Ecological Considerations Related to Thin-layer Sand Capping

Reservoir 2

Nyanza Site Operable Unit 4

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Outline for Reservoir 2

- Ecological risk investigations
- Current ecological risk potential
- Current habitat values
- Why “no-action” was not the chosen remedy
- Expected effects of sand cap and post-cap recovery
- How will we know if it works?
- Questions

Overview of Ecological Risk Studies

- Operable Unit 4, Sudbury River, established in 1993 recognizing that potential risks extended downstream of clean-up in Eastern Wetland. Existing fish mercury data were considered inadequate by mercury experts at that time and further study was needed to evaluate rest of river.

- 1995-1997 : Task force of scientists from EPA, NOAA, and USGS conducted sampling of sediment and fish, mussel and mayfly toxicity testing, and depth profiling of mercury in sediment
- Task Force results summarized in a preliminary Baseline Ecological Risk Assessment (1999)

Overview of Ecological Risk Studies

- 2003-2005 Supplemental ecological studies included more sampling of fish and sediments, field studies for fish-eating birds and mammals, and field studies of insect-eating birds.
- All available ecological risk information analyzed and presented in 2008 Supplemental Baseline Ecological Risk Assessment
- 2005-2012 Various focused pre-design data collections including small fish sampling, sediment sampling, and habitat surveys

Study Subjects for Reservoir 2

- Reservoir 2 ecological study subjects
  - Sediment-dwellers (mayfly, freshwater mussel, crayfish)
  - Fish (sunfish, bullhead, yellow perch, largemouth bass)
  - Birds (tree swallow, great blue heron, kingfisher, hooded merganser)
  - Mammals (mink)

Ecological Risk Overview

- Determine if mercury causes or could cause adverse effects on plants, animals, or habitats
- Superfund typically sets “adverse effects” usually set at the population level (such as fewer fish or birds, altered ecological community) to drive clean-up actions

Ecological Risk Overview -2-

Assessment Endpoint – general statement of population or value to be evaluated

Example:

Sufficient rate of survival, growth, and reproduction to sustain populations of fish-eating birds

Measurement Endpoint – measurable biological response to a chemical which relates to the assessment endpoint

Example:

Comparison of measured fish concentrations with concentrations found to be toxic to birds that eat fish

Food Chain Modeling – all on paper!

- Birds and mammals selected to represent feeding guilds (e.g., kingfisher represents “fish-eating birds”)
- Feeding rates and food sources from scientific literature used to estimate a dose of contaminant
- Dose compared with toxicity values from scientific literature
- Toxicity values usually come in pairs. Many experiments establish “no-effect” and “effect” doses.

Food Chain Modeling – all on paper!

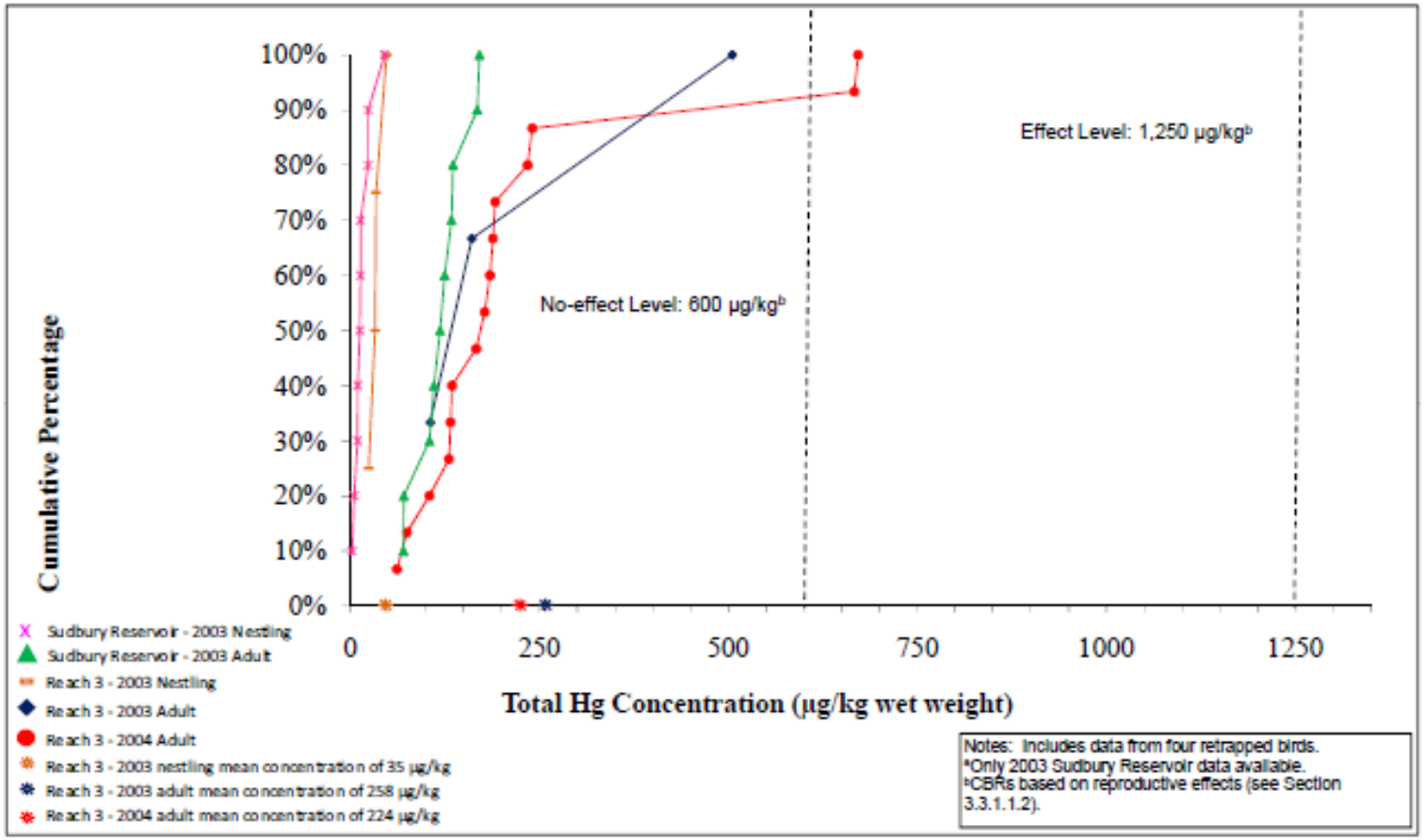
- A “No-effect” value can be thought of as a “safe” dose
- An “Effect” values can be thought of as a potentially unsafe dose
- If the estimated dose is over the “Effect” reference value, there is potential risk
- Direct measures of food items is given greater weight than estimations in decision-making

Examples of mercury CBRs

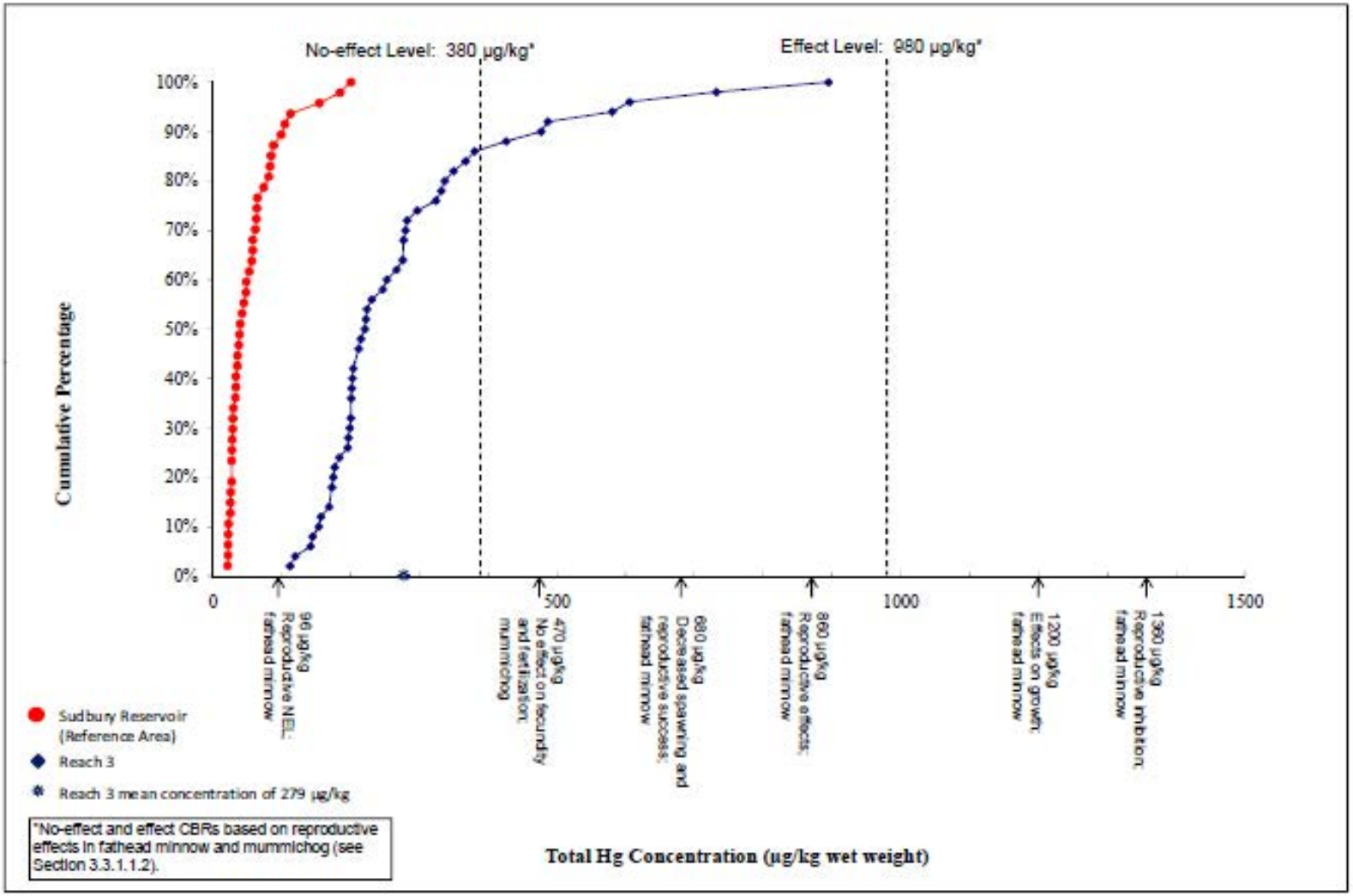
Target Tissue	"no effect" CBR (mg/kg)	"effect" CBR (mg/kg)
Whole fish	0.38	0.98
Bird egg (tree swallow)	0.80	1.6
Bird egg (water birds)	0.50	1.0
Bird blood (all species)	0.60	1.25

Example of CBR Use Tree Swallows

Figure 4-27
Cumulative Frequency Distribution of Total Mercury Concentrations in 2003 and 2004 Nestling and Adult Tree Swallow Blood from Reach 3 and Sudbury Reservoir Reference Area[a]
Nyanza Superfund Site OU IV Sudbury River Mercury Contamination



Example Of CBR Use Fish (Bass)



Ecological Assessment

- *229 Measurement Endpoints –*
  - food chain modeling results
  - site-specific/species-specific measurements
  - Measurement endpoint = species x media (e.g., blood, egg, feather, fur)
  - More weight given to site-specific tissue measurements over generic modeling based on sediment and water data.

Ecological Risk Assessment Summary For Reservoir 2

- A baseline ecological risk assessment (BERA) was finalized in 2008 for the Sudbury River, including Reservoir 2
- Res 2 receptor groups of interest
  - Benthic invertebrates (generic community, mayfly, *Elliptio* mussel, crayfish)
  - Fish (generic community, sunfish, bullhead, yellow perch, largemouth bass)
  - Birds (tree swallow, great blue heron, kingfisher)
  - Mammals (mink)

Eco Risk Summary for Reservoir 2 (cont'd)

- Risk calculations for Hg (cont'd)
  - Birds
    - Use food chain modeling to estimate Hg uptake in birds; compare uptakes to bird toxicity values for Hg
    - Compare field-collected swallow tissues (eggs, blood, feathers) to bird tissue benchmarks for Hg
  - Mammals
    - Use food chain modeling to estimate Hg uptake in mink; compare uptake to mammal toxicity values for Hg
    - Compare field-collected mink samples (blood and fur) to mammal tissue benchmarks for Hg

Eco Risk Summary for Res 2 (cont'd)

Receptor Group	Exposure Type	Risk Conclusion
BENTHIC INVERTEBRATES		
generic inverts.	sediment data	risk possible/low certainty (generic benchmark)
mayfly	laboratory test	risk unlikely/high certainty
Elliptio mussel	field exposures	risk possible/low certainty (problems with study)
crayfish	field collection	risk unlikely/high certainty
FISH		
generic fish	water data	risk possible/low certainty (generic benchmark)
fish (<20 cm)	field collection	risk unlikely/high certainty
fish (> 20 cm)	field collection	risk possible, but no population-level response

Eco Risk Summary for Res 2 (cont'd)

Receptor Group	Exposure Type	Risk Conclusion
BIRDS		
heron	food chain modeling	risk possible, but only with worst case exposure assumptions
kingfisher	food chain modeling	risk possible/moderate certainty (marginal habitat)
swallow	food chain modeling	risk possible/low certainty (insect tissue not measured)
swallow	field (egg)	risk unlikely/high certainty
swallow	field (blood)	risk unlikely/high certainty
swallow	field (feather)	risk possible, but only under high exposure assumption
MAMMALS		
mink	food chain modeling	risk possible, but only worst case exposure assumption
mink	field (blood)	risk unlikely/low certainty (only one blood sample)
mink	field (fur)	risk possible/low certainty (only one fur sample)

Res 2 Eco Risk Conclusions

- The 2008 BERA found evidence of Hg exposures well above background for some animals but at levels unlikely to cause observable "population-level" effects. However, <u>adverse effects below this threshold level are likely occurring in some receptors</u>
- Population-level risk is a "high bar"
- Other potential adverse effects, short of mortality:
  - Slower growth rates
  - Decreased life spans

Current Habitat Values

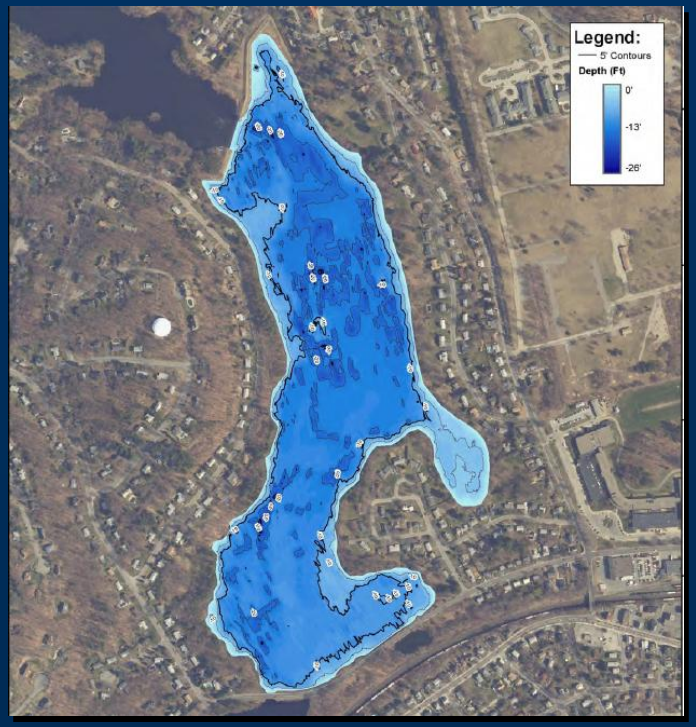
- US Army Corps performed a detailed habitat assessment in 2011
- This study will be used to minimize any adverse effects of capping, and return habitat functions post-capping
- Assessment included detailed survey of Reservoir bottom, habitat types, and areas of special interest

Habitat Survey Findings

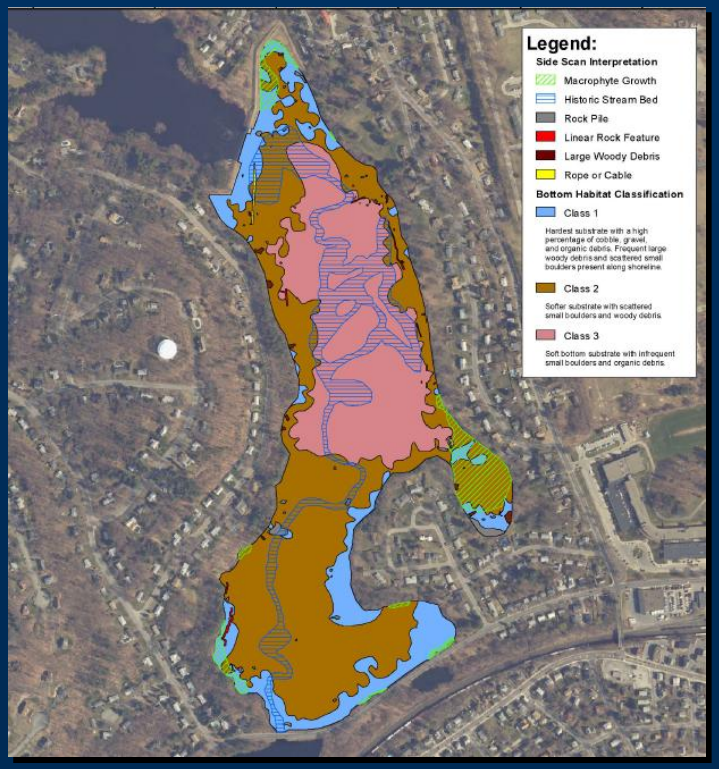
- Much of Reservoir >10’ in depth has very low dissolved oxygen in summer, limiting habitat value
- Shallow edge areas (especially sandy areas) provide best habitat for fish nesting
- Small areas of aquatic vegetation were identified
- Survey report includes recommendations to minimize impacts of capping and enhance recovery

Reservoir 2 Depths and Habitats

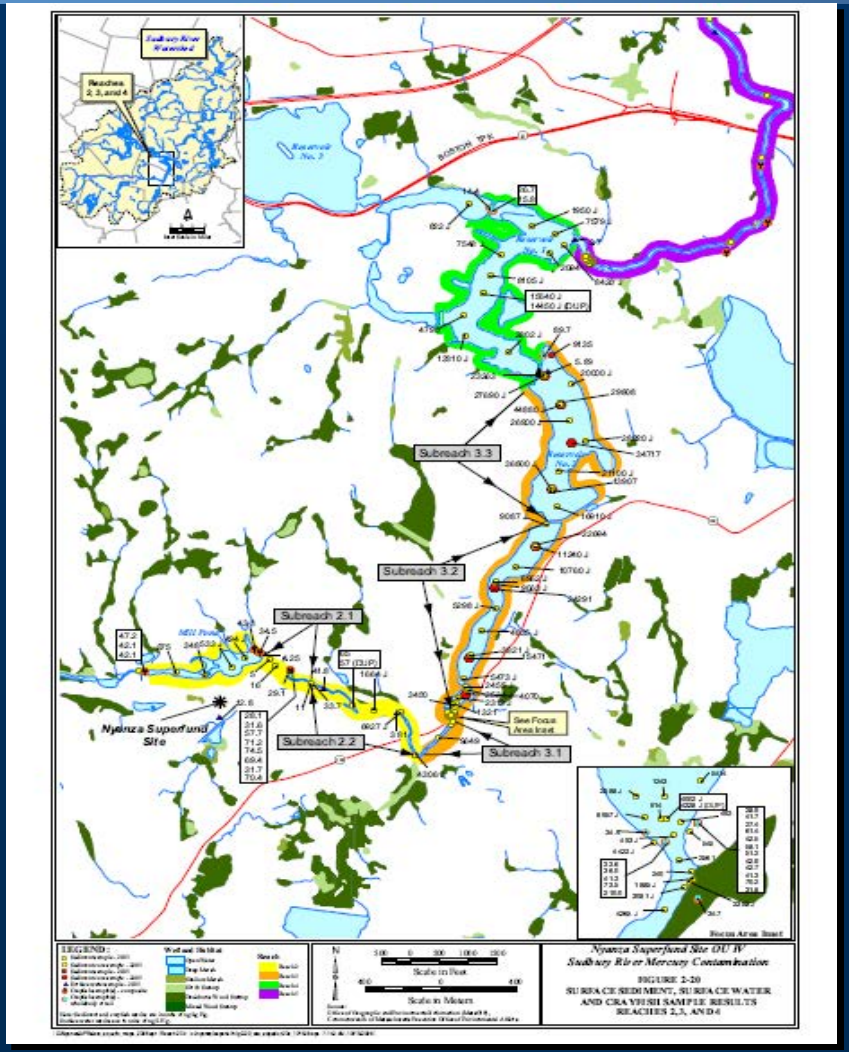
Water Depths

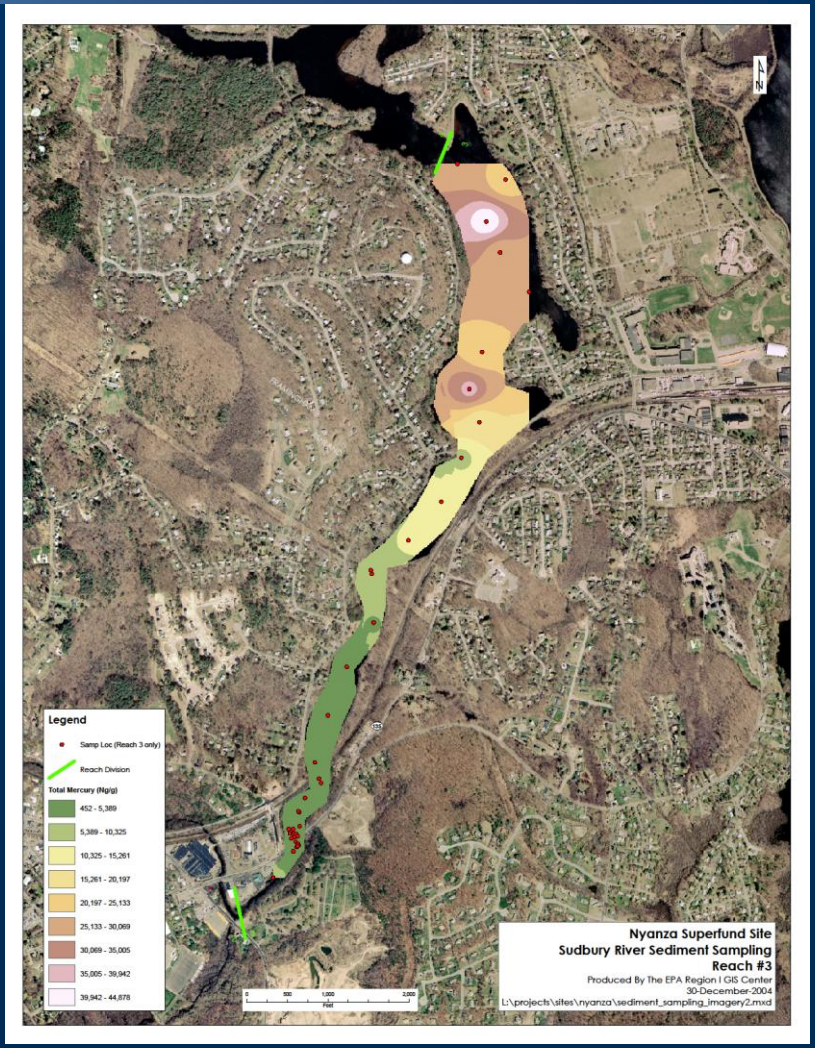


Habitat Types

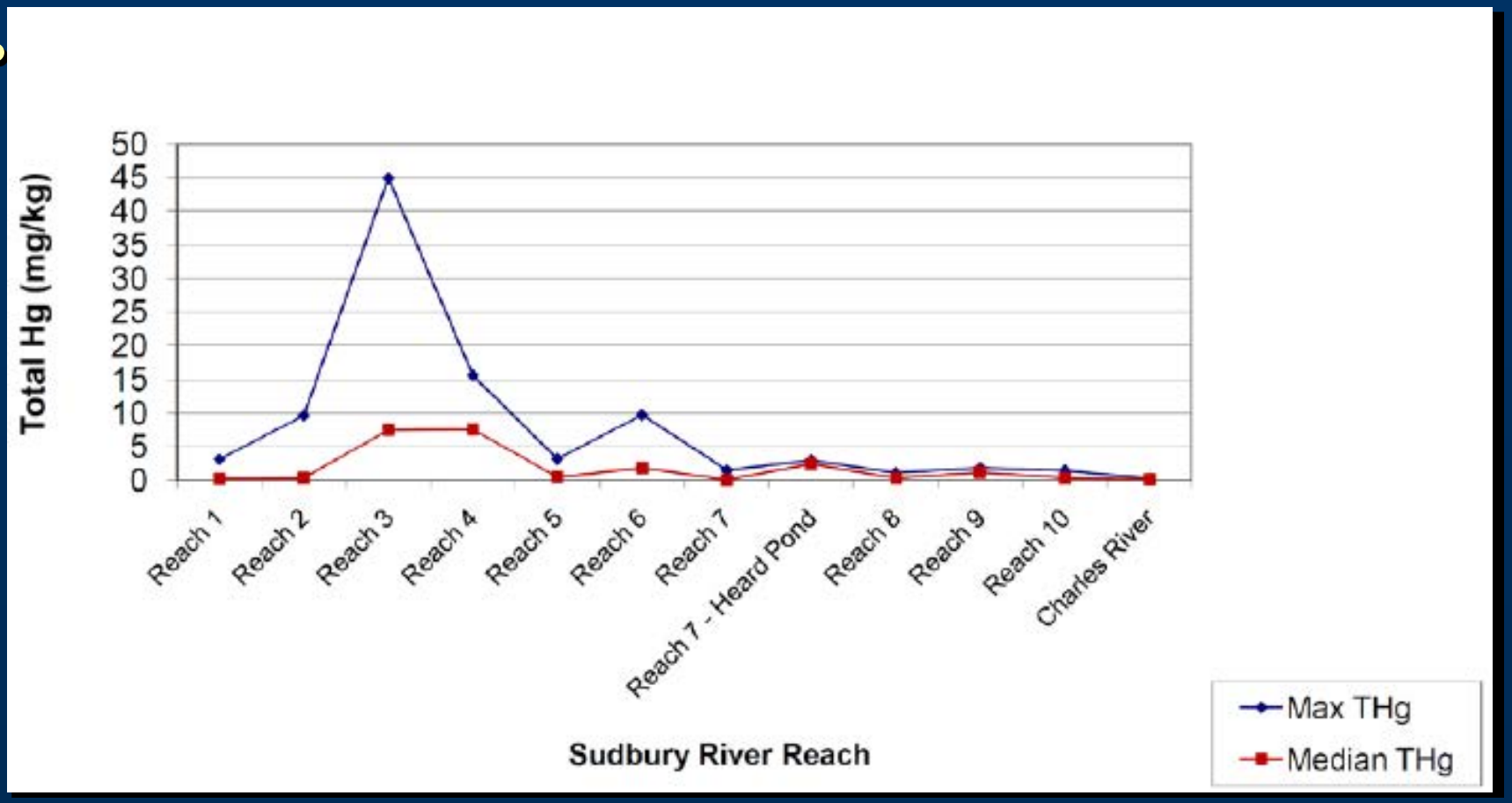


Mercury Distribution in Reservoir 2





Mercury Distribution - Sediment



Why "No Action" Option Was Not Selected

- Deposition rate of new sediment in Reservoir 2 is very low based on Task Force studies. Recent 0-5cm sediment samples indicated that high mercury sediments are still very near the surface
- EPA has 20 years of fish tissue data indicating no reduction in fish tissue levels over that time
- Mercury model suggests that some mercury from sediment may be contributing to downstream loading.
- No action will not reduce fish tissue and other wildlife exposures, and will not reduce risk from humans eating fish, in a reasonable time frame

Expected Effects of Sand Cap and Post-Cap Recovery

- Sand layer not dissimilar to native sediment
- Other projects have shown re-colonization in as little as 5 years.
- "Sediment Remedy Effectiveness Case Studies" (ASTSWMO, 2013):

Overall, the cap and the ENR layer are both functioning to isolate contaminants and both remain stable after ten years. There is no sign of upward migration of contaminants from underlying sediments into the cap or ENR layer. The ENR layer functioned similarly to the cap and benthic community recolonization occurred from external recruitment. There is no evidence that bioturbation in the ENR layer has mixed the underlying sediments into the surface layer above. The benthic community in both areas shows characteristics of a more robust, species rich community compared to the pre-capping state. By these criteria, remediation of the Pier 53-55 Site was concluded to be successful.

The various lines of evidence indicate that the 2002 benthic community at Pier 53-55 is healthier and more species are present than prior to cap placement. The community may still be changing with time as more sediment fines are deposited. However, the project goal appears to have been met.

Effect of Thin-Layer Sand Capping

- Many examples can be found of recovery following dredged sediment disposal, which has same overall effect as thin-layer sand capping
- Sediment disposal studies show the following general sequence of events:
  - Drop in benthic invertebrate abundance just after sediment disposal due to burial or smothering
  - Quick recolonization of new sediment layer via vertical migration and larval or peripheral recruitment
  - Communities fully re-established in 1-24 months
  - Final community structure depends on environmental conditions (such as dissolved oxygen) and original species makeup

Factors Affecting Cap Recolonization

- Cap thickness
  - Thicker caps (> 12”) impede re-emergence
- Cap build-up rate
  - Gradual & uniform application reduces community-level effects (2 separate shallow deposits vs single)
- Cap material
  - Pre-disturbance community re-establishes more quickly if cap texture is similar to underlying sediment

Factors Affecting Cap Re-Colonization

- Benthic species composition
  - Ability to migrate vertically or re-colonize new substrate is species specific
- Season
  - Re-colonization rates differ seasonally

BUT: clean sediments in the right environment will <u>always</u> be resettled with benthic invertebrates given enough time

Examples of Thin-Layer Sand Caps

Site Name	State	Habitat Type	Contaminants of Concern	Area Capped
Nyanza Chemical Waste Dump Superfund Site	MA	reservoir	mercury	80 acres
Onondaga Lake Superfund Site	NY	lake	mercury	154 acres
Atlantic Wood Industries Superfund Site	VA	river	PAHs; heavy metals; dioxin	7 acres
Plymouth Wood Treating Plant Superfund Site	NC	creek	dioxin	18 acres
Lower Fox River & Green Bay Superfund Site	WI	lake	PCBs	37 acres
Pudget Sound Naval Shipyard Superfund Site	WA	estuary	PCBs; mercury	13 acres

Selected Remedy
Thin Layer Capping

- Is being implemented more frequently
  - Centerdale Manor Wetlands (RI)
  - GE/Silver Lake (MA)
  - Onandaga Lake(NY)
- It is a proven remedial solution

Thin Layer Caps of Varying Grain Size

Photos courtesy of Germano & Associates, Inc.

Case-Study of Thin-Layer Sand Cap Re-Colonization

- Ketchikan Pulp Co. Superfund Site (Alaska)
  - Dissolving sulfite pulp mill
  - Mill effluents have impacted marine sediment with ammonia, sulfide and 4-methylphenol
  - March 2000 ROD selected a thin-layer sand cap to remediate 21 acres of sediment (27 acres were ultimately capped)
  - Purpose of cap was to reduce toxicity and provide clean substrate for benthic organisms
  - ROD mandated long-term monitoring to measure cap re-colonization

Case-Study of Thin-Layer Sand Cap Re-Colonization (cont'd)

- Long-term monitoring effort
  - Thin-layer sand cap in place by 2001
  - Monitoring occurred every 3 years based on the following components
    - Sediment chemistry
    - Sediment toxicity
    - Benthic community health (abundance + richness)
  - All three components showed full benthic community recovery by 2007
  - Long-term monitoring ended after 2007

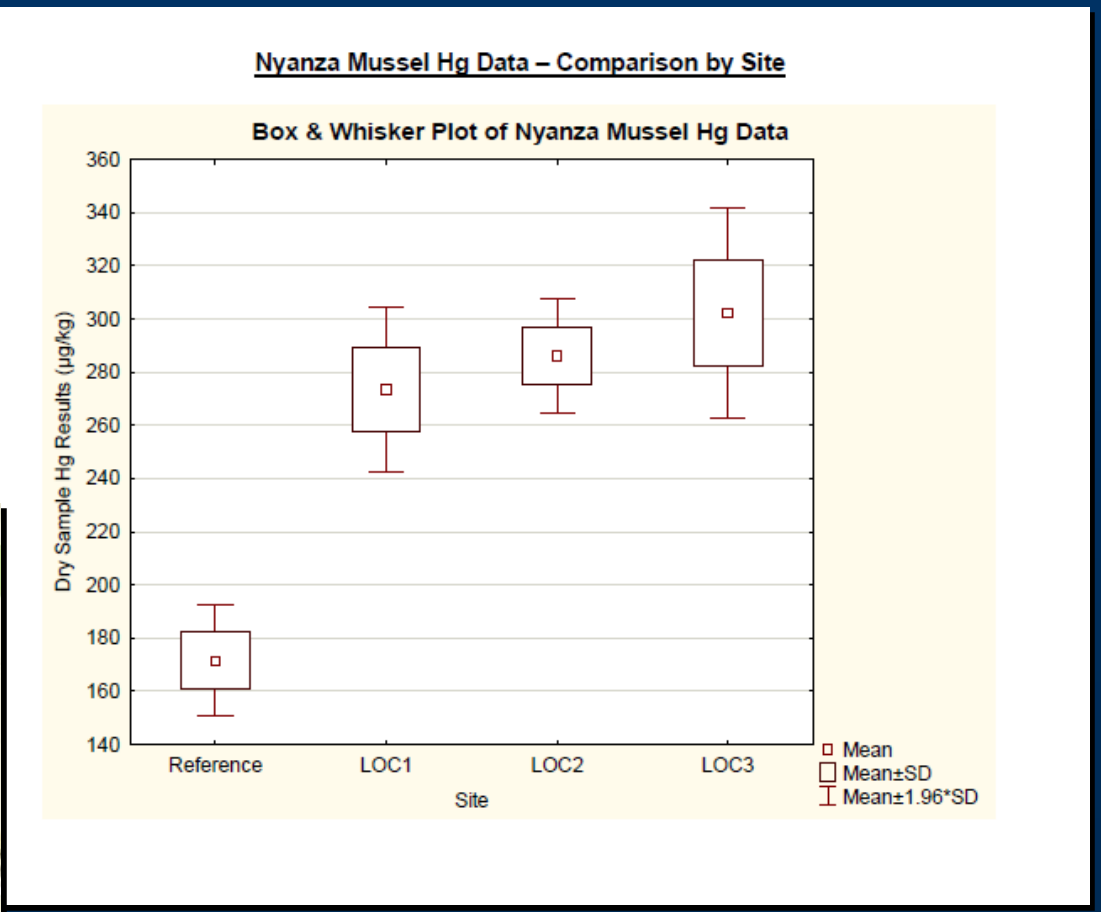
How Will We Know If IT Works?

- Pre-design studies included an updated mussel uptake study and collection of small fish. Both will be repeated post-remediation to look for improvement
- Long-term monitoring plan will include monitoring large fish tissue and water chemistry for improvement

Mussel Study Overview

- Mussels were collected from Sudbury Reservoir (low mercury) and deployed for 60 days in Reservoir 2 and Sudbury Reservoir.
- Mercury was measured in mussels at end of study
- Significant uptake was observed in Reservoir 2 mussels

Mussel Study 2012



Photos of Mussel Study

Thin Layer Capping

- The impacts from capping have already been evaluated (i.e., short-term impacts).
- We are required to select the ***Least-damaging practical alternative*** to reduce a risk (implicit is that some injury/damage is associated with any construction project).
- EPA wants to work with the Town and Community to mitigate these impacts to the maximum extent practicable.

Scope and Impacts

- Duration 2 constructions seasons*
- Operating from 100% State-owned lands
- Consists of clearing 2 – 3 acres from 2 parcels
- Comply with all local noise and dust ordinances

Restoration

- 98% of the Shoreline/bank will not be disturbed.
- Cap only extends to 3 foot water depth
- Most of the shoreline habitat is preserved
- Staging areas will be surveyed prior to construction to document existing vegetation for replacement .

Questions?