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SUMMARY OF PHYSICAL PROPERTIES OF ST. LAWRENCE RIVER SEDIMENTS AT CORNWALL, ONTARIO

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NWRI Contribution No. 97-212

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Executive Summary

This report is a compilation of new and older data on the physical properties of contaminated St. Lawrence River sediments at Cornwall collected over the past 5 years. It was prepared to assist remediation planning by the local RAP and site selection for a coring survey in October 1997. It includes a discussion of the data and the GIS procedures used to analyze it, a series of maps and reports on sediment type, thickness and volume, and some recommendations for new sample sites.

1. Introduction

Physical data on the bottom sediments of the St. Lawrence River at Cornwall have been collected since 1993 in support of a RAP project on remediation of contaminated sediments (Rukavina 1993, 1994a, 1994b, 1996). The previous focus was on the reach of the river extending from Windmill Point to Pilon Island opposite the former Courtauld's plant (Rukavina 1996). In 1997, the sediment surveys were extended to provide coverage for the entire reach of the north channel from the Boat Launch site on the west to Finigans Point on the east (Figure 1). Part of the purpose of the more extensive coverage was to provide the data needed for selection of sites for a final coring survey to be conducted in October 1997. This report discusses the results of GIS analysis of the data on acoustic classification, grain-size types, and sediment-thickness, and presents the maps and reports on the distribution and statistics of sediment type and thickness required for site selection.

2.0 Data Types

2.1 Acoustic bottom classification:

Acoustic mapping of bottom-sediment types was done with a RoxAnn™ seabed classification system (Rukavina and Caddell 1997). This uses echo-sounder data on acoustic hardness and roughness to classify the bottom as one of 8 types: mud, muddy sand, sand, coarse sand, gravel, boulders/hard, weeds on soft, weeds on hard. The system is run in a survey mode at boat speeds of 2-3 m/s and collects data at 1-second intervals. That permits a continuity of coverage that is not possible with any other procedure. The combined RoxAnn™ data collected since 1993 produced a map file with more than 100,000 points (Figure 2).

Because the interest in this case is in fine-grained sediments which have the closest association with contaminants, the number of bottom classes used in mapping was reduced to three: mud, muddy sand, and other. The acoustic map of bottom types was generated in an Arc Info GIS with a voronoi-polygon procedure. This is a procedure used for discrete data like sediment labels which cannot be contoured. It assigns an polygon to each sample point defined by half the distance to adjacent points. The polygon is then assigned a colour to represent the bottom type. Finally adjacent polygons of the same type are merged to produce areas showing the overall sediment pattern. Figure 3 is the result.

The fine-grained sediments shown in Figure 3 are concentrated in the part of the reach east of Windmill Point. The largest deposits occur in the inshore areas of the north and south shores between Windmill Point and Pilon Island. The northern deposit is known from earlier surveys but the deposit off the northeast corner of Pilon Island was not mapped until earlier this year. Smaller areas of mud and muddy sand are present inshore of Pilon Island and as a discontinuous ribbon extending from the south shore of the island eastward to Flanigans Point. In the western half of the reach, there are small patches of finer sediment on the south shore opposite Windmill Point and at the Tank Farm and Boat Launch sites on the north shore.

The areal extent of the study area and of the fine-grained sediments was computed by GIS analysis (Table 1). Total area is 5.6 km^2 and the areas of mud and muddy sand are 0.3 km^2 (5%) and 0.6 km^2 (10%) respectively.

The accuracy of RoxAnn™'s bottom labels depends upon a number of factors including sediment composition and gas content which have been discussed in Rukavina and Caddell (1997). In this case a measure of accuracy was possible because of the large number of sediment samples and cores available as control data. Samples were analysed for particle size and grouped into 3 classes: >67% sand (sand), 33-67% sand (muddy sand), <33% sand (mud). RoxAnn™ labels were mud, muddy sand, sand, coarse sand, gravel, boulders/hard, weeds on soft and weeds on hard. A spreadsheet macro was used to search for RoxAnn™ fixes within 5 m of the sample location. If the RoxAnn™ label fell within the same size class as the sample the rating was good, if one size class removed fair, and otherwise poor. Where no size data were available, the sample description was used to decide on fit. For the 107 sites for which comparison was possible, classification was good for 57%, fair for 33% and poor for 10%. This is good agreement considering that it is based on comparison of samples and television data which have a small footprint relative to that of the sounder.

2.2 Grain-size data:

Since 1993, samples and cores have been collected at more than 300 sites and analysed for grain size. For mapping purposes the size data have been reduced to 5 classes: mud (>67% finer than 4 microns), muddy sand (33-67% mud), sand (<33% mud), a "hard" class for the gravel and boulder samples for which size analysis was not possible, and a weed class where weed cover prevented recovery of samples. Size data for samples collected in July 1997 are not yet available so one of the above classes was assigned on the basis of the sample descriptions.

Figure 4 is a grain-size map produced by the same GIS polygon procedure described above. Continuous mapping was done only for the Windmill Point to Pilon Island and Tank Farm areas because sample density elsewhere was too small to warrant it. The remaining samples were represented by coloured squares. The distribution of fine-grained sediments is similar to that of the RoxAnn™ acoustic map which is not surprising given the reasonably good correspondence of acoustic and sample data discussed above.

Figure 5 is a larger map of the deposit west of Pilon in which the locations of grab samples and cores collected by OMEE in a 1994 survey are superposed to show the distribution of samples over the area of finer sediments.

The area of the deposit determined by GIS analysis is 0.8 km^2 and the proportions of the size types are 31% muddy sand, 23% hard, 23% sand, 14% mud, 1% weeds and 8% undefined (Table 2).

2.3 Sediment Thickness and Volume

Since 1993, data on sediment thickness have been collected from more than 750 sites by coring, diver probing and underwater-television measurements with a calibrated probe or frame. Figure 6 is a GIS map of thickness data for 5 classes ranging from less than 10 cm to greater than 70 cm. The majority of data fall within the Windmill Point to Pilon deposit and this is the only area where data density is high enough to permit GIS polygon mapping. Figure 7 is a larger map of the area with the 1994 OMEE samples and cores superposed. GIS statistics for the area are shown in Table 3. Forty-four percent of deposit has a thickness less than 10 cm, about the same percentage falls within the 10-30 and 30-50 cm classes combined, and less than 10 percent is thicker than 50 cm. The total volume of the deposit is about 180,000 cubic metres.

By superimposing the thickness polygons on the grain-size polygons, it is possible to compute the proportion of the sediment volume falling into each size class (Table 4). Muddy sand accounts for 45% of the volume, mud and sand for about 20% each, hard bottom and weeds combined for less than 10%, and 4% is undefined.

A crude estimate of mud and muddy-sand volumes for the entire reach can be computed by using the RoxAnn™ areas from Table 1 and by assuming that the average thicknesses of mud (33 cm) and muddy sand (31 cm) for the Windmill Point to

Pilon area are representative of the reach as a whole. This yields a total mud volume of about 100 thousand cubic metres and a muddy-sand volume of about 176,000 cubic metres.

2.4 Exotics:

Many of the sediment samples contained material which would not be reflected in the grain-size classification: exotics like shells, wood fragments, oil and grease, fibrous material and weed fragments. They were considered to be important because of their possible relationship to contaminants and because they could have some influence on the acoustic classification. The distribution of exotics is shown on individual maps in Figures 8-12. The "o" symbols indicate the sites where the exotic material was observed and the "+" symbols the sites where it was not present.

3. Recommended Coring Sites

Previous coring in 1994 was restricted to the major deposit between Windmill Point and Pilon Island and core density there appears to be adequate to properly represent the deposit. It could be improved with a small number of cores in the areas of thicker sediments which were not sampled previously.

Only the top and bottom 10-cm segments of the 1994 cores were subsampled for physical and chemical analysis; the central part of the core was archived for possible future analysis. Consequently the information on changes in physical and chemical properties with depth is limited to average values for the surficial and basal sediment. Better definition of vertical changes with subsamples at 1 or 2-cm intervals would be useful for determining the stability of the deposit, its contaminant history, and the potential for recovery by natural sedimentation. This could be done with about a dozen new cores at representative sites.

The large deposit on the south shore just northeast of Cornwall Island has apparently been sampled previously with one or two cores but the core locations are too poorly defined to be of use. Shipek samples at the sites shown in Figure 4 were collected in July 1997 and subsamples of 3 have been submitted for chemical analysis. More detailed information about this deposit is desirable whether or not it is contaminated. If it is contaminated, data on contaminant levels and distribution and on sediment volume will be needed to characterize it. If not, it will be useful as an uncontaminated reference site for comparison with the contaminated deposit on the north shore. Fifteen to 25 cores should be adequate to map the deposit.

The smaller deposits in the balance of the area generally do not have the thickness data available to determine whether coring is warranted. New thickness data collected with the underwater-television probe during the October 1997 survey could be used to locate potential coring sites in the areas north and south of Pilon Island and in the ribbon of finer sediment extending from Pilon Island to Flanigans Point.

4. Acknowledgements

H. Biberhofer of Environment Canada, Ontario Region, requested the report and outlined the specifications required. NWRI's Technical Operations Section provided the launch and staff support for field surveys with RoxAnn™, and the Canadian Hydrographic Service, Central Region, supplied and maintained the positioning system. The RoxAnn™ operator was B. Trapp of NWRI's New Technology Research Branch, T. Egan of Nordsea Ltd. was contracted as the RoxAnn™ consultant, J. Ford of NWRI Engineering advised on acoustic issues. M. Dunnett and D. Gilroy, NWRI contractors, were responsible for reduction of much of the RoxAnn™ data, and D. Gilroy also assisted in the field surveys. L. Richman of OMEE, Toronto, provided the data on OMEE cores. L. Kohler of the NWRI GIS Centre was responsible for the Arc Info GIS analysis. The development of RoxAnn™ as a sediment mapping tool is being funded by Environment Canada's Great Lakes 2000 Cleanup Fund.

5. References Cited

Rukavina, N A. 1993. St. Lawrence River bottom-sediment distribution at the Tank Farm site, Cornwall, Ontario. NWRI Lakes Research Branch Technical Note.

Rukavina, N.A. 1994a. Volume and properties of St. Lawrence river bed sediments at the proposed Courtaulds' dredging site, Cornwall, Ontario. NWRI New Technologies Research Branch Contribution 94-154.

Rukavina, N.A. 1994b. GIS analysis of properties of St. Lawrence river bed sediments at the proposed Courtaulds' dredging site, Cornwall, Ontario. NWRI New Technologies Research Branch Contribution 94-155.

Rukavina, N.A. 1996. Site selection and GIS analysis of contaminated-sediment distribution and volume for the proposed Courtaulds' dredge site, Cornwall, Ontario. NWRI Contribution No. 96-204.

Rukavina, N.A. and Caddell, S.E. 1997. Applications of an acoustic sea-bed classification system to freshwater environmental research and remediation in Canada. In Proceedings, 4th Conference on Remote Sensing for Marine and Coastal Environments, Orlando, Fla., March 1997.

Tables

Figures

Table 1. GIS areas and volumes for acoustic types

Acoustic Type	Area, sq m	Area, sq km	Percent	Avg Thickness, m	Volume, cu m
Mud	298656	0.299	6.8	0.33	99408
Muddy Sand	751876	0.752	17.1	0.31	236423
Other	3357476	3.357	76.2		
Total	4408007	4.408	100		

Table 2. Areal distribution of grain-size types, Windmill Point to Pilon Island

Type	Area, sq m	Area, sq km	Percent
Muddy Sand	257509	0.2575	31.2
Hard	193052	0.1931	23.4
Sand	186237	0.1862	22.5
Mud	117045	0.1170	14.2
Undefined	63552	0.0636	7.7
Weeds	9211	0.0092	1.1
Total	826606	0.8266	100.0

Table 3. Areal distribution of sediment thickness, Windmill Point to Pilon Island

Thickness, cm	Area, sq m	Area, sq km	Percent
0-10	369834	0.370	43.7
10-30	222486	0.222	26.3
30-50	174093	0.174	20.6
50-70	60519	0.061	7.2
>70	19243	0.019	2.3
Total	846175	0.846	100.0

Table 4. Grain-size volumes, Windmill Point to Pilon Island

Type	Area, sq m	Avg thickness, m	Volume, cu m	Percent
Muddy Sand	257509	0.31	80902	44.5
Mud	117045	0.33	38958	21.4
Sand	186237	0.19	35609	19.6
Hard	193052	0.08	15781	8.7
Undefined	63552	0.12	7642	4.2
Weeds	9211	0.31	2896	1.6
Total	826606	0.22	181790	100.0

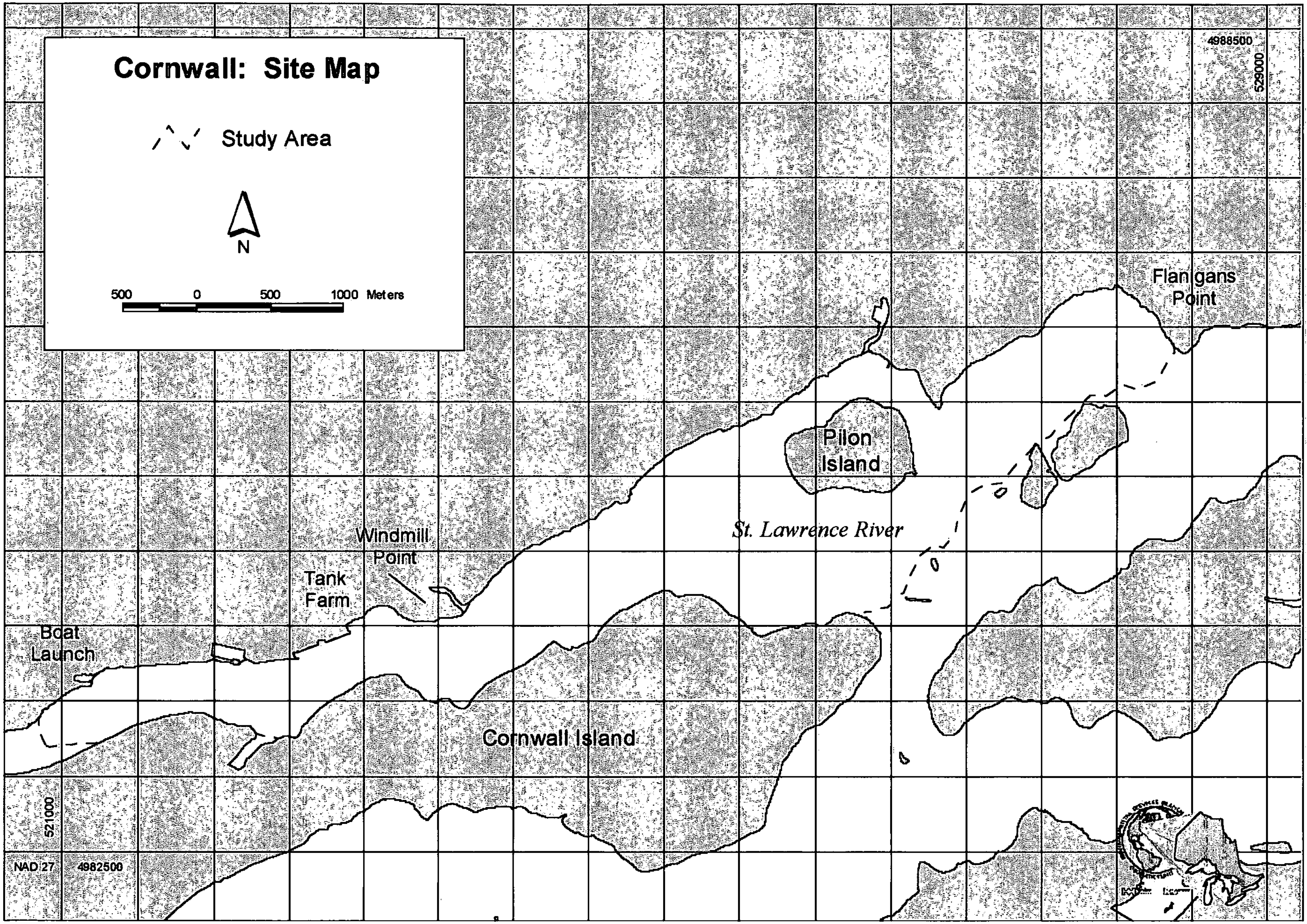

Figure 1: Cornwall: Site Map

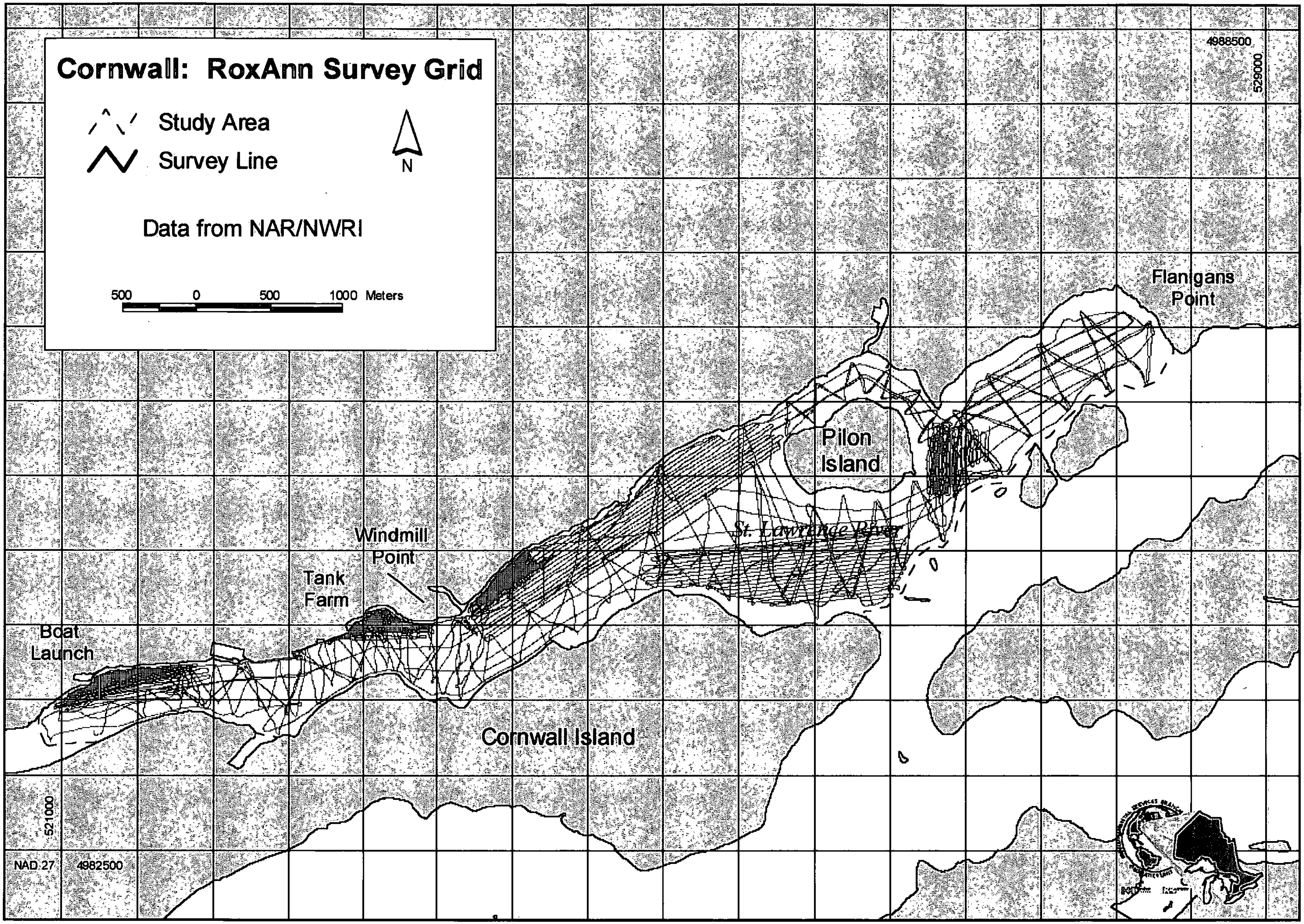

Figure 2: Cornwall: RoxAnn Survey Grid

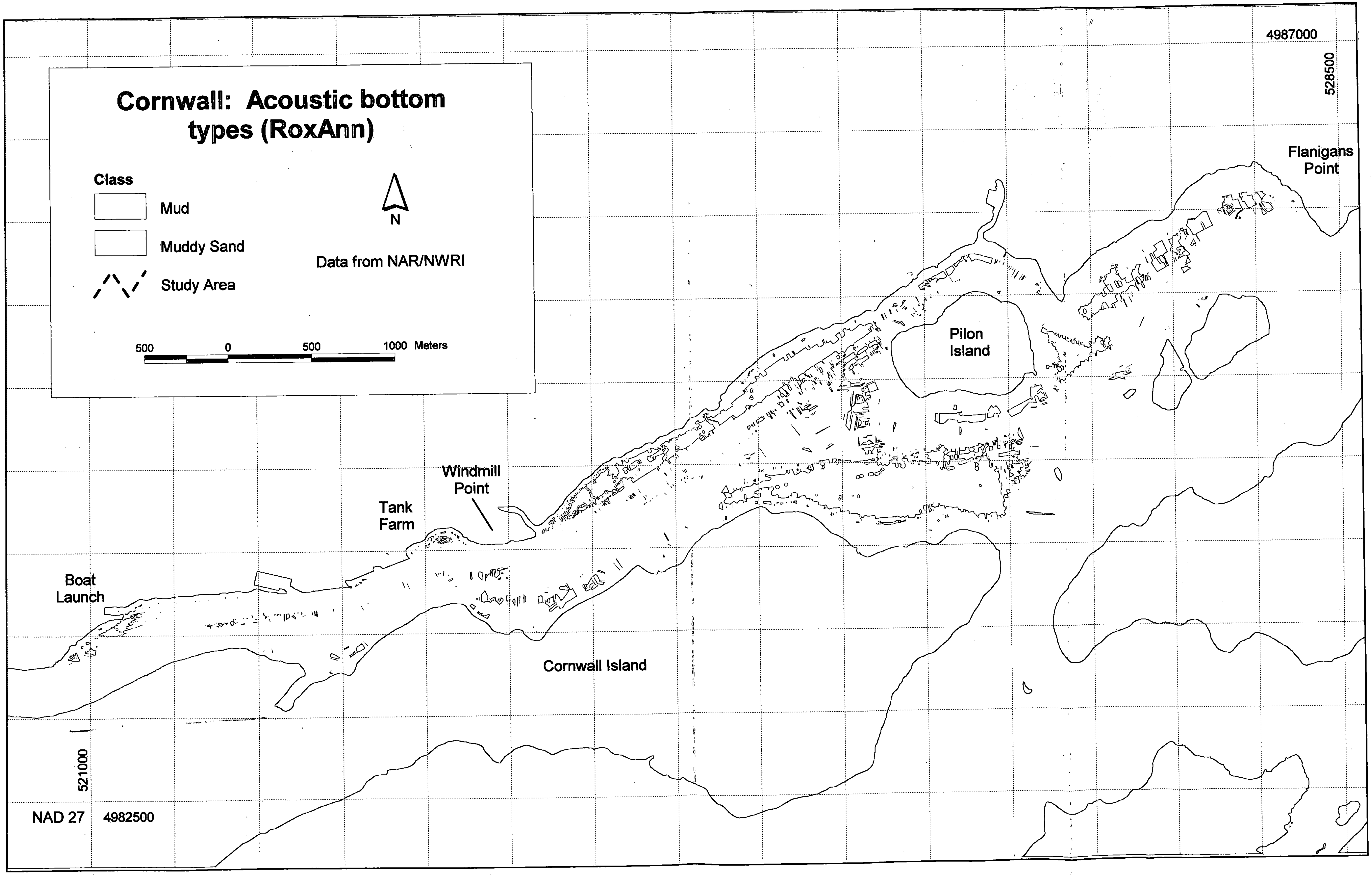

Figure 3: Cornwall: Acoustic bottom types (RoxAnn)

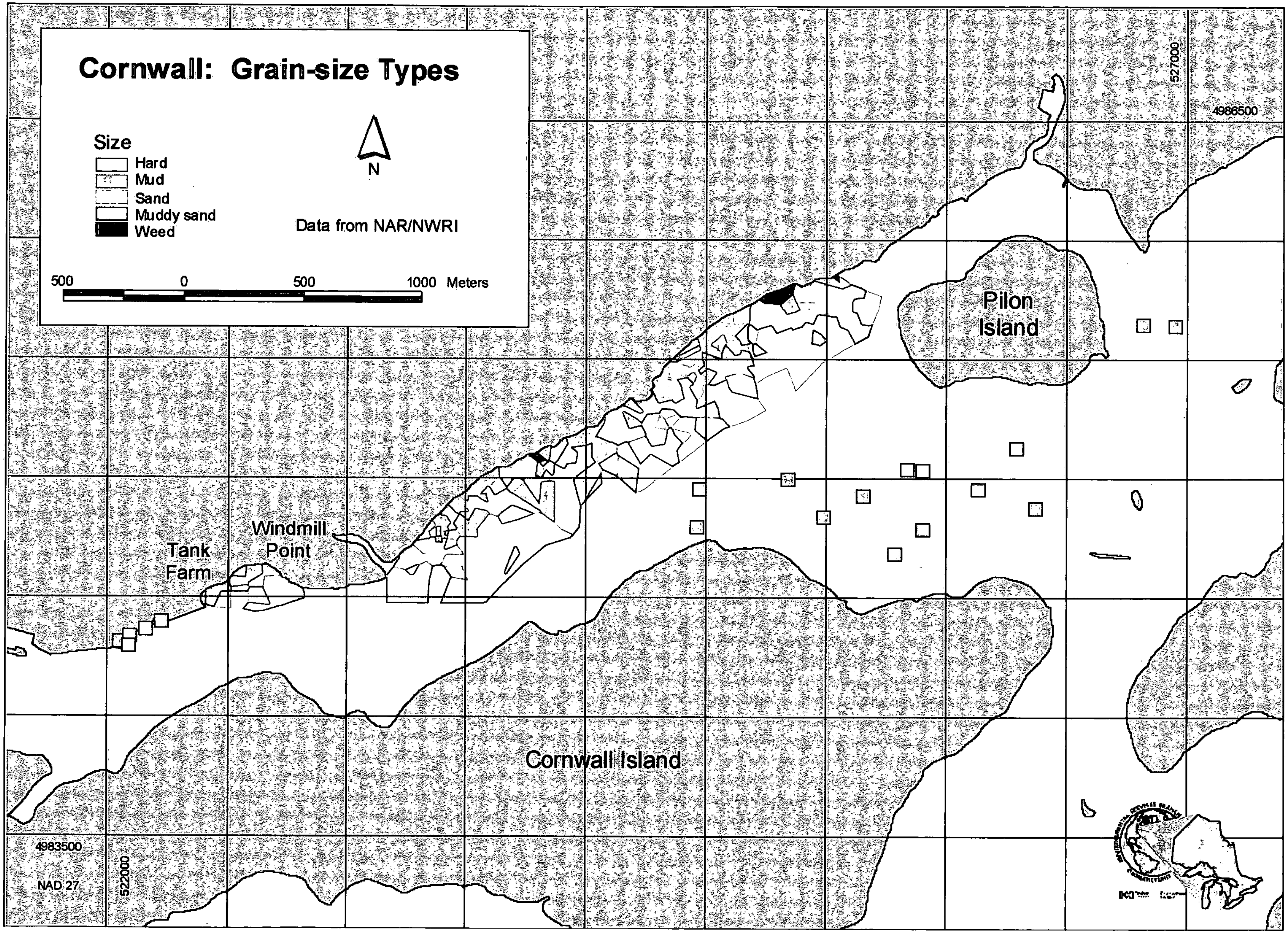

Figure 4: Cornwall: Grain-size Types

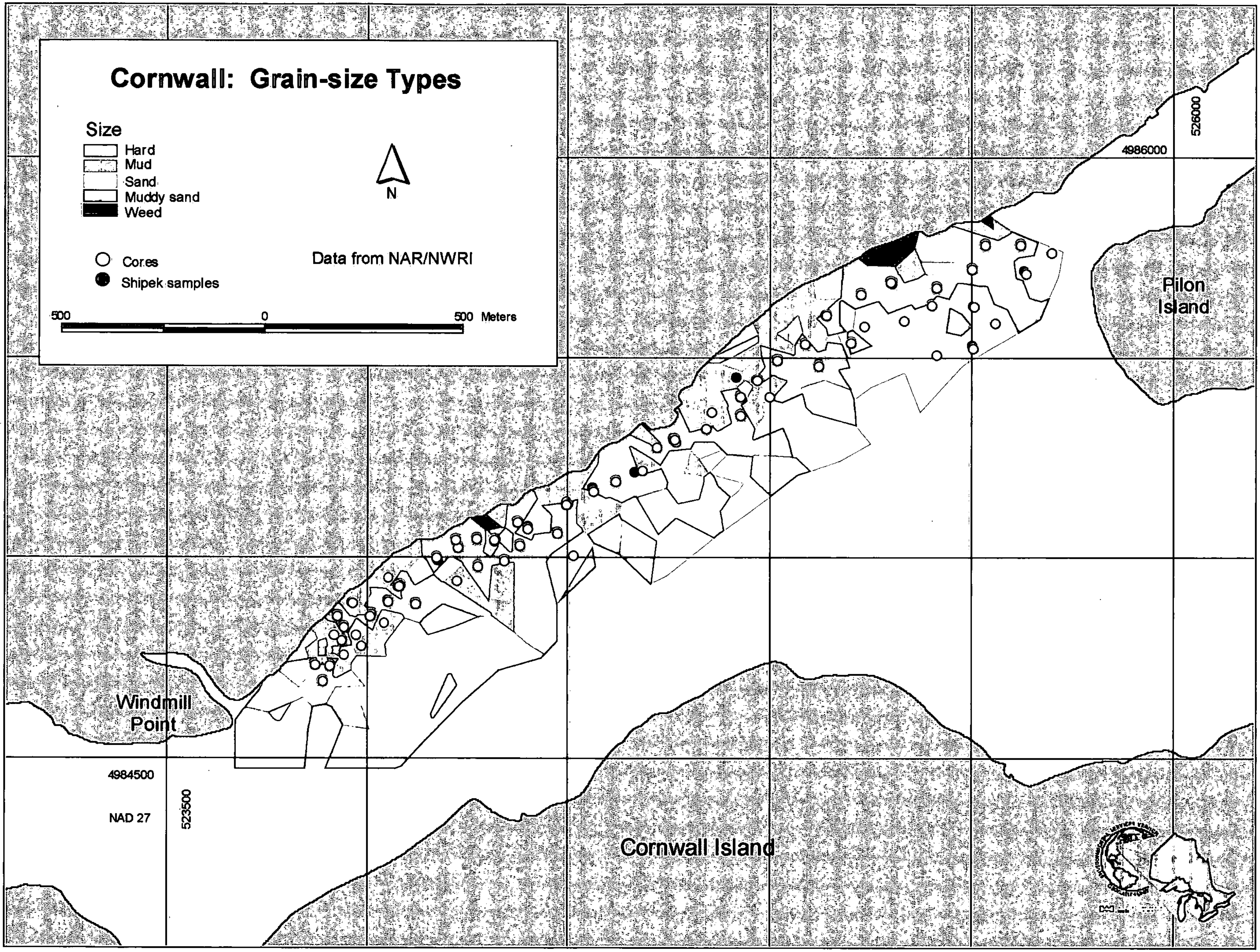

Figure 5: Cornwall: Grain-size Types, Windmill Point - Pilon Island

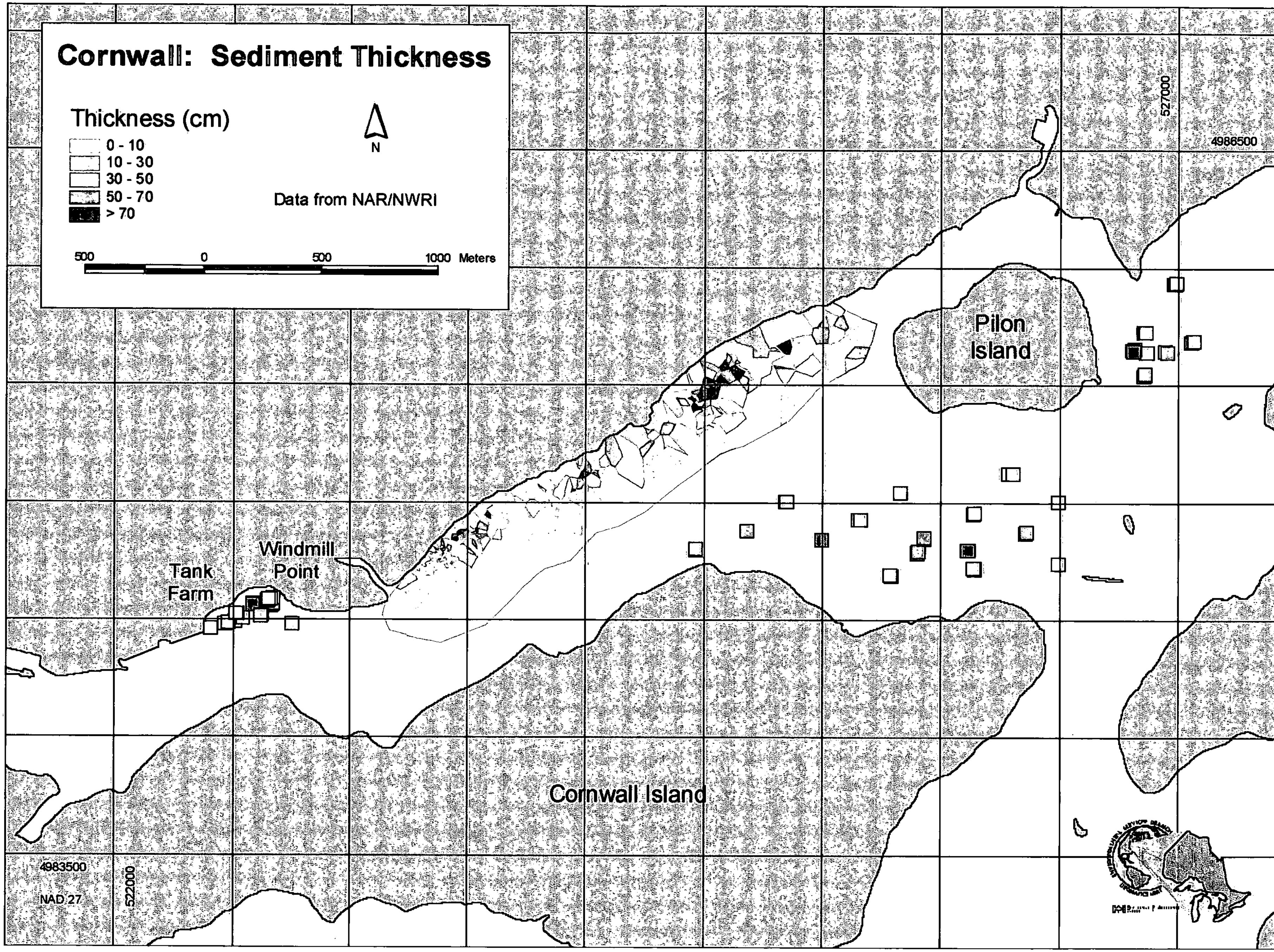

Figure 6: Cornwall: Sediment Thickness

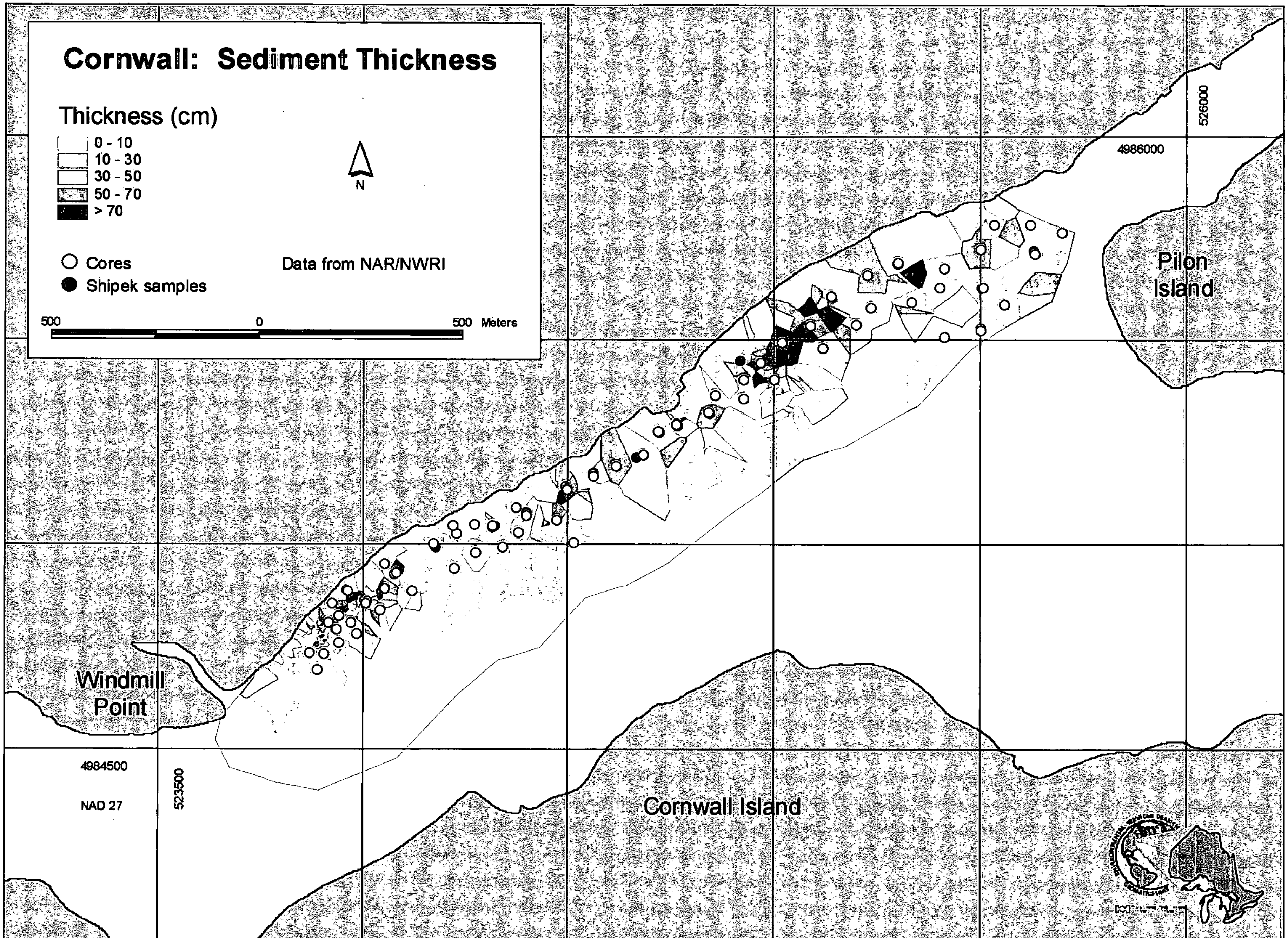

Figure 7: Cornwall: Sediment Thickness, Windmill Point - Pilon Island

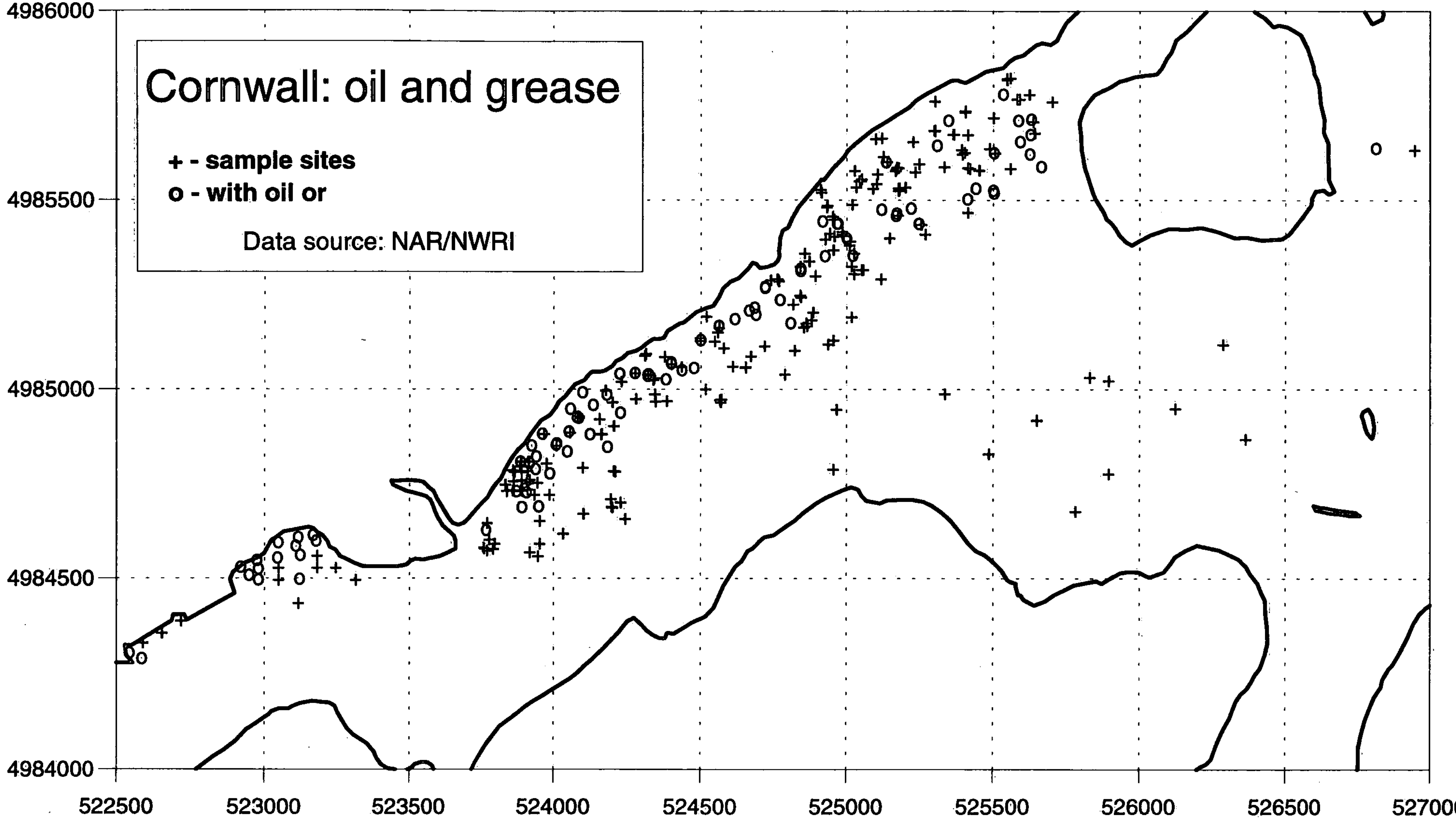

Figure 8: Cornwall Oil and Grease

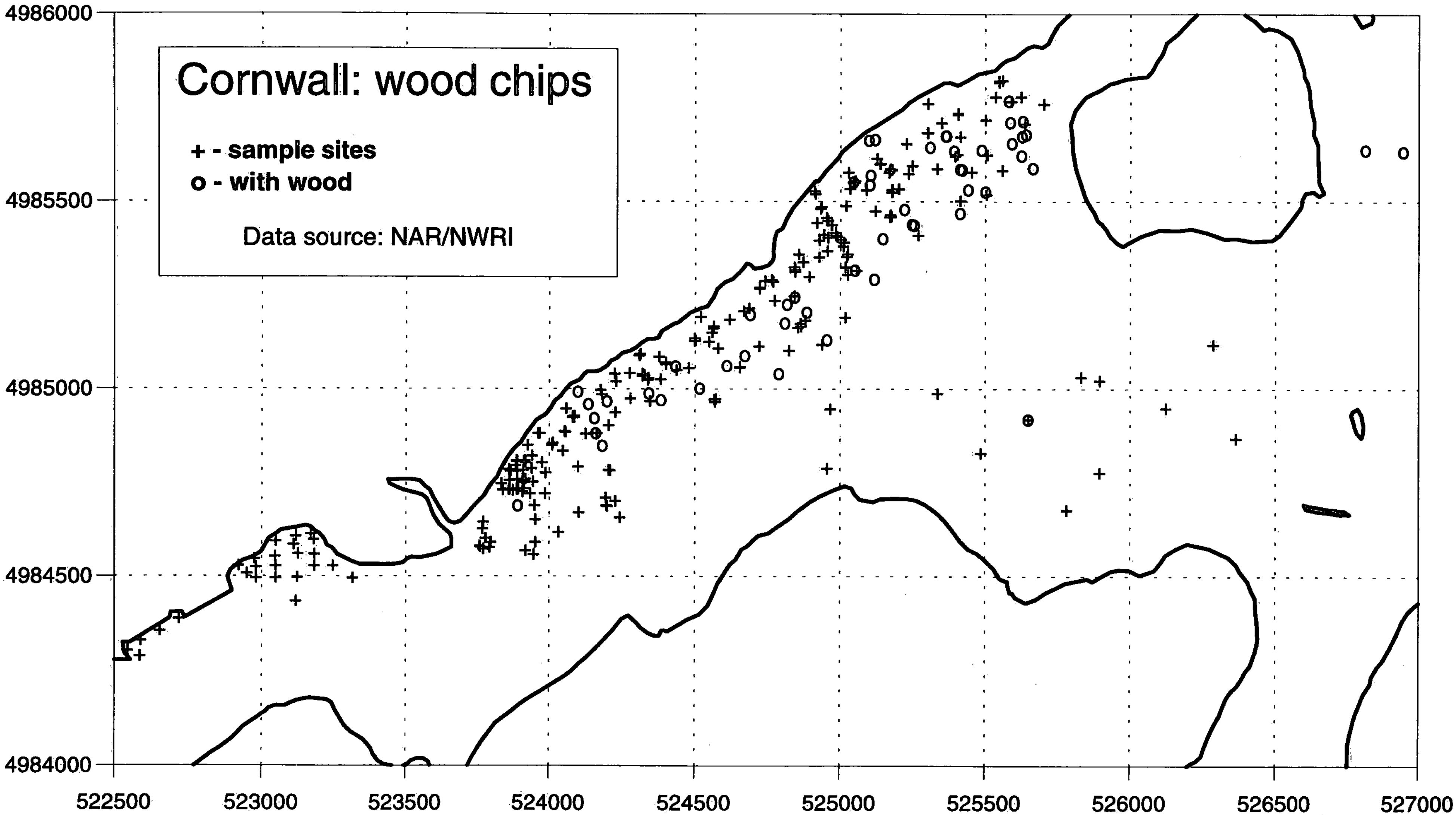

Figure 9: Cornwall Wood Chips

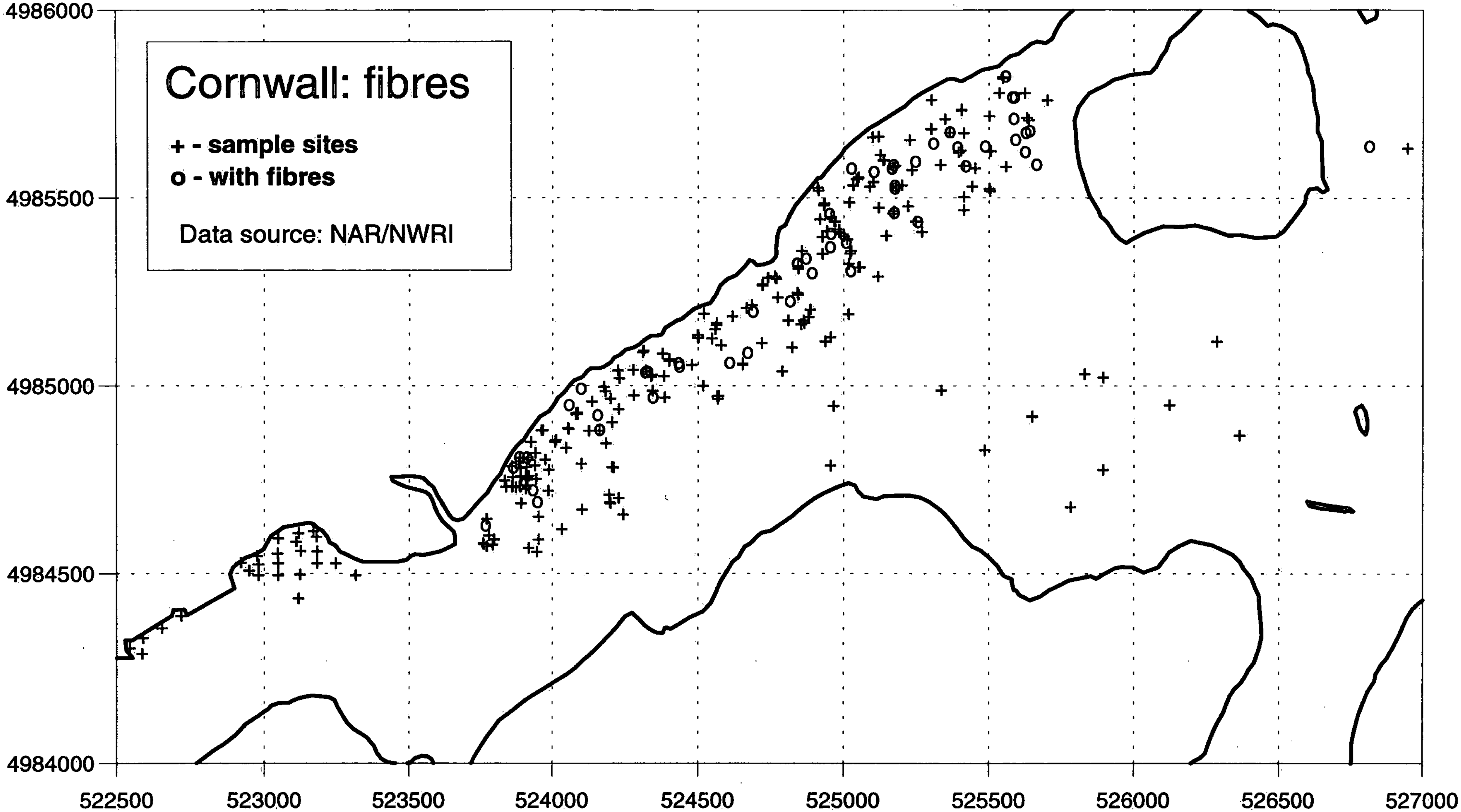

Figure 10: Cornwall Fibres

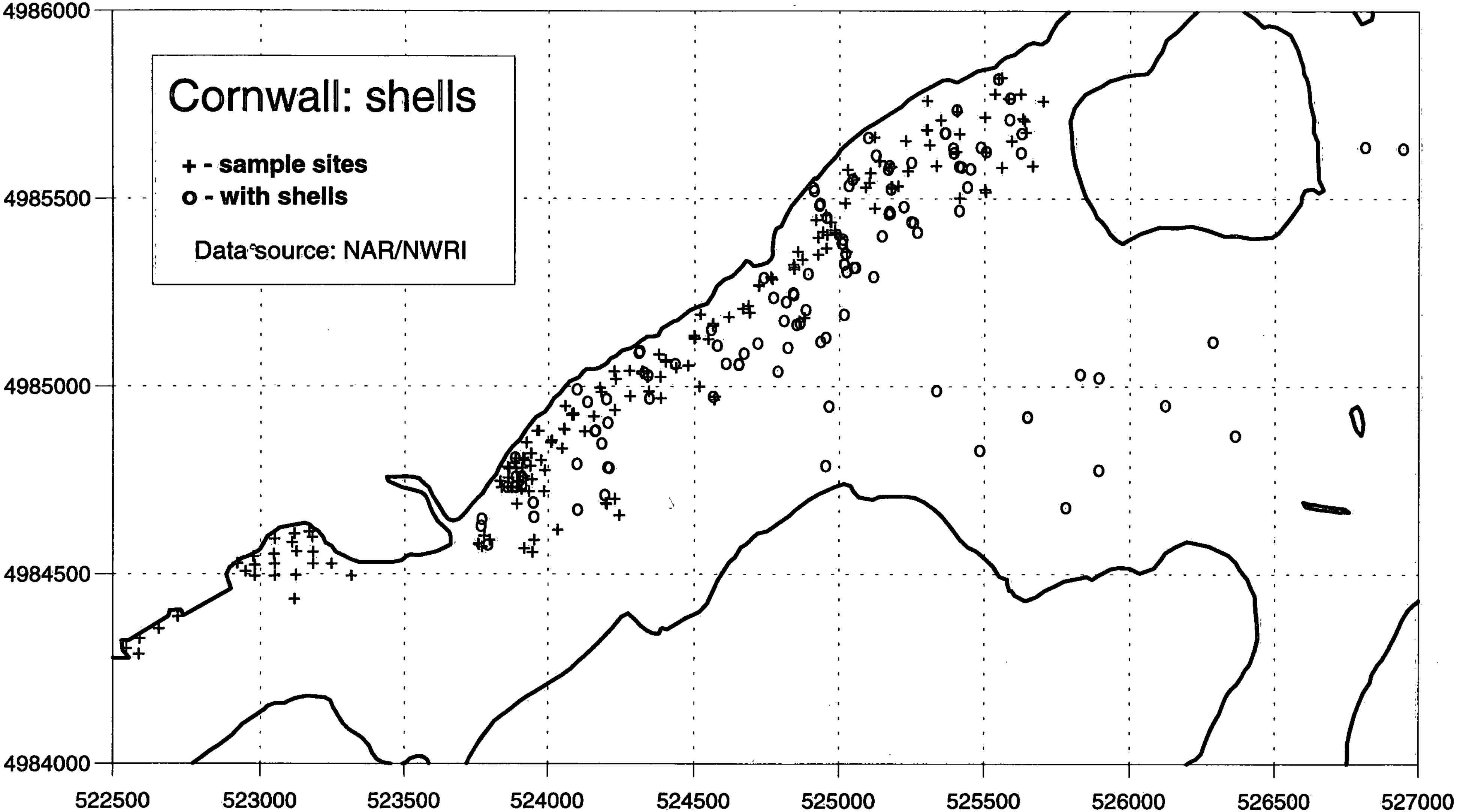

Figure 11: Cornwall Shells

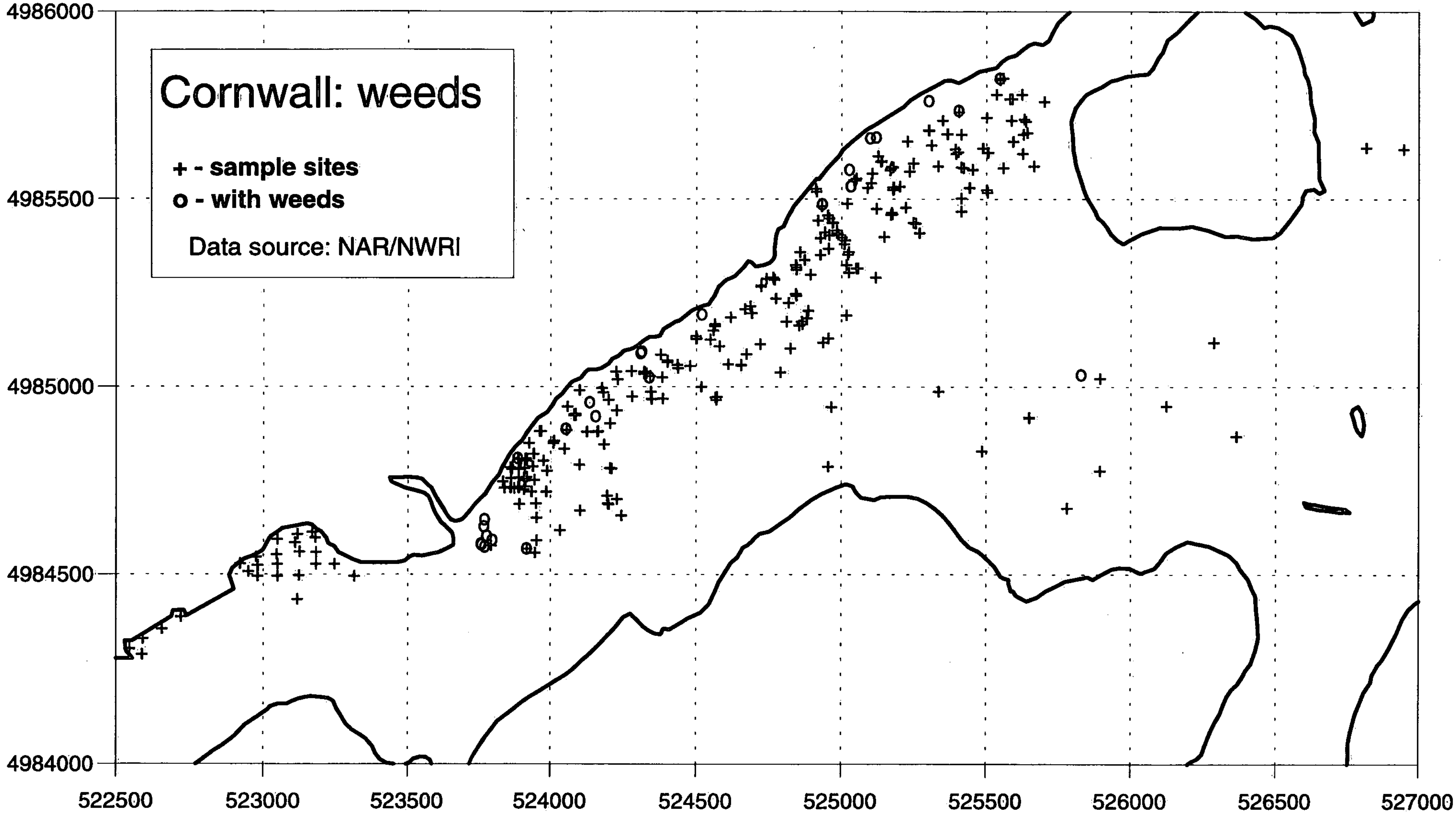

Figure 12: Cornwall Weeds

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