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NWRI Contribution No. 99-210

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MANAGEMENT PERSPECTIVE

This work was done as a collaborative study with the Toronto Region Conservation Authority and was funded by the authority. It is a continuation of mapping of the Toronto Waterfront begun in 1996 to provide planning information for the authority and to update NWRI's 1968 nearshore-sediment survey.

This report describes a survey of Lake Ontario nearshore sediments along the Scarborough shoreline conducted by NWRI for the Toronto Region Conservation Authority (TRCA). This is a continuation of the survey begun in Toronto Harbour and at East Point in 1996. The survey provides TRCA with pre-construction information about the bottom sediments and bathymetry in an area designated for shoreline improvement and NWRI with an update of earlier data on coastal sediments of the Toronto waterfront. The report presents maps of bottom-sediment type and bathymetry and data on their areal coverage.

Future work will include an expansion of the survey to the Ashbridge's Bay area in 1999, analysis of 1996-1999 data and comparison with original data from 1968, and publication on changes in the Toronto nearshore zone, 1968-1999.

This management perspective is currently being translated into French.

Abstract

NWRI's RoxAnn seabed-classification system has been used to map the sediment types and bathymetry of the Toronto waterfront between Port Union Road and the Rouge River on behalf of the Toronto Region Conservation Authority (TRCA). This is a continuation of waterfront mapping begun in 1996 to provide TRCA with data needed for shoreline management and engineering and to update NWRI's nearshore-sediments file.

The acoustic data were calibrated with underwater-television observations and then analyzed and mapped with the geographic information system, SPANS. The study area is an erosional zone composed mainly of boulders and cobbles with one large sand deposit at the northeast corner of the zone south of the Rouge River mouth and three smaller areas of sand and muddy sand in the central part of the area. Bathymetry mirrors the bottom types; contours are highly irregular in the boulder and cobble areas and smoother over the deposits of sand and muddy sand.

1. Introduction

Environment Canada conducted a sediment-mapping survey of the Scarborough nearshore zone for the Toronto Region Conservation Authority in July 1998. The survey was a continuation of work done in 1996 and 1997 on the East Point to Port Union reach of the shoreline. The 1998 survey area extended from Port Union Road to the Rouge River. The purpose of the survey was to determine the general distribution of bottom-sediment types as a planning aid for redevelopment of the East Point shoreline. Data are also being used for an NWRI study on changes in the Toronto nearshore zone since it was first surveyed as part of the nearshore survey program in 1968 (Rukavina 1969).

This report describes the field equipment and procedures used and discusses the results obtained by acoustic and video mapping of bottom types and bathymetry with a RoxAnn seabed-classification system and an underwater-television system.

2. Background

The sediments of the study reach were originally mapped in 1968 as part of Environment Canada's nearshore-sediment survey of Lake Ontario (Rukavina 1969). The dominant bottom type was found to be glacial drift and associated lag deposits inshore, and exposed bedrock offshore in depths greater than about 15 m. The lag deposits occur as a patchy veneer of sediments of sand to boulder size produced by selective erosion of the glacial sediment and removal of its finer grain sizes. The bedrock samples recovered were green and black shales of the Ordovician Meaford-Dundas and Collingwood formations respectively (Caley 1940).

The nearshore zone at Scarborough is predominantly erosional because it is exposed to waves from both the west and east. Sediment generated by erosion of the local bluffs and the nearshore slope generally moves through the zone without accumulating because of the strong littoral currents generated by the waves. The direction of littoral drift is east or west depending on the wave approach, but accumulation patterns behind shore structures suggest that net movement is towards the west because of the longer fetch of the waves from the eastern sector (Rukavina 1976).

3. Field Equipment and Methods

Bottom-sediment type and morphology were surveyed with a RoxAnn acoustic seabed-classification system (Chivers et al 1990, Rukavina and Caddell 1997, Rukavina 1997a, Rukavina 1998). The equipment and survey procedures are described in earlier MTRCA reports (Rukavina 1996, 1997b). RoxAnn analyzes echo-sounder returns to produce a classification of bottom-sediment type which is then confirmed with samples or diver and underwater-television observations. All survey data on bottom type and depth are logged to a computer file which can be used for further processing of the results with a geographic-information system (GIS). Details of the survey work are shown in Appendix 2.

No pre-calibration of RoxAnn was attempted. The default limits for the 8 bottom categories from previous surveys were used pending ground-truth data from follow-up underwater-television surveys. The categories were mud, muddy sand, sand, coarse sand, gravel, boulders/hard, weeds on soft and weeds on hard.

Navigation for the survey was provided by a Sercel differential GPS with corrections from a local shore receiver set up at benchmarks at the TRCA office building on the bluff behind Bluffers Park and at a surveyed site at East Point (Appendix 1). Static checks of accuracy at second benchmarks at the Bluffers Park marina and at East Point indicated a sub-metre error for the TRCA site and a consistent 3-m error in easting for the East Point site. TRCA surveyors were unable to account for the error and no adjustment for it has been made in the data sets.

The TRCA requirement was for detailed coverage of the shore reach between Port Union Road and the Rouge River mouth and between the shoreline and the 5-m contour (Figure 1). A small reconnaissance survey of the reach was run in 1997 as a single zig-zag traverse. The same zig-zag line was repeated in 1998 as a check on consistency of the 1997 and 1998 data.

Groundtruth for the RoxAnn acoustic classification was provided by a limited underwater-television survey because the diver survey committed by TRCA as their contribution to the study did not materialize. The composite RoxAnn map was used to select 7 sites for UWTV inspection. In each case the site was chosen within an area of consistent RoxAnn type. The survey launch then navigated onto the site and several drops of the underwater-television frame were made within an circle of several metres from the target location. Television data were recorded on videotape and a mixer was used to superimpose the GPS coordinates on the video so that the record was completely georeferenced. Video records showed the type of surficial sediments and also the thickness of any unconsolidated sediments.

4. Data Analysis

RoxAnn parameters for the 1997 and 1998 zig-zag surveys across the site were compared to check for consistency. Averages for individual line segments were generally higher in the earlier survey. Bottom roughness ranged from 13% higher in 1998 to 16% lower; 1998 hardness values were higher by 13 to 37%. Part of the difference is the result of a lower RoxAnn response in 1998. Our standard sounder simulator checks on RoxAnn performance showed that average roughness was 6% lower and average hardness was 10% lower in 1998. The likely cause of the balance of the difference was the timing of the two surveys. The 1997 data were collected in November during the storm period and at a time of degradation of the algal cover. Reduced algae and the removal of finer sediments by erosion would both result in an acoustically rougher, harder bottom. The 1998 survey was in July, during relatively quiescent weather and increasing temperature and water clarity. Accelerated algal growth and accumulation of finer inshore sediments associated with such conditions could account for the reduced bottom roughness and hardness observed.

The Roxann calibration data from the underwater-television survey are listed in Appendix 3 and compared with the RoxAnn labels in Table 1. The accuracy of the acoustic classification varies from good where bottom type is uniform (sand or densely-packed boulders) to fair where the bottom is variable. Because RoxAnn integrates the roughness and hardness data over its footprint, it cannot distinguish, for example, a mix of cobbles and sand from a uniform gravel with the same average acoustic properties. It can also be confused by thick algal cover which has the effect of reducing both the roughness and the hardness.

RoxAnn™ labels and the roughness and hardness boundaries which determine them can be adjusted to best match the ground-truth data at any time following the survey and can be updated as new data become available. In this case as in the past, we have adjusted the default labels so that they better represent the UWTV observations. The RoxAnn classes of muddy sand, sand, and coarse sand appear to reflect the actual sediment type. Gravel is interpreted as a mix of cobbles, pebbles and sand, weed on soft as algae-covered cobbles, and weed on hard as algae-covered boulders. Because no exposed glacial sediment was observed, the interpreted labels differ from those of the 1997 survey.

To prepare the RoxAnn file for GIS analysis, all the data were checked, fixes with poor GPS quality were removed, and depths were corrected to IGLD85. The edited file was then imported into a SPANS GIS for voronoi-polygon analysis of the RoxAnn bottom types and roughness and hardness parameters. This type of analysis produces a chloropleth map by associating with each data point an area (polygon) extending half the distance to surrounding data points and grouping areas of the same type. The result is a map with georeferenced boundaries and a table of areas of coverage of the data classes. SPANS was also used to produce a contour map of bathymetry from the RoxAnn depth data.

5. Results and Discussion

The GIS map of RoxAnn bottom types is shown in Figure 2 and the areal coverage of each type is listed in Table 2. The map legend shows both the default RoxAnn classes and also the bottom types they represent. Boulder bottom is the dominant type and accounts for 48% of the total area of the zone. Boulders occur across the zone but are most prominent in its southern third and in the short reach north of the Rouge River entrance. A mix of coarse lag deposits and sand (RoxAnn gravel) is next in importance at 28%. This occurs as a patchy distribution in the central offshore part of the zone where it forms an offshore or alongshore extension of the inshore sands and muddy sands. Weed on soft (6%) appears to be the same bottom type but with a thicker algae cover. Sand (15%) and muddy sand (2%) occur as five discrete deposits the largest and coarsest of which extends across the entire zone just south of the Rouge River mouth. The smaller deposits are located in the central part of the area and consist of a mix of sand and muddy sand. The remaining classes weeds on hard (algae-covered boulders), coarse sand, and mud collectively account for just over one percent of the survey area.

Figure 3 shows the maps of the RoxAnn parameters E1 (acoustic roughness) and E2 (acoustic hardness). The patterns are similar to that for bottom type. The highest values are associated with the boulder areas at the two extremes of the reach and the lowest with the unconsolidated deposits. The range of hardness values is limited presumably because of the attenuating effect of weed and algae cover in the boulder and cobble areas.

The bathymetry of the study area is shown in Figure 4 as 1-m depth contours. The contour shape reflects the bottom types. Contours are highly irregular in the boulder and cobble areas and smoother over the deposits of sand and muddy sand. The offshore slope varies across the reach from 0.9° to 0.6° in the southwest, 0.8° in the central and north-central area and 0.4° at the northeastern end. The depth distribution is shown in Table 2. More than half of the area falls with the depth interval 1-4 m, the interval 4-6 m accounts for about 30%, and 8% of the area is deeper than 6 m.

The reconnaissance survey of the reach between the Rouge River and Frenchman's Bay consisted of a zigzag traverse across the inshore zone to the Bay, and then a shore-parallel run back. Bottom type was mainly boulders in the south half of the area and sand and muddy sand on the approach to Frenchman's Bay.

6. Conclusions

RoxAnn mapping of the nearshore zone of Lake Ontario just east of Port Union Road, Scarborough, has shown it be an erosional zone composed mainly of boulders and cobbles. No exposed glacial sediment was observed. The depositional area is restricted to a major sand deposit at the northeast corner of the zone south of the Rouge River mouth and to three smaller areas of sand and muddy sand in the central part of the area. Boulder bottom occurs across the zone in the southern third of the area and at its northern limit. In the central part of the reach, boulders inshore give way to cobbles at the offshore margin. Underwater-television observations indicate that there is thin to thick algal cover on most of the coarse deposits.

RoxAnn roughness and hardness values for a check line run in 1998 were generally lower than for those for the same line in 1997 by as much as 37%. Part of the difference is the result of lower RoxAnn sensitivity in 1998. The rest is likely caused by seasonal differences in algal cover and sediment erosion or accumulation. Because a seasonal effect was observed, RoxAnn data from a single survey cannot be used to represent average bottom conditions. RoxAnn surveys provide only a snapshot of the sediment distribution pattern at the time of the survey, in this case the relatively quiescent summer period, and this pattern may not apply during the spring and fall stormy seasons.

7. Acknowledgements

G. McPherson of TRCA requested the survey and arranged for funding. R. Portiss of TRCA assisted with the field logistics and participated in the surveys. NWRI's Technical Operations Section provided the launch and coxswain, Dave Gilroy, for the surveys. The RoxAnn operator was B. Trapp of NWRI's Aquatic Ecosystem Restoration Branch. M. Dunnett, NWRI contractor was responsible for reduction of much of the RoxAnn data; Dave Gilroy extracted the video data. GIS analysis and mapping of the RoxAnn data was done under contract by Geomatics International. The development of RoxAnn as a sediment mapping tool is being funded by Environment Canada's Great Lakes 2000 Cleanup Fund.

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Figures

Tables

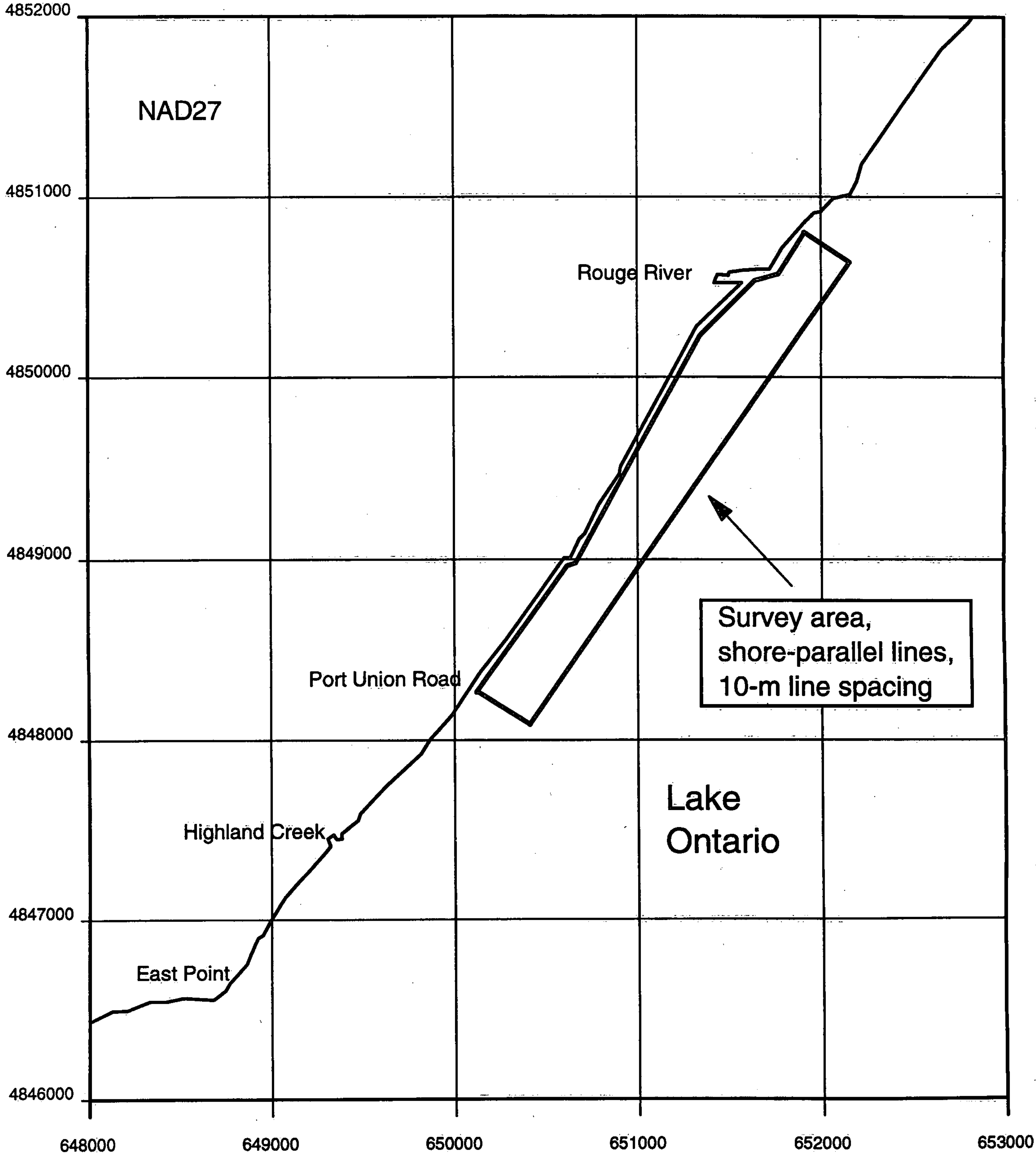

Figure 1. Survey Area

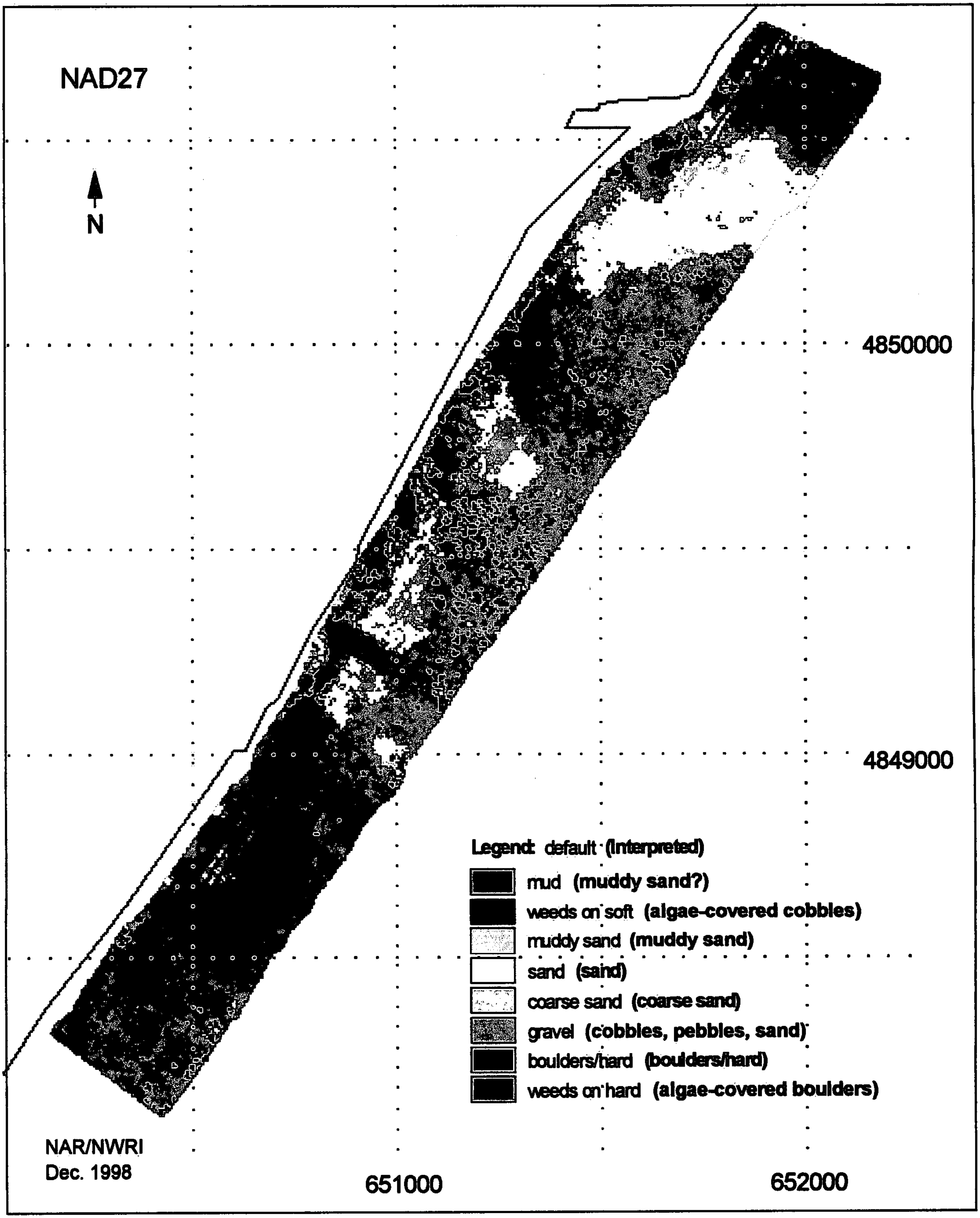

Figure 2. GIS Map of RoxAnn Bottom Types

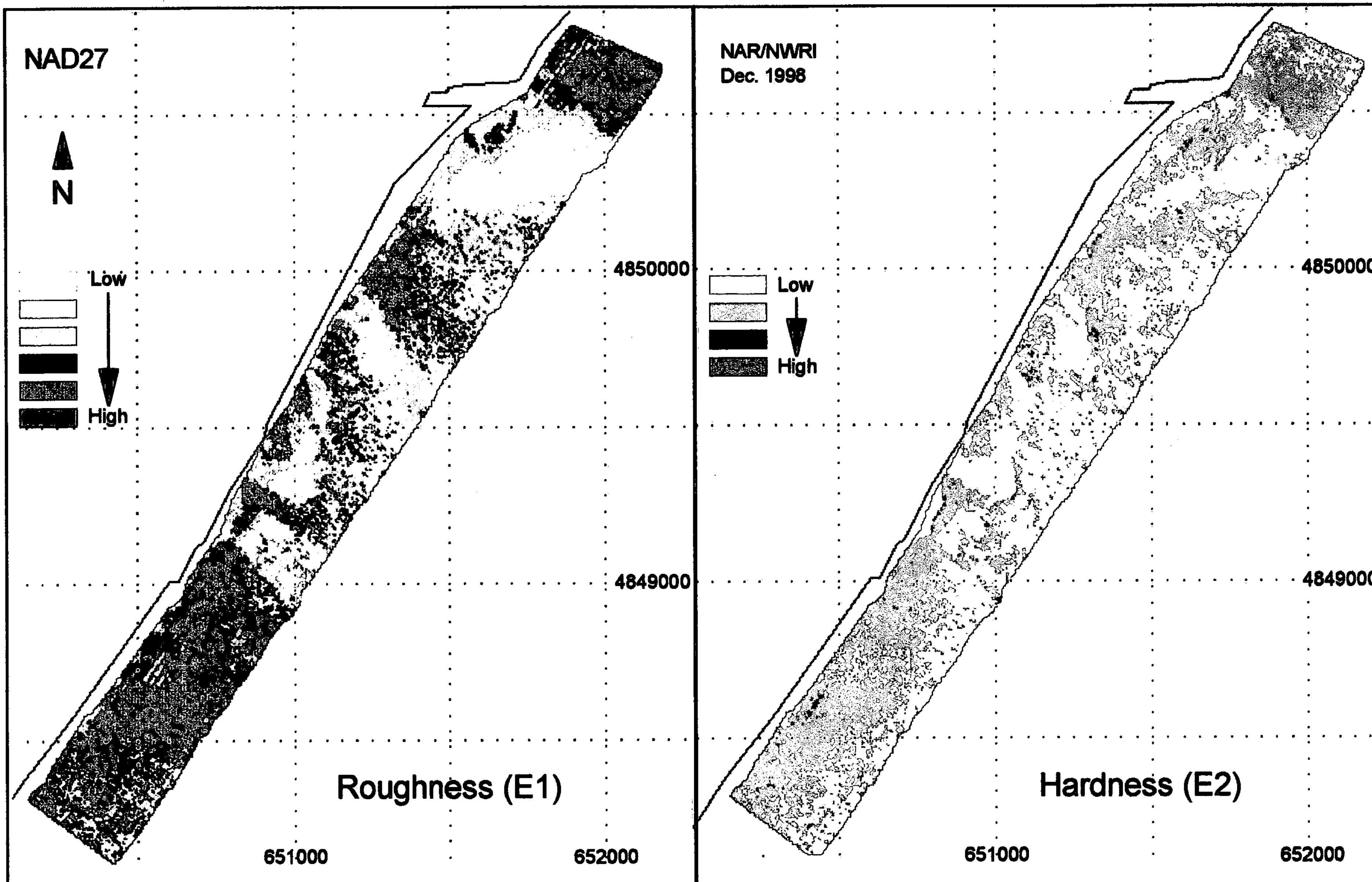

Figure 3. GIS Map of RoxAnn Roughness and Hardness Parameters

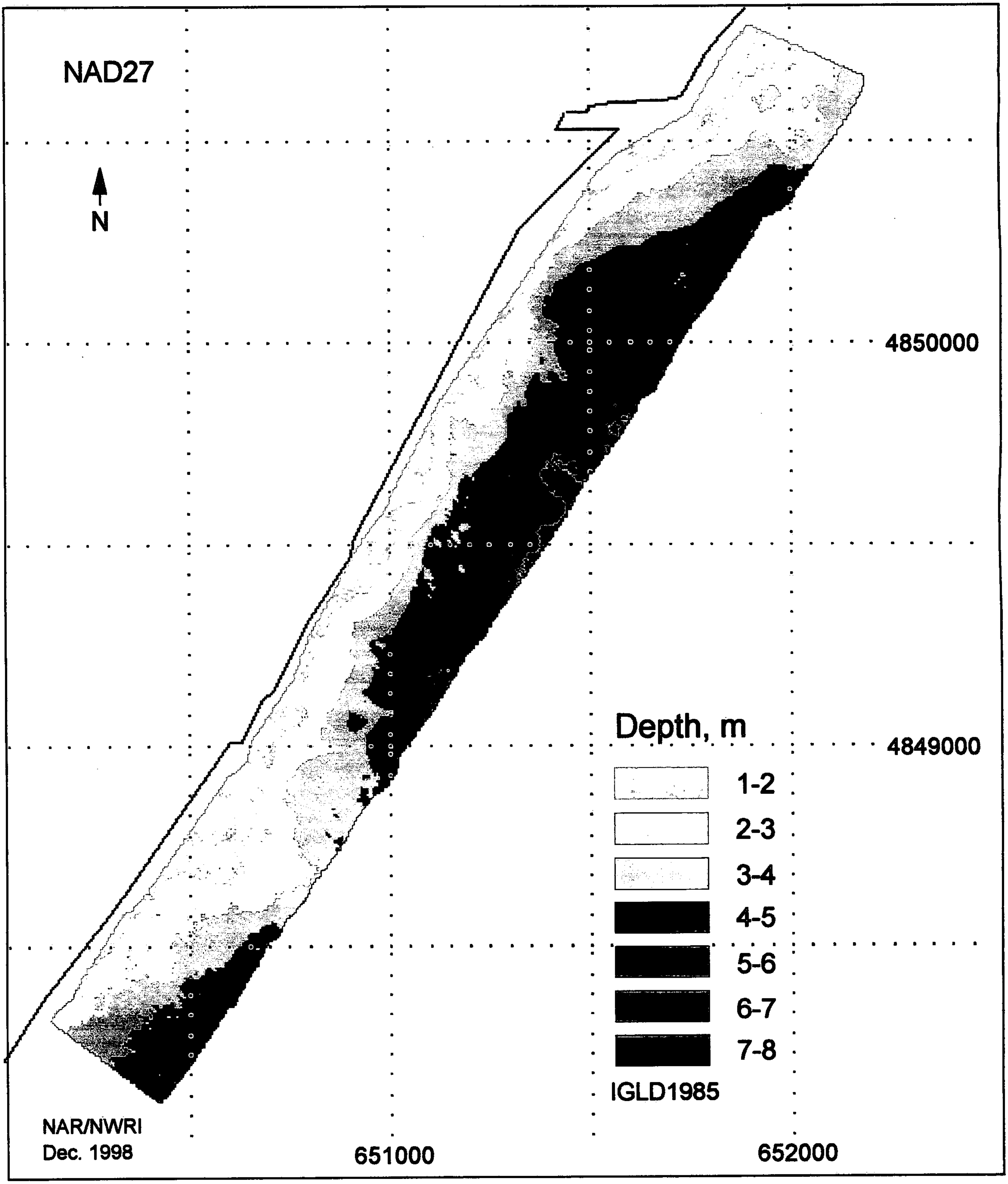

Figure 4. GIS Map of Bathymetry

Table 1: RoxAnn labels vs Underwater-television observations

Site	RoxAnn Label	UWTV Data	Fit
3	mud	Soft rippled sand with loose algae	fair
4	gravel	sand and algae-covered cobbles	good
5	sand/muddy sand	rippled sand, loose algae	good
8-1	gravel	large pebbles and sand	good
8-2	sand	flat sand	good
11	boulders	cobbles, boulders with algae	good
14	gravel/weed on soft	cobbles on sand, thick algal cover	good
16-1	gravel	cobbles with algal cover	good
16-2	sand	rippled muddy sand	fair

Table 2: GIS Area Analysis of Bottom Type and Depth

RoxAnn Type			
Default	Interpreted	Area, sq m	Area %
Boulders/hard	Boulders/hard	540780	47.7
Gravel	Cobbles, Pebbles, Sand	313200	27.6
Sand	Sand	171580	15.1
Weeds on soft	Algae-covered Cobbles	67590	6.0
Muddy sand	Muddy Sand	24970	2.2
Weeds on hard	Algae-covered Boulders	9380	0.8
Coarse sand	Coarse sand	4720	0.4
Mud	Sandy Mud	1420	0.1
Total		1133650	100.0

Depth Interval, m	Area, sq m	Area %
1-2	150020	13.2
2-3	283230	25.0
3-4	246510	21.8
4-5	211640	18.7
5-6	157160	13.9
6-7	72710	6.4
7-8	12340	1.1
Total	1133610	100.0

Appendix 1: GPS Site Data

The shore receiver for the differential GPS was initially installed on the property of the TRCA East office behind Bluffers Park. The receiver's GPS antenna was placed on a benchmark at the bluff edge, EV-2, which had been surveyed by TRCA staff. A second site, BOLLARD, was set up at the Bluffers Park marina as a GPS check. This setup was used to repeat the 1997 zig-zag line on July 13.

On July 14, the receiver was moved to a new site surveyed at East Point (Base 2) and a second check point accessible by boat was established just east of East Point (Check).

GPS shore-receiver coordinates

benchmark EV-2:

UTM NAD27	4841413.0 N 642324.8 E		Elevation 154.867 masl
Geographic NAD83	43.71209 (lat)	79.23334 (long)	

Base 2:

UTM NAD27	4846799.989 648836.612 E		Elevation 82.5187 masl
Geographic NAD83	43.76129 (lat)	79.15083 (long)	

GPS check sites

benchmark BOLLARD:

Located at the centre of the bollard on the east side of the central public boat slip at the Bluffers Park marina.

UTM NAD27	4849583.302 N	642280.952 E	Elevation 75.553 masl

benchmark CHECK:

Located on a pile of concrete or limestone blocks at the shoreline just east of East Point

UTM NAD27	4847117.660 N	649053.433 E	Elevation 75.776 masl

Appendix 2: Survey Logs

July 13: Left CCIW at 1010, met TRCA staff at the Bluffers Park marina at 1115. Launched the Puffin and setup the GPS at the same TRCA office site as last year. Confirmed good boat fixes at the bollard reference site. GPS check at the new East Point site for shore receiver shows easting to be 3 m high. Brisk winds from the west with 1-2 foot waves. Reran the 1997 zigzag line between Highland Creek and the Rouge River, completed at 1610. Survey crew: coxswain, Dave Gilroy; RoxAnn operator, Brian Trapp; TRCA observer, Rick Portiss; and geologist, Norm Rukavina. Completed packing and transport of the Puffin to the TRCA office lot and takedown of the GPS by 1800. Checked in to the Scarborough Comfort Inn. In the evening, produced a reduced shoreline for the Rouge area and extended the offshore reference line past the river mouth.

July 14: Launched the Puffin while the GPS shore receiver was set up at the new site at East Point. TRCA student Ralph left to maintain the site. Gilroy, Trapp and Rukavina as boat crew. GPS checks at the marina bollard and local benchmark both show a 3-m error in easting. Brisk winds from the west, waves building to 2 feet. Started shore-parallel longline survey at the offshore limit of the area at 950 and ran till 1415. Zigzag run to Frenchman's Bay for gas and ran back on the extension of the offshore boundary line. Restarted the longline survey at 1430 and ran 10-m interlines from offshore in. 18 lines completed by 1630. GPS check at East Point reference. Takedown of the Puffin and GPS site completed by 1800. TRCA's Dave Young informed of GPS error. In the evening, checked the RoxAnn longlines and picked uwtv sites.

July 15: Launched the Puffin while GPS shore receiver was set up at East Point with TRCA staff member John as attendant. Gilroy, Trapp, Portiss and Rukavina as crew. Left East Point to continue interlining at 1000. Winds light with low waves and swell from yesterday; sea state improved as the day progressed. Completed interlining at 1610. Stopped to rig the uwtv system and then quickly checked 7 sites. Good visibility and good correspondence with RoxAnn. TV survey complete at 1730. Competed takedown of equipment by 1845 and left for CCIW. Arrived CCIW at 2000.

Appendix 3: Underwater-television Observations

Sta. #	UTM NAD27 Northing	Easting	Water depth (m)	Penetration (cm)	Description
3	4848975	651012	6.5	0-5	Sandy bottom with small patches of loose algae and ripples with 10-20 cm spacing.
4	4849377	650966	3.5		Transition zone from sand to algae-covered cobbles and small boulders with interstitial sand. Algae 5 cm thick.
5	4849332	651003	4.4	5	Sand with ripples with 10-cm spacing. Very uniform bottom. Small patches of loose algae on the sand surface.
8-1	4850354	651645	4.2		Large pebbles with overgrowth of 5-cm thick algae. Some areas of silt and sand.
8-2	4850352	651672	4.1		Flat sandy bottom without ripples. Small patches of algae on the sand surface.
11	4850592	651991	3.3		Boulder and cobble area covered with 10-20 cm of algae.
14	4849902	651593	6.5		Cobbles with algal overgrowth on a firm sandy bottom. Algae are 20 cm thick.
16-1	4849039	650930	5		Uniform bottom of cobbles with cover of 5-cm thick algae.
16-2	4849025	650947	4.8		Firm muddy sand with ripples spaced 40-50 cm. Areas of loose algae.

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