Monitoring Cruise at the Cape Arundel Disposal Site, October 1987

# Disposal Area Monitoring System DAMOS

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Field investigations were conducted in 1987 at the Cape Arundel Disposal Site (CADS) to determine the extent of the dredged material deposit resulting from disposal operations since May 1985, and to identify whether and where the disposal buoy should be moved. Field operations consisted of precision bathymetric and REMOTS® sediment profile surveys conducted on 16 and 17 October 1987.

Both the precision bathymetric and REMOTS® surveys at CADS indicated the accumulation of dredged material in the general vicinity of the buoy. The material apparently occurred as a sand layer having a maximum thickness on the order of one meter or less over a relatively broad area, which explains in part why a distinct bell-shaped mound was not apparent at the disposal point.

The bathymetric results show that a maximum depth change of about 1.0 meter occurred at and east of the buoy and continued north about 150 meters. As a maximum estimate, this represents 10,600 $m^2$ of bottom which would account for about 10,600 $m^3$ of dredged material. The layers less than about 12 cm thick observed in REMOTS® photos at stations up to 550 meters north of the buoy occupied an estimated 50,000 $m^2$ of bottom. A blanket of dredged material 12 cm thick deposited evenly in this area would add another 6,000 $m^3$, bringing the estimated total to approximately 16,600 $m^3$ of dredged material. This is considerably less than the scow log volume estimate of 195,646 $m^3$ of dredged material deposited at CADS since the previous bathymetric and REMOTS® surveys in May 1985. This large discrepancy is due to a combination of factors including mass balance considerations, limitations of the survey equipment to detect small changes in depth on an irregular bottom, and the survey not covering the entire dredged material deposit.

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# MONITORING CRUISE AT THE CAPE ARUNDEL DISPOSAL SITE, OCTOBER 1987

**CONTRIBUTION #67**

June 1990

Report No.
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AT THE CAPE ARUNDEL DISPOSAL SITE
OCTOBER 1987

## 1.0 INTRODUCTION

The Cape Arundel Disposal Site (CADS) is located approximately 2.75 nautical miles southeast of Cape Arundel, Maine. The site consists of a 500 yard diameter circle centered at 43° 17.800 N and 70° 27.200 W. This circle is at the southern end of a north-south trending trough running 1 km in length and 50 to 250 meters wide. This trough has a maximum depth of 43 meters and a bottom covered by a thin (less than 10 cm) layer of silt and sand. It is flanked by hard rock ridges shoaling up to 30 to 32 meters in depth. The capacity of the disposal site is estimated to be approximately $1.5 \times 10^6$ $m^3$ of dredged material (SAIC, 1987).

Near-bottom currents at CADS are generally less than 10 cm/sec and northerly in direction, while near-surface currents are dominated by a southerly net drift also moving at rates less than 15 cm/sec. Although there is unlimited fetch to the northeast, near-surface currents have little effect on bottom currents due to the highly variable topography of the area which disrupts the coherence of near-bottom currents (SAIC, 1987).

Previous REMOTS® and precision bathymetric surveys were conducted at CADS between 28 May and 2 June 1985. Disposal activities were minimal prior to these surveys; scow logs indicate that 17,320 $m^3$ (22,640 $yd^3$) of dredged material were deposited at the site from February to May 1985. However, scow logs indicate that 195,646 $m^3$ (255,500 $yd^3$) of dredged material were deposited at CADS since May 1985. The objectives of the 1987 field investigations were to determine the extent of the dredged sediment deposit and to identify whether and where the disposal buoy should be moved. Field operations consisted of precision bathymetric and REMOTS® sediment profile surveys conducted on 16 and 17 October 1987. A scheduled sidescan survey was abandoned due to the high density of lobster pots in the area of the disposal site.

## 2.0 METHODS

### 2.1 Bathymetry and Navigation

The precision navigation required for bathymetry was carried out utilizing the SAIC Integrated Navigation and Data Acquisition System (INDAS). This system uses a Hewlett-Packard 9920 series computer to collect position, depth, and time data for subsequent analysis, as well as to provide real-time navigation. Positions were determined to an accuracy of ±3 meters from ranges provided by a Del Norte Trisponder System. Shore stations were established at previously used benchmarks at the Wells Beach Fire Control Tower (located at 43° 17.198 N, 70° 34.322 W) and the Kennebunk River Breakwater Light (located at 43° 20.756 N and 70° 28.590 W) in Maine (SAIC, 1985).

Individual depth measurements were determined to a resolution of 3.0 cm (0.1 feet) using a Raytheon DE-719 Precision Survey Fathometer with a 208 kHz transducer and a Raytheon SSD-100 Digitizer, as described in DAMOS Contribution #48 (SAIC, 1985). An estimated speed of sound of 4800 ft/sec was used during the survey. The actual speed of sound was determined from the water temperature and salinity data obtained using an Applied Microsystems CTD probe. The difference between the actual and the estimated speed of sound value was used during analysis to correct the depth measurements.

The precision bathymetric survey was conducted at CADS on 17 October 1987. This survey consisted of forty-nine lanes spaced 25 meters apart, covering an area with dimensions 600 meters (east to west) by 1200 meters (north to south). The survey lanes were run east and west (<u>perpendicular</u> to the trough) to insure maximum detection of depth changes over the bottom (within approximately every 3 meters). In contrast, lanes run parallel to the trough (north and south) would yield depth changes <u>across</u> the trough only every 25 meters unless the lane spacing was reduced. The survey included the area in the vicinity of the disposal buoy and the north-south trending trough north of the buoy. During analysis of the bathymetric data the raw depth data were corrected to Mean Low Water by adjusting for ship draft, for changes in tide heights during the survey, and for the speed of sound in the water column. A more detailed description of the bathymetric analysis procedure is provided in DAMOS Contribution #60 (SAIC, 1989).

## 2.2 REMOTS® Sediment-Profile Photography

REMOTS® photography is used to detect and map the distribution of thin (1-20 cm) dredged material layers. This capability complements the precision bathymetric data which can resolve bottom elevation changes greater than 15 cm. A detailed description of REMOTS® image acquisition, analysis and interpretative rationale is given in DAMOS Contribution #60 (SAIC, 1989).

A 51 station orthogonal grid (3 x 17) was occupied during the previous REMOTS® survey at CADS in May 1985. The results of that survey indicated dredged material present as far as 200 meters north of the disposal site boundary. The present survey was designed to further investigate these results. In the present survey, 27 of the original 51 grid stations were reoccupied on 16 and 17 October 1987. These 27 stations, which comprised a 3 x 9 orthogonal grid having 50 m spacing, were deliberately located up to 500 meters north of the disposal site boundary in order to detect the extent of dredged material occurring outside the site (Figure 2-1). Three replicate REMOTS® photographs were obtained at each of these stations. Five additional stations extending south of the grid and spaced 100 m apart also were occupied in order to determine the thickness and distribution of dredged material layers within the disposal site boundaries (Figure 2-1). Two replicate photos were obtained at each of these additional stations.

## 3.0 RESULTS

### 3.1 Bathymetry

Tabulation of scow log records indicated a total of 195,646 $m^3$ (255,579 $yd^3$) of dredged material was deposited at CADS between the May 1985 and October 1987 surveys. A comparison of the 1985 and 1987 contour plots (Figures 3-1 and 3-2, respectively) shows a reduction in depth of about 1 meter in the area immediately east of the disposal buoy, as well as north of the buoy at the disposal site boundary. Enlargements of the area in the vicinity of the buoy allowed a better comparison between the 1985 and 1987 surveys. Compared to the enlarged 1985 plot (Figure 3-3), the enlarged 1987 plot (Figure 3-4) reveals reductions in depth of between 0.25 and 1.00 meters inside the 42 meter contour. This reduction in depth apparently extended up to 150 meters north of the buoy.

### 3.2 REMOTS® Sediment-Profile Photography

Within the CADS boundaries, dredged material as inferred from the REMOTS® photos exceeded the depth of penetration of the camera prism at all stations except 16-C (Figure 3-5). At station 16-C, the bottom consisted of large rocks (10-15 cm diameter). It is impossible to determine whether these rocks were introduced with the dredged material or were naturally-occurring deposits derived from the bordering outcrops. Outside the disposal site boundaries, measurable layers of dredged material were found as far north as station 6-C, located about 550 m from the buoy. The thickness of the deposit decreased steadily going from south to north away from the disposal site boundary.

Consistent with its description prior to disposal, the sediment identified as dredged material in the REMOTS® photos was predominantly fine to medium sand (Figure 3-6). A sand over mud stratigraphy was apparent at many stations in the region north of the disposal site (Figure 3-7). In the previous REMOTS® survey at CADS (May 1985), these stations were dominated by ambient silt-clay sediments (Figure 3-8). In addition to station 16-C, prism penetration was prevented or inhibited by rocks at several eastern grid stations. A physical process map (Figure 3-9) illustrates the distribution of rocks, sand over mud stratigraphy, and other physical sediment features at CADS.

## 4.0 DISCUSSION

Both the precision bathymetric and REMOTS® surveys at CADS indicated the accumulation of dredged material in the general vicinity of the buoy. The material apparently occurred as a sand layer having a maximum thickness on the order of one meter or less over a relatively broad area, which explains in part why a distinct bell-shaped mound was not apparent at the disposal point. A plot of disposal points based on scow log records dated between 1 February 1986 and 10 May 1987 indicates that most disposal occurred within a 100 meter radius of the buoy (Figure 4-1). However, a significant number of disposal points occurred outside this 100 meter radius. This may help to account for the observed dispersal of material on the bottom.

The bathymetric results show that a maximum depth change of about 1.0 meter occurred at and east of the buoy and continued north about 150 meters. As a maximum estimate, this represents 10,600 $m^2$ of bottom which would account for about 10,600 $m^3$ of dredged material. The layers less than about 12 cm thick observed in REMOTS® photos at stations up to 550 meters north of the buoy occupied an estimated 50,000 $m^2$ of bottom. A blanket of dredged material 12 cm thick deposited evenly in this area would add another 6,000 $m^3$, bringing the estimated total to approximately 16,600 $m^3$ of dredged material. This is considerably less than the scow log volume estimate of 195,646 $m^3$ of dredged material deposited at CADS since the previous bathymetric and REMOTS® surveys in May 1985. This large discrepancy is due to a combination of factors including mass balance considerations, limitations of the survey equipment to detect small changes in depth on an irregular bottom, and the survey not covering the entire dredged material deposit.

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 at the flanks of the mounds 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 approximately 115,000 $m^3$ of material, compared to the depth difference volume estimate (based only on the precision bathymetric survey) of 10,600 $m^3$. At CADS as well as at the other DAMOS disposal sites, dredged material volumes calculated from bathymetric data have consistently been less than the corrected scow log volumes (SAIC, 1988 and SAIC, 1989). Until a comprehensive mass balance study is performed and methods are developed to easily and accurately measure scow volumes, attempts to reconcile the two volume estimates almost certainly will result in such a discrepancy.

The difficulty in detecting small changes in depth is related to the fact that the disposal site contains a trough with a silt/clay bottom admixed with fine sand and bordered by hard rock outcrops. Given the reported locations for disposal, it is likely that a significant portion of the disposed material was deposited among the rocky outcrops, where it would not be detected by bathymetry (or REMOTS®). This is because depths are measured by the first return signal to the fathometer (i.e., the return signal from the shallowest point) from an area with a diameter of approximately 13 meters (for the Raytheon fathometer used in the 1985 and 1987 surveys at CADS). Within this area "sensed" by the fathometer, dredged material accumulating among rock outcrops would be missed because the rocks would always be the shallowest point. Use of a fathometer with a narrower beam width in future surveys will reduce the area measured to approximately 2 meters in diameter and should therefore increase the chances of detecting the deposited material.

There is also strong evidence that the bathymetry and REMOTS® surveys did not adequately sample the entire sediment deposit. The REMOTS® mapping showed dredged material in excess of the prism penetration depth at station 22-C (Figure 3-6), located over 200 meters south of the buoy. The volume of dredged material located further south of this station cannot be estimated but is likely to be significant, especially since scow log records show that disposal did in fact occur there (Figure 4-1). Most of the area south of the buoy was not included in the 1985 bathymetric survey, so that the volume of material which might be there cannot be estimated based on depth difference calculations. Even if this area had been included in the 1985 survey, the presence of numerous rock outcrops in the region would probably confound comparisons with the 1987 bathymetry data for the reasons stated above.

It is not likely that a significant amount of material was lost from the site as a result of resuspension and transport by bottom currents. Previous surveys have found that bottom currents at CADS generally have low velocities, on the order of 10-15 cm/sec in a northerly direction (SAIC, 1987). These surveys also found that strong wind- or storm-induced surface currents did not persist near the bottom at the disposal site because the topographic variability in the region disrupts their flow. It was calculated that winds in excess of 50 mph would have to blow for at least 6 hours to generate waves which could cause any resuspension of dredged material at CADS. However, storms with winds of this intensity and duration occur infrequently (on the average of once every three to five years) and would not persist long enough to remove the volume of material "unaccounted for" in the October 1987 surveys.

## 5.0 RECOMMENDATIONS

The attempt to determine the extent of the dredged material deposit at CADS points to the difficulties imposed by the unique topography of the site. If the main objective of future surveys is to determine the areal extent and thickness of dredged material, then several additional approaches should be considered. The bathymetric and REMOTS® surveys should be enlarged to encompass the entire region surrounding the buoy, in order to better detect the extent and topography of the dredged material deposit. Side scan sonar (as was attempted in the October survey) and sub-bottom surveys may provide additional insight into the bottom topography of the disposal site and the surrounding trough area. Although the latter two approaches do not quantify the amount of material present, they may prove useful in detecting "pockets" of dredged material occurring among the rocky outcrops, which are not readily detectable with bathymetry.

The results of the bathymetry analysis can be improved by using a fathometer with a narrow-beam transducer (e.g., an ODOM fathometer). Further improvements can only be accomplished by increasing the amount of data collected. Running two surveys perpendicular to each other would reduce the dimensions of each depth matrix cell and increase the resolution of the survey. The magnitude of this increase can best be determined empirically in future surveys. A decision could then be made as to whether the additional survey time was justified.

The volume of dredged material might be more accurately tracked if the disposal point were placed more toward the center of the trough, on soft bottom away from the highly irregular topography of rock outcrops to the south where it is difficult or impossible to detect deposited sediment. This would require moving the disposal buoy north of its present location and positioning it midway between the sides of the trough. Tighter clustering of disposal points around the buoy also may help minimize the dispersal of material onto rocky bottom, where it is unlikely to be detected with current monitoring techniques.

## 6.0 REFERENCES

SAIC. 1985. Standard Operating Procedure Manual for DAMOS Monitoring Activities. DAMOS Contribution #48 (SAIC Report #SAIC-85/7516&C48). US Army Corps of Engineers, New England Division, Waltham, MA.

SAIC. 1987. Environmental Information in Support of Site Designation Documents for the Cape Arundel Disposal Site - Physical Oceanography. SAIC Report #SAIC-85/7527&92.

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SAIC. 1989. Monitoring Surveys at the New London Disposal Site, August 1985 - July 1986. DAMOS Contribution #60 (SAIC Report #SAIC-86/7540&C60). US Army Corps of Engineers, New England Division, Waltham, MA.

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.

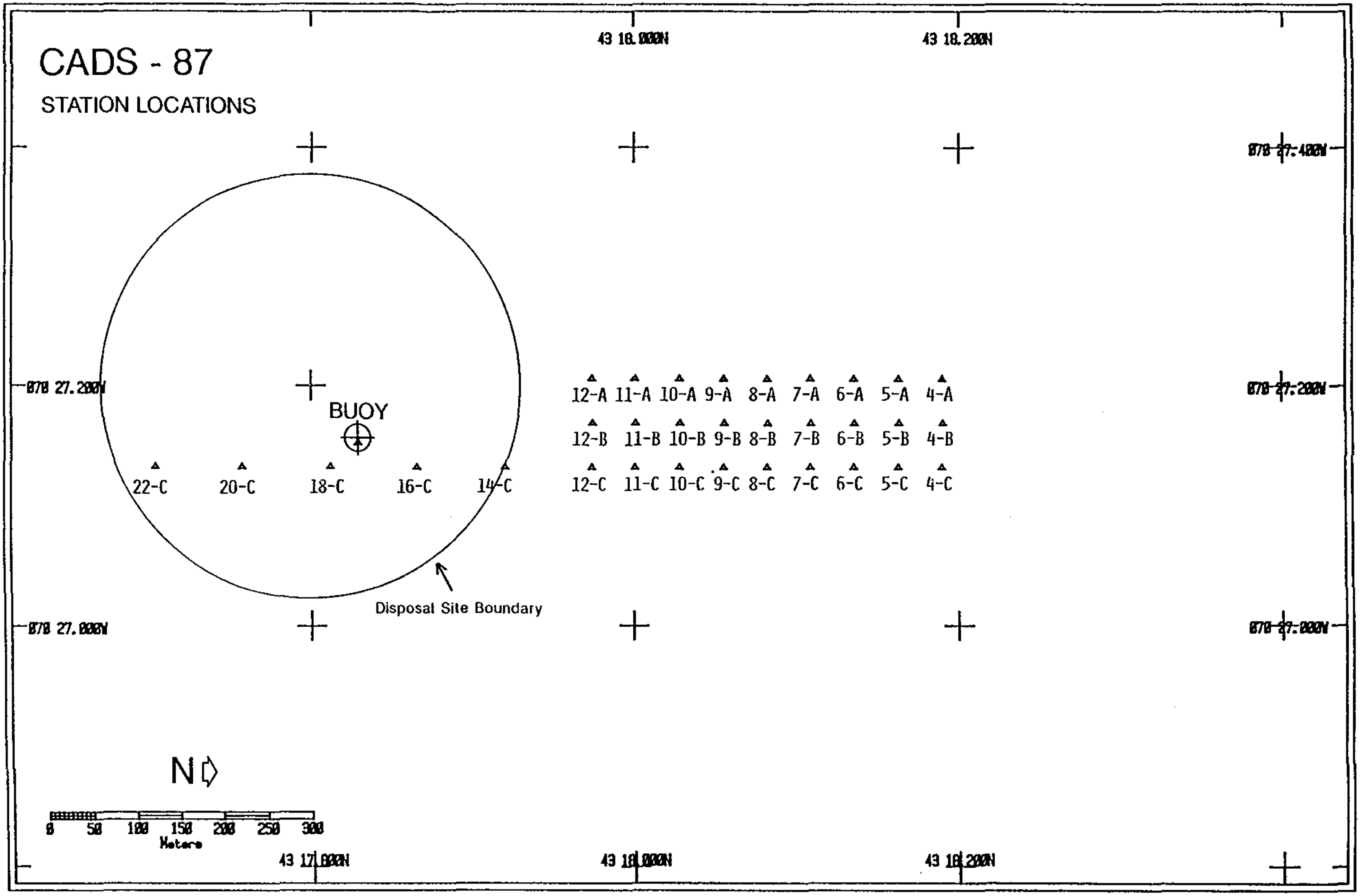


**Figure 2-1.** Locations and designations of REMOTS® stations occupied at CADS, October 1987.

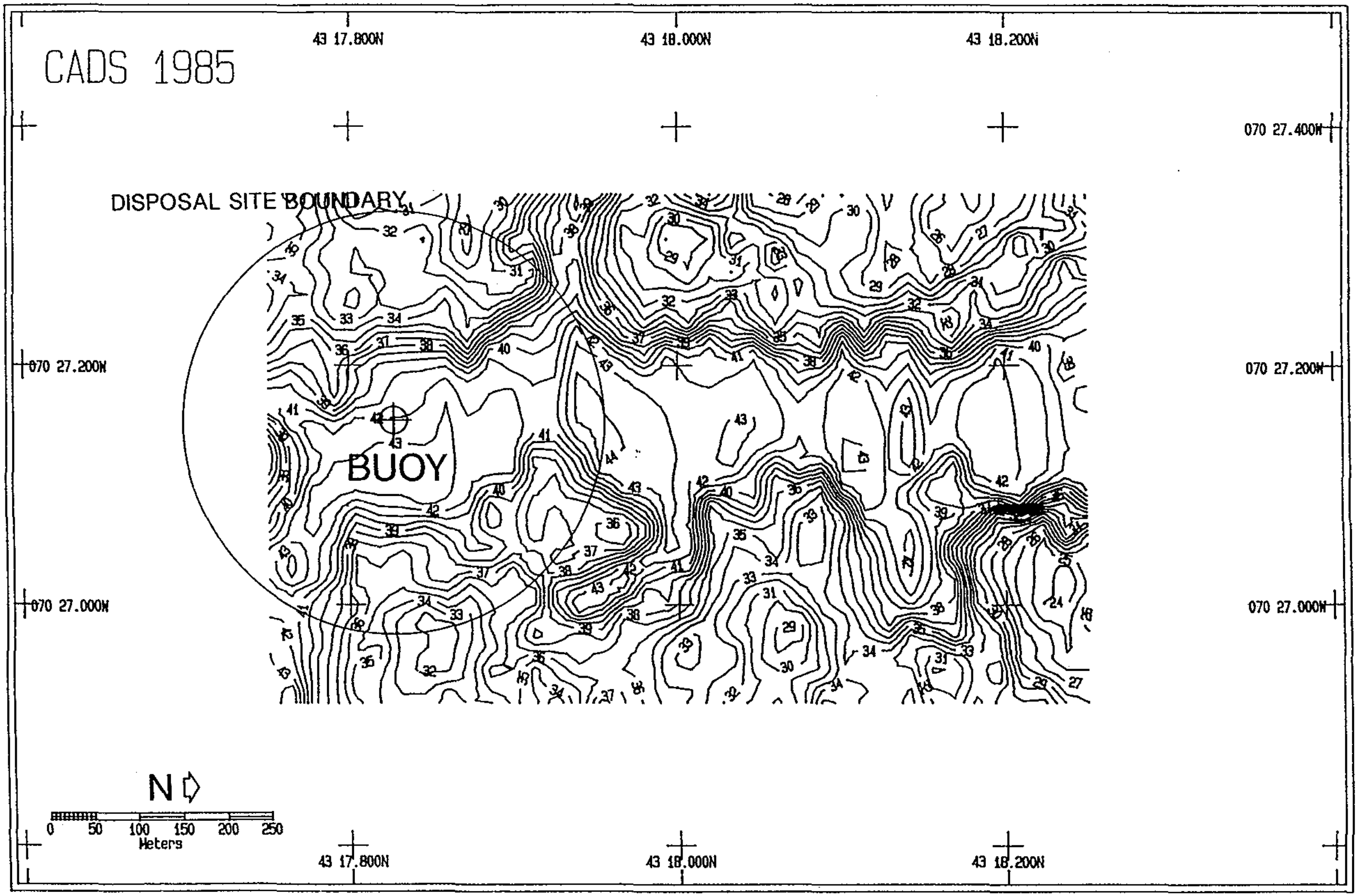


**Figure 3-1.** Contoured bathymetric chart (m) of CADS, 28 May 1985. The contour interval is 1 meter.

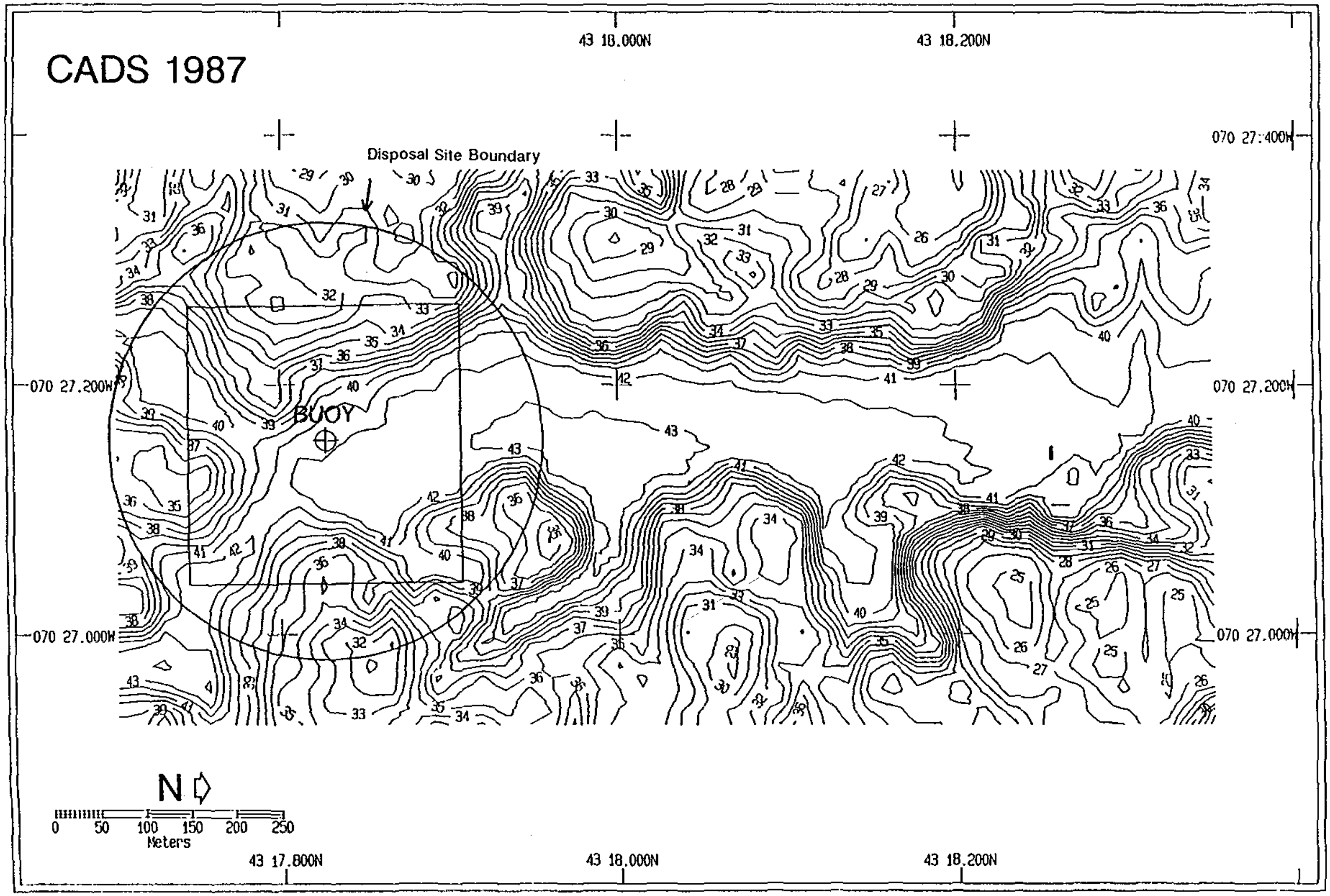


**Figure 3-2.** Contoured bathymetric chart (m) of CADS, 17 October 1987. The contour interval is 1 meter. The square around the buoy delimits the area which has been enlarged in Figures 3-3 and 3-4.

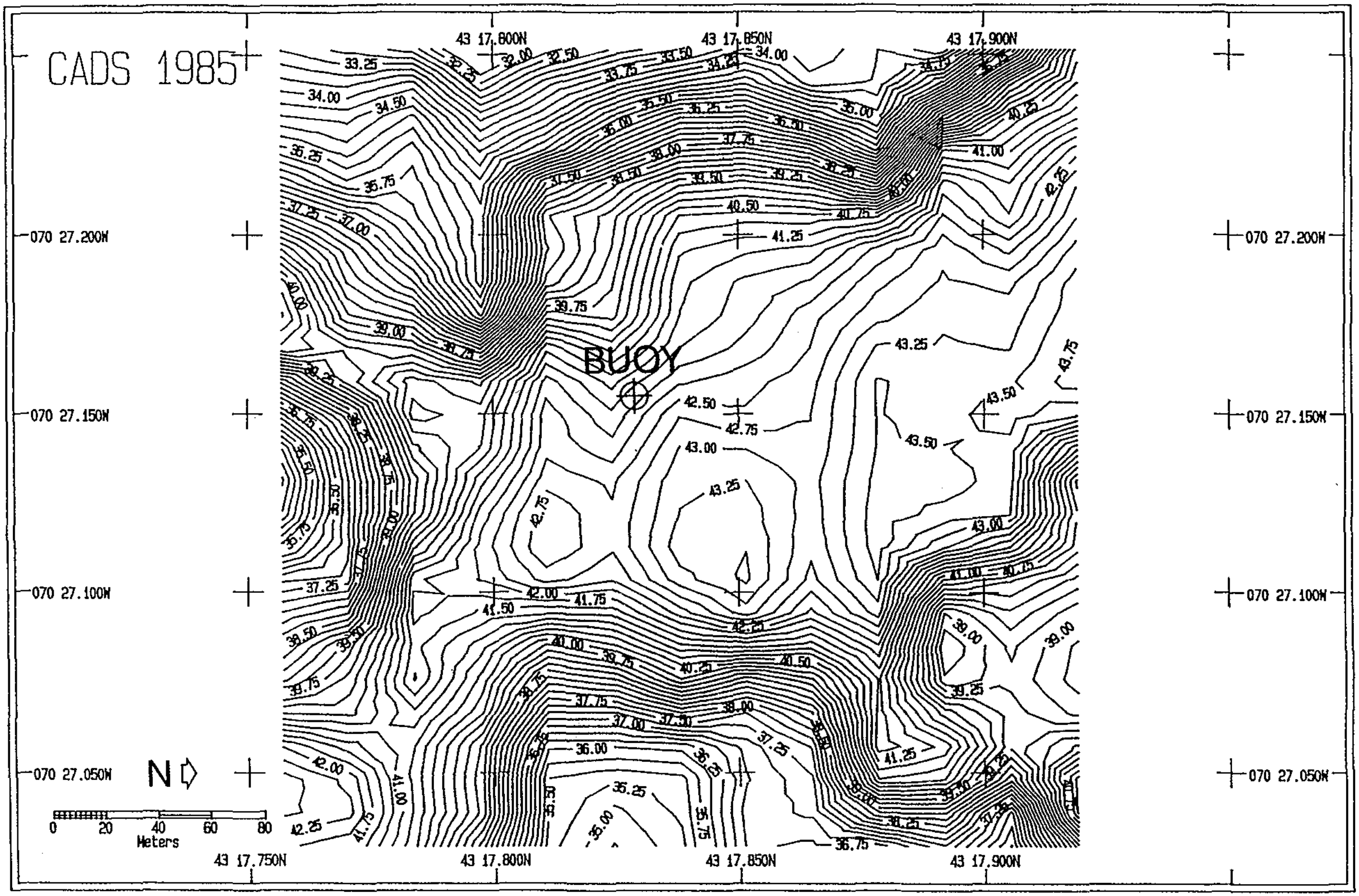


**Figure 3-3.** Coontoured bathymetric chart (m) of the area surrounding the buoy at CADS, 28 May 1985. The contour interval is 0.25 meters. Figure 3-2 shows the area which has been enlarged to produce this chart.

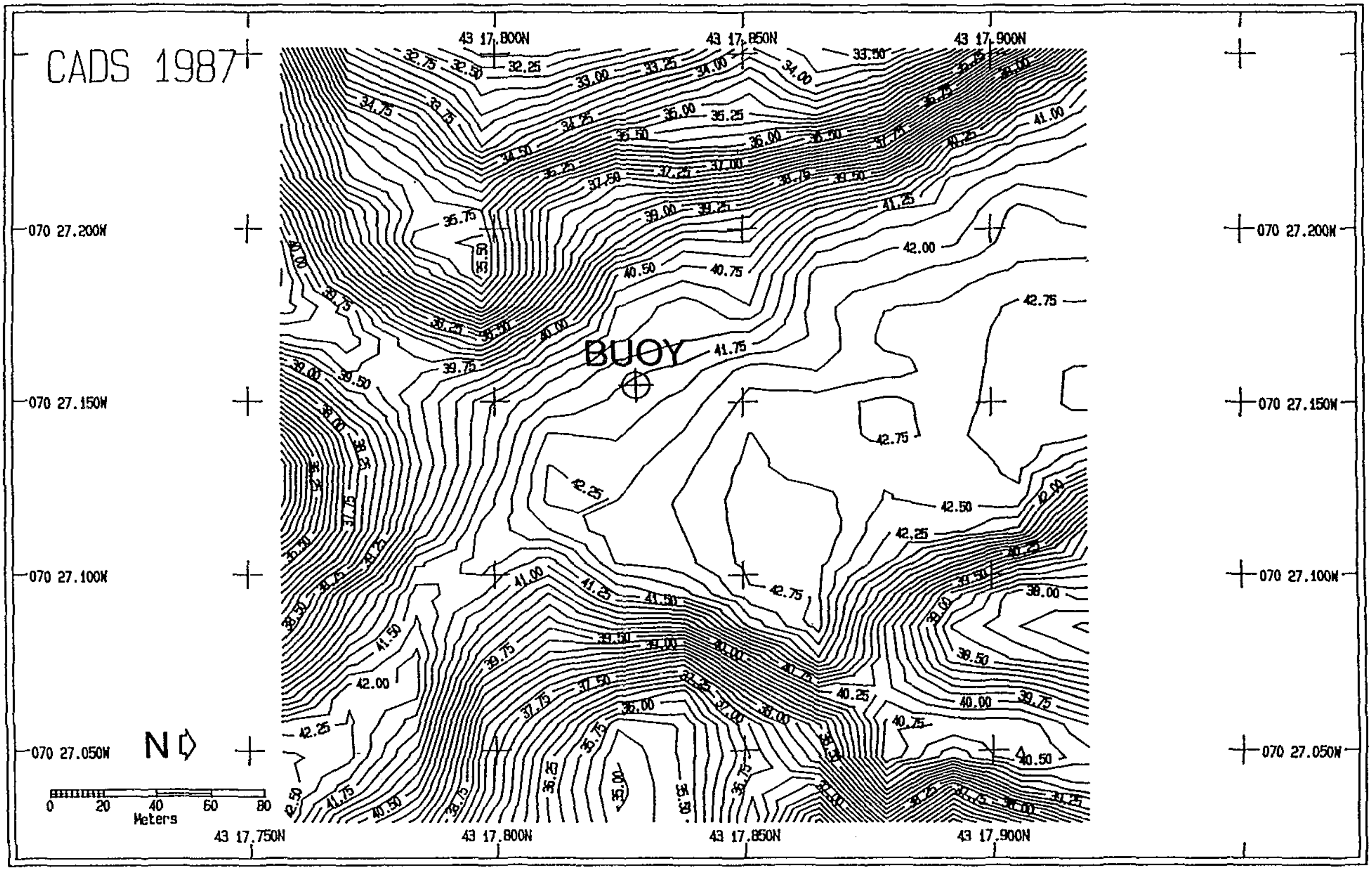


**Figure 3-4.** Contoured bathymetric chart (m) of the area surrounding the buoy at CADS, 17 October 1987. The contour interval is 0.25 meters. Figure 3-2 shows the area which has been enlarged to produce this chart.

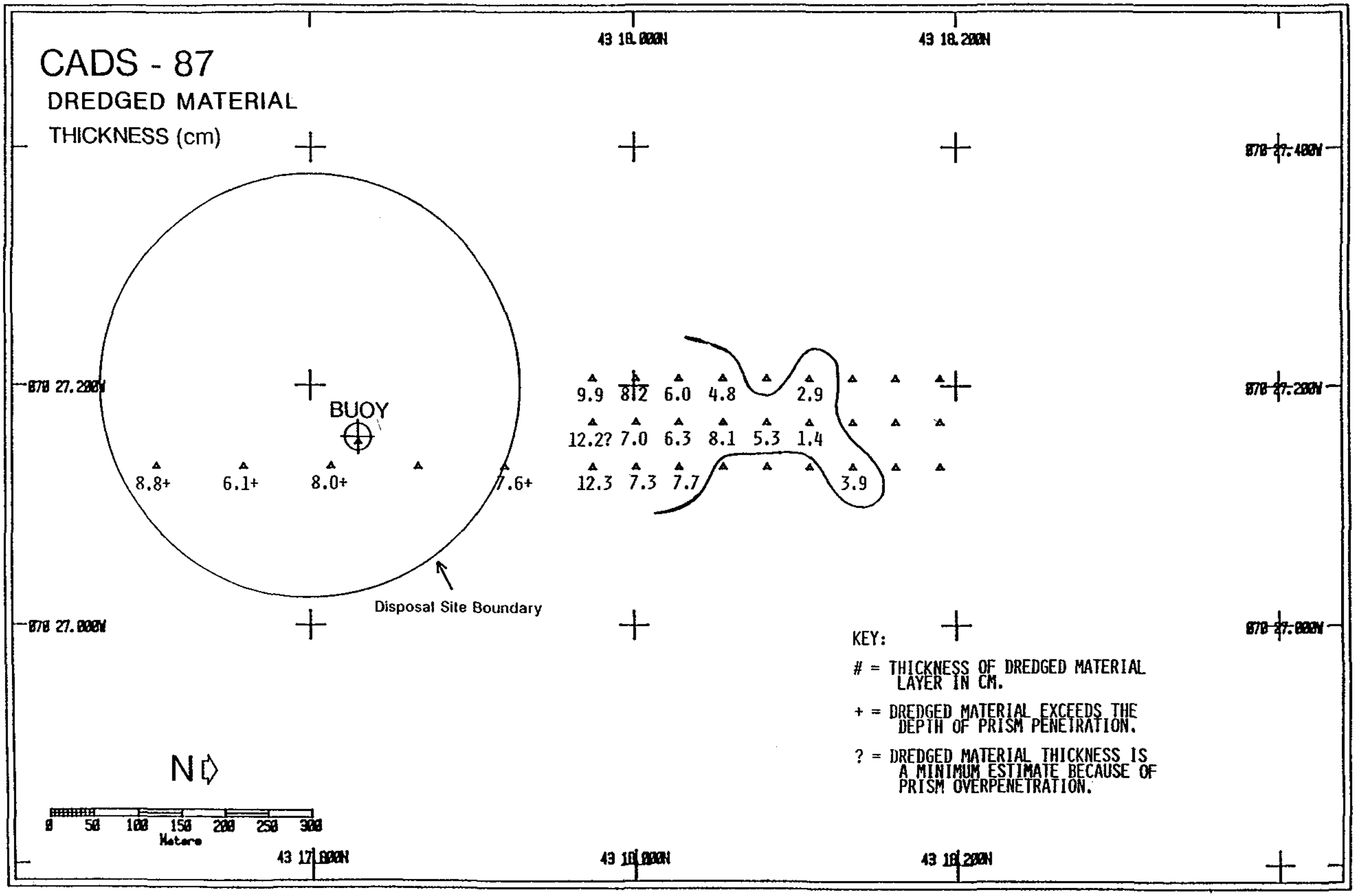


Figure 3-5. Distribution and thickness of dredged material layers at CADS, October 1987. The contour delimits the northern extent of dredged material as inferred from the REMOTS® photos. No dredged material was apparent at the unmarked stations.

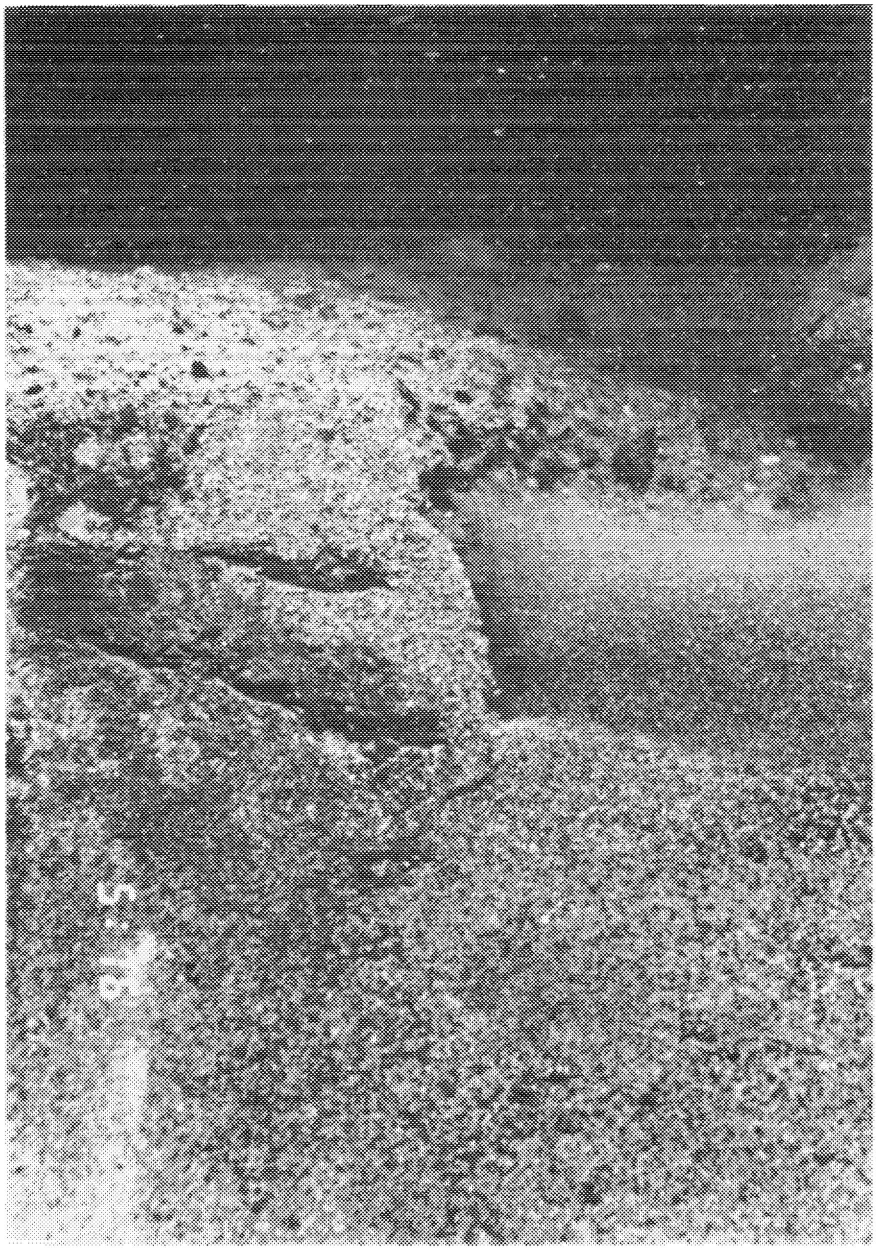

**Figure 3-6.** REMOTS® photo from station 22-C within the disposal site boundary showing fine to medium sand exceeding the depth of prism penetration. This sand is presumed to be recently-disposed dredged material. Scale = 1X.

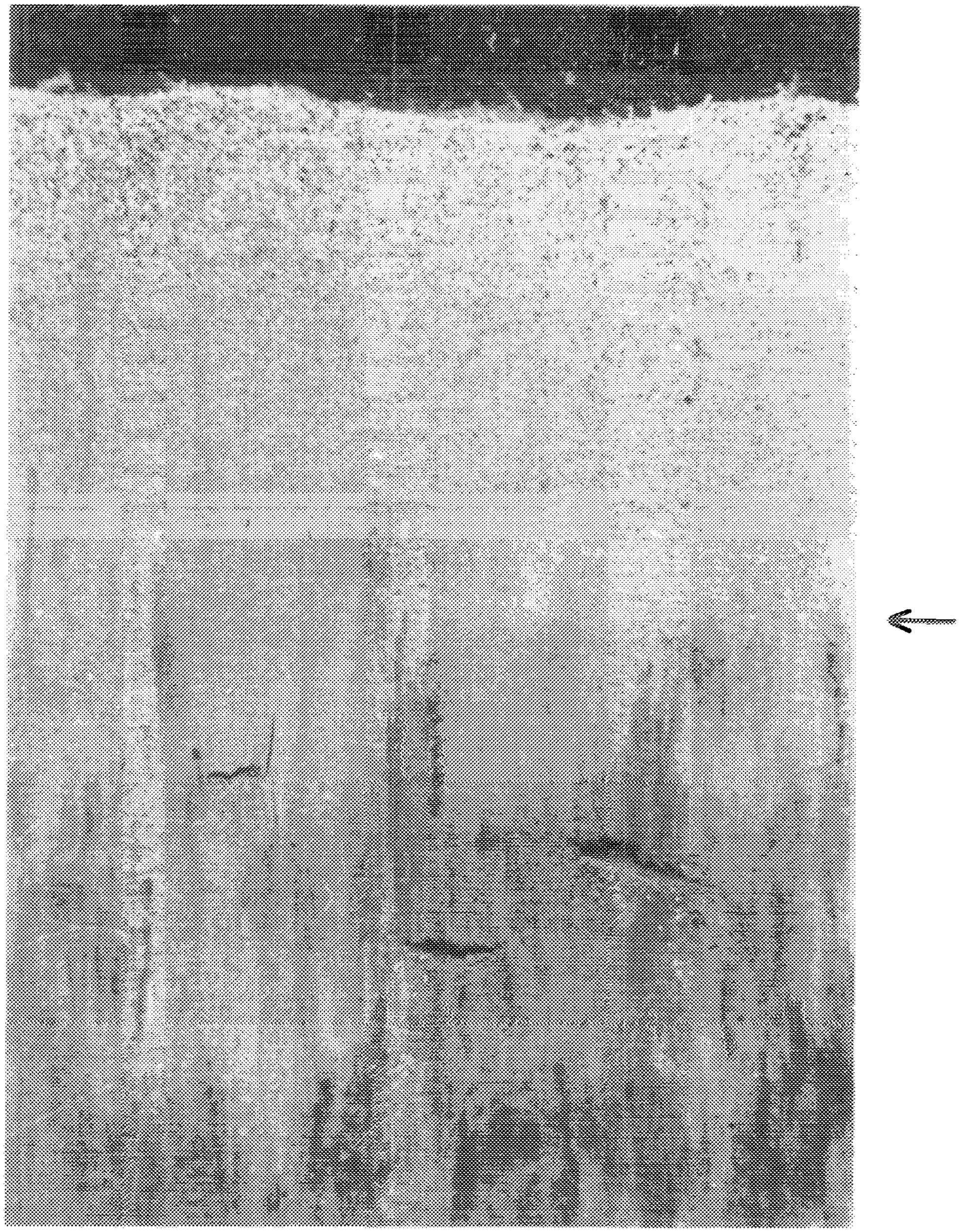

**Figure 3-7.** REMOTS® photo from station 11-A in October 1987, showing sand over mud stratigraphy. The sand presumably represents dredged material deposited since the May 1985 REMOTS® survey. The point of contact between the sand and mud layers (arrow) is not distinct. This may be due in part to bioturbational mixing by infaunal organisms, whose presence is indicated by the numerous feeding voids visible in the underlying mud layer. Scale = 1X.

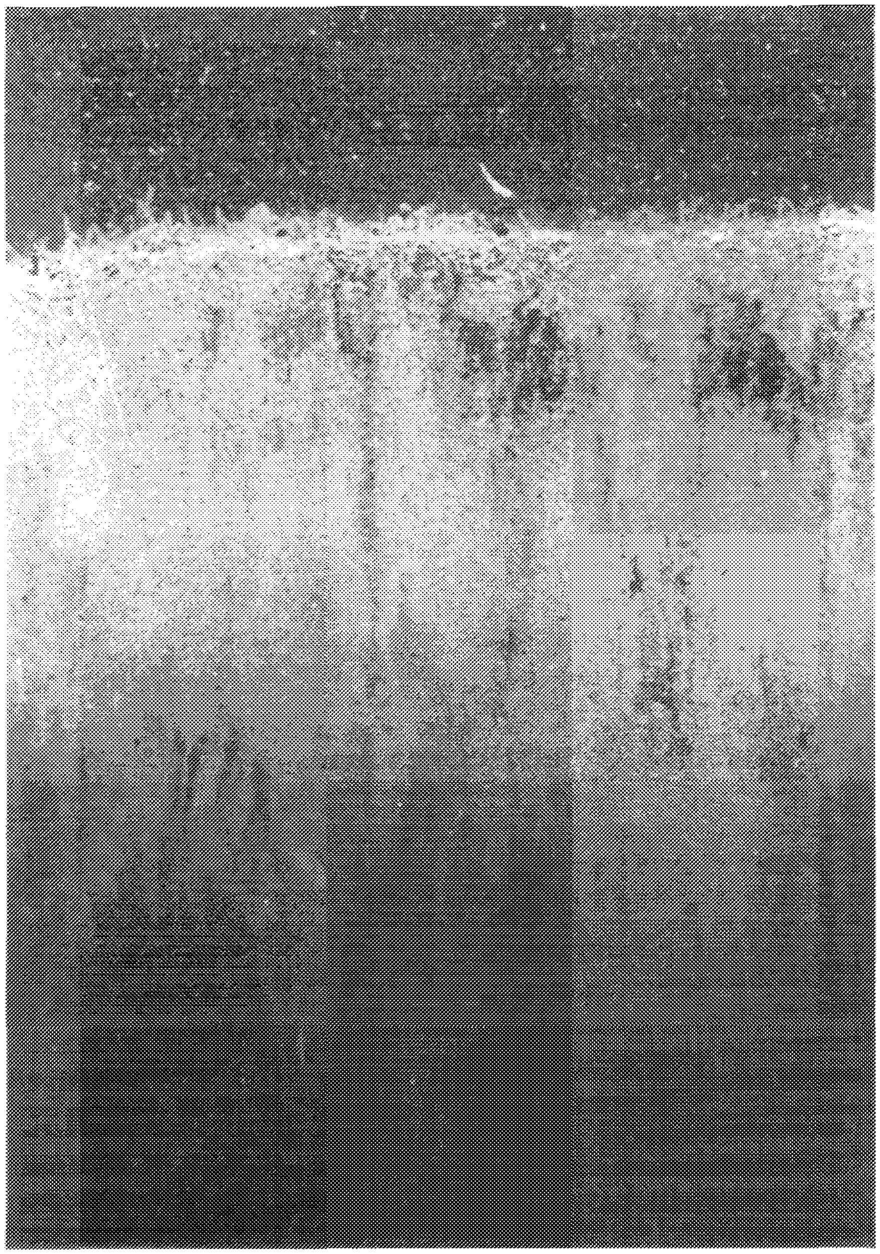

**Figure 3-8.** REMOTS® photo from station 11-A in May 1985, showing apparent ambient bottom dominated by silt-clay sediments. Scale = 1X.

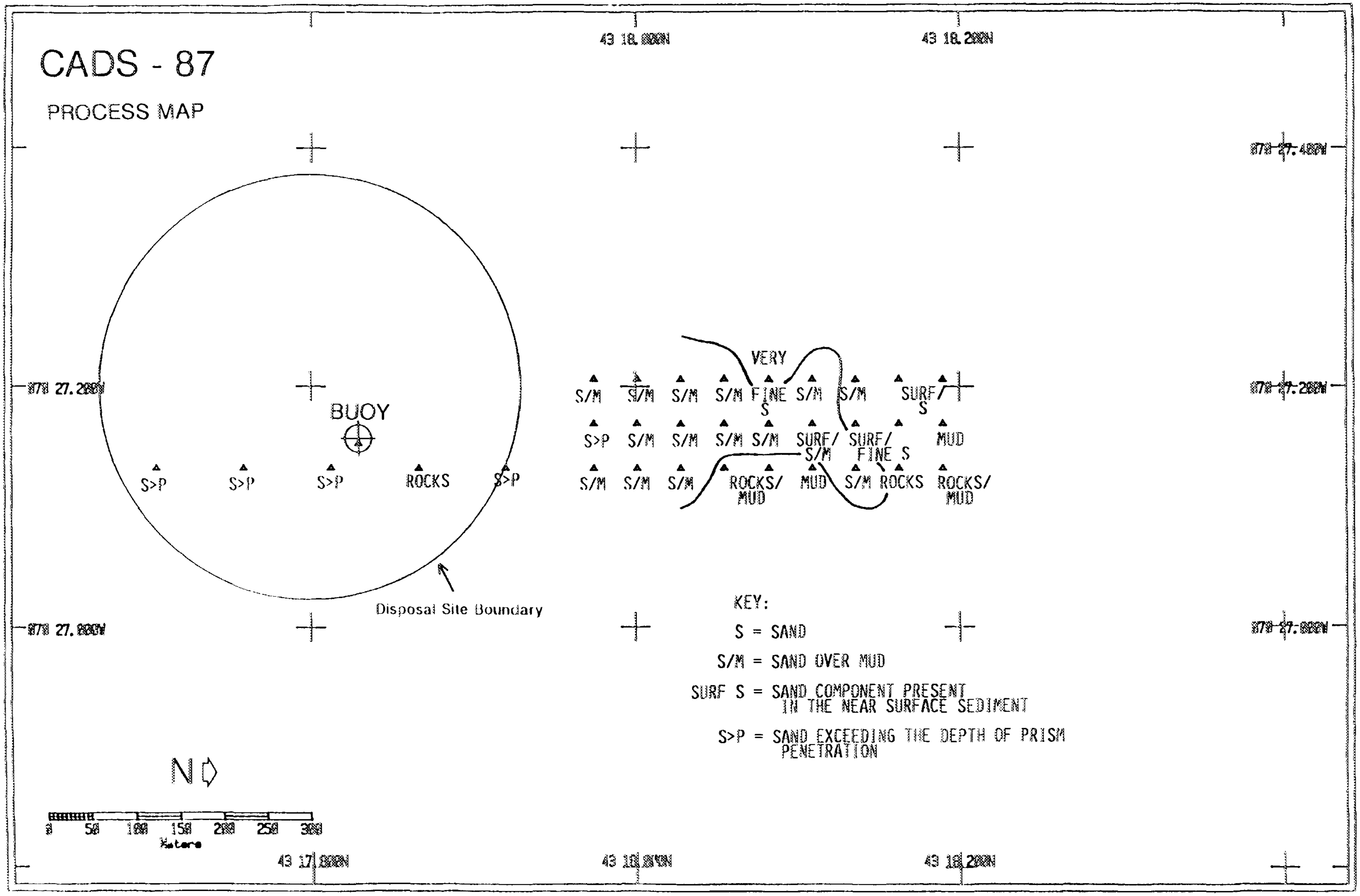


Figure 3-9. Process map illustrating physical features at the REMOTS® stations at CADS, October 1987. The contour delimits the northern extent of dredged material based on the REMOTS® photos, as indicated in Figure 3-5.

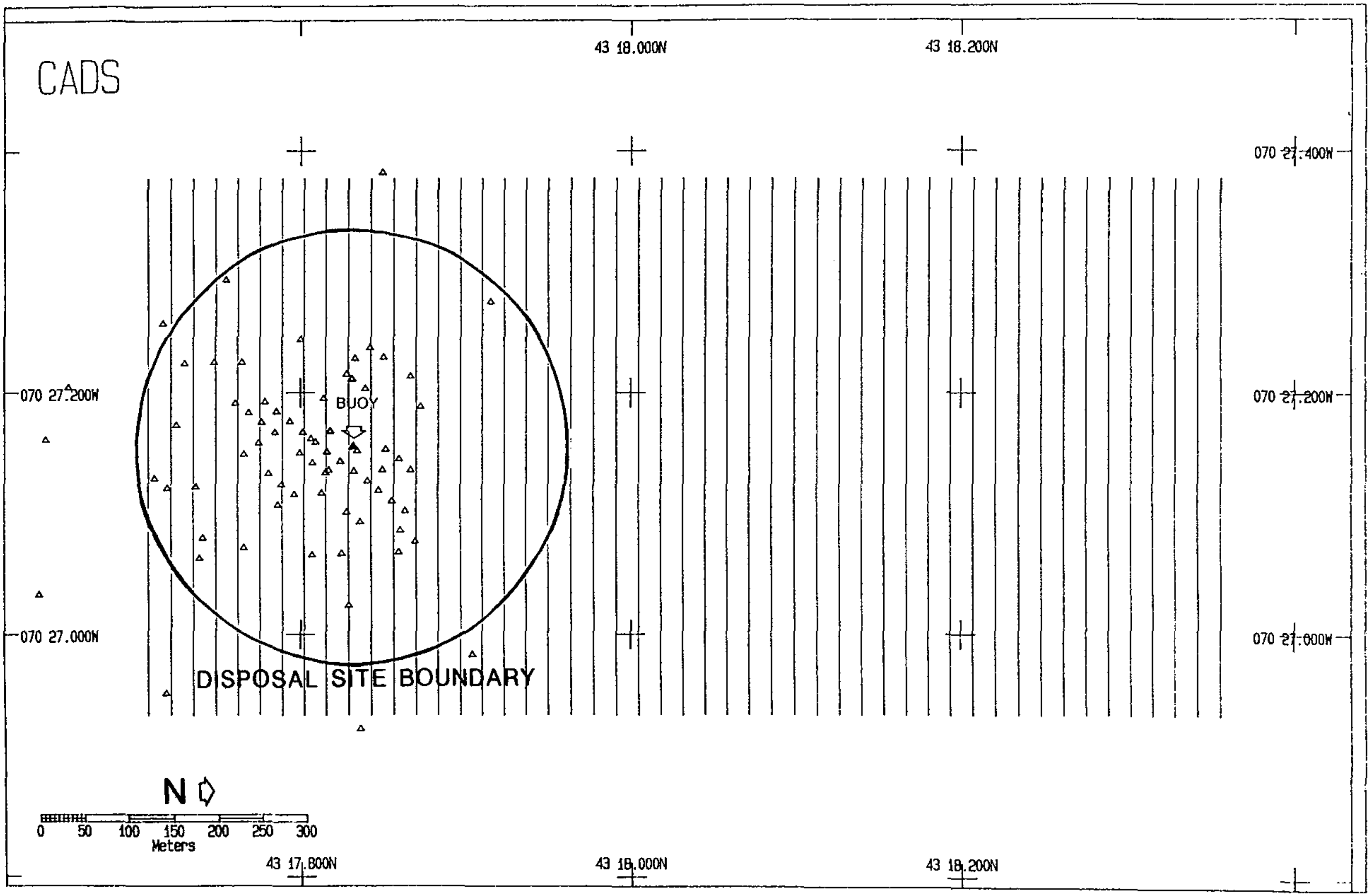


Figure 4-1. Plotted disposal locations at CADS (triangles) based on scow log records dated between 1 February 1986 and 10 May 1987. Loran reading errors may be present in some reports. A check of those plotted outside the disposal site indicates the inspector determined the distance to the buoy as 200 meters or less.