

Appendix E:
Sediment & Water Quality Report
EIA for Cayman Islands Berthing Facility



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Glossary

Abbreviation	Description
As	Arsenic
BOD	Biological Oxygen Demand
Cr	Chromium
Cu	Copper
DO	Dissolved Oxygen
Hg	Mercury
Ni	Nickel
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
Pb	Lead
Sn	Tin
STD	Standard/Criteria
TPH	Total Petroleum Hydrocarbon
TSS	Total Suspended Solids
V	Vanadium
Zn	Zinc

1. Introduction

The TOR requires the EIA to determine chemical characteristics of sediment that will be dredged, grain size, main inorganic pollutants, likely heavy metals and synthetic organic pollutants. This includes baseline levels in coastal waters for salinity, temperature, turbidity, dissolved oxygen, concentration of chemical parameters (PAHs, nutrients, chlorophyll “A”, BOD, suspended solids etc.). Review data previously collected by Department of Environment.

With regard to water quality, the TOR requires the EIA to:

- Establish baseline levels in coastal waters for salinity, temperature, turbidity, dissolved oxygen, concentration of chemical parameters (PAHs, nutrients, chlorophyll “A”, BOD, suspended solids etc.);
- review data previously collected by Department of Environment;
- evaluate the impact of dredged sediment on water quality using water quality parameters selected for establishing baseline;
- assess impacts of the proposed project on site water quality, such as the potential influence on any existing shoreline discharges or outfalls

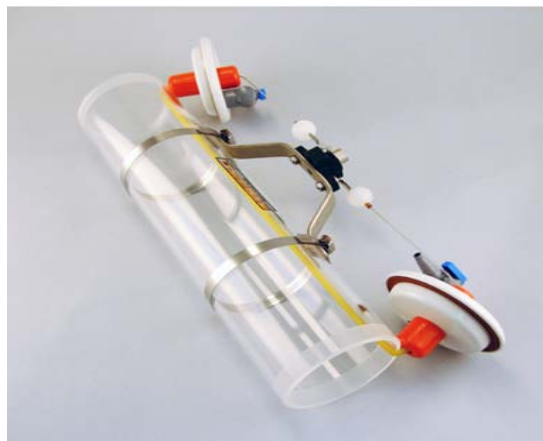
The assessment is based on comparison of baseline levels with established criteria and standards from USEPA, Environment Canada, Jamaica and NOAA.

2. Method Statement

2.1 Water Quality

Samples were collected at two depths throughout the water column depending on depth. Sampling at depth was achieved using the Model SKU 1920-G65 Wildco Van Dorn type Beta Horizontal Sampler (Figure 1). This sampler constructed from acrylic will contain no metal parts and is designed for trace metal sampling. Intended for shallow or deep waters, these bottles are called “horizontal” because they will descend parallel to the substrate and are therefore ideal for sampling just above the bottom sediments.

Figure 1: Beta Horizontal Sampler



Water and sediment sampling sites are presented at Figure 1

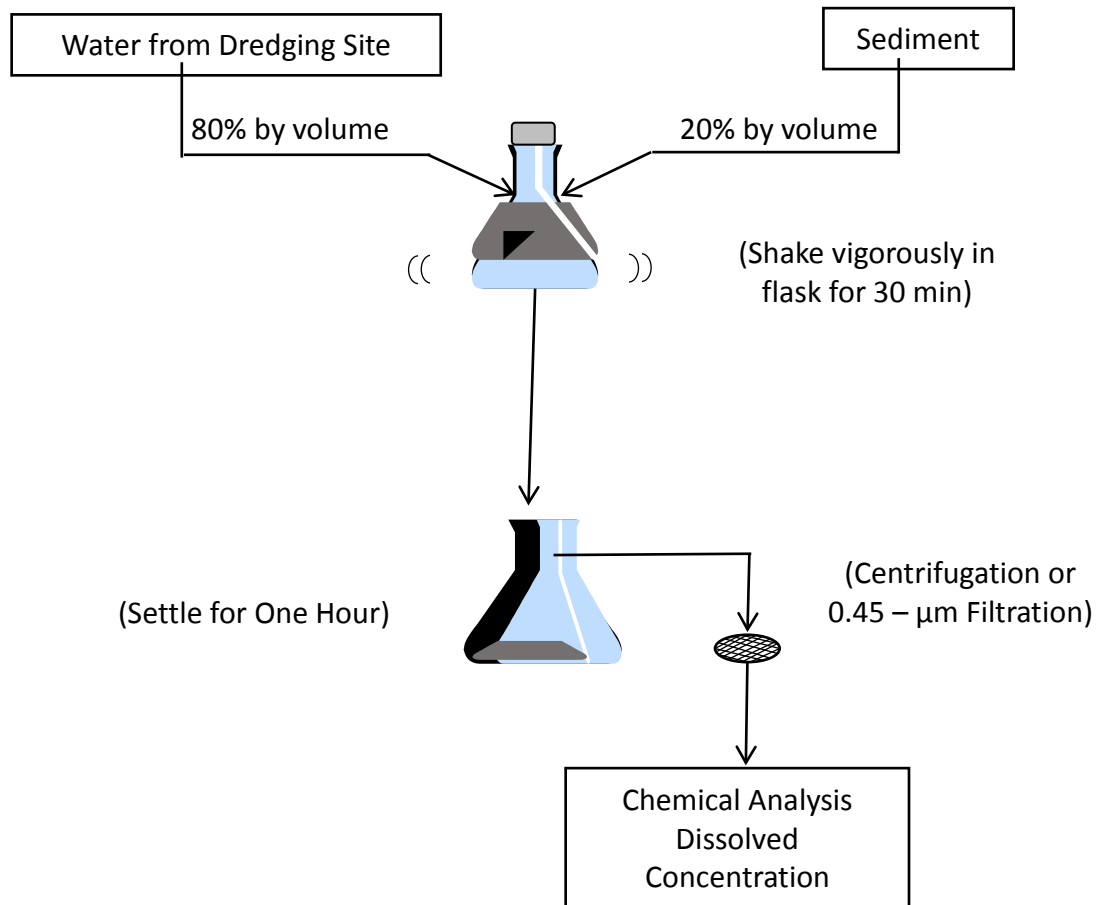


Figure 1: Water and Sediment Sampling Sites

2.2 Elutriate

Elutriate testing was employed to evaluate the impact of dredged sediment on water quality. Elutriate preparation was based on the original elutriate test (Federal Register 1973a, 1973b) and subsequent modification (Federal Register 1977, US Environmental Protection Agency and US Army Corps of Engineers 1977) to include the use of forced air for mixing. The Standard Elutriate Test procedure used for this investigation (illustrated in Figure 2) specifies that 20 percent by volume of undisturbed bottom sediments from the dredging site be mixed with 80 percent by volume of water from the dredging site.

Figure 2: Elutriate Test – Schematic



This mixture is then vigorously agitated by mechanical shaking and release of compressed air through a diffuser tube for 30 min (EPA/CE 1972). The infusion of oxygen into the system during mixing is used to offset any potential oxygen demand exerted by the sediments. This is significant as reduction in dissolved oxygen causes a drop in pH that may result in the release of chemical forms that do not normally occur at the dredging site. The addition of oxygen has also been shown to increase the reproducibility of the test.

Figure 3: Typical Elutriate Preparation Set Up



A typical bench set up to prepare the elutriate is shown in Figure 3.

2.3 Analyses

Water samples and elutriates were analysed for a suite of parameters bearing in mind present impacts and that included, biological oxygen demand (BOD), dissolved oxygen, salinity, temperature, total petroleum hydrocarbons (TPH), PAHs, PCBs and trace metals (arsenic, chromium, copper, mercury, lead, nickel, tin, vanadium and zinc).

Samples were analysed by NELAC accredited ALS Environmental Laboratory in Jacksonville Florida. The analytical methodology employed is summarised in Table 1.

Table 1: Summary of Analytical Methods

Parameter	Method	Detection Limit/Range	
		Water	Sediment
Non Metals:			
Biological Oxygen Demand (BOD)	5-Day Bottle method. Standard Methods. Method No. 5210 B	≥.1mg/l	
DO	U-10 Horiba Water Checker or YSI Model 85 O-S-C-T meter	0 – 19.9	N/A
NO ₃			
PO ₄			
pH	U-10 Horiba Water Checker or YSI Model 85 O-S-C-T meter	0 – 14	N/A
Salinity	U-10 Horiba Water Checker or YSI Model 85 O-S-C-T meter	0 – 40ppt	N/A
Temperature	U-10 Horiba Water Checker or YSI Model 85 O-S-C-T meter	0 – 50°C	N/A
Total Petroleum Hydrocarbons (TPH)	FL-PRO: Solvent Extraction & Gas Chromatography With FID	≥.581mg/l	N/A

Turbidity	U-10 Horiba Water Checker	0 – 800NTU	N/A
Heavy metals:			
Arsenic (As)	EPA Method 200.7/6010B: Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES)	6µg/l	≥.23mg/Kg
Chromium (Cr)	EPA Method 200.7/6010B: Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES)	0.9µg/l	≥.02mg/Kg
Copper (Cu)	EPA Method 200.7/6010B: Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES)	2.0µg/l	≥.13mg/Kg
Lead (Pb)	EPA Method 200.7/6010B: Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES)	6µg/l	≥.26mg/Kg
Mercury (Hg)	EPA 245.1/7471B - Cold Vapour Atomic Absorption	≥.02µg/l	≥.0014mg/Kg
Nickel (Ni)	EPA Method 6010B: Inductively Coupled	0.9µg/l	≥.04mg/Kg

	Plasma-Atomic Emission Spectrometry (ICP-AES)		
Tin (Sn)	EPA Method 200.7/6010B: Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES)	2.0µg/l	≥.2mg/Kg
Vanadium (V)	EPA Method 200.7/6010B: Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES)	1.0µg/l	≥.11mg/Kg
Zinc (Zn)	EPA Method 200.7/6010B: Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES)	0.7µg/l	≥.4mg/Kg

3. Results

3.1 Water Quality

Baseline water quality is assessed in terms of the basic parameters (DO, temperature, nutrients, pH) as well as other pollutants including trace metals and organic compounds.

All samples taken in wet and dry season returned undetected levels of PCBs, poly aromatic hydrocarbons (PAHs) and total petroleum hydrocarbons (TPH). Baseline levels of trace metals were well below the USEPA criteria for marine waters for all samples (Table 2 and 3)

Table 2: Baseline Levels of Trace Metals in the Dry Season Compared to the USEPA Criteria

ID	Ar	STD	Cr	STD	Cu	STD	Pb	STD	Hg	STD	Ni	STD	Sn	STD	V	STD	Zn	STD
T13T	1.10	36	0.33	50	<2	3.1	0.073	8.1	<0.02	0.94	1	8.2	<3	8	<4	29	<2	81
T13B	1.20	36	0.41	50	<2	3.1	0.112	8.1	<0.02	0.94	1	8.2	<3	8	<4	29	<2	81
T10T	1.20	36	0.38	50	<2	3.1	0.550	8.1	<0.02	0.94	1	8.2	<3	8	<4	29	<2	81
T10B	1.20	36	0.39	50	<2	3.1	0.103	8.1	<0.02	0.94	1	8.2	<3	8	<4	29	<2	81
T6T	1.20	36	0.35	50	<2	3.1	0.041	8.1	<0.02	0.94	1	8.2	<3	8	<4	29	<2	81
T6B	1.20	36	0.41	50	<2	3.1	0.043	8.1	<0.02	0.94	2	8.2	<3	8	<4	29	<2	81
T3T	1.20	36	0.37	50	<2	3.1	0.041	8.1	<0.02	0.94	1	8.2	<3	8	<4	29	<2	81
T3B	1.30	36	0.42	50	<2	3.1	0.048	8.1	<0.02	0.94	2	8.2	<3	8	<4	29	<2	81

Table 3: Baseline Levels of Trace Metals in the Wet Season Compared to the USEPA Criteria

ID	Ar	STD	Cr	STD	Cu	STD	Pb	STD	Hg	STD	Ni	STD	Sn	STD	V	STD	Zn	STD
T3T	<1.30	36	<0.61	50	0.477	3.1	<0.041	210	<0.02	0.9	<0.83	8.2	<3.0	8	<2.2	29	<4.5	81
T6T	<1.40	36	<0.44	50	<0.358	3.1	<0.054	210	<0.02	0.9	<0.16	8.2	<3.0	8	<2.6	29	<0.9	81
T10T	<1.2	36	<0.38	50	0.510	3.1	<0.039	210	<0.02	0.9	<0.16	8.2	<3.0	8	<1.4	29	<1.3	81
T13T	<1.30	36	<0.43	50	<0.399	3.1	<0.032	210	<0.02	0.9	<0.17	8.2	<3.0	8	<2.6	29	<1.4	81
T3T4	<1.20	36	<0.36	50	0.477	3.1	<0.048	210	<0.02	0.9	<0.20	8.2	<3.0	8	<2.3	29	<1.0	81
T6T4	<1.20	36	<0.42	50	<0.370	3.1	<0.048	210	<0.02	0.9	<0.16	8.2	<3.0	8	<2.1	29	<1.1	81
T10T4	<1.3	36	<0.38	50	0.450	3.1	<0.032	210	<0.02	0.9	<0.16	8.2	<3.0	8	<2.5	29	<1.1	81
T13T4	<1.3	36	<0.47	50	0.386	3.1	<0.032	210	<0.02	0.9	<0.16	8.2	<3.0	8	<2.5	29	<0.9	81

Dissolved oxygen levels were generally within 85% of the saturation value with an overall range of 6.01mg/l – 6.34mg/l for the dry season. The range for the wet season was slightly lower(5.29mg/l to 6.05mg/l). The minimal DO deficit was complemented by a BOD range that was .01mg/l to 2.64mg/l for all sampling occasions. For both sampling occasions (dry and wet season), the higher BODs were determined during the morning hours (Table 4 and 5).

Table 4: Tabulated Field Data Results in Dry Season – Morning Session

ID	Time	Depth (Ft)	SAL (ppt)	pH	T°C	DO (mg/l)	DOsat (mg/l)	DD (%)	TURB (NTU)	TSS (mg/l)	BOD	DO STD (mg/l)
T13T	1130		34.80	7.89	28.9	6.18	6.30	1.86	0	<1	2.64	4.8
T13B	1122	31.8	34.70	7.87	28.9	6.21	6.30	1.38	0	2	0.92	4.8
T10T	1156		34.90	7.93	28.8	6.21	6.30	1.38	1	1	2.31	4.8
T10B	1150	16.3	34.90	7.89	28.8	6.16	6.30	2.18	0	1	0.47	4.8
T6T	1218		35.00	7.97	28.8	6.23	6.30	1.06	0	2	0.33	4.8
T6B	1212	19.4	35.00	7.98	28.8	6.14	6.30	2.49	0	<1	0.88	4.8
T3T	1229		35.10	7.99	28.9	6.32	6.30	-0.37	0	ND		4.8
T3B	1224	12.7	35.00	8.01	28.9	6.34	6.30	-0.68	0	<1	1.06	4.8
Average			34.93	7.94	28.85	6.22	6.30	1.16	0.13	0.86	1.23	
Max		31.8	35.1	8.01	28.9	6.34	6.30	2.49	1	2	2.64	
Min		12.7	34.7	7.87	28.8	6.14	6.30	-0.68	0	0	0.33	

ND – No data.

Table 5: Results Obtained During Afternoon Session

ID	Time	Depth (Ft)	SAL (ppt)	pH	T°C	DO (mg/l)	DOsat (mg/l)	DD (%)	TURB (NTU)	TSS (mg/l)	BOD (mg O/L)
T13T	1637		35.0	7.98	28.9	6.10	6.30	3.13	0	0	0.82
T13B	1630	13.1	34.8	7.83	29.1	6.05	6.30	3.92	0	1	0.21
T10T	1652		35.1	8.03	28.8	6.01	6.30	4.56	0	1	1.12
T10B	1644	22.6	35.1	8.02	28.7	6.03	6.30	4.24	0	0	0.35
T6T	1714		35.1	8.01	28.3	6.12	6.30	2.81	0	3	1.44
T6B	1708	20	35.1	8.03	28.6	6.03	6.30	4.24	1	1	0.97
T3T	1736		35.1	8.01	28.9	6.20	6.30	1.54	0	ND	ND
T3B	1730	13.4	35.1	8.02	28.6	6.06	6.30	3.76	0	0	0.42
Average			35.1	8.0	28.7	6.1	6.3	3.5	0.1	0.9	0.8
Max		22.6	35.1	8.03	29.1	6.20	6.30	4.56	1	3	1.44
Min		13.1	34.8	7.83	28.3	6.01	6.30	1.54	0	0	0.21

Table 6: Tabulated Field Data Results in Wet Season – Morning Session

ID	Time	Depth (Ft)	SAL (ppt)	pH	T°C	DO (mg/l)	DOsat (mg/l)	DD (%)	TURB (NTU)	TSS (mg/l)	BOD (mg O/L)
T13T	1045		35.2	8.07	29.5	5.39	6.20	13.02	1	1	0.13
T13B	1033	11.1	35.2	8.12	29.5	5.34	6.20	13.83	2	1	0.19
T10T	1026		35.2	8.07	29.5	5.39	6.20	13.06	3	1	0.21
T10B	1007	13.4	35.2	8.09	29.5	5.29	6.20	14.68	1	0	0.35
Anch T	1001		35.1	8.04	29.3	5.68	6.30	9.80	2	0	0.35
Anch B	950	53.1	35.1	8.11	29.3	5.42	6.30	13.97	0	0	0.34
T6T	946		35.1	8.06	29.4	5.54	6.30	12.06	0	1	0.51
T6B	927	36.4	35.1	8.07	29.5	5.49	6.20	11.45	0	0	0.50
T3T	858		35.0	8.07	29.5	5.58	6.20	10.00	0	0	0.01
T3B	823	24.2	34.8	8.05	29.5	5.38	6.20	13.23	0	1	0.22
Average		27.64	35.1	8.08	29.45	5.45	6.23	12.51	0.9	0.5	0.28
Max		53.1	35.2	8.12	29.5	5.68	6.30	14.68	3	1	0.51
Min		11.1	34.8	8.04	29.3	5.29	6.20	9.80	0	0	0.01

Table 7: Tabulated Field Data Results in Wet Season – Morning Session

ID	Time	Depth (Ft)	SAL (ppt)	pH	T°C	DO (mg/l)	DOsat (mg/l)	DD (%)	TURB (NTU)	TSS (mg/l)	BOD (mg O/L)
T13T	1602		35.3	8.05	29.7	6.05	6.20	2.42	0	0	0.20
T13B	1550	10.9	35.1	8.05	29.6	5.71	6.20	7.90	1	1	0.27
T10T	1546		35.2	8.10	29.7	5.63	6.20	9.19	0	0	0.14
T10B	1534	14.4	35.3	8.07	29.8	5.66	6.20	8.71	0	0	0.59
Anch T	1528		35.1	8.11	29.6	5.82	6.20	6.13	0	0	0.48
Anch B	1524	66	35.3	8.17	29.6	5.60	6.20	9.68	0	1	0.08
T6T	1504		35.3	8.07	29.7	5.97	6.20	3.71	1	0	0.10
T6B	1450	39.6	35.2	8.13	29.8	5.95	6.20	4.03	4	0	0.09
T3T	1518		35.3	8.10	29.9	5.99	6.20	3.39	2	0	0.20
T3B	1506	10.8	35.2	8.16	29.6	5.80	6.20	6.45	0	0	0.14
Average		28.34	35.2	8.10	29.7	5.818	6.20	6.1613	0.8	0.2	0.23
Max		66	35.3	8.17	29.9	6.05	6.20	9.68	4	1	0.59
Min		10.8	35.1	8.05	29.6	5.6	6.20	2.42	0	0	0.08

Average nutrient levels (N and P) for all sites were determined to be <.002mg/l for NO₃ and .023mg/l for phosphorous. Phosphate level is higher than the NEPA standard (**Figure 4** and **Figure 5**), and orders of magnitude over levels determined by DoE. o-phosphate which was determined to be 4 X 10⁻⁵mg/l by DoE in 2000 compared to 2 X 10⁻²mg/l by TEMN for this study.

Turbidity was in the narrow range (0 – 1NTU) for all sites during the **dry season sampling** for morning and afternoon sampling exercises. These value were mirrored by levels of **total suspended solids (TSS)** which were in the narrow range <1 to 3mg/l for morning and afternoon sampling occasions in the dry season. For the **wet season** the results were marginally different with a measured range of 0 to 4NTU for turbidity and <1 to 2mg/l for TSS. The high value of 4NTU occurred on one occasion at the site closest to the Cali wreck (T6) during an afternoon sampling event.

Table 8: Results of George Town Harbour Nutrients June 17, AM

ID	Nitrate as Nitrogen (mg/L)	Nitrate as Nitrogen Standard (mg/L)	o-PO4	o-PO4 Std
T13T	<0.002	0.003	0.0226	0.014
T13B	<0.002	0.003	0.0226	0.014
T10T	<0.002	0.003	0.0238	0.014
T10B	<0.002	0.003	0.0230	0.014
T6T	<0.002	0.003	0.0232	0.014
T6B	<0.002	0.003	0.0234	0.014
T3T	<0.002	0.003	0.0233	0.014
T3B	<0.002	0.003	0.0226	0.014

NB: Results in mg/L unless otherwise stated

STD: NEPA Interim Ambient Standards For Marine Waters

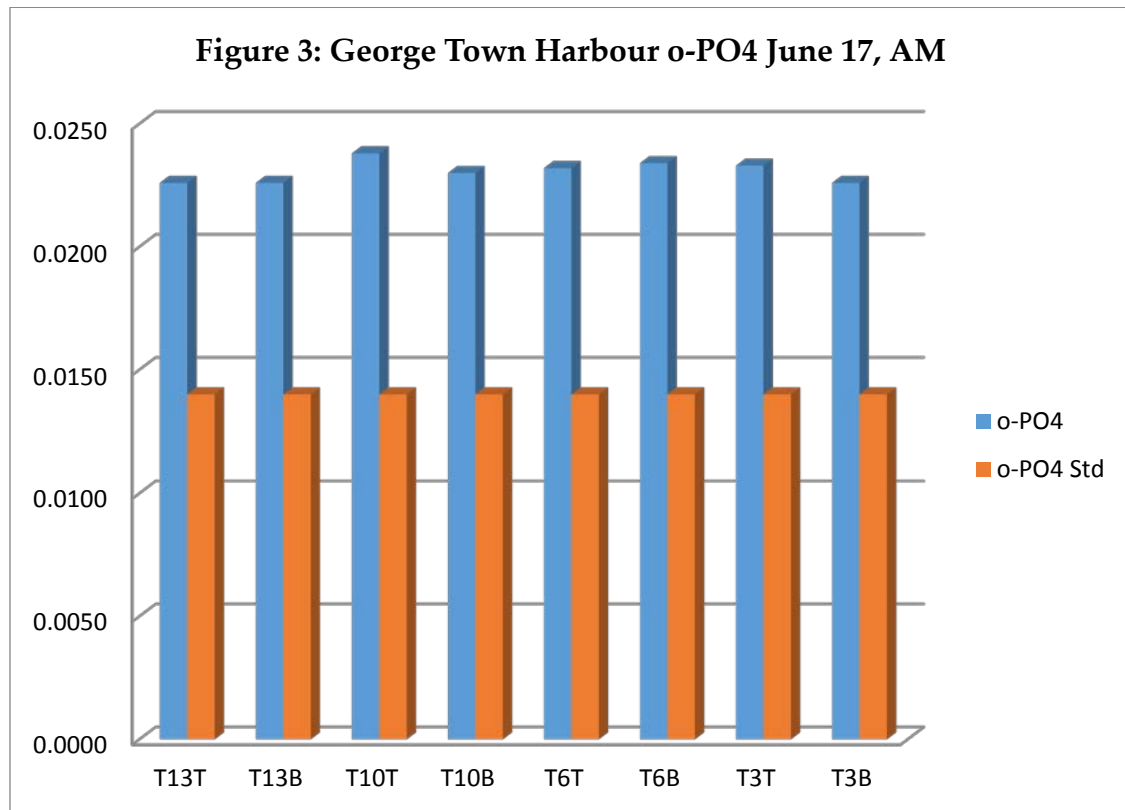
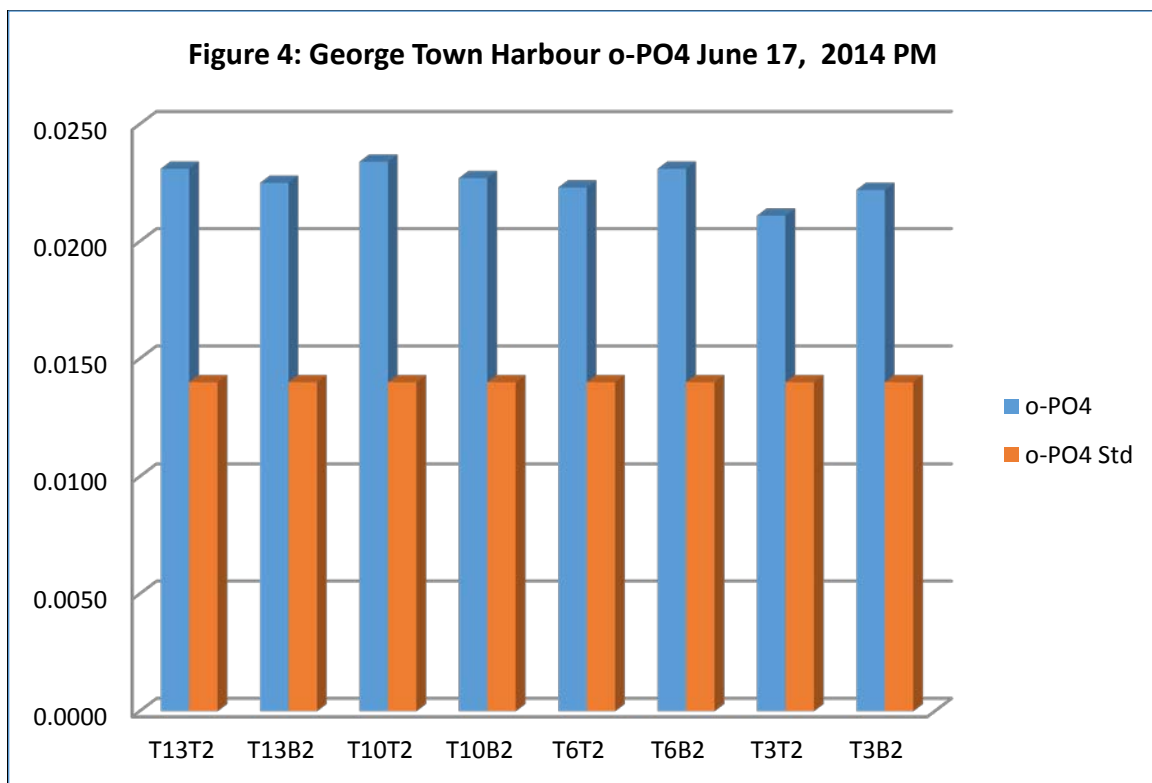


Table 9: Results of George Town Harbour Nutrients June 17, PM

ID	Nitrate as Nitrogen (mg/L)	Nitrate as Nitrogen Standard (mg/L)	o-PO4	o-PO4 Std
T13T2	0.008	0.003	0.0231	0.014
T13B2	<0.002	0.081	0.0225	0.014
T10T2	<0.002	0.081	0.0234	0.014
T10B2	<0.002	0.081	0.0227	0.014
T6T2	<0.002	0.081	0.0223	0.014
T6B2	<0.002	0.081	0.0231	0.014
T3T2	<0.002	0.081	0.0211	0.014
T3B2	<0.002	0.081	0.0222	0.014

NB: Results in mg/L unless otherwise stated

STD: NEPA Interim Ambient Standards For Marine Waters



3.2 Elutriate

Analysis of elutriate prepared from sediment taken at the sites closest to the Cali and the Balboa indicated some leaching of the target trace metals, though for most metals, the leached levels remained well below the USEPA criterion continuous concentration (CCC) for marine organism (Table 8).

Table 10: Results of Elutriate Compared to USEPA Criteria

ID	Ar	STD	Cr	STD	Cu	STD	Pb	STD	Hg	STD	Ni	STD	Sn	STD	V	STD	Zn	STD
T13	8.10	36	4.10	50	7.06	3.1	7.06	8.1	0.09	0.94	2.4	8.2	<3	8	1.3	29	<2	81
T3	3.10	36	3.00	50	3.51	3.1	3.85	8.1	0.09	0.94	2.5	8.2	<3	8	1.2	29	<2	81

The exception was copper, which exceeded the CCC for both elutriates. For the elutriate prepared from sediment taken near the north easternmost site (T3), leached copper was 3.5µg/l compared to the USEPA CCC of 3.1µg/l (Graph 1). The leached value was greater for elutriate prepared from sediment taken near the Balboa (T13) indicating a leached concentration of 7.06µg/l (Graph 2).

Figure 5: Station T3 - Background Concentration of Trace Metals Compared to Concentration in Elutriate

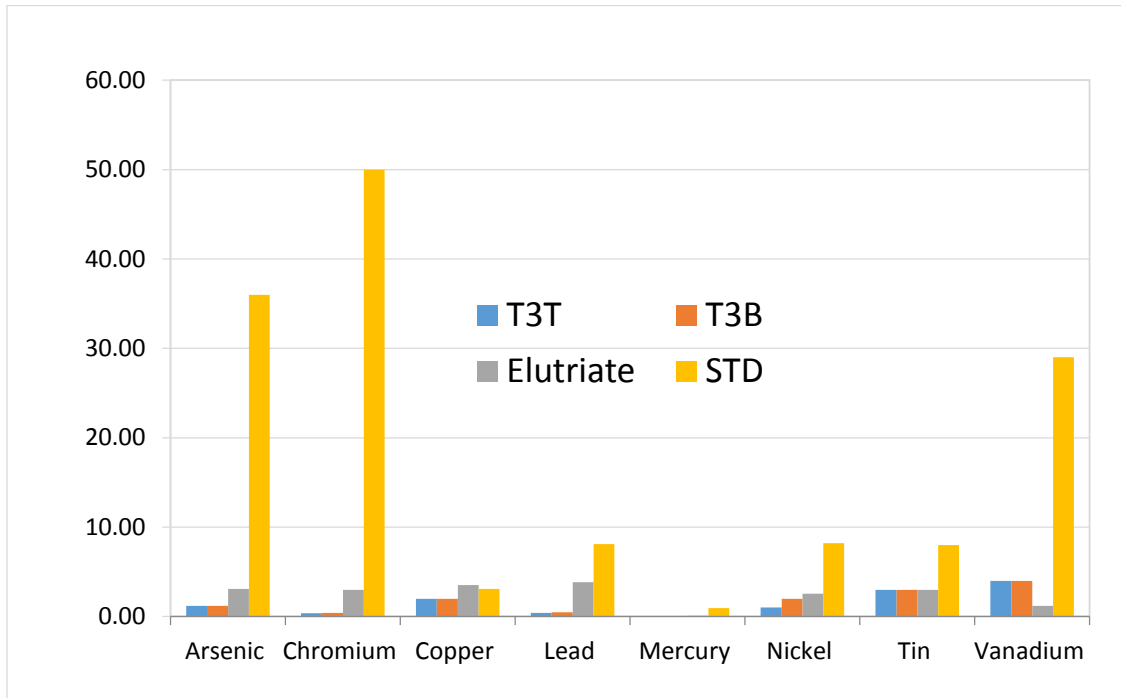
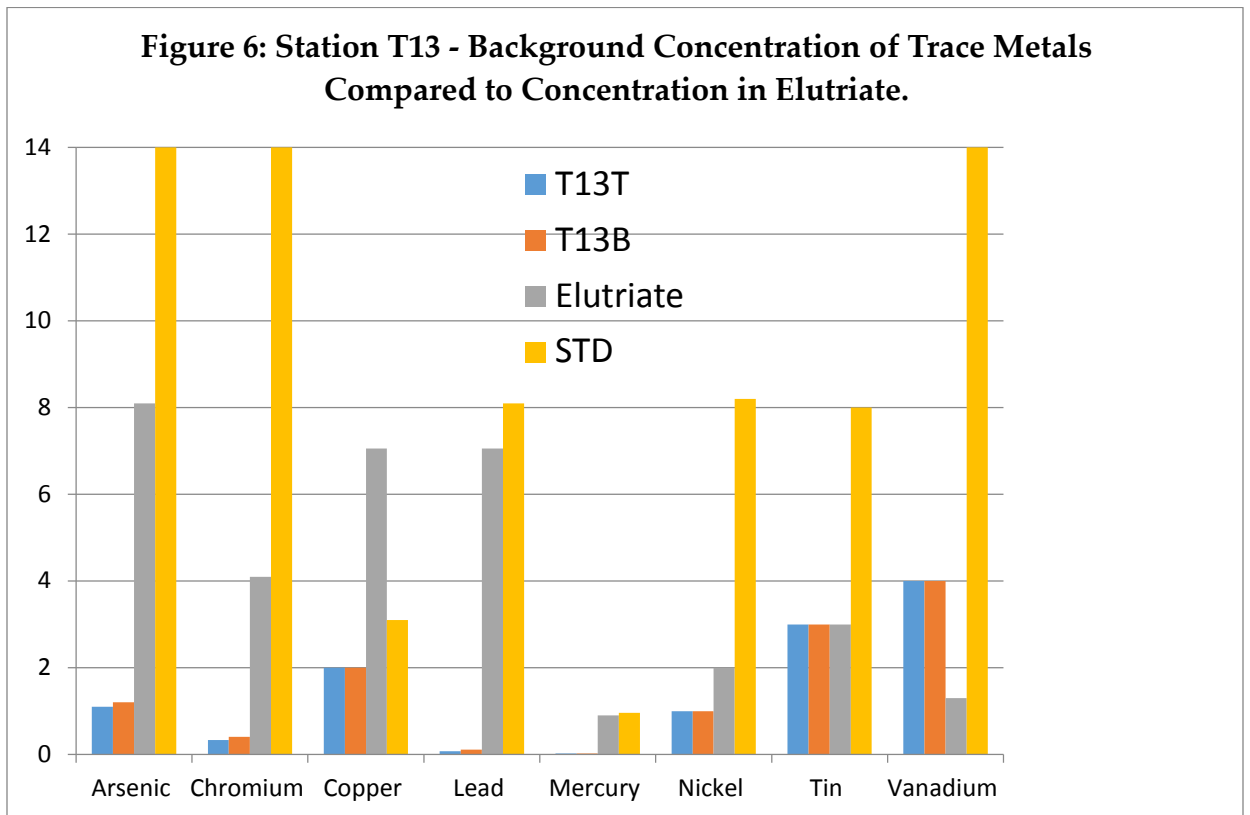


Figure 6: Station T13 - Background Concentration of Trace Metals Compared to Concentration in Elutriate.



3.3 Sediment

Sediment samples obtained from four locations within the proposed development area were analysed for a range of trace metals and organic compounds. The results of the laboratory tests are summarised below:

Analyses conducted on sediment samples returned trace metals levels that were well within the guideline values and in some cases below the test detection limit (Table .

Table 11: Cayman Islands: Trace Metals in Sediment - Sampling Date: June 23, 2014

ID	As	STD 1)	Cr	STD 2)	Cu	STD 2)	Pb	STD 3)	Hg	STD 2)	Ni	STD 3)	Sn 4)	STD	V 5)	STD	Zn 3)	STD
T3T	<0.9	50	4.08	160	12.0	108	<1.0	47	<.002	0.7	1.00	21	<0.5	8	4	150	3.10	150
T6T	<0.9	50	5.32	160	13.5	108	<1.0	47	<.002	0.7	0.82	21	<0.5	8	3	150	5.10	150
T10T	<0.8	50	3.49	160	12.7	108	<1.0	47	<.002	0.7	0.63	21	<0.5	8	<2	150	1.50	150
T13T	<0.9	50	4.15	160	13.4	108	<1.0	47	<.002	0.7	0.77	21	<0.5	8	3	150	3.00	150

- 1) Maher, W., & Butler, E. (1988) Arsenic in the marine environment. 2 (3), 191-214. doi:10.1002/aoc.590020302
- 2) Environment Canada, Canadian Council of Ministers of the Environment. Canadian sediment quality guidelines for the protection of aquatic life 1999.
- 3) NOAA, Sediment Quality Guidelines developed for the National Status and Trends Program 1999. <http://ccma.nos.noaa.gov/publications/sqg.pdf>
- 4) World Health Organization
Geneva, Concise International Chemical Assessment Document 65
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Arsenic (As), lead (Pb) and tin (Sn) were below the test detection limits of .9mg/Kg, .1mg/Kg and .5Kg respectively. The test detection limits were comfortably below the guideline values for these parameters of 50mg/Kg, 47mg/Kg and 8mg/Kg respectively.

Chromium was in the range 3.49mg/Kg to 5.30mg/Kg for all sites sampled. The highest concentration was determined from sediment samples taken at T6 (Cali NW) while the lowest concentration was detected in sediment taken from T10 (Balboa NE). At T3 (Harbour NW), sediment level of Cr was 4.08mg/Kg while at T13 (Harbour S), Cr in sediment was 4.15mg/Kg.

Copper (Cu) concentration was in the range 12mg/Kg to 13.5mg/Kg for all sediment samples. Copper was highest (13.5mg/Kg) for sediment taken from T6 (Cali NW) and lowest in sediment from T3 (Harbour S). For T10 (Balboa NE) and T13 (Harbour S) copper in sediment was 12.7mg/Kg and 13.4mg/Kg respectively. These levels were an order of magnitude below the Environment Canada guideline value of 160mg/Kg.

Mercury (Hg) was in the range .003mg/Kg to .006mg/Kg. These levels were 3 orders of magnitude below the Environment Canada guideline value.

Nickel (Ni) concentrations were in the range .63mg/Kg to .82mg/Kg for all sediment samples. These results were well within the NOAA guideline value of 21mg/Kg.

Vanadium (V) concentrations were in the narrow range 3mg/Kg to 4mg/Kg for all sediment samples. These levels were well below reported background levels. No specific criteria or guideline levels were found for this parameter.

TPH and PCB's were undetected in all samples taken.

4. Environmental Impact

Present water quality is good with all parameters returning values within USEPA criteria. There is a concern that the increase in levels determined by this EIA relative to this determined by DoE in 2014 could indicate a trending up of nutrient levels, particularly phosphate. The levels determined for this study are however well within the NEPA interim ambient marine standards for protection of coral reefs. The low chlorophyll levels support this.

From the results of the analysis, apart from the temporary effects of increased suspended solids, the sediment examined is considered "clean" and can be disposed of safely in the marine environment or on land.

Impacts to water quality impacts will mainly be associated with high turbidity levels from dredging and to a lesser extent leaching of some trace/heavy metals. The low level of hazardous organic material detected indicates no risk of toxicity associated with the sediment samples taken from George Town Harbour.

4.1 Projected Impact

a) Impact from turbidity/TSS

For the Falmouth cruise port development where TSS and turbidity were monitored for the 16 month duration of the activity turbidity averaged 16, 18 and 34NTU at the top middle and bottom of the water column. Maximum levels at surface, middle and bottom of the water column were 82, 184 and 300NTU respectively over the 16 months. TSS levels corroborated the levels of turbidity (Table 6). These levels were determined at a distance approximately 30m from the dredge. These levels are considered to be worst case as water quality at the Falmouth dredge site is influenced by the outflow of the Martha Brae River.

The impact to turbidity levels will be temporary, lasting the duration of the dredging. Impact will mainly be localised but areas down-current of the dredge site will impacted to a lesser extent.

Table 6: Turbidity Levels Within 30m of a Mechanical Dredge (Clam Shell)

STRATA	TURBIDITY			TSS		
	AVG	SD	MAX	AVG	SD	MAX
TOP (T)	15	15	63	11	15	82
MIDDLE (M)	15	29	184	22	78	550
BOTTOM (B)	22	42	232	31	59	312

Source: TEMN 2010

b) Impact from Petroleum Pollutants

Increased shipping will bring the additional risk of accidents and other incidents leading to releases of petroleum products. In general, the results returned indicated trace levels of a few PAHs it is of note that the sediment returning these results were from the southernmost site.

Increased shipping brings increased risk of accidents/incidents involving spillage of product.

c) Impact from leaching

Copper levels are known to be elevated in harbours due to discharge from ships (cooling water and leaching of copper biocides from the hull). Copper biocides are the replacement for the highly toxic organo tin compounds. Baseline levels of 2ppb in all the samples taken suggest that impact from shipping is presently negligible. Copper is toxic to a wide range of aquatic organisms, which makes it an ideal biocide, preventing the colonisation of biofouling organisms on the vessel surface. There is concern that copper concentrations may become elevated in areas of high boating density such as marinas and estuaries with potential damaging effects on the animal and plant communities. The fact that copper levels are presently below the test detection limit (<2ppb) suggests that impact from shipping is presently negligible. Moreover, the cupric ion is highly reactive and forms moderate to strong complexes and precipitates with many inorganic and organic constituents of natural waters, e.g., carbonate, phosphate and amino acids, and is readily absorbed onto surfaces of suspended solids" (U.S. EPA, 1994b). When these complexes and precipitates are formed, the copper within them is either completely nontoxic or its toxicity is significantly reduced (Meador, 1991). This process will be enhanced in slightly alkaline environment as exists in George Town Harbour (pH ≥ 8). In addition, the elutriate test does not account for the dilution factor in the marine environment.

Impact associated with leaching will be localised with the potential to affect areas immediately adjacent and down-current the dredge site. The effect is expected to be minor given the natural forces that will tend to trap leached copper to the sediment. Impact of leaching will be temporary.

Impact from increased shipping is not likely to be significant given the baseline levels (<2ppb) which obtain after the many years of shipping in George Town.

5. Mitigation

Arresting the escalation of phosphate levels is essential to controlling unwanted phenomenon in coastal waters such as algal blooms (eutrophication) and associated deleterious effects in the future. Policies and regulations to achieve this may involve a consideration of all or a combination of the following:

- Ban on the use of phosphate detergents. Such a ban would require time to be implanted and a framework put in place to effectively screen imports to ensure importation of only phosphate-free soaps and detergents;
- Implementing a permitting process to selectively allow importation of phosphate containing detergents. Switzerland for example bans phosphates in washing powder, but still allows phosphates in washing-up liquid and dishwasher powder though it sets a limit of 2.5 grams per washing cycle;
- Institute a threshold concentration for phosphate in detergent;
- Offer incentives/disincentives to discourage use of phosphate containing detergents and fertilisers;

Immediate actions to heighten public awareness of this potential problem could revolve around implementing a public education programme targeting likely users of phosphate containing detergents and fertilisers. This would likely engender buy in to future necessary actions geared at controlling levels of phosphate in the environment due to anthropogenic activity. A more aware public can prompt a greater level of self-regulation leading to a reduction in demand for phosphate containing materials thus enhancing the chances of successful implementations of relevant policies and regulations.

Mitigation of turbidity levels associated with dredging can be achieved by effective deployment of silt screens. Silt screens also called silt or turbidity curtains have been designated a “best management practice (BMP)” by the Corps of Engineers (Francingues, and Palermo, 2005).

From a weekly monitoring event of a clam shell dredge for the Falmouth Cruise Pier Development, a measured turbidity level inside the screen of 99 NTU corresponded to a level of 8 NTU (Table 7). In general success in keeping within the permitted limit of 30 mg/l outside the screen enclosure was better than 70% for the entire period (Figure 7 and Figure 8).

These snapshot data are consistent with data reported by other sources which have recorded turbidity levels outside the silt screen 80 to 90% lower than levels within the enclosure or up-current of the screen enclosure (JBF Scientific 1978).

Table 7: Falmouth Port Development Dredge Monitoring December 3, 2009 Comparison of Levels Inside and Outside Silt Screen

Water Column	TUR Dredge	TSS Dredge	TUR Outside Screen	TSS Outside Screen
Top (T)	10	5	3	0
Middle (M)	55	17	8	5
Bottom (B)	232	192	14	8
AVERAGE	99	71	8	4

Source: TEMN 2009, Unpublished Data

Figure 7: Falmouth Port Development Turbidity Inside Silt Screen Enclosure -

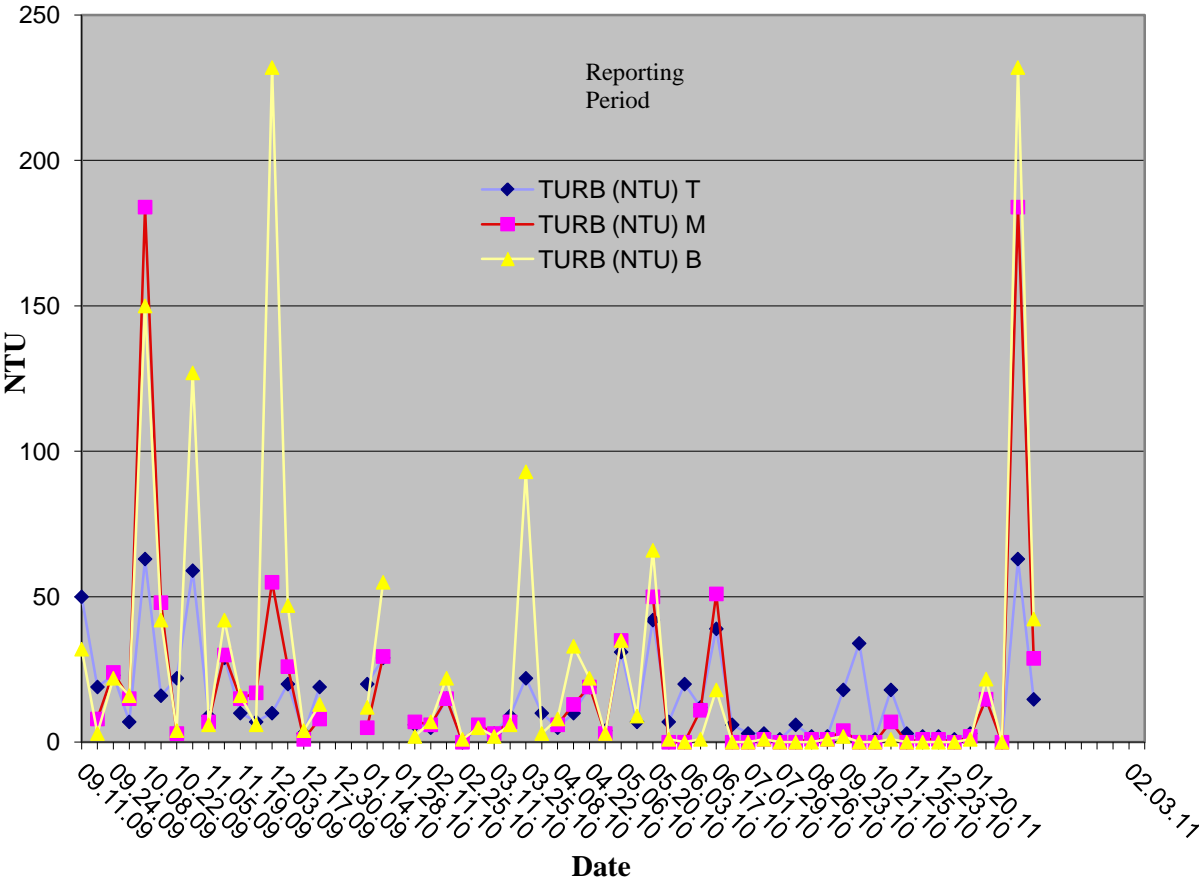
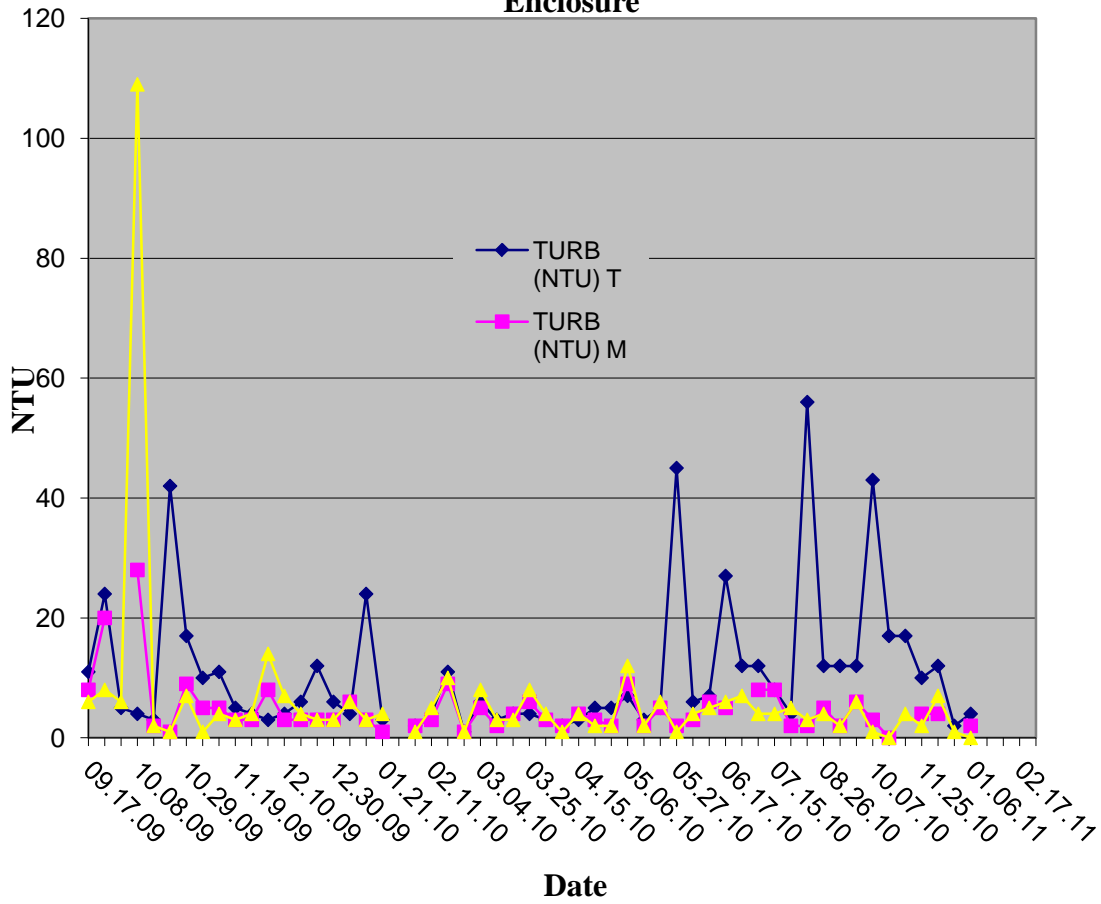


Figure 8: Falmouth Port Development Turbidity Outside Silt Screen Enclosure



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