Monitoring Cruise at the Rockland Disposal Site
July 1989

# Disposal Area Monitoring System DAMOS

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221 Third Street
Newport, RI 02840

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A monitoring cruise was conducted at the Rockland Disposal Site in June 1989 to delineate and map the distribution of dredged material disposed since the May 1985 survey and to determine the progress of benthic recolonization at the site. The data collected included precision bathymetry, side scan sonar, and REMOTS sediment profile photography.

The side scan sonar survey showed patches of fresh and relict dredged material, including some areas immediately outside of the disposal site boundary. These results were confirmed by the REMOTS® survey. The dredged material mound detected by the bathymetric survey was not as distinctive as that predicted prior to the survey. This was partially explained by the fact that this site is not served with a taut-wire buoy. A depth difference contour chart of the 1989 and 1985 bathymetric surveys revealed an eliptical (100 m X 300 m) mound 200 m southeast of the buoy with a maximum thickness of 1.3 m. Smaller mounds of material, 0.3 to 0.7 meters thick, were located at greater distances from the disposal buoy.

Benthic recolonization was determined from the analysis of REMOTS® photographs obtained at the Rockland Disposal Site and at three outlying reference areas. As predicted, Stage I dominated the REMOTS® stations located on the disposal site. Stage I alone was found in the center of the site near the disposal buoy where dredged material deposits were thickest. Stage III was found away from the buoy in conjunction with Stage I, indicating recolonization. The reference areas, with only one replicate per station, had a predominance of Stage III and/or I on III. A minority of the reference area stations had only stage I organisms.

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# MONITORING CRUISE AT THE ROCKLAND DISPOSAL SITE JUNE 1989

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424 Trapelo Road
Waltham, MA 02254-9149

Submitted by:

Science Applications International Corporation
Admiral's Gate
221 Third Street
Newport, RI 02840
(401) 847-4210

US Army Corps
of Engineers
New England Division

## EXECUTIVE SUMMARY

This document presents data collected from a monitoring survey at the Rockland Disposal Site in June 1989 as part of the DAMOS (Disposal Area Monitoring System) program. The objectives of the field operations were to delineate and map the distribution of dredged material disposed since the May 1985 survey and to determine the progress of benthic recolonization at the site. The data collected included precision bathymetry, side scan sonar, and REMOTS® sediment profile photography. It was predicted that the dredged material would form a mound 1.6 m thick and 500 m in radius. Benthic recolonization was expected to be mixed Stage I and III over most of the disposal site with Stage I being more abundant at the disposal site and Stage III being more common at the reference areas.

The side scan sonar survey showed patches of fresh and relict dredged material, including some areas immediately outside of the disposal site boundary. These results were confirmed by the REMOTS® survey. The dredged material mound detected by the bathymetric survey was not as distinctive as that predicted prior to the survey. This was partially explained by the fact that this site is not served with a taut-wire buoy. A depth difference contour chart of the 1989 and 1985 bathymetric surveys revealed an eliptical (100 m X 300 m) mound 200 m southeast of the buoy with a maximum thickness of 1.3 m. Smaller mounds of material, 0.3 to 0.7 meters thick, were located at greater distances from the disposal buoy.

Benthic recolonization was determined from the analysis of REMOTS® photographs obtained at the Rockland Disposal Site and at three outlying reference areas. As predicted, Stage I dominated the REMOTS® stations located on the disposal site. Stage I alone was found in the center of the site near the disposal buoy where dredged material deposits were thickest. Stage III was found away from the buoy in conjunction with Stage I, indicating recolonization. The reference areas, with only one replicate per station, had a predominance of Stage III and/or I on III. A minority of the reference area stations had only stage I organisms.

*TABLE OF CONTENTS*

**LIST OF FIGURES**

**LIST OF FIGURES**
(Continued)

**MONITORING SURVEYS AT THE ROCKLAND DISPOSAL SITE JUNE 1989**

## 1.0 INTRODUCTION

The Rockland Disposal Site is located in the center of West Penobscot Bay approximately 3.3 nautical miles northeast of the Rockland Harbor breakwater (Figure 1-1). The site is a 0.5 nautical mile square with sides running true north-south and east-west, centered at 44° 07.1'N, 69° 00.3'W (Figure 1-2). Dredged material disposal began at this site in October 1973; environmental monitoring by the U.S. Army Corps of Engineers, New England Division (NED) has occurred since 1977. The disposal point within the site is marked with a buoy deployed and maintained by the U.S. Coast Guard. This buoy has a conventional mooring (resulting in a wide scope) centered at 44° 07.177'N and 69° 00.393'W (Figure 1-2).

A baseline characterization survey consisting of precision bathymetry, sediment grab sampling, sidescan sonar, and REMOTS® sediment-profile photography was performed at the site in September 1984. Precision bathymetric and sidescan sonar surveys subsequently were performed in May 1985, after an estimated 275,400 $m^3$ of dredged material from Searsport, Maine had been deposited. Since May 1985, an estimated 430,000 $m^3$ (based on scow records) of dredged material have been disposed at the site.

Field operations for the surveys discussed in this report were conducted at the Rockland Disposal Site from 19 to 23 June 1989. The field operations consisted of sidescan sonar, a grab sample, precision bathymetry, and REMOTS® sediment-profile photographic surveys centered southeast of the disposal buoy (Figures 1-2 and 2-1). Sidescan sonar was used as a reconnaissance technique to map the general location of dredged material and determine the appropriate configuration of the subsequent bathymetric and REMOTS® surveys. The objectives of the precision bathymetric survey were to delineate the distribution of dredged material disposed since May 1985 and to map that portion of the dredged material deposit greater than 0.3 meters thick. The purposes of the REMOTS® survey were to determine the extent and thickness of dredged material not detectable with bathymetry and to determine the progress of benthic colonization at the site.

The 1989 monitoring scheme at the Rockland Disposal Site was designed to test the following predictions:

- Sediment disposed within 250 meters of the buoy would add to the existing deposit of dredged material. Assuming a 400 meter radius of disposal operations, the DAMOS disposal model predicted the resulting deposit would be approximately 1.6 meters thick in the center and have a radius of 500 meters.

- Benthic community recolonization would be mixed Stage I and II over much of the deposit, with the percentage of Stage III organisms lower and with Stage I being more abundant than at the reference areas.

## 2.0 METHODS

### 2.1 Navigation and Bathymetry

The precision navigation required for all field operations was provided by the SAIC Integrated Navigation and Data Acquisition System (INDAS). A comprehensive description of this system and its operation is provided in DAMOS Contribution #48 (SAIC, 1985). Microwave trisponders were positioned in Maine at the Deadman Point and Owl's Head Lighthouse shore stations (SAIC, 1985). These shore stations were identical to those used during previous surveys, to ensure accurate comparisons.

Depth measurements were obtained by an Odom Echotrac® model DF3200 survey fathometer using a narrow-beam 208 kHz transducer. The speed of sound in the water column was calculated from temperature and salinity profiles collected with an Applied Microsystems CTD at the beginning and end of the survey. The speed of sound value was used during analysis of the bathymetric data to correct the recorded depths. A detailed description of the instrumentation and methods used for precision bathymetric surveys is provided in DAMOS Contribution #48 (SAIC, 1985).

The bathymetric survey conducted on 21 June 1989 consisted of a 1400 X 1200 m grid with 25 m lane spacing, centered at coordinates 44° 07.093'N and 69° 00.275'W, near the center of the disposal site (Figure 1-2). This grid encompassed the 1200 X 1200 m grid used in the May 1985 bathymetric survey of the site; the survey lanes were extended 200 meters west to detect any material disposed outside the western site boundary. A sediment grab sample obtained prior to the bathymetric survey had shown apparent dredged material (poorly-sorted sand and silt, with wood chips and bark) in this vicinity (Figure 1-2).

### 2.2 REMOTS® Sediment-Profile Photography

REMOTS® photography was used to detect the distribution of thin (1 to 20 cm) dredged material layers, map benthic disturbance gradients, and monitor the process of infaunal recolonization on and adjacent to the dredged material deposit. A detailed description of REMOTS® photograph acquisition, analysis, and interpretative rationale is given in DAMOS Contribution #60 (SAIC, 1989).

The 43 REMOTS® stations occupied on 22 and 23 June 1989 were spaced at 100 meter intervals in a cross-shaped grid (Figure 2-1). An attempt was made to obtain three replicate photographs at each station; however, only two photographs from stations 200S, 400NE, and 400NW, and only one from station 300S, could be analyzed because of either inadequate prism penetration or movement of the camera during exposure. Photographs were not obtained at stations 700W and 800W due to a camera malfunction.

Thirteen REMOTS® stations, arranged in a cross-shaped pattern and spaced 100 m apart, were occupied at each of three reference areas to allow comparisons between ambient conditions and conditions on the deposit. The reference areas were located 2000 meters north (N-REF), east (E-REF), and south (S-REF) of the center of the disposal site REMOTS® grid. Reference area N-REF was located in 70 meters of water at coordinates 44° 08.172'N, 69° 00.275'W; E-REF occurred at the same depth at 44° 07.090'N, 68° 58.700'W; and S-REF was located in approximately 80 meters of water at 44° 06.013'N, 69° 00.275'W.

## 2.3 Sidescan Sonar Survey

A Klein Graphic Sonar Recorder connected to a single frequency (100 kHz) towfish was utilized in the sidescan sonar survey. This survey was identical to the one performed in May 1985 and consisted of 17 lanes spaced 100 meters apart, roughly covering a 1600 X 1600 meter area encompassing the disposal site and its surrounding area (Figure 1-2). The total width of the sidescan record was 200 meters, providing 100% overlap of the survey track lines.

The height of the towfish above the bottom generally was maintained at 20 meters and was controlled manually by adjusting the cable length. During the survey, the position and time data obtained from the INDAS system were stored on magnetic disk, printed out, and annotated on the sidescan record. A real-time plot of the ship's position in relation to the survey lines also was generated automatically.

For analysis and interpretation of the sidescan records, an 11 X 17 base chart of the survey track lines first was reconstructed and annotated with time. The sidescan records for each survey were reviewed and analyzed, and prominent features were noted on the base charts as a function of time (and position). The records also were compared to those obtained in May 1985 to determine features common to both surveys.

## 3.0 RESULTS

### 3.1 Bathymetry

Both the 1985 and 1989 precision bathymetric surveys showed the north-south-trending trough which characterizes the northern half of the disposal site and widens and shoals toward the south (Figures 3-1 and 3-2). Extending the bathymetric survey lanes 200 meters west in the 1989 survey revealed the presence of a small mound-like feature, possibly a rock outcrop, just outside the western disposal site boundary (Figure 3-2). The 1989 survey also revealed part of a trough-like feature extending away from the southwest corner of the site. Neither the 1985 nor 1989 bathymetric charts showed a distinct disposal mound near the buoy location. Careful comparison of the two surveys did reveal decreases in depth near the buoy, as evidenced by subtle shifts in the 67, 68, and 69 meter contours (Figures 3-1 and 3-2).

In order to estimate the overall accumulation of dredged material since the last bathymetric survey in 1985, a depth difference chart was produced by comparing the 1985 and 1989 depth matrices. The results of this exercise must be used only as a rough estimate because of several significant differences between the two surveys. In 1985, the survey was conducted with a 24kHz, 20° beam width transducer at a 50 meter lane spacing; whereas in 1989, depths were obtained from a 208kHz, 3° transducer along lanes spaced 25 meters apart. The resolution of the depth difference calculations is limited by that of the 1985 survey (approximately 30-40 cm). An additional consideration is that only every other lane of the 1989 survey was used in the comparison. In 1989, the vessel travelled in the same direction on these lanes; whereas in 1985, the vessel reversed its direction between lanes. This resulted in the standard offset between the navigation antenna and fathometer transducer being inconsistent on every other lane. Allowance for this was made during the analysis of the bathymetric data.

The depth difference contour chart clearly illustrates an elliptically-shaped dredged material deposit with a maximum height of 1.3 meters occurring immediately southeast of the buoy (Figure 3-3). Depth changes on the order of 0.3 to 0.5 meters continued for approximately 450 to 500 meters south, southwest, and west of this deposit. Localized depth changes of 0.7 and 0.9 meters also occurred in two areas northeast of this deposit. Changes in depth of approximately 0.3 m apparently continued an unknown distance beyond the western disposal site boundary as indicated by the open contours. However, it is possible that the magnitude of depth changes at the boundary are exaggerated due to differences in resolution between the 1985 and 1989 surveys and resultant noise in the depth-difference plot.

Based on the depth difference comparison, it was estimated that the dredged material which had accumulated since the 1985 survey had a volume of 209,600 $m^3$ (95% confidence limits; 192,666 $m^3$ to 226,543 $m^3$). Scow records indicate that an uncorrected estimate of 430,000 $m^3$ of material was disposed within 250 meters of the Rockland buoy between the 1985 and 1989 surveys.

### 3.2 REMOTS® Sediment-Profile Photography

Apparent dredged material was evident in the REMOTS® photographs from stations within a 500 to 700 meter radius around the disposal buoy (Figure 3-4). The thickness of the apparent dredged material layers at most stations exceeded the depth of penetration of the camera prism. The dredged material at stations 100W and 200NW appeared to have been recently disposed (i.e., within the past year; Figure 3-5). Elsewhere, the dredged material was distinguished either by its higher sand content compared with ambient silt-clay sediments (Figure 3-6), or by homogeneity in grain-size and optical reflectance atypical of the natural surrounding sediments (Figure 3-7). It was difficult to determine when disposal of such material occurred. At stations 400SE, 600SW, and 600W, dredged material was visible in only one of the three REMOTS® photographs obtained, suggesting a patchy or otherwise discontinuous spatial distribution.

Silt-clay sediments mixed with significant amounts of very fine sand (major mode of >4-3 phi) occurred at most of the REMOTS® grid stations (Figure 3-8). As indicated above, the presence of the fine sand fraction served as a marker for identifying disposed material at stations surrounding the buoy. Silt-clay (>4 phi) characterized all other disposal site and reference area REMOTS® stations. The majority of small-scale surface boundary roughness values at the disposal site stations having dredged material fell in the range 0 to 1.0 cm, while most of the reference area values were in the range 0 to 0.6 cm (Figure 3-9). Boundary roughness values at the disposal site stations were not significantly different from those at the reference areas (Mann-Whitney U-test, $p = 0.4254$), although more values at the disposal site fell within the higher class intervals (Figure 3-9). This reflected physical bottom disturbance related to dredged material disposal.

The frequency distribution of apparent RPD depths for the REMOTS® stations having dredged material had a major mode at the 1.0 cm class interval, while the distribution of RPD depths for the reference areas had a major mode at the 5.0 cm class interval (Figure 3-10). The reference area RPD depths were significantly deeper (Mann-Whitney U-test, $p < 0.001$). RPD depths less than 3.0 cm occurred at stations within a 700 to 900 meter radius of the buoy, encompassing most of the area having dredged material (Figure 3-11). All the RPD depths at the reference areas exceeded 3.0 cm.

Only Stage I organisms were present in the replicate REMOTS® photographs from a cluster of stations (200NW, 200W, 100W, CTR, 100N, 200N, 200NE, and 200SW) occurring at, and immediately southeast of, the disposal buoy (Figure 3-12). At the remainder of the disposal site stations, there was evidence of Stage III taxa (i.e., head-down, deposit-feeding infauna) in at least one of the replicate photographs. Most of these stations were designated as having either a Stage III or Stage I on III successional stage (Figure 3-13). Altogether, 48% of the replicate photographs at the stations having dredged material showed evidence of Stage III taxa, compared to 72% of the reference area replicates.

Based on the results of past REMOTS® surveys, Organism-Sediment Index (OSI) values of +6 or less are considered indicative of chronically-stressed benthic habitats and/or those which have experienced recent disturbance (e.g., erosion, dredged material disposal, hypoxia, demersal predator foraging, etc.). Mean OSI values $\leq$ +6 occurred at stations surrounding the Rockland disposal buoy (Figure 3-14). These low values were due to a combination of relatively shallow RPD depths and an absence of Stage III infauna, conditions attributable to recent inputs of dredged material at the buoy. OSI values exceeded +6 at all but three of the thirty-six reference area replicates. These three replicates exhibited relatively deep RPD depths, but only had Stage I successional designations.

The frequency distribution of reference station OSI values had a major mode at +11, while the OSI values at the disposal site stations having dredged material were distributed unevenly and ranged between +1 and +11 (Figure 3-15). The reference station OSI values were significantly greater (Mann-Whitney U-test, $p < 0.001$). The overall average OSI value was 9.7 for the reference areas and 6.8 for the disposal site stations, compared with a mean value of 5.8 for just those disposal site stations having dredged material.

### 3.3 Sidescan Sonar Survey

The sidescan records from a relatively large area southeast of the disposal buoy showed high acoustic reflectance, considered indicative of dredged material (Figure 3-16). Low to intermediate reflectance characterized the natural silt-clay sediments occurring both within and outside the disposal site, allowing ambient bottom to be distinguished from areas where dredged material had been deposited (Figures 3-16 and 3-17).

The mapped distribution of dredged material southeast of the buoy is nearly identical to that mapped in the May 1985 sidescan survey of the site. Smaller patches of dredged material also occurred near the northeast corner of the disposal site and in several places outside the disposal site boundaries (Figure 3-16). As in May 1985, much of this material occurred in long, narrow, discrete deposits, probably as a result of a single disposal event occurring while the scow was underway or turning. In interpreting the sidescan records, it was assumed that very strong acoustic reflectance indicated the dredged material had been deposited relatively recently (Figure 3-18). In several instances, dredged material deposits which were clearly "fresh" in the May 1985 records were observed again as "weathered" deposits in the June 1989 survey (Figure 3-19).

## 4.0 DISCUSSION

One objective of the combined precision bathymetric, sidescan sonar, and REMOTS® photographic surveys was to delineate the distribution and topography of dredged material disposed since the May 1985 surveys at Rockland. Specifically, the purpose of the bathymetric survey was to map that portion of the dredged material mound greater than 0.3 meters thick. This survey showed a significant accumulation of dredged material centered approximately 200 meters southeast of the buoy; the small, elliptical deposit in this location had a maximum thickness of 1.3 meters at its apex (Figure 3-3). This closely approximated the DAMOS disposal model prediction that the deposit would have a maximum height of 1.6 meters. The material on the deposit "flanks" did not occur in a symmetrical pattern around the central elliptical deposit, as is typical of deposits in shallower waters. Rather, irregular changes in depth between 0.3 and 0.5 meters were detected 400 to 500 meters to the south, southwest, and west of the deposit. Two smaller mound-like deposits also occurred northeast of the buoy, and a deposit up to 0.5 m thick was detected near the southwest corner of the disposal site. The 0.3 meter changes in depth at the western disposal site boundary are open contours, indicating possible continuation of the depth changes (accumulation of dredged material) beyond the site in this direction (Figure 3-3). Since the resolution of the 1985 survey was at a minimum of 0.3 meters, however, it is possible that these changes are exaggerated.

The distribution of dredged material observed by sidescan sonar and REMOTS® photography confirmed the bathymetric survey results. Sidescan sonar showed the most extensive accumulation of dredged material was southeast of the buoy, corresponding to the elliptical deposit detected by bathymetry. Smaller areas of dredged material observed in the sidescan records near the northeast and southwest corners of the disposal site roughly corresponded in location with the small mound-like deposits seen in the depth difference contour chart (Figures 3-3 and 3-16). The REMOTS® photographs from station 600SW indicated dredged material near the southwest corner of the disposal site had a patchy distribution (Figure 3-4), consistent with the pattern of discrete, elongated deposits detected by sidescan sonar in this area. Likewise, the photographs from stations 600W, 500E, 500N, 600N, and 600NW confirmed that some disposed material was distributed outside the site boundaries. A grab sample taken prior to the bathymetric survey (Figure 1-2) also had recovered dredged material outside the western site boundary (see Section 2.1 above).

The radius of dredged material determined by REMOTS® photography (500 to 700 meters) was greater than the radius determined by bathymetry (400 to 500 meters) and also exceeded the 500 meter radius predicted by the DAMOS disposal model. The REMOTS® mapping indicated dredged material occurred farther west, north, and east of the buoy (Figure 3-4) than indicated by bathymetry (Figure 3-3). This is mainly due to the camera's ability to detect thin dredged material layers below the limits of detection by precision bathymetry. The wide scope of the conventionally-moored disposal buoy at the site most likely contributed to the wide distribution of material on the bottom. In addition, lack of strict control on the scow release points may have resulted in disposal at a distance from the intended location. This was suggested in part by the side scan survey that detected dredged material outside the disposal site boundaries.

The thin layers of dredged material detected by REMOTS®, but missed by bathymetry, were unaccounted for in the volume difference calculation. The area encompassing these thin layers was estimated to be roughly 636,000 $m^2$. Assuming that the layers had an average thickness of 15 cm (based on the fact that they exceeded the prism penetration at most stations), an estimated total of at least 95,400 $m^3$ of dredged material was not accounted for in the bathymetric depth difference calculation. Adding this to the depth difference volume estimate of 209,600 $m^3$ results in a final total of approximately 305,000 $m^3$ of dredged material detected on the bottom using the two techniques.

The final total volume estimate of 305,000 $m^3$ is less than the scow log volume estimate of 430,000 $m^3$ of disposed material. A relatively small amount of undetected material may have occurred beyond the limits of the area surveyed. In addition, Tavolaro (1984) showed that volume estimates based on scow log records considerably overestimate the amount of dredged material because of the significant amount of interstitial water associated with the dredged material in the barges. He calculated that "depth difference" volume estimates based on successive bathymetric surveys will be as much as 41% less than the scow log volume estimates. The discrepancy was attributed not only to the scow log inaccuracies, but also to the compaction of dredged material on the bottom following disposal and the significant volume of material deposited in layers too thin to be detected acoustically. Applying the 41% factor to the scow log estimates in the present study results in a corrected volume of 255,000 $m^3$ of material, compared to the depth difference volume estimate of 209,600 $m^3$. Similar discrepancies between these two estimates have been found at other

DAMOS disposal sites; such results have pointed to the need for a comprehensive mass balance study and for more accurate ways to measure scow volumes in cases where this information will be important.

A second objective of the REMOTS® survey was to assess the progress of benthic recolonization at the disposal site. Stations with only Stage I taxa were limited to a relatively small area extending southeast of the buoy, corresponding to the area where the thickest dredged material deposit occurred. Relatively shallow RPD depths occurred at most of the REMOTS® stations within the disposal site. This probably reflected higher concentrations of labile organic matter and, therefore, increased sediment oxygen demand of the disposed material compared to ambient sediments, as well as the low level of benthic colonization due to recent deposition. The benthic recolonization and RPD values were integrated in the mapped distribution of OSI values at the site.

Immediately outside the small elliptical area representing the thickest accumulation (>50 cm) of dredged material, both Stage I and Stage III taxa were prevalent, indicating significant recolonization within the disposal site by head-down, deposit-feeding taxa. This may be related to the relatively thin layers of material (30 to 50 centimeters) occurring over most of the area. This area apparently experienced physical disturbance (e.g., burial by disposed material) much less frequently than the area in the immediate vicinity of the buoy. As predicted, the percentage of Stage III organisms was lower, and the percentage of Stage I higher, at the stations having dredged material compared with the reference stations, particularly at the stations nearest the buoy. However, indigenous infauna have colonized much of the area affected by disposal operations within the site.

## 5.0 CONCLUSIONS

The combined results of the bathymetric and REMOTS® surveys provided a rough estimate of 305,000 $m^3$ of material accumulated at the Rockland Disposal Site since the May 1985 surveys. This was less than the scow log volume estimate of 430,000 $m^3$ of disposed material, but such discrepancies are expected because of the inaccuracies of scow estimates, the compaction of the dredged material on the bottom following disposal, and the significant amount of interstitial water associated with the dredged material in the barges.

Most of the dredged material disposed at the Rockland site since May 1985 occurred as an elliptical deposit with a maximum thickness of 1.3 meters, centered approximately 200 meters southeast of the disposal buoy. Based on changes in bathymetry, dredged material layers on the order of 0.3 to 0.5 meters thick extended 400 to 500 meters beyond this deposit to the south, southwest, and west. Smaller mound-like deposits also occurred northeast of the buoy and near the southwest corner of the disposal site. REMOTS® sediment-profile photography indicated the radius of dredged material on the bottom was between 500 to 700 meters, with the material occurring farther west, north, and east of the disposal buoy than indicated by bathymetry. Dredged material was detected outside the disposal site boundaries, particularly to the west. Sidescan sonar generally confirmed the distribution of dredged material as determined by precision bathymetry and REMOTS® photography. Detection of dredged material outside of the disposal site boundary may be due to both the conventionally moored buoy and a lack of attention to the location of scow release points. It is recommended that a taut wire buoy would reduce the variability in buoy location and that greater care in the location of scow release points would contain the dredged material within the disposal site boundary.

The inputs of dredged material resulted in significantly shallower RPD depths at the disposal site versus the reference areas (Mann-Whitney U-test, $p < 0.001$). As predicted, the percentage of Stage III organisms also was lower at the disposal site compared with the reference areas. Stage I organisms alone dominated the area near the disposal buoy where the thickest layers of dredged material had accumulated. Outside this relatively small area, however, the prevalence of both Stage I and Stage III taxa provided evidence of significant recolonization within the disposal site by head-down, deposit-feeding taxa. This recolonization supports the conclusion reached in the permit evaluation stage that the material would not have adverse effects.

## 6.0 REFERENCES

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Tavolaro, J.F. 1984. Sediment budget study for clamshell dredging and ocean disposal activities in the New York Bight. Environ. Geol. Water Sci. 6 (3): 133-140.

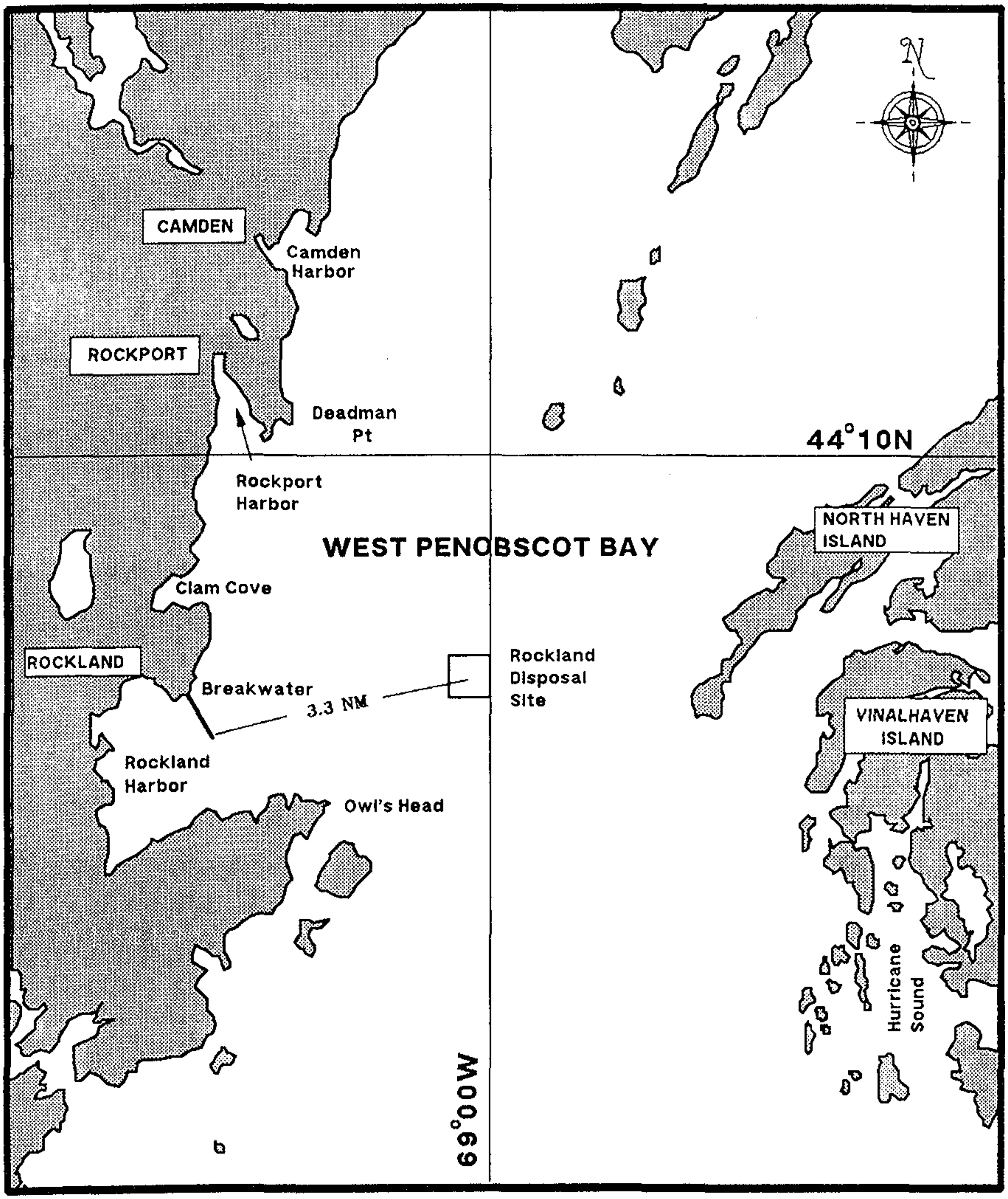



**Figure 1-1.** General location chart of the Rockland Disposal Site.

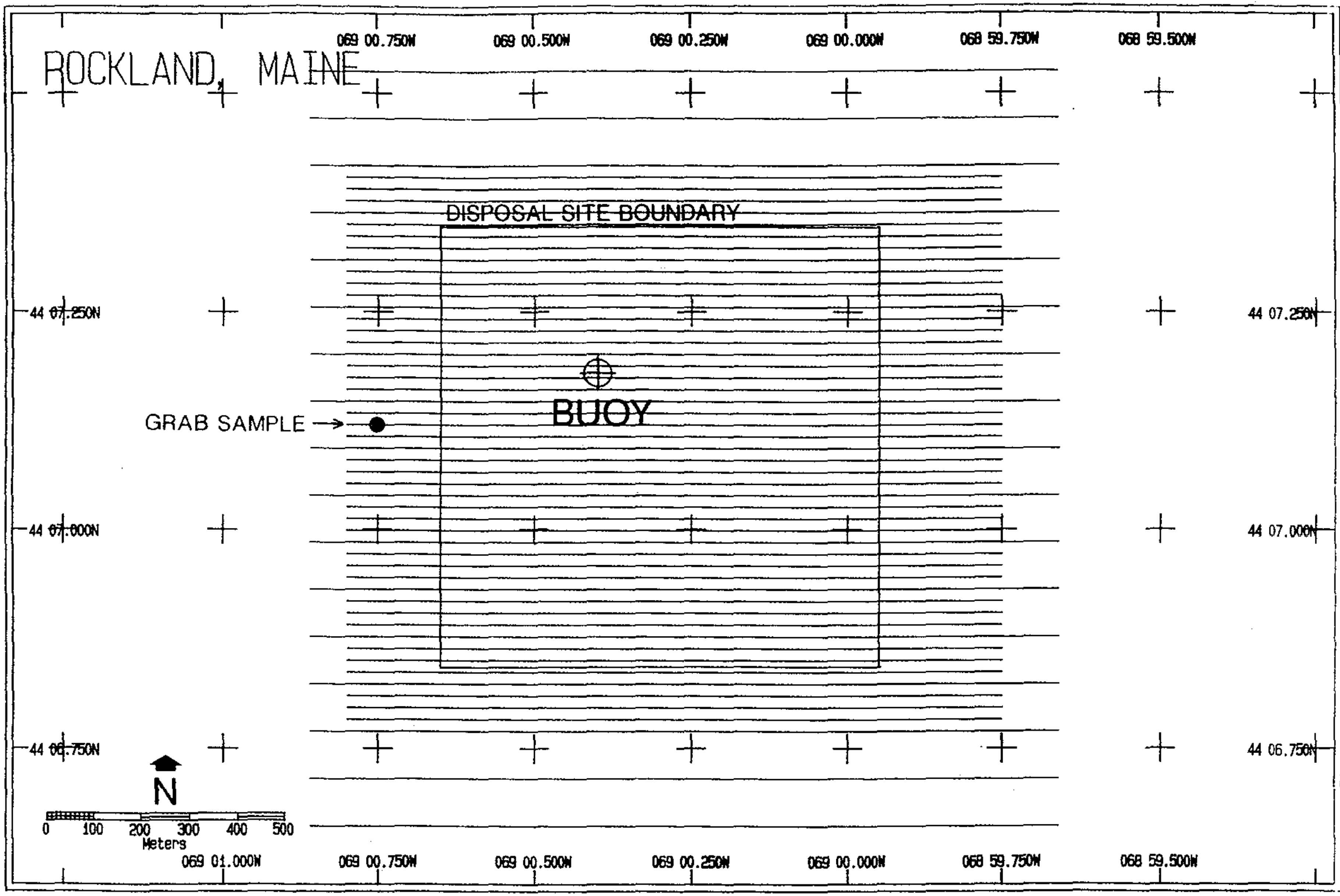



**Figure 1-2.** The Rockland Disposal Site showing the locations of the disposal buoy, sidescan survey lanes at 100 meter spacing, and precision bathymetric survey lanes at 25 meter spacing. The location of a grab sample taken prior to the bathymetric survey also is indicated.

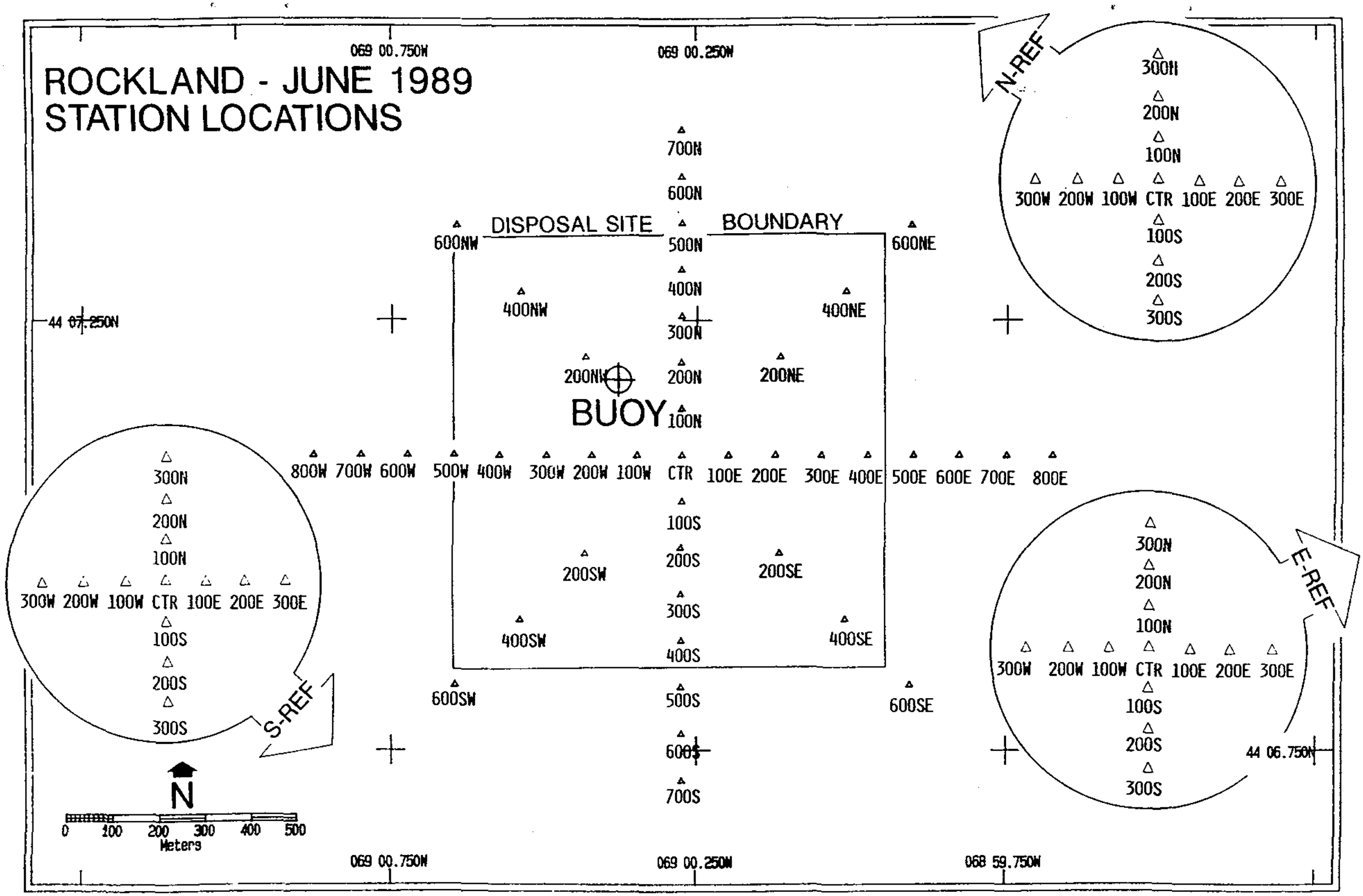



**Figure 2-1.** Locations and designations of REMOTS® stations (triangles) at the Rockland Disposal Site, June 1989. Cross-shaped grids with 100 m station spacing were used at each of the three reference areas (N-REF, E-REF, and S-REF) which were located beyond the area shown in the figure.

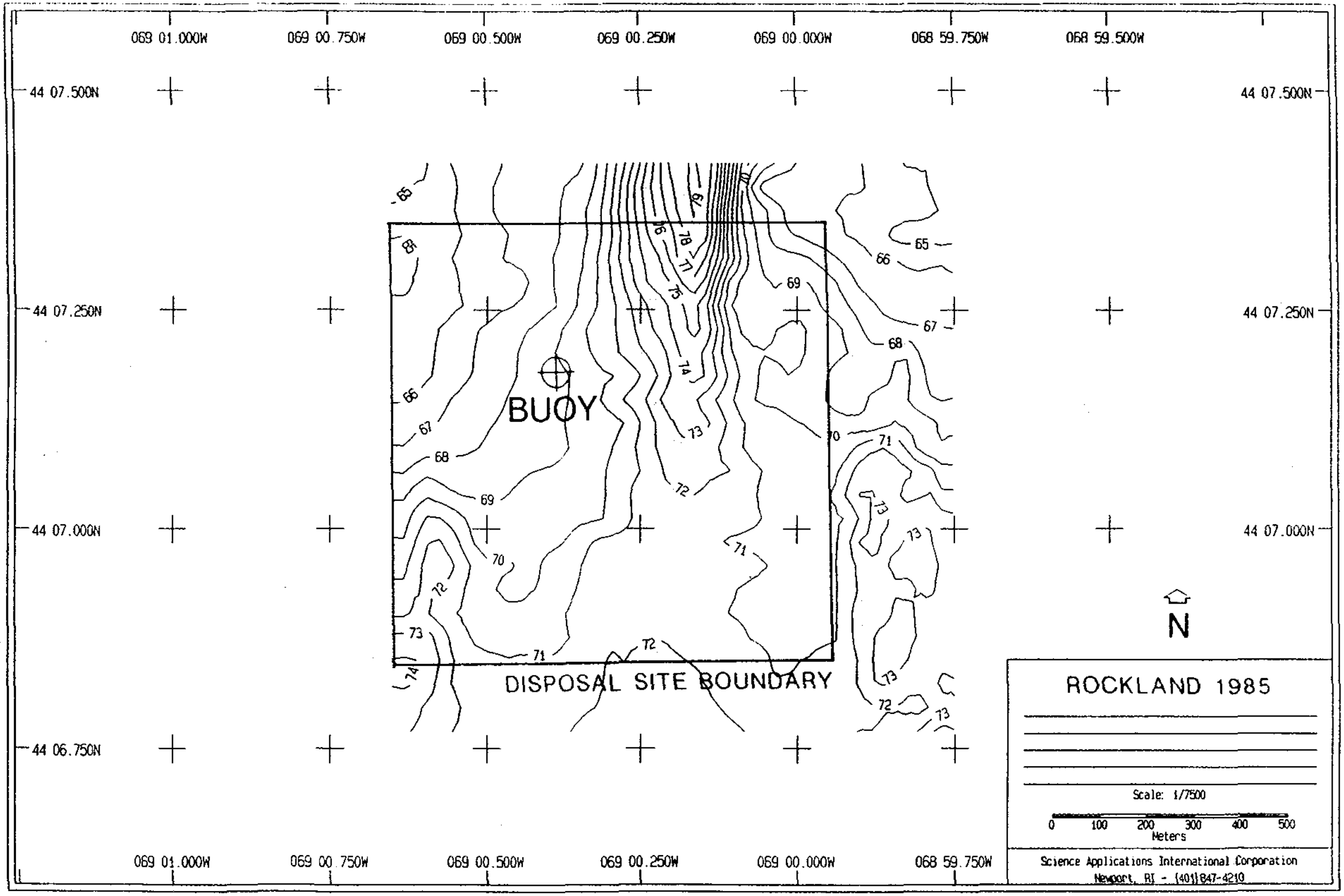



**Figure 3-1.** Bathymetric contour chart of the Rockland Disposal Site, May 1985. Depths are in meters.

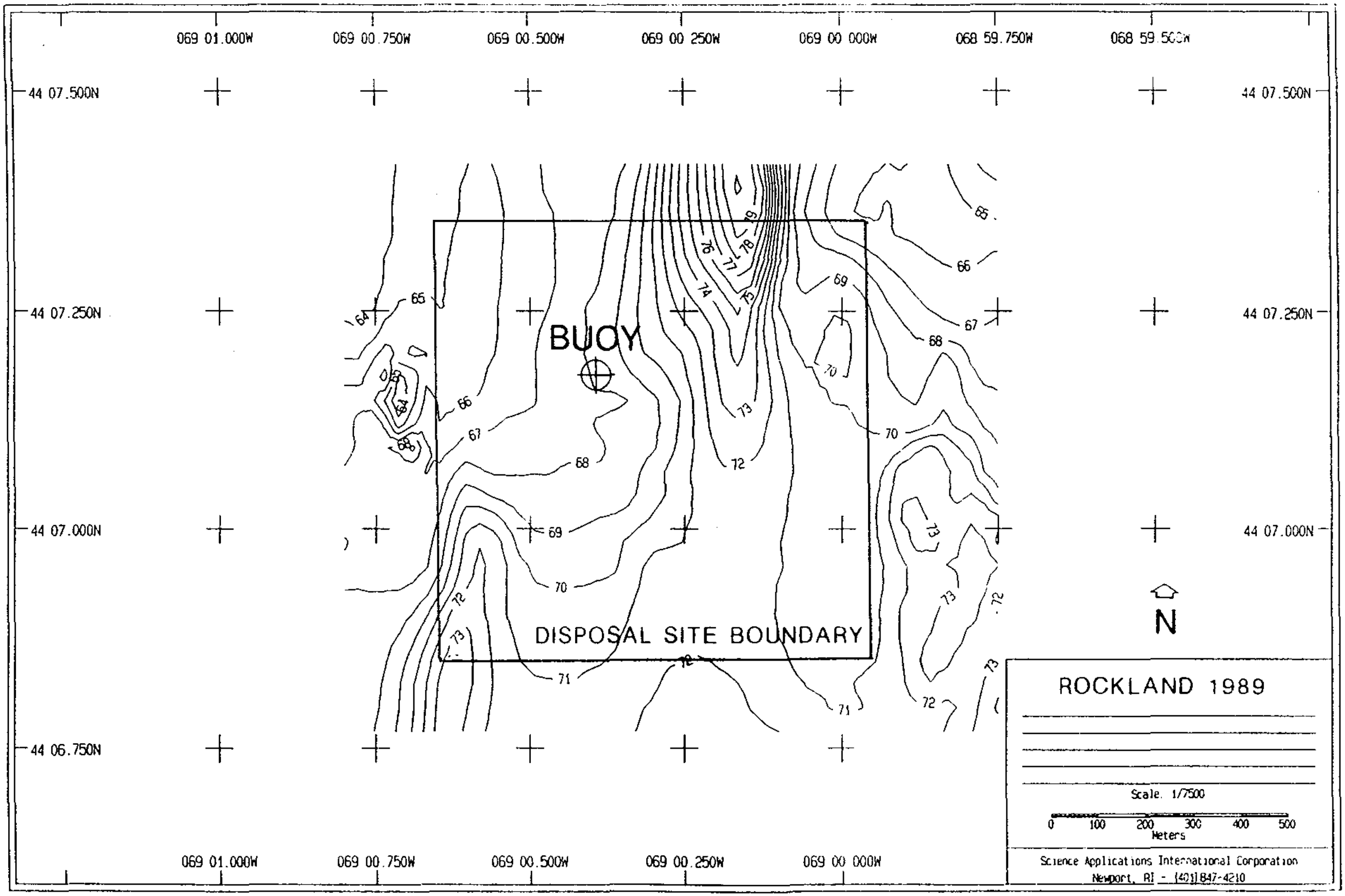



**Figure 3-2.** Bathymetric contour chart of the Rockland Disposal Site, June 1989. Depths are in meters.

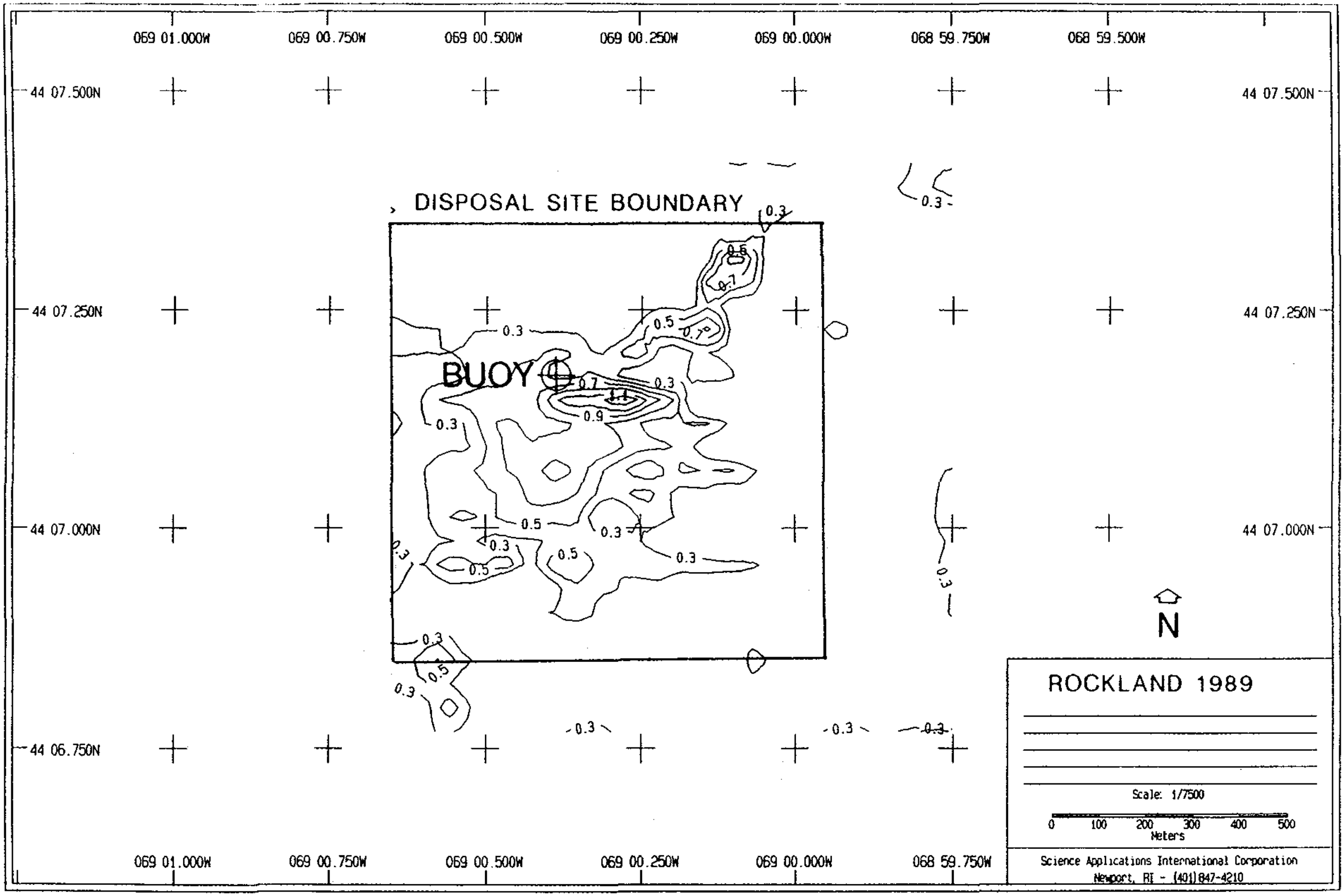



**Figure 3-3.** Depth difference contour chart based on comparison of the May 1985 and June 1989 bathymetric surveys at the Rockland Disposal Site. The contour interval begins at 0.3 meters and continues in 0.2 meter increments.

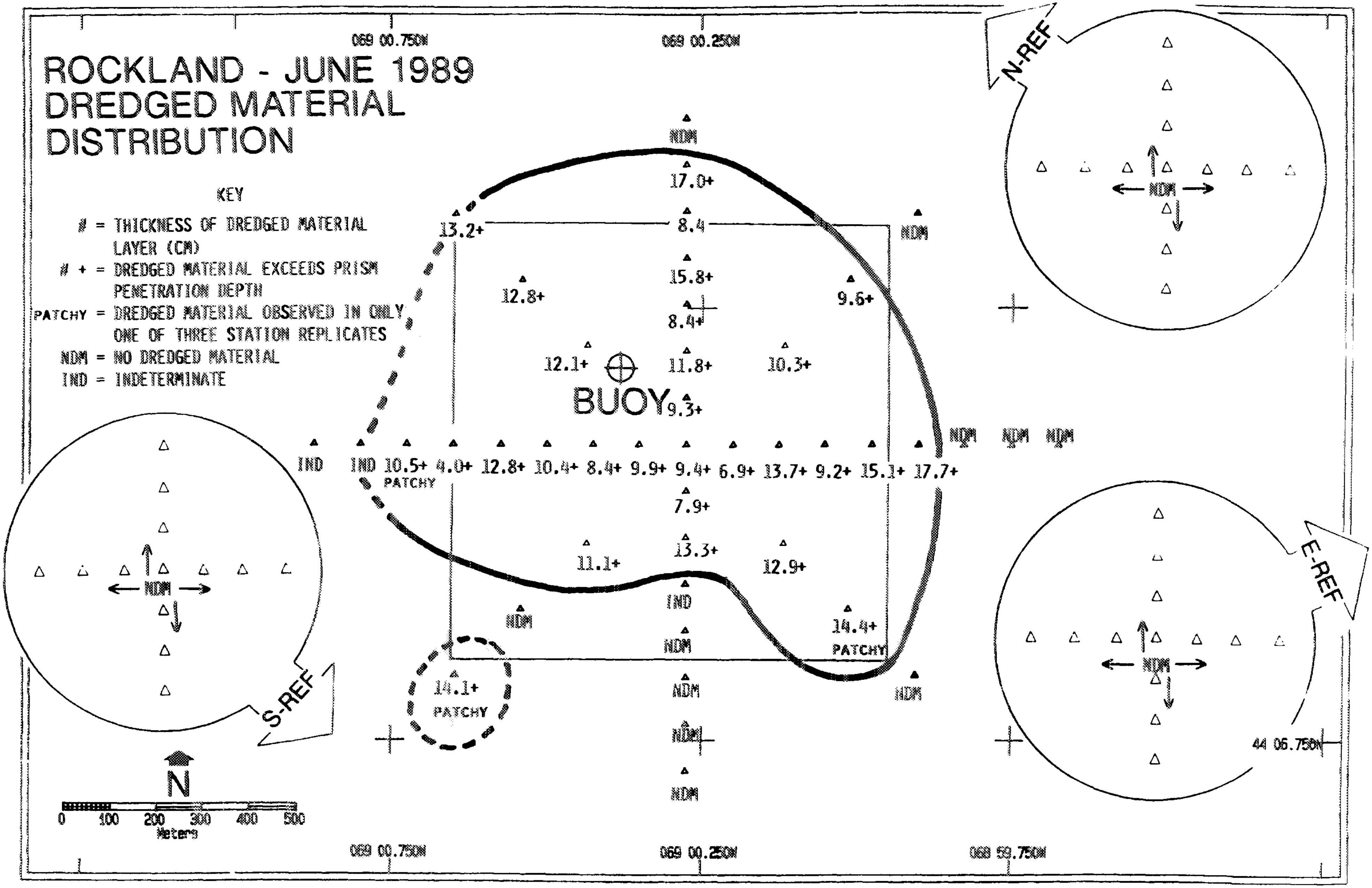
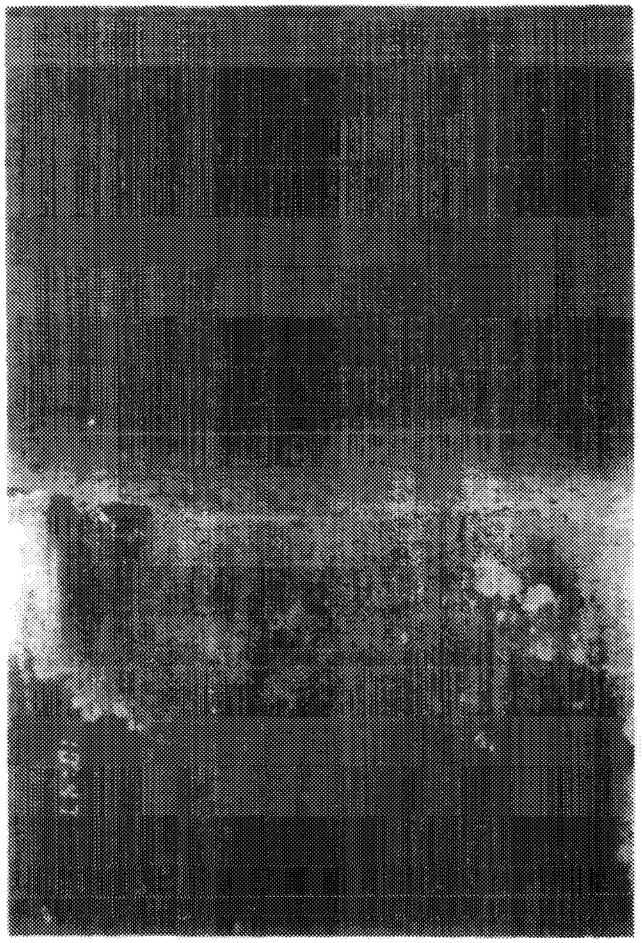



Figure 3-4. The contoured distribution of dredged material at REMOTS® stations at the Rockland Disposal Site, June 1989. The broken contour indicates uncertainity in the extent of the material beyond the farthest REMOTS® stations.



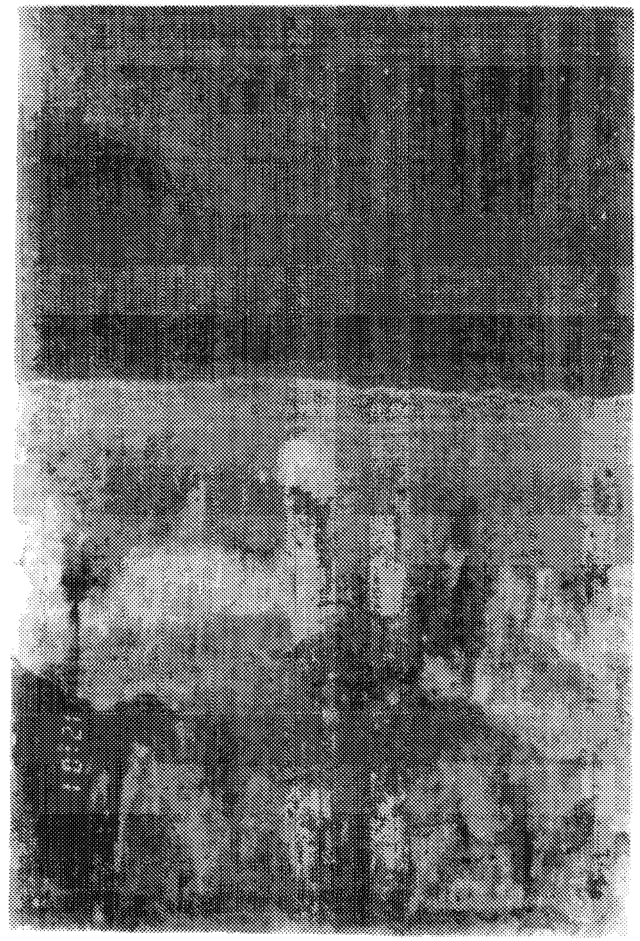


Figure 3-5. REMOTS® photographs from stations 100W (left) and 200NW (right) showing typical fresh dredged material near the disposal buoy. This material consisted of low reflectance silt-clay mixed with sand at station 100W and alternating patches of high and low reflectance silt-clay mixed with sand at station 200NW. Scale = 0.5X.

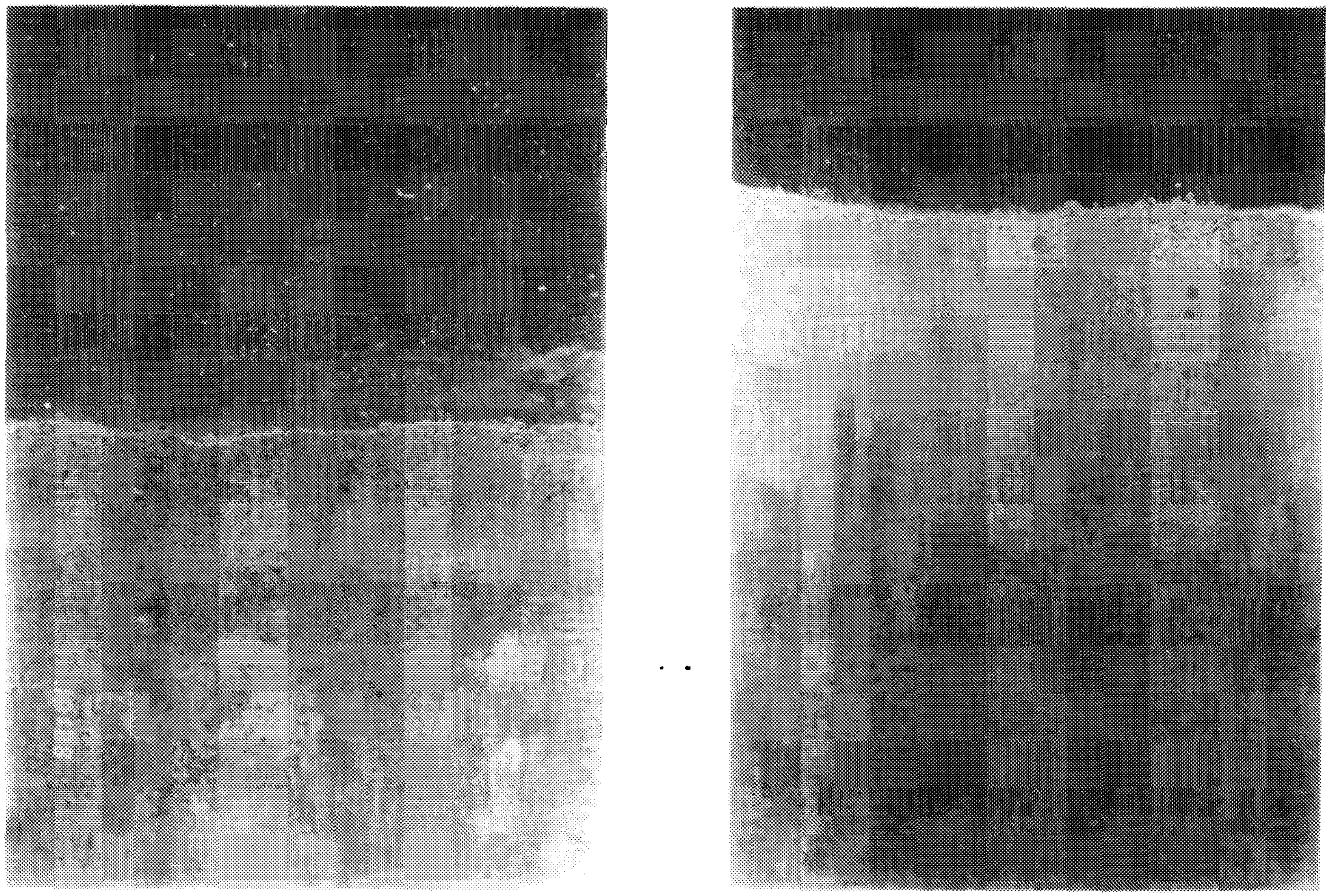


**Figure 3-6.** The apparent dredged material exceeding the depth of prism penetration in the REMOTS® photograph from station 300W (left) shows a much higher sand content compared to the ambient silt-clay observed at station 800E (right). Scale = 0.5X.

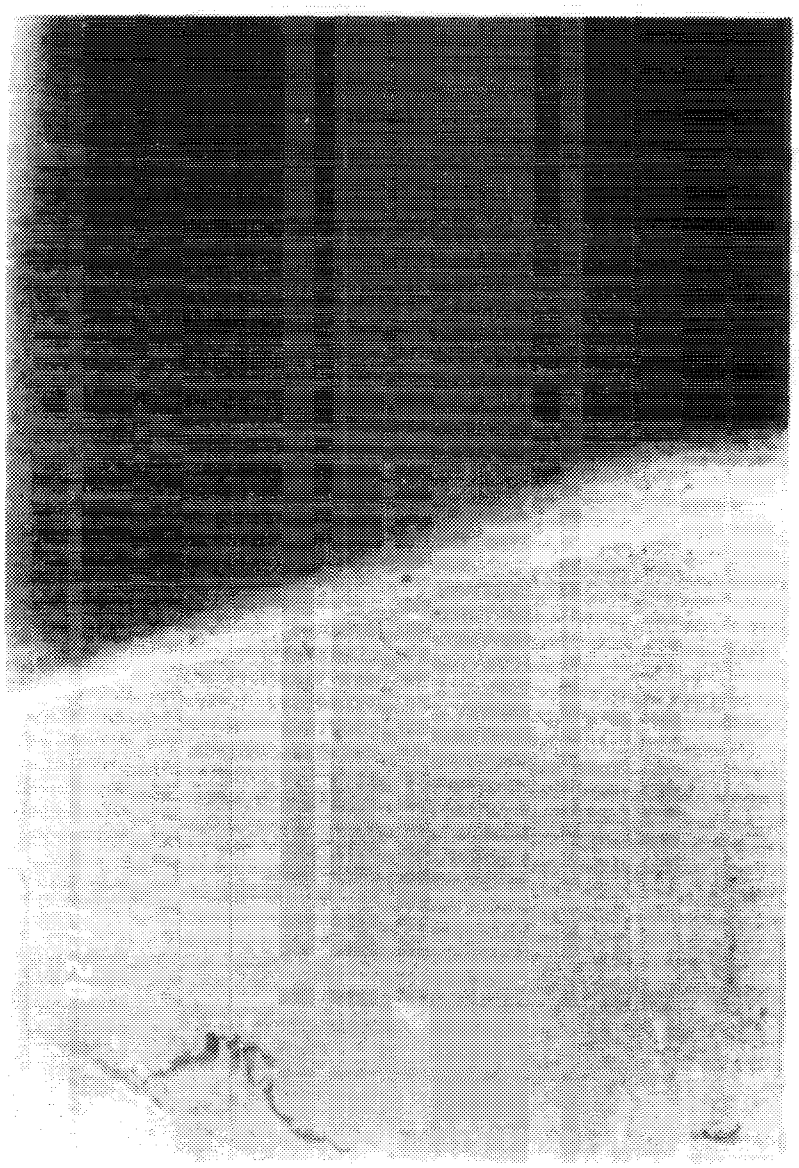


Figure 3-7. The sediment in this REMOTS® photograph from station 400NE exhibits unusual homogeneity in grain-size and optical reflectance, suggesting it is disposed material. Scale = 0.65X.

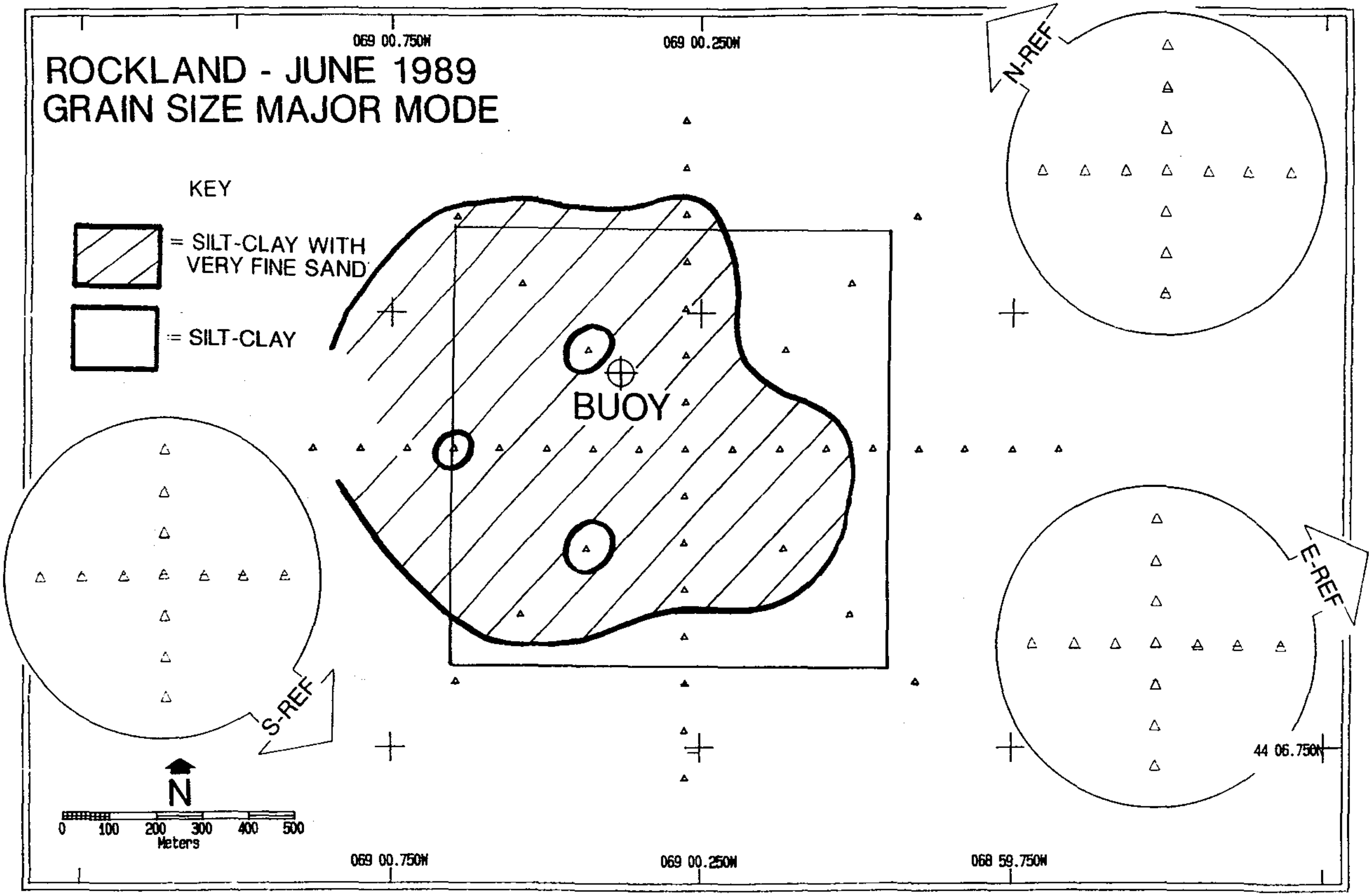
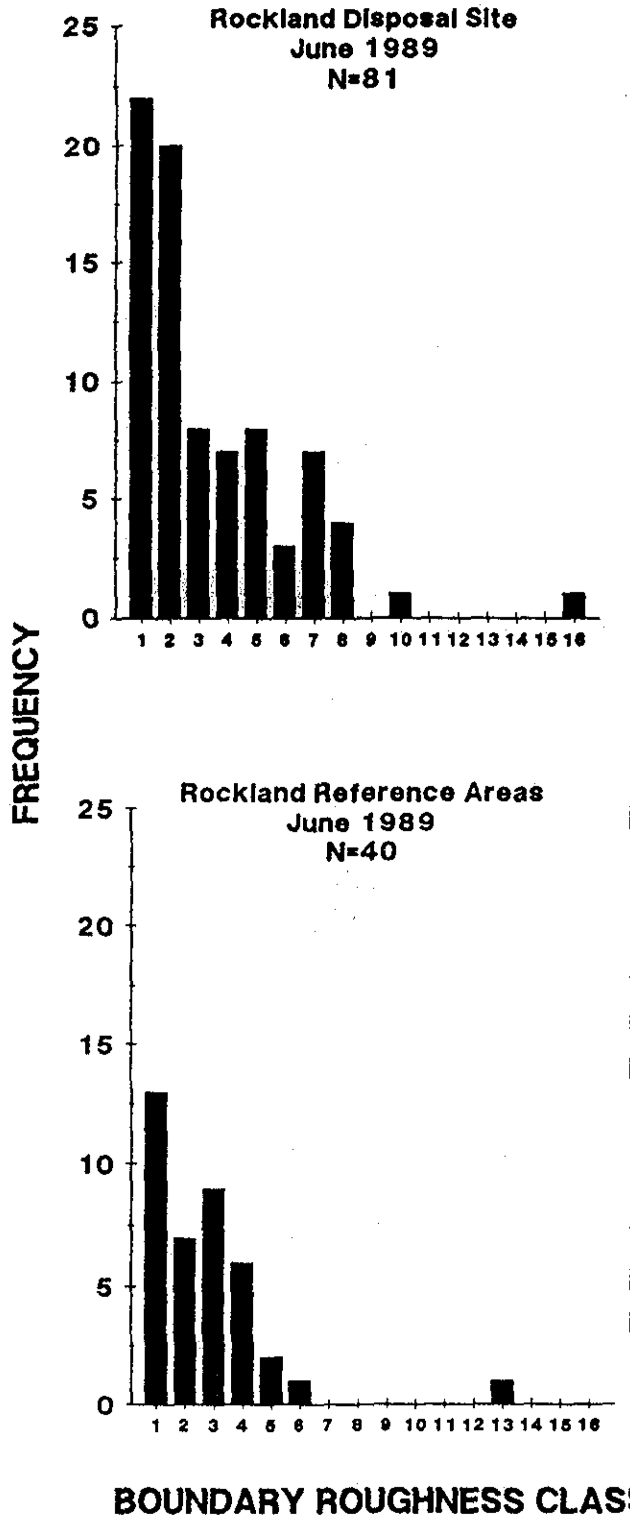



**Figure 3-8.** Map of sediment grain size major mode at the Rockland Disposal Site, June 1989. The solid line delimits stations having Silt-Clay with Very Fine Sand.




**KEY**

| CLASS INTERVAL | RANGE OF VALUES (CM) |
|---|---|
| 1 | 0.0 - 0.6 |
| 2 | 0.6 - 1.0 |
| 3 | 1.0 - 1.4 |
| 4 | 1.4 - 1.8 |
| 5 | 1.8 - 2.2 |
| 6 | 2.2 - 2.6 |
| 7 | 2.6 - 3.0 |
| 8 | 3.0 - 3.4 |
| 9 | 3.4 - 3.8 |
| 10 | 3.8 - 4.2 |
| 11 | 4.2 - 4.6 |
| 12 | 4.6 - 5.0 |
| 13 | 5.0 - 5.4 |
| 14 | 5.4 - 5.8 |
| 15 | 5.8 - 6.2 |
| 16 | 6.2 - 6.6 |

Figure 3-9. Frequency distributions of small-scale surface boundary roughness values for all replicates at the reference areas and at the Rockland Disposal Site stations having dredged material, June 1989 (n = number of photographs).

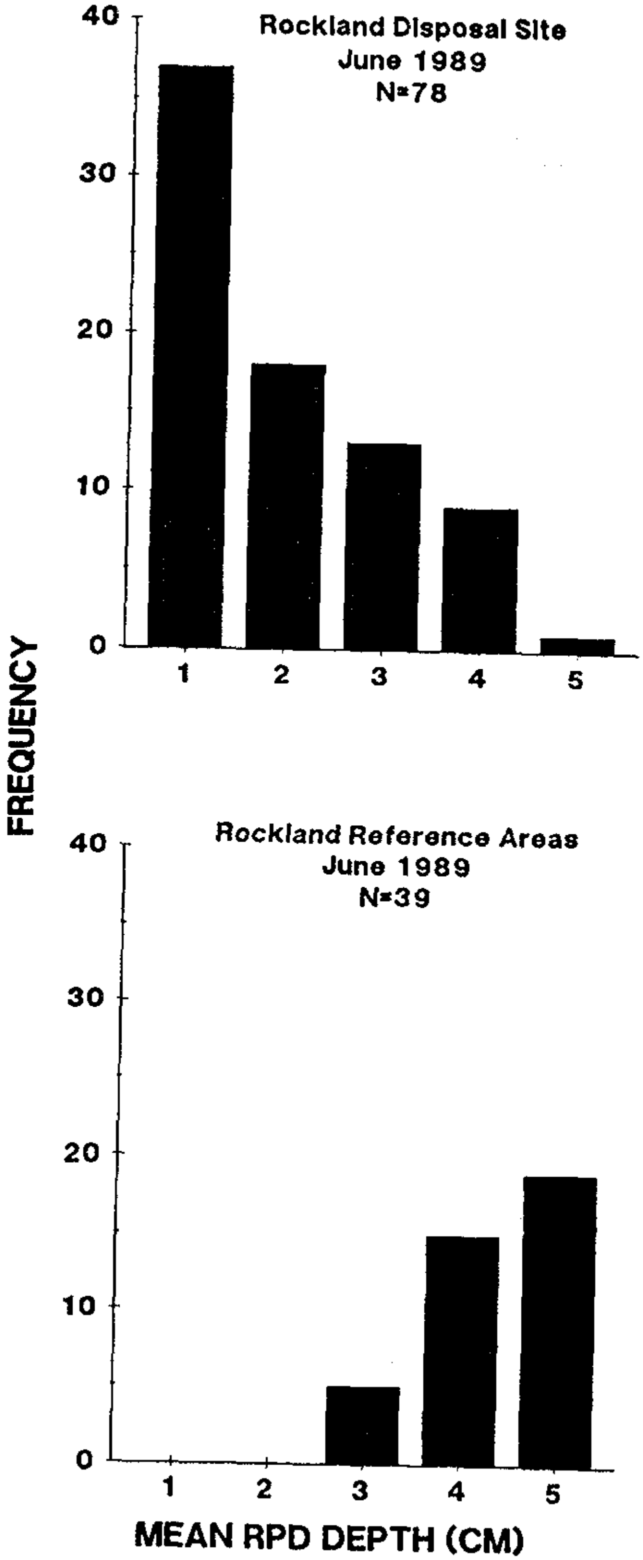



**Figure 3-10.** Frequency distributions of apparent RPD depths for all replicates at the reference areas and the Rockland Disposal Site stations having dredged material, June 1989 (n = number of photographs).

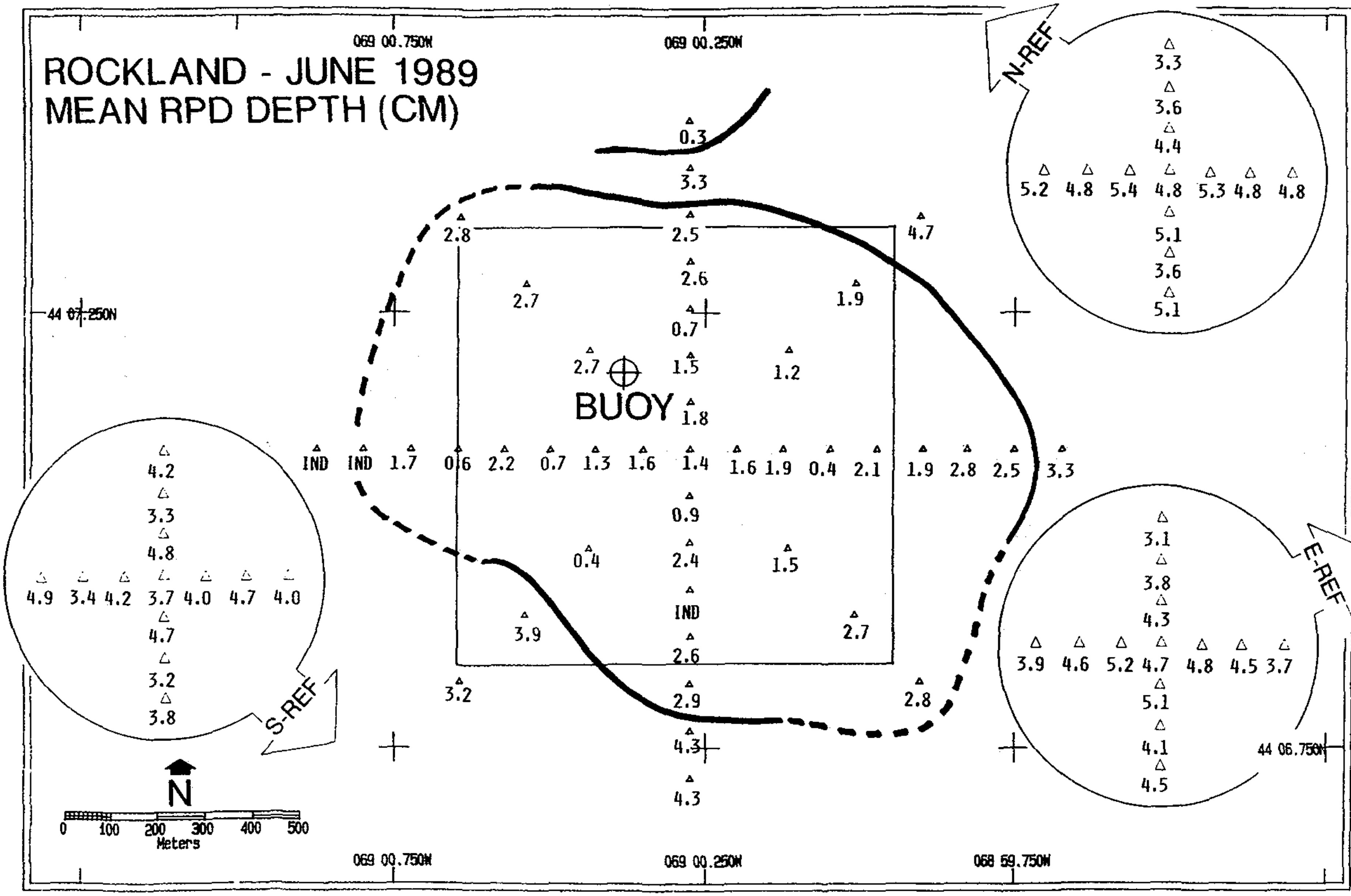



**Figure 3-11.** The mapped distribution of apparent RPD depths (cm), averaged by station, at Rockland in June 1989. The solid line delimits stations having mean apparent RPD depths < 3 cm. The broken line indicates uncertainty in contouring beyond the outermost REMOTS® stations. At the reference areas, the mapped RPD values were based on a single REMOTS® photograph.

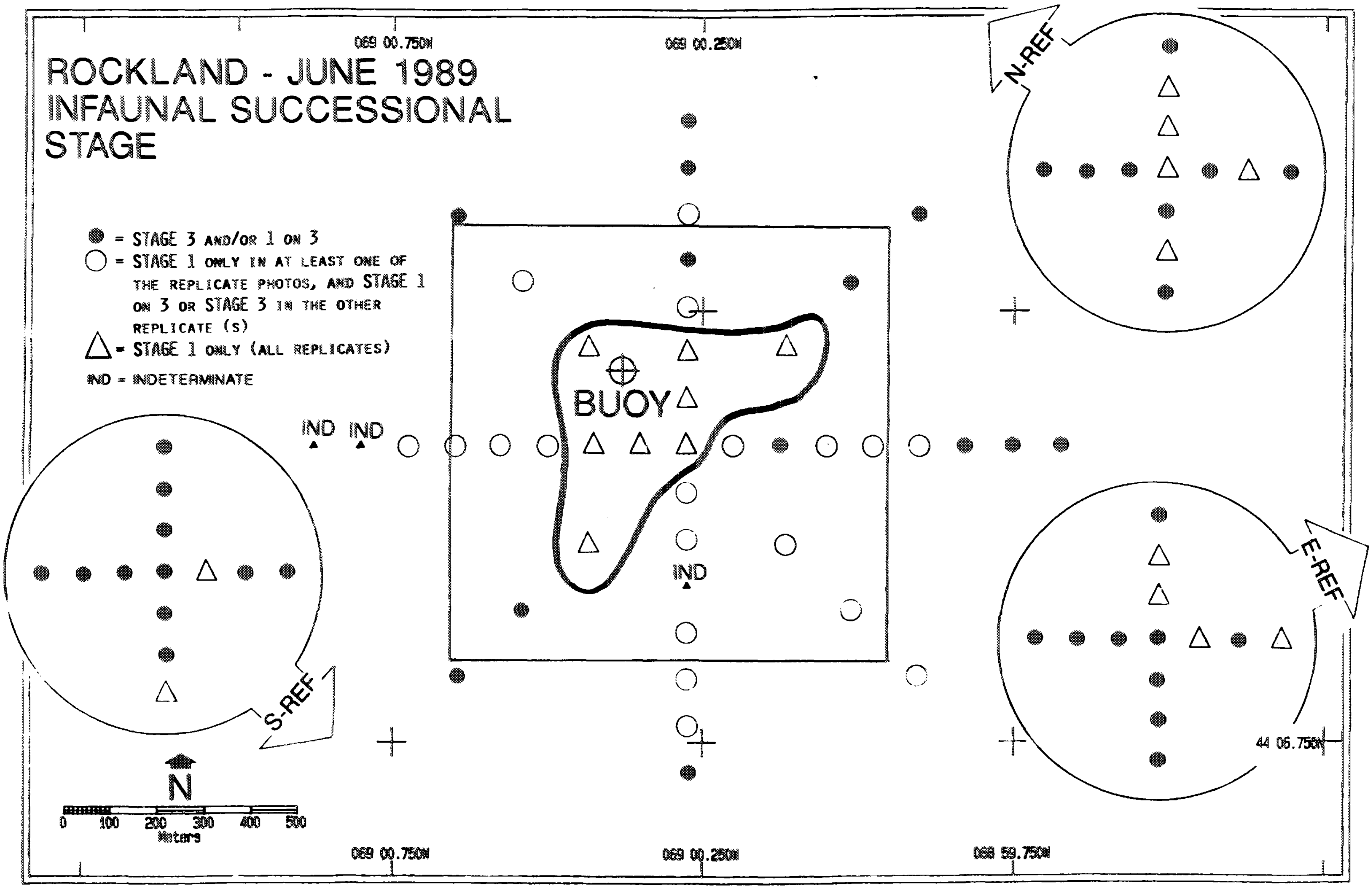



Figure 3-12. The mapped distribution of infaunal successional stages at the Rockland Disposal Site, June 1989. Disposal Site stations were based on 2 to 3 replicate REMOTS® photographs. Successional stages mapped at the reference areas were based on a single REMOTS® photograph.

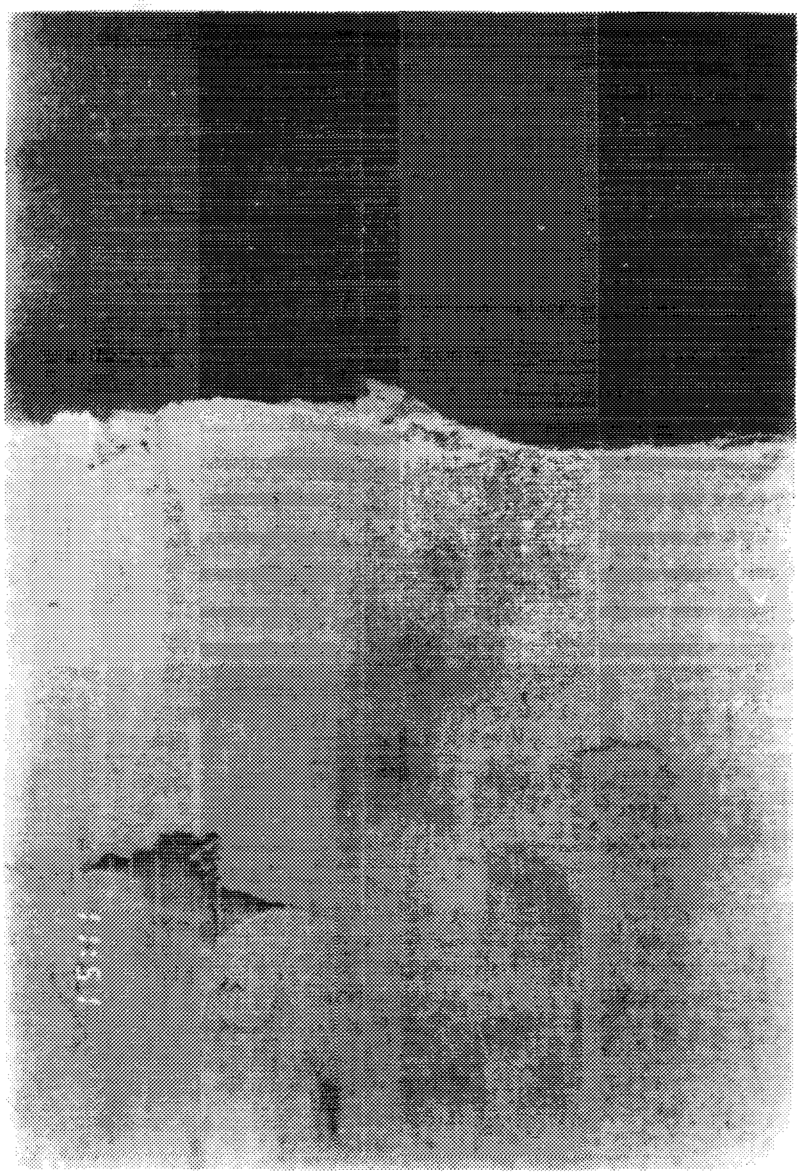


Figure 3-13. The large feeding void at depth indicates the presence of Stage III organisms in this REMOTS® photograph from disposal site station 200SE. Scale = 0.65X.

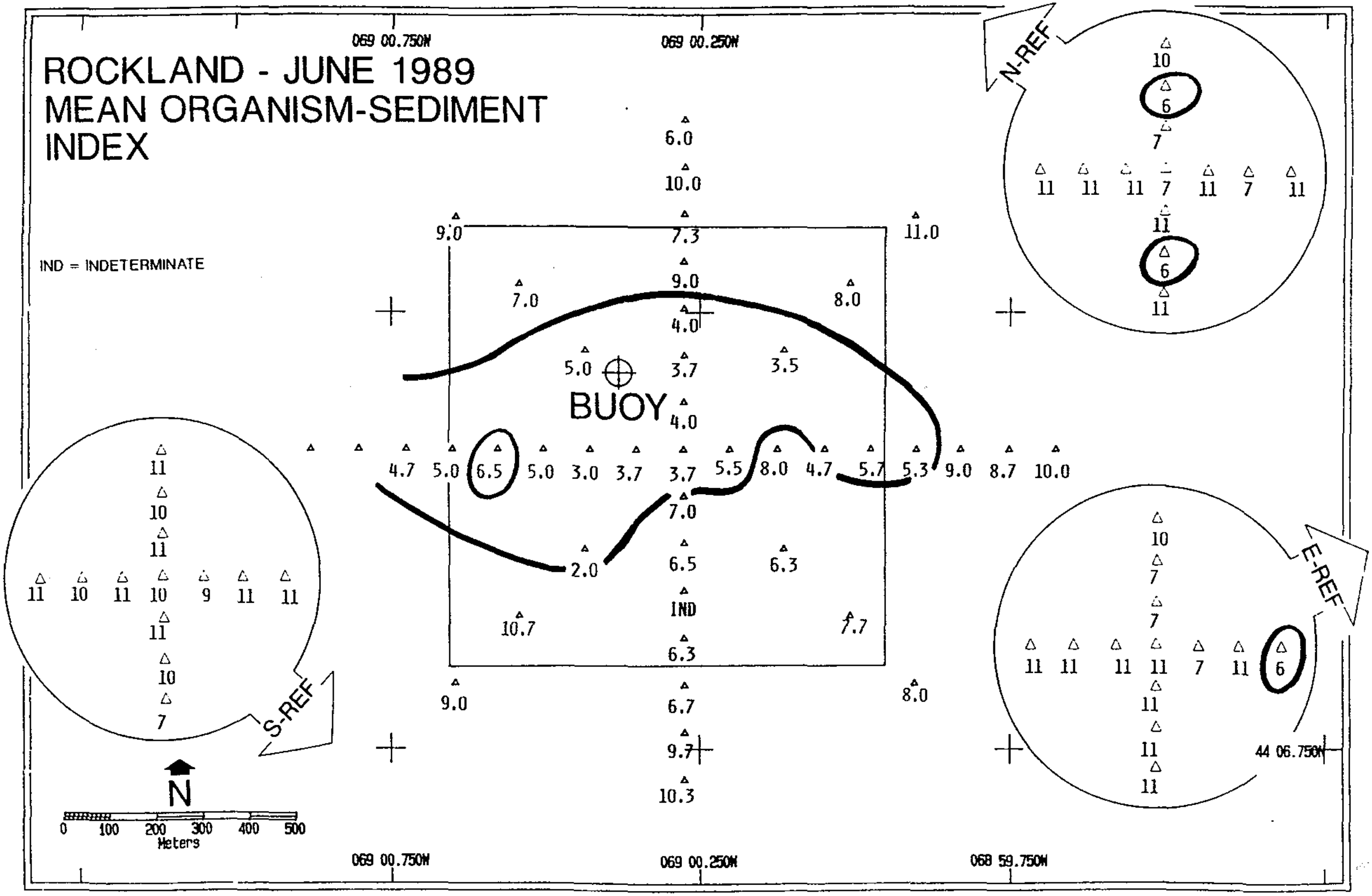



**Figure 3-14.** The distribution of Organism-Sediment Indices, at the Rockland Disposal Site in June 1989. The solid line delimits OSI values ≤ +6. The Disposal Site OSI values were the mean value of 2 to 3 replicate REMOTS® photographs. The OSI values at the reference areas were calculated based on a single REMOTS® photograph.

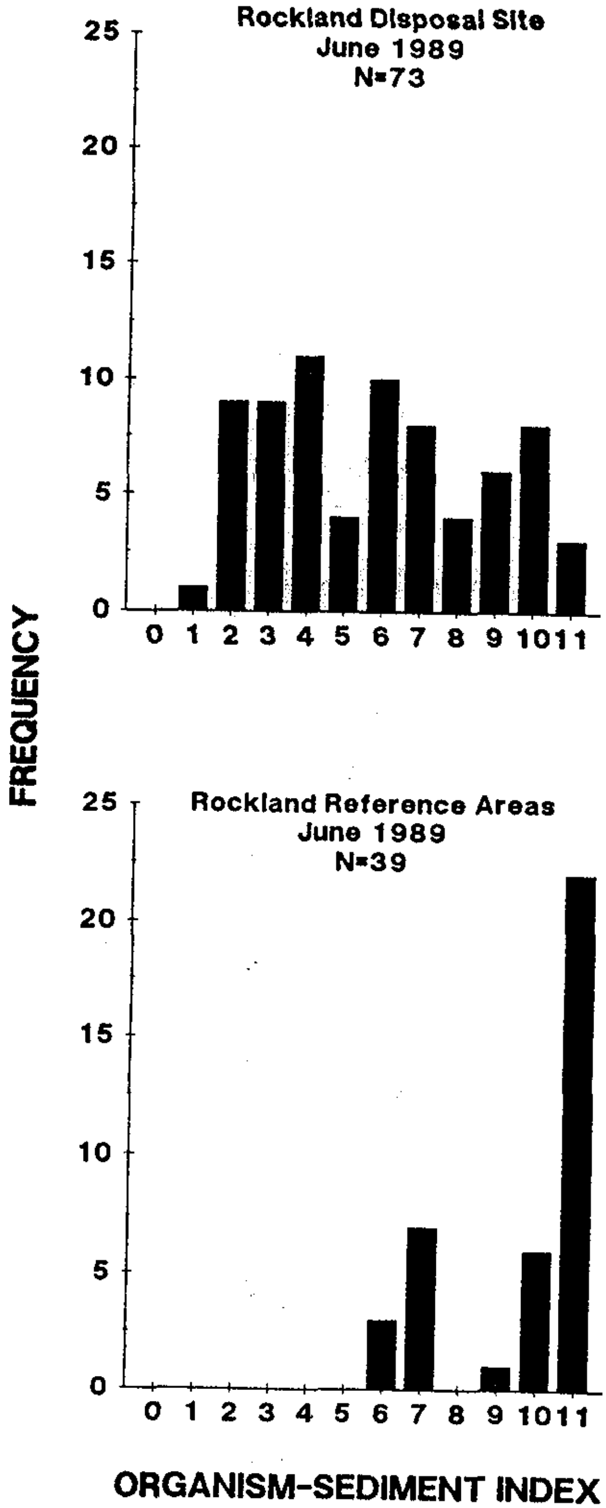



**Figure 3-15.** Frequency distributions of Organism-Sediment Indices for all replicates at both the reference areas and at the Rockland Disposal Site stations having dredged material, June 1989 (n = number of photographs).

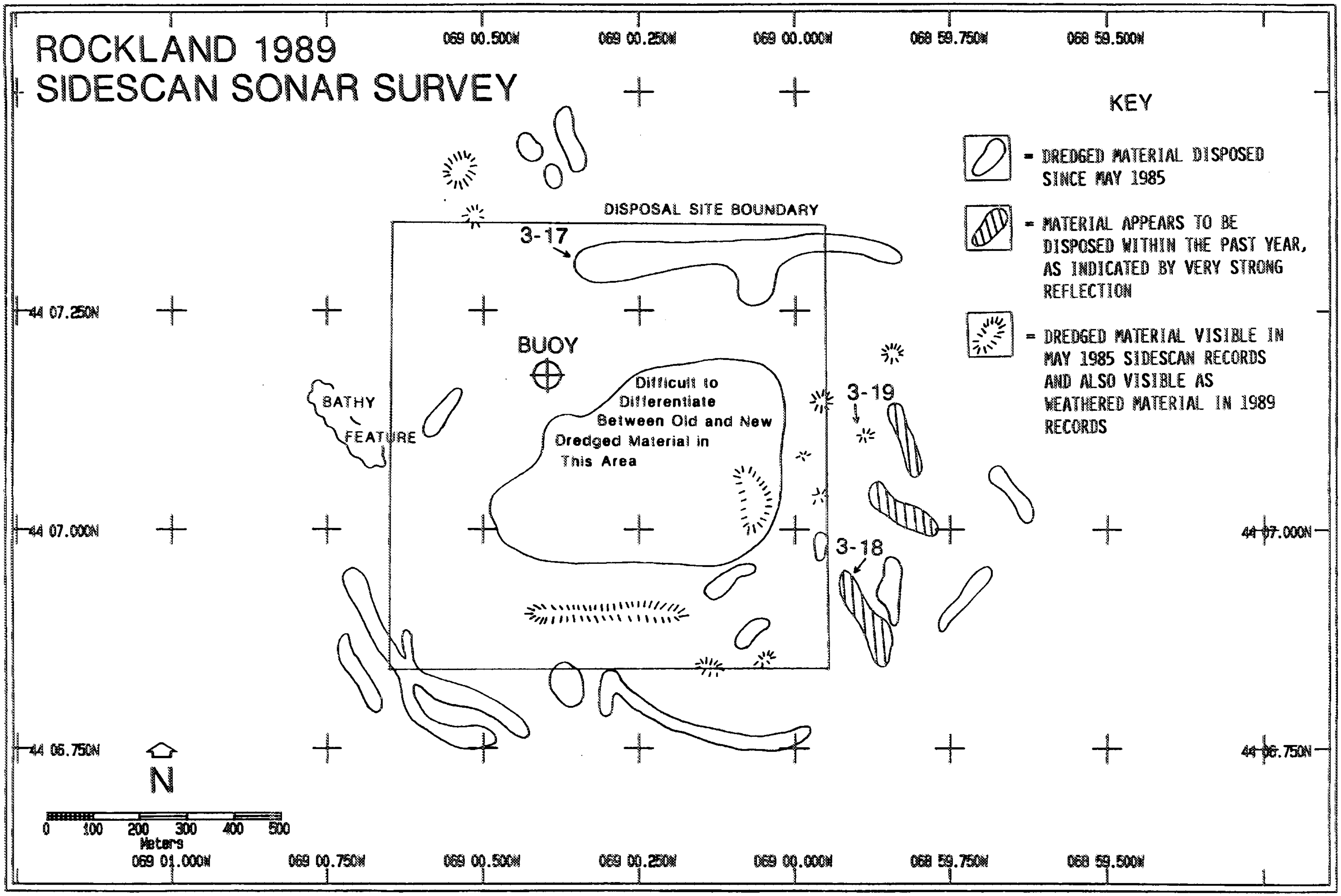



Figure 3-16. Results of the sidescan sonar survey at the Rockland Disposal Site, June 1989. Representative sidescan records from the areas indicated on the map are presented in Figures 3-17 through 3-19.

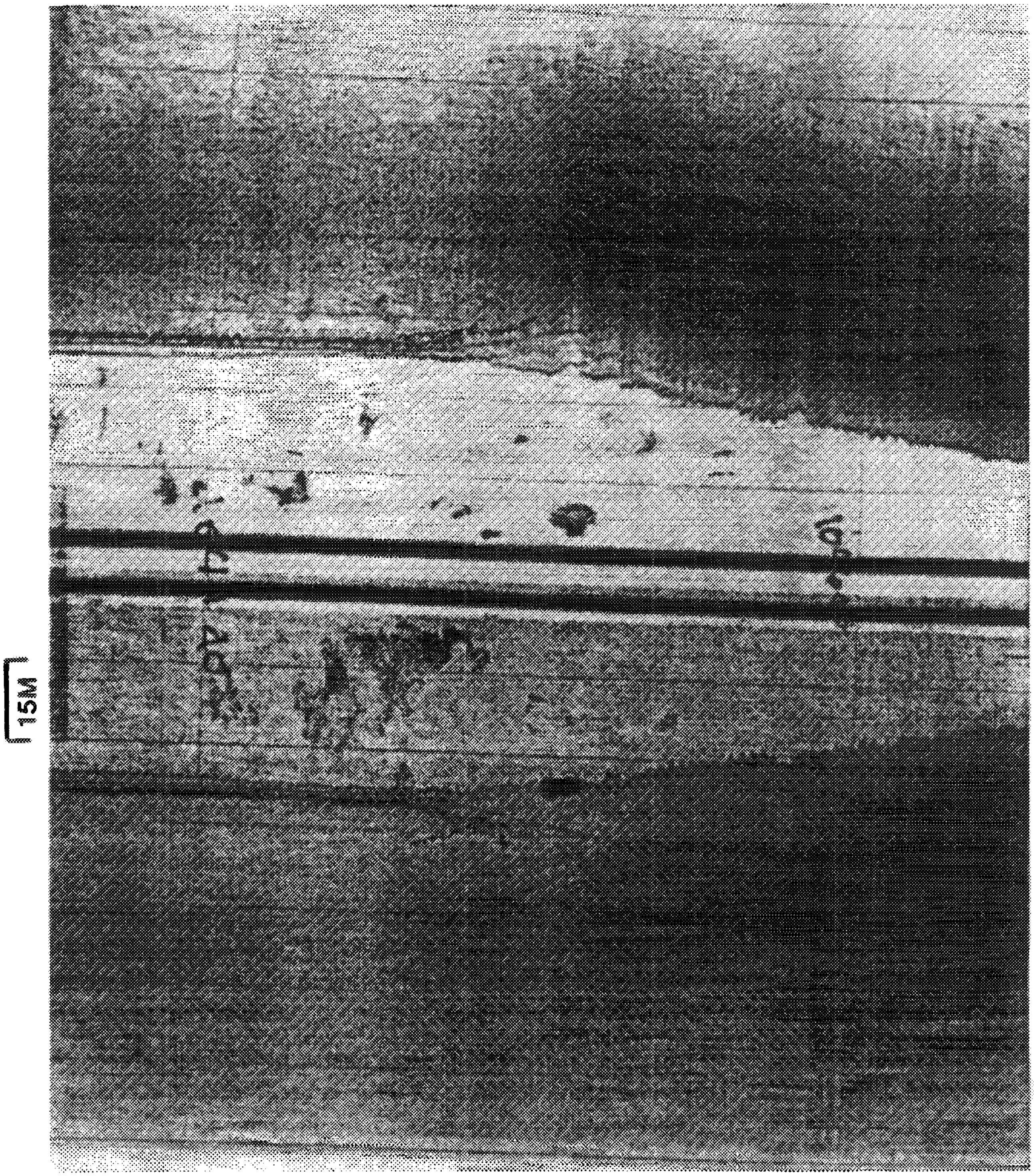


Figure 3-17. Sidescan record showing an increase in bottom reflectance going from left (intermediate reflectance) to right (high reflectance). The high reflectance sediment is assumed to be disposed material. The location of this record is shown in Figure 3-16.

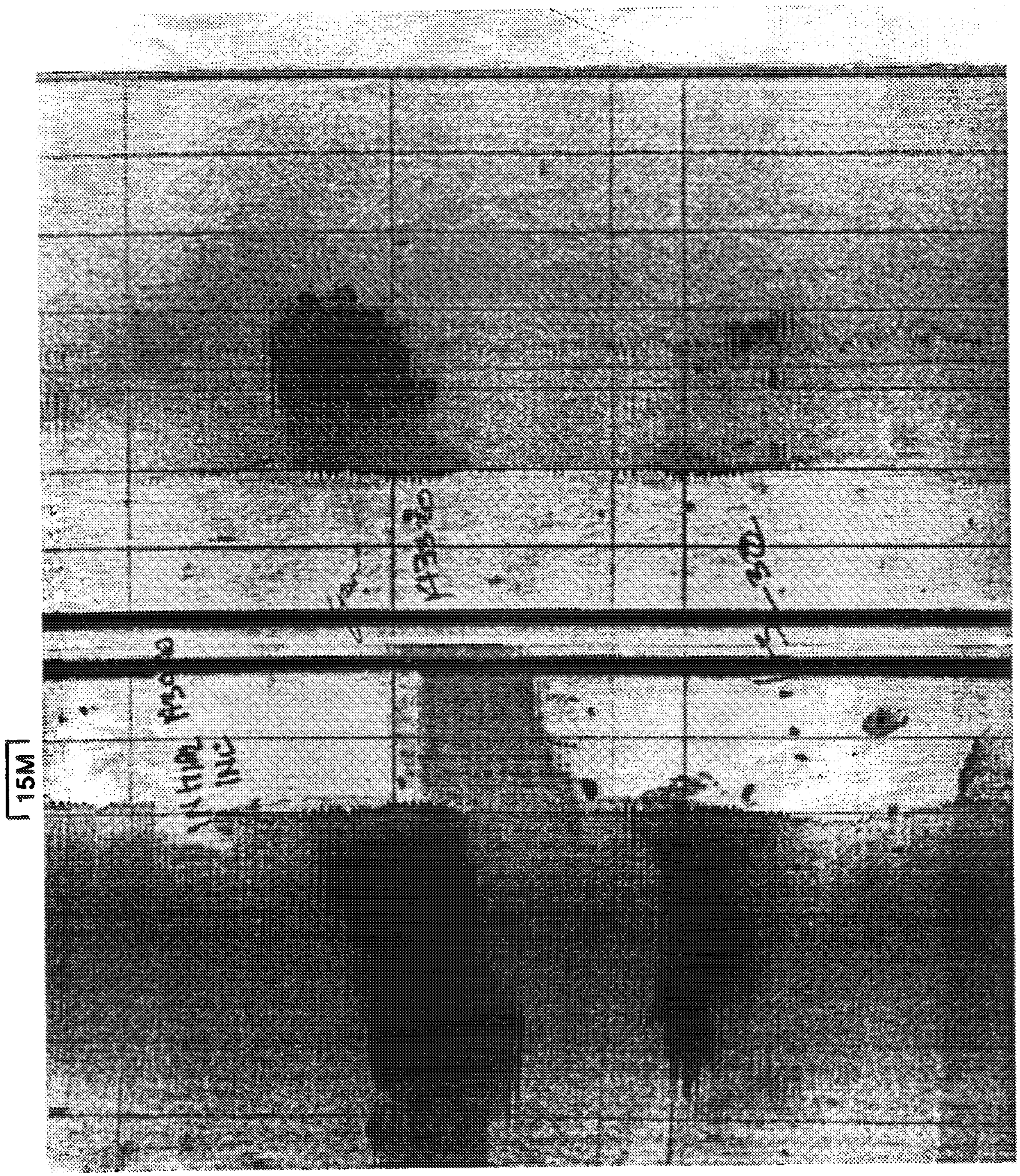



**Figure 3-18.** Sidescan record showing a narrow patch with very strong reflectance, assumed to be recently-disposed dredged material. The location of this record is indicated in Figure 3-16.

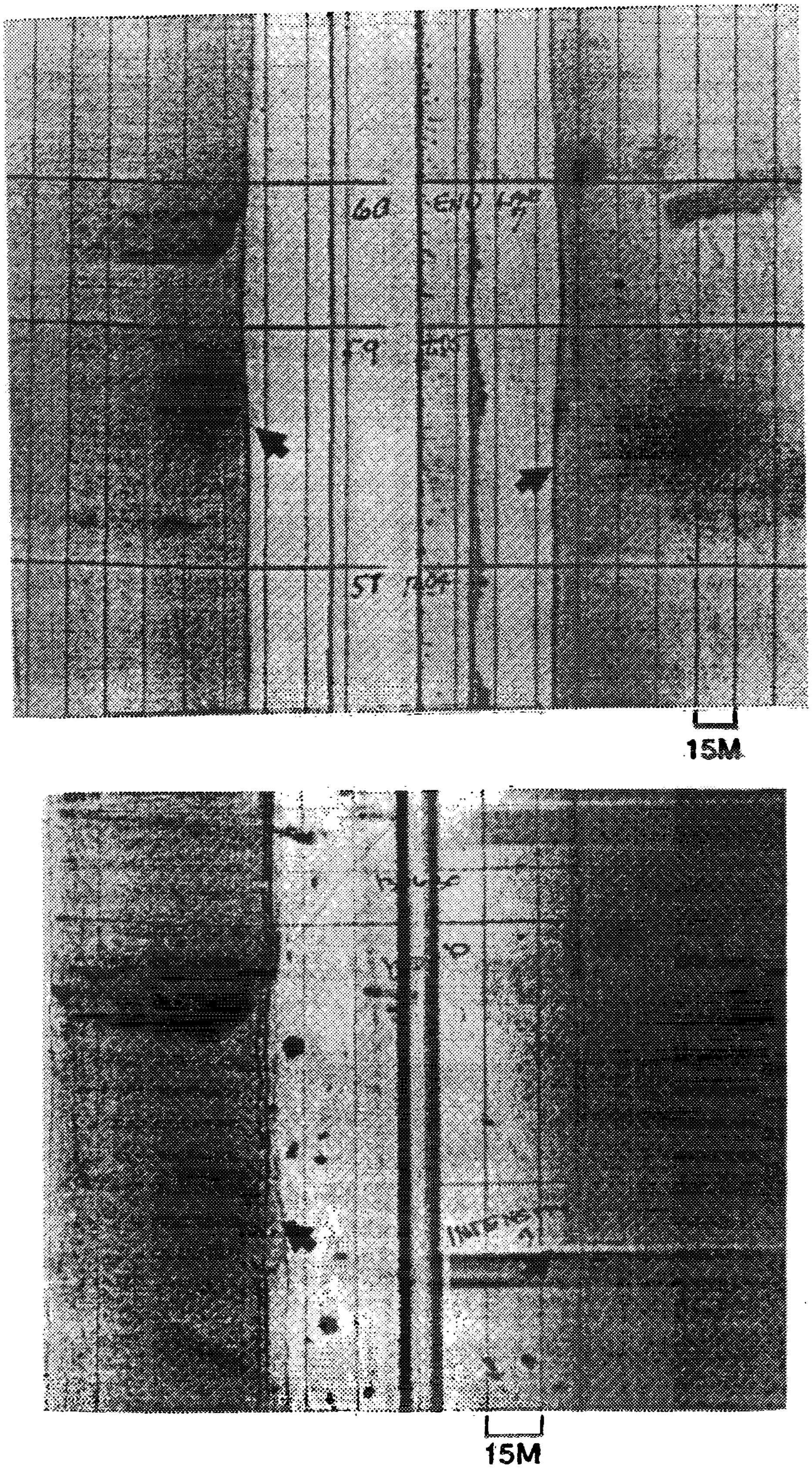



**Figure 3-19.** Arrows indicate recently-disposed dredged material having a strong acoustic signature in the sidescan record from May 1985 (top, see Figure 3-16 for location). As a result of weathering, the material has substantially less reflectance in the June 1989 sidescan record from the same location (bottom).

## INDEX
## MONITORING SURVEYS AT THE ROCKLAND DISPOSAL SITE, JUNE 1989