Collected	9	8	0	9	2	8

Time Coll.	1	1	4	0
Gear	0	4		
Tide	F			

	Meters				Feet			
Water Depth		5	.	3	1	7	.	4

Temp.[2] °C	pH[2]	DO[2] mg/l	Salinity[2] ppt, ‰	Conductivity[2] µmhos/cm	Turbidity[2] NTU
2 3 . 0	7 . 1	8 . 2	9 . 0	1 5 8 0 0	4 . 7

[2]Water quality measurements are from the bottom layer.

	YR		MO		DY	
Date Completed	9	8	1	2	3	0
QA/QC Date	9	8	1	2	3	0

Analyzed By	C	E	B
QA/QC By	M	C	R

I. Water Content Analysis

Weight of Pan (a)	Weight of Pan + Wet Sediment (b)	Weight of Wet Sediment (c = b-a)	Weight of Dry Sediment (d)	Water Weight (e = c-d)	Percent Water (f = [e/c]*100)
2.697	53.051	50.354	20.774	29.580	58.74

II. Grain Size Analysis

	Weight of Pan (g)	Weight of Pan + Fraction (h)	Weight of Fraction (i = h-g)	Percent of Total (j = [i/d]*100)
Dry Weight, Sieve # 10 (2.00 mm; gravel)	2.697	3.077	0.380	1.83
Dry Weight, Sieve # 230 (63 µm; sand)	2.675	4.295	1.620	7.80
Dry Weight, Pan (silt/clay)	2.696	21.470	18.774	90.37
Total Dry Weight (d)			20.774	

Note 1: Latitude and Longitude are in degrees, decimal minutes.
Note 2: The water quality parameters DO, Salinity, Temperature, Conductivity, and pH are bottom measurements.
Note 3: All weights are in grams.

III. Comments

"Gravel" consisted of small shell fragments.

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION
Sediment Grain Size and Water Content Analysis Sheet

Survey Site 92 Collector Evans, Lathrop-Davis, Kamens Station S92-4A

Lat.[1]	Long.[1]	MD Code
3 9 1 4 8 3 1 4	7 6 1 7 2 5 7 8	X I G 4 4 1 0

[1]Latitude and Longitude are in degrees, decimal minutes.

Date Collected YR	MO	DY	Time Coll.	Gear	Tide	Water Depth Meters	Feet
9 8	0 9	2 8	0 8 5 0	0 4	F	5 . 5	1 8 . 0

Temp.[2] °C	pH[2]	DO[2] mg/l	Salinity[2] ppt, ‰	Conductivity[2] µmhos/cm	Turbidity[2] NTU
2 2 . 8	7 . 0	7 . 8	8 . 9	1 5 6 0 0	7 . 2

[2]Water quality measurements are from the bottom layer.

Date Completed YR	MO	DY	Analyzed By	QA/QC By	QA/QC Date YR	MO	DY
9 9	0 1	0 7	J E L				

I. Water Content Analysis

Weight of Pan (a)	Weight of Pan + Wet Sediment (b)	Weight of Wet Sediment (c = b-a)	Weight of Dry Sediment (d)	Water Weight (e = c-d)	Percent Water (f = [e/c]*100)
4.395	53.591	49.196	22.623	26.573	54.01

II. Grain Size Analysis

	Weight of Pan (g)	Weight of Pan + Fraction (h)	Weight of Fraction (i = h-g)	Percent of Total (j = [i/d]*100)
Dry Weight, Sieve # 10 (2.00 mm; gravel)	1.699	6.401	4.702	20.78
Dry Weight, Sieve # 230 (63 µm; sand)	2.697	4.642	1.945	8.60
Dry Weight, Pan (silt/clay)	2.706	18.682	15.976	70.62
Total Dry Weight (d)			22.623	

Note 1: Latitude and Longitude are in degrees, decimal minutes.
Note 2: The water quality parameters DO, Salinity, Temperature, Conductivity, and pH are bottom measurements.
Note 3: All weights are in grams.

III. Comments

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION

Sediment Grain Size and Water Content Analysis Sheet

Survey Site 92 Collector Evans, Lathrop-Davis, Kamens Station S92-5

Lat.[1] 3 9 1 4 8 4 8 8 Long.[1] 7 6 1 6 7 3 5 2 MD Code X I G 4 7 2 2

[1]Latitude and Longitude are in degrees, decimal minutes.

Date Collected			Time Coll.	Gear	Tide	Water Depth	
YR	MO	DY				Meters	Feet
9 8	0 9	2 8	0 9 1 5	0 4	F	5 . 0	1 6 . 4

Temp.[2]	pH[2]	DO[2]	Salinity[2]	Conductivity[2]	Turbidity[2]
°C		mg/l	ppt. ‰	µmhos/cm	NTU
2 2 . 8	6 . 9	7 . 1	9 . 0	1 6 1 0 0	1 5 . 1

[2]Water quality measurements are from the bottom layer.

Date Completed			Analyzed By	QA/QC By	QA/QC Date		
YR	MO	DY			YR	MO	DY
9 9	0 1	0 7	J E L				

I. Water Content Analysis

Weight of Pan (a)	Weight of Pan + Wet Sediment (b)	Weight of Wet Sediment (c = b-a)	Weight of Dry Sediment (d)	Water Weight (e = c-d)	Percent Water (f = [e/c]*100)
4.387	56.526	52.139	30.260	21.879	41.96

II. Grain Size Analysis

	Weight of Pan (g)	Weight of Pan + Fraction (h)	Weight of Fraction (i = h-g)	Percent of Total (j = [i/d]*100)
Dry Weight, Sieve # 10 (2.00 mm; gravel)	1.687	18.267	16.580	54.79
Dry Weight, Sieve # 230 (63 µm; sand)	1.681	3.322	1.641	5.42
Dry Weight, Pan (silt/clay)	2.709	14.748	12.039	39.79
Total Dry Weight (d)			30.260	

Note 1: Latitude and Longitude are in degrees, decimal minutes.

Note 2: The water quality parameters DO, Salinity, Temperature, Conductivity, and pH are bottom measurements.

Note 3: All weights are in grams.

III. Comments

Couple of medium *Rangia*; 1 had been alive.

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION

Sediment Grain Size and Water Content Analysis Sheet

Survey Site 92 Collector Evans, Lathrop-Davis, Kamens Station S92-6

Lat.[1] 3 9 1 4 9 8 0 2 Long.[1] 7 6 1 6 1 7 7 2 MD Code X I G 4 9 3 1

[1]Latitude and Longitude are in degrees, decimal minutes.

Date Collected			Time Coll.	Gear	Tide	Water Depth	
YR	MO	DY				Meters	Feet
98	09	28	0945	04	F	5.0	16.4

Temp.[2]	pH[2]	DO[2]	Salinity[2]	Conductivity[2]	Turbidity[2]
°C		mg/l	ppt, ‰	µmhos/cm	NTU
22.8	7.0	7.1	9.0	16100	4.7

[2]W2ater quality measurements are from the bottom layer.

Date Completed			Analyzed By	QA/QC By	QA/QC Date		
YR	MO	DY			YR	MO	DY
99	01	27	CEB				

I. Water Content Analysis

Weight of Pan (a)	Weight of Pan + Wet Sediment (b)	Weight of Wet Sediment (c = b-a)	Weight of Dry Sediment (d)	Water Weight (e = c-d)	Percent Water (f = [e/c]*100)
14.667	69.894	55.227	22.853	32.374	58.62

II. Grain Size Analysis

	Weight of Pan (g)	Weight of Pan + Fraction (h)	Weight of Fraction (i = h-g)	Percent of Total (j = [i/d]*100)
Dry Weight, Sieve # 10 (2.00 mm; gravel)	1.698	2.819	1.121	4.91
Dry Weight, Sieve # 230 (63 µm; sand)	2.697	5.996	3.299	14.44
Dry Weight, Pan (silt/clay)	2.687	21.120	18.433	80.66
Total Dry Weight (d)			22.853	

Note 1: Latitude and Longitude are in degrees, decimal minutes.

Note 2: The water quality parameters DO, Salinity, Temperature, Conductivity, and pH are bottom measurements.

Note 3: All weights are in grams.

III. Comments

Very fine mud in silt/clay portion = long settling time.
"Gravel" consisted of small shell fragments.

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION
Sediment Grain Size and Water Content Analysis Sheet

Survey Site 92 Collector Evans, Lathrop-Davis, Kamens Station S92-7

Lat.[1] 3 9 1 5 1 4 6 4 Long.[1] 7 6 1 6 8 7 0 2 MD Code X I G 5 2 2 0

[1]Latitude and Longitude are in degrees, decimal minutes.

Date Collected			Time Coll.	Gear	Tide
YR	MO	DY			
9 8	0 9	2 8	1 0 5 5	0 4	F

Water Depth	
Meters	Feet
-6 . 2	2 0 . 3

Temp.[2]	pH[2]	DO[2]	Salinity[2]	Conductivity[2]	Turbidity[2]
°C		mg/l	ppt, ‰	µmhos/cm	NTU
2 2 . 9	6 . 8	7 . 6	9 . 0	1 5 8 0 0	1 2 . 4

[2]Water quality measurements are from the bottom layer.

Date Completed			Analyzed By	QA/QC By	QA/QC Date		
YR	MO	DY			YR	MO	DY
9 9	0 2	0 1	J E L				

I. Water Content Analysis

Weight of Pan (a)	Weight of Pan + Wet Sediment (b)	Weight of Wet Sediment (c = b-a)	Weight of Dry Sediment (d)	Water Weight (e = c-d)	Percent Water (f = [e/c]*100)
4.383	57.929	53.546	22.698	30.848	57.61

II. Grain Size Analysis

	Weight of Pan (g)	Weight of Pan + Fraction (h)	Weight of Fraction (i = h-g)	Percent of Total (j = [i/d]*100)
Dry Weight, Sieve # 10 (2.00 mm; gravel)	1.687	3.416	1.729	7.62
Dry Weight, Sieve # 230 (63 µm; sand)	2.697	3.815	1.118	4.93
Dry Weight, Pan (silt/clay)	2.708	22.559	19.851	87.46
Total Dry Weight (d)			22.698	

Note 1: Latitude and Longitude are in degrees, decimal minutes.

Note 2: The water quality parameters DO, Salinity, Temperature, Conductivity, and pH are bottom measurements.

Note 3: All weights are in grams.

III. Comments

"Gravel" consisted of small shell fragments.
2 small *Rangia*.

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION

Sediment Grain Size and Water Content Analysis Sheet

Survey Site 92 Collector Evans, Lathrop-Davis, Kamens Station S92-R1

Lat.[1] 3 9 1 4 3 3 5 2 Long.[1] 7 6 1 6 7 7 5 4 MD Code X I G 3 9 2 1

[1]Latitude and Longitude are in degrees. decimal minutes.

Date Collected	YR	MO	DY
	9 8	0 9	2 8

Time Coll. 0 8 1 7

Gear 0 4

Tide LS

Water Depth	Meters	Feet
	4 . 4	1 4 . 5

Temp.[2] °C	pH[2]	DO[2] mg/l	Salinity[2] ppt, ‰	Conductivity[2] µmhos/cm	Turbidity[2] NTU
2 2 . 8	7 . 2	7 . 7	9 . 5	1 6 2 3 0	1 0 . 9

Water quality measurements are from the bottom layer.

Date Completed	YR	MO	DY
	9 9	0 1	1 5

Analyzed By J E L

QA/QC By

QA/QC Date	YR	MO	DY

I. Water Content Analysis

Weight of Pan (a)	Weight of Pan + Wet Sediment (b)	Weight of Wet Sediment (c = b-a)	Weight of Dry Sediment (d)	Water Weight (e = c-d)	Percent Water (f = [e/c]*100)
4.389	53.743	49.354	21.660	27.694	56.11

II. Grain Size Analysis

	Weight of Pan (g)	Weight of Pan + Fraction (h)	Weight of Fraction (i = h-g)	Percent of Total (j = [i/d]*100)
Dry Weight, Sieve # 10 (2.00 mm; gravel)	1.686	3.821	2.135	9.86
Dry Weight, Sieve # 230 (63 µm; sand)	2.696	6.741	4.045	18.67
Dry Weight, Pan (silt/clay)	2.969	18.449	15.480	71.47
Total Dry Weight (d)			21.660	

Note 1: Latitude and Longitude are in degrees, decimal minutes.

Note 2: The water quality parameters DO, Salinity, Temperature, Conductivity, and pH are bottom measurements.

Note 3: All weights are in grams.

III. Comments

"Gravel" consisted of ≈ 6 valves (*Rangia*) and a large amount of tiny shell fragments. Many very small shell fragments in sand portion.

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION

Sediment Grain Size and Water Content Analysis Sheet

Survey Site 92 Collector Evans, Lathrop-Davis, Kamens Station S92-R2

Lat.[1] 3 9 1 4 9 7 7 2 Long.[1] 7 6 1 5 6 9 0 6 MD Code X I G 4 9 3 9

[1]Latitude and Longitude are in degrees, decimal minutes.

Date Collected	YR	MO	DY
	9 8	0 9	2 8

Time Coll. 1 0 2 0

Gear 0 4

Tide F

Water Depth	Meters	Feet
	5 . 5	1 8 . 0

Temp.[2]	pH[2]	DO[2]	Salinity[2]	Conductivity[2]	Turbidity[2]
°C		mg/l	ppt, ‰	umhos/cm	NTU
2 2 . 8	6 . 9	6 . 9	9 . 0	1 5 7 0 0	4 . 4

[2]Water quality measurements are from the bottom layer.

Date Completed	YR	MO	DY
	9 9	0 2	0 1

Analyzed By J E L

QA/QC By

QA/QC Date	YR	MO	DY

I. Water Content Analysis

Weight of Pan (a)	Weight of Pan + Wet Sediment (b)	Weight of Wet Sediment (c = b-a)	Weight of Dry Sediment (d)	Water Weight (e = c-d)	Percent Water (f = [e/c]*100)
4.408	54.568	50.160	22.944	27.216	54.26

II. Grain Size Analysis

	Weight of Pan (g)	Weight of Pan + Fraction (h)	Weight of Fraction (i = h-g)	Percent of Total (j = [i/d]*100)
Dry Weight, Sieve # 10 (2.00 mm; gravel)	2.706	2.848	0.142	0.62
Dry Weight, Sieve # 230 (63 μm; sand)	1.703	4.043	2.340	10.20
Dry Weight, Pan (silt/clay)	2.699	23.161	20.462	89.18
Total Dry Weight (d)			22.944	

Note 1: Latitude and Longitude are in degrees, decimal minutes.
Note 2: The water quality parameters DO, Salinity, Temperature, Conductivity, and pH are bottom measurements.
Note 3: All weights are in grams.

III. Comments

"Gravel" consisted of shell fragments.

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION
Sediment Grain Size and Water Content Analysis Sheet

Survey Site 92 Collector Evans, Lathrop-Davis, Kamens Station MDE-R1

Lat.[1] 39154542 Long.[1] 76159054 MD Code XIG5736

[1]Latitude and Longitude are in degrees, decimal minutes.

Date Collected			Time Coll.	Gear	Tide	Water Depth	
YR	MO	DY				Meters	Feet
98	09	28	1350	04	E	4.1	13.4

Temp.[2]	pH[2]	DO[2]	Salinity[2]	Conductivity[2]	Turbidity[2]
°C		mg/l	ppt. ‰	µmhos/cm	NTU
22.9	7.3	7.1	8.8	15600	3.5

[2]Water quality measurements are from the bottom layer.

Date Completed			Analyzed By	QA/QC By	QA/QC Date		
YR	MO	DY			YR	MO	DY
99	01	07	JEL	MCR	99	01	07

I. Water Content Analysis

Weight of Pan (a)	Weight of Pan + Wet Sediment (b)	Weight of Wet Sediment (c = b-a)	Weight of Dry Sediment (d)	Water Weight (e = c-d)	Percent Water (f = [e/c]*100)
10.544	60.704	50.160	24.847	25.313	50.46

II. Grain Size Analysis

	Weight of Pan (g)	Weight of Pan + Fraction (h)	Weight of Fraction (i = h-g)	Percent of Total (j = [i/d]*100)
Dry Weight, Sieve # 10 (2.00 mm; gravel)	2.688	2.720	0.032	0.13
Dry Weight, Sieve # 230 (63 µm; sand)	2.709	4.601	1.892	7.61
Dry Weight, Pan (silt/clay)	2.699	25.622	22.923	92.26
Total Dry Weight (d)			24.847	

Note 1: Latitude and Longitude are in degrees, decimal minutes.

Note 2: The water quality parameters DO, Salinity, Temperature, Conductivity, and pH are bottom measurements.

Note 3: All weights are in grams.

III. Comments

"Gravel" portion consisted of 2 small *Rangia* valves and small amount of organic detritus.

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION
Sediment Grain Size and Water Content Analysis Sheet

Survey Site 92

Collector Evans, Lathrop-Davis, Kamens

Station MDE-R2

Lat.[1] 3 9 1 7 6 7 0 6

Long.[1] 7 6 1 4 3 0 7 0

MD Code X I G 9 4 6 2

[1]Latitude and Longitude are in degrees, decimal minutes.

	YR	MO	DY
Date Collected	9 8	0 9	2 8

Time Coll. 1 4 3 0

Gear 0 4

Tide E

	Meters	Feet
Water Depth	4 . 0	1 3 . 1

Temp.[2]	pH[2]	DO[2]	Salinity[2]	Conductivity[2]	Turbidity[2]
°C		mg/l	ppt, ‰	umhos/cm	NTU
2 3 . 0	7 . 2	7 . 1	8 . 0	1 4 2 3 0	4 . 7

[2]Water quality measurements are from the bottom layer.

	YR	MO	DY
Date Completed	9 9	0 1	1 5

Analyzed By J E L

QA/QC By

	YR	MO	DY
QA/QC Date			

I. Water Content Analysis

Weight of Pan (a)	Weight of Pan + Wet Sediment (b)	Weight of Wet Sediment (c = b-a)	Weight of Dry Sediment (d)	Water Weight (e = c-d)	Percent Water (f = [e/c]*100)
4.403	59.001	54.598	32.929	21.669	39.69

II. Grain Size Analysis

	Weight of Pan (g)	Weight of Pan + Fraction (h)	Weight of Fraction (i = h-g)	Percent of Total (j = [i/d]*100)
Dry Weight, Sieve # 10 (2.00 mm; gravel)	1.700	16.738	15.038	45.67
Dry Weight, Sieve # 230 (63 µm; sand)	2.703	6.048	3.345	10.16
Dry Weight, Pan (silt/clay)	2.703	17.249	14.546	44.17
Total Dry Weight (d)			32.929	

Note 1: Latitude and Longitude are in degrees, decimal minutes.

Note 2: The water quality parameters DO, Salinity, Temperature, Conductivity, and pH are bottom measurements.

Note 3: All weights are in grams.

III. Comments

"Gravel" consisted of shell fragments.

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION

Sediment Grain Size and Water Content Analysis Quality Control
Sample: **S92-2**

QC Check #1

I. Water Content Analysis

Weight of Pan (a)	Weight of Pan + Wet Sediment (b)	Weight of Wet Sediment (c = b-a)	Weight of Dry Sediment (d)	Water Weight (e = c-d)	Percent Water (f = [e/c]*100)
15.669	70.486	54.817	23.663	31.154	56.83

II. Grain Size Analysis

	Weight of Pan (g)	Weight of Pan + Fraction (h)	Weight of Fraction (i = h-g)	Percent of Total (j = [i/d]*100)
Dry Weight, Sieve # 10 (2.00 mm; gravel)	2.705	2.843	0.138	0.58
Dry Weight, Sieve # 230 (63 µm; sand)	2.699	5.197	2.498	10.56
Dry Weight, Pan (silt/clay)	2.704	23.731	21.027	88.86
Total Dry Weight (d)			23.663	

	Percent Water	Percent Gravel	Percent Sand	Percent Silt/Clay
Standard Deviation: Original Sample & QC #1	19.564	2.57	3.17	0.60

QC Check #2

I. Water Content Analysis

Weight of Pan (a)	Weight of Pan + Wet Sediment (b)	Weight of Wet Sediment (c = b-a)	Weight of Dry Sediment (d)	Water Weight (e = c-d)	Percent Water (f = [e/c]*100)
15.662	70.193	54.531	23.873	30.658	56.22

II. Grain Size Analysis

	Weight of Pan (g)	Weight of Pan + Fraction (h)	Weight of Fraction (i = h-g)	Percent of Total (j = [i/d]*100)
Dry Weight, Sieve # 10 (2.00 mm; gravel)	2.681	2.746	0.065	0.27
Dry Weight, Sieve # 230 (63 µm; sand)	1.697	4.437	2.740	11.48
Dry Weight, Pan (silt/clay)	1.700	22.768	21.068	88.25
Total Dry Weight (d)			23.873	

	Percent Water	Percent Gravel	Percent Sand	Percent Silt/Clay
Average: Original Sample, QC#1 & QC#2	47.406	1.691	9.371	88.938
Standard Deviation: Original Sample, QC#1 & QC#2	15.80	2.19	2.89	0.73

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION

Sediment Grain Size and Water Content Analysis Quality Control
Sample: **S92-3A**

QC Check #1

I. Water Content Analysis

Weight of Pan (a)	Weight of Pan + Wet Sediment (b)	Weight of Wet Sediment (c = b-a)	Weight of Dry Sediment (d)	Water Weight (e = c-d)	Percent Water (f = [e/c]*100)
15.658	65.710	50.052	20.787	29.265	58.47

II. Grain Size Analysis

	Weight of Pan (g)	Weight of Pan + Fraction (h)	Weight of Fraction (i = h-g)	Percent of Total (j = [i/d]*100)
Dry Weight, Sieve # 10 (2.00 mm; gravel)	2.709	3.093	0.384	1.84
Dry Weight, Sieve # 230 (63 µm; sand)	2.699	4.617	1.918	9.23
Dry Weight, Pan (silt/clay)	2.706	21.191	18.485	88.93
Total Dry Weight (d)			20.787	

	Percent Water	Percent Gravel	Percent Sand	Percent Silt/Clay
Standard Deviation: Original Sample & QC #1	0.191	0.007	1.004	1.025

QC Check #2

I. Water Content Analysis

Weight of Pan (a)	Weight of Pan + Wet Sediment (b)	Weight of Wet Sediment (c = b-a)	Weight of Dry Sediment (d)	Water Weight (e = c-d)	Percent Water (f = [e/c]*100)

II. Grain Size Analysis

	Weight of Pan (g)	Weight of Pan + Fraction (h)	Weight of Fraction (i = h-g)	Percent of Total (j = [i/d]*100)
Dry Weight, Sieve # 10 (2.00 mm; gravel)				
Dry Weight, Sieve # 230 (63 µm; sand)				
Dry Weight, Pan (silt/clay)				
Total Dry Weight (d)				

	Percent Water	Percent Gravel	Percent Sand	Percent Silt/Clay
Average: Original Sample, QC#1 & QC#2				
Standard Deviation: Original Sample, QC#1 & QC#2				

MARYLAND DEPARTMENT OF THE ENVIRONMENT
TECHNICAL AND REGULATORY SERVICES ADMINISTRATION
DREDGING COORDINATION AND ASSESSMENT DIVISION

Sediment Grain Size and Water Content Analysis Quality Control
Sample: **MDE-R1**

QC Check #1

I. Water Content Analysis

Weight of Pan (a)	Weight of Pan + Wet Sediment (b)	Weight of Wet Sediment (c = b-a)	Weight of Dry Sediment (d)	Water Weight (e = c-d)	Percent Water (f = [e/c]*100)
4.400	54.730	50.330	24.986	25.344	50.36

II. Grain Size Analysis

	Weight of Pan (g)	Weight of Pan + Fraction (h)	Weight of Fraction (i = h-g)	Percent of Total (j = [i/d]*100)
Dry Weight, Sieve # 10 (2.00 mm; gravel)	1.700	1.701	0.001	0.004
Dry Weight, Sieve # 230 (63 µm; sand)	2.700	4.625	1.925	7.70
Dry Weight, Pan (silt/clay)	2.703	25.763	23.06	92.29
Total Dry Weight (d)			24.986	

	Percent Water	Percent Gravel	Percent Sand	Percent Silt/Clay
Standard Deviation: Original Sample & QC #1	0.077	0.089	0.063	0.021

QC Check #2

I. Water Content Analysis

Weight of Pan (a)	Weight of Pan + Wet Sediment (b)	Weight of Wet Sediment (c = b-a)	Weight of Dry Sediment (d)	Water Weight (e = c-d)	Percent Water (f = [e/c]*100)

II. Grain Size Analysis

	Weight of Pan (g)	Weight of Pan + Fraction (h)	Weight of Fraction (i = h-g)	Percent of Total (j = [i/d]*100)
Dry Weight, Sieve # 10 (2.00 mm; gravel)				
Dry Weight, Sieve # 230 (63 µm; sand)				
Dry Weight, Pan (silt/clay)				
Total Dry Weight (d)				

	Percent Water	Percent Gravel	Percent Sand	Percent Silt/Clay
Average: Original Sample, QC#1 & QC#2				
Standard Deviation: Original Sample, QC#1 & QC#2				

APPENDIX VII

Benthic Community Spreadsheets
September 1998

Site 92 Sampling Station S92-1

September 28, 1998

		Grab		Composite	Standard
Taxon	1	2	3	Average	Deviation
NEMERTINEA *					
Carinoma tremephorus *	30		30	20	0
MOLLUSCA					
Hydrobia sp. •					
Mytilopsis leucophaeata •					
Macoma balthica +			20	7	
Macoma mitchelli					
Rangia cuneata +	30	130	50	70	53
ANNELIDA					
POLYCHAETA					
Heteromastus filiformis					
Hypereteone heteropoda #					
Hobsonia florida		20	20	13	0
Marenzelleria viridis +	430	440	730	533	170
Neanthes succinea *	40	20	80	47	31
Polydora cornuta					
Streblospio benedicti #	20	20	30	23	6
OLIGOCHAETA					
Tubificoides sp		10	30	13	14
ARTHROPODA					
Balanus improvisus •					
Rhithropanopeus harrisii •					
Neomysis americana					
ISOPODA					
Cyathura polita +*	90	70	140	100	36
Chiridotea almyra *					
Edotea triloba •	10	40	50	33	21
AMPHIPODA					
Ameroculodes spp. complex		10	40	17	21
Apocorophium lacustre •					
Gammarus sp.					
Gammarus mucronatus					
Leptocheirus plumulosus	80		100	60	14
Melita nitida •					
INSECTA					
Chironomidae *					
Coelotanypus sp #*	20	40	10	23	15
Total Abundance (#/m^2)	**740**	**760**	**1280**	**927**	**306.16**
Taxa Richness[1]	**8**	**9**	**12**	**12**	**2.08**
Shannon-Wiener Diversity Index[2]				**2.28**	
Pollution-Indicative Taxa Abundance	**5.41**	**7.89**	**3.13**	**5.48**	**2.39**
Pollution-Sensitive Taxa Abundance	**74.32**	**84.21**	**73.44**	**77.32**	**5.98**

Note: Only infaunal taxa have been included in metric calculations

[1] Taxa Richness for the composite is the total number of infaunal taxa for all replicates.

[2] Shannon-Wiener Diversity Index was calculated based on a composite of the 3 replicates

•Epifaunal Taxon

#Pollution-Indicative Taxon

+Pollution-Sensitive Taxon

*Carnivore/Omnivore Taxa

Site 92 Sampling Station S92-2

September 28, 1998

Taxon	Grab 1	2	3	Composite Average	Standard Deviation
NEMERTINEA *					
Cannoma tremephorus *	40	10	50	33	21
MOLLUSCA					
Hydrobia sp. •					
Mytilopsis leucophaeata •					
Macoma balthica +					
Macoma mitchelli					
Rangia cuneata +	1000	800	650	817	176
ANNELIDA					
POLYCHAETA					
Heteromastus filiformis					
Hypereteone heteropoda #			20	7	
Hobsonia florida					
Marenzelleria viridis +	60	60	40	53	12
Neanthes succinea *	20	40	40	33	12
Polydora cornuta					
Streblospio benedicti #		80	50	43	21
OLIGOCHAETA					
Tubificoides sp		60	30	30	21
ARTHROPODA					
Balanus improvisus •					
Rhithropanopeus harrisii •					
Neomysis americana					
ISOPODA					
Cyathura polita +*	60	140	60	87	46
Chiridotea almyra *					
Edotea triloba •		10	10	7	0
AMPHIPODA					
Ameroculodes spp. complex		10	40	17	21
Apocorophium lacustre •					
Gammarus sp.					
Gammarus mucronatus					
Leptocheirus plumulosus			10	3	
Melita nitida •				0	
INSECTA					
Chironomidae *					
Coelotanypus sp #*		10	40	17	
Total Abundance (#/m^2)	**1180**	**1210**	**1030**	**1140**	**96.44**
Taxa Richness[1]	**5**	**9**	**11**	**11**	**3.06**
Shannon-Wiener Diversity Index [2]				**1.70**	
Pollution-Indicative Taxa Abundance	**0.00**	**7.44**	**10.68**	**6.04**	**5.48**
Pollution-Sensitive Taxa Abundance	**94.92**	**82.64**	**72.82**	**83.46**	**11.07**

Note: Only infaunal taxa have been included in metric calculations

[1] Taxa Richness for the composite is the total number of infaunal taxa for all replicates.

[2] Shannon-Wiener Diversity Index was calculated based on a composite of the 3 replicates

•Epifaunal Taxon

#Pollution-Indicative Taxon

+Pollution-Sensitive Taxon

*Carnivore/Omnivore Taxa

Site 92 Sampling Station S92-3A

September 28, 1998

	Grab			Composite	Standard
Taxon	1	2	3	Average	Deviation
NEMERTINEA *					
Carinoma tremephorus *	30	20	20	23	6
MOLLUSCA					
Hydrobia sp. •					
Mytilopsis leucophaeata •			10	3	
Macoma balthica +					
Macoma mitchelli					
Rangia cuneata +	1180	1310	1010	1167	150
ANNELIDA					
POLYCHAETA					
Heteromastus filiformis					
Hypereteone heteropoda #			10	3	
Hobsonia florida					
Marenzelleria viridis +	70	40	80	63	21
Neanthes succinea *	60	30	100	63	35
Polydora cornuta					
Streblospio benedicti #					
OLIGOCHAETA					
Tubificoides sp					
ARTHROPODA					
Balanus improvisus •					
Rhithropanopeus harrisii •		10		3	
Neomysis americana					
ISOPODA					
Cyathura polita +*	60	70	30	53	21
Chiridotea almyra *					
Edotea triloba •	10	10	10	10	0
AMPHIPODA					
Ameroculodes spp. complex	10		10	7	0
Apocorophium lacustre •					
Gammarus sp.					
Gammarus mucronatus					
Leptocheirus plumulosus					
Melita nitida •					
INSECTA					
Chironomidae *					
Coelotanypus sp #*	10	10		7	0
Total Abundance (#/m^2)	**1420**	**1480**	**1260**	**1387**	**113.72**
Taxa Richness[1]	**7**	**6**	**7**	**8**	**0.58**
Shannon-Wiener Diversity Index [2]				**0.99**	
Pollution-Indicative Taxa Abundance	**0.70**	**0.68**	**0.79**	**0.72**	**0.06**
Pollution-Sensitive Taxa Abundance	**92.25**	**95.95**	**88.89**	**92.36**	**3.53**

Note: Only infaunal taxa have been included in metric calculations

[1] Taxa Richness for the composite is the total number of infaunal taxa for all replicates.

[2] Shannon-Wiener Diversity Index was calculated based on a composite of the 3 replicates

•Epifaunal Taxon

#Pollution-Indicative Taxon

+Pollution-Sensitive Taxon

*Carnivore/Omnivore Taxa

Site 92 Sampling Station S92-4A

September 28, 1998

	Grab			Composite	Standard
Taxon	1	2	3	Average	Deviation
NEMERTINEA *					
Carinoma tremephorus *	20	30	40	30	10
MOLLUSCA					
Hydrobia sp. •					
Mytilopsis leucophaeata •			30	10	
Macoma balthica +		10		3	
Macoma mitchelli	10	20		10	7
Rangia cuneata +	1060	1060	1280	1133	127
ANNELIDA					
POLYCHAETA					
Heteromastus filiformis					
Hypereteone heteropoda #					
Hobsonia florida					
Marenzelleria viridis +	20	30	40	30	10
Neanthes succinea *	40	110	70	73	35
Polydora cornuta					
Streblospio benedicti #		10		3	
OLIGOCHAETA					
Tubificoides sp					
ARTHROPODA					
Balanus improvisus •					
Rhithropanopeus harrisii •					
Neomysis americana					
ISOPODA					
Cyathura polita +*	100	100	110	103	6
Chiridotea almyra *					
Edotea triloba •	10			3	
AMPHIPODA					
Ameroculodes spp. complex	10	10	10	10	0
Apocorophium lacustre •					
Gammarus sp.					
Gammarus mucronatus					
Leptocheirus plumulosus	10	20	50	27	21
Melita nitida •					
INSECTA					
Chironomidae *					
Coelotanypus sp #*			20	7	
Total Abundance (#/m^2)	**1270**	**1400**	**1620**	**1430**	**176.92**
Taxa Richness[1]	**8**	**10**	**8**	**11**	**1.15**
Shannon-Wiener Diversity Index [2]				**1.28**	
Pollution-Indicative Taxa Abundance	**0.00**	**0.71**	**1.23**	**0.65**	**0.62**
Pollution-Sensitive Taxa Abundance	**92.91**	**85.71**	**88.27**	**88.97**	**3.65**

Note: Only infaunal taxa have been included in metric calculations

[1] Taxa Richness for the composite is the total number of infaunal taxa for all replicates.

[2] Shannon-Wiener Diversity Index was calculated based on a composite of the 3 replicates

•Epifaunal Taxon

#Pollution-Indicative Taxon

+Pollution-Sensitive Taxon

*Carnivore/Omnivore Taxa

Site 92 Sampling Station S92-5

September 28, 1998

Taxon	Grab 1	2	3	Composite Average	Standard Deviation
NEMERTINEA •					
Carinoma tremephorus •	10	10	30	17	12
MOLLUSCA					
Hydrobia sp.•					
Mytilopsis leucophaeata •					
Macoma balthica +		10		3	
Macoma mitchelli					
Rangia cuneata +	990	1070	1270	1110	144
ANNELIDA					
POLYCHAETA					
Heteromastus filiformis					
Hypereteone heteropoda #	20	30		17	7
Hobsonia florida					
Marenzelleria viridis +	50	230	20	100	114
Neanthes succinea •	150	300	210	220	75
Polydora cornuta					
Streblospio benedicti #		30		10	
OLIGOCHAETA					
Tubificoides sp		20		7	
ARTHROPODA					
Balanus improvisus •					
Rhithropanopeus harrisii •	10			3	
Neomysis americana		10		3	
ISOPODA					
Cyathura polita +•	90	100	70	87	15
Chiridotea almyra •					
Edotea triloba •	20	10	10	13	6
AMPHIPODA					
Ameroculodes spp. complex	10	60	50	40	26
Apocorophium lacustre •					
Gammarus sp.					
Gammarus mucronatus		10		3	
Leptocheirus plumulosus	40	80	20	47	31
Melita nitida •					
INSECTA					
Chironomidae •					
Coelotanypus sp #•	10	20	10	13	6
Total Abundance (#/m^2)	**1370**	**1970**	**1680**	**1673**	**300.06**
Taxa Richness[1]	**9**	**13**	**8**	**13**	**2.65**
Shannon-Wiener Diversity Index [2]				**1.81**	
Pollution-Indicative Taxa Abundance	**2.19**	**4.06**	**0.60**	**2.28**	**1.73**
Pollution-Sensitive Taxa Abundance	**82.48**	**71.57**	**80.95**	**78.34**	**5.91**

Note: Only infaunal taxa have been included in metric calculations

[1] Taxa Richness for the composite is the total number of infaunal taxa for all replicates.

[2] Shannon-Wiener Diversity Index was calculated based on a composite of the 3 replicates

•Epifaunal Taxon

#Pollution-Indicative Taxon

+Pollution-Sensitive Taxon

•Carnivore/Omnivore Taxa

Site 92 Sampling Station S92-6

September 28, 1998

Taxon	Grab 1	2	3	Composite Average	Standard Deviation
NEMERTINEA *					
Carinoma tremephorus *	10	30	20	20	10
MOLLUSCA					
Hydrobia sp. ^{e}					
Mytilopsis leucophaeata ^{e}			20	7	
Macoma balthica +					
Macoma mitchelli					
Rangia cuneata +	980	840	1050	957	107
ANNELIDA					
POLYCHAETA					
Heteromastus filiformis		10		3	
Hypereteone heteropoda #	10		10	7	0
Hobsonia florida					
Marenzelleria viridis +	10		30	13	14
Neanthes succinea *	210	230	500	313	162
Polydora comuta					
Streblospio benedicti #	40	10	50	33	21
OLIGOCHAETA					
Tubificoides sp	60	30	80	57	25
ARTHROPODA					
Balanus improvisus ^{e}	100	50	100	83	29
Rhithropanopeus harrisii ^{e}		10		3	
Neomysis americana ^{e}					
ISOPODA					
Cyathura polita +*	150	40	140	110	61
Chiridotea almyra *					
Edotea triloba ^{e}	50	10	40	33	21
AMPHIPODA					
Ameroculodes spp. complex	70	20	120	70	50
Apocorophium lacustre ^{e}					
Gammarus sp.					
Gammarus mucronatus					
Leptocheirus plumulosus	30	30	10	23	12
Melita nitida ^{e}					
INSECTA					
Chironomidae *					
Coelotanypus sp #*			10	3	
Total Abundance (#/m^2)	**1570**	**1240**	**2020**	**1610**	**391.54**
Taxa Richness[1]	**10**	**9**	**11**	**12**	**1.00**
Shannon-Wiener Diversity Index [2]				**1.95**	
Pollution-Indicative Taxa Abundance	**3.18**	**0.81**	**3.47**	**2.49**	**1.46**
Pollution-Sensitive Taxa Abundance	**72.61**	**70.97**	**60.40**	**67.99**	**6.63**

Note: Only infaunal taxa have been included in metric calculations

[1] Taxa Richness for the composite is the total number of infaunal taxa for all replicates.

[2] Shannon-Wiener Diversity Index was calculated based on a composite of the 3 replicates

^{e}Epifaunal Taxon

#Pollution-Indicative Taxon

+Pollution-Sensitive Taxon

*Carnivore/Omnivore Taxa

Site 92 Sampling Station S92-7

September 28, 1998

	Grab			Composite	Standard
Taxon	1	2	3	Average	Deviation
NEMERTINEA *					
Carinoma tremephorus *	30	50	10	30	20
MOLLUSCA					
Hydrobia sp.^{e}					
Mytilopsis leucophaeata ^{e}					
Macoma balthica +			10	3	
Macoma mitchelli					
Rangia cuneata +	2330	1650	1430	1803	469
ANNELIDA					
POLYCHAETA					
Heteromastus filiformis			10	3	
Hypereteone heteropoda #					
Hobsonia florida					
Marenzelleria viridis +	60	30	50	47	15
Neanthes succinea *	50	40	50	47	6
Polydora comuta					
Streblospio benedicti #	10			3	
OLIGOCHAETA					
Tubificoides sp					
ARTHROPODA					
Balanus improvisus ^{e}					
Rhithropanopeus harrisii ^{e}					
Neomysis americana					
ISOPODA					
Cyathura polita +*	110	90	100	100	10
Chiridotea almyra *					
Edotea triloba ^{e}	10			3	
AMPHIPODA					
Ameroculodes spp. complex	10	10		7	0
Apocorophium lacustre ^{e}		10		3	
Gammarus sp.					
Gammarus mucronatus					
Leptocheirus plumulosus					
Melita nitida ^{e}					
INSECTA					
Chironomidae ^{e}					
Coelotanypus sp #*		20	30	17	7
Total Abundance (#/m^{2})	**2600**	**1890**	**1690**	**2060**	**478.23**
Taxa Richness[1]	**7**	**7**	**8**	**10**	**0.58**
Shannon-Wiener Diversity Index [2]				**0.84**	
Pollution-Indicative Taxa Abundance	**0.38**	**1.06**	**1.78**	**1.07**	**0.70**
Pollution-Sensitive Taxa Abundance	**96.15**	**93.65**	**94.08**	**94.63**	**1.34**

Note: Only infaunal taxa have been included in metric calculations

[1] Taxa Richness for the composite is the total number of infaunal taxa for all replicates.

[2] Shannon-Wiener Diversity Index was calculated based on a composite of the 3 replicates

^{e}Epifaunal Taxon

#Pollution-Indicative Taxon

+Pollution-Sensitive Taxon

*Carnivore/Omnivore Taxa

Site 92 Sampling Station S92-R1

September 28, 1998

Taxon	Grab 1	Grab 2	Grab 3	Composite Average	Standard Deviation
NEMERTINEA *					
Carinoma tremephorus *	30	40	10	27	15
MOLLUSCA					
Hydrobia sp. ^{e}					
Mytilopsis leucophaeata ^{e}	20	10		10	7
Macoma balthica +					
Macoma mitchelli					
Rangia cuneata +	1420	1650	1690	1587	146
ANNELIDA					
POLYCHAETA					
Heteromastus filiformis			20	7	
Hypereteone heteropoda #	10			3	
Hobsonia florida					
Marenzelleria viridis +	60	40	80	60	20
Neanthes succinea *	360	230	340	310	70
Polydora cornuta					
Streblospio benedicti #	10		10	7	0
OLIGOCHAETA					
Tubificoides sp	10			3	
ARTHROPODA					
Balanus improvisus ^{e}					
Rhithropanopeus harrisii ^{e}					
Neomysis americana					
ISOPODA					
Cyathura polita +*	100	130	50	93	40
Chiridotea almyra *					
Edotea triloba ^{e}	20	10	10	13	6
AMPHIPODA					
Ameroculodes spp. complex	20	30	20	23	6
Apocorophium lacustre ^{e}	10		30	13	14
Gammarus sp.					
Gammarus mucronatus					
Leptocheirus plumulosus	20	10	10	13	6
Melita nitida ^{e}					
INSECTA					
Chironomidae *					
Coelotanypus sp #*	10			3	
Total Abundance (#/m^2)	**2050**	**2130**	**2230**	**2137**	**90.18**
Taxa Richness[1]	**11**	**7**	**9**	**12**	**2.00**
Shannon-Wiener Diversity Index[2]				**1.36**	
Pollution-Indicative Taxa Abundance	**1.46**	**0.00**	**0.45**	**0.64**	**0.75**
Pollution-Sensitive Taxa Abundance	**77.07**	**85.45**	**81.61**	**81.38**	**4.19**

Note: Only infaunal taxa have been included in metric calculations

[1] Taxa Richness for the composite is the total number of infaunal taxa for all replicates.

[2] Shannon-Wiener Diversity Index was calculated based on a composite of the 3 replicates

^{e}Epifaunal Taxon

#Pollution-Indicative Taxon

+Pollution-Sensitive Taxon

*Carnivore/Omnivore Taxa

Site 92 Sampling Station S92-R2

September 28, 1998

Taxon	Grab 1	 2	 3	Composite Average	Standard Deviation
NEMERTINEA *					
Carinoma tremephorus *	20	20	30	23	6
MOLLUSCA					
Hydrobia sp. •					
Mytilopsis leucophaeata •		10	10	7	0
Macoma balthica +	10			3	
Macoma mitchelli	10			3	
Rangia cuneata +	40	30	20	30	10
ANNELIDA					
POLYCHAETA					
Heteromastus filiformis	10			3	
Hypereteone heteropoda #		10	10	7	0
Hobsonia florida	10			3	
Marenzellena viridis +	10	70		27	42
Neanthes succinea *	480	440	610	510	89
Polydora cornuta					
Streblospio benedicti #	60	120		60	42
OLIGOCHAETA					
Tubificoides sp	150	70		73	57
ARTHROPODA					
Balanus improvisus •	70	70	190	110	69
Rhithropanopeus harrisii •	30	60	30	40	17
Neomysis americana					
ISOPODA					
Cyathura polita +*	180	210	100	163	57
Chiridotea almyra *					
Edotea triloba •	30			10	
AMPHIPODA					
Ameroculodes spp. complex		10	60	23	35
Apocorophium lacustre •					
Gammarus sp.					
Gammarus mucronatus					
Leptocheirus plumulosus	10	10		7	0
Melita nitida •		30	20	17	7
INSECTA					
Chironomidae *					
Coelotanypus sp #*		10		3	
Total Abundance (#/m^2)	**990**	**1000**	**830**	**940**	**95.39**
Taxa Richness[1]	**12**	**11**	**6**	**15**	**3.21**
Shannon-Wiener Diversity Index [2]				**2.27**	
Pollution-Indicative Taxa Abundance	**6.06**	**14.00**	**1.20**	**7.09**	**6.46**
Pollution-Sensitive Taxa Abundance	**24.24**	**31.00**	**14.46**	**23.23**	**8.32**

Note: Only infaunal taxa have been included in metric calculations

[1] Taxa Richness for the composite is the total number of infaunal taxa for all replicates.

[2] Shannon-Wiener Diversity Index was calculated based on a composite of the 3 replicates

•Epifaunal Taxon

#Pollution-Indicative Taxon

+Pollution-Sensitive Taxon

*Carnivore/Omnivore Taxa

Site 92 Sampling Station MDE-R1

September 28, 1998

Taxon	Grab 1	2	3	Composite Average	Standard Deviation
NEMERTINEA *					
Carinoma tremephorus *	70	30	50	50	20
MOLLUSCA					
Hydrobia *sp.* ^{e}					
Mytilopsis leucophaeata ^{e}		10		3	
Macoma balthica +					
Macoma mitchelli					
Rangia cuneata +	90	60	60	70	17
ANNELIDA					
POLYCHAETA					
Heteromastus filiformis					
Hypereteone heteropoda #	10			3	
Hobsonia florida	10	20	60	30	26
Marenzelleria viridis +	800	1350	560	903	405
Neanthes succinea *	60	60	40	53	12
Polydora cornuta					
Streblospio benedicti #	10	10	30	17	12
OLIGOCHAETA					
Tubificoides *sp*					
ARTHROPODA					
Balanus improvisus ^{e}		10		3	
Rhithropanopeus harrisii ^{e}		10		3	
Neomysis americana					
ISOPODA					
Cyathura polita +*	370	310	360	347	32
Chiridotea almyra *		10		3	
Edotea triloba ^{e}	120	100	50	90	36
AMPHIPODA					
Ameroculodes spp. complex	20	20	40	27	12
Apocorophium lacustre ^{e}					
Gammarus sp.	10			3	
Gammarus mucronatus					
Leptocheirus plumulosus	10	50	50	37	23
Melita nitida ^{e}					
INSECTA					
Chironomidae *					
Coelotanypus *sp* #*					
Total Abundance (#/m^{2})	**1460**	**1920**	**1250**	**1543**	**342.69**
Taxa Richness[1]	**11**	**10**	**9**	**12**	**1.00**
Shannon-Wiener Diversity Index [2]				**1.93**	
Pollution-Indicative Taxa Abundance	**1.37**	**0.52**	**2.40**	**1.43**	**0.94**
Pollution-Sensitive Taxa Abundance	**86.30**	**89.58**	**78.40**	**84.76**	**5.75**

Note: Only infaunal taxa have been included in metric calculations

[1] Taxa Richness for the composite is the total number of infaunal taxa for all replicates.

[2] Shannon-Wiener Diversity Index was calculated based on a composite of the 3 replicates

^{e}Epifaunal Taxon

#Pollution-Indicative Taxon

+Pollution-Sensitive Taxon

*Carnivore/Omnivore Taxa

Site 92 Sampling Station MDE-R2

September 28, 1998

	Grab			Composite Average	Standard Deviation
Taxon	1	2	3		
NEMERTINEA •					
Carinoma tremephorus •	40	10	40	30	17
MOLLUSCA					
Hydrobia sp. ●					
Mytilopsis leucophaeata ●			10	3	
Macoma balthica +					
Macoma mitchelli					
Rangia cuneata +	80	40	60	60	20
ANNELIDA					
POLYCHAETA					
Heteromastus filiformis					
Hypereteone heteropoda #		10		3	
Hobsonia florida					
Marenzelleria viridis +	20	20	20	20	0
Neanthes succinea •	80	70	340	163	153
Polydora cornuta					
Streblospio benedicti #	50	20	20	30	17
OLIGOCHAETA					
Tubificoides sp	160	50	30	80	70
ARTHROPODA					
Balanus improvisus ●	150	140	120	137	15
Rhithropanopeus harrisii ●					
Neomysis americana					
ISOPODA					
Cyathura polita +•	60	40	40	47	12
Chiridotea almyra •					
Edotea triloba ●					
AMPHIPODA					
Ameroculodes spp. complex	50	10		20	28
Apocorophium lacustre ●					
Gammarus sp.					
Gammarus mucronatus					
Leptocheirus plumulosus					
Melita nitida ●					
INSECTA					
Chironomidae •					
Coelotanypus sp #•					
Total Abundance (#/m^2)	540	270	550	453	158.85
Taxa Richness[1]	8	9	7	9	1.00
Shannon-Wiener Diversity Index[2]				2.66	
Pollution-Indicative Taxa Abundance	9.26	11.11	3.64	8.00	3.89
Pollution-Sensitive Taxa Abundance	29.63	37.04	21.82	29.49	7.61

Note: Only infaunal taxa have been included in metric calculations

[1] Taxa Richness for the composite is the total number of infaunal taxa for all replicates.

[2] Shannon-Wiener Diversity Index was calculated based on a composite of the 3 replicates

●Epifaunal Taxon

#Pollution-Indicative Taxon

+Pollution-Sensitive Taxon

•Carnivore/Omnivore Taxa

APPENDIX VIII

Water Quality and Benthic Community Summary Tables for Previous Studies In G-South and In the vicinity of G-East

Table VIII-1. Average *In-situ* Water Quality Measured During Previous Studies of the Pooles Island Area.

Area, Date	Temperature (°C)	Dissolved Oxygen (ppm)	Salinity (‰)
Pooles Island, August 1991[1]	25.8	5.5	9.3
Pooles Island, August 1992[1]	24.9	6.3	2.5
Pooles Island, May 1993[1]	18.8	7.5	1.9
Pooles Island, July 1993[1]	23.0	5.0	10.6
G-East, September 1995[2]	25.4	6.1	10.0
G-South, September 1996[3]	24.9	6.3	5.5

[1] Ranasinghe and Richkus 1993
[2] Dalal et al. 1996
[3] Dalal et al. 1998a

Table VIII-2. Benthic Community Composition in the G-South Dredged Material Placement Area During Selected Months of the Pooles Island Baseline and Early Post-Placement Studies, August 1991 to July 1993.

(Adapted from Ranasinghe and Richkus

TAXON	Date of Sampling					
	Aug-91	Aug-92	Oct-92	May-93	Jun-93	Jul-93
PLATYHELMINTHES						
Euplana gracilis						15
Planariidae	15					
NEMERTINEA *						
Carinoma tremephoros *	150	105	45		15	105
MOLLUSCA						
Littoridinops tenuipes	15	555		45	75	255
Mytilopsis leucophaeata^{e}						45
Macoma balthica +	150	375	195	45	60	
Macoma mitchelli	450	45	60			60
Rangia cuneata +	3825	210	540	105	30	2205
ANNELIDA						
POLYCHAETA						
Bocardiella ligerica						45
Heteromastus filiformis	45	330	75	90		60
Hypereteone heteropoda #	120					
Marenzelleria viridis +	420	2490	1905	2550	1638	2850
Neanthes succinea *	105			30		15
Polydora cornuta			15			15
Streblospio benedicti #	180	270	105			615
OLIGOCHAETA						
Tubificoides sp	195	615	405	420	2115	405
ARTHROPODA						
Balanus improvisus ^{e}			15			
Rhithropanopeus harrisii ^{e}		15			15	15
Neomysis americana		15			75	
ISOPODA						
Cyathura polita +*	300	630	825	165	420	465
Chiridotea almyra *	15				15	
Edotea triloba ^{e}	15	180	285		15	30
AMPHIPODA						
Ameroculodes spp. complex		45	75	705	375	15
Apocorophium lacustre ^{e}	135			15	15	
Gammarus sp.					30	
Gammarus daiberi				60	15	
Leptocheirus plumulosus	15	690	390	60	795	390
Melita nitida ^{e}		30	45			
INSECTA						
Chironomidae *						
Procladius sp *				15		
Cryptochironomus sp *				15		
Coelotanypus sp #*			15			
Total Abundance (#/m2)	**5,985**	**6,360**	**4,650**	**4,305**	**5,583**	**7,500**
Taxa Richness	**14**	**12**	**13**	**13**	**12**	**14**
Shannon-Wiener Diversity Index	**2.09**	**2.86**	**2.64**	**2.05**	**2.30**	**2.51**
Carnivore/Omnivore Abundance	**9.65**	**11.60**	**19.98**	**4.84**	**7.01**	**7.88**
Pollution-Indicative Taxa Abundance	**5.04**	**4.29**	**2.62**	**0.00**	**0.00**	**7.96**
Pollution-SensitiveTaxa Abundance	**78.41**	**53.67**	**74.26**	**65.61**	**36.98**	**72.76**

NOTE: Only infaunal taxa have been included in metric calculations.

^{e} Epifaunal taxon

\# Pollution-indicative Taxon

\+ Pollution-sensitive Taxon

* Carnivore/Omnivore Taxon

Table VIII-3. Benthic Community Composition in the G-South Dredged Material Placement Area During the Post-Placement Study, September 1996. (Adapted from Dalal et al. 1998a)

TAXON	Benthic Assessment Station				
	GS-1	GS-2	GS-3	GS-4	GS-5
NEMERTINEA	107	90	57	50	117
MOLLUSCA					
Brachidontes recurvus[e]	3				
Gemma gemma	90	3			
Rangia cuneata +	143	3	23	70	50
Macoma balthica +	3		3	7	
Macoma mitchelli	3			13	
ANNELIDA					
POLYCHAETA					
Hypereteone heteropoda #					
Marenzelleria viridis +	2430	1023	1443	807	940
Streblospio benedicti #	103	140	123	10	97
Neanthes succinea	7	10	3		43
Heteromastus filiformis	10	10	30	7	3
OLIGOCHAETA					
Immature Tub. w/o cap. chaetae #	83	307	27	387	50
ARTHROPODA					
ISOPODA					
Cyathura polita +	530	334	750	653	593
Chiridotea almyra	3		100		
Chiridotea sp.			7		
AMPHIPODA					
Gammarus daiberi	80		27	100	40
Ameroculodes spp. complex	43	10	57	30	30
Leptocheirus plumulosus	153	27	87	517	57
INSECTA					
Coelotanypus sp. +	3	7		20	23
Procladius sp. +	3	3		17	
Total Abundance	**3,597**	**1,921**	**2,593**	**2,103**	**1,933**
Taxa Richness	**14**	**9**	**12**	**10**	**9**
Shannon-Wiener Diversity Index	**1.73**	**1.94**	**1.82**	**2.14**	**2.02**
Pollution-indicative Taxa Abundance	**5.38**	**23.78**	**5.78**	**20.60**	**8.79**
Pollution-sensitive Taxa Abundance	**86.38**	**70.84**	**85.60**	**73.06**	**81.90**

[e] Epifaunal Taxon

\# Pollution-indicative Taxon

\+ Pollution-sensitive Taxon

Table VIII-4. Pre-Placement Benthic Community Composition in the Vicinity of the G-East Area, September 1995. (Adapted from Dalal et al. 1996)

TAXON	Benthic Assessment Station				
	GE-1	GE-2	GE-3	GE-4	GE-5
NEMERTINEA	183		130	243	183
MOLLUSCA					
Brachidontes recurvus [c]			7		10
*Rangia cuneata**	137	1067	410	503	9557
*Macoma balthica**		2903	57	1477	837
Macoma mitchelli		37		10	30
ANNELIDA					
POLYCHAETA					
Boccardiella ligerica				3	
Hypereteone heteropoda #		10			3
Marenzelleria viridis	23	230	13	70	290
Streblospio benedicti #	13	10		73	
Hobsonia florida					
Neanthes succinea	380	20	400	17	110
Heteromastus filiformis	37	87	47	240	27
OLIGOCHAETA					
Tubificidae					
ARTHROPODA					
ISOPODA					
*Cyathura polita**	157	1320	47	653	463
AMPHIPODA					
Gammarus sp.	13	23			7
Gammarus daiberi	7	20		3	
Total Abundance (individals/m^2)	**950**	**5,727**	**1,110**	**3,293**	**1,1517**
Taxa Richness	**9**	**11**	**7**	**11**	**10**
Shannon-Wiener Diversity Index	**2.35**	**1.88**	**2.15**	**2.27**	**1.04**
Pollution-Indicative Taxa Abundance (%)	**1.40**	**0.35**	**0.00**	**2.23**	**0.03**
Pollution-Sensitive Taxa Abundance (%)	**14.39**	**69.32**	**42.04**	**60.12**	**90.25**

[c] Epifaunal Taxon

\# Pollution-indicative Taxon

\+ Pollution-sensitive Taxon

APPENDIX IX

STATISTICAL DATA TABLES

Table IX-1. Correlation Among Selected Habitat Parameters Measured During the Site 92 Baseline Study, 1998

Water Quality Parameter	Date	Secchi Depth (m)	Temperature (°C)	PH	Dissolved Oxygen (ppm)	Salinity (‰)
Secchi Depth (m)	0.86					
Temperature (°C)	0.61	0.67				
pH	-0.84	-0.74	-0.55			
Dissolved Oxygen (ppm)	-0.59	-0.68	-0.93	0.60		
Salinity (‰)	1.00	0.84	0.58	-0.85	-0.55	
Turbidity (NTU)	0.44	0.37	0.70	-0.42	-0.58	0.40

Note: **All** correlations are significant at $p < 0.05$.

Table IX-2. Correlation Between Selected Habitat and Benthic Community Parameters Measured During the Site 92 Baseline Study, 1998

Water Quality Parameter	Total Abundance	Taxa Richness	Shannon-Wiener Diversity Index	Pollution-indicative Taxa Abundance (%)	Pollution-Sensitive Taxa Abundance (%)	Numeric Abundance of *Rangia cuneata*	Relative Abundance of *Rangia cuneata* (%)	Numeric Abundance of *Marezelleria viridis*	Relative Abundance of *Marezelleria viridis* (%)	Relative Abundance of *R. cuneata* and *M. viridis*, combined
Secchi Depth (m)	**-0.55**	0.14	0.25	**0.55**	**0.38**	-0.26	0.06	**-0.45**	**-0.37**	**-0.40**
Temperature (°C)	**-0.41**	**0.39**	0.12	0.29	-0.16	0.00	0.28	**-0.51**	**-0.46**	-0.17
pH	**0.40**	0.15	0.16	**-0.43**	**0.38**	-0.03	-0.34	**0.56**	**0.66**	**0.36**
Dissolved Oxygen (ppm)	**0.44**	**0.42**	-0.29	**-0.35**	0.31	0.01	-0.22	**0.55**	**0.50**	0.32
Salinity (ppt)	**-0.52**	0.12	0.18	**0.54**	**-0.40**	-0.18	0.16	**-0.51**	**-0.50**	**-0.41**
Turbidity	-0.19	0.13	0.05	0.11	0.01	0.18	**0.39**	**-0.39**	**-0.43**	0.01
% Silt/Clay	-0.06	0.32	-0.24	0.15	0.19	-0.20	-0.06	0.13	0.15	0.11

NOTE: Correlations in bold type are significant at $p < 0.05000$

Table IX-3. Correlation Among Selected Benthic Community Parameters Measured During the Site 92 Baseline Study, 1998

Benthic Community Parameter	Total Abundance	Taxa Richness	Shannon-Wiener Diversity Index	Pollution-Indicative Taxa Abundance (%)	Pollution-Sensitive Taxa Abundance (%)	Numeric Abundance of *Rangia cuneata*	Relative Abundance of *Rangia cuneata* (%)	Numeric Abundance of *Marezelleria viridis*	Relative Abundance of *Marezelleria viridis* (%)
Taxa Richness	-0.16								
Shannon-Wiener Diversity Index	**-0.60**	**0.37**							
Pollution-Indicative Taxa Abundance (%)	**-0.47**	0.33	**0.66**						
Pollution-Sensitive Taxa Abundance (%)	**0.49**	**-0.35**	**-0.72**	**-0.81**					
Numeric Abundance of *Rangia cuneata*	**0.57**	-0.11	**-0.46**	**-0.38**	**0.41**				
Relative Abundance of *Rangia cuneata* (%)	0.14	-0.16	**-0.40**	-0.27	**0.39**	**0.78**			
Numeric Abundance of *Marezelleria viridis*	**0.71**	-0.22	**-0.41**	-0.32	**0.35**	-0.15	**-0.46**		
Relative Abundance of *Marezelleria viridis* (%)	0.28	-0.08	-0.16	-0.30	0.30	**-0.46**	**-0.75**	**0.76**	
Relative Abundance of *R. cuneata* and *M. viridis*, combined	**0.58**	**-0.34**	**-0.79**	**-0.79**	**0.96**	**0.57**	**0.51**	0.31	0.19

NOTE: Correlations in **bold** type are significant at $p < 0.05$

Table IX-4: Results of T-tests Performed to Determine Whether Significant Differences Exist Among Station Types at Site 92 During May, July, and September 1998.

Site 92-Reference versus Site 92-Inner									
MAY									
Benthic Community Parameter	Mean INNER	Mean REF	t-value	df	p	Std.Dev. INNER	Std.Dev. REF	F-ratio variancs	p variancs
Taxa Abundance	2706.667	2931.667	-0.300989	25	0.76591220	1727.783	1047.844	2.71885	0.270823411
Pollution Sensitive Taxa Abundance	87.3819	93.98	-1.702058	25	0.10114959	9.31136	1.958867	22.59521	0.002649665
Rangia cuneata (%)	**50.16762**	**28.58667**	**2.341554**	**25**	**0.02747467**	**18.14438**	**25.79057**	**2.020401**	**0.238663029**
Marenzelleria viridis (%)	**31.10048**	**60.09333**	**-3.630491**	**25**	**0.00127106**	**15.30641**	**23.47214**	**2.351572**	**0.156454667**
JULY									
Taxa Abundance	1755.714	1486.667	0.766011	25	0.45084203	596.2346	1206.858	4.097115	0.020121193
Pollution Sensitive Taxa Abundance	**89.47611**	**69.99524**	**3.872343**	**25**	**0.00068718**	**10.47094**	**12.32773**	**1.386101**	**0.543075205**
Rangia cuneata (%)	**69.05587**	**35.56005**	**3.741473**	**25**	**0.00095936**	**16.45886**	**28.04563**	**2.903561**	**0.079070815**
Marenzelleria viridis (%)	12.93053	16.11035	-0.662719	25	0.51357449	5.236593	20.67597	15.58958	5.25422E-06
SEPT									
Taxa Abundance	1460.952	1538.333	-0.344551	25	0.73331333	430.2314	660.6789	2.358179	0.155155816
Pollution Sensitive Taxa Abundance	**83.29499**	**52.3051**	**3.8949**	**25**	**0.00064865**	**10.34711**	**32.38669**	**9.797039**	**0.000150478**
Rangia cuneata (%)	65.4691	38.6616	1.977087	25	0.05915916	26.30947	39.0007	2.197458	0.19023423
Marenzelleria viridis (%)	11.07744	2.734247	1.023349	25	0.31594380	19.65265	2.455401	64.06155	0.000208538

G-South (1998) versus Site 92 Reference									
MAY									
Benthic Community Parameter	Mean G-SOUTH	Mean REF	t-value	df	p	Std.Dev. G-SOUTH	Std.Dev. REF	F-ratio variancs	p variancs
Taxa Abundance	**5846.667**	**2931.667**	**3.262983**	**7**	**0.01380741**	**1685.714**	**1047.844**	**2.588063**	**0.338453276**
Pollution Sensitive Taxa Abundance	**97.67**	**93.98**	**3.002993**	**7**	**0.01985788**	**0.988079**	**1.958867**	**3.930308**	**0.430362024**
Rangia cuneata (%)	0.056667	28.58667	-1.851052	7	0.10660241	0.09815	25.79057	69047.07	2.89655E-05
Marenzelleria viridis (%)	88.95333	60.09333	2.051212	7	0.07938825	2.889366	23.47214	65.99336	0.029987519
JULY									
Taxa Abundance	1596.667	1486.667	0.144088	7	0.88949156	662.143	1206.858	3.322071	0.494812377
Pollution Sensitive Taxa Abundance	88.57667	69.99524	2.46309	7	0.04326894	4.294885	12.32773	8.238788	0.223536559
Rangia cuneata (%)	1.143489	35.56005	-2.052195	7	0.07927320	1.543022	28.04563	330.3592	0.006041211
Marenzelleria viridis (%)	**75.46449**	**16.11035**	**4.63836**	**7**	**0.00237418**	**8.80276**	**20.67597**	**5.516889**	**0.321072086**

Table IX-4. Continued

SEPT									
Benthic Community Parameter	Mean G-SOUTH	Mean REF	t-value	df	p	Std.Dev. G-SOUTH	Std.Dev. REF	F-ratio variancs	p variancs
Taxa Abundance	1543.333	1538.333	0.012033	7	0.99073526	342.6855	660.6789	3.716974	0.450974753
Pollution Sensitive Taxa Abundance	84.76157	52.3051	1.666458	7	0.13956185	5.748476	32.38669	31.74152	0.061645234
Rangia cuneata (%)	4.696461	38.6616	-1.456826	7	0.18851049	1.522335	39.0007	656.3332	0.003043986
Marenzelleria viridis (%)	**56.63567**	**2.734247**	**10.61957**	**7**	**0.00001438**	**12.85552**	**2.455401**	**27.41159**	**0.00403907**

Northeast versus Site 92 Reference									
MAY									
Benthic Community Parameter	Mean G-EAST	Mean REF	t-value	df	p	Std.Dev. G-EAST	Std.Dev. REF	F-ratio variancs	p variancs
Taxa Abundance	1630	2931.667	-2.076122	7	0.07652201	81.85353	1047.844	163.8771	0.012152327
Pollution Sensitive Taxa Abundance	**86.42**	**93.98**	**-4.162932**	**7**	**0.00422626**	**3.673255**	**1.958867**	**3.516351**	**0.222611276**
Rangia cuneata (%)	0.42	28.58667	-1.827411	7	0.11036342	0.36428	25.79057	5012.46	0.00039895
Marenzelleria viridis (%)	78.39	60.09333	1.30241	7	0.23398772	2.03315	23.47214	133.2804	0.0149275
JULY									
Taxa Abundance	3500	1486.667	1.254473	7	0.24993361	3793.31	1206.858	9.879254	0.036655893
Pollution Sensitive Taxa Abundance	79.82796	69.99524	0.997502	7	0.35174546	17.32739	12.32773	1.975605	0.466391442
Rangia cuneata (%)	59.53458	35.56005	1.231306	7	0.25796782	26.21819	28.04563	1.144261	1
Marenzelleria viridis (%)	14.89539	16.11035	-0.096663	7	0.92570311	6.092458	20.67597	11.5172	0.163623627
SEPT									
Taxa Abundance	**453.3333**	**1538.333**	**-2.716779**	**7**	**0.02990450**	**158.85**	**660.6789**	**17.29841**	**0.111096211**
Pollution Sensitive Taxa Abundance	29.49495	52.3051	-1.165727	7	0.28190397	7.610321	32.38669	18.11036	0.106302758
Rangia cuneata (%)	13.51291	38.6616	-1.078281	7	0.31665726	2.254971	39.0007	299.132	0.006670396
Marenzelleria viridis (%)	4.915825	2.734247	1.299453	7	0.23494515	2.158036	2.455401	1.294575	0.979774619

NOTE: Parameters in bold type are significant at $p < 0.05$

Table IX-5: Results of T-test Comparisons of the G-South Benthic Community Found During August 1991, August 1992, September 1995, and September 1998

August 1991 (pre-placment) versus August 1992 (post-placement 1yr.)									
Benthic Community Parameter	Mean Aug-91	Mean Aug-92	t-value	df	p	Std.Dev. Aug-91	Std.Dev. Aug-92	F-ratio variancs	p variancs
Taxa Abundance	5985	6360	-0.232732	4	0.82739	360.00	2767.53049	59.09896	0.033278448
Pollution Sensitive Taxa Abundance	78.41	53.67	2.199187	4	0.09274	1.48	19.4263455	173.419	0.01146664
***Rangia cuneata* (%)**	**63.86**	**3.45**	**21.07177**	**4**	0.00003	**4.75**	**1.43542098**	**10.96813**	**0.167110495**
Marenzellaria viridis (%)	6.94	31.97	-1.493096	4	0.20970	5.73	28.4688479	24.68926	0.07785353
September 1998 versus August 1991 (pre-placement)									
Benthic Community Parameter	Mean Aug-91	Mean Sep-98	t-value	df	p	Std.Dev. Sep-98	Std.Dev. Aug-91	F-ratio variancs	p variancs
Taxa Abundance	**5985**	**1543**	**-15.4785**	**4**	0.00010	**342.69**	360.00	**1.103605**	**0.950748874**
Pollution Sensitive Taxa Abundance	78.41	84.76	1.854675	4	0.13724	5.75	1.48	15.18518	0.123569829
***Rangia cuneata* (%)**	63.88	**4.70**	**-20.52912**	**4**	0.00003	**1.52**	**4.75**	**9.751485**	**0.186020807**
***Marenzellaria viridis* (%)**	**6.94**	**58.84**	**6.116114**	**4**	**0.00362**	**12.86**	**5.73**	**5.034396**	**0.331433318**
September 1996 versus September 1998									
Benthic Community Parameter	Mean Sep-96	Mean Sep-98	t-value	df	p	Std.Dev. Sep-96	Std.Dev. Sep-98	F-ratio variancs	p variancs
Taxa Abundance	**2613**	**1543**	**2.568896**	**7**	**0.03707**	**662.19**	**342.69**	**3.733999**	**0.449257878**
Pollution Sensitive Taxa Abundance	67.08	84.76	-1.615672	7	0.15020	17.95	5.75	9.746262	0.191327162
***Rangia cuneata* (%)**	**1.83**	**4.70**	**-2.903392**	**7**	**0.02288**	**1.35**	**1.52**	**1.279152**	**0.711859341**
Marenzellaria viridis (%)	41.87	56.64	-1.114986	7	0.30167	20.62	12.86	2.573199	0.606350834

NOTE: Parameters in bold type are significant at $p < 0.05$

Table IX-6: Results of T-test Comparisons of the Northeast Benthic Community (September 1998) with a Previous Study (September 1995) in the Vicinity of G-East

September 1995 versus September 1998									
Benthic Community Parameter	Mean Sep-96	Mean Sep-98	t-value	df	p	Std.Dev. My98	Std.Dev. Jl98	F-ratio variancs	p variancs
Taxa Abundance	4519.4	453.3333	1.560859	6	0.1695785	4367.304	158.850	755.879	0.003
Pollution Sensitive Taxa Abundance	55.224	29.49495	1.478571	6	0.1897356	28.682	7.610	14.204	0.134
Rangia cuneata (%)	33.644	13.51291	1.159961	6	0.2901318	29.061	2.255	166.094	0.012
Marenzelleria viridis (%)	2.4644	4.915825	-2.244248	6	0.0659607	1.013	2.158	4.534	0.187

NOTE: Parameters in bold type are significant at $p < 0.05$

Figure IX-1. Total Infaunal Abundance at Northeast Station, MDE-R2, July and September 1998

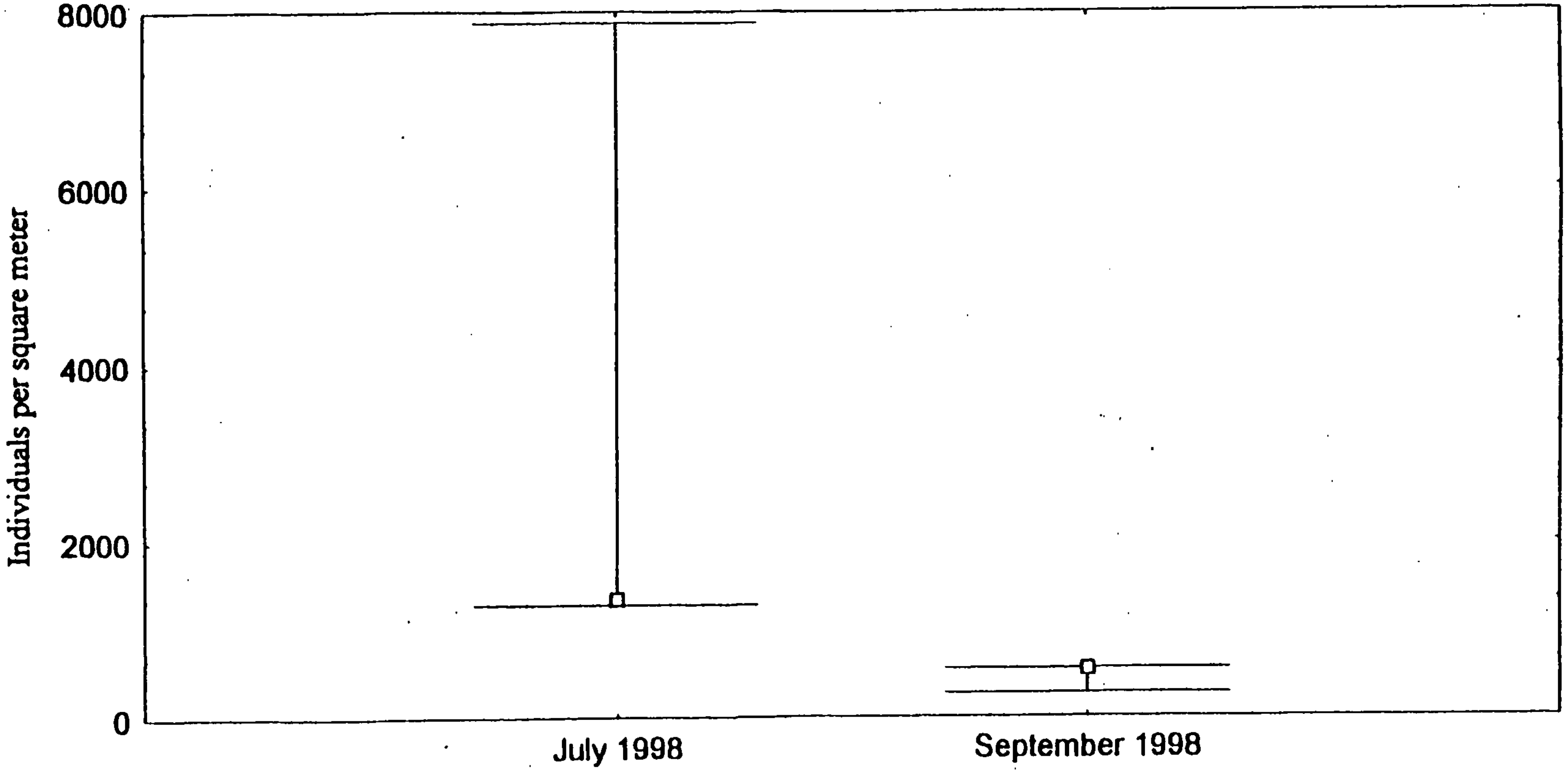


Figure IX-2. Total Abundance at the Northeast Station, MDE-R2, in September 1998, and in the vicinity of G-East during September 1995.

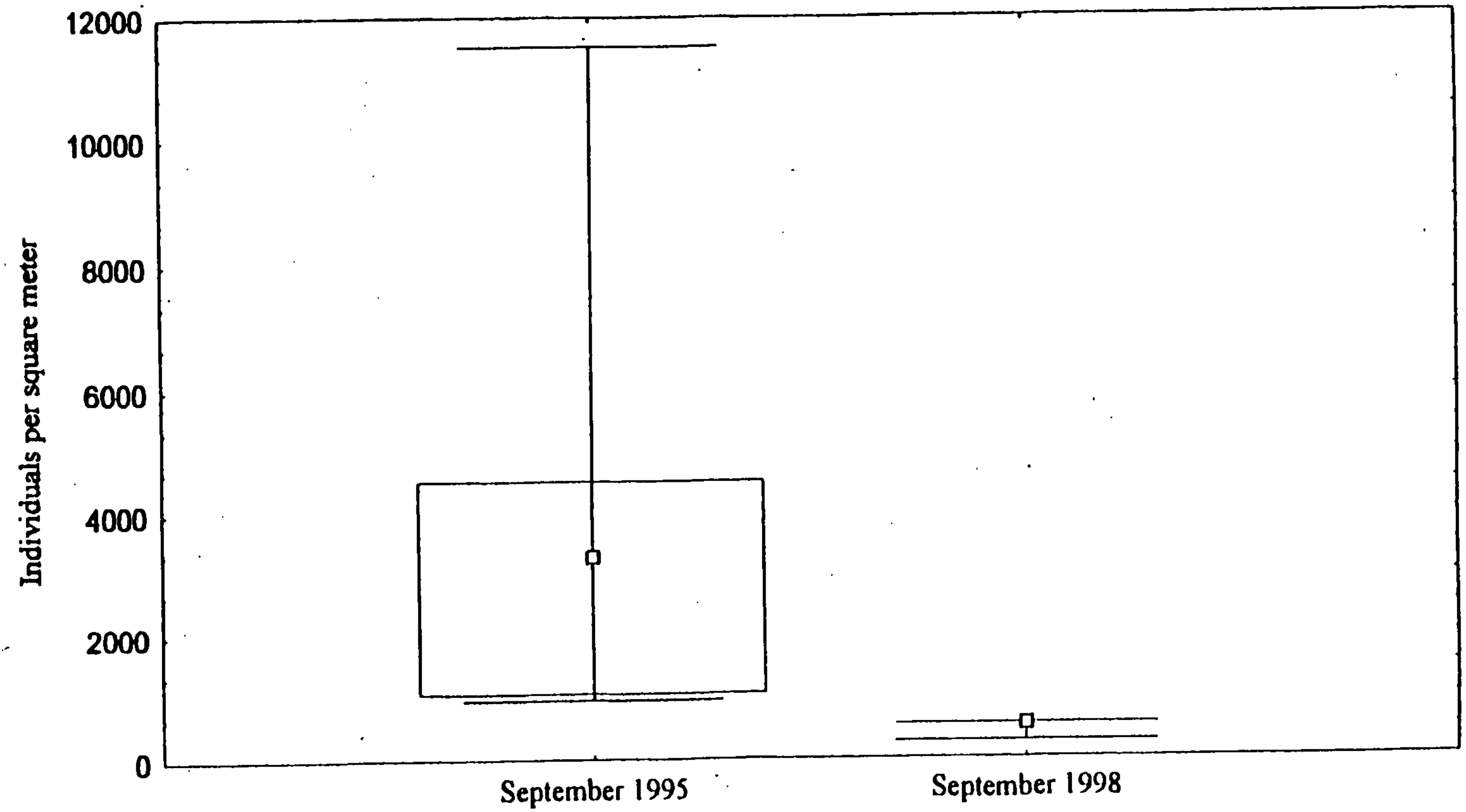
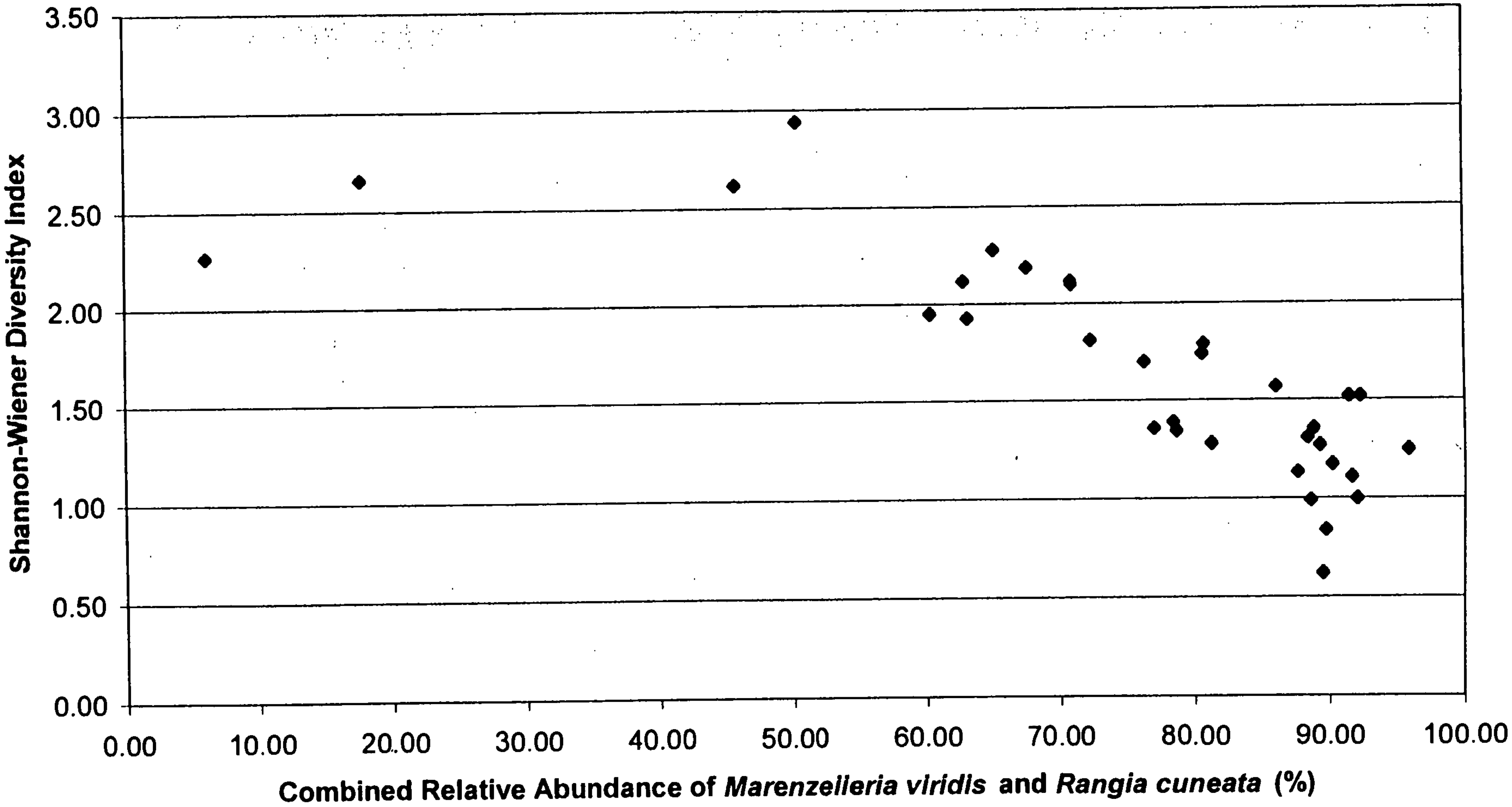


Figure IX-3. Relationship of the Combined Relative Abundance of *Marenzelleria viridis* and *Rangia cuneata* to the Shannon-Wiener Diversity Index at Pooles Island, 1998



APPENDIX X

BENTHIC COMMUNITY SUMMARY TABLES
FOR SITE 92
MAY, JULY AND SEPTEMBER 1998

Table X-1. Average taxa abundance (per m^2) and composite metric values for *Inner*, *Reference*, *G-South* and *Northeast* Stations, May 1998

	STATION										
TAXON	S92-1	S92-2	S92-3	S92-4	S92-5	S92-6	S92-7	S92-R1	S92-R2	MDE-R1	MDE-R2
NEMERTINEA •											
Carinoma tremephoros	37	23	37	20	20	3	30	10	10	7	13
MOLLUSCA											
Macoma balthica +	10	3	10		7		13		3		
Rangia cuneata +	563	2693	2983	230	1517	490	2107	1890	127	3	7
ANNELIDA											
POLYCHAETA											
Hobsonia florida	3		3							17	7
Marenzelleria viridis +	540	1517	653	387	1973	177	833	1487	1780	5233	1277
Neanthes succinea •	3	3	20	10	10	50		57	30	10	83
OLIGOCHAETA											
Tubificidae											
Tubificoides sp	17		10	3		3	3	13		37	3
ARTHROPODA											
Balanus improvisus°						3			13		147
Rhithropanopeus harrisii°	3			3		10				3	83
ISOPODA											
Cyathura polita +•	120	80	113	107	167	80	100	137	110	483	123
Chiridotea almyra •				3			3				
Edotea triloba°	10	7	33	3	20		10		10	3	
AMPHIPODA											
Americoludes spp. complex	3	7	30	10	17	17	43	23	27	20	10
Apocorophium lacustre°	3		7		3	17		13	17	87	10
Gammarus daiberi	10	17	20	3	23	23	37	20	60	30	40
Leptocheirus plumulosus	313	37	210	97	107	97	207	53	23	7	47
Melita nitida°									3		17
INSECTA											
Chironomidae •											
Coelotanypus sp #•	10	7					3				3
Procladius sp #•	3	3					3		3		7
Crytochironomus sp •											3
Polypedilum sp •											3
Dicrotendipes sp •											3
Total Abundance (#/m^2)	1633	4390	4090	870	3840	940	3183	3690	2173	5847	1630
Taxa Richness[1]	13	11	11	10	9	9	12	9	10	10	15
Shannon-Wiener Diversity Index [2]	2.19	1.25	1.36	2.12	1.52	2.10	1.57	1.52	1.13	0.62	1.35
Pollution-Indicative Taxa Abundance	0.80	0.21	0.00	0.00	0.00	0.00	0.18	0.00	0.10	0.00	0.63
Pollution-Sensitive Taxa Abundance	74.76	97.77	89.60	83.87	95.40	79.74	90.54	95.23	92.72	97.67	86.42

Note 1: Only Infaunal taxa have been included in metric calculations

Note 2: Revised from Delal et al. 1998a

Pollution-Indicative Taxon

+ Pollution-Sensitive Taxon

° Epifaunal Taxon

• Carnivore/Omnivore Taxa

[1] Taxa Richness for the composite is the total number of taxa for all replicates.

[2] Shannon-Wiener Diversity Index was calculated based on a composite of the 3 replicates

Table X-2 Average taxa abundance (per m^2) and composite metric values for *Inner*, *Reference*, *G-South* and *Northeast* Stations, July 1998

	STATION										
TAXON	S92-1	S92-2	S92-3A	S92-4A	S92-5	S92-8	S92-7	S92-R1	S92-R2	MDE-R1	MDE-R2
NEMERTINEA •											
Carinoma tremaphoros •	37	33	23	37	33	17	7	27	27	17	7
MOLLUSCA											
Hydrobia sp.	7				3		3	7			3
Bivalvia					3						
Congeria sp. •					3			7			3
Macoma balthica +			7	10			17	3			
Rangia cuneata +	2213	1797	937	923	390	1093	1577	1460	83	23	2727
ANNELIDA											
POLYCHAETA											
Heteromastus filiformis								13	3		
Hobsonia florida	7				3					10	
Marenzelleria viridis +	197	270	180	280	150	227	223	87	170	1230	370
Neanthes succinea •					13	23	3	50	30	13	20
Polydora cornuta	33	17	3	80	97	33	37	423	30	3	107
Streblospio benedicti #			10	10	17	3		80	7		
OLIGOCHAETA								3			
Tubificoides sp	3			3	27	3	3	133	7	3	17
ARTHROPODA											
Balanus improvisus•					40		3		70		
Rhithropanopeus harrisii•					13	3		30	40	17	
Crangon sp.									3		
ISOPODA											
Cyathura polita +•	57	87	63	117	180	133	97	97	147	180	93
Chiridolea almyra •	10	3	7		7	3		7		23	37
Edolea triloba•	10	17	3		3	27		23	3	13	20
AMPHIPODA											
Amerocoludes spp. complex	27	30	10	7	50	83	13	43	7	27	47
Apocorophium lacustre•										7	3
Gammarus sp.	20	10			23	17	3	3	17	23	57
Leptocheirus plumulosus	7		3	17	37	13	10	13		60	0
Melita nitida•								3	60	10	3
INSECTA											
Chironomidae •											
Coelotanypus sp #•					10			7			3
Procladius sp #•	3			3	33	7	3	10	3		13
Cryptochironomus sp •	3	7	3	3	3			7		3	
Polypedilum sp •											3
Total Abundance (#/m^2)	2617	2253	1227	1490	1073	1637	1993	2463	510	1597	3500
Taxa Richness[1]	13	9	11	12	16	13	12	17	12	13	13
Shannon-Wiener Diversity Index [2]	1.00	1.11	1.27	1.79	2.94	1.74	1.17	2.12	2.62	1.39	1.31
Pollution-Indicative Taxa Abundance	0.11	0.00	0.73	1.00	6.70	0.56	0.14	3.35	1.37	0.00	1.29
Pollution-Sensitive Taxa Abundance	94.39	95.59	95.13	89.34	66.58	89.20	96.11	67.95	72.04	88.57	79.83

Note 1: Only infaunal taxa have been included in metric calculations

Note 2: Revised from Dalal et al. 1998b

\# Pollution-Indicative Taxon

\+ Pollution-Sensitive Taxon

• Epifaunal Taxon

• Carnivore/Omnivore Taxa

[1] Taxa Richness for the composite is the total number of taxa for all replicates.

[2] Shannon-Wiener Diversity Index was calculated based on a composite of the 3 replicates

Table X-3. Average taxa abundance (per m²) and composite metric values for *Inner*, *Reference*, *G-South* and *Northeast* Stations, September 1998

	STATION										
TAXON	S92-1	S92-2	S92-3A	S92-4A	S92-5	S92-6	S92-7	S92-R1	S92-R2	MDE-R1	MDE-R2
NEMERTINEA •											
Carinoma tremephoros •	20	33	23	30	17	20	30	27	23	50	30
MOLLUSCA											
Mytilopsis leucophaeata•			3	10		7		10	7	3	3
Macoma balthica +	7			3			3		3		
Macoma mitchelli				10	3				3		
Rangia cuneata +	70	817	1187	1133	1110	957	1803	1587	30	70	60
ANNELIDA											
POLYCHAETA											
Helermaslus filiformis						3	3	7	3		
Hypereleone heteropoda		7	3		17	7		3	7	3	3
Hobsonia florida	13								3.	30	
Marenzelleria viridis +	533	53	63	30	100	13	47	80	27	903	20
Neanthes succinea •	47	33	63	73	220	313	47	310	510	53	183
Polydora cornuta											
Streblospio benedicti #	23	43		3	10	33	3	7	60	17	30
OLIGOCHAETA											
Tubificoides sp	13	30			7	57		3	73		80
ARTHROPODA											
Balanus improvisus•						83			110	3	137
Rhithropanopeus harrisii•			3		3	3			40	3	
Neomysis americana					3						
ISOPODA											
Cyathura polita +•	100	87	53	103	87	110	100	93	183	347	47
Chiridotea almyra •										3	
Edotea triloba•	33	7	10	3	13	33	3	13	10	80	
AMPHIPODA											
Ameroculodes spp. complex	17	17	7	10	40	70	7	23	23	27	20
Apocorophium lacustre•							3	13			
Gammarus sp.										3	
Gammarus mucronatus					3						
Leptocheirus plumulosus	80	3		27	47	23		13	7	37	
Melita nitida•									17		
INSECTA											
Chironomidae •											
Coelotanypus sp #•	23	17	7	7	13	3	17	3	3		
Total Abundance (#/m²)	927	1140	1387	1430	1673	1610	2060	2137	940	1543	453
Taxa Richness[1]	12	11	8	11	13	12	10	12	15	12	9
Shannon-Wiener Diversity Index[2]	2.28	1.70	0.99	1.28	1.81	1.95	0.84	1.36	2.27	1.93	2.66
Pollution-Indicative Taxa Abundance	5.48	6.04	0.72	0.65	2.28	2.49	1.07	0.64	7.09	1.43	8.00
Pollution-Sensitive Taxa Abundance	77.32	83.46	92.36	88.97	78.34	67.99	94.63	81.38	23.23	84.76	29.49

Note: Only infaunal taxa have been included in metric calculations

•Epifaunal Taxon

\# Pollution-Indicative Taxon

\+ Pollution-Sensitive Taxon

• Carnivore/Omnivore Taxa

[1] Taxa Richness for the composite is the total number of taxa for all replicates.

[2] Shannon-Wiener Diversity Index was calculated based on a composite of the 3 replicates