Woodard & Curran

Ecological Risk Assessment of Sediment at a Dam Removal

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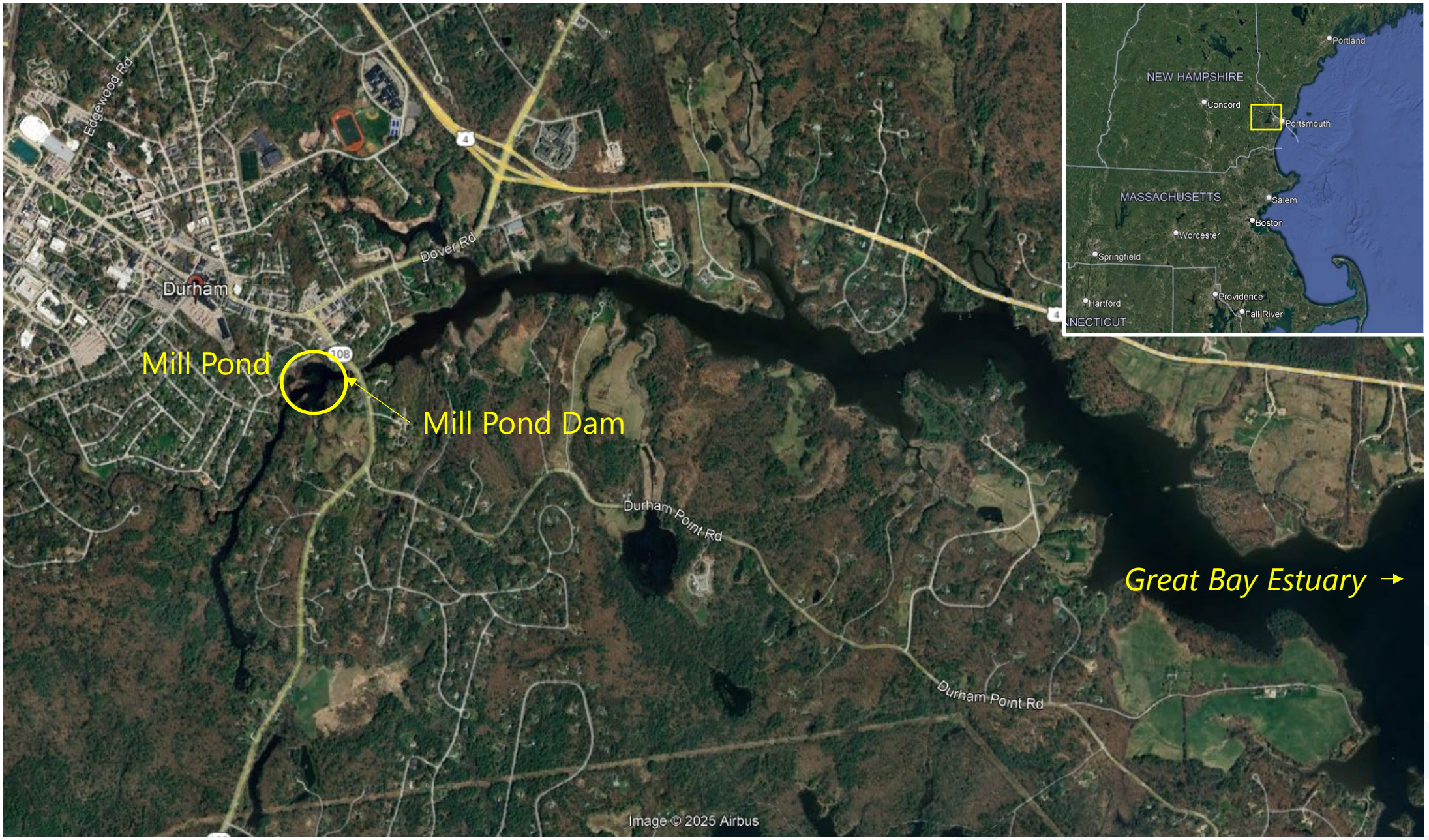
SMWG Fall Forum, October 2025


Edgewood Rd
4
Dover Rd
Durham
Mill Pond
108
Mill Pond Dam
Durham Point Rd
Durham Point Rd
Great Bay Estuary
Image © 2025 Airbus
NEW HAMPSHIRE
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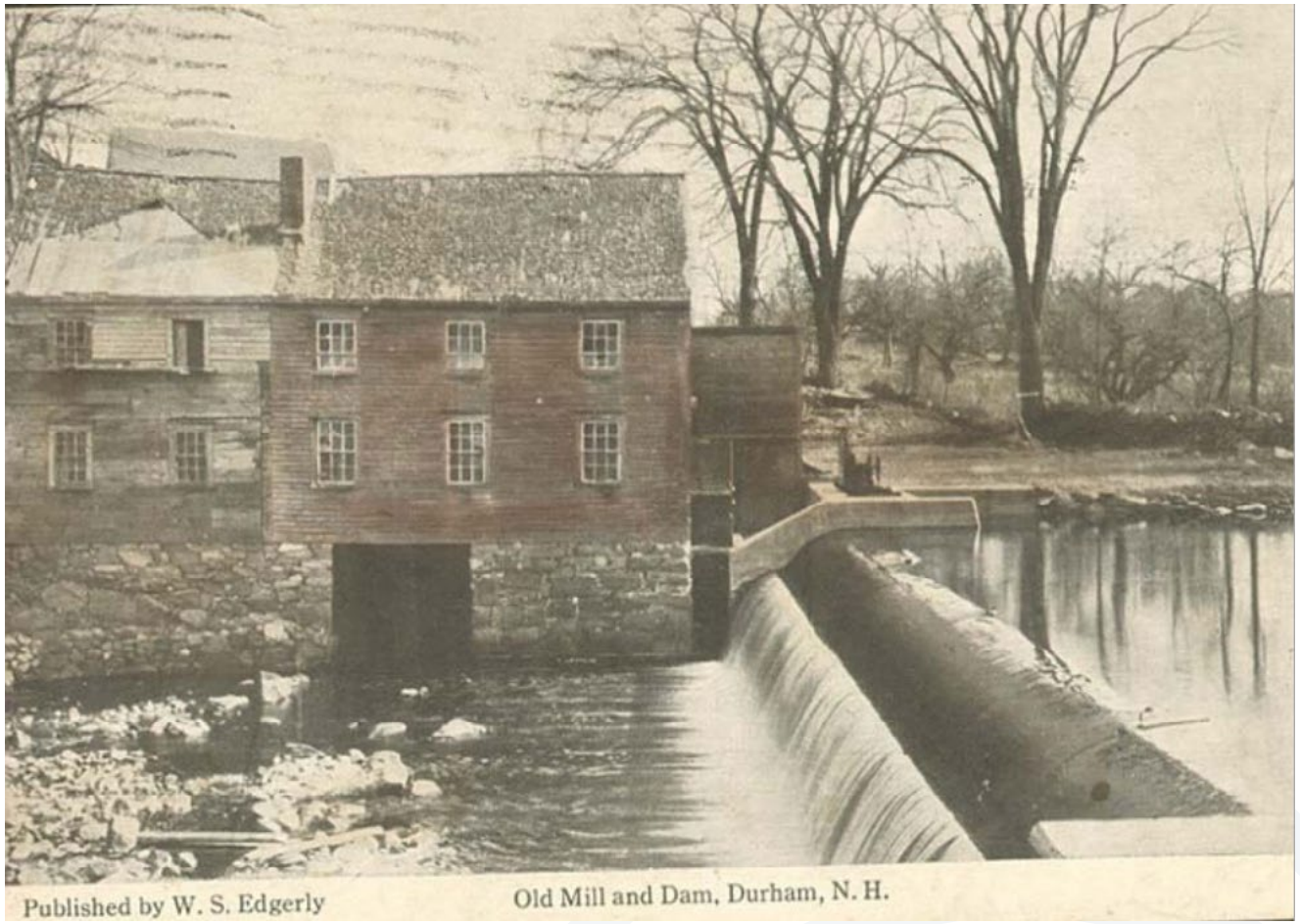
Site Background

- Oyster River is homelands of Abenaki/Wabanaki people
- Dam built in 1913 for "philanthropic purposes"
- Dam granted historic status in 2014 (first Ambursen dam in NH)
- Deemed deficient in 2018
- Feasibility study resulted in two viable options: stabilization or removal
- Strong support for dam removal



Site Ecology

- Oyster River water quality issues partly related to stagnant water conditions and nutrient loading in Mill Pond, causing eutrophication and algae blooms
- Dam is primary factor in the local decline of the anadromous fish population due to the loss of habitat connectivity and declining water quality in the system
- Intention to restore Alewife and Blueback Herring runs

Screening level assessment

Table 3.3-3 Summary of Findings - Ecological Screening Assessment of Sediment Sample Analytical Results

Upstream Samples

Sample ID	SED1	SED-13	SED-14
Date	10/31/09	6/23/20	6/23/20
PAHs	ND	Low	Mod
Pesticides	ND	ND	ND
PCBs	ND	ND	ND
Metals	High	High	High
VOCs	ND	NA	NA

HQ-TEC<1 was qualified as low risk;
HQ-TEC>1 was qualified as moderate risk; and
HQ-PEC>1 was qualified as high risk.

Mill Pond Samples

Sample ID	SED2	SED3	SED4	SED5	SED6	SED7	SED8	SED9	SED10a	SED10b	SED11a	SED11b	SED-15	SED-16	SED-DP
Date	10/30/09	10/31/09	10/31/09	10/31/09	10/31/09	10/31/09	10/31/09	10/31/09	11/2/09	11/2/09	11/2/09	11/2/09	6/23/20	6/23/20	6/23/20
PAHs	High	High	High	ND	High	High	High	ND	High	High	ND	ND	High	High	High
Pesticides	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	High
PCBs	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Metals	High	Mod	High	High	High	High	High	High	High	High	High	High	High	High	High
VOCs	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA

Downstream Samples

Sample ID	SED12	SED-17	SED-18
Date	11/2/09	6/23/20	6/23/20
PAHs	ND	Mod	High
Pesticides	ND	ND	ND
PCBs	ND	ND	ND
Metals	High	Mod	Mod
VOCs	ND	NA	NA

Downstream Samples - EMD

00-0049A	00-0053A	01-0042A	01-0046A	01-0048A	02-0249A	03-0244A	04-0252A	05-0248A	06-0042A
7/13/00	7/10/00	6/25/01	7/5/01	7/12/01	8/30/02	7/15/03	7/15/04	7/7/05	6/15/06
Mod	Mod	Mod	Mod	Mod	Mod	Mod	Low	Mod	Mod
Low	Mod	Low	Low	Low	ND	ND	ND	Mod	Low
Low	Low	Low	Low	Low	ND	Low	Low	Low	Low
Mod	Mod	Mod	Mod	Low	Mod	Mod	Mod	High	Mod
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Key:

Low	Results for one or more target analyte in group indicates low risk of adverse effects to ecological receptors.
Mod	Results for one or more target analyte in group indicates moderate risk of adverse effects to ecological receptors.
High	Results for one or more target analyte in group indicates high risk of adverse effects to ecological receptors.
NA	Target analytes not analyzed.
ND	Target analytes not detected.

Goal: Provide a comprehensive comment response to Comment #16 from the May 10, 2024 NHDES Request for More Information (RFMI) letter.

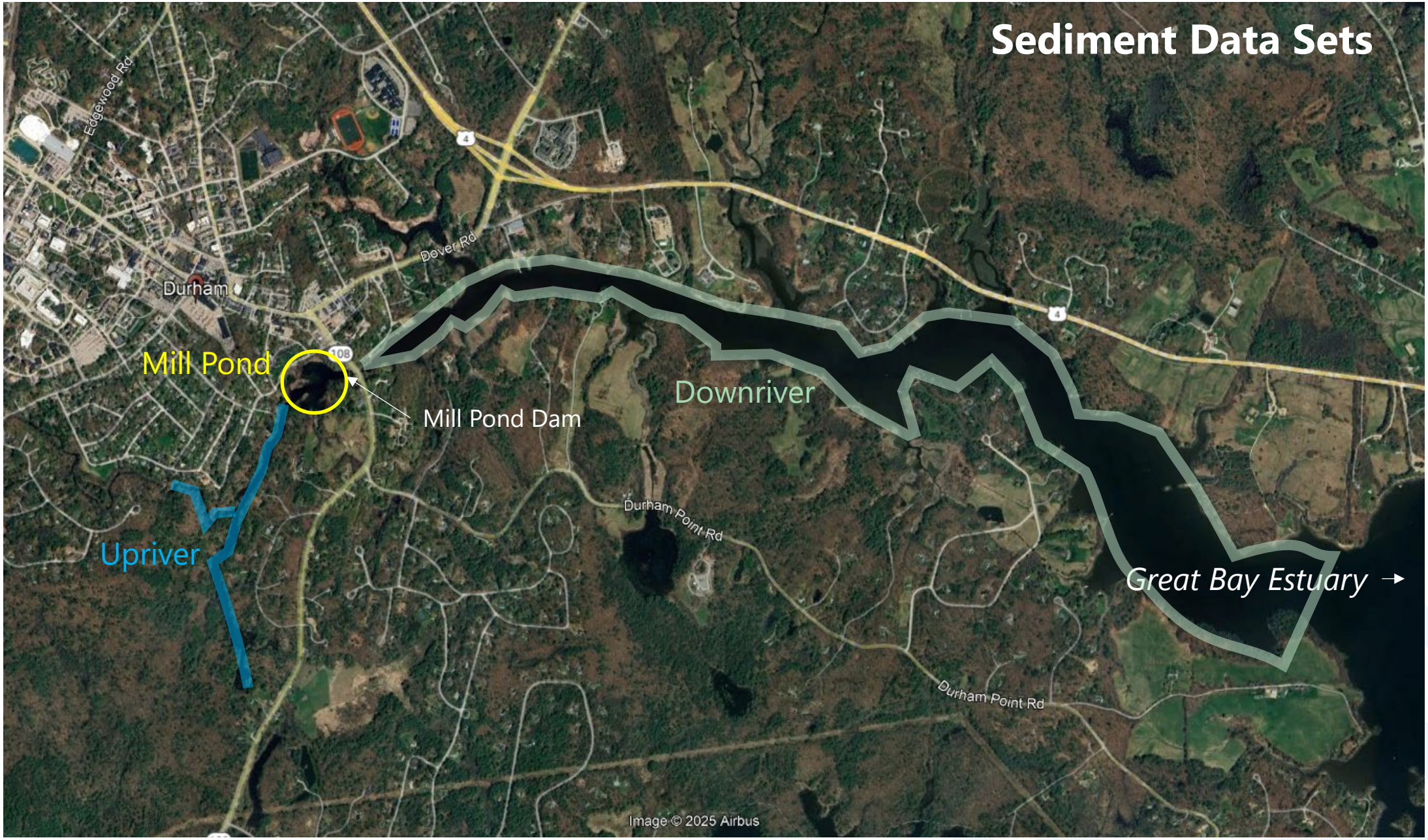
Comment #16: In accordance with Env-Wt 605.01(b), in addition to the avoidance and minimization requirements in Env-Wt 307, Env-Wt 311.07, Env-Wt 313, and Env-Wt 603.04, ensure that the proposed project in coastal areas does not impair commerce of the general public. Specifically, numerous oyster farms are located downstream. The follow statement in Section 5.3.4 of the Application is very alarming, "Regarding ecological risk, the study results indicated that sediment samples collected throughout the study area **contained concentrations of PAHs and/or metals with a moderate to high potential for adverse effects to ecological receptors** (marine and/or freshwater). This is in conflict with the statute, RSA482-A:1 *Finding of Public Purpose. – It is found to be for the public good and welfare of this state to protect and preserve its submerged lands under tidal and fresh waters and its wetlands, (both salt water and fresh-water), as herein defined, from despoliation and unregulated alteration…*

Next Step: Ecological Risk Assessment Refinement

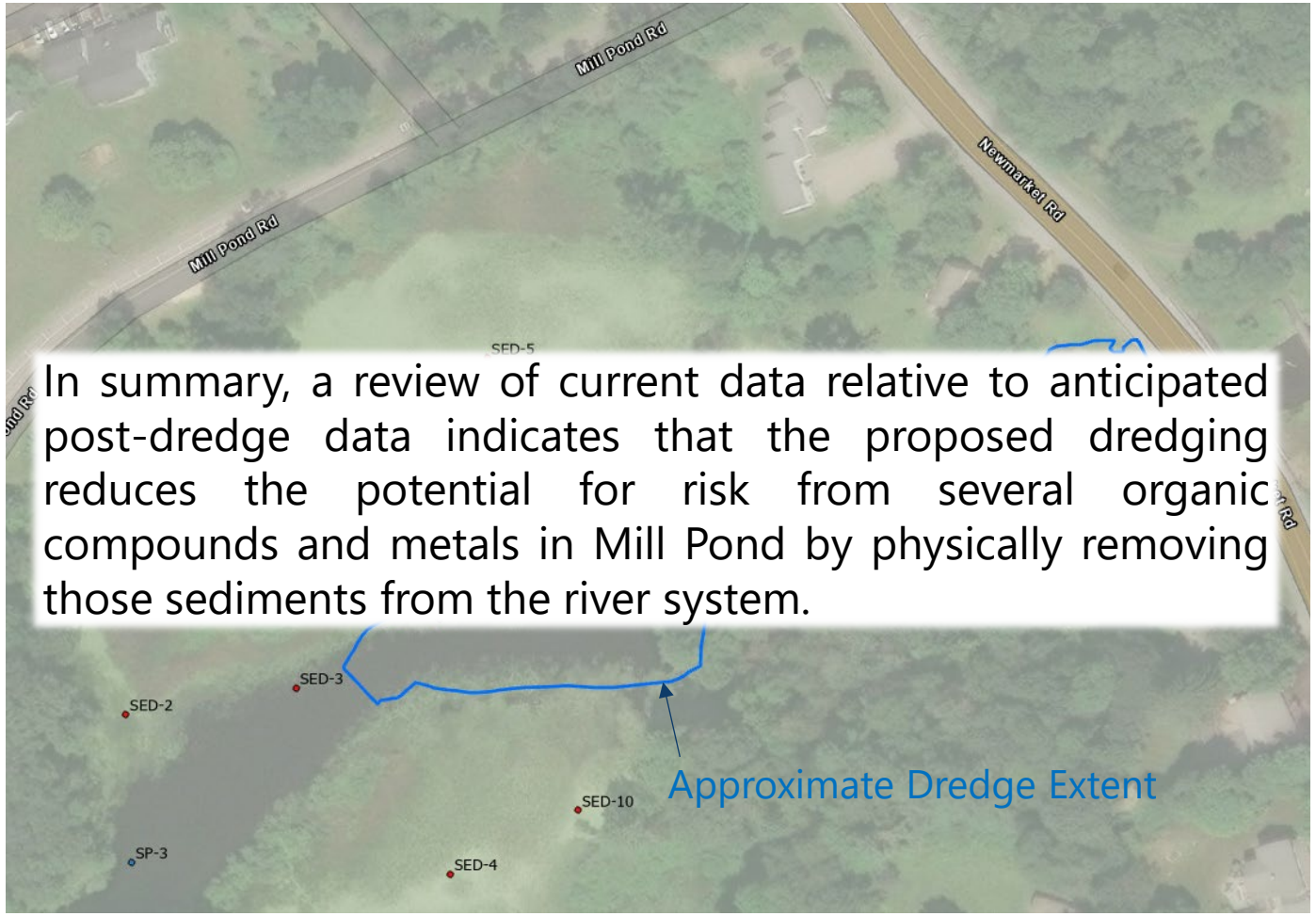
Study Questions:

1. How will the planned dredging reduce ecological risk in Mill Pond?
2. Are concentrations of chemicals in Mill Pond sediment significantly different than those already present in downriver sediment?
3. Does sediment currently located behind the Mill Pond Dam present an actual risk to ecological receptors located downriver?

Sediment Data Sets



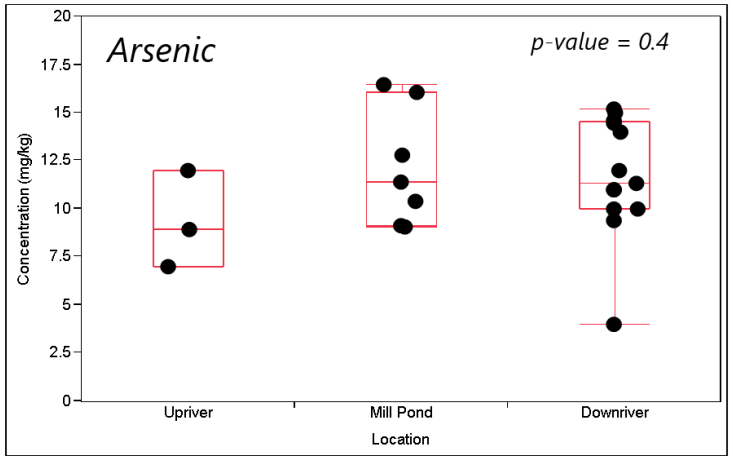
1. How will the planned dredging reduce chemical concentrations in Mill Pond?

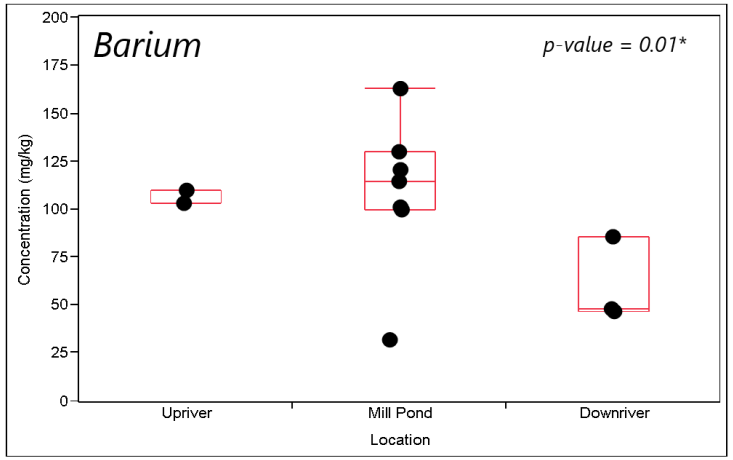


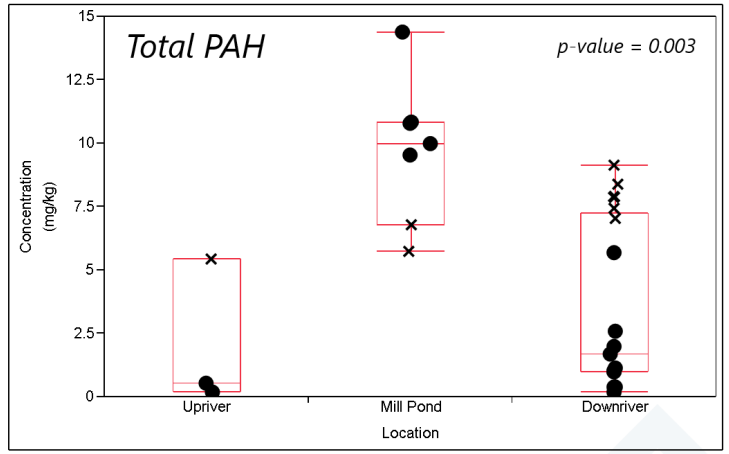
In summary, a review of current data relative to anticipated post-dredge data indicates that the proposed dredging reduces the potential for risk from several organic compounds and metals in Mill Pond by physically removing those sediments from the river system.

	Current Conditions	
	Exceeds "No Effect" Level	Exceeds "Effect" Level
Polycyclic Aromatic Hydrocarbons (PAHs)		
Naphthalene	X	X
2-methylnaphthalene	X	X
Acenaphthylene	X	X
Acenaphthene	X	X
Fluorene	X	X
Phenanthrene	X	X
Anthracene	X	X
Fluoranthene	X	X
Pyrene	X	X
Benzo(a)anthracene	X	X
Chrysene	X	X
Benzo(b)fluoranthene	X	X
Benzo(k)fluoranthene	X	X
Benzo(a)pyrene	X	X
Indeno(1,2,3-cd)pyrene	X	X
Dibenzo(a,h)anthracene	X	X
Benzo(g,h,i)perylene	X	X
Metals		
Chromium	X	
Lead	X	
Cadmium	X	
Silver	X	
Arsenic	X	
Selenium	No value	
Barium	X	X
Mercury	X	X

2. Are concentrations in Mill Pond sediment significantly different than downriver?







***In summary*, concentrations of arsenic, chromium, lead, and mercury in Mill Pond sediment will be consistent with those in downriver sediment after dredging, and therefore any sediment potentially transported downriver due to dam removal would not be expected to result in an increase in downriver sediment concentrations.**

Cadmium, barium, and PAHs were investigated further to evaluate potential downstream risk.

3. Does sediment currently located behind the Mill Pond Dam present an actual risk to ecological receptors located downriver?

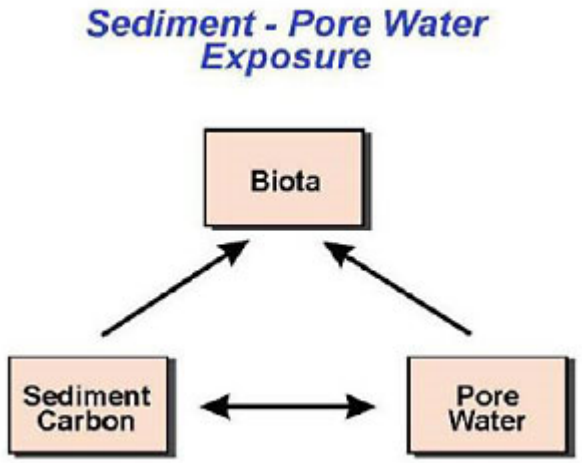
Site-specific risk was evaluated using two methodologies:

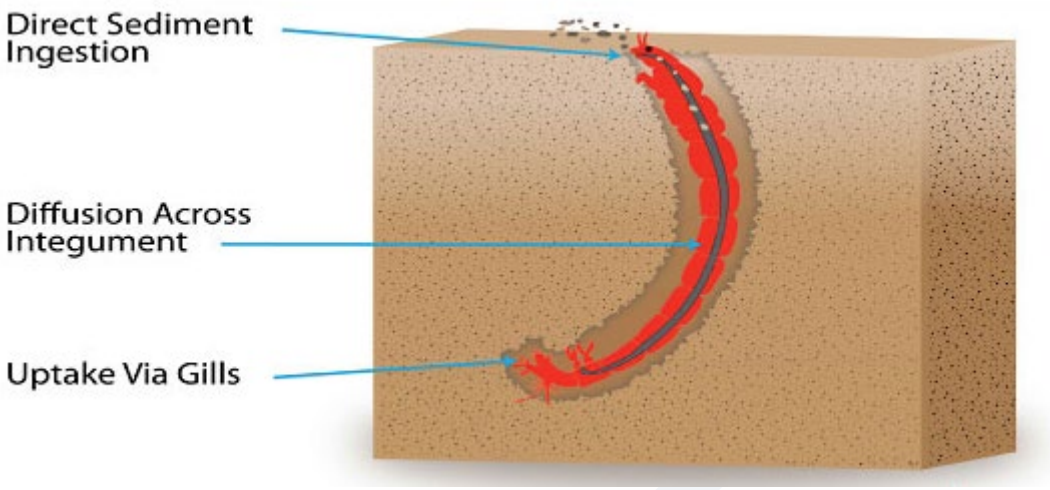
- Bioavailability of sediment PAH to receptors
- Bioaccumulation of PAHs and metals into receptor tissues

Note: As a conservative assumption, all of these analyses assume exposure to Mill Pond sediment at the observed concentrations within the Pond. In reality, any sediment that may move downstream would deposit over a much larger area, resulting in substantially lower concentrations than those evaluated here.

3. Does sediment currently located behind the Mill Pond Dam present an actual risk to ecological receptors located downriver?

Bioavailability of PAHs: The bioavailability of PAHs is mediated to a large degree by the amount of organic carbon present in sediment. Organic carbon plays a significant role in binding PAHs, which reduces their ability to partition into porewater and surface water, and therefore their toxicity to aquatic and benthic organisms.





Bioavailability of PAHs

- Ecological effects of PAHs generally manifest as a result of a mixture of multiple PAHs present in the sediment (Swartz 1999; Long et al. 1995). Consequently, benchmarks based on total PAH correlate better with toxicity than those of individual PAHs.

- Site-specific organic carbon-normalized criteria (TEC_{OC} and PEC_{OC}) were calculated for Total PAH with the equation presented below (from Swartz 1999):

$$TEC_{OC} = TEC_{\ Literature}\left(\frac{mg\ PAH}{g\ OC}\right) * TOC_{\ Site}\left(\frac{g\ OC}{kg\ sed}\right)$$

- At 1% organic carbon, TPAH benchmarks are 2.90 mg/kg and 18 mg/kg. Since the site-specific organic carbon values are greater than 1%, the site-specific benchmarks (TEC_{OC} and PEC_{OC}) are higher.

- Both the average TPAH concentration and the average TOC content in Mill Pond are higher than downriver.
  - Average TOC from the 7 Mill Pond samples = **5.9%**
  - Average TOC from 17 downriver samples = **2.5%**

Bioavailability of PAHs

- Site-specific TPAH organic carbon-normalized TECs and PECs were established for the Mill Pond and downriver areas using Swartz, 1999.

- Hazard Quotients (HQs) were calculated as a ratio of the Site concentration to the oc-normalized benchmarks:

Sample Area	Mill Pond	Downriver
TPAH (Average, mg/kg)	9.58	1.53
TOC (%)	5.9	2.5
TEC_{oc} (mg/kg)	17.1	7.3
PEC_{oc} (mg/kg)	106.2	45.5
TEC_{oc}-HQ	0.6	0.3
PEC_{oc}-HQ	0.1	0.0

Adjusted "no effect level" →

Adjusted "effect level" →

Average HQs for Mill Pond are less than 1, meaning that **PAH concentrations are below organic carbon normalized benchmarks** (both no-effect and effect level)

Maximum concentration in Mill Pond was also below oc-normalized benchmarks.

3. Does sediment currently located behind the Mill Pond Dam present an actual risk to ecological receptors located downriver?

Bioaccumulation: Literature-based BSAFs (biota-sediment accumulation factors) are values representing the ratio of sediment concentrations to benthic invertebrate tissue concentrations.

This provides a mechanism to **estimate the concentration of a chemical anticipated to accumulate in the tissues of aquatic organisms based on the measured concentrations in sediment**. These calculated tissue concentrations can then be compared to concentrations of contaminants in the tissues of organisms that are associated with adverse biological effects, known as tissue residue effect levels (TRELs).

An analysis of bioaccumulation was completed for PAHs, cadmium, and barium

Bioaccumulation of PAHs and Metals

Estimated tissue concentrations for PAHs: $BSAF = \frac{\frac{C_O}{f_l}}{\frac{C_{sed}}{foc}}$

$\frac{C_O}{f_l}$ ← Lipid fraction

$\frac{C_{sed}}{foc}$ ← Organic carbon fraction

Estimated tissue concentrations for metals: $C_o = C_{sed} * BSAF$

- These calculated tissue concentrations are compared to concentrations of contaminants in the tissues of organisms that are associated with adverse biological effects, known as tissue residue effect levels (TRELs).
  - *Where available, whole-body mollusk tissue values were used*

- The ratio of the estimated tissue concentration to the TREL represents a **tissue-based HQ**, with HQs greater than one indicating a potential for risk.

Bioaccumulation of PAHs and Metals

COPC	Location	C_{Sed} Average mg/kg	C_{sed} Max mg/kg	BSAF	foc	F_L	Average Invertebrate Conc. mg/kg wet wt.	Max Invertebrate Conc. mg/kg wet wt.	Tissue Residue Effect Level (TREL) mg/kg wet wt.	Average HQ	Max HQ	BSAF Source	TREL Source
Benzo(a)pyrene	Mill Pond	0.70	0.99	0.31	0.059	0.03	0.11	0.16	27.61	0.0	0.0	1	2
Benzo(a)pyrene	Downriver	0.14	0.51	0.31	0.025	0.03	0.05	0.19	27.61	0.0	0.0		
Benzo(a)anthracene	Mill Pond	0.67	0.91	0.36	0.059	0.03	0.12	0.17	0.58	0.2	0.3	1	3
Benzo(a)anthracene	Downriver	0.13	0.55	0.36	0.025	0.03	0.06	0.24	0.58	0.1	0.4		
Pyrene	Mill Pond	1.03	1.97	0.46	0.059	0.03	0.25	0.47	1.08	0.2	0.4	1	3
Pyrene	Downriver	0.23	0.95	0.46	0.025	0.03	0.13	0.53	1.08	0.1	0.5		
Chrysene	Mill Pond	0.74	1.14	0.44	0.059	0.03	0.17	0.26	0.93	0.2	0.3	1	3
Chrysene	Downriver	0.14	0.56	0.44	0.025	0.03	0.07	0.30	0.93	0.1	0.3		

COPC	Location	C_{sed} Average mg/kg	C_{sed} Max mg/kg	BSAF dry wt.: dry wt.	Average Invertebrate Conc. mg/kg dry wt.	Maximum Invertebrate Conc. mg/kg dry wt.	Average Invertebrate Conc. mg/kg wet wt. ^	Maximum Invertebrate Conc. mg/kg wet wt. ^	Tissue Residue Effect Level mg/kg wet wt.	Average HQ	Max HQ	BSAF Source	TREL Source
Barium, Total	Mill Pond	108.9	163.0	0.015	1.6	2.4	0.4	0.5	3.98	0.1	0.1	1	2
Barium, Total	Downriver	15.8	86.0	0.015	0.2	1.3	0.1	0.3	3.98	0.0	0.1		
Cadmium, Total	Mill Pond	0.88	1.1	0.614	0.5	0.7	0.1	0.1	4	0.0	0.0	3	4
Cadmium, Total	Downriver	0.45	1.4	0.614	0.3	0.9	0.1	0.2	4	0.0	0.0		

Maximum tissue-based HQs in Mill Pond are well below 1, indicating a low probability of risk from the bioaccumulation of barium, cadmium, or PAHs

3. Does sediment currently located behind the Mill Pond Dam present an actual risk to ecological receptors located downriver?

- Based on an evaluation of PAH bioavailability and estimated tissue concentrations of PAH and metals, potential risks to downriver ecological receptors is low.

Conclusions

- Concentrations of several metals are similar to or lower than concentrations present in downriver sediment, and targeted dredging will remove highest concentrations.

- Bioavailability of PAHs is expected to be low, and a low risk from bioaccumulation of metals and PAHs is anticipated.

Based on this analysis, NHDES approved the Standard Dredge and Fill Wetlands Permit for the Mill Pond dam removal project.

Woodard & Curran

Thank you to our partners

VHB

Town of Durham

Questions?

Woodard & Curran