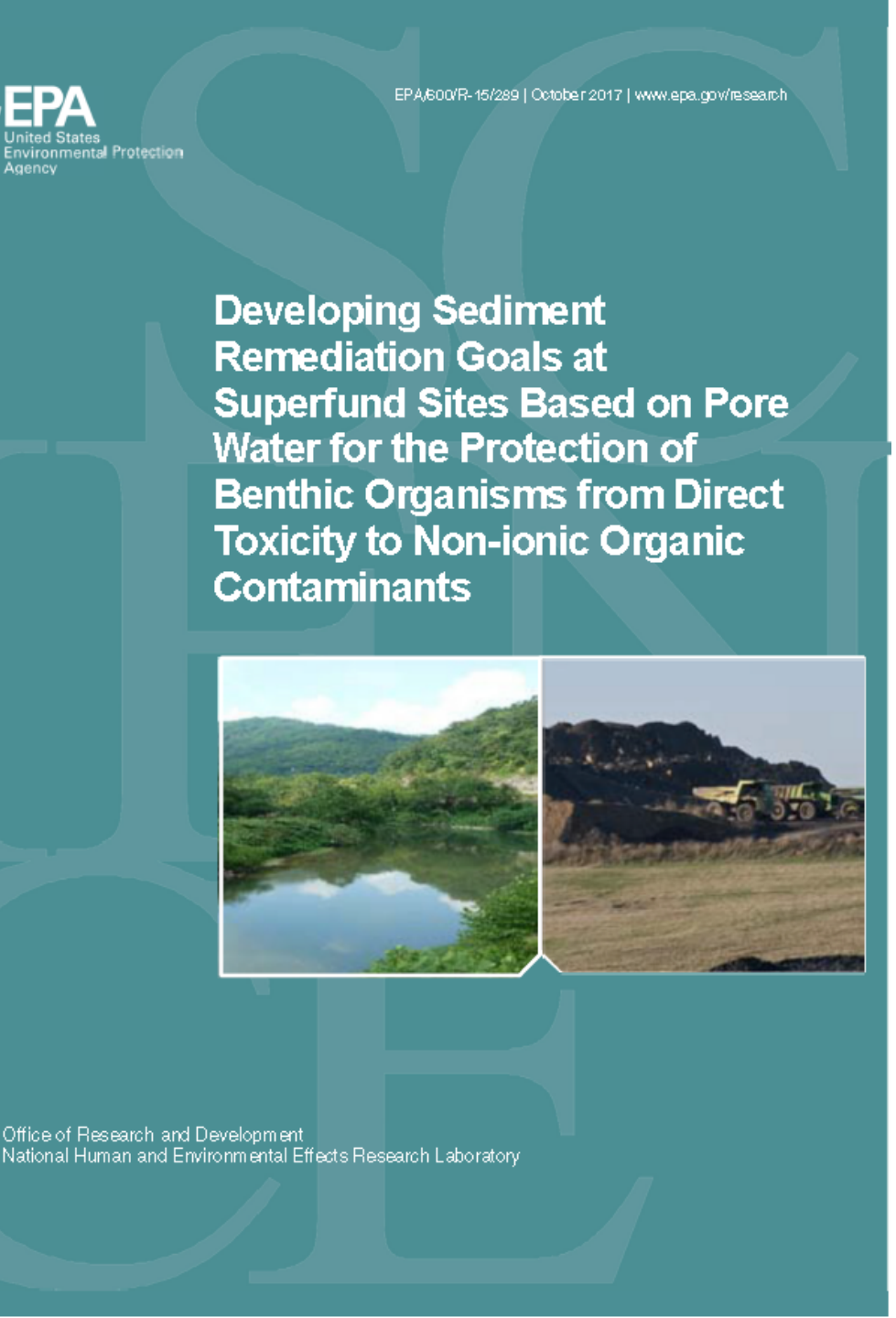
Pore Water Remedial Goals (PWRGs) for the Protection of Benthic Organisms

- Sediment toxicity testing on samples from your site
- YES or NO

- Goal today:
  - Show how PWRGs and sediment toxicity testing data can be examined together
  - When consistent
    - Reasonably assured
      A. The causes of toxicity are identified properly
      B. PWRGs will be protective of benthic organisms at the site

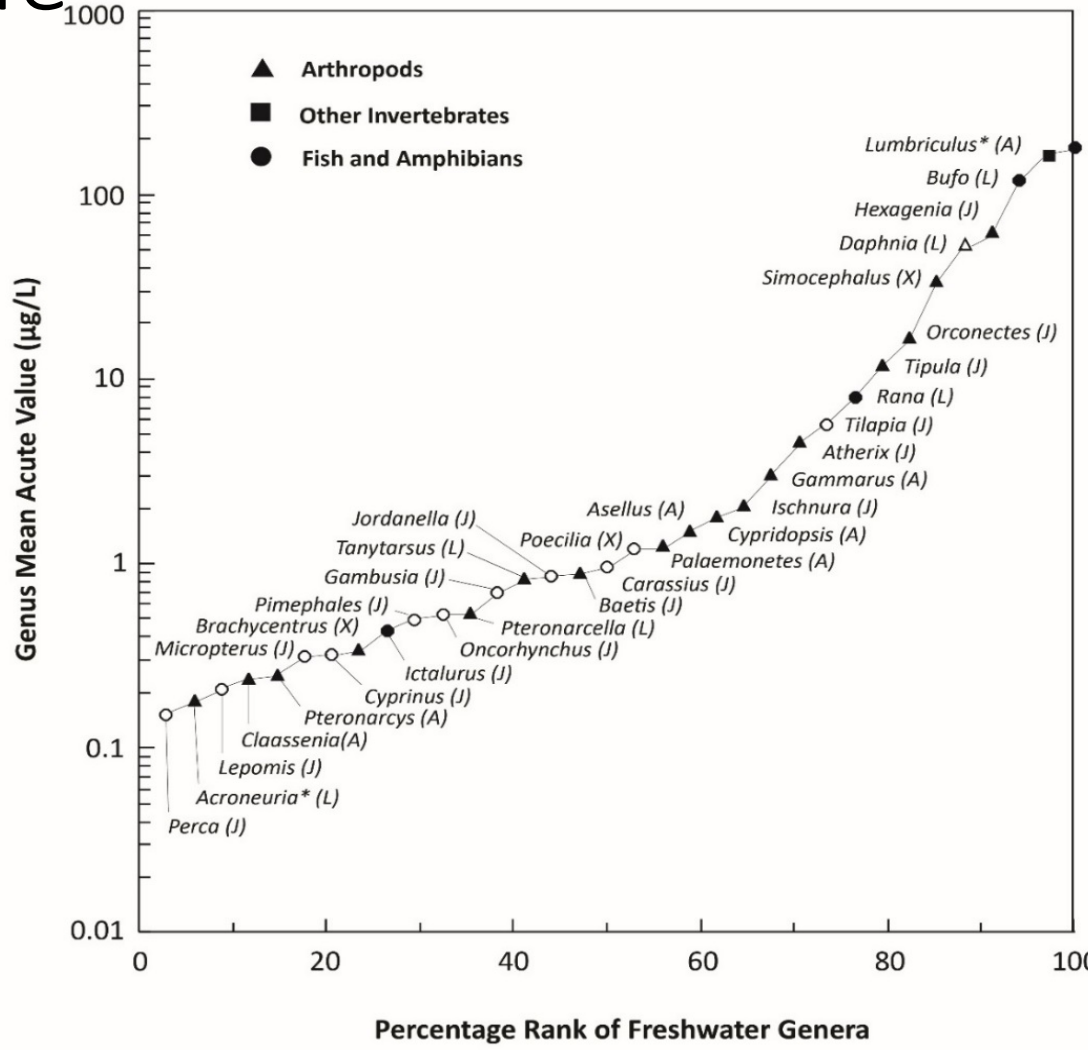


Guidance Approach

- Two basic elements
  - Method of measuring/inferring freely dissolved chemical concentrations in sediment pore water
  - Threshold chemical concentrations that delineates acceptable and unacceptable exposures

Acceptable and Unacceptable Exposure Thresholds from EPA's Ambient Water Quality Criteria (AWQC) for Aquatic Life

- Species sensitivity distribution for Endrin
  - Freshwater species
- Final Acute Value (FAV) 5th percentile
  - 0.1803 µg/L
- Final Acute to Chronic Ratio (FACR)
  - 3.106
- Final Chronic Value (FCV)
  - 0.05805 µg/L



Toxicity Testing Results

PAH mixture species sensitivity distribution genus mean acute values for marine and freshwater toxicity testing species		
Species	Genus Mean Acute Value (µmole/ g octanol)	Percentage Rank of Genera
5th Percentile distribution value	FAV = 9.32	5.0%
Hyalella azteca **	13.9**	10.2%**
Leptocheirus plumulosus	19.0	22.4%
Rhepoxynius abronius	19.9	26.5%
Eohaustorius estuarius	22.1	32.6%
Ampelisca abdita	30.9	55.1%
Chironomus tentans	68.4	79.5%

PWRG Methodology

Follows Superfund's eight-step ecological risk assessment guidance

1) **Screening Level Characterization of the Nature and Extent of Contamination**
   A. Measure f_{OC} and C_S for all COCs (µg/kg-dw) in surficial sediments across the site
   B. Compute C_{SOC} (µg/kg-OC) for all COCs

2) **Screening Level Ecological Risk Assessment**
   C. Compute Toxic Units (TUs) for COCs
      - For single toxicant case, TU = C_{SOC}/ESB
      - For mixture of toxicants,
        - For each COC: $TU_i = C_{SOC,i}/ESB_i$
        - Total TUs = $\sum TU_i$

ESB=Equilibrium Sediment Benchmark
Developed by EPA 2003, uses EqP theory
Assumes all organic carbon in sediments is from diagenesis of plant materials.
Conservative, units – µg/g_{OC}

PWRG Methodology

3) **Problem Formulation**
   - Develop CSM, exposure pathways, and assessment endpoints
4) **Study Design and DQO Process**
   - Develop Work Plan (WP) and Sampling and Analysis Plan (SAP) in support of CSM and data needs
5) **Site Investigation and Data Analysis**
   D. Passively sample surface sediments where total TUs > 1.0
   E. Derive C_{free} and K_{OC} values for surface sediments with total TUs > 1.0

PWRG Methodology

6) Risk Characterization

7) **Baseline Ecological Risk Assessment**

F. Compute Toxic Units (TUs) for COCs

- For single toxicant case, PWTU = C_{free}/FCV
- For mixture of toxicants, for each COC in the mixture:
  - Compute pore water TU for each COC, $PWTU_i = C_{free,i}/FCV_i$
  - Compute total mixture pore water TUs, $PWTU_{Mixture} = \Sigma PWTU_i$

G. For locations where:

- Total PWTUs ≤ 1.0, little potential for risk to benthic organisms.
- Total PWTUs > 1.0, unacceptable risks to benthic organisms indicated, proceed to Remedial Goal Development

PWRG Methodology

8) Remedial Goal Development

PWRGs expressed on bulk sediment basis ($C_{S:PWRG}$ µg/kg dry weight):

Derive site specific $f_{OC:SS}$ and $K_{OC:SS}$ values

$$K_{OC:SS} = C_S/(f_{OC:SS} \times C_{free})$$

a) For single toxicant, PWRG on bulk sediment basis:

$C_{S:PWRG} = K_{OC:SS} \times f_{OC:SS} \times C_{free:PWRG}$ where $C_{free:PWRG}$ = FCV

or

$C_{S:PWRG} = C_S \times (1/PWTU)$ where PWTU = C_{free}/FCV

PWRG Methodology

8) Remedial Goal Development

b) For mixture of toxicants:

Derive site-specific composition of the mixture

PWRG for each COC:

$$C_{S:PWRG,i} = K_{OC:SS,i} \times f_{OC:SS} \times C_{free,i} \times (1/ PWTU_{Mixture})$$

$PWTU_i = C_{free,i}/FCV_i$

$PWTU_{Mixture} = \sum PWTU_i$

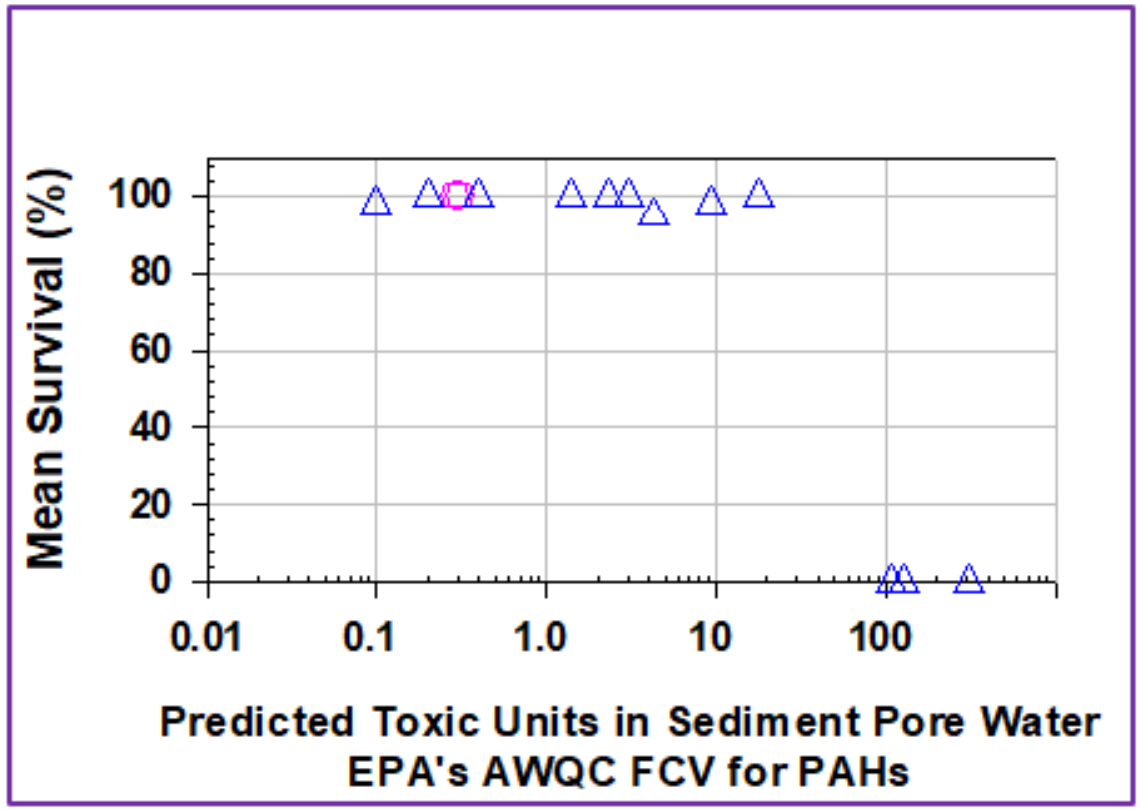
$PWTU_{Mixture} = 58.7$ TUs

$1/PWTU_{Mixture} = 1.70\%$

Total bulk concentration of mixture:

$$C_{S:PWRG,Mixture} = \Sigma C_{S:PWRG,i}$$

Toxicity Testing Results:



Hyalella azteca survival in 28-day toxicity tests with sediments contaminated with PAHs (Kreitinger et al 2007).

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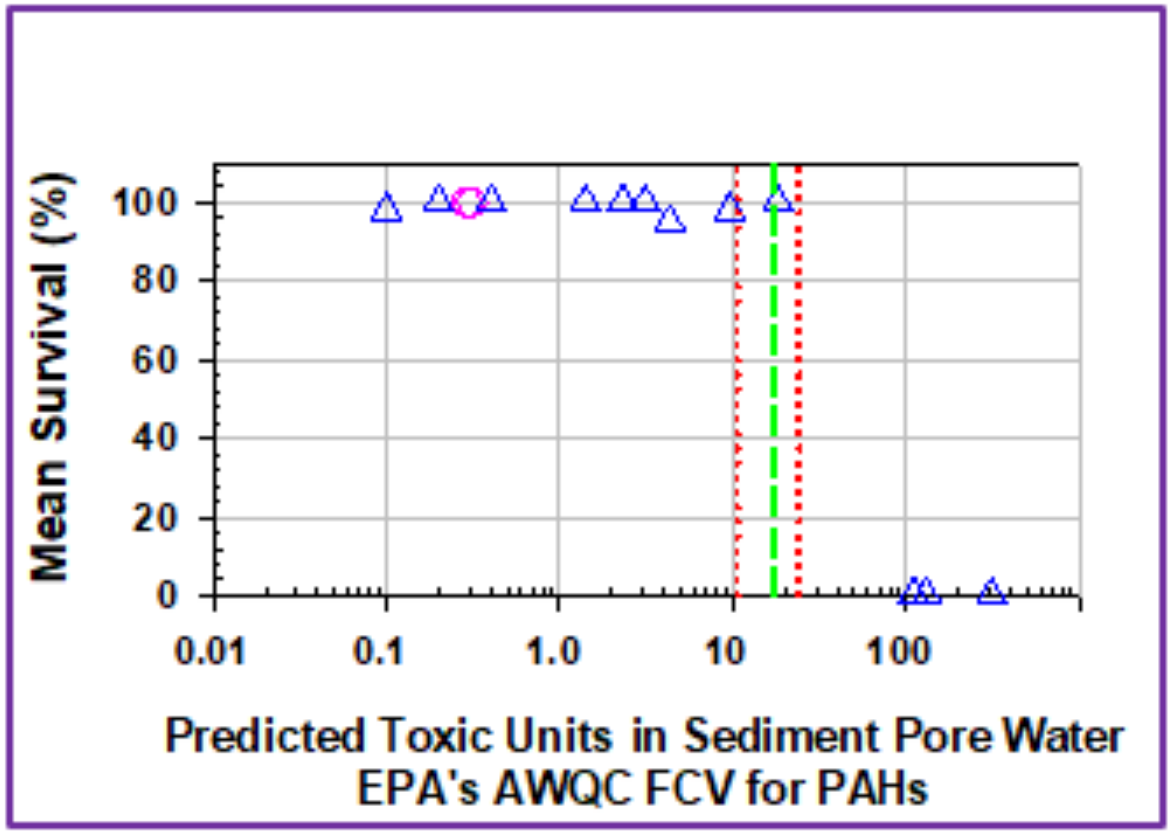

H. azteca less sensitive than the AWQC 5th percentile for PAHs.

Hyalella azteca survival in 28-day toxicity tests with sediments contaminated with PAHs (Kreitinger et al 2007).

- - - - and •••• lines are the mean and 95% confidence levels for the EC50 derived from the water-only toxicity testing data for *H. azteca*.

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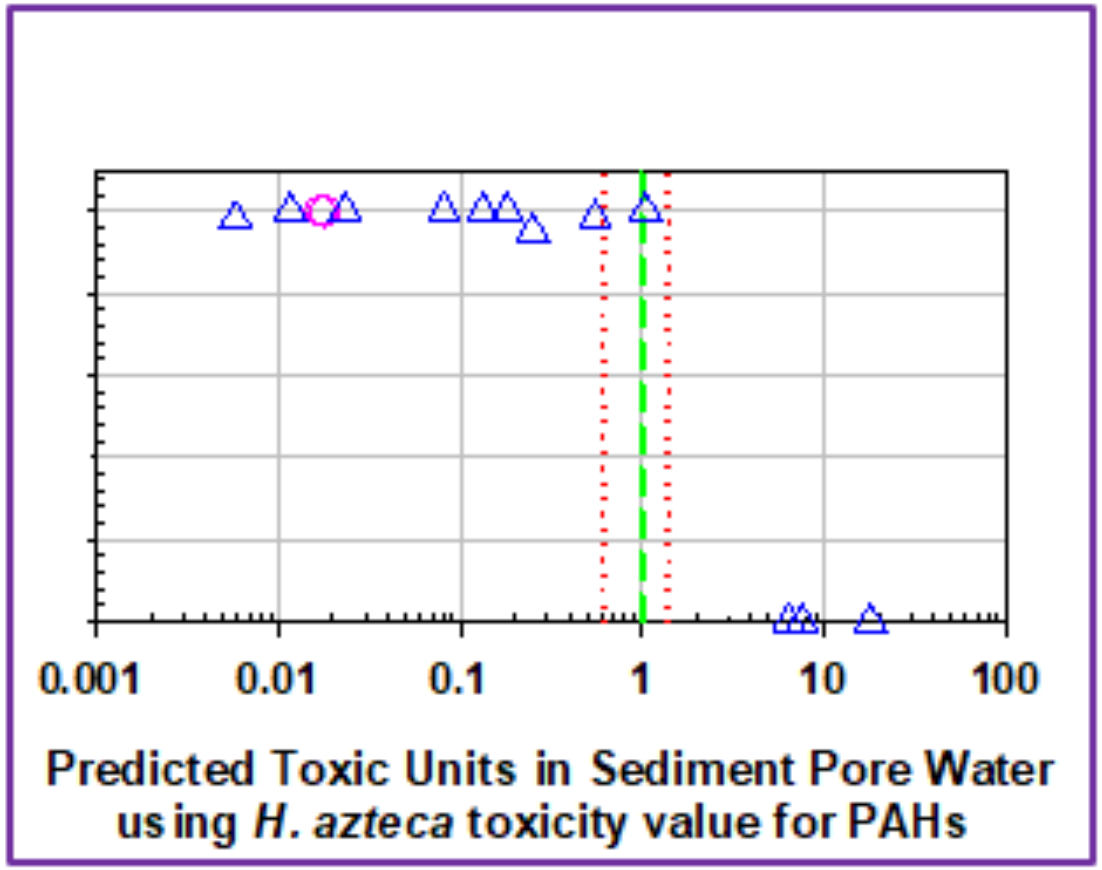
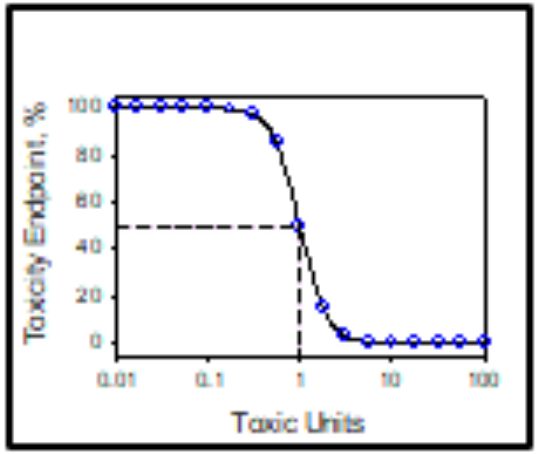


Results follow dose-response curve and breakpoint aligns with toxicity data for *H. azteca*.



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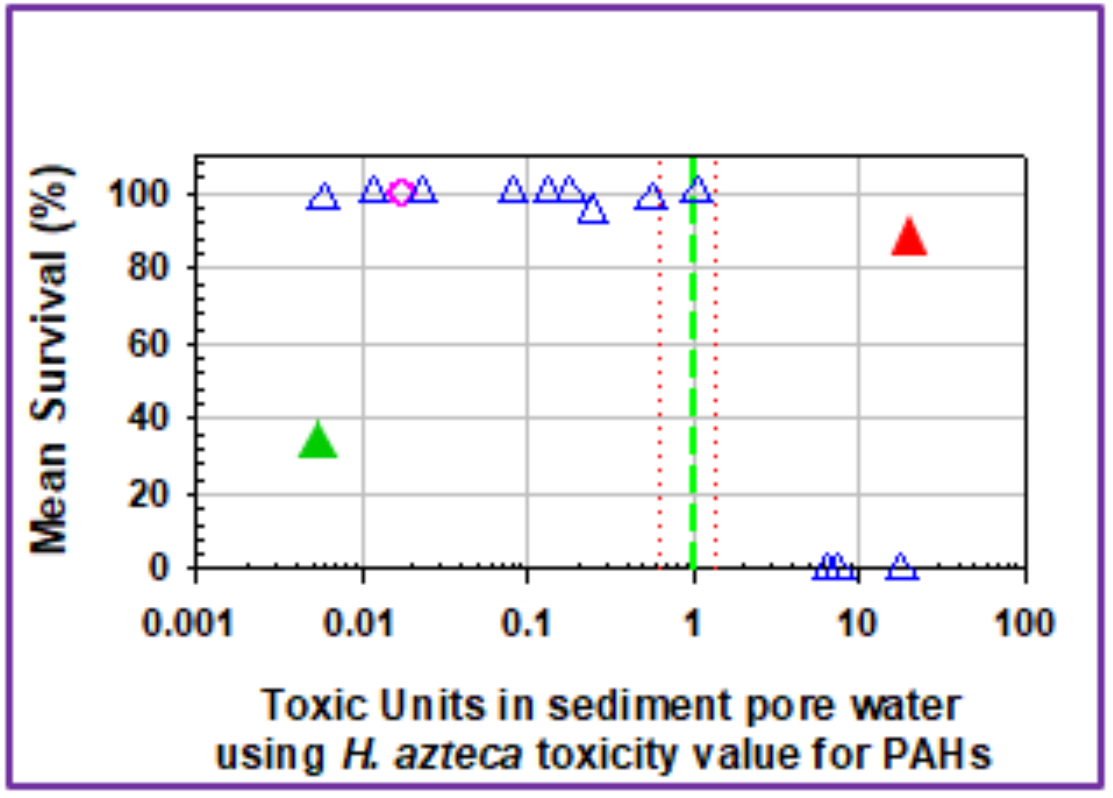

If data exists in the data set illustrated by

▲ - Suggests: Presence of other unidentified toxicants

▲ - Suggests: Wrong toxicants have been identified

Consistency not demonstrated!

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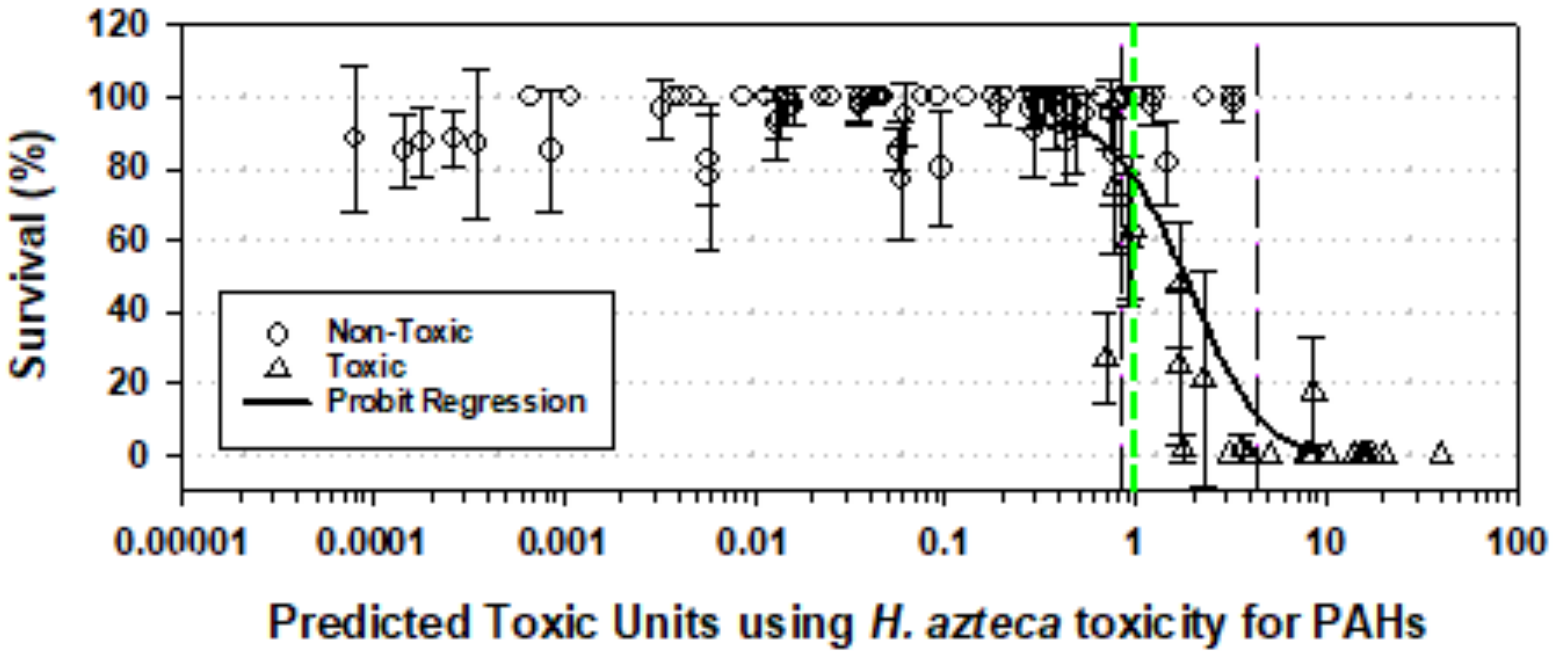
Toxicity Testing Results

- 28-day survival data for 97 samples from six MPG and two Al-smelter sites (Hawthorne et al. 2007)
  - Results:
    - Form dose-response shape
    - Breakpoint between toxic and non-toxic samples



Long-Term Monitoring

- With PWRGs
  - Know breakpoint between acceptable and unacceptable exposures
    - Site specific
    - Bulk and/or pore water basis

- In a long-monitoring program
  - Concentrations over time allows documenting
    - Trends towards acceptable thresholds or
    - If acceptable thresholds are present and maintained.
  - Allows potentially less toxicity testing in the monitoring program

Summary

- When PWRGs and toxicity testing data are consistent
  - Reasonably assured
    A. The causes of toxicity are identified properly
    B. PWRGs will be protective of benthic organisms at the site

- PWRGs
  - Accounts for contaminant bioavailability considerations

- Questions