

Port Gardner Regional Background Characterization

Phase II Summary of Results

Study Design and Spatial Distribution of Bioaccumulative Contaminants of Concern (BCOC)

Phase II Summary of Results

Revisions for Phase II



Phase I sampling was conducted in early 2013 at:

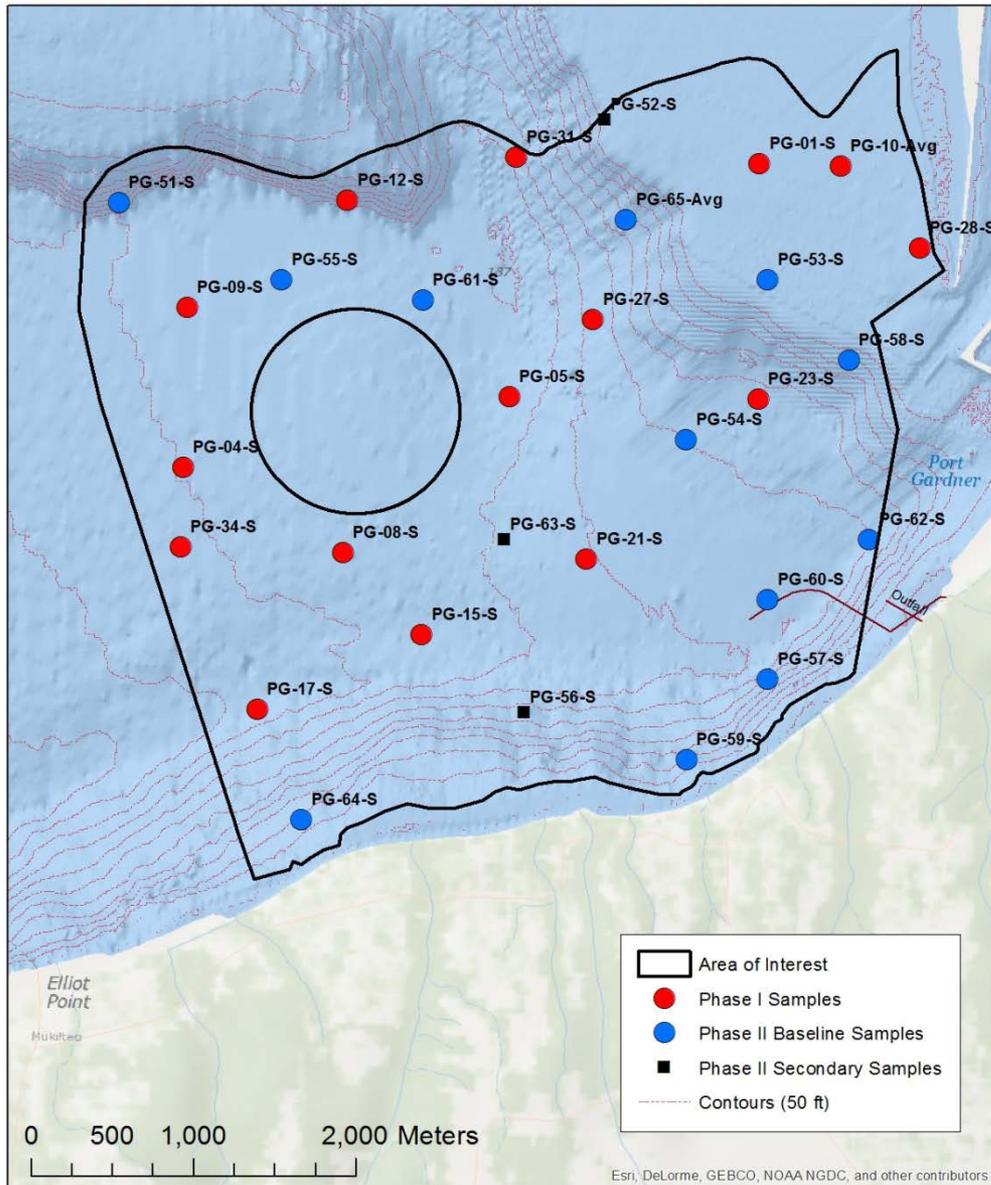
- 25 baseline locations.
- 25 secondary locations.

Locations were spread throughout the original area of interest (white outline).

This area was revised (yellow outline) for 2014 sampling because:

- Samples from the Snohomish Delta were not considered representative of regional background.
- Samples from the NW corner of the original AOI were not thought to be consistent with Port Gardner from a hydrological standpoint.
- Additional samples were added in the nearshore areas to be more representative of regional background.

Phase II Study Design



The revised regional background data set is a mixture of Phase I (2013) and Phase II (2014) results.

Samples analyzed for the full suite of COPCs:

- 11 baseline samples from Phase I.
- 4 secondary samples from Phase I.
- 12 baseline samples from Phase II.

Samples only analyzed for mercury:

- 3 secondary samples from Phase II.

Phase I secondary mercury samples excluded because not all locations met the minimum distance criteria.

Data Quality Objectives

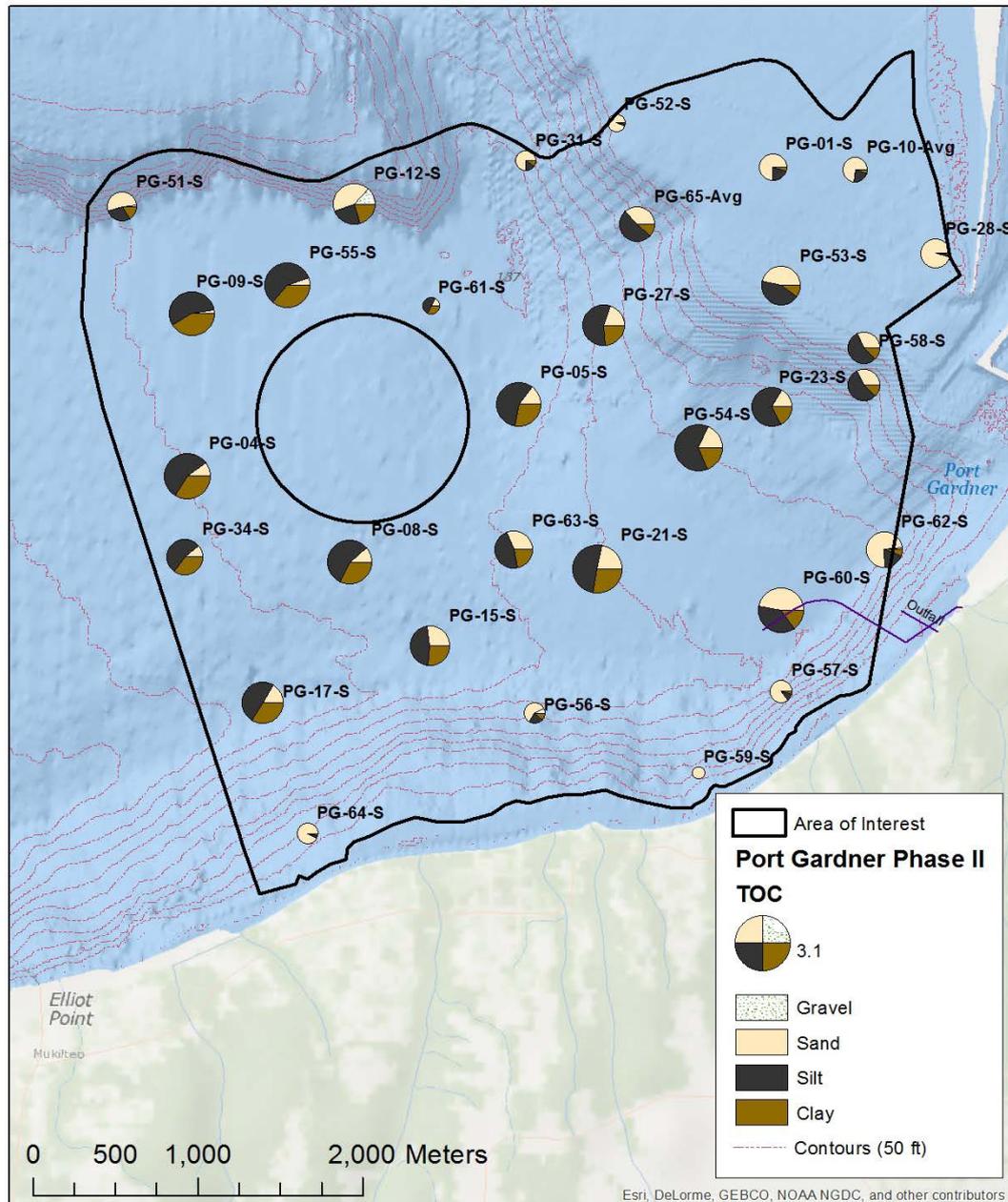
- Low PQLs were targeted to assure as few non-detects and as many unqualified results as possible (target PQLs listed below).
- All results have undergone a QA2 (USEPA Stage 3/4) independent data validation by EcoChem, Inc.

Analyte	Method	PQL	Units	# of Results Below PQL
Arsenic	EPA 200.8	0.5	mg/kg	0/27
Cadmium	EPA 200.8	0.1	mg/kg	2/27
Mercury	EPA 7471A	0.025	mg/kg	5/30
cPAH*	EPA 8270 SIM LL	0.76	µg/kg	0/27
PCB congeners*	EPA 1668	0.052	ng/kg	2/27
Dioxins/furans*	EPA 1613B	2.3	ng/kg	12/27

* PQLs represent a TEQ value calculated by multiplying the congener-specific PQLs by the TEF value from Ecology 2007 (Evaluating the Toxicity and Assessing the Carcinogenic Risk of Environmental Mixtures Using Toxicity Equivalency Factors) and then summing the results.

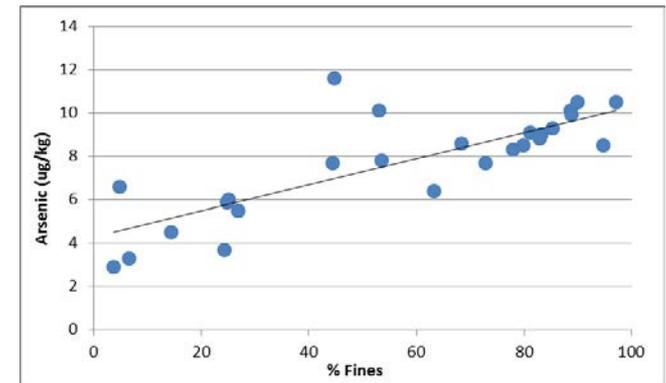
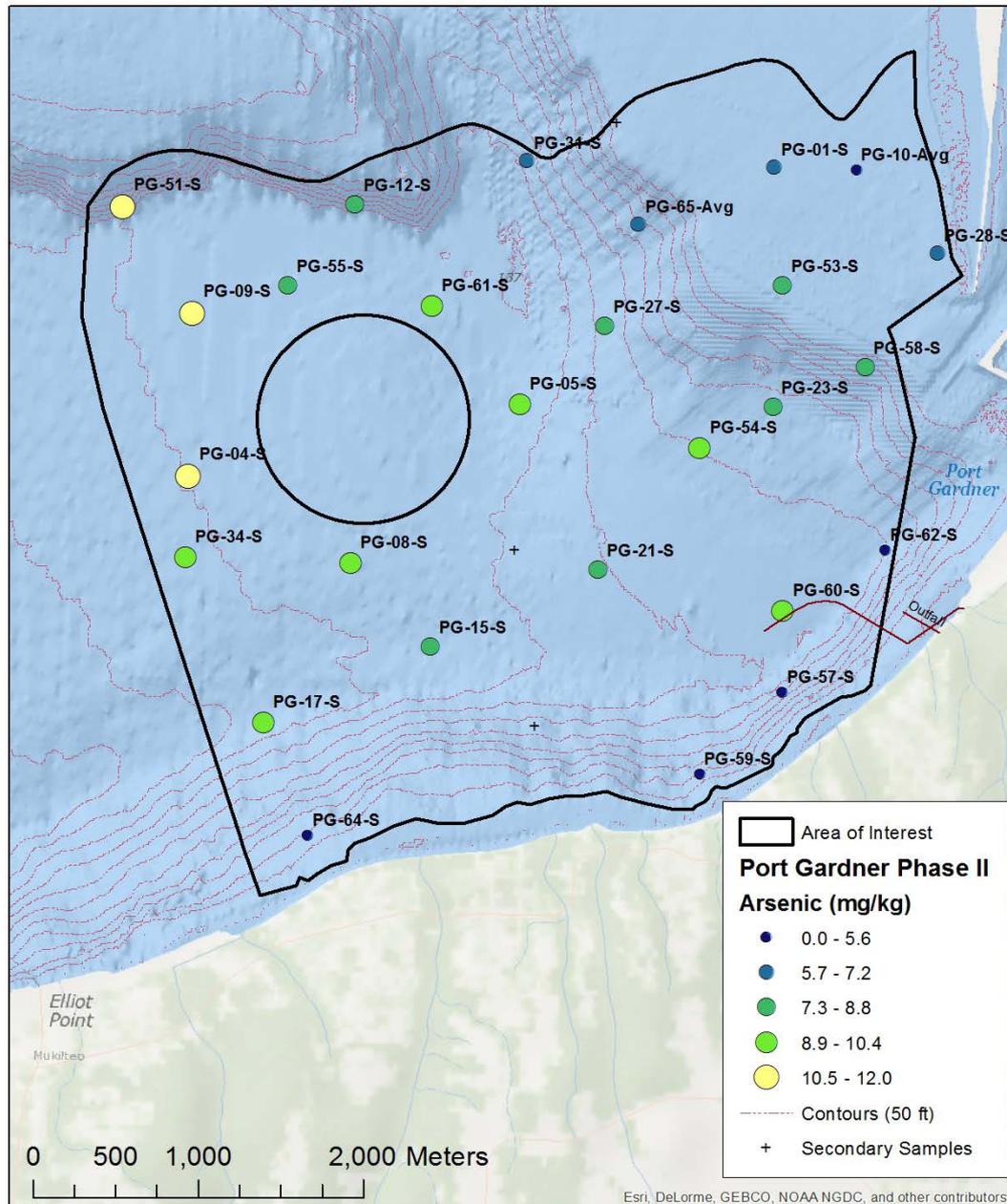
Percent Fines/TOC

- Fines ranged from 4 to 97%
- Sandy/low TOC sediments were present near the Snohomish River Delta and the SE nearshore area.
- Deeper samples typically had higher TOC.



Arsenic

Correlated to fines with an r-value of 0.800 (TOC, 0.635)

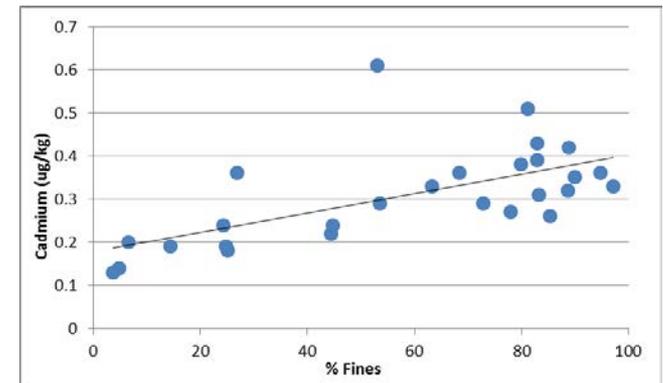
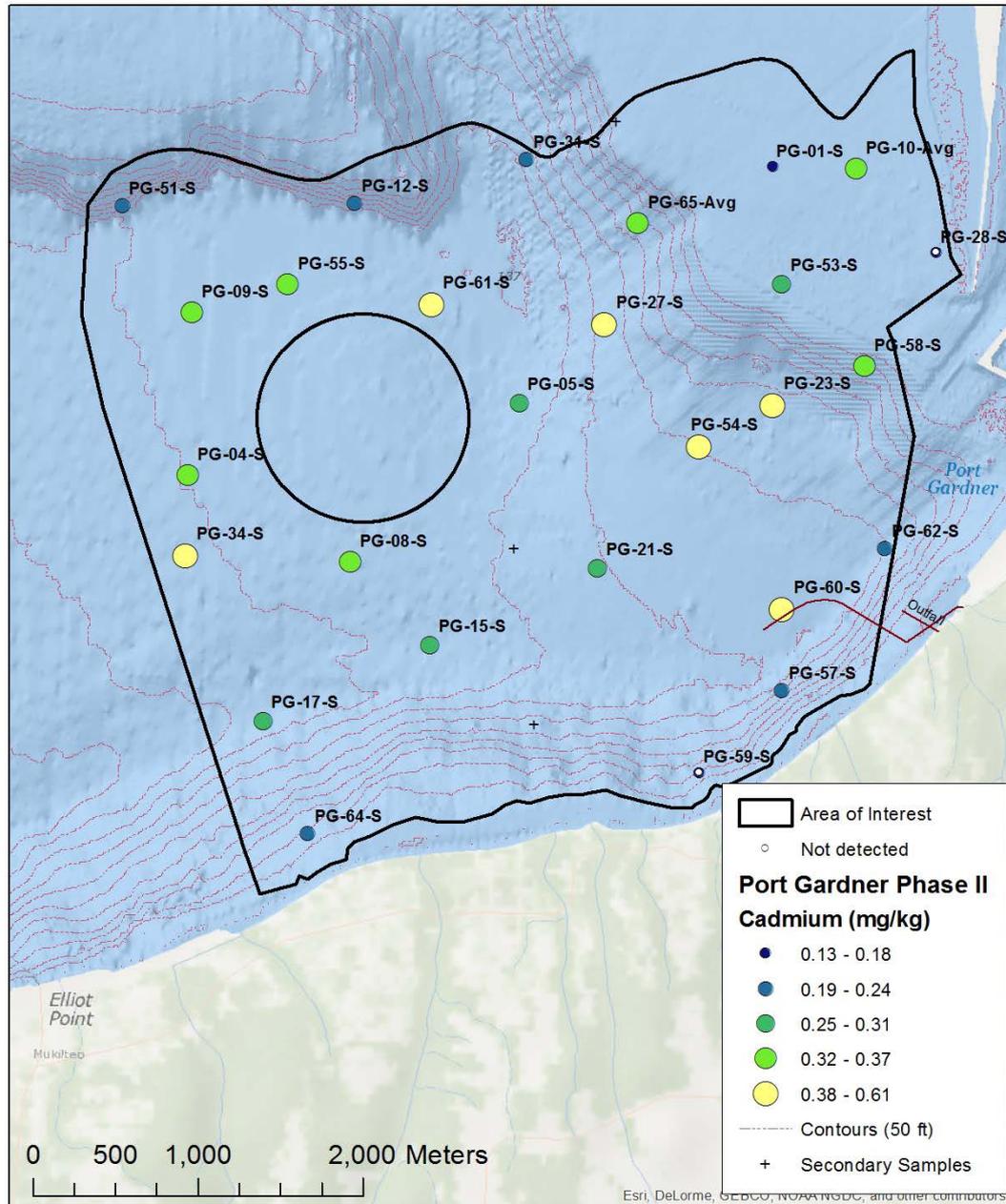


	Arsenic
	mg/kg DW
Summary Statistics	
Sample Size	27
Minimum	2.9
Average	7.8
Median	8.5
Maximum	11.6

Cadmium

Correlated to fines with an r-value of 0.628 (TOC, 0.519)

2 non-detect results

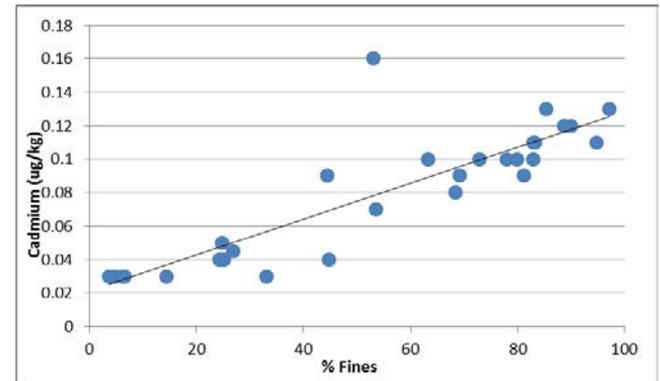
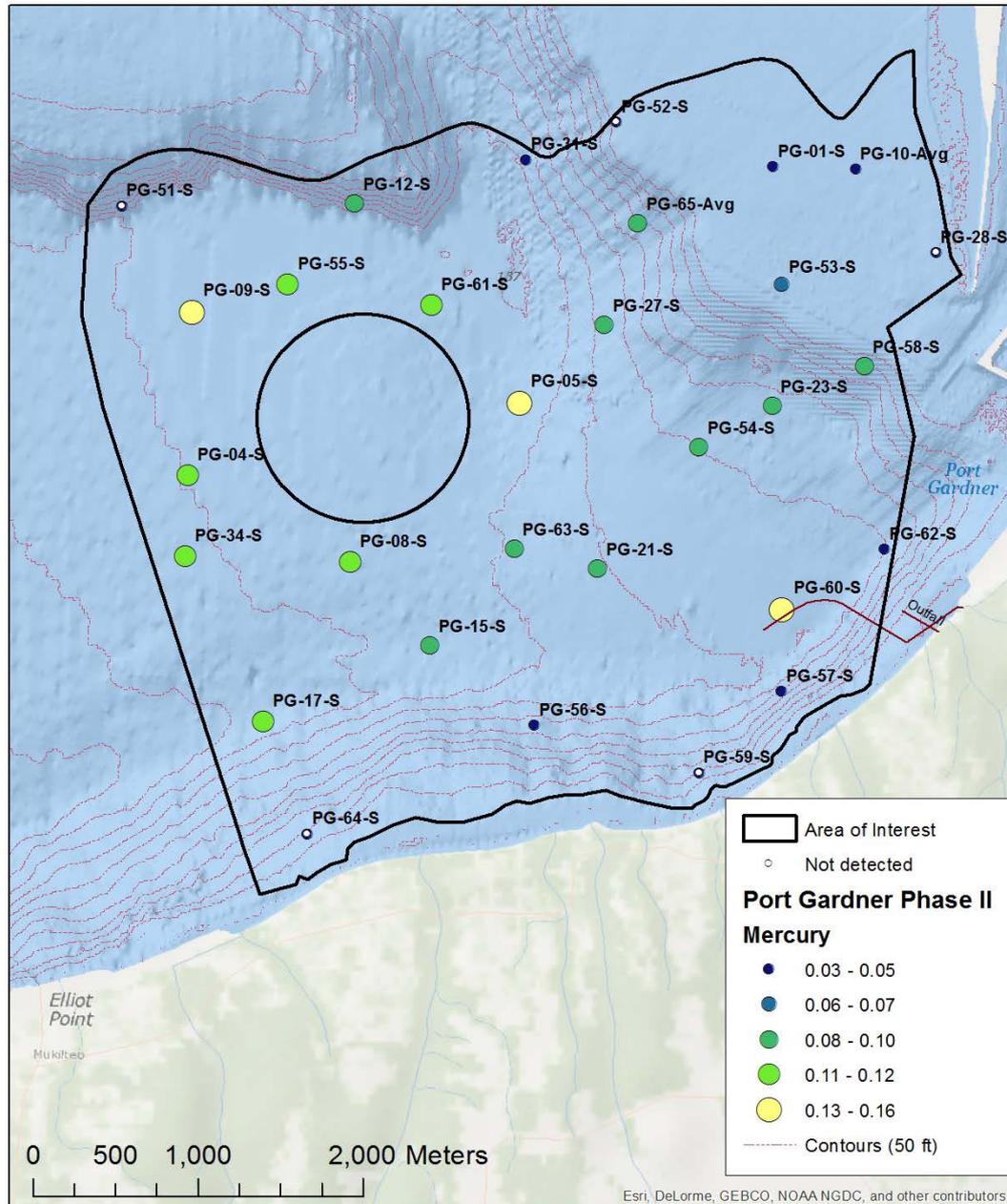


	Cadmium
	mg/kg DW
Summary Statistics	
Sample Size	27
Minimum	0.13
Average	0.31
Median	0.31
Maximum	0.61

Mercury

Correlated to fines with an r-value of 0.871 (TOC, 0.778)

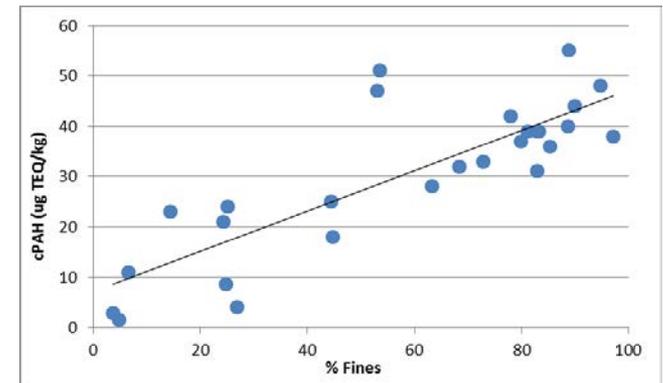
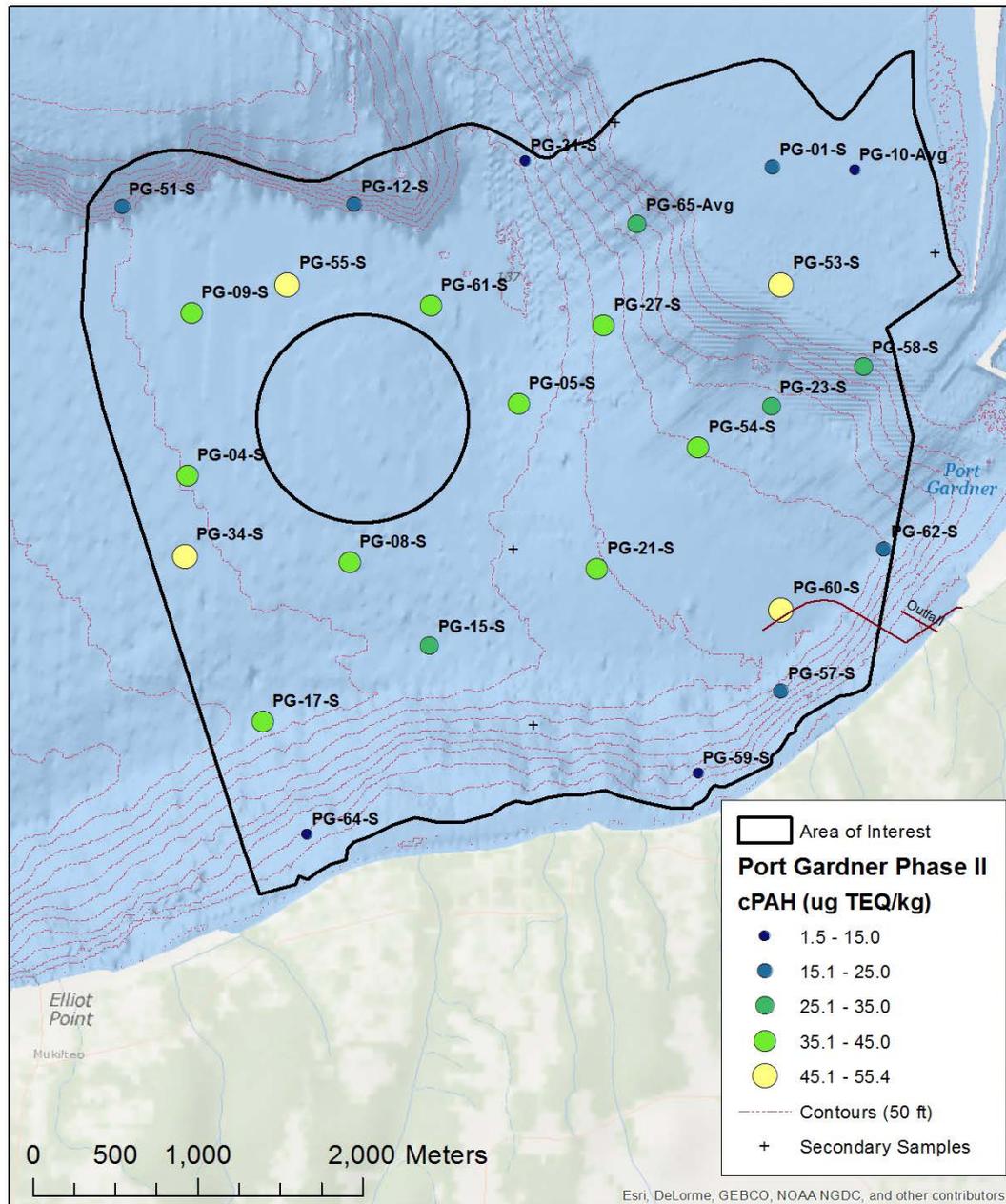
3 Phase II secondary samples included



	Mercury
	mg/kg DW
Summary Statistics	
Sample Size	30
Minimum	0.030
Average	0.081
Median	0.090
Maximum	0.16

Carcinogenic PAH TEQ

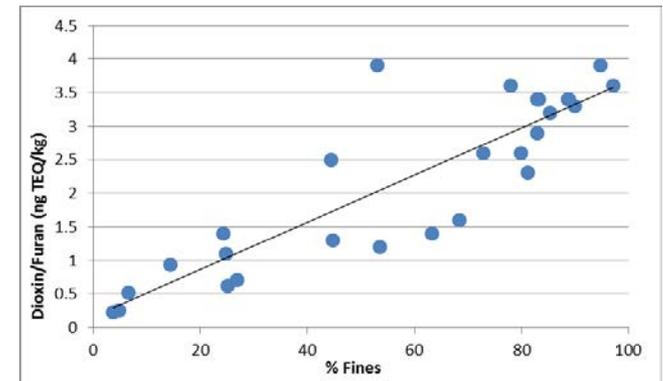
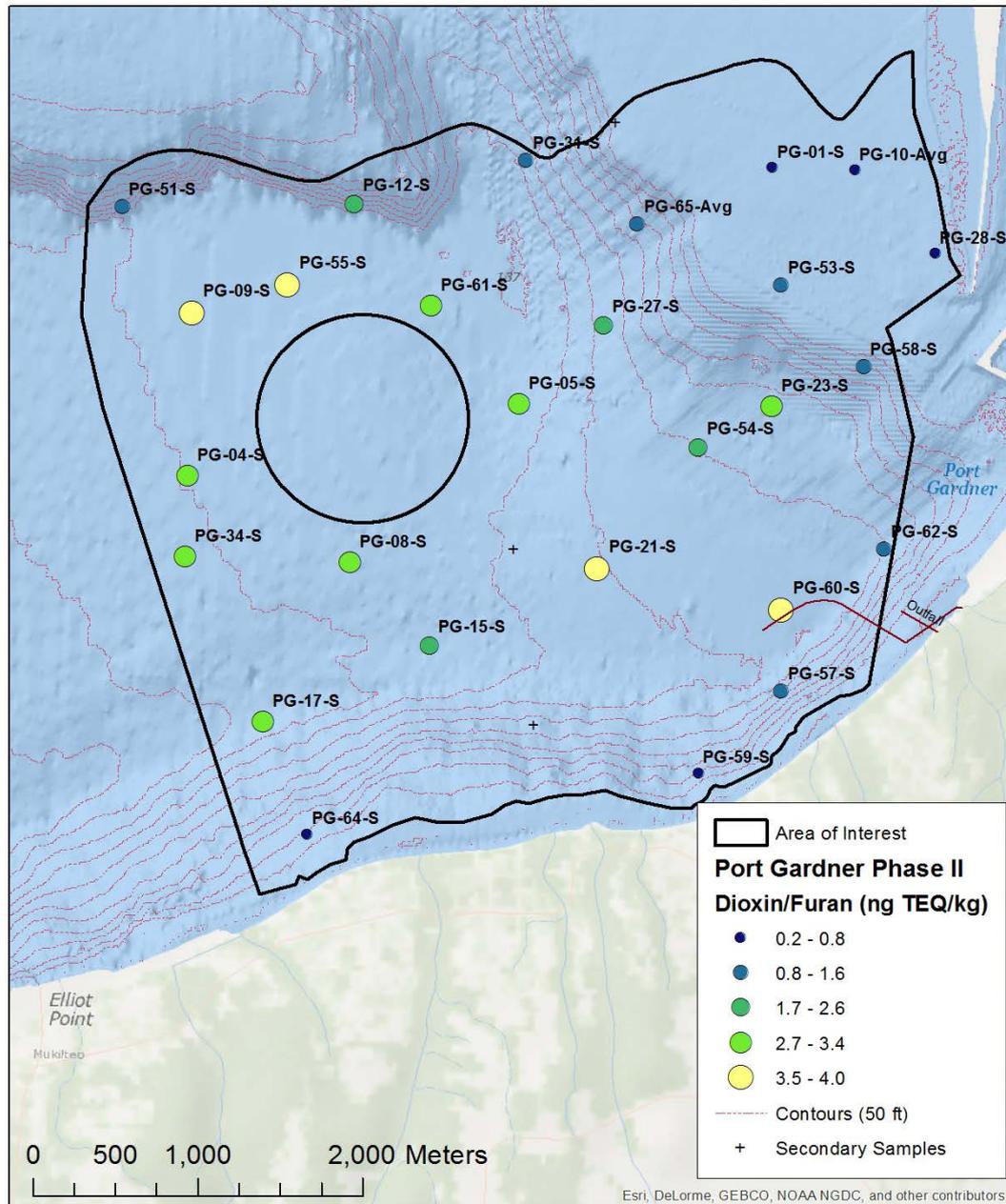
Correlated to fines with an r-value of 0.831
(TOC, 0.712)



	cPAH TEQ
	µg/kg
Summary Statistics	
Sample Size	27
Minimum	1.5
Average	30
Median	33
Maximum	55

Dioxin/Furan TEQ

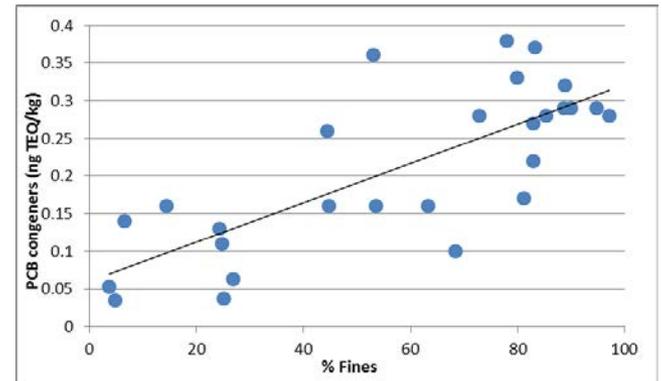
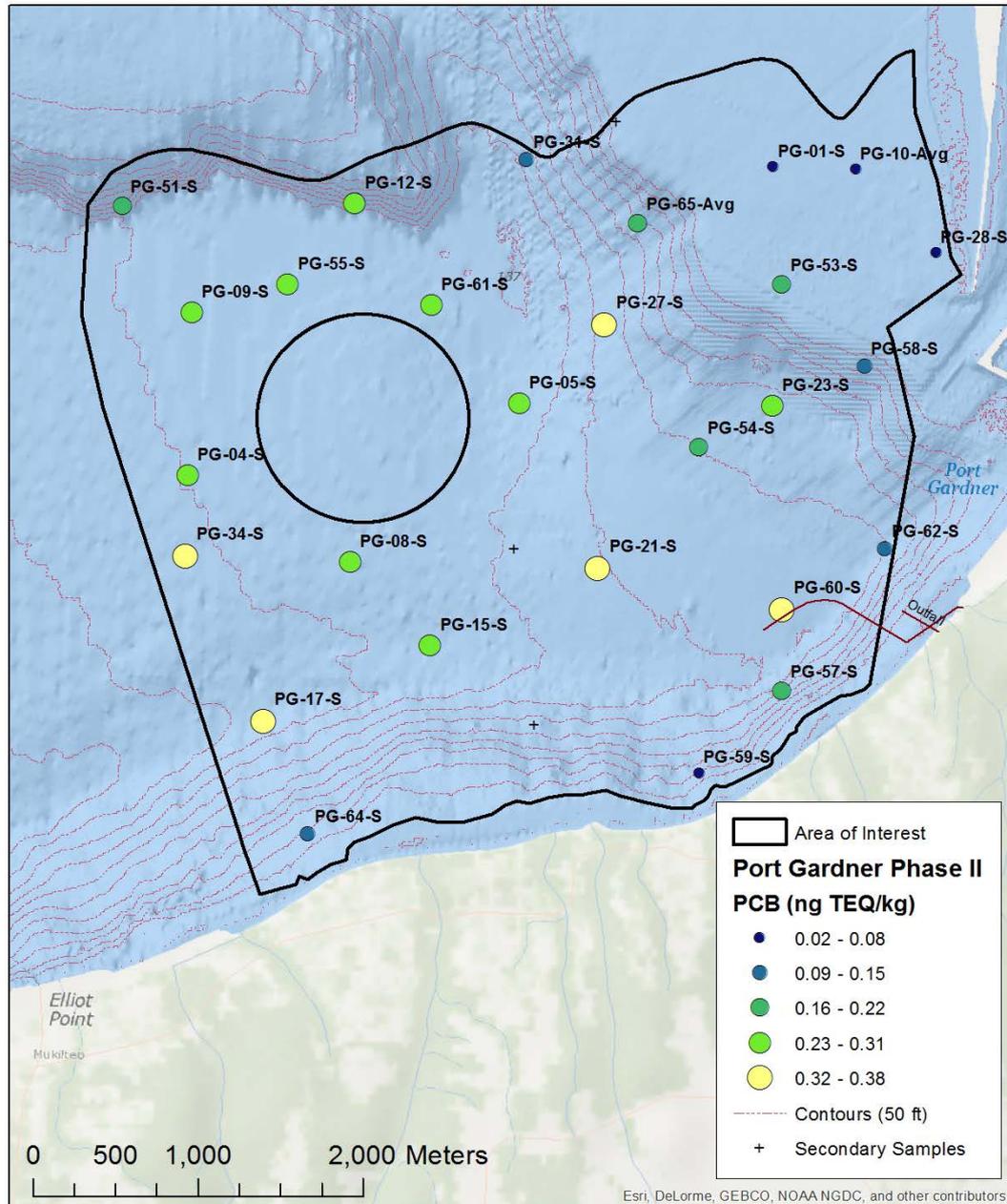
Correlated to fines with
an r-value of 0.879
(TOC, 0.782)



Location ID	D/F TEQ
Units	ng/kg
Summary Statistics	
Sample Size	27
Minimum	0.23
Average	2.2
Median	2.5
Maximum	3.9

PCB Congener TEQ

Correlated to fines with
an r-value of 0.764
(TOC, 0.749)



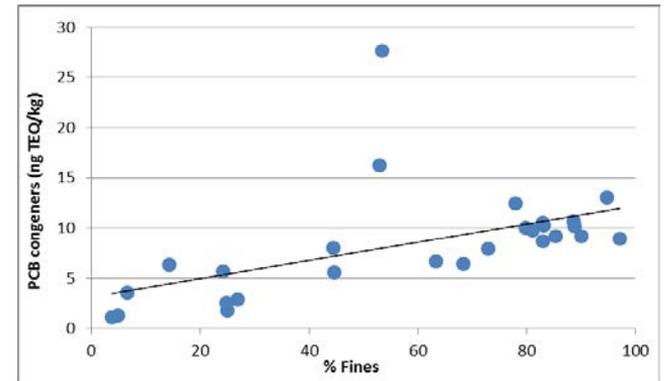
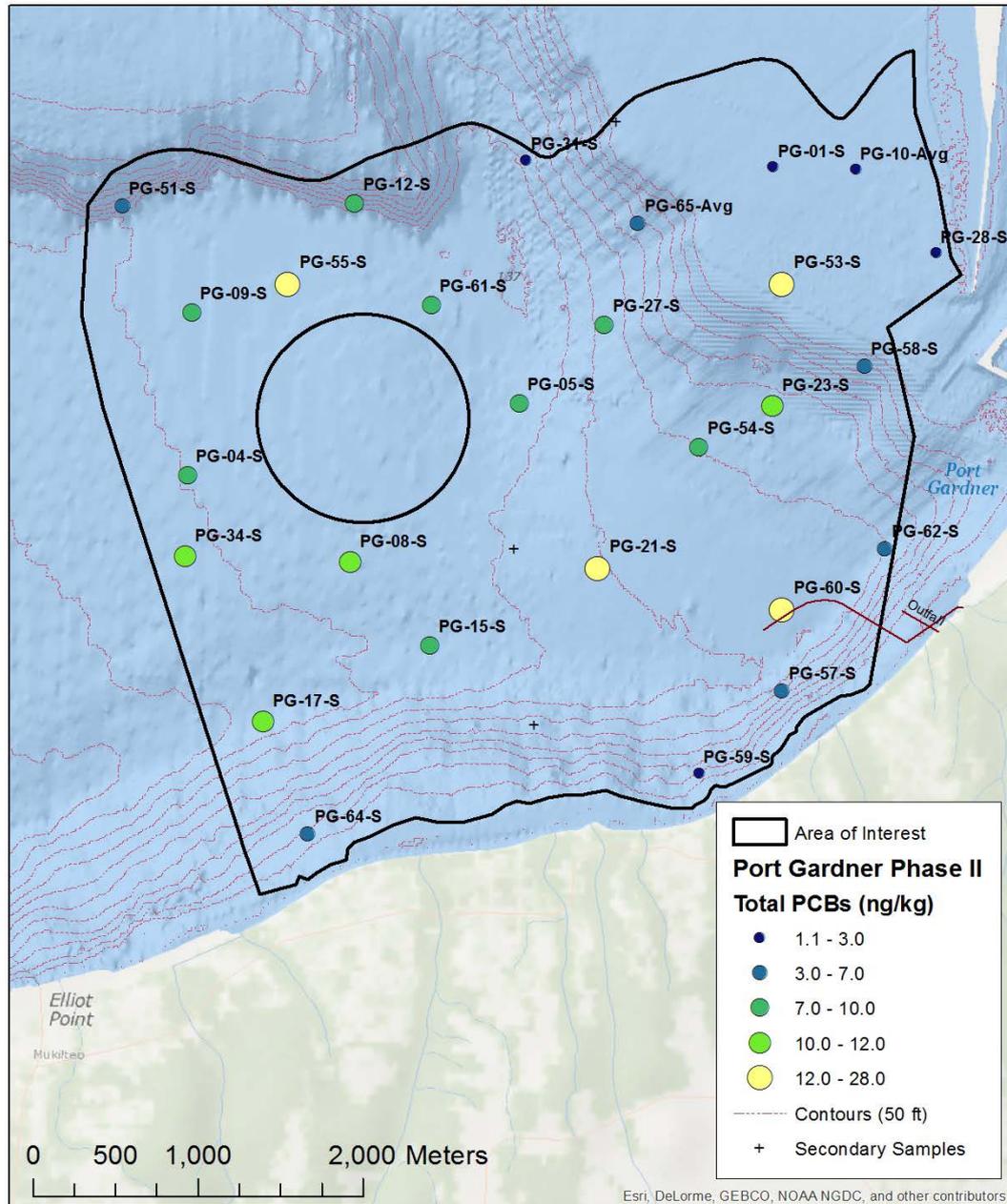
	PCB TEQ
	ng/kg
Summary Statistics	
Sample Size	27
Minimum	0.035
Average	0.20
Median	0.16
Maximum	0.38

Total PCBs

(sum of detected congeners)

Correlated to fines with
an r-value of 0.525

(TOC, 0.597)



	Total PCBs
	µg/kg
Summary Statistics	
Sample Size	27
Minimum	1.13
Average	8.37
Median	8.65
Maximum	27.6

*Total PCBs presented for reference purposes. 90/90 UTL values will only be calculated for PCB TEQ.

Statistical Analysis of Results

Analysis of Distributions

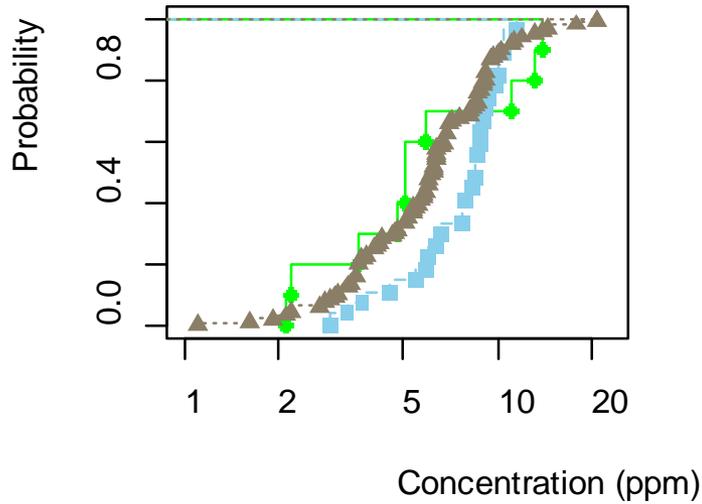
The results were evaluated using Empirical Cumulative Distribution Functions (ECDF) plots.

Some notes on interpreting ECDF plots:

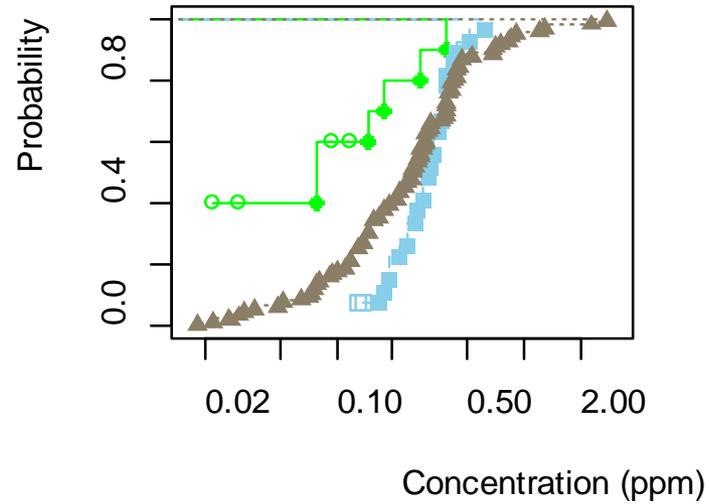
- The concentration is shown on the x-axis.
- The cumulative probability is shown on the y-axis.
- The shape of the curve describes the distribution of the data:
 - Curves shifted to the right indicate higher concentrations.
 - Steeper curves have less variance (i.e., many samples within small concentration range).
 - Flatter or skewed curves have larger variance (i.e., fewer samples across a large concentration range).
- Port Gardner results were compared to the Bold Plus data set using ECDF plots.

ECDF Plots for Metals

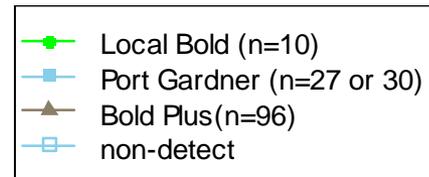
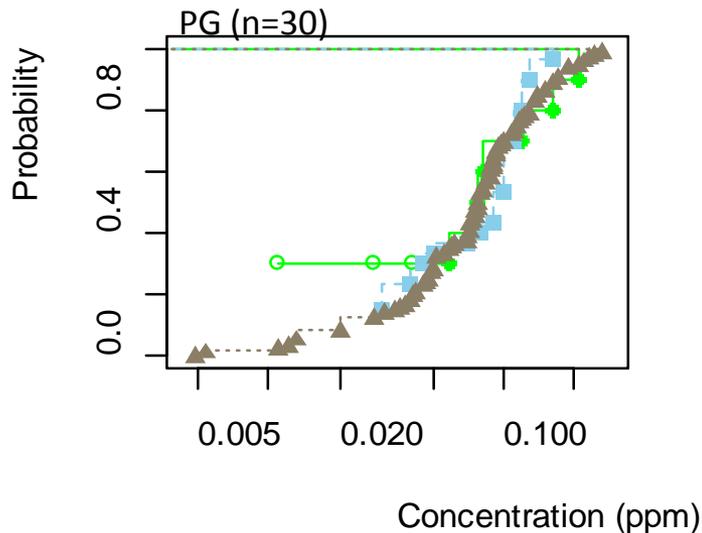
Arsenic



Cadmium



Mercury

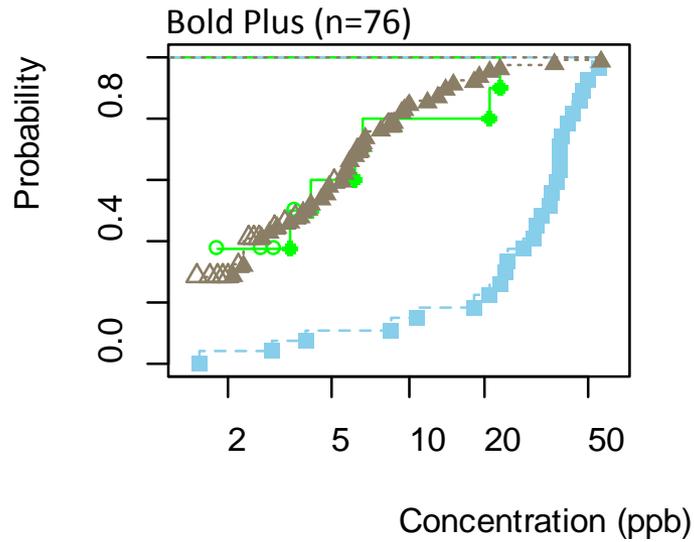


*The 'Local Bold' data set is comprised of 5 samples from Port Susan (PSPS) and 5 samples from North Central Puget Sound (NCPS) – a subset of the Bold dataset. These values are shown here for a local comparison to the Port Gardner Regional data.

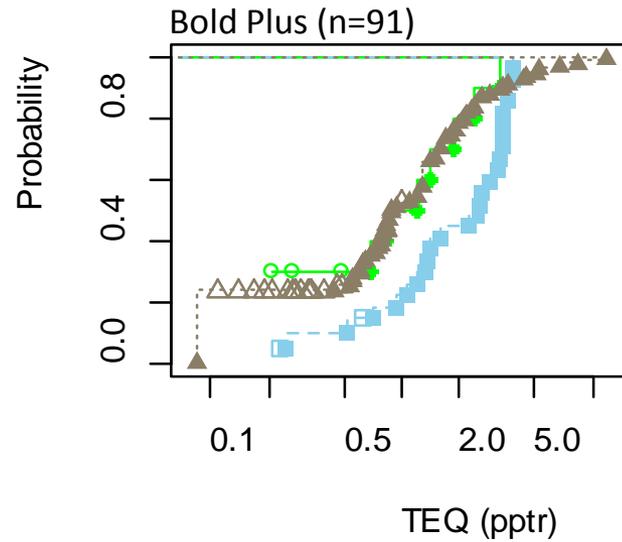
Dry Weight Concentrations

ECDF Plots for Organics

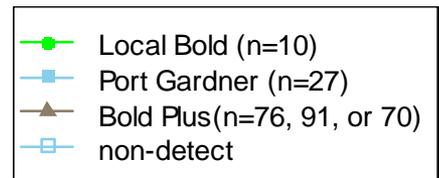
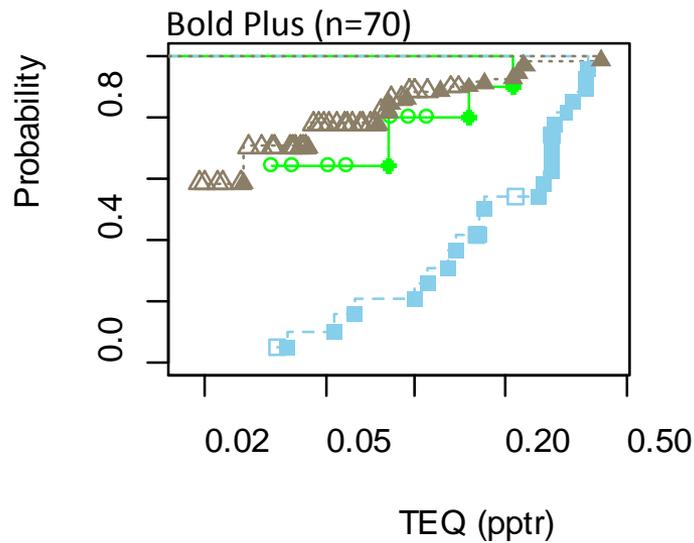
cPAH TEQ



Dioxin/Furan TE

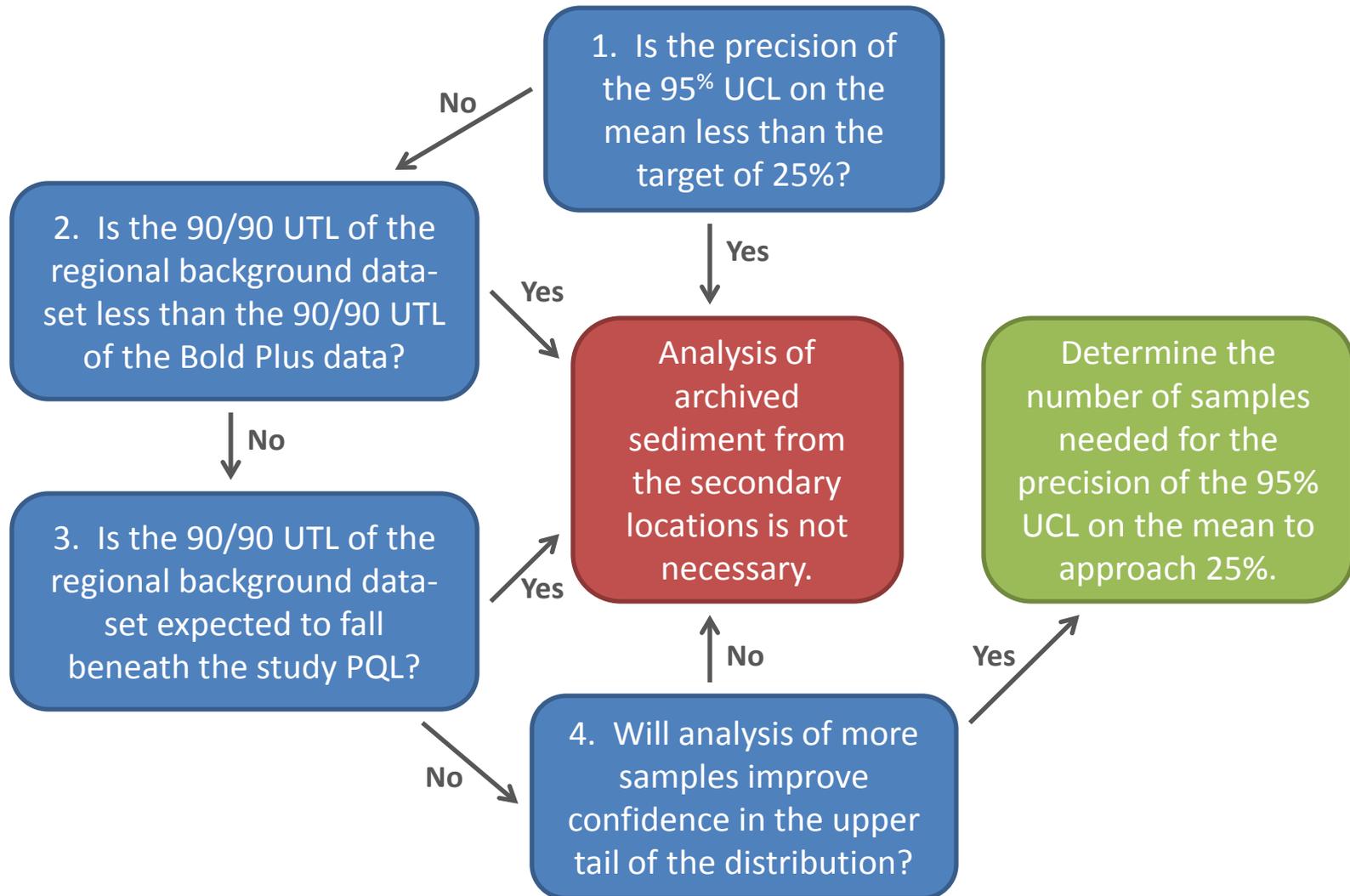


PCBs TEQ



Dry Weight Concentrations

Process for the Selection of Secondary Samples for Analysis



Decision Process for Secondary Sample Analysis

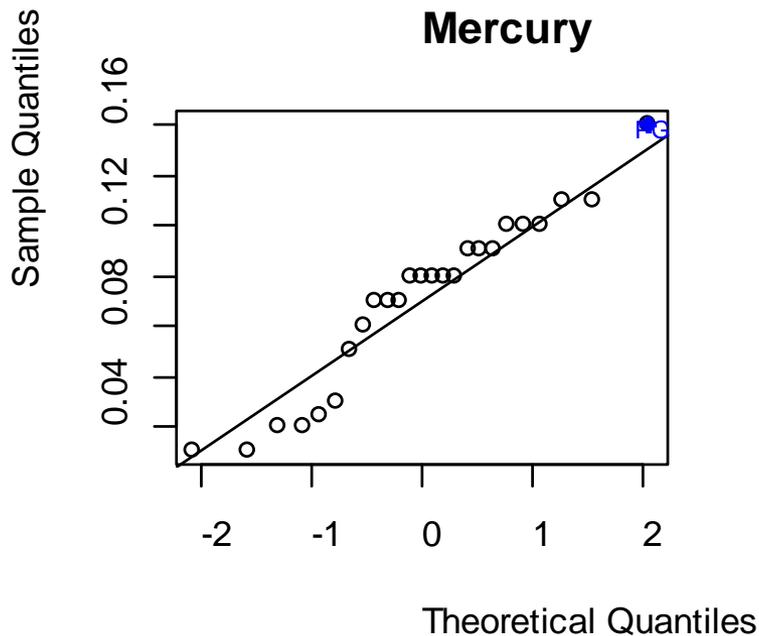
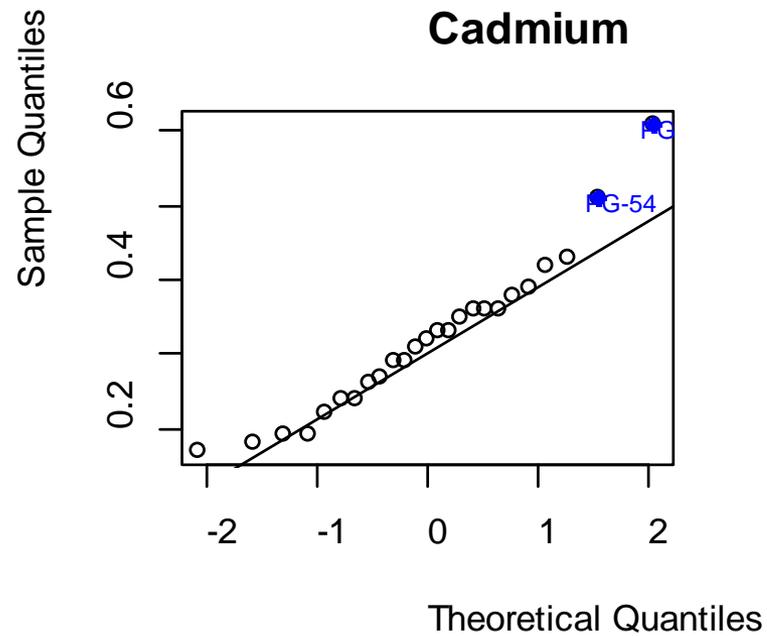
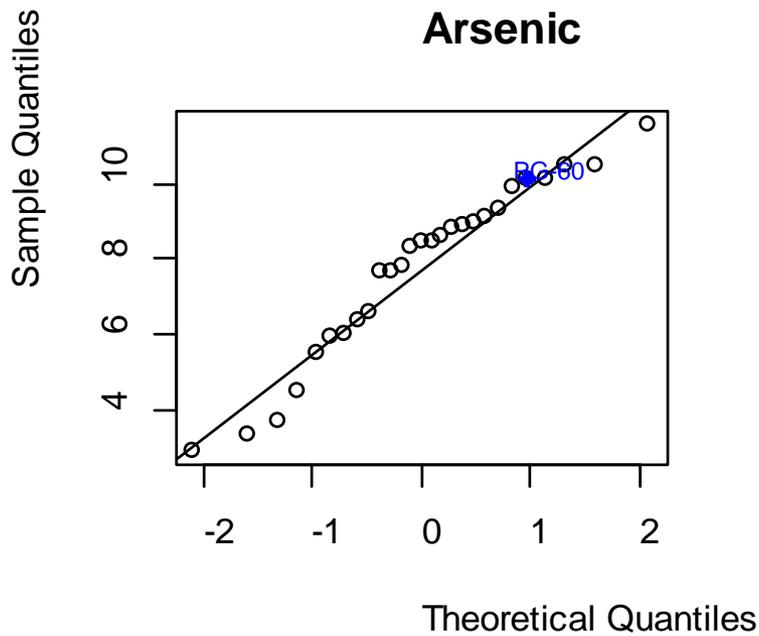
Step 1. All endpoints had excellent precision (<25%).

Step 2. Not required

Step 3. Not required

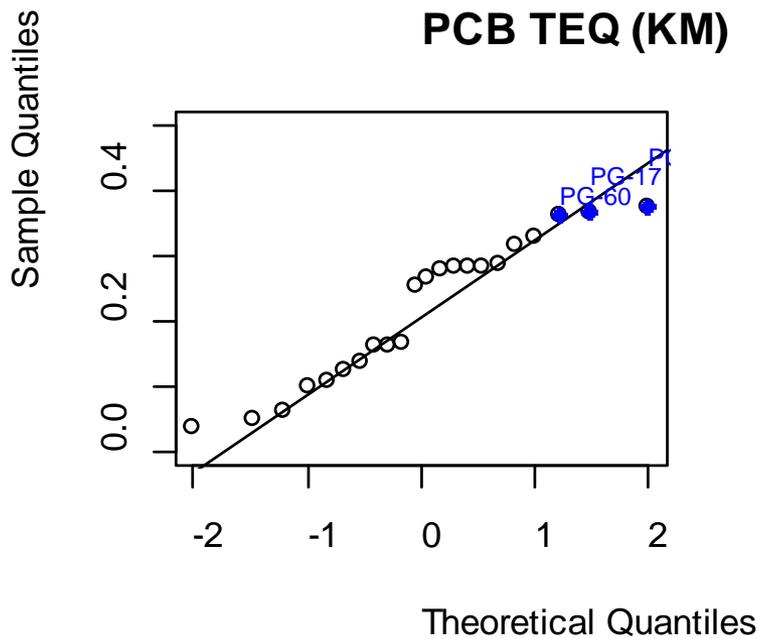
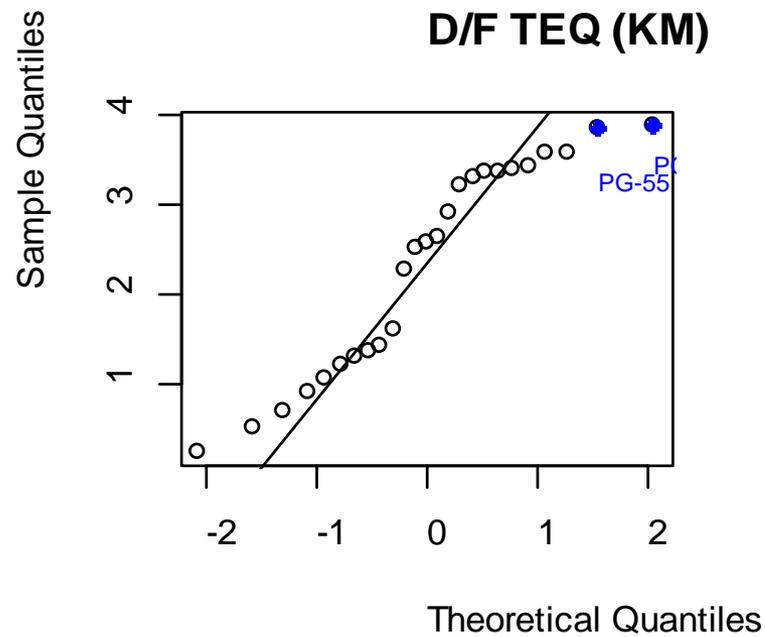
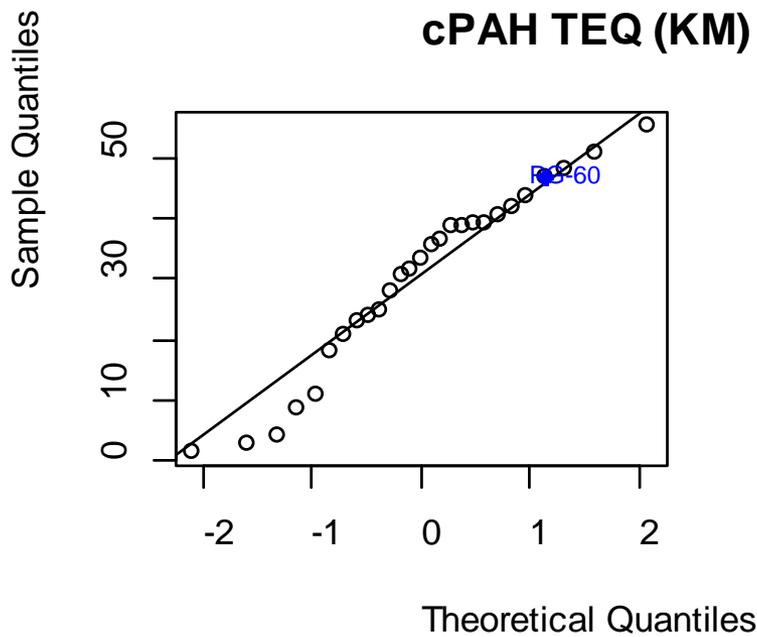
Step 4. Not required

Analysis of secondary samples not required.



Evaluation of PG-60 as a potential outlier:

- PG-60 is located near the diffuser outfall.
- PG-60 is in the upper tail for all metals, but is only a statistical outlier for cadmium.
- PG-60 falls within the Bold Plus natural background range for all metals, including cadmium.



Evaluation of PG-60 as a potential outlier:

- PG-60 is in the upper tail for all organics, but is not a potential statistical outlier.
- Concentrations are all within the range of natural background (Bold Plus).

Outlier Analysis for PG-60

- PG-60 was located near a potential point source (the diffuser outfall) and therefore, an outlier evaluation was conducted with respect to both the Port Gardner and Bold Plus data sets.
- Concentrations at this station were within the upper tail of the Port Gardner concentration distributions for all analytes.
- PG-60 had the maximum concentration for Port Gardner for both mercury and cadmium. However, only cadmium was a statistical outlier for the Port Gardner data set.
- The cadmium and mercury concentrations from PG-60 were just below the 90th percentile of the Bold Plus data set and the concentrations for other analytes were also within the Bold Plus distribution.
- Port Gardner concentrations are within natural background for the metals (see the final slide), so any statistical outliers for metals within Port Gardner are not expected to influence regional background.
- To test this hypothesis, the 90/90 UTL for Port Gardner was calculated both with and without the data for PG-60, and there were no significant differences in the results, even for chemicals with elevated regional backgrounds (e.g., cPAH TEQ = 56 vs. 55, PCB TEQ = 0.38 vs. 0.37).

Port Gardner Statistical Summary

Parameter	N	% Detect	Min	Median	Mean	Max	CV	Precision	Outliers	90/90 UTL	Dist'n
Arsenic (mg/kg)	27	100%	2.9	8.5	7.8	12	0.30	10%	none	12	N
Cadmium (mg/kg)	27	93%	0.13	0.31	0.31	0.61	0.35	11%	PG-60?	0.49	N
Mercury (ppm)	30	83%	0.03	0.090	0.081	0.16	0.49	15%	none	0.14	N
cPAH TEQ (KM; µg/kg)	27	100%	1.5	33	30	55	0.50	16%	none	56	N
Dioxin/furan TEQ (KM; ng/kg)	27	93%	0.23	2.5	2.2	3.9	0.57	19%	none	3.9	NP
PCBs TEQ (KM; ng/kg)	27	81%	0.035	0.16	0.20	0.38	0.60	19%	none	0.38	N

All data sets include both Phase 1 and 2 samples.

The precision column shows the half-width of the 95% UCL on the mean relative to the mean (e.g., for a normal distribution, $t \times \text{std.dev.}/\text{sqrt}(n)/\text{mean}$); the target value was 25%.

Outlier tests included Dixon's (normal data, $n < 25$), Rosner's (normal data, $n \geq 25$), or Tukey's rule of $2 \times$ IQR from median (non-parametric). *Multivariate outliers were not assessed.*

The distribution column shows N (normal), G (gamma), or NP (non-parametric). The best distribution was determined by the goodness-of-fit tests in ProUCL (detected concentrations only).

Port Gardner vs. BOLD Plus

Analyte	Units	Port Gardner	Bold Plus
Arsenic	(mg/kg)	12	11
Cadmium	(mg/kg)	0.49	1
Mercury	(mg/kg)	0.13	0.2
cPAH TEQ	(µg/kg)	56	16
Dioxin/furan TEQ	(ng/kg)	4	4
PCB TEQ	(ng/kg)	0.4	0.2

- Arsenic, cadmium, mercury, and dioxin/furan concentrations in Port Gardner are consistent with natural background.
- cPAH TEQ and PCB TEQ have elevated regional backgrounds compared to Bold Plus.
- Port Gardner values are the 90/90 UTLs from the previous slide.
- Bold Plus 90/90 UTL values are from Table 11-1 of the draft SCUM II, publication no12-09-057.