Sediment Investigations in the Lake George Channel of the St. Marys River

Interim Report

Water Quality Monitoring and Surveillance Office
Ontario Region
WQM&S
Environment Canada

Science and Technology Branch Report No. 07-851

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Abstract

The St. Marys River is a binational Great Lakes Area of Concern. It is an international border river which divides Sault Ste Marie, Ontario and Sault Ste. Marie Michigan. Sugar Island is located within Sault Ste. Marie Michigan just south of the Canadian East End Water Treatment Plant (EEWTP). Until recently the EEWTP was a primary wastewater treatment plant which discharged into the Lake George Channel of the St. Marys River. The Lake George Channel runs along the north shore of Sugar Island. The shoreline of Sugar Island has experienced episodes of impaired water quality and noxious pollution over the last several years. There have also been high levels of bacteria measured at the beaches on Sugar Island which has caused a no contact order to be in effect for most of the 2006 summer months. In August 2006 the EEWTP was upgraded to treatment with discharge occurring further downstream in faster moving water.

A study of the St. George Channel was undertaken in September 2006 to characterize the sediment downstream of the EEWTP and to determine if contaminated sediment could be contributing to impaired water quality. The acoustic survey technique, RoxAnn, was used to describe the bottom sediment of the channel and to help locate core and ponar sampling sites. Surficial sediments were collected at eight transects down the channel. Each transect consisted of 4-5 sites across the channel. Sediment cores were also taken to assess the historical contamination of the river bed. Samples were analyzed for e-coli, total phosphorus (TP), total kjeldahl nitrogen (TKN) and total petroleum hydrocarbons (TPH). Further analysis is ongoing.

The sediment in the channel displayed consistent physical and chemical characteristics in transects moving downstream from the old EEWTP discharge. These characteristics

differed across the channel showing more deposition along the shoreline with a higher sand content along the southern shore. The middle of the channel had little deposition which was consistent with flow modeling programs. The contaminant maps for e-coli, TP and TPH showed higher concentrations close to the north shore and downstream near Little Lake George. This also corresponds to the deeper depositional zones identified by RoxAnn. Cores in this area revealed e-coli generally in the top 5 cm with a maximum value in the surficial layer. There was no historical enrichment of nutrients. The cores also revealed a history of TPH contamination with levels often exceeding guidelines throughout the top twenty centimeters. While some of the levels of TKN and TP in surface sediment were enriched compared to Lake Superior sediment, concentrations were consistent with samples taken in the St. Marys River upstream of the channel. There were no levels above the federal guidelines probable effects levels.

Introduction

The Lake George Channel within the St. Marys Area of Concern (AOC) has been impacted by point and non point sources discharging into the St. Marys River for well over a century. Dividing Sault Ste. Marie Michigan and Sault Ste. Marie, Ontario, the Lake George Channel, is located along the north shore of Sugar Island and downstream of the main shipping channel (Appendix A: figure A1). The channel is also downstream of a variety of industrial discharges. Upstream industry discharging into the river are a source of several chemicals including benzene, polycyclic aromatic hydrocarbons

(PAHs), oil and grease as well as foreign material including wood fibres and chips (Kilgour, Morton, and Kauss, 2001). In addition, two sewage treatment plants (STPs) serving Sault Ste. Marie Ontario, the West End Water Pollution Control Plant (WEWPCP, secondary treatment), upstream of the Lake George Channel, and the East End Wastewater Treatment Plant (EEWTP, secondary treatment, August 2006), have been discharging into the river for over forty years. The EEWTP is the only point source discharge directly to the Lake George Channel. STPs are known to be sources of bacteria and suspended solids. Suspended solids have also been added to the system from the City's storm sewer system and now separated combined sewer overflow. Historical sources of pollution entering upstream of the Lake George Channel also include a tannery and a chrome plant.

While there are potential sources of contamination on the American side of the St. Marys River upstream of Lake George Channel, the RMA2 hydrodynamic model, developed by the U.S. Army Corps of Engineers demonstrates that the vast majority of water from the American shore flows down the main channel to the south of Sugar Island. While no industry exists on Sugar Island there are septic systems which may be a potential source of bacteria to the channel.

The shoreline of Sugar Island has experienced episodes of impaired water quality and noxious pollution over the last several years. There have also been high levels of bacteria measured at the beaches on Sugar Island which has caused a no contact order to be in effect for most of the 2006 summer months. In August 2006 the secondary wastewater treatment plant came on line discharging further downstream in faster moving water.

The purpose of the study was twofold: 1. to assess sediment quality in the Lake George Channel timed to coincide with the changeover of the EEWTP from a primary to secondary treatment and the relocation of the plants outflow (Appendix a; Figure: A2); and 2. as part of Environment Canada's response to concerns expressed about elevated levels of bacteria in the Lake George channel. This field program is also complementary to other work to identify the source (sources) of floating material and elevated bacteria levels.

In an effort to provide timely information to stakeholders, this report is intended as a preliminary evaluation of the work conducted by Environment Canada in October 2006. An in depth interpretation of the information contained herein was not conducted.

Methodology:

(i) Sample Collection:

Substrate mapping of the Lake George channel was conducted by the National Water Research Institute prior to sample collection. RoxAnn, an acoustic seabed classification system, was used to classify bottom-sediment based on sediment roughness and hardness from sounder echoes. Data on time, position, depth, and classification parameters were logged to a computer and exported to a geographic-information system (GIS) for processing. (Substrate Mapping in the Great Lakes Nearshore Zone with a RoxAnn Acoustic Seabed Classification System, (Rukavina, 1997) The resulting maps were used to select sample sites for surficial sediment and to locate deep soft sediment locations for core sampling.

Sampling was conducted over five days from a 23-foot P class survey launch. Surficial sediment samples were collected on a grid longitudinally down the channel (Figure 1 and appendix A figures A3 and A4). Four to five samples were collected on a transect across the channel beginning just upstream of the old EEWTP outfall. The absence of soft substrate limited the sampling to two reference samples between the upstream EEWTP site and the main channel and another upstream of Bellevue Marine Park. Sample locations, specifically shore locations, were physically limited by the depth of the water accessible by the boat. Some sampling locations deviated from the grid due to a lack of suitable substrate and this was most common in midstream. Three depositional areas upstream of the sampling grid were selected using Roxann with one site upstream of the main channel and two sites just east of the main channel. These upstream sites were used as references stations.

The sampling program was based on the Guidelines for Collecting and Processing Samples of Stream Bed Sediment for Analysis of Trace Elements and Organic Contaminants (Capel and Shelton, 1994). A single sample consisted of a composite of a minimum of three ponar grabs taken from the same location. A Wildco petit ponar rinsed in ambient river water was used to sample soft sediments that were subsequently sieved through a 2-mm stainless steel sieve to remove the larger size fractions and to assist with homogenization of the sample. The sample was further homogenized by mixing with a stainless steel spoon for approximately two minutes. Typically, five jars were filled:

- 125-mL sterile glass jar filled with no headspace for e-coli analysis;
- 250-mL glass container filled with no headspace for the analysis of total kjeldahl nitrogen (TKN), total phosphorus (TP), Petroleum Hydrocarbons

(PHC) both F1(C6-C10)/BTEX; F2(C10-C16), F3(C16-C34) and F4(C34-C50);

- 250-mL amber glass container with Teflon-lined screw cap for organochlorine (OC), polychlorinated biphenyl (PCB), and polyaromatic hydrocarbon (PAH) analysis;
- One 125-mL polyethylene container for metal analysis;
- One 125-mL polyethylene container for total organic carbon (TOC), Loss on ignition (LOI) and grain size.

Core samples were taken at five locations where RoxAnn indicated soft sediment of greater than 20 cm depth. A depositional area which transected the channel was located just upstream of Little Lake George (Figure 1). A transect of four core samples were taken at this location. In addition to this transect a core sample was taken just downstream of the EEWTP old outflow on the Canadian side of the channel.

Cores were collected using an Environment Canada technical operations gravity corer and sub-sampled in 1-cm increments for the first 15 cm, then sub-sampled in two cm increments for the remainder of the core. The cores ranged in length from 15 cm to 25 cm. Each section was collected in a separate zip-lock polyethylene bag. Twelve cores were collected for each site; sections from the individual cores corresponding to equivalent depths were pooled. Two sample jars were filled at each site.

- 125-mL glass jar filled with no headspace for e-coli analysis;
- 250-mL glass container filled with no headspace for the analysis of TKN, TP, PHC and BTEX (benzene, toluene, ethylbenzene and xylene)

The remainder of the sample was left in the bag on ice and transferred to a 250 mL jar at the laboratory. After the appropriate sample jars were filled, the sampling equipment was thoroughly rinsed in the ambient river water.

Ottawa sand was used as a field blank, and was exposed to the sampling environment and subsequently jarred for analysis. The field blank for the sediment coring consisted of a composite of approximately 10 grams of Ottawa sand added to the sample bag during sampling of individual cores. Blanks were stored and submitted with field samples. Duplicate samples were also taken at various times during the five sampling days.

Information recorded on sample containers included the site location (latitude/longitude), date, time, organization, and parameters for analysis. The site location was taken using a Magnavox MX 300 geographic positioning system (GPS). Samples were immediately stored on ice.

Samples for e-coli, TP, TKN, and PHC were shipped on ice twice daily by Purolator courier service to Maxxam Analytical Inc. Samples collected in the morning and early afternoon were shipped at 3:00 p.m. for early next day arrival and samples collected in the late afternoon or evening were shipped at 9:00 a.m. the next day for late afternoon delivery. All samples arrived in time to be processed within the protocol holding time of forty-eight hours. All samples arrived in the appropriate condition and temperature as specified in the analysis protocol (see Laboratory Processing). All samples not immediately submitted for analysis were kept on ice and transported back to Canada Centre for Inland Waters and frozen.

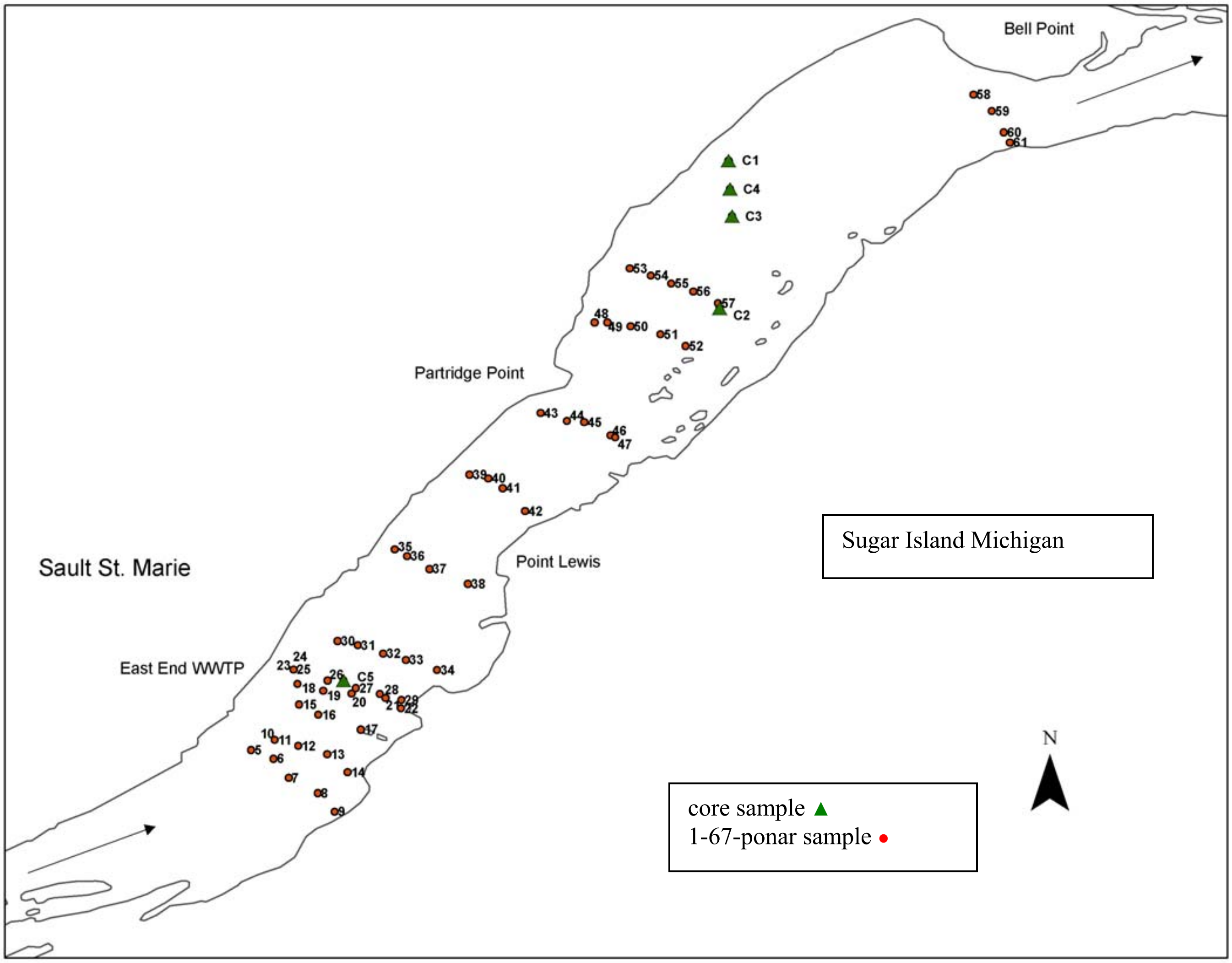

Figure 1: Core and Ponar sample locations in Lake George Channel

Laboratory Processing:

Maxxam Analytical Inc has Canadian Association for Environmental Analytical Laboratories (CAEL) accreditation for the analyses. Their QA/QC program consisted of blanks, spiked blanks and duplicate samples (i.e., laboratory replicate runs). Laboratory methods used for the analysis in this report were:

- E. Coli (cfu/g)-MOEE E3433 (ref MOEE E3433)

- Petroleum Hydrocarbons CCME F1 & BTEX in Soil- CAM SOP-00315 (ref CCME CWS)
- Petroleum hydrocarbons F2-F4 in Soil- CAM SOP-00316 (ref CCME CWS)
- F4G (CCME hydrocarbons Gravimetric)- CAM SOP-00316 (ref CCME CWS)
- Total metals analysis by ICP (Total Phosphorus) - Ont SOP 0072 (ref EPA 6010)
- Moisture- Ont SOP-0114 (ref MOE Handbook (1983))
- Total Kjeldahl Nitrogen (soil) NT SOP-0823 (ref EPA 351.2 Rev 2)

Results and Discussion:

A full listing of results can be found in Appendix B and C. Results are compared to applicable criteria where regulations exists (PHC analysis) or guidelines (Persaud et al., 1992) (TP and TKN) when available. (See appendix notes). Half detection limit values were used for calculation of the mean in cases of non-detects. With the exception of e-coli results, concentrations are given in dry weight. Dry weight e-coli results were calculated using the wet weight and % moisture results. A definition of TPH fractions1-4 and 4G can be found in appendix B notes.

Petroleum Hydrocarbons:

Petroleum hydrocarbon concentrations were compared to provincial criteria, Ontario regulation 153/04). There were few detections for total petroleum hydrocarbons (TPHs) lighter than 6 carbons (C6). Ethylbenzene (detection limit 0.02 ug/g) and total xylene (detection limit 0.02 ug/g) were not detected. TPHs in F1 (C6-C10) (detection limit 10 ug/g) were also less than the detection limit in every sample. Benzene (detection limit 0.02 ug/g) was found in two surficial samples at the method detection limit while toluene (detection limit 0.02 ug/g) was detected in 32 samples. Toluene was well below the provincial criteria of 2.1 μg/g (Ontario regulation 153/04), ranging from <0.02-1.4 μg/g with a mean value 0.16 ± 0.27 μg/g, as compared to the upstream reference sites which exhibited a range of <0.02-0.08 μg/g. While not detected in cores 1 and 4 collected on the north side of the channel, toluene was detected at levels just above the detection limit in the top 4 cm of cores 2 and 3. In core 5, taken just downstream of the EEWTP outflow, toluene was found in the top 9 cm, declining steadily with decreasing depth from 0.35-0.07 μg/g.

TPH F2 (C10-C16) were detected in 27% of surficial samples and all concentrations were below provincial criteria of 250 μg/g. TPH F2 concentrations ranged from <10 ug/g-49 μg/g. Concentrations of TPH F2 were found in the cores closest to shore with only a few detections in cores 2 and 3. While all values were below the provincial criteria, (Ontario regulation 153/04) core 5 had the highest TPH levels ranging from 43-380 μg/g, with the highest levels found below 10 cm in depth. TPH F3 (C16-C34) were detected in 98% of the surficial samples ranging from <10-1500 μg/g, and exceeding the criteria of 800 μg/g at fourteen sites. Mean concentration for TPH F3 was 422 ug/g ± 76% (rsd) with the highest concentrations found on the north side of the channel. Cores 1 and 4 on the north side of the channel had levels that exceeded the criteria for the top 11 and 15 cm, respectively, while cores 2 and 3 had a more shallow depth maxima, and overall lower concentrations. Core 5 concentrations exceeded the provincial criteria (Ontario regulation 153/04) for the entire length of the core, with a maximum concentration at 12 cm. The depth profile for core 4 for TPHs is typical of those observed in depositional environments in many of the connecting channels; an increasing trend from the bottom of the core to a sub-surface maximum indicative of historical contamination, followed by a trend toward decreasing values at the surface indicative of a general reduction in discharges over the past several decades.

Typical petroleum products comprising F4 include motor oil and lubricating oil. A mean concentration of 252 µg/g ± 106% (rsd) was found for surficial samples with 51 samples above the detection limit and a corresponding maximum value of 1,300 µg/g, which is well below the 5,600 µg/g criteria. Twenty-five F4 chromatograms did not reach baseline indicating that heavier petroleum hydrocarbons were present in the sample. For these samples an F4G analysis was performed to include hydrocarbons with >C50, which typically include heavy lubricating oils and asphaltenes. All data were below provincial criteria (Ontario regulation 153/04) for surface sediments. Some depth sections in cores 1 and 5 exhibited levels above the provincial criteria. Core 1 had a maximum concentration of 7,700 µg/g at 7 cm depth, while core 5 exceeded criteria between 8 and 14 cm. with a maximum concentration of 7,600 µg/g.

Escherichia Coli

E- Coli concentrations are measured in colony forming units (cfu)/gram and is reported as wet weight and dry weight. Dry weight is reported from calculations using sample moisture content and wet weight data. E-Coli was detected in 92% of the surficial samples ranging from <10 cfu/g - 660 cfu/g wet weight, or <15 cfu/g-3263 cfu/g dry weight. Mean concentrations expressed as wet weight and dry weight were 114 cfu/g ± 149% and 290 cfu/g ± 155%, respectively. Core 1 exhibited a decreasing concentration profile from the surface to a 7 cm depth, declining rapidly from a surface concentration of 620 cfu/g wet wt. to 120 cfu/g wet wt. at 2 cm. Levels were found above detection in the top four cm of cores 3 and 4 but at much lower concentrations ranging between 10 - 40 cfu/g wet wt. Core 2 had detections of 10 cfu/g wet wt. Core 5 just downstream from the EEWTP, had a surface concentration of 90 cfu/g wet wt., and levels just above the detection limit of 10 cfu/g wet wt. to a depth of 6 cm.

In general, higher levels of e-coli were found in the sediment along the north side of the channel, which corresponded to the depositional areas identified by Roxann. (Figure: 2)

Two of the three upstream samples Ponar 1, 2 and 3 had e-coli concentrations above the detection limit. Ponar 1 and Ponar 3 had values of 333 cfu/g wet wt. and 102 cfu/g wet wt. respectively. Eighty four percent of the samples had e-coli concentrations less than the reference site (ponar 1) while forty-one percent were less than the reference site (ponar 3).

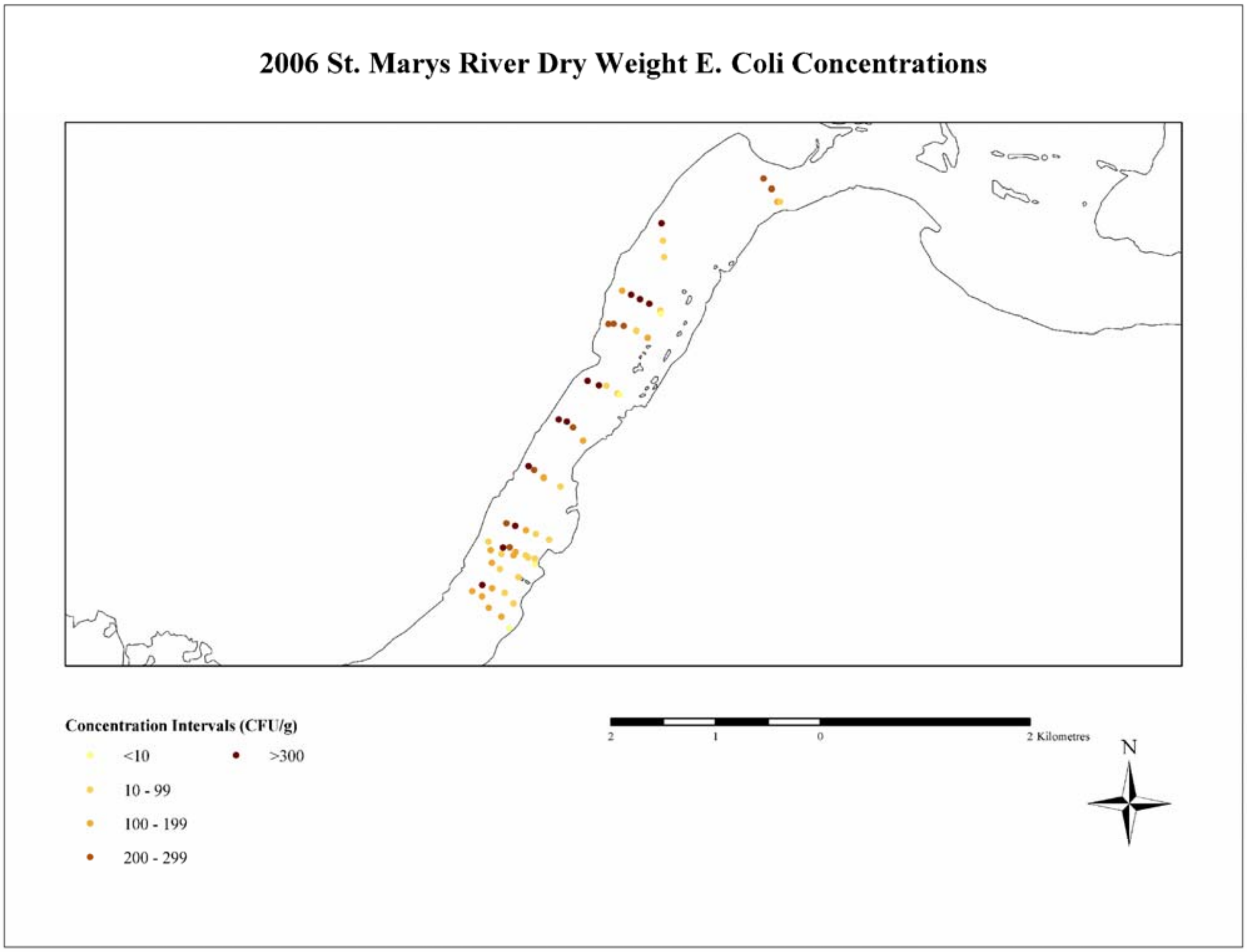

Figure 2: E-coli Concentrations in Lake George Channel Sediment cfu/g dry wt.

Total Kjeldahl Nitrogen

Total kjeldahl nitrogen was measured in the surficial sediment between 142 µg/g and 4,410 µg/g with a mean value of 1,406 µg/g ± 80%. Upstream reference values were 955, 2190 and 1050 µg/g for ponars 1, 2 and 3, respectively. While 68% of the samples were above the Ontario Ministry of the Environment lowest effect level (LEL) guideline of 550 µg/g, there were no samples above the severe effect level (SEL) value of 4,800 µg/g. Background values for Lake Superior sediment are 1,100 ug/g (Environment Canada, 2006)

A comparison with upstream samples from both this study and those reported by Milani and Grapentine 2006 show little enrichment in the Lake George Channel sediment. Spatially, higher concentrations were found on the north side of the channel and in the depositional area toward the upstream area of Little Lake George. Lower values are found in the scoured areas down the middle of the channel. Core 1 had somewhat higher values throughout the depths; however, these values were not inconsistent with overall values. With the exception of core 4, there is a surficial maximum indicating a steady input of nitrogen over time.

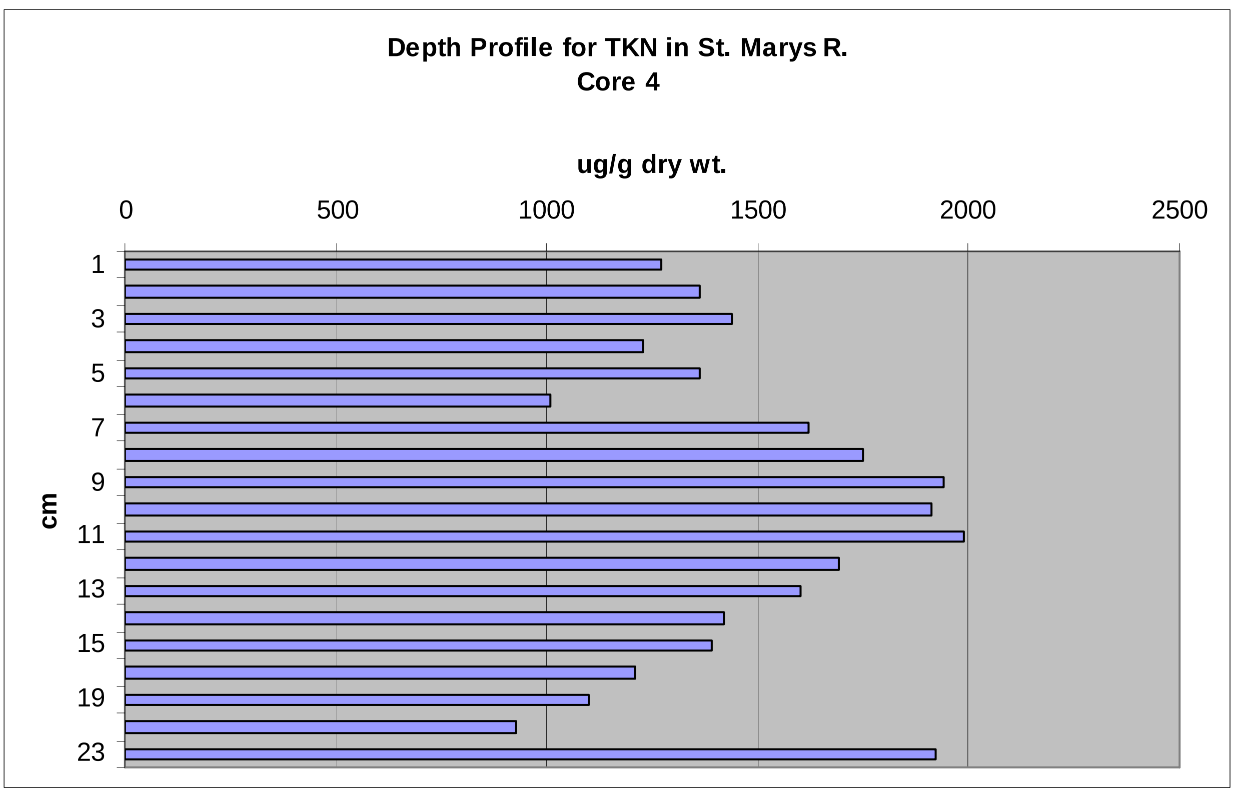

Figure 3: Depth profile for total kjeldahl nitrogen in Lake George Channel sediment

Total Phosphorus

Background levels for Lake Superior sediment are 800 µg/g (Environment Canada, 2006). Phosphorus levels at upstream reference sites were 320, 490, and 390 µg/g for ponars 1, 2 and 3, respectively. Surficial samples ranged between 120 and 1,300 µg/g with 11 samples exceeding the provincial LEL. No samples surpassed the provincial SEL of 2,000 µg/g. The mean concentration was 475 µg/g ± 47%. While overall levels were similar to Lake Superior background values, the highest levels in the study were found in the channel along the north shore. (Figure: 4) Cores 1, 2, 3 and 5 had surficial maximums which indicate a consistent input over time.

Summary

The spatial distribution for the parameters measured and reported in this study show higher levels along the north shore and in deeper deposition areas where cores 1 and 4 were sampled. While elevated sediment concentrations may be attributed to a local source, sediment transport factors such as bathymetry, flow regime and sedimentology also effect the spatial distribution. While provincial LELs for TKN and TP were exceeded in some locations, all levels are well below the provincial SEL. Petroleum hydrocarbons with hydrocarbon chains >C16 are found throughout the channel and in the upper reaches of the river (Milani and Grapentine 2006). Deposition of petroleum hydrocarbons is ongoing as shown in the surficial samples however these contemporary levels are well below historical ones as seen in the core 4 profile. E-Coli values in sediment were quite variable from site to site but generally higher along the north shore with decreasing concentrations across the channel.

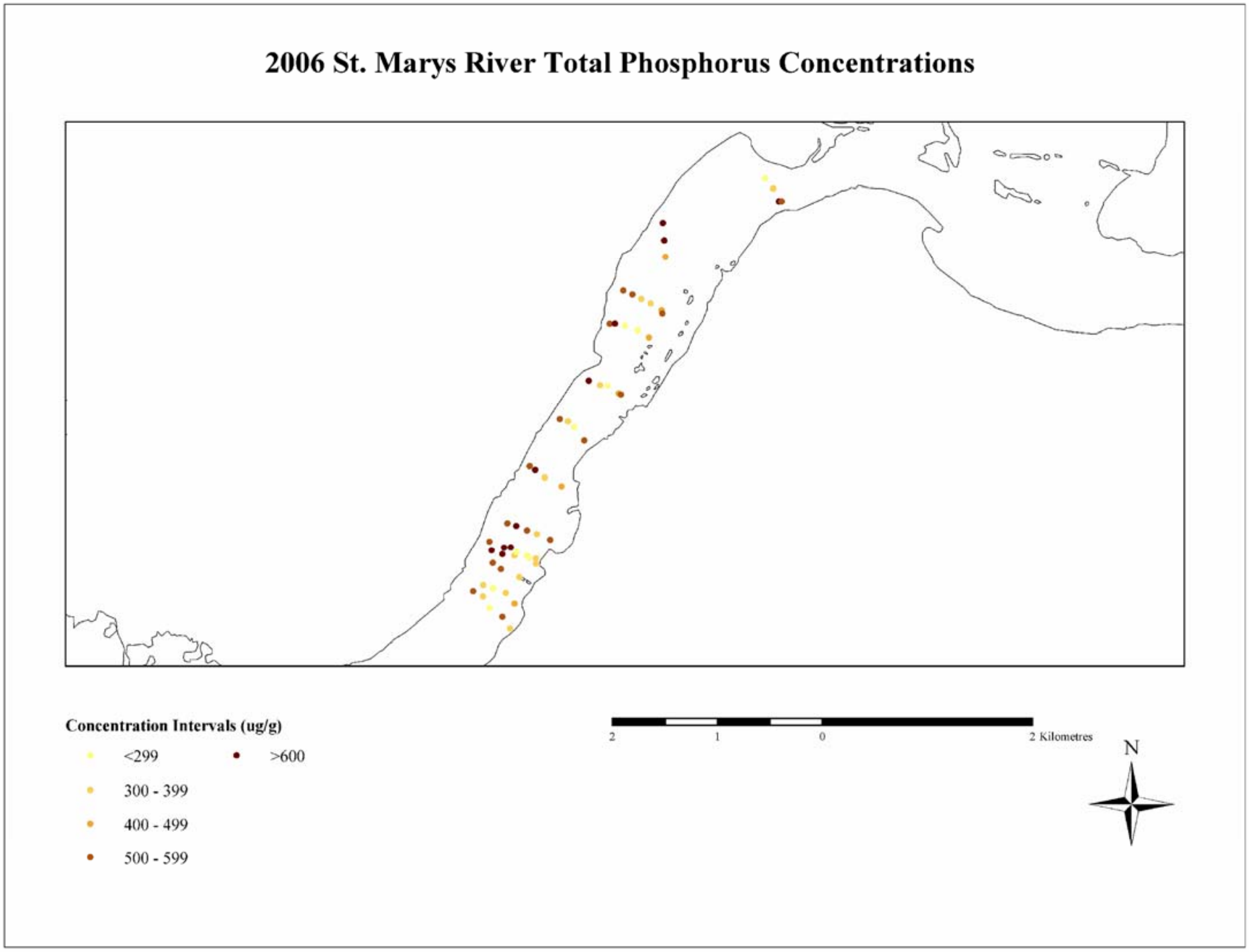

Figure 4: Total Phosphorus concentrations in surficial sediment in Lake George Channel

This data will have further interpretation with the results of further analysis such as PCBs, organochlorines, PAHs, metals and TOC, LOI and sedimentology. Future work should include sampling in the locations near shore which are accessible only by land. Monitoring plans for the 2007 season are currently being developed.

References

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4. Milani, D., and Grapentine, Lee 2006. The Application of Beast Sediment Quality Guidelines to the St. Marys River Area of Concern. NWRI Contribution No. 06-415, Environment Canada, Aquatic Ecosystem Impacts Research Branch, National Water Research Institute, 867 Lakeshore Road, P. O. Box 5050, Burlington, Ontario L7R 4A6

5. Persaud, D., Jaagumagi, R. and Hayton, A. 1992: Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario, Water Resources Branch, Ontario Ministry of the Environment and Energy, June 1992.
6. Rukavina, Norm 1997, Substrate Mapping in the Great Lakes Nearshore Zone with a RoxAnn Acoustic Seabed Classification System. Proceedings of the 1997 Canadian Coastal Conference

Appendices

Appendix A: Site and sample Location Maps

Appendix B: Ponar Sample Results

Appendix C: Core Sample Results

Appendix D: Contaminant Maps

Appendix E: Core Profiles

Appendix A: Site and sample Location Maps

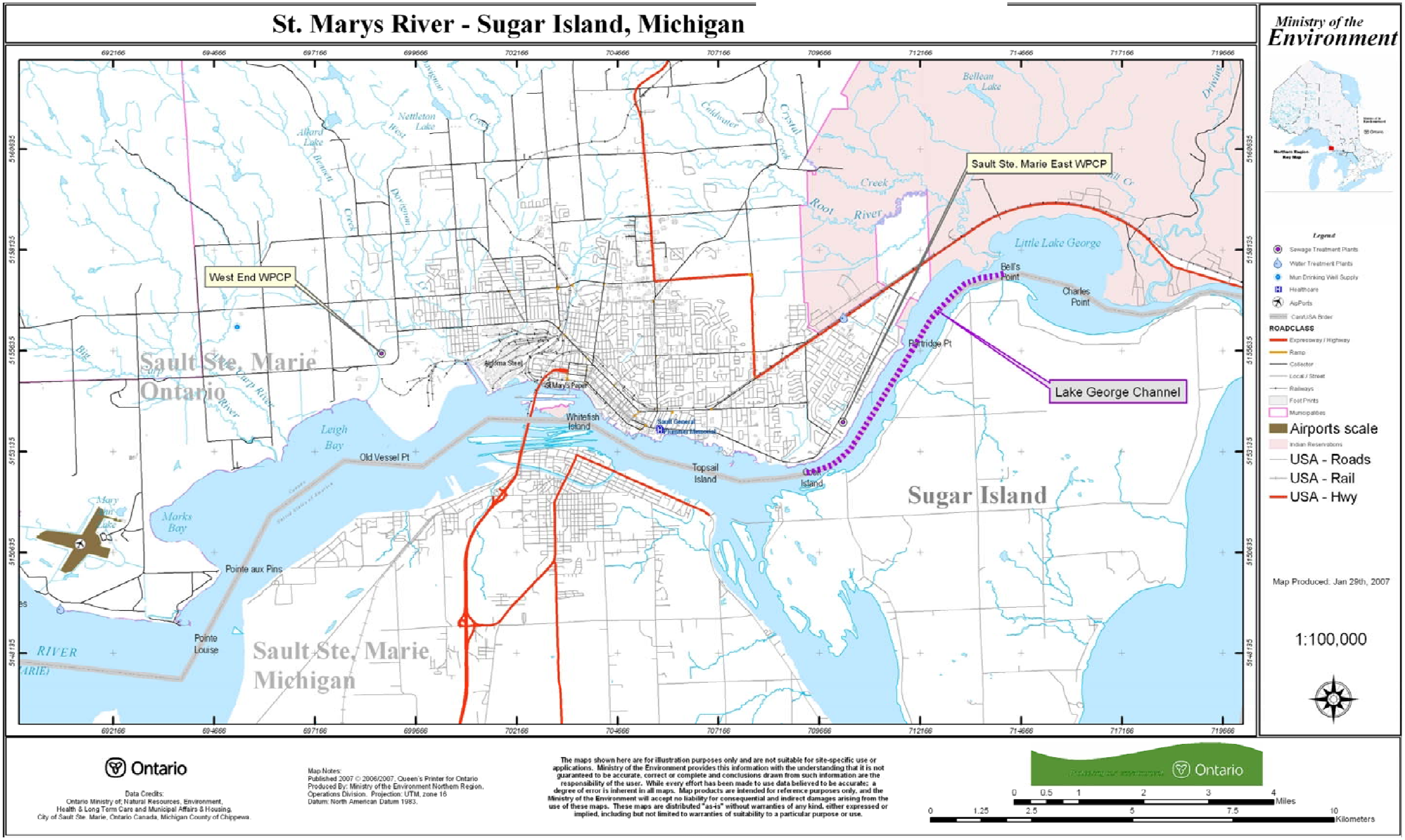


Figure A1: Lake George Channel of the St. Marys River

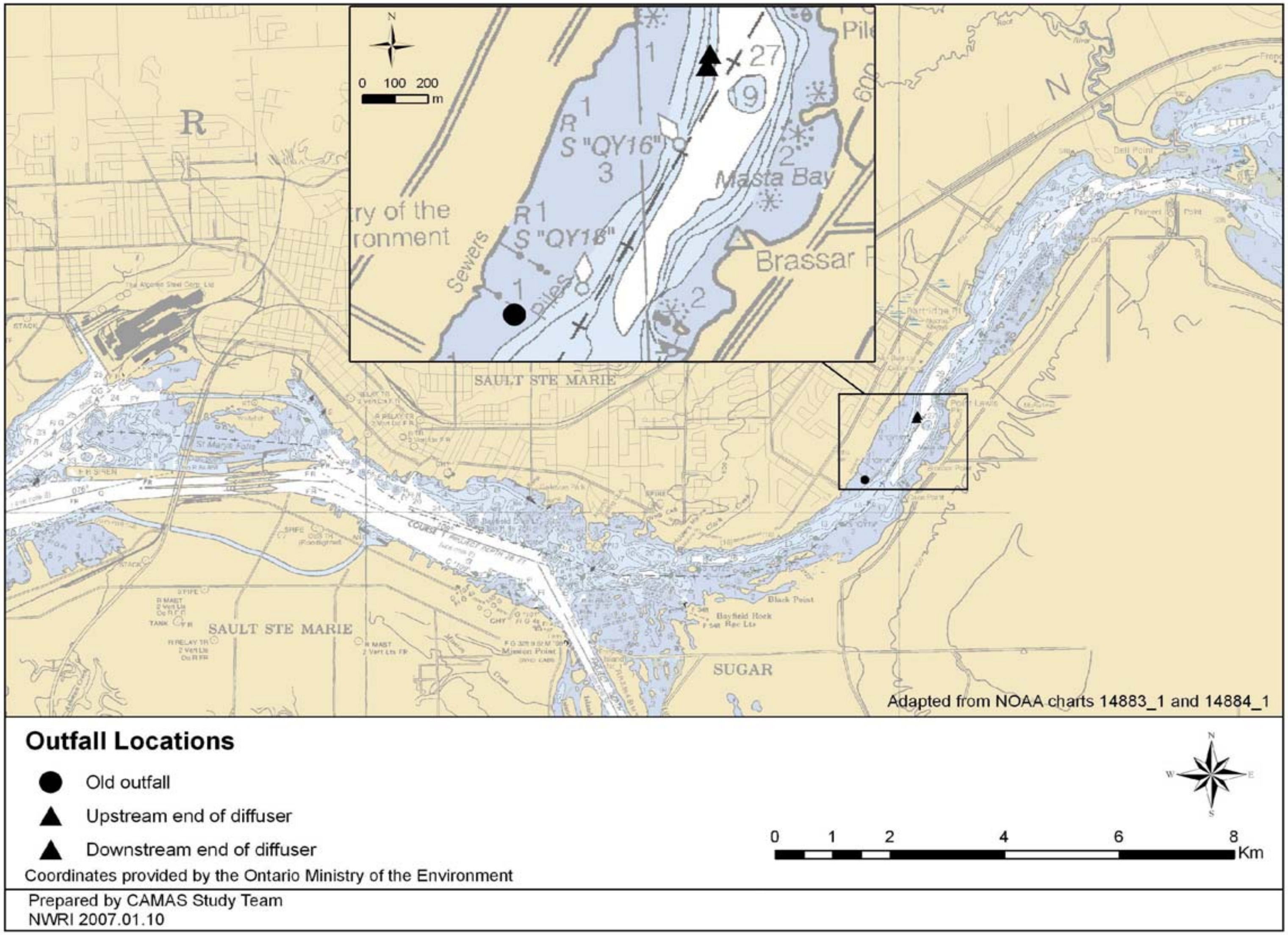


Figure A2: Lake George Channel and location of old and new EEWWTP outflow

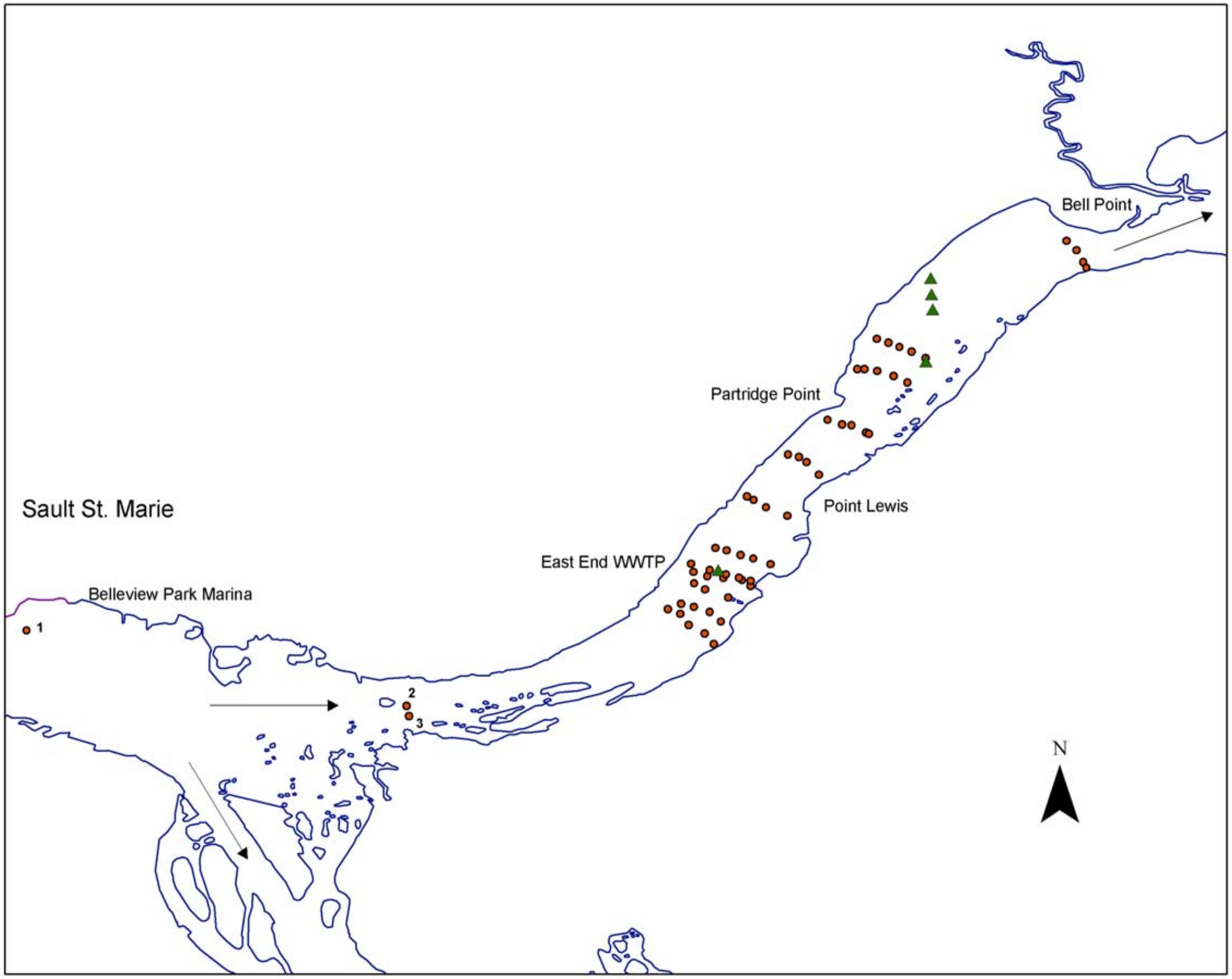


Figure A3: Sample sites including upstream reference sites

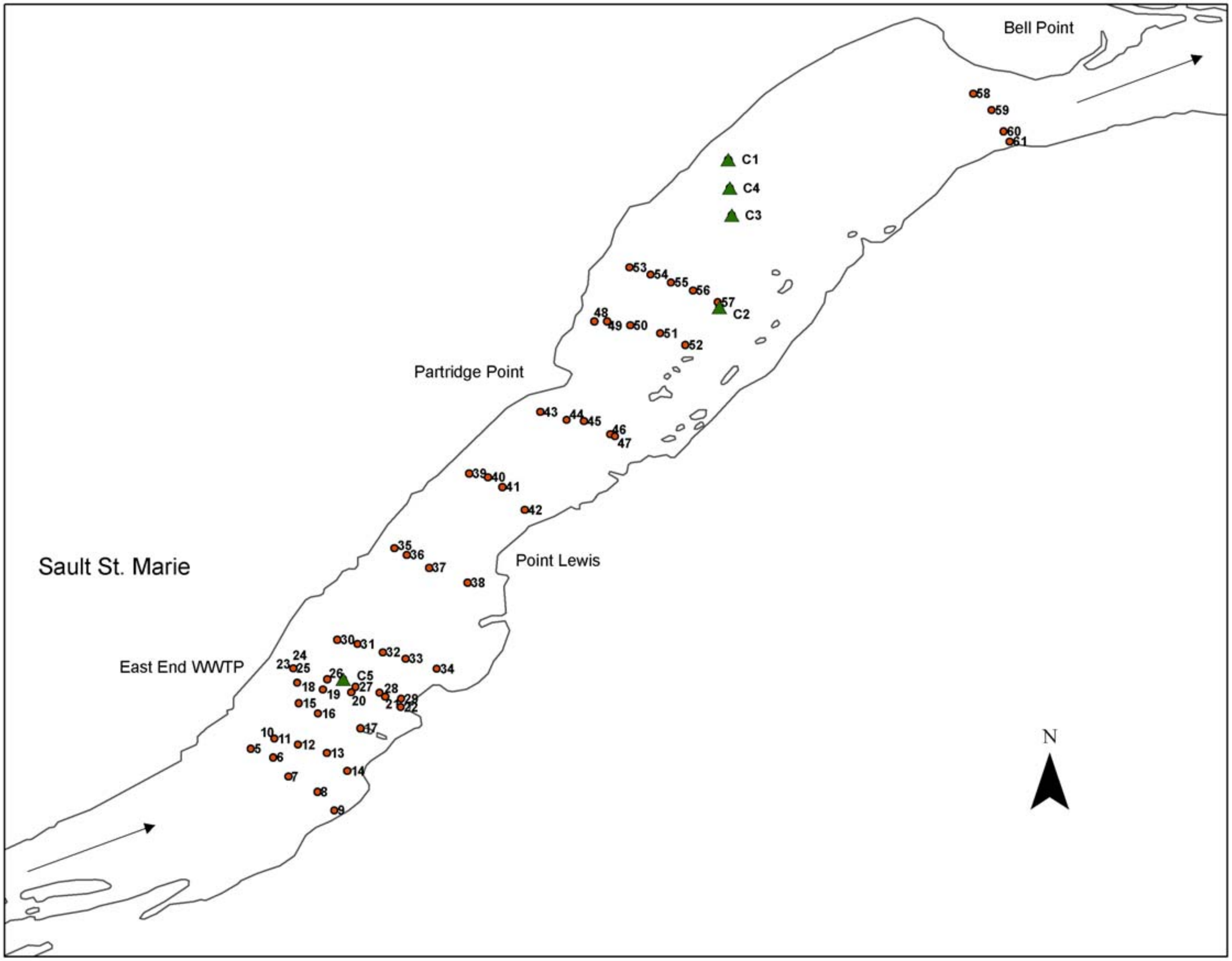


Figure A4: Sample sites in the Lake George Channel

Appendix B: Ponar Sample Results

Appendix Note: The Following Compounds were not detected in any sample and are not included in the core data results table

Benzene
Ethylbenzene
o-xylene p+m-xylene
Total Xylene
PHC F1 (C6-C10)

Abbreviations

PHC	Petroleum Hydrocarbon
TKN	Total Kjeldahl Nitrogen
TP	Total Phosphorus
CFU	colony forming units
NA	not available
F1	fraction 1
F2	fraction 2
F3	fraction 3
F4	fraction 4
F4G	fraction 4 gravimetric

TPH fractions are distinguished by hydrocarbon weight

F1	six-ten hydrocarbon chain
F2	ten - sixteen hydrocarbon chain
F3	sixteen - thirtyfour hydrocarbon chain
F4	thirtyfour - fifty hydrocarbon chain
F4G	includes >fifty hydrocarbon chain

Criteria and Guidelines

		LEL	SEL	Criteria
Total Phosphorus	ug/g	600	2000	
Total Kjeldahl Nitrogen	ug/g	550	4800	
Toluene	ug/g			2.1
PHC F2	ug/g			250
PHC F3	ug/g			800
PHC F4	ug/g			5600

LEL: Provincial Lowest Effects Level
SEL: Provincial Severe Effects Level
Criteria: Ref. to Ontario Regulation 153/04 made under the Environmental Protection Act on May 12/2004
F4 criteria is compared to either F4 or F4G results, whichever is of a greater concentration

Sample Name	Sample Date	Easting	Northing	% moisture	E-Coli CFU/g dry wt.	E- Coli CFU/g wet wt	Total Phosphorus ug/g dry wt.	TKN ug/g dry wt.	Benzene ug/g dry wt.	Toluene ug/g dry wt.	Ethylbenzene ug/g dry wt.	o-Xylene ug/g dry wt.	p+m Xylene ug/g dry wt.	total Xylenes ug/g dry wt.	PHC F1 C6-C10 ug/g dry wt.	PHC F2 C16-C34 ug/g dry wt.	PHC F3 C16-C34 ug/g dry wt.	PHC F4 C34-C50 ug/g dry wt.	PHC F4G >C50 ug/g dry wt.
Ponar 1	28-Sep-06	705886	5153215	31	333	230	320	955	<0.02	0.05	<0.02	<0.02	<0.02	<0.02	<0.02	15	370	150	1700
Ponar 2	28-Sep-06	708692	5152527	57	23	10	490	2190	<0.02	0.08	<0.02	<0.02	<0.02	<0.02	<0.02	<20	280	170	2000
Ponar 3	28-Sep-06	708713	5152424	41	102	60	390	1050	<0.02	<0.02	<0.02	<0.02	<0.04	<0.04	<10	<10	280	260	2200
Ponar 5	28-Sep-06	710567	5153599	40	100	60	500	938	<0.02	0.26	<0.02	<0.02	<0.04	<0.04	<10	<10	18	210	2800
Ponar 6	28-Sep-06	710660	5153551	25	133	100	340	384	<0.02	<0.02	<0.02	<0.02	<0.04	<0.04	<10	<10	29	<30	<100
Ponar 7	28-Sep-06	710724	5153440	21	139	110	220	311	<0.02	<0.02	<0.02	<0.02	<0.04	<0.04	<10	<30	20	<30	<100
Ponar 8	28-Sep-06	710845	5153356	67	121	40	510	2990	<0.06	<0.06	<0.06	<0.06	<0.1	<0.1	<30	<30	950	770	3300
Ponar 9	28-Sep-06	710917	5153249	49	<20	<10	380	1600	<0.02	<0.02	<0.02	<0.02	<0.04	<0.04	<10	10	300	180	2200
Ponar 11	28-Sep-06	710661	5153660	38	48	30	330	971	<.02	0.08	<0.02	<0.02	<0.04	<0.04	<10	<10	320	150	2300
Ponar 12	28-Sep-06	710756	5153628	19	148	120	160	232	<0.02	0.08	<0.02	<0.02	<0.04	<0.04	<10	<10	320	11	<100
Ponar 13	28-Sep-06	710875	5153583	18	61	50	310	271	<0.02	<0.02	<0.02	<0.02	<0.04	<0.04	<10	<10	15	<30	<100
Ponar 14	28-Sep-06	710960	5153481	59	24	10	480	2020	<0.04	<0.04	<0.04	<0.04	<0.08	<0.08	<20	<20	650	400	3100
Ponar 15	28-Sep-06	710752	5153872	37	111	70	560	1250	<0.02	0.27	<0.02	<0.02	<0.04	<0.04	<10	16	330	130	<100
Ponar 16	28-Sep-06	710831	5153813	53	43	20	530	1450	<0.04	0.54	<0.04	<0.04	<0.08	<0.08	<20	<20	380	230	1000
Ponar 17	28-Sep-06	711005	5153734	27	41	30	300	468	<0.02	<0.02	<0.02	<0.02	<0.04	<0.04	<10	<10	33	20	<100
Ponar 18	28-Sep-06	7110741	5153992	18	122	100	970	2220	<0.02	0.39	<0.02	<0.02	<0.04	<0.04	<10	38	930	320	1600
Ponar 19	28-Sep-06	710845	5153955	57	47	20	990	2740	<0.04	0.7	<0.04	<0.04	<0.08	<0.08	<20	<20	980	370	1700
Ponar 20	28-Sep-06	710961	5153942	29	169	120	300	493	<0.02	0.07	<0.02	<0.02	<0.04	<0.04	<10	<10	75	46	310
Ponar 21	28-Sep-06	711099	5153921	15	94	80	210	142	<0.02	na	na	na	na	na	na	na	na	na	na
Ponar 22	28-Sep-06	711163	5153862	35	<15	<10	380	839	<0.02	0.08	<0.02	<0.02	<0.04	<0.04	<10	<10	71	17	<100
Ponar 23	29-Sep-06	710721	5154075	49	20	10	580	1190	<0.02	0.07	<0.02	<0.02	<0.04	<0.04	<10	30	650	210	<100
Ponar 26	29-Sep-06	710861	5154017	61	359	140	1300	2400	<0.04	0.33	<0.04	<0.04	<0.08	<0.08	<20	38	740	220	<100
Ponar 27	29-Sep-06	710978	5153975	30	114	80	280	478	<0.02	0.06	<0.02	<0.02	<0.04	<0.04	<10	<10	83	<30	<100
Ponar 28	29-Sep-06	711076	5153943	19	74	60	200	219	<0.02	<0.02	<0.02	<0.02	<0.04	<0.04	<10	<10	<30	<30	<100
Ponar 29	29-Sep-06	711163	5153912	30	29	20	320	567	<0.02	<0.02	<0.02	<0.02	<0.04	<0.04	<10	<10	47	<30	<100
Ponar 30	29-Sep-06	710893	5154249	43	211	120	590	1210	<0.02	0.17	<0.02	<0.02	<0.04	<0.04	<10	15	380	99	<100
Ponar 31	29-Sep-06	710976	5154225	67	303	100	750	3330	<0.06	0.52	<0.06	<0.06	<0.1	<0.1	<30	39	680	250	<100
Ponar 32	29-Sep-06	711080	5154181	43	105	60	500	980	<0.02	0.21	<0.02	<0.02	<0.04	<0.04	<10	20	330	110	<100
Ponar 33	29-Sep-06	711173	5154147	25	80	60	310	330	<0.02	<0.02	<0.02	<0.02	<0.04	<0.04	<10	<10	13	<30	<100
Ponar 34	29-Sep-06	711301	5154092	55	89	40	520	1720	<0.04	<0.04	<0.04	<0.04	<0.08	<0.08	<20	<20	330	180	<100
Ponar 35	29-Sep-06	711105	5154791	48	481	250	530	1790	<0.02	0.28	<0.02	<0.02	<0.04	<0.04	<10	12	560	260	1700
Ponar 36	29-Sep-06	711157	5154755	59	244	100	620	1830	<0.04	0.57	<0.04	<0.04	<0.08	<0.08	<20	49	1000	660	2600
Ponar 37	29-Sep-06	711249	5154683	27	137	100	360	358	<0.02	0.5	<0.02	<0.02	<0.04	<0.04	<10	<10	110	76	780
Ponar 38	29-Sep-06	711408	5154601	42	52	30	430	1080	<0.02	0.03	<0.02	<0.02	<0.04	<0.04	<10	<10	270	120	1100
Ponar 39	29-Sep-06	711392	5155237	53	766	360	580	1290	<0.04	0.11	<0.04	<0.04	<0.08	<0.08	<20	47	800	370	1900
Ponar 40	29-Sep-06	711469	5155217	29	423	300	350	502	<0.02	0.04	<0.02	<0.02	<0.04	<0.04	<10	<10	140	100	810
Ponar 41	29-Sep-06	711529	5155163	21	228	180	120	184	<0.02	0.02	<0.02	<0.02	<0.04	<0.04	<10	<10	19	<30	<100
Ponar 42	29-Sep-06	711624	5155035	69	161	50	570	2880	<0.06	<0.06	<0.06	<0.06	<0.1	<0.1	<30	34	920	840	4200
Ponar 43	30-Sep-06	711667	5155607	69	1000	310	610	2360	<0.06	0.87	<0.06	<0.06	<0.1	<0.1	<30	<30	1000	610	<100
Ponar 44	30-Sep-06	711775	5155565	32	382	260	350	460	0.02	0.04	<0.02	<0.02	<0.04	<0.04	<10	<10	74	57	<100
Ponar 45	30-Sep-06	711845	5155559	22	38	30	150	218	<0.02	<0.02	<0.02	<0.02	<0.04	<0.04	<10	<10	13	<30	<100
Ponar 46	30-Sep-06	711953	5155486	41	17	10	490	854	<0.02	0.03	<0.02	<0.02	<0.04	<0.04	<10	17	440	200	17
Ponar 47	30-Sep-06	711973	5155476	72	<36	<10	580	3610	<0.02	0.12	<0.02	<0.02	<0.04	<0.04	<10	<40	530	380	3600
Ponar 48	30-Sep-06	711866	5156146	74	269	70	550	4410	<0.04	0.24	<0.04	<0.04	<0.08	<0.08	<20	<40	930	650	1100
Ponar 49	30-Sep-06	711917	5156148	67	212	70	670	3520	<0.06	1.4	<0.06	<0.06	<0.1	<0.1	<30	<10	970	650	3600
Ponar 50	30-Sep-06	712012	5156127	33	284	190	250	635	<0.02	0.07	<0.02	<0.02	<0.04	<0.04	<10	<10	190	100	<100
Ponar 51	30-Sep-06	712134	5156084	26	95	70	280	303	<0.02	0.02	<0.02	<0.02	<0.04	<0.04	<10	<10	66	50	<100
Ponar 52	30-Sep-06	712239	5156020	40	100	60	450	990	<0.02	0.02	<0.02	<0.02	<0.04	<0.04	<10	<10	350	200	<100
Ponar 53	30-Sep-06	711997	5156465	70	100	30	580	3900	<0.06	0.27	<0.06	<0.06	<0.1	<0.1	<30	<30	1500	1300	4600
Ponar 54	30-Sep-06	712083	5156427	65	800	280	590	2870	<0.06	1	<0.06	<0.06	<0.1	<0.1	<30	<30	930	650	3000
Ponar 55	30-Sep-06	712167	5156383	31	957	660	310	488	0.03	0.08	<0.02	<0.02	<0.04	<0.04	<10	<10	84	23	<100
Ponar 56	30-Sep-06	712257	5156340	29	563	400	340	538	<0.02	0.04	<0.02	<0.02	<0.04	<0.04	<10	<10	110	75	<100

Sample Name	Sample Date	Easting	Northing	% moisture	E-Coli CFU/g dry wt.	E- Coli CFU/g wet wt	Total Phosphorus ug/g dry wt.	TKN ug/g dry wt.	Benzene ug/g dry wt.	Toluene ug/g dry wt.	Ethylbenzene ug/g dry wt.	o-Xylene ug/g dry wt.	p+m Xylene ug/g dry wt.	total Xylenes ug/g dry wt.	PHC F1 C6-C10 ug/g dry wt.	PHC F2 C16-C34 ug/g dry wt.	PHC F3 C16-C34 ug/g dry wt.	PHC F4 C34-C50 ug/g dry wt.	PHC F4G >C50 ug/g dry wt.
Ponar 57	30-Sep-06	712360	5156275	43	35	20	460	1030	<0.02	0.04	<0.02	<0.02	<0.04	<0.04	<10	14	560	290	<100
Ponar 58	30-Sep-06	713347	5157532	27	288	210	250	435	<0.02	0.04	<0.02	<0.02	<0.04	<0.04	<10	<10	87	63	<100
Ponar 59	30-Sep-06	713425	5157437	38	290	180	330	224	<0.02	<0.02	<0.02	<0.02	<0.04	<0.04	<10	<10	17	<30	<100
Ponar 60	30-Sep-06	713478	5157315	62	158	60	610	2160	<0.06	<0.06	<0.06	<0.06	<0.1	<0.1	<30	<30	1100	540	<100
Ponar 61	30-Sep-06	713504	5157315	74	38	10	560	3910	<0.08	<0.08	<0.08	<0.08	<0.2	<0.2	<40	<40	430	320	<100
Core 1_1cm	26-Sep-06	712373	5157111	81	3263	620	750	3290	<0.02	<0.02	<0.02	<0.02	<0.04	<0.04	<10	<10	900	640	<100
Core 2_1cm	26-Sep-06	712368	5156244	56	<23	<10	560	1330	<0.02	<0.02	<0.02	<0.02	<0.04	<0.04	<10	<10	610	710	<100
Core 3_1cm	27-Sep-06	712398	5156786	30	57	40	420	582	<0.02	<0.02	<0.02	<0.02	<0.04	<0.04	<10	<10	110	25	<100
Core 4_1cm	27-Sep-06	712385	5156944	55	89	40	610	1270	<0.02	<0.02	<0.02	<0.02	<0.04	<0.04	<10	<10	600	280	<100
Core 5_1cm	29-Sep-06	710925	5154019	67	273	90	1100	1960	<0.02	<0.02	<0.02	<0.02	<0.04	<0.04	<10	43	1100	470	<100

Appendix C: Core Sample Results

Core 1

Sample Date: 09/26/06
Easting: 712373
Northing: 5157111

cm	E-Coli cfu/g wet wt.	E-Coli cfu/g dry wt.	TKN ug/g dry wt.	TP ug/g dry wt.	Toluene	PHC F2 (C10-C16) ug/g dry	PHC F3 (C16-C34) ug/g dry	PHC F4 (C34-C50) ug/g dry	PHC F4G >C50 ug/g dry wt.
1	620	3263	3290	750	<0.02	<10	900	640	2700
2	120	444	3570	640	<0.02	52	2000	1600	NA
3	70	292	3270	660	<0.02	<10	1900	1600	4500
4	40	148	2510	680	<0.02	110	2800	2200	4500
5	<10	<34	2530	730	<0.02	98	3400	2300	6800
6	10	34	2420	790	<0.02	160	4100	2300	7700
7	20	65	2260	810	<0.02	140	3300	1500	5500
8	<10	<32	2260	820	<0.02	130	3200	1300	4500
9	<10	<32	2340	840	<0.02	160	2600	1000	4200
10	<10	<29	2000	630	<0.02	100	2000	690	3300
11	<10	<26	1630	550	<0.02	50	1300	330	1800
12	<10	<22	1340	470	<0.02	<10	620	120	<100
13	<10	<20	1310	480	<0.02	<10	470	75	<100
14	<10	<18	1130	410	<0.02	12	200	28	<100
15	<10	<17	988	410	<0.02	<10	62	<10	<100
17	<10	<17	1160	400	<0.02	<10	54	<10	<100
19	<10	<16	973	390	<0.02	<10	20	<10	<100
21	<10	<15	827	380	<0.02	<10	0	<10	<100
23	<10	<15	719	400	<0.02	<10	14	<10	<100
25	<10	<15	790	410	<0.02	<10	<10	<10	<100

Core 2

Sample Date: 09/26/06
Easting: 712368
Northing: 5156244

cm	E-Coli cfu/g wet wt.	E-Coli cfu/g dry wt.	TKN ug/g dry wt.	TP ug/g dry wt.	Toluene	PHC F2 (C10-C16) ug/g dry wt.	PHC F3 (C16-C34) ug/g dry wt.	PHC F4 (C34-C50) ug/g dry wt.	PHC F4G >C50 ug/g dry wt.
1	<10	<23	1330	560	0.05	<10	610	270	710
2	<10	<22	1030	560	<0.02	<10	700	280	840
3	<10	<23	1040	560	0.04	<10	830	280	1400
4	10	22	1060	530	<0.02	<10	730	220	1000
5	<10	<19	802	480	<0.02	<10	460	130	<100
6	<10	<17	660	460	<0.02	<10	260	57	<100
7	<10	<15	468	430	<0.02	<10	150	26	<100
8	<10	<15	495	390	<0.02	<10	110	13	<100
9	10	15	553	360	<0.02	<10	88	11	<100
10	<10	<15	535	360	<0.02	<10	73	<10	<100
11	<10	<15	518	360	<0.02	<10	32	<10	<100
12	<10	<15	410	350	<0.02	<10	23	<10	<100
13	<10	<15	390	380	<0.02	<10	33	<10	<100
14	<10	<15	381	380	<0.02	<10	18	<10	<100
15	<10	<16	413	410	<0.02	<10	14	<10	<100
17	<10	<16	646	410	<0.02	<10	13	<10	<100
19	<10	<17	544	440	<0.02	<10	15	<10	<100
21	<10	<18	594	460	<0.02	<10	10	<10	<100

Core 3
Sample Date: 09/26/06
Easting: 712398
Northing: 5156786

cm	E-Coli cfu/g wet wt.	E-Coli cfu/g dry wt.	TKN ug/g dry wt.	TP ug/g dry wt.	Toluene ug/g dry wt.	PHC F2 (C10-C16) ug/g dry	PHC F3 (C16-C34) ug/g dry	PHC F4 (C34-C50) ug/g dry	PHC F4G >C50 ug/g dry
1	40	57	582	420	0.04	<10	110	25	<100
2	40	58	524	380	0.05	<10	160	41	<100
3	20	29	434	440	<0.02	<10	190	55	<100
4	10	14	466	400	0.02	10	300	87	<100
5	<10	<15	386	290	<0.02	11	260	36	<100
6	<10	<14	255	220	<0.02	<10	110	<100	<100
7	<10	<13	195	140	<0.02	<10	57	<100	<100
8	<10	<13	152	160	<0.02	<10	17	<100	<100
9	<10	<13	128	140	<0.02	<10	<10	<100	<100
10	<10	<13	135	110	<0.02	<10	<10	<100	<100
11	<10	<13	118	140	<0.02	<10	<10	<100	<100
12	<10	<13	81	180	<0.02	10	<10	<100	<100
13	<10	<13	120	140	<0.02	<10	<10	<100	<100
14	<10	<13	112	180	<0.02	<10	<10	<100	<100
15	<10	<13	112	86	<0.02	<10	<10	<100	<100

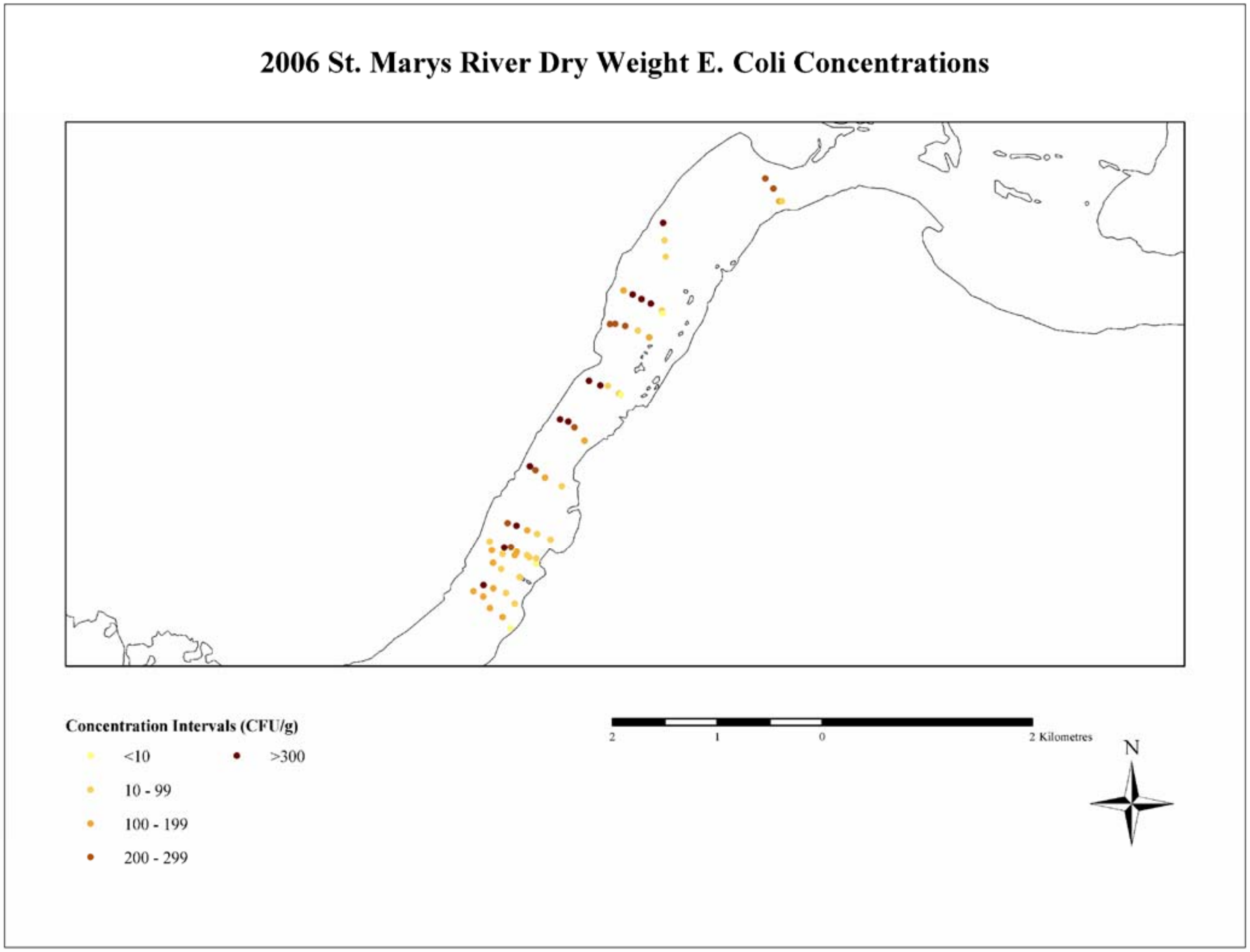
Core 4
Sample Date: 09/26/06
Easting: 712385
Northing: 5156944

cm	E-Coli cfu/g wet wt.	E-Coli cfu/g dry wt.	TKN ug/g dry wt.	TP ug/g dry wt.	Toluene ug/g dry wt.	PHC F2 (C10-C16) ug/g dry wt.	PHC F3 (C16-C34) ug/g dry wt.	PHC F4 (C34-C50) ug/g dry wt.	PHC F4G >C50 ug/g dry wt.
1	40	89	1270	610	<0.02	<10	600	280	1700
2	10	22	1360	590	<0.02	<10	730	340	1800
3	10	22	1440	600	<0.02	33	1300	620	2400
4	20	43	1230	640	<0.02	62	1600	710	3400
5	<10	<24	1360	680	<0.02	150	2400	950	4700
6	<10	<23	1010	790	<0.02	160	2300	800	<100
7	<10	<19	1620	800	<0.02	180	2700	860	<100
8	<10	<27	1750	810	<0.02	190	2500	180	4600
9	<10	<29	1940	810	<0.02	180	2200	680	3700
10	<10	<29	1910	820	<0.02	190	2300	680	<100
11	<10	<30	1990	750	<0.02	160	2200	560	<100
12	<10	<29	1690	740	<0.02	140	2000	510	<100
13	<10	<26	1600	710	<0.02	120	1500	330	<100
14	<10	<26	1420	660	<0.02	78	1300	240	<100
15	<10	<26	1390	620	<0.02	61	1000	140	<100
17	<10	<21	1210	530	<0.02	23	470	42	<100
19	<10	<20	1100	450	<0.02	18	320	23	<100
21	<10	<21	928	520	<0.02	51	620	83	<100
23	<10	<29	1920	720	<0.02	86	1200	160	<100

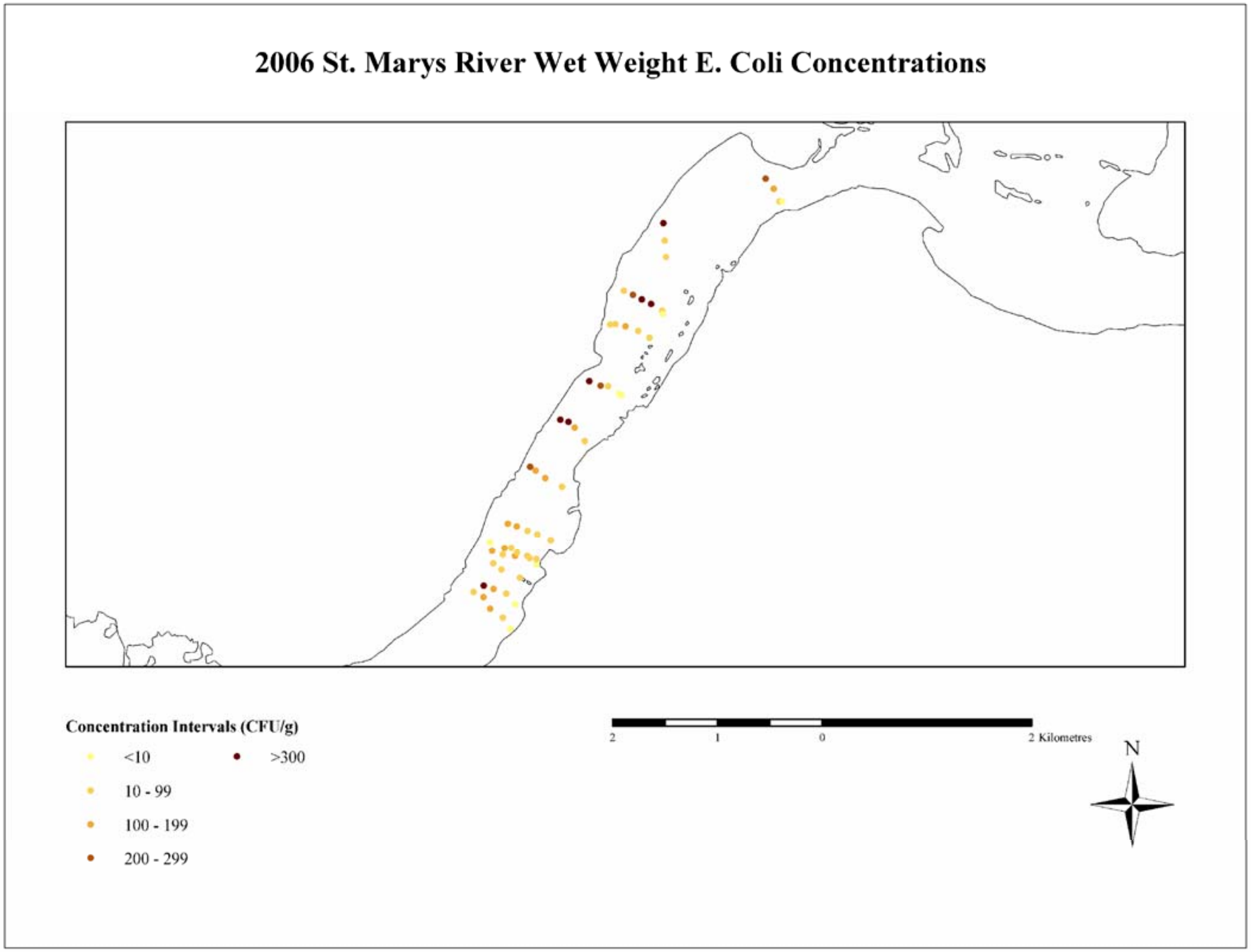
Core 5
Sample Date: 09/29/06
Easting: 710925
Northing: 5154019

cm	E-Coli cfu/g wet wt.	E-Coli cfu/g dry wt.	TKN ug/g dry wt.	TP ug/g dry wt.	Toluene	PHC F2 (C10-C16) ug/g dry	PHC F3 (C16-C34) ug/g dry	PHC F4 (C34-C50) ug/g dry	PHC F4G >C50 ug/g dry
1	90	273	1960	1100	0.36	43	1100	470	2100
2	20	53	1840	1100	0.37	49	1200	540	2200
3	30	75	1610	980	0.26	63	1300	630	2400
4	10	24	2330	770	0.19	97	1800	990	3400
5	10	28	2130	820	0.15	140	2300	1200	4400
6	<10	<25	1590	870	0.16	190	2500	1300	4100
7	10	26	1370	810	0.1	190	2800	1400	5000
8	<10	<29	1830	740	0.11	290	3900	1900	6300
9	<10	<29	1460	890	0.07	220	2700	1200	7200
10	<10	<31	1510	920	<0.02	370	4400	1900	7600
11	10	32	1590	920	<0.02	380	4500	1900	6900
12	<10	<33	1880	760	<0.02	370	4500	1800	6700
13	<10	<32	2020	860	<0.02	330	3800	1500	6200
14	<10	<31	1890	820	<0.02	290	3500	1300	5300
15	<10	<33	1920	780	<0.02	290	3300	1100	4900
17	<10	<34	1860	580	<0.02	280	3100	910	<100
19	<10	<34	1880	730	<0.02	170	2100	510	<100
21	<10	<32	1620	490	<0.02	190	2500	530	<100
23	<10	<19	863	390	<0.02	45	680	170	<100
25	<10	<19	858	370	<0.02	63	810	220	<100

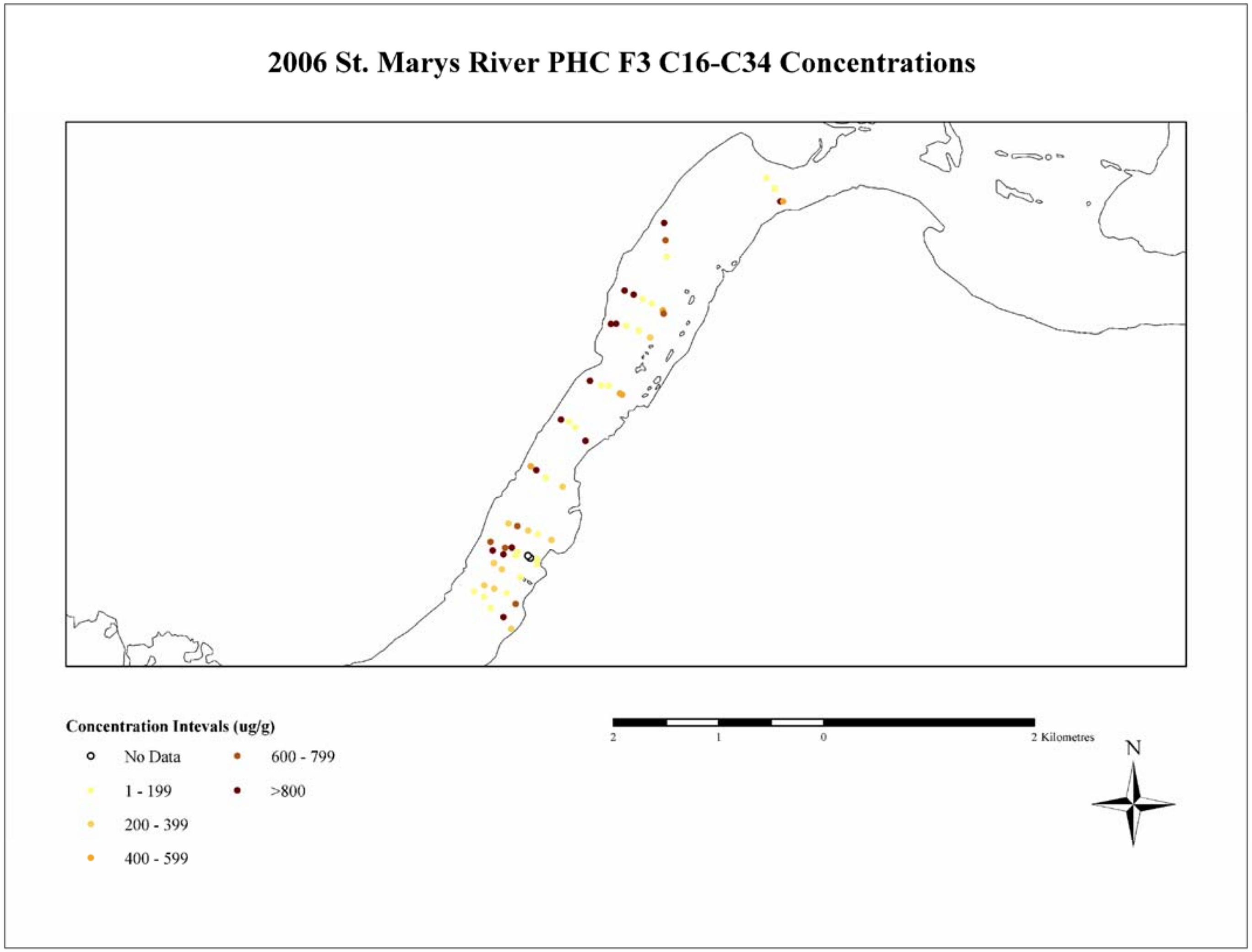
Appendix D: Contaminant Maps



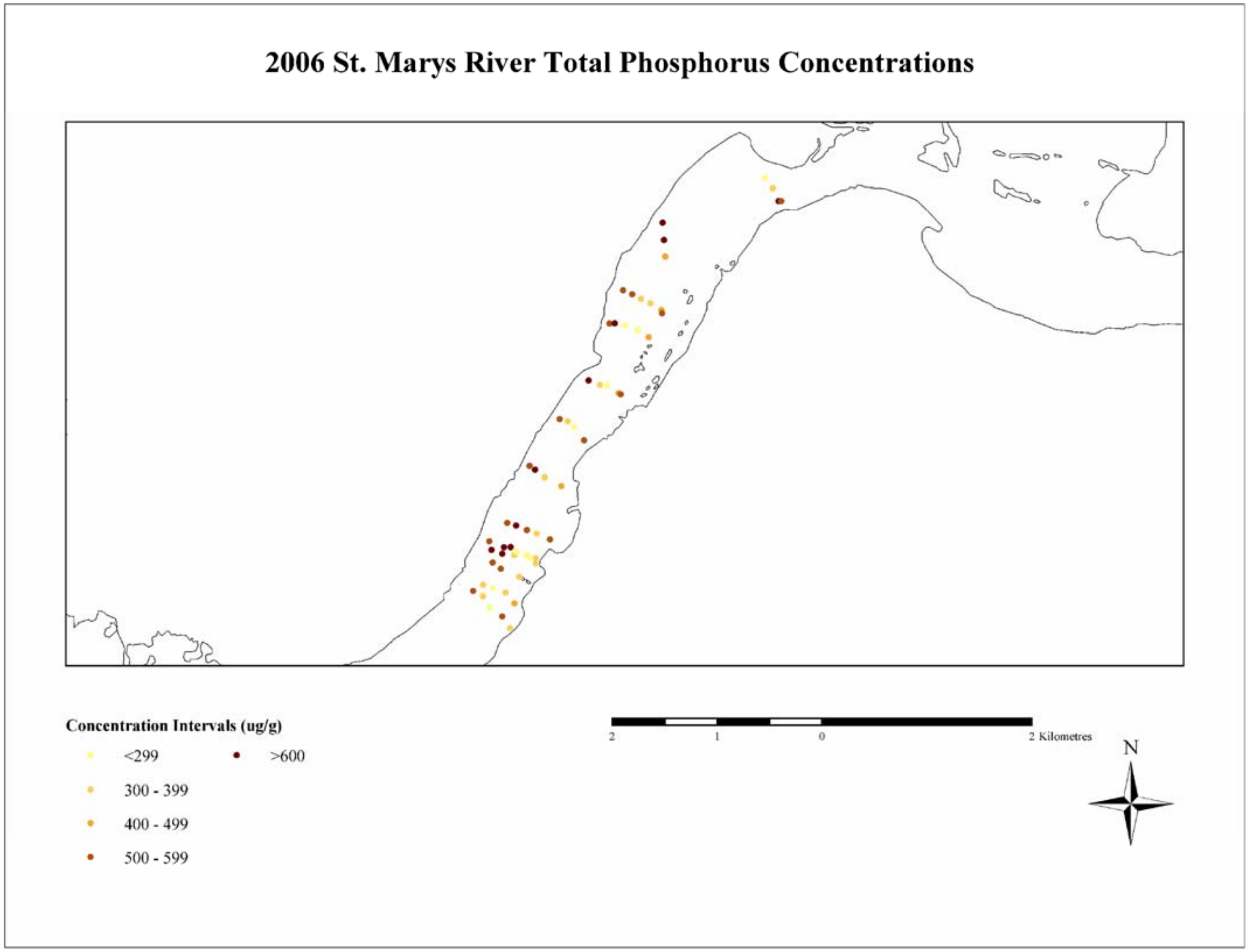
D1: E-Coli Concentrations in the Lake George Channel sediment



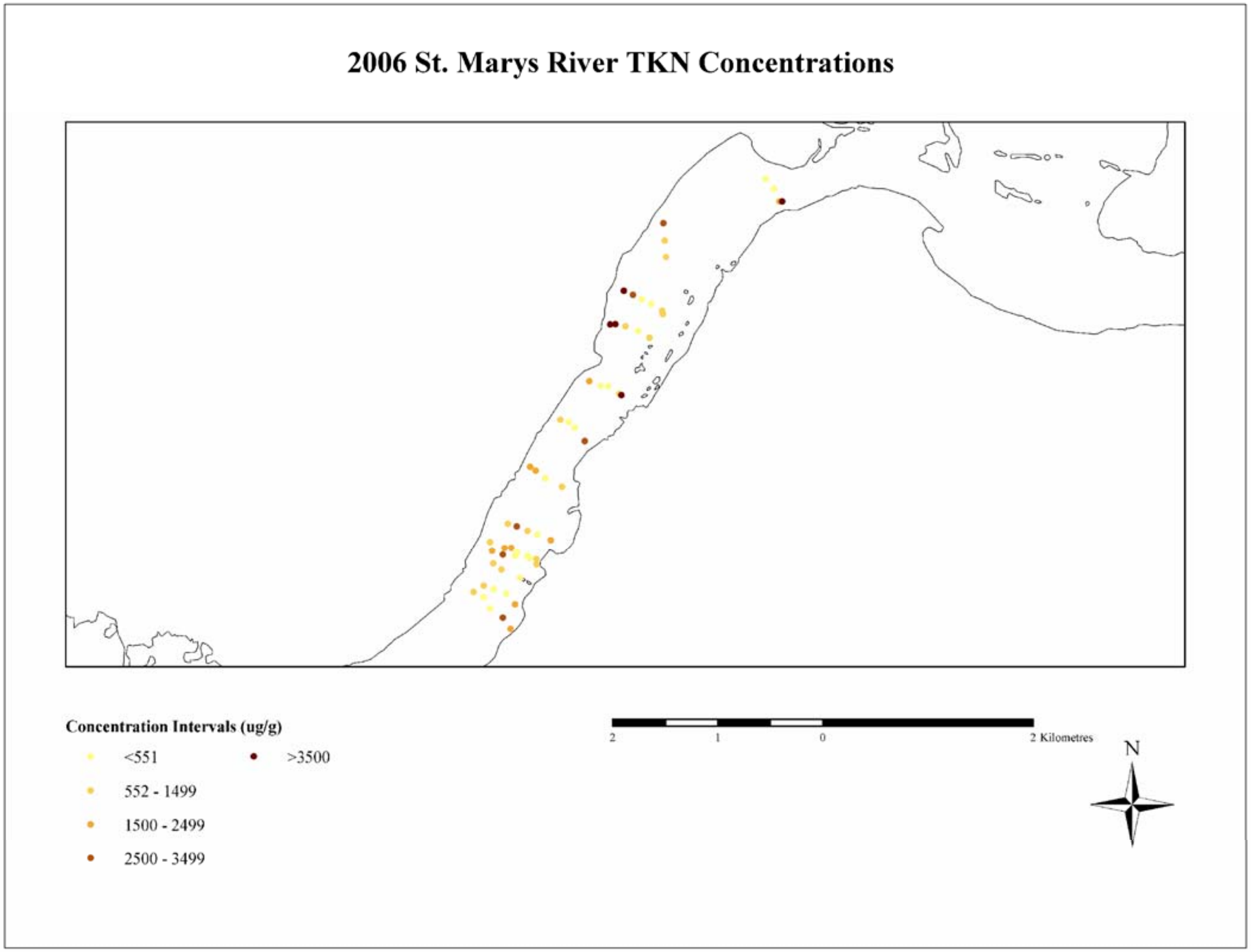
D2: E-Coli Concentrations in the Lake George Channel sediment



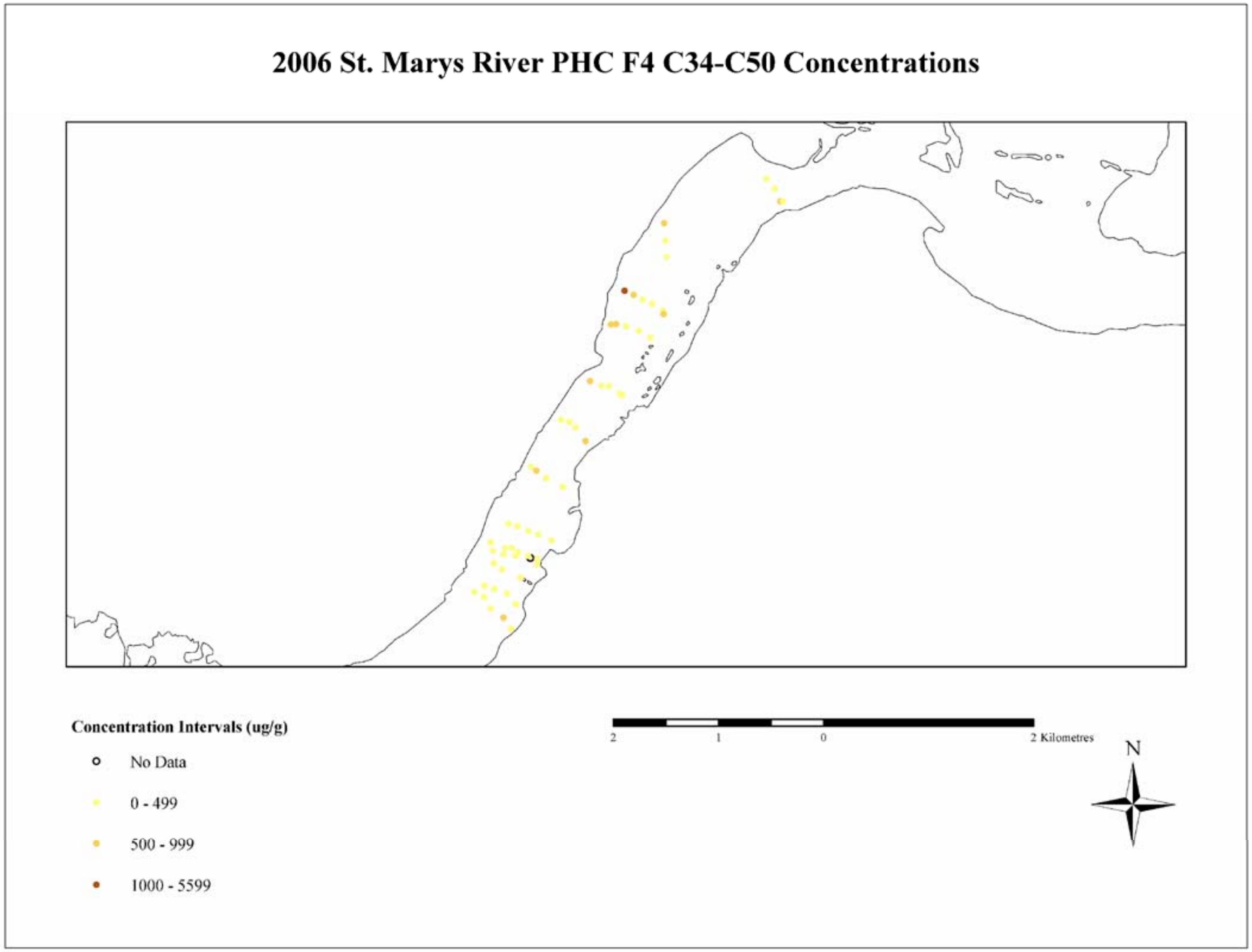
D3: Petroleum Hydrocarbon (F3) Concentrations in the Lake George Channel sediment



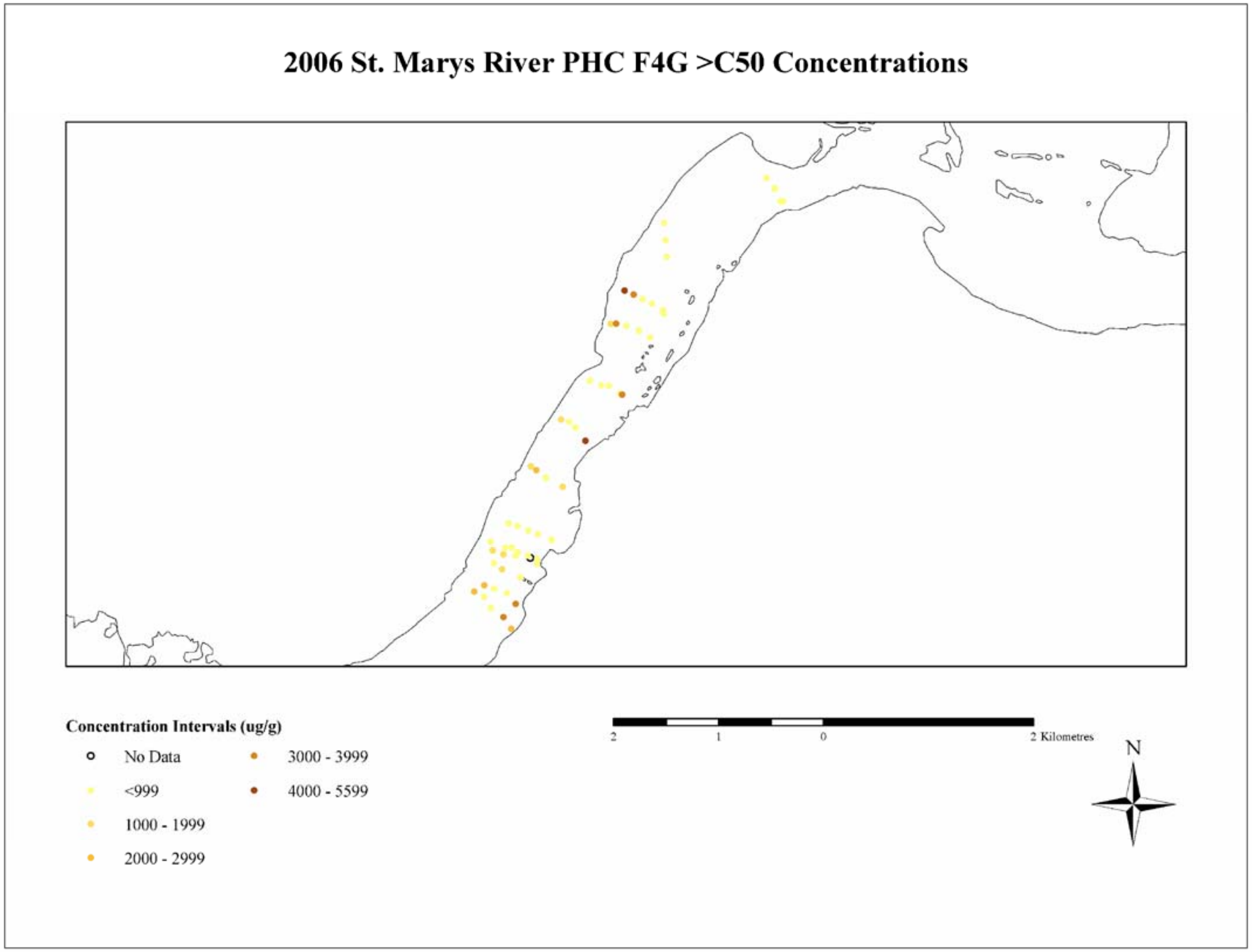
D4:Total Phosphorus Concentrations in the Lake George Channel sediment



D5: Total Kjeldahl Nitrogen Concentrations in the Lake George Channel sediment

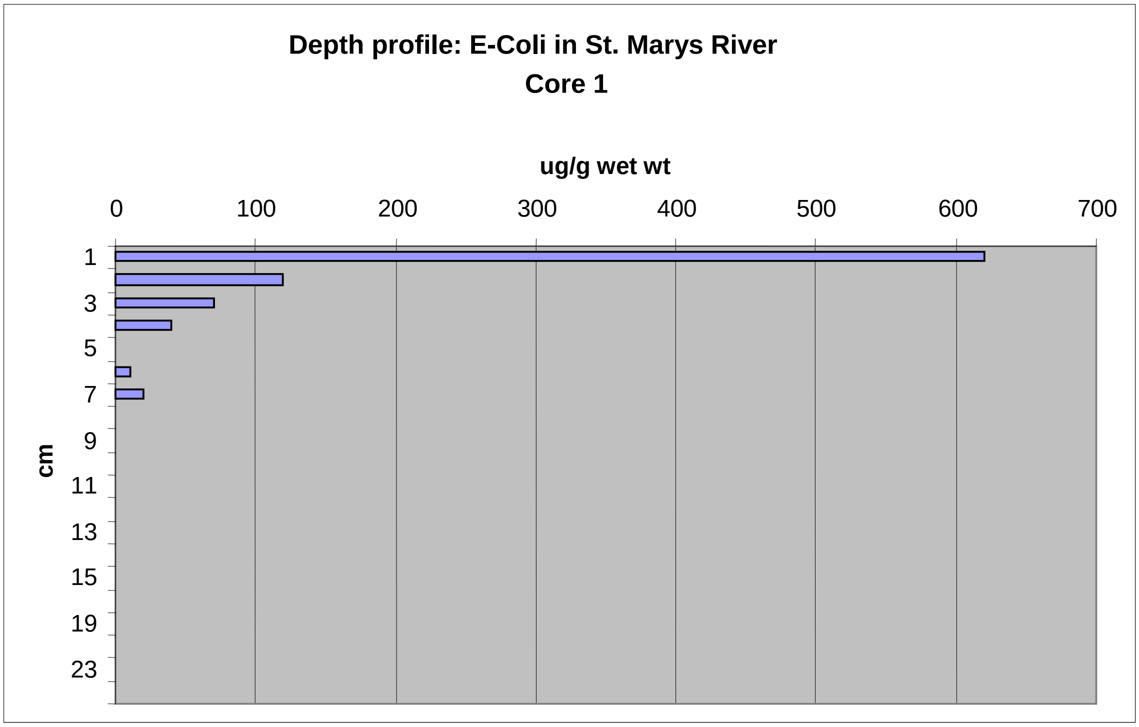


D6: Petroleum Hydrocarbon (F4) Concentrations in the Lake George Channel sediment

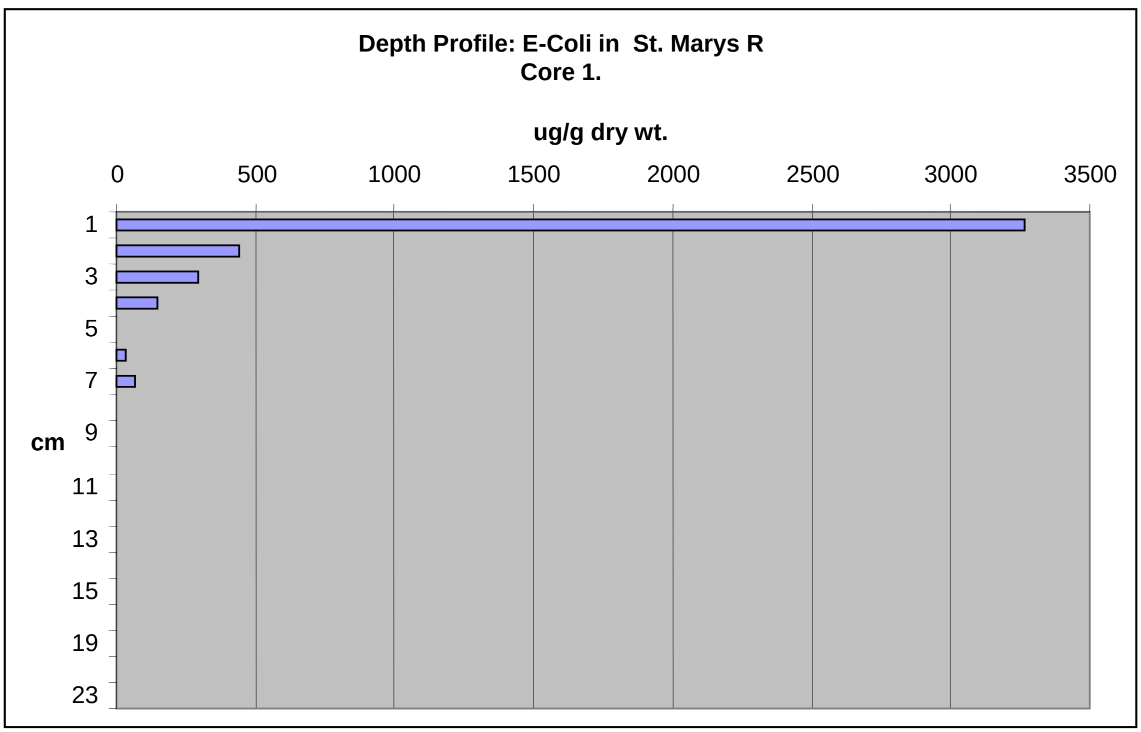


D7: Petroleum Hydrocarbon (F4G) Concentrations in the Lake George Channel sediment

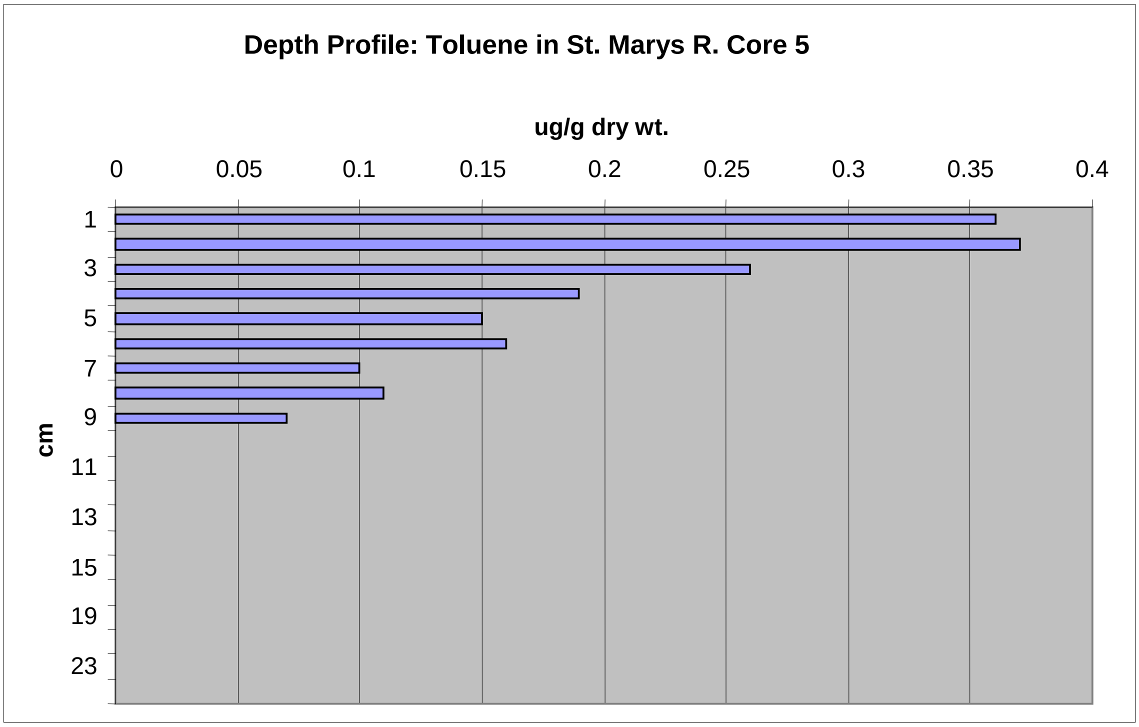
Appendix E: Core Profiles



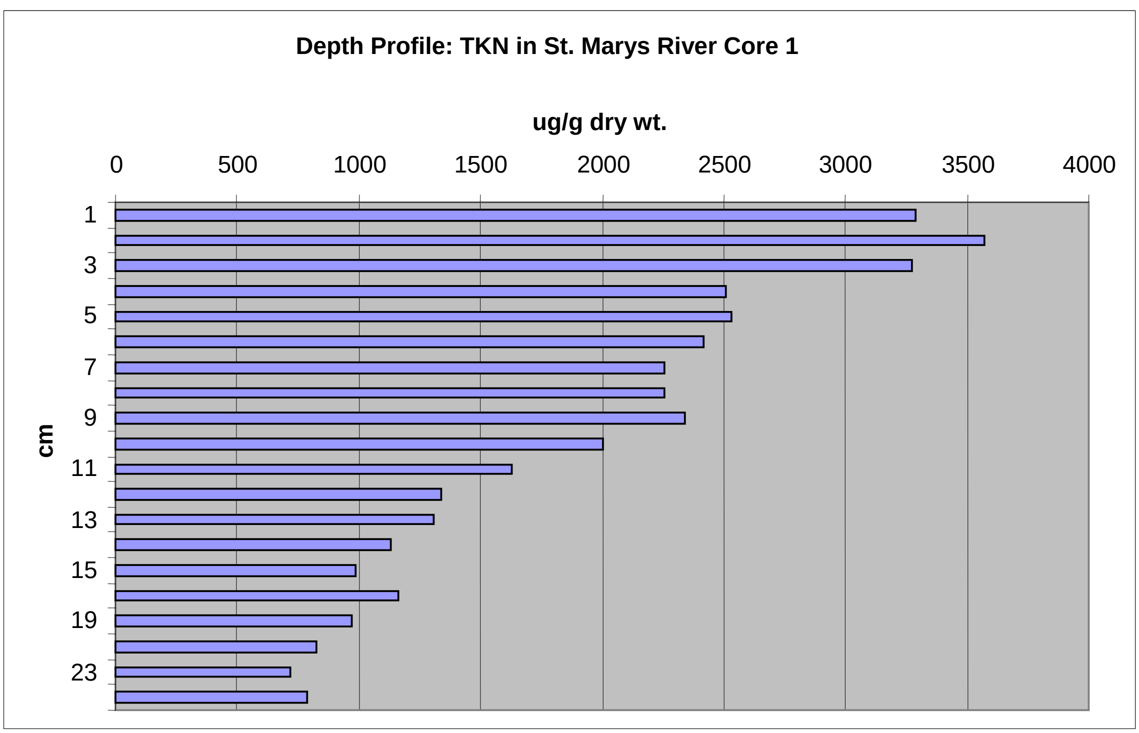
E1: E-Coli wet weight - core 1 depth profile



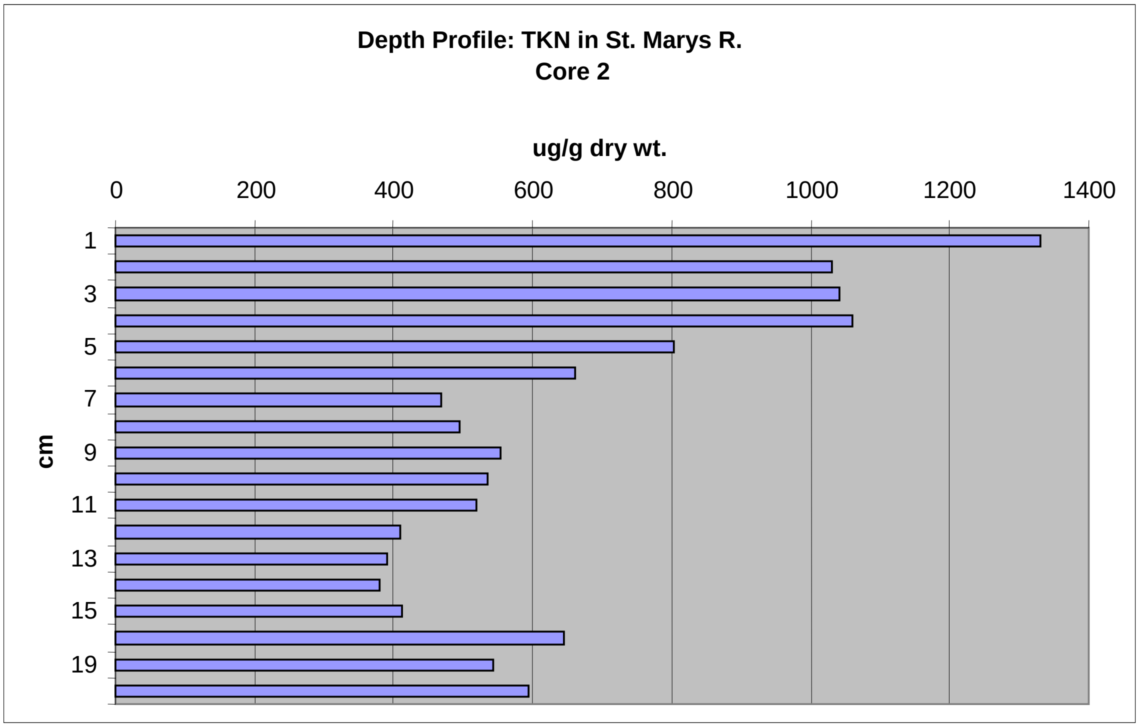
E2: E-Coli dry weight- core 1 depth profile



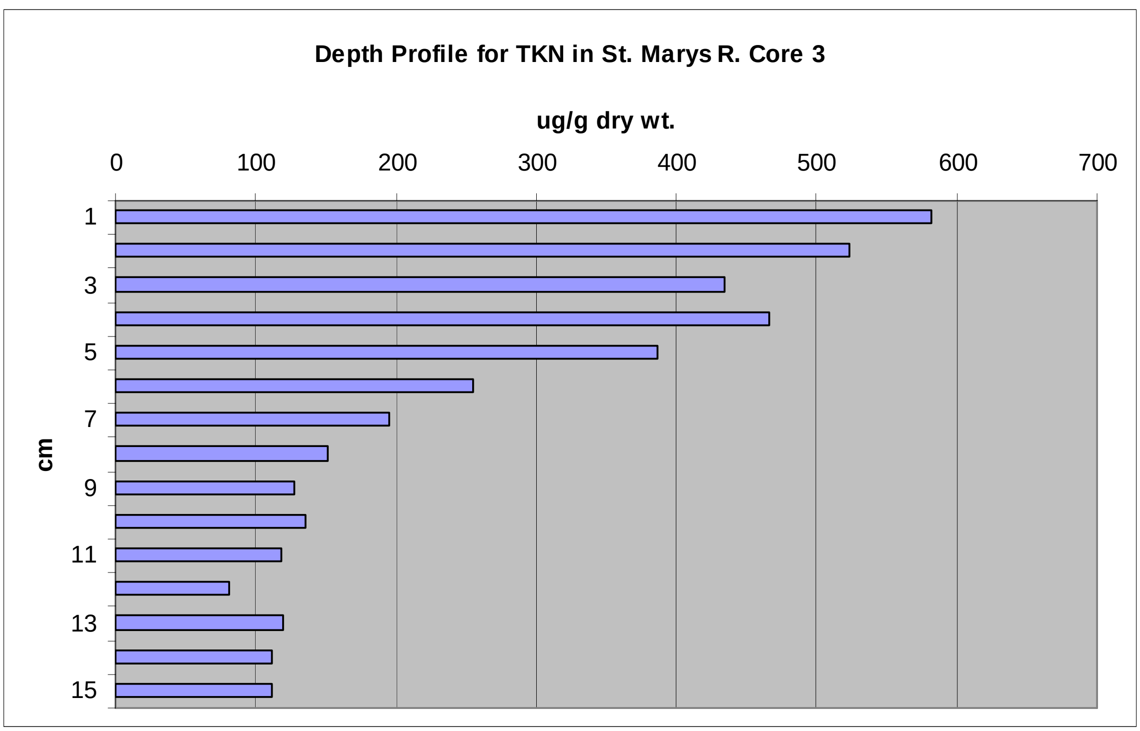
E3: Toluene- core 5 depth profile



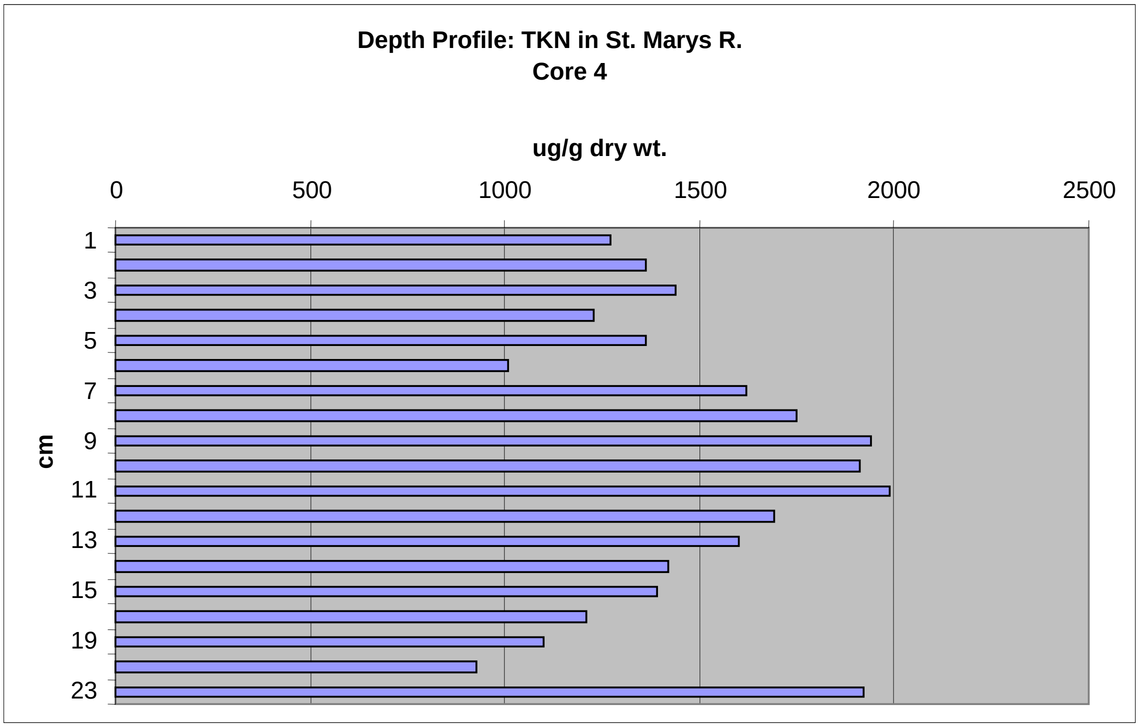
E4: Total kjeldahl nitrogen- core 1 depth profile



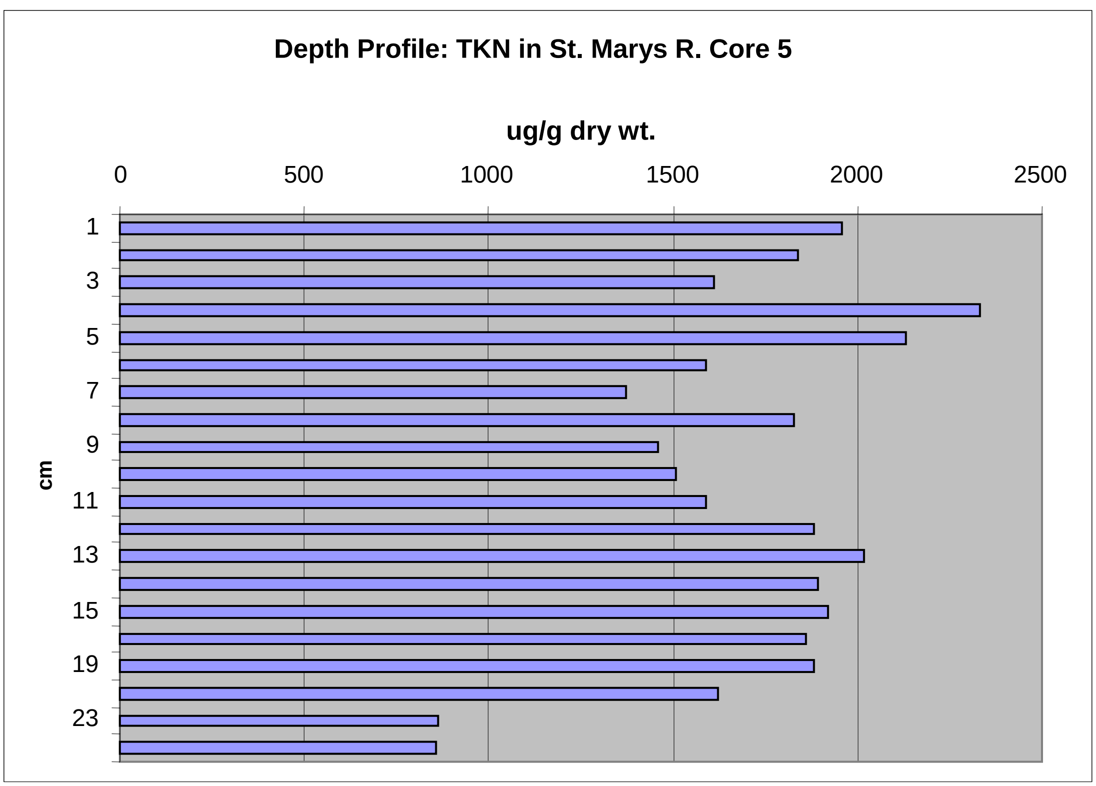
E5: Total kjeldahl nitrogen- core 2 depth profile



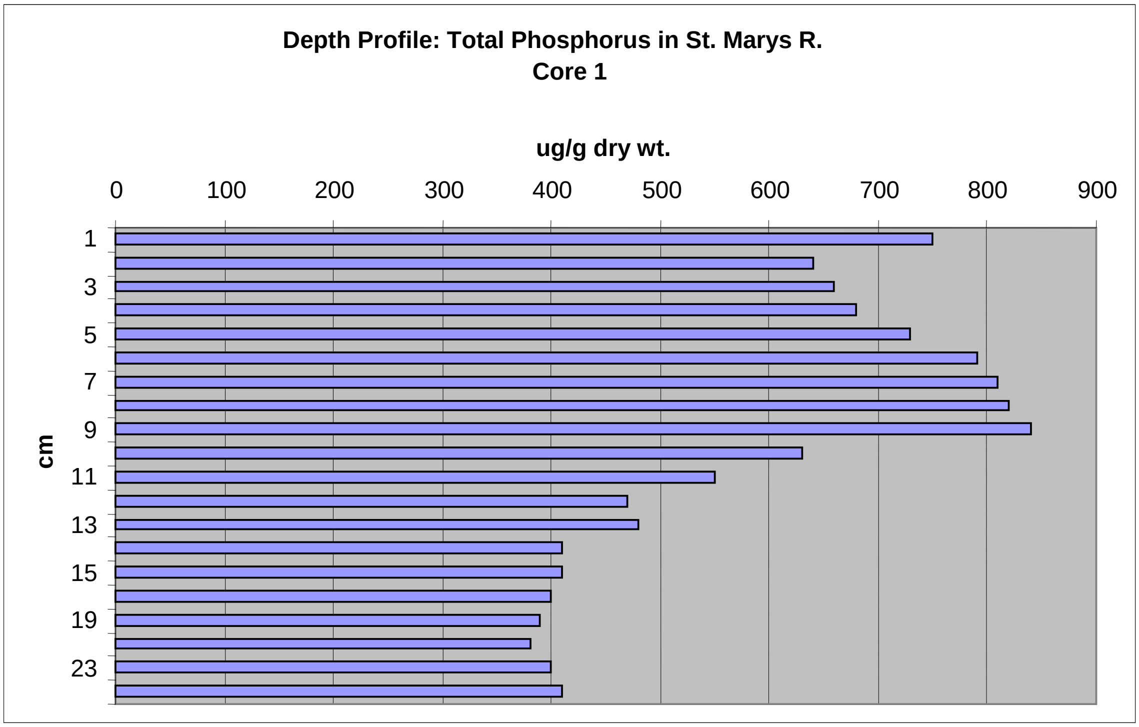
E6: Total kjeldahl nitrogen- core 3 depth profile



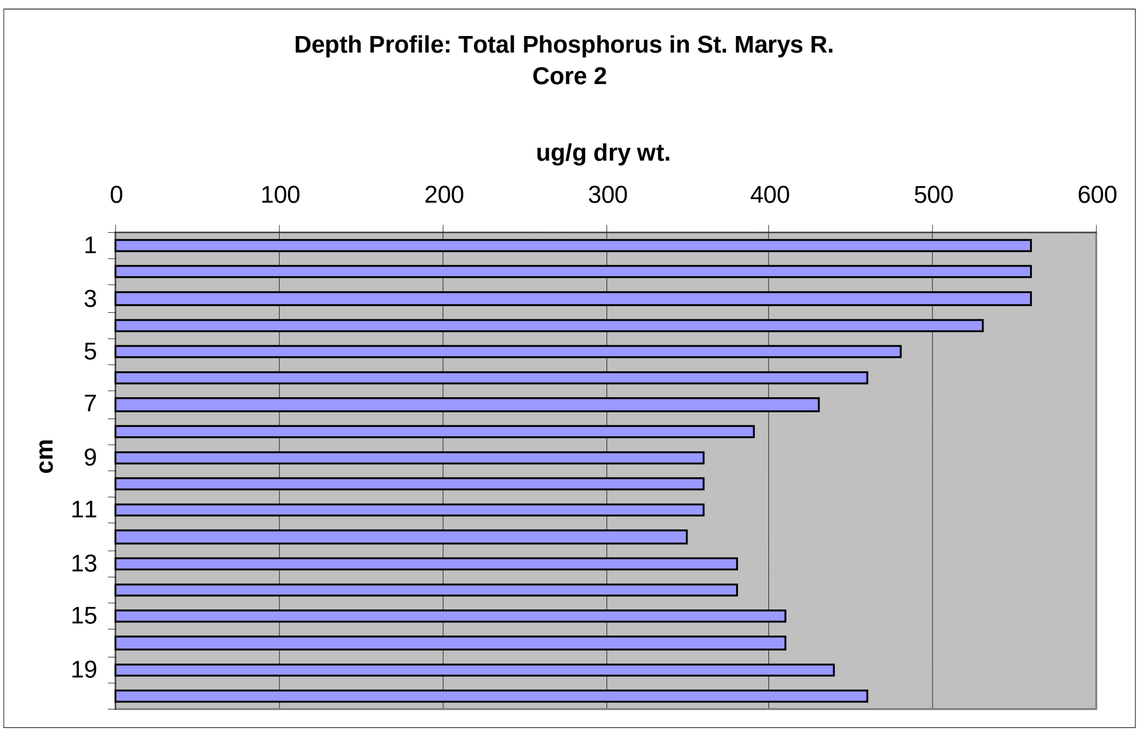
E7: Total kjeldahl nitrogen- core 4 depth profile



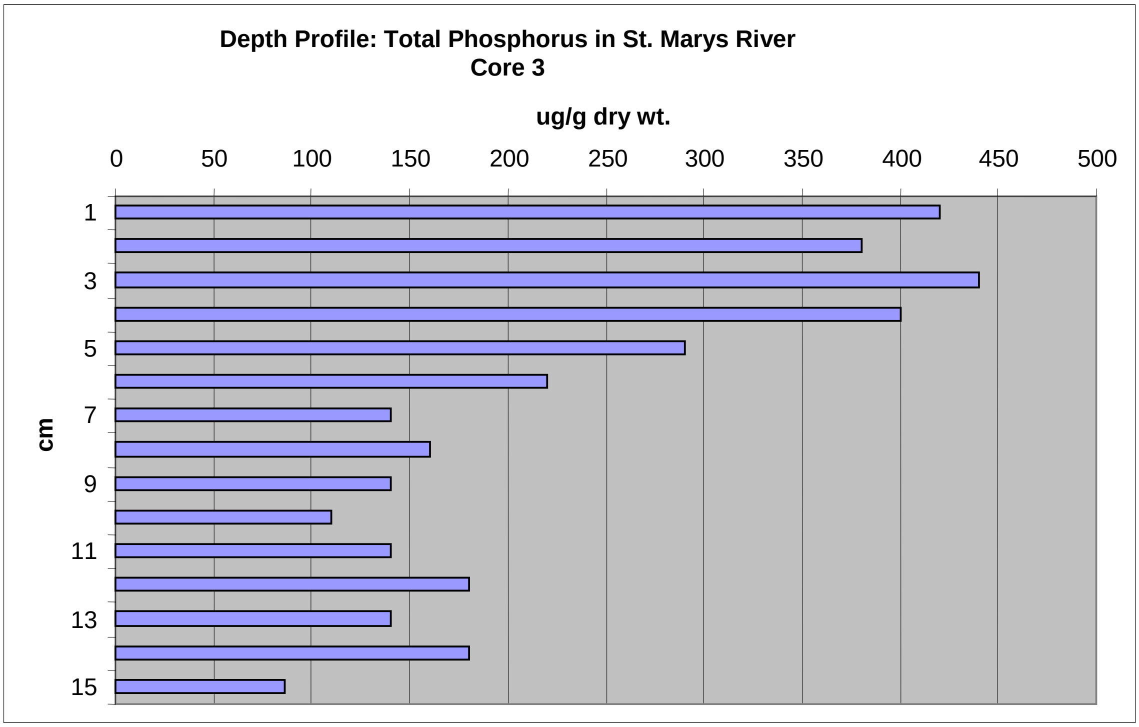
E8: Total kjeldahl nitrogen- core 5 depth profile



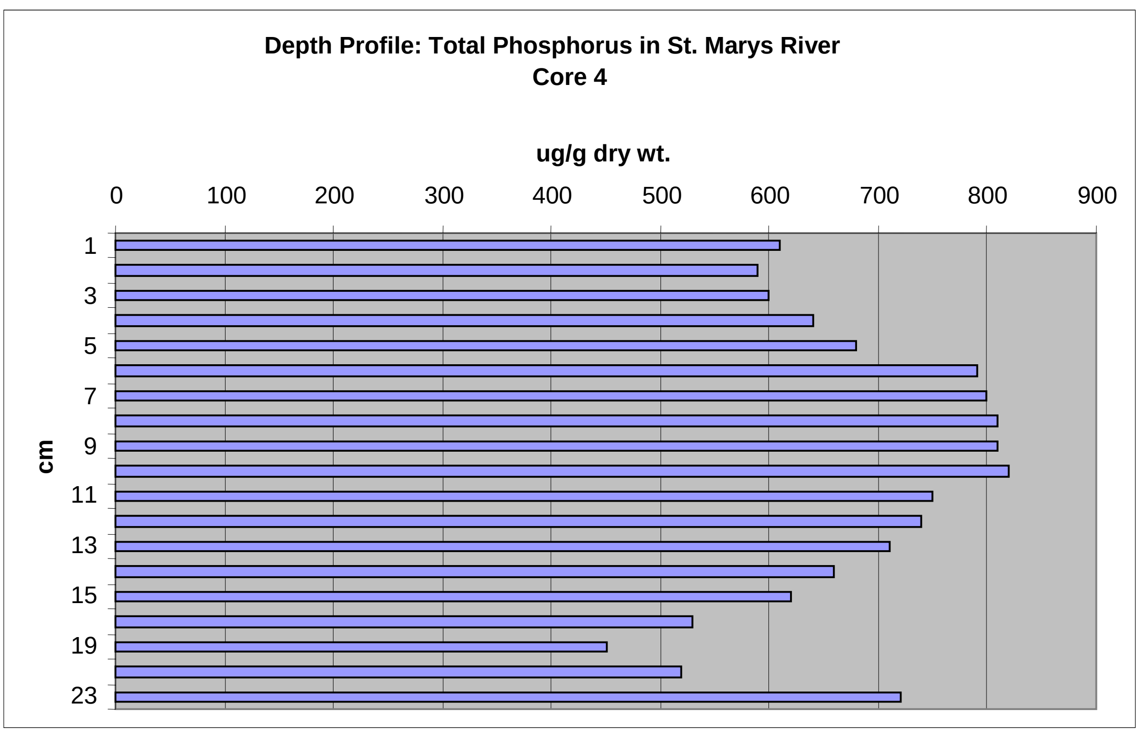
E9: Total phosphorus -core 1 depth profile



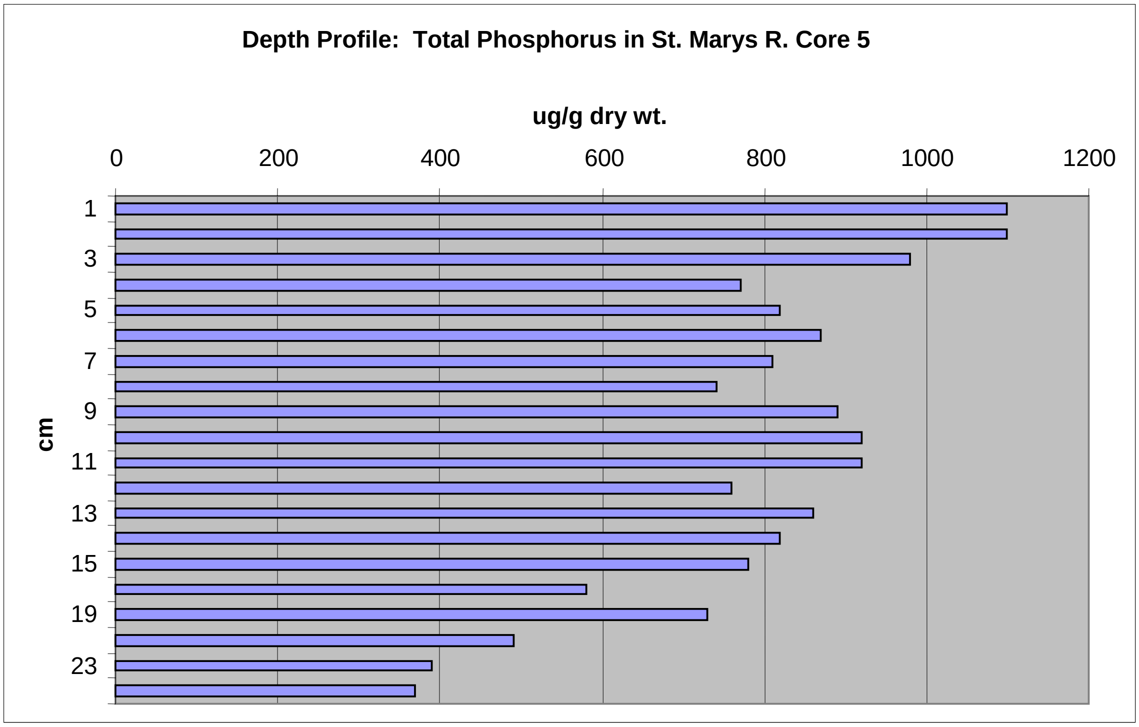
E10: Total phosphorus - core 2 depth profile



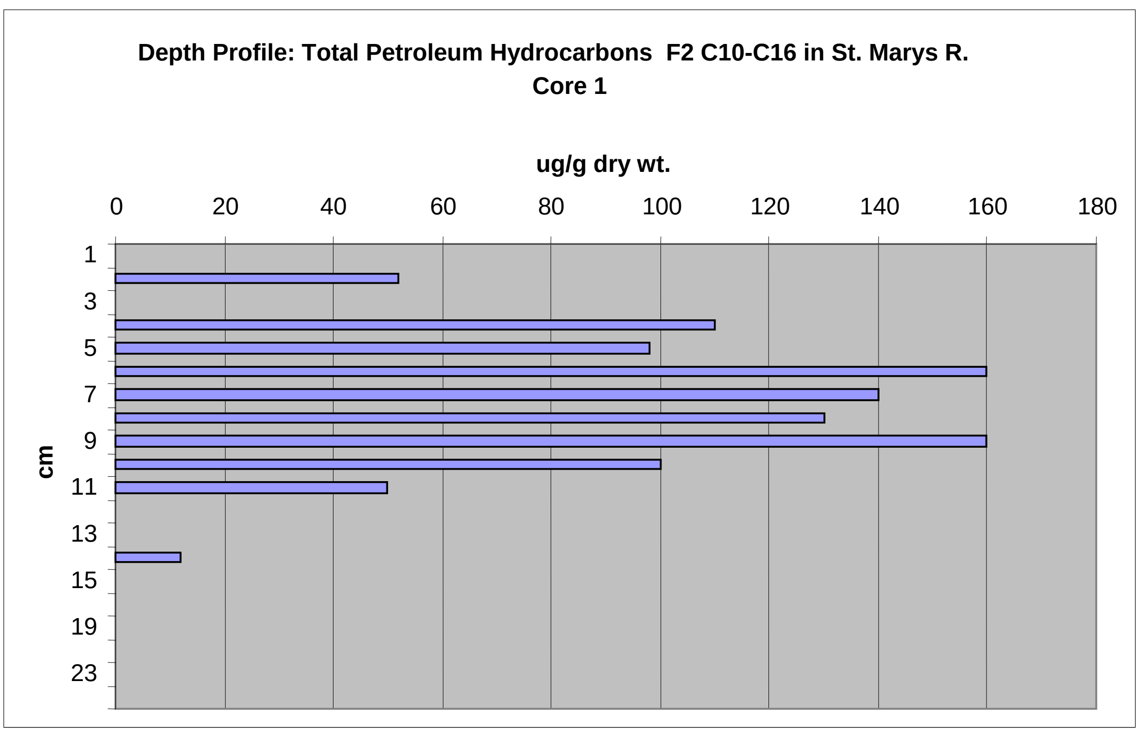
E11: Total phosphorus - core 3 depth profile



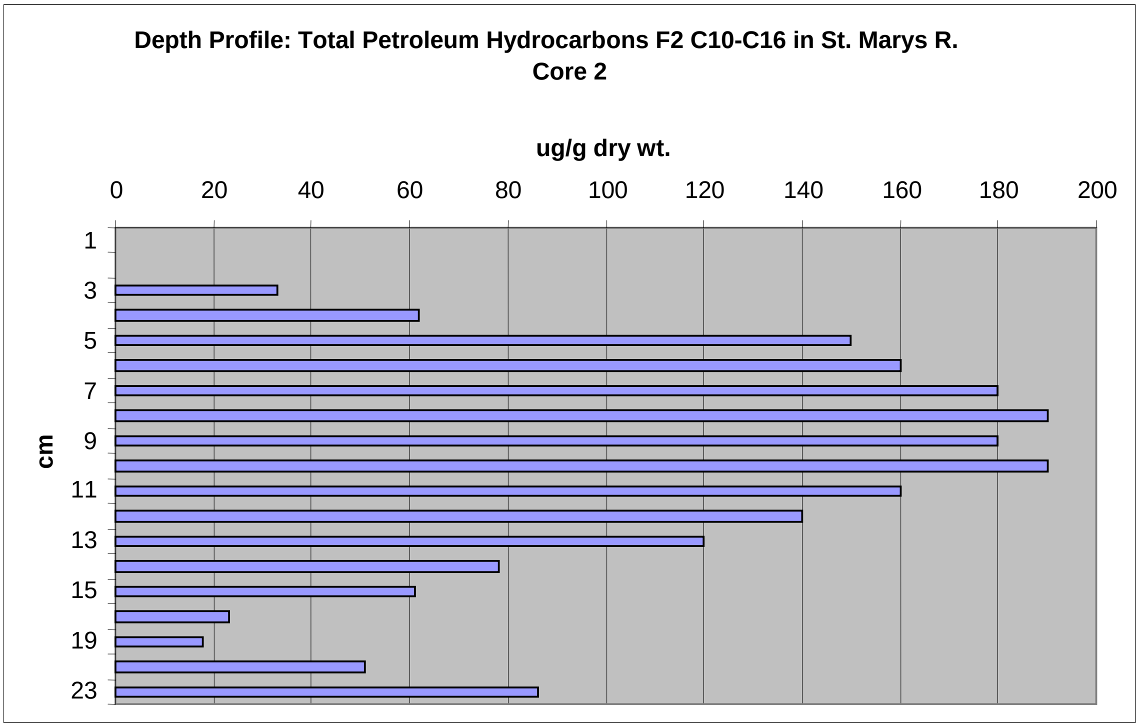
E12: Total phosphorus - core 4 depth profile



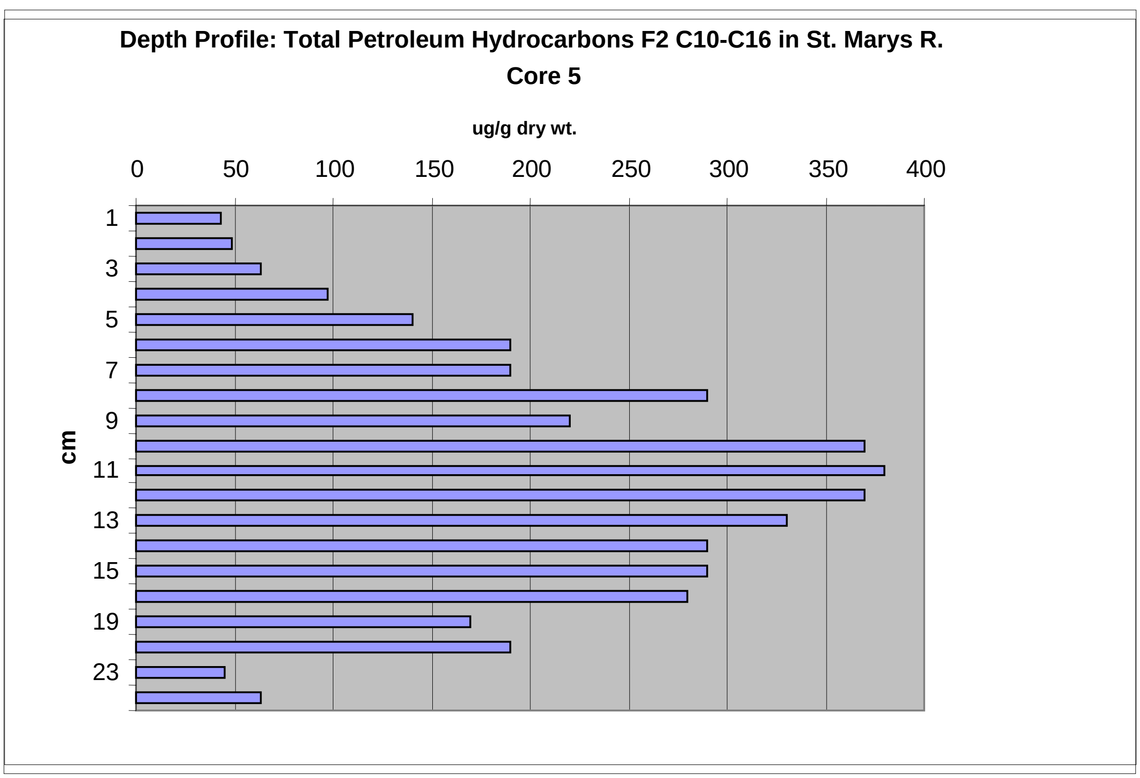
E13: Total phosphorus - core 5 depth profile



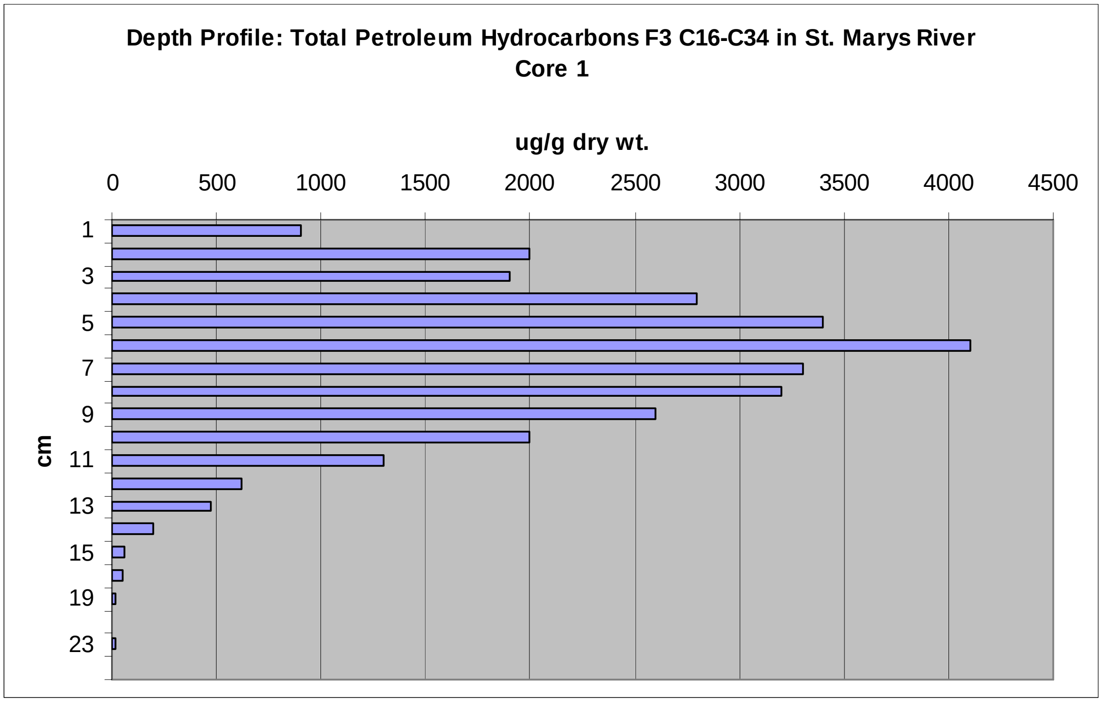
E14: Total petroleum hydrocarbons (F2) - core 1 depth profile



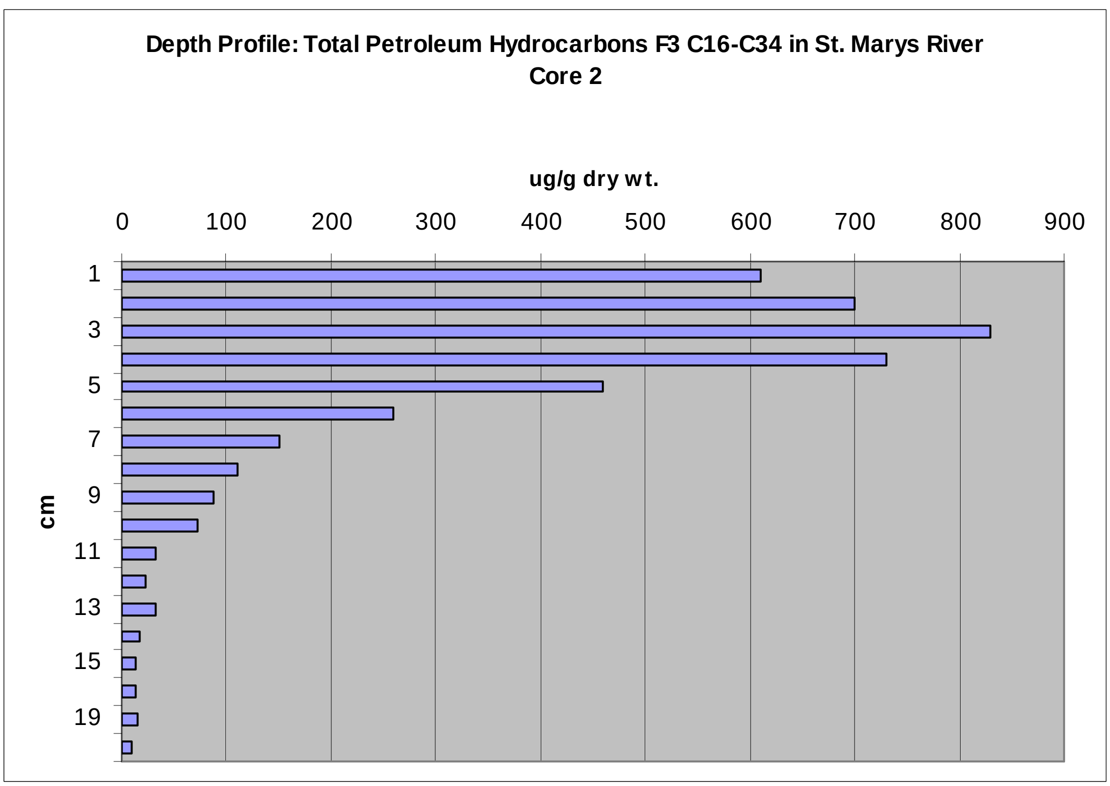
E15: Total petroleum hydrocarbons (F2) - core 2 depth profile



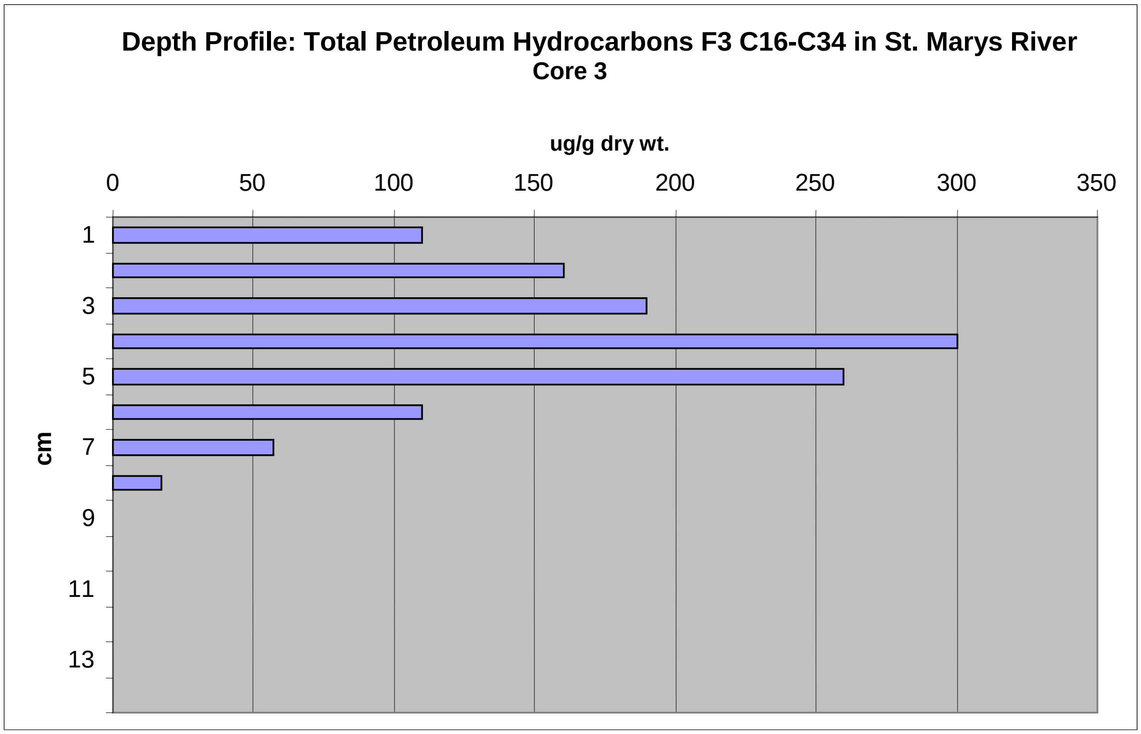
E16: Total petroleum hydrocarbons (F2) - core 5 depth profile



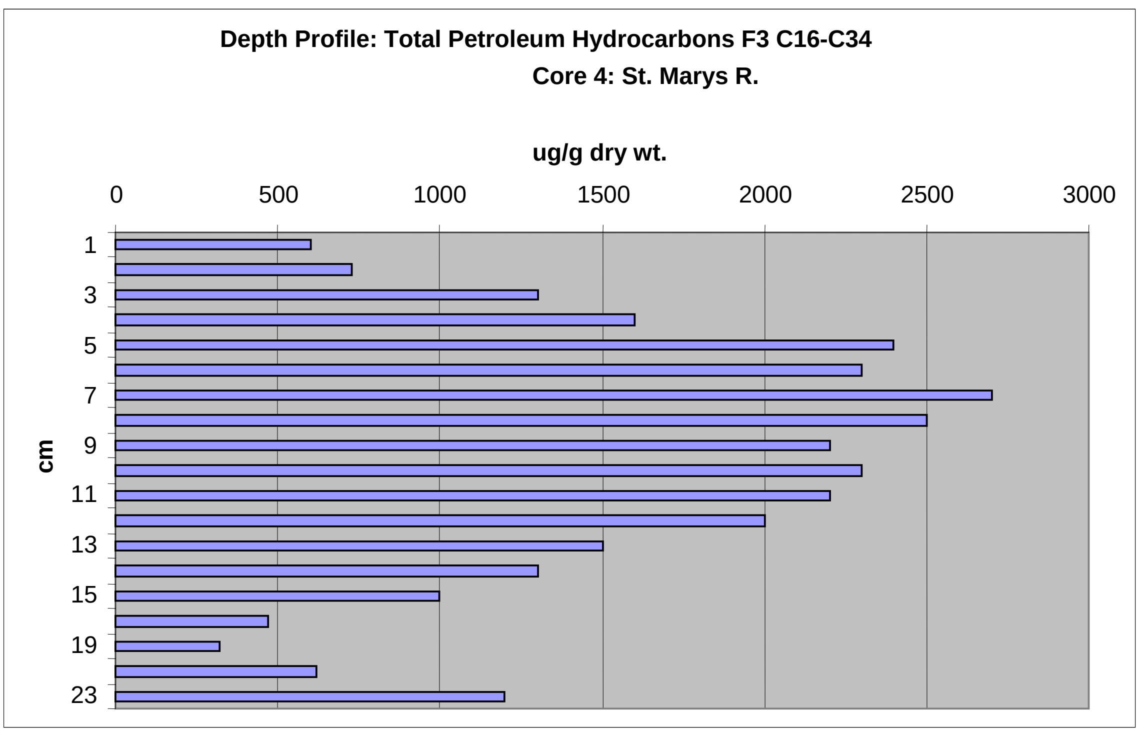
E17: Total petroleum hydrocarbons (F3) - core 1 depth profile



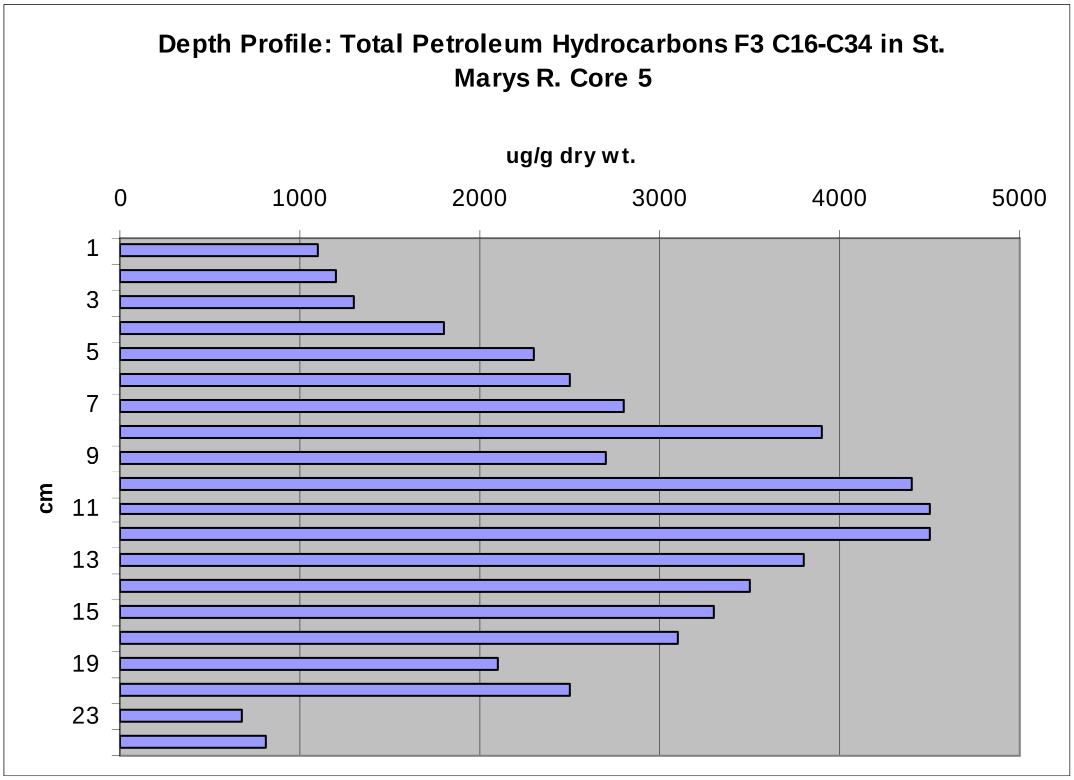
E18: Total petroleum hydrocarbons (F3) - core 2 depth profile



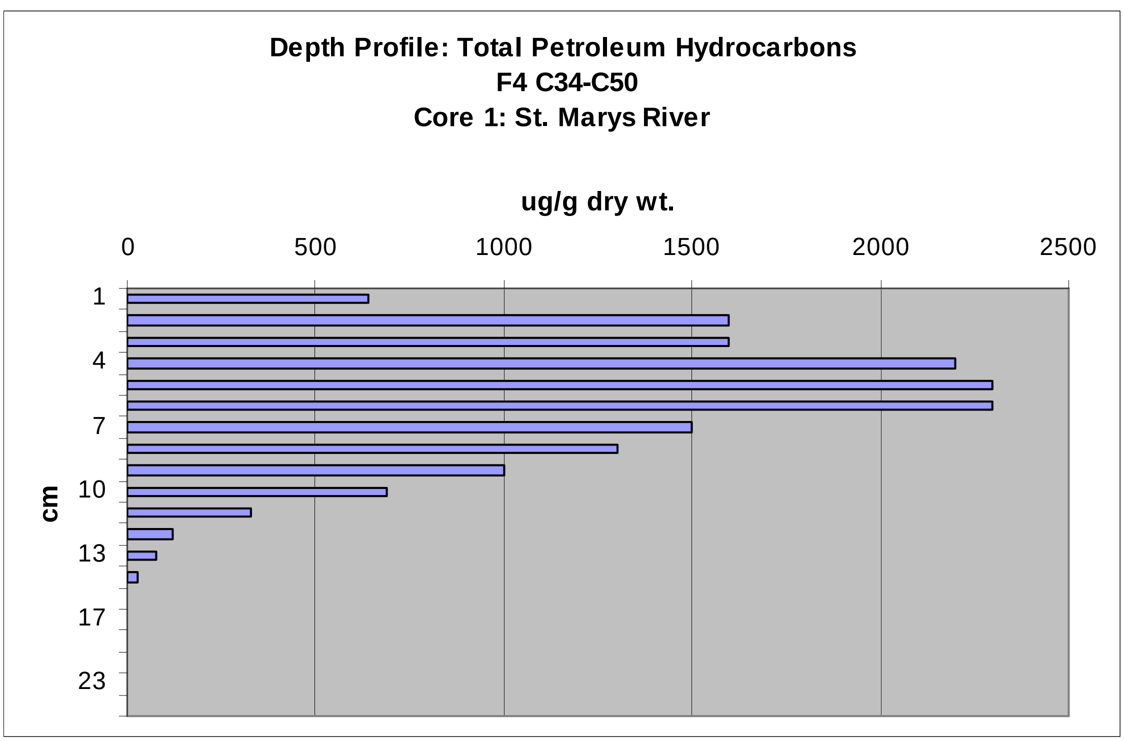
E19: Total petroleum hydrocarbons (F3) - core 3 depth profile



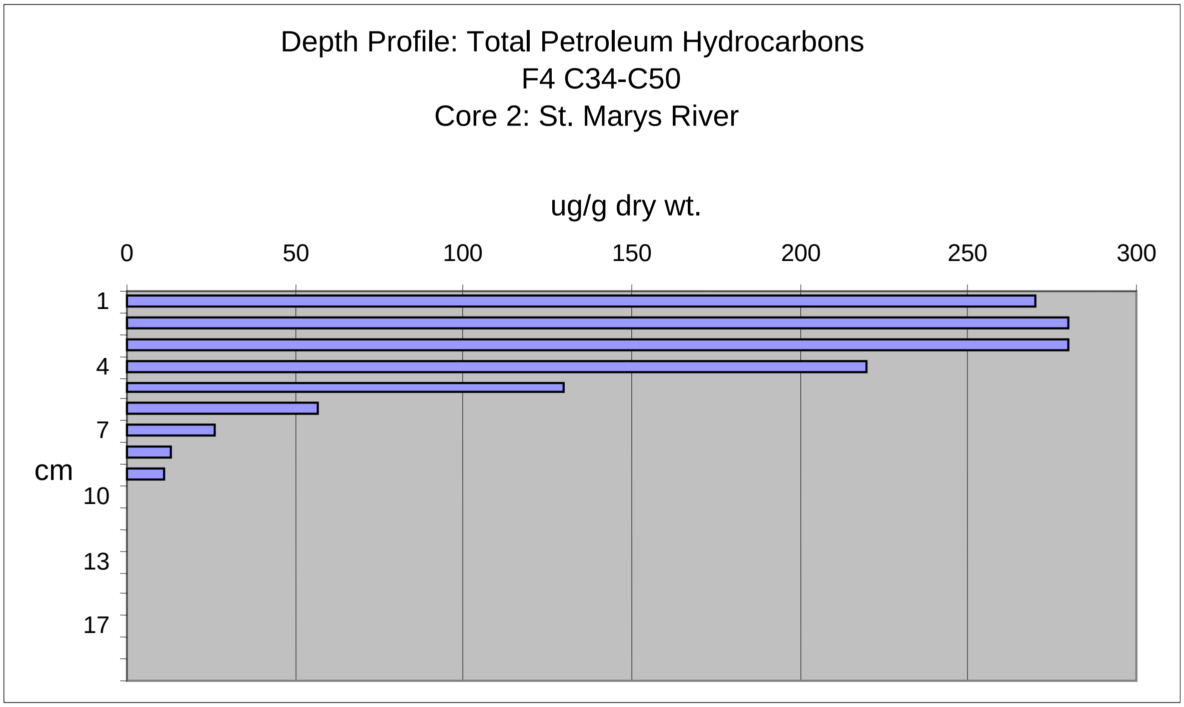
E20: Total petroleum hydrocarbons (F3) - core 4 depth profile



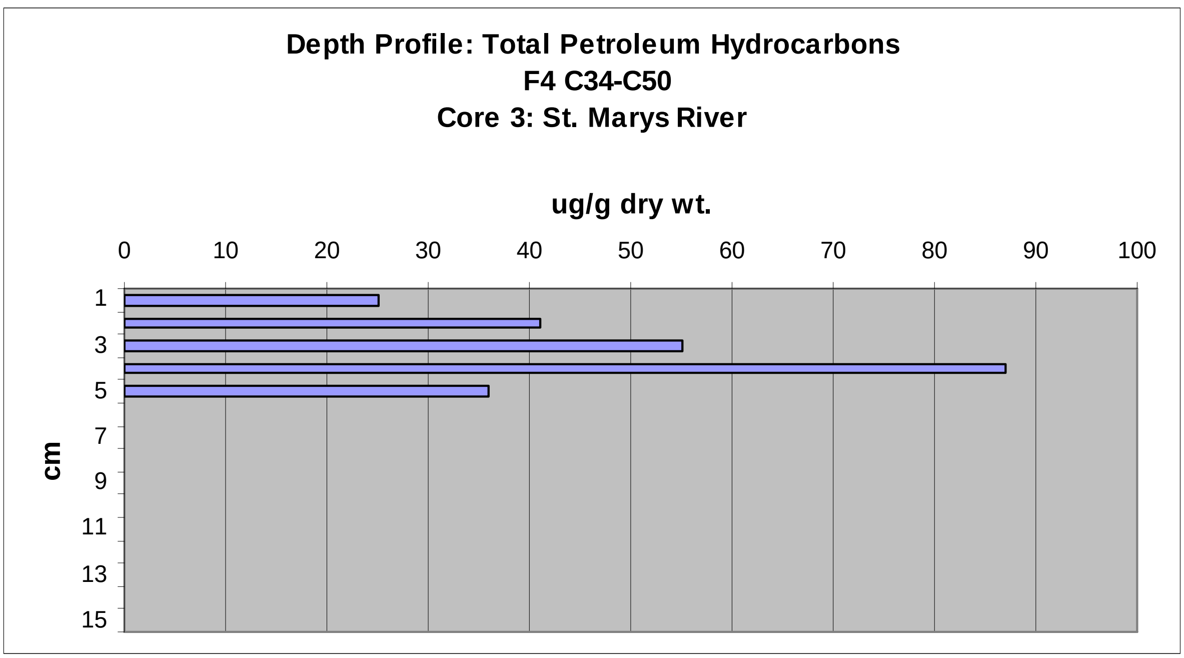
E21: Total petroleum hydrocarbons (F3) - core 5 depth profile



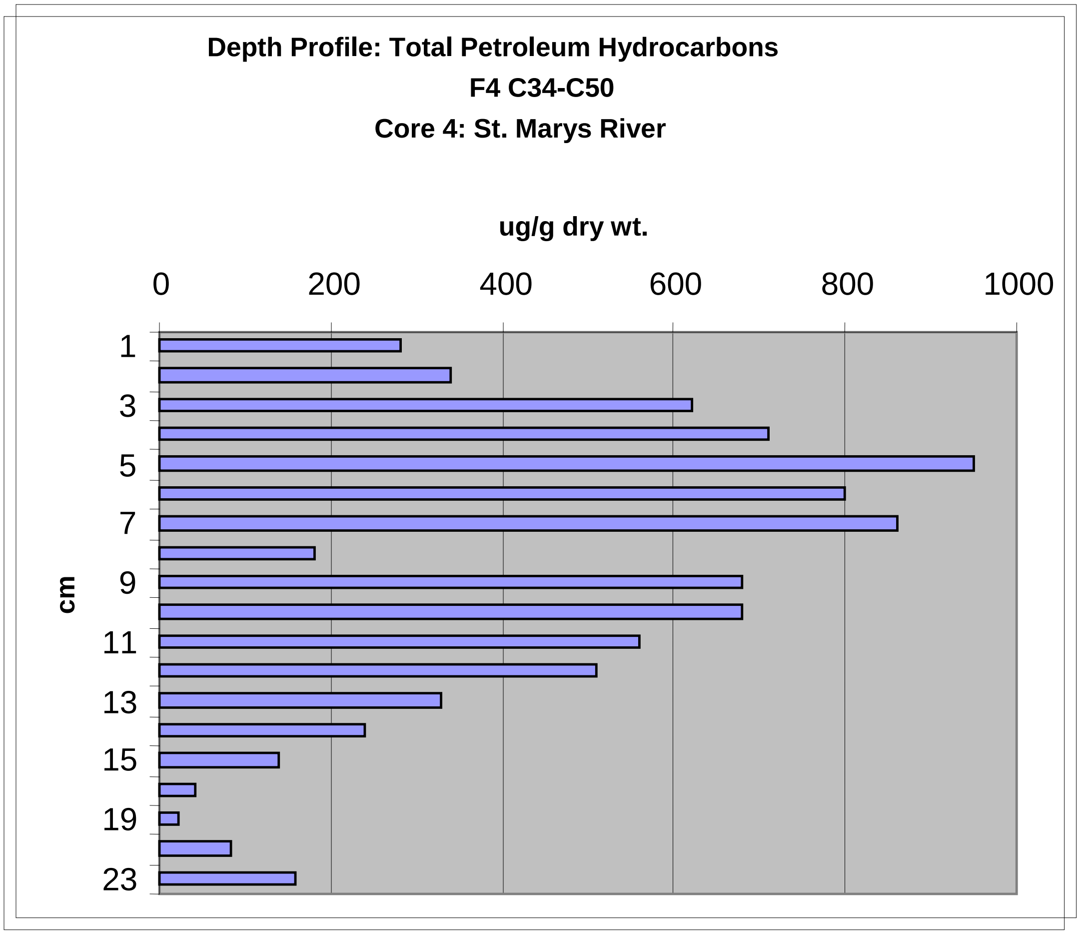
E22: Total petroleum hydrocarbons (F4) - core 1 depth profile



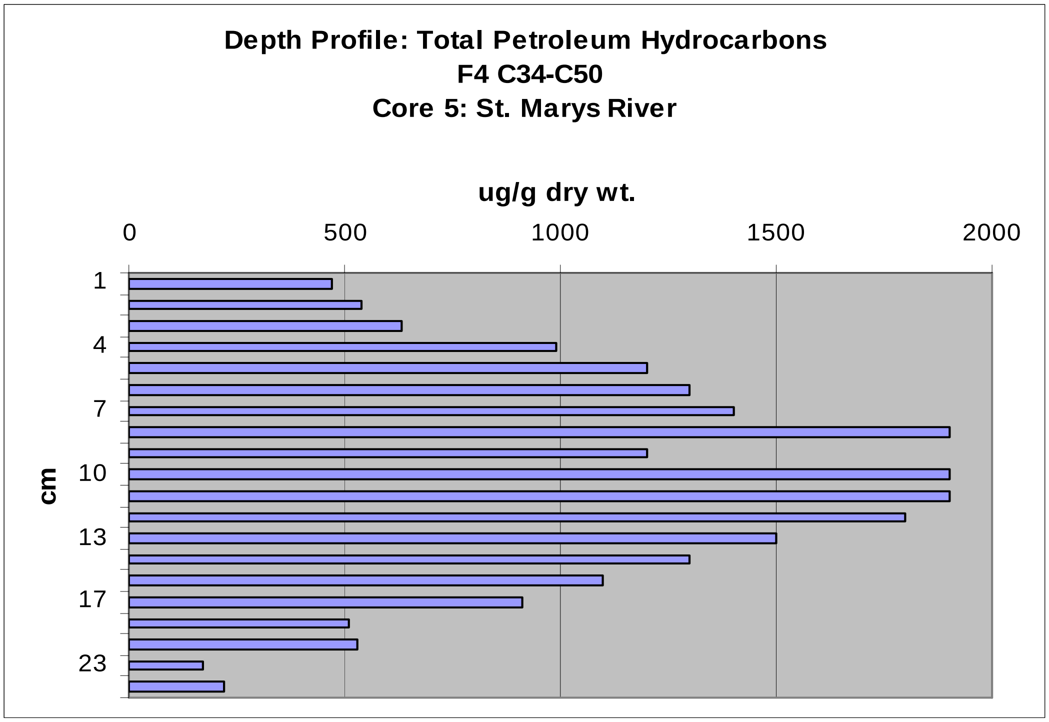
E23: Total petroleum hydrocarbons (F4) - core 2 depth profile



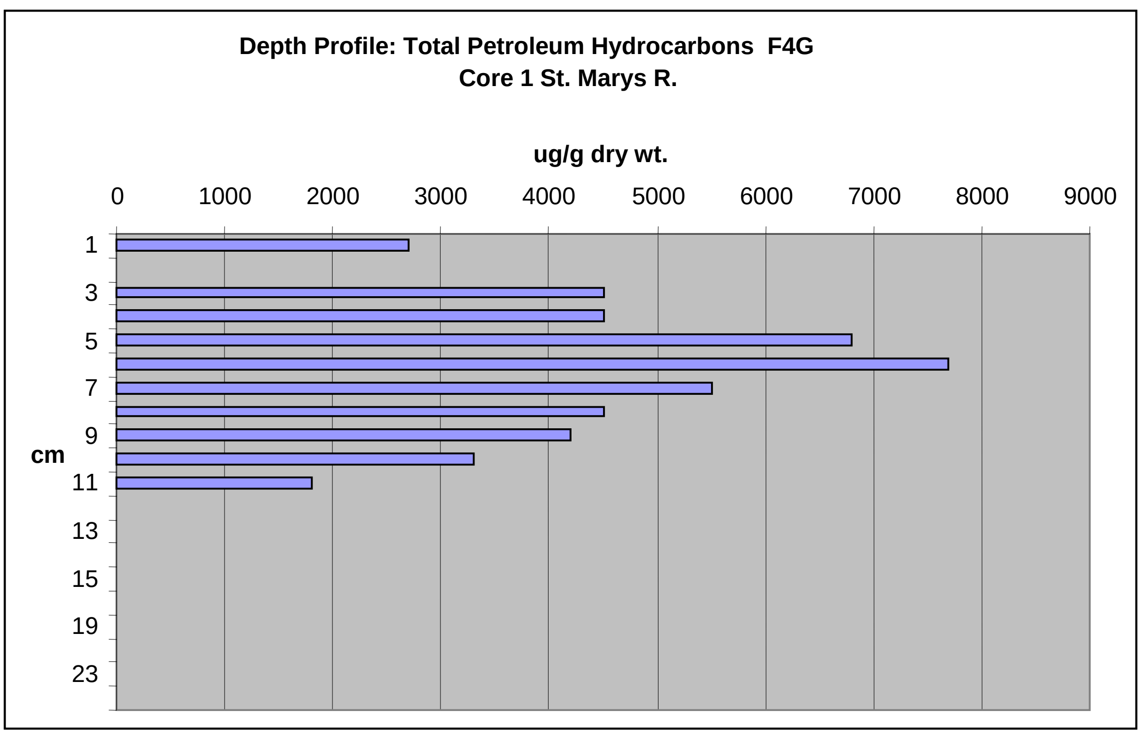
E24: Total petroleum hydrocarbons (F4) - core 3 depth profile



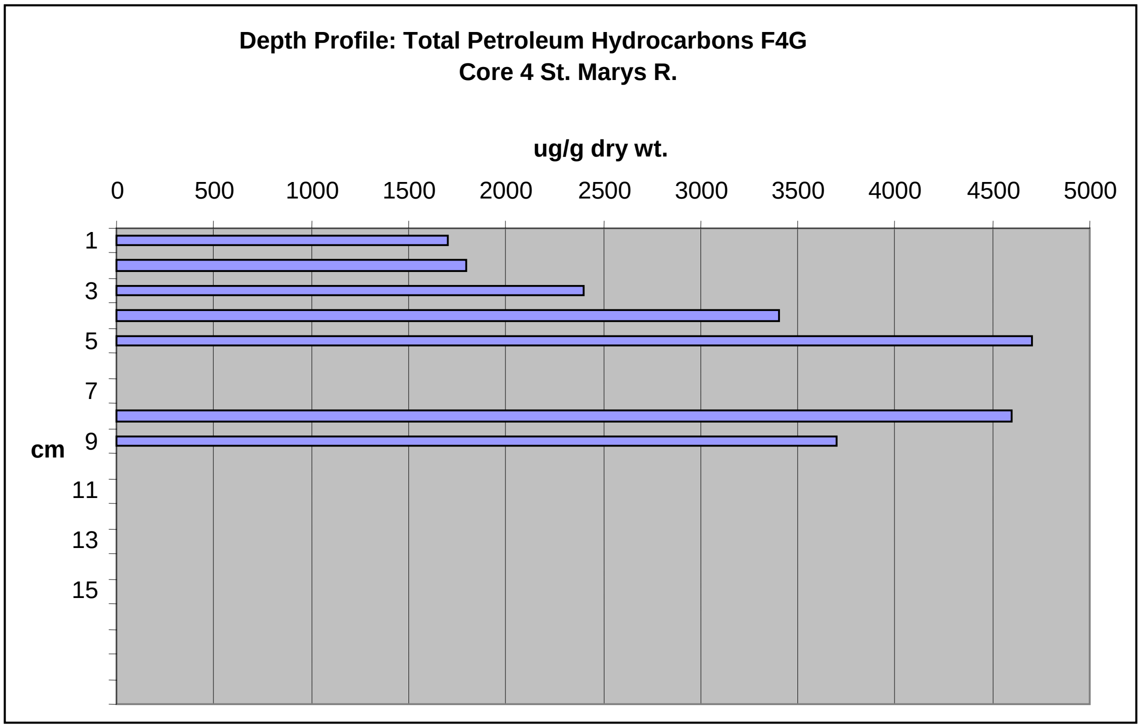
E25: Total petroleum hydrocarbons (F4) - core 4 depth profile



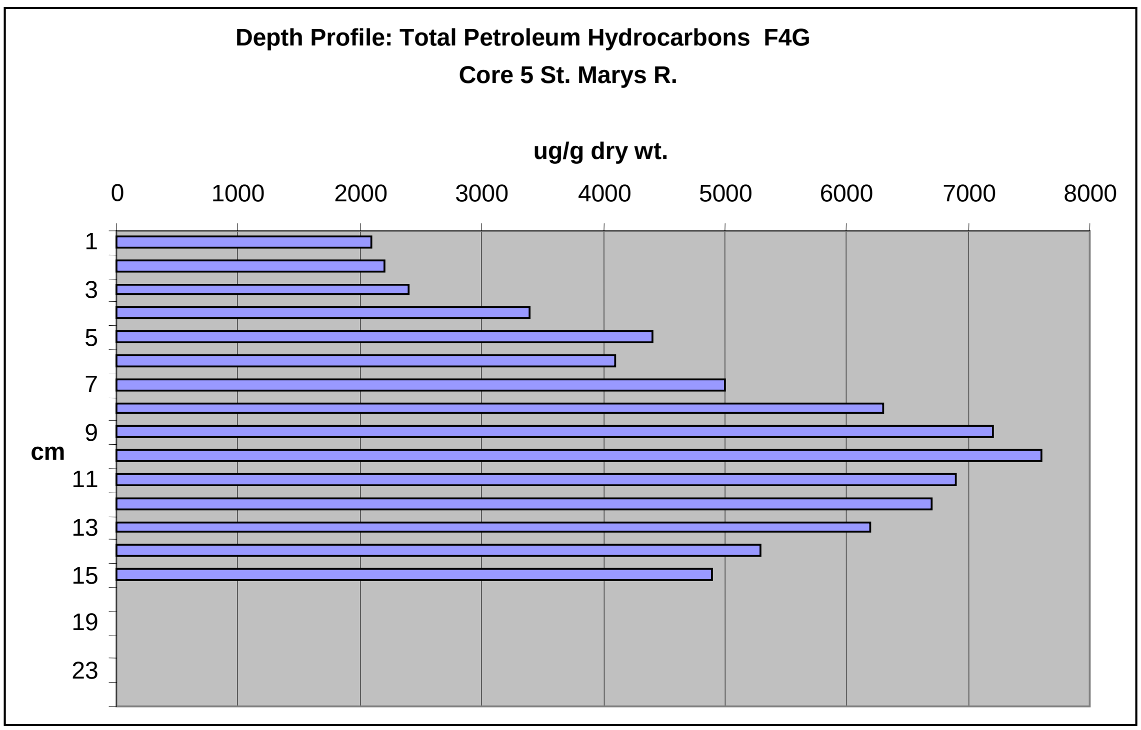
E26: Total petroleum hydrocarbons (F4) - core 5 depth profile



E27: Total petroleum hydrocarbons (F4G) - core 1 depth profile



E28: Total petroleum hydrocarbons (F4G) - core 4 depth profile



E29: Total petroleum hydrocarbons (F4G) - core 5 depth profile