Overview of the Program

Disposal Area Monitoring System DAMOS

December 1985

US Army Corps
of Engineers
New England Division

DAMOS

DISPOSAL AREA MONITORING SYSTEM

Overview of the Program

Dredged Material Management Section
Regulatory Branch
Operations Division
New England Division
US Army Corps of Engineers
Waltham, MA 02254

December 1985

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*NOTE: Although the chronology in Table 5-1 begins in January 1981, the text of this report relates DAMOS activities since the program's inception in 1977.

OVERVIEW OF DAMOS PROGRAM

1.0 INTRODUCTION

The Disposal Area Monitoring System (DAMOS) program was initiated in 1977 by the New England Division (NED) of the U.S. Army Corps of Engineers to provide scientific data for management and monitoring of dredged material disposal sites throughout New England. During the eight years since its inception, DAMOS has developed into a comprehensive, multi-disciplined program with flexibility to address the many important site-specific parameters required by NED to manage disposal operations.

During the first three years of the program, an Annual Report was produced and a symposium was held to disseminate the results of the monitoring efforts. This also provided an opportunity for peer review of the scientific aspects of the program and suggestions for future work. However, between 1980 and 1983, the major thrusts of DAMOS were related to a few comprehensive studies, such as the Stamford/New Haven Capping Project and the Field Verificaton Program (FVP), which had their own public and scientific reporting and review provisions, and since these forums were available for dissemination of information, the DAMOS symposia were discontinued.

During the latter part of 1983 and 1984, the DAMOS program was again expanded to cover a number of disposal sites and, as a result of previous work, has included new procedures and approaches to monitoring and management that can be applied to future projects. Therefore, the New England Division sponsored a symposium in January 1985 where the approaches, techniques, and status of the DAMOS program were presented for review by state and federal agencies, concerned environmental groups and the public in general.

An earlier (and very similar) version of this summary report was prepared to provide background information for people attending the symposium. It was supported by three additional volumes of information and data submitted to NED. The structure of the four volumes is indicated on the next page. Following the symposium, the New England Division, based on favorable response to the overview volume, decided to update that volume and issue it in this format in the hope that it will be useful to people who want more information about DAMOS than a single-sheet handout can provide but who do not have the time to read through all of the other volumes.

DAMOS
DISPOSAL AREA MONITORING SYSTEM
Summary of Program Results
1981-1984

VOLUME

*I. Overview of DAMOS Program

II. DAMOS Studies at Central Long Island Sound Disposal Site

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- II. Ongoing Surveys
- III. Field Verification Program

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Section
- I. Western Long Island Sound Disposal Site
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Section
- I. Development of DAMOS Data Base Management System
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- III. Mussel Watch Program
- IV. Mass Balance Calculations
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- VI. Submersible and ROV Surveys at Deep Water Disposal Sites
- VII. Green Harbor Wave Climate

* Note: As indicated above, this Overview was adapted from Volume I of a series of summary reports prepared in 1985 describing DAMOS activities. While the emphasis in those reports was on the period of 1981-1984, they cover a wide range of subjects to considerable detail, as indicated above. This Overview provides a synopsis of those reports. Table 5-2 lists earlier, additional reports on specific subjects.

2.0 DESCRIPTION OF THE DAMOS PROGRAM

The DAMOS program has developed into a multi-disciplined project covering many aspects of dredged material disposal management and monitoring. The project is managed by the Dredged Material Management Section of the New England Division's Regulatory Branch through a contract to Science Applications International Corporation (SAIC). Dr. Robert Morton is the SAIC Program Manager for DAMOS, with responsibility for coodination of field activities, analysis and interpretation of data and reporting of results. Because of the broad scope of work required to conduct a monitoring program of this nature, several subcontracts with local universities and companies are also managed by SAIC. Use of the subcontractors provides an ability to achieve technical expertise in various fields of study and specific knowledge of local conditions, while maintaining overall program direction, as well as consistency in sampling and analysis procedures.

The DAMOS program was started and developed in response to unique situations prevailing in New England relative to management of dredged material disposal. Specifically, the New England region requires dredging from a wide range of estuaries and disposal of material in a variety of disposal sites, and therefore, a flexible management plan capable of addressing the individual parameters of each situation. Consequently, DAMOS has always been dynamic, changing in accordance with the results obtained and the requirements of the New England Division; however, the primary objective of the program has always been to investigate and control the physical, chemical, and biological impacts of dredged material disposal operations. Figure 2-1 presents an overview of the DAMOS program, including the names and affiliations of principal investigators. All of the measurements are intergrated through a common data base maintained by SAIC. Bathymetric and side scan procedures are employed to assess the distribution of material; current, wave, and suspended sediment measurements are used to characterize the energy regime of disposal sites; benthic sampling, REMOTS photography, and diving operations are applied to assess biological response to disposal; and in-situ measurement of bioaccumulation in mussels are used to evaluate the potential uptake of contaminants.

Measurements are currently made throughout the New England region at the disposal sites shown in Figure 2-2. In addition to monitoring of disposal operations, the basic principles of in-situ measurements are also applied to other aspects of disposal management such as site designation, control of disposal procedures and development of management strategies such as containment, capping, burial, or point dumping.

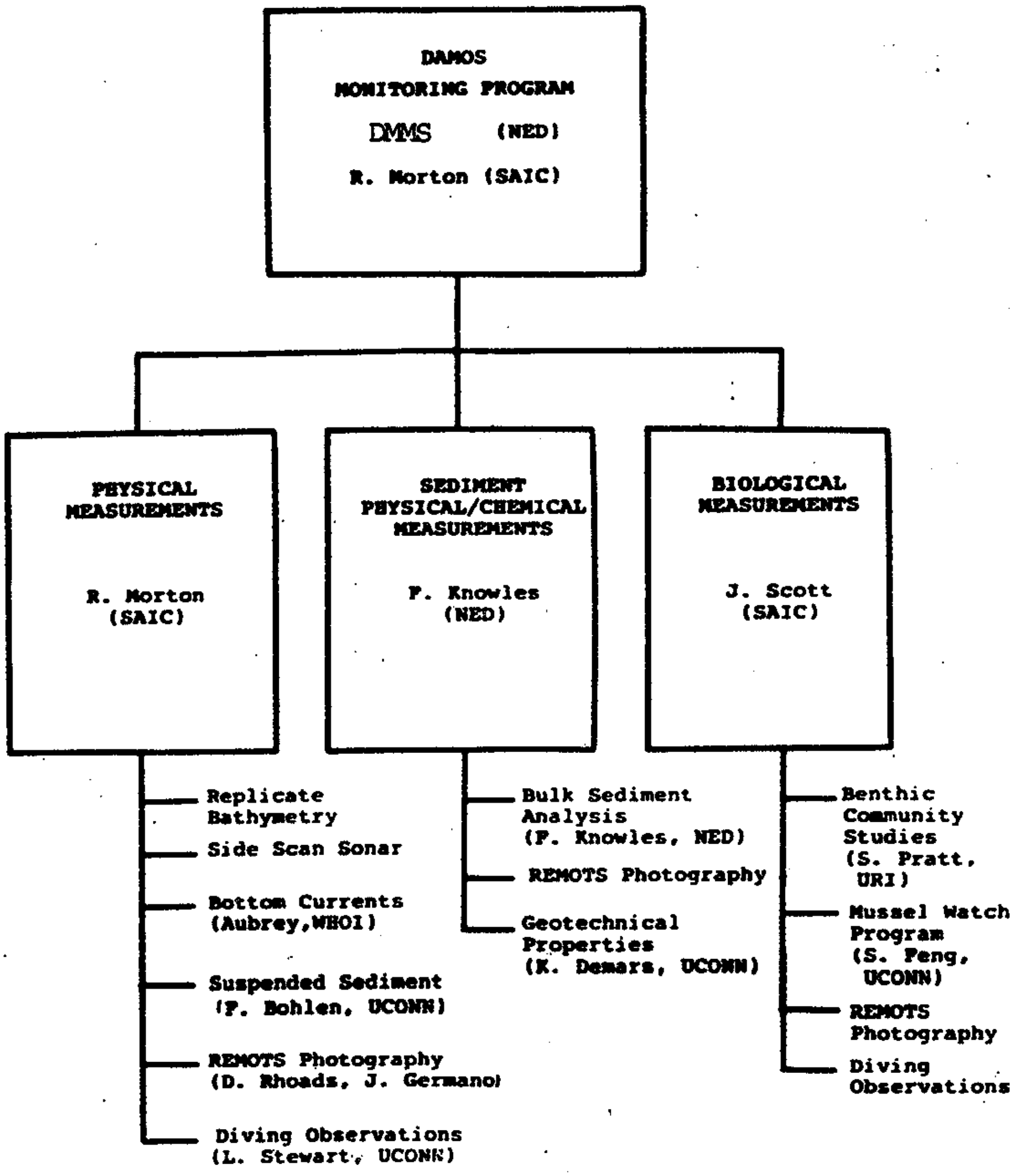


Figure 2-1. Components of DAMOS Program

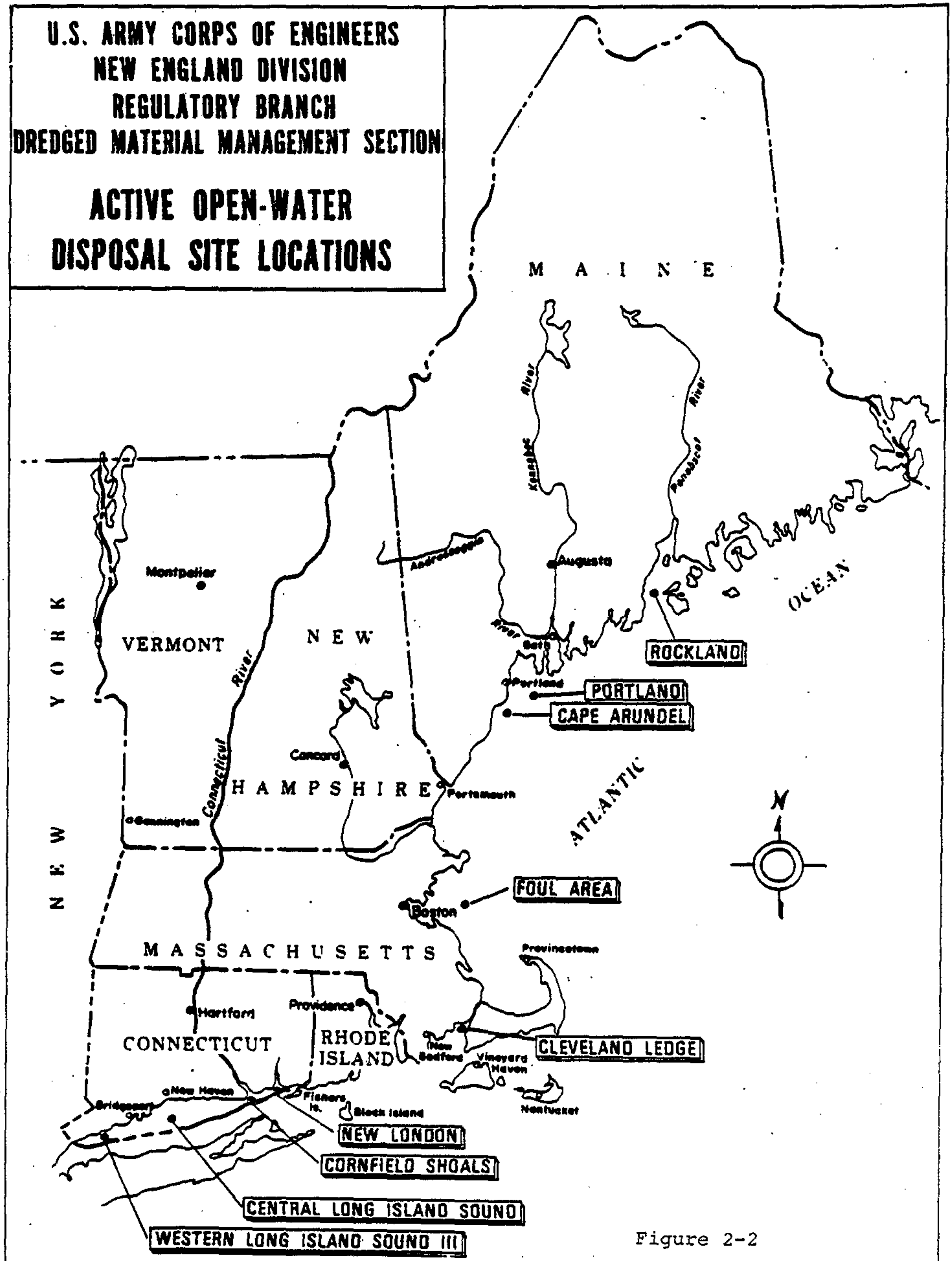

U.S. ARMY CORPS OF ENGINEERS
NEW ENGLAND DIVISION
REGULATORY BRANCH
DREDGED MATERIAL MANAGEMENT SECTION
ACTIVE OPEN-WATER
DISPOSAL SITE LOCATIONS
MAINE
NEW YORK
VERMONT
NEW HAMPSHIRE
MASSACHUSETTS
CONNECTICUT
RHODE ISLAND
ATLANTIC OCEAN
N
Kennebec River
Penobscot River
Androscoggin River
Connecticut River
Augusta
Bath
Portland
Portsmouth
Concord
Montpelier
Bennington
Boston
Provincetown
Hartford
Providence
New Bedford
Vineyard Haven
Nantucket
New Haven
Bridgeport
Fishers Is.
Block Island
ROCKLAND
PORTLAND
CAPE ARUNDEL
FOUL AREA
CLEVELAND LEDGE
NEW LONDON
CORNFIELD SHOALS
CENTRAL LONG ISLAND SOUND
WESTERN LONG ISLAND SOUND III

Figure 2-2

All of the measurements described above are tied to an overall assessment of the impacts of dredged material disposal on both a short and long term basis. Measurements of the volume and distribution of dredged material at a site are combined with bulk sediment analysis to obtain an understanding of the potential exposure levels of contaminants available to the biota in the region. Close monitoring of long-term changes, with concurrent measurements of physical parameters at the site provide an estimate of the potential availability of contaminated material that is actually exposed to the environment. Finally, assessments of the impact on local biota through benthic population studies and bioaccumulation measurements provide insight into dosage response, long term effects and the possible link to impact on human activity.

The DAMOS program utilizes modern instrumentation and sampling procedures to insure that monitoring of disposal is maintained at the highest level possible considering the funding available. One important aspect of the instrumentation that was started during the original DAMOS effort and that has been maintained throughout the program has been the use of an accurate navigation system applied to bathymetry, sediment sampling, and all other monitoring operations. This system, provided by SAIC, uses microwave positioning units interfaced to computerized navigation and data acquisition systems to reduce the error in replicate sampling and surveying to less than ± 5 meters. As a result of these procedures, sampling programs are based on disposal mound topography and on the distribution of dredged material observed at the site. Differences observed within and between surveys can thus be attributed to actual gradients resulting from disposal rather than to random variability of the bottom within a disposal area. Diving observations coordinated with remote measurements have confirmed this ability to distinguish small scale changes.

Measurements of physical conditions at the site have been conducted over the years using several different instrumentation packages. Mean current velocity one meter above the bottom and at various levels in the water column have been obtained using ENDECO ducted impeller current meters. Measurements of stress exerted on the bottom and turbulent flow in the bottom boundary layer were measured by the Boundary Layer Turbulence (BOLT) System. Additional measurements of boundary layer flow and corresponding levels of suspended sediment load have recently been conducted by Dr. Frank Bohlen of the University of Connecticut (UCONN), utilizing the Disposal Area In-Situ System (DAISY) at the New London and Central Long Island Sound Disposal Sites. Dr. David Aubrey of WHOI has measured the wave energy in the vicinity of Green Harbor for evaluation of potential dredging and disposal operations.

Physical, chemical and geotechnical parameters of the disposed dredged material and natural bottom are measured using a variety of techniques. SAIC personnel are utilizing a Nuclear Density Probe for in-situ measurement of sediment density, which is then combined with geotechnical data obtained through core sampling and laboratory procedures by Drs. Kenneth Demars and Richard Long of UCONN. Sediment samples are obtained at appropriate locations using a Smith-McIntyre grab sampler, immediately iced, and sent to he NED laboratory where physical and chemical measurements are conducted under the direction of Forrest Knowles. During the early stages of the DAMOS program, interpretation of chemical data was accomplished under the direction of Dr. Everett Jones of NUSC (Naval Underwater Systems Center).

Recent work at several of the DAMOS sites has emphasized the use of sediment-water interface photography with the REMOTS camera. This camera provides information combining the distribution of dredged material, measurement of the physical properties of the sediment, limited chemical data and substantial insight into the benthic population. Interpretation of REMOTS photographs by Drs. Donald Rhoads and Joseph Germano has added significantly to the overall understanding of disposal sites in Long Island Sound, and is now being applied to other areas as well.

Benthic infaunal samples are taken at several disposal sites, primarily as background information to assess the nature of the benthic community structure. Samples are sieved aboard ship and provided to Mr. Sheldon Pratt of the University of Rhode Island (URI) for taxonomic identification. Following identification, analysis of the results is performed by Drs. K. John Scott and Charles Comiskey of SAIC in conjuction with Mr. Pratt. A study of the long term impact of disposal at the CLIS site also includes Drs. Albert Brooks of NUSC and Donald Rhoads, who have previously studied the benthic infauna of the site.

Monitoring of contaminant uptake by the blue mussel Mytilius edulis is conducted under the direction of Dr. Sung Feng of UCONN. This procedure, which has always been a major portion of the DAMOS program, has recently been confined to active sites, particularly CLIS and WLIS III, where dispersion of contaminants beyond the disposal site is of primary concern. Mussels collected from a control population of Latimers Light in Fishers Island Sound are placed on a PVC platform one meter above the bottom in the vicinity of the disposal point and at a reference station located on natural bottom. These platforms and the control population are sampled monthly and the mussels are analyzed to determine bioaccumulation and depuration of contaminants, including trace metals and PCB's.

Visual observations of the disposal site are made under the directon of Dr. Lance Stewart, also of UCONN. Several methods have been utilized for these observations including: in-situ diver operations which consist of transects across the disposal site acquiring epibenthic samples, observing the physical properties and distribution of dredged material, and taking photographs of important fauna and sediment conditions, use of remote controlled underwater TV, again providing transects across deeper disposal sites where diving operations are not practical, and application of submersibles and Remote Operated Vehicles (ROV's) to baseline and post-disposal characterization of deeper sites.

Other projects are often undertaken as part of the DAMOS program, either in response to emergencies, as part of disposal management procedure or to develop new techniques for monitoring of disposal sites. When a submarine ran aground at the New London Disposal Site, DAMOS personnel immediately conducted bathymetric surveys and obtained sediment samples so that dredging of the site could be conducted to remove shoal areas. DAMOS personnel also provide support in the control of buoys for point dumping, providing Loran-C control systems for implementation of disposal procedures.

3.0 HISTORY OF THE DAMOS PROGRAM

The DAMOS program began during 1977 as a result of studies conducted by personnel at the Naval Underwater Systems Center (NUSC) to address the public concerns related to disposal of dredged material from the Thames River in New London, Connecticut. In order to address these concerns, the New England Division (NED) agreed to initiate a regional monitoring program to determine the short and long term impacts of open water disposal throughout New England.

During the first year of the program, the major emphasis was placed on acquisition of baseline data at the ten sites shown in Figure 3-1. All sites were surveyed using the precision navigation and data acquisition system to obtain bathymetric charts of the site. Sediment and benthic samples were taken at specific locations within each site and currents were measured to assess the containment potential of the oceanographic regime. Table 3-1 presents a summary of the characteristics of each site and Figure 3-2 provides a comparison of the current velocities for several sites. Most of these sites had been used for disposal of dredged material prior to 1977, however, Portland, Isles of Shoals and WLIS were all examined as potential sites for new disposal operations. Previous disposal operations were controlled to some extent at

TABLE 3-1

Characteristics of Original Regional Disposal Sites Studied Under the Damos Program

SITE	MUSSEL REFERENCE STATION	DEPTH(m)	ENERGY REGIME	ENERGY RANKING	SEDIMENT CHARACTER	HISTORY	DREDGED MATERIAL DISTRIBUTION	DREDGED MATERIAL CHARACTER
Rockland	Drunkard's Ledge	65-85	Currents	High	Silty Clay	'74,Camden Rockland	Scattered (mound reported)	Organic mud
Portland	Bulwark Shoal	60	Wave	Low	Rock out-crops, sand	New	-	-
Isle of Shoals	Smutty nose	75	Wave	Low	Mud	New	-	-
Boston Foul Ground	Halfway Rock	90	Wave	Low	Mud	Continuous permit	Scattered	Black organic oily mud
Boston Lightship	Halfway Rock	60	Wave	Low	Mud	Continuous permit	Near Buoy	Construction rocks
Brenton Reef	Ocean Drive	03	Wave	Low	Sand	'74, Provi dence	Mound	Organic mud covered with sand
New London	Latimer's Light	20	Currents	High	Sand	'77, New London	Two mounds	Variable silty sands
Cornfield Shoals	1.6 kM NNW	55	Currents	High	Sand & Gravel	'77, North	Scattered	Black oily silt
New Haven	3.2 km NW	20	Currents	Medium	Soft silky clay	'74, New Haven, Stam-ford-New Haven	Mound	Variable sands, silt, and clay
Western L.I. Sound	Easton's Neck	30	Currents	Medium	Soft silty clay	New	-	-
Cable & Anchor Reef	Easton's Neck	30	Currents	Medium	Soft silty clay		Two Mounds	

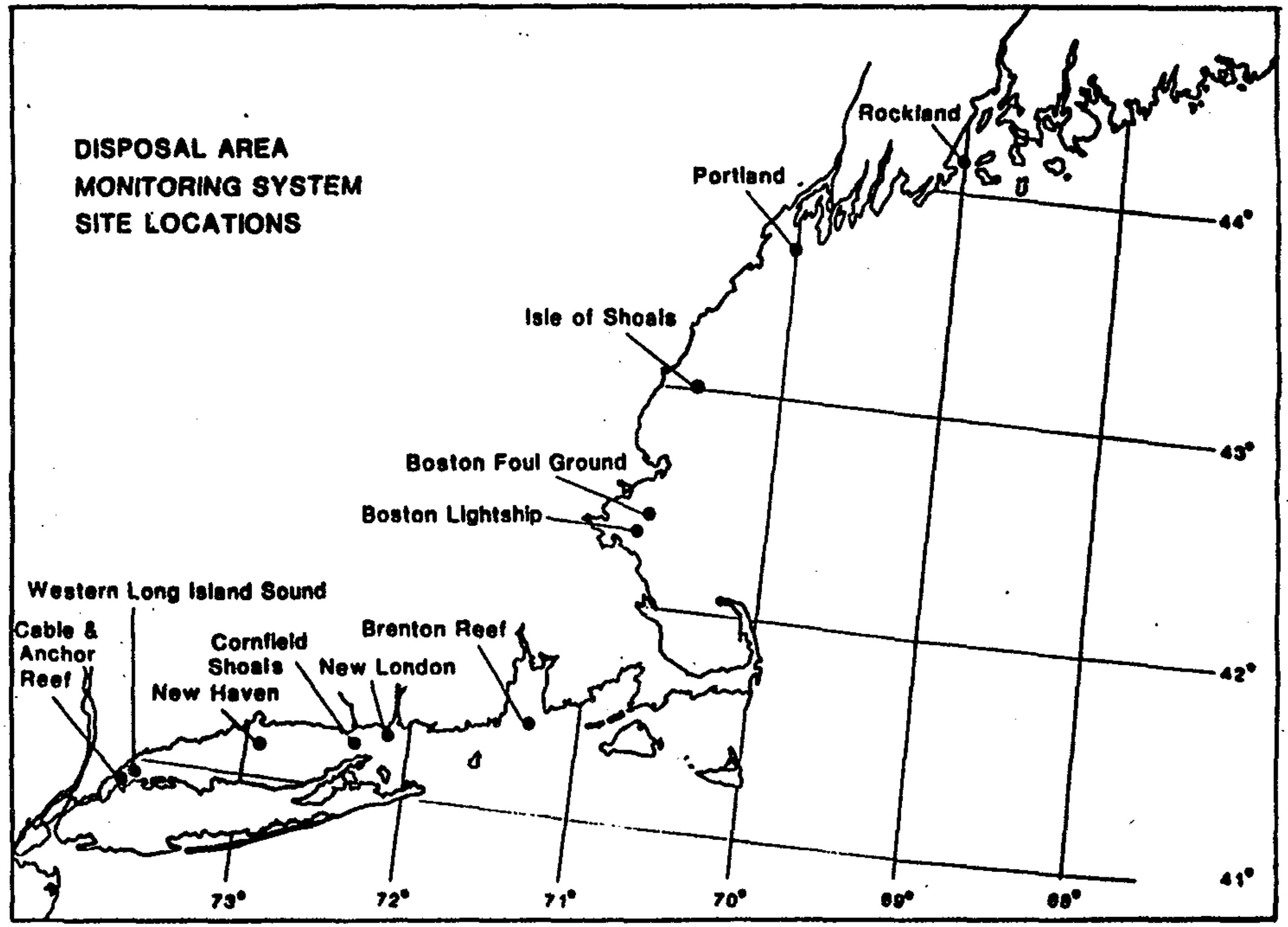


Figure 3-1. Initial DAMOS disposal sites.

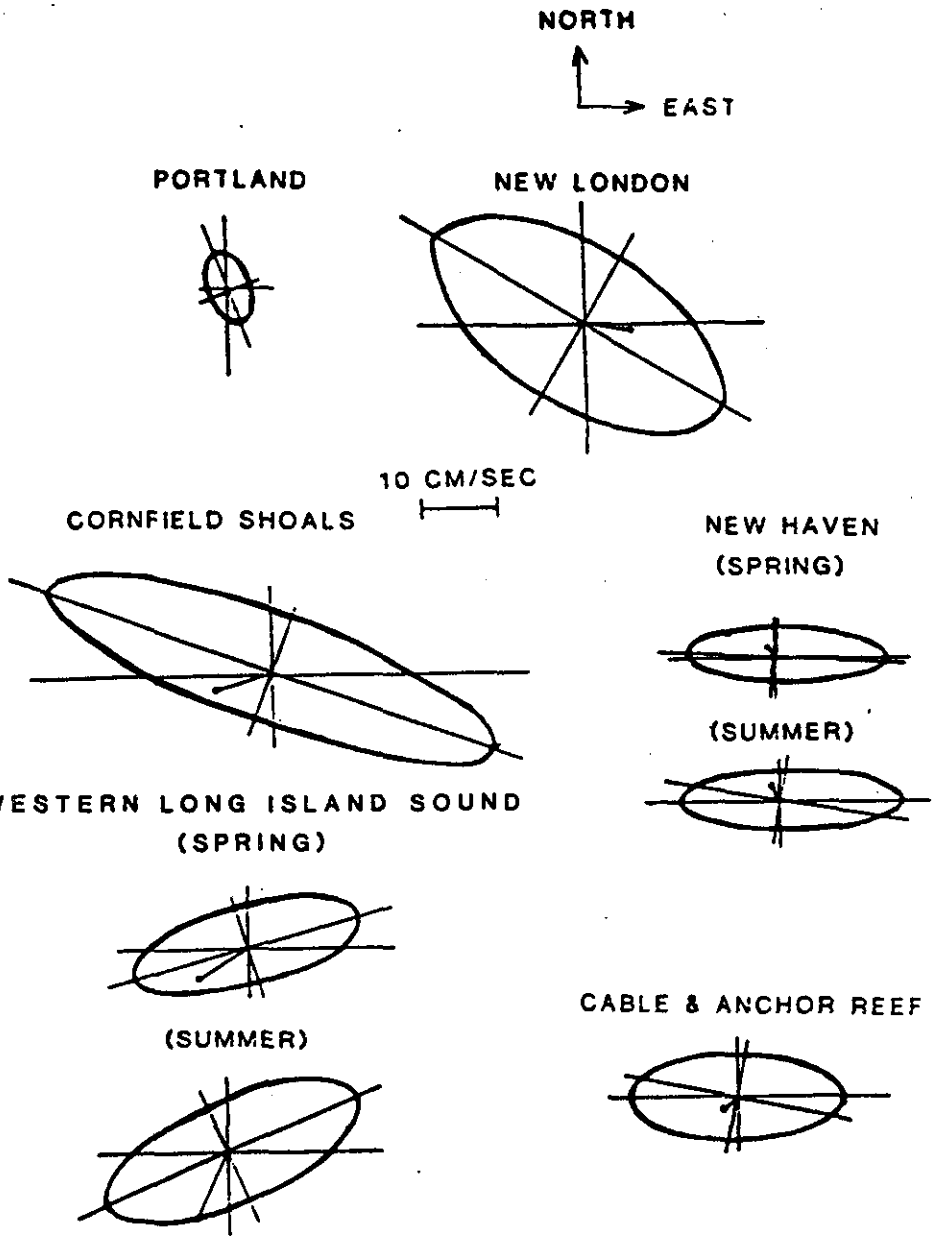


Figure 3-2. Total Motion Ellipses for DAMOS Disposal Sites

the Brenton Reef, New London, New Haven and Cable and Anchor Reef sites, where dredged material mounds were created. Disposal at Rockland, the Massachusetts Bay sites and Cornfield Shoals was less controlled and produced scattered deposits of dredged material over a larger area.

In general, the disposal sites can be divided into two major types; those located in deep, open water environments with low tidal currents, where wave action, though reduced because of depth, is the only source of substantial energy; and enclosed, shallow water sites with limited wave fetch, where tidal currents are relatively strong. Under normal conditions, all sites, except for the Cornfield Shoals area, are containment sites and, except for Cornfield Shoals and Portland, all have a soft, mud bottom. Although they are generally low energy regions, all of these sites can potentially be affected by storm events which could significantly increase the stress exerted on the bottom sediment and dredged material, and thus create a possibility for erosion and transport. Consequently, a major emphasis of the DAMOS program was initiated to evaluate the interaction between the dredged material and the overlying water column.

This was accomplished through bottom boundary layer current measurements made in conjunction with in-situ sediment sampling to relate stress exerted on the bottom to erosion of dredged material. In addition, a program was established to measure suspended sediment loads over the disposal sites to examine the response of the dredged material and natural bottom to strong, high energy storm events. If erosion were to occur, then the potential impact on the surrounding area should be a function of the contaminant level of the dredged material relative to natural conditions. Consequently, another section of the DAMOS program was started to conduct bulk sediment analyses for assessment of the potential impact and identification of dredged material at the disposal site.

In general, the contaminant level of dredged material was found to be higher than natural sediment. Figure 3-3 shows the concentration of copper relative to iron for harbor sediments from the western end of Long Island Sound. Iron is used as an indicator of natural metal accumulation in the sediment since it is readily available throughout the marine environment. An enrichment of a metal such as copper relative to iron indicates the anthropogenic input or contamination of the sediment. From these figures it is readily apparent that, although the natural sediments at the disposal sites are quite low in copper, the sediment from the harbors can have a wide range of copper concentration, sometimes an order of magnitude higher than offshore sediments, but often at the same level of enrichment. For example, sediments from New Haven and Norwalk harbors, as well as natural sediment at the disposal site, all have Cu/Fe ratios of .05 - .10, even though Cu levels are as high as 300 ppm, indicating relatively clean sediments. Conversely, sediments from Stamford Harbor have Cu/Fe ratios greater than .2 and as high as .3, showing definite contamination.

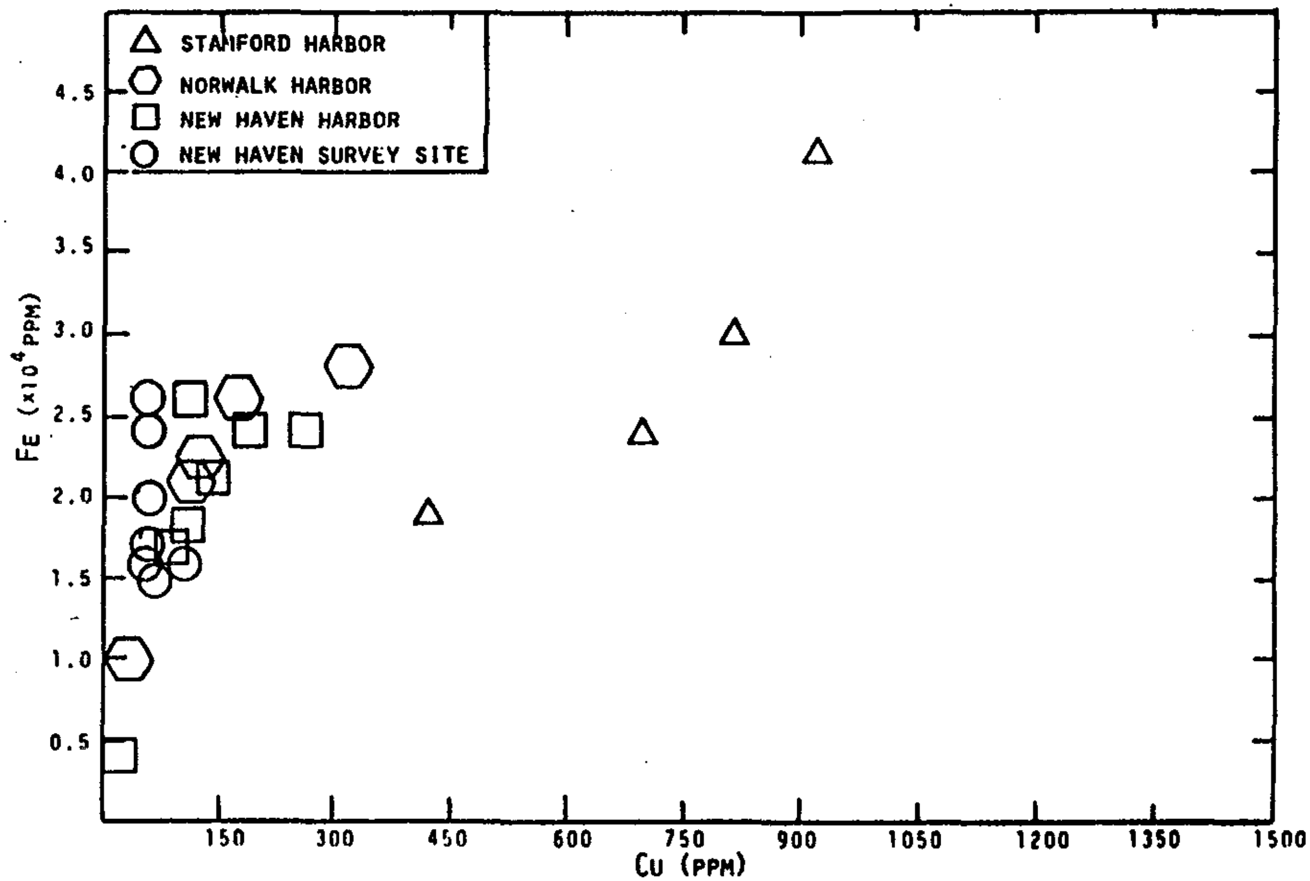


Figure 3-3. Regional Distribution of Copper Concentration Stamford to New Haven

Analysis of dredged material at the disposal sites has often revealed the higher concentrations of metals in the sediments, but more significantly has displayed a higher coefficient of variation in metal concentration than natural sediment. Figure 3-4 reflects these results extremely well. This figure compares the concentration of copper and the coefficient of variation of copper in natural sediment at the STNH-N site prior to disposal, with relatively contaminated disposed dredged material from Stamford Harbor, and clean sand from New Haven Harbor that was used to cover the Stamford material. In this case, the natural sediment had a copper concentration around 70 ppm and a low coefficient of variation of approximately 1.5%. The contaminated Stamford material had the highest copper and highest variation, however, the mean concentration of about 350 ppm was only about one third the highest concentration measured in the harbor (Fig. 3-3). The sand cap, which has copper concentration levels less than the natural sediment, still maintains a coefficient of variation twice that of natural deposits.

From these data, it is apparent that the dredging, transport and disposal procedure combines sediments of different contamination levels, derived from both vertical and spatial gradients within the harbor. This creates a deposit with much more chemical variability than the natural sediment which is derived from a variety of distant sources and combined into a homogenous deposit characteristic of the entire region. Therefore, when attempting to delineate the spread of dredged material, replicate samples are needed to assess the variability of the deposit which is a much better indicator of the presence of material than metal concentration alone.

Assuming there is a contaminant level associated with dredged material, then its impact on the surrounding environment must be measured through its effect on biota in the region. Consequently, a two part effort in biological assessment was initiated as part of the DAMOS program. This included a benthic population study characterizing the benthos at each of the disposal sites and a bioaccumulation study using mussels as the indicator organisms.

The benthic population studies included replicate sampling at stations distributed throughout the disposal sites and at reference stations removed from the influence of disposal operations. Samples were obtained by anchor dredge during the first year of the program and by Smith-McIntyre grab sampling in later years. All samples were sieved aboard ship through a 1 mm mesh screen and identified to species level in the laboratory. Overall distribution of benthic infauna throughout the study area is shown in Figure 3-5, which presents the variation in the percent of the total number of individuals in each of the three major phyla for all original DAMOS stations in winter and spring. Based on these data, there appeared to be minor seasonal differences in the abundance of individuals of a given phylum at each station, with the exception of annelids and molluscs in Western Long Island Sound. When the percent of annelids in

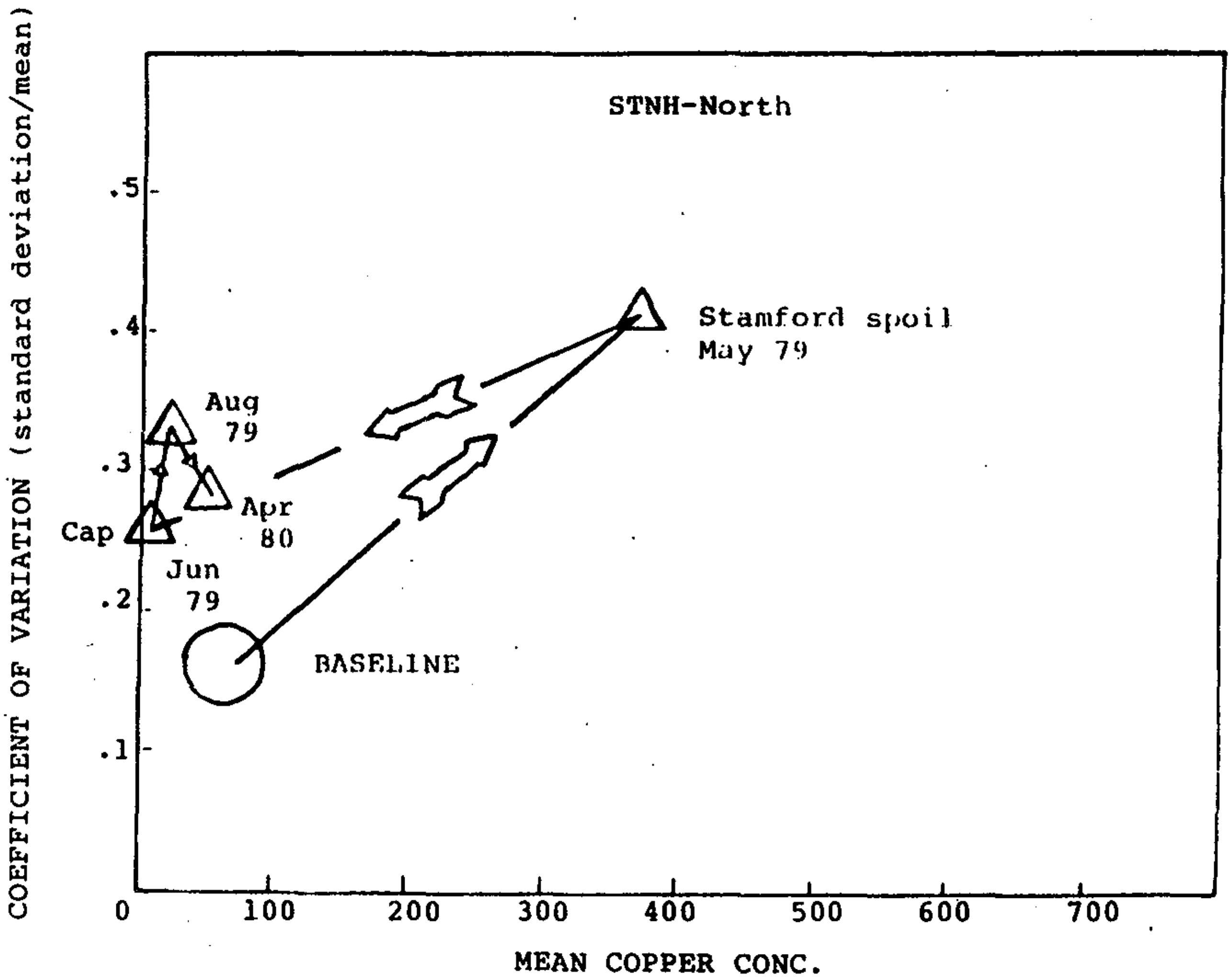


Figure 3-4. Summary of mean Copper (Cu) concentrations at the Stamford-New Haven - North Disposal Site; May, 1979 - April, 1980.

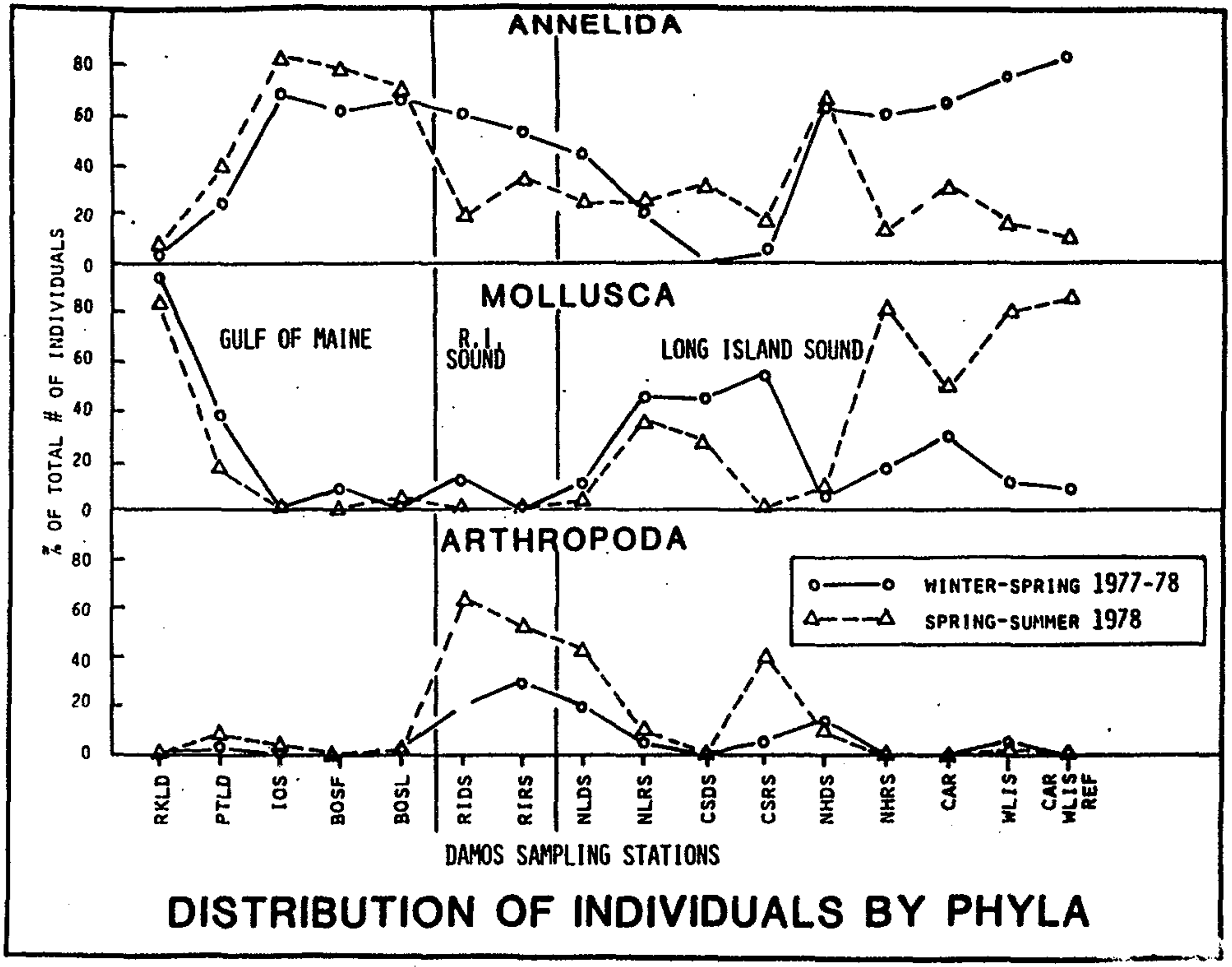


Figure 3-5. Distribution of Individuals by Phyla at DAMOS Disposal Sites

samples was high in Western Long Island Sound, that of molluscs was low and vice versa. Anthropods were relatively sparse except at the Brenton Reef and New London sites.

The general conclusions reached as a result of preliminary baseline studies of benthic infauna were:

- sample-to-sample variability in number of individuals (N) and species (S) was high with standard deviations often exceeding their means,

- with rare exceptions, the coefficients of dispersion indicated a highly clumped spatial distribution pattern at all stations,

- a small percentage of the total number of species predominated, commonly accounting for 80 percent or more of the total number of individuals collected at a given station,

- no seasonal differences could be demonstrated for N or S at any of the sampling sites except at the Brenton Reef site where both were significantly greater in the summer,

- no significant seasonal differences could be demonstrated for species diversity (H') at any of the sample stations,

- in the winter, the mean number of individuals was highest at the Brenton Reef site and lowest at the Cornfield Shoals site,

- in the summer, the highest mean number of species was collected at the New London site; lowest was found in samples taken at the Cornfield Shoals dump site,

- mean diversity was higher in the Gulf of Maine stations (H' = 2-3) and lower at the stations in Rhode Island Sound and Long Island Sound (H' = 1-2),

- during both summer and winter seasons, molluscs and annelids predominate in the Gulf of Maine; anthropods and annelids comprise the largest percentage of benthos at the Rhode Island Sound stations, and the Long Island Sound fauna is dominated by anthropods, molluscs and annelids.

Because of the high variability encountered on these baseline cruises, it was apparent that statistically significant differences resulting from dredged material disposal could only be determined through acquisition of a large number of samples or a reduction of variability, possibly through discriminant function techniques. Therefore, future sampling programs were developed to address these sampling and analysis procedures.

The mussel watch program was also started during the first year of the project with the objective of first determining the background variability of trace metals in mussels at the various sites and establishing a workable procedure to deploy and retrieve the mussels. Mussels were obtained from local populations and deployed at the disposal sites using PVC cages, weighted with cement clumps, to keep them in place (Fig. 3-6). North of Cape Cod, the mussels used for this project were Modiolus modiolus obtained from local sources which were then used as reference populations. South of Cape Cod, Mytilus edulis were used as the monitoring mussel. Although a reference population was maintained at Brenton Reef; all mussels deployed in Long Island Sound were obtained from a reference population at Latimers Light and placed at reference stations in the vicinity of the disposal sites using the same cages as deployed in the vicinity of the disposal mound.

During the initial years of the program, mussels were sampled on a quarterly basis and analyzed for Cd, Co, Cu, Fe, Hg, Ni, Pb, V and Zn. As the project continued, it became apparent that more frequent sampling was required. Because the metal content of the organisms responded to internal physiological changes and external factors of the environment, alterations in the conditions at the site had to be documented before changes due to dredged material could be detected. Consequently, monthly sampling was initiated at several locations where active disposal was taking place and the quarterly sampling was terminated at other sites where no disposal was planned. This resulted in concentrated efforts at Portland, the Foul Area (previously known as Boston Foul Ground), New London and Central Long Island Sound (previously known as New Haven).

Another important subject that received attention during the initial stages of the DAMOS program was an assessment at each site of fishing intensity in the nearby waters. Each region was examined in terms of local fishing grounds and for potential spawning areas that might be impacted by disposal operations. Interviews were conducted with fishermen throughout each area and summaries of catch data were examined to assess the existing fisheries. Charts were made for each disposal site describing the overall situation and contacts were established and maintained with specific fishermen throughout the course of the DAMOS program to insure that disposal impacts on the fishing industry were minimal.

Lastly, a diving program was initiated to provide visual observations in order to examine in detail the conditions of dredged material at the site. Specifically, the interactions between the sediment, the overlying water column, the local benthic community and the macrobenthos were studied. In deeper areas where efficient diving was not feasible, underwater TV cameras were used. These observations added significantly to development of baseline parameters describing the existing conditions at the disposal site. Primarily they served to

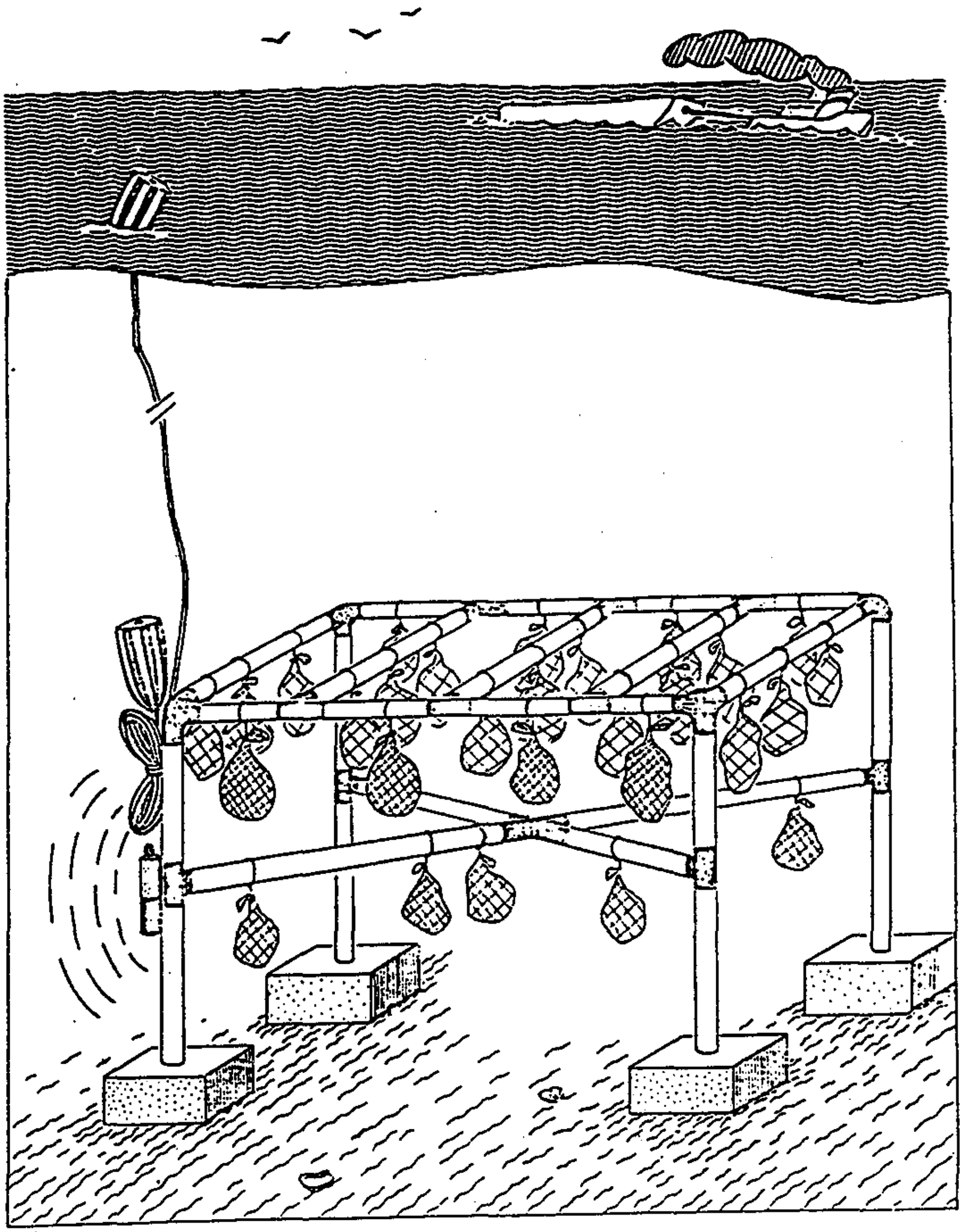


Figure 3-6. PVC Mussel platform.

confirm intuitive concepts developed from remote sensing. In particular, observations of cohesive clumps of dredged material, discrete boundaries between dredged material and natural sediment, bioturbation resulting from macrobenthos and overall recolonization of the disposal mounds were all concepts derived from remote sensing that could be observed and better understood through in-situ observation.

During the second year of the DAMOS program, the major emphasis remained with the baseline studies described above, however, additional work specifically oriented toward disposal operations at New London and Portland was undertaken. At New London, further dredging was required for deepening of the channel to accomodate Trident submarines. This dredging required designation of new disposal points within the New London disposal site and continuous monitoring as large volumes of dredged material were dumped over a relatively short time span.

At Portland, a major effort was undertaken to designate a new disposal site that was both environmentally safe and compatible with fishing interests in the area. For the first time in the New England region, a comprehensive study was initiated so that the site could be selected based on sufficient scientific data, and not simply an historic precedent or political considerations. The data were derived from surveys designed as a result of monitoring programs at other sites to measure the important parameters affecting dredged material disposal. With this information, NED was able to present alternative solutions to the fishing industry so that disposal management decisions were made with the cooperation and understanding of the concerned parties. Once the basic selection process had been completed, more detailed surveys of the selected site were made to develop a comprehensive pre-disposal data base for use in the post-disposal monitoring program. Another important aspect of this approach to site selection and monitoring was the ability, through formalized interaction with concerned interest groups, to modify both pre- and post-disposal studies to be responsive to specific concerns for that site.

At the end of the second year of the program, a seminar was held at the Naval War College in Newport, RI to present the results of the study to interested state and federal agencies as well as concerned citizens and interest groups. This seminar was considered an important part of the overall program, since dissemination and discussion of the results is essential if the project is to be responsive to the needs of the region.

During 1979, several major changes occurred in the DAMOS program. Most important of these was a reduced emphasis on baseline studies and monitoring of inactive sites and increased effort at the Central Long Island Sound site. Capping of contaminated Stamford material by relatively clean New Haven silt and sand was closely monitored to evaluate the procedure as a possible mitigating measure for nationwide application. Prior to this operation, some defacto capping operations had been conducted at New London and Brenton Reef by dredging more contaminated areas first and covering them with cleaner material at a later time. However, the Stamford/New Haven operation was the first program specifically managed as a capping project. In order to complete this operation, taut-wire moored buoys were used to control disposal at the STNH-N and STNH-S sites within the Central Long Island Sound Disposal Area (Fig. 3-7). This resulted in two mounds, each of approximately 30,000 m^3, covering an area approximately 150 m in diameter. The STNH-S mound was then capped with 80,000 m^3 of silt from New Haven, creating a substantial deposit several meters thick covering the Stamford material (Fig. 3-8). The STNH-N mound was covered with 50,000 m^3 of sand dredged from the outer harbor of New Haven with a large hopper dredge. The deposit formed at this site was a broad smooth mound as shown in Figure 3-9.

In the fall of 1979, Hurricane David passed over the Central Long Island Sound site with winds in excess of 80 knots and waves of sufficient height and period to have an effect on the sediment at the site. The silt cap at the STNH-S site was eroded to a level of 19 meters (Fig. 3-10), however, the sand cap at STNH-N and other deposits in the area were not affected. Based on this evidence, it was generally concluded that sand caps are more stable, however, several other factors were considered important in selection of capping material, including the following:

- Silt, though less stable than sand as a capping material, is generally more available and thicker caps can be created to cover contaminated sediment, resulting in equal isolation of contaminated material.

- Silt caps tend to recolonize with species more common to the region of the disposal site. Figure 3-11 compares the faunal assemblage found at the STNH-N site following capping operations with natural populations in the area and those found at the STNH-S site. From these data it is readily apparent that a completely different population exists on the sand cap.

- Once initial settling, compaction, and bioturbation of the silt cap occurs, it is probably as stable as a sand cap. Hurricane David occurred approximately 4 months after deposition of the STNH-S mound. Since that time, neither the continuous tidal currents, nor aperiodic storm events have caused any further erosion of the mound.

Also during 1979, continuous monitoring of the Portland Disposal site was initiated. Side scan sonar and underwater TV photography were used to document the distribution of dredged material, along with sediment sampling to evaluate the type of material deposited, and mussel watch data to determine any potential impacts beyond the site. Because the site selected was

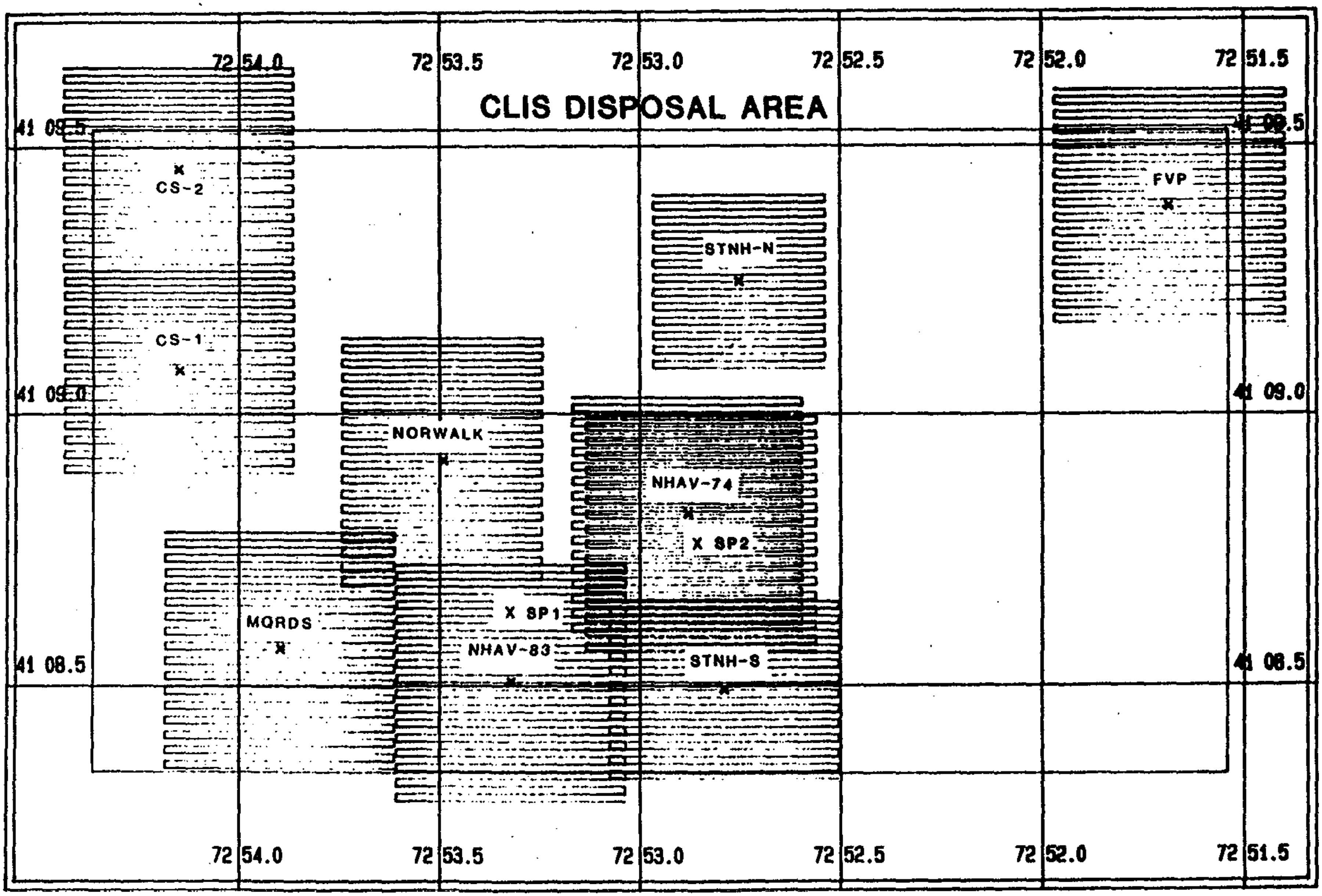


Figure 3-7. Location of surveys at Central Long Island Sound Disposal Site.

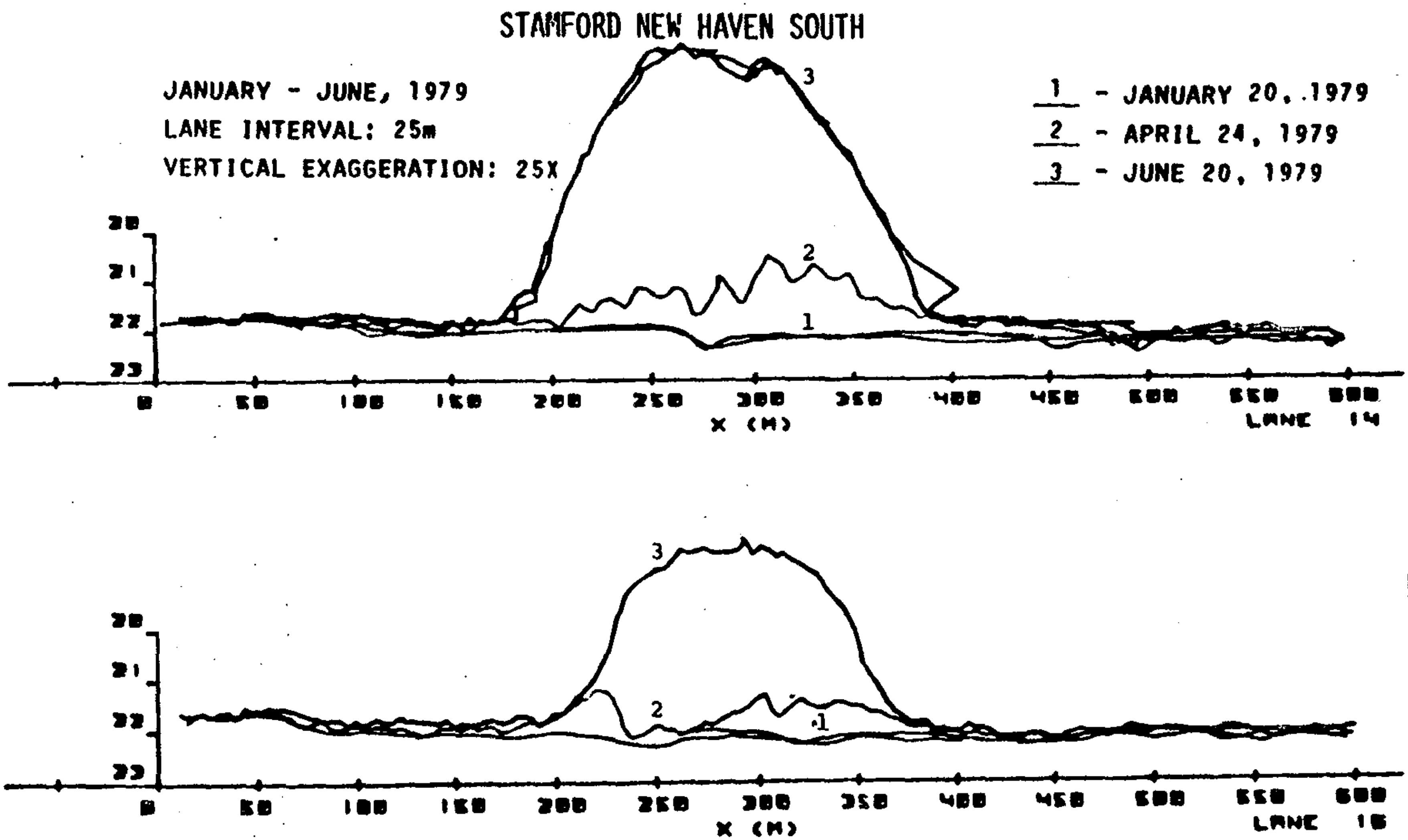


Figure 3-8. Cap thickness profile - STNH-S.

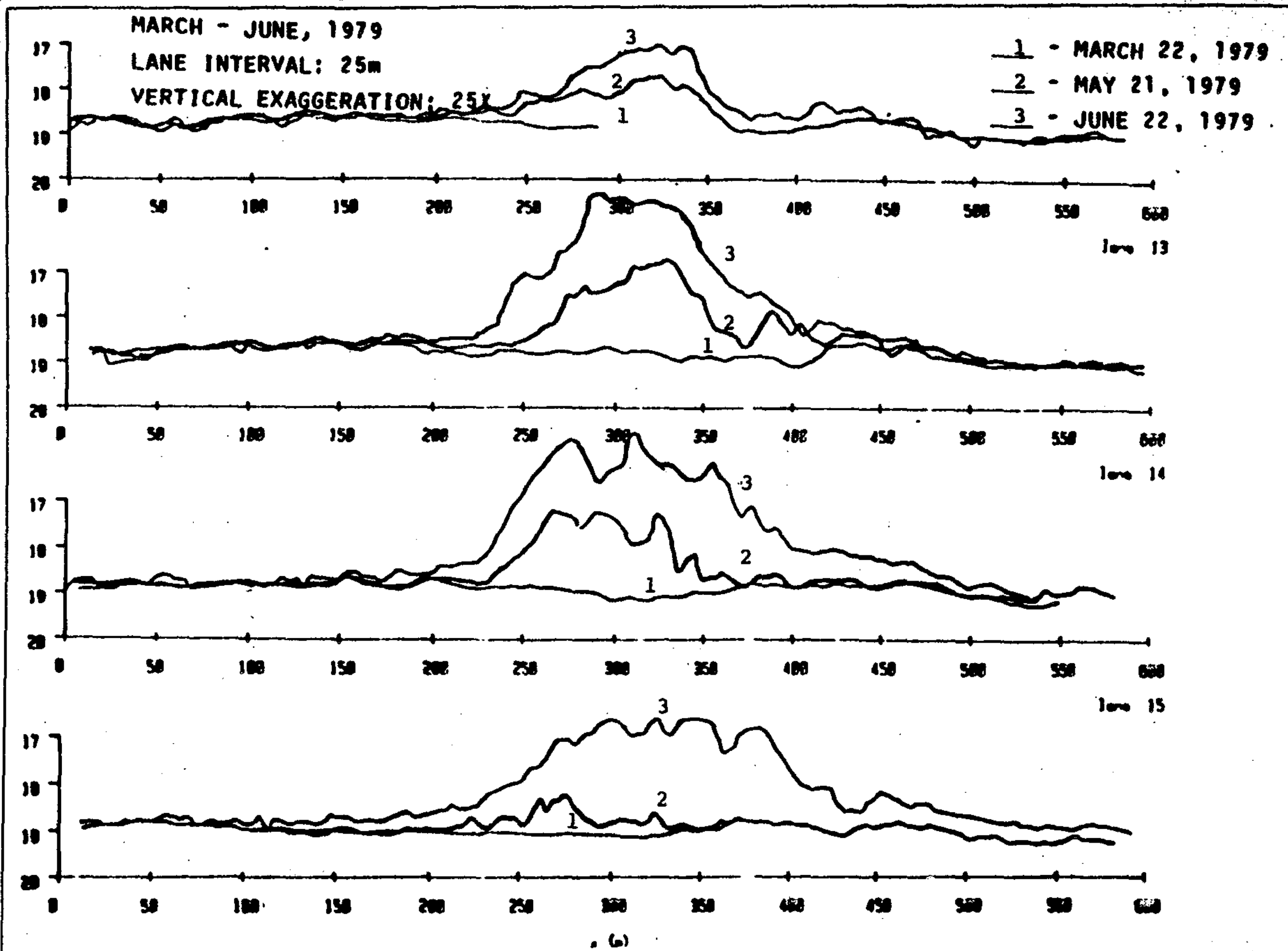


Figure 3-9. Depth profiles - STNH-N.

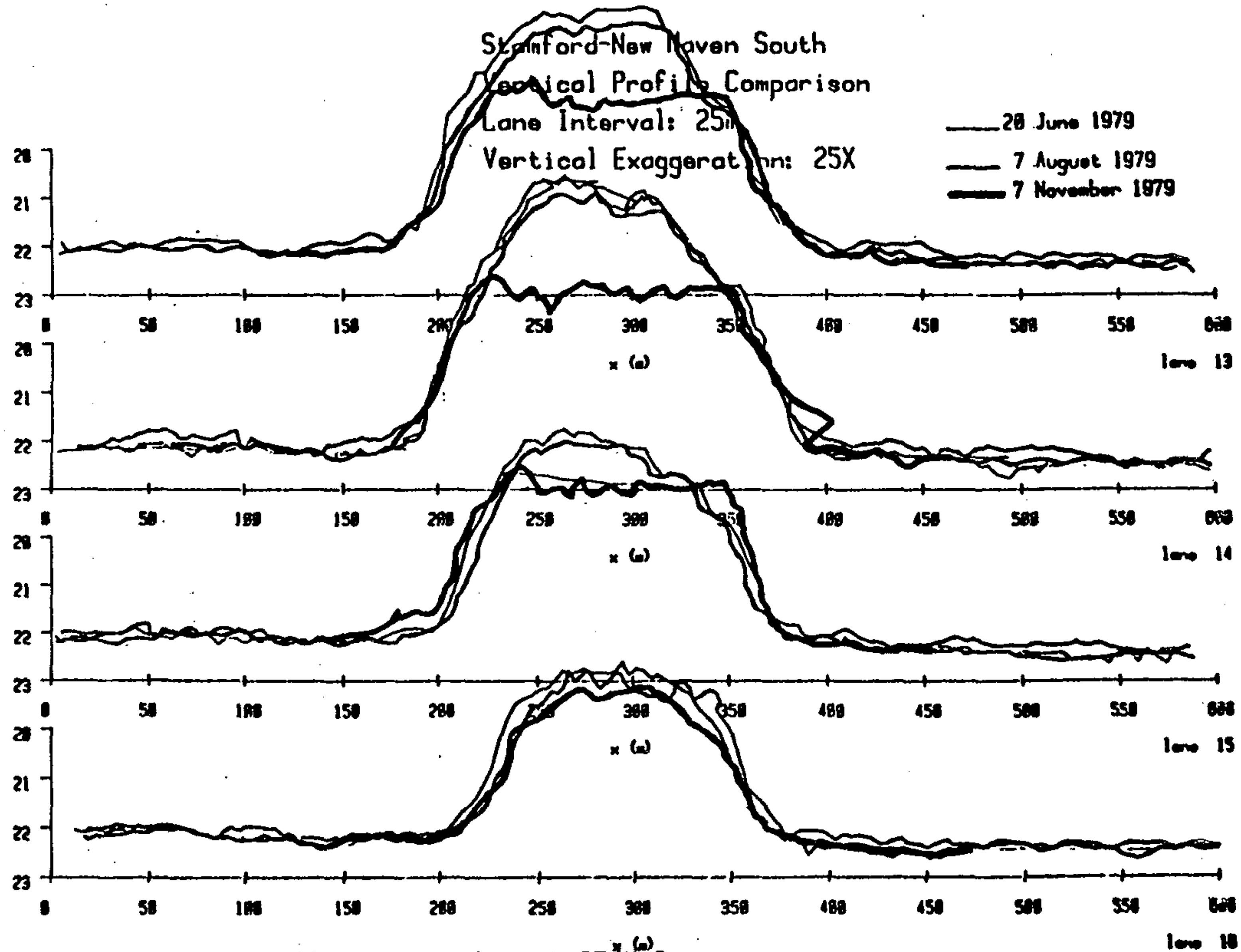
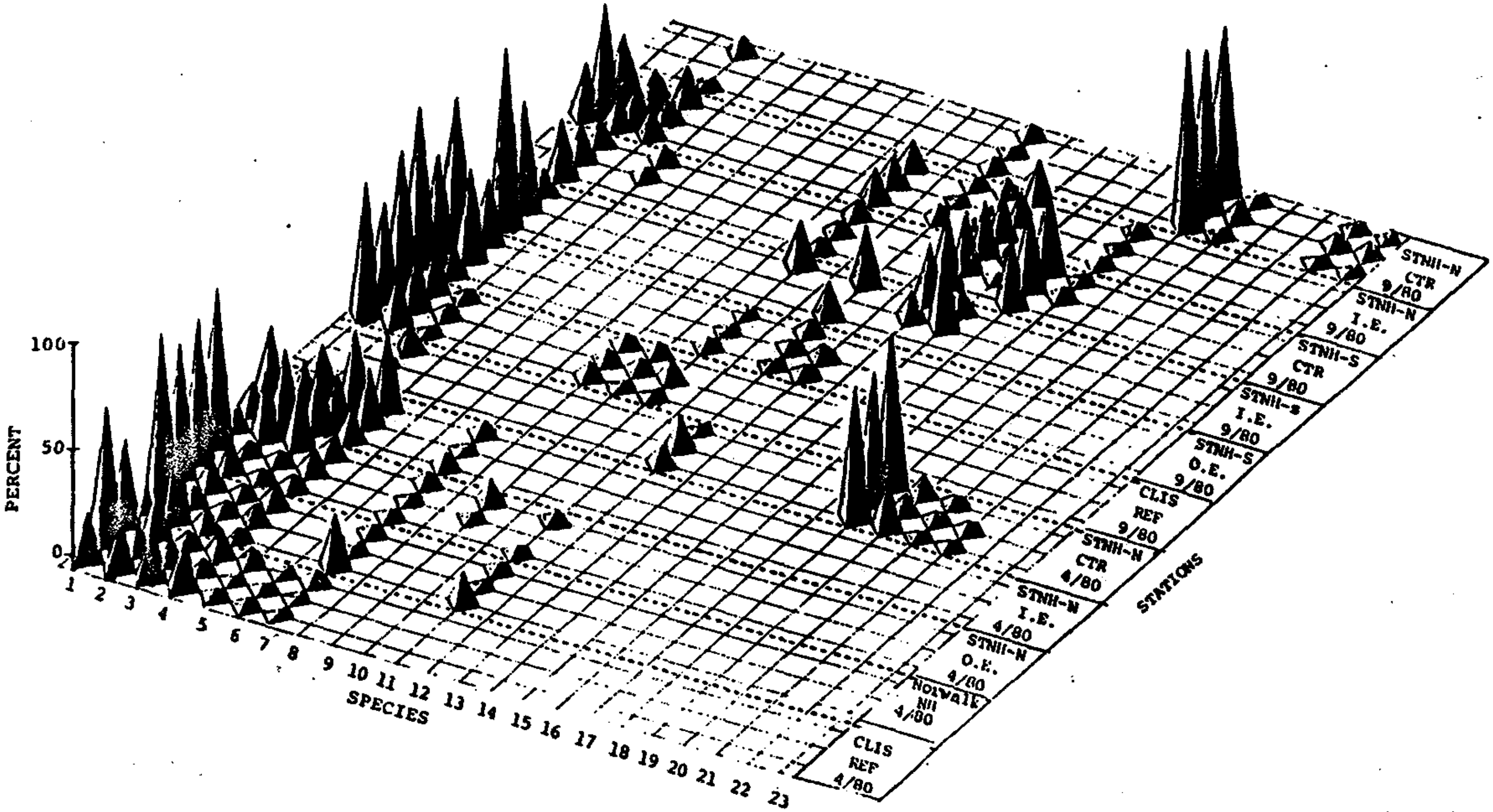


Figure 3-10. Silt cap erosion at STNH-S.



3-D PLOT OF PERCENT COMPOSITION OF PREDOMINANT SPECIES

AT NEW HAVEN REFERENCE AND DISPOSAL SITES

Figure 3-11. Species Composition at CLIS Disposal Sites.

located in a depression between hard rock ledge in 60 meters of water, the dredged material was contained in a relatively small area. The only indication of material beyond the margins of the depression were isolated clumps of material to the west of the site that were apparently caused by spillage from overfilled scows.

As in the previous year, a symposium was held in Newport to present the results of the DAMOS program for 1979. Several scientists were requested to act as a review team to evaluate the program and their comments were used to develop the project plan for subsequent years. Also at this time, the U.S. Navy at NUSC made a policy decision to withdraw from participation in the DAMOS program, since only a small portion was directly related to Navy projects. Consequently, most of the NUSC personnel associated with DAMOS transferred to Science Applications, Inc. (later SAIC) and the program continued under contract to NED.

In 1980, much of the work conducted on the Stamford/New Haven project was made available to the general public as that program became a focal point for discussion regarding future disposal management policies in New England. The capping project and replicate bathymetric survey monitoring concept were presented at the WHOI symposium on "Dredged Material Disposal in the Ocean" along with papers concerning the DAMOS Mussel Watch program and diving observations. Furthermore, testimony was presented at several public hearings and before the Congressional Merchant Marine subcommittee with regard to disposal in Long Island Sound and capping in general. Because so much of the DAMOS data were available through these forums, no symposium was held in 1980.

Field work during this year was again concentrated at the Central Long Island Sound Disposal site as continued monitoring of the Stamford/New Haven operation took place. In addition, baseline surveys for disposal of material from Norwalk were completed and, following that disposal operation, monitoring was conducted on a periodic basis. Although only a small fraction of the Norwalk material was considered contaminated, it was treated in a manner similar to the Stamford sediment and successfully capped with material from outer Norwalk harbor. Monitoring was also continued at the Portland Disposal site in conjunction with EPA's Ocean Disposal Site Designation project.

The disposal of Norwalk dredged material at the Central Long Island Sound Disposal Site emphasized the need for a suitable location in the western end of the sound to reduce the transportation costs associated with disposal, and thus make smaller dredging projects economically feasible. Therefore, during 1981, a portion of the DAMOS program was directed toward designation of a Western Long Island Sound Disposal Site. Previous work in this area at the Cable and Anchor Reef Site (Fig. 3-12) indicated that dredged material sites used on earlier projects were now lobster fishing grounds and no longer available for disposal. Consequently, an area to the east

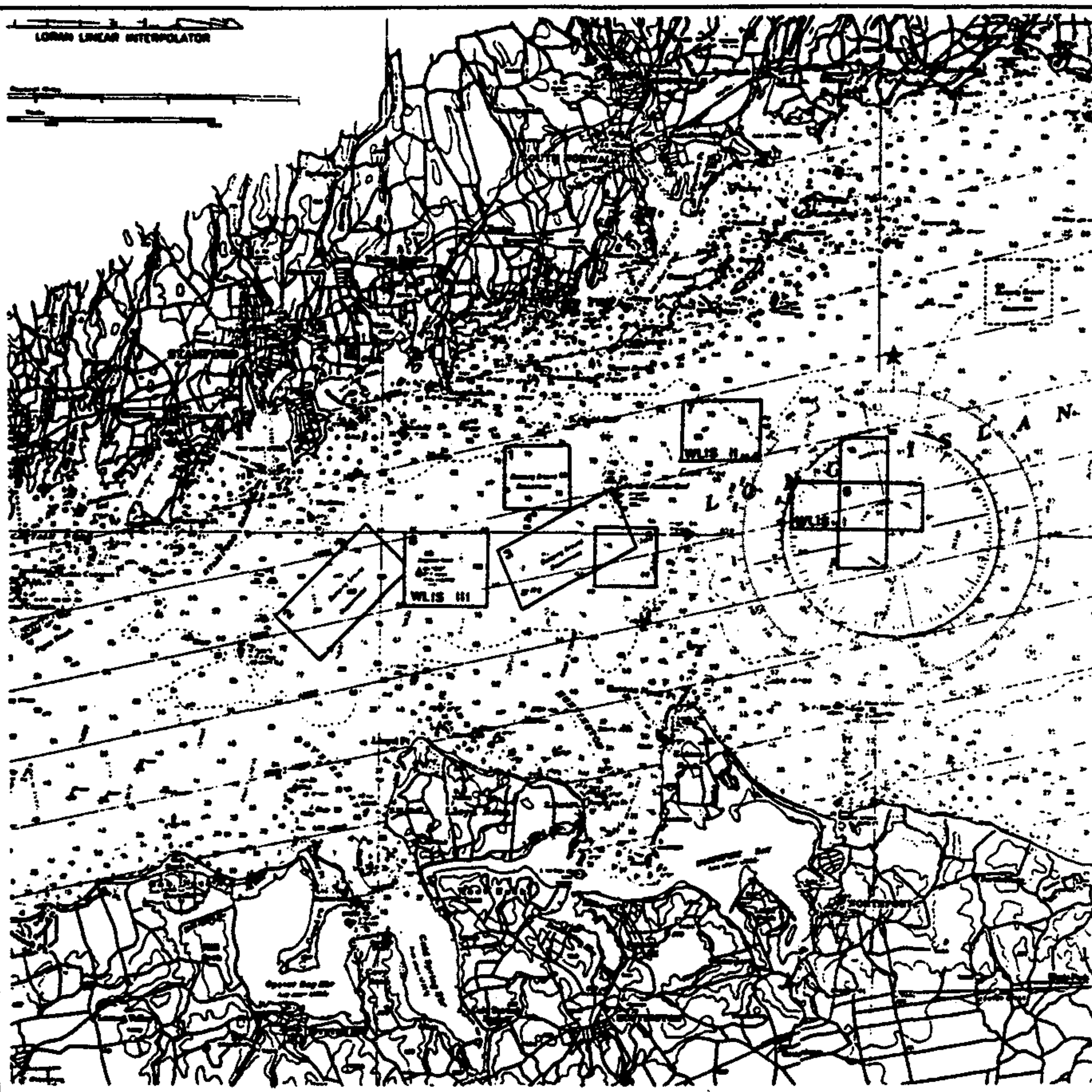


Figure 3-12. Potential Regional Disposal Sites Considered for Western Long Island Sound

1. South Norwalk
2. Stamford
3. Cable Anchor Reef
4. Public Hearing Site
5. Dames and Moore EIR
6. WLIS I
7. WLIS II
8. WLIS III

1-3 Previously Used Site
4-7 Proposed Sites
8 Selected Site

of the reef (WLIS II) was examined as a potential site, however, through consultation with fishing interests, it became apparent that this site was also actively used for lobstering. After extensive discussions with fishermen from both the Connecticut and Long Island areas, including educational forums in Norwalk and Huntington, a third site, WLIS III, was suggested for study. Extensive baseline surveys were conducted at this site and the data were used to support designation of the site. As a result of this work, designation was completed, a buoy was deployed and dredged material from Mamaroneck Harbor was deposited at the site beginning in March 1982.

Selection of the Wellfleet Disposal site in Cape Cod Bay also took place during 1981. On this project, DAMOS and NED worked closely with personnel from state agencies to conduct baseline surveys and to develop a monitoring program responsive to the particular constraints of the project. Once these surveys were complete and a monitoring program established, a disposal buoy was deployed and the project was accomplished. Post-disposal monitoring showed that no permanent mound feature was observed at this site, most likely because tug operators were not required to stop at the disposal buoy. Sediment samples and diver observations both indicated a comparatively wide distribution of dredged material in the area west of the disposal buoy (the tug and scows all approached from the east). Since the material from Wellfleet was relatively clean sediment, no significant impacts from disposal were observed and recolonization of the site took place during the summer following disposal.

Beginning in early 1982, continued monitoring of the WLIS III site was accomplished during the initial stages of disposal. Dredged material at this site behaved generally as expected, creating a circular mound several meters thick immediately south of the disposal point. Sediment in the disposal mound had lower levels of contaminants than the surrounding sediments, hence the potential impact of such material on the ambient conditions was extremely low.

A third capping operation was also conducted during this period at the Central Long Island Sound Disposal Site. On this project, material from the Mill River in New Haven was capped by silt from the Quinnipiac River also from New Haven. A unique situation developed on this project because the Mill River sediment contained a high percentage of wood pulp which did not behave in the same manner as usual silty dredged material. The Mill River sediment was less dense and much less cohesive than normal sediment and, consequently, spread over a much larger area and, even though a small mound was formed, capping of the flanks of this deposit could not be effectively accomplished with the amount of Quinnipiac River sediment available.

During 1982, a large dredging project in Boston Harbor was initiated and disposal of dredged material at the Foul Area was proposed. Because of concern over possible dispersal of material toward the east, where Stellwagon Bank provides a food source for whales, a monitoring program to evaluate such transport was begun. Reference stations to the east of the disposal area gave no indication of material spreading in that direction. However, bathymetric surveys and sediment sampling closer to the disposal point showed very little controlled dumping in spite of a taut-wire moored disposal buoy at the site. In a case similar to the Wellfleet project, tugs towed scows on long hawsers and dumped randomly over an area nearly a kilometer in diameter. As a result of this operation, dredged material was spread thinly over the bottom and no topographic expression of disposal could be detected. Monitoring was restricted primarily to sediment sampling to delineate the overall spread of material.

As part of a continuing effort to improve the management of dredging and disposal operations, the New England Division worked with the Waterways Experiment Station (WES) of the Corps of Engineers, and the Narragansett Environmental Research Laboratory (ERLN) of EPA to develop the Field Verification Program. This program has as a primary objective the verification of laboratory testing and regulatory procedures through field observations. Using this approach, new techniques could also be developed that might be more sensitive to actual conditions at the disposal site. To accomplish these objectives, relatively contaminated material from Black Rock Harbor was dredged and dumped at the CLIS disposal site without capping or other measures to mitigate the potential for impact at the site.

During the initial planning stages, the results of DAMOS monitoring, particularly at the Stamford/New Haven sites, were an important factor in developing sampling strategies, insuring that effects from other disposal operations would not influence the FVP results and providing assurance that potential impacts would be confined to a relatively small area. Also during the start of this program, DAMOS procedures were used to determine baseline conditions at the designated disposal site and DAMOS personnel conducted an extensive sampling operation within Black Rock Harbor using a large box corer to obtain sediment material for laboratory testing. The DAMOS Mussel Watch techniques were also compared with those of EPA to evaluate potential differences in results. During this period, REMOTS photography of the sediment-water interface was introduced as a standard DAMOS monitoring tool for measuring the biological conditions in the upper layers of the sediment column. This included measures of habitat quality and bioturbation effects as detected through the REMOTS computer image analysis program. In addition, the DAISY instrumentation for measurement of suspended sediment load and water column energy was targeted specifically for the FVP project to measure potential influence from other disposal operations.

During the spring of 1983, the DAMOS program experienced its most extensive period of monitoring as three major projects were conducted simultaneously at the CLIS disposal site while normal disposal operations were underway at WLIS III and the Foul Area in Massachusetts Bay. At CLIS, the FVP project was monitored closely during disposal to determine the initial impact of dumping and to insure adequate control of disposal was maintained. At this time, the REMOTS photography was combined with the replicate bathymetry procedures to develop a comprehensive measure of the distribution of dredged material. While not as readily available as diving observations, the REMOTS data provided a quantitative measure of the vertical thickness of dredged material on the margins of the mound that was previously obtained only by sediment sampling procedures. During this period, both the DAISY instrumentation and mussel cages were placed east of the FVP disposal point to assess the amount and impact of suspended sediment transport during disposal. The DAISY system was able to document that no significant impact occurred from disposal taking place on the western margin of the CLIS site, and was able to observe specific disposal events at the FVP site.

The major difference between EPA and DAMOS mussel observations lies in the length of exposure to the environment. DAMOS cages are left in place for extended periods, while EPA mussels are deployed and retrieved on a monthly basis. Both techniques were able to ascertain similar background levels from the reference station, detect increased levels of bioaccumulation during disposal operations, and a return to ambient conditions following disposal.

While the FVP project was underway, a capping operation was conducted at Cap Sites #1 and #2 on the western margins of the CLIS site (Fig. 3-7). As in previous capping studies, two disposal mounds were created with Black Rock sediment which were then covered with silt (CS#1) and sand (CS#2) from New Haven Harbor. The objectives of this study were to examine geotechnical and geophysical properties of sediments affecting the capping of contaminated material, and to assess the parameters controlling the effectiveness of such operations. The results of the capping procedures were not as successful as previous efforts due to problems in placing the cap. However, several important factors affecting capping operations were detected. In particular, the behavior of the capped material during and after placement was observed to be affected by mixing and settlement. Furthermore, problems in adequately sampling the capped material were identified and geotechnical measurements were conducted to determine changes in the deposited material resulting from dredging and disposal.

The third major project conducted at the CLIS site was additional capping of the Mill-Quinnipiac River mound by a large volume of New Haven silt. In order to spread material over a larger area to insure coverage and maintain the minimum depth below 19 meters, a Loran-C control system was used with multiple disposal points. This approach to capping worked exceptionally well in this case, and a low broad disposal mound was created fully covering the earlier deposit. Following the completion of this work, a large bathymetric survey covering most of the CLIS disposal site was conducted to provide an overview of conditions at that site. A contour chart of that survey is presented as Figure 3-13 and a 3-D version as 3-14.

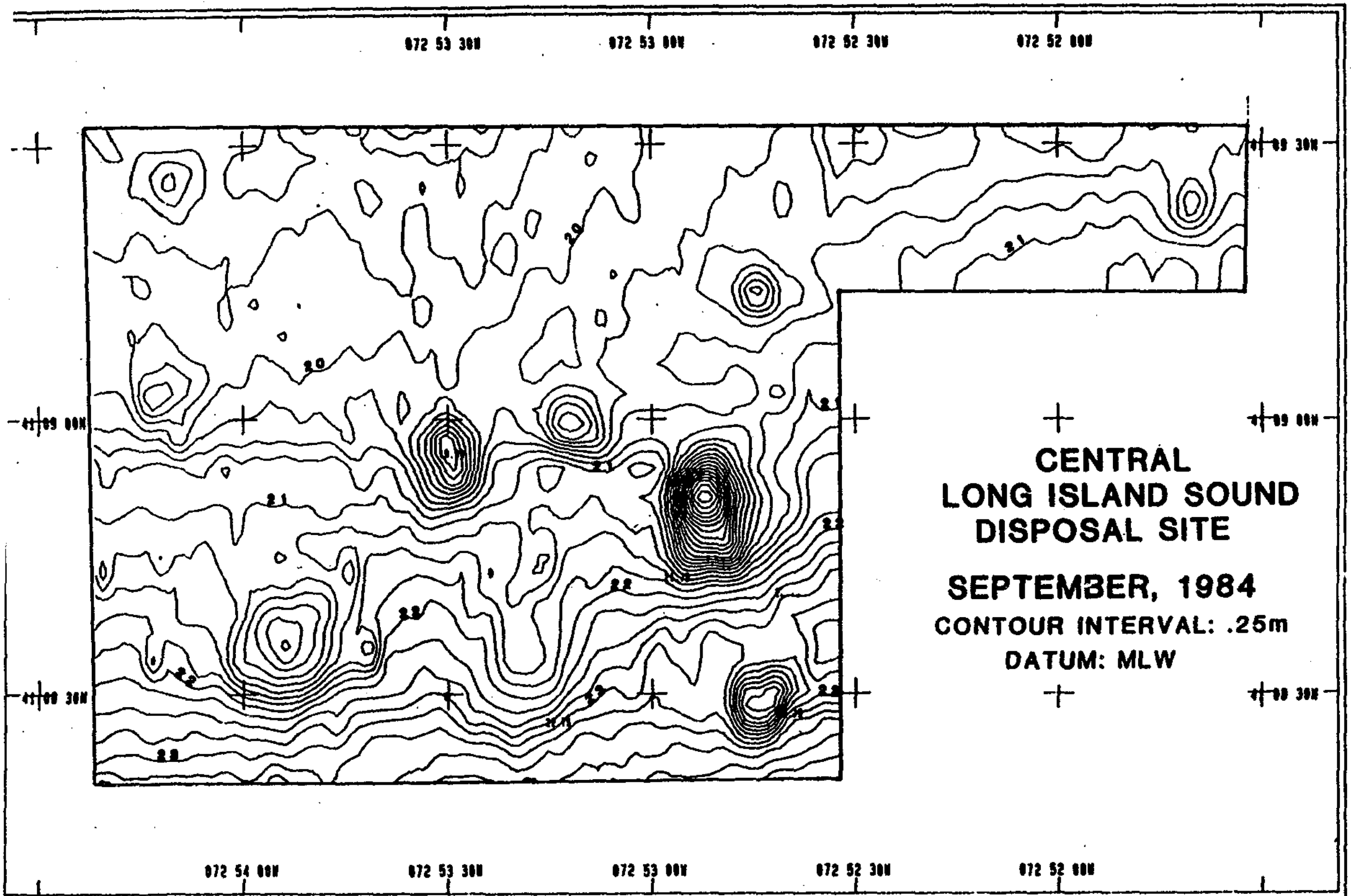


Figure 3-13. Contour chart. Central Long Island Sound Disposal Site, September 1984.

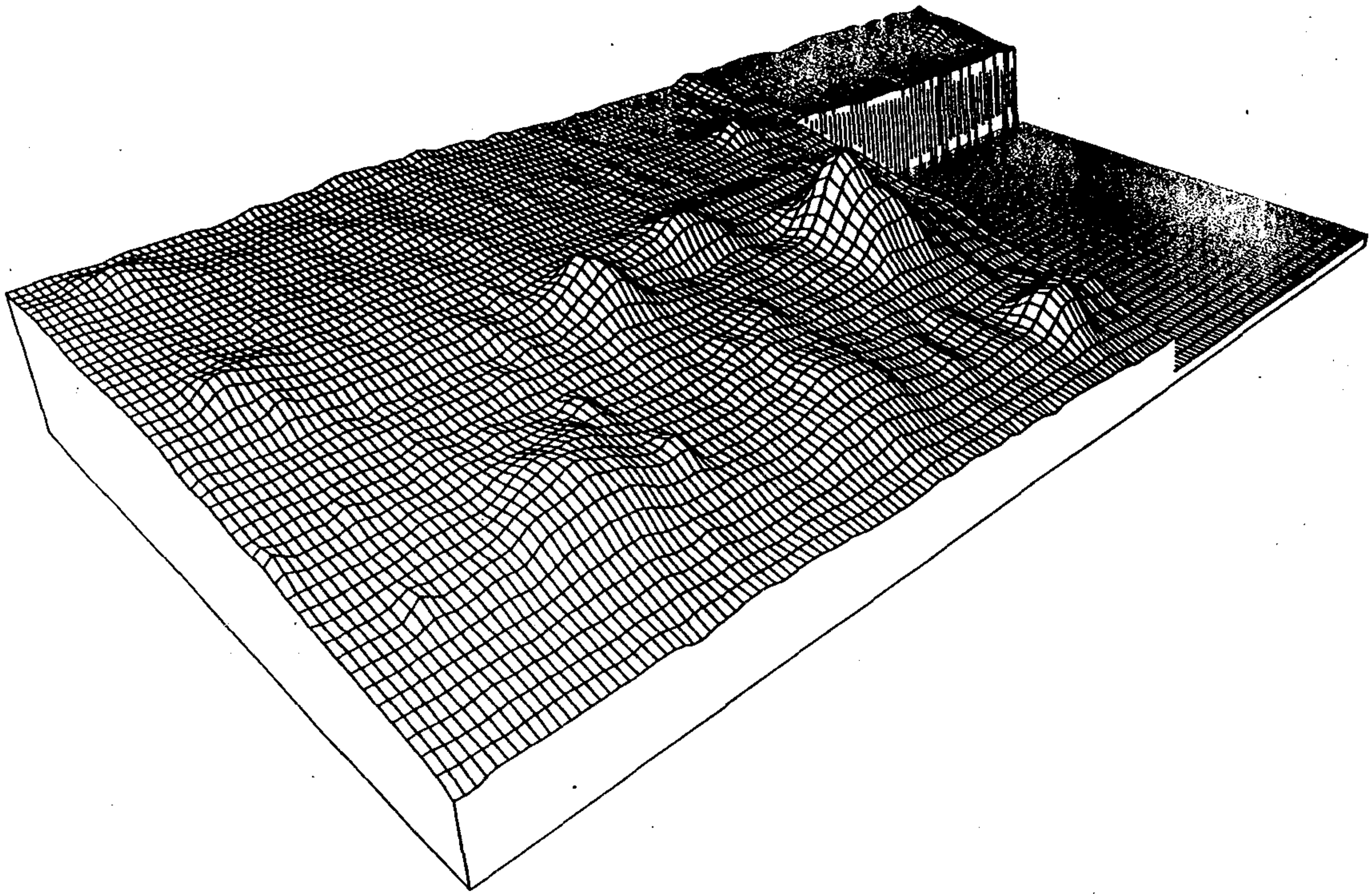


Figure 3-14. Three dimensional view of Central Long Island Sound Disposal Site, September, 1984

A Loran-C control system, similar to that developed for the MQR project was used at the Foul Area to control disposal of silt from a hopper dredge. This project was extremely important as it was the first time a hopper dredge had been used to dispose of silt material in New England. There was a great deal of concern as to whether the increased water content associated with the hopper dredge would result in much wider dispersion of material at the disposal site. In order to address this question, plume tracking with a dual frequency sonar system was conducted which indicated a situation similar to clamshell scow operations, where most of the material went directly to the bottom as part of a convective flow and only a small percentage remained in suspension to be transported by currents. Because the Loran-C system was able to control the dredge so that 90% of the disposal operations were within a 50 m radius of the designated location, the deposit created on the bottom from 65 disposal events did not extend beyond the margins of the original scow operation deposit. Therefore, it was concluded that hopper dredge operations are feasible for disposal of silt in New England and may be an excellent technique for deposition of a silt cap.

The WLIS III disposal site was also used during 1983 and continued monitoring of that site with emphasis on mussel watch measurements was accomplished. In addition, emergency surveys at New London were implemented as a result of submarines running aground on a disposal mound. Plans were made, based on these surveys, to remove the upper portion of the mound and place the sediment in a deeper portion of the site. A small study was also conducted at Green Harbor, MA to assess the potential influence of waves on sediment movement.

During the past two years, the DAMOS program has continued to provide monitoring data at specific locations, particularly at the New London, CLIS, WLIS III and Foul Area sites.

Another important area of study is concerned with analysis of the long term effect of disposal on the benthic population. This is being addessed through examination of benthic data obtained prior to and during disposal at the CLIS disposal site. The data available at that location provide a unique opportunity to assess the long term changes that have occurred over a decade of disposal in a relatively small area. Furthermore, the various sampling and analysis techniques used over that time should give insight into planning and execution of future sampling programs.

An immediate application of modern technology to this problem was development of a management data base system for input of the benthic data. Initial work on the data base has focused exclusively on benthic data to support the long term study. Future applications will include such parameters as physical and chemical properties of dredged material and natural sediment, bathymetric data acquired from replicate surveys, mussel watch bioaccumulation information, dredging and disposal operation summaries, and others as appropriate.

4.0 RESULTS OF THE DAMOS PROGRAM AND THEIR EFFECT ON DISPOSAL MANAGEMENT POLICIES

The primary objective of the DAMOS program has always been to provide data for input to decisions that must be made by the New England Division either for permitting of open water disposal or management of such disposal once the permits have been granted. Over the years, this objective has been achieved, and the Division now has a sound, rational management procedure that is based on scientific data and is responsive to the environmental concerns of the region. These management procedures also maintain the ability to complete the important dredging operations necessary for the economic viability of New England harbors.

Key factors in the management program employed by the New England Division for management of dredged material disposal include the following:

- Classification of material

  Samples of sediment from the proposed dredging location are obtained to determine the physical properties of the material and the potential contaminant levels of the sediment. Bulk chemical analysis, bioassays and other tests are conducted as necessary for permitting requirements and each project is considered on its own merits as to whether or not ocean dumping is a feasible alternative for disposal. Other research and development programs are currently underway to improve these regulatory testing procedures and to make more efficient use of existing data so that harbors with similar sediment characteristics can be evaluated in a more cost effective manner.

- Designation of disposal sites

  A relatively few, regional disposal sites have been designated throughout the New England area for disposal of dredged material. The small number of sites is particularly important to increase the effectiveness of post disposal monitoring through concentrated efforts at well known locations. General criteria for selection of a site include:

  - previous use as a disposal site

  - sufficient distance from fishing grounds, significant habitats, commercial projects or other aesthetically important features to reduce potential impact

- bottom sediment similar to expected dredged material

- low energy levels to ensure containment, achieved through greater depth, limited fetch, minimal tidal current velocity

- location close enough to important dredging sites to make transportation safe and economical

- sufficient size to meet the disposal needs of the region for an extended period of time

- configured to improve monitoring through features such as flat bottom, consistent sediment distribution, etc.

• Control of Disposal Operations

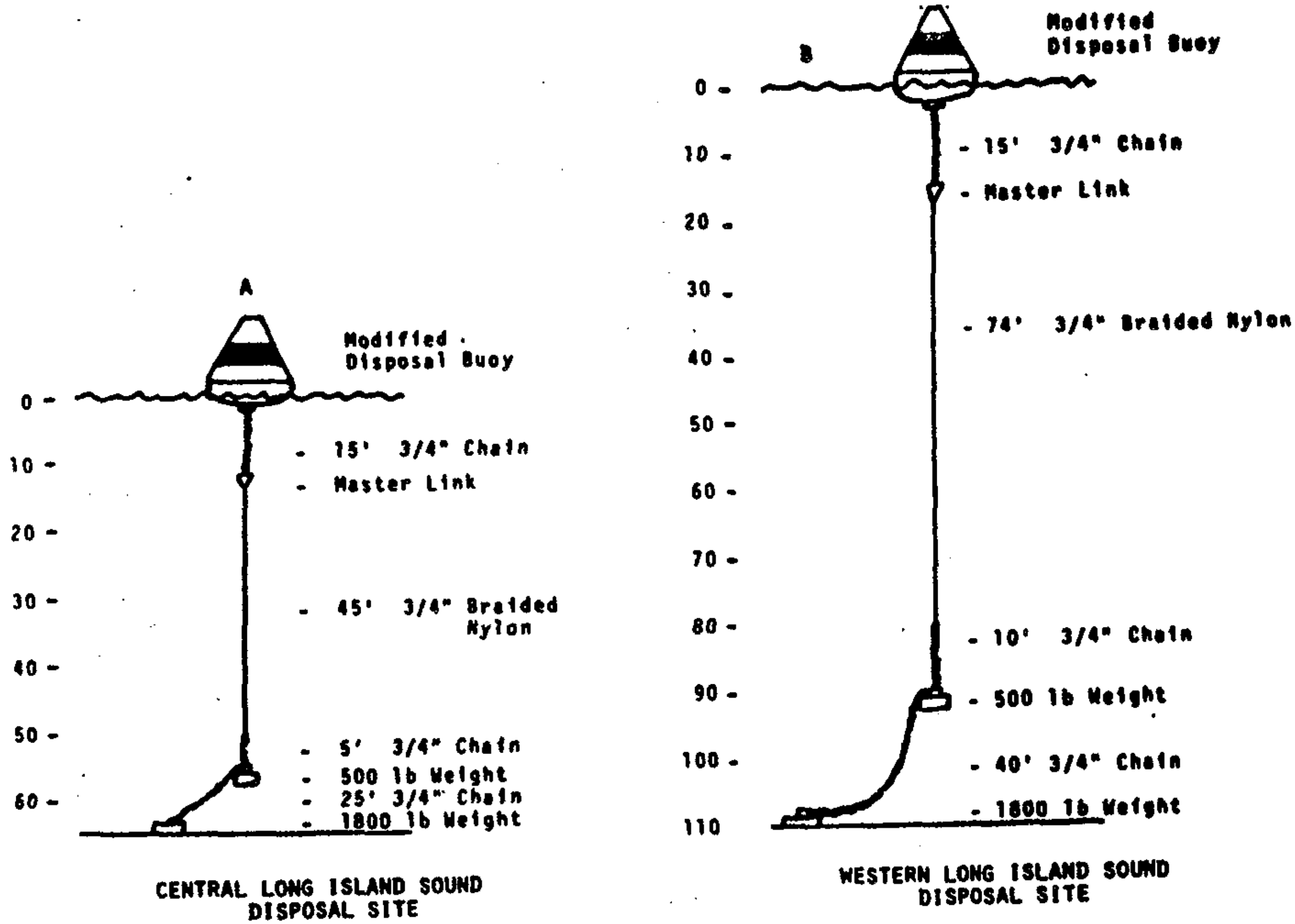
In order to reduce the spread of material and, therefore, the amount of contaminants available for dispersion, dredged material mounds are created at the disposal sites through point-dumping techniques to provide a definitive feature for post disposal monitoring . Point dumping is generally achieved using a "taut-wire" moored disposal buoy, deployed in the configuration shown in Figure 4-1 at a specified location. General control and routing of the disposal operation is provided through use of Loran-C navigation.

On some projects, particularly those involving capping operations, more sophisiticated Loran-C units interfaced to computerized display systems are used to distribute material at the disposal site. Although these computerized systems do have a recording capability, all disposal operations are monitored by a Corps inspector.

Using these techniques, dredged material is frequently deposited at several locations within a disposal site to allow specific monitoring of results for a particular project, to maintain the minimum depths of disposal mounds below a specified level, or to allow routine permit dumping to proceed while a major environmentally sensitive project is being conducted.

• Mitigating Measures

Should the characterization of dredged material indicate a potential for adverse impact resulting from disposal in the ocean environment, there are



MOORING DESIGN SCHEMATICS

LONG ISLAND SOUND DISPOSAL BUOYS

Figure 4-1 DAMOS Taut-Wire Mooring.

several procedures used by the New England Division to reduce or eliminate such an occurrence. Most drastic of these is the no action alternative; however, other choices are available. Most dredging projects in New England are engineered so that the more contaminated sediments are dredged first and then covered by cleaner material as the project progresses. Small permit projects of relatively contaminated dock areas are scheduled concurrently with larger federal projects to provide covering material with low contaminant levels. Specific projects conducting "capping" operations with less contaminated material dredged either from another project or specifically for covering contaminated material are frequently initiated. In some cases, burial of contaminated material is accomplished through dredging of a pit, partially filling it with contaminated material, and covering that material with natural sediment from the area. Finally, other alternatives such as upland or wetland disposal, diked containment sites or deep ocean disposal are all considered. Regardless of the alternative chosen, such projects receive special attention and are carefully monitored both during and after disposal.

- Monitoring of Disposal Operations

The results of disposal operations are routinely monitored through the DAMOS program, and the results are used to modify the approach to disposal management when warranted. The routine monitoring conducted by DAMOS includes measurement of dredged material distribution and stability of the disposal mound at the site, as well as impact assessment through observation of biological response following disposal. Potential human impacts, particularly related to the fishing industry, are addressed through open communication with industry representatives and concerned environmental organizations.

- Dissemination of Results

The New England Division, while maintaining final permitting authority over dredging projects, operates in coordination with other Federal and State agencies to develop a consistent disposal management plan. Results of pre-dredging tests, proposed disposal plans and monitoring programs are all discussed with appropriate agencies and concerned parties before final decisions are reached. Results of the monitoring program are provided periodically through published reports, public hearings, local symposia, and contributions to scientific meetings.

The following sections provide an overview of some of the important results of the DAMOS program that have affected the management procedures described above.

4.1 Characterization of Dredged Material

Although the DAMOS program is generally not directly involved with analysis and characterization of sediments from the dredging site, the results of those procedures are extremely important for monitoring. Disposal operating procedures are determined based on the physical and chemical properties of the sediments and detection of dredged material at the disposal site requires a knowledge of the sediment characteristics. During the past several years, the DAMOS program has generated a great deal of information relative to the detection and identification of dredged material and developed a multi-faceted approach to such identification.

Early attempts at characterization were based on the assumption of chemical composition differences between dredged material and natural sediment at the site and assumed decreasing concentrations away from the disposal mound. General results of sampling at sites throughout New England have indicated this approach is not feasible for several reasons:

- Dredged material at the disposal site is generally less contaminated than expected from pre-dredging surveys and is characteristically highly variable in composition. This probably occurs as a result of mixing contaminated maintenance material and uncontaminated natural sediment during the dredging operation.

- Contamination levels characteristically reach a peak on the flanks of the mound, for a short time following disposal as fine sediments containing most of the contaminants flow to the margins as turbidity deposits.

- These higher levels can generally be related to a distinctive reduced layer of sediment overlying the oxidized natural bottom. However, the reduced layer and the high levels of contaminants are not permanent features as recolonization and bioturbation of the margins of the mound soon mix dredged material and natural sediment.

- Beyond the margins of the mound, dredged material is essentially undetectable by sediment sampling as natural variability of the sediments is greater than the input of contaminants from the dredged material.

Based on these results, different approaches to detection of dredged material have been developed. Sediment/water interface photographs obtained by the REMOTS camera have been used to map the initial distribution of dredged material. This technique has shown that the flanks of the mound cover a much wider area than shown by bathymetric sensors, but has also shown that these margins are soon recolonized and mixed with the natural sediment, thus making post-disposal detection of dredged material impossible.

The mussel watch program has provided the best means for detection of dredged material beyond the margins of the mound. While not a quantitative measure of sediment loading, this approach is certainly the most reliable for determining the presence or absence of contaminants. Detection of dredged material by mussels is based on the bioaccumulation of contaminants. By comparing mussels in the vicinity of the disposal site to control mussels exposed to the natural environment, increases at the disposal site relative to background levels can be considered indicative of dispersal of contaminants from dredged material. To date, mussels have been able to detect disposal operations through these increased levels, however, ongoing past disposal monitoring has never resulted in a positive accumulation of contaminants after disposal operations have stopped, thus indicating stability of dredged material once deposition has taken place.

It is important to note, however, even the mussel watch approach to detection of dredged material is subject to the same problems experienced with sediment sampling in that as distances from the disposal mound become larger, the contaminant levels caused by dredged material are once again at the level of natural variability. This results from the fact that the forces which attract and bind the contaminants to the sediment in the estuary are still acting at the marine disposal site and although a small amount of leaching may take place, most of the contaminants are buried in the mound and the only significant means of lateral transport is through erosion of the mound surface by physical forces or biological activity. These erosive forces act on the natural sediment as well and in most cases the percentage of the bottom covered by dredged material is very low and its contribution to the total sediment load is correspondingly small.

4.2 Dredged Material Stability and Containment

Since detection of contaminants derived from dredged material is extremely difficult, monitoring of the stability of a dredged material deposit becomes correspondingly important. If material is contained within a stable mounded deposit then the contaminants are not available to the environment and detection beyond the margins of the disposal site will not take place. Therefore, one of the most important concepts that the DAMOS project has provided to disposal management is the classification of disposal points as containment or dispersal sites. This concept is then reflected in the overall management of the site. If containment of material can be achieved; then point dumping, creation of disposal mounds, capping and continued monitoring of the impacts of disposal in the vicinity of the site are all possible. However, if the site is a dispersal site; then point dumping or other techniques to limit the spread of material are not warranted and monitoring of impacts is much more difficult simply because of a much larger zone of potential impact. For these reasons the general policy for designation of disposal sites in New England has been to find areas where dredged material is relatively stable and contaminants can be contained within the disposal mounds created. Over the years, evidence has continually pointed to the conclusion that with the exception of Cornfield Shoals, all sites studied under the DAMOS program can be considered as containment sites.

Dredged material stability has been monitored primarily through bathymetric techniques to evaluate changes in topography which could result from energy levels sufficent to cause erosion and transport of dredged material. The results of these surveys have shown conclusively that sediments at all sites are stable under normal conditions. However, storm events and bioturbation can cause resuspension and transport of material on both large and small scales. Bioturbation by macrofauna appears to be a major factor in breaking down the large clumps of material associated with clamshell dredging and benthic infauna can provide either a stabilizing effect or bioturbation effect depending on the type of organism present.

The only major change in topography observed during DAMOS monitoring efforts occurred at the STNH-S site during Hurricane David in the fall of 1979. This resulted in a significant loss of material from the top of the silt cap, but no change in any of the older disposal mounds in the same area. Since that time no changes in that mound have been observed and it was concluded that the occurence of the storm before the dredged material had stabilized was the probable reason for erosion at the site.

None of the disposal mounds have given any indication of bed load transport resulting in a spread of material in the vicinity of the flanks, and it appears that if material is in suspension it is transported a substantial distance from the site before being deposited. Consequently, as described earlier, the dilution of materials in background sediment loads makes detection of material impossible.

In addition to bathymetric techniques for measuring stability, REMOTS photography, diving observations and sediment sampling also provide input toward assessing stability and behavior of the dredged material. All have indicated no significant loss of material once disposal and consolidation of deposits are complete. Remote sensing of dredged material through the DAISY instrumentation and mussel watch program have also indicated no detection of dredged material once disposal has ceased.

4.3 Disposal Operation Procedures

With the knowledge that disposal sites designated throughout New England are containment sites, specific procedures for disposal of dredged material have been developed to create dredged material mounds. The taut-wire moored buoys have been extremely successful in Long Island Sound where tugs have stopped the disposal scows close aboard the buoy, but less successful in open water areas where longer hawsers are used and the scows are moving during disposal. Depending on the volume of material to be dumped, and the requirements to create a small mound, motion of the disposal scow appears to be an important factor in point dumping and creation of mounds.

Loran-C navigation has also been used for overall control of disposal operations. Transit lanes to and from the disposal site are frequently based on Loran-C lines of position and the absolute check to insure the disposal buoy is not off station is made through recording of Loran coordinates at the time of disposal.

More sophisticated use of Loran-C to control disposal and monitor disposal operations has also proven successful on some occasions, but has also revealed problems that must be addressed prior to fully automatic operation. Most important of these is calibration of the system to correct for overland path distortion and to detect cycle jumps resulting in errors of 10 micro-sec multiples. When these problems are resolved, which simply require careful use of the Loran-C system, the accuracy is sufficient to control disposal in almost all cases. The capping operation at the MQR site conducted during 1983 and the hopper dredge disposal operations at the Foul Area both showed conclusively that properly operated Loran-C systems could be effective disposal control and monitoring tools. Conversely, problems encountered at Cap Sites #1 and #2 at the CLIS site showed that slight errors in calibration combined with the direction of approach to the site could result in disposal errors sufficent to reduce the effectiveness of capping.

4.4 Capping Operations

The New England Division has been investigating the feasibility and effectiveness of "capping" contaminated dredged material with cleaner sediment for a number of years. Although early projects at Brenton Reef and New London disposal sites covered more contaminated material with cleaner sediments, it was not until the Stamford/New Haven project in 1979 that specific "capping" techniques were developed and applied. Since that time, additional capping operations have taken place with Norwalk material, Mill and Quinnipiac River sediments, and Black Rock Harbor/New Haven material at the CLIS site, Boston Harbor sediments at the Foul Area, and Portland Harbor sediments in Maine.

In general, the results of the capping procedures have been favorable. The Stamford/New Haven project showed that careful dumping of contaminated material produced a small mound that could be covered with cleaner material. Disposal of capping sediment during that operation produced mounds that covered the center of the site extremely well, but left a thinner cap on the margins. Consequently, a technique to spread the cap over a larger area was required.

The most successful capping operation in that regard was the MQR/New Haven project conducted in 1983. Using Loran-C control, a uniformly thick deposit of New Haven silt was spread over the contaminated Mill-Quinnipiac River sediment. This deposit has remained stable for nearly two years and has begun recolonization with benthic infauna similar to natural populations.

Less successful operations have taken place at the Foul Area, where scows towed with long hawsers spread material over too large an area to be effectively capped. At Cap Sites #1 and #2, capping material was not placed directly over the contaminated sediment. Both of these projects have revealed operational problems rather than conceptual problems and capping appears to be a feasible technique if sufficient control of disposal is exercised.

Management procedures existing today are based on the results of monitoring previous operations and consist of the following parameters:

- Contaminated sediment must be dumped under strict control at a taut-wire buoy, with scows moving as slowly as possible.

- The volume of capping material is now considered more important than the type of sediment and should be at least three times the volume of contaminated sediment with additional material added as the depth of the disposal site increases.

- The capping material should be spread over the contaminated sediment either through multiple point disposal or moving scow operations controlled by a precision navigation system (Loran-C).

- Monitoring of the distribution of material using both bathymetric and REMOTS procedures should be conducted at least once during each phase of the operation and at the completion of contaminated sediment disposal and placement of the cap.

- Post-disposal monitoring should take place within one month of disposal to evaluate settling and stabilization of the deposit.

4.5 Biological Measurements of Disposal Impacts

The final evaluation of dredged material disposal impacts rests with biological response to the dredged material However, measurement of this response is often tenuous and difficult to interpret, particularly when effects are small and variability is high. Studies of benthic infauna conducted over the course of the DAMOS program have revealed high variability in population and community parameters and with the exception of impacts directly associated with burial by dredged material, have not detected any significant changes due to disposal. Ongoing studies at the CLIS disposal site provide the first opportunity for assessment of long term trends and may provide new insight into the effects on biota.

In order to improve the potential for assessing biological impacts, the DAMOS program has recently incorporated the REMOTS camera into the program. Use of the REMOTS in the reconnaissance mode has provided information on the distribution of dredged material and, therefore, the best location for cost effective quantitative sampling of benthic infauna. The camera provides information, not only on biological activity, but on an entire suite of parameters affecting that activity and appears capable of assessing the health of the environment through development of a Benthic Index. Monitoring of the Benthic Index provides direct input to management of the site through estimates of environmental stress caused by disposal activity.

Finally, the mussel watch program provides data for assessment of dredged material dispersal through bioaccumulation measurements, but also assesses the impact of such accumulation through histopathological response. These studies provide an indication of the potential for food chain accumulation of bioavailable contaminants which may impact human health. To date, no adverse effects have been observed in mussels located outside the immediate area of disposal, thus confirming the overall containment ability of designated disposal sites in New England.

5.0 Key to Abbreviations Used in Chronology of Events Table

BFG	:	Boston Foul Ground, now known as Foul Area
BREN	:	Brenton Reef Disposal Area (RI)
CADS	:	Cape Arundel Disposal Area (ME)
CLIS	:	Central Long Island Sound Disposal Area
CS-1,2	:	Cap Sites 1 and 2 within CLIS area
FVP	:	Field Verification Program
IOS	:	Isle of Shoals Disposal Area (ME)
MQRDS	:	Mill and Quinnipiac Rivers Disposal Site within CLIS area
NHAV-83	:	Mound of New Haven Harbor material deposited at CLIS area in 1983
NLON	:	New London Disposal Area (CT)
NOR	:	Mound of Norwalk Harbor (CT) material deposited at CLIS area
PORT	:	Portland Disposal Area (ME)
ROCK	:	Rockland Disposal Area (ME)
STNH-N	:	Mound of Stamford and New Haven Harbors material within CLIS area--Northern Mound
STNH-S	:	Mound of Stamford and New Haven Harbors material within CLIS area--Southern Mound
WES	:	Corps of Engineers Waterways Experiment Station
WLFLT	:	Wellfleet Disposal Area in Cape Cod Bay
WLIS	:	Western Long Island Sound Disposal Area (also known as WLIS III)

TABLE 5-1

DAMOS CHRONOLOGY OF EVENTS

1 JANUARY 1981 TO 10 DECEMBER 1985

Date	Event
1/14/81	Recover current meter at IOS.
1/20/81	Conduct bathvmetric survey at NLON.
1/21/81	Obtain sediment samples at NLON.
1/22/81	Conduct diver survey at NLON.
3/20/81	Deploy disposal buoy at WLFLT.
4/28/81	Conduct bathymetric and diver surveys at NOR
4/29/81	Obtain sediment samples at NOR. Conduct diver surveys at STNH-S.
8/5/81	Conduct bathymetric survey at BREN.
8/6/81	Conduct diver survey and obtain sediment samples at BREN.
8/12/81	Conduct bathymetric survey at WLFLT. Obtain sediment samples at WLFLT.
8/13/81	Conduct diver survey at WLFLT.
8/14/81	Deploy mussel cage at BREN.
8/19/81	Conduct bathymetric survey, obtain sediment and water samples at NOR.
8/20/81	Conduct diver survey at NOR.
12/17/81	Obtain sediment samples at WLFLT, conduct diver survey at WLFLT.
12/18/81	Recover disposal buoy at WLFLT.
12/20/81	Obtain sediment samples at PORT, conduct bathymetric survey at PORT.
12/21/81	Deploy disposal buoy at PORT.

TABLE 5-1 (cont.)

Date	Event
1/13/82	Obtain sediment samples at New London. Conduct bathymetric survey at New London.
1/19/82	Deploy current meter at WLIS. Obtain sediment samples at WLIS.
1/20/82	Conduct side scan sonar survey at WLIS.
1/25/82	Recover current meter at WLIS. Obtain water and benthic samples at WLIS. Conduct bathymetric survey at WLIS III.
1/27/82	Recover Norwalk disposal buoy. Conduct bathymetric survey at STNH-N.
1/29/82	Obtain biological and chemical samples at CLIS. Conduct bathymetric surveys at STNH-S and Norwalk.
1/30/82	Obtain biological and chemical samples at CLIS.
2/4/82	Obtain biological, chemical and water samples at CLIS.
2/5/82	Obtain biological, chemical and water samples at CLIS.
2/24/82	Conduct fathometer survey in Portland Harbor.
3/9/82	Obtain core and grab samples in Portland Harbor.
3/10/82	Deploy disposal buoy at Portland. Deploy mussel cage at Portland. Obtain sediment and water samples at Portland.
3/19/82	Deploy disposal buoys at MQRDS and WLIS III.
3/23/82	Obtain sediment samples at Black Rock and MQRDS. Perform diver survey at Black Rock. Perform underwater television survey at Black Rock.

TABLE 5-1 (cont.)

Date	Event
3/24/82	Conduct baseline bathymetric survey at MQRDS.
4/3/82	Conduct side scan sonar survey at Boston Foul Ground.
4/21/82	Conduct bathymetric survey at MQRDS. Conduct diver survey at MQRDS.
4/22/82	Obtain sediment samples at MQRDS
4/23/82	Conduct diver survey at WLIS III. Obtain sediment samples at WLIS III. Deploy DAISY array at WLIS III.
4/24/82	Obtain sediment samples at MQRDS. Conduct side scan sonar survey at proposed Black Rock site.
4/26/82	Obtain gravity cores for WES at Black Rock Harbor.
4/27/82	Obtain bulk sediment for WES at Black Rock Harbor.
4/29/82	Obtain bulk sediment at Black Rock Harbor.
5/3/82	Obtain sediment samples at proposed Black Rock (FVP) site.
5/4/82	Obtain sediment samples at FVP. Conduct diver survey at FVP. Deploy bio-assay cages at FVP.
6/1/82	Conduct bathymetric survey at FVP.
6/2/82	Obtain sediment samples at MQRDS and FVP.
6/3/82	Recover disposal buoy at MQRDS. Conduct bathymetric survey at MQRDS. Recover disposal buoy at WLIS III.
7/7/82	Obtain sediment samples at Boston Foul Ground (BFG).
7/8/82	Deploy disposal buoy at BFG. Obtain sediment samples at BFG.
8/10/82	Conduct bathymetric survey at New London.

TABLE 5-1 (cont.)

Date	Event
8/11/82	Conduct diver and television surveys at New London.
8/12/82	Obtain sediment samples at New London. Deploy mussel cage at New London.
8/16/82	Conduct bathymetric survey at WLIS III.
8/19/82	Obtain sediment samples at WLIS III.
8/23/82	Obtain sediment samples at FVP. Conduct diver survey at FVP.
8/24/82	Conduct REMOTS survey at FVP.
8/25/82	Continue REMOTS survey at FVP.
8/26/82	Continue REMOTS survey at FVP.
8/27/82	Complete REMOTS survey at FVP.
8/30/82	Conduct bathymetric survey at MQRDS.
8/31/82	Conduct bathymetric survey at STNH-N and STNH-S.
9/1/82	Conduct bathymetric surveys at Black Rock and Norwalk.
9/2/82	Obtain sediment samples at CLIS.
9/3/82	Deploy DAISY array at CLIS. Conduct diver survey at MQRDS.
9/14/82	Deploy disposal buoy at Wellfleet.
9/21/82	Conduct bathymetric survey at Portland. Obtain sediment samples at Portland.
9/23/82	Obtain benthic samples at Portland.
9/24/82	Conduct bathymetric survey at BFG.
10/28/82	Conduct side scan sonar survey at BFG.
10/29/82	Conduct bathymetric survey at BFG.

TABLE 5-1 (cont.)

Date	Event
12/7/82	Obtain sediment samples at FVP. Conduct diver survey at FVP.
12/8/82	Obtain sediment samples at FVP.
12/10/82	Obtain sediment samples at FVP and STNH-N. Conduct diver surveys at STNH-N and MQRDS. Conduct baseline bathymetric survey at FVP.
12/11/82	Conduct bathymetric surveys at Norwalk and MQRDS.
12/13/82	Conduct bathymetric surveys at STNH-S and STNH-N. Obtain sediment samples at MQRDS.
12/15/82	Obtain sediment samples at CLIS.
	1983
1/5/83	Deploy disposal buoy at Wellfleet.
1/13/83	Deploy disposal buoy at Boston Foul Ground South (BFGS). Obtain sediment samples at BFGS.
1/14/83	Conduct bathymetric survey at BFGS.
1/19/83	Conduct bathymetric survey at WLIS III. Conduct REMOTS survey at WLIS III.
1/20/83	Obtain sediment samples at WLIS III.
1/21/83	Conduct diver survey at WLIS III.
1/26/83	Conduct REMOTS surveys at MQRDS and STNH-S.
1/27/83	Conduct REMOTS surveys at Norwalk and STNH-N.
2/1/83	Conduct disposal plume survey at BFG.
2/2/83	Obtain bulk sediment for WES at Black Rock Harbor.
2/3/83	Obtain bulk sediment for WES at New Haven Harbor.

TABLE 5-1 (cont.)

Date	Event
2/13/83	Deploy disposal buoy at BFG.
2/25/83	Conduct bathymetric survey at BFG.
2/28/83	Deploy UCONN mussel cages at FVP.
3/1/83	Deploy EPA mussel cages at FVP.
3/4/83	Deploy disposal buoy at MQRDS. Conduct diver survey at FVP. Obtain sediment samples at FVP.
3/11/83	Perform dye study at Morris Cove, New Haven, CT
3/15/83	Deploy disposal buoy at FVP. Conduct REMOTS survey at FVP.
4/5/83	Obtain sediment samples at CS-1 and CS-2.
4/6/83	Deploy disposal buoy at CS-1. Perform REMOTS survey at CS-1 and CS-2.
4/7/83	Conduct bathymetric surveys at CS-1 and CS-2. Conduct side scan sonar surveys at CS-1 and CS-2.
4/8/83	Conduct diver surveys at CS-1 and CS-2.
4/13/83	Obtain sediment samples at BFG.
4/14/83	Conduct bathymetric survey at BFGS.
4/18/83	Recover disposal buoy at CS-1. Deploy disposal buoy at CS-2. Conduct diver surveys at FVP and CS-2.
4/21/83	Deploy disposal buoy at WLIS III.
4/22/83	Obtain water and mussel samples at FVP.
4/23/83	Obtain sediment samples at FVP.
4/26/83	Conduct sidescan sonar survey at FVP.
4/27/83	Conduct density probe measurements at CS-1 and CS-2.

TABLE 5-1 (cont.)

Date	Event
4/28/83	Conduct bathymetric surveys at FVP, CS-1 and CS-2. Conduct density probe measurements in Quinnipiac River, New Haven Bight and New Haven Harbor.
5/4/83	Obtain sediment samples at FVP.
5/5/83	Conduct bathymetric survey at FVP. Conduct side scan sonar survey at FVP.
5/6/83	Conduct bathymetric survey at MQRDS. Conduct diver surveys at FVP and CS-1.
5/10/83	Obtain sediment samples at CS-2 and MQRDS. Conduct density probe measurements in dredge scow.
5/11/83	Conduct side scan survey at CS-2. Conduct diver surveys at CS-1 and FVP.
5/19/83	Conduct bathymetric survey at FVP.
5/23/83	Obtain water samples at FVP.
5/24/83	Condduct REMOTS survey at FVP.
5/25/83	Conduct diver survey at FVP. Recover disposal buoy at FVP.
5/31/83	Sample fluff layer at Black Rock Harbor.
6/1/83	Conduct high frequency sonar survey at Black Rock Harbor.
6/2/83	Obtain sediment samples at FVP.
6/3/83	Obtain sediment samples at FVP.
6/7/83	Obtain water samples at FVP.
6/8/83	Conduct bathymetric surveys at CS-1 and CS-2.
6/9/83	Conduct bathymetric surveys at MQRDS. Obtain sediment samples at MQRDS and CS-2.
6/10/83	Conduct side scan surveys at CS-2 and CS-1.

TABLE 5-1 (cont.)

Date	Event
6/13/83	Conduct REMOTS surveys at FVP, CS-1 and CS-2.
6/14/83	Obtain gravity cores at CLIS.
6/21/83	Conduct bathymetric survey at FVP.
7/13/83	Obtain sediment samples at CLIS.
7/15/83	Conduct diver surveys at FVP, CS-1 and CS-2.
7/19/83	Conduct REMOTS survey at FVP. Conduct bathymetric survey at FVP.
7/20/83	Conduct bathymetric survey at CS-1.
7/21/83	Obtain water samples at FVP.
7/26/83	Obtain sediment samples at FVP.
7/27/83	Conduct side scan survey at CS-1 and CS-2. Conduct diver survey at CS-1.
7/28/83	Obtain gravity cores at FVP, CS-1 and CS-2.
8/2/83	Conduct CLIS-Master bathymetric survey.
8/17/83	Recover disposal buoys at WLIS III and FVP.
8/22/83	Obtain sediment samples at CLIS.
8/23/83	Conduct bathymetric surveys at CS-1 and CS-2.
8/24/83	Conduct bathymetric survey at WLIS III.
8/25/83	Conduct REMOTS survey at WLIS III.
8/26/83	Conduct bathymetric survey at FVP.
8/29/83	Conduct REMOTS surveys at FVP, CS 1 and CS 2.
8/30/83	Conduct REMOTS surveys at MQRDS.
8/31/83	Conduct REMOTS surveys at STNH-N and STNH-S.

TABLE 5-1 (cont.)

Date	Event
9/1/83	Obtain sediment samples at FVP.
9/7/83	Conduct diver and REMOTS survey at WLIS III.
9/8/83	Conduct CLIS Master side scan survey.
10/13/83	Deploy disposal buoys at NHAV-83 and WLIS III.
10/18/83	Conduct density probe measurements at CS-1, CS-2, and FVP.
10/19/83	Obtain baseline sediment samples at NHAV-83. Deploy BDMD at NHAV-83.
10/21/83	Conduct REMOTS survey at NHAV-83.
10/22/83	Conduct baseline bathymetric survey at NHAV-83.
11/23/83	Obtain mussel and sediment samples at FVP.
12/5/83	Obtain sediment samples at FVP.
12/6/83	Conduct bathymetric survey at FVP.
12/9/83	Obtain sediment samples at FVP.
12/20/83	Conduct side scan sonar survey at FVP. Conduct post-disposal bathymetric survey at NHAV-83.
12/21/83	Obtain sediment samples at FVP and NHAV-83. Obtain sediment density measurements at FVP.
12/27/83	Deploy disposal buoy at NLON-83. Conduct small bathymetric survey at NLON.
	1984
1/3/84	Conduct side scan sonar survey at NLON.
1/4/84	Obtain sediment samples at NLON-83.
1/5/84	Conduct large bathymetric surey at NLON.

TABLE 5-1 (cont.)

Date	Event
1/6/84	Obtain gravity cores at NLON.
1/23/84	Conduct REMOTS surveys at FVP and NHAV-83.
3/12/84	Conduct bathymetric survey at FVP.
3/14/84	Conduct WLIS Master bathymetric survey. Obtain sediment samples at WLIS III B.
3/15/84	Conduct REMOTS survey at WLIS III B. Deploy disposal buoy at WLIS III B. Conduct side scan survey at WLIS III B.
3/16/84	Conduct REMOTS survey at FVP.
3/19/84	Obtain sediment samples at FVP. Conduct side scan survey at FVP.
3/28/84	Obtain vibra-cores at NLON.
4/10/84	Conduct post-storm bathymetric surveys at CLIS.
5/21/84	Conduct bathymetric survey at Portland.
5/22/84	Obtain sediment samples at Portland.
5/23/84	Conduct side scan survey at Portland.
5/24/84	Conduct baseline survey at CADS. Conduct side scan survey at CADS. Obtain sediment samples at CADS.
5/30/84	Conduct expanded side scan survey at CADS. Conduct expanded bathymetric survey at CADS.
5/31/84	Designate and sample sediment at CADS Reference.
6/6/84	Conduct side scan survey at FVP. Conduct bathymetric survey at FVP.
6/7/84	Conduct REMOTS survey at FVP.
6/19/84	Deploy current meters at CADS. Obtain sediment samples at CADS

TABLE 5-1 (cont.)

Date	Event
6/20/84	Conduct bathymetric survey at NLON.
6/22/84	Conduct REMOTS survey at NLON.
6/23/84	Obtain sediment samples at NLON.
6/25/8	Conduct bathymetric surveys at WLIS III A and B. Obtain sediment samples at WLIS III A and B.
6/26/8	Conduct REMOTS survey at WLIS III B.
7/17/84	Recover disposal buoy at NLON.
7/18/84	Recover disposal buoy at WLIS III B.
7/23/84	Conduct submersible surveys at BFG.
7/26/84	Conduct submersible surveys at CADS.
7/27/84	Conduct submersible surveys at Portland.
9/3/84	Conduct REMOTS survey at FVP.
9/6/84	Conduct REMOTS survey at STNH-N.
9/7/84	Conduct REMOTS surveys at STNH-S, MQRDS and CS-1.
9/11/84	Obtain sediment samples at FVP.
9/12/84	Obtain sediment samples at NHAV-83, CS-1, CS-2, NHAV-74, MQRDS, NOR, STNH-N, and STNH-S.
9/13/84	Conduct REMOTS surveys at CS-2, NHAV-74, NHAV-83 and NOR.
9/14/84	Obtain gravity cores at FVP, STNH-N, STNH-S, CS-1 and CS-2.
9/18/84	Conduct 3 replicate bathymetric surveys at FVP. Conduct CLIS Master bathymetric survey.
9/20/84	Deploy disposal buoys at CS-1 and WLIS III.

TABLE 5-1 (cont.)

Date	Event
9/27/84	Obtain sediment samples at ROCK. Conduct bathymetric survey at ROCK.
10/1/84	Conduct REMOTS survey at ROCK. Conduct side scan survey at ROCK.
10/9/84	Conduct REMOTS survey at BFG.
10/11/84	Recover current meters at CADS. Deploy wave guage at CADS.

(cont.)

TABLE 5-1 (con't)

Date	**Event**
11/16/84	Service wave gauge at CADS Deploy Disposal Buoy at CADS
12/5/84	Conduct bathymetric survey at NLON Conduct two side scan surveys at NLON Collect visual classification samples at NLON
12/8/84	Recover wave gauge at CADS
12/11/84	Collect visual classification samples at NLON Conduct diver survey at NLON
12/18/84	Conduct REMOTS survey at CLIS
12/19/84	Conduct REMOTS survey at FVP
12/20/84	Obtain sediment samples at CLIS-REF CTD cast at CLIS-REF
2/27/85	Conduct search for buoy at CADS
3/4/85	Deploy disposal buoy at CADS
3/19/85	Conduct bathymetric survey at FVP Right buoy at CS-1
3/20/85	Obtain benthic and chemical samples at CLIS and FVP Obtain sediment cores at FVP
3/21/85	Obtain sediment samples at CLIS-REF Service disposal buoy at CS-1 Conduct bathymetric survey at FVP
3/22/85	Conduct REMOTS survey at FVP Obtain sediment samples at FVP
5/8/85	Conduct diving survey of possible errant disposal operations at New London
5/18/85	Deploy current meter array at CADS Conduct CTD/current profiles at CADS
5/19/85	Set-up shore stations at ROCK
5/20/85	Deploy mooring at ROCK Conduct bathymetric survey at ROCK Collect visual classification samples at ROCK
5/21/85	Conduct CTD/current profiles at ROCK Obtain water samples at ROCK

TABLE 5-1 (con't)

	Conduct plume study at ROCK
5/22/85	Conduct CTD/current profiles at ROCK Conduct plume study at ROCK Conduct side scan survey at ROCK
5/23/85	Conduct CTD/current profiles at ROCK
5/24/85	Conduct CTD/current profiles at ROCK Conduct plume study at ROCK
5/29/85	Collect CTD/current profiles at CADS Collect water samples at CADS Reference Site Collect Sediment samples at CADS Reference Site
5/30/85	Set and recover gill nets at CADS Collect body burden animals at CADS Reference Site Conduct precision bathymetric Survey at CADS Begin REMOTS survey at CADS
6/2/85	Complete REMOTS survey at CADS
6/3/85	Begin REMOTS survey at FADS
6/4/85	Continue REMOTS survey at FADS
6/5/85	Continue REMOTS survey at FADS
6/6/85	Collect vertical current profiles at FADS Deploy and recover gill nets at FADS Collect water samples at FADS
6/7/85	Deploy and recover gill nets at FADS Collect body burden animals at FADS Reference Site Conduct whale watching transect at FADS Begin submersible operations at FADS
6/8/85	Complete submersible operations at FADS
6/9/85	Submersible operations at CADS
6/25/85	Obtain sediment samples at FVP Deploy EPA mussel buoys at FVP
6/26/85	Conduct REMOTS survey at FVP and CLIS Recover Disposal buoy at CLIS Recover Current Meter Array at CADS
6/27/85	Recover current meter array at ROCK
7/2/85	Deploy Current Meter Array at FADS
7/30/85	Conduct REMOTS survey at New London

TABLE 5-1 (con't)

7/31/85	Complete REMOTS survey at New London Retrieve Disposal Buoy at CADS
8/5/85	Conduct bathymetric survey at New London
8/6/85	Complete bathymetric survey at New London Recover current meter array at FADS
8/8/85	Conduct CLIS Master bathymetric survey
8/9/85	Complete CLIS Master bathymetric survey Conduct bathymetric survey at STNH-S, MQRDS, NHAV-83, CLIS-SP
8/12/85	Deploy and recover DAISY at CLIS Conduct REMOTS survey at CS-2, STNH-N, CS-1, and CLIS-REF
8/13/85	Deploy DAISY at CLIS Conduct divers survey at STNH-N, STNH-S, CS-1 and CS-2 Conduct REMOTS survey at STNH-S and Norwalk
8/14/85	Conduct REMOTS survey at CS-1, NHAV-74 and NHAV-83 Conduct divers survey at FVP Obtain sediment samples at FVP and CLIS-REF
8/15/85	Conduct REMOTS survey at MQRDS and CLIS-SE Recover DAISY at FVP
8/20/85	Conduct bathymetric surveys at FVP, CS-1, CS-2, Norwalk, NHAV-74, and CLIS-85
8/21/85	Obtain sediment samples at CLIS-85 and CLIS-85 Conduct side scan survey at CLIS-SE and CS-2
8/22/85	Conduct REMOTS survey at WLIS Conduct divers survey at WLIS-A and WLIS-B Conduct bathymetric survey at WLIS
8/26/85	Obtain sediment samples at WLIS
8/28/85	Conduct side scan survey at New London
8/29/85	Conduct REMOTS survey at New London Obtain benthic and chemistry samples at New London
9/20/85	Obtain water chemistry samples at CADS Obtain sediment samples at CADS Deploy gill nets at CADS Obtain CTD/current profiles at CADS

TABLE 5-1 (con't)

9/21/85	Recover gill nets at CADS Obtain CTD/current profiles at CADS Obtain Benthic sediment samples at CADS Re-deploy gill nets at CADS
9/23/85	Obtain CTD/current profiles at CADS Obtain body burden animals at CADS
9/24/85	Begin REMOTS survey at FADS
9/26/85	Deploy DAISY at FADS
9/30/85	Continue REMOTS Survey at FADS
10/1/85	Complete REMOTS survey at FADS
10/2/85	Obtain body burden animals at FADS
10/7/85	Obtain sediment chemistry samples at FADS Obtain benthic sediment samples at FADS Begin trawling operations at FADS Deploy gill nets at FADS Recover DAISY at FADS
10/8/85	Recover Gill Nets at FADS Complete trawler operations at FADS Obtain BRAT box cores at FADS Obtain sediment chemistry samples at FADS Obtain benthic sediment samples at FADS Deploy and recover trammel nets at FADS
10/9/85	Obtain body burden samples at FADS
10/10/85	Obtain body burden samples at FADS
10/17/85	Conduct Side Scan sonar survey at FADS Conduct precision bathymetric survey at FADS
10/18/85	Recover current meter array at FADS
10/22/85	Obtain sediment samples at FVP and CLIS-REF Conduct bathymetric survey at FVP
10/23/85	Conduct bathymetric survey at CS-2 Conduct REMOTS survey at FVP and CLIS-REF
10/24/85	Conduct bathymetric survey at CS-1, MQRDS, and STNH-S
10/25/85	Conduct bathymetric survey at STNH-N Conduct REMOTS/boxcore transect
10/28/85	Conduct REMOTS survey at CS-1 and CS-2

TABLE 5-1 (con't)

10/29/85	Conduct REMOTS survey at STNH-S and MQRDS Conduct REMOTS transect from New Haven Harbor entrance to Disposal site
10/30/85	Conduct bathymetric survey at WLIS Obtain sediment samples at WLIS
10/31/85	Conduct REMOTS transect from Green Light to WLIS
11/1/85	Service disposal buoy at CLIS Conduct REMOTS survey at STNH-N Conduct REMOTS survey at FVP Obtain sediment samples at STNH-N, STNH-S, MQRDS, CS-1 and CS-2
11/7/85	Obtain sediment samples at New London Conduct REMOTS survey at New London
11/9/85	Deploy disposal buoy at FADS
11/14/85	Deploy disposal buoy at New London Conduct bathymetric survey at New London
12/10/85	Service buoy at WLIS

TABLE 5-2

LIST OF DAMOS CONTRIBUTIONS

#1	Stamford/New Haven Disposal Operation Monitoring Survey Report - Baseline Surveys
#2	Stamford/New Haven Disposal Operation Monitoring Survey Report - 20,000 yd^3 Increment
#3	Stamford/New Haven Disposal Operation Monitoring Survey Report - $50,000^3$ Southern Side, $10,000^3$ Nothern Side
#4	Completion of Stamford Disposal (Stamford/New Haven)
#5	Post Disposal Surveys (Stamford/New Haven)
#6	Post Disposal Monitoring (Stamford/New Haven)
#7	Stamford/New Haven Disposal Operation Monitoring Survey Report
#8	Management and Monitoring of Dredge Spoil and Capping Procedures in Central Long Island Sound
#9	Chronological Records of In-Situ Physical and Biological Conditions Obtained by Diver Survey at CLIS and New London
#10	Changes in the Levels of PCB's in Mytilus edulis Associated with Dredge Spoil Material
#11	"Capping" Procedures as an Alternative Technique to Isolate Contaminated Dredge Material in the Marine Environment
#12	Precision Disposal Operations Using a Computerized Loran-C System
#13	Disposal Area Monitoring System Progress Report March 15 - May '80
#14	Disposal Area Monitoring System Progress Report - May 15 - July 30, 1980
#15	Precision Bathymetry, Diving Observations and Sediment Description - Norwalk Disposal Area Operation Monitoring Survey Report Post Disposal Surveys, April 1981

TABLE 5-2 (cont.)

#16	Deployment of Dredged Material Disposal Buoys at the Central Longs Island Sound and Western Long Island Sound Disposal Sites
#17	Disposal Area Monitoring System Annual Report, 1980
#18	Interim Survey of Western Long Island Sound III Disposal Site
#19	Baseline Survey of the Proposed WLIS III Dredged Material Disposal Site (June 30, 1982)
#20	DAMOS Mussel Watch Program: Histological Studies of Mussels from Dredged Material Disposal Sites (Feng)
#21	Mussel Watch Program - New London Disposal Site Monitoring Projects - 1977-1979
#22	DAMOS Mussel Watch Program: Monitoring of the "Capping" Procedure Using Mytilus edulis at the Central Long Island Sound Disposal Site; 1980-81 (Feng)
#23	Site Selection and Baseline Surveys of the Black Rock Disposal Site for the Field Verification Program
#24	A Study of The Benthic Macrofauna at the CLIS Disposal Site
#25	CLIS Status Report
#26	Results of Loran-C Control of Disposal Operations at the Boston Foul Ground (Sugar Island)
#27	Summary of Measurements Made at the WLIS III Disposal Site
#28	Interim Report on the Concentration of Trace Metals in Mytilus Edulis Deployed at the Western Long Island Sound Disposal Site.
#30	OSV Antelope Cruise Report - June, 1983
#31	Green Harbor Wave Data Preliminary Report (Green Harbor #1)
#35	Post-Disposal Survey of the WLIS III Disposal Site; August - September, 1983
#36	A Feasibility Study of the Disposal of Dredged Material @ Morris Cover, New Haven Harbor

TABLE 5-2 (cont.)

#37	Wave Climate, Green Harbor #2
#38	Results of Monitoring Studies @ Cap Sites #1, #2, and the FVP Site in Central Long Island Sound and a Classification Scheme for the Management of Capping Procedures
#39	Sediment Characterization - NLON Disposal Site; March - April, 1984
#40	Wave Climate - Green Harbor #3
#41	Dredged Material Disposal Operations at the Boston Foul Ground; June 1982 - February 1983
#42	Evaluation of the Effectiveness of Dredging on the Kennebec River
#43	Mussel Watch: Eastern Long Island Sound Disposal Site and Portland Disposal Site Monitoring Projects
#44	Baseline and Post-Disposal Surveys at the WLIS III "B" Disposal Site
#45	Rhode Island and Southeastern Massachusetts Dredging Needs Survey, 1985-1995
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TABLE 5-2 (cont.)

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