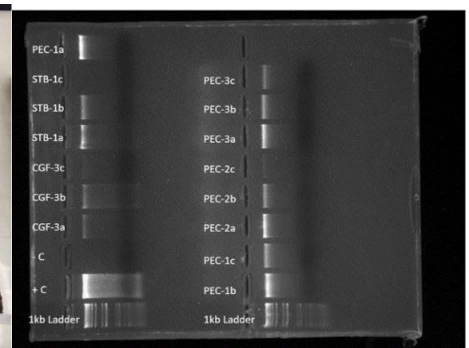
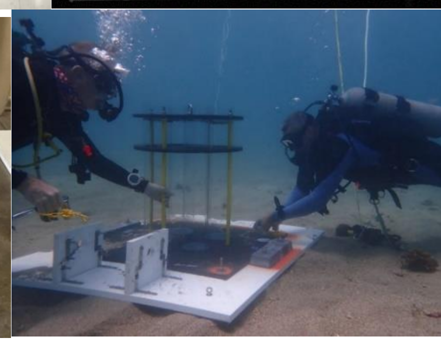
Heavy Metal Implications to Sediment Microbiome and Coral Reef Community





FLORIDA'S CORAL REEF

Heavy Metal Implications to Sediment Microbiome and Coral Reef Community

Final Report

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Management Summary

Heavy metal results from 18 cores collected at five Port Everglades, Florida locations, indicate moderate-to-strong As and Mo contamination and moderate-to-significantly high overall metal contamination based on the geo-accumulation, potential ecological risk, enrichment factor indices, threshold and probable effect levels (TEL and PEL). The port sediments have elevated levels of As, Cd, and Mo, above continental crust values, while the pollution load index shows no contamination. Some port subsamples exceed Cd, Cu, and Ni TEL levels. The control cores and some of the reef samples show As levels that exceed TEL, indicating moderate-to-significantly high As contamination.

Sediments collected from the top, middle and bottom of each core were processed for molecular genetics, preserved in RNAShield reagent, and stored at –80° C for future RNA isolation to determine potential viral pathogens of coral. 16S rRNA gene amplicons microbial community analyses indicate that site type is the most influential factor affecting bacterial community composition. Forty-eight genomic DNA subsamples analyzed for metagenomics were successfully sequenced. Some of the data was partially analyzed, but most was archived until Phase II.

Six platforms were constructed to accommodate an Ocean Innovation ST-30 sediment trap and an Aqua TROLL 600 sonde. They were deployed at six sites adjacent to the three reef tracts. Sondes were retrieved one week later; data downloaded, sensors verified and calibrated, and returned to their respective platforms. The range of data for temperature, conductivity (salinity), pressure (depth), dissolved oxygen, pH, and turbidity were consistent and were of expected values across the sites.

Preliminary results indicate moderate to high ecological risk to benthic organisms from heavy metal contaminated port sediment. The control site has a distinct microbial community suggesting that human activities have altered the port microbiomes. Due to an imminent dredging at Port Everglades, contaminated sediment could harm the threatened adjacent coral communities.

Executive Summary

Eighteen sediment cores were collected from five Port Everglades, Florida sites and a control site; surface sediment was collected at six nearby coral reef sites adjacent to the port. Sediment cores, sampled every 10 cm, were analyzed for 16 heavy metals using inductively coupled plasma-mass spectrometry (ICP-MS). Sediment cores, sampled at the top, middle, and bottom, and surface sediment at six coral reef locations, were processed for microbial profiling. Instrument platforms were positioned at the six coral reef sites with ST-30 sediment traps and Aqua TROLL sensors, and abiotic data (temperature, conductivity, pressure, dissolved oxygen, pH, and turbidity) were measured.

Heavy Metal Data. Heavy metal results from the eighteen cores collected in five Port Everglades, Florida locations indicate moderate-to-strong As and Mo contamination and moderate-to-significantly high overall metal contamination based on the geo-accumulation (I_{geo}), potential ecological risk (PER), and enrichment factor (EF) indices. The port sediment has high levels of As, Cd, and Mo, well above upper continental crust values, while the pollution load index (PLI) shows no heavy metal pollution. All port sites (except the port inlet) have sediment core subsamples with As concentrations above threshold effect level (TEL, 7.24 µg/g) and above probable effect level (PEL, 41.6 µg/g), while Mo concentrations greatly exceed the background continental crust level threshold (1.5 µg/g). Some port subsamples exceeded TEL levels for Cd, Cu, and Ni. The control site and some of the reef surface sediments show high levels of As that exceed TEL and indicate moderate-to-significantly high overall As contamination.

Sedimentation and Abiotic Data. The four acrylic cylinders, comprising a single sediment trap, at each of the six reef site platforms had only a dusting (< 2 mm) of sediment collected during the 22-days deployed (north reef sites) and the 9-days deployed (south reef sites). Preliminary results for water chemistry data, including temperature, conductivity (salinity), pressure (depth), dissolved oxygen, pH, and turbidity, indicate relative correlation in data ranges among the six reef sites.

Microbiome/ Metagenomics. Extensive data from 16S rRNA amplicon libraries and metagenome sequencing has been generated in Phase I of this project. Full integration of the molecular and chemistry data will be conducted in Phase II.

Recommended Actions/Next Steps specific to management
Preliminary results of this study indicate a moderate to high ecological risk to benthic organisms from heavy metal contaminated sediment. Due to an imminent dredging at Port Everglades, this could harm the threatened adjacent coral communities. We will be analyzing the sediment collected in the sediment traps over the next year for heavy metal concentrations and microbiome profiling to determine if sedimentation has any heavy metal and/or bacterial contaminants. We will also be conducting statistics with the heavy metal and microbiome results to confirm the minimal potential contamination (to 95% confidence). We will be monitoring the water chemistry for any changes.

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LIST OF ACRONYMS

DCC (Dania Cutoff Canal)
PEC (Park Education Center)
PEI (Port Everglades Inlet)
PHQ (Park Headquarters)
STB (South Turning Basin)
WL (West Lake)
1N (Reef North Location 1)
2N (Reef North Location 2)
3N (Reef North Location 3)
1S (Reef South Location 1)
2S (Reef South Location 2)
3S (Reef South Location 3)

1. INTRODUCTION

Protecting endangered coral reef communities in the marine environment is of extreme environmental and economic importance. Healthy coral reefs, where half of all federally managed fisheries reside, support jobs and businesses through tourism and recreation (Riegl and Dodge, 2008). A suite of environmental conditions impact coral community survivability (Riegl et al., 2009; Hay and Rasher, 2010).

1.1 Heavy Metals in Sediment

Coastal sediments associated with commercial activities can be laden with inorganic and organic pollutants (Qian, et al., 2015; Armiento et al., 2020). Sediments can become contaminated when metals and persistent organic pollutants (POPs) attach or sorb to mineral surfaces or biofilms on mineral surfaces, making them useful indicators for anthropogenic contaminants (Power and Chapman, 2018).

Contaminated sediments in aquatic ecosystems throughout the world have been linked with ecological risks (Long et al., 1996; Turgeon et al., 1998; U.S. EPA, 2002). Dredged sediments can be contaminated with chemical pollutants, and if resuspended, the metals can be remobilized and may be distributed, ingested, or absorbed by marine organisms. This could result in toxic effects through bioaccumulation in the food web and pose a potential risk to biological organisms, particularly in benthic communities (U.S. EPA, 2021). Evidence of remobilized contaminants has been found in sentinel crabs (*Macrophthalmus* spp.), common periwinkle (*Littorina littorea*), and Sydney rock oysters (*Saccostrea glomerata)* (Davies et al., 2009; Hedge et al., 2009; Saadati et al., 2020). Prior to the pending dredging event, Giarikos et al. (in review) analyzed replicate sediment samples from Port Everglades, a nearby control site, and the adjacent nearshore coral reef for 16 heavy metals (Al, As, Cd, Co, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Se, Sn, V, Zn). Geo-accumulation index reveals that the port sediments have **moderate to strong contamination** of As and Mo and potential ecological risk index indicates **moderate to significantly high** overall heavy metal contamination. Arsenic concentrations in port sediment exceed both threshold effect level (TEL, 7.24 µg/g) and probable effect level (PEL, 41.6 µg/g). TEL is the minimum level for benthic biologic effects and PEL is when a large percentage of benthic organisms exhibit a toxic response. Heavy metal concentration spikes above TEL were also observed in the port sediment cores for Cd, Cu, Hg, Mo, Pb, Sn, and Zn. Conversely, the coral reef surface sediment had very low contaminant concentrations. The contaminated port sediment dredge material is proposed to be deposited on the ocean floor 1.19 nmi offshore from the outer reef tract and these contaminants are of major concern to biological organisms (White, 2021).

This study will provide key information to develop an ecological risk assessment to understand the impact port dredging has on imperiled nearby coral reef communities and will advance knowledge in the fields of environmental and marine chemistry to help create new management and environmental dredging risk assessments.

1.2 Sedimentation and Abiotic Data

Several studies have shown that resuspended sediments and accompanying increased turbidity of seawater can degrade coral reef health around the world (Dodge and Vaisnys 1977; Fabricius 2005; Wolanski et al., 2009; Bessell-Browne et al., 2017; Nascimento et al., 2020). Sedimentation rate can be calculated by quantifying the volume or mass of sediment settled in a known size chamber over several days. Six sediment traps (Ocean Innovations ST-30) were mounted on anchored platforms which were deployed at each of the six nearshore coral reef sites (Fig. 2). After a maximum of 22 days, < 2 mm of sediment had settled from the water column into the traps. Sediment will be collected on a quarterly basis for heavy metal analysis and potentially grain size analysis during Phase 2.

1.3 Sediment Microbiome

Microbial communities (also known as the "microbiome") provide important ecological and biogeochemical processes; therefore, microbial community profiling also reveals valuable information about any ecosystem (Egger et al., 2018). When combined with corresponding environmental metadata, microbiomes can provide source information about water masses and serve as indicators of degradation or alteration of water quality. Microbes also act as integral symbionts to most resident organisms, such as in sensitive ecosystems like coral reefs. For example, Peixoto et al. (2017) have shown certain microbial symbionts positively affect and protect coral species. O'Connell et al. (2018) conducted a weekly sampling of Port Everglades Inlet (PEI) surface waters and found a stable microbial composition, with increased microbial abundance and richness in the early spring and late summer months, most likely related to increased temperatures, ultraviolet radiation, and precipitation. Thus, understanding microbial dynamics positively impacts the health of human and resident marine life.

In 2020 and 2021, the Guy Harvey Oceanographic Center Marine Molecular Genomics laboratory run by Dr. Jose Lopez was contracted by Florida Department of Environmental Protection (FDEP) to characterize PEI and proximal Florida Coral Reef surface sediments for Coral Reef Conservation Program (CRCP) project number 13 (CRCP 13)[1]. Results from CRCP 13 established baseline bacterial community characterizations and their patterns of diversity prior to and after maintenance dredging (Krausfeldt et al., 2023). Port Everglades sediment samples were collected from the PEI and surface sediments from the adjacent coral reef for two consecutive years, 2020 (Phase I, before maintenance dredging) and 2021 (Phase II, after maintenance dredging). Despite the proximity and tidal connections through the PEI, reef and port sediment microbial communities were distinct. Changes in microbial diversity within the intracoastal waterway, a route for community exchange or transfers, were the greatest after maintenance dredging occurred. Microbial diversity in reef sediments also changed after dredging, indicating potential influence from resuspended sediments due to an associated increase in heavy metals and decrease in cyanobacterial diversity. Determining physical factors that can affect

[1] https://floridadep.gov/rcp/coral/documents/analysis-sediments-port-everglades-inlet-pei-microbiome-characterization-phase

microbiomes requires proper experimental design and attention to metadata (Knight et al, 2012). Sediments were identified as a possible source of human and coral pathogens, although dredging did not affect the relative abundances of these indicator microorganisms. This study highlighted the utility and relative ease of applying current molecular ecology methods to address macroscale questions with environmental management ramifications.

1.4 Viruses in Sediment

Over the years, diseases have been linked to major declines in coral abundance, reef functionality, and reef-related ecosystems services. A new disease outbreak has been reshaping coral reef functionality and has decimated coral populations. Stony coral tissue loss disease (SCTLD), an infection with high mortality, was first identified in Florida in 2014 and reached the northern Mesoamerican Reef by summer 2018, where it spread across the ~450-km reef system in only a few months. This emergent disease is likely to become the most lethal disturbance ever recorded (Gintert et al., 2019; Alvarez-Filip et al., 2022). The sources of transmission and cause are not yet fully understood, although the disease is transmitted through seawater, with bacteria being involved at some level in disease progression, and viruses of the algal symbionts being found in pathological studies, suggesting a disruption of host–symbiont physiology (Aeby et al., 2019; Landsberg et al., 2020; Work et al., 2021). Attempts to determine the precise pathogen(s) of SCTLD have advanced in the last few years, but they remain equivocal. Field sampling, lab experiments, and modeling approaches have also suggested that reef sediments may play a role in SCTLD transmission, though a positive link has not been tested experimentally (Studivan et al., 2022).

2. METHODOLOGY

2.1 Sediment Sampling

Permits for sediment core collection were provided by Broward County (Environmental Resource License # DF22-1259), U.S. Army Corps of Engineers (# SAJ-2022-03494), Florida Department of State Historical Resources (# 2022-7512), Florida Department of Environmental Protection Division of Recreation and Parks (#11302215), and Florida Department of Environmental Protection (#06-427980-001,002-EE).

Eighteen, 0.4-2.5 m sediment cores were collected 8-9 April 2023. Fifteen cores were taken from five Port Everglades sites (triplicates per site) and three cores from a control location, West Lake (WL), approximately three miles south of Port Everglades along the U.S. Intracoastal Waterway (ICW) (Table 1). West Lake was selected as a control since it is in a 1500-acre mangrove preserve and no motorized vessels have been permitted since 1988, which greatly reduced anthropogenic input. Three cores were taken from each port site: Port Everglades Inlet (PEI), Park Education Center (PEC), Park Headquarters (PHQ), South Turning Basin

(STB), and Dania Cutoff Canal (DCC). All sites are near ship traffic, vessels, equipment maintenance, and fueling activities. All cores were collected in water depths less than 2 m along the water body margin representing the main port environment.

A total of eighteen surface sediment samples, triplicates at each site, were collected using a plastic scoop and 55 oz capacity, sterile polyethylene sample bags from the by the dive team, at six reef sites approximately 1.5 km north (1N, 2N, 3N) and south (1S, 2S, 3S) of the inlet to Port Everglades (Fig. 1 and Table 2). The core and grab sediments were taken to compare 16 heavy metal (Al, As, Cd, Co, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Se, Sn, V, and Zn) concentration variations within each site, as marine sediments are subject to dispersal by water movement (Wang and Andutta, 2012).

Table 1. *Locations of sediment cores in latitude and longitude.*

Site ID	Location	Location
Dania Cutoff Canal (DCC)	N 26.06448°	W 80.11358°
Park Education Center (PEC)	N 26.08426°	W 80.11244°
Port Everglades Inlet (PEI)	N 26.09468°	W 80.10833°
Park Headquarters (PHQ)	N 26.08709°	W 80.11276°
South Turning Basin (STB)	N 26.07569°	W 80.11619°
West Lake (WL)	N 26.02345°	W 80.12214°

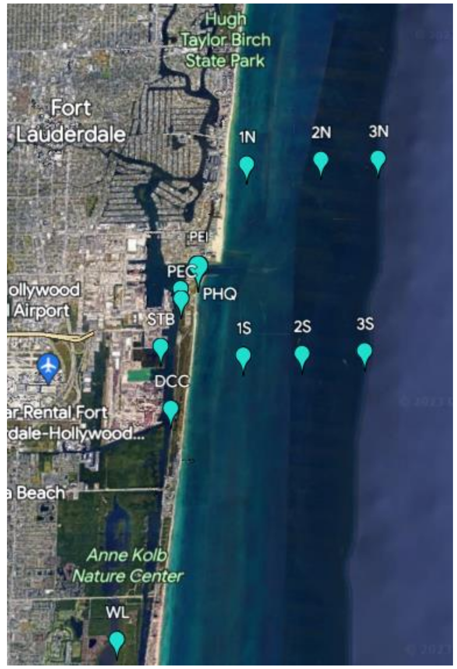

Figure 1. *Map of Port Everglades study site showing the Intracoastal Waterway, Port Everglades, sediment core and surface sample locations. Port Everglades Inlet (PEI), Park Education Center (PEC), Park Headquarters (PHQ), South Turning Basin (STB), Dania Cut-Off Canal (DCC), Westlake (WL), north coral reef sites – 1N, 2N, 3N, and south coral reef sites – 1S, 2S, 3S.*

Table 2: *Platform deployments for sediment traps and sondes. Locations of platforms in latitude and longitude, decimal degrees, and degrees minutes seconds.*

Date	**Time**	**Site ID**	**Sonde Serial #**	**Platform Number**	**Location**	**Location**	**Depth (ft)**
05/18/2023	11:35	3N	993608	3	N 26.11085° W 80.09067°	N 26°06’39.1’’ W 80°05’26.4’’	42.4
05/18/2023	14:06	2N	993687	4	N 26.11012° W 80.09828°	N 26°6’36.4314’’ W 80°5’53.808’’	23.7
05/19/2023	09:42	1N	993629	5	N 26.11003° W 80.10068°	N 26°6’36.1074’’ W 80°6’2.4474’’	19.5
05/31/2023	10:38	3S	993611	1	N 26.07447° W 80.09432°	N 26°4’28.092’’ W 80°5’39.551’’	37.5
05/31/2023	11:59	2S	993649	6	N 26.07465° W 80.09805°	N 26°4’28.7394’’ W 80°5’52.98’’	30.5
05/31/2023	13:15	1S	993630	2	N 26.07578° W 80.10707°	N 26°4’32.808’’ W 80°6’25.451’’	13.4

To collect the cores, a Bradford pneumatic vibrator, powered by an air compressor, was clamped to an aluminum barrel (7.5 cm diameter and 3 m length) supported by a vibracore extraction land-based tripod. Core catchers were positioned at the base of each barrel to ensure complete recovery of the sediments, after which the barrels were cut to length and capped. The cores were split longitudinally using a circular saw with diamond embedded blades. Each sediment core was subsampled using sterile plastic scoops and any type of debris (i.e., twigs, rocks, plastic) from the sediment was removed by hand while wearing disposable nitrile gloves. Once the debris was removed, the sediment was homogenized across 10 cm with a sterile spatula and approximately 20 g were placed in 100 ml polypropylene bottles for heavy metal analysis and a second bottle for microbiome analysis. Once subsampling was completed, each core was wrapped in plastic, placed inside plastic sleeves to prevent desiccation, and stored horizontally at 4° C in a Continental CH3R-GD refrigerator.

2.2 Platform Deployment with Sediment Traps and Sonde

Six platforms were constructed (Fig 2.) using high-density polyethylene marine board and marine grade stainless steel fasteners. Each platform was equipped with an ST-30 sediment trap (Ocean Innovations) to collect sediment for heavy metal analyses and assess sedimentation rates. In-Situ Aqua TROLL 600 multiparameter sondes outfitted with temperature, conductivity (salinity), pressure, dissolved oxygen, pH, and turbidity sensors were mounted on the anchored platforms at the same six reef sites (1N, 2N, 3N, 1S, 2S, 3S) where the surface sediment was sampled (Fig. 1 and Table 2). Each platform was weighted with 100# lead and anchored both with rebar stakes and leashed to an augured anchor.

Water chemistry data, including temperature, conductivity (salinity), pressure, dissolved oxygen, pH, and turbidity, are recorded hourly by each of the six sondes. Sonde sensors were calibrated before deployment. Data were downloaded after one week (2-9 June) to determine successful function and assess the level of biofouling on the platform. Sonde data appeared in acceptable ranges (Table 20). Biofouling, consisting solely of algal growth, was nominal to nearly nonexistent to the naked eye. Platforms, sediment traps, and sondes were all manually wiped with microfiber towels while in place.

Figure 2*. Constructed platform with ST-30 sediment trap and Aqua TROLL 600 sonde*.

2.3 Digestion and Analysis

Subsamples of sediment were taken at 10 cm intervals along the entire length of each core from surface to base and US Environmental Protection Agency (EPA) digestion method 3050B (EPA 1996) for the heavy metal analysis of the 16 heavy metals Al, As, Cd, Cr, Co, Cu, Fe, Pb, Mo, Mn, Hg, Ni, Se, Sn, V, and Zn was employed. In addition, subsamples at the top, middle and bottom of each core were taken and US Environmental Protection Agency (EPA) digestion method 1631E was used for Hg analysis (EPA 2002). Heavy metal analyses were performed at the NELAC-certified (E87982) Brooks Applied Lab in Seattle, WA using an inductively coupled plasma mass spectrometer (ICP-MS) for the 16 heavy metals and Cold Vapor Atomic Fluorescence Spectrometry for Hg. Standard reference material SRM 2702-Inorganics in Marine Sediment (MilliporeSigma) was used to evaluate reliability of the analytical method (Table 3).

Table 3*. Recovery % for standard reference material, SRM 2702-inorganics in marine sediment to evaluate reliability of analytical method.*

Heavy Metal	%
As	72
Cd	78
Co	71
Cr	67
Cu	77
Hg	84
Mn	79
Mo	76
Ni	71
Pb	93
Se	81
Sn	80
V	65
Zn	77

2.4 Continental Crust Composition

The elemental composition of the Earth's upper crust, also referred to as background elemental composition concentrations, is used as a tool for assessing geochemical anomalies (heavy metal contamination) (Table 4). Since comprehensive background values for marine sediments for all 16 heavy metals have not been determined for this area, the concentrations were compared to continental crust values derived from the post-Archean Australian average shale (PAAS), European shale composite (ES), and North American shale composite (NASC) (Taylor and McLennan, 1995; Al-Mutairi and Yap, 2021).

Table 4*. Threshold Effect Level (TEL), Probable Effect Level (PEL), and continental crust values. NA is not available.*

Heavy metals	**Sediment Quality Assessment Guidelines (µg/g)**		**Continental Crust (µg/g)**
	TEL	**PEL**	
As	7.24	41.6	1.5
Cd	0.676	4.21	0.098
Cr	52.3	160	35
Co	NA	NA	10
Cu	18.7	108	25
Pb	30.2	112	20
Mn	NA	NA	600
Hg	0.13	0.626	0.098
Mo	NA	NA	1.5
Ni	15.9	42.8	20
Se	NA	NA	50
Sn	NA	NA	5.5
V	NA	NA	60
Zn	124	271	71

2.5 Geo-Accumulation Index

The geo-accumulation index (I_{geo}) is a quantitative measure of the degree of contamination in sediments (Förstner, 1980) and was used here to measure the pollution intensity at individual sample locations. The I_{geo} is calculated as follows:

$$I_{geo} = \log_2 \left(\frac{C_n}{1.5 x B_n}\right)$$

C_n = concentrations within the sediment cores and B_n = background continental crust levels. Rudnick and Gao (2014) provides values that quantify the degree of contamination: 4 - 5: strongly to extremely contaminated; 3 - 4: strongly contaminated; 2 - 3: moderately to strongly contaminated; 1 - 2: moderately contaminated; 0 - 1: uncontaminated to moderately contaminated; < 0: uncontaminated.

2.6 Pollution Load Index

The pollution load index (PLI) was developed by Tomlinson et al. (1980) and is calculated using contamination factors (CF), represented by the concentrations of the sample metals and the background continental crust values $C_{metal}/C_{background}$. The calculation for PLI is:

$$PLI = (CF_1 \text{ x } CF_2 \text{ x } CF_3 \text{ x} \ldots CF_n)^{1/n}$$

where n = number of elements. This approach assesses total contamination load within the sediment and provides a PLI value that explains overall metal pollution within each sample. A sample with a PLI > 1 is classified as polluted while a sample with a PLI < 1 indicates no contamination (Tomlinson et al., 1980; Ray et al., 2006; Badr et al., 2009).

2.7 Threshold effect levels (TEL) and Probable effect levels (PEL)

The Florida Department of Environmental Protection created sediment quality assessment guidelines (SQAGs) to address coastal ecosystem contamination concerns. Numerical SQAGs were derived for nine metals (As, Cd, Cr, Cu, Hg, Ni, Pb, tributyltin, Zn) that occur in Florida coastal sediments (MacDonald et al., 1996; Table 3). A threshold effect level (TEL) and probable effect level (PEL) were developed for these metals as powerful tools to assess contaminant levels in sediment (MacDonald et al., 1996; MacDonald and Ingersoll, 1993). The TEL is the concentration below which adverse effects rarely occur to benthic organisms while the PEL is the concentration above which adverse effects frequently occur (Thompson and Wasserman, 2015; Geoenvironmental Engineering, 2015).

2.8 Potential Ecological Risk Index

The potential ecological risk index (PER) determines the degree of contamination for combined metal concentrations within each sediment sample (Guo et al., 2010). The PER is calculated as:

$$\mathrm{PER} = \sum \mathrm{E}$$

$$\mathrm{E} = \mathrm{TC}$$

$$\mathrm{C} = \mathrm{C_a}/\mathrm{C_b}$$

where C_a = element content within sample, C_b = reference value of the element, and T = toxic response factor for metals: Mn and Zn = 1, Cr = 2, Cu and Pb = 5, Ni = 6, As = 10, and Cd = 30 (Hakanson, 1980; Fu et al., 2009; Guo et al., 2010; Cao et al., 2015).

2.9 Enrichment Factor (EF)

The enrichment factor (EF) ascertains whether heavy metals in sediments are of anthropogenic origin. EF is a means of quantifying the enrichment of a potentially contaminant-derived heavy metal in sediment relative to a defined background composition using Fe and Al as the reference metals (Zoller et al., 1974). The E_F is calculated as:

$$E_F = \left(\frac{C_n}{C_{ref}}\right)/\left(\frac{B_n}{B_{ref}}\right)$$

C_n is concentration of the examined element in the sediment; C_{ref} is concentration of the examined element in the Earth's crust (upper continental crust); B_n is the concentration of the reference element (Al or Fe) in the sediment; B_{ref} is the concentration of the reference element (Al or Fe) in the Earth's crust (upper continental crust)

2.10 16SrRNA gene amplicon microbiome analyses

Microbial genomic DNA/RNA that can be used for both 16S amplicon and metagenomics (and metatranscriptomics) was extracted from sediment samples following the routine protocol for the QIAGEN DNEasy PowerLyzer PowerSoil Kit (100) or ZymoBiomics DNA/RNA Miniprep kit. For DNA and RNA extraction, the manufacturer's protocols were followed. DNA and RNA were quantified using a Qubit 4.0.

16S rRNA gene amplicons were sequenced using standard Earth Microbiome Project protocols for the Illumina MiSeq platform (Thompson et al., 2017; Eason and Lopez, 2019). The 515F and 806R primers were used to amplify the ~300bp sequence of the V3 and V4 region of the 16S gene (Caporaso et al., 2011; Eason and Lopez, 2019) The PCR products were then cleaned using AMPure XP beads. This process is used to purify the 16S V3 and V4 amplicon away from free primers and primer dimer species. The final DNA (and RNA) concentrations were checked to high precision using a Qubit® 4.0 Fluorometer. Once concentrations were obtained, each sample was then diluted to a normalization of 4 pM. All the samples were library pooled and rechecked on the Qubit to make sure the concentration was between 4-6 ng/µL. If the pool passes then a final quality check was done using an Agilent 4150TS Tapestation, which checks the quality of DNA and for any possible contamination. The pooled DNA product was loaded into the Illumina MiSeq for 16S metagenomic DNA using the MiSeq Reagent Kit v3 at 600 cycles of sequencing following a modified Illumina workflow protocol. All DNA samples were prepared for library preparation and sequencing on an Illumina NextSeq or HiSeq at CosmosID.

2.11 Sequence Data Analyses

Once 16S rRNA gene amplicon sequencing was completed, initial sequence analyses were conducted on CosmosID metagenomics pipeline (https://www.cosmosid.com/metagenomics-app/). More detailed alpha and beta diversity were assessed using the statistical software QIIME2 and R Studio following routine methods performed in the Lopez laboratory of Halmos College of Arts and Sciences (HCAS) for analysis of other sample types such as South Florida surface water samples (Campbell et al, 2015; O'Connell et al., 2018; Easson and Lopez, 2019; Krausfeldt et al., 2023), deep-sea anglerfish (Freed et al., 2019), sharks (Karns et al., 2017), sponges (Cuvelier et al., 2014) and bacterioplankton in coordination with the DEEPEND consortium (Easson and Lopez, 2019).

The Quantitative Insights into Microbial Ecology v.2 (QIIME2) pipeline was used to demultiplex, quality filter, assign taxonomy, reconstruct phylogeny, and produce diversity analysis and visualizations from the FASTQ DNA sequence files (Caporaso et al., 2010). Quality filtering and data trimming was conducted in DADA2 using the "dada2 denoise" command, which was then used to create a feature-table. The QIIME2-generated sequences were assigned taxonomy through a learned SILVA classifier (silva-132-99-515-806-nb-classifier.qza).

The R Studio statistical software packages "vegan" and "phyloseq" were utilized to assess diversity between samples (McMurdie Holmes, 2013; Oksanen et al., 2018). Alpha diversity, which describes the species richness and evenness within a sampling location, was looked at for each sample. This was determined using multiple measures such as Observed and Chao1 for species richness estimators and Shannon and Inverse Simpson indices for relative abundance diversity (Lande, 1996; Kim et al. 2017). Statistical differences between samples will be calculated after normality determination using Analysis of Variance (ANOVA) or Kruskal-Wallis one-way analysis of variance test.

2.12 Metagenomic Methods

All sediment samples were stored immediately after subsampling at -80º C until they are needed for DNA extractions. Purified genomic DNA samples were sent to a high throughput sequencing vendor, CosmosID. Partial analyses have been applied with the CosmosID online analysis hub using bacterial databases. Viruses and protists have yet to be applied to this dataset. Reads from metagenomes generated from sediment samples collected will be trimmed and filtered for quality using bbduk within the bbtools package (minlen=25, trimq=20, qtrim=rl ref=adapters.fa) (Bushnell, 2014). Reads will be taxonomically annotated on the CosmosID-HUB (https://docs.cosmosid.com/docs/methods). Metagenomes will also be co-assembled by location in Kbase using MegaHit v1.2.9 (Li et al., 2016).

3. RESULTS/DISCUSSION

The results and discussion presented below are preliminary. Data analysis and statistics will be performed in Phase II of the project (July 2023-June 2024).

3.1 Heavy Metal Concentrations in Port, Control, and Reef Sites and Continental Crust Value Comparison

The concentrations of the 16 heavy metals were determined by ICP-MS in the 18 sediment cores from the port and control sites and are shown in Table 5, while the concentration of the heavy metals in surface sediment from the six coral reef sites are shown in Table 6. The ranges of the 16 heavy metal concentrations per location are shown in Table 7. The total Hg concentrations using EPA method 1631E at the top, middle, and bottom of each core are shown in Table 8.

The data indicated that all of the port sites (DCC, PEC, PHQ, PEI, and STB), the control site (WL), and the reef sites (1N, 2N, 3N, 1S, 2S, and 3S) have As concentrations above the upper continental crust value of 1.5 µg/g. The port sediment at DCC, PEC, PHQ, and STB also have Cd and Mo concentrations above the upper continental crust values of 0.098 µg/g and 1.5 µg/g, respectively. The control site also has Cd and Cu concentrations above the upper continental crust values of 0.098 µg/g and 25 µg/g, respectively. These values could indicate anthropogenic contamination in the sediment.

Table 5*. Heavy metal concentrations (µg/g) by sediment core depth (cm) for Dania Cutoff Canal (DCC), Park Education Center (PEC), Park Headquarters (PHQ), Port Everglades Inlet (PEI), South Turning Basin (STB), and West Lake (WL). Bolded numbers indicate above upper continental crust (background) values shown in Table 4.*

	depth (cm)	**Al**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Fe**	**Hg**	**Mn**	**Mo**	**Ni**	**Pb**	**Se**	**Sn**	**V**	**Zn**
DCC-1	10	2390	**7.03**	0.076	0.361	12.1	5.77	4150	0.032	6.98	**4.68**	3.77	1.89	0.968	0.268	12.8	28.9
	20	2420	**13.7**	**0.122**	0.343	15.9	8.63	4820	0.033	8.77	**9.95**	5.34	2.90	1.13	0.282	18.8	13.1
	30	1390	**11.6**	**0.182**	0.400	8.04	17.4	3690	0.024	8.31	**13.1**	4.14	2.25	0.921	0.412	23.3	29.5
	40	4370	**15.6**	**0.628**	0.710	22.9	4.86	1710	0.059	12.4	**49.4**	9.34	1.95	1.95	0.499	42.9	7.85
	50	5720	**15.3**	**0.632**	0.825	**35.2**	11.2	21900	0.046	42.6	**38.9**	11.4	3.34	2.45	0.391	31.7	10.3
	60	7050	**20.1**	**0.633**	0.917	**48.9**	9.83	32400	0.051	50.5	**35.3**	14.8	3.81	3.6	0.43	34.1	7.53
	70	6530	**22.7**	**0.370**	0.774	**46.5**	8.72	34400	0.045	48.3	**24.2**	14.3	3.62	3.57	0.386	22.7	6.64
	80	4220	**21.3**	**0.219**	0.561	30.3	5.83	26600	0.033	48.7	**18.6**	9.29	2.30	2.32	0.28	19.1	5.00
	90	3650	**19.7**	**0.135**	0.514	24.2	4.62	22100	0.028	51.8	**17.8**	7.72	2.00	2.05	0.241	19.1	3.79
	100	660	**14.5**	0.041	0.424	3.33	0.61	8560	0.017	128	**6.00**	1.44	0.566	0.564	0.143	3.02	2.25
	110	106	**12.8**	0.036	0.354	0.812	0.48	6630	0.015	121	**1.87**	0.562	0.094	0.356	0.126	0.394	1.98
	120	77.5	**12.1**	0.037	0.389	0.842	0.50	5790	0.015	134	0.886	0.603	0.085	0.338	0.131	0.32	2.06
	130	118	**10.2**	0.037	0.271	0.832	0.49	4840	0.015	131	0.293	0.429	0.095	0.219	0.129	0.569	2.03
	140	142	**13.5**	0.035	0.325	0.781	0.46	5320	0.014	127	0.382	0.682	0.15	0.279	0.121	0.569	1.91
	150	4330	**14.6**	0.034	0.570	5.62	0.45	7080	0.014	134	0.364	1.80	1.29	0.449	0.12	3.74	1.88
	160	17200	**23.5**	0.035	1.25	22.5	1.80	16400	0.022	76.2	**1.52**	4.53	5.92	0.699	0.479	15.9	7.25
DCC-2	10	616	**3.38**	0.046	0.198	4.08	7.02	2000	0.019	9.75	**1.56**	1.16	1.51	0.387	0.161	4.70	10.3
	20	1610	**13.2**	**0.136**	0.338	8.88	9.94	5080	0.044	9.41	**11.6**	3.44	2.05	1.04	0.28	16.7	17.3
	30	3390	**25.9**	**0.293**	0.597	19.2	8.81	9290	0.058	11.8	**42.5**	7.95	2.13	1.89	0.488	40.6	28.5
	40	4100	**17.0**	**0.62**	0.631	21.6	7.25	15400	0.056	14.0	**40.4**	9.08	2.34	1.85	0.475	34.1	8.47
	50	6340	**15.3**	**0.729**	0.914	**38.8**	8.88	24500	0.054	46.8	**39.9**	13.0	3.23	2.67	0.46	34.6	7.22
	60	3420	**30.2**	**0.246**	0.541	25.1	4.97	25900	0.033	47.6	**20.4**	8.18	1.93	2.16	0.241	22.9	4.51
	70	274	**15.6**	0.04	0.358	1.58	0.53	7920	0.016	124	**5.67**	0.73	0.115	0.466	0.139	1.77	2.19

	80	140	**13.1**	0.036	0.339	0.815	0.48	5860	0.015	123	**2.15**	0.467	0.081	0.378	0.127	0.418	1.99
	90	99.9	**12**	0.037	0.312	0.836	0.49	6140	0.015	118	0.75	0.471	0.084	0.339	0.13	0.149	2.04
	100	72.1	**12.2**	0.035	0.311	0.787	0.46	5630	0.014	116	0.697	0.486	0.079	0.227	0.122	0.152	1.92
	10	2670	**13.6**	**0.372**	0.521	13.2	12.7	10900	0.053	16.2	**23.6**	6.51	2.31	1.33	0.359	22.8	19.7
	20	5950	**15.9**	**0.659**	0.832	34.7	9.75	25400	0.052	38.4	**33.4**	12.4	3.63	2.56	0.355	32.4	9.31
	30	5250	**68.6**	**0.440**	0.914	32.5	10.1	34300	0.045	46.8	**33.3**	11.5	3.08	3.05	0.305	29.6	9.98
	40	2550	**21.1**	**0.121**	0.456	17.5	3.55	21000	0.026	58.7	**14.5**	5.31	1.42	1.37	0.176	14.2	2.77
	50	878	**12.5**	0.042	0.376	4.44	0.92	8380	0.022	88.8	**6.39**	1.95	0.434	0.612	0.147	5.3	2.32
DCC-3	60	405	**13.8**	0.034	0.358	2.02	0.85	7120	0.019	104	**5.15**	1.10	0.247	0.498	0.119	2.87	1.87
	70	81.4	**10.6**	0.035	0.304	0.797	0.47	5140	0.018	112	**1.99**	0.420	0.080	0.346	0.124	0.569	1.95
	80	45.8	**10.8**	0.03	0.291	0.669	0.39	4830	0.015	144	0.852	0.35	0.067	0.210	0.104	0.296	1.64
	90	157	**10.4**	0.034	0.304	0.759	0.45	4390	0.017	111	0.652	0.342	0.09	0.227	0.118	0.622	1.85
	100	5380	**12.7**	0.033	0.534	7.50	0.47	8170	0.017	102	0.674	1.63	1.55	0.412	0.147	4.72	1.83
	110	28000	**18.9**	0.033	1.81	33.7	1.39	22300	0.017	57.1	1.14	6.16	8.67	0.556	0.781	19.2	6.36

	depth (cm)	**Al**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Fe**	**Hg**	**Mn**	**Mo**	**Ni**	**Pb**	**Se**	**Sn**	**V**	**Zn**
	10	1330	**2.71**	0.067	0.331	9.84	**26.6**	2660	0.061	12.5	1.46	3.55	5.4	0.293	0.362	14.3	26.1
	20	2260	**4.09**	**0.129**	0.615	15.6	14.7	4220	0.092	16.7	**2.66**	10.3	7.98	0.42	0.44	45.8	18.0
	30	2050	**5.73**	**0.206**	0.895	16.7	21.1	6240	**0.207**	17.3	**3.42**	17.9	10.5	0.484	0.613	**71.6**	24.5
	40	2890	**4.38**	**0.143**	0.763	18.4	11.5	5340	**0.112**	18.5	**2.59**	11.0	6.87	0.403	0.462	41.4	14.9
	50	3240	**2.91**	0.056	0.646	18.3	2.31	3790	0.027	17.5	**1.87**	3.37	2.32	0.281	0.18	12.6	4.11
	60	6030	**3.78**	0.06	0.789	23.5	1.96	4820	0.027	21.8	**2.28**	4.01	2.98	0.405	0.225	15.6	3.92
PEC-1	70	7340	**5.35**	0.081	1.03	29.3	4.98	7100	0.048	32.7	**3.47**	5.89	5.72	0.500	0.474	16.8	8.76
	80	6640	**3.58**	0.071	0.90	27.9	3.65	5050	0.045	25.4	**2.27**	4.73	4.00	0.385	0.33	15.3	5.65
	90	5950	**3.19**	0.063	0.815	24.6	2.30	4600	0.039	22.1	**2.11**	4.41	3.34	0.367	0.258	14.5	5.12
	100	5760	**4.08**	0.066	0.876	24.1	2.61	5230	0.036	23.8	**2.94**	4.38	3.55	0.401	0.255	14.8	4.76
	110	7120	**4.65**	0.069	1.02	24.9	2.70	5560	0.043	32.3	**2.60**	4.90	4.15	0.399	0.296	15.8	5.57
	120	1910	**8.41**	**0.198**	0.459	9.29	12.7	6290	**0.224**	16.5	**2.83**	5.54	11.1	0.538	0.596	25.6	19.0
	130	1180	**9.51**	**0.117**	0.254	9.39	2.65	6950	0.056	16.2	**6.53**	2.71	1.89	0.662	0.13	10.9	3.49

	140	822	**8.47**	0.080	0.180	8.38	1.29	6090	0.024	12.9	**5.23**	2.33	0.649	0.54	0.093	9.3	1.47
	150	714	**9.65**	0.072	0.239	6.40	1.01	7500	0.036	10.5	**8.55**	2.25	1.03	0.639	0.144	9.86	2.26
	160	5210	**3.97**	0.053	0.681	8.62	1.26	10600	0.039	12.5	**9.74**	3.01	2.22	0.612	0.143	8.33	30.3
	170	2230	**13.1**	**0.099**	0.792	7.09	2.13	22800	0.088	10.1	**43.2**	3.94	1.01	1.62	0.345	13.3	5.42
	180	4450	**6.67**	0.084	0.841	8.89	3.86	11400	0.075	11.2	**17.5**	3.32	1.62	1.22	0.295	11.2	4.63
	190	7320	**3.57**	0.079	0.609	11.5	2.37	8510	0.052	13.9	**9.52**	3.28	2.51	0.875	0.205	9.73	3.23
	200	8850	**4.67**	0.066	0.823	14.9	2.14	14800	**0.100**	18.00	**9.40**	4.80	3.67	1.10	0.248	15.3	3.40
	210	4130	**2.3**	0.043	1.00	6.33	0.41	6180	0.038	18.8	**4.52**	2.35	2.27	0.285	0.111	6.15	1.89
	220	8070	**3.98**	0.049	0.997	11.6	0.56	15200	0.032	17.6	**8.17**	4.44	3.99	0.372	0.196	9.62	3.10
	230	7340	**3.75**	0.042	0.462	10.2	0.45	17100	0.048	14.1	**5.94**	3.41	3.31	0.251	0.182	9.49	2.48
	10	985	**2.27**	0.055	0.273	7.09	16.6	1790	0.026	9.74	**1.53**	2.34	3.8	0.19	0.233	9.75	18.6
	20	1870	**3.52**	**0.101**	0.413	10.9	16.4	3110	0.068	12.4	**1.84**	6.45	5.74	0.331	0.353	27.4	19.2
	30	1880	**5.74**	**0.167**	0.678	13.4	15.0	4790	**0.135**	15.3	**3.02**	13.3	7.31	0.396	0.46	55.4	18.6
	40	2390	**5.78**	**0.132**	0.696	16.0	17.3	5900	**0.152**	16.9	**2.29**	11.2	7.53	0.455	0.484	41.4	19.4
	50	3900	**2.85**	0.047	0.647	19.8	1.74	3750	0.021	19.0	**1.58**	3.69	2.04	0.34	0.138	12.4	3.40
	60	5140	**3.44**	0.05	0.693	21.3	1.83	4380	0.018	19.4	**2.05**	3.77	2.51	0.355	0.184	13.6	3.20
	70	7980	**4.39**	0.069	0.861	27.1	2.60	5850	0.024	29	**2.42**	5.07	3.81	0.420	0.333	14.7	5.38
	80	6880	**3.78**	0.079	0.896	28.8	3.51	5350	0.031	25.6	**2.37**	5.10	3.92	0.400	0.304	15.0	5.42
	90	5660	**3.20**	0.062	0.817	22.8	2.40	4380	0.025	23.1	**2.27**	4.47	2.97	0.395	0.218	14.1	4.07
	100	2590	**8.16**	**0.168**	0.544	12.3	19.0	6780	**0.32**	21.9	**1.79**	9.16	12.1	0.587	0.689	29.0	20.1
PEC-2	110	753	**9.27**	0.076	0.18	6.32	1.93	5760	0.036	10.2	**6.45**	2.05	1.21	0.448	0.102	11.5	2.25
	120	904	**7.29**	0.071	0.18	6.74	1.09	4550	0.010	11.5	**5.23**	2.06	0.641	0.43	0.105	9.46	1.74
	130	690	**21.5**	0.053	0.424	5.61	0.87	13600	0.021	17.8	**19.2**	1.66	0.588	0.894	0.159	8.86	2.50
	140	569	**36.5**	0.066	0.763	5.12	0.87	15900	0.033	70.3	**29.1**	1.78	0.362	1.15	0.23	11.5	3.61
	150	749	**23.4**	0.058	0.711	4.72	1.11	13400	0.019	48.3	**27.6**	2.86	0.405	1.07	0.18	15.2	2.83
	160	159	**11.0**	0.054	0.769	1.20	0.71	6230	0.018	56.0	**5.37**	0.799	0.12	0.497	0.187	1.51	2.94
	170	3630	**7.74**	0.053	1.25	5.46	0.74	8040	0.03	20.8	**6.73**	1.63	1.28	0.738	0.185	4.38	2.91
	180	10800	**2.49**	0.045	0.519	14.0	1.05	5190	0.02	15.1	**1.65**	1.88	3.86	0.586	0.286	7.54	2.50
	190	8170	**2.54**	0.034	0.885	10.6	0.98	3930	0.012	11.6	1.17	1.70	3.13	0.49	0.201	6.33	1.87
	200	11200	**2.54**	0.037	0.92	14.7	1.37	4990	0.015	15.2	0.946	2.40	4.25	0.568	0.307	9.67	2.05

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
	210	14900	**3.88**	0.056	1.06	23.5	6.02	8420	0.046	44.0	**2.61**	3.92	5.83	0.776	0.448	32.1	5.53
PEC-3	10	737	1.07	0.047	0.157	6.91	7.23	1200	0.023	8.3	0.582	2.10	2.00	0.105	0.09	6.96	8.72
PEC-3	20	2620	**2.76**	0.098	0.512	15.1	12.5	3630	0.059	17.7	1.59	9.35	6.80	0.248	0.293	42.6	13.0
PEC-3	30	2080	**4.55**	**0.230**	0.752	18.5	19.8	6510	**0.16**	19.2	3.18	18.3	10.5	0.376	0.525	**74.8**	23.3
PEC-3	40	2340	**2.80**	0.075	0.514	18.7	4.30	3990	0.017	15.9	2.14	5.46	2.97	0.2	0.148	21.0	7.72
PEC-3	50	3290	**2.30**	0.058	0.451	19.6	1.35	3370	0.038	17.0	1.52	3.09	1.68	0.202	0.099	11.3	2.95
PEC-3	60	4430	**3.73**	0.058	0.632	24.0	1.92	5470	0.036	21.5	2.43	4.07	2.36	0.289	0.165	14.7	3.82
PEC-3	70	7930	**5.54**	0.088	0.960	33.2	3.75	8400	0.048	33.5	3.78	6.73	5.32	0.481	0.374	18.7	8.07
PEC-3	80	8140	**5.77**	**0.103**	0.972	34.8	5.75	8660	**0.110**	36.0	4.08	7.02	6.27	0.547	0.504	19.9	11.8
PEC-3	90	7120	**3.52**	0.084	0.749	30.1	2.93	5530	0.031	25.8	3.10	5.08	3.59	0.296	0.231	16.2	5.21
PEC-3	100	6680	**3.77**	0.08	0.784	29.9	2.91	6120	0.025	26.1	2.92	5.54	3.98	0.295	0.264	17.3	5.06
PEC-3	110	3380	**7.42**	**0.133**	0.615	16.7	13.1	7520	**0.218**	27.5	2.73	8.81	8.87	0.467	0.522	26.4	15.8
PEC-3	120	815	**7.77**	0.084	0.300	6.69	4.49	6800	**0.105**	10.0	4.55	2.91	2.61	0.544	0.194	12.8	6.71
PEC-3	130	1160	**26.6**	0.087	0.757	8.43	2.92	20500	**0.117**	69.0	30.4	3.17	1.87	1.12	0.186	16.2	2.99
PEC-3	140	327	**18.9**	0.049	0.539	2.4	1.24	8440	0.053	68.7	10.9	1.09	0.779	0.58	0.171	4.82	2.69
PEC-3	150	137	**15.2**	0.035	0.51	1.04	0.55	6850	0.061	69.6	4.24	0.587	0.263	0.325	0.124	1.67	1.94
PEC-3	160	374	**18.4**	0.067	2.32	1.59	0.88	9430	0.036	67.0	9.82	1.19	0.15	0.866	0.234	2.52	3.67
PEC-3	170	9040	**4.99**	0.053	0.636	14.7	1.95	9790	0.05	15.6	3.31	2.65	3.57	1.00	0.232	8.87	3.21
PEC-3	180	11500	**3.46**	0.041	1.65	18.5	1.65	7630	0.027	16.2	1.35	2.96	4.71	0.685	0.308	10.3	2.54
PEC-3	190	15700	**3.98**	0.036	1.64	24.1	1.85	8970	0.06	23.5	1.07	4.63	6.64	0.921	0.423	14.4	3.48

	depth (cm)	**Al**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Fe**	**Hg**	**Mn**	**Mo**	**Ni**	**Pb**	**Se**	**Sn**	**V**	**Zn**
PHQ-1	10	276.0	0.696	0.023	0.102	2.77	2.83	508	0.020	5.68	0.288	0.404	1.61	0.093	0.073	2.27	8.63
PHQ-1	20	311	1.46	0.035	0.126	3.06	3.47	1030	0.022	5.85	0.94	0.606	2.94	0.117	0.091	3.24	13.5
PHQ-1	30	996	**10.0**	**0.131**	0.308	6.49	5.59	8830	0.036	7.97	**16.9**	2.53	2.27	0.55	0.185	12.7	59.3
PHQ-1	40	644	**6.99**	0.047	0.152	5.99	5.15	7390	0.027	4.75	**13.8**	1.97	1.72	0.445	0.127	8.83	11.8
PHQ-1	50	1980	**15.2**	**0.241**	0.445	17.1	20.3	12700	0.094	7.67	**33.8**	6.68	3.92	1.29	0.328	41.9	44.9
PHQ-1	60	3720	**20.6**	**0.244**	0.525	28.8	3.92	20700	0.077	8.15	**60.5**	13.6	3.73	2.86	0.391	40.5	6.15
PHQ-1	70	1810	**21.2**	**0.22**	0.311	17.3	2.51	18500	0.058	9.21	**55.9**	5.08	0.995	1.50	0.293	**71.4**	4.60

	80	1080	**9.56**	**0.163**	0.159	10.5	0.98	9950	0.033	3.54	**35.8**	3.83	0.860	0.931	0.168	24.3	2.63
	90	1380	**15.1**	**0.253**	0.232	13.0	1.50	13600	0.047	5.78	**54.5**	4.40	0.950	1.13	0.226	36.7	3.54
	100	760	**7.76**	0.076	0.126	7.17	1.02	5430	0.024	4.12	**28.3**	1.94	0.713	0.49	0.122	12.3	1.92
	110	584	**8.22**	0.061	0.105	5.83	0.77	6950	0.022	5.32	**15.3**	1.39	1.02	0.378	0.111	6.15	1.74
	120	465	**8.20**	0.056	0.086	4.38	0.65	4470	0.020	3.85	**17.6**	1.41	0.476	0.326	0.102	5.49	1.61
	130	604	**9.77**	0.08	0.103	6.34	0.6	5020	0.016	5.21	**13.9**	1.35	0.553	0.298	0.084	14.2	1.32
	140	841	**11.2**	**0.114**	0.17	8.48	1.14	7480	0.024	8.65	**12.4**	2.36	0.815	0.583	0.123	11.3	1.94
	150	755	**13.2**	**0.124**	0.159	8.13	1.06	8670	0.019	10.3	**15.1**	2.36	0.69	0.519	0.097	8.71	1.52
	160	908	**19.5**	**0.125**	0.174	10.6	1.47	12700	0.022	12.9	**18.2**	2.78	0.902	0.663	0.111	11.0	1.74
	170	608	**10.9**	0.063	0.118	6.83	0.95	7350	0.018	7.94	**8.10**	1.74	0.66	0.424	0.093	7.38	1.47
	180	531	**9.05**	0.052	0.143	5.88	0.67	5850	0.022	9.24	**8.59**	1.41	0.481	0.466	0.110	7.74	1.73
	190	919	**19.2**	0.079	0.462	11.3	1.04	15800	0.054	23.2	**32.5**	2.68	0.465	1.16	0.275	23.8	4.32
	200	953	**19.6**	**0.127**	1.47	11.8	1.68	13600	0.087	22.3	**29.0**	3.23	0.525	1.76	0.445	14.6	6.99
	210	769	**17.4**	**0.129**	1.55	9.47	1.71	11200	0.089	20.9	**21.5**	3.00	0.360	1.78	0.451	11.0	7.09
	10	193	0.827	0.02	0.126	3.01	2.66	525	0.013	6.42	0.102	0.379	2.06	0.088	0.072	2.16	7.92
	20	1750	**30.6**	**0.143**	0.350	10.1	8.04	26900	0.076	15.2	**49.0**	4.07	2.84	1.13	0.202	20.1	11.5
	30	3470	**32.3**	**0.26**	0.738	20.5	3.27	46300	**0.099**	12.9	**87.7**	10.5	2.54	2.59	0.368	42.2	5.92
	40	1220	**11.0**	**0.106**	0.281	9.12	4.06	14400	0.037	9.75	**23.6**	3.22	2.14	0.664	0.19	16.7	7.99
	50	2850	**14.5**	**0.207**	0.416	23.4	3.19	15800	0.072	8.42	**49.5**	7.93	2.04	2.03	0.366	45.4	5.75
	60	2780	**10.3**	**0.128**	0.298	20.7	1.80	9280	0.07	4.23	**39.5**	7.89	1.86	1.59	0.355	35.2	5.57
	70	1900	**11.7**	**0.201**	0.236	17.6	1.38	13400	0.065	4.18	**48.5**	7.77	1.70	1.54	0.331	34.2	5.20
	80	1480	**12.2**	**0.248**	0.26	14.0	4.50	11600	0.047	4.11	**52.0**	4.69	1.49	1.04	0.24	50.2	6.23
PHQ-2	90	1170	**7.33**	**0.108**	0.132	9.12	1.94	7410	0.025	6.28	**31.3**	2.91	0.837	0.624	0.129	15.7	2.03
	100	826	**5.03**	0.055	0.114	8.29	1.04	3970	0.012	3.03	**15.9**	1.94	0.734	0.480	0.105	10.1	1.65
	110	553	**6.32**	0.053	0.101	4.64	0.69	4250	0.011	4.04	**8.92**	1.47	0.557	0.401	0.096	4.80	1.51
	120	392	**4.61**	0.039	0.070	3.03	0.42	2370	0.008	3.17	**5.87**	0.949	0.422	0.231	0.09	4.11	1.42
	130	448	**5.12**	0.052	0.081	4.06	0.47	3310	0.007	3.39	**5.86**	1.03	0.434	0.259	0.072	5.14	1.13
	140	347	**4.74**	0.035	0.070	3.28	0.34	2530	0.007	3.55	**4.89**	0.804	0.337	0.211	0.069	3.58	1.09
	150	1200	**15.4**	**0.104**	0.209	11.3	1.49	9830	0.009	14.0	**10.8**	2.97	1.00	0.675	0.102	12.7	3.55
	160	860	**11.9**	0.077	0.151	9.45	1.03	7790	0.011	10.6	**8.02**	2.30	0.659	0.563	0.122	12.8	1.92

	170	605	**8.14**	0.043	0.119	4.92	0.49	5040	0.008	7.63	**4.85**	1.44	0.536	0.318	0.091	4.82	1.43
	180	608	**8.24**	0.05	0.166	6.17	0.64	5320	0.01	9.12	**7.74**	1.50	0.444	0.488	0.11	9.44	1.73
	190	766	**19.3**	**0.105**	0.824	9.43	1.40	14000	0.036	33.3	**24.6**	2.53	0.237	1.87	0.369	12.0	5.80
	200	254	**7.02**	0.065	0.465	3.11	0.86	3920	0.021	35.9	**7.66**	1.05	0.146	0.617	0.227	3.96	3.57
	210	156	**7.35**	0.055	0.747	2.20	0.73	2870	0.018	38.7	**3.89**	0.862	0.125	0.61	0.194	2.27	3.04
	220	231	**9.99**	0.077	1.19	4.12	1.01	5010	0.025	52.9	**6.69**	1.59	0.172	0.895	0.268	4.33	4.21
	10	582	**4.38**	0.046	0.19	4.47	12.2	2560	0.014	8.85	**2.66**	1.64	3.62	0.272	0.325	8.87	17.9
	20	2370	**22.1**	**0.212**	0.721	14.3	7.07	30200	**0.102**	12.3	**49.8**	9.22	3.27	2.04	0.223	30.6	8.60
	30	2580	**19.8**	**0.138**	0.49	17.5	2.87	30600	0.036	11.8	**52**	7.18	1.21	2.13	0.386	42.5	6.06
	40	2080	**30.7**	**0.254**	0.517	15.5	5.63	48800	0.059	28.7	**78.6**	6.5	1.45	2.06	0.322	43.9	7.49
	50	2190	**17.1**	**0.27**	0.376	17.1	7.87	22300	0.025	23.6	**43.1**	6.89	1.61	1.76	0.273	39.2	17.6
	60	1960	**13.5**	**0.182**	0.321	15.2	3.45	10200	0.030	7.32	**50.3**	6.41	1.57	1.57	0.324	30.5	5.29
	70	1840	**10.9**	**0.253**	0.227	16.2	1.32	17300	0.024	5.89	**53.7**	5.95	1.32	1.61	0.255	39.2	4.01
	80	2180	**7.46**	**0.137**	0.248	17.9	1.66	8940	0.019	4.31	**41.7**	5.28	1.49	1.28	0.202	27.4	3.17
	90	1210	**6.48**	0.091	0.170	9.58	1.51	6110	0.014	4.05	**27.6**	2.91	0.942	0.787	0.146	12.1	2.29
	100	494	**6.87**	0.049	0.089	4.21	0.63	3510	0.008	3.36	**10.9**	1.42	0.495	0.333	0.086	5.14	1.36
	110	738	**7.20**	0.058	0.110	6.31	1.00	5220	0.011	3.92	**17.6**	1.84	0.652	0.46	0.089	7.61	1.40
PHQ-3	120	302	**4.32**	0.032	0.061	2.68	0.32	2150	0.008	2.54	**6.40**	0.88	0.323	0.214	0.085	3.86	1.34
	130	334	**5.43**	0.035	0.058	2.74	0.34	2750	0.008	4.07	**4.89**	0.885	0.355	0.239	0.072	2.83	1.14
	140	630	**7.97**	0.061	0.103	5.74	0.65	4830	0.008	7.71	**6.80**	1.51	0.511	0.372	0.088	6.35	1.38
	150	1100	**14.1**	**0.107**	0.200	12.2	1.39	9420	0.017	12.9	**11.0**	2.98	0.856	0.717	0.099	14.4	1.55
	160	619	**8.30**	0.042	0.11	6.77	0.81	5610	0.007	8.23	**4.93**	1.47	0.471	0.337	0.079	5.64	1.24
	170	522	**8.66**	0.039	0.163	4.89	0.47	5040	0.010	9.14	**6.83**	1.37	0.394	0.413	0.113	7.65	1.78
	180	993	**18.5**	0.08	0.718	9.82	1.07	12900	0.026	27.8	**18.6**	2.62	0.505	1.36	0.281	17.3	4.42
	190	725	**11.1**	0.056	0.463	6.37	1.05	7550	0.018	23.5	**12.6**	3.98	0.495	1.02	0.197	9.89	3.10
	200	251	**9.40**	0.059	2.55	2.93	0.78	2980	0.019	35.2	**5.04**	1.13	0.133	0.784	0.207	3.44	3.25
	210	228	**10.8**	0.055	2.55	3.53	0.72	3740	0.027	67.3	**5.87**	1.60	0.123	0.769	0.191	3.87	3.00
	220	267	**9.27**	0.077	3.21	4.09	2.58	3680	0.034	24.2	**7.03**	3.24	0.173	1.13	0.27	3.43	4.24

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
PEI-1	10	213	**2.76**	0.022	0.546	3.15	0.650	747	0.014	9.52	0.09	0.757	0.907	0.094	0.069	2.82	3.51
	20	184	**3.17**	0.022	0.143	3.40	0.570	822	0.016	9.28	0.08	0.321	0.829	0.104	0.077	2.77	2.65
	30	193	**3.39**	0.022	0.163	4.04	0.570	924	0.016	11.9	0.077	0.341	0.965	0.106	0.078	3.13	3.03
	40	187	**3.08**	0.023	0.157	3.98	0.570	871	0.016	12.7	0.068	0.345	0.901	0.104	0.077	2.81	2.99
PEI-2	10	161	**2.93**	0.020	0.143	3.09	0.320	831	0.013	10.2	0.057	0.309	0.697	0.086	0.063	2.49	2.21
	20	146	**3.31**	0.019	0.155	2.93	0.350	856	0.014	6.99	0.062	0.291	0.621	0.09	0.066	2.65	2.3
	30	167	**3.05**	0.020	0.149	3.12	0.300	822	0.014	11.5	0.081	0.26	0.607	0.093	0.069	2.66	2.13
	40	177	**3.35**	0.025	0.161	3.59	0.370	810	0.015	11.7	0.088	0.356	0.751	0.102	0.075	2.74	2.54
	50	135	**2.53**	0.020	0.149	2.57	0.300	676	0.014	8.86	0.051	0.266	0.582	0.093	0.069	2.10	2.07
PEI-3	7	140	**3.00**	0.022	0.154	3.32	0.360	830	0.017	8.68	0.081	0.276	0.678	0.103	0.076	2.55	2.44
	14	134	**3.01**	0.022	0.164	3.03	0.330	810	0.016	9.25	0.072	0.286	0.678	0.107	0.079	2.45	2.24
	21	98	**2.43**	0.023	0.149	2.34	0.300	575	0.018	10.8	0.07	0.212	0.519	0.107	0.079	2.01	1.93

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
STB-1	10	3130	**22.3**	**0.204**	0.803	16.5	8.28	28300	**0.101**	8.98	**18.6**	6.29	2.41	1.88	0.442	17.2	9.59
	20	2830	**38.4**	**0.191**	0.766	14.2	4.65	39500	0.071	7.96	**26.1**	4.89	2.00	1.54	0.383	20.8	6.46
	30	1640	**24.8**	**0.152**	0.622	8.81	2.48	35900	0.062	13.6	**26.8**	3.29	1.25	1.22	0.377	17.5	5.92
	40	781	**18.4**	**0.122**	0.916	5.18	4.91	23100	0.037	18.6	**52.4**	2.13	0.875	0.872	0.385	12.0	6.38
	50	2620	**8.82**	**0.117**	0.517	10.2	1.55	14200	0.031	12.0	**24.3**	4.12	1.02	1.41	0.41	13.9	6.44
	60	1360	**8.20**	**0.101**	0.279	5.00	1.33	12100	0.026	7.17	**15.1**	2.67	0.612	1.29	0.352	7.51	5.53
	70	1770	**8.14**	**0.113**	0.775	6.12	1.50	13500	0.03	6.63	**16.6**	3.04	0.679	1.28	0.396	13.8	6.22
	80	2910	**9.10**	**0.099**	0.682	8.25	1.31	10800	0.073	9.5	**23.2**	4.99	1.11	1.44	0.346	15.1	5.43
	90	1800	**11.8**	**0.117**	1.46	6.88	1.55	21500	0.041	8.0	**32.2**	5.36	1.21	1.61	0.41	28.2	6.44
	100	2870	**12.8**	**0.139**	1.28	10.5	1.84	17700	0.036	15.5	**40.4**	6.00	1.61	1.87	0.487	26.9	7.65
	110	4400	**16.4**	**0.125**	0.814	18.7	1.57	13500	0.047	12.9	**40.6**	7.06	2.48	1.83	0.416	45.9	6.53

	120	1900	**15.5**	**0.156**	0.716	11.0	1.87	18600	0.064	12.0	**57.0**	4.93	1.36	1.53	0.404	48.8	6.35
	130	3700	**50.2**	**0.129**	1.05	15.0	9.71	39600	**0.107**	82.9	**44.9**	6.08	2.67	2.09	0.435	33.1	8.83
	10	2640	**6.94**	**0.125**	0.58	12.7	5.30	9620	**0.123**	7.47	**16.5**	4.24	2.62	1.58	0.439	14.4	7.62
	20	3160	**9.66**	**0.139**	0.471	16.0	3.70	18100	**0.124**	6.57	**11.2**	5.32	2.37	2.11	0.488	16.1	7.66
	30	2760	**14.2**	**0.124**	0.662	16.1	2.29	16600	0.072	7.09	**17.5**	6.29	2.50	2.16	0.401	16.6	6.30
	40	2220	**17.7**	**0.12**	0.558	13.0	1.59	26900	0.06	7.14	**23.0**	4.44	1.50	1.69	0.420	16.3	6.60
	50	1500	**16.6**	**0.144**	0.6	8.44	1.90	27600	**0.171**	8.86	**24.1**	2.89	1.14	1.33	0.503	15.3	7.90
	60	1080	**14.0**	**0.13**	0.807	4.24	1.72	23300	**0.106**	22.0	**52.8**	1.60	0.537	1.04	0.455	10.7	7.16
	70	1080	**9.33**	**0.125**	0.519	4.75	1.65	7880	0.066	12.8	**24.6**	1.87	0.577	0.928	0.436	8.21	6.85
	80	2690	**21.6**	**0.128**	0.885	10.4	1.78	31100	0.091	27.6	**51.3**	4.00	1.56	1.96	0.396	13.1	6.22
	90	2550	**8.48**	**0.130**	0.565	8.93	1.72	15100	0.073	10.4	**18.6**	4.38	1.23	1.64	0.453	12.2	7.12
STB-2	100	1550	**10.9**	**0.127**	0.691	7.33	1.69	19300	0.064	12.2	**23.1**	3.07	0.714	1.62	0.445	20.2	7.00
	110	2300	**12.1**	**0.113**	1.16	7.68	1.49	24600	**0.141**	15.2	**33.4**	3.85	1.25	1.99	0.394	18.3	6.19
	120	2110	**9.42**	**0.129**	0.795	8.03	1.71	11200	0.087	10.1	**24.9**	4.76	0.984	1.64	0.451	15.8	7.09
	130	2100	**9.2.**	**0.129**	0.856	7.37	1.71	8200	0.078	7.98	**24.0**	4.53	0.906	1.44	0.451	23.3	7.08
	140	2950	**11.1**	**0.139**	1.76	10.6	1.85	17200	0.075	16.5	**32.1**	7.30	1.55	1.99	0.488	30.6	7.66
	150	6460	**10.4**	**0.127**	0.98	21.5	1.68	8760	0.067	19.7	**24.0**	9.17	2.96	1.86	0.444	25.7	6.97
	160	2520	**15.8**	**0.14**	0.914	12.0	1.97	14600	0.070	20.9	**47.2**	6.14	2.05	1.97	0.490	42.8	7.69
	170	2280	**28.6**	**0.253**	1.01	12.9	1.82	18000	**0.155**	17.7	**101**	7.01	2.07	2.10	0.481	**62.3**	7.55
	10	2480	**25.7**	**0.175**	0.597	14.5	16.8	28000	0.088	8.89	**23.8**	5.45	3.74	1.55	0.379	18.9	21.3
	20	3310	**15.6**	**0.15**	0.657	19.2	**46.1**	21400	**0.132**	13.8	**16.8**	6.96	8.22	1.88	0.639	21.1	51.4
	30	1780	**19.7**	**0.155**	0.411	9.75	1.57	26100	**0.116**	10.8	**23.4**	3.44	0.922	1.47	0.416	16.2	6.53
	40	1080	**16.8**	**0.135**	0.69	5.68	1.78	28400	**0.106**	20.0	**40.1**	2.04	0.63	1.49	0.471	12.8	7.4
	50	1930	**10.4**	**0.104**	0.702	9.07	1.38	16400	**0.118**	12.7	**25.2**	3.58	0.934	1.17	0.365	11.2	5.73
STB-3	60	1950	**11.0**	**0.113**	0.583	6.87	1.50	15200	**0.174**	11.8	**31.8**	3.72	0.89	1.69	0.395	9.70	6.21
	70	1680	**10.8**	**0.151**	0.784	6.88	2.00	19400	0.077	9.59	**28.9**	3.81	0.749	1.58	0.53	13.9	8.32
	80	2430	**11.2**	**0.107**	1.14	7.60	1.42	20400	0.091	11.3	**30.8**	4.02	1.32	1.70	0.374	22.7	5.88
	90	1930	**8.98**	**0.128**	1.02	6.65	1.90	13200	0.089	9.83	**31.3**	4.36	1.33	1.53	0.447	16.9	7.02
	100	2100	**9.55**	**0.124**	1.09	6.26	1.64	12400	0.038	10.0	**26.5**	3.93	0.868	1.70	0.433	24.5	6.80

110	2390	**11.8**	**0.122**	0.954	8.60	1.62	13600	0.047	12.4	**36.8**	5.88	1.22	1.86	0.427	23.2	6.70
120	4220	**11.2**	**0.124**	0.918	15.5	1.64	13600	0.059	15.6	**38.9**	7.95	1.89	2.03	0.434	23.9	6.82
130	3350	**13.6**	**0.132**	1.08	14.8	1.75	12100	0.041	17.6	**42.3**	7.73	1.92	2.05	0.463	30.7	7.27
140	2680	**18.9**	**0.235**	0.775	16.2	2.18	21300	0.08	11.6	**74.6**	8.41	1.73	1.92	0.45	50.0	7.08
150	2890	**17.3**	**0.135**	0.703	16.4	1.84	20700	0.035	13.2	**60.4**	6.05	1.32	1.35	0.388	33.0	6.09
160	3460	**60.9**	**0.319**	0.809	23.2	4.62	**55500**	0.033	24.6	**157**	9.31	2.39	2.14	0.446	42.2	7.01
170	3800	**32.5**	**0.128**	0.688	20.8	7.47	36600	0.077	31.7	**65.9**	7.84	2.78	1.71	0.425	35.6	6.86
180	2950	**31.5**	**0.11**	0.845	7.89	17.4	26200	0.035	110.	**17.5**	4.36	3.46	1.39	0.442	11.7	20.4
190	13100	**4.31**	0.027	0.656	18.3	2.30	8240	0.012	64.0	0.285	3.12	4.41	0.405	0.388	11.5	4.38

	depth (cm)	**Al**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Fe**	**Hg**	**Mn**	**Mo**	**Ni**	**Pb**	**Se**	**Sn**	**V**	**Zn**
WL-1	10	1580	**25.5**	**0.123**	0.411	7.37	**52.9**	17100	**0.128**	52.1	1.24	2.95	12.6	0.469	0.879	7.80	**99.9**
	20	778	**18.6**	0.05	0.386	2.58	8.35	16100	0.055	60.9	**1.92**	1.39	3.75	0.646	0.26	4.62	18.1
	30	276	**17.5**	0.033	0.438	0.847	2.15	9870	0.017	80.1	1.13	0.562	1.34	0.378	0.116	1.37	4.62
	40	108	**70.7**	0.036	0.455	0.800	0.470	22900	0.018	80.4	1.20	0.222	0.08	0.368	0.124	0.198	1.95
	50	91.1	**32.1**	0.036	0.303	0.813	0.480	12800	0.019	89.7	0.538	0.226	0.081	0.308	0.126	0.165	1.99
	60	93.6	**27.3**	0.035	0.403	0.780	0.460	12700	0.018	87.1	0.404	0.347	0.107	0.386	0.121	0.235	1.91
	70	82.4	**16.6**	0.029	0.258	0.656	0.390	11200	0.015	113	0.189	0.291	0.066	0.280	0.102	0.121	1.60
	80	713	**28.3**	0.030	0.392	0.936	0.400	13300	0.016	120	0.229	0.489	0.202	0.461	0.106	0.561	1.67
WL-2	10	990	**23.3**	**0.115**	0.354	4.60	**30.4**	15800	**0.119**	42.9	1.03	2.25	8.51	0.475	0.542	5.73	67.9
	20	982	**15.7**	0.070	0.350	3.82	20.7	11600	0.077	57.2	1.16	1.69	6.83	0.404	0.483	4.71	39.7
	30	137	**19.4**	0.034	0.399	0.761	0.53	12000	0.017	88.5	0.794	0.275	0.187	0.308	0.118	0.385	1.86
	40	618	**20.0**	0.049	0.337	2.58	13.6	10700	0.037	63.4	0.865	1.09	3.98	0.386	0.265	3.00	27.7
	50	1270	**20.2**	**0.103**	0.451	6.23	**36.9**	12900	**0.109**	53.0	1.12	2.77	10.4	0.466	0.747	6.73	69.7
	60	2640	**18.3**	**0.126**	0.336	6.25	**35.1**	16900	0.090	64.2	0.971	2.60	10.4	0.42	0.652	6.94	65.8
	70	1300	**31.5**	**0.109**	0.329	5.97	**38.8**	16700	0.096	43.2	1.01	2.41	10.0	0.373	0.652	6.56	**74.2**
	80	2140	**31.9**	**0.129**	0.355	6.63	**43.8**	14500	**0.112**	55.1	**3.23**	2.84	11.3	0.427	0.731	7.54	**80.4**
WL-3	10	1440	**29.3**	**0.16**	0.528	6.82	**40.8**	19600	**0.111**	59.7	**2.34**	3.18	11.2	0.592	0.688	8.46	**82.5**

20	764	**17.4**	**0.105**	0.555	3.69	10.6	14600	0.078	59.6	1.29	2.04	6.42	0.476	0.364	5.45	22.6
30	199	**38.4**	0.038	0.467	0.845	1.34	15200	0.027	74.7	1.13	0.626	0.685	0.351	0.131	1.86	3.17
40	66.5	**37.7**	0.033	0.35	0.744	0.44	14700	0.024	79.5	0.738	0.207	0.074	0.205	0.116	0.104	1.82
50	114	**26.0**	0.034	0.386	0.754	0.44	10600	0.024	81.6	0.429	0.304	0.075	0.322	0.117	0.228	1.84
60	62.4	14.6	0.035	0.286	0.785	0.46	8320	0.025	106	0.204	0.305	0.078	0.209	0.122	0.07	1.92

Table 6. *Triplicate reef heavy metal concentrations (µg/g) of surface sediment samples (0-5cm) for 1N, 2N, 3N, 1S, 2S, and 3S locations. Bolded numbers indicate above upper continental crust (background) values.*

	depth (cm)	**Al**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Fe**	**Hg**	**Mn**	**Mo**	**Ni**	**Pb**	**Se**	**Sn**	**V**	**Zn**
1N-1	0-5	184	**8.23**	0.048	0.187	8.34	0.620	1670	0.008	14.7	0.233	0.503	1.44	0.135	0.11	9.82	3.32
1N-2	0-5	167	**9.04**	0.055	0.227	8.42	0.670	2010	0.007	18.7	0.229	0.579	1.50	0.149	0.112	10.9	3.39
1N-3	0-5	188	**9.21**	0.049	0.183	8.80	0.590	1780	0.008	17.4	0.245	0.538	1.40	0.144	0.105	10.9	3.31

	depth (cm)	**Al**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Fe**	**Hg**	**Mn**	**Mo**	**Ni**	**Pb**	**Se**	**Sn**	**V**	**Zn**
2N-1	0-5	185	**7.69**	0.062	0.201	8.18	0.630	1580	0.006	17.3	0.199	0.542	1.32	0.159	0.087	9.34	2.82
2N-2	0-5	208	**8.84**	0.054	0.211	9.70	0.520	1740	0.007	18.2	0.235	0.586	1.28	0.151	0.091	10.5	3.23
2N-3	0-5	188	**9.21**	0.049	0.183	8.80	0.590	1780	0.008	17.4	0.245	0.538	1.40	0.144	0.105	10.9	3.31

	depth (cm)	**Al**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Fe**	**Hg**	**Mn**	**Mo**	**Ni**	**Pb**	**Se**	**Sn**	**V**	**Zn**
3N-1	0-5	135	**4.69**	0.077	0.226	8.10	0.460	933	0.012	14.4	0.238	0.600	1.01	0.204	0.081	5.42	1.70
3N-2	0-5	133	**4.58**	0.055	0.208	7.92	0.450	871	0.007	13.6	0.187	0.581	0.901	0.206	0.080	5.18	1.47
3N-3	0-5	156	**5.25**	0.059	0.209	9.22	0.420	1010	0.009	14.7	0.212	0.660	0.959	0.196	0.083	5.83	1.65

	depth (cm)	**Al**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Fe**	**Hg**	**Mn**	**Mo**	**Ni**	**Pb**	**Se**	**Sn**	**V**	**Zn**
1S-1	0-5	175	**5.5**	0.049	0.239	8.33	0.780	1360	0.007	14.7	0.184	0.499	1.59	0.136	0.095	8.32	6.13
1S-2	0-5	279	**8.27**	0.055	0.261	9.72	0.890	1930	0.008	18.7	0.201	0.631	1.81	0.168	0.108	10.7	5.22
1S-3	0-5	203	**5.59**	0.045	0.185	6.56	0.603	1290	0.007	12.6	0.153	0.425	1.30	0.131	0.09	7.55	3.80

	depth (cm)	**Al**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Fe**	**Hg**	**Mn**	**Mo**	**Ni**	**Pb**	**Se**	**Sn**	**V**	**Zn**
2S-1	0-5	154	**6.85**	0.065	0.221	9.00	0.430	1370	0.007	17.5	0.168	0.575	1.09	0.164	0.074	8.35	1.98
2S-2	0-5	137	**6.62**	0.063	0.218	8.89	0.410	1370	0.007	16.1	0.199	0.529	1.09	0.170	0.071	8.28	1.91
2S-3	0-5	138	**7.41**	0.075	0.223	8.55	0.380	1600	0.007	19.1	0.196	0.514	1.10	0.145	0.074	9.13	1.98

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
3S-1	0-5	95.5	**4.06**	0.058	0.209	7.29	0.370	772	0.008	13.3	0.221	0.481	0.917	0.226	0.084	4.47	1.70
3S-2	0-5	117	**5.03**	0.053	0.218	8.95	0.390	1060	0.007	13.5	0.206	0.584	1.02	0.189	0.077	5.70	2.00
3S-3	0-5	113	**3.95**	0.047	0.206	7.27	0.350	782	0.007	12.2	0.173	0.515	0.906	0.182	0.076	4.53	1.70

***Table 7**: Ranges of 16 heavy metals analyzed in the 18 Port Everglades (DCC, PEC, PHQ, PEI, and STB) and control (WL) sediment cores and the six reef (NR and SR) surface sediment samples. Nd= non-detected. The bolded values show the highest concentration of heavy metal detected.*

Heavy Metals	DCC Ranges (µg/g)	PEC Ranges (µg/g)	PHQ Ranges (µg/g)	PEI Ranges (µg/g)	STB Ranges (µg/g)	WL Ranges (µg/g)	NR Ranges (µg/g)	SR Ranges (µg/g)
Al	45.8-**28000**	137-15700	156-3720	98.0-213	781-13100	62.4-2640	133-208	95.5-279
As	3.38-68.6	1.07-36.5	0.696-32.3	2.43-3.39	4.31-60.9	14.6-**70.7**	4.58-9.21	3.95-8.27
Cd	0.030-**0.729**	0.034-0.230	0.020-0.270	0.019-0.025	0.027-0.319	0.029-0.16	0.048-0.077	0.045-0.075
Co	0.198-1.81	0.157-2.32	0.058-**3.21**	0.143-0.546	0.279-1.76	0.258-0.555	0.183-0.227	0.185-0.261
Cr	0.669-**48.9**	1.04-34.8	2.20-28.8	2.34-4.04	4.24-23.2	0.656-7.37	7.92-9.70	6.56-9.72
Cu	0.390-17.4	0.410-26.6	0.320-20.3	0.300-0.650	1.31-**46.1**	0.390-52.9	0.183-0.670	0.350-0.890
Fe	2000-34400	1200-22800	508-48800	575-924	7880-**55500**	8320-22900	871-2010	772-1930
Hg	0.014-0.059	0.010-**0.320**	0.007-0.102	0.013-0.018	0.012-0.174	0.015-0.128	0.006-0.013	0.007-0.008
Mn	6.98-**144**	8.30-70.3	2.54-67.3	6.99-12.7	6.57-110	42.9-120	13.6-18.7	12.2-19.1
Mo	0.293-49.4	0.582-43.2	0.102-87.7	0.051-0.090	0.285-**157**	0.189-3.23	0.187-0.245	0.153-0.221
Ni	0.342-14.8	0.587-**18.3**	0.379-13.6	0.212-0.757	1.60-9.31	0.207-3.18	0.503-0.660	0.425-0.631

Pb	0.067-8.67	0.120-12.1	0.123-3.92	0.519-0.965	0.537-8.22	0.066-**12.6**	0.901-1.50	0.906-1.81
Se	0.21-**3.60**	0.105-1.62	0.088-2.86	0.086-0.107	0.405-2.16	0.205-0.646	0.135-0.206	0.131-0.226
Sn	0.104-0.781	0.090-0.689	0.069-0.451	0.063-0.079	0.346-0.639	0.102-**0.879**	0.080-0.112	0.071-0.108
V	0.149-42.9	1.51-**74.8**	2.16-71.4	2.01-3.13	7.51-62.3	0.070-8.46	5.18-10.9	4.47-10.7
Zn	1.64-29.5	1.47-30.3	1.09-59.3	1.93-3.51	4.38-51.4	1.60-**99.9**	1.47-3.39	1.7-6.13

***Table 8**. Total Hg concentrations (µg/g) using EPA method 1631E at the top, middle, and bottom core depths (cm) for Dania Cutoff Canal (DCC), Park Education Center (PEC), Port Everglades Inlet (PEI), Park Headquarters (PHQ), South Turning Basin (STB), and West Lake (WL).*

		Top		Middle		Bottom	
Site	**Cores**	**Depth Range (cm)**	**Hg (µg/g)**	**Depth Range (cm)**	**Hg (µg/g)**	**Depth Range (cm)**	**Hg (µg/g)**
	1	0-50	0.0218	50-100	0.0197	100-152	0.00704
DCC	2	0-30	0.0226	30-60	0.0254	60-93	0.0059
	3	0-40	0.0265	40-70	0.00757	70-105	0.00681
	1	0-70	0.0516	70-140	0.0362	140-229	0.0321
PEC	2	0-70	0.0576	70-140	0.0686	140-206	0.0272
	3	0-60	0.0643	60-130	0.0722	130-188	0.0339
	1	0-20	0.00108	20-30	0.00121	30-37	0.00127
PEI	2	0-20	0.000882	20-40	0.000976	40-50	0.000877
	3	0-7	0.000917	7-14	0.00116	14-21	0.00112
	1	0-70	0.0129	70-140	0.00502	140-206	0.0127
PHQ	2	0-70	0.00876	70-150	0.00415	150-215	0.0209
	3	0-70	0.0393	70-150	0.00272	150-220	0.0101
	1	0-40	0.0601	40-90	0.0524	90-129	0.0367
STB	2	0-50	0.0869	50-110	0.0267	110-167	0.0281
	3	0-60	0.0735	60-130	0.0436	130-187	0.0158
	1	0-30	0.0708	30-50	0.00664	50-79	0.00888
WL	2	0-30	0.0422	30-50	0.0646	50-79	0.128
	3	0-20	0.103	20-40	0.0111	40-58	0.00814

3.2 Geo-accumulation Index (I_{geo})

Geo-accumulation index measures the pollution intensity of individual sample locations and is a quantitative measure of the contamination degree in sediments relative to background continental crust values (Förstner, 1980).

The geo-accumulation index by sediment core depth (cm) for the port and control sites are shown in Table 9, and for the coral reef sites in Table 10 below.

Arsenic is the only heavy metal that exhibits strongly to extremely contaminated geo-accumulation values in the port and control sites but moderate to strongly contamination at the reef sites. The port cores at PEI are the exception, with moderate contamination which could be due to the sandy composition and the small depth of the core.

Molybdenum also exhibits strongly to extremely contaminated geo-accumulation values in all port cores (except PEI) but showed no Mo contamination in the control and reef sites.

Table 9. *Port geo-accumulation index by sediment core depth (cm) for Dania Cutoff Canal (DCC), Park Education Center (PEC), Park Headquarters (PHQ), Port Everglades Inlet (PEI), South Turning Basin (STB), and West Lake (WL). The color of the value indicates the following: uncontaminated (dark green), uncontaminated to moderately contaminated (light green), moderately contaminated (yellow), moderately to strongly contaminated (orange), strongly contaminated (red), strongly to extremely contaminated (dark red), and extremely contaminated (black). White numbers indicate strongly to extremely contaminated.*

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
DCC-1	10	-5.7	1.6	-1.0	-5.4	-2.1	-0.3	-4.2	-2.2	-7.0	1.1	-3.0	-4.0	-6.3	-4.9	-2.8	-1.9
	20	-5.7	2.6	-0.3	-5.5	-1.7	-0.1	-4.0	-2.1	-6.7	2.1	-2.5	-3.4	-6.1	-4.9	-2.3	-3.0
	30	-6.5	2.4	0.3	-5.2	-2.7	0.2	-4.3	-2.6	-6.8	2.5	-2.9	-3.7	-6.3	-4.3	-1.9	-1.9
	40	-4.8	2.8	2.1	-4.4	-1.2	-0.4	-2.1	-1.3	-6.2	4.5	-1.7	-3.9	-5.3	-4.0	-1.1	-3.8
	50	-4.4	2.8	2.1	-4.2	-0.6	0.0	-1.8	-1.6	-4.4	4.1	-1.4	-3.2	-4.9	-4.4	-1.5	-3.4
	60	-4.1	3.2	2.1	-4.0	-0.1	-0.1	-1.2	-1.5	-4.2	4.0	-1.0	-3.0	-4.4	-4.3	-1.4	-3.8
	70	-4.2	3.3	1.3	-4.3	-0.2	-0.1	-1.1	-1.7	-4.2	3.4	-1.1	-3.1	-4.4	-4.4	-2.0	-4.0
	80	-4.9	3.2	0.6	-4.7	-0.8	-0.3	-1.5	-2.1	-4.2	3.0	-1.7	-3.7	-5.0	-4.9	-2.2	-4.4
	90	-5.1	3.1	-0.1	-4.9	-1.1	-0.4	-1.8	-2.4	-4.1	3.0	-2.0	-3.9	-5.2	-5.1	-2.2	-4.8
	100	-7.5	2.7	-1.8	-5.1	-4.0	-1.3	-3.1	-3.1	-2.8	1.4	-4.4	-5.7	-7.1	-5.9	-4.9	-5.6
	110	-10.2	2.5	-2.0	-5.4	-6.0	-1.4	-3.5	-3.3	-2.9	-0.3	-5.7	-8.3	-7.7	-6.0	-7.8	-5.7
	120	-10.6	2.4	-2.0	-5.3	-6.0	-1.4	-3.7	-3.3	-2.7	-1.3	-5.6	-8.5	-7.8	-6.0	-8.1	-5.7

	130	-10.0	2.2	-2.0	-5.8	-6.0	-1.4	-4.0	-3.3	-2.8	-2.9	-6.1	-8.3	-8.4	-6.0	-7.3	-5.7
	140	-9.7	2.6	-2.1	-5.5	-6.1	-1.4	-3.8	-3.4	-2.8	-2.6	-5.5	-7.6	-8.1	-6.1	-7.3	-5.8
	150	-4.8	2.7	-2.1	-4.7	-3.2	-1.4	-3.4	-3.4	-2.7	-2.6	-4.1	-4.5	-7.4	-6.1	-4.6	-5.8
	160	-2.8	3.4	-2.1	-3.6	-1.2	-0.8	-2.2	-2.7	-3.6	-0.6	-2.7	-2.3	-6.7	-4.1	-2.5	-3.9
DCC-2	10	-7.6	0.6	-1.7	-6.2	-3.7	-0.2	-5.2	-2.9	-6.5	-0.5	-4.7	-4.3	-7.6	-5.7	-4.3	-3.4
	20	-10.7	2.4	-2.1	-5.6	-6.1	-1.4	-3.7	-3.4	-3.0	-1.7	-5.9	-8.6	-8.4	-6.1	-9.2	-5.8
	30	-5.2	3.5	1.0	-4.7	-1.5	-0.1	-3.0	-1.3	-6.3	4.2	-1.9	-3.8	-5.3	-4.1	-1.1	-1.9
	40	-4.9	2.9	2.1	-4.6	-1.3	-0.2	-2.3	-1.4	-6.0	4.2	-1.7	-3.7	-5.3	-4.1	-1.4	-3.7
	50	-4.3	2.8	2.3	-4.0	-0.4	-0.1	-1.6	-1.4	-4.3	4.1	-1.2	-3.2	-4.8	-4.2	-1.4	-3.9
	60	-5.2	3.7	0.7	-4.8	-1.1	-0.4	-1.5	-2.1	-4.2	3.2	-1.9	-4.0	-5.1	-5.1	-2.0	-4.6
	70	-8.8	2.8	-1.9	-5.4	-5.1	-1.3	-3.2	-3.2	-2.9	1.3	-5.4	-8.0	-7.3	-5.9	-5.7	-5.6
	80	-9.8	2.5	-2.0	-5.5	-6.0	-1.4	-3.7	-3.3	-2.9	-0.1	-6.0	-8.5	-7.6	-6.0	-7.8	-5.7
	90	-10.3	2.4	-2.0	-5.6	-6.0	-1.4	-3.6	-3.3	-2.9	-1.6	-6.0	-8.5	-7.8	-6.0	-9.2	-5.7
	100	-10.7	2.4	-2.1	-5.6	-6.1	-1.4	-3.7	-3.4	-3.0	-1.7	-5.9	-8.6	-8.4	-6.1	-9.2	-5.8
DCC-3	10	-5.5	2.6	1.3	-4.8	-2.0	0.1	-2.8	-1.4	-5.8	3.4	-2.2	-3.7	-5.8	-4.5	-2.0	-2.4
	20	-4.4	2.8	2.2	-4.2	-0.6	-0.1	-1.6	-1.5	-4.6	3.9	-1.3	-3.0	-4.9	-4.5	-1.5	-3.5
	30	-4.5	4.9	1.6	-4.0	-0.7	0.0	-1.1	-1.7	-4.3	3.9	-1.4	-3.3	-4.6	-4.8	-1.6	-3.4
	40	-5.6	3.2	-0.3	-5.0	-1.6	-0.5	-1.8	-2.5	-3.9	2.7	-2.5	-4.4	-5.8	-5.6	-2.7	-5.3
	50	-7.1	2.5	-1.8	-5.3	-3.6	-1.1	-3.2	-2.7	-3.3	1.5	-3.9	-6.1	-6.9	-5.8	-4.1	-5.5
	60	-8.2	2.6	-2.1	-5.4	-4.7	-1.1	-3.4	-2.9	-3.1	1.2	-4.8	-6.9	-7.2	-6.1	-5.0	-5.8
	70	-10.5	2.2	-2.1	-5.6	-6.0	-1.4	-3.9	-3.0	-3.0	-0.2	-6.2	-8.6	-7.8	-6.1	-7.3	-5.8
	80	-11.4	2.3	-2.3	-5.7	-6.3	-1.5	-4.0	-3.3	-2.6	-1.4	-6.4	-8.8	-8.5	-6.3	-8.2	-6.0
	90	-9.6	2.2	-2.1	-5.6	-6.1	-1.4	-4.1	-3.1	-3.0	-1.8	-6.5	-8.4	-8.4	-6.1	-7.2	-5.8
	100	-4.5	2.5	-2.2	-4.8	-2.8	-1.4	-3.2	-3.1	-3.1	-1.7	-4.2	-4.3	-7.5	-5.8	-4.3	-5.9
	110	-2.1	3.1	-2.2	-3.1	-0.6	-0.9	-1.7	-3.1	-4.0	-1.0	-2.3	-1.8	-7.1	-3.4	-2.2	-4.1

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
PEC-1	10	-6.5	0.3	-1.1	-5.5	-2.4	0.4	-4.8	-1.2	-6.2	-0.6	-3.1	-2.5	-8.0	-4.5	-2.7	-2.0
	20	-5.8	0.9	-0.2	-4.6	-1.8	0.1	-4.2	-0.6	-5.8	0.2	-1.5	-1.9	-7.5	-4.2	-1.0	-2.6
	30	-5.9	1.3	0.5	-4.1	-1.7	0.3	-3.6	0.5	-5.7	0.6	-0.7	-1.5	-7.3	-3.8	-0.3	-2.1
	40	-5.4	1.0	0.0	-4.3	-1.5	0.0	-3.8	-0.4	-5.6	0.2	-1.4	-2.1	-7.5	-4.2	-1.1	-2.8
	50	-5.2	0.4	-1.4	-4.5	-1.5	-0.7	-4.3	-2.4	-5.7	-0.3	-3.2	-3.7	-8.1	-5.5	-2.8	-4.7
	60	-4.3	0.7	-1.3	-4.2	-1.2	-0.8	-4.0	-2.4	-5.4	0.0	-2.9	-3.3	-7.5	-5.2	-2.5	-4.8
	70	-4.1	1.2	-0.9	-3.9	-0.8	-0.4	-3.4	-1.6	-4.8	0.6	-2.3	-2.4	-7.2	-4.1	-2.4	-3.6
	80	-4.2	0.7	-1.0	-4.1	-0.9	-0.5	-3.9	-1.7	-5.1	0.0	-2.7	-2.9	-7.6	-4.6	-2.6	-4.2
	90	-4.4	0.5	-1.2	-4.2	-1.1	-0.7	-4.0	-1.9	-5.3	-0.1	-2.8	-3.2	-7.7	-5.0	-2.6	-4.4
	100	-4.4	0.9	-1.2	-4.1	-1.1	-0.6	-3.8	-2.0	-5.2	0.4	-2.8	-3.1	-7.5	-5.0	-2.6	-4.5
	110	-4.1	1.0	-1.1	-3.9	-1.1	-0.6	-3.8	-1.7	-4.8	0.2	-2.6	-2.9	-7.6	-4.8	-2.5	-4.3
	120	-6.0	1.9	0.4	-5.0	-2.5	0.1	-3.6	0.6	-5.8	0.3	-2.4	-1.4	-7.1	-3.8	-1.8	-2.5
	130	-6.7	2.1	-0.3	-5.9	-2.5	-0.6	-3.4	-1.4	-5.8	1.5	-3.5	-4.0	-6.8	-6.0	-3.0	-4.9
	140	-7.2	1.9	-0.9	-6.4	-2.6	-0.9	-3.6	-2.6	-6.1	1.2	-3.7	-5.5	-7.1	-6.5	-3.3	-6.2
	150	-7.4	2.1	-1.0	-6.0	-3.0	-1.0	-3.3	-2.0	-6.4	1.9	-3.7	-4.9	-6.9	-5.8	-3.2	-5.6
	160	-4.5	0.8	-1.5	-4.5	-2.6	-1.0	-2.8	-1.9	-6.2	2.1	-3.3	-3.8	-6.9	-5.9	-3.4	-1.8
	170	-5.8	2.5	-0.6	-4.2	-2.9	-0.7	-1.7	-0.7	-6.5	4.3	-2.9	-4.9	-5.5	-4.6	-2.8	-4.3
	180	-4.8	1.6	-0.8	-4.2	-2.6	-0.5	-2.7	-0.9	-6.3	3.0	-3.2	-4.2	-5.9	-4.8	-3.0	-4.5
	190	-4.1	0.7	-0.9	-4.6	-2.2	-0.7	-3.1	-1.5	-6.0	2.1	-3.2	-3.6	-6.4	-5.3	-3.2	-5.0
	200	-3.8	1.1	-1.2	-4.2	-1.8	-0.7	-2.3	-0.5	-5.6	2.1	-2.6	-3.0	-6.1	-5.1	-2.6	-5.0
	210	-4.9	0.0	-1.8	-3.9	-3.1	-1.4	-3.6	-1.9	-5.6	1.0	-3.7	-3.7	-8.0	-6.2	-3.9	-5.8
	220	-3.9	0.8	-1.6	-3.9	-2.2	-1.3	-2.3	-2.2	-5.7	1.9	-2.8	-2.9	-7.7	-5.4	-3.2	-5.1
	230	-4.1	0.7	-1.8	-5.0	-2.4	-1.4	-2.1	-1.6	-6.0	1.4	-3.1	-3.2	-8.2	-5.5	-3.2	-5.4
PEC-2	10	-7.0	0.0	-1.4	-5.8	-2.9	0.2	-5.4	-2.5	-6.5	-0.6	-3.7	-3.0	-8.6	-5.1	-3.2	-2.5
	20	-6.0	0.6	-0.5	-5.2	-2.3	0.2	-4.6	-1.1	-6.2	-0.3	-2.2	-2.4	-7.8	-4.5	-1.7	-2.5
	30	-6.0	1.4	0.2	-4.5	-2.0	0.1	-4.0	-0.1	-5.9	0.4	-1.2	-2.0	-7.6	-4.2	-0.7	-2.5
	40	-5.7	1.4	-0.2	-4.4	-1.7	0.2	-3.7	0.1	-5.7	0.0	-1.4	-2.0	-7.4	-4.1	-1.1	-2.5
	50	-5.0	0.3	-1.6	-4.5	-1.4	-0.8	-4.3	-2.8	-5.6	-0.5	-3.0	-3.9	-7.8	-5.9	-2.9	-5.0

	60	-4.6	0.6	-1.6	-4.4	-1.3	-0.8	-4.1	-3.0	-5.5	-0.1	-3.0	-3.6	-7.7	-5.5	-2.7	-5.1
	70	-3.9	1.0	-1.1	-4.1	-1.0	-0.6	-3.7	-2.6	-5.0	0.1	-2.6	-3.0	-7.5	-4.6	-2.6	-4.3
	80	-4.1	0.7	-0.9	-4.1	-0.9	-0.5	-3.8	-2.2	-5.1	0.1	-2.6	-2.9	-7.6	-4.8	-2.6	-4.3
	90	-4.4	0.5	-1.2	-4.2	-1.2	-0.7	-4.1	-2.5	-5.3	0.0	-2.7	-3.3	-7.6	-5.2	-2.7	-4.7
	100	-5.6	1.9	0.2	-4.8	-2.1	0.2	-3.5	1.2	-5.4	-0.3	-1.7	-1.3	-7.0	-3.6	-1.6	-2.4
	110	-7.3	2.0	-1.0	-6.4	-3.1	-0.8	-3.7	-2.0	-6.5	1.5	-3.9	-4.6	-7.4	-6.3	-3.0	-5.6
	120	-7.1	1.7	-1.0	-6.4	-3.0	-1.0	-4.0	-3.8	-6.3	1.2	-3.9	-5.5	-7.4	-6.3	-3.3	-5.9
	130	-7.5	3.3	-1.5	-5.1	-3.2	-1.1	-2.5	-2.8	-5.7	3.1	-4.2	-5.7	-6.4	-5.7	-3.3	-5.4
	140	-7.7	4.0	-1.2	-4.3	-3.4	-1.1	-2.2	-2.1	-3.7	3.7	-4.1	-6.4	-6.0	-5.2	-3.0	-4.9
	150	-7.3	3.4	-1.3	-4.4	-3.5	-1.0	-2.5	-2.9	-4.2	3.6	-3.4	-6.2	-6.1	-5.5	-2.6	-5.2
	160	-9.6	2.3	-1.4	-4.3	-5.5	-1.2	-3.6	-3.0	-4.0	1.3	-5.2	-8.0	-7.2	-5.5	-5.9	-5.2
	170	-5.1	1.8	-1.5	-3.6	-3.3	-1.2	-3.2	-2.3	-5.4	1.6	-4.2	-4.6	-6.7	-5.5	-4.4	-5.2
	180	-3.5	0.1	-1.7	-4.9	-1.9	-1.0	-3.9	-2.8	-5.9	-0.4	-4.0	-3.0	-7.0	-4.9	-3.6	-5.4
	190	-3.9	0.2	-2.1	-4.1	-2.3	-1.1	-4.3	-3.6	-6.3	-0.9	-4.1	-3.3	-7.3	-5.4	-3.8	-5.8
	200	-3.4	0.2	-2.0	-4.0	-1.8	-0.9	-3.9	-3.3	-5.9	-1.3	-3.6	-2.8	-7.0	-4.7	-3.2	-5.7
	210	-3.0	0.8	-1.4	-3.8	-1.2	-0.3	-3.2	-1.6	-4.4	0.2	-2.9	-2.4	-6.6	-4.2	-1.5	-4.3
	10	-7.4	-1.1	-1.6	-6.6	-2.9	-0.2	-6.0	-2.6	-6.8	-2.0	-3.8	-3.9	-9.5	-6.5	-3.7	-3.6
	20	-5.5	0.3	-0.6	-4.9	-1.8	0.0	-4.4	-1.3	-5.7	-0.5	-1.7	-2.1	-8.2	-4.8	-1.1	-3.0
	30	-5.9	1.0	0.6	-4.3	-1.5	0.2	-3.5	0.2	-5.6	0.5	-0.7	-1.5	-7.6	-4.0	-0.3	-2.2
	40	-5.7	0.3	-1.0	-4.9	-1.5	-0.4	-4.2	-3.1	-5.8	-0.1	-2.5	-3.3	-8.6	-5.8	-2.1	-3.8
	50	-5.2	0.0	-1.3	-5.1	-1.4	-0.9	-4.5	-1.9	-5.7	-0.6	-3.3	-4.2	-8.5	-6.4	-3.0	-5.2
	60	-4.8	0.7	-1.3	-4.6	-1.1	-0.8	-3.8	-2.0	-5.4	0.1	-2.9	-3.7	-8.0	-5.6	-2.6	-4.8
	70	-3.9	1.3	-0.7	-4.0	-0.7	-0.5	-3.2	-1.6	-4.7	0.7	-2.2	-2.5	-7.3	-4.5	-2.3	-3.7
PEC-3	80	-3.9	1.4	-0.5	-3.9	-0.6	-0.3	-3.1	-0.4	-4.6	0.9	-2.1	-2.3	-7.1	-4.0	-2.2	-3.2
	90	-4.1	0.6	-0.8	-4.3	-0.8	-0.6	-3.8	-2.2	-5.1	0.5	-2.6	-3.1	-8.0	-5.2	-2.5	-4.4
	100	-4.2	0.7	-0.9	-4.3	-0.8	-0.6	-3.6	-2.5	-5.1	0.4	-2.4	-2.9	-8.0	-5.0	-2.4	-4.4
	110	-5.2	1.7	-0.1	-4.6	-1.7	0.1	-3.3	0.6	-5.0	0.3	-1.8	-1.8	-7.3	-4.0	-1.8	-2.8
	120	-7.2	1.8	-0.8	-5.6	-3.0	-0.4	-3.5	-0.5	-6.5	1.0	-3.4	-3.5	-7.1	-5.4	-2.8	-4.0
	130	-6.7	3.6	-0.8	-4.3	-2.6	-0.6	-1.9	-0.3	-3.7	3.8	-3.2	-4.0	-6.1	-5.5	-2.5	-5.2
	140	-8.5	3.1	-1.6	-4.8	-4.5	-1.0	-3.2	-1.4	-3.7	2.3	-4.8	-5.3	-7.0	-5.6	-4.2	-5.3

150	-9.8	2.8	-2.1	-4.9	-5.7	-1.3	-3.5	-1.2	-3.7	0.9	-5.7	-6.8	-7.9	-6.1	-5.8	-5.8
160	-8.3	3.0	-1.1	-2.7	-5.0	-1.1	-3.0	-2.0	-3.7	2.1	-4.7	-7.6	-6.4	-5.1	-5.2	-4.9
170	-3.8	1.1	-1.5	-4.6	-1.8	-0.8	-2.9	-1.5	-5.9	0.6	-3.5	-3.1	-6.2	-5.2	-3.3	-5.1
180	-3.4	0.6	-1.8	-3.2	-1.5	-0.8	-3.3	-2.4	-5.8	-0.7	-3.3	-2.7	-6.8	-4.7	-3.1	-5.4
190	-3.0	0.8	-2.0	-3.2	-1.1	-0.8	-3.1	-1.3	-5.3	-1.1	-2.7	-2.2	-6.3	-4.3	-2.6	-4.9

	depth (cm)	**Al**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Fe**	**Hg**	**Mn**	**Mo**	**Ni**	**Pb**	**Se**	**Sn**	**V**	**Zn**
	10	-8.8	-1.7	-2.7	-7.2	-4.2	-0.6	-7.2	-2.8	-7.3	-3.0	-6.2	-4.2	-9.7	-6.8	-5.3	-3.6
	20	-8.6	-0.6	-2.1	-6.9	-4.1	-0.5	-6.2	-2.7	-7.3	-1.3	-5.6	-3.4	-9.3	-6.5	-4.8	-3.0
	30	-6.9	2.2	-0.2	-5.6	-3.0	-0.3	-3.1	-2.0	-6.8	2.9	-3.6	-3.7	-7.1	-5.5	-2.8	-0.8
	40	-7.6	1.6	-1.6	-6.6	-3.1	-0.3	-3.3	-2.4	-7.6	2.6	-3.9	-4.1	-7.4	-6.0	-3.3	-3.2
	50	-5.9	2.8	0.7	-5.1	-1.6	0.3	-2.6	-0.6	-6.9	3.9	-2.2	-2.9	-5.9	-4.7	-1.1	-1.2
	60	-5.0	3.2	0.7	-4.8	-0.9	-0.5	-1.9	-0.9	-6.8	4.7	-1.1	-3.0	-4.7	-4.4	-1.2	-4.1
	70	-6.1	3.2	0.6	-5.6	-1.6	-0.7	-2.0	-1.3	-6.6	4.6	-2.6	-4.9	-5.6	-4.8	-0.3	-4.5
	80	-6.8	2.1	0.1	-6.6	-2.3	-1.1	-2.9	-2.1	-8.0	4.0	-3.0	-5.1	-6.3	-5.6	-1.9	-5.3
	90	-6.5	2.7	0.8	-6.0	-2.0	-0.9	-2.5	-1.6	-7.3	4.6	-2.8	-5.0	-6.1	-5.2	-1.3	-4.9
	100	-7.3	1.8	-1.0	-6.9	-2.9	-1.0	-3.8	-2.6	-7.8	3.7	-4.0	-5.4	-7.3	-6.1	-2.9	-5.8
PHQ-1	110	-7.7	1.9	-1.3	-7.2	-3.2	-1.2	-3.4	-2.7	-7.4	2.8	-4.4	-4.9	-7.6	-6.2	-3.9	-5.9
	120	-8.0	1.9	-1.4	-7.4	-3.6	-1.2	-4.1	-2.8	-7.9	3.0	-4.4	-6.0	-7.8	-6.3	-4.0	-6.0
	130	-7.7	2.1	-0.9	-7.2	-3.0	-1.3	-3.9	-3.2	-7.4	2.6	-4.5	-5.8	-8.0	-6.6	-2.7	-6.3
	140	-7.2	2.3	-0.4	-6.5	-2.6	-1.0	-3.3	-2.6	-6.7	2.5	-3.7	-5.2	-7.0	-6.1	-3.0	-5.8
	150	-7.3	2.6	-0.2	-6.6	-2.7	-1.0	-3.1	-2.9	-6.4	2.7	-3.7	-5.4	-7.2	-6.4	-3.4	-6.1
	160	-7.1	3.1	-0.2	-6.4	-2.3	-0.9	-2.6	-2.7	-6.1	3.0	-3.4	-5.1	-6.8	-6.2	-3.0	-5.9
	170	-7.6	2.3	-1.2	-7.0	-2.9	-1.1	-3.4	-3.0	-6.8	1.8	-4.1	-5.5	-7.5	-6.5	-3.6	-6.2
	180	-7.8	2.0	-1.5	-6.7	-3.2	-1.2	-3.7	-2.7	-6.6	1.9	-4.4	-6.0	-7.3	-6.2	-3.5	-5.9
	190	-7.1	3.1	-0.9	-5.0	-2.2	-1.0	-2.2	-1.4	-5.3	3.9	-3.5	-6.0	-6.0	-4.9	-1.9	-4.6
	200	-7.0	3.1	-0.2	-3.4	-2.2	-0.8	-2.5	-0.7	-5.3	3.7	-3.2	-5.8	-5.4	-4.2	-2.6	-3.9
	210	-7.3	3.0	-0.2	-3.3	-2.5	-0.8	-2.7	-0.7	-5.4	3.3	-3.3	-6.4	-5.4	-4.2	-3.0	-3.9

10	-9.3	-1.4	-2.9	-6.9	-4.1	-0.6	-7.2	-3.5	-7.1	-4.5	-6.3	-3.9	-9.7	-6.8	-5.4	-3.7

PHQ-2	20	-6.1	3.8	0.0	-5.4	-2.4	-0.1	-1.5	-0.9	-5.9	4.4	-2.9	-3.4	-6.1	-5.4	-2.2	-3.2
	30	-5.1	3.8	0.8	-4.3	-1.4	-0.5	-0.7	-0.5	-6.1	5.3	-1.5	-3.6	-4.9	-4.5	-1.1	-4.2
	40	-6.6	2.3	-0.5	-5.7	-2.5	-0.4	-2.4	-2.0	-6.5	3.4	-3.2	-3.8	-6.8	-5.4	-2.4	-3.7
	50	-5.4	2.7	0.5	-5.2	-1.2	-0.5	-2.2	-1.0	-6.7	4.5	-1.9	-3.9	-5.2	-4.5	-1.0	-4.2
	60	-5.5	2.2	-0.2	-5.7	-1.3	-0.8	-3.0	-1.0	-7.7	4.1	-1.9	-4.0	-5.6	-4.5	-1.4	-4.3
	70	-6.0	2.4	0.5	-6.0	-1.6	-0.9	-2.5	-1.1	-7.8	4.4	-1.9	-4.1	-5.6	-4.6	-1.4	-4.4
	80	-6.4	2.4	0.8	-5.9	-1.9	-0.4	-2.7	-1.6	-7.8	4.5	-2.7	-4.3	-6.2	-5.1	-0.8	-4.1
	90	-6.7	1.7	-0.4	-6.8	-2.5	-0.8	-3.3	-2.5	-7.2	3.8	-3.4	-5.2	-6.9	-6.0	-2.5	-5.7
	100	-7.2	1.2	-1.4	-7.0	-2.7	-1.0	-4.2	-3.6	-8.2	2.8	-4.0	-5.4	-7.3	-6.3	-3.2	-6.0
	110	-7.8	1.5	-1.5	-7.2	-3.5	-1.2	-4.1	-3.7	-7.8	2.0	-4.4	-5.8	-7.5	-6.4	-4.2	-6.1
	120	-8.3	1.0	-1.9	-7.7	-4.1	-1.4	-5.0	-4.2	-8.1	1.4	-5.0	-6.2	-8.3	-6.5	-4.5	-6.2
	130	-8.1	1.2	-1.5	-7.5	-3.7	-1.4	-4.5	-4.4	-8.1	1.4	-4.9	-6.1	-8.2	-6.8	-4.1	-6.6
	140	-8.5	1.1	-2.1	-7.7	-4.0	-1.5	-4.9	-4.4	-8.0	1.1	-5.2	-6.5	-8.5	-6.9	-4.7	-6.6
	150	-6.7	2.8	-0.5	-6.2	-2.2	-0.9	-2.9	-4.0	-6.0	2.3	-3.3	-4.9	-6.8	-6.3	-2.8	-4.9
	160	-7.1	2.4	-0.9	-6.6	-2.5	-1.0	-3.3	-3.7	-6.4	1.8	-3.7	-5.5	-7.1	-6.1	-2.8	-5.8
	170	-7.7	1.9	-1.8	-7.0	-3.4	-1.4	-3.9	-4.2	-6.9	1.1	-4.4	-5.8	-7.9	-6.5	-4.2	-6.2
	180	-7.6	1.9	-1.6	-6.5	-3.1	-1.2	-3.8	-3.8	-6.6	1.8	-4.3	-6.1	-7.3	-6.2	-3.3	-5.9
	190	-7.3	3.1	-0.5	-4.2	-2.5	-0.9	-2.4	-2.0	-4.8	3.5	-3.6	-7.0	-5.3	-4.5	-2.9	-4.2
	200	-8.9	1.6	-1.2	-5.0	-4.1	-1.1	-4.3	-2.8	-4.6	1.8	-4.8	-7.7	-6.9	-5.2	-4.5	-4.9
	210	-9.6	1.7	-1.4	-4.3	-4.6	-1.2	-4.7	-3.0	-4.5	0.8	-5.1	-7.9	-6.9	-5.4	-5.3	-5.1
	220	-9.0	2.2	-0.9	-3.7	-3.7	-1.0	-3.9	-2.5	-4.1	1.6	-4.2	-7.4	-6.4	-4.9	-4.4	-4.7
	10	-7.7	1.0	-1.7	-6.3	-3.6	0.0	-4.9	-3.4	-6.7	0.2	-4.2	-3.1	-8.1	-4.7	-3.3	-2.6
	20	-5.7	3.3	0.5	-4.4	-1.9	-0.2	-1.3	-0.5	-6.2	4.5	-1.7	-3.2	-5.2	-5.2	-1.6	-3.6
	30	-5.6	3.1	-0.1	-4.9	-1.6	-0.6	-1.3	-2.0	-6.3	4.5	-2.1	-4.6	-5.1	-4.4	-1.1	-4.1
	40	-5.9	3.8	0.8	-4.9	-1.8	-0.3	-0.6	-1.3	-5.0	5.1	-2.2	-4.4	-5.2	-4.7	-1.0	-3.8
PHQ-3	50	-5.8	2.9	0.9	-5.3	-1.6	-0.2	-1.7	-2.5	-5.3	4.3	-2.1	-4.2	-5.4	-4.9	-1.2	-2.6
	60	-6.0	2.6	0.3	-5.5	-1.8	-0.5	-2.9	-2.3	-6.9	4.5	-2.2	-4.3	-5.6	-4.7	-1.6	-4.3
	70	-6.1	2.3	0.8	-6.0	-1.7	-0.9	-2.1	-2.6	-7.3	4.6	-2.3	-4.5	-5.5	-5.0	-1.2	-4.7
	80	-5.8	1.7	-0.1	-5.9	-1.6	-0.8	-3.1	-2.9	-7.7	4.2	-2.5	-4.3	-5.9	-5.4	-1.7	-5.1
	90	-6.7	1.5	-0.7	-6.5	-2.5	-0.9	-3.6	-3.4	-7.8	3.6	-3.4	-5.0	-6.6	-5.8	-2.9	-5.5

	100	-7.9	1.6	-1.6	-7.4	-3.6	-1.3	-4.4	-4.2	-8.1	2.3	-4.4	-5.9	-7.8	-6.6	-4.1	-6.3
	110	-7.4	1.7	-1.3	-7.1	-3.1	-1.1	-3.8	-3.7	-7.8	3.0	-4.0	-5.5	-7.3	-6.5	-3.6	-6.2
	120	-8.7	0.9	-2.2	-7.9	-4.3	-1.5	-5.1	-4.2	-8.5	1.5	-5.1	-6.5	-8.5	-6.6	-4.5	-6.3
	130	-8.5	1.3	-2.1	-8.0	-4.3	-1.5	-4.8	-4.2	-7.8	1.1	-5.1	-6.4	-8.3	-6.8	-5.0	-6.5
	140	-7.6	1.8	-1.3	-7.2	-3.2	-1.2	-4.0	-4.2	-6.9	1.6	-4.3	-5.9	-7.7	-6.6	-3.8	-6.3
	150	-6.8	2.6	-0.5	-6.2	-2.1	-0.9	-3.0	-3.1	-6.1	2.3	-3.3	-5.1	-6.7	-6.4	-2.6	-6.1
	160	-7.6	1.9	-1.8	-7.1	-3.0	-1.1	-3.7	-4.4	-6.8	1.1	-4.4	-6.0	-7.8	-6.7	-4.0	-6.4
	170	-7.9	1.9	-1.9	-6.5	-3.4	-1.4	-3.9	-3.8	-6.6	1.6	-4.5	-6.3	-7.5	-6.2	-3.6	-5.9
	180	-6.9	3.0	-0.9	-4.4	-2.4	-1.0	-2.5	-2.5	-5.0	3.0	-3.5	-5.9	-5.8	-4.9	-2.4	-4.6
	190	-7.4	2.3	-1.4	-5.0	-3.0	-1.0	-3.3	-3.0	-5.3	2.5	-2.9	-5.9	-6.2	-5.4	-3.2	-5.1
	200	-8.9	2.1	-1.3	-2.6	-4.2	-1.2	-4.7	-2.9	-4.7	1.2	-4.7	-7.8	-6.6	-5.3	-4.7	-5.0
	210	-9.1	2.3	-1.4	-2.6	-3.9	-1.2	-4.3	-2.4	-3.7	1.4	-4.2	-7.9	-6.6	-5.4	-4.5	-5.1
	220	-8.8	2.0	-0.9	-2.2	-3.7	-0.6	-4.3	-2.1	-5.2	1.6	-3.2	-7.4	-6.1	-4.9	-4.7	-4.7

	depth (cm)	**Al**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Fe**	**Hg**	**Mn**	**Mo**	**Ni**	**Pb**	**Se**	**Sn**	**V**	**Zn**
PEI-1	10	-9.2	0.3	-2.7	-4.8	-4.1	-1.2	-6.6	-3.4	-6.6	-4.6	-5.3	-5.0	-9.6	-6.9	-5.0	-4.9
	20	-9.4	0.5	-2.7	-6.7	-3.9	-1.3	-6.5	-3.2	-6.6	-4.8	-6.5	-5.2	-9.5	-6.7	-5.0	-5.3
	30	-9.3	0.6	-2.7	-6.5	-3.7	-1.3	-6.3	-3.2	-6.2	-4.9	-6.5	-5.0	-9.5	-6.7	-4.8	-5.1
	40	-9.3	0.5	-2.7	-6.6	-3.7	-1.3	-6.4	-3.2	-6.1	-5.0	-6.4	-5.1	-9.5	-6.7	-5.0	-5.2
PEI-2	10	-9.6	0.4	-2.9	-6.7	-4.1	-1.5	-6.5	-3.5	-6.5	-5.3	-6.6	-5.4	-9.8	-7.0	-5.2	-5.6
	20	-9.7	0.6	-3.0	-6.6	-4.2	-6.7	-6.5	-3.4	-7.0	-5.2	-6.7	-5.6	-9.7	-7.0	-5.1	-5.5
	30	-9.4	0.6	-2.6	-6.5	-3.9	-1.5	-6.5	-3.3	-6.3	-4.7	-6.4	-5.3	-9.5	-6.8	-5.0	-5.4
	40	-9.4	0.6	-2.6	-6.5	-3.9	-1.5	-6.5	-3.3	-6.3	-4.7	-6.4	-5.3	-9.5	-6.8	-5.0	-5.4
	50	-9.8	0.2	-2.9	-6.7	-4.4	-1.6	-6.8	-3.4	-6.7	-5.5	-6.8	-5.7	-9.7	-6.9	-5.4	-5.7
PEI-3	7	-9.7	0.41	-2.7	-6.6	-3.9	-1.5	-6.5	-3.1	-6.7	-4.8	-6.8	-5.5	-9.5	-6.8	-5.1	-5.4
	14	-9.8	0.4	-2.7	-6.5	-4.1	-1.5	-6.5	-3.2	-6.6	-5.0	-6.7	-5.5	-9.5	-6.7	-5.2	-5.6
	21	-10.3	0.1	-2.7	-6.7	-4.5	-1.6	-7.0	-3.0	-6.4	-5.0	-7.1	-5.9	-9.5	-6.7	-5.5	-5.8

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
STB-1	10	-5.3	3.3	0.5	-4.2	-1.7	-0.1	-1.4	-0.5	-6.6	3.0	-2.3	-3.6	-5.3	-4.2	-2.4	-3.5
	20	-5.4	4.1	0.4	-4.3	-1.9	-0.4	-0.9	-1.0	-6.8	3.5	-2.6	-3.9	-5.6	-4.4	-2.1	-4.0
	30	-6.2	3.5	0.0	-4.6	-2.6	-0.7	-1.1	-1.2	-6.0	3.6	-3.2	-4.6	-5.9	-4.5	-2.4	-4.2
	40	-7.3	3.0	-0.3	-4.0	-3.3	-0.4	-1.7	-2.0	-5.6	4.5	-3.8	-5.1	-6.4	-4.4	-2.9	-4.1
	50	-5.5	2.0	-0.3	-4.9	-2.4	-0.9	-2.4	-2.2	-6.2	3.4	-2.9	-4.9	-5.7	-4.3	-2.7	-4.0
	60	-6.5	1.9	-0.5	-5.7	-3.4	-0.9	-2.6	-2.5	-7.0	2.7	-3.5	-5.6	-5.9	-4.6	-3.6	-4.3
	70	-6.1	1.9	-0.4	-4.3	-3.1	-0.9	-2.5	-2.3	-7.1	2.9	-3.3	-5.5	-5.9	-4.4	-2.7	-4.1
	80	-5.4	2.0	-0.6	-4.5	-2.7	-0.9	-2.8	-1.0	-6.6	3.4	-2.6	-4.8	-5.7	-4.6	-2.6	-4.3
	90	-6.1	2.4	-0.3	-3.4	-2.9	-0.9	-1.8	-1.8	-6.8	3.8	-2.5	-4.6	-5.5	-4.3	-1.7	-4.0
	100	-5.4	2.5	-0.1	-3.6	-2.3	-0.8	-2.1	-2.0	-5.9	4.2	-2.3	-4.2	-5.3	-4.1	-1.7	-3.8
	110	-4.8	2.9	-0.2	-4.2	-1.5	-0.9	-2.5	-1.6	-6.1	4.2	-2.1	-3.6	-5.4	-4.3	-1.0	-4.0
	120	-6.0	2.8	0.1	-4.4	-2.3	-0.8	-2.0	-1.2	-6.2	4.7	-2.6	-4.5	-5.6	-4.4	-0.9	-4.1
	130	-5.0	4.5	-0.2	-3.8	-1.8	-0.1	-0.9	-0.4	-3.4	4.3	-2.3	-3.5	-5.2	-4.2	-1.4	-3.6
STB-2	10	-5.5	1.6	-0.2	-4.7	-2.0	-0.3	-3.0	-0.2	-6.9	2.9	-2.8	-3.5	-5.6	-4.2	-2.6	-3.8
	20	-5.3	2.1	-0.1	-5.0	-1.7	-0.5	-2.1	-0.2	-7.1	2.3	-2.5	-3.7	-5.2	-4.1	-2.5	-3.8
	30	-5.5	2.7	-0.2	-4.5	-1.7	-0.7	-2.2	-1.0	-7.0	3.0	-2.3	-3.6	-5.1	-4.4	-2.4	-4.1
	40	-5.8	3.0	-0.3	-4.7	-2.0	-0.9	-1.5	-1.3	-7.0	3.4	-2.8	-4.3	-5.5	-4.3	-2.5	-4.0
	50	-6.3	2.9	0.0	-4.6	-2.6	-0.8	-1.4	0.2	-6.7	3.4	-3.4	-4.7	-5.8	-4.0	-2.6	-3.8
	60	-6.8	2.6	-0.2	-4.2	-3.6	-0.8	-1.7	-0.4	-5.4	4.6	-4.2	-5.8	-6.2	-4.2	-3.1	-3.9
	70	-6.8	2.1	-0.2	-4.9	-3.5	-0.8	-3.3	-1.1	-6.1	3.5	-4.0	-5.7	-6.3	-4.2	-3.5	-4.0
	80	-5.5	3.3	-0.2	-4.1	-2.3	-0.8	-1.3	-0.7	-5.0	4.5	-2.9	-4.3	-5.3	-4.4	-2.8	-4.1
	90	-5.6	1.9	-0.2	-4.7	-2.6	-0.8	-2.3	-1.0	-6.4	3.0	-2.8	-4.6	-5.5	-4.2	-2.9	-3.9
	100	-6.3	2.3	-0.2	-4.4	-2.8	-0.8	-2.0	-1.2	-6.2	3.4	-3.3	-5.4	-5.5	-4.2	-2.2	-3.9
	110	-5.7	2.4	-0.4	-3.7	-2.8	-0.9	-1.6	0.0	-5.9	3.9	-3.0	-4.6	-5.2	-4.4	-2.3	-4.1
	120	-5.9	2.1	-0.2	-4.2	-2.7	-0.8	-2.7	-0.7	-6.5	3.5	-2.7	-4.9	-5.5	-4.2	-2.5	-3.9
	130	-5.9	2.0	-0.2	-4.1	-2.8	-0.8	-3.2	-0.9	-6.8	3.4	-2.7	-5.0	-5.7	-4.2	-1.9	-3.9

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
	140	-5.4	2.3	-0.1	-3.1	-2.3	-0.8	-2.1	-0.9	-5.8	3.8	-2.0	-4.3	-5.2	-4.1	-1.6	-3.8
	150	-4.2	2.2	-0.2	-3.9	-1.3	-0.8	-3.1	-1.1	-5.5	3.4	-1.7	-3.3	-5.3	-4.2	-1.8	-3.9
	160	-5.6	2.8	-0.1	-4.0	-2.1	-0.8	-2.4	-1.0	-5.4	4.4	-2.3	-3.9	-5.3	-4.1	-1.1	-3.8
	170	-5.7	3.7	0.8	-3.9	-2.0	-0.8	-2.1	0.1	-5.7	5.5	-2.1	-3.9	-5.2	-4.1	-0.5	-3.8

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
STB-3	10	-5.6	3.5	0.3	-4.7	-1.9	0.2	-1.4	-0.7	-6.7	3.4	-2.5	-3.0	-5.6	-4.4	-2.3	-2.3
	20	-5.2	2.8	0.0	-4.5	-1.5	0.6	-1.8	-0.1	-6.0	2.9	-2.1	-1.9	-5.3	-3.7	-2.1	-1.1
	30	-6.1	3.1	0.1	-5.2	-2.4	-0.9	-1.5	-0.3	-6.4	3.4	-3.1	-5.0	-5.7	-4.3	-2.5	-4.0
	40	-6.8	2.9	-0.1	-4.4	-3.2	-0.8	-1.4	-0.4	-5.5	4.2	-3.9	-5.6	-5.7	-4.1	-2.8	-3.8
	50	-6.0	2.2	-0.5	-4.4	-2.5	-0.9	-2.2	-0.3	-6.1	3.5	-3.1	-5.0	-6.0	-4.5	-3.0	-4.2
	60	-6.0	2.3	-0.4	-4.7	-2.9	-0.9	-2.3	0.3	-6.3	3.8	-3.0	-5.1	-5.5	-4.4	-3.2	-4.1
	70	-6.2	2.3	0.0	-4.3	-2.9	-0.8	-2.0	-0.9	-6.6	3.7	-3.0	-5.3	-5.6	-4.0	-2.7	-3.7
	80	-5.6	2.3	-0.5	-3.7	-2.8	-0.9	-1.9	-0.7	-6.3	3.8	-2.9	-4.5	-5.5	-4.5	-2.0	-4.2
	90	-6.0	2.0	-0.2	-3.9	-3.0	-0.8	-2.5	-0.7	-6.5	3.8	-2.8	-4.5	-5.6	-4.2	-2.4	-3.9
	100	-5.9	2.1	-0.2	-3.8	-3.1	-0.8	-2.6	-1.9	-6.5	3.6	-2.9	-5.1	-5.5	-4.3	-1.9	-4.0
	110	-5.7	2.4	-0.3	-4.0	-2.6	-0.8	-2.5	-1.6	-6.2	4.0	-2.4	-4.6	-5.3	-4.3	-2.0	-4.0
	120	-4.9	2.3	-0.2	-4.0	-1.8	-0.8	-2.5	-1.3	-5.9	4.1	-1.9	-4.0	-5.2	-4.2	-1.9	-4.0
	130	-5.2	2.6	-0.2	-3.8	-1.8	-0.8	-2.6	-1.8	-5.7	4.2	-2.0	-4.0	-5.2	-4.2	-1.6	-3.9
	140	-5.5	3.1	0.7	-4.3	-1.7	-0.7	-1.8	-0.8	-6.3	5.1	-1.8	-4.1	-5.3	-4.2	-0.8	-3.9
	150	-5.4	2.9	-0.1	-4.4	-1.7	-0.8	-1.9	-2.0	-6.1	4.7	-2.3	-4.5	-5.8	-4.4	-1.4	-4.1
	160	-5.1	4.8	1.1	-4.2	-1.2	-0.4	-0.4	-2.1	-5.2	6.1	-1.7	-3.6	-5.1	-4.2	-1.1	-3.9
	170	-5.0	3.9	-0.2	-4.4	-1.3	-0.2	-1.0	-0.9	-4.8	4.9	-1.9	-3.4	-5.5	-4.3	-1.3	-4.0
	180	-5.4	3.8	-0.4	-4.1	-2.7	0.2	-1.5	-2.0	-3.0	3.0	-2.8	-3.1	-5.8	-4.2	-2.9	-2.4
	190	-3.2	0.9	-2.4	-4.5	-1.5	-0.7	-3.2	-3.6	-3.8	-3.0	-3.3	-2.8	-7.5	-4.4	-3.0	-4.6

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
WL-1	10	-6.3	3.5	-0.3	-5.2	-2.8	0.7	-2.1	-0.2	-4.1	-0.9	-3.3	-1.3	-7.3	-3.2	-3.5	-0.1
	20	-7.3	3.0	-1.6	-5.3	-4.3	-0.1	-2.2	-1.4	-3.9	-0.2	-4.4	-3.0	-6.9	-5.0	-4.3	-2.6
	30	-8.8	3.0	-2.2	-5.1	-6.0	-0.7	-2.9	-3.1	-3.5	-1.0	-5.7	-4.5	-7.6	-6.2	-6.0	-4.5
	40	-10.1	5.0	-2.0	-5.0	-6.0	-1.4	-1.7	-3.0	-3.5	-0.9	-7.1	-8.6	-7.7	-6.1	-8.8	-5.8

	50	-10.4	3.8	-2.0	-5.6	-6.0	-1.4	-2.6	-2.9	-3.3	-2.1	-7.1	-8.5	-7.9	-6.0	-9.1	-5.7
	60	-10.3	3.6	-2.1	-5.2	-6.1	-1.4	-2.6	-3.0	-3.4	-2.5	-6.4	-8.1	-7.6	-6.1	-8.6	-5.8
	70	-10.5	2.9	-2.3	-5.9	-6.3	-1.5	-2.7	-3.3	-3.0	-3.6	-6.7	-8.8	-8.1	-6.3	-9.5	-6.1
	80	-7.4	3.7	-2.3	-5.3	-5.8	-1.5	-2.5	-3.2	-2.9	-3.3	-5.9	-7.2	-7.3	-6.3	-7.3	-6.0
WL-2	10	-6.9	3.4	-0.4	-5.4	-3.5	0.4	-2.2	-0.3	-4.4	-1.1	-3.7	-1.8	-7.3	-3.9	-4.0	-0.6
	20	-7.0	2.8	-1.1	-5.4	-3.8	0.3	-2.7	-0.9	-4.0	-1.0	-4.1	-2.1	-7.5	-4.1	-4.3	-1.4
	30	-9.8	3.1	-2.1	-5.2	-6.1	-1.3	-2.6	-3.1	-3.3	-1.5	-6.8	-7.3	-7.9	-6.1	-7.9	-5.8
	40	-7.6	3.2	-1.6	-5.5	-4.3	0.1	-2.8	-2.0	-3.8	-1.4	-4.8	-2.9	-7.6	-5.0	-4.9	-1.9
	50	-6.6	3.2	-0.5	-5.1	-3.1	0.5	-2.5	-0.4	-4.1	-1.0	-3.4	-1.5	-7.3	-3.5	-3.7	-0.6
	60	-5.5	3.0	-0.2	-5.5	-3.1	0.5	-2.1	-0.7	-3.8	-1.2	-3.5	-1.5	-7.5	-3.7	-3.7	-0.7
	70	-6.6	3.8	-0.4	-5.5	-3.1	0.5	-2.2	-0.6	-4.4	-1.2	-3.6	-1.6	-7.7	-3.7	-3.8	-0.5
	80	-5.8	3.8	-0.2	-5.4	-3.0	0.6	-2.4	-0.4	-4.0	0.5	-3.4	-1.4	-7.5	-3.5	-3.6	-0.4
WL-3	10	-6.4	3.7	0.1	-4.8	-2.9	0.6	-1.9	-0.4	-3.9	0.1	-3.2	-1.4	-7.0	-3.6	-3.4	-0.4
	20	-7.3	3.0	-0.5	-4.8	-3.8	0.0	-2.4	-0.9	-3.9	-0.8	-3.9	-2.2	-7.3	-4.5	-4.0	-2.2
	30	-9.3	4.1	-2.0	-5.0	-6.0	-0.9	-2.3	-2.4	-3.6	-1.0	-5.6	-5.5	-7.7	-6.0	-5.6	-5.1
	40	-10.8	4.1	-2.2	-5.4	-6.1	-1.4	-2.4	-2.6	-3.5	-1.6	-7.2	-8.7	-8.5	-6.2	-9.8	-5.9
	50	-10.1	3.5	-2.1	-5.3	-6.1	-1.4	-2.8	-2.6	-3.5	-2.4	-6.6	-8.6	-7.9	-6.1	-8.6	-5.9
	60	-10.9	2.7	-2.1	-5.7	-6.1	-1.4	-3.2	-2.5	-3.1	-3.5	-6.6	-8.6	-8.5	-6.1	-10.3	-5.8

Table 10*. Triplicate reef geo-accumulation index of surface sediment samples (0-5cm) for 1N, 2N, 3N, 1S, 2S, and 3S locations. The color of the value indicates the following: uncontaminated (dark green), uncontaminated to moderately contaminated (light green), moderately contaminated (yellow), moderately to strongly contaminated (orange), strongly contaminated (red), strongly to extremely contaminated (dark red), and extremely contaminated (black).*

	depth (cm)	**Al**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Fe**	**Hg**	**Mn**	**Mo**	**Ni**	**Pb**	**Se**	**Sn**	**V**	**Zn**
1N-1	0-5	-9.4	1.9	-1.6	-6.3	-2.7	-1.3	-5.5	-4.2	-5.9	-3.3	-5.9	-4.4	-9.1	-6.2	-3.2	-5
1N-2	0-5	-9.5	2	-1.4	-6	-2.6	-1.2	-5.2	-4.4	-5.6	-3.3	-5.7	-4.3	-9	-6.2	-3	-5
1N-3	0-5	-9.3	2	-1.6	-6.4	-2.6	-1.3	-5.4	-4.2	-5.7	-3.2	-5.8	-4.4	-9	-6.3	-3	-5

	depth (cm)	**Al**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Fe**	**Hg**	**Mn**	**Mo**	**Ni**	**Pb**	**Se**	**Sn**	**V**	**Zn**
2N-1	0-5	-9.4	1.8	-1.2	-6.2	-2.7	-1.3	-5.6	-4.6	-5.7	-3.5	-5.8	-4.5	-8.9	-6.6	-3.3	-5.2
2N-2	0-5	-9.2	2	-1.4	-6.2	-2.4	-1.3	-5.4	-4.4	-5.6	-3.3	-5.7	-4.6	-9	-6.5	-3.1	-5
2N-3	0-5	-9.5	1.7	-1.6	-6.3	-2.7	-1.3	-5.5	-3.5	-5.8	-3.5	-5.9	-4.3	-9.1	-6.4	-3.2	-5.2

	depth (cm)	**Al**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Fe**	**Hg**	**Mn**	**Mo**	**Ni**	**Pb**	**Se**	**Sn**	**V**	**Zn**
3N-1	0-5	-9.8	1.1	-0.9	-6.1	-2.7	-1.4	-6.3	-3.6	-6	-3.2	-5.6	-4.9	-8.5	-6.7	-4.1	-6
3N-2	0-5	-9.8	1	-1.4	-6.2	-2.7	-1.4	-6.4	-4.4	-6	-3.6	-5.7	-5.1	-8.5	-6.7	-4.1	-6.2
3N-3	0-5	-9.6	1.2	-1.3	-6.2	-2.5	-1.4	-6.2	-4	-5.9	-3.4	-5.5	-5	-8.6	-6.6	-3.9	-6

	depth (cm)	**Al**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Fe**	**Hg**	**Mn**	**Mo**	**Ni**	**Pb**	**Se**	**Sn**	**V**	**Zn**
1S-1	0-5	-9.4	1.3	-1.6	-6	-2.7	-1.2	-5.8	-4.4	-5.9	-3.6	-5.9	-4.2	-9.1	-6.4	-3.4	-4.1
1S-2	0-5	-8.8	1.9	-1.4	-5.8	-2.4	-1.1	-5.3	-4.2	-5.6	-3.5	-5.6	-4.1	-8.8	-6.3	-3.1	-4.4
1S-3	0-5	-9.2	1.3	-1.7	-6.3	-3	-1.3	-5.9	-4.4	-6.2	-3.9	-6.1	-4.5	-9.2	-6.5	-3.6	-4.8

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
2S-1	0-5	-9.6	1.6	-1.2	-6.1	-2.5	-1.4	-5.8	-4.4	-5.7	-3.7	-5.7	-4.8	-8.8	-6.8	-3.4	-5.7
2S-2	0-5	-9.8	1.6	-1.2	-6.1	-2.6	-1.4	-5.8	-4.4	-5.8	-3.5	-5.8	-4.8	-8.8	-6.9	-3.4	-5.8
2S-3	0-5	-9.8	1.7	-1	-6.1	-2.6	-1.5	-5.6	-4.4	-5.6	-3.5	-5.9	-4.8	-9	-6.8	-3.3	-5.7

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
3S-1	0-5	-10.3	0.9	-1.3	-6.2	-2.8	-1.5	-6.6	-4.2	-6.1	-3.3	-6	-5	-8.4	-6.6	-4.3	-6
3S-2	0-5	-10	1.2	-1.5	-6.1	-2.6	-1.5	-6.1	-4.4	-6.1	-3.4	-5.7	-4.9	-8.6	-6.7	-4	-5.7
3S-3	0-5	-10.1	0.8	-1.6	-6.2	-2.9	-1.5	-6.6	-4.4	-6.2	-3.7	-5.9	-5	-8.7	-6.8	-4.3	-6

3.3 Threshold and Probable Effect Levels (TEL and PEL)

Threshold effect level (TEL) and a probable effect level (PEL) have been derived for nine metals (As, Cd, Cr, Cu, Hg, Ni, Pb, tributyltin, Zn) that occur in Florida coastal sediments (MacDonald, 1994).

Of the 223 port, 22 control, and 18 reef sediment samples collected, each site has varying TEL and PEL values for As. Four out of the five port sites have As concentrations above TEL (7.24 µg/g) and PEL (41.6 µg/g). PEI did not have any. That could be due to the sandy nature and the short length of the core. Within the port, 97% of DCC (34/35) samples are above As TEL while 3% (1/35) are above PEL. The PEC site has 30% (19/63) of its samples above TEL and none above PEL. PHQ has 75% of its samples (49/65) above TEL and none above PEL, while STB has 96% of its samples (47/49) above As TEL and 4% (2/49) above PEL. The control site, WL, has 100% of its samples (22/22) above TEL and 5% (1/22) above PEL. The reef sites, RF, have 44% (8/18) above As TEL and none above PEL (Tables 11 and 12).

Table 11. *Port heavy metal concentrations (µg/g) by sediment core depth (cm) for Dania Cutoff Canal (DCC), Park Education Center (PEC), Park Headquarters (PHQ), Port Everglades Inlet (PEI), South Turning Basin (STB), and West Lake (WL). Highlighted orange numbers indicate values above TEL and red indicate values above PEL.*

	depth (cm)	**Al**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Fe**	**Hg**	**Mn**	**Mo**	**Ni**	**Pb**	**Se**	**Sn**	**V**	**Zn**
	10	2390.00	7.03	0.076	0.361	12.1	5.77	4150	0.032	6.98	4.68	3.77	1.89	0.968	0.268	12.8	28.9
	20	2420.00	13.70	0.122	0.343	15.9	8.63	4820	0.033	8.77	9.95	5.34	2.90	1.13	0.282	18.8	13.1
	30	1390.00	11.60	0.182	0.400	8.04	17.4	3690	0.024	8.31	13.1	4.14	2.25	0.921	0.412	23.3	29.5
	40	4370.00	15.60	0.628	0.710	22.9	4.86	17100	0.059	12.4	49.4	9.34	1.95	1.95	0.499	42.9	7.85
	50	5720.00	15.30	0.632	0.825	35.2	11.2	21900	0.046	42.6	38.9	11.4	3.34	2.45	0.391	31.7	10.3
	60	7050.00	20.10	0.633	0.917	48.9	9.83	32400	0.051	50.5	35.3	14.8	3.81	3.6	0.43	34.1	7.53
DCC-1	70	6530.00	22.70	0.37	0.774	46.5	8.72	34400	0.045	48.3	24.2	14.3	3.62	3.57	0.386	22.7	6.64
	80	4220.00	21.30	0.219	0.561	30.3	5.83	26600	0.033	48.7	18.6	9.29	2.30	2.32	0.28	19.1	5.00
	90	3650.00	19.70	0.135	0.514	24.2	4.62	22100	0.028	51.8	17.8	7.72	2.00	2.05	0.241	19.1	3.79
	100	660.00	14.50	0.041	0.424	3.33	0.61	8560	0.017	128	6.00	1.44	0.566	0.564	0.143	3.02	2.25
	110	106.00	12.80	0.036	0.354	0.812	0.48	6630	0.015	121	1.87	0.562	0.094	0.356	0.126	0.394	1.98
	120	77.50	12.10	0.037	0.389	0.842	0.50	5790	0.015	134	0.886	0.603	0.085	0.338	0.131	0.32	2.06
	130	118.00	10.20	0.037	0.271	0.832	0.49	4840	0.015	131	0.293	0.429	0.095	0.219	0.129	0.569	2.03

	140	142.00	13.50	0.035	0.325	0.781	0.46	5320	0.014	127	0.382	0.682	0.15	0.279	0.121	0.569	1.91
	150	4330.00	14.60	0.034	0.570	5.62	0.45	7080	0.014	134	0.364	1.80	1.29	0.449	0.12	3.74	1.88
	160	17200.00	23.50	0.035	1.25	22.5	1.80	16400	0.022	76.2	1.52	4.53	5.92	0.699	0.479	15.9	7.25
	10	616	3.38	0.046	0.198	4.08	7.02	2000	0.019	9.75	1.56	1.16	1.51	0.387	0.161	4.70	10.3
	20	1610	13.2	0.136	0.338	8.88	9.94	5080	0.044	9.41	11.6	3.44	2.05	1.04	0.28	16.7	17.3
	30	3390	25.9	0.293	0.597	19.2	8.81	9290	0.058	11.8	42.5	7.95	2.13	1.89	0.488	40.6	28.5
	40	4100	17.0	0.62	0.631	21.6	7.25	15400	0.056	14.0	40.4	9.08	2.34	1.85	0.475	34.1	8.47
DCC-2	50	6340	15.3	0.729	0.914	38.8	8.88	24500	0.054	46.8	39.9	13.0	3.23	2.67	0.46	34.6	7.22
	60	3420	30.2	0.246	0.541	25.1	4.97	25900	0.033	47.6	20.4	8.18	1.93	2.16	0.241	22.9	4.51
	70	274	15.6	0.04	0.358	1.58	0.53	7920	0.016	124	5.67	0.73	0.115	0.466	0.139	1.77	2.19
	80	140	13.1	0.036	0.339	0.815	0.48	5860	0.015	123	2.15	0.467	0.081	0.378	0.127	0.418	1.99
	90	99.9	12	0.037	0.312	0.836	0.49	6140	0.015	118	0.75	0.471	0.084	0.339	0.13	0.149	2.04
	100	72.1	12.2	0.035	0.311	0.787	0.46	5630	0.014	116	0.697	0.486	0.079	0.227	0.122	0.152	1.92
	10	2670	13.6	0.372	0.521	13.2	12.7	10900	0.053	16.2	23.6	6.51	2.31	1.33	0.359	22.8	19.7
	20	5950	15.9	0.659	0.832	34.7	9.75	25400	0.052	38.4	33.4	12.4	3.63	2.56	0.355	32.4	9.31
	30	5250	68.6	0.44	0.914	32.5	10.1	34300	0.045	46.8	33.3	11.5	3.08	3.05	0.305	29.6	9.98
	40	2550	21.1	0.121	0.456	17.5	3.55	21000	0.026	58.7	14.5	5.31	1.42	1.37	0.176	14.2	2.77
	50	878	12.5	0.042	0.376	4.44	0.92	8380	0.022	88.8	6.39	1.95	0.434	0.612	0.147	5.3	2.32
DCC-3	60	405	13.8	0.034	0.358	2.02	0.85	7120	0.019	104	5.15	1.10	0.247	0.498	0.119	2.87	1.87
	70	81.4	10.6	0.035	0.304	0.797	0.47	5140	0.018	112	1.99	0.420	0.080	0.346	0.124	0.569	1.95
	80	45.8	10.8	0.03	0.291	0.669	0.39	4830	0.015	144	0.852	0.35	0.067	0.210	0.104	0.296	1.64
	90	157	10.4	0.034	0.304	0.759	0.45	4390	0.017	111	0.652	0.342	0.09	0.227	0.118	0.622	1.85
	100	5380	12.7	0.033	0.534	7.50	0.47	8170	0.017	102	0.674	1.63	1.55	0.412	0.147	4.72	1.83
	110	28000	18.9	0.033	1.81	33.7	1.39	22300	0.017	57.1	1.14	6.16	8.67	0.556	0.781	19.2	6.36

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
	10	1330	2.71	0.067	0.331	9.84	26.6	2660	0.061	12.5	1.46	3.55	5.4	0.293	0.362	14.3	26.1
	20	2260	4.09	0.129	0.615	15.6	14.7	4220	0.092	16.7	2.66	10.3	7.98	0.42	0.44	45.8	18.0
	30	2050	5.73	0.206	0.895	16.7	21.1	6240	0.207	17.3	3.42	17.9	10.5	0.484	0.613	71.6	24.5
	40	2890	4.38	0.143	0.763	18.4	11.5	5340	0.112	18.5	2.59	11.0	6.87	0.403	0.462	41.4	14.9
	50	3240	2.91	0.056	0.646	18.3	2.31	3790	0.027	17.5	1.87	3.37	2.32	0.281	0.18	12.6	4.11
	60	6030	3.78	0.06	0.789	23.5	1.96	4820	0.027	21.8	2.28	4.01	2.98	0.405	0.225	15.6	3.92
	70	7340	5.35	0.081	1.03	29.3	4.98	7100	0.048	32.7	3.47	5.89	5.72	0.500	0.474	16.8	8.76
	80	6640	3.58	0.071	0.90	27.9	3.65	5050	0.045	25.4	2.27	4.73	4.00	0.385	0.33	15.3	5.65
	90	5950	3.19	0.063	0.815	24.6	2.30	4600	0.039	22.1	2.11	4.41	3.34	0.367	0.258	14.5	5.12
	100	5760	4.08	0.066	0.876	24.1	2.61	5230	0.036	23.8	2.94	4.38	3.55	0.401	0.255	14.8	4.76
	110	7120	4.65	0.069	1.02	24.9	2.70	5560	0.043	32.3	2.60	4.90	4.15	0.399	0.296	15.8	5.57
PEC-1	120	1910	8.41	0.198	0.459	9.29	12.7	6290	0.224	16.5	2.83	5.54	11.1	0.538	0.596	25.6	19.0
	130	1180	9.51	0.117	0.254	9.39	2.65	6950	0.056	16.2	6.53	2.71	1.89	0.662	0.13	10.9	3.49
	140	822	8.47	0.080	0.180	8.38	1.29	6090	0.024	12.9	5.23	2.33	0.649	0.54	0.093	9.3	1.47
	150	714	9.65	0.072	0.239	6.40	1.01	7500	0.036	10.5	8.55	2.25	1.03	0.639	0.144	9.86	2.26
	160	5210	3.97	0.053	0.681	8.62	1.26	10600	0.039	12.5	9.74	3.01	2.22	0.612	0.143	8.33	30.3
	170	2230	13.1	0.099	0.792	7.09	2.13	22800	0.088	10.1	43.2	3.94	1.01	1.62	0.345	13.3	5.42
	180	4450	6.67	0.084	0.841	8.89	3.86	11400	0.075	11.2	17.5	3.32	1.62	1.22	0.295	11.2	4.63
	190	7320	3.57	0.079	0.609	11.5	2.37	8510	0.052	13.9	9.52	3.28	2.51	0.875	0.205	9.73	3.23
	200	8850	4.67	0.066	0.823	14.9	2.14	14800	0.100	18.00	9.40	4.80	3.67	1.10	0.248	15.3	3.40
	210	4130	2.3	0.043	1.00	6.33	0.41	6180	0.038	18.8	4.52	2.35	2.27	0.285	0.111	6.15	1.89
	220	8070	3.98	0.049	0.997	11.6	0.56	15200	0.032	17.6	8.17	4.44	3.99	0.372	0.196	9.62	3.10
	230	7340	3.75	0.042	0.462	10.2	0.45	17100	0.048	14.1	5.94	3.41	3.31	0.251	0.182	9.49	2.48
	10	985	2.27	0.055	0.273	7.09	16.6	1790	0.026	9.74	1.53	2.34	3.8	0.19	0.233	9.75	18.6
	20	1870	3.52	0.101	0.413	10.9	16.4	3110	0.068	12.4	1.84	6.45	5.74	0.331	0.353	27.4	19.2
PEC-2	30	1880	5.74	0.167	0.678	13.4	15.0	4790	0.135	15.3	3.02	13.3	7.31	0.396	0.46	55.4	18.6
	40	2390	5.78	0.132	0.696	16.0	17.3	5900	0.152	16.9	2.29	11.2	7.53	0.455	0.484	41.4	19.4

	50	3900	2.85	0.047	0.647	19.8	1.74	3750	0.021	19.0	1.58	3.69	2.04	0.34	0.138	12.4	3.40
	60	5140	3.44	0.05	0.693	21.3	1.83	4380	0.018	19.4	2.05	3.77	2.51	0.355	0.184	13.6	3.20
	70	7980	4.39	0.069	0.861	27.1	2.60	5850	0.024	29	2.42	5.07	3.81	0.420	0.333	14.7	5.38
	80	6880	3.78	0.079	0.896	28.8	3.51	5350	0.031	25.6	2.37	5.10	3.92	0.400	0.304	15.0	5.42
	90	5660	3.20	0.062	0.817	22.8	2.40	4380	0.025	23.1	2.27	4.47	2.97	0.395	0.218	14.1	4.07
	100	2590	8.16	0.168	0.544	12.3	19.0	6780	0.32	21.9	1.79	9.16	12.1	0.587	0.689	29.0	20.1
	110	753	9.27	0.076	0.18	6.32	1.93	5760	0.036	10.2	6.45	2.05	1.21	0.448	0.102	11.5	2.25
	120	904	7.29	0.071	0.18	6.74	1.09	4550	0.010	11.5	5.23	2.06	0.641	0.43	0.105	9.46	1.74
	130	690	21.5	0.053	0.424	5.61	0.87	13600	0.021	17.8	19.2	1.66	0.588	0.894	0.159	8.86	2.50
	140	569	36.5	0.066	0.763	5.12	0.87	15900	0.033	70.3	29.1	1.78	0.362	1.15	0.23	11.5	3.61
	150	749	23.4	0.058	0.711	4.72	1.11	13400	0.019	48.3	27.6	2.86	0.405	1.07	0.18	15.2	2.83
	160	159	11.0	0.054	0.769	1.20	0.71	6230	0.018	56.0	5.37	0.799	0.12	0.497	0.187	1.51	2.94
	170	3630	7.74	0.053	1.25	5.46	0.74	8040	0.03	20.8	6.73	1.63	1.28	0.738	0.185	4.38	2.91
	180	10800	2.49	0.045	0.519	14.0	1.05	5190	0.02	15.1	1.65	1.88	3.86	0.586	0.286	7.54	2.50
	190	8170	2.54	0.034	0.885	10.6	0.98	3930	0.012	11.6	1.17	1.70	3.13	0.49	0.201	6.33	1.87
	200	11200	2.54	0.037	0.92	14.7	1.37	4990	0.015	15.2	0.946	2.40	4.25	0.568	0.307	9.67	2.05
	210	14900	3.88	0.056	1.06	23.5	6.02	8420	0.046	44.0	2.61	3.92	5.83	0.776	0.448	32.1	5.53
	10	737	1.07	0.047	0.157	6.91	7.23	1200	0.023	8.3	0.582	2.10	2.00	0.105	0.09	6.96	8.72
	20	2620	2.76	0.098	0.512	15.1	12.5	3630	0.059	17.7	1.59	9.35	6.80	0.248	0.293	42.6	13.0
	30	2080	4.55	0.230	0.752	18.5	19.8	6510	0.16	19.2	3.18	18.3	10.5	0.376	0.525	74.8	23.3
	40	2340	2.80	0.075	0.514	18.7	4.30	3990	0.017	15.9	2.14	5.46	2.97	0.2	0.148	21.0	7.72
	50	3290	2.30	0.058	0.451	19.6	1.35	3370	0.038	17.0	1.52	3.09	1.68	0.202	0.099	11.3	2.95
	60	4430	3.73	0.058	0.632	24.0	1.92	5470	0.036	21.5	2.43	4.07	2.36	0.289	0.165	14.7	3.82
PEC-3	70	7930	5.54	0.088	0.960	33.2	3.75	8400	0.048	33.5	3.78	6.73	5.32	0.481	0.374	18.7	8.07
	80	8140	5.77	0.103	0.972	34.8	5.75	8660	0.110	36.0	4.08	7.02	6.27	0.547	0.504	19.9	11.8
	90	7120	3.52	0.084	0.749	30.1	2.93	5530	0.031	25.8	3.10	5.08	3.59	0.296	0.231	16.2	5.21
	100	6680	3.77	0.08	0.784	29.9	2.91	6120	0.025	26.1	2.92	5.54	3.98	0.295	0.264	17.3	5.06
	110	3380	7.42	0.133	0.615	16.7	13.1	7520	0.218	27.5	2.73	8.81	8.87	0.467	0.522	26.4	15.8
	120	815	7.77	0.084	0.300	6.69	4.49	6800	0.105	10.0	4.55	2.91	2.61	0.544	0.194	12.8	6.71
	130	1160	26.6	0.087	0.757	8.43	2.92	20500	0.117	69.0	30.4	3.17	1.87	1.12	0.186	16.2	2.99

140	327	18.9	0.049	0.539	2.4	1.24	8440	0.053	68.7	10.9	1.09	0.779	0.58	0.171	4.82	2.69
150	137	15.2	0.035	0.51	1.04	0.55	6850	0.061	69.6	4.24	0.587	0.263	0.325	0.124	1.67	1.94
160	374	18.4	0.067	2.32	1.59	0.88	9430	0.036	67.0	9.82	1.19	0.15	0.866	0.234	2.52	3.67
170	9040	4.99	0.053	0.636	14.7	1.95	9790	0.05	15.6	3.31	2.65	3.57	1.00	0.232	8.87	3.21
180	11500	3.46	0.041	1.65	18.5	1.65	7630	0.027	16.2	1.35	2.96	4.71	0.685	0.308	10.3	2.54
190	15700	3.98	0.036	1.64	24.1	1.85	8970	0.06	23.5	1.07	4.63	6.64	0.921	0.423	14.4	3.48

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
	10	276.0	0.696	0.023	0.102	2.77	2.83	508	0.020	5.68	0.288	0.404	1.61	0.093	0.073	2.27	8.63
	20	311	1.46	0.035	0.126	3.06	3.47	1030	0.022	5.85	0.94	0.606	2.94	0.117	0.091	3.24	13.5
	30	996	10.0	0.131	0.308	6.49	5.59	8830	0.036	7.97	16.9	2.53	2.27	0.55	0.185	12.7	59.3
	40	644	6.99	0.047	0.152	5.99	5.15	7390	0.027	4.75	13.8	1.97	1.72	0.445	0.127	8.83	11.8
	50	1980	15.2	0.241	0.445	17.1	20.3	12700	0.094	7.67	33.8	6.68	3.92	1.29	0.328	41.9	44.9
	60	3720	20.6	0.244	0.525	28.8	3.92	20700	0.077	8.15	60.5	13.6	3.73	2.86	0.391	40.5	6.15
	70	1810	21.2	0.22	0.311	17.3	2.51	18500	0.058	9.21	55.9	5.08	0.995	1.50	0.293	71.4	4.60
	80	1080	9.56	0.163	0.159	10.5	0.98	9950	0.033	3.54	35.8	3.83	0.860	0.931	0.168	24.3	2.63
	90	1380	15.1	0.253	0.232	13.0	1.50	13600	0.047	5.78	54.5	4.40	0.950	1.13	0.226	36.7	3.54
	100	760	7.76	0.076	0.126	7.17	1.02	5430	0.024	4.12	28.3	1.94	0.713	0.49	0.122	12.3	1.92
PHQ-1	110	584	8.22	0.061	0.105	5.83	0.77	6950	0.022	5.32	15.3	1.39	1.02	0.378	0.111	6.15	1.74
	120	465	8.20	0.056	0.086	4.38	0.65	4470	0.020	3.85	17.6	1.41	0.476	0.326	0.102	5.49	1.61
	130	604	9.77	0.08	0.103	6.34	0.6	5020	0.016	5.21	13.9	1.35	0.553	0.298	0.084	14.2	1.32
	140	841	11.2	0.114	0.17	8.48	1.14	7480	0.024	8.65	12.4	2.36	0.815	0.583	0.123	11.3	1.94
	150	755	13.2	0.124	0.159	8.13	1.06	8670	0.019	10.3	15.1	2.36	0.69	0.519	0.097	8.71	1.52
	160	908	19.5	0.125	0.174	10.6	1.47	12700	0.022	12.9	18.2	2.78	0.902	0.663	0.111	11.0	1.74
	170	608	10.9	0.063	0.118	6.83	0.95	7350	0.018	7.94	8.10	1.74	0.66	0.424	0.093	7.38	1.47
	180	531	9.05	0.052	0.143	5.88	0.67	5850	0.022	9.24	8.59	1.41	0.481	0.466	0.110	7.74	1.73
	190	919	19.2	0.079	0.462	11.3	1.04	15800	0.054	23.2	32.5	2.68	0.465	1.16	0.275	23.8	4.32
	200	953	19.6	0.127	1.47	11.8	1.68	13600	0.087	22.3	29.0	3.23	0.525	1.76	0.445	14.6	6.99
	210	769	17.4	0.129	1.55	9.47	1.71	11200	0.089	20.9	21.5	3.00	0.360	1.78	0.451	11.0	7.09

	10	193	0.827	0.02	0.126	3.01	2.66	525	0.013	6.42	0.102	0.379	2.06	0.088	0.072	2.16	7.92
	20	1750	30.6	0.143	0.350	10.1	8.04	26900	0.076	15.2	49.0	4.07	2.84	1.13	0.202	20.1	11.5
	30	3470	32.3	0.26	0.738	20.5	3.27	46300	0.099	12.9	87.7	10.5	2.54	2.59	0.368	42.2	5.92
	40	1220	11.0	0.106	0.281	9.12	4.06	14400	0.037	9.75	23.6	3.22	2.14	0.664	0.19	16.7	7.99
	50	2850	14.5	0.207	0.416	23.4	3.19	15800	0.072	8.42	49.5	7.93	2.04	2.03	0.366	45.4	5.75
	60	2780	10.3	0.128	0.298	20.7	1.80	9280	0.07	4.23	39.5	7.89	1.86	1.59	0.355	35.2	5.57
	70	1900	11.7	0.201	0.236	17.6	1.38	13400	0.065	4.18	48.5	7.77	1.70	1.54	0.331	34.2	5.20
	80	1480	12.2	0.248	0.26	14.0	4.50	11600	0.047	4.11	52.0	4.69	1.49	1.04	0.24	50.2	6.23
	90	1170	7.33	0.108	0.132	9.12	1.94	7410	0.025	6.28	31.3	2.91	0.837	0.624	0.129	15.7	2.03
	100	826	5.03	0.055	0.114	8.29	1.04	3970	0.012	3.03	15.9	1.94	0.734	0.480	0.105	10.1	1.65
	110	553	6.32	0.053	0.101	4.64	0.69	4250	0.011	4.04	8.92	1.47	0.557	0.401	0.096	4.80	1.51
PHQ-2	120	392	4.61	0.039	0.070	3.03	0.42	2370	0.008	3.17	5.87	0.949	0.422	0.231	0.09	4.11	1.42
	130	448	5.12	0.052	0.081	4.06	0.47	3310	0.007	3.39	5.86	1.03	0.434	0.259	0.072	5.14	1.13
	140	347	4.74	0.035	0.070	3.28	0.34	2530	0.007	3.55	4.89	0.804	0.337	0.211	0.069	3.58	1.09
	150	1200	15.4	0.104	0.209	11.3	1.49	9830	0.009	14.0	10.8	2.97	1.00	0.675	0.102	12.7	3.55
	160	860	11.9	0.077	0.151	9.45	1.03	7790	0.011	10.6	8.02	2.30	0.659	0.563	0.122	12.8	1.92
	170	605	8.14	0.043	0.119	4.92	0.49	5040	0.008	7.63	4.85	1.44	0.536	0.318	0.091	4.82	1.43
	180	608	8.24	0.05	0.166	6.17	0.64	5320	0.01	9.12	7.74	1.50	0.444	0.488	0.11	9.44	1.73
	190	766	19.3	0.105	0.824	9.43	1.40	14000	0.036	33.3	24.6	2.53	0.237	1.87	0.369	12.0	5.80
	200	254	7.02	0.065	0.465	3.11	0.86	3920	0.021	35.9	7.66	1.05	0.146	0.617	0.227	3.96	3.57
	210	156	7.35	0.055	0.747	2.20	0.73	2870	0.018	38.7	3.89	0.862	0.125	0.61	0.194	2.27	3.04
	220	231	9.99	0.077	1.19	4.12	1.01	5010	0.025	52.9	6.69	1.59	0.172	0.895	0.268	4.33	4.21
	10	582	4.38	0.046	0.19	4.47	12.2	2560	0.014	8.85	2.66	1.64	3.62	0.272	0.325	8.87	17.9
	20	2370	22.1	0.212	0.721	14.3	7.07	30200	0.102	12.3	49.8	9.22	3.27	2.04	0.223	30.6	8.60
	30	2580	19.8	0.138	0.49	17.5	2.87	30600	0.036	11.8	52	7.18	1.21	2.13	0.386	42.5	6.06
	40	2080	30.7	0.254	0.517	15.5	5.63	48800	0.059	28.7	78.6	6.5	1.45	2.06	0.322	43.9	7.49
PHQ-3	50	2190	17.1	0.27	0.376	17.1	7.87	22300	0.025	23.6	43.1	6.89	1.61	1.76	0.273	39.2	17.6
	60	1960	13.5	0.182	0.321	15.2	3.45	10200	0.030	7.32	50.3	6.41	1.57	1.57	0.324	30.5	5.29
	70	1840	10.9	0.253	0.227	16.2	1.32	17300	0.024	5.89	53.7	5.95	1.32	1.61	0.255	39.2	4.01
	80	2180	7.46	0.137	0.248	17.9	1.66	8940	0.019	4.31	41.7	5.28	1.49	1.28	0.202	27.4	3.17

90	1210	6.48	0.091	0.170	9.58	1.51	6110	0.014	4.05	27.6	2.91	0.942	0.787	0.146	12.1	2.29
100	494	6.87	0.049	0.089	4.21	0.63	3510	0.008	3.36	10.9	1.42	0.495	0.333	0.086	5.14	1.36
110	738	7.20	0.058	0.110	6.31	1.00	5220	0.011	3.92	17.6	1.84	0.652	0.46	0.089	7.61	1.40
120	302	4.32	0.032	0.061	2.68	0.32	2150	0.008	2.54	6.40	0.88	0.323	0.214	0.085	3.86	1.34
130	334	5.43	0.035	0.058	2.74	0.34	2750	0.008	4.07	4.89	0.885	0.355	0.239	0.072	2.83	1.14
140	630	7.97	0.061	0.103	5.74	0.65	4830	0.008	7.71	6.80	1.51	0.511	0.372	0.088	6.35	1.38
150	1100	14.1	0.107	0.200	12.2	1.39	9420	0.017	12.9	11.0	2.98	0.856	0.717	0.099	14.4	1.55
160	619	8.30	0.042	0.11	6.77	0.81	5610	0.007	8.23	4.93	1.47	0.471	0.337	0.079	5.64	1.24
170	522	8.66	0.039	0.163	4.89	0.47	5040	0.010	9.14	6.83	1.37	0.394	0.413	0.113	7.65	1.78
180	993	18.5	0.08	0.718	9.82	1.07	12900	0.026	27.8	18.6	2.62	0.505	1.36	0.281	17.3	4.42
190	725	11.1	0.056	0.463	6.37	1.05	7550	0.018	23.5	12.6	3.98	0.495	1.02	0.197	9.89	3.10
200	251	9.40	0.059	2.55	2.93	0.78	2980	0.019	35.2	5.04	1.13	0.133	0.784	0.207	3.44	3.25
210	228	10.8	0.055	2.55	3.53	0.72	3740	0.027	67.3	5.87	1.60	0.123	0.769	0.191	3.87	3.00
220	267	9.27	0.077	3.21	4.09	2.58	3680	0.034	24.2	7.03	3.24	0.173	1.13	0.27	3.43	4.24

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
PEI-1	10	213	2.76	0.022	0.546	3.15	0.650	747	0.014	9.52	0.09	0.757	0.907	0.094	0.069	2.82	3.51
	20	184	3.17	0.022	0.143	3.40	0.570	822	0.016	9.28	0.08	0.321	0.829	0.104	0.077	2.77	2.65
	30	193	3.39	0.022	0.163	4.04	0.570	924	0.016	11.9	0.077	0.341	0.965	0.106	0.078	3.13	3.03
	40	187	3.08	0.023	0.157	3.98	0.570	871	0.016	12.7	0.068	0.345	0.901	0.104	0.077	2.81	2.99
PEI-2	10	161	2.93	0.020	0.143	3.09	0.320	831	0.013	10.2	0.057	0.309	0.697	0.086	0.063	2.49	2.21
	20	146	3.31	0.019	0.155	2.93	0.350	856	0.014	6.99	0.062	0.291	0.621	0.09	0.066	2.65	2.3
	30	167	3.05	0.020	0.149	3.12	0.300	822	0.014	11.5	0.081	0.26	0.607	0.093	0.069	2.66	2.13
	40	177	3.35	0.025	0.161	3.59	0.370	810	0.015	11.7	0.088	0.356	0.751	0.102	0.075	2.74	2.54
	50	135	2.53	0.020	0.149	2.57	0.300	676	0.014	8.86	0.051	0.266	0.582	0.093	0.069	2.10	2.07
PEI-3	7	140	3.00	0.022	0.154	3.32	0.360	830	0.017	8.68	0.081	0.276	0.678	0.103	0.076	2.55	2.44
	14	134	3.01	0.022	0.164	3.03	0.330	810	0.016	9.25	0.072	0.286	0.678	0.107	0.079	2.45	2.24

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
	21	98	2.43	0.023	0.149	2.34	0.300	575	0.018	10.8	0.07	0.212	0.519	0.107	0.079	2.01	1.93
STB-1	10	3130	22.3	0.204	0.803	16.5	8.28	28300	0.101	8.98	18.6	6.29	2.41	1.88	0.442	17.2	9.59
	20	2830	38.4	0.191	0.766	14.2	4.65	39500	0.071	7.96	26.1	4.89	2.00	1.54	0.383	20.8	6.46
	30	1640	24.8	0.152	0.622	8.81	2.48	35900	0.062	13.6	26.8	3.29	1.25	1.22	0.377	17.5	5.92
	40	781	18.4	0.122	0.916	5.18	4.91	23100	0.037	18.6	52.4	2.13	0.875	0.872	0.385	12.0	6.38
	50	2620	8.82	0.117	0.517	10.2	1.55	14200	0.031	12.0	24.3	4.12	1.02	1.41	0.41	13.9	6.44
	60	1360	8.20	0.101	0.279	5.00	1.33	12100	0.026	7.17	15.1	2.67	0.612	1.29	0.352	7.51	5.53
	70	1770	8.14	0.113	0.775	6.12	1.50	13500	0.03	6.63	16.6	3.04	0.679	1.28	0.396	13.8	6.22
	80	2910	9.10	0.099	0.682	8.25	1.31	10800	0.073	9.5	23.2	4.99	1.11	1.44	0.346	15.1	5.43
	90	1800	11.8	0.117	1.46	6.88	1.55	21500	0.041	8.0	32.2	5.36	1.21	1.61	0.41	28.2	6.44
	100	2870	12.8	0.139	1.28	10.5	1.84	17700	0.036	15.5	40.4	6.00	1.61	1.87	0.487	26.9	7.65
	110	4400	16.4	0.125	0.814	18.7	1.57	13500	0.047	12.9	40.6	7.06	2.48	1.83	0.416	45.9	6.53
	120	1900	15.5	0.156	0.716	11.0	1.87	18600	0.064	12.0	57.0	4.93	1.36	1.53	0.404	48.8	6.35
	130	3700	50.2	0.129	1.05	15.0	9.71	39600	0.107	82.9	44.9	6.08	2.67	2.09	0.435	33.1	8.83
STB-2	10	2640	6.94	0.125	0.58	12.7	5.30	9620	0.123	7.47	16.5	4.24	2.62	1.58	0.439	14.4	7.62
	20	3160	9.66	0.139	0.471	16.0	3.70	18100	0.124	6.57	11.2	5.32	2.37	2.11	0.488	16.1	7.66
	30	2760	14.2	0.124	0.662	16.1	2.29	16600	0.072	7.09	17.5	6.29	2.50	2.16	0.401	16.6	6.30
	40	2220	17.7	0.12	0.558	13.0	1.59	26900	0.06	7.14	23.0	4.44	1.50	1.69	0.420	16.3	6.60
	50	1500	16.6	0.144	0.6	8.44	1.90	27600	0.171	8.86	24.1	2.89	1.14	1.33	0.503	15.3	7.90
	60	1080	14.0	0.13	0.807	4.24	1.72	23300	0.106	22.0	52.8	1.60	0.537	1.04	0.455	10.7	7.16
	70	1080	9.33	0.125	0.519	4.75	1.65	7880	0.066	12.8	24.6	1.87	0.577	0.928	0.436	8.21	6.85
	80	2690	21.6	0.128	0.885	10.4	1.78	31100	0.091	27.6	51.3	4.00	1.56	1.96	0.396	13.1	6.22
	90	2550	8.48	0.130	0.565	8.93	1.72	15100	0.073	10.4	18.6	4.38	1.23	1.64	0.453	12.2	7.12
	100	1550	10.9	0.127	0.691	7.33	1.69	19300	0.064	12.2	23.1	3.07	0.714	1.62	0.445	20.2	7.00
	110	2300	12.1	0.113	1.16	7.68	1.49	24600	0.141	15.2	33.4	3.85	1.25	1.99	0.394	18.3	6.19
	120	2110	9.42	0.129	0.795	8.03	1.71	11200	0.087	10.1	24.9	4.76	0.984	1.64	0.451	15.8	7.09
	130	2100	9.2.	0.129	0.856	7.37	1.71	8200	0.078	7.98	24.0	4.53	0.906	1.44	0.451	23.3	7.08

Sample	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
	140	2950	11.1	0.139	1.76	10.6	1.85	17200	0.075	16.5	32.1	7.30	1.55	1.99	0.488	30.6	7.66
	150	6460	10.4	0.127	0.98	21.5	1.68	8760	0.067	19.7	24.0	9.17	2.96	1.86	0.444	25.7	6.97
	160	2520	15.8	0.14	0.914	12.0	1.97	14600	0.070	20.9	47.2	6.14	2.05	1.97	0.490	42.8	7.69
	170	2280	28.6	0.253	1.01	12.9	1.82	18000	0.155	17.7	101	7.01	2.07	2.10	0.481	62.3	7.55
STB-3	10	2480	25.7	0.175	0.597	14.5	16.8	28000	0.088	8.89	23.8	5.45	3.74	1.55	0.379	18.9	21.3
	20	3310	15.6	0.15	0.657	19.2	46.1	21400	0.132	13.8	16.8	6.96	8.22	1.88	0.639	21.1	51.4
	30	1780	19.7	0.155	0.411	9.75	1.57	26100	0.116	10.8	23.4	3.44	0.922	1.47	0.416	16.2	6.53
	40	1080	16.8	0.135	0.69	5.68	1.78	28400	0.106	20.0	40.1	2.04	0.63	1.49	0.471	12.8	7.4
	50	1930	10.4	0.104	0.702	9.07	1.38	16400	0.118	12.7	25.2	3.58	0.934	1.17	0.365	11.2	5.73
	60	1950	11.0	0.113	0.583	6.87	1.50	15200	0.174	11.8	31.8	3.72	0.89	1.69	0.395	9.70	6.21
	70	1680	10.8	0.151	0.784	6.88	2.00	19400	0.077	9.59	28.9	3.81	0.749	1.58	0.53	13.9	8.32
	80	2430	11.2	0.107	1.14	7.60	1.42	20400	0.091	11.3	30.8	4.02	1.32	1.70	0.374	22.7	5.88
	90	1930	8.98	0.128	1.02	6.65	1.90	13200	0.089	9.83	31.3	4.36	1.33	1.53	0.447	16.9	7.02
	100	2100	9.55	0.124	1.09	6.26	1.64	12400	0.038	10.0	26.5	3.93	0.868	1.70	0.433	24.5	6.80
	110	2390	11.8	0.122	0.954	8.60	1.62	13600	0.047	12.4	36.8	5.88	1.22	1.86	0.427	23.2	6.70
	120	4220	11.2	0.124	0.918	15.5	1.64	13600	0.059	15.6	38.9	7.95	1.89	2.03	0.434	23.9	6.82
	130	3350	13.6	0.132	1.08	14.8	1.75	12100	0.041	17.6	42.3	7.73	1.92	2.05	0.463	30.7	7.27
	140	2680	18.9	0.235	0.775	16.2	2.18	21300	0.08	11.6	74.6	8.41	1.73	1.92	0.45	50.0	7.08
	150	2890	17.3	0.135	0.703	16.4	1.84	20700	0.035	13.2	60.4	6.05	1.32	1.35	0.388	33.0	6.09
	160	3460	60.9	0.319	0.809	23.2	4.62	55500	0.033	24.6	157	9.31	2.39	2.14	0.446	42.2	7.01
	170	3800	32.5	0.128	0.688	20.8	7.47	36600	0.077	31.7	65.9	7.84	2.78	1.71	0.425	35.6	6.86
	180	2950	31.5	0.11	0.845	7.89	17.4	26200	0.035	110.	17.5	4.36	3.46	1.39	0.442	11.7	20.4
	190	13100	4.31	0.027	0.656	18.3	2.30	8240	0.012	64.0	0.285	3.12	4.41	0.405	0.388	11.5	4.38

Sample	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
WL-1	10	1580	25.5	0.123	0.411	7.37	52.9	17100	0.128	52.1	1.24	2.95	12.6	0.469	0.879	7.80	99.9
	20	778	18.6	0.05	0.386	2.58	8.35	16100	0.055	60.9	1.92	1.39	3.75	0.646	0.26	4.62	18.1
	30	276	17.5	0.033	0.438	0.847	2.15	9870	0.017	80.1	1.13	0.562	1.34	0.378	0.116	1.37	4.62
	40	108	70.7	0.036	0.455	0.800	0.470	22900	0.018	80.4	1.20	0.222	0.08	0.368	0.124	0.198	1.95

	50	91.1	32.1	0.036	0.303	0.813	0.480	12800	0.019	89.7	0.538	0.226	0.081	0.308	0.126	0.165	1.99
	60	93.6	27.3	0.035	0.403	0.780	0.460	12700	0.018	87.1	0.404	0.347	0.107	0.386	0.121	0.235	1.91
	70	82.4	16.6	0.029	0.258	0.656	0.390	11200	0.015	113	0.189	0.291	0.066	0.280	0.102	0.121	1.60
	80	713	28.3	0.030	0.392	0.936	0.400	13300	0.016	120	0.229	0.489	0.202	0.461	0.106	0.561	1.67
	10	990	23.3	0.115	0.354	4.60	30.4	15800	0.119	42.9	1.03	2.25	8.51	0.475	0.542	5.73	67.9
	20	982	15.7	0.070	0.350	3.82	20.7	11600	0.077	57.2	1.16	1.69	6.83	0.404	0.483	4.71	39.7
	30	137	19.4	0.034	0.399	0.761	0.53	12000	0.017	88.5	0.794	0.275	0.187	0.308	0.118	0.385	1.86
WL-2	40	618	20.0	0.049	0.337	2.58	13.6	10700	0.037	63.4	0.865	1.09	3.98	0.386	0.265	3.00	27.7
	50	1270	20.2	0.103	0.451	6.23	36.9	12900	0.109	53.0	1.12	2.77	10.4	0.466	0.747	6.73	69.7
	60	2640	18.3	0.126	0.336	6.25	35.1	16900	0.090	64.2	0.971	2.60	10.4	0.42	0.652	6.94	65.8
	70	1300	31.5	0.109	0.329	5.97	38.8	16700	0.096	43.2	1.01	2.41	10.0	0.373	0.652	6.56	74.2
	80	2140	31.9	0.129	0.355	6.63	43.8	14500	0.112	55.1	3.23	2.84	11.3	0.427	0.731	7.54	80.4
	10	1440	29.3	0.16	0.528	6.82	40.8	19600	0.111	59.7	2.34	3.18	11.2	0.592	0.688	8.46	82.5
	20	764	17.4	0.105	0.555	3.69	10.6	14600	0.078	59.6	1.29	2.04	6.42	0.476	0.364	5.45	22.6
WL-3	30	199	38.4	0.038	0.467	0.845	1.34	15200	0.027	74.7	1.13	0.626	0.685	0.351	0.131	1.86	3.17
	40	66.5	37.7	0.033	0.35	0.744	0.44	14700	0.024	79.5	0.738	0.207	0.074	0.205	0.116	0.104	1.82
	50	114	26.0	0.034	0.386	0.754	0.44	10600	0.024	81.6	0.429	0.304	0.075	0.322	0.117	0.228	1.84
	60	62.4	14.6	0.035	0.286	0.785	0.46	8320	0.025	106	0.204	0.305	0.078	0.209	0.122	0.07	1.92

Table 12*. Triplicate reef heavy metal concentrations (µg/g) of surface sediment samples (0-5cm) for 1N, 2N, 3N, 1S, 2S, and 3S locations. Values highlighted in orange are above upper continental crust (background) values.*

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
1N-1	0-5	184	8.23	0.048	0.187	8.34	0.620	1670	0.008	14.7	0.233	0.503	1.44	0.135	0.11	9.82	3.32
1N-2	0-5	167	9.04	0.055	0.227	8.42	0.670	2010	0.007	18.7	0.229	0.579	1.50	0.149	0.112	10.9	3.39
1N-3	0-5	188	9.21	0.049	0.183	8.80	0.590	1780	0.008	17.4	0.245	0.538	1.40	0.144	0.105	10.9	3.31
	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
2N-1	0-5	185	7.69	0.062	0.201	8.18	0.630	1580	0.006	17.3	0.199	0.542	1.32	0.159	0.087	9.34	2.82
2N-2	0-5	208	8.84	0.054	0.211	9.70	0.520	1740	0.007	18.2	0.235	0.586	1.28	0.151	0.091	10.5	3.23
2N-3	0-5	188	9.21	0.049	0.183	8.80	0.590	1780	0.008	17.4	0.245	0.538	1.40	0.144	0.105	10.9	3.31
	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
3N-1	0-5	135	4.69	0.077	0.226	8.10	0.460	933	0.012	14.4	0.238	0.600	1.01	0.204	0.081	5.42	1.70
3N-2	0-5	133	4.58	0.055	0.208	7.92	0.450	871	0.007	13.6	0.187	0.581	0.901	0.206	0.080	5.18	1.47
3N-3	0-5	156	5.25	0.059	0.209	9.22	0.420	1010	0.009	14.7	0.212	0.660	0.959	0.196	0.083	5.83	1.65
	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
1S-1	0-5	175	5.5	0.049	0.239	8.33	0.780	1360	0.007	14.7	0.184	0.499	1.59	0.136	0.095	8.32	6.13
1S-2	0-5	279	8.27	0.055	0.261	9.72	0.890	1930	0.008	18.7	0.201	0.631	1.81	0.168	0.108	10.7	5.22
1S-3	0-5	203	5.59	0.045	0.185	6.56	0.603	1290	0.007	12.6	0.153	0.425	1.30	0.131	0.09	7.55	3.80
	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
2S-1	0-5	154	6.85	0.065	0.221	9.00	0.430	1370	0.007	17.5	0.168	0.575	1.09	0.164	0.074	8.35	1.98
2S-2	0-5	137	6.62	0.063	0.218	8.89	0.410	1370	0.007	16.1	0.199	0.529	1.09	0.170	0.071	8.28	1.91

2S-3	0-5	138	7.41	0.075	0.223	8.55	0.380	1600	0.007	19.1	0.196	0.514	1.10	0.145	0.074	9.13	1.98

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
3S-1	0-5	95.5	4.06	0.058	0.209	7.29	0.370	772	0.008	13.3	0.221	0.481	0.917	0.226	0.084	4.47	1.70
3S-2	0-5	117	5.03	0.053	0.218	8.95	0.390	1060	0.007	13.5	0.206	0.584	1.02	0.189	0.077	5.70	2.00
3S-3	0-5	113	3.95	0.047	0.206	7.27	0.350	782	0.007	12.2	0.173	0.515	0.906	0.182	0.076	4.53	1.70

3.4 Pollution Load Index (PLI)

The ratio of metal concentration and background upper continental crust value yields the pollution load index. No significant PLI>1.00 were found for any of sediments at any of the sites, indicating no pollution (Tables 13 and 14).

Table 13. *Port pollution load index (PLI) by sediment core depth (cm) for Dania Cutoff Canal (DCC), Park Education Center (PEC), Park Headquarters (PHQ), Port Everglades Inlet (PEI), South Turning Basin (STB), and West Lake (WL). PLI>1 is considered polluted sediment.*

Depth (cm)	DCC-1	DCC-2	DCC-3	PEC-1	PEC-2	PEC-3	PHQ-1	PHQ-2	PHQ-3	PEI-1	PEI-2	PEI-3
10	0.169	0.085	0.298	0.162	0.115	0.071	0.039	0.035	0.109	0.039	0.029	0.031
20	0.211	0.047	0.436	0.245	0.189	0.197	0.056	0.273	0.336	0.034	0.030	0.030
30	0.213	0.354	0.468	0.336	0.266	0.320	0.181	0.384	0.274	0.036	0.034	0.027
40	0.353	0.351	0.219	0.256	0.271	0.138	0.116	0.178	0.348	0.035	0.028	
50	0.436	0.455	0.108	0.127	0.120	0.107	0.341	0.285	0.303	0.039	0.027	
60	0.493	0.305	0.081	0.154	0.133	0.144	0.353	0.222	0.222			
70	0.434	0.071	0.047	0.238	0.182	0.238	0.249	0.218	0.202			
80	0.316	0.050	0.037	0.186	0.184	0.284	0.138	0.216	0.168			
90	0.271	0.043	0.043	0.162	0.153	0.177	0.191	0.122	0.113			
100	0.099	0.039	0.106	0.172	0.302	0.179	0.097	0.080	0.060			
110	0.040	0.085	0.262	0.191	0.105	0.287	0.083	0.065	0.079			
120	0.046			0.263	0.085	0.148	0.069	0.047	0.041			
130	0.042			0.142	0.122	0.232	0.078	0.051	0.043			
140	0.047			0.096	0.159	0.114	0.110	0.042	0.069			
150	0.097			0.109	0.149	0.069	0.105	0.126	0.122			
160	0.243			0.164	0.071	0.111	0.130	0.100	0.066			
170				0.216	0.127	0.166	0.084	0.063	0.070			
180				0.198	0.123	0.157	0.081	0.078	0.167			
190				0.169	0.101	0.200	0.177	0.177	0.124			
200				0.215	0.125		0.221	0.083	0.087			
210				0.104	0.243		0.199	0.069	0.096			

220	0.157	0.105	0.109
230	0.133		

Depth (cm)	**STB-1**	**STB-2**	**STB-3**	**WL-1**	**WL-2**	**WL-3**
10	0.310	0.228	0.329	0.307	0.237	0.324
20	0.288	0.243	0.423	0.162	0.192	0.192
30	0.230	0.240	0.218	0.078	0.050	0.080
40	0.202	0.222	0.212	0.052	0.142	0.041
50	0.190	0.225	0.196	0.043	0.262	0.044
60	0.134	0.196	0.204	0.046	0.267	0.035
70	0.162	0.154	0.211	0.035	0.255	
80	0.193	0.272	0.227	0.057	0.311	
90	0.221	0.203	0.216			
100	0.260	0.200	0.201			
110	0.279	0.243	0.229			
120	0.256	0.208	0.267			
130	0.426	0.201	0.272			
140		0.278	0.316			
150		0.282	0.255			
160		0.288	0.427			
170		0.355	0.379			
180			0.332			
190			0.145			
200						
210						
220						
230						

Table 14. *Triplicate reef pollution load index (PLI) of surface sediment samples (0-5cm) for 1N, 2N, 3N, 1S, 2S, and 3S locations. PLI>1 is considered polluted sediment.*

Depth (cm)	**1N-1**	**1N-2**	**1N-3**	**2N-1**	**2N-2**	**2N-3**	**3N-1**	**3N-2**	**3N-3**
0-5	0.054	0.058	0.056	0.053	0.056	0.054	0.048	0.043	0.047
Depth (cm)	**1S-1**	**1S-2**	**1S-3**	**2S-1**	**2S-2**	**2S-3**	**3S-1**	**3S-2**	**3S-3**
0-5	0.054	0.065	0.047	0.049	0.048	0.049	0.041	0.044	0.039

3.5 Potential Ecological Risk (PER)

The combined metal concentrations within each sediment sample determine the potential ecological risk (Guo et al., 2010). Sediment samples are ranked within five levels, (low, moderate, considerable, high, and significantly high). All port sites (except PEI) exhibit moderate-to-significantly high potential ecological risk while the control (WL) exhibits high to significantly high contamination (Tables 15 and 16). The high contaminations are primarily due to As.

Table 15. *Port potential ecological risk (PER) by sediment core depth (cm) for Dania Cutoff Canal (DCC), Park Education Center (PEC), Park Headquarters (PHQ), Port Everglades Inlet (PEI), South Turning Basin (STB), and West Lake (WL). The color of the value indicates the following: low contamination (green), moderate contamination (yellow), considerable contamination (orange), high contamination (red), and significantly high contamination (dark red).*

Depth (cm)	DCC-1	DCC-2	DCC-3	PEC-1	PEC-2	PEC-3	PHQ-1	PHQ-2	PHQ-3	PEI-1	PEI-2	PEI-3
10	74	39	211	47	38	25	13.06	13.09	47.64	26	26	27
20	134	93	316	76	62	56	22.43	252.1	218.2	29	27	27
30	139	269	600	115	99	114	110.4	300.6	178.4	30	31	24
40	302	309	182	82	89	46	63.56	108.7	286.9	28	23	
50	304	334	98	40	37	36	183.8	165.0	202.0		23	
60	338	282	103	47	42	46	219.6	112.3	149.7			
70	274	117	82	67	55	70	212.0	143.6	153.5			
80	215	99	82	50	54	77	115.8	160.8	95.04			
90	178	92	80	45	44	54	180.8	83.96	73.05			
100	110	93	96	52	116	55	76.41	51.85	61.74			
110	97		143	57	87	99	74.67	59.37	67.06			
120	93			124	72	80	72.76	43.34	39.18			
130	80			102	161	207	90.8	50.82	47.52			
140	101			83	265	142	111.2	42.92	72.88			
150	109			88	175	113	127.6	136.7	128.9			
160	172			45	90	144	170.3	104.6	69.33			
170				120	69	52	93.25	68.41	70.60			
180				73	33	39	77.31	71.32	149.6			

190				51	29	42	154.1	162.6	93.12
200				55	31		171.8	67.51	81.53
210				30	48		157.5	66.51	89.85
220				45				91.28	87.24
230				40					

Depth (cm)	**STB-1**	**STB-2**	**STB-3**	**WL-1**	**WL-2**	**WL-3**
10	216	88	232	224	201	258
20	318	111	165	143	133	153
30	214	137	181	128	140	268
40	162	158	155	483	153	262
50	97	157	103	225	178	184
60	87	134	110	193	172	108
70	91	102	120	120	256	
80	94	186	110	198	266	
90	*117*	*99*	*102*			
100	*131*	*114*	*104*			
110	*152*	*118*	*119*			
120	*154*	*105*	*117*			
130	*380*	*103*	*135*			
140		*120*	*202*			
150		*113*	*160*			
160		*152*	*509*			
170		*272*	*262*			
180			*250*			
190			*41*			
200						
210						
220						
230						

Table 16. *Triplicate reef potential ecological risk (PER) of surface sediment samples (0-5cm) for 1N, 2N, 3N, 1S, 2S, and 3S locations. The color of the value indicates the following: low contamination (green), moderate contamination (yellow), considerable contamination (orange), high contamination (red), and significantly high contamination (dark red).*

Depth (cm)	1N-1	1N-2	1N-3	2N-1	2N-2	2N-3	3N-1	3N-2	3N-3
0-5	70.74	78.35	77.61	71.4	76.69	65.54	55.87	48.36	54.16

Depth (cm)	1S-1	1S-2	1S-3	2S-1	2S-2	2S-3	3S-1	3S-2	3S-3
0-5	52.96	73.45	52.07	66.67	64.49	73.41	45.73	50.83	42.63

3.6 Enrichment Factor Based on Fe

The enrichment factor (EF) is used to determine how much the presence of an element (heavy metal) in sediment has increased, due to human activity, relative to the average natural abundance based off the Fe in the upper continental crust.

Tables 17 and 18 show the EFs in the port and control sediment cores and in the surface sediment of the six coral reef locations, respectively. The overall degree of enrichment for all the results seems relatively high; therefore, just using EF to determine contamination is not recommended. This could be since the upper continental crust value for Fe (50,000 µg/g) is much higher than the Fe found in the South FL marine environment, which can skew the degree of enrichment.

Preliminary results show overall high enrichment in As and Cd in all locations (port, control and reef) as well as high enrichment for Mo in the port sites.

Table 17*. Port enrichment factors (EF) based on Fe by sediment core depth (cm) for Dania Cutoff Canal (DCC), Park Education Center (PEC), Park Headquarters (PHQ), Port Everglades Inlet (PEI), South Turning Basin (STB), and West Lake (WL). The color of the value indicates the following: depletion to mineral enrichment (green), moderate enrichment (yellow), significant enrichment (orange), very high enrichment (red), and extremely high enrichment (dark red).*

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
DCC-1	10	0.4	56.5	9.3	0.4	4.2	2.8		4.0	0.1	37.6	2.3	1.1	0.2	0.6	2.6	4.9
	20	0.3	94.7	12.9	0.4	4.7	3.6		3.6	0.2	68.8	2.8	1.5	0.2	0.5	3.3	1.9
	30	0.2	104.8	25.2	0.5	3.1	9.4		3.4	0.2	118.3	2.8	1.5	0.2	1.0	5.3	5.6
	40	0.2	30.4	18.7	0.2	1.9	0.6		1.8	0.1	96.3	1.4	0.3	0.1	0.3	2.1	0.3
	50	0.2	23.3	14.7	0.2	2.3	1.0		1.1	0.2	59.2	1.3	0.4	0.1	0.2	1.2	0.3
	60	0.1	20.7	10.0	0.1	2.2	0.6		0.8	0.1	36.3	1.1	0.3	0.1	0.1	0.9	0.2
	70	0.1	22.0	5.5	0.1	1.9	0.5		0.7	0.1	23.4	1.0	0.3	0.1	0.1	0.5	0.1
	80	0.1	26.7	4.2	0.1	1.6	0.4		0.6	0.2	23.3	0.9	0.2	0.1	0.1	0.6	0.1
	90	0.1	29.7	3.1	0.1	1.6	0.4		0.7	0.2	26.8	0.9	0.2	0.1	0.1	0.7	0.1
	100	0.0	56.5	2.4	0.2	0.6	0.1		1.0	1.2	23.4	0.4	0.2	0.1	0.2	0.3	0.2
	110	0.0	64.4	2.8	0.3	0.2	0.1		1.2	1.5	9.4	0.2	0.0	0.1	0.2	0.0	0.2
	120	0.0	69.7	3.3	0.3	0.2	0.2		1.3	1.9	5.1	0.3	0.0	0.1	0.2	0.0	0.3
	130	0.0	70.2	3.9	0.3	0.2	0.2		1.6	2.3	2.0	0.2	0.0	0.0	0.2	0.1	0.3
	140	0.0	84.6	3.4	0.3	0.2	0.2		1.4	2.0	2.4	0.3	0.1	0.1	0.2	0.1	0.3

Site	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
	150	0.4	68.7	2.5	0.4	1.1	0.1		1.0	1.6	1.7	0.6	0.5	0.1	0.2	0.4	0.2
	160	0.6	47.8	1.1	0.4	2.0	0.2		0.7	0.4	3.1	0.7	0.9	0.0	0.3	0.8	0.3
DCC-2	10	0.2	56.3	11.7	0.5	2.9	7.0		4.9	0.4	26.0	1.5	1.9	0.2	0.7	2.0	3.6
	20	0.2	86.6	13.7	0.3	2.5	3.9		4.5	0.2	76.1	1.7	1.0	0.2	0.5	2.7	2.4
	30	0.2	92.9	16.1	0.3	3.0	1.9		3.3	0.1	152.5	2.1	0.6	0.2	0.5	3.6	2.2
	40	0.2	36.8	20.5	0.2	2.0	0.9		1.9	0.1	87.4	1.5	0.4	0.1	0.3	1.8	0.4
	50	0.2	20.8	15.2	0.2	2.3	0.7		1.1	0.2	54.3	1.3	0.3	0.1	0.2	1.2	0.2
	60	0.1	38.9	4.8	0.1	1.4	0.4		0.7	0.2	26.3	0.8	0.2	0.1	0.1	0.7	0.1
	70	0.0	65.7	2.6	0.2	0.3	0.1		1.1	1.3	23.9	0.2	0.0	0.1	0.2	0.2	0.2
	80	0.0	74.5	3.1	0.3	0.2	0.2		1.3	1.7	12.2	0.2	0.0	0.1	0.2	0.1	0.2
	90	0.0	65.1	3.1	0.3	0.2	0.2		1.3	1.6	4.1	0.2	0.0	0.1	0.2	0.0	0.2
	100	0.0	72.2	3.2	0.3	0.2	0.2		1.3	1.7	4.1	0.2	0.0	0.0	0.2	0.0	0.2
DCC-3	10	0.2	41.6	17.4	0.2	1.7	2.3		2.5	0.1	72.2	1.5	0.5	0.1	0.3	1.7	1.3
	20	0.1	20.9	13.2	0.2	2.0	0.8		1.1	0.1	43.8	1.2	0.4	0.1	0.1	1.1	0.3
	30	0.1	66.7	6.5	0.1	1.4	0.6		0.7	0.1	32.4	0.8	0.2	0.1	0.1	0.7	0.2
	40	0.1	33.5	2.9	0.1	1.2	0.3		0.6	0.2	23.0	0.6	0.2	0.1	0.1	0.6	0.1
	50	0.1	49.7	2.6	0.2	0.8	0.2		1.4	0.9	25.4	0.6	0.1	0.1	0.2	0.5	0.2
	60	0.0	64.6	2.4	0.3	0.4	0.2		1.4	1.2	24.1	0.4	0.1	0.1	0.2	0.3	0.2
	70	0.0	68.7	3.5	0.3	0.2	0.2		1.8	1.8	12.9	0.2	0.0	0.1	0.2	0.1	0.3
	80	0.0	74.5	3.2	0.3	0.2	0.2		1.6	2.5	5.9	0.2	0.0	0.0	0.2	0.1	0.2
	90	0.0	79.0	4.0	0.3	0.2	0.2		2.0	2.1	5.0	0.2	0.1	0.1	0.2	0.1	0.3
	100	0.4	51.8	2.1	0.3	1.3	0.1		1.1	1.0	2.7	0.5	0.5	0.1	0.2	0.5	0.2
	110	0.8	28.3	0.8	0.4	2.2	0.1		0.4	0.2	1.7	0.7	1.0	0.0	0.3	0.7	0.2
PEC-1	10	0.3	34.0	12.9	0.6	5.3	20.0		11.9	0.4	18.3	3.3	5.1	0.1	1.2	4.5	6.9
	20	0.3	32.3	15.6	0.7	5.3	7.0		11.4	0.3	21.0	6.1	4.7	0.1	0.9	9.0	3.0
	30	0.2	30.6	16.8	0.7	3.8	6.8		17.3	0.2	18.3	7.2	4.2	0.1	0.9	9.6	2.8

	40	0.3	27.3	13.7	0.7	4.9	4.3	10.9	0.3	16.2	5.1	3.2	0.1	0.8	6.5	2.0
	50	0.5	25.6	7.5	0.9	6.9	1.2	3.7	0.4	16.4	2.2	1.5	0.1	0.4	2.8	0.8
	60	0.8	26.1	6.4	0.8	7.0	0.8	2.9	0.4	15.8	2.1	1.5	0.1	0.4	2.7	0.6
	70	0.6	25.1	5.8	0.7	5.9	1.4	3.5	0.4	16.3	2.1	2.0	0.1	0.6	2.0	0.9
	80	0.8	23.6	7.2	0.9	7.9	1.4	4.6	0.4	15.0	2.3	2.0	0.1	0.6	2.5	0.8
	90	0.8	23.1	7.0	0.9	7.6	1.0	4.4	0.4	15.3	2.4	1.8	0.1	0.5	2.6	0.8
	100	0.7	26.0	6.4	0.8	6.6	1.0	3.6	0.4	18.7	2.1	1.7	0.1	0.4	2.4	0.6
	110	0.8	27.9	6.3	0.9	6.4	1.0	4.0	0.5	15.6	2.2	1.9	0.1	0.5	2.4	0.7
	120	0.2	44.6	16.1	0.4	2.1	4.0	18.5	0.2	15.0	2.2	4.4	0.1	0.9	3.4	2.1
	130	0.1	45.6	8.6	0.2	1.9	0.8	4.2	0.2	31.3	1.0	0.7	0.1	0.2	1.3	0.4
	140	0.1	46.4	6.7	0.1	2.0	0.4	2.1	0.2	28.6	1.0	0.3	0.1	0.1	1.3	0.2
	150	0.1	42.9	4.9	0.2	1.2	0.3	2.5	0.1	38.0	0.8	0.3	0.1	0.2	1.1	0.2
	160	0.3	12.5	2.6	0.3	1.2	0.2	1.9	0.1	30.6	0.7	0.5	0.1	0.1	0.7	2.0
	170	0.1	19.2	2.2	0.2	0.4	0.2	2.0	0.0	63.2	0.4	0.1	0.1	0.1	0.5	0.2
	180	0.2	19.5	3.8	0.4	1.1	0.7	3.4	0.1	51.2	0.7	0.4	0.1	0.2	0.8	0.3
	190	0.5	14.0	4.7	0.4	1.9	0.6	3.2	0.1	37.3	1.0	0.7	0.1	0.2	1.0	0.3
	200	0.4	10.5	2.3	0.3	1.4	0.3	3.5	0.1	21.2	0.8	0.6	0.1	0.2	0.9	0.2
	210	0.4	12.4	3.5	0.8	1.5	0.1	3.2	0.3	24.4	1.0	0.9	0.0	0.2	0.8	0.2
	220	0.3	8.7	1.6	0.3	1.1	0.1	1.1	0.1	17.9	0.7	0.7	0.0	0.1	0.5	0.1
	230	0.3	7.3	1.3	0.1	0.9	0.1	1.5	0.1	11.6	0.5	0.5	0.0	0.1	0.5	0.1
	10	0.3	42.3	15.7	0.8	5.7	18.5	7.6	0.5	28.5	3.3	5.3	0.1	1.2	4.5	7.3
	20	0.4	37.7	16.6	0.7	5.0	10.5	11.4	0.3	19.7	5.2	4.6	0.1	1.0	7.3	4.3
	30	0.2	39.9	17.8	0.7	4.0	6.3	14.7	0.3	21.0	6.9	3.8	0.1	0.9	9.6	2.7
	40	0.2	32.7	11.4	0.6	3.9	5.9	13.4	0.2	12.9	4.7	3.2	0.1	0.7	5.8	2.3
	50	0.6	25.3	6.4	0.9	7.5	0.9	2.9	0.4	14.0	2.5	1.4	0.1	0.3	2.8	0.6
PEC-2	60	0.7	26.2	5.8	0.8	6.9	0.8	2.1	0.4	15.6	2.2	1.4	0.1	0.4	2.6	0.5
	70	0.8	25.0	6.0	0.7	6.6	0.9	2.1	0.4	13.8	2.2	1.6	0.1	0.5	2.1	0.6
	80	0.8	23.6	7.5	0.8	7.7	1.3	3.0	0.4	14.8	2.4	1.8	0.1	0.5	2.3	0.7
	90	0.8	24.4	7.2	0.9	7.4	1.1	3.0	0.4	17.3	2.6	1.7	0.1	0.5	2.7	0.7
	100	0.2	40.1	12.6	0.4	2.6	5.6	24.6	0.3	8.8	3.4	4.5	0.1	0.9	3.6	2.1

	110	0.1	53.6	6.7	0.2	1.6	0.7	3.3	0.1	37.3	0.9	0.5	0.1	0.2	1.7	0.3
	120	0.1	53.4	8.0	0.2	2.1	0.5	1.1	0.2	38.3	1.1	0.4	0.1	0.2	1.7	0.3
	130	0.0	52.7	2.0	0.2	0.6	0.1	0.8	0.1	47.1	0.3	0.1	0.1	0.1	0.5	0.1
	140	0.0	76.5	2.1	0.2	0.5	0.1	1.1	0.4	61.0	0.3	0.1	0.1	0.1	0.6	0.2
	150	0.0	58.2	2.2	0.3	0.5	0.2	0.7	0.3	68.7	0.5	0.1	0.1	0.1	0.9	0.1
	160	0.0	58.9	4.4	0.6	0.3	0.2	1.5	0.7	28.7	0.3	0.0	0.1	0.3	0.2	0.3
	170	0.3	32.1	3.4	0.8	1.0	0.2	1.9	0.2	27.9	0.5	0.4	0.1	0.2	0.5	0.3
	180	1.3	16.0	4.4	0.5	3.9	0.4	2.0	0.2	10.6	0.9	1.9	0.1	0.5	1.2	0.3
	190	1.3	21.5	4.4	1.1	3.9	0.5	1.6	0.2	9.9	1.1	2.0	0.1	0.5	1.3	0.3
	200	1.4	17.0	3.8	0.9	4.2	0.5	1.6	0.3	6.3	1.2	2.1	0.1	0.6	1.6	0.3
	210	1.1	15.4	3.4	0.6	4.0	1.4	2.8	0.4	10.3	1.2	1.7	0.1	0.5	3.2	0.5
PEC-3	10	0.4	29.7	20.0	0.7	8.2	12.1	10.0	0.6	16.2	4.4	4.2	0.1	0.7	4.8	5.1
	20	0.4	25.3	13.8	0.7	5.9	6.9	8.5	0.4	14.6	6.4	4.7	0.1	0.7	9.8	2.5
	30	0.2	23.3	18.0	0.6	4.1	6.1	12.8	0.2	16.3	7.0	4.0	0.1	0.7	9.6	2.5
	40	0.4	23.4	9.6	0.6	6.7	2.2	2.2	0.3	17.9	3.4	1.9	0.1	0.3	4.4	1.4
	50	0.6	22.7	8.8	0.7	8.3	0.8	5.9	0.4	15.0	2.3	1.2	0.1	0.3	2.8	0.6
	60	0.5	22.7	5.4	0.6	6.3	0.7	3.4	0.3	14.8	1.9	1.1	0.1	0.3	2.2	0.5
	70	0.6	22.0	5.3	0.6	5.6	0.9	3.0	0.3	15.0	2.0	1.6	0.1	0.4	1.9	0.7
	80	0.6	22.2	6.1	0.6	5.7	1.3	6.6	0.3	15.7	2.0	1.8	0.1	0.5	1.9	1.0
	90	0.8	21.2	7.7	0.7	7.8	1.1	2.9	0.4	18.7	2.3	1.6	0.1	0.4	2.4	0.7
	100	0.7	20.5	6.7	0.6	7.0	1.0	2.1	0.4	15.9	2.3	1.6	0.0	0.4	2.4	0.6
	110	0.3	32.9	9.0	0.4	3.2	3.5	15.1	0.3	12.1	2.9	2.9	0.1	0.6	2.9	1.5
	120	0.1	38.1	6.3	0.2	1.4	1.3	8.0	0.1	22.3	1.1	1.0	0.1	0.3	1.6	0.7
	130	0.0	43.3	2.2	0.2	0.6	0.3	3.0	0.3	49.4	0.4	0.2	0.1	0.1	0.7	0.1
	140	0.0	74.6	3.0	0.3	0.4	0.3	3.3	0.7	43.0	0.3	0.2	0.1	0.2	0.5	0.2
	150	0.0	74.0	2.6	0.4	0.2	0.2	4.6	0.8	20.6	0.2	0.1	0.0	0.2	0.2	0.2
	160	0.0	65.0	3.6	1.2	0.2	0.2	2.0	0.6	34.7	0.3	0.0	0.1	0.2	0.2	0.3
	170	0.6	17.0	2.8	0.3	2.1	0.4	2.7	0.1	11.3	0.7	0.9	0.1	0.2	0.8	0.2
	180	0.9	15.1	2.7	1.1	3.5	0.4	1.8	0.2	5.9	1.0	1.5	0.1	0.4	1.1	0.2
	190	1.1	14.8	2.0	0.9	3.8	0.4	3.5	0.2	4.0	1.3	1.9	0.1	0.4	1.3	0.3

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
PHQ-1	10	0.3	45.7	23.1	1.0	7.8	11.1		20.5	0.9	18.9	2.0	7.9	0.2	1.3	3.7	12.0
	20	0.2	47.2	17.3	0.6	4.2	6.7		11.1	0.5	30.4	1.5	7.1	0.1	0.8	2.6	9.2
	30	0.1	37.8	7.6	0.2	1.0	1.3		2.1	0.1	63.8	0.7	0.6	0.1	0.2	1.2	4.7
	40	0.1	31.5	3.2	0.1	1.2	1.4		1.9	0.1	62.2	0.7	0.6	0.1	0.2	1.0	1.1
	50	0.1	39.9	9.7	0.2	1.9	3.2		3.9	0.1	88.7	1.3	0.8	0.1	0.2	2.7	2.5
	60	0.1	33.2	6.0	0.1	2.0	0.4		1.9	0.0	97.4	1.6	0.5	0.1	0.2	1.6	0.2
	70	0.1	38.2	6.1	0.1	1.3	0.3		1.6	0.0	100.7	0.7	0.1	0.1	0.1	3.2	0.2
	80	0.1	32.0	8.4	0.1	1.5	0.2		1.7	0.0	119.9	1.0	0.2	0.1	0.2	2.0	0.2
	90	0.1	37.0	9.5	0.1	1.4	0.2		1.8	0.0	133.6	0.8	0.2	0.1	0.2	2.2	0.2
	100	0.1	47.6	7.1	0.1	1.9	0.4		2.3	0.1	173.7	0.9	0.3	0.1	0.2	1.9	0.2
	110	0.1	39.4	4.5	0.1	1.2	0.2		1.6	0.1	73.4	0.5	0.4	0.1	0.1	0.7	0.2
	120	0.1	61.1	6.4	0.1	1.4	0.3		2.3	0.1	131.2	0.8	0.3	0.1	0.2	1.0	0.3
	130	0.1	64.9	8.1	0.1	1.8	0.2		1.7	0.1	92.3	0.7	0.3	0.1	0.2	2.4	0.2
	140	0.1	49.9	7.8	0.1	1.6	0.3		1.7	0.1	55.3	0.8	0.3	0.1	0.1	1.3	0.2
	150	0.1	50.7	7.3	0.1	1.3	0.2		1.1	0.1	58.1	0.7	0.2	0.1	0.1	0.8	0.1
	160	0.0	51.2	5.0	0.1	1.2	0.2		0.9	0.1	47.8	0.5	0.2	0.1	0.1	0.7	0.1
	170	0.1	49.4	4.4	0.1	1.3	0.3		1.3	0.1	36.7	0.6	0.2	0.1	0.1	0.8	0.1
	180	0.1	51.6	4.5	0.1	1.4	0.2		2.0	0.1	48.9	0.6	0.2	0.1	0.2	1.1	0.2
	190	0.0	40.5	2.6	0.1	1.0	0.1		1.8	0.1	68.6	0.4	0.1	0.1	0.2	1.3	0.2
	200	0.0	48.0	4.8	0.5	1.2	0.2		3.3	0.1	71.1	0.6	0.1	0.1	0.3	0.9	0.4
	210	0.0	51.8	5.9	0.7	1.2	0.3		4.1	0.2	64.0	0.7	0.1	0.2	0.4	0.8	0.4
PHQ-2	10	0.2	52.5	19.4	1.2	8.2	10.1		12.9	1.0	6.5	1.8	9.8	0.2	1.2	3.4	10.6
	20	0.0	37.9	2.7	0.1	0.5	0.6		1.5	0.0	60.7	0.4	0.3	0.0	0.1	0.6	0.3
	30	0.0	23.3	2.9	0.1	0.6	0.1		1.1	0.0	63.1	0.6	0.1	0.1	0.1	0.8	0.1
	40	0.1	25.5	3.8	0.1	0.9	0.6		1.3	0.1	54.6	0.6	0.4	0.0	0.1	1.0	0.4
	50	0.1	30.6	6.7	0.1	2.1	0.4		2.4	0.0	104.4	1.3	0.3	0.1	0.2	2.4	0.3
	60	0.2	37.0	7.0	0.2	3.2	0.4		3.9	0.0	141.9	2.1	0.5	0.2	0.3	3.2	0.4

	70	0.1	29.1	7.7	0.1	1.9	0.2		2.5	0.0	120.6	1.4	0.3	0.1	0.2	2.1	0.3
	80	0.1	35.1	10.9	0.1	1.7	0.8		2.1	0.0	149.4	1.0	0.3	0.1	0.2	3.6	0.4
	90	0.1	33.0	7.4	0.1	1.8	0.5		1.8	0.1	140.8	1.0	0.3	0.1	0.2	1.8	0.2
	100	0.1	42.2	7.1	0.1	3.0	0.5		1.6	0.1	133.5	1.2	0.5	0.1	0.2	2.1	0.3
	110	0.1	49.6	6.4	0.1	1.6	0.3		1.3	0.1	70.0	0.9	0.3	0.1	0.2	0.9	0.3
	120	0.1	64.8	8.4	0.1	1.8	0.4		1.8	0.1	82.6	1.0	0.4	0.1	0.3	1.4	0.4
	130	0.1	51.6	8.0	0.1	1.8	0.3		1.1	0.1	59.0	0.8	0.3	0.1	0.2	1.3	0.2
	140	0.1	62.5	7.1	0.1	1.9	0.3		1.4	0.1	64.4	0.8	0.3	0.1	0.2	1.2	0.3
	150	0.1	52.2	5.4	0.1	1.6	0.3		0.5	0.1	36.6	0.8	0.3	0.1	0.1	1.1	0.3
	160	0.1	50.9	5.0	0.1	1.7	0.3		0.7	0.1	34.3	0.7	0.2	0.1	0.1	1.4	0.2
	170	0.1	53.8	4.4	0.1	1.4	0.2		0.8	0.1	32.1	0.7	0.3	0.1	0.2	0.8	0.2
	180	0.1	51.6	4.8	0.2	1.7	0.2		1.0	0.1	48.5	0.7	0.2	0.1	0.2	1.5	0.2
	190	0.0	46.0	3.8	0.3	1.0	0.2		1.3	0.2	58.6	0.5	0.0	0.1	0.2	0.7	0.3
	200	0.0	59.7	8.5	0.6	1.1	0.4		2.8	0.8	65.1	0.7	0.1	0.2	0.5	0.8	0.6
	210	0.0	85.4	9.8	1.3	1.1	0.5		3.3	1.1	45.2	0.8	0.1	0.2	0.6	0.7	0.7
	220	0.0	66.5	7.8	1.2	1.2	0.4		2.6	0.9	44.5	0.8	0.1	0.2	0.5	0.7	0.6
	10	0.1	57.0	9.2	0.4	2.5	9.5		2.8	0.3	34.6	1.6	3.5	0.1	1.2	2.9	4.9
	20	0.0	24.4	3.6	0.1	0.7	0.5		1.8	0.0	55.0	0.8	0.3	0.1	0.1	0.8	0.2
	30	0.1	21.6	2.3	0.1	0.8	0.2		0.6	0.0	56.6	0.6	0.1	0.1	0.1	1.2	0.1
	40	0.0	21.0	2.7	0.1	0.5	0.2		0.6	0.0	53.7	0.3	0.1	0.0	0.1	0.7	0.1
	50	0.1	25.6	6.2	0.1	1.1	0.7		0.6	0.1	64.4	0.8	0.2	0.1	0.1	1.5	0.6
	60	0.1	44.1	9.1	0.2	2.1	0.7		1.5	0.1	164.4	1.6	0.4	0.2	0.3	2.5	0.4
	70	0.1	21.0	7.5	0.1	1.3	0.2		0.7	0.0	103.5	0.9	0.2	0.1	0.1	1.9	0.2
PHQ-3	80	0.1	27.8	7.8	0.1	2.9	0.4		1.1	0.0	155.5	1.5	0.4	0.1	0.2	2.6	0.2
	90	0.1	35.4	7.6	0.1	2.2	0.5		1.2	0.1	150.6	1.2	0.4	0.1	0.2	1.7	0.3
	100	0.1	65.2	7.1	0.1	1.7	0.4		1.2	0.1	103.5	1.0	0.4	0.1	0.2	1.2	0.3
	110	0.1	46.0	5.7	0.1	1.7	0.4		1.1	0.1	112.4	0.9	0.3	0.1	0.2	1.2	0.2
	120	0.1	67.0	7.6	0.1	1.8	0.3		1.9	0.1	99.2	1.0	0.4	0.1	0.4	1.5	0.4
	130	0.1	65.8	6.5	0.1	1.4	0.2		1.5	0.1	59.3	0.8	0.3	0.1	0.2	0.9	0.3
	140	0.1	55.0	6.4	0.1	1.7	0.3		0.9	0.1	46.9	0.8	0.3	0.1	0.2	1.1	0.2

	150	0.1	49.9	5.8	0.1	1.9	0.3		0.9	0.1	38.9	0.8	0.2	0.1	0.1	1.3	0.1
	160	0.1	49.3	3.8	0.1	1.7	0.3		0.6	0.1	29.3	0.7	0.2	0.1	0.1	0.8	0.2
	170	0.1	57.3	3.9	0.2	1.4	0.2		1.0	0.2	45.2	0.7	0.2	0.1	0.2	1.3	0.2
	180	0.0	47.8	3.2	0.3	1.1	0.2		1.0	0.2	48.1	0.5	0.1	0.1	0.2	1.1	0.2
	190	0.1	49.0	3.8	0.3	1.2	0.3		1.2	0.3	55.6	1.3	0.2	0.1	0.2	1.1	0.3
	200	0.1	105.1	10.1	4.3	1.4	0.5		3.3	1.0	56.4	0.9	0.1	0.3	0.6	1.0	0.8
	210	0.0	96.3	7.5	3.4	1.3	0.4		3.8	1.5	52.3	1.1	0.1	0.2	0.5	0.9	0.6
	220	0.0	84.0	10.7	4.4	1.6	1.4		4.8	0.5	63.7	2.2	0.1	0.3	0.7	0.8	0.8

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
PEI-1	10	0.2	123.2	15.0	3.7	6.0	1.7		9.8	1.1	4.0	2.5	3.0	0.1	0.8	3.1	3.3
	20	0.1	128.5	13.7	0.9	5.9	1.4		10.1	0.9	3.2	1.0	2.5	0.1	0.9	2.8	2.3
	30	0.1	122.3	12.1	0.9	6.2	1.2		9.0	1.1	2.8	0.9	2.6	0.1	0.8	2.8	2.3
	40	0.1	117.9	13.5	0.9	6.5	1.3		9.6	1.2	2.6	1.0	2.6	0.1	0.8	2.7	2.4
PEI-2	10	0.1	117.5	12.3	0.9	5.3	0.8		8.1	1.0	2.3	0.9	2.1	0.1	0.7	2.5	1.9
	20	0.1	128.9	11.3	0.9	4.9	0.8		8.5	0.7	2.4	0.8	1.8	0.1	0.7	2.6	1.9
	30	0.1	123.7	12.4	0.9	5.4	0.7		8.9	1.2	3.3	0.8	1.8	0.1	0.8	2.7	1.8
	40	0.1	137.9	15.7	1.0	6.3	0.9		9.6	1.2	3.6	1.1	2.3	0.1	0.8	2.8	2.2
	50	0.1	124.8	15.1	1.1	5.4	0.9		10.8	1.1	2.5	1.0	2.2	0.1	0.9	2.6	2.2
PEI-3	7	0.1	120.5	13.5	0.9	5.7	0.9		10.7	0.9	3.3	0.8	2.0	0.1	0.8	2.6	2.1
	14	0.1	123.9	13.9	1.0	5.3	0.8		10.3	1.0	3.0	0.9	2.1	0.1	0.9	2.5	1.9
	21	0.1	140.9	20.4	1.3	5.8	1.0		16.3	1.6	4.1	0.9	2.3	0.2	1.2	2.9	2.4

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
	10	0.1	26.3	3.7	0.1	0.8	0.6		1.9	0.0	21.9	0.6	0.2	0.1	0.1	0.5	0.2
	20	0.0	32.4	2.5	0.1	0.5	0.2		0.9	0.0	22.0	0.3	0.1	0.0	0.1	0.4	0.1
	30	0.0	23.0	2.2	0.1	0.4	0.1		0.9	0.0	24.9	0.2	0.1	0.0	0.1	0.4	0.1
	40	0.0	26.6	2.7	0.2	0.3	0.4		0.8	0.1	75.6	0.2	0.1	0.0	0.2	0.4	0.2
	50	0.1	20.7	4.2	0.2	1.0	0.2		1.1	0.1	57.0	0.7	0.2	0.1	0.3	0.8	0.3
	60	0.1	22.6	4.3	0.1	0.6	0.2		1.1	0.0	41.6	0.6	0.1	0.1	0.3	0.5	0.3
	70	0.1	20.1	4.3	0.3	0.6	0.2		1.2	0.0	41.0	0.6	0.1	0.1	0.3	0.9	0.3
STB-1	80	0.2	28.1	4.7	0.3	1.1	0.2		3.5	0.1	71.6	1.2	0.3	0.1	0.3	1.2	0.4
	90	0.1	18.3	2.8	0.3	0.5	0.1		1.0	0.0	49.9	0.6	0.1	0.1	0.2	1.1	0.2
	100	0.1	24.1	4.0	0.4	0.8	0.2		1.1	0.1	76.1	0.8	0.2	0.1	0.3	1.3	0.3
	110	0.2	40.5	4.7	0.3	2.0	0.2		1.8	0.1	100.2	1.3	0.5	0.1	0.3	2.8	0.3
	120	0.1	27.8	4.3	0.2	0.8	0.2		1.8	0.1	102.2	0.7	0.2	0.1	0.2	2.2	0.2
	130	0.1	42.3	1.7	0.1	0.5	0.5		1.4	0.2	37.8	0.4	0.2	0.1	0.1	0.7	0.2
	10	0.2	24.0	6.6	0.3	1.9	1.1		6.7	0.1	57.2	1.1	0.7	0.2	0.4	1.2	0.6
	20	0.1	17.8	3.9	0.1	1.3	0.4		3.6	0.0	20.6	0.7	0.3	0.1	0.2	0.7	0.3
	30	0.1	28.5	3.8	0.2	1.4	0.3		2.3	0.0	35.1	0.9	0.4	0.1	0.2	0.8	0.3
	40	0.1	21.9	2.3	0.1	0.7	0.1		1.2	0.0	28.5	0.4	0.1	0.1	0.1	0.5	0.2
	50	0.0	20.0	2.7	0.1	0.4	0.1		3.2	0.0	29.1	0.3	0.1	0.0	0.2	0.5	0.2
	60	0.0	20.0	2.8	0.2	0.3	0.1		2.4	0.1	75.5	0.2	0.1	0.0	0.2	0.4	0.2
	70	0.1	39.5	8.1	0.3	0.9	0.4		4.4	0.1	104.1	0.6	0.2	0.1	0.5	0.9	0.6
STB-2	80	0.1	23.2	2.1	0.1	0.5	0.1		1.5	0.1	55.0	0.3	0.1	0.1	0.1	0.4	0.1
	90	0.1	18.7	4.4	0.2	0.8	0.2		2.5	0.1	41.1	0.7	0.2	0.1	0.3	0.7	0.3
	100	0.0	18.8	3.4	0.2	0.5	0.2		1.7	0.1	39.9	0.4	0.1	0.1	0.2	0.9	0.3
	110	0.1	16.4	2.3	0.2	0.4	0.1		3.0	0.1	45.3	0.4	0.1	0.1	0.1	0.6	0.2
	120	0.1	28.0	5.9	0.4	1.0	0.3		4.0	0.1	74.1	1.1	0.2	0.1	0.4	1.2	0.4
	130	0.2	37.4	8.0	0.5	1.3	0.4		5.0	0.1	97.6	1.4	0.3	0.2	0.5	2.4	0.6
	140	0.1	21.5	4.1	0.5	0.9	0.2		2.3	0.1	62.2	1.1	0.2	0.1	0.3	1.5	0.3

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
	150	0.5	39.6	7.4	0.6	3.5	0.4		4.0	0.2	91.3	2.6	0.8	0.2	0.5	2.4	0.6
	160	0.1	36.1	4.9	0.3	1.2	0.3		2.5	0.1	107.8	1.1	0.4	0.1	0.3	2.4	0.4
	170	0.1	53.0	7.2	0.3	1.0	0.2		4.5	0.1	187.0	1.0	0.3	0.1	0.2	2.9	0.3
STB-3	10	0.1	30.6	3.2	0.1	0.7	1.2		1.6	0.0	28.3	0.5	0.3	0.1	0.1	0.6	0.5
	20	0.1	24.3	3.6	0.2	1.3	4.3		3.2	0.1	26.2	0.8	1.0	0.1	0.3	0.8	1.7
	30	0.0	25.2	3.0	0.1	0.5	0.1		2.3	0.0	29.9	0.3	0.1	0.1	0.1	0.5	0.2
	40	0.0	19.7	2.4	0.1	0.3	0.1		1.9	0.1	47.1	0.2	0.1	0.1	0.2	0.4	0.2
	50	0.1	21.1	3.2	0.2	0.8	0.2		3.7	0.1	51.2	0.5	0.1	0.1	0.2	0.6	0.2
	60	0.1	24.1	3.8	0.2	0.6	0.2		6.0	0.1	69.7	0.6	0.1	0.1	0.2	0.5	0.3
	70	0.1	18.6	4.0	0.2	0.5	0.2		2.1	0.0	49.7	0.5	0.1	0.1	0.2	0.6	0.3
	80	0.1	18.3	2.7	0.3	0.5	0.1		2.3	0.0	50.3	0.5	0.2	0.1	0.2	0.9	0.2
	90	0.1	22.7	4.9	0.4	0.7	0.3		3.5	0.1	79.0	0.8	0.3	0.1	0.3	1.1	0.4
	100	0.1	25.7	5.1	0.4	0.7	0.3		1.6	0.1	71.2	0.8	0.2	0.1	0.3	1.6	0.4
	110	0.1	28.9	4.6	0.4	0.9	0.2		1.8	0.1	90.2	1.1	0.2	0.1	0.3	1.4	0.3
	120	0.2	27.5	4.7	0.3	1.6	0.2		2.3	0.1	95.3	1.5	0.3	0.1	0.3	1.5	0.4
	130	0.2	37.5	5.6	0.4	1.7	0.3		1.8	0.1	116.5	1.6	0.4	0.2	0.3	2.1	0.4
	140	0.1	29.6	5.6	0.2	1.1	0.2		2.0	0.0	116.7	1.0	0.2	0.1	0.2	2.0	0.2
	150	0.1	27.9	3.3	0.2	1.1	0.2		0.9	0.1	97.3	0.7	0.2	0.1	0.2	1.3	0.2
	160	0.0	36.6	2.9	0.1	0.6	0.2		0.3	0.0	94.3	0.4	0.1	0.0	0.1	0.6	0.1
	170	0.1	29.6	1.8	0.1	0.8	0.4		1.1	0.1	60.0	0.5	0.2	0.0	0.1	0.8	0.1
	180	0.1	40.1	2.1	0.2	0.4	1.3		0.7	0.3	22.3	0.4	0.3	0.1	0.2	0.4	0.5
	190	1.0	17.4	1.7	0.4	3.2	0.6		0.8	0.6	1.2	0.9	1.3	0.0	0.4	1.2	0.4
WL-1	10	0.1	49.7	3.7	0.1	0.6	6.2		3.9	0.3	2.4	0.4	1.8	0.0	0.5	0.4	4.1
	20	0.0	38.5	1.6	0.1	0.2	1.0		1.8	0.3	4.0	0.2	0.6	0.0	0.1	0.2	0.8
	30	0.0	59.1	1.7	0.2	0.1	0.4		0.9	0.7	3.8	0.1	0.3	0.0	0.1	0.1	0.3
	40	0.0	102.9	0.8	0.1	0.0	0.0		0.4	0.3	1.7	0.0	0.0	0.0	0.0	0.0	0.1
	50	0.0	83.6	1.4	0.1	0.1	0.1		0.8	0.6	1.4	0.0	0.0	0.0	0.1	0.0	0.1

	60	0.0	71.7	1.4	0.2	0.1	0.1	0.7	0.6	1.1	0.1	0.0	0.0	0.1	0.0	0.1
	70	0.0	49.4	1.3	0.1	0.1	0.1	0.7	0.8	0.6	0.1	0.0	0.0	0.1	0.0	0.1
	80	0.0	70.9	1.2	0.1	0.1	0.1	0.6	0.8	0.6	0.1	0.0	0.0	0.1	0.0	0.1
WL-2	10	0.0	49.2	3.7	0.1	0.4	3.8	3.9	0.2	2.2	0.4	1.3	0.0	0.3	0.3	3.0
	20	0.1	45.1	3.1	0.2	0.5	3.6	3.5	0.4	3.3	0.4	1.5	0.0	0.4	0.3	2.4
	30	0.0	53.9	1.4	0.2	0.1	0.1	0.7	0.6	2.2	0.1	0.0	0.0	0.1	0.0	0.1
	40	0.0	62.3	2.3	0.2	0.3	2.5	1.8	0.5	2.7	0.3	0.9	0.0	0.2	0.2	1.8
	50	0.1	52.2	4.1	0.2	0.7	5.7	4.4	0.3	2.9	0.5	2.0	0.0	0.5	0.4	3.8
	60	0.1	36.1	3.8	0.1	0.5	4.2	2.8	0.3	1.9	0.4	1.5	0.0	0.4	0.3	2.7
	70	0.0	62.9	3.3	0.1	0.5	4.6	3.0	0.2	2.0	0.4	1.5	0.0	0.4	0.3	3.1
	80	0.1	73.3	4.5	0.1	0.7	6.0	4.0	0.3	7.4	0.5	1.9	0.0	0.5	0.4	3.9
WL-3	10	0.0	49.8	4.2	0.1	0.5	4.2	2.9	0.3	4.0	0.4	1.4	0.0	0.3	0.4	3.0
	20	0.0	39.7	3.7	0.2	0.4	1.5	2.8	0.3	2.9	0.3	1.1	0.0	0.2	0.3	1.1
	30	0.0	84.2	1.3	0.2	0.1	0.2	0.9	0.4	2.5	0.1	0.1	0.0	0.1	0.1	0.1
	40	0.0	85.5	1.1	0.1	0.1	0.1	0.9	0.5	1.7	0.0	0.0	0.0	0.1	0.0	0.1
	50	0.0	81.8	1.6	0.2	0.1	0.1	1.2	0.6	1.3	0.1	0.0	0.0	0.1	0.0	0.1
	60	0.0	58.5	2.1	0.2	0.1	0.1	1.6	1.1	0.8	0.1	0.0	0.0	0.1	0.0	0.2

Table 18*. Triplicate reef Fe enrichment factors (EF) of surface sediment samples (0-5cm) for 1N, 2N, 3N, 1S, 2S, and 3S locations. The color of the value indicates the following: depletion to mineral enrichment (green), moderate enrichment (yellow), significant enrichment (orange), very high enrichment (red), and extremely high enrichment (dark red).*

	depth (cm)	**Al**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Fe**	**Hg**	**Mn**	**Mo**	**Ni**	**Pb**	**Se**	**Sn**	**V**	**Zn**
1N-1	0-5	0.068	164.3	14.66	0.56	7.134	0.743		2.495	0.734	4.651	0.753	2.156	0.081	0.599	4.9	1.4
1N-2	0-5	0.051	149.9	13.96	0.565	5.984	0.667		1.814	0.775	3.798	0.72	1.866	0.074	0.507	4.519	1.188
1N-3	0-5	0.065	172.5	14.04	0.514	7.063	0.663		2.341	0.815	4.588	0.756	1.966	0.081	0.536	5.103	1.31

	depth (cm)	**Al**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Fe**	**Hg**	**Mn**	**Mo**	**Ni**	**Pb**	**Se**	**Sn**	**V**	**Zn**
2N-1	0-5	0.072	162.2	20.02	0.636	7.396	0.797		1.978	0.912	4.198	0.858	2.089	0.101	0.501	4.926	1.257
2N-2	0-5	0.074	169.3	15.83	0.606	7.964	0.598		2.095	0.872	4.502	0.842	1.839	0.087	0.475	5.029	1.307
2N-3	0-5	0.061	146	15.18	0.571	6.862	0.655		4.03	0.794	3.988	0.75	2.217	0.082	0.541	4.831	1.22

	depth (cm)	**Al**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Fe**	**Hg**	**Mn**	**Mo**	**Ni**	**Pb**	**Se**	**Sn**	**V**	**Zn**
3N-1	0-5	0.089	167.6	42.11	1.211	12.4	0.986		6.699	1.286	8.503	1.608	2.706	0.219	0.789	4.841	1.283
3N-2	0-5	0.094	175.3	32.22	1.194	12.99	1.033		4.186	1.301	7.157	1.668	2.586	0.237	0.835	4.956	1.189
3N-3	0-5	0.095	173.3	29.8	1.035	13.04	0.832		4.641	1.213	6.997	1.634	2.374	0.194	0.747	4.81	1.15

	depth (cm)	**Al**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Fe**	**Hg**	**Mn**	**Mo**	**Ni**	**Pb**	**Se**	**Sn**	**V**	**Zn**
1S-1	0-5	0.079	134.8	18.38	0.879	8.75	1.147		2.681	0.901	4.51	0.917	2.923	0.1	0.635	5.098	3.174
1S-2	0-5	0.089	142.8	14.54	0.676	7.195	0.922		2.159	0.807	3.472	0.817	2.345	0.087	0.509	4.62	1.905
1S-3	0-5	0.097	144.4	17.8	0.717	7.265	0.977		2.826	0.814	3.953	0.824	2.519	0.102	0.634	4.877	2.074

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
2S-1	0-5	0.069	166.7	24.21	0.807	9.385	0.628		2.661	1.064	4.088	1.049	1.989	0.12	0.491	5.079	1.018
2S-2	0-5	0.062	161.1	23.46	0.796	9.27	0.599		2.661	0.979	4.842	0.965	1.989	0.124	0.471	5.036	0.982
2S-3	0-5	0.053	154.4	23.92	0.697	7.634	0.475		2.279	0.995	4.083	0.803	1.719	0.091	0.42	4.755	0.871

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
3S-1	0-5	0.076	175.3	38.33	1.354	13.49	0.959		5.397	1.436	9.542	1.558	2.97	0.293	0.989	4.825	1.551
3S-2	0-5	0.068	158.2	25.51	1.028	12.06	0.736		3.439	1.061	6.478	1.377	2.406	0.178	0.66	4.481	1.329
3S-3	0-5	0.089	168.4	30.66	1.317	13.28	0.895		4.662	1.3	7.374	1.646	2.896	0.233	0.884	4.827	1.531

3.7 Enrichment Factor Based on Al

The enrichment factor (EF) is used to determine how much the presence of an element (heavy metal) in sediment has increased, due to human activity, relative to the average natural abundance based off the Al in the upper continental crust.

Table 19 below shows the EFs in the port and control sediment cores, and Table 20 in the surface sediment of the six coral reef locations.

Preliminary results show overall high enrichment in all heavy metals except for Mn. The overall degree of enrichment for all the metals and all the results is extremely high, so using EF based on Al to determine contamination is not recommended as the sole source of contaminant information. This is due to the much lower Al concentrations found in the sediment cores compared to the upper continental crust value for Al (81,300 µg/g).

***Table 19**. Port enrichment factors (EF) based on Al by sediment core depth (cm) for Dania Cutoff Canal (DCC), Park Education Center (PEC), Park Headquarters (PHQ), Port Everglades Inlet (PEI), South Turning Basin (STB), and West Lake (WL). The color of the value indicates the following: depletion to mineral enrichment (green), moderate enrichment (yellow), significant enrichment (orange), very high enrichment (red), and extremely high enrichment (dark red).*

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
DCC-1	10		159.4	26.38	1.228	11.76	7.851	2.823	11.34	0.396	106.1	6.412	3.215	0.659	1.658	7.257	13.85
	20		306.8	41.82	1.152	15.26	11.6	3.239	11.55	0.491	222.8	8.97	4.871	0.759	1.723	10.53	6.199
	30		452.3	108.6	2.34	13.44	40.71	4.317	14.62	0.81	510.8	12.11	6.58	1.077	4.381	22.71	24.3
	40		193.5	119.2	1.321	12.17	3.617	6.363	11.43	0.384	612.7	8.688	1.814	0.726	1.688	13.3	2.057
	50		145	91.66	1.173	14.29	6.368	6.225	6.811	1.009	368.6	8.102	2.374	0.696	1.01	7.509	2.062
	60		154.5	74.49	1.057	16.11	4.534	7.473	6.126	0.971	271.4	8.534	2.197	0.83	0.902	6.554	1.223
	70		188.4	47.01	0.964	16.54	4.343	8.566	5.836	1.002	200.9	8.902	2.253	0.889	0.874	4.71	1.164
	80		273.6	43.05	1.081	16.68	4.493	10.25	6.622	1.564	238.9	8.949	2.216	0.894	0.981	6.133	1.357
	90		292.5	30.68	1.145	15.4	4.116	9.845	6.497	1.923	264.3	8.598	2.227	0.913	0.976	7.091	1.189
	100		1191	51.54	5.223	11.72	3.006	21.09	21.81	26.28	492.7	8.869	3.486	1.389	3.203	6.2	3.904
	110		6545	281.7	27.15	17.79	14.73	101.7	119.8	154.7	956.2	21.55	3.605	5.461	17.57	5.037	21.39
	120		8462	396.1	40.81	25.24	20.98	121.5	163.9	234.3	619.6	31.63	4.458	7.091	24.99	5.595	30.44
	130		4685	260.1	18.67	16.38	13.5	66.69	107.7	150.4	134.6	14.78	3.273	3.018	16.16	6.534	19.7
	140		5153	204.5	18.61	12.78	10.53	60.92	83.49	121.2	145.8	19.52	4.294	3.195	12.6	5.43	15.4

	150		182.8	6.514	1.07	3.015	0.338	2.659	2.738	4.193	4.5563	1.69	1.211	0.169	0.41	1.17	0.497
	160		74.05	1.688	0.591	3.039	0.34	1.55	1.083	0.6	4.7898	1.071	1.399	0.066	0.412	1.253	0.483
DCC-2	10		297.4	61.95	2.613	15.39	37.06	5.279	26.12	2.145	137.3	7.655	9.965	1.022	3.863	10.34	19.15
	20		444.4	70.08	1.707	12.81	20.08	5.13	23.14	0.792	390.5	8.685	5.176	1.05	2.571	14.05	12.3
	30		414.1	71.7	1.432	13.16	8.451	4.456	14.49	0.472	679.5	9.533	2.554	0.907	2.128	16.23	9.627
	40		224.7	125.5	1.251	12.24	5.75	6.107	11.57	0.463	534.1	9.002	2.32	0.734	1.713	11.27	2.366
	50		130.8	95.39	1.172	14.22	4.555	6.283	7.213	1	341.1	8.335	2.071	0.685	1.072	7.395	1.304
	60		478.6	59.67	1.286	17.05	4.726	12.31	8.172	1.886	323.3	9.723	2.294	1.027	1.042	9.073	1.51
	70		3086	121.1	10.62	13.39	6.29	47	49.45	61.32	1121.6	10.83	1.706	2.765	7.499	8.753	9.152
	80		5072	213.3	19.69	13.52	11.15	68.06	90.74	119.0	832.4	13.56	2.352	4.39	13.41	4.046	16.28
	90		6511	307.3	25.39	19.44	15.95	99.94	127.2	160.1	406.9	19.17	3.418	5.518	19.24	2.021	23.38
	100		9171	402.7	35.07	25.35	20.75	127.0	164.4	218.0	524.0	27.4	4.454	5.119	25.01	2.857	30.49
DCC-3	10		276.1	115.6	1.586	11.48	15.47	6.638	16.81	0.822	479.1	9.911	3.517	0.81	1.988	11.57	8.449
	20		144.8	91.88	1.137	13.55	5.329	6.941	7.401	0.874	304.2	8.472	2.48	0.7	0.882	7.378	1.792
	30		708.2	69.53	1.415	14.38	6.256	10.62	7.259	1.208	343.8	8.904	2.385	0.945	0.859	7.64	2.177
	40		448.5	39.36	1.454	15.94	4.527	13.39	8.635	3.119	308.2	8.465	2.264	0.874	1.02	7.545	1.244
	50		771.6	39.68	3.482	11.75	3.408	15.52	21.22	13.7	394.5	9.028	2.009	1.133	2.475	8.179	3.026
	60		1847	69.64	7.187	11.59	6.825	28.59	39.73	34.8	689.2	11.04	2.479	1.999	4.343	9.602	5.287
	70		7058	356.7	30.36	22.74	18.78	102.7	187.3	186.4	1325	20.97	3.995	6.911	22.52	9.472	27.43
	80		12781	543.4	51.66	33.93	27.69	171.5	277.4	426.0	1008.3	31.06	5.947	7.455	33.57	8.757	41
	90		3590	179.7	15.74	11.23	9.321	45.47	91.7	95.8	225.1	8.855	2.33	2.351	11.11	5.368	13.49
	100		127.9	5.089	0.807	3.238	0.284	2.469	2.676	2.569	6.7901	1.232	1.171	0.125	0.404	1.189	0.389
	110		36.59	0.978	0.526	2.796	0.161	1.295	0.514	0.276	2.2067	0.894	1.259	0.032	0.412	0.929	0.26
	depth (cm)	**Al**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Fe**	**Hg**	**Mn**	**Mo**	**Ni**	**Pb**	**Se**	**Sn**	**V**	**Zn**
PEC-1	10		110.4	41.8	2.0	17.2	65.0	3.3	38.8	1.3	59.5	10.9	16.5	0.4	4.0	14.6	22.5
	20		98.1	47.4	2.2	16.0	21.2	3.0	34.5	1.0	63.8	18.5	14.4	0.3	2.9	27.5	9.1

	30	151.5	83.4	3.5	18.9	33.5	4.9	85.5	1.1	90.4	35.5	20.8	0.4	4.4	47.3	13.7
	40	82.1	41.0	2.1	14.8	12.9	3.0	32.8	0.9	48.6	15.5	9.7	0.2	2.4	19.4	5.9
	50	48.7	14.3	1.6	13.1	2.3	1.9	7.1	0.7	31.3	4.2	2.9	0.1	0.8	5.3	1.5
	60	34.0	8.3	1.1	9.1	1.1	1.3	3.8	0.5	20.5	2.7	2.0	0.1	0.6	3.5	0.7
	70	39.5	9.2	1.1	9.3	2.2	1.6	5.5	0.6	25.6	3.3	3.2	0.1	1.0	3.1	1.4
	80	29.2	8.9	1.1	9.8	1.8	1.2	5.7	0.5	18.5	2.9	2.4	0.1	0.7	3.1	1.0
	90	29.1	8.8	1.1	9.6	1.3	1.3	5.6	0.5	19.2	3.0	2.3	0.1	0.6	3.3	1.0
	100	38.4	9.5	1.2	9.7	1.5	1.5	5.3	0.6	27.7	3.1	2.5	0.1	0.7	3.5	0.9
	110	35.4	8.0	1.2	8.1	1.2	1.3	5.1	0.6	19.8	2.8	2.4	0.1	0.6	3.0	0.9
	120	238.7	86.0	2.0	11.3	21.6	5.4	99.3	1.2	80.3	11.8	23.6	0.5	4.6	18.2	11.4
	130	436.8	82.3	1.8	18.5	7.3	9.6	40.2	1.9	299.9	9.3	6.5	0.9	1.6	12.5	3.4
	140	558.5	80.7	1.8	23.7	5.1	12.0	24.7	2.1	344.8	11.5	3.2	1.1	1.7	15.3	2.0
	150	732.5	83.7	2.7	20.8	4.6	17.1	42.7	2.0	649.0	12.8	5.9	1.5	3.0	18.7	3.6
	160	41.3	8.4	1.1	3.8	0.8	3.3	6.3	0.3	101.3	2.3	1.7	0.2	0.4	2.2	6.7
	170	318.4	36.8	2.9	7.4	3.1	16.6	33.4	0.6	1050.0	7.2	1.8	1.2	2.3	8.1	2.8
	180	81.2	15.7	1.5	4.6	2.8	4.2	14.3	0.3	213.1	3.0	1.5	0.4	1.0	3.4	1.2
	190	26.4	9.0	0.7	3.6	1.1	1.9	6.0	0.3	70.5	1.8	1.4	0.2	0.4	1.8	0.5
	200	28.6	6.2	0.8	3.9	0.8	2.7	9.6	0.3	57.6	2.2	1.7	0.2	0.4	2.3	0.4
	210	30.2	8.6	2.0	3.6	0.3	2.4	7.8	0.6	59.3	2.3	2.2	0.1	0.4	2.0	0.5
	220	26.7	5.0	1.0	3.3	0.2	3.1	3.4	0.3	54.9	2.2	2.0	0.1	0.4	1.6	0.4
	230	27.7	4.7	0.5	3.2	0.2	3.8	5.5	0.3	43.9	1.9	1.8	0.1	0.4	1.8	0.4
PEC-2	10	124.9	46.3	2.3	16.7	54.8	3.0	22.4	1.3	84.2	9.7	15.7	0.3	3.5	13.4	21.6
	20	102.0	44.8	1.8	13.5	28.5	2.7	30.8	0.9	53.3	14.0	12.5	0.3	2.8	19.9	11.8
	30	165.5	73.7	2.9	16.6	25.9	4.1	60.8	1.1	87.1	28.8	15.8	0.3	3.6	39.9	11.3
	40	131.1	45.8	2.4	15.6	23.5	4.0	53.9	1.0	51.9	19.0	12.8	0.3	3.0	23.5	9.3
	50	39.6	10.0	1.3	11.8	1.5	1.6	4.6	0.7	22.0	3.8	2.1	0.1	0.5	4.3	1.0
	60	36.3	8.1	1.1	9.6	1.2	1.4	3.0	0.5	21.6	3.0	2.0	0.1	0.5	3.6	0.7
	70	29.8	7.2	0.9	7.9	1.1	1.2	2.5	0.5	16.4	2.6	1.9	0.1	0.6	2.5	0.8
	80	29.8	9.5	1.1	9.7	1.7	1.3	3.8	0.5	18.7	3.0	2.3	0.1	0.7	3.0	0.9
	90	30.6	9.1	1.2	9.4	1.4	1.3	3.7	0.6	21.7	3.2	2.1	0.1	0.6	3.4	0.8

	100	170.8	53.8	1.7	11.0	23.9	4.3	104.6	1.1	37.5	14.4	19.0	0.4	3.9	15.2	8.9
	110	667.2	83.7	1.9	19.5	8.3	12.4	40.5	1.8	464.3	11.1	6.5	1.0	2.0	20.7	3.4
	120	437.1	65.2	1.6	17.3	3.9	8.2	9.4	1.7	313.6	9.3	2.9	0.8	1.7	14.2	2.2
	130	1688.8	63.7	5.0	18.9	4.1	32.0	25.8	3.5	1508.2	9.8	3.5	2.1	3.4	17.4	4.1
	140	3476.8	96.2	10.9	20.9	5.0	45.4	49.1	16.7	2771.9	12.7	2.6	3.3	6.0	27.4	7.3
	150	1693.3	64.2	7.7	14.6	4.8	29.1	21.5	8.7	1997.2	15.5	2.2	2.3	3.6	27.5	4.3
	160	3749.7	281.7	39.3	17.5	14.5	63.7	95.9	47.7	1830.5	20.4	3.1	5.1	17.4	12.9	21.2
	170	115.6	12.1	2.8	3.5	0.7	3.6	7.0	0.8	100.5	1.8	1.4	0.3	0.8	1.6	0.9
	180	12.5	3.5	0.4	3.0	0.3	0.8	1.6	0.2	8.3	0.7	1.5	0.1	0.4	0.9	0.3
	190	16.9	3.5	0.9	3.0	0.4	0.8	1.2	0.2	7.8	0.8	1.6	0.1	0.4	1.0	0.3
	200	12.3	2.7	0.7	3.0	0.4	0.7	1.1	0.2	4.6	0.9	1.5	0.1	0.4	1.2	0.2
	210	14.1	3.1	0.6	3.7	1.3	0.9	2.6	0.4	9.5	1.1	1.6	0.1	0.4	2.9	0.4

	10	78.7	52.9	1.7	21.8	31.9	2.6	26.4	1.5	42.8	11.6	11.0	0.2	1.8	12.8	13.5
	20	57.1	31.0	1.6	13.4	15.5	2.3	19.1	0.9	32.9	14.5	10.6	0.2	1.7	22.0	5.7
	30	118.6	91.7	2.9	20.7	31.0	5.1	65.1	1.3	82.9	35.8	20.5	0.3	3.7	48.7	12.8
	40	64.9	26.6	1.8	18.6	6.0	2.8	6.2	0.9	49.6	9.5	5.2	0.1	0.9	12.2	3.8
	50	37.9	14.6	1.1	13.8	1.3	1.7	9.8	0.7	25.0	3.8	2.1	0.1	0.4	4.7	1.0
	60	45.6	10.9	1.2	12.6	1.4	2.0	6.9	0.7	29.7	3.7	2.2	0.1	0.6	4.5	1.0
	70	37.9	9.2	1.0	9.7	1.5	1.7	5.1	0.6	25.8	3.4	2.7	0.1	0.7	3.2	1.2
	80	38.4	10.5	1.0	9.9	2.3	1.7	11.4	0.6	27.2	3.5	3.1	0.1	0.9	3.3	1.7
	90	26.8	9.8	0.9	9.8	1.3	1.3	3.7	0.5	23.6	2.9	2.0	0.1	0.5	3.1	0.8
PEC-3	100	30.6	9.9	1.0	10.4	1.4	1.5	3.2	0.5	23.7	3.4	2.4	0.1	0.6	3.5	0.9
	110	119.0	32.6	1.5	11.5	12.6	3.6	54.6	1.1	43.8	10.6	10.7	0.2	2.3	10.6	5.4
	120	516.7	85.5	3.0	19.1	17.9	13.6	109.1	1.7	302.6	14.5	13.0	1.1	3.5	21.3	9.4
	130	1242.9	62.2	5.3	16.9	8.2	28.7	85.4	8.1	1420.4	11.1	6.6	1.6	2.4	18.9	3.0
	140	3132.7	124.3	13.4	17.0	12.3	42.0	137.3	28.5	1806.7	13.6	9.7	2.9	7.7	20.0	9.4
	150	6013.4	211.9	30.3	17.6	13.1	81.3	377.1	68.8	1677.4	17.4	7.8	3.9	13.4	16.5	16.2
	160	2666.5	148.6	50.4	9.9	7.7	41.0	81.5	24.3	1423.1	12.9	1.6	3.8	9.2	9.1	11.2
	170	29.9	4.9	0.6	3.8	0.7	1.8	4.7	0.2	19.8	1.2	1.6	0.2	0.4	1.3	0.4
	180	16.3	3.0	1.2	3.7	0.5	1.1	2.0	0.2	6.4	1.0	1.7	0.1	0.4	1.2	0.3

	190		13.7	1.9	0.8	3.6	0.4	0.9	3.2	0.2	3.7	1.2	1.7	0.1	0.4	1.2	0.3

Site	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
	10		136.7	69.1	3.0	23.3	33.3	3.0	61.4	2.8	56.6	6.0	23.7	0.5	3.9	11.1	35.8
	20		254.4	93.4	3.3	22.9	36.3	5.4	59.9	2.5	163.8	7.9	38.4	0.6	4.3	14.1	49.7
	30		544.2	109.1	2.5	15.1	18.3	14.4	30.6	1.1	919.7	10.3	9.3	0.9	2.7	17.3	68.2
	40		588.3	60.5	1.9	21.6	26.0	18.7	35.5	1.0	1161.4	12.4	10.9	1.1	2.9	18.6	21.0
	50		416.1	101.0	1.8	20.1	33.3	10.4	40.2	0.5	925.2	13.7	8.0	1.1	2.4	28.7	26.0
	60		300.1	54.4	1.1	18.0	3.4	9.0	17.5	0.3	881.5	14.9	4.1	1.3	1.6	14.8	1.9
	70		634.8	100.8	1.4	22.2	4.5	16.6	27.1	0.7	1673.9	11.4	2.2	1.3	2.4	53.5	2.9
	80		479.8	125.2	1.2	22.6	3.0	15.0	25.9	0.4	1796.6	14.4	3.2	1.4	2.3	30.5	2.8
	90		593.1	152.1	1.4	21.9	3.5	16.0	28.8	0.6	2140.5	13.0	2.8	1.3	2.4	36.0	2.9
	100		553.4	83.0	1.3	21.9	4.4	11.6	26.7	0.7	2018.2	10.4	3.8	1.0	2.4	21.9	2.9
PHQ-1	110		762.9	86.7	1.5	23.2	4.3	19.4	31.9	1.2	1420.0	9.7	7.1	1.1	2.8	14.3	3.4
	120		955.8	99.9	1.5	21.9	4.5	15.6	36.4	1.1	2051.4	12.3	4.2	1.1	3.2	16.0	4.0
	130		876.7	109.9	1.4	24.4	3.2	13.5	22.4	1.2	1247.3	9.1	3.7	0.8	2.1	31.9	2.5
	140		721.8	112.5	1.6	23.4	4.4	14.5	24.2	1.4	799.1	11.4	3.9	1.1	2.2	18.2	2.6
	150		947.6	136.3	1.7	25.0	4.6	18.7	21.3	1.8	1084.0	12.7	3.7	1.1	1.9	15.6	2.3
	160		1164.0	114.2	1.6	27.1	5.3	22.7	20.5	1.9	1086.4	12.4	4.0	1.2	1.8	16.4	2.2
	170		971.7	86.0	1.6	26.1	5.1	19.7	25.1	1.8	722.1	11.6	4.4	1.1	2.3	16.4	2.8
	180		923.7	81.2	2.2	25.7	4.1	17.9	35.1	2.4	876.8	10.8	3.7	1.4	3.1	19.8	3.7
	190		1132.4	71.3	4.1	28.6	3.7	28.0	49.8	3.4	1916.8	11.9	2.1	2.1	4.4	35.1	5.4
	200		1114.7	110.6	12.5	28.8	5.7	23.2	77.3	3.2	1649.3	13.8	2.2	3.0	6.9	20.8	8.4
	210		1226.4	139.2	16.4	28.6	7.2	23.7	98.0	3.7	1515.3	15.9	1.9	3.8	8.7	19.4	10.6
	10		232.2	86.0	5.3	36.2	44.8	4.4	57.0	4.5	28.6	8.0	43.4	0.7	5.5	15.2	47.0
	20		947.7	67.8	1.6	13.4	14.9	25.0	36.8	1.2	1517.6	9.5	6.6	1.0	1.7	15.6	7.5
PHQ-2	30		504.5	62.2	1.7	13.7	3.1	21.7	24.2	0.5	1369.8	12.3	3.0	1.2	1.6	16.5	2.0
	40		488.7	72.1	1.9	17.4	10.8	19.2	25.7	1.1	1048.5	10.7	7.1	0.9	2.3	18.5	7.5

	50	275.8	60.3	1.2	19.1	3.6	9.0	21.4	0.4	941.4	11.3	2.9	1.2	1.9	21.6	2.3
	60	200.8	38.2	0.9	17.3	2.1	5.4	21.3	0.2	770.1	11.5	2.7	0.9	1.9	17.2	2.3
	70	333.8	87.8	1.0	21.5	2.4	11.5	29.0	0.3	1383.5	16.6	3.6	1.3	2.6	24.4	3.1
	80	446.8	139.0	1.4	22.0	9.9	12.7	26.9	0.4	1904.3	12.9	4.1	1.1	2.4	46.0	4.8
	90	339.6	76.6	0.9	18.1	5.4	10.3	18.1	0.7	1450.0	10.1	2.9	0.9	1.6	18.2	2.0
	100	330.1	55.2	1.1	23.3	4.1	7.8	12.3	0.5	1043.3	9.5	3.6	0.9	1.9	16.6	2.3
	110	619.4	79.5	1.5	19.5	4.1	12.5	16.8	1.0	874.3	10.8	4.1	1.2	2.6	11.8	3.1
	120	637.4	82.5	1.5	18.0	3.5	9.8	17.3	1.1	811.6	9.8	4.4	1.0	3.4	14.2	4.1
	130	619.4	96.3	1.5	21.1	3.4	12.0	13.2	1.0	709.0	9.3	3.9	0.9	2.4	15.5	2.9
	140	740.4	83.7	1.6	22.0	3.2	11.9	17.1	1.4	763.8	9.4	3.9	1.0	2.9	14.0	3.6
	150	695.6	71.9	1.4	21.9	4.0	13.3	6.4	1.6	487.8	10.1	3.4	0.9	1.3	14.3	3.4
	160	750.0	74.3	1.4	25.5	3.9	14.7	10.8	1.7	505.4	10.9	3.1	1.1	2.1	20.2	2.6
	170	729.2	59.0	1.6	18.9	2.6	13.5	11.2	1.7	434.5	9.7	3.6	0.9	2.2	10.8	2.7
	180	734.6	68.2	2.2	23.6	3.4	14.2	13.9	2.0	690.0	10.0	3.0	1.3	2.7	21.0	3.3
	190	1365.6	113.7	8.7	28.6	5.9	29.7	39.8	5.9	1740.6	13.4	1.3	4.0	7.1	21.2	8.7
	200	1498.0	212.3	14.9	28.4	11.0	25.1	70.0	19.2	1634.5	16.8	2.3	3.9	13.2	21.1	16.1
	210	2553.7	292.5	38.9	32.8	15.2	29.9	97.7	33.6	1351.5	22.5	3.3	6.4	18.4	19.7	22.3
	220	2344.0	276.5	41.9	41.4	14.2	35.3	91.7	31.0	1569.7	28.0	3.0	6.3	17.1	25.4	20.9
	10	407.9	65.6	2.7	17.8	68.2	7.2	20.4	2.1	247.7	11.5	25.3	0.8	8.3	20.7	35.2
	20	505.4	74.2	2.5	14.0	9.7	20.7	36.4	0.7	1138.9	15.8	5.6	1.4	1.4	17.5	4.2
	30	416.0	44.4	1.5	15.8	3.6	19.3	11.8	0.6	1092.4	11.3	1.9	1.3	2.2	22.3	2.7
	40	800.0	101.3	2.0	17.3	8.8	38.1	24.0	1.9	2048.1	12.7	2.8	1.6	2.3	28.6	4.1
	50	423.2	102.3	1.4	18.1	11.7	16.6	9.7	1.5	1066.7	12.8	3.0	1.3	1.8	24.3	9.2
	60	373.3	77.0	1.3	18.0	5.7	8.5	13.0	0.5	1390.9	13.3	3.3	1.3	2.4	21.1	3.1
PHQ-3	70	321.1	114.1	1.0	20.5	2.3	15.3	11.0	0.4	1581.8	13.1	2.9	1.4	2.0	28.9	2.5
	80	185.5	52.1	0.9	19.1	2.5	6.7	7.4	0.3	1036.8	9.8	2.8	1.0	1.4	17.0	1.7
	90	290.3	62.4	1.1	18.4	4.1	8.2	9.8	0.5	1236.3	9.8	3.2	1.1	1.8	13.6	2.2
	100	753.8	82.3	1.5	19.8	4.1	11.6	13.7	0.9	1195.9	11.7	4.1	1.1	2.6	14.1	3.2
	110	528.8	65.2	1.2	19.9	4.4	11.5	12.6	0.7	1292.6	10.1	3.6	1.0	1.8	14.0	2.2
	120	775.3	87.9	1.6	20.6	3.4	11.6	22.4	1.1	1148.6	11.8	4.3	1.2	4.2	17.3	5.1

130		881.2	86.9	1.4	19.1	3.3	13.4	20.3	1.7	793.5	10.8	4.3	1.2	3.2	11.5	3.9
140		685.7	80.3	1.3	21.2	3.4	12.5	10.8	1.7	585.0	9.7	3.3	1.0	2.1	13.7	2.5
150		694.7	80.7	1.5	25.8	4.1	13.9	13.1	1.6	542.0	11.0	3.2	1.1	1.3	17.7	1.6
160		726.8	56.3	1.4	25.4	4.3	14.7	9.6	1.8	431.7	9.7	3.1	0.9	1.9	12.3	2.3
170		899.2	62.0	2.5	21.8	2.9	15.7	16.2	2.4	709.2	10.7	3.1	1.3	3.2	19.9	3.9
180		1009.8	66.8	5.9	23.0	3.5	21.1	22.2	3.8	1015.2	10.7	2.1	2.2	4.2	23.6	5.1
190		829.8	64.1	5.2	20.4	4.7	16.9	21.0	4.4	942.0	22.3	2.8	2.3	4.0	18.5	4.9
200		2029.8	195.0	82.6	27.1	10.1	19.3	64.1	19.0	1088.3	18.3	2.2	5.1	12.2	18.6	14.8
210		2567.4	200.1	90.9	36.0	10.3	26.7	100.3	40.0	1395.4	28.5	2.2	5.5	12.4	23.0	15.1
220		1881.8	239.2	97.7	35.6	31.4	22.4	107.8	12.3	1427.1	49.3	2.6	6.9	14.9	17.4	18.2

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
PEI-1	10		702.3	85.7	20.8	34.4	9.9	5.7	55.7	6.1	22.9	14.4	17.3	0.7	4.8	17.9	18.9
	20		933.8	99.2	6.3	42.9	10.1	7.3	73.6	6.8	23.6	7.1	18.3	0.9	6.2	20.4	16.5
	30		952.0	94.6	6.9	48.6	9.6	7.8	70.2	8.4	21.6	7.2	20.3	0.9	6.0	22.0	18.0
	40		892.7	102.0	6.8	49.4	9.9	7.6	72.5	9.2	19.7	7.5	19.6	0.9	6.1	20.4	18.3
PEI-2	10		986.4	103.1	7.2	44.6	6.5	8.4	68.4	8.6	19.2	7.8	17.6	0.9	5.8	21.0	15.7
	20		1228.8	108.0	8.6	46.6	7.8	9.5	81.2	6.5	23.0	8.1	17.3	1.0	6.7	24.6	18.0
	30		989.9	99.4	7.3	43.4	5.8	8.0	71.0	9.3	26.3	6.3	14.8	0.9	6.1	21.6	14.6
	40		1025.8	117.2	7.4	47.1	6.8	7.4	71.8	9.0	26.9	8.2	17.2	0.9	6.3	21.0	16.4
	50		1015.7	122.9	9.0	44.2	7.2	8.1	87.8	8.9	20.5	8.0	17.5	1.1	7.6	21.1	17.6
PEI-3	7		1161.4	130.4	8.9	55.1	8.4	9.6	102.8	8.4	31.4	8.0	19.7	1.2	8.0	24.7	20.0
	14		1217.5	136.2	10.0	52.5	8.0	9.8	101.1	9.4	29.1	8.7	20.6	1.3	8.7	24.8	19.1
	21		1343.9	194.7	12.4	55.5	10.0	9.5	155.5	14.9	38.7	8.8	21.5	1.8	11.9	27.8	22.6

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
STB-1	10		386.2	54.1	2.1	12.2	8.6	14.7	27.3	0.4	322.1	8.2	3.1	1.0	2.1	7.4	3.5
	20		735.4	56.0	2.2	11.7	5.3	22.7	21.2	0.4	499.9	7.0	2.9	0.9	2.0	10.0	2.6
	30		819.6	76.9	3.1	12.5	4.9	35.6	32.0	1.1	885.7	8.2	3.1	1.2	3.4	14.5	4.1
	40		1276.9	129.6	9.5	15.4	20.4	48.1	40.1	3.2	3636.5	11.1	4.6	1.8	7.3	20.8	9.4
	50		182.5	37.0	1.6	9.0	1.9	8.8	10.0	0.6	502.7	6.4	1.6	0.9	2.3	7.2	2.8
	60		326.8	61.6	1.7	8.5	3.2	14.5	16.2	0.7	601.8	8.0	1.8	1.5	3.8	7.5	4.7
	70		249.3	53.0	3.6	8.0	2.8	12.4	14.4	0.5	508.3	7.0	1.6	1.2	3.3	10.6	4.0
	80		169.5	28.2	1.9	6.6	1.5	6.0	21.2	0.4	432.1	7.0	1.6	0.8	1.8	7.0	2.1
	90		355.3	53.9	6.6	8.9	2.8	19.4	19.3	0.6	969.6	12.1	2.7	1.5	3.4	21.2	4.1
	100		241.7	40.2	3.6	8.5	2.1	10.0	10.6	0.7	763.0	8.5	2.3	1.1	2.5	12.7	3.1
	110		202.0	23.6	1.5	9.9	1.2	5.0	9.0	0.4	500.1	6.5	2.3	0.7	1.4	14.1	1.7
	120		442.2	68.1	3.1	13.4	3.2	15.9	28.5	0.9	1626.0	10.5	2.9	1.3	3.1	34.8	3.8
	130		735.4	28.9	2.3	9.4	8.5	17.4	24.5	3.0	657.7	6.7	2.9	0.9	1.7	12.1	2.7
STB-2	10		142.5	39.3	1.8	11.2	6.5	5.9	39.5	0.4	338.8	6.5	4.0	1.0	2.5	7.4	3.3
	20		165.7	36.5	1.2	11.8	3.8	9.3	33.2	0.3	192.1	6.8	3.0	1.1	2.3	6.9	2.8
	30		278.9	37.3	2.0	13.6	2.7	9.8	22.1	0.3	343.7	9.3	3.7	1.3	2.1	8.1	2.6
	40		432.1	44.8	2.0	13.6	2.3	19.7	22.9	0.4	561.5	8.1	2.7	1.2	2.8	9.9	3.4
	50		599.8	79.6	3.3	13.1	4.1	29.9	96.5	0.8	870.8	7.8	3.1	1.4	5.0	13.8	6.0
	60		702.6	99.9	6.1	9.1	5.2	35.1	83.1	2.8	2649.8	6.0	2.0	1.6	6.2	13.4	7.6
	70		468.2	96.0	3.9	10.2	5.0	11.9	51.8	1.6	1234.6	7.0	2.2	1.4	6.0	10.3	7.3
	80		435.2	39.5	2.7	9.0	2.2	18.8	28.6	1.4	1033.6	6.0	2.4	1.2	2.2	6.6	2.6
	90		180.2	42.3	1.8	8.1	2.2	9.6	24.2	0.6	395.3	7.0	2.0	1.0	2.6	6.5	3.2
	100		381.1	68.0	3.6	11.0	3.5	20.2	35.0	1.1	807.8	8.1	1.9	1.7	4.2	17.7	5.2
	110		285.1	40.8	4.1	7.8	2.1	17.4	51.9	0.9	787.1	6.8	2.2	1.4	2.5	10.8	3.1
	120		242.0	50.7	3.1	8.8	2.6	8.6	34.9	0.6	639.6	9.2	1.9	1.3	3.2	10.1	3.8
	130		237.4	51.0	3.3	8.2	2.6	6.3	31.5	0.5	619.4	8.8	1.8	1.1	3.2	15.0	3.9
	140		203.9	39.1	4.9	8.3	2.0	9.5	21.5	0.8	589.8	10.1	2.1	1.1	2.4	14.1	3.0
	150		87.3	16.3	1.2	7.7	0.8	2.2	8.8	0.4	201.4	5.8	1.9	0.5	1.0	5.4	1.2

	160		339.8	46.1	2.9	11.1	2.5	9.4	23.5	1.1	1015.2	9.9	3.3	1.3	2.9	23.0	3.5
	170		679.9	92.1	3.6	13.1	2.6	12.8	57.6	1.1	2401.0	12.5	3.7	1.5	3.1	37.0	3.8
STB-3	10		561.7	58.5	2.0	13.6	22.0	18.4	30.1	0.5	520.1	8.9	6.1	1.0	2.3	10.3	9.8
	20		255.4	37.6	1.6	13.5	45.3	10.5	33.8	0.6	275.1	8.5	10.1	0.9	2.9	8.6	17.8
	30		599.9	72.2	1.9	12.7	2.9	23.8	55.2	0.8	712.5	7.9	2.1	1.3	3.5	12.3	4.2
	40		843.1	103.7	5.2	12.2	5.4	42.8	83.1	2.5	2012.4	7.7	2.4	2.2	6.4	16.1	7.8
	50		292.1	44.7	3.0	10.9	2.3	13.8	51.8	0.9	707.7	7.5	2.0	1.0	2.8	7.9	3.4
	60		305.7	48.1	2.4	8.2	2.5	12.7	75.6	0.8	883.9	7.8	1.9	1.4	3.0	6.7	3.6
	70		348.4	74.6	3.8	9.5	3.9	18.8	38.8	0.8	932.4	9.2	1.8	1.5	4.7	11.2	5.7
	80		249.8	36.5	3.8	7.3	1.9	13.7	31.7	0.6	687.0	6.7	2.2	1.1	2.3	12.7	2.8
	90		252.2	55.0	4.3	8.0	3.2	11.1	39.1	0.7	879.0	9.2	2.8	1.3	3.4	11.9	4.2
	100		246.5	49.0	4.2	6.9	2.5	9.6	15.3	0.6	684.0	7.6	1.7	1.3	3.0	15.8	3.7
	110		267.6	42.3	3.2	8.4	2.2	9.3	16.7	0.7	834.5	10.0	2.1	1.3	2.6	13.2	3.2
	120		143.8	24.4	1.8	8.5	1.3	5.2	11.8	0.5	499.6	7.7	1.8	0.8	1.5	7.7	1.9
	130		220.0	32.7	2.6	10.3	1.7	5.9	10.4	0.7	684.4	9.4	2.3	1.0	2.0	12.4	2.5
	140		382.2	72.7	2.4	14.0	2.6	12.9	25.3	0.6	1508.7	12.8	2.6	1.2	2.5	25.3	3.0
	150		324.4	38.8	2.0	13.2	2.1	11.6	10.3	0.6	1132.8	8.5	1.9	0.8	2.0	15.5	2.4
	160		954.0	76.5	1.9	15.6	4.3	26.1	8.1	1.0	2459.4	10.9	2.8	1.0	1.9	16.5	2.3
	170		463.6	27.9	1.5	12.7	6.4	15.7	17.2	1.1	939.9	8.4	3.0	0.7	1.7	12.7	2.1
	180		578.7	30.9	2.3	6.2	19.2	14.4	10.0	5.1	321.5	6.0	4.8	0.8	2.2	5.4	7.9
	190		17.8	1.7	0.4	3.2	0.6	1.0	0.8	0.7	1.2	1.0	1.4	0.1	0.4	1.2	0.4

	depth (cm)	**Al**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Fe**	**Hg**	**Mn**	**Mo**	**Ni**	**Pb**	**Se**	**Sn**	**V**	**Zn**
WL-1	10		874.7	64.6	2.1	10.8	108.9	17.6	68.6	4.5	42.5	7.6	32.4	0.5	8.2	6.7	72.4
	20		1295.8	53.3	4.0	7.7	34.9	33.6	59.9	10.6	133.8	7.3	19.6	1.4	4.9	8.0	26.6
	30		3436.6	99.2	12.9	7.1	25.3	58.1	52.2	39.3	221.9	8.3	19.7	2.2	6.2	6.7	19.2
	40		35480.9	276.5	34.3	17.2	14.2	344.8	141.1	100.9	602.2	8.4	3.0	5.5	17.0	2.5	20.7
	50		19097.9	327.8	27.0	20.7	17.1	228.5	176.6	133.4	320.1	10.1	3.6	5.5	20.4	2.5	25.0
	60		15808.3	310.2	35.0	19.4	16.0	220.6	162.9	126.1	233.9	15.1	4.6	6.7	19.1	3.4	23.4

	70	10918.9	292.0	25.5	18.5	15.4	221.0	154.2	185.8	124.3	14.4	3.3	5.5	18.3	2.0	22.2
	80	2151.3	34.9	4.5	3.0	1.8	30.3	19.0	22.8	17.4	2.8	1.2	1.1	2.2	1.1	2.7
WL-2	10	1275.6	96.4	2.9	10.8	99.9	26.0	101.8	5.9	56.4	9.2	34.9	0.8	8.1	7.8	78.5
	20	866.5	59.1	2.9	9.0	68.6	19.2	66.4	7.9	64.0	7.0	28.3	0.7	7.3	6.5	46.3
	30	7675.0	205.9	23.7	12.9	12.6	142.4	105.1	87.5	314.1	8.2	5.5	3.7	12.7	3.8	15.5
	40	1754.0	65.8	4.4	9.7	71.6	28.2	50.7	13.9	75.9	7.2	26.2	1.0	6.3	6.6	51.3
	50	862.1	67.3	2.9	11.4	94.5	16.5	72.7	5.7	47.8	8.9	33.3	0.6	8.7	7.2	62.8
	60	375.7	39.6	1.0	5.5	43.2	10.4	28.9	3.3	19.9	4.0	16.0	0.3	3.7	3.6	28.5
	70	1313.3	69.6	2.1	10.7	97.1	20.9	62.5	4.5	42.1	7.5	31.3	0.5	7.4	6.8	65.4
	80	807.9	50.0	1.3	7.2	66.6	11.0	44.3	3.5	81.8	5.4	21.5	0.3	5.0	4.8	43.0
WL-3	10	1102.8	92.2	3.0	11.0	92.1	22.1	65.3	5.6	88.1	9.0	31.6	0.7	7.1	8.0	65.6
	20	1234.4	114.0	5.9	11.2	45.1	31.1	86.5	10.6	91.5	10.9	34.2	1.0	7.0	9.7	33.9
	30	10458.7	158.4	19.1	9.9	21.9	124.2	114.9	50.9	307.8	12.8	14.0	2.9	9.7	12.7	18.2
	40	30726.9	411.7	42.8	26.0	21.5	359.4	305.6	162.0	601.5	12.7	4.5	5.0	25.8	2.1	31.3
	50	12361.4	247.4	27.5	15.4	12.6	151.2	178.3	97.0	204.0	10.8	2.7	4.6	15.2	2.7	18.5
	60	12681.4	465.3	37.3	29.2	24.0	216.8	339.3	230.2	177.2	19.9	5.1	5.4	28.9	1.5	35.2

Table 20. *Triplicate reef Al enrichment factors (EF) of surface sediment samples (0-5cm) for 1N, 2N, 3N, 1S, 2S, and 3S locations. The color of the value indicates the following: depletion to mineral enrichment (green), moderate enrichment (yellow), significant enrichment (orange), very high enrichment (red), and extremely high enrichment (dark red).*

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
1N-1	0-5		2424	216.4	8.263	105.3	10.96	14.76	36.82	10.83	68.63	11.11	31.81	1.193	8.837	72.32	20.66
1N-2	0-5		2934	273.2	11.05	117.1	13.05	19.57	35.5	15.17	74.32	14.09	36.51	1.451	9.914	88.44	23.24
1N-3	0-5		2655	216.2	7.914	108.7	10.21	15.4	36.04	12.54	70.63	11.63	30.27	1.245	8.256	78.56	20.16

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
2N-1	0-5		2253	278	8.833	102.7	11.07	13.89	27.47	12.67	58.3	11.91	29	1.397	6.951	68.41	17.45
2N-2	0-5		2304	215.4	8.247	108.3	8.13	13.6	28.5	11.86	61.24	11.45	25.02	1.18	6.467	68.4	17.78
2N-3	0-5		2389	248.4	9.347	112.2	10.71	16.36	65.92	12.98	65.23	12.27	36.27	1.334	8.851	79.03	19.95

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
3N-1	0-5		1883	473.2	13.61	139.4	11.08	11.24	75.28	14.45	95.55	18.07	30.41	2.457	8.869	54.4	14.42
3N-2	0-5		1866	343.1	12.71	138.3	11	10.65	44.57	13.86	76.21	17.76	27.54	2.518	8.891	52.77	12.66
3N-3	0-5		1824	313.8	10.89	137.3	8.755	10.53	48.86	12.77	73.66	17.2	24.99	2.043	7.865	50.64	12.11

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
1S-1	0-5		1703	232.3	11.1	110.6	14.49	12.64	33.88	11.38	56.99	11.59	36.93	1.264	8.024	64.42	40.11
1S-2	0-5		1607	163.5	7.605	80.93	10.37	11.25	24.28	9.082	39.05	9.194	26.37	0.979	5.722	51.97	21.42
1S-3	0-5		1493	183.9	7.409	75.06	10.09	10.33	29.2	8.41	40.85	8.51	26.03	1.049	6.554	50.4	21.43

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
2S-1	0-5		2411	350.2	11.67	135.8	9.08	14.47	38.49	15.4	59.13	15.18	28.77	1.732	7.103	73.47	14.72
2S-2	0-5		2619	381.5	12.94	150.7	9.732	16.26	43.27	15.92	78.73	15.7	32.34	2.018	7.661	81.89	15.96
2S-3	0-5		2910	450.9	13.14	143.9	8.955	18.85	42.96	18.75	76.98	15.14	32.4	1.708	7.926	89.65	16.43

	depth (cm)	Al	As	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Se	Sn	V	Zn
3S-1	0-5		2304	503.8	17.79	177.3	12.6	13.14	70.94	18.87	125.4	20.47	39.03	3.848	13	63.42	20.38
3S-2	0-5		2330	375.8	15.15	177.7	10.84	14.73	50.67	15.63	95.43	20.29	35.44	2.627	9.728	66.01	19.57
3S-3	0-5		1895	345.1	14.82	149.4	10.07	11.25	52.46	14.63	82.98	18.53	32.59	2.619	9.942	54.32	17.23

3.8 Abiotic Data

Water chemistry data are collected hourly during deployment at the six reef sites. The depth of each site ranged from 18-46.5 ft with generally less than 1 ft variation due to tidal range. While multiple chemistry measures are captured, the primary variables for this study are temperature, salinity, pressure, dissolved oxygen, pH, and turbidity. These variables will provide not only a measure of physical similarity and differences at the coral reef, but also provide additional explanations for the measure of biological production at the sites (e.g., coral species). The preliminary data exhibited in Table 21 indicates a relatively close correlation in these six variables among the six sites. The temperature on the benthos ranged from 27.1-29.0° C, while salinity ranged from 37.5-43.6 psu. Pressure values ranged from 6.7-20.6 psi. Dissolved oxygen ranged from 4.58-7.75 mg/L, a moderately high oxygen saturation. These values will be monitored in relation to ocean temperature, which can influence oxygen saturation. The pH values, or ocean alkalinity, remained relatively constant at 8.15-8.37, while turbidity ranged from 0-165 NTU. The nephelometric turbidity unit (NTU) is a measure of suspended particles; this is determined through the comparison of light transmission versus light scattering in the water column. Turbidity is expected to have natural fluctuations due to variations in the extent of surface and bottom currents as well as the extent of the nearshore counter current and the offshore Florida Current. Tidal change and coastal water runoff, largely influenced by precipitation, can also affect the volume and rate of various sediment grain sizes throughout the water column, as well as larger storm (wind) activity. These additional data can be acquired from local tide charts and rain gauges overseen by the South Florida Water Management District to test for their influence on turbidity. The combined use of the sediment traps with the turbidity values will allow us to measure the grain sizes being distributed prior to and during dredging events.

Table 21. *Sonde abiotic data ranges by reef site (1N, 2N, 3N, 1S, 2S, 3S), 2-9 June 2023.*

	1N	**2N**	**3N**	**1S**	**2S**	**3S**
Actual Conductivity (mS/cm)	65165-67599	61014-63052	58240-60639	59320-61778	63318-65262	62703-65052
Specific Conductivity (mS/cm)	61623-63387	57361-59057	55655-56974	55504-57846	60089-61092	59776-61131
Salinity (PSU)	42.2-43.6	38.9-40.2	37.7-38.6	37.5-39.3	41.0-41.8	40.8-41.8
Resistivity (Wcm)	14.8-15.3	15.9-16.4	16.5-17.2	16.2-16.8	15.3-15.8	15.4-15.9
Density (g/cm^3)	1.03	1.03	1.10-1.11	1.02-1.03	1.03	1.03
Total Dissolved Solids (ppt)	40.1-41.2	37.3-38.4	36.1-37.0	36.1-37.6	39.1-39.7	38.9-39.7
Turbidity (NTU)	0.00-4.83	0-107	0.00-9.34	0.64-5.09	0.92-2.90	0.07-165
pH (pH)	8.21-8.32	8.26-8.35	8.32-8.37	8.15-8.30	8.23-8.31	8.24-8.36
ORP (mV)	126-255	104-200	126-178	89-180	106-220	130-184
RDO Concentration (mg/L)	5.13-7.45	5.05-6.75	5.48-6.47	4.58-7.75	5.49-7.15	5.03-7.34
RDO Saturation (%Sat)	83.2-121.5	81.3-109.6	87.6-105.4	74.2-125.8	88.1-116.2	81.3-118.0

Oxygen Partial Pressure (Torr)	114-167	117-157	126-151	102-173	122-160	111-162
Temperature (°C)	27.8-28.7	27.7-28.6	27.1-28.6	27.8-29.0	27.5-28.6	27.2-28.6
Pressure (psi)	8.06-9.95	10.7-12.4	18.8-20.6	6.67-8.42	13.8-15.6	16.9-18.6
Depth (ft)	18.0-22.2	24.1-28.0	42.4-46.5	15.0-19.0	31.2-35.1	38.0-41.9

3.9 Microbiome Analyses with the standard 16S rRNA gene marker

Our Microbiology and Molecular Genomics Laboratory (MMG) has essentially completed all the sequencing and preliminary analyses of the 16S rRNA gene amplicon libraries as indicated in the FDEP scope of work. All samples for microbiome sequencing (and later metagenomics) with their respective ID numbers are listed in Table 22. However, full integration with chemistry and metagenomics results are not yet complete and so final conclusions and interpretations of the data are also incomplete.

We have now completed 16S rRNA based microbiome analyses of all sites, except for the reef surface sediment samples, which were delayed. A total of 48 samples provided 16S rRNA gene sequence data after processing. Only two samples failed for currently unexplainable reasons. The bulk of the samples (48) were run initially, and just recently followed by repeat samples that did not sequence initially, and six new sediment trap samples collected later. Only five samples did not yield any DNA results likely due to inhibitors in the sample (see file – "PEI sediments Microbiome Master list 6 26 23.xls". Methods and approaches are like the analyses carried out for a previous FL DEP CRCP 13 (Krausfeldt and Lopez, 2023). Sediments represent one of the most diverse habitats for bacteria. Relative abundance comparisons are shown by stacked bar charts (Figures 3 - 5). At all taxonomic levels a clear difference between PEI samples and other sites appeared. PEI showed a predominance of Proteobacteria, such as Order Steroidobacterioales. By contrast, the other PEI sites were dominated by phylum Chloroflexi, Chernarcheota. [**Please note that PEI is the name for the previously termed Coast Guard Station, Fort Lauderdale (CGF) location].**

All of the raw 16S rRNA sequence data generated has been shared and now uploaded as compressed Fastq files to these temporary Dropbox links – a) https://www.dropbox.com/scl/fo/05kly04mvoljjfomez6a1/h?dl=0&rlkey=l2e5vz1j180lz2ip3pzlrzu3n; b) https://www.dropbox.com/scl/fo/frer80dkuwgfvtbiu0on2/h?dl=0&rlkey=ir749f98gtspz2qafc3m0i3y4). These are large files but available for download. (Please provide the PI with an authorized DEP email and a timeframe to allow access).

Cluster analyses through non-metric dimensional scaling (NMDS) was applied on the 16S rRNA gene data as a form of beta diversity analyses (Figures 6 and 7). Each point on the plot represents the taxonomic composition of the bacteria based on 16S rRNA in the sample relative to all other samples in the dataset. The NMDS plot based on sample types did not reveal any significant clustering. This was surprising since some soil types could easily be distinguished visually, grain size (loam, mud, clays) and color, which could consequently affect microbial communities. By contrast, NMDS based on site type showed that PEI and WL sites separated from the other sites significantly. These separations appear supported by even more extensive sequencing by metagenomics described below.

3.10 Metagenomics Analyses with deep sequencing (Task 5)

Metagenomics analyses of subsets of the samples was planned in Phase I since broader sequencing goes beyond a single gene analyses of community diversity such as 16S rRNA gene markers. There is consensus that inclusion of broader sequences will provide more information on function and taxonomic identities. The metagenomics dataset sequenced by CosmosID has the dataset ID of

“CP04992”. Examples of raw metagenomics data are shown in the spreadsheets and folders uploaded to the final report folder for Task 5. These include metagenomics analyses for bacteria, viruses, protists, fungi and combined analyses such as “ca-port-everglades-inlet-metagenomes-2023c_2023_06_13_22_24.tsv” At this point, raw sequence data transfer for n = 47 samples has not been finalized since this is over 350 GB. Alternatively, this data can be delivered to FL DEP by a physical hard drive. Raw sequence is typically not deposited into a public database such as NCBI until the principal investigators have had a chance to fully analyze the data. The remaining sediment samples will be sent to CosmosID for final metagenomic sequencing this week. To meet Task 6 deliverables effort was made to preserve samples for RNA integrity at the time Phase I was planned because RNA viruses were potential SCTLD pathogens. This effort includes storing subsamples of sediments in RNAshield buffer.

Although the bulk of metagenomic analyses will be performed in Phase II of this project, and will be pending, we have been able to carry out some basic analyses using CosmosID’s online metagenomics tools (https://app.cosmosid.com/) (Figures 3 -12). More extensive analyses will be planned after hiring a dedicated metagenomics consultant. It was reassuring to see some broad concordance in that PEI samples appeared the most distinct cluster in Alpha diversity plots using ChaoI or Shannon diversity indices (Figures 10 and 11) and PCoA analyses using Bray-Curtis distances (Figure 12). The PEI distinction was less pronounced using the latter index.

Table 22. Sample identifications for microbiome and metagenomic sequencing

Sample ID	DNA yield (Qubit) ng/ul
DCC-1a	0.994
DCC-1b	0.477
DCC-1c	Failed
DCC-2a	1.56
DDC-2b	0.822
DDC-2c	Failed
DDC-3a	0.567
DDC-3b	0.29
DDC-3c	Failed
STB-1a	2.29
STB-1b	1.45

STB-1c	0.32
STB-2a	1.58
STB-2b	2.3
STB-2c	2.73
STB-3a	3.75
STB-3b	2.33
STB-3c	3.53
PEC-1a	4.36
PEC-1b	2.83
PEC-1c	1.14
PEC-2a	2.36
PEC-2b	1.15
PEC-2c	0.167
PEC-3a	2.54
PEC-3b	1.6
PEC-3c	0.813
PHQ-1a	7.3
PHQ-1b	1.89
PHQ-1c	2.03
PHQ-2a	3.78
PHQ-2b	1.02
PHQ-2c	1.27
PHQ-3a	4.49
PHQ-3b	1.14
PHQ-3c	1.22
CGF-1a	0.87
CGF-1b	1.49

CGF-1c	0.864
CGF-2a	0.685
CGF-2b	0.98
CGF-2c	1.03
CGF-3a	1.29
CGF-3b	1.16
CGF-3c	1.76
WL-1a	8.95
WL-1b	Failed
WL-1c	Failed
WL-2a	1.7
WL-2b	1.64
WL-2c	19.1
WL-3a	2.38
WL-3b	14.8
WL-3c	16.3
1N-APSST-1	9.31
2N-APSST-2	7.75
3N-APSST-3	5.83
1S-APSST-4	3.94
2S-APSST-5	8.14
3S-APSST-6	9.95

(This table still shows the sample “CGF = PEI” because computer scripts have not yet been fully updated. Surface sediment samples at the six coral reef sites (1N, 2N, 3N, 1S, 2S, and 3S) were initially labeled as “PSST1- 6” and then subsequently changed).

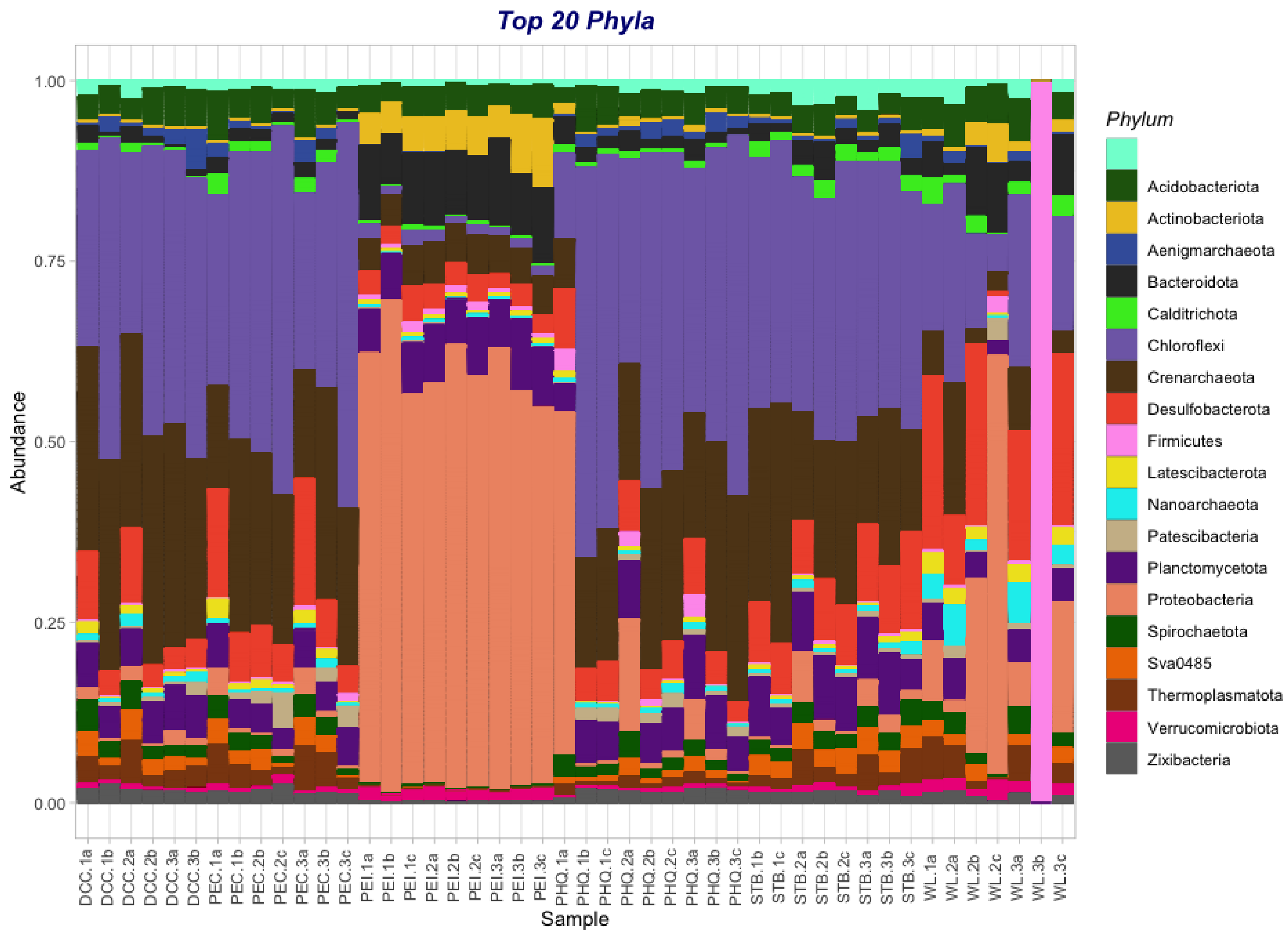

***Figure 3**. Relative abundances of Top 20 bacterial taxa by Phyla*

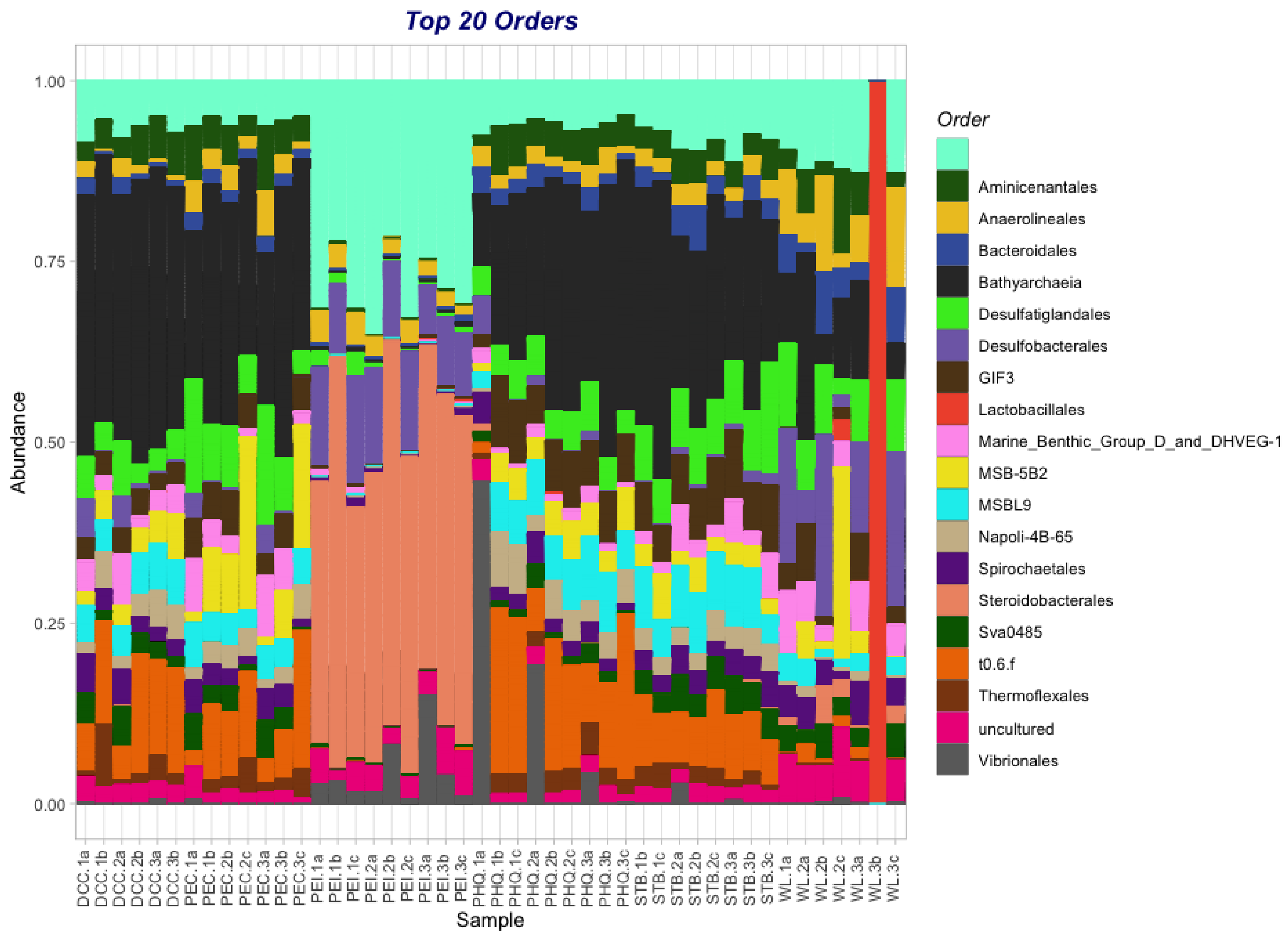

***Figure 4**. Relative abundances of Top 20 bacterial Orders*

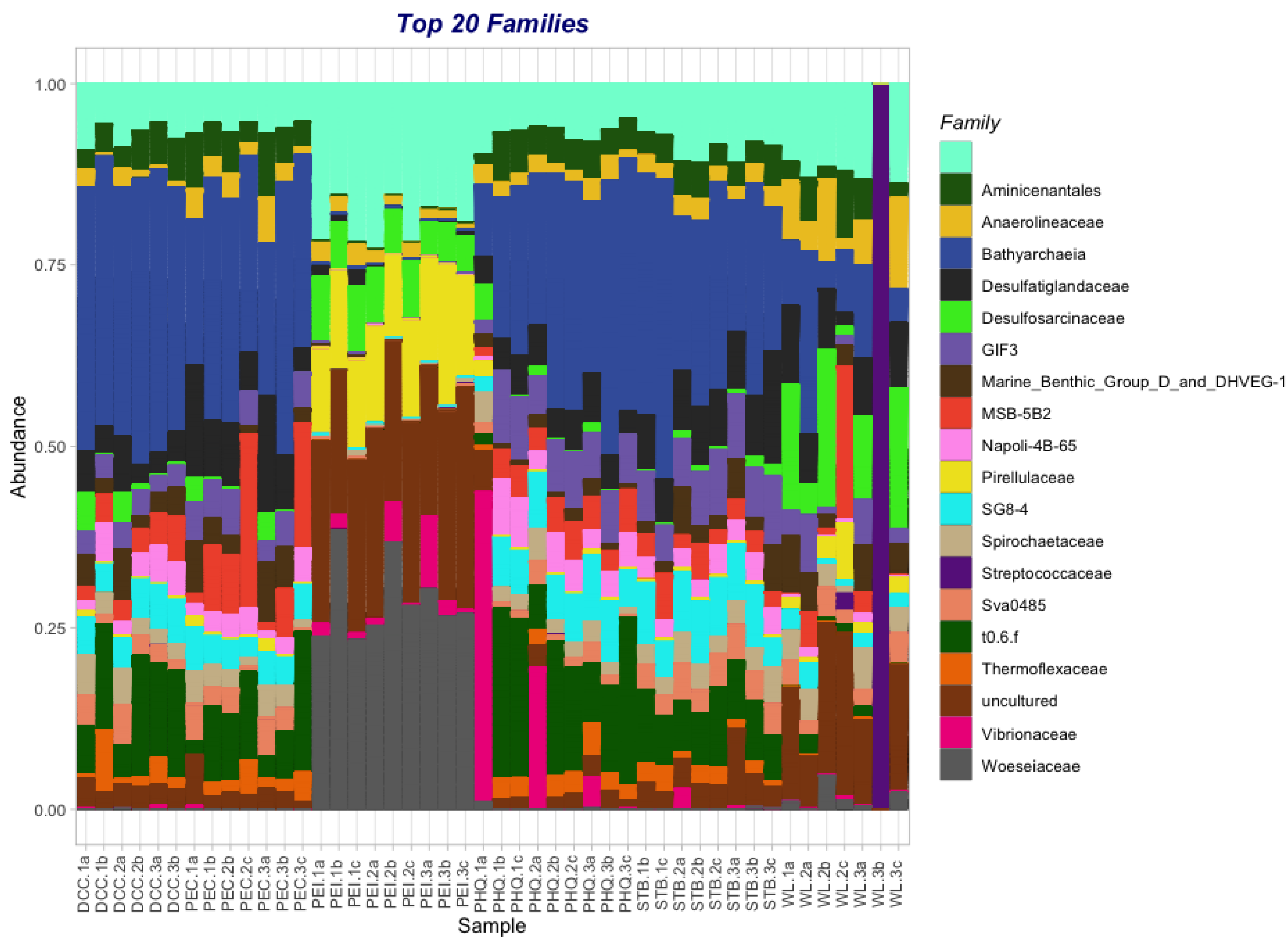

***Figure 5**. Relative abundances of Top 20 bacterial taxa by Family*

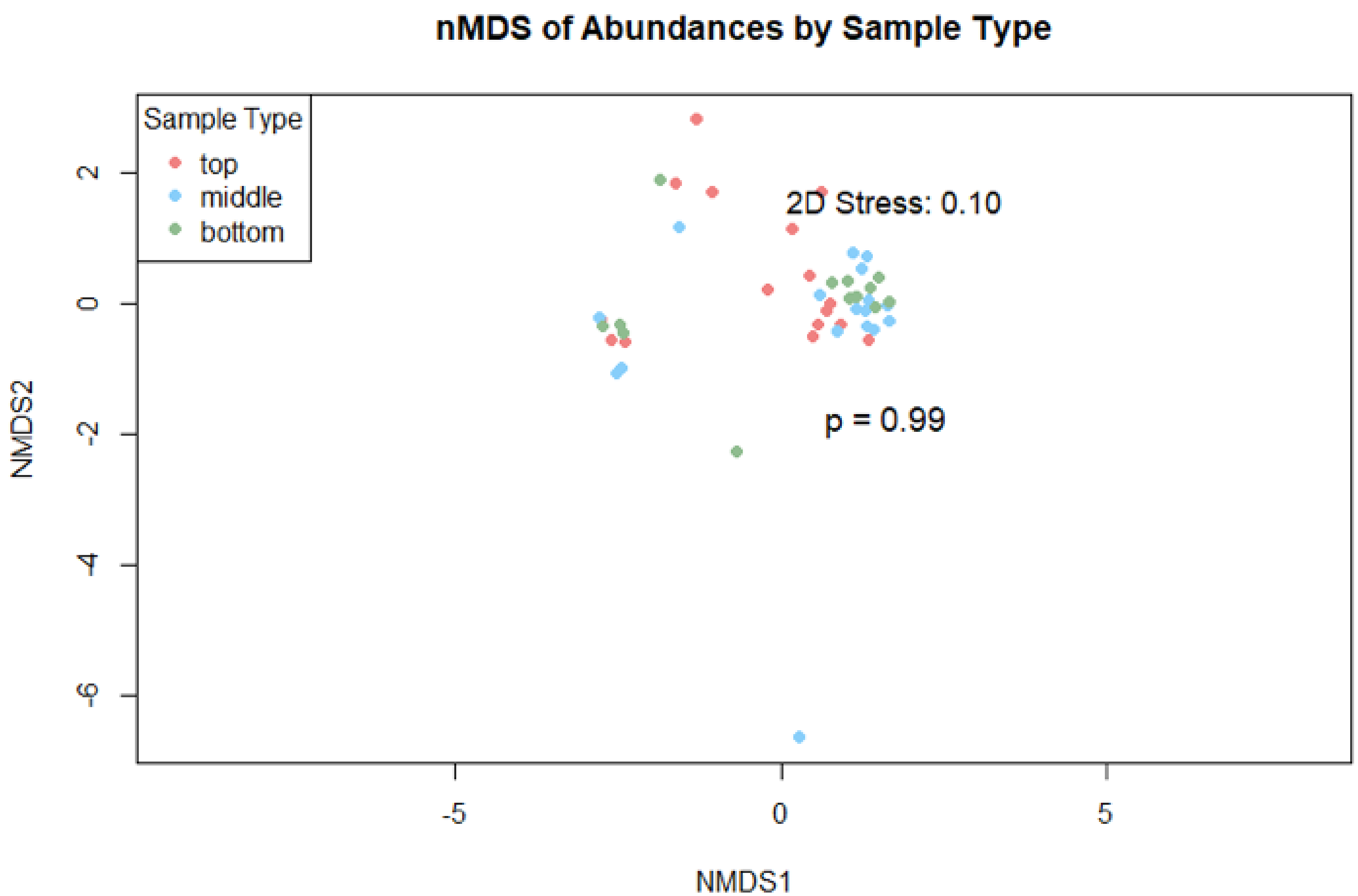

Figure 6. *Non-metric dimensional scaling (NMDS) plot by port sample type*

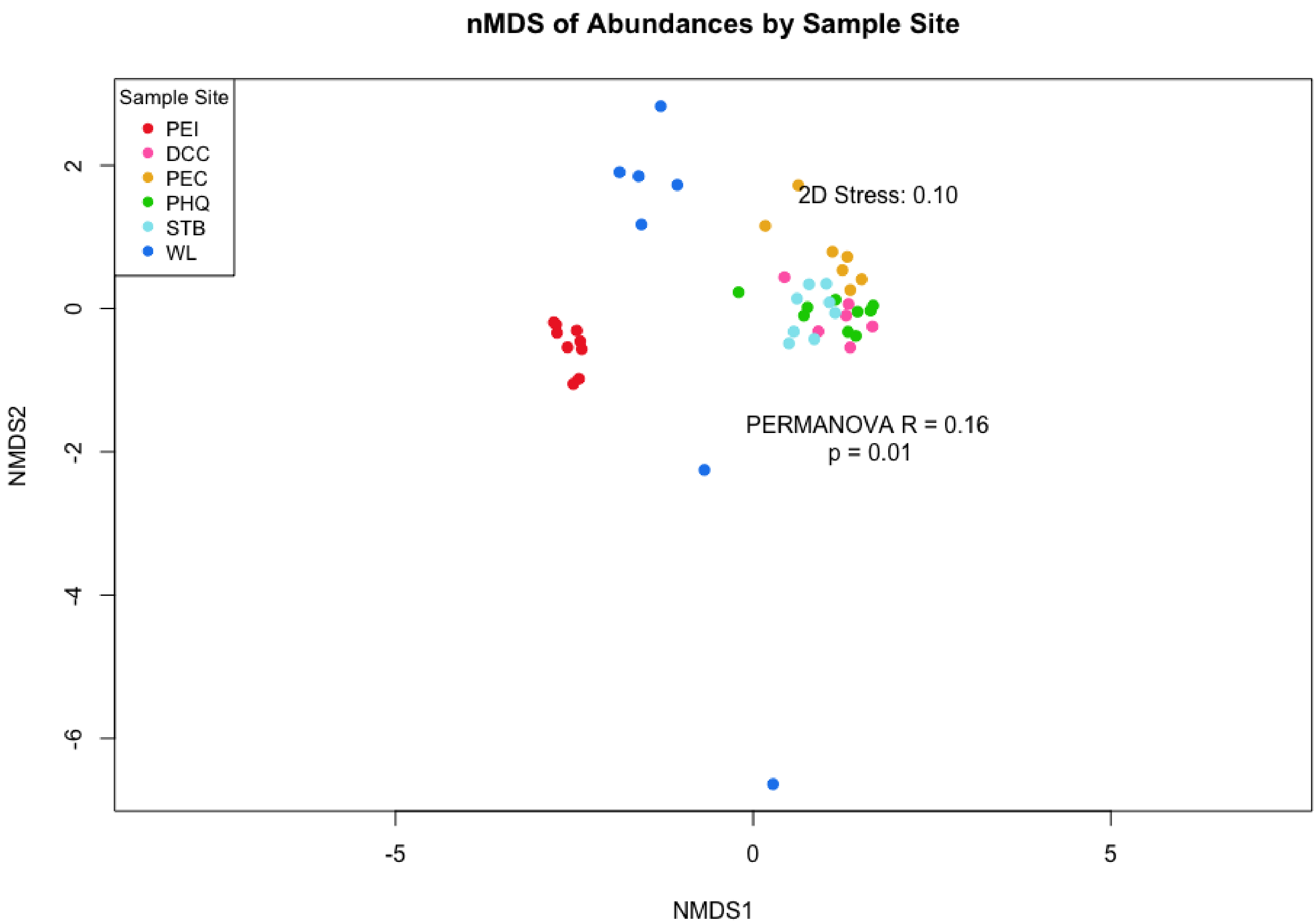

Figure 7. *Non-metric dimensional scaling (NMDS) plot by port site type.*

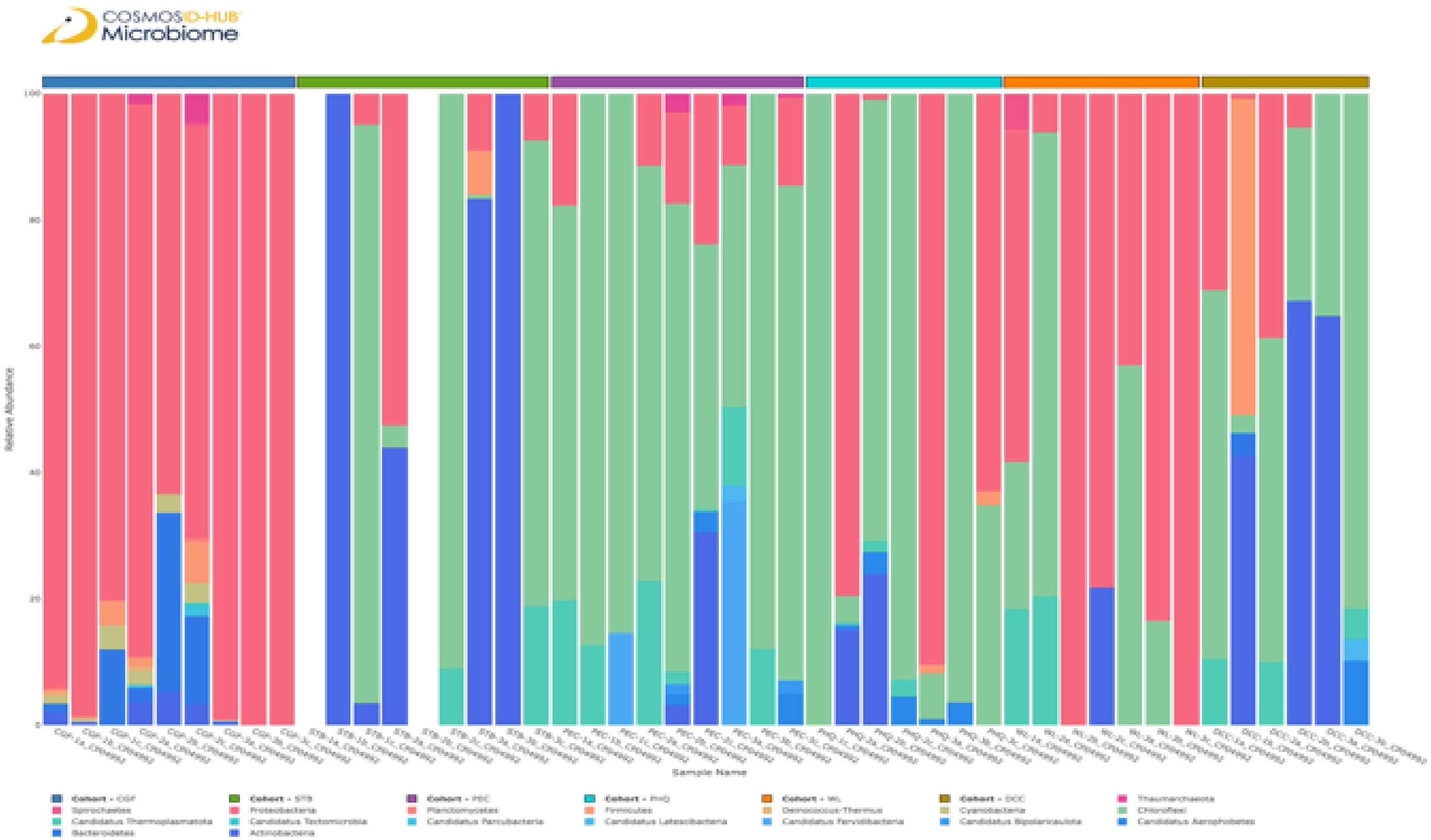

***Figure 8**. Relative abundances at Phylum level based on metagenomic data. (In this diagram, the "CGF" site and ID is synonymous with the PEI site).*

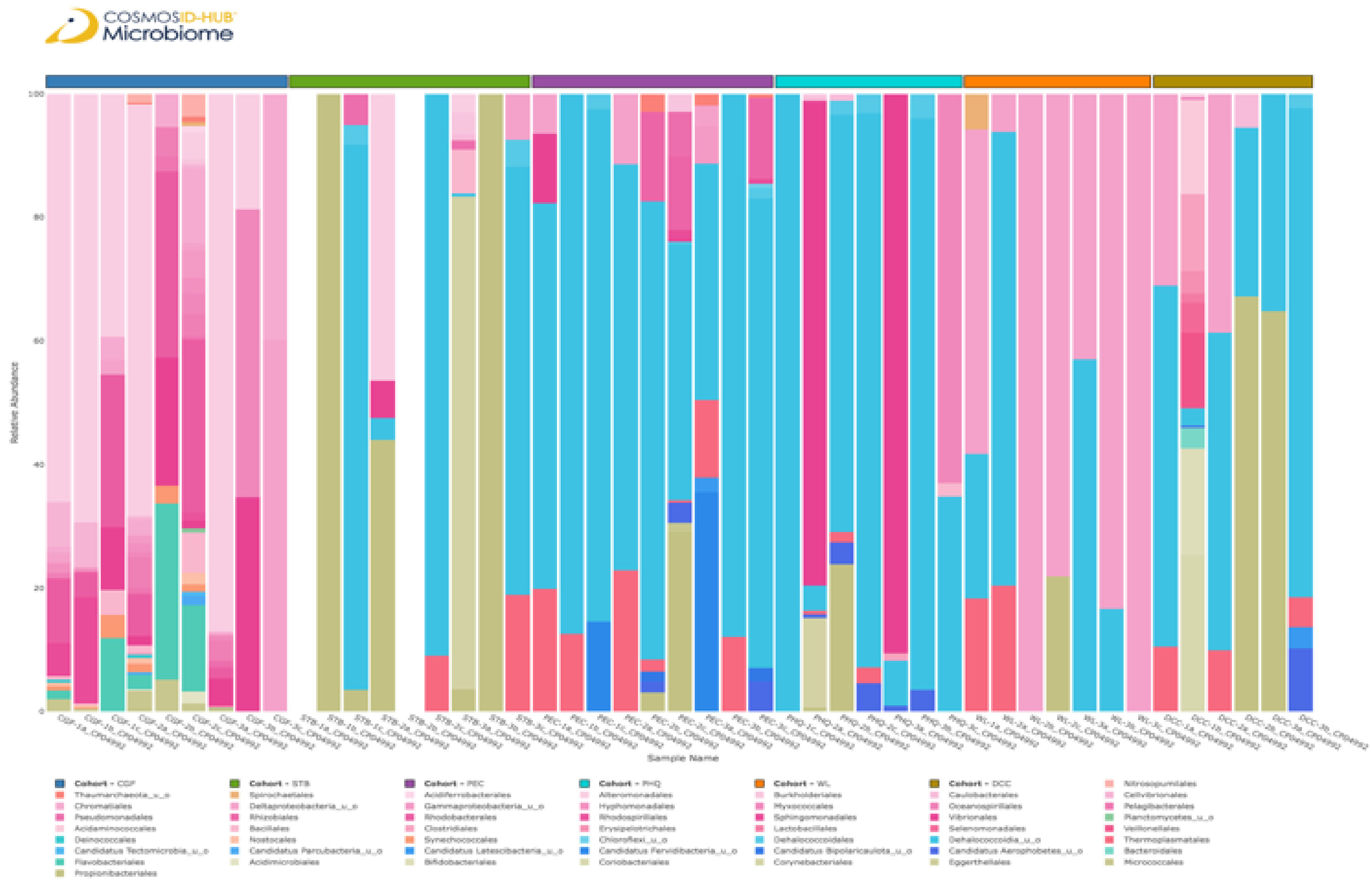

***Figure 9**. Relative abundances at Order level based on metagenomic data. (CGF is synonymous with the PEI site).*

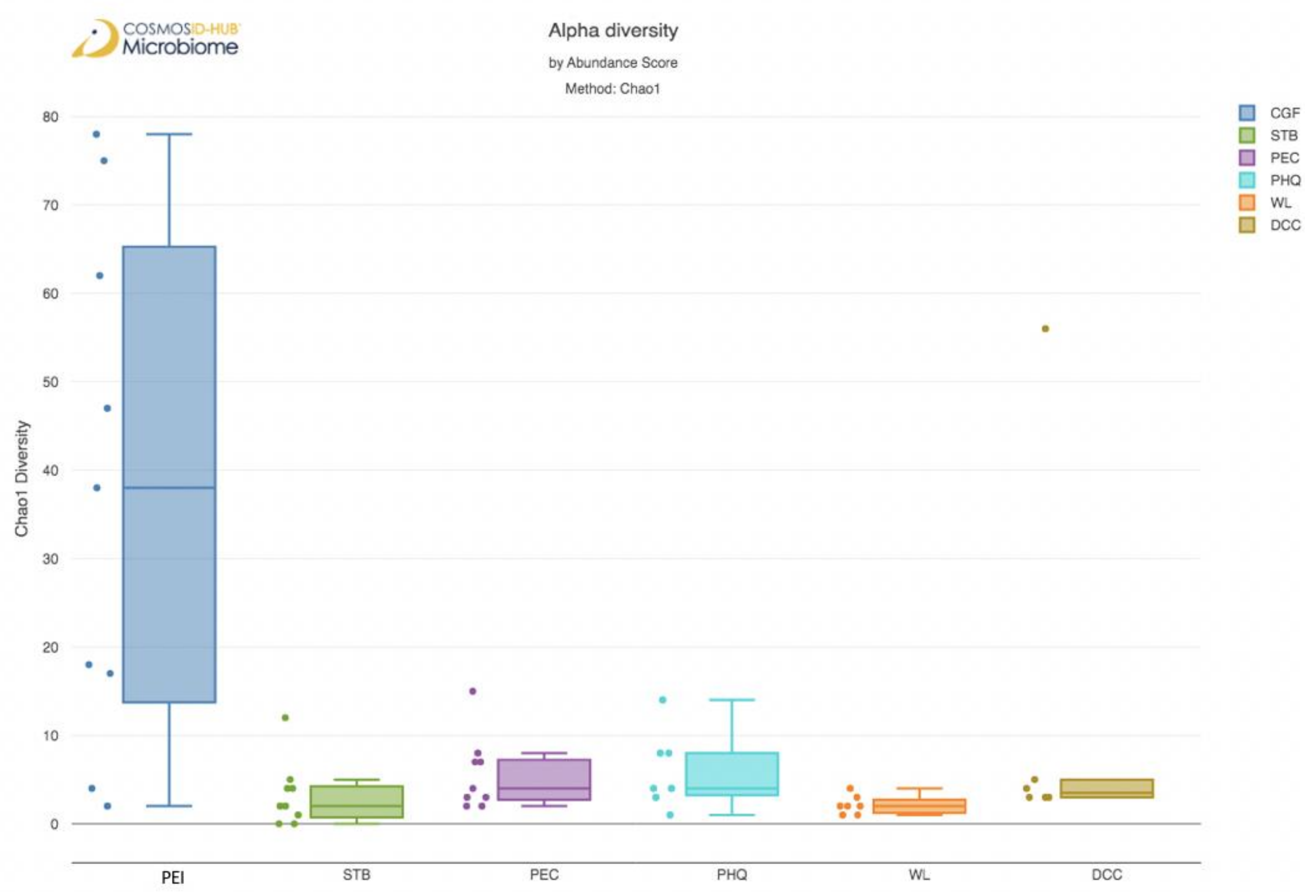

Figure 10. *Box plots showing alpha diversity via the Chao I index. (CGF is synonymous with the PEI site).*

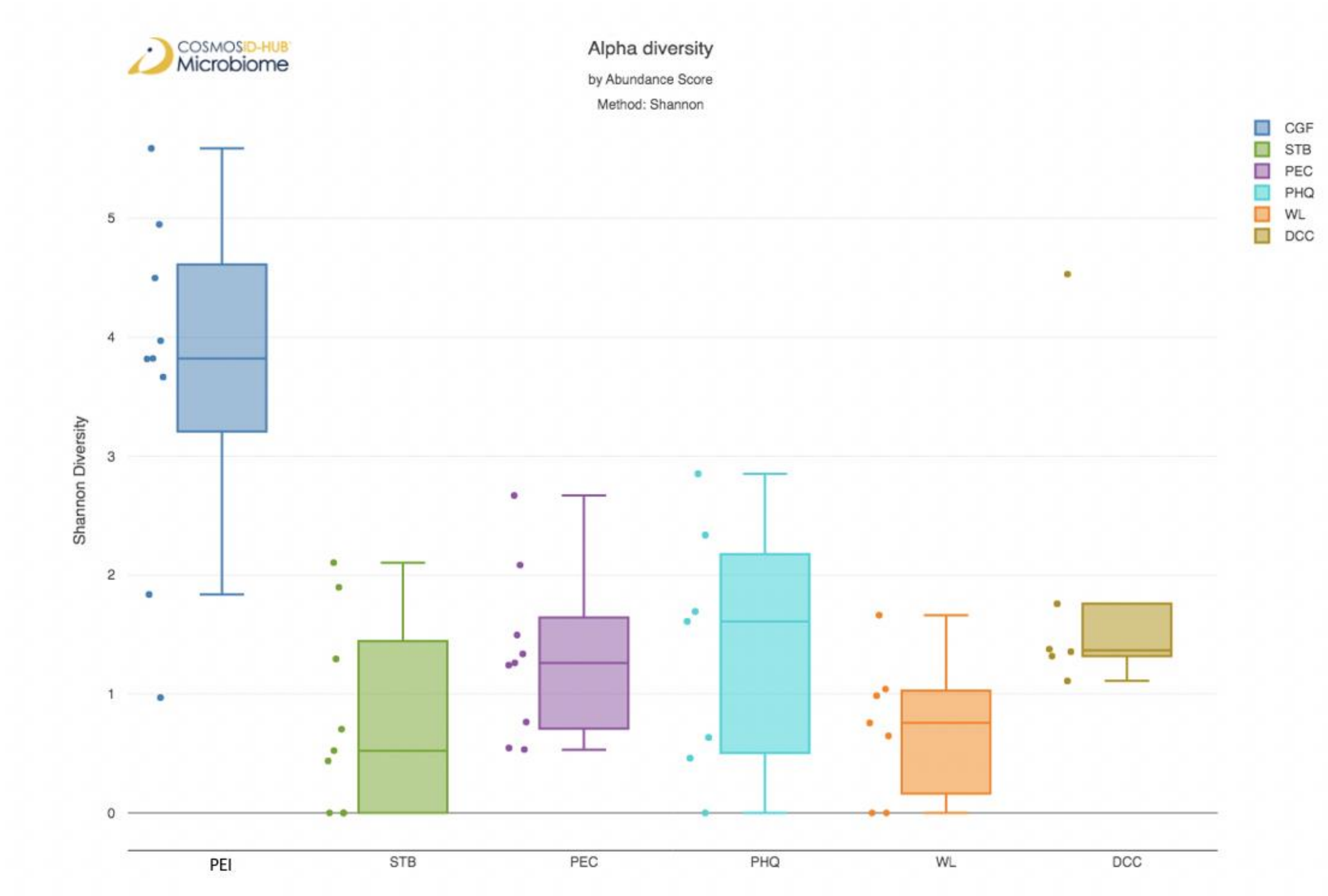

Figure 11. *Box plots showing alpha diversity via the Shannon index. (CGF is synonymous with the PEI site).*

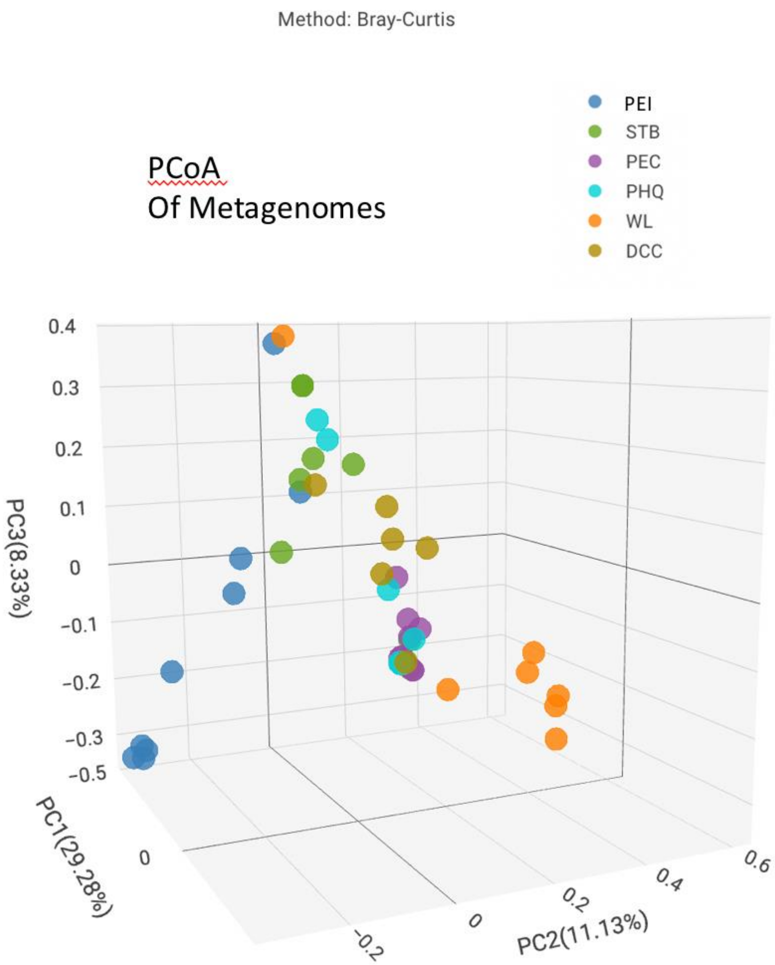

Figure 12. *PCoA plot of beta diversity based on preliminary metagenomics reads.*

4. CONCLUSIONS AND RECOMMENDATIONS

Preliminary heavy metal results of this study indicate a moderate to high overall ecological risk from sediment due to metal contamination. Due to an imminent dredging at Port Everglades, this could harm the threatened adjacent coral communities and surrounding protected habitats. Preliminary microbiome and metagenome data support the expectations that sediments harbor diverse microbial communities. Also, the finding that WL has a distinct microbial community from the other more developed, unnatural habitats suggests that human industrial activities have altered some of the microbiomes in the port. It will be interesting to fully search for correlations with other metadata collected in this project. We can examine and compare the present port sediment profiles with growing molecular datasets on marine pathogens and diseases.

We will be analyzing the sediment collected in the sediment traps during the period July 2023-June 2024 for heavy metal concentrations and microbiome profiling to determine if sedimentation has any heavy metal and/or bacterial contaminants. We will also be conducting statistics with the heavy metal and microbiome results to confirm the potential contamination (to 95% confidence). Sedimentation rate and grain size will be calculated once sediment collected in the reef site traps is collected, at the same time as heavy metal analysis and microbiome profiling. Water chemistry data will allow us to monitor for abiotic fluctuations and potential biotic responses at the reef sites.

Literature Cited

Aeby, G. S. et al. (2019) Pathogenesis of a tissue loss disease affecting multiple species of corals along the Florida Reef Tract. *Front Mar Sci*, 6, 1–18.

Al-Mutairi K. A. and Yap C. K. (2021) A review of heavy metals in coastal surface sediments from the Red Sea: Health-ecological risk assessments. *Inter J Env Res Pub Health*, 18, 1-24. https://doi.org/10.3390/ijerph18062798.

Alvarez-Filip, L. et al. (2022) Stony coral tissue loss disease decimated Caribbean coral populations and reshaped reef functionality. *Commun Biol*, 5, 440. https://doi.org/10.1038/s42003-022-03398-6

Armiento, G. et al. (2020) Current status of coastal sediments contamination in the former industrial area of Bagnoli-Coroglio (Naples, Italy) *J Chem Ecol* 36(6), 579-597. https://doi.org/10.1080/02757540.2020.1747448

Badr N., El-Fiky A., Mostafa, A., and Al-Mur, B. (2009) Metal pollution records in core sediments of some Red Sea coastal areas, Kingdom of Saudi Arabia. *Env Mon Ass* 155, 509–526. 10.1007/s10661-008-0452-x.

Bessell-Browne, P. et al. (2017) Impacts of turbidity on corals: The relative importance of light limitation and suspended sediments. *Mar Pollut Bull*, 117(1–2), 161-170. https://doi.org/10.1016/j.marpolbul.2017.01.050.

Bushnell, B. (2014) A fast, accurate, splice-aware aligner. United States, https://www.osti.gov/servlets/purl/1241166

Cao, L., Hong, G., and Liu, S. (2015) Metal elements in the bottom sediments of the Changjiang estuary and its adjacent continental shelf of the East China Sea. *Mar Pollut Bull*, 95, 458–468. https://doi:10.1016/j.marpolbul.2015.03.013.

Campbell, A. M. et al. (2015) Dynamics of marine bacterial community diversity of the coastal waters of the reefs, inlets, and wastewater outfalls of southeast Florida. *Microbio Open*, 4(3), 390-408. https://doi: 10.1002/mbo3.245

Caporaso, J. G., et al. (2011) Global patterns of 16S rRNA diversity at a depth of millions of sequences per sample. *PNAS*, 108 (Supplement 1), 4516-4522.

Cuvelier, M., et al. (2014). Two distinct microbial communities revealed in the sponge *Cinachyrella*. *Front Microbio*, 5, 00581. https://doi:10.3389/fmicb.2014.00581.

Davies, O. A. et al. (2009) Bioaccumulation of heavy metals in water, sediment and periwinkle (*Tympanotonus fuscatus var radula*) from the Elechi Creek, Niger Delta. *Afr J Biotechnol, 5*(10), 968-973.

Dodge, R. E. and Vaisnys, J. R. (1977) Coral populations and growth patterns: Responses to sedimentation and turbidity associated with dredging. *J Mar Res*, 35(4), 715-730.

Easson, C. G. and Lopez, J. V. (2019) Depth-dependent environmental drivers of microbial plankton community structure in the Northern Gulf of Mexico. *Front Microbio,* 9(3175). https://doi:10.3389/fmicb.2018.03175

Eggers, S. et al. (2018) Heavy metal exposure and nasal *Staphylococcus aureus* colonization: Analysis of the National Health and Nutrition Examination Survey (NHANES). *Environ Health* 17:2. https://doi.org/10.1186/s12940-017-0349-7

EPA. US. (1996) EPA Method 3050B: Acid digestion of sediments, sludges, and soils Washington, DC. Available at: https://www.epa.gov/esam/epa-method-3050b-acid-digestion-sediments-sludges-and-soils (accessed 10 January 2023)

EPA. US. (2002) EPA Method 1631E: Mercury in water by oxidation, purge and trap, and cold vapor atomic fluorescence spectrometry Washington, DC. Available at: https://www.epa.gov/sites/default/files/2015-08/documents /method_1631e_2002.pdf (accessed 19 April 2023)

Fabricius, K. E. (2005) Effects of terrestrial runoff on the ecology of corals and coral reefs: Review and synthesis. *Mar Pollut Bull*, 50(2), 125-146. https://doi.org/10.1016/j.marpolbul.2004.11.028.

Förstner, U. (1980) cc. In: Olausson EC, I., ed. *Chem Biogeochem Est*, 309-348.

Freed, L. et al. (2019) Characterization of the microbiome and bioluminescent symbionts across life stages of Ceratioid anglerfishes of the Gulf of Mexico. *FEMS-Microbio Ecol*,.95(10), fiz146. https://doi.org/10.1093/femsec/fiz146

Fu, C. et al. (2009) Potential ecological risk assessment of heavy metal pollution in sediments of the Yangtze River within the Wanzhou section, China. *Biological Trace Element Reseacrh*, 129,270–277. https://doi.org/10.1007/s12011-008-8300-y.

Geoenvironmental Engineering (2015) Sediment quality guidelines (sqgs): A review and their use in practice. Available at https://www.geoengineer.org/education/web-class-projects/cee-549-geoenvironmental-engineering-fall-2015/assignments/sediment-quality-guidelines-sqgs-a-review-and-their-use-in-practice (accessed 19 December 2023).

Giarikos, D. et al. (in review) Assessing the ecological risk of heavy metal sediment contamination from Port Everglades Florida USA. *PeerJ*.

Gintert, B. E. et al. (2019). Regional coral disease outbreak overwhelms impacts from local dredge project. *Environ Monit Assess*, 191, 1–39. https://doi.org/10.1007/s10661-019-7767-7

Guo, W. L., Xianbin, L., and Zhanguang, L. G. (2010) Pollution and potential ecological risk evaluation of heavy metals in the sediments around Dongjiang Harbor, Tianjin. *Procedia Environ Sci*, 2,729–736. https://doi.org/10.1016/j.proenv.2010.10.084.

Hakanson, L. (1980) An ecological risk index for aquatic pollution control: a sedimento-logical approach. *Water Res*, 14,975–1001. https://doi.org/10.1016/0043-1354(80)90143-8.

Hay M. E. and Rasher D.B. (2010) Coral reefs in crisis: reversing the biotic death spiral. F1000 *Biol Rep* Sep 23;2:71. https://doi.org/10.3410/B2-71.

Hedge, L. H. et al. (2009) Dredging related metal bioaccumulation in oysters. *Mar Pollut Bull*, *58*(6), 832–840. https://doi.org/10.1016/j.marpolbul.2009.01.020

Karns, R. et al. (2021) Microbiome analyses demonstrate specific communities within five shark species. *Front Microbio*, 12, 139. https://doi.org/10.3389/fmicb.2021.605285

Knight R. et al. 2012. Designing better metagenomic surveys: The role of experimental design and metadata capture in making useful metagenomic datasets for ecology and biotechnology. *Nature Biotech*, 30, 513–520.

Krausfeldt, L. Lopez JV et al. (2023) Change and stasis of distinct sediment microbiomes across Port Everglades Inlet (PEI) and the adjacent coral reefs. *Peer J*, 11, e14288. https://doi.org/10.7717/peerj.14288

Kim, B. R. et al. (2017) Deciphering diversity indices for a better understanding of microbial communities. *J Microbio Biotech*, 27(12), 2089-2093. https://doi.org/10.4014/jmb.1709.09027.

Lande, R. (1996) Statistics and partitioning of species diversity, and similarity among multiple communities. *Oikos*, 5-13. https://doi.org/10.2307/3545743

Landsberg, J. H. et al. (2020) Stony coral tissue loss disease in Florida is associated with disruption of host–zooxanthellae physiology. *Front Mar Sci*, 7, 1–24. https://doi.org/10.3389/fmars.2020.576013

Li. D., et al. (2016) MEGAHIT v1.0: A fast and scalable metagenome assembler driven by advanced methodologies and community practices. *Methods*, 102, 3-11. https://doi.org/10.1016/j.ymeth.2016.02.020.

Long, E. R. et al. (1996) *Environ Sci Tech* 30(12), 3585–3592. https://doi.org/10.1021/es9602758

MacDonald, D. D. (1994) *Approach to the Assessment of Sediment Quality in Florida Coastal Waters. Volume 1 - Development and Evaluation of Sediment Quality Assessment Guidelines. Florida Department of Environmental Protection*, Tallahassee, Florida.

MacDonald, D. D. et al. (1996) Development and evaluation of sediment quality guidelines for Florida coastal waters. *Ecotox Environ Saf*, 5, 253–278. https://doi.org/10.1007/BF00118995.

MacDonald, D. D. and Ingersoll, C. G. (1993) The development and evaluation of numerical sediment quality assessment guidelines for Florida coastal waters. In: Protection FDoE, editor.

McMurdie, P. J. and Holmes, S. (2013). phyloseq: an R package for reproducible interactive analysis and graphics of microbiome census data. *PLOS ONE*, 8(4), e61217.

Nascimento L. D., et al. (2020) Statistical approach on mixed carbonate-siliciclastic sediments of the NE Brazilian outer shelf. *Geo-Mar Lett* 40, 1001–1013. https://doi.org/10.1007/s00367-019-00625-8

O'Connell, L. et al. (2018) Fine grained compositional analysis of PEI Everglades Inlet microbiome using high throughput DNA sequencing. *Peer J*, 6, e4671. https://doi.org/10.7717/peerj.4671.

Oksanen, J., et al. (2018) Vegan: Community Ecology Package.

Peixoto, R. S. et al. (2017) Beneficial microorganisms for corals (BMC): Proposed mechanisms for coral health and resilience. *Front Microbio*, 8:341. https://doi.org/10.3389/fmicb.2017.00341

Power, E. A. and Chapman, P.M. (2018) Assessing sediment quality. *Sediment Toxicology Assessment* CRC Press, 1-18.

Qian, Y. et al. (2015) Metal pollution in coastal sediments. *Curr Pollut Rep*, 1, 203–219. https://doi.org/10.1007/s40726-015-0018-9

Ray, A. et al. (2006) Assessment of Godavari estuarine mangrove ecosystem through trace metal studies. *Environ Inter* 32, 219–223. https://doi.org/10.1016/j.envint.2005.08.014.

Riegl, B. and Dodge, R. (2008) *Coral Reefs of the USA*. Dordrecht; London: Springer Science + Business Media B.V.

Riegl, B. et al. (2009) Coral reefs: Threats and conservation in an era of global change. *Ann NY Acad Sci*, 1162, 136-86. https://doi.org/10.1111/j.1749-6632.2009.04493.x.

Rudnick, R.L. and Gao, S. (2014) Composition of the continental crust. *Treatise on Geochemistry*, 2nd edition 1-51. Elsevier. https://doi.org/10.1016/B978-0-08-095975-7.00301-6.

Saadati, M., et al. (2020) Bioaccumulation of heavy metals (Hg, Cd and Ni) by sentinel crab (*Macrophthalmus depressus*) from sediments of Mousa Bay, Persian Gulf. *Ecotoxicol Environ Saf 191*, 109986. https://doi.org/10.1016/j.ecoenv.2019.109986

Studivan, M. S., et al. (2022) Reef sediments can act as a stony coral tissue loss disease vector. *Front Mar Sci*, 8, 1-15. https://doi.org/10.3389/fmars.2021.815698

Taylor, S. R. and McLennan, S. M. (1995) The geochemical evolution of the continental crust. *Rev Geophys*, 33(2), 241– 265, https://doi.org/10.1029/95RG00262.

Tomlinson, D. et al. (1980) Problems in the assessment of heavy-metal levels in estuaries and the formation of a pollution index. *Helgo Mar Res* 33, 566–575. https://doi.org/10.1007/BF02414780.

Thompson, R. and Wasserman, H. (2015) Sediment quality guidelines (SQGs): A review and their use in practice. *Geoenvironmental Engineering*:11.

Thompson, L. R. et al. (2017) A communal catalogue reveals Earth's multiscale microbial diversity. *Nature*, 551, 457-463.

Turgeon, D. D. et al. (1998) Sediment Toxicity in U.S. Coastal Waters; NOAA, National Ocean Service, Coastal Monitoring and Bioeffects Division, Office of Ocean Resources Conservation and Assessment, Coastal Ocean Program. Available at https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwj81enxpaL-AhUAbzABHZP2C1MQFnoECBEQAQ&url=https%3A%2F%2Frepository.library.noaa.gov%2Fview%2Fnoaa%2F26764&usg=AOvVaw1ugP5zBUey3l4LIGqpA_lU (Accessed 23, October 2022).

Wang, X. H. and Andutta, F. P. (2012) Sediment transport dynamics in ports, estuaries and other coastal environments. In: Manning, AJ, ed. *Sediment Transport*: INTECH, 3-35. https://doi.org/10.5772/51022

White, L. (2021) Element Contamination in Port Everglades – Preparing for Ecological Impacts. Master's thesis. Nova Southeastern University. Retrieved from NSUWorks, (72). https://nsuworks.nova.edu/hcas_etd_all/72.

Work, T. M. et al. (2021) Viral-like particles are associated with endosymbiont pathology in Florida corals affected by stony coral tissue loss disease. *Front Mar Sci* 8, 1–18.

Wolanski, E. et al. (2009) Quantifying the impact of watershed urbanization on a coral reef: Maunalua Bay, Hawaii. *Estuar Coast Shelf Sci*, 84(2), 259-268. https://doi.org/10.1016/j.ecss.2009.06.029.

Zoller, W. H. et. al. (1974) Atmospheric concentrations and sources of trace metals at the South Pole. *Science*, 183(4121), 198 -200. https://doi.org/10.1126/science.183.4121.198