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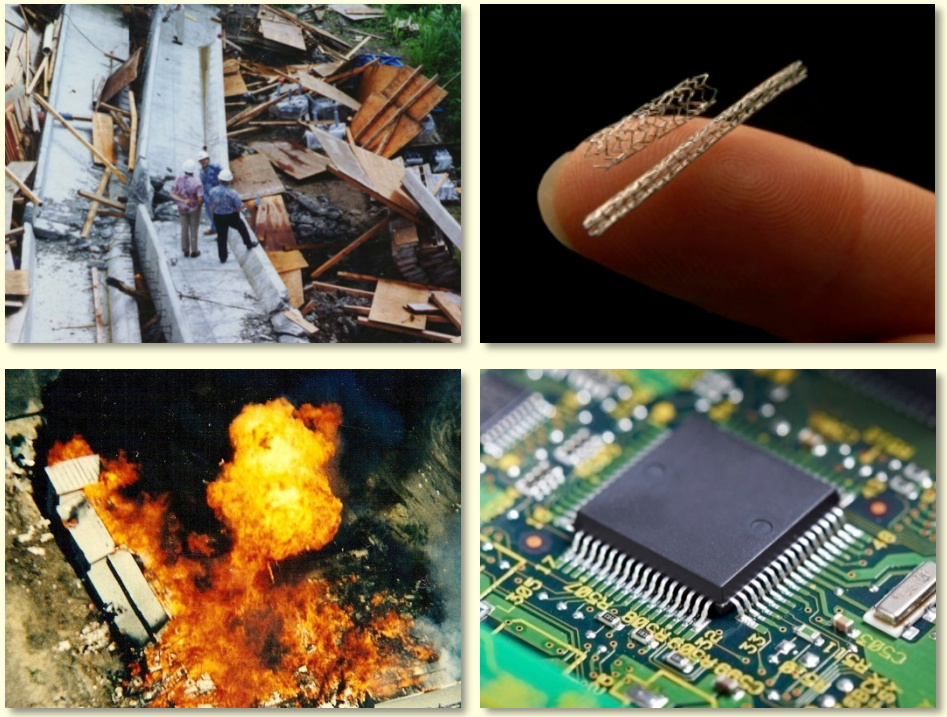

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Sediment Bioavailability Initiative (SBI): Development of Standard Methods and Approaches for the Use of Passive Samplers in Assessment and Management of Contaminated Sediment

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Exponent

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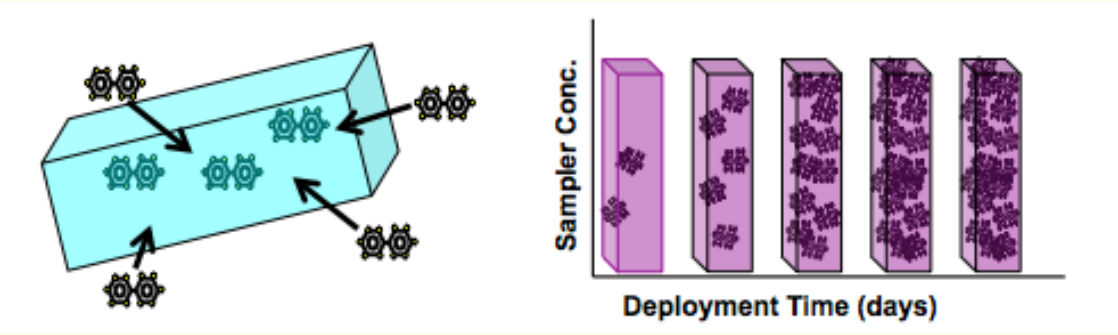
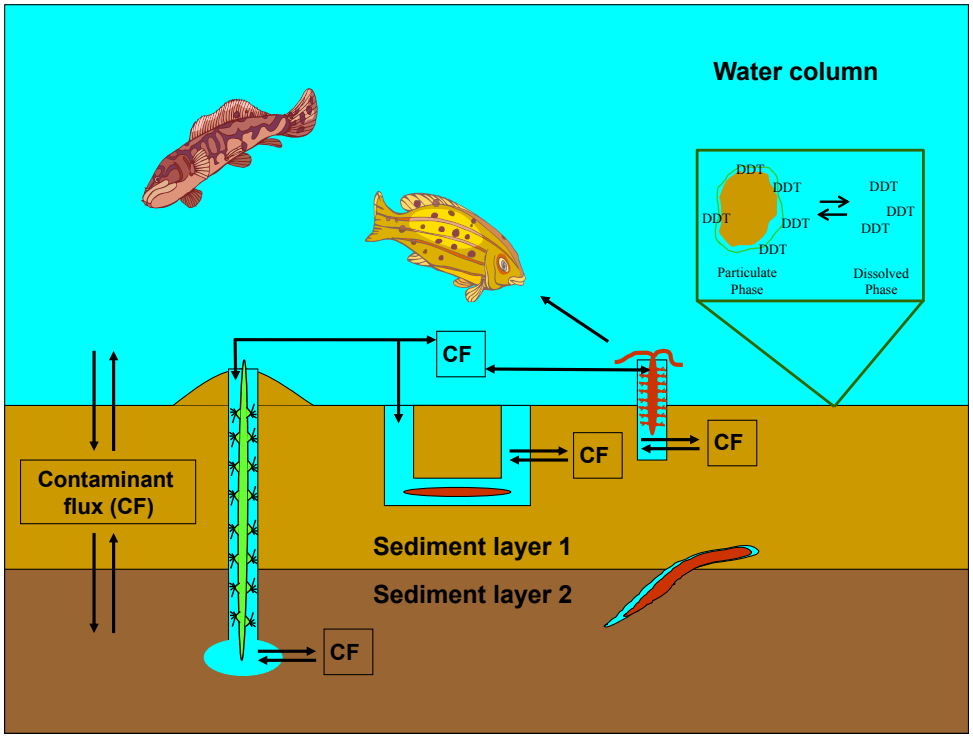
Problem Statement

- Bioavailability of chemicals in sediment is recognized as a critical aspect for exposure, risk, and management
- Passive sampler methods (PSMs) can be used to measure concentrations of freely dissolved contaminants (C_{free}), which is a useful predictor of bioavailability



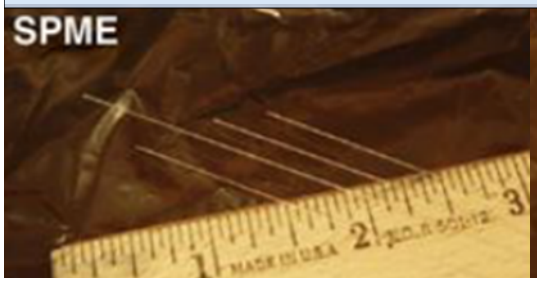
PSMs are Better Predictor of Bioavailability for 3 Key Exposure Pathways

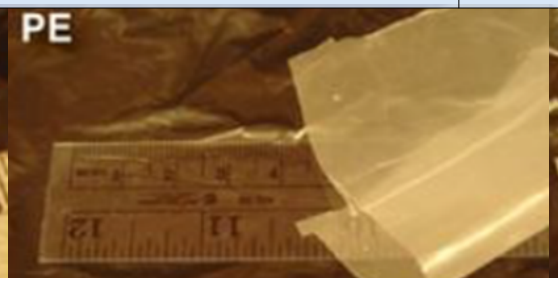
1. Direct exposure to invertebrates (toxicity, bioaccumulation)
2. Flux from sediments to overlying water column
3. Exposures in water column

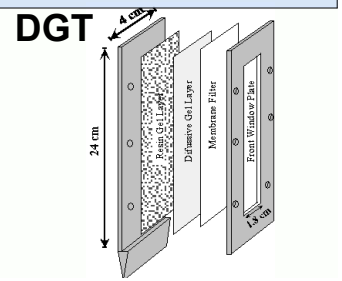


Ex-situ or *in-situ* application of PSMs to measure C_{free} relative to these pathways will reduce uncertainty in risk assessment and subsequent risk management decisions

Passive Sampling Phase or Media	Configuration	Target Analytes
Polydimethylsiloxane (PDMS)	Coated fiber, vial	HOCs
Polyethylene (PE)	Film/sheet, tube	HOCs
Polyoxymethylene (POM)	Film/sheet	HOCs
Ethylvinylacetate (EVA)	Coated vial	HOCs
Silicone rubber (SR)	Sheet, Ring	HOCs
Gels (e.g., DGT)	Thin film “DGT”	Metals
Resin impregnated polyacrylamide gel	“Gellyfish”	Metals
Metal-chelating media	Disk/membrane	Metals
Water-filled equilibration cell	“Peeper”	Metals







Problem Statement

…So why aren't passive samplers more widely used?

- **Key barriers to regulatory acceptance and use include:**
  - Failure of practitioners and decision makers to understand the advantages and limitations of these chemical-based approaches over traditional analytical methods
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- **Lack of:**
  - Technical guidance for PSM selection and standard methods
  - Use in regulatory decision-making contexts
- **Limited experience in use and analysis by commercial laboratories and site managers**
- **Uncertainty over cost versus benefit**

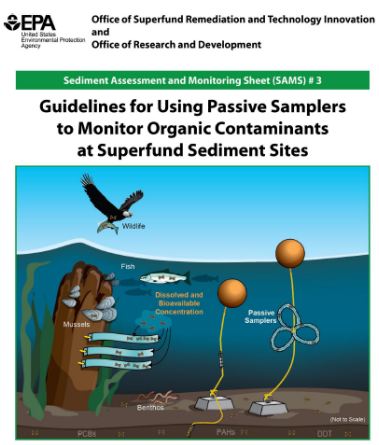
Problem Statement

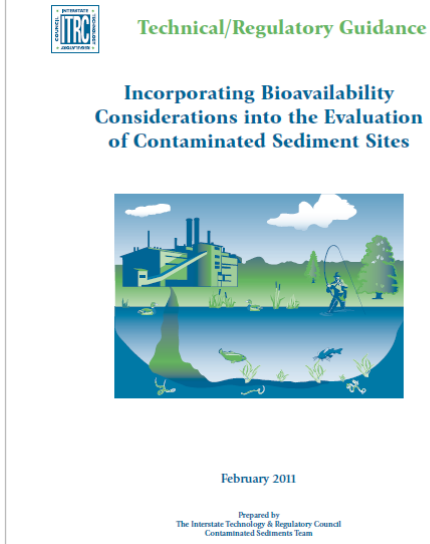
…So why aren't passive samplers more widely used?

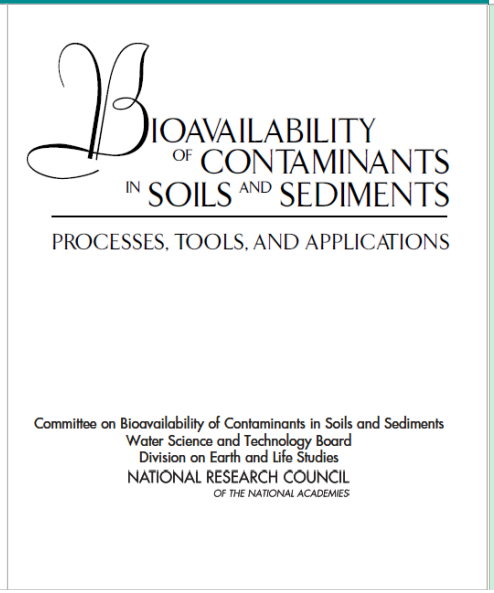
- **"A big barrier to use is that the methods are not standardized (i.e., EPA or ASTM), and that there are not a number of accredited commercial labs doing this work. End users do not want to go to the universities to have this done; there needs to be a method that is "off-the-shelf", has appropriate QA/QC, and that can produce comparable numbers across the different laboratories. Without a "price" and a "part number", acceptance will be limited."**

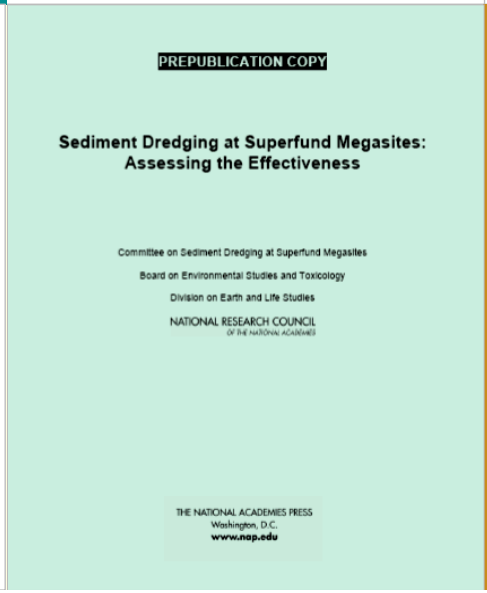
Problem Statement *(continued)*

There is a need to move from insights, research, and general guidance to specific guidelines and actions









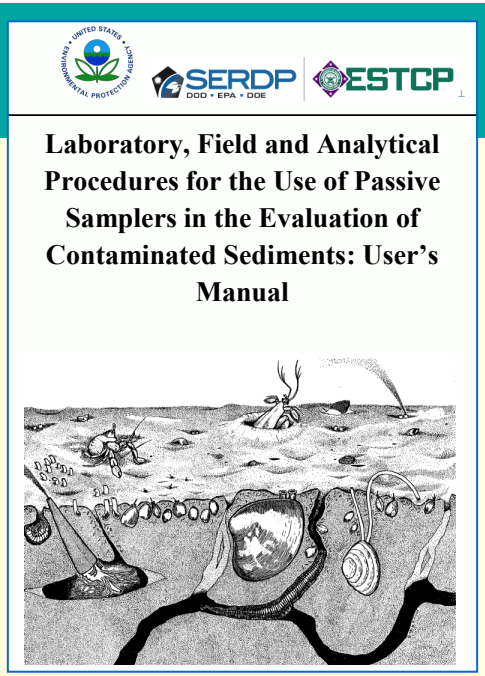
SETAC Pellston Workshop —Technical Guidance on Bioavailability Measurements using Passive Sampling Methods for Management of Contaminated Sediments. 7–9 November, 2012 Costa Mesa, CA

5 papers published in IEAM

- **State of the Science for Organic Contaminants**
- **State of the Science for Metals**
  - Summarize literature; types and uses of PSMs in sediment
- **Scientific Rationale Supporting Use of Freely Dissolved Concentrations**
  - Articulate technical basis for advancing use of PSMs as a bioavailability-based LOE in investigations and decisions
- **Practical Guidance for Selection, Calibration and Implementation**
  - Provide practical technical guidance for laboratory and field deployment of PSMs (method selection, standardization, QA)
- **Risk Assessment and Management**
  - Define current and future management applications; identify communication needs for PSMs in decision contexts; identify research needs

User's Manual

- **Joint EPA/SERDP/ESTCP publication with focus on organic contaminants:**
  - Introduction
  - Sampler-specific sections on POM, PDMS and LDPE
    - Introduction
    - Laboratory Applications
    - Field Applications
    - Data Analysis
  - Evaluation of Equilibrium and Use of PRCs
  - Extraction and
  - Instrumental Analysis
    - Standard Procedures
    - Detection Limits
  - QA/QC
    - Accuracy and Precision
  - Appendix: Provisional Partition Coefficients



Practices Manual

- **Based on 5 key guiding principles for selection, preparation, implementation and validation of PSMs**

1. Define question(s) posed by managers to be addressed by measurement of C_{free} using PSMs

Endpoints addressed by PSMs

- Sediment toxicity
- Benthic organism bioaccumulation
- Transport, i.e., direction of flux, gradients
- Spatial extent delineation
- Site-specific K_{oc}
- Model calibration/verification

Practices Manual *(continued)*

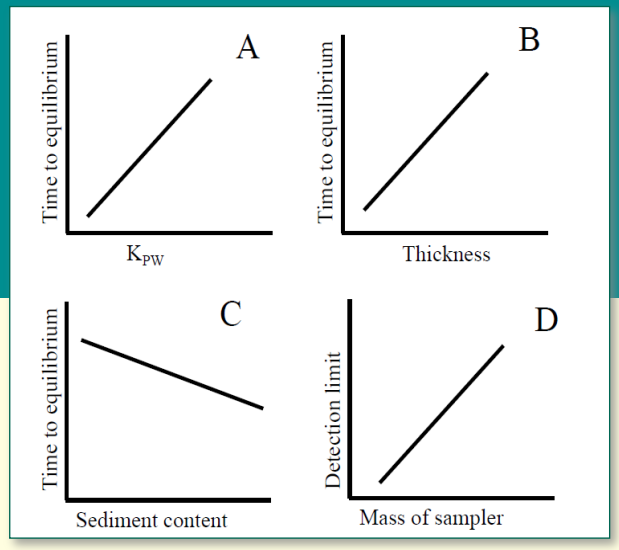
2. Determine pros/cons of *ex-situ* (bring sediment sample back to lab) versus *in-situ* application of PSMs

Other considerations

- Site accessibility/security
- Time/cost
- Level of expertise required
- Regulatory considerations
- Importance of spatial resolution (heterogeneity; grab versus fine scale)
- Temporal resolution

Practices Manual *(continued)*

3. Perform trade-off of key considerations to select the most appropriate PSM(s)



Technical considerations

- Target analytes (magnitude of K_{ow}, organic/ inorganic)
- Physicochemical parameters
- Time for deployment
- Performance specifications (sensitivity, accuracy, precision)
- Commercial availability

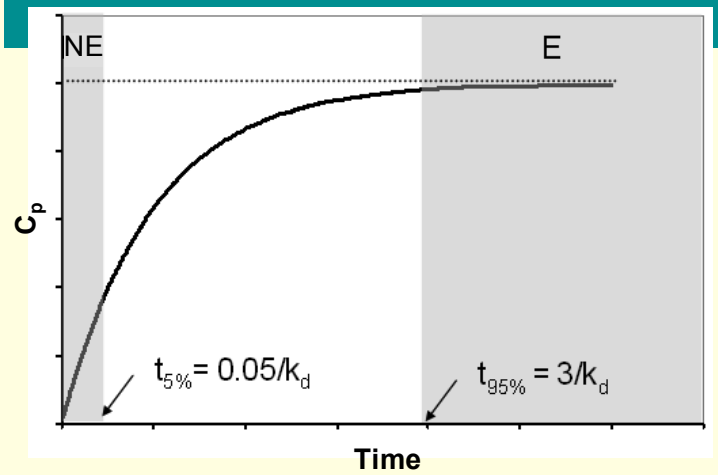
Practices Manual *(continued)*

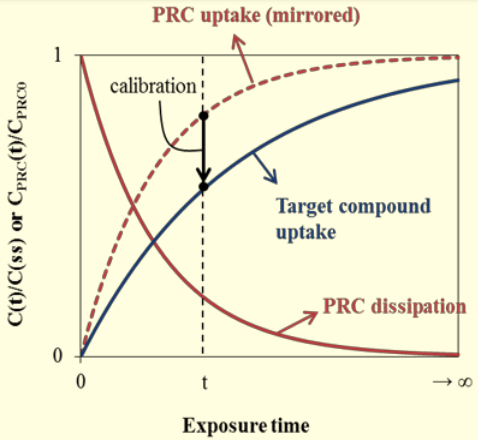
4. Establish QA/QC guidelines for project

- Selection and use of appropriate pre-calibration parameters (e.g., Kpw values and potential temperature/ salinity corrections)
- **Provisions to ensure attainment of equilibrium, or alternatively, for correction to an equilibrium condition**

NE = Non-Equilibrium Sampling (linear uptake phase)

E = Equilibrium Sampling (steady-state phase)





Practices Manual *(continued)*

5. Quantify PSM measurement uncertainty and propagate through the assessment

PSMs uses in sediment assessments and decision frameworks

- Nature and extent
- Flux measurements
- Evaluating remedial options
- Exposure and risk assessment
- Use in tiered assessment approaches

Our current understanding of uncertainty associated with C_{free} measurement using PSMs is expected to be only a fraction of the uncertainty associated with the status quo

Case Studies Demonstrate Value for Site Management

- **Lake Cochituate, MA**—PCBs, PE, Nature and extent
- **Grasse River, NY—**PCBs, POM, Post remediation monitoring
- **Maryland Rivers**—PCBs, POM, Surface water screening
- **Bailey's Creek and Canal Creek, VA**—PCBs, POM, Post remediation monitoring
- **Anacostia River , Washington DC**—PAHs, PDMS, Post remediation monitoring/bioaccumulation (capping)
- **Naval Station San Diego, San Diego Bay, CA**—PAHs, PDMS, Assessment/bioaccumulation
- **Elliott Bay, WA**—PAHs, PDMS, Post remediation monitoring
- **Hunters Point Naval Shipyard, San Francisco Bay, CA**—PCBs, PDMS, Bioaccumulation/post remedy monitoring (activated carbon)

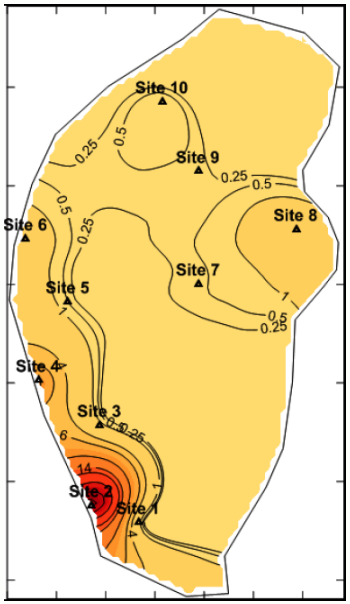
Case Studies Demonstrate Value for Site Management

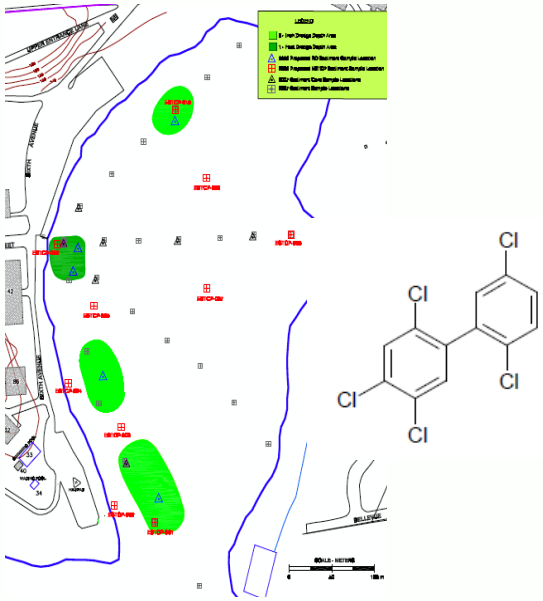
- **Pensacola Harbor, FL** —PAHs, PDMS, Assessment/bioaccumulation
- **McCormick and Baxter Portland Harbor Site, Portland, OR**—PAHs, PDMS, Post remedy monitoring (capping)
- **Tennessee Products, Chattanooga, TN**—PAHs, PDMS, Post remedy monitoring (capping)
- **Pacific Sound Resources, Seattle, WA**—PAHs, PDMS, Post remedy monitoring (capping)
- **Wyckoff/Eagle Harbor Site (Bainbridge Island, WA)** —PAHs, PDMS, Post remedy monitoring (capping)
- **San Jacinto River Waste Pits (Baytown, TX)** —Dioxins, PDMS, Post remedy monitoring (capping)
- **Roxana Marsh, Hammond, IN**—PAHs, PDMS, Post remedy monitoring (capping)
- **Potrero Power Plant Site, San Francisco, CA**—PAHs, PDMS, Assessment/ bioaccumulation
- **Quantico Marine Base (Quantico, VA)**—DDX, PDMS, Assessment/bioaccumulation
- **Port Forchon, LA** —PAHs, PDMS, Assessment
- **Bay Jimmy, Barataria Bay, LA**—PAHs, PDMS, Assessment

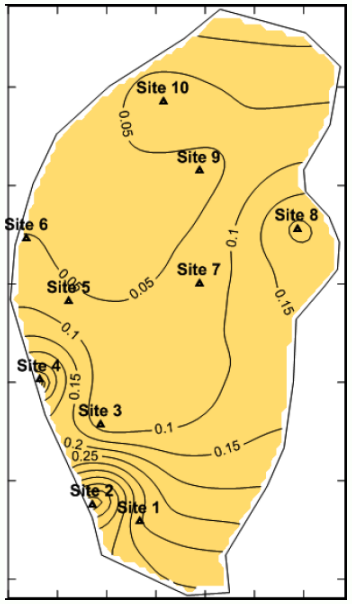
Case Study: Lake Cochicuate

- **Pore water concentrations (ng/L) for PCB congeners:**

Estimated used sediment data ($C_{sed}/f_{oc}K_{oc}$) versus Measured PE data (C_{PE}/K_{PEw})







1. Porewater concentrations estimated from sediment concentrations average 20x higher than concentrations measured with PE
2. Hotspot identified in additional areas of high chemical activity

Risk Management Applications

- **Improvements to management applications utilizing C_{free} determinations and data include:**
  - Ambient or compliance monitoring programs
  - Identifying contaminant sources
  - Develop exposure-response relationships (e.g., sediment toxicity tests) for use in development of cleanup goals
  - Understanding of risk zones based on likelihood of effects

Risk Management Applications *(continued)*

- **Improvements to management applications utilizing C_{free} determinations and data include:**
  - Modeling (input parameters or verification data)
  - Evaluating remedial options and designs
  - Short- and long-term monitoring of chemical bioavailability
  - Evaluating results of sediment treatment, disposal, or beneficial reuse following management actions
  - Evaluating remedy effectiveness

Cost Assessment

12 Ponar Grab sampling versus 12 PE sampling

Cost Element	Ponar Grab Sampling Cost	PE Sampling Cost	% Difference
Expendable Items	$169	$37	128%
Non-Expendable Items	$960	$948	1%
Field Labor	$1,530	$1,240	21%
Sample Shipment	$243	$104	80%
Total Field Cost	**$2,902**	**$2,330**	**22%**
Total Analytical Cost	**$10,080**	**$11,022**	**-9%**
Totals	**$12,982**	**$13,352**	**-3%**

Note: Cost assessment from Dr. P. Gschwend assumes contract lab charges same for PE analysis as sediment analysis.

Questions?