



Hydraulics Research
Wallingford

SLUDGE DISPOSAL IN LIVERPOOL BAY

**Vertical profiles of heavy metals and
organic carbon in bed sediments
April 1986**

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**Report No. SR 108
January 1987**

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This report describes work funded by the Department of the Environment under Research Contract PECD7/7/051. The project was managed by Mr M F C Thorn with technical direction from Messrs M J Crickmore and P R Kiff of the Technical Services Department of Hydraulics Research Ltd, Wallingford. The report is published on behalf of the Department of the Environment.

ABSTRACT

Data obtained from sediment cores, taken to investigate the depth of organic and heavy metal enrichment in the mud fraction of the surface sediments in Liverpool Bay, are described. The depth reached by man-made metal contaminants, variously arising out of the marine disposal of large quantities of sewage sludge and dredging spoil as well as the flow from the Mersey, differs markedly over the survey area. In the west, in the vicinity of the sludge disposal ground "natural background" metal concentrations are reached within 0.3m of the surface. By contrast, in the east to either side of the Mersey outflow, obvious contamination by heavy metals is found to at least 1.2m. The depth profiles complement annual surveys of the horizontal distributions of metals and organics in the top 25mm bed layer. They will also be used to support a numerical model designed by Hydraulics Research to simulate the movement and deposition of sewage sludge particulates.

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1 INTRODUCTION

Since 1973 Hydraulics Research (HR) has recovered bed sediment samples from Liverpool Bay, generally every year, for the long-term monitoring of the effects of discharging sewage sludge on the Bay. The main objective of this sediment surveillance is to detect whether any trends are taking place in the concentration of organic carbon and heavy metals in the surface 25mm of the bed. The surface layer is obtained either by grab sampling or from short cores, less than 0.3m long. From time to time the sampling and analysis have been expanded to allow the vertical distribution of organic carbon and heavy metals in the bed to be investigated. This has necessitated the recovery of cores of greater length than obtained on the regular sampling cruises. The field handling of the heavier equipment is somewhat more demanding and consequently fewer stations are occupied than on a normal bed sampling survey.

Three "long core" surveys have been undertaken: one in March 1985 was carried out in conjunction with the 12th bed monitoring survey (Ref. 1), while the other two in February 1983 (Ref. 2) and April 1986, were mounted specifically for the purpose of obtaining vertical profiles. In total 45 cores, distributed over 31 different sites, have been obtained (Fig. 1). The first survey in 1983 was confined to the eastern sector of the Bay area customarily monitored by HR, whereas the two later coring exercises although recovering fewer cores were more widespread and included stations within the sludge disposal ground. A further distinction between the three coring trips has been the desire to obtain progressively deeper cores in order to reach basal "unpolluted" strata. Thus the latest exercise whose results are reported here has employed a 2-metre long, 50mm diameter HR vibro-corer instead of the smaller 1-metre version used previously.

The objective of the coring is not to detect temporal trends but to yield information on how deep man-made contaminants penetrate the bed layers and to indicate how the depth varies for different parts of the Bay. The heavy metal profiles disclose a contaminated zone, beneath which heavy metals may still be present in the sediments but at significantly lower concentration. The concentrations in the basal layer are assumed to represent typical background levels of metals in

fine-grained sediments derived from the source rocks responsible for the unconsolidated deposits of Liverpool Bay. The depth of enrichment in the more superficial layers due to anthropogenic inputs can obviously be in response to the present day turn-over of sediment by current and wave action combined with re-working of bed sediment by benthic organisms. However, in areas subject to net deposition the depth to which contamination is found can also reflect past inputs of metal-rich sediment, subsequently incorporated in the accreting strata, and not necessarily disturbed thereafter. It is also possible that some penetration is achieved below the physically disturbed level by the inter-particle transfer of metals by desorption and re-adsorption. Notwithstanding the difficulty of deciding on the relative significance of the various processes that can govern the depth of metal enrichment from place to place, basic data on depth profiles provide valuable guidance for the numerical modelling of the movement and dispersion of sediment-bound heavy metals (Ref. 3).

2 CORE RECOVERY

The vessel "Branding" under charter from the Carnet Tug Company, Birkenhead was employed for the recovery of cores from 14 stations on 3 April 1986. Stations, where past records indicated that a reasonable proportion of mud ($< 63\mu\text{m}$) could be expected, were selected for coring because adsorbed heavy metals are typically associated with the finer sediment grades. Interest centred on three areas: the very muddy zone to the north of Newcome Knoll, a former spoil ground for dredgings but taken out of use in 1960; north of the Mersey outflow off Jordans Spit and currently used for the disposal of dredging spoil; and lastly, the dumping ground for sewage sludge and along the line of its suspected migration towards the Mersey. Attempts to sample a further station K10 failed, the bed seemingly too coarse or too firm to allow the corer to penetrate. Duplicate cores were obtained at selected stations and passed to MAFF Burnham staff who were also present on the cruise.

The length of cores extracted varied up to a maximum of 1.3m, which compares with a maximum of 0.9m on the previous coring campaigns. Penetration of the 2-m corer in some cases was arrested by shell or pebble layers in the west of the area and by hard compacted mud in the east. It seems likely that the compacted mud layer corresponds to the level that has not been disturbed in the long term and it is hoped that MAFF Burnham will succeed in their aim to date the basal strata of the duplicate cores.

The 50mm diameter cores were not extracted from their PVC liners on-board but instead were stored vertically for transport back to the laboratory at Wallingford.

3 **LABORATORY TREATMENT AND ANALYSIS**

On return the cores were extruded from their liners using compressed air. In some cases, the cores and liners were cut horizontally before extrusion where a full core proved impossible to move with the pressure of compressed air available. The cores were then divided into strata following previous practice i.e. top 25mm, the next 75mm and at 100mm intervals thereafter unless obvious layering existed when divisions were made at the discontinuities.

HR's standard approach of determining the heavy metals and organic carbon in only the mud fraction ($< 63 \mu\text{m}$) of the strata was again adopted. The mud was first separated by washing each sample through a stainless steel sieve with tap water, dried at 50°C and crushed. Heavy metal and organic carbon determinations were normally made on subsamples but where the quantity of mud was insufficient for both, the organic carbon analysis was omitted.

Analytical procedures were the same as employed on previous HR work in Liverpool Bay sediments. With the exception of mercury, heavy metals were determined by atomic absorption spectrophotometry after dissolution in nitric/perchloric acid, evaporation to dryness and redissolving in hydrochloric acid. Mercury was measured separately by the cold-vapour atomic absorption method. All heavy metal analyses were carried out by a commercial analytical laboratory and concentrations have been adjusted in accordance with a number of standards that were incorporated with the same batches. The metal extraction procedure is a vigorous one and results in values that correspond to essentially the total metal content of the mud fraction.

Organic matter was determined by wet oxidation of the carbonate-free dried mud fraction with the gravimetric estimation of the evolved carbon dioxide. Again as on previous surveys the organic carbon is reported as organic matter by the simple expedient of multiplying by a factor of 2.5 to convert carbon to the equivalent of dried organic residues.

4 RESULTS

The analytical results for each individual core stratum are listed in Table 1 and shown graphically as vertical profiles in Fig 2. Both the organic matter percentages and heavy metal concentrations relate to the mud fraction only ($< 63 \mu\text{m}$) and not to their abundance in the total sediment.

4.1 Mud distribution

In common with previous surveys the stations in the vicinity and to the north of Newcome Knoll (ie U9, YY3, YY4) feature the most muddy beds with mud contents over the top 0.5m often in excess of 50 per cent. The four cores representing this area showed a tendency for mud content to decrease at increasing depths below 0.5m. Elsewhere, with the exception of the consistently muddy core from T12 just north of the Mersey outflow, only occasional strata exceeded 25 per cent mud content. Over the eastern area the cores often exhibit detailed layering, sometimes with alternate mud and fine sand layers of millimetre thickness. In these cases the tabulated and plotted average values for the 100mm strata mask the true vertical micro-structure of the bed.

4.2 Organic matter in the mud fraction

Surface concentrations of organic matter are consistent with those given by the regular monitoring surveys, ranging generally between 4 and 8 per cent. The muddy core from T12 is unusual, being surprisingly low in organic matter with 2 per cent or less persisting throughout its length. West of the "T" line the organic content decreases with depth in the bed, presumably in response to the slow decomposition of old organic matter at levels that are too rarely disturbed to allow organic renewal. In contrast, the more uniform depth distributions exemplified by T14, U9, YY4 are indicative of the mixing of the surface sediments by wave and tidal processes experienced by the shallower stations farther east.

4.3 Heavy metals in the mud fraction

Most of the metals found in the mud fraction are adsorbed on the surface of clay particles but some may be present as natural mineral grains (Ref 4). It is also possible that some of the adsorbed metals do not originate from pollutant sources but

instead enter the system as desorbed metals from minerals naturally occurring in river or sea-bed sediments, in and around Liverpool Bay. Judgements on what proportion of the measured heavy metals is man-made and what is naturally derived from geological sources, are best guided by the concentrations found in the lower strata of cores taken in the west of the working area. The basement material is thought to be little disturbed by the flow and the heavy metals present there owe little to man-made additions. Identification of the upper boundary of the basement is somewhat subjective but some cores display an abrupt decrease in the concentrations of several heavy metals at a particular level. It seems likely that the concentration existing below this level are representative of background metal concentrations.

Confining our attention to the basal strata of nine cores that feature a simultaneous abrupt decrease of several metals with depth the mean "natural background" concentrations have been derived from 34 strata and compared below with similar values obtained from 35 strata taken on the 1983 coring exercise (Ref 2). A few freak high values of certain metals have been excluded eg. copper and chromium data for three strata of L10, copper for one strata of U9, and lead for one strata of M10.

	Concentration μ g/g					
	Mercury	Copper	Zinc	Lead	Nickel	Chromium
1986	0.04 (0.03)	24(10)	78(11)	27(16)	43(6)	47(14)
1983	0.09 (0.05)	19(8)	98(30)	51(33)	36(6)	25(6)

(figures in brackets = standard deviation)

Bearing in mind the greater areal coverage and longer cores of the 1986 survey the agreement between the two surveys seems reasonable. Copper concentrations in the basal strata of the west (L10, L11, M10, Q9) are significantly higher than those farther east, 33 cp 19 μ g/g. It is conjectural whether this difference is due to differences in the geological source of the sediments of the two areas; or whether it is the consequence of downward migration of copper from the enriched sediment above. The surface layer consistently has higher concentrations for this particular metal in the west than nearer the Mersey.

The average organic matter for the 34 basal strata was only 2.6 per cent compared with 5.9 per cent for the surface 100mm of the same cores.

The present exercise confirms and adds to our previous findings on the depth of penetration of obvious metal enrichment. For the first time in the Newcome Knoll area, core lengths were sufficient, at least for some stations, to reach the basal strata, at a depth of 0.8m at U9, and 1.2m at YY4. North of the Mersey outflow the basal strata remained beyond the reach of the corer with stations T12 and T14 showing above-background concentration of the major metals to a depth of at least 1.1m.

The depths of metal enrichment obtained on the three "long core" surveys are shown together in Fig 3. The spatial density of data is insufficient for confident demarcation of areal variations in the depth but it is evident that distinct zonal differences do exist. Enrichment rarely extends below 0.4m over the western half of the surveyed area and is more likely to be only 0.2 to 0.3m. On the other hand, to the east enrichment never fails to reach at least 0.5m and in many instances is proven to 1.0m or more. To the north of the Mersey outflow these greater depths are found as far west as the 18m submarine contour but farther south they appear to be more restricted, not extending much beyond the western tip of Newcome Knoll. Halfway between there and the sludge disposal ground, an area that is often considered to be on the return track of sludge solids to the Mersey, displays unusually shallow enrichment with depths of only 0.1 and 0.2m for cores P10, Q11, R9, R10, R11, and S11.

Concentrations in the upper strata of the cores reveal considerable metal enrichment by five of the six metals examined, nickel being the only exception. Enrichment factors for individual metals obtained from cores grouped into three zones are tabulated later on the assumption that the mean background values given earlier for the basal strata prevail uniformly over the survey area. The three zones are somewhat akin to the groupings adopted for the 1983 coring campaign, although in this instance the western sector covers ground much farther west not sampled on the earlier survey.

Zone	1986 Cores	Number of strata	Mean Enrichment Factor					
			Mercury	Copper	Zinc	Lead	Chromium	Nickel
West	L10, L11, M10, Q9, Q11, R13	29(29)	53(15)	6(9)	6(4)	25(6)	1.6(1.3)	1.4
North of Mersey Outflow	T12, T13, T14	33(39)	58(32)	4(5)	5(5)	9(22)	2.1(1.2)	1.2
South of Mersey Outflow	T9, T10, U9, YY3, YY4 (two)	56(22)	57(36)	4(4)	6(5)	7(4)	1.8(1.8)	1.1
TOTAL		118	57	5	6	11	1.8	1.2

Figures in brackets refer to 1983 survey (Ref 2)

The very high enrichment factors for mercury are in part due to the low background of that particular metal. Similarly the apparent increase in its enrichment between 1983 and 1986 is attributable to the lower background value adopted in 1986 (0.04 cp 0.09 μ g/g) rather than any increase in mercury concentration.

Enrichment factors for lead in excess of X20 for the western sector in 1986 and for north of the Mersey outflow in 1983 are misleading. They arise from the undue influence of a few exceptionally high values: in 1986 the single core M10 and in 1983 a number of strata from cores T15 and U15 having a very low proportion of mud (less than one per cent). If M10 is excluded from the 1986 western group the lead enrichment factor drops from X25 to X7 and the survey average from X11 to X7.

Spot random occurrence of very high concentrations, particularly mercury, have frequently been observed in past surveys (Refs 5 and 6). The present survey is no exception with freak peaks of not only mercury but many other metals being recorded. The lead anomalies at M10 have already been noted but for two strata between 0.1 and 0.3m of that core the high lead concentrations were accompanied by well-above average concentrations of copper, zinc, nickel and chromium. Elsewhere peaks of individual metals appear to be uncorrelated. For instance, we can note single zinc peaks in certain deep-lying strata of R13 and T14; an exceptional mercury maximum in T10; and atypically high chromium and copper values nearly one metre below the surface at YY3 and U9 respectively. The cause of these random peaks is not known. Bearing in mind the dispersion that accompanies the movement of fine-grained solids, it seems more likely that they originate from the dumping of direct industrial residues or dredgings close to where they are found, rather than sewage sludge discharged many kilometres distant. Unfortunately, although few in number, the concentration values are so excessively above normal that they can grossly weight the group averages of the small sample sets. Such obvious anomalies as the mercury peak in T10 have therefore been omitted from the averaging, as have several of the unusually high values in the basal strata. In all other cases, however, the values are included in the group averages previously tabulated.

5 CONCLUSIONS AND RECOMMENDATIONS

- 1 The sediments of Liverpool Bay in both the sludge disposal ground and the approaches to the Mersey display considerable surface enrichment by five of the six metals studied. Nickel is alone in being reasonably uniform over the sampled depth. By virtue of its low natural background, mercury shows the greatest proportional enrichment throughout the survey area.
- 2 The longer cores recovered by the 2-metre vibro-corer succeeded for the first time in penetrating below the greater depth of enrichment that exists nearer the Mersey. In conjunction with data from shorter cores obtained on earlier surveys the new depth profiles underline the major spatial differences in the thickness of metal enrichment in Liverpool Bay. Near the sludge disposal ground and for some distance east the enriched depth is generally limited to about 0.3m whereas nearer the Mersey it increases to more than 0.5m and reaches more than 1.0m both north and south of the Mersey outflow.
- 3 Heavy metal concentrations found in the basal strata below the enriched zone are thought to represent the natural geological background, free from man-made contaminants. Values are reasonably in accord with those obtained in 1983 although differences in copper concentrations between west and east suggest that the sub-surface sediments in the disposal ground area could be derived from a more copper-rich source than those nearer the Mersey.
- 4 Organic matter content in the undisturbed basement is less than half that in the superficial sediments.
- 5 It remains conjectural whether the enriched depths represent the level to which sediment is regularly disturbed by the flow processes and benthic organisms or whether man-made metals have historically become incorporated as part of a slowly accreting bed. MAFF's efforts to date strata taken from near the base of the enriched layer, particularly in the two zones to the north and south of the Mersey outflow, should be encouraged as a means of possibly resolving this question.

6

The depth profiles obtained from the occasional coring exercises provide a valuable complement to the more regular horizontal mapping of the surface distribution of metals. It is recommended that further deep cores are taken in the course of future standard surveys to substantiate and improve our existing knowledge of the spatial non-uniformity of enriched depths. The numerical modelling study of the fate of sludge particulates, currently being undertaken by HR with funding from DOE, is dependent on reliable input data for prescribing the depth to which metals mix in the bed.

6 **ACKNOWLEDGEMENTS**

We wish to thank Mr Jonathan Binks of HR's Field Studies Section for his successful completion of the coring programme. We are also pleased to acknowledge the valuable assistance given to Mr Binks on the cruise by Mr D Limpenny of MAFF Fisheries Laboratory, Burnham-on-Crouch and by the crew of M V Branding.

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Tables

TABLE 1 - DEPTH PROFILES OF MUD, ORGANICS AND METALS

Site	Level mm	Mud %	Organics %	Mercury µg/g	Copper µg/g	Zinc µg/g	Lead µg/g	Nickel µg/g	Chromium µg/g
L10	0- 25	5.01	i.s	1.37	134	310	238	53	91
	25-100	2.76	6.94	2.05	150	347	174	115	327
	100-200	5.96	5.67	1.62	115	281	139	57	85
	200-300	5.72	3.29	0.25	53	134	55	53	63
	300-400	2.44	3.87	0.08	62	76	36	41	63
	400-500	0.83	3.60	0.05	123	83	60	45	117
	500-600	0.72	4.71	0.05	118	70	66	41	130
L11	0- 25	9.44	5.37	1.14	81	251	112	51	64
	25-100	8.56	4.39	0.91	58	193	93	40	36
	100-150	28.41	2.32	0.11	31	85	28	39	36
	150-200	61.49	2.31	0.03	28	56	9	36	26
	200-250	66.42	2.82	0.02	42	76	14	51	28
	250-420	9.05	2.71	0.02	38	65	17	44	44
M10	0-25	13.50	4.41	1.00	282	570	1047	73	69
	25-100	1.37	5.22	1.95	428	710	1488	86	78
	100-130	6.76	7.12	1.84	730	1000	6265	130	95
	130-260	10.33	4.24	2.13	629	1327	3641	159	105
	260-350	5.30	2.90	0.07	55	86	117	35	66
	350-500	5.33	2.91	0.18	47	66	46	31	64
	500-520	24.99	2.93	0.02	25	47	17	24	44
Q9	0-25	2.29	2.72	0.35	44	114	115	35	37
	25-100	3.57	5.99	0.91	157	356	455	51	36
	100-200	1.63	7.05	1.55	105	410	278	52	43
	200-300	8.50	5.99	0.91	121	673	528	52	42
	300-400	1.58	4.13	0.68	89	427	372	51	31
	400-510	24.30	2.81	0.03	22	98	33	47	30
	510-600	7.07	2.55	i.s.	28	88	49	43	32
	600-680	4.63	2.95	0.07	37	92	71	48	30
	680-810	19.17	3.13	0.03	23	74	24	43	33
810-850	21.83	2.89	0.03	21	90	31	42	36	
Q11	0-25	24.22	6.09	1.92	89	347	162	51	71
	25-100	14.12	5.22	1.43	65	258	118	51	49
	100-200	18.55	2.98	0.11	24	104	37	50	42
	200-300	24.73	1.43	0.03	17	83	22	45	49
	300-400	35.78	1.60	0.03	17	76	21	41	39
	400-500	28.57	1.21	0.01	16	71	16	41	37
	500-600	30.34	1.39	0.02	16	68	11	39	38
	600-650	50.53	1.31	0.01	15	71	10	38	49

TABLE 1 (continued)

Site	Level mm	Mud %	Organics %	Mercury µg/g	Copper µg/g	Zinc µg/g	Lead µg/g	Nickel µg/g	Chromium µg/g
R13	0-25	3.61	4.33	4.21	167	401	396	58	89
	25-100	1.12	2.44	3.64	100	303	210	43	74
	100-130	3.28	4.11	10.11	141	273	166	57	63
	130-200	10.04	1.90	1.81	69	305	249	52	64
	200-300	3.84	2.55	2.19	118	402	301	53	74
	300-400	2.26	2.37	5.64	156	710	264	60	69
	400-500	6.62	2.45	4.48	107	256	133	54	89
	500-600	7.64	2.07	3.25	133	1748	171	57	103
	600-700	6.18	1.63	3.01	63	222	82	52	52
700-750	10.34	1.39	1.15	51	129	41	59	46	
T9	0-25	18.00	8.27	2.85	110	495	222	61	74
	25-100	20.62	6.94	2.32	103	486	215	58	94
	100-200	20.29	1.96	1.48	89	345	183	58	83
	200-300	13.85	4.61	0.72	68	223	147	52	67
	300-340	48.89	2.69	0.01	19	79	36	44	55
	340-400	34.97	1.28	0.03	21	86	28	57	65
	400-500	27.05	3.11	0.01	17	79	22	43	45
	500-600	21.04	1.16	0.05	22	86	23	47	72
	600-650	47.91	2.87	0.10	21	88	26	42	54
T10	0-25	0.23	i.s	0.02	223	205	419	55	267
	25-100	0.14	i.s	99.02	220	309	254	63	129
	100-200	0.14	i.s	3.01	101	249	176	36	71
	200-300	0.08	i.s	i.s	221	388	462	55	100
	300-400	0.12	i.s	3.58	187	561	321	52	59
	400-500	0.18	i.s	3.17	158	579	282	47	31
	500-550	0.42	i.s	7.07	224	813	297	54	56
T12	0-25	31.75	1.47	2.62	101	432	172	51	91
	25-100	23.46	2.09	2.47	106	935	366	50	100
	100-200	33.65	1.34	1.39	74	318	138	52	92
	200-300	48.21	1.56	1.06	62	252	108	45	77
	300-400	57.87	1.39	1.03	68	257	119	47	59
	400-500	74.12	1.99	1.06	62	241	124	44	60
	500-600	44.87	2.15	1.29	70	239	117	42	92
	600-700	58.55	1.62	1.43	65	258	118	46	67
	700-800	31.43	1.96	0.85	61	224	112	45	120
	800-900	54.74	1.89	1.21	70	250	125	50	67
	900-1000	81.74	1.95	1.07	73	255	131	53	60
1000-1120	66.06	1.93	0.89	56	226	111	47	65	

TABLE 1 (continued)

Site	Level mm	Mud %	Organics %	Mercury μ g/g	Copper μ g/g	Zinc μ g/g	Lead μ g/g	Nickel μ g/g	Chromium μ g/g
T13	0-25	11.32	5.87	2.44	86	353	162	47	71
	25-100	8.65	6.36	2.57	92	410	173	65	177
	100-200	8.05	5.46	2.19	85	332	178	54	88
	200-300	3.26	4.60	2.61	82	296	215	40	110
	300-400	2.72	4.74	3.53	96	370	246	45	78
	400-500	1.69	5.76	3.40	108	387	272	49	79
	500-600	2.06	3.90	1.90	62	210	177	30	34
	600-650	1.35	3.69	3.73	110	267	283	44	64
	650-700	26.52	2.59	0.03	19	73	14	45	53
	700-800	27.49	2.48	0.04	19	74	14	45	48
	800-900	33.39	2.44	0.03	23	84	20	52	34
	900-1000	27.47	2.45	0.01	23	80	18	51	42
	1000-1100	30.53	2.54	0.03	20	75	18	52	46
	1100-1200	33.95	2.42	0.05	18	74	17	49	35
1200-1270	44.03	2.22	0.02	18	71	16	45	41	
T14	0-25	1.18	i.s.	2.67	152	454	305	52	141
	25-100	1.45	6.43	2.36	123	388	207	54	104
	100-200	3.83	6.87	3.24	140	467	294	59	146
	200-300	3.14	7.05	3.12	139	626	537	56	132
	300-400	4.62	6.07	3.29	156	663	250	60	159
	400-500	4.26	5.87	2.61	112	433	169	52	87
	500-600	10.95	7.31	3.76	140	439	218	54	99
	600-700	2.38	6.19	2.61	139	626	205	57	118
	700-800	5.34	7.33	3.15	144	654	229	59	128
	800-900	1.19	6.92	2.56	151	626	231	53	137
	900-1000	4.07	6.62	2.88	129	196	213	54	104
1000-1100	1.44	6.01	2.50	141	561	203	54	96	
1100-1150	5.96	i.s.	3.49	220	1449	363	61	119	
U9	0-25	28.94	6.51	2.89	95	617	182	46	80
	25-100	25.06	7.78	2.99	117	710	230	52	100
	100-200	41.35	5.63	1.70	74	314	139	47	93
	200-300	32.88	6.44	1.77	86	345	151	48	80
	300-400	44.23	4.78	1.08	68	274	132	49	68
	400-500	60.46	3.99	0.75	51	199	99	41	52
	500-600	47.78	4.89	0.91	68	231	129	45	71
	600-700	20.39	5.31	0.73	75	227	162	46	62
	700-800	10.90	3.92	0.17	65	121	85	48	51
	800-900	8.31	4.11	0.02	286	86	31	42	67
	900-1000	5.95	4.14	0.01	22	92	34	44	75

TABLE 1 (continued)

Site	Level mm	Mud %	Organics %	Mercury μ g/g	Copper μ g/g	Zinc μ g/g	Lead μ g/g	Nickel μ g/g	Chromium μ g/g
YY3	0-25	56.19	5.44	1.72	70	287	105	36	50
	25-100	59.47	5.82	1.95	72	313	122	40	53
	100-200	8.45	7.10	2.68	124	719	200	52	83
	200-300	19.46	4.08	2.23	84	394	151	44	76
	300-400	27.69	5.43	1.98	71	361	114	38	48
	400-500	2.58	6.38	3.15	126	476	215	52	70
	500-560	3.18	i.s.	10.06	248	925	460	43	75
	560-700	1.12	3.98	0.47	104	142	74	36	262
	700-800	1.39	3.77	0.13	108	75	33	34	248
	800-910	1.08	3.24	0.20	283	120	43	45	321
YY4	0-25	71.75	6.29	2.33	90	362	157	47	71
	25-100	59.22	5.64	2.03	70	321	116	38	57
	100-200	61.95	6.10	2.97	96	598	170	45	64
	200-300	68.78	5.97	2.48	77	391	136	39	66
	300-400	61.90	5.11	1.68	63	313	105	35	56
	400-500	87.01	5.92	2.27	90	398	156	41	61
	500-600	36.35	5.54	2.30	98	443	178	43	61
	600-700	30.42	7.31	2.70	114	607	180	48	63
	700-800	44.46	6.73	2.32	105	607	158	48	56
	800-900	50.21	5.30	1.83	86	407	139	41	45
	900-1000	16.92	6.80	2.08	98	551	183	52	70
	1000-1100	12.31	6.49	1.63	82	432	227	52	70
1100-1140	18.30	2.08	1.10	60	259	121	50	75	
YY4 Dec 1985	0-25	89.57	4.39	2.25	62	570	133	54	77
	25-100	94.91	5.17	2.57	70	490	141	55	68
	100-200	58.70	5.32	2.96	80	730	160	58	75
	200-300	63.94	4.24	2.35	62	570	126	45	62
	300-400	55.72	3.77	2.39	68	580	143	51	88
	400-500	53.90	4.94	3.13	80	670	178	56	98
	500-600	33.87	3.98	2.19	72	530	149	48	74
	600-700	23.77	5.38	2.57	90	680	177	59	130
	700-800	27.82	4.79	2.05	87	600	173	61	105
	800-900	16.09	4.56	2.16	89	580	212	53	85
	900-1000	17.19	4.97	1.79	87	520	200	54	70
	1000-1100	50.58	3.63	1.03	47	300	102	41	48
	1100-1200	32.16	3.13	0.67	39	350	100	45	64
1200-1300	19.67	2.01	0.10	16	99	19	44	72	

i.s. = insufficient sample

Figures

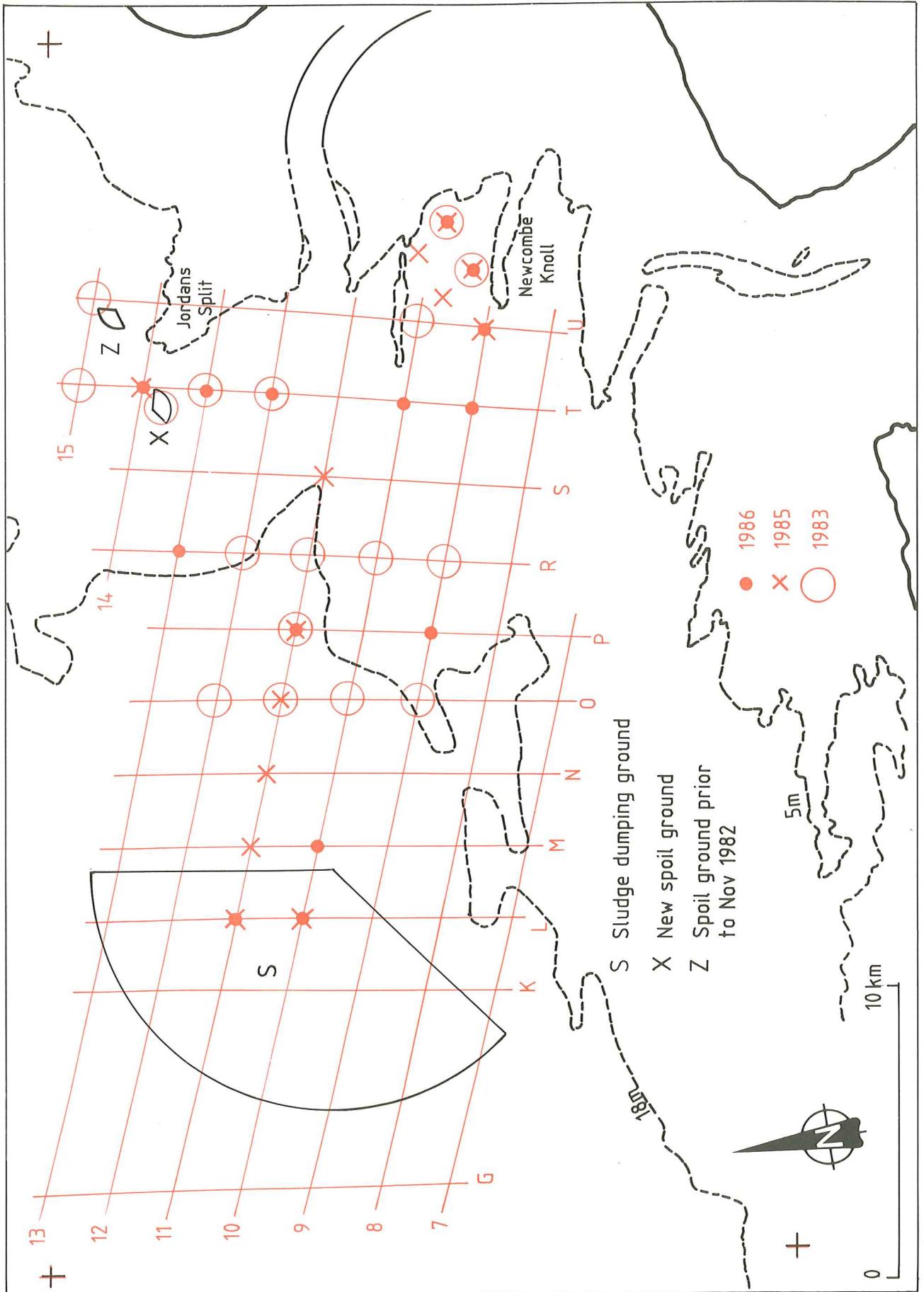
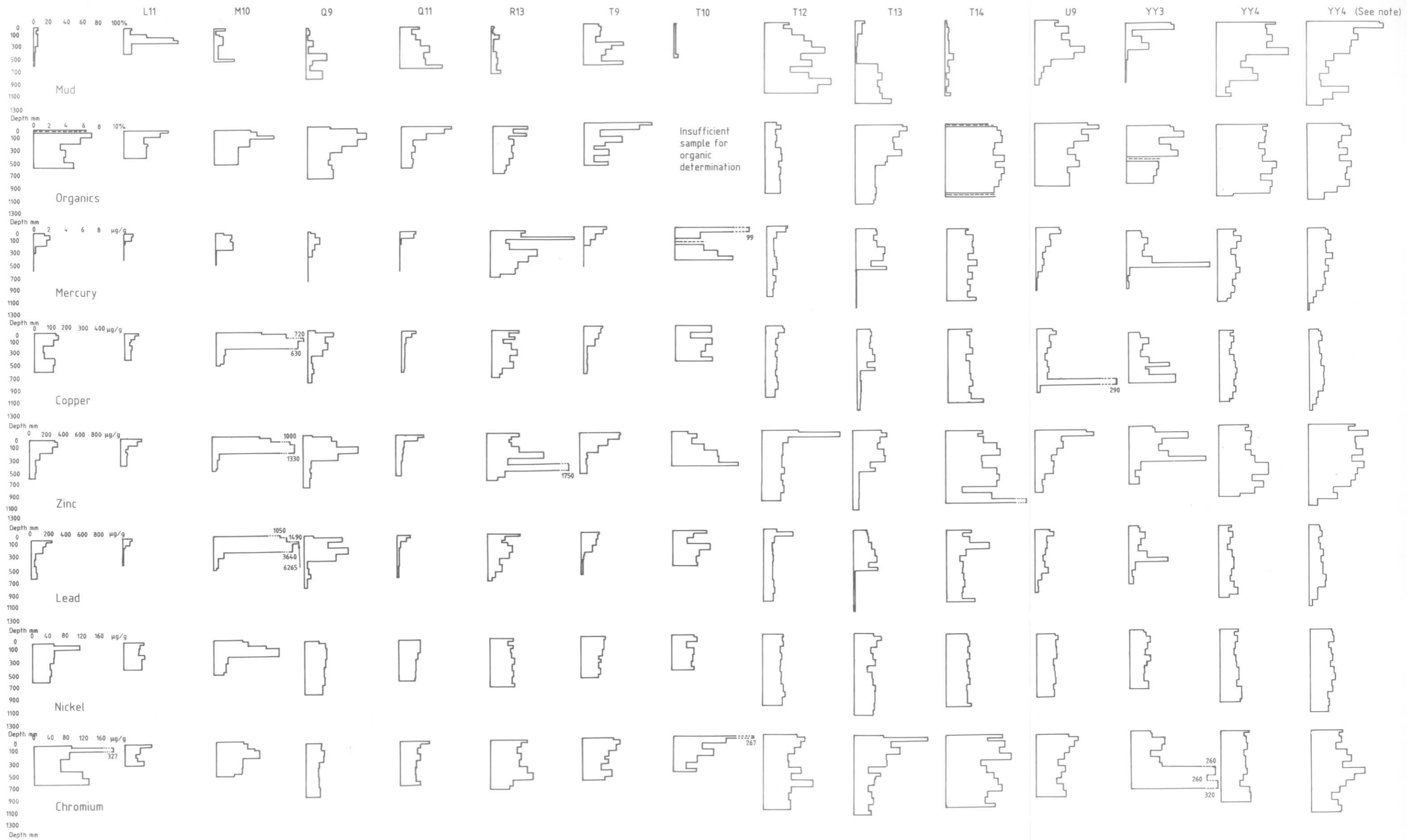


Fig 1 Coring positions



Depth profiles

Fig 2

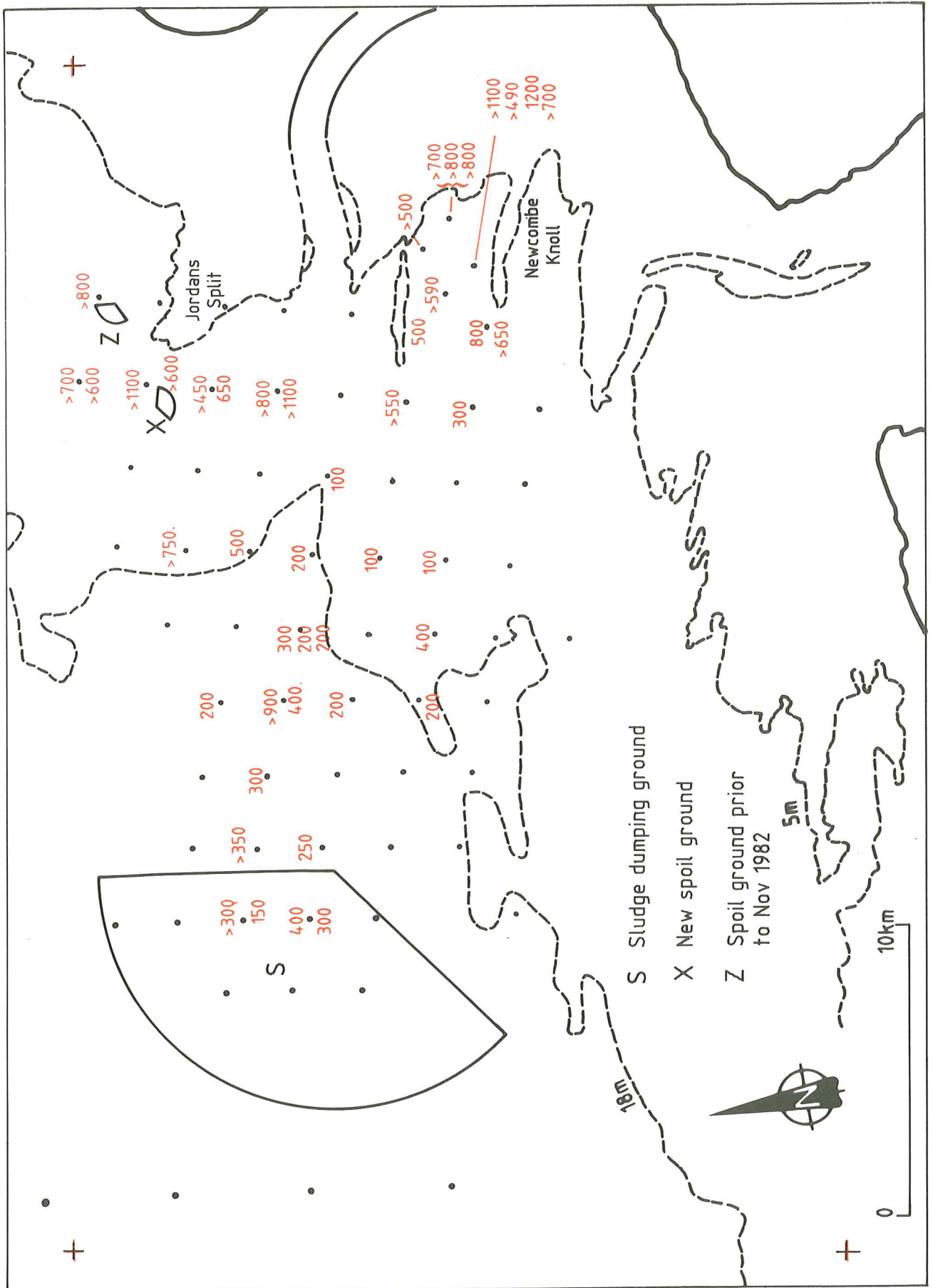


Fig 3 Depth of metal enrichment, combined data 1983 to 1986 (mm)

