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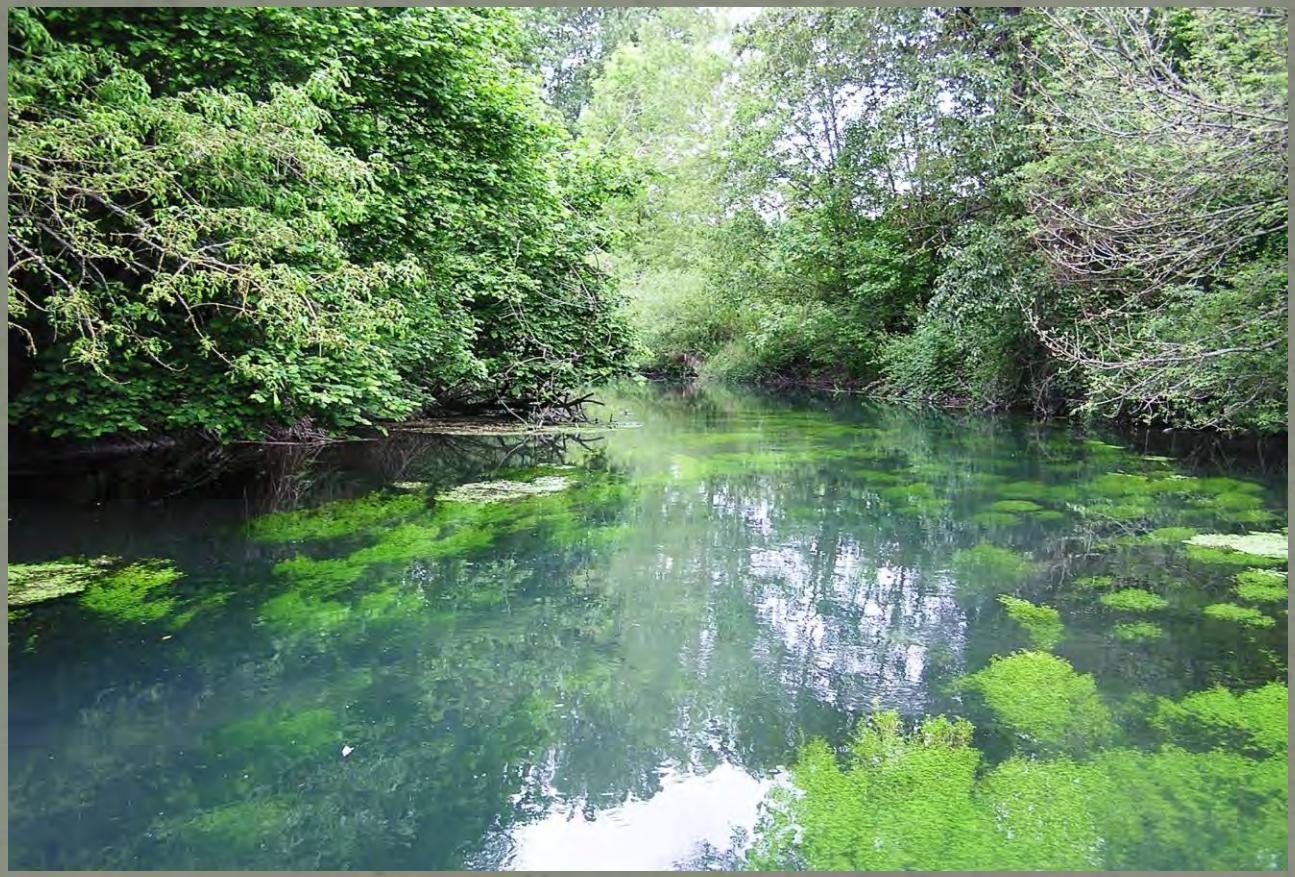
Quality

Columbia Slough Sediment Study



DEQ Cleanup Program- Northwest Region
Paul Seidel; Annette Dietz; Jennifer Sutter; Bob Williams; Sarah Miller; Ken Cameron
Funded by EPA Grant #**EM-96054601-0**

Columbia Slough- Previous information

- Previous investigations provide baseline of data which was used and supplemented.
- Previous Portland BES sediment data provides understanding of sediment contamination- 1994, 2005
- USGS deployed semipermeable membrane devices (SPMDs) in the water column 2004, 2005.
- Portland BES fish (carp) sampling in 2005

Columbia Slough Sediment Study

- Objectives of Study
  - Determine average concentrations of contaminants in slough sediment and developing new, updated estimates of baseline concentrations in the sampled segments
  - Development of predictive relationships between sediment and fish tissue: DEQ's 2009 work found good correlations between sediment and fish tissue.
  - Validate DEQ's bioaccumulation guidance using data specific to the Columbia Slough.
  - Perform exploratory multivariate analyses and PCB source attribution.

Sampling Design

- **Incremental Sample**-Three 2-mile reaches of the Columbia Slough surrounding prior fish tissue collection areas. 50 incremental locations were evenly spaced and placed into three replicates to produce a statistically valid average.

- **Targeted Sites**-Four sites with 5-8 locations in each composite sample near possible elevated sediment concentrations.

- **Bioaccumulation**- Sediments collected at targeted sites to determine worm tissue uptake from Slough sediments in a controlled laboratory

COLUMBIA SLOUGH INCREMENTAL SAMPLE SCHEME

N

- Lower Slough 2009 IS sample
- Whitaker 2011 IS sample
- Upper Upper IS sites
- Upper Middle IS sites
- Lower Middle IS sites
- Slough Waterway

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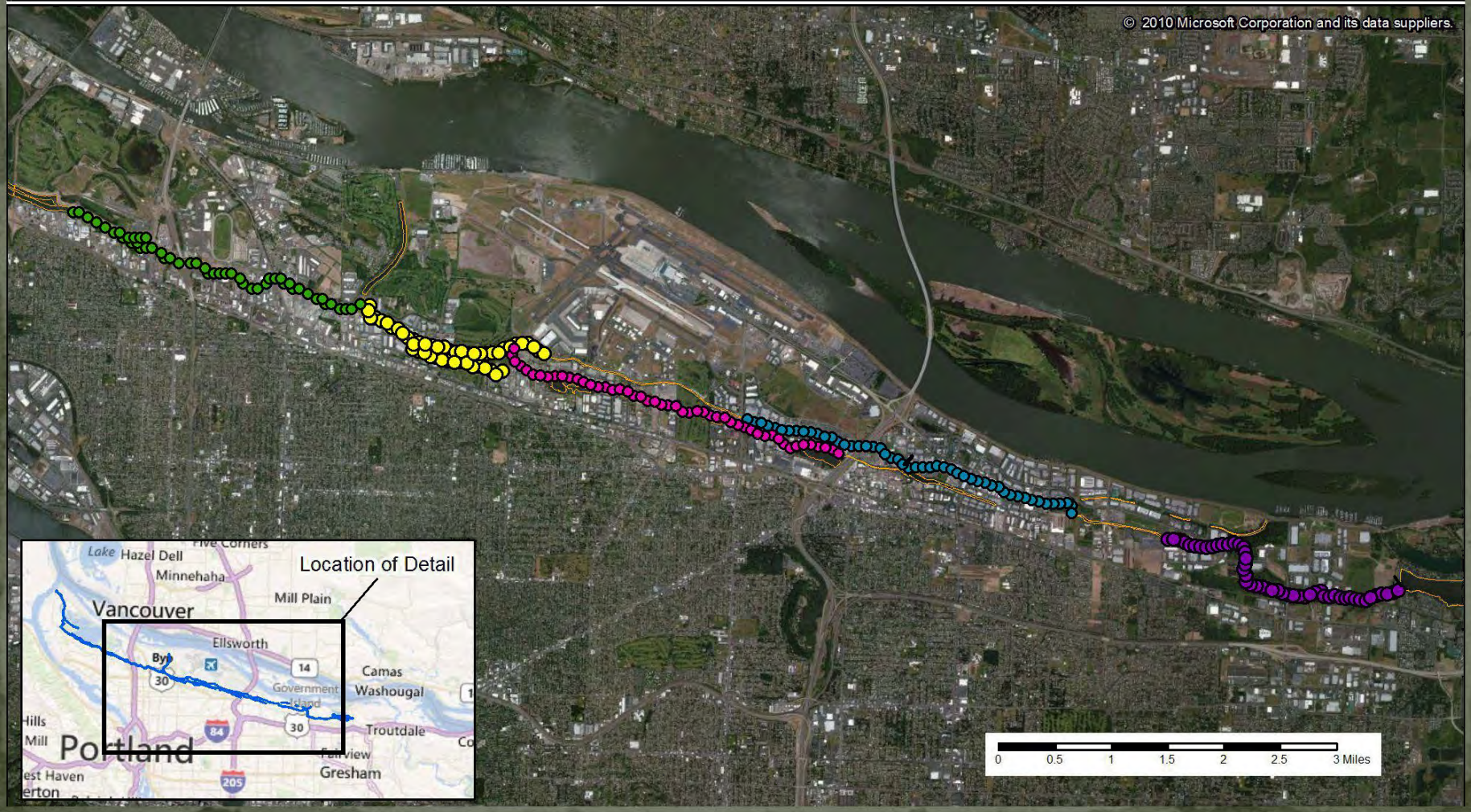

COLUMBIA SLOUGH INCREMENTAL SAMPLE SCHEME

Lower Middle Buffalo Slough

N

Incremental Sample Location

Increment Sample A

Increment Sample B

Increment Sample C

Targeted Sites

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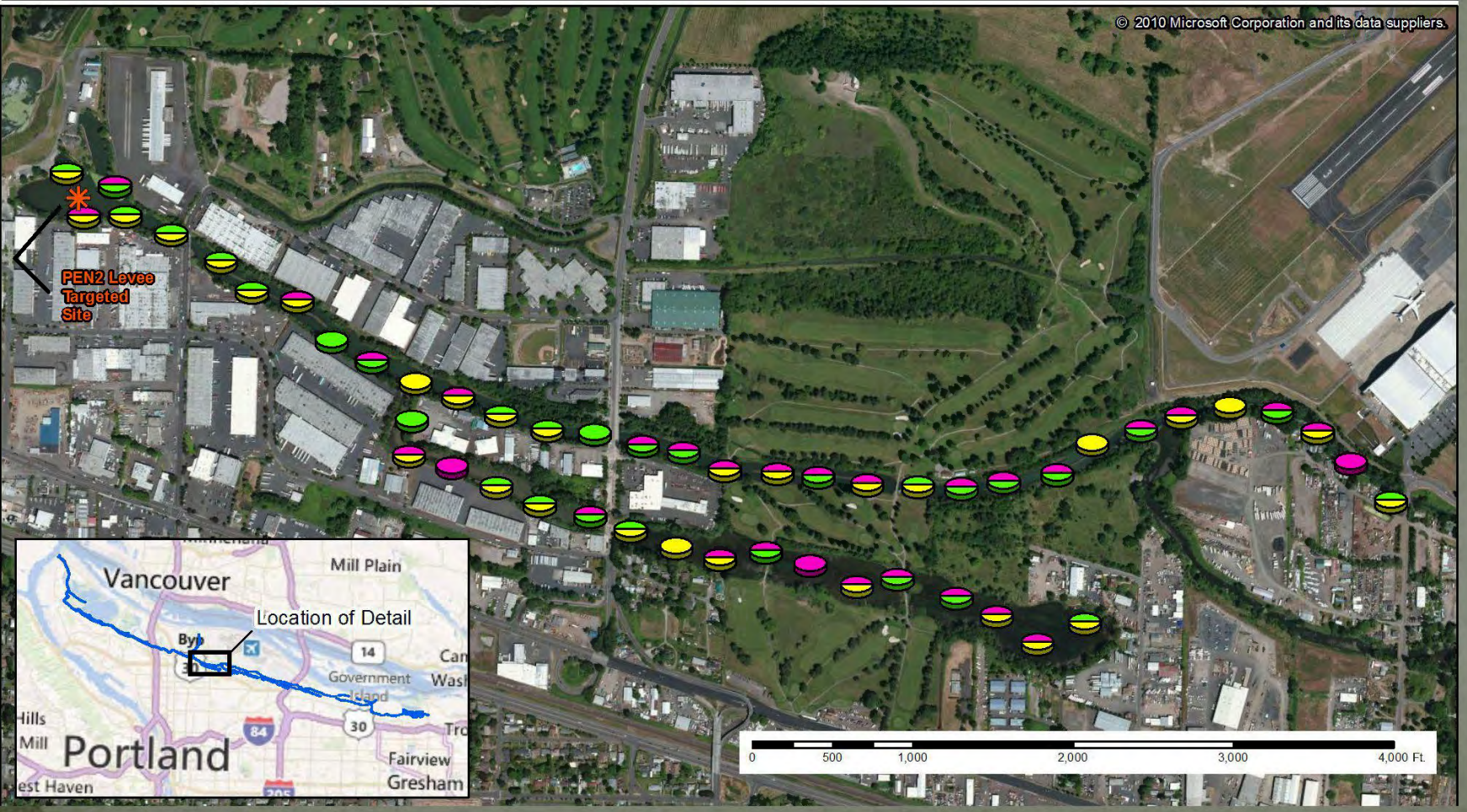

COLUMBIA SLOUGH INCREMENTAL SAMPLE SCHEME

Upper Middle Slough

N

Incremental Sample Location
Increment Sample A
Increment Sample B
Increment Sample C
Targeted Sites

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COLUMBIA SLOUGH INCREMENTAL SAMPLE SCHEME

Upper Upper Slough

N

Incremental Sample Location
Increment Sample A
Increment Sample B
Increment Sample C
Targeted Sites

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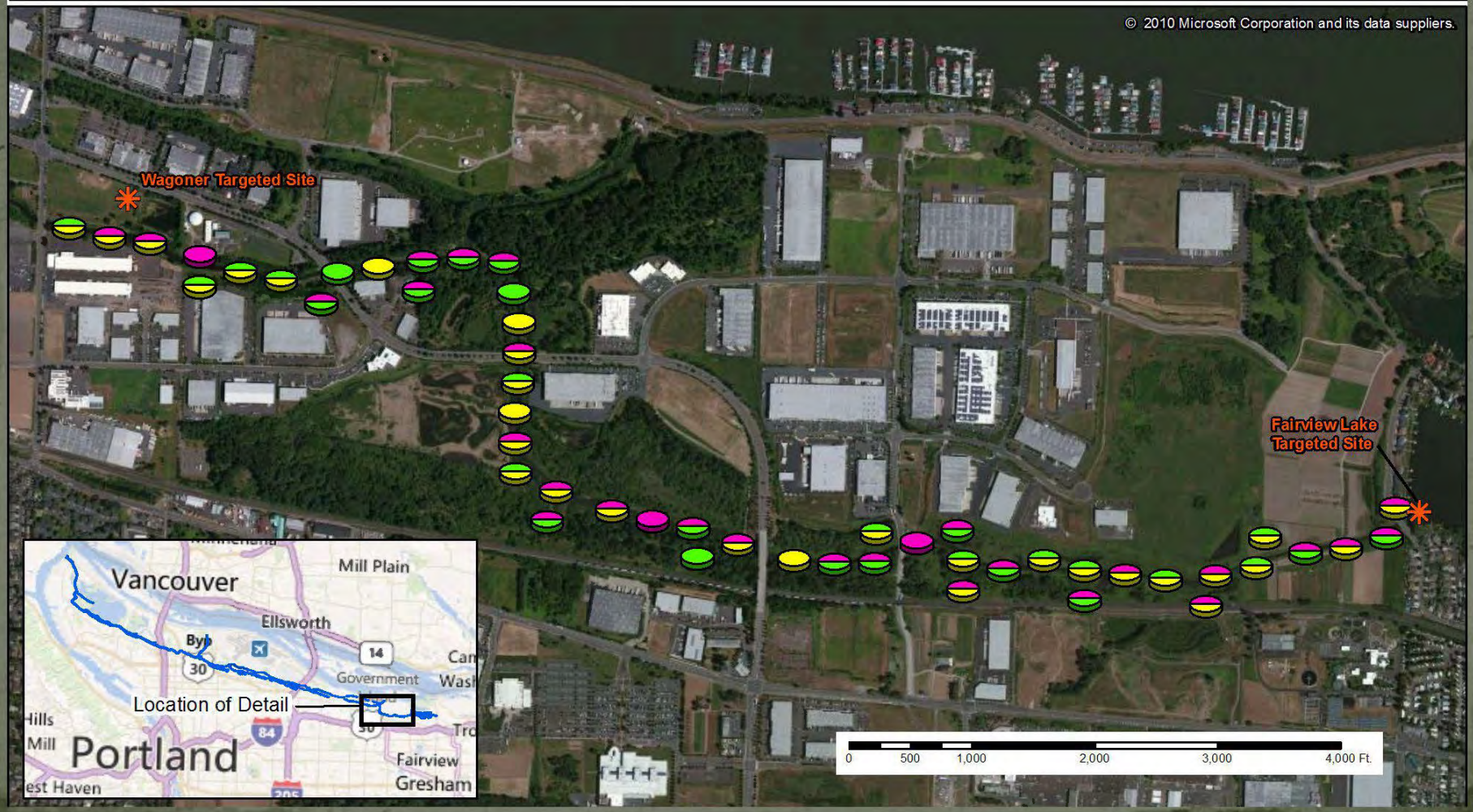


Sediment Analyses Performed

- Focus on Bioaccumulative Analyses-
- Pesticide EPA 1699- *high resolution pg/g*
- PCB-Aroclor EPA 8082
- PCB Congener EPA 1668A- *high resolution ng/kg*
- grain size/TOC/solids
- Bio-accumulation **test** with *Lumbriculus* worms*
  - Worm tissue analyzed for PCB Congeners and Pesticides

* Targeted sediment sites only.

Let the Sampling Begin!

Incremental Sampling Equipment

Aquatic Plants were constant companions!

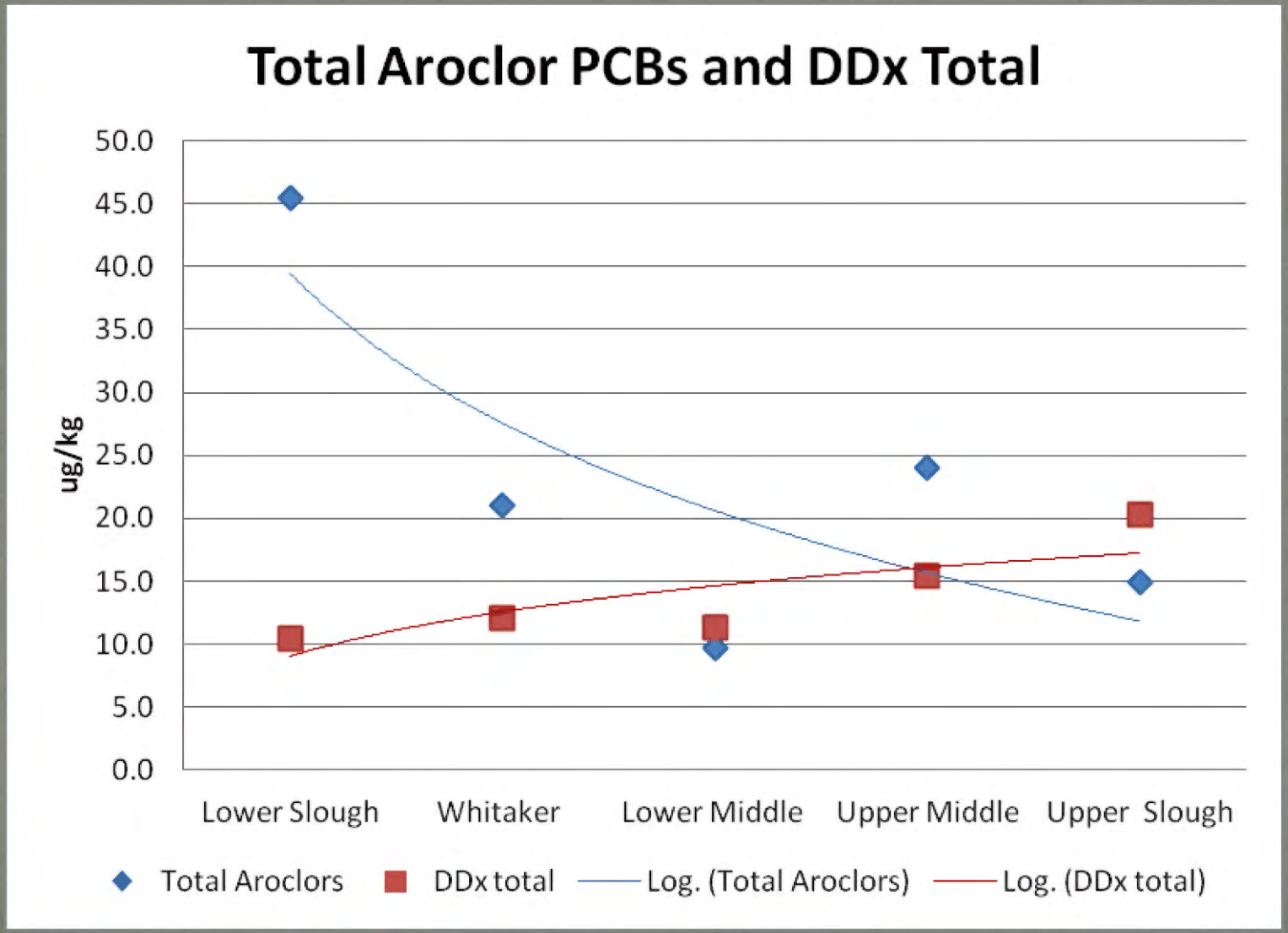
I asked for Mud Pie, not Salad Greens!!

Bioaccumulation Sample-how many gallons of sediment do you need to grow 100g of worm tissue?

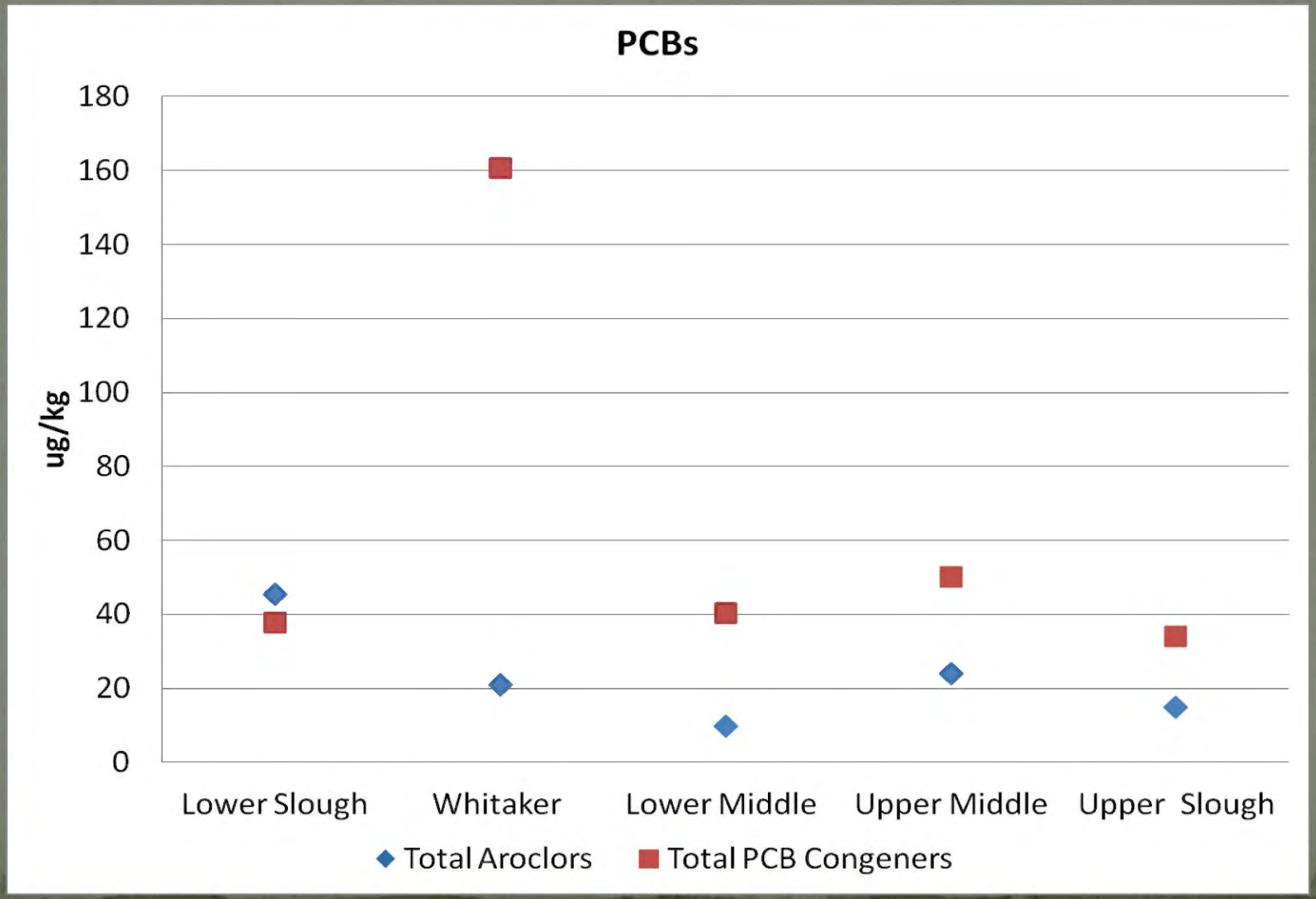
Triplicate Sediment Sample-QA review. Were samples less than 30% Relative Standard Deviation (RSD)?

Location	Parameter	Relative Percent Difference	Pass QA?
Lower Middle Columbia Slough	PCB Congeners Average of RSDs	32%	Just barely
Lower Middle Columbia Slough	Pesticide Average of RSDs	29 %	Yes
Upper Middle Columbia Slough	PCB Congeners Average of RSDs	26%	Yes
Upper Middle Columbia Slough	Pesticide Average of RSDs	24%	Yes
Upper Columbia Slough	PCB Congener Average RSDs	5%	Yes
Upper Columbia Slough	Pesticide Average of RSDs	17%	Yes

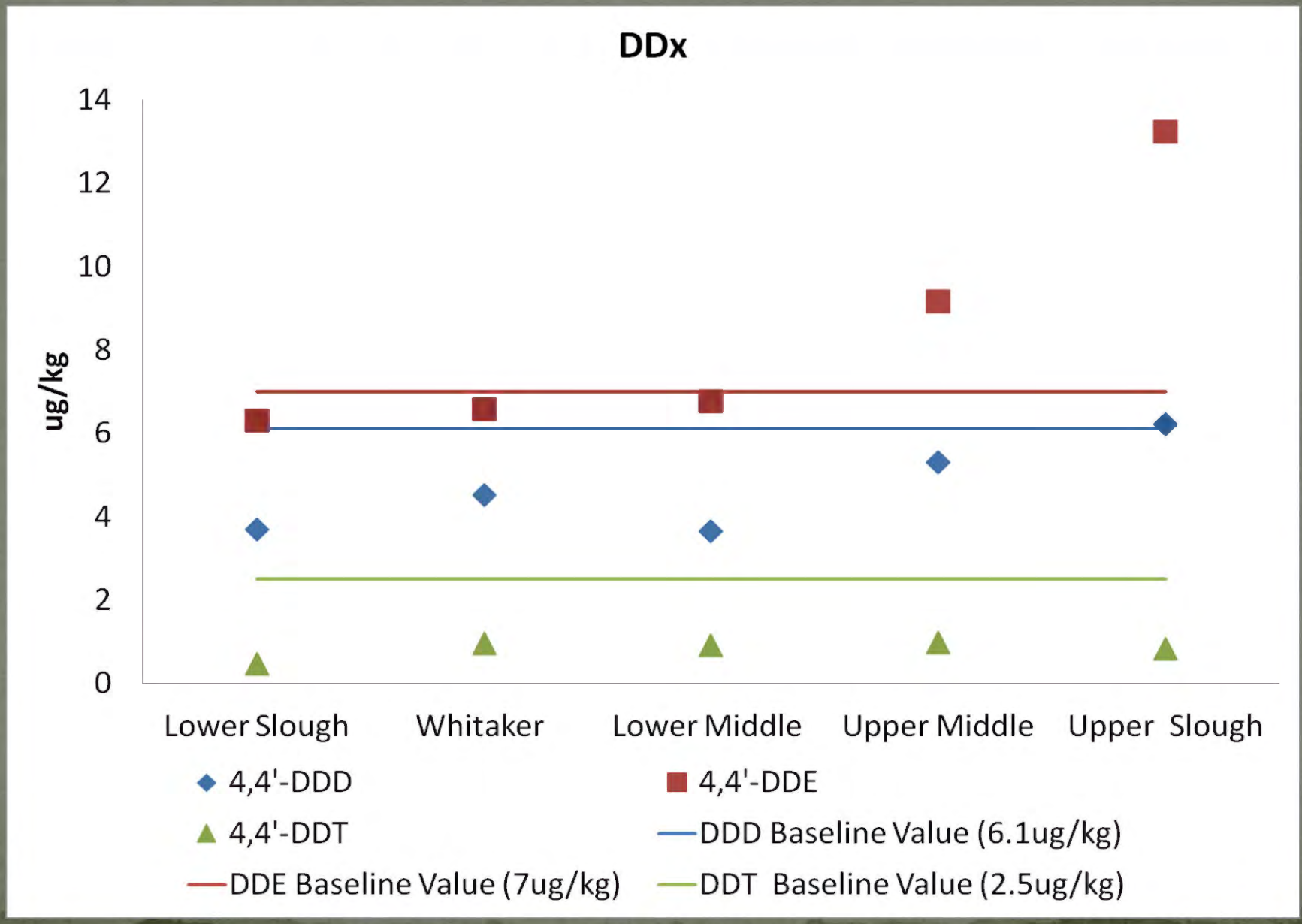
Columbia Slough Sediment: Average Total Aroclor PCB and DDx Concentrations



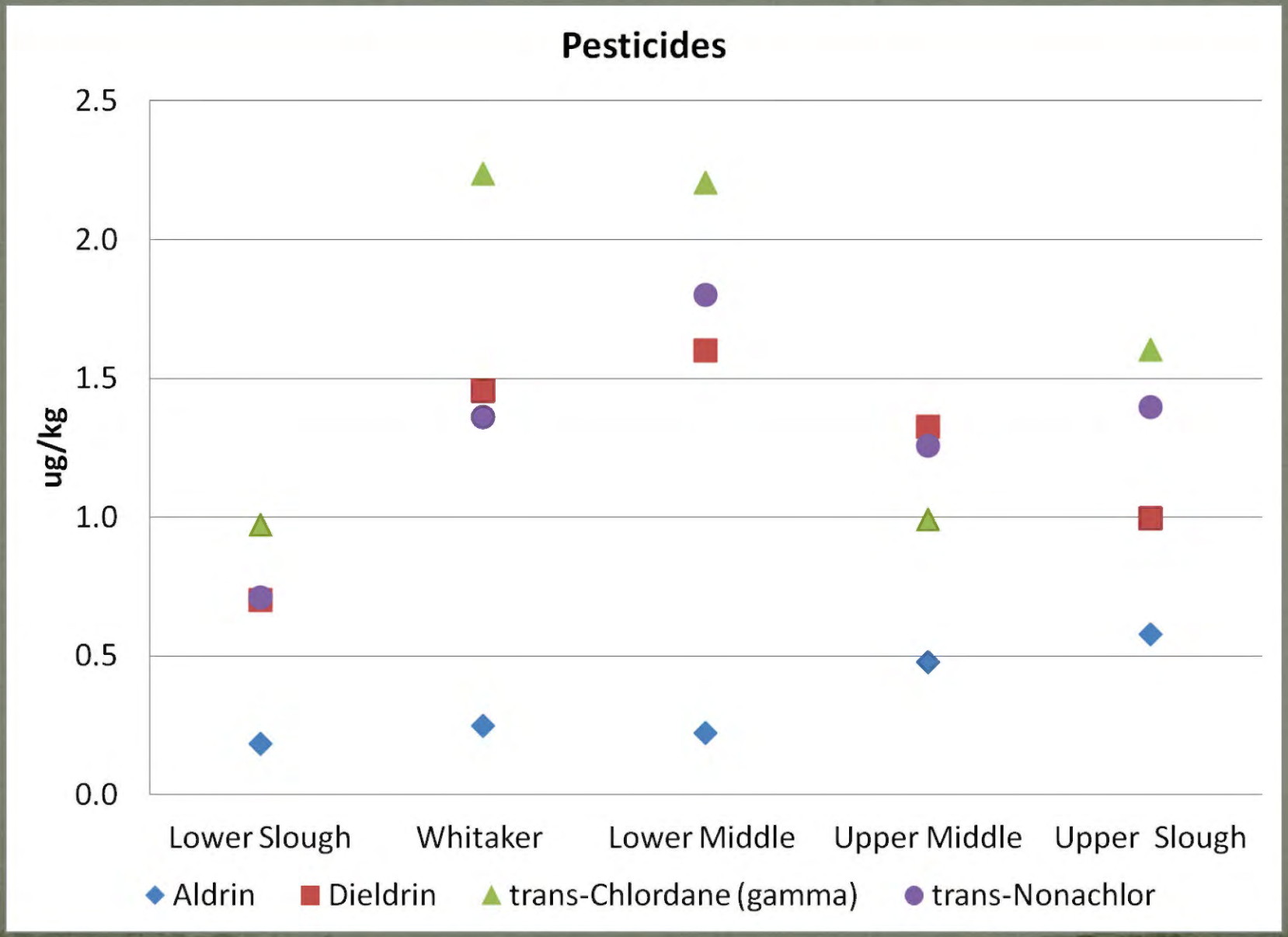
Columbia Slough Sediment PCB Average Concentrations



Columbia Slough Average DDx Concentrations



Columbia Slough Average Pesticide Concentrations



Targeted Site Sediment Results

Analyte-ug/kg	Pen 2 Levee	East of I-205	Wagner Mining	Fairview Lake
Total PCB Aroclors	7.7	15	29	3u
Total PCB Congeners	39	39	114	3
Total DDx	9.6	50	36	9.4

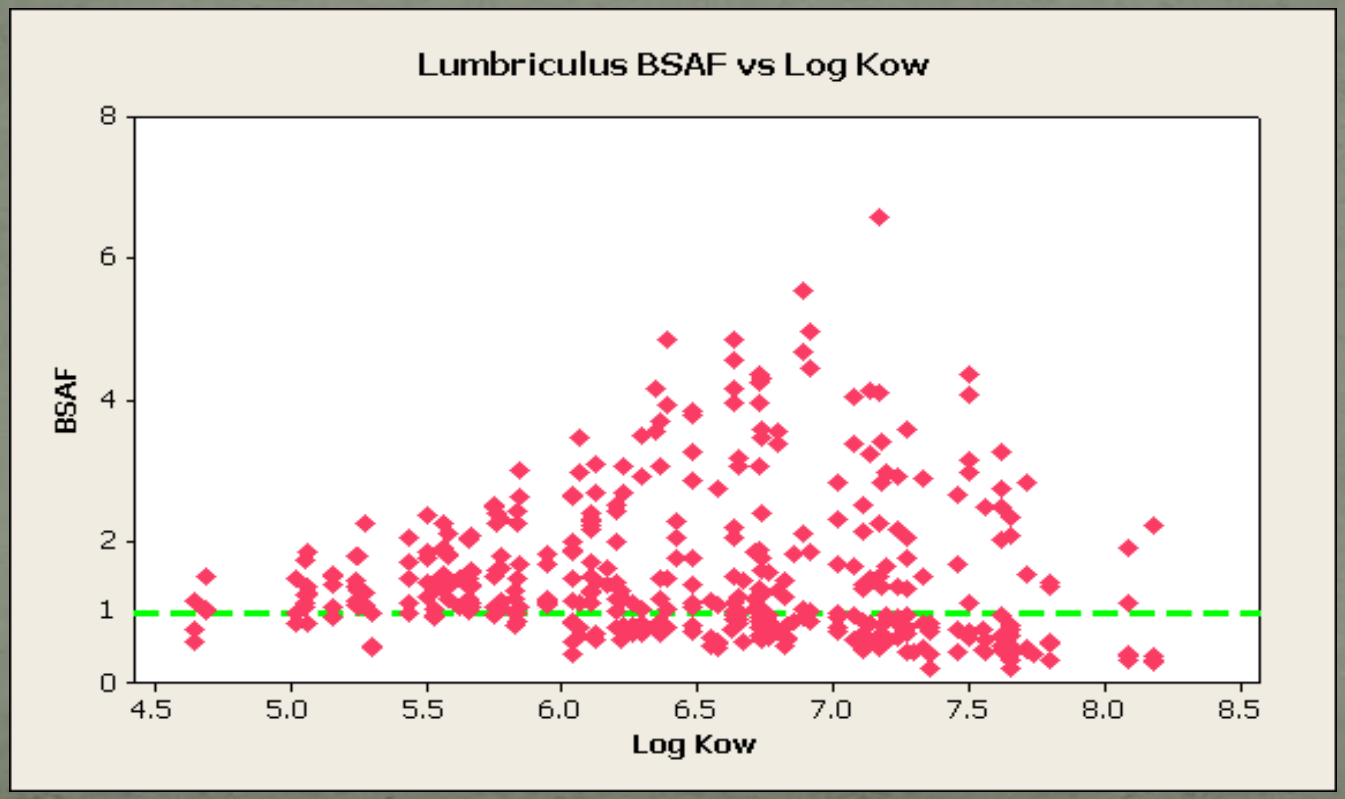
Pen 2 levee

Replicate Sample Results- PCBs (ug/kg)

Location	Total Congeners	RSD	Total Aroclors	RSD
Lower Slough	37.8	11.7%	40.5	34.2%
	33.5		29.9	
	42.4		59.1	
Lower Middle	56.6	40.8%	14.8	53.6%
	23.8		4.7	
	40.3		8.9	
Upper Slough	36.6	4.8%	15.6	8.9%
	33.9		13.4	
	33.6		15.8	
Upper Middle	67.6	36.1%	16.3	69.2%
	51.7		43	
	31.4		12.6	

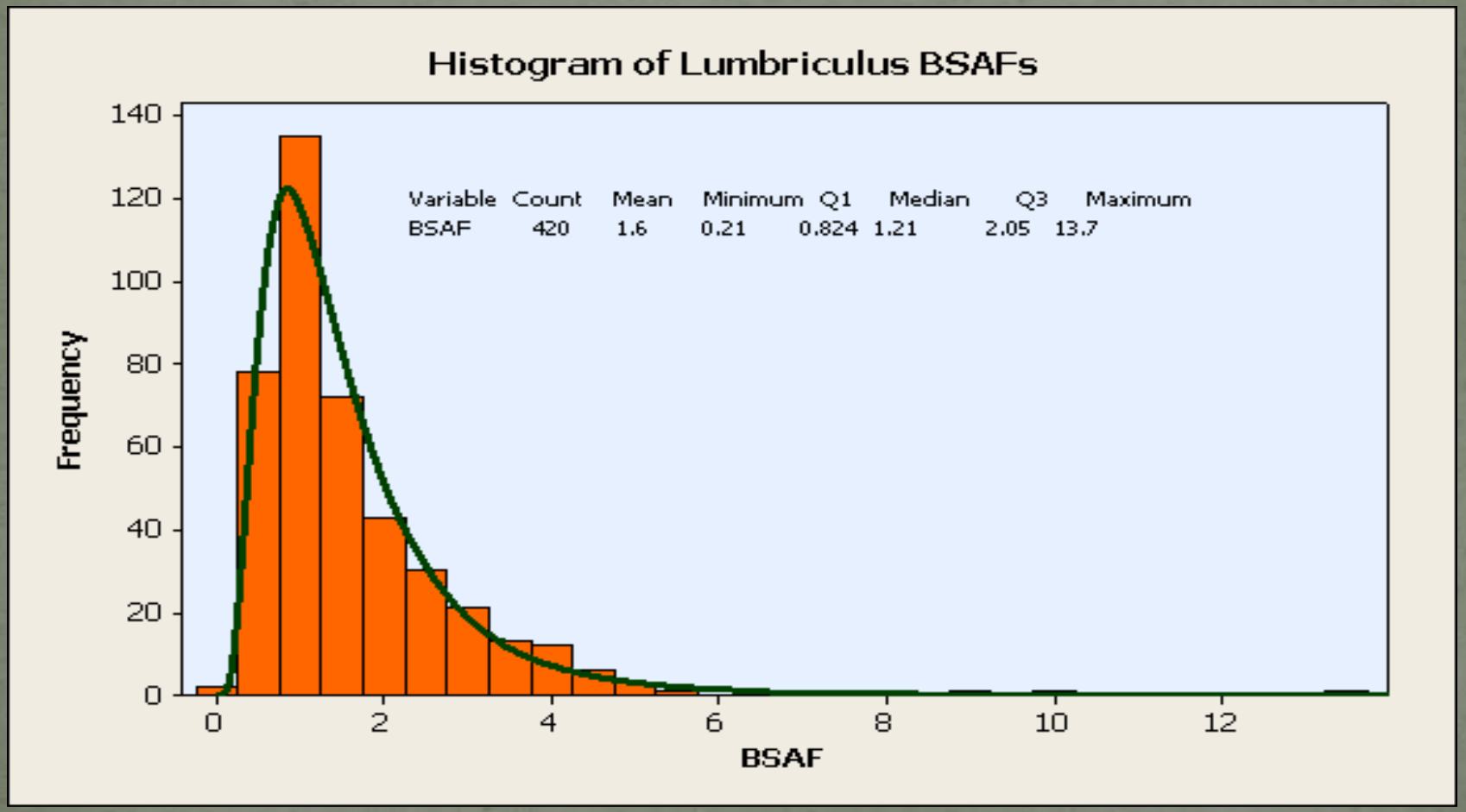
Invertebrate Biota-Sediment Factors

- BSAFs are “standardized” ratios of tissue to sediment: used as a measure of bioaccumulation potential.
- Calculated for each PCB congener detected in both sediment and Lumbriculus (worm) tissue .



Invertebrate Biota-Sediment Factors

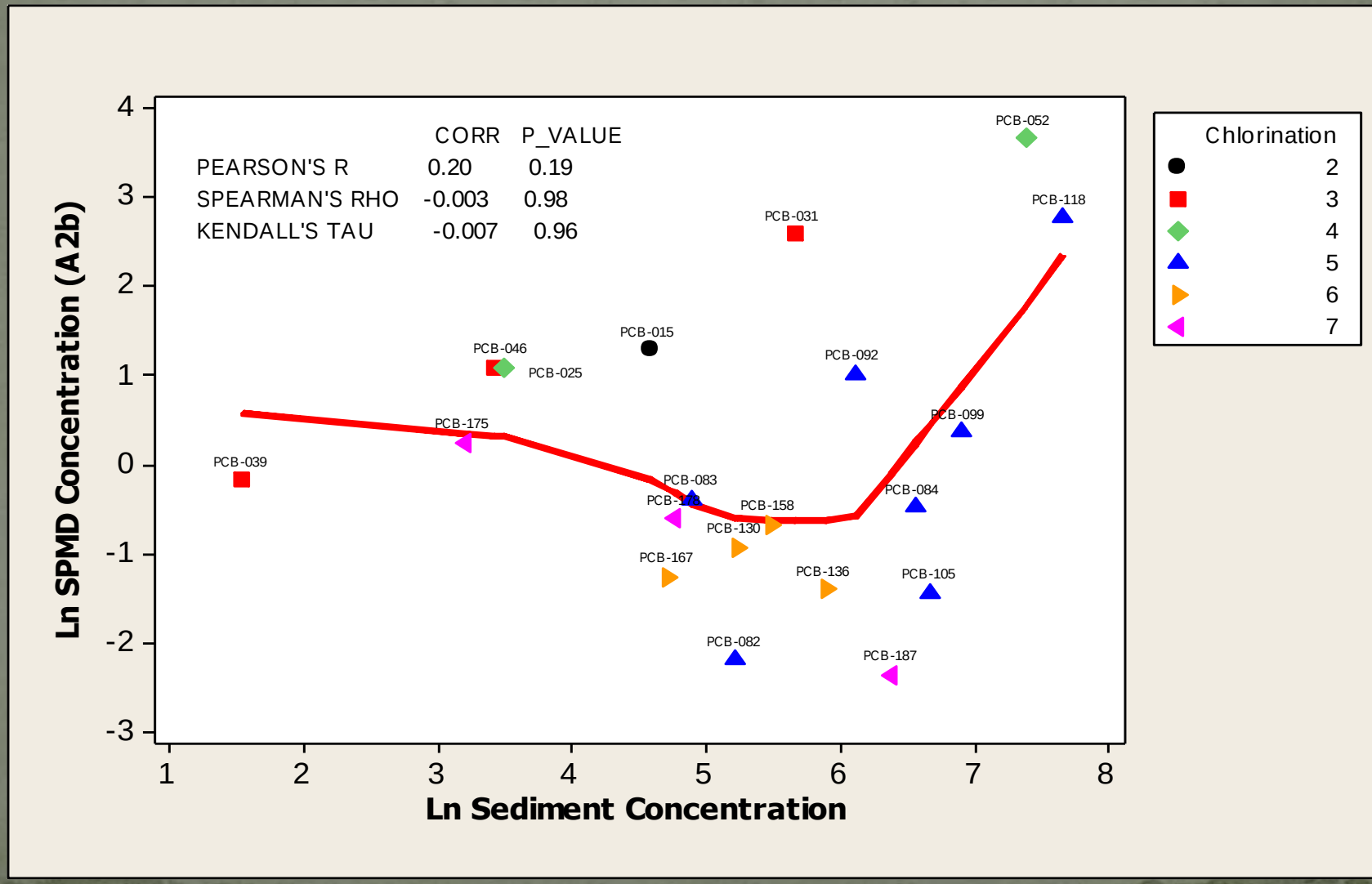
For all PCB Congeners combined most BSAFs < 2



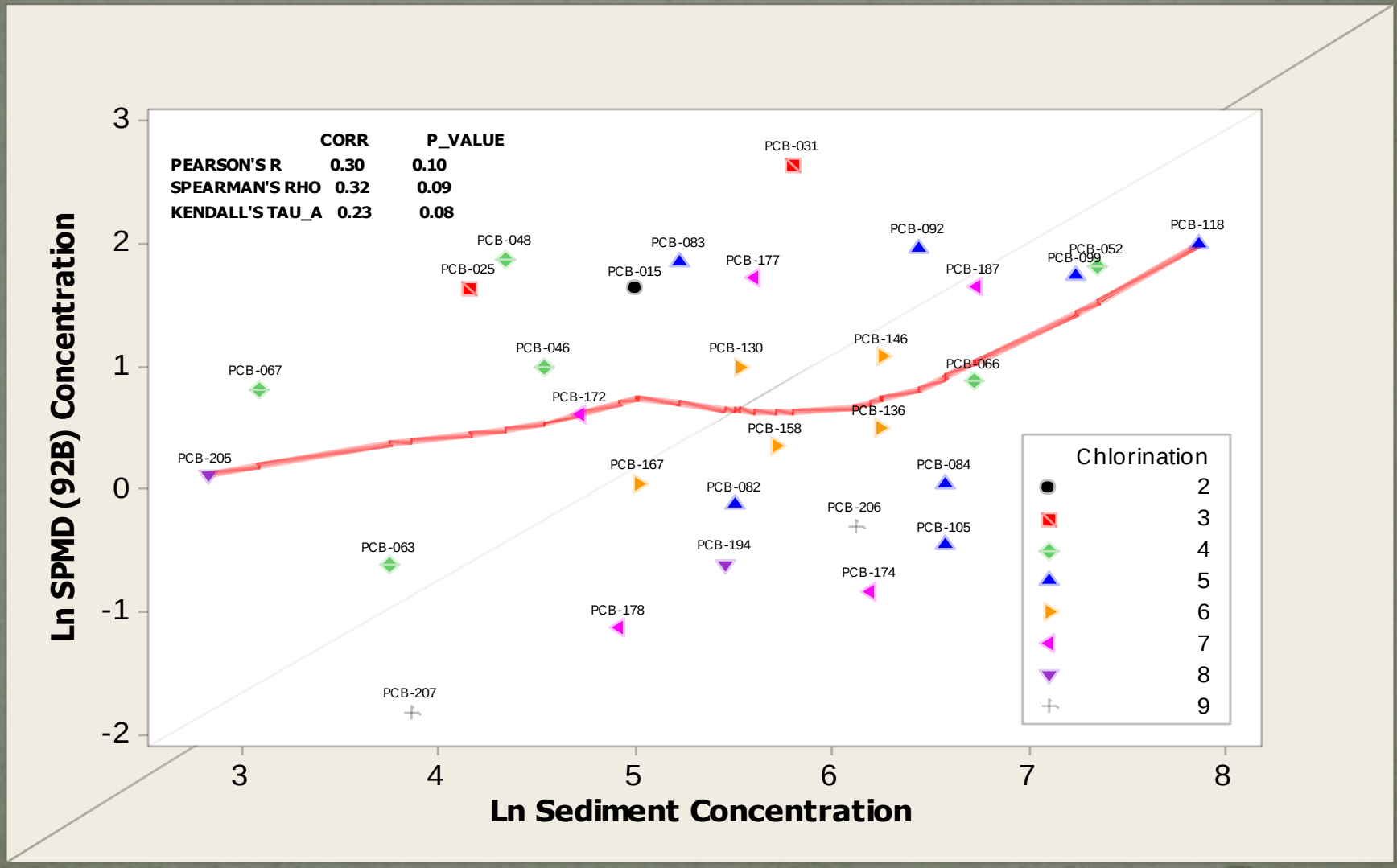
Total PCB BSAFs by Method

Location	Parameter	Sediment (oc norm)	Invert Tissue (lipid norm)	BSAF
LMCS-Pen-2	Total Aroclor	356,481	1,554,278	4.36
	Total PCB (Congener Sum)	2,133,987	1,554,278	0.73
UMCS-I-205	Total Aroclor	407,557	1,654,018	4.06
	Total PCB (Congener Sum)	1,470,715	1,654,018	1.12
US-WgnrM	Total Aroclor	856,716	2,697,833	3.15
	Total PCB (Congener Sum)	4,211,406	2,697,833	0.64

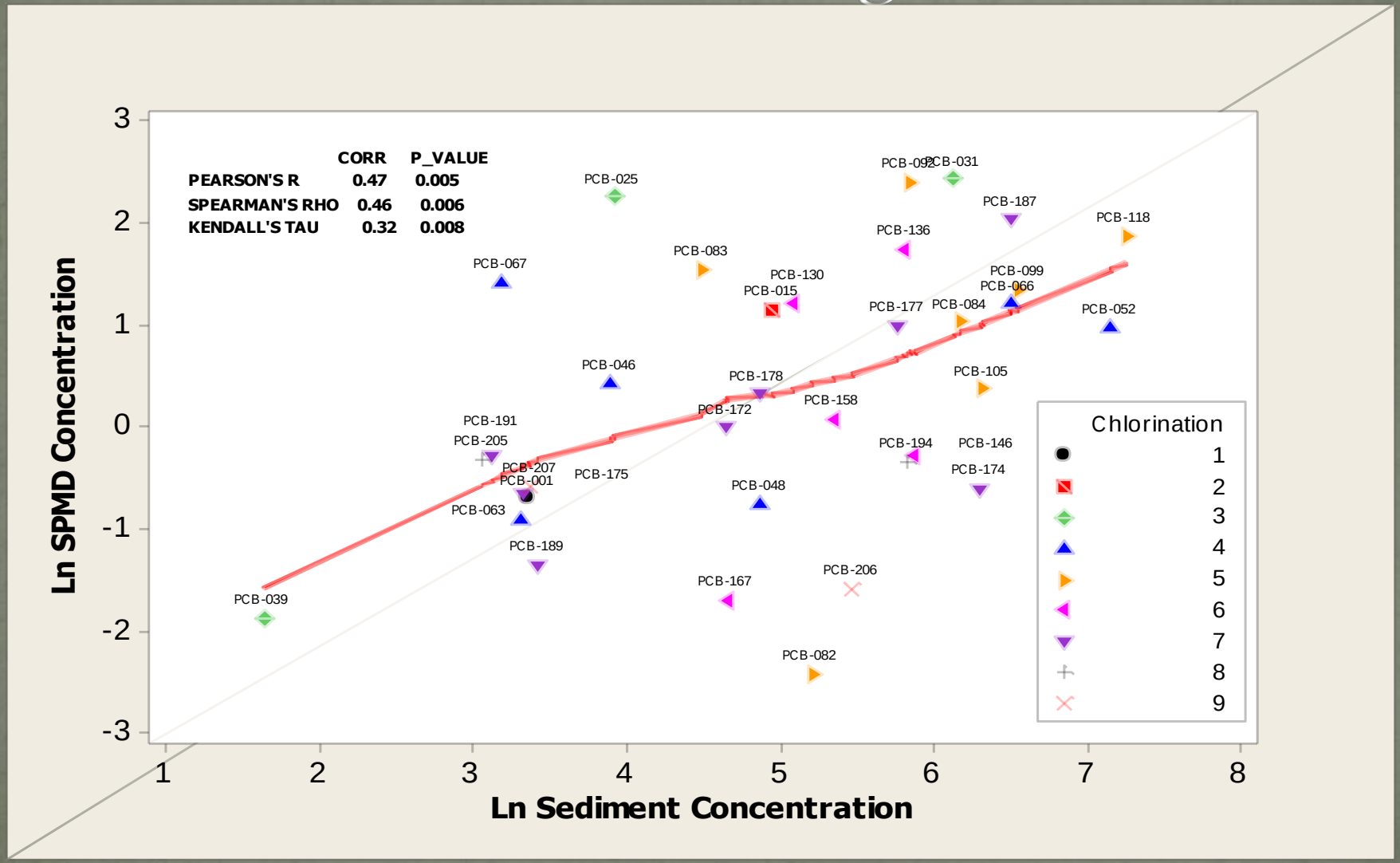
Sediment v. Water (SPMD)
Buffalo Slough-Deep



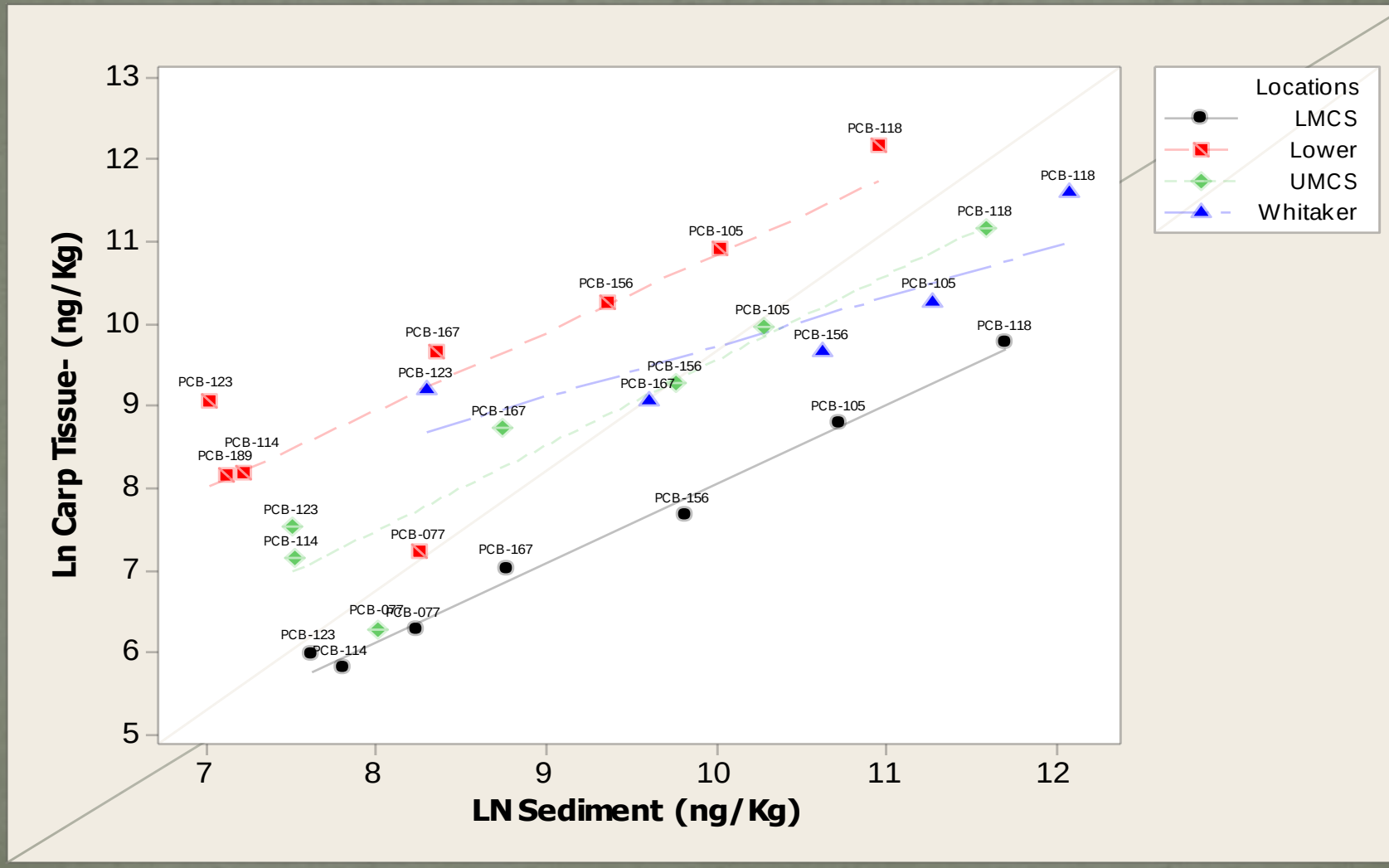
Sediment v. Water (SPMD) Upper Middle



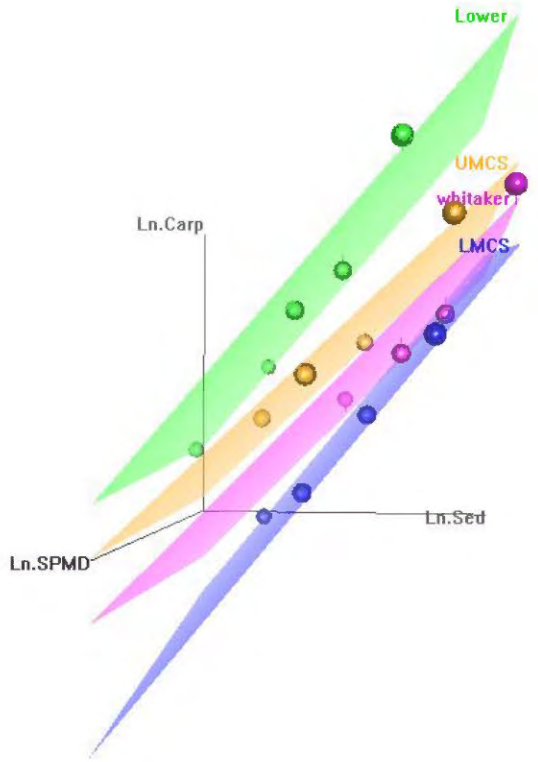
Sediment v. Water (SPMD) Lower Slough



Sediment vs. Carp
All Reaches Select PCB Congeners



SPMD, Sediment, Carp Interactions



Predictive Modeling

- How to relate correlation between sediment (or SPMDs) to acceptable levels in Carp tissue?
- Since relationships between sediment and Carp tissue appear nearly linear, regression approach selected.
- Using reach-specific models, and assuming the Carp concentration at DEQ risk-based levels (for Aroclor 4.7 ug/kg-wet); predict corresponding sediment concentration.

Predictive Modeling-Results

	Regression Predicted Sediment Concentration (ug/kg-dry weight)		
PCB Congener	Lower Slough	Upper Middle Slough	Lower Middle Slough
PCB-77	0.037	0.66	1.0
PCB-81	0.012	0.17	0.33
PCB-105	0.13	3.0	3.7
PCB-114	0.13	3.0	3.7
PCB-118	0.13	3.0	3.7
PCB-123	0.13	3.0	3.7
PCB-126	0.000026	0.00012	0.00077
PCB-156	0.13	3.01	3.7
PCB-157	0.13	3.01	3.7
PCB-167	0.13	3.01	3.7
PCB-169	0.000093	0.00053	0.0027
PCB-189	0.13	3.0	3.7
Total PCB TEQ	0.00002	0.0001	0.0006
Total PCB as Aroclor	0.034	0.59	0.94

Total PCB guidance default = 0.39 ug/kg

Predictive Modeling- Interpretation

- Predicted Sediment Concentrations for Total PCB (as Aroclor) in lower and middle upper slough are similar to existing DEQ PCB sediment screening levels for human health.

- Predicted risk-based sediment levels for lower slough 10x lower than existing DEQ sediment criteria, inconsistent with carp tissue /ATLs. Lower Slough Carp PCBs ~ 200 ug/kg.

- Both Sediment and SPMDs appear to be related to tissue concentrations, limited tissue data prevents further consideration of whether water or sediment is more important for tissue loadings

Predictive Modeling- Interpretation

- Sediment levels for congeners exceeding on the order of 10x. However, excluding the lower slough Aroclor exceeds by approximately a factor of 100x.
- Concentration reduction of 10x (i.e., 90%) could reduce dioxin like risks to acceptable levels, but:
- If Aroclor based criteria are the relevant then 100x (99%) reduction would be required to reach risk-based levels.

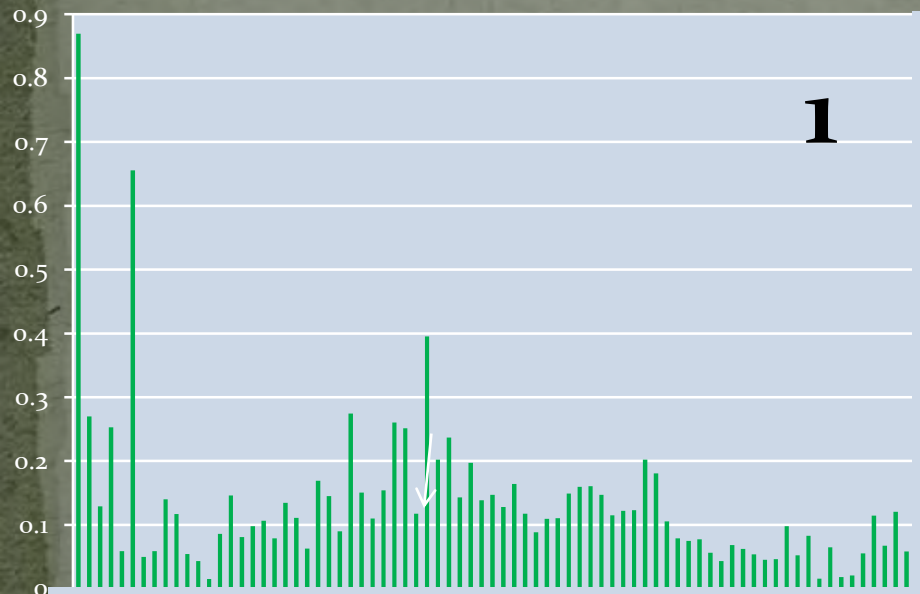
Source Attribution

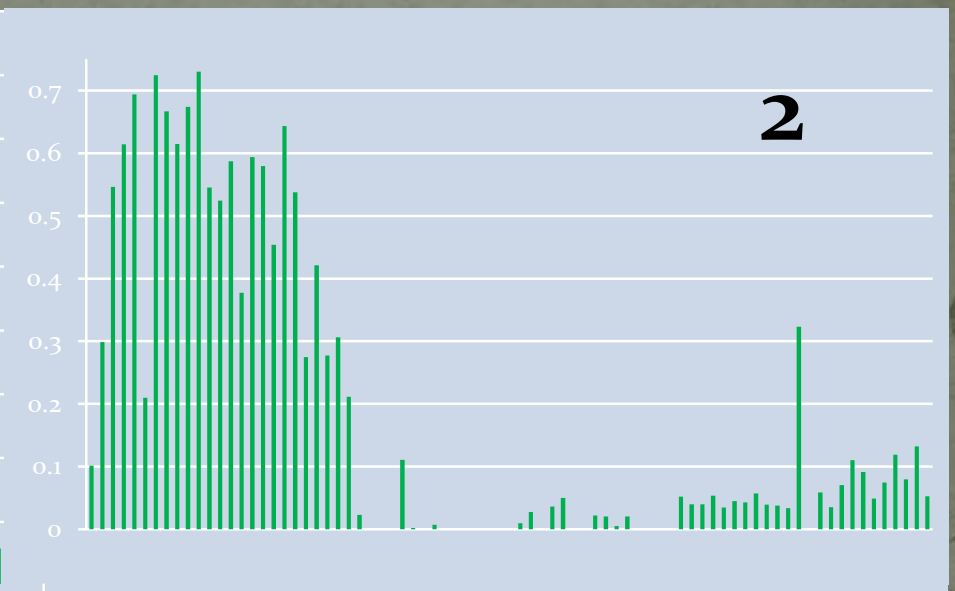
- Since PCB levels in sediment and tissue appear stable and not declining, what are the sources?; and can they be controlled?
- Approach: Use mathematical “unmixing” algorithm.
- Method also termed receptor modeling has been used in air pollution monitoring.

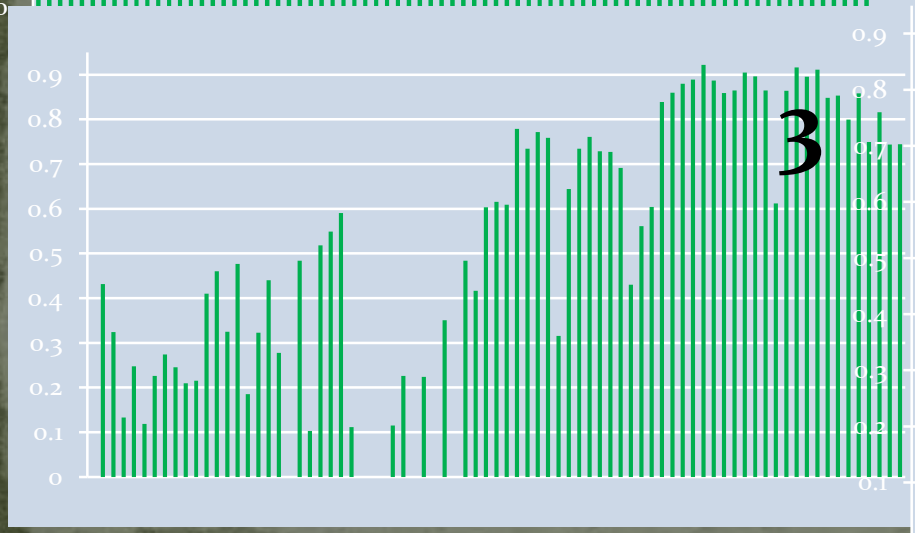
Source Attribution

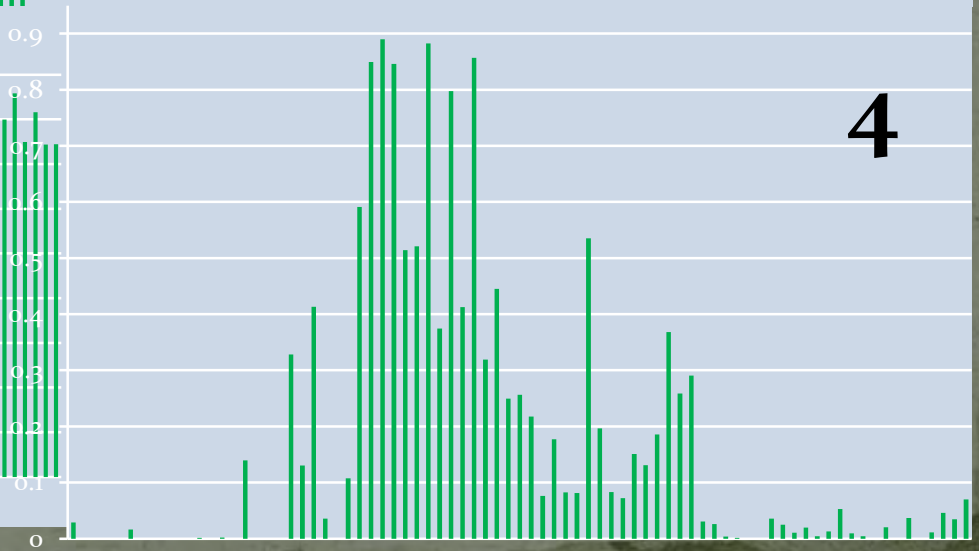
- PCB Congener Data from multiple regional sources compiled in a single database, including Columbia River, Puget Sound, Lower Willamette River and the Columbia Slough.
- Data processed to create a single consistent database of approximately 85 congeners. Non-detections replaced with model estimated values
- Data analyzed using commercial software with unmixing algorithm

Source Attribution- Four Profiles

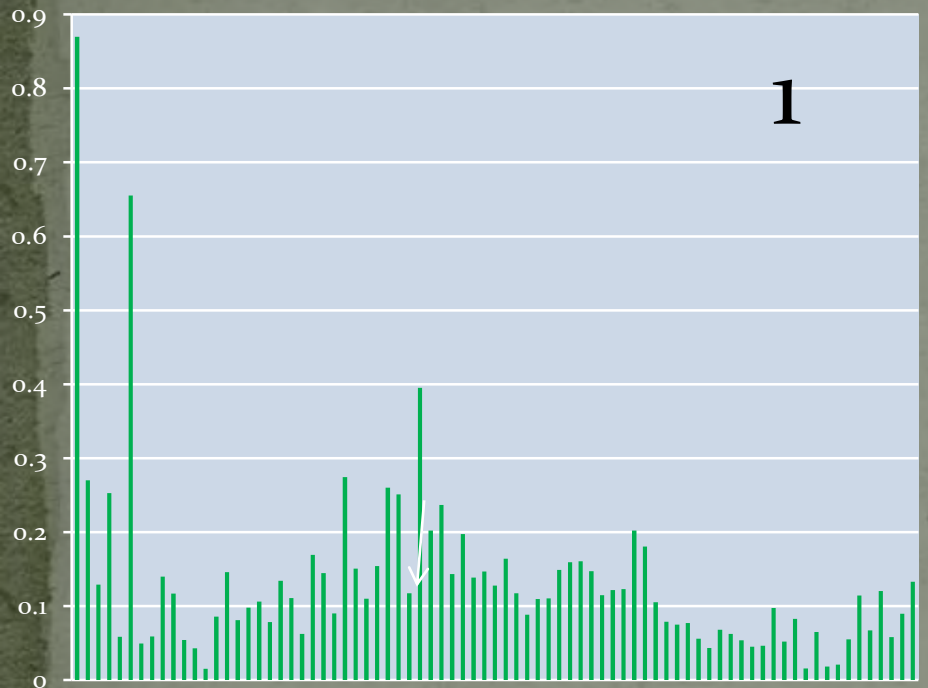


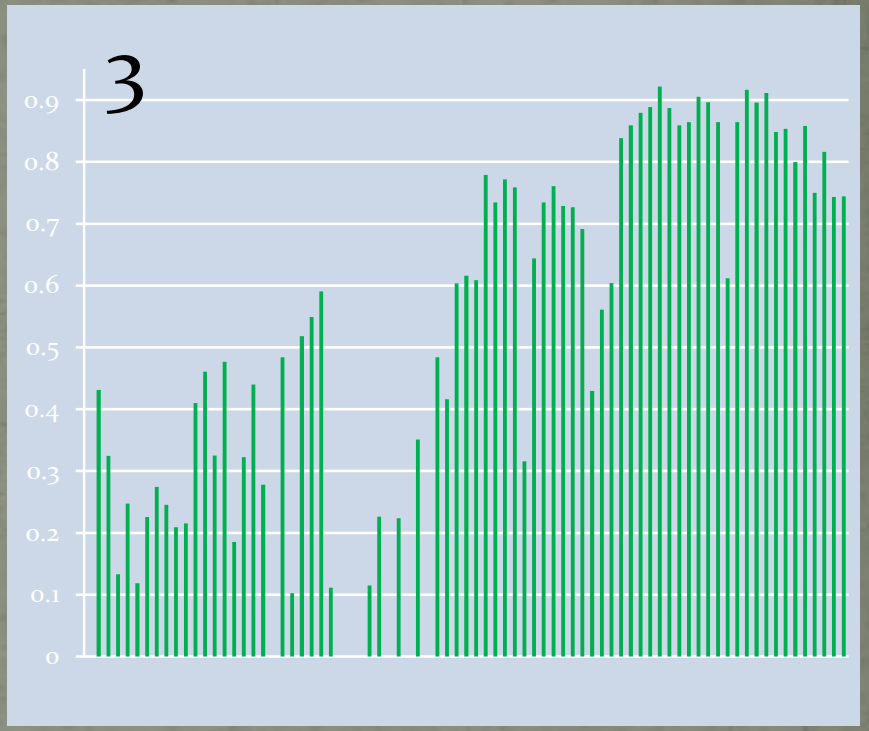






Source Attribution-Interpretation



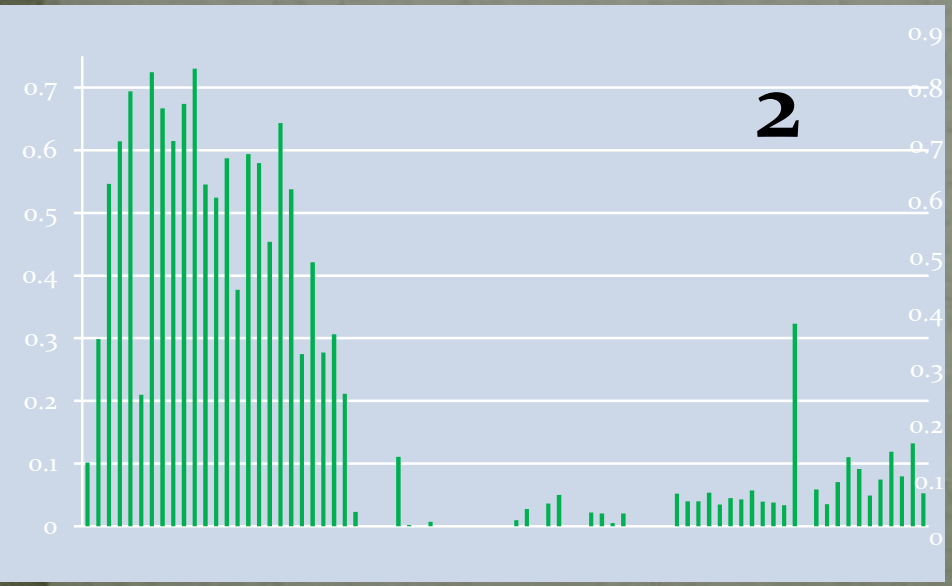


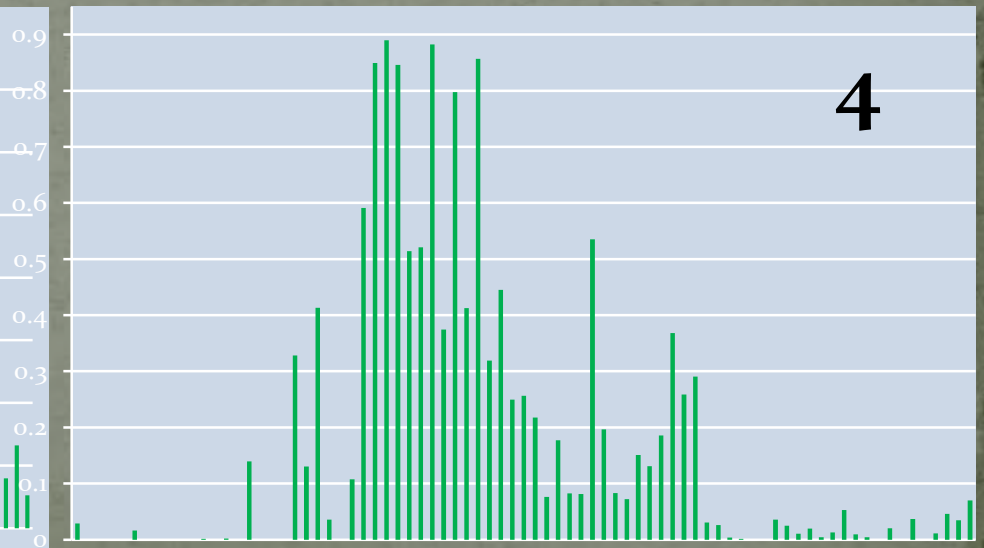
First pattern appear consistent with Atmospheric Transport, associated with low concentration (<3 ug/kg) and remote locations.

Third pattern consistent with weathered recalcitrant residual material.

Source Attribution-Interpretation

- Second and fourth patterns consistent with Aroclor 1248/42 and 1254 as original sources. Approximately equal mix and consistent with other literature.





Source Proportions

Sample Location	Air	1242/1248	Residual	1254
Known 1254 Release near Bradford Island	0%	3%	11%	86%
Mid Columbia Reference Area	0%	17%	32%	50%
Lower Columbia near St. Helens	0%	25%	35%	39%
Lower Middle Slough	1%	26%	12%	62%
Lower Slough	0%	31%	28%	41%
Upper Slough	0%	52%	21%	27%
Upper Middle Slough	1%	26%	16%	56%
Whitaker Slough	0%	34%	50%	15%
Rural background near Cascade Locks	73%	0%	8%	19%
Rural background near Cascade Locks	100%	0%	0%	0%

Source Attribution- Unaddressed Questions

- Which congeners/homologues are most significant in terms of differentiating between Lower Willamette and Columbia Rivers?
- Of the Aroclor patterns identified, where are /did they come from? (stormwater, point sources)? Can they be controlled?
- What is loading fish tissue? Is weathered component in sediment significant? Complete congener data in tissue needed to assess.

Did we meet our Objectives?

- Objectives of Study
  - Determine average concentrations of contaminants in slough sediment and developing new, updated estimates of baseline concentrations in the sampled segments -
    - Yes- Updated five(5) Slough segments with individual estimates of baseline concentrations in sediments for PCBs and Pesticides
  - Development of predictive relationships between sediment and fish tissue: DEQ's 2009 work found good correlations between sediment and fish tissue.
    - Yes- three of four sediment vs tissue slopes were similar. Likely another unknown factor influencing tissue concentrations-possibly stormwater?

Did we meet our Objectives?

- Validate DEQ's bioaccumulation guidance using data specific to the Columbia Slough.
  - Yes-Two of Three segments within 'ball park' of DEQ guidance for PCBs. Pesticides not calculated.

- Perform exploratory multivariate analyses and PCB source attribution.
  - Yes-Found four(4) distinct types of PCB signatures –
    - Air deposition/background
    - Weathered and recalcitrant PCBs
    - Two types consistent with Aroclor 1248/42 and Aroclor 1254 as original sources

Overall Summary

- ISM sampling effective in determining average concentrations in sediment. ISM data appears useful to assess bioaccumulation, at least in some cases.

- Model predicted sediment concentrations appear to validate default screening levels for PCBs of <1 ppb.

- High quality congener data useful for assessing sources. Needed in all matrices including tissue to address most effective control strategies, assess sources to tissue.

Any Questions?

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http://www.deq.state.or.us/lq/cu/nwr/columbiaslough