

PCBs: Background Information

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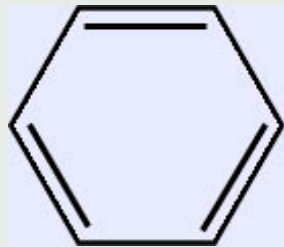
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What are Polychlorinated Biphenyls (PCBs)?

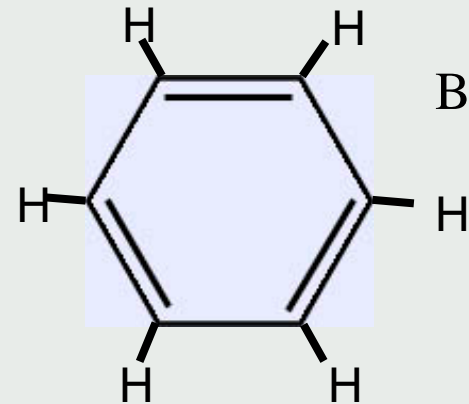
- Chemicals used widely as cooling, insulating and di-electric fluids, especially in transformers.
- Manufactured by Monsanto from 1930s to 1970s.
- Persistent in nature and not very soluble in water.
- Accumulate in sediments and can accumulate in animal and plant life.
- PCBs are found widely in sediments.
- They are associated with cancer and non-cancer health effects in animals and people.

What are Polychlorinated Biphenyls (PCBs)?... *the Chemistry*

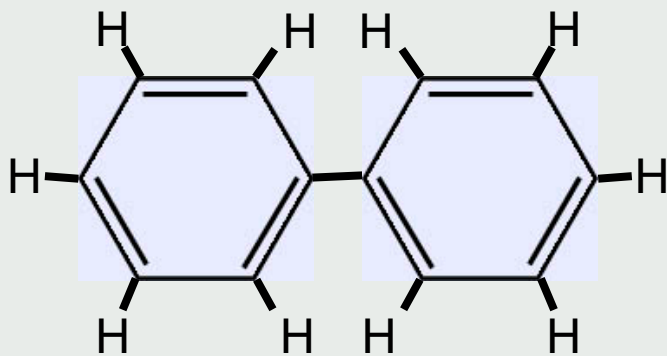


6 Carbon "Aromatic"
Ring: Very Stable

Add
Hydrogen



Benzene

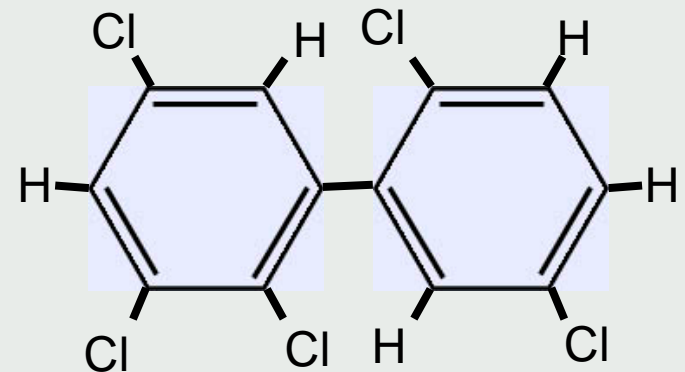


2 benzenes linked together is
A "Biphenyl"

Replace
Hydrogen with



Chlorine
to get PCBs



Example: a *pentachlorobiphenyl*

What are Polychlorinated Biphenyls (PCBs)?

- There are 209 different combinations of hydrogen and chlorine around the biphenyl, so 209 different PCBs.
- PCB toxicity, movement and degradation vary among the 209 different PCBs

For our purposes, consider them all immobile, long-lasting and potentially toxic..

What are Aroclors?

- Aroclors are commercial mixtures of PCBs
- Aroclors measured in the environment only roughly correspond to the original mixture (different migration and degradation)
- Aroclor analyses can help to identify unique sources of PCBs

***For our purposes, Total PCBs are important,
not the Aroclor.***

Implications of PCB Chemistry

- PCBs “stick” to soil and sediment
- PCBs are not particularly soluble in water
- PCBs are not particularly volatile
(air emissions not a significant problem)
- PCBs tend to accumulate in fatty tissue of animals, fish... and humans.

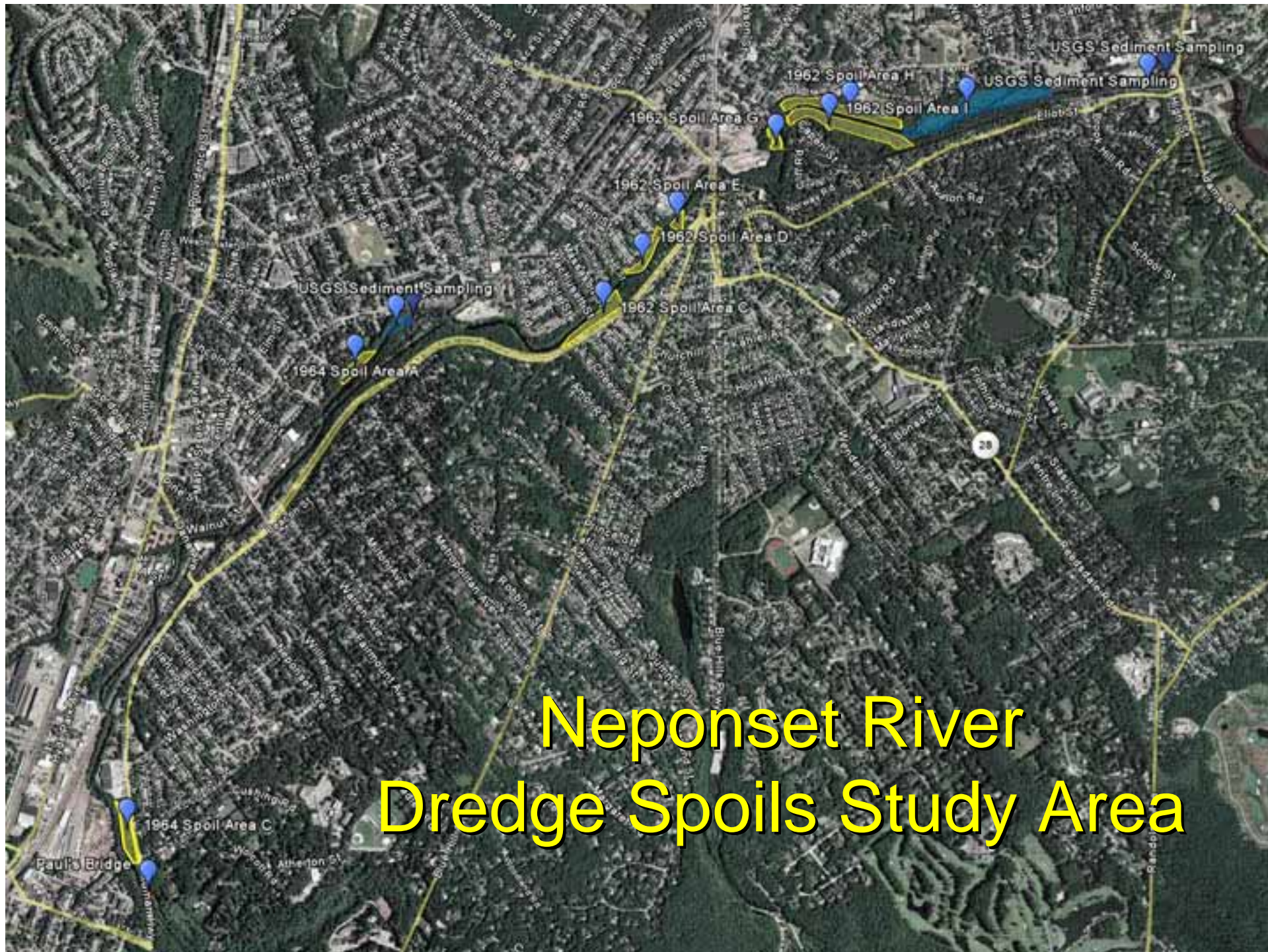
Next

PCBs and Sediments

PCBs and Soils



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Neponset River Dredge Spoils Study Area



Purpose of Project

- Historical dredge spoils had been placed in areas along the Neponset River that are currently accessible to and used by the public
- Some recent studies of the Neponset River suggested that the dredge spoils might contain PCBs and possibly metals at levels of concern
- These areas were investigated to determine if they are safe for recreational use

Scope of Soil Sampling

- 80 surface soil sample locations (160 PCB samples) and 4 sediment samples at canoe launches
- Sampling completed in the most publicly accessible areas:
 - Trails
 - Playgrounds, Baseball outfield
 - Vegetable gardens (Raised Bed)
 - Canoe Launches
- 67 of these soil samples also analyzed for metals

Status of Sampling Program

| <i>Dredge Year</i> | <i>Dredge Spoil Area</i> | <i>Description and Nearest Receptor</i> | <i>Sampling Status</i> |
|--------------------|--------------------------|---|--|
| 1962 | Spoil Area "C" | Residential Area near Truman Highway, Milton | Completed |
| | Spoil Area "D" | Kennedy Playground and Walking Trail, Residential Area near Edgewater Drive, Boston | Completed |
| | Spoil Area "E" | DCR building on Truman Highway, Milton | Phase 1 completed, waiting for Phase 2 lab results |
| | Spoil Area "G" | Public access/path near Riverside Place, Boston | Completed |
| | Spoil Area "H" | Ryan Playground (DCR) near River Street, Boston | Completed |
| | Spoil Area "I" | Residential Area near Eliot Street, Boston | Phase 1 completed, waiting for Phase 2 lab results |
| 1964 | Spoil Area "A" | Business/Residential Area near Railroad Avenue/Riverside Square, Boston | To be scheduled |
| | Spoil Area "C" | Business area (Stop & Shop) near Truman Highway, Milton | To be scheduled |

MassDEP Soil Standards

Chemicals in soil at average levels greater than or equal to the following could pose a potential health risk over a lifetime:

PCBs: 2 parts per million (ppm)

Total Lead: 300 ppm

Total Arsenic: 20 ppm

Total Nickel: 20 ppm

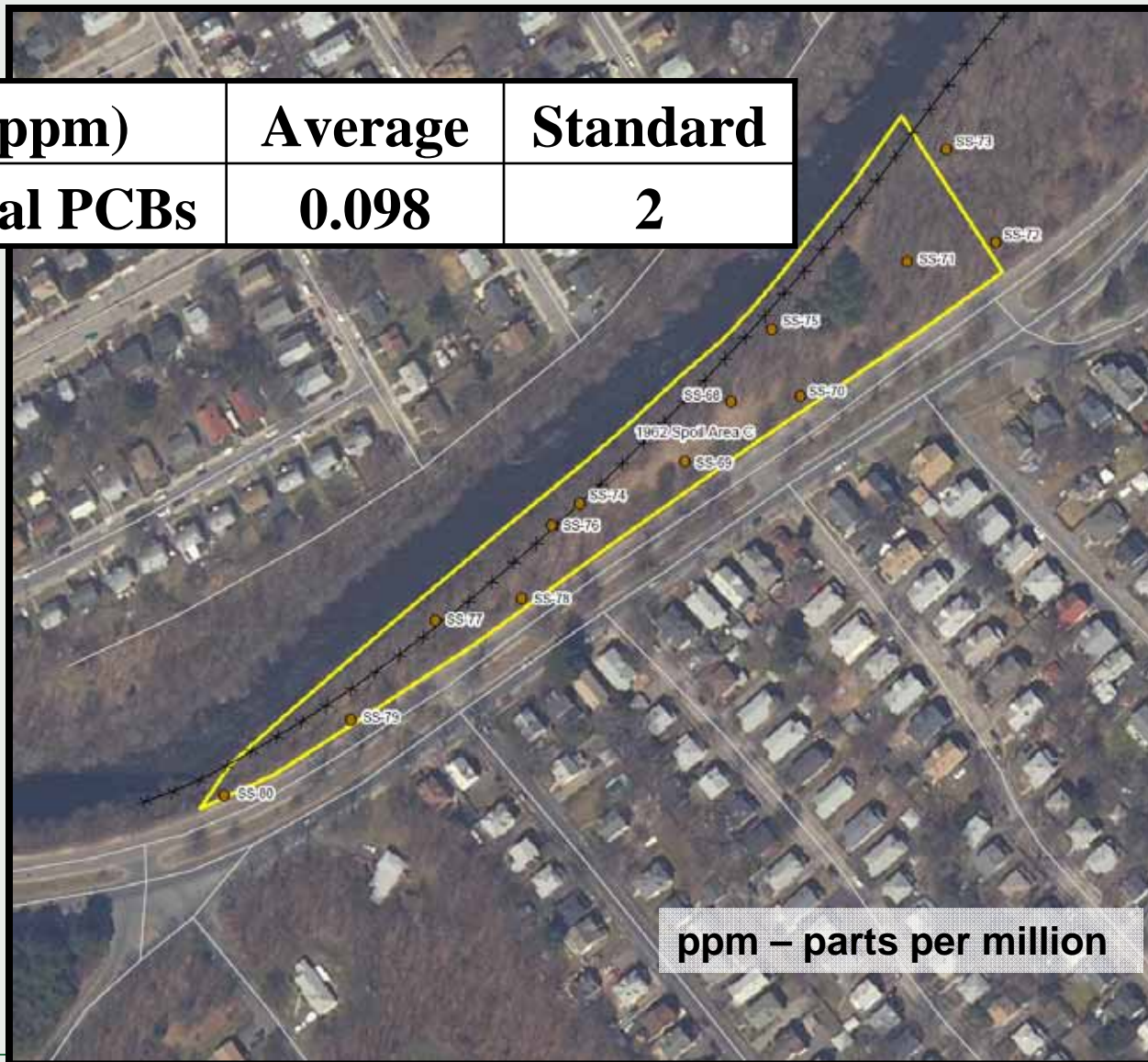
Prevent direct contact with chemicals in soil at levels greater than or equal to the following:

PCBs: 10 ppm

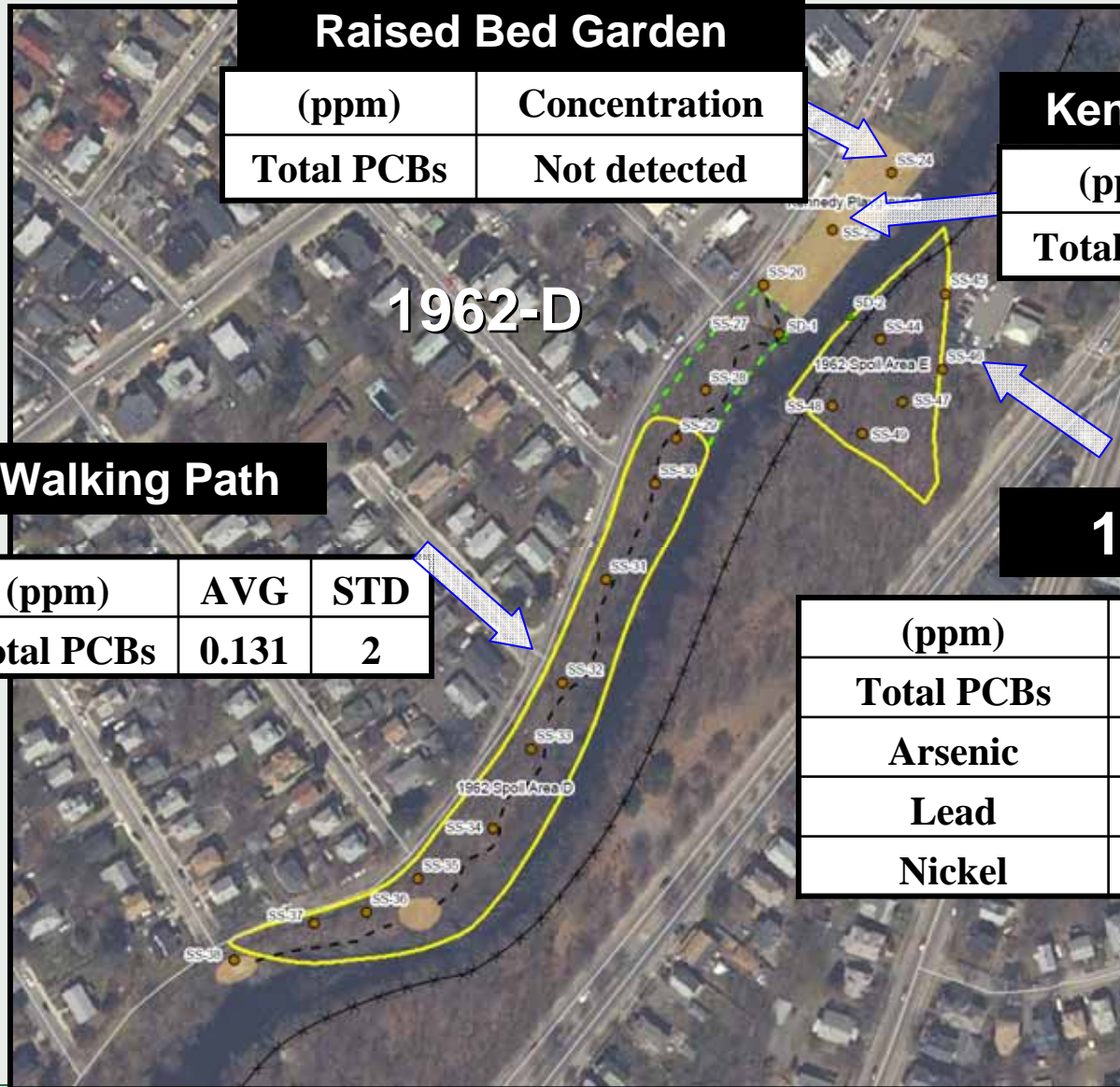
Total Arsenic: 40 ppm

Dredge Spoil 1962-C

| (ppm) | Average | Standard |
|-------------------|--------------|----------|
| Total PCBs | 0.098 | 2 |



Dredge Spoil 1962-D & 1962-E



| Raised Bed Garden | |
|-------------------|---------------|
| (ppm) | Concentration |
| Total PCBs | Not detected |

| Kennedy Playground | | |
|--------------------|-------|-----|
| (ppm) | AVG | STD |
| Total PCBs | 0.016 | 2 |

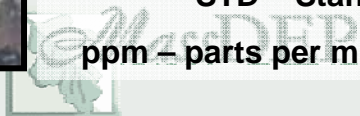
Walking Path

| (ppm) | AVG | STD |
|------------|-------|-----|
| Total PCBs | 0.131 | 2 |

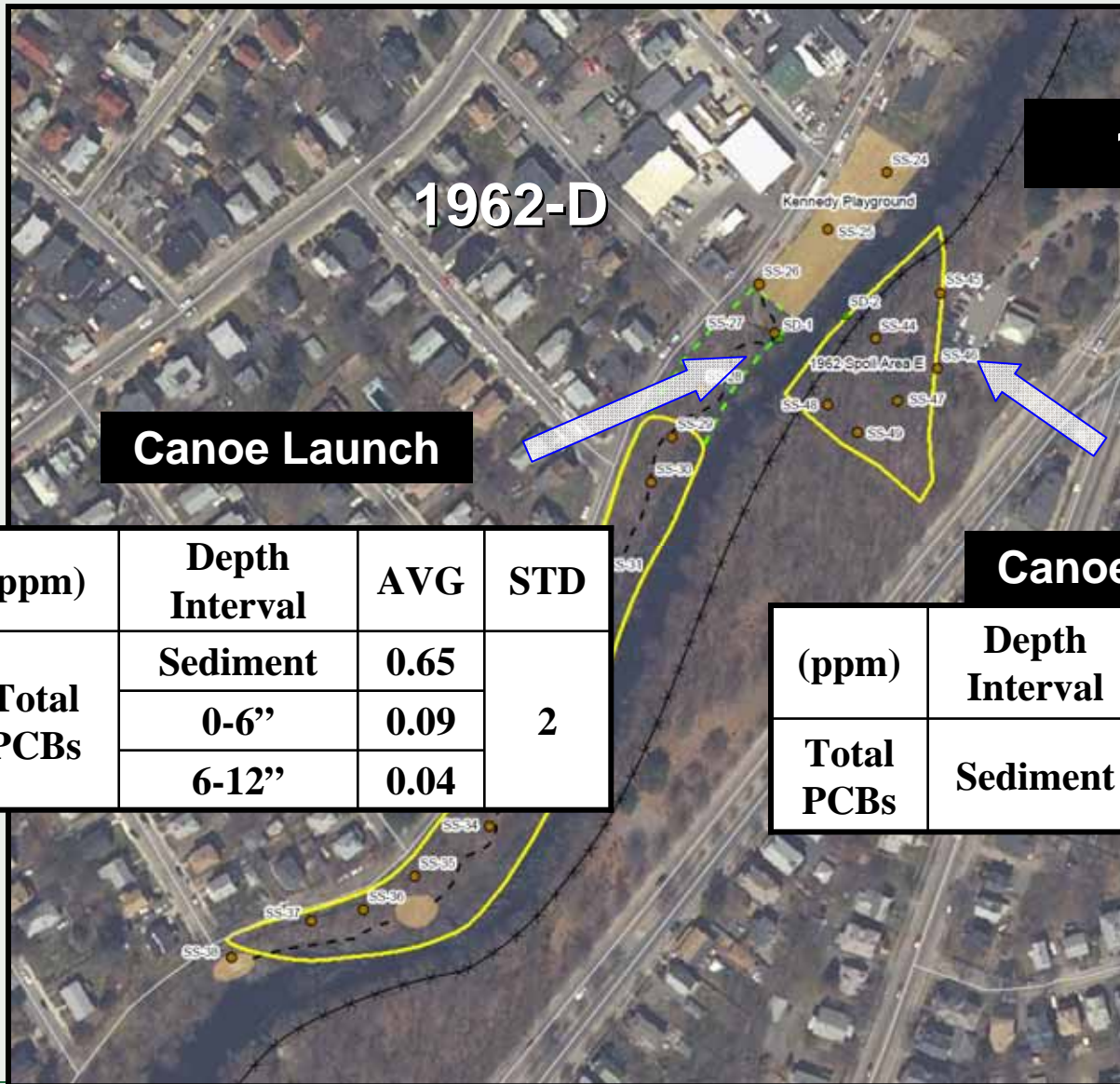
1962-E

| (ppm) | AVG | STD |
|------------|-------|-----|
| Total PCBs | 0.212 | 2 |
| Arsenic | 8.0 | 20 |
| Lead | 539 | 300 |
| Nickel | 9.5 | 20 |

AVG – Average
 STD – Standard
 ppm – parts per million



Dredge Spoil 1962-D & 1962-E



Canoe Launch

1962-E

| (ppm) | Depth Interval | AVG | STD |
|------------|----------------|------|-----|
| Total PCBs | Sediment | 0.65 | 2 |
| | 0-6" | 0.09 | |
| | 6-12" | 0.04 | |

Canoe Launch

| (ppm) | Depth Interval | AVG | STD |
|------------|----------------|--------------|-----|
| Total PCBs | Sediment | Not detected | 2 |

AVG – Average
 STD – Standard
 ppm – parts per million

Dredge Spoil 1962-G, 1962- H & 1962-I

Walking Path

| (ppm) | AVG | STD |
|------------|------|-----|
| Total PCBs | 0.68 | 2 |

Ryan Playground

| (ppm) | AVG | STD |
|------------|-------|-----|
| Total PCBs | <0.02 | 2 |

1962-H

| (ppm) | AVG | STD |
|------------|------|-----|
| Total PCBs | 0.12 | 2 |
| Arsenic | 5.7 | 20 |
| Lead | 103 | 300 |

1962-I

1962-G

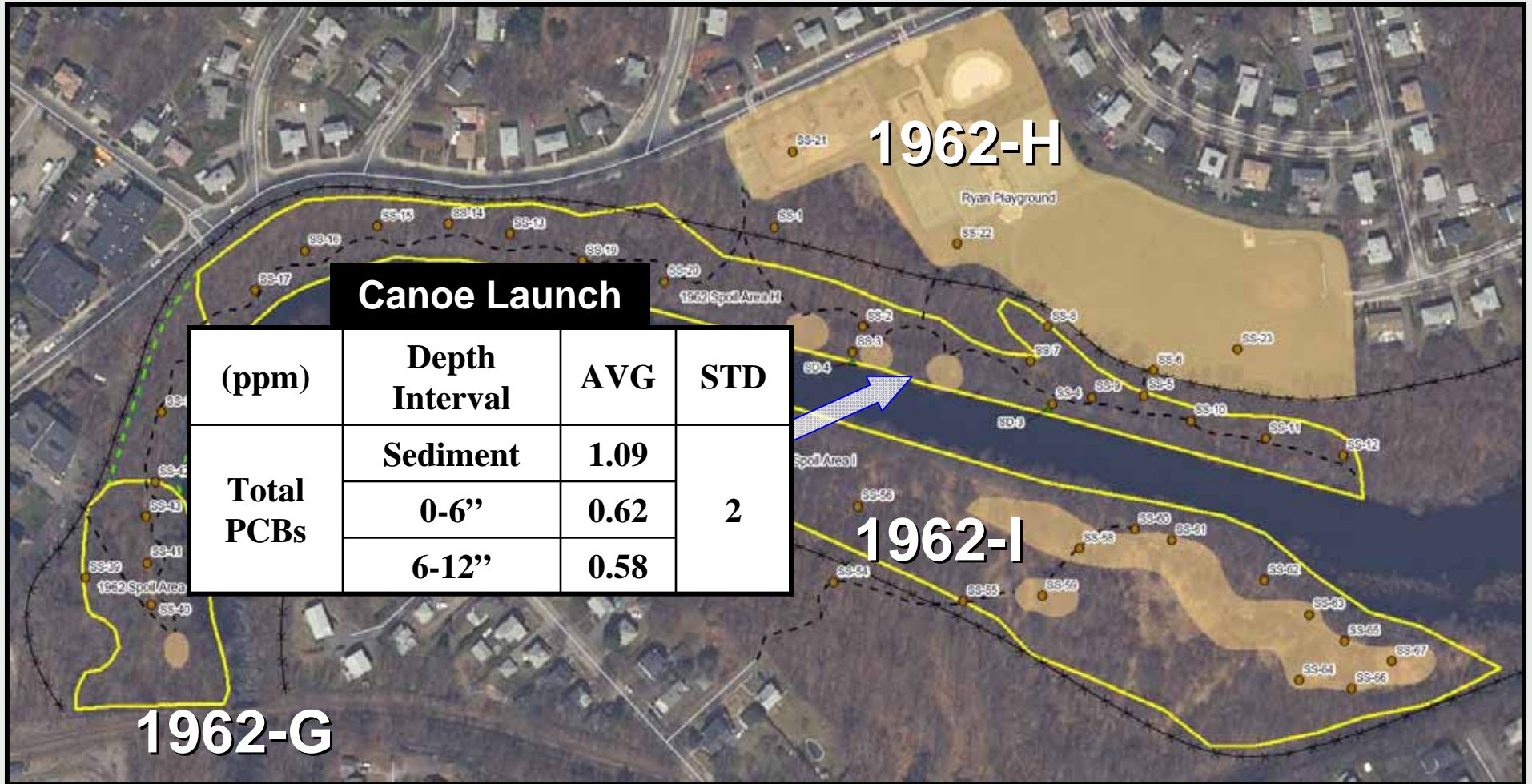
| (ppm) | AVG | STD |
|------------|-------|-----|
| Total PCBs | 0.745 | 2 |

| (ppm) | AVG | STD |
|------------|------|-----|
| Total PCBs | 0.27 | 2 |
| Arsenic | 17.9 | 20 |
| Lead | 187 | 300 |

AVG – Average
 STD – Standard
 ppm – parts per million



Dredge Spoil 1962-G, 1962- H & 1962-I



AVG – Average
 STD – Standard
 ppm – parts per million

PCB Sampling Results

- With respect to PCBs, soils are safe for recreational use
- No soil cleanup necessary for PCBs
- No restrictions necessary

Metals Sampling Results

- With respect to metals, soil at all areas except Area 1962-E are safe for recreational use and even for residential use.
- No cleanup necessary, except for lead at one location at Area 1962-E
 - Lead at one sampling location in Area 1962-E will be removed

Dredge Spoil Area 1962-E DCR Building



DCR Building

Summary of Results and Conclusions

- Sampling shows that all areas except Area 1962-E are safe for recreational use and no cleanup is necessary
- One location at Area 1962-E required further sampling and limited soil removal due to lead concentrations
 - Soil sampling complete, results pending, and removal is planned
- Confirmatory testing for metals has been conducted at three locations in Area 1962-I (results pending)
- Due diligence sampling confirms historical dredging does not impact public safety in these areas

Human Health Risks and PCBs

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Risk Assessment

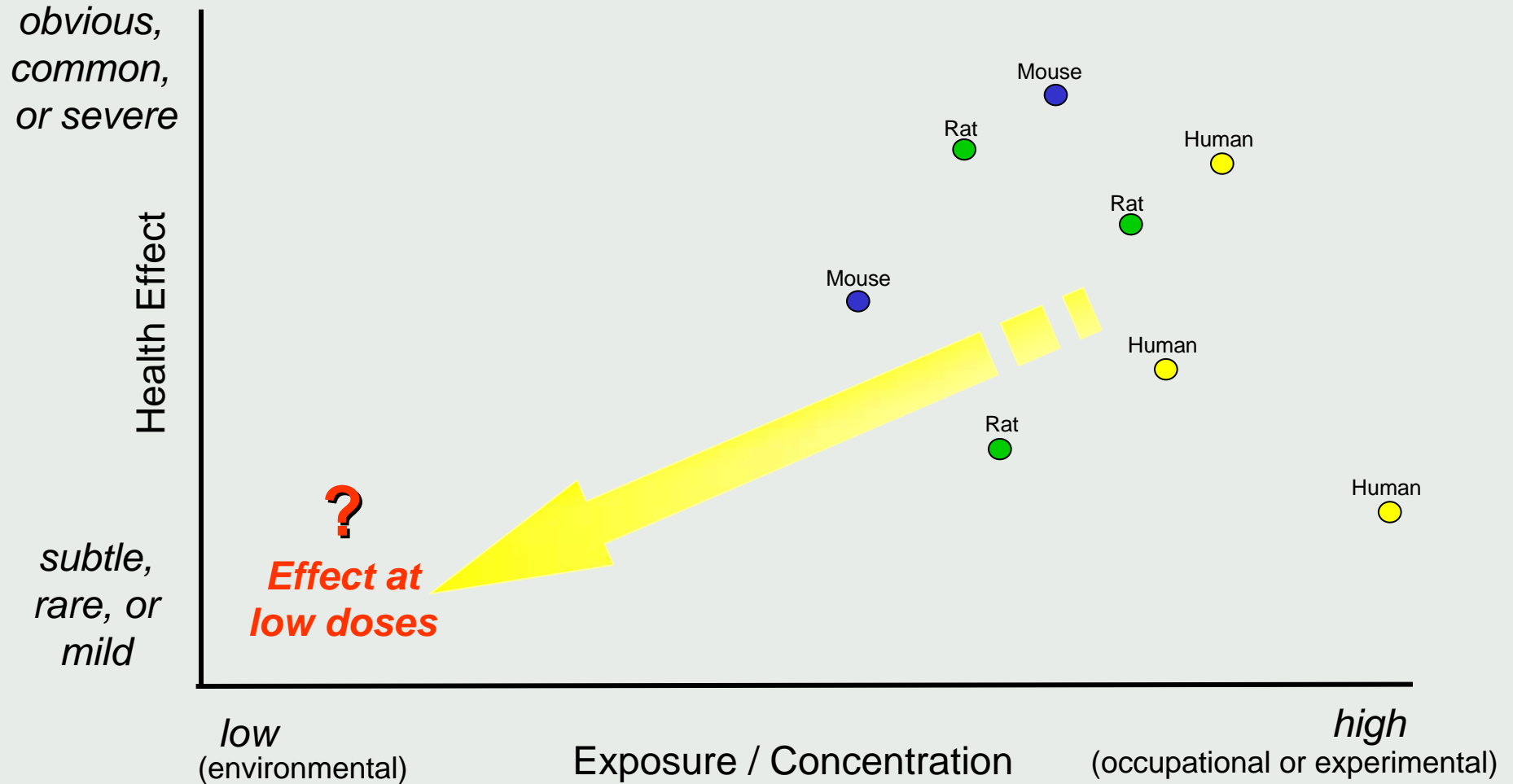
$$\textit{Risk} = \textit{Hazard} \times \textit{Exposure}$$

- Contaminant's *toxicity* determines the potential hazard.
Properties such as *solubility*, *volatility* and *biodegradation potential* determine where the contaminant ends up.
- Exposure is determined by *how much contact* you have with the contaminated material

PCB HEALTH EFFECTS

- As a general rule, the more highly chlorinated compounds (those with 48% chlorine or greater) are more potent enzyme inducers, more resistant to metabolism, and, for some endpoints, more toxic than the lower-chlorinated compounds
- Health effects of concern:
 - Cancer
 - Reproductive/developmental
 - Neurologic
 - Immunological
 - Other organ systems
 - Skin, liver, cardiovascular, endocrine/thyroid

Evaluating Toxicity



PCBs in the Neponset

- Reported in sediment, up to 231 ppm (parts-per-million)
 - Average around 30 ppm (higher in some locations)
 - Lower concentrations top layer (0.3 to 22 ppm)
- Reported in soil
(up to approximately 4 ppm, all averages less than 2 ppm)
- Reported in fish (brown bullhead and white sucker)
- Reported in water (0.002 - 0.044 ppb, parts-per-billion)

Potential Neponset River Exposures

- Contact with contaminated sediment (playing in water, launching canoes etc.)
- Contact with contaminated soil (playing, hiking along river)
- Contact with contaminated water (skin contact and incidental drinking)
- Consumption of contaminated fish

Neponset River Risk Concerns

- Exposure to PCB-contaminated sediment is limited, resulting in low current risk. Concerns remain about *future* risk.
- PCB soil concentrations along shoreline are less than residential standards, resulting in low current risk. (Additional testing planned)

Neponset River Risk Concerns

- Water concentrations are well below PCB drinking water standard, resulting in low current risk.
- PCB fish tissue concentrations warrant DPH Advisories for species tested. Concerns about additional species remain and questions about extending Advisories to other areas.
(Additional testing conducted, results pending)

Ecological Risks and PCBs

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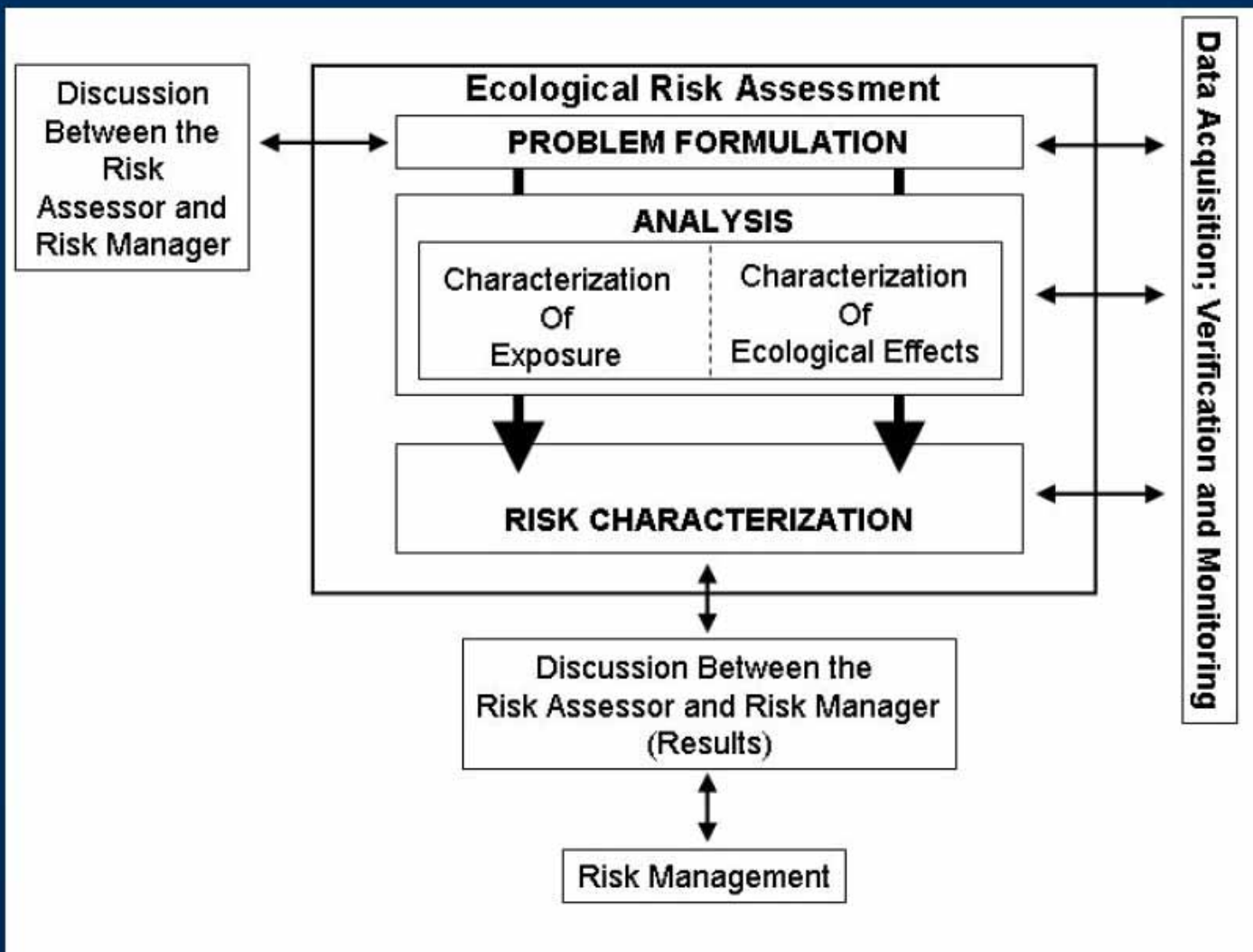


Neponset River Ecological Risk Assessment

- No comprehensive ecological assessment has been conducted evaluate the effects of PCBs in the Lower Neponset River
- Look at the Housatonic River example
 - PCBs in sediment and floodplain of Housatonic at greater concentrations
 - Housatonic is “wilder” than the Lower Neponset
 - Comparison may still be illustrative

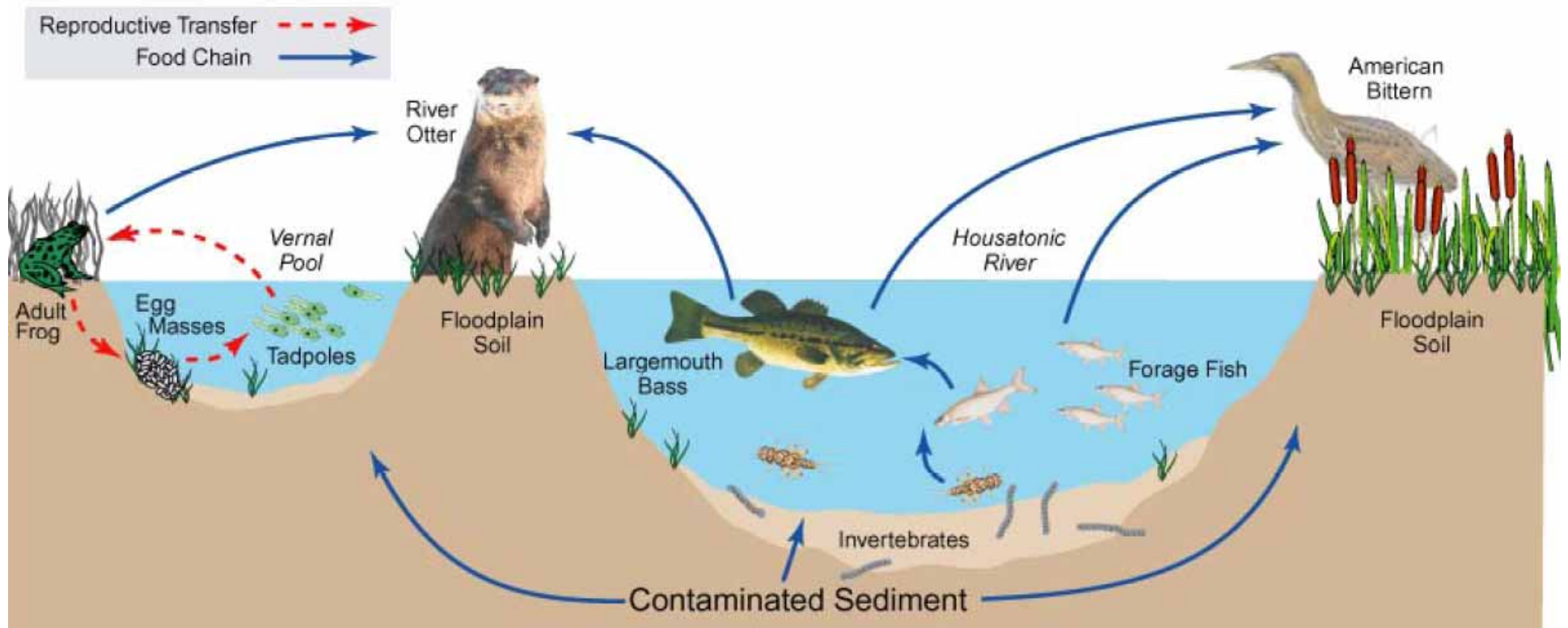


Framework for Ecological Risk Assessment (ERA)





Objectives – Food Chain





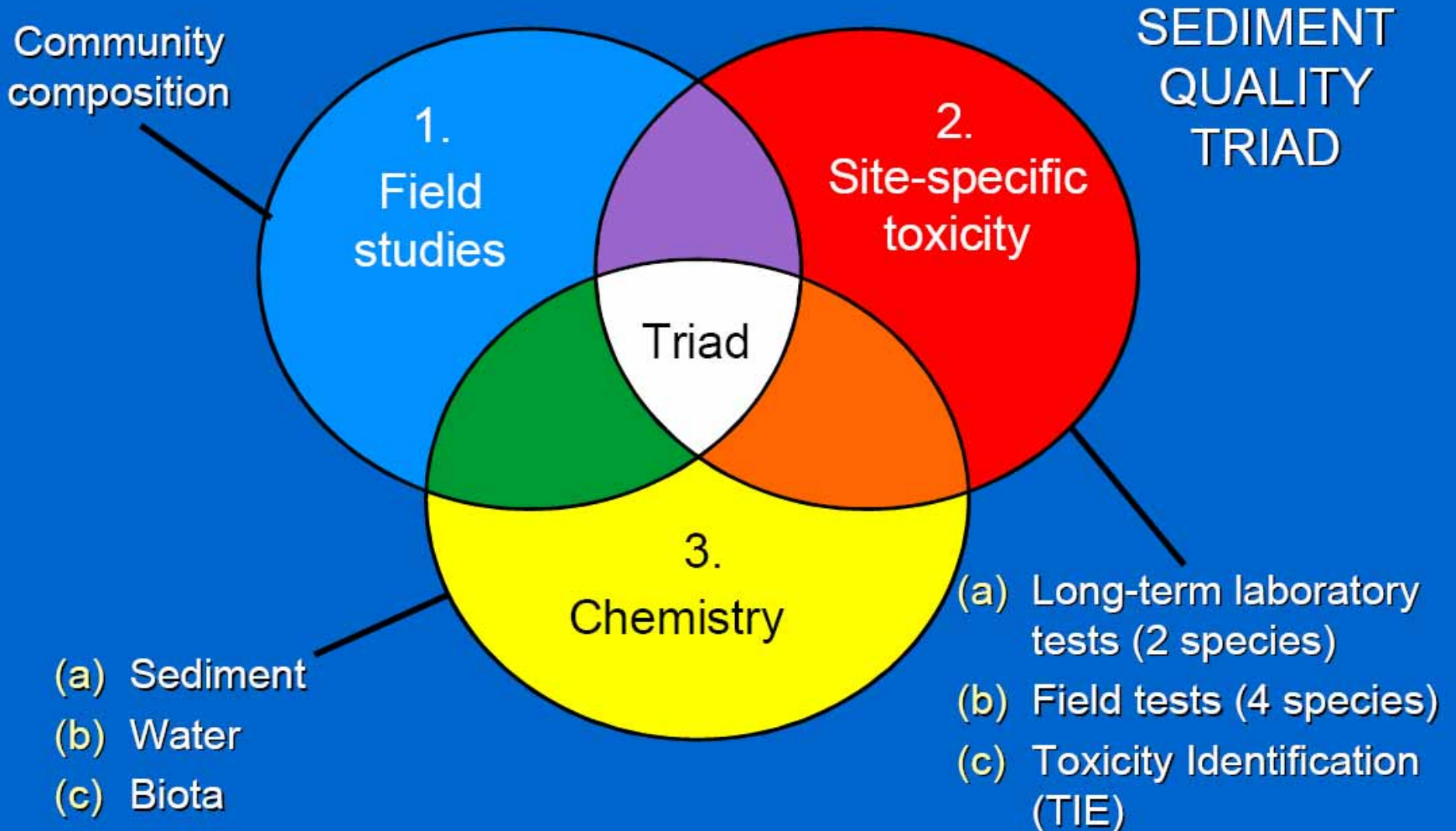
Assessment Endpoints

- Community condition, survival, reproduction, and development of:
 - Benthic invertebrates
 - Amphibians
- Survival, growth and reproductive success of:
 - Fish
 - Insectivorous birds
 - Piscivorous birds
 - Piscivorous mammals
 - Omnivorous and carnivorous mammals
 - Endangered species



Measurement Endpoints and Lines of Evidence

(Benthic Invertebrates)





Risk Characterization

(Benthic Invertebrates)

| Measurement Endpoints | Weighting | Coarse-Grained Sediments | |
|---|-----------|--------------------------|--------------|
| | | Evidence of Harm | Magnitude |
| C. Chemical Measures | | | |
| C-1. Water chemistry | Low/ Mod | Yes | Intermediate |
| C-2. Sediment chemistry | Low/ Mod | Yes | High |
| C-3. Tissue chemistry | | | |
| T. Toxicological Measures | | | |
| T-1. Sediment toxicity (lab) | | | |
| T-2. Sediment toxicity (field) | | | |
| T-3. Indications of PCB effects | | | |
| B. Benthic Community | | | |
| B-1. Abundance, richness of benthic invertebrates, relative to reference | | | |
| B-2. Benthic community structure multivariate assessment | | | |
| B-3. Modified Hilsenhoff Biotic Index (MHBI) indicator of organic pollution | Moderate | No | — |

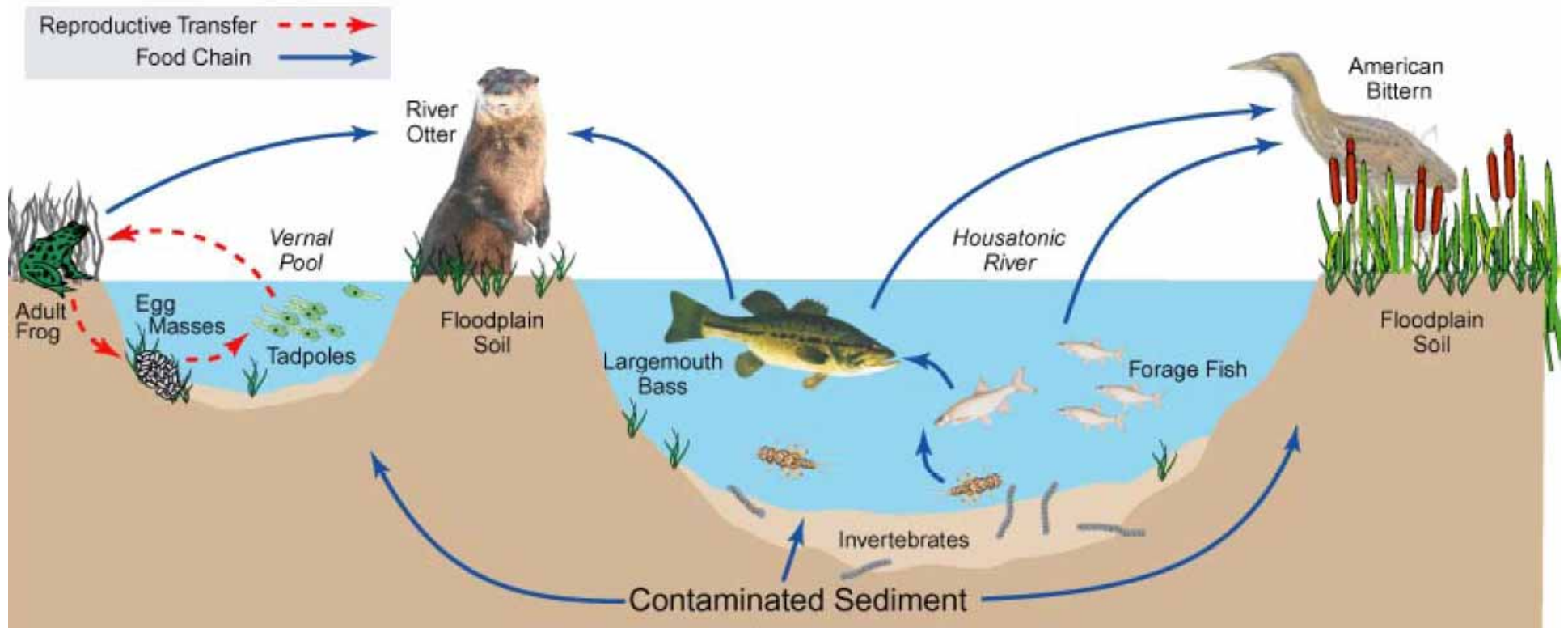
Conclusion:

Sediment concentrations greater than 3 mg/kg of total PCBs resulted in risk to benthic invertebrates.

Is that a problem?



Objectives – Food Chain





Representative Species

Predators



Yellow Perch



Largemouth bass

Forage Fish



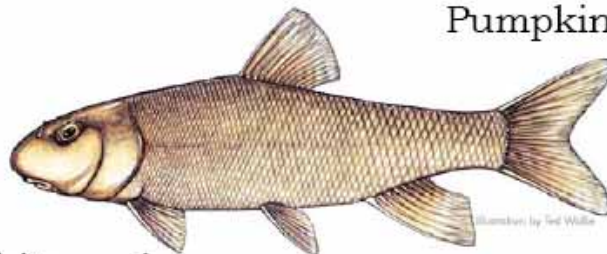
Bluegill

**Assessment Endpoint:
Survival, growth and
reproduction of fish**



Pumpkinseed

Bottom Fish



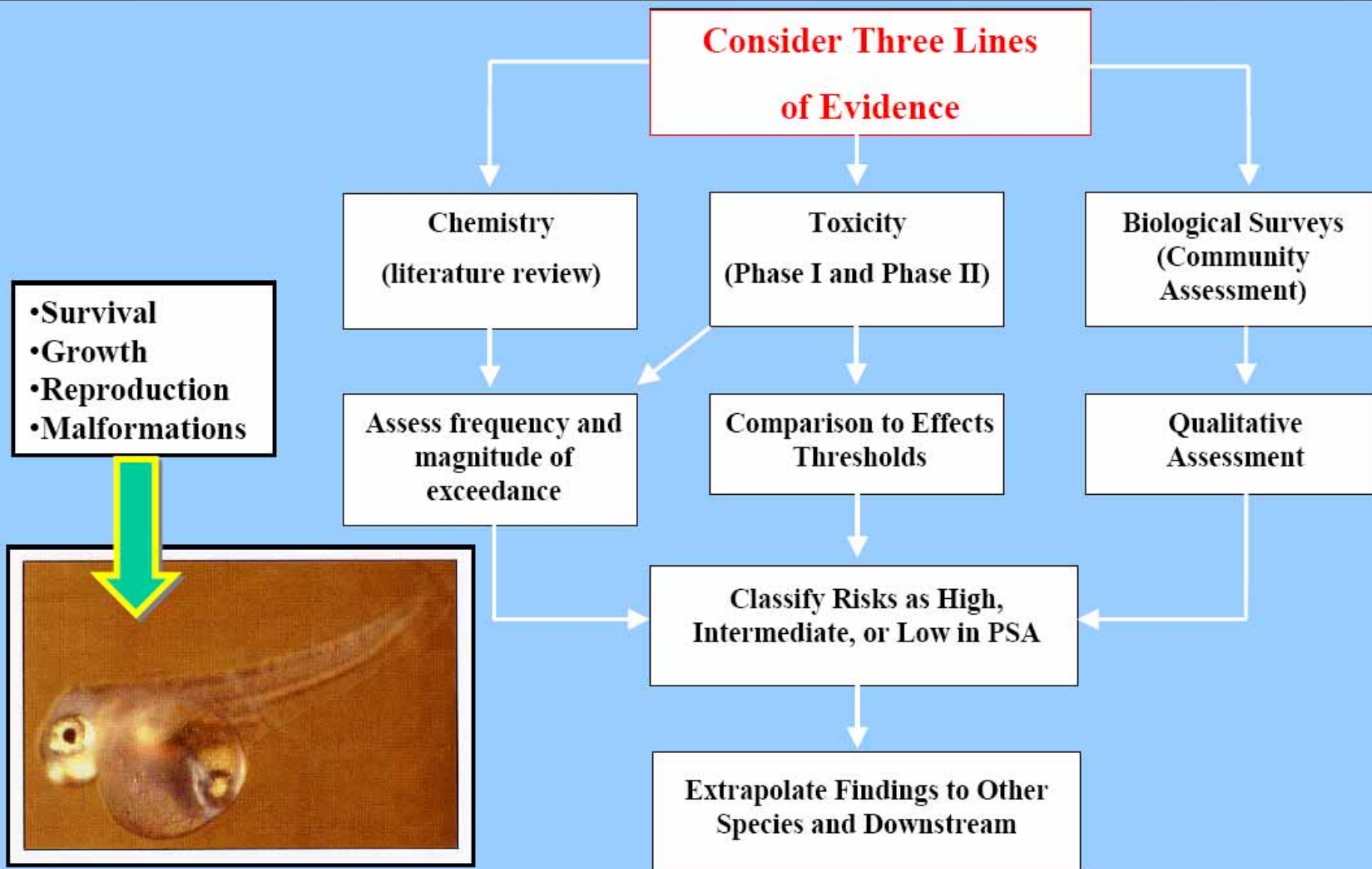
White sucker



Brown bullhead



3 Lines of Evidence





Deformity Rates (N/1000) in 15-Day Offspring of Largemouth Bass Fry from the Housatonic River

| Deformity | Three-Mile Pond | Rising Pond | Woods Pond | Deep Reach |
|----------------------------|-----------------|------------------|------------------|------------------|
| Swim Bladder | | | | |
| - Uninflated | ND | 333 ^a | 9 ^a | 24 ^a |
| - Partially-inflated | ND | 120 ^a | 429 ^a | 88 ^a |
| - External | ND | 67 ^a | 27 ^a | 24 ^a |
| Shortened Operculum | ND | ND | ND | 220 ^a |
| Tail Deformity | ND | ND | 18 ^a | ND |



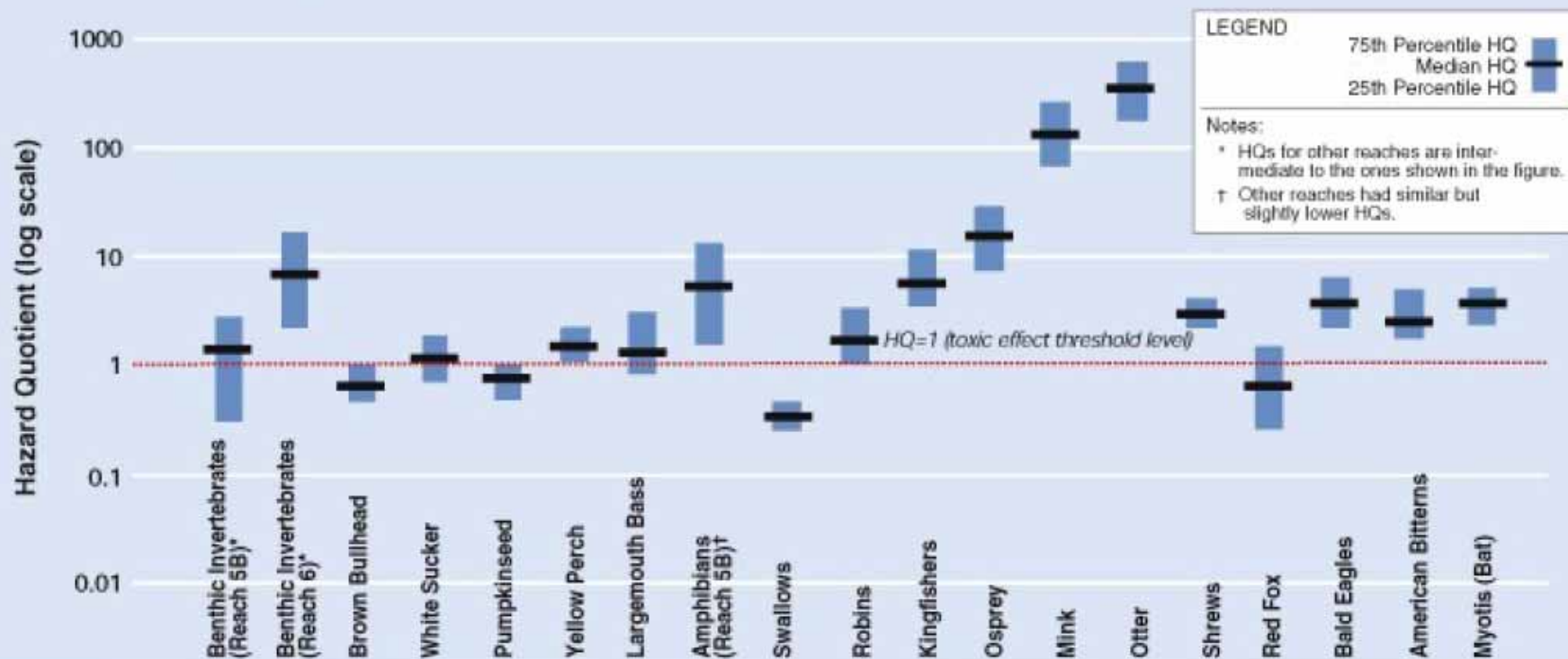
Risk Characterization

| Measurement Endpoints | Weighting | Evidence of Harm | Magnitude |
|--------------------------------------|---|------------------|--------------|
| A. Site-Specific Toxicity | | | |
| A1. Phase I reproductive effects | Mod/High | Yes | Low |
| A2. Phase II reproductive effects | High | Yes | Intermediate |
| B. Fish Body Burden | | | |
| B1. Observed fish tissue/ I | <div style="border: 2px solid black; padding: 10px; text-align: center;"> <p>Conclusion:</p> <p>Threshold effects level = 49 ppm</p> </div> | | |
| B2. Observed fish tissue/ F | | | |
| B3. Observed fish tissue/ F | | | |
| C: Fish Community and | | | |
| C1: EPA Study and GE Community Study | Low/Mod | Undetermined | - |
| C2: GE Reproduction Study | Low/Mod | Undetermined | - |



Summary of Risks in PSA

Summary of the Range of Hazard Quotients from Total PCBs for Selected Species



Implications for Neponset?

- Concentrations of PCBs in Lower Neponset likely to have effects on ecosystem.
- Neponset itself not studied, so extent, magnitude and significance of effects unknown.
- Decreases in PCB sediment concentrations can reduce potential risks to ecosystem.

MassDEP Objectives

- Maintain current condition of No Significant Risk from contact with soil, sediment and surface water;
- Continue work on fish ingestion/advisories with DCR, DPH and others;
- Insure that any restoration alternative does not increase current or future risk to health or the ecosystem.