Dam Removal Webinar Series

Part 3B:
Rapid sediment analyses to inform restoration planning in Moodna Creek, New York

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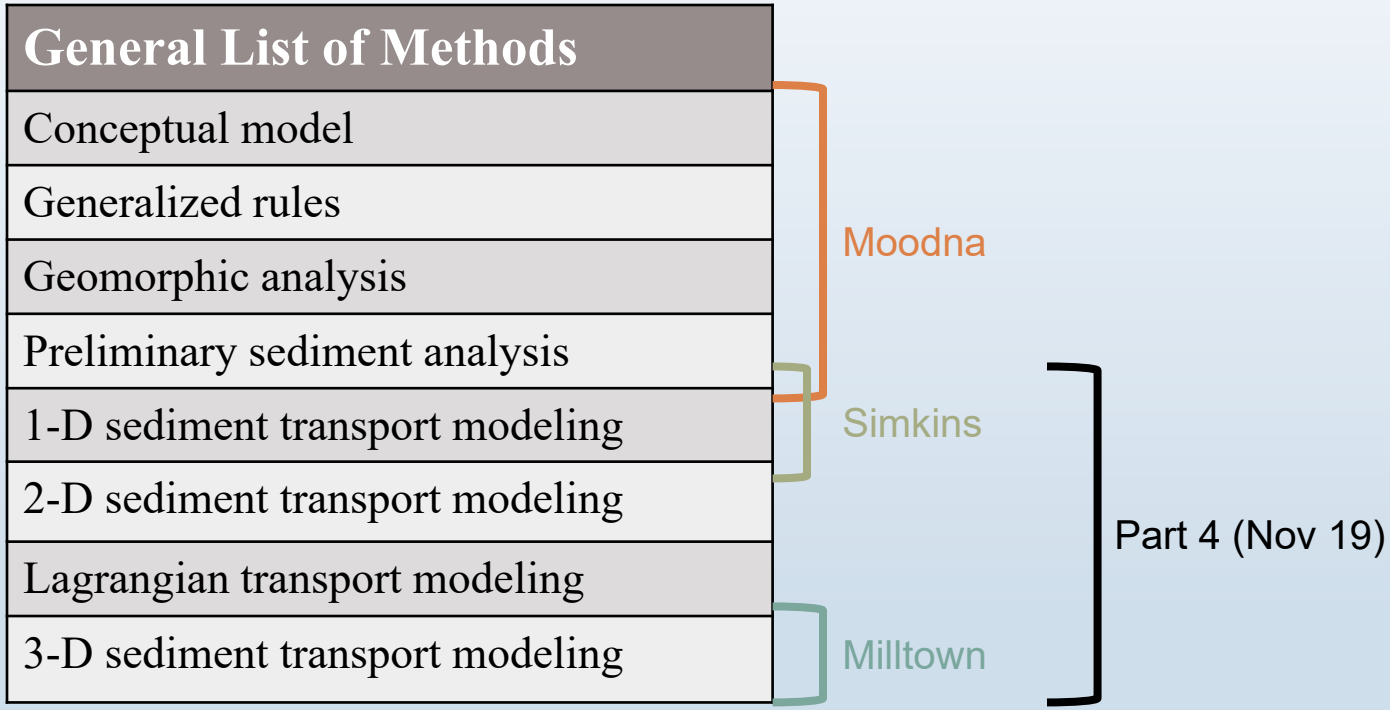
Overview of Case Studies

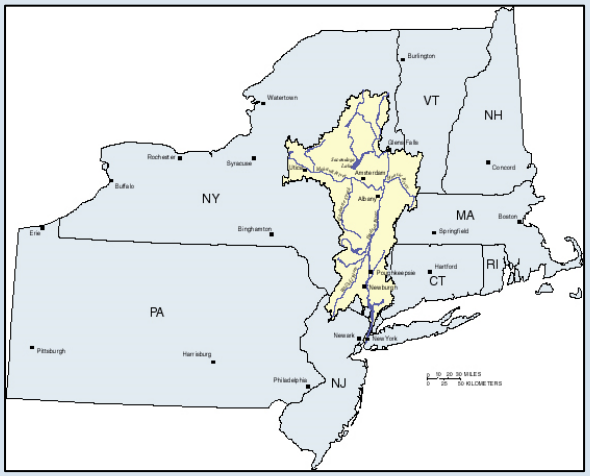


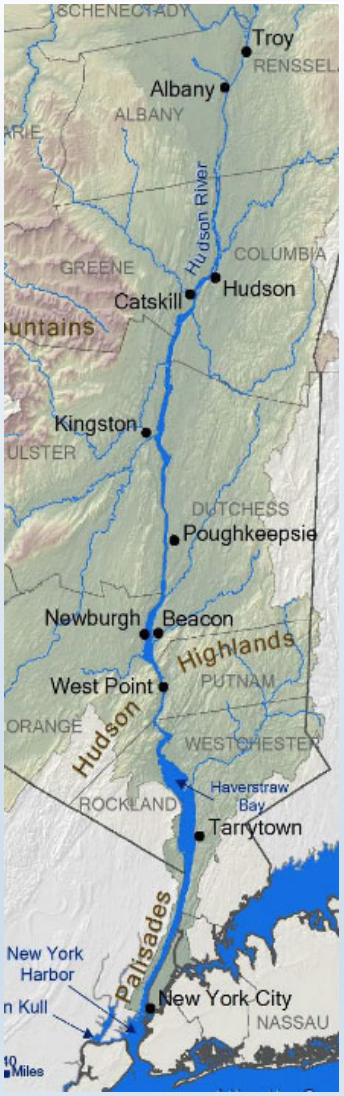
Overview

- Hudson River Habitat Restoration
- Moodna Creek
- Rapid sediment analyses

Hudson River Habitat Restoration

- Section 551 of the Water Resources Development Act of 1996 (P.L. 104-303)
- ~125 miles of Hudson River from Troy L&D to Mario M. Cuomo Bridge (including tributaries)
- HRHR Video: https://youtu.be/8CVcwbZWjpw

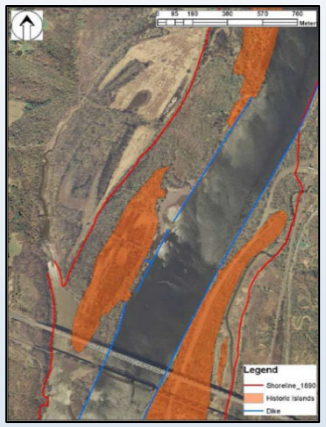




Problem Identification

Over the past 200 years, ~4,000 acres of aquatic habitat has been lost due to USACE Federal Navigation Channel and development:

- More than 85% of river side channels and islands were lost from dredging and filling
  - 28/29 side channels lost in upper portion of the study area
  - More than 70 miles of shoreline eliminated
  - 3,300 ac of wetlands lost
  - 700 ac of shallow water habitat lost
- USACE constructed longitudinal dikes and dams along the Hudson. Bulkheads and rip-rap were used to harden over 10,100 acres of shoreline (53%)
- More than 1,600 dams were constructed in the watershed disconnecting the river from its tributaries.



Lost Side Channels

Hardened Shorelines

Fish Passage Barriers

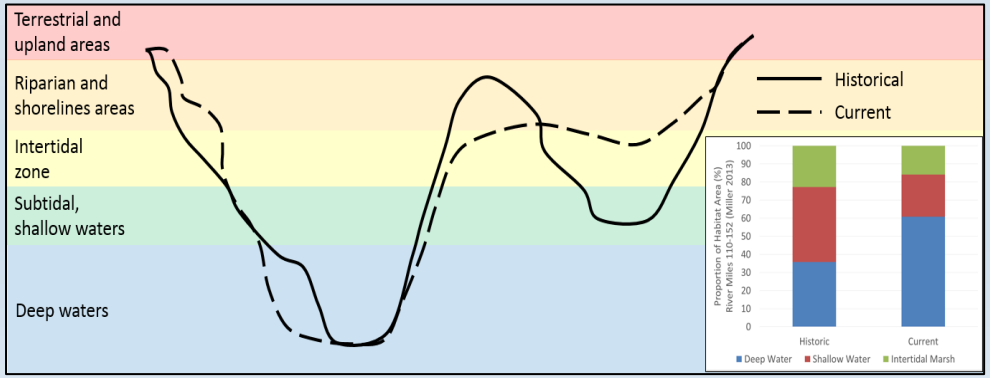
Study Objectives

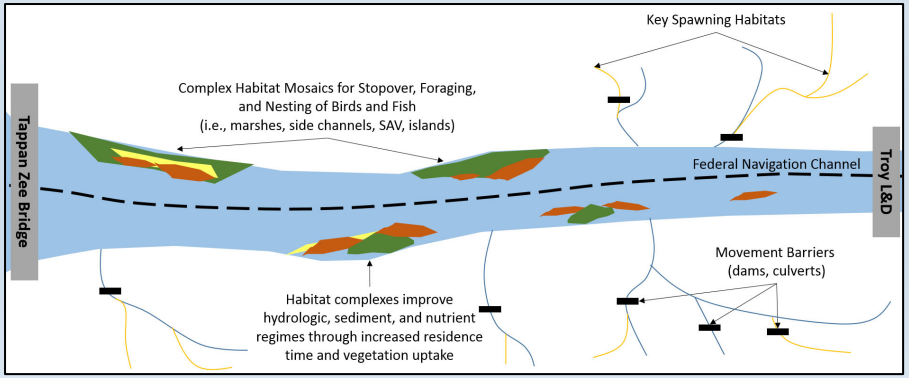
Goal 1: Restore a mosaic of interconnected, large river ecosystems.

- 1.1 – Increase the extent & quality of ***subtidal, shallow water habitats***.
- 1.2 – Increase the extent & quality of ***intertidal habitats***.
- 1.3 – Promote neighboring ***shoreline, riparian, and upland ecosystems*** contributing to aquatic ecosystem integrity.
- 1.4 – Promote a ***balanced mosaic*** of habitat types.

Goal 2: Restore lost ecological connectivity within the Hudson River and its tributaries.

- 2.1 – Increase the connectivity of spawning, foraging, and resting habitats for ***migratory fish***.
- 2.2 – Increase the connectivity of stopover, nesting, and foraging habitat for ***migratory and resident birds*** from freshwater ecosystems to the ocean.
- 2.3 – Promote actions improving the ***transport regime*** of water, sediment, and nutrients to the estuary.





Alternatives and Measures Considered

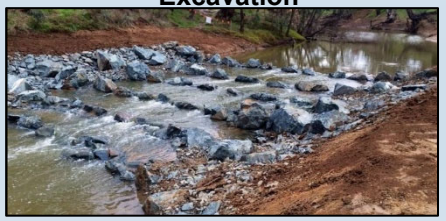
- Large mosaic of habitats: side channels and wetland restoration
  - Excavation and removal of upland soil to restore channel
  - Excavation and regrading to improve hydrology
  - Removal of Invasive vegetation
  - Native plantings
- Shoreline restoration
  - Removal recontouring
  - Shoreline stabilization
  - Shoreline softening
  - Removal of invasive vegetation
- Fish passage connectivity
  - Fish ladders
  - Dam removal
  - Partial dam removal/breach
  - Culvert modification

Native planting

Side Channels

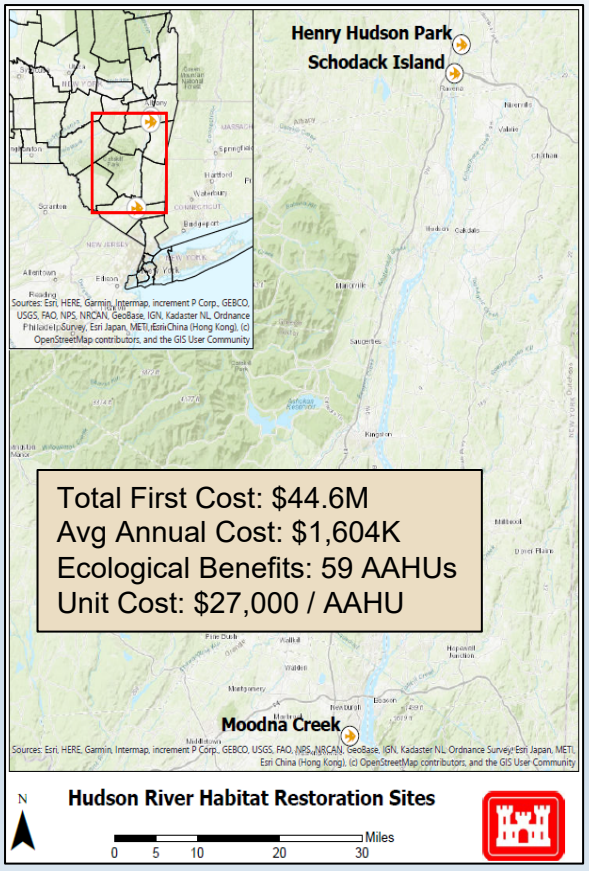
Excavation

Dam Removal



Rock Ramp

National Ecosystem Restoration (NER) Recommended Plan



Shoreline Restoration: Henry Hudson Park

- Tidal wetland restoration (3.7 acres)
- Replacement of hardened shoreline with a vegetated rip/rap living shoreline (0.6 acres of wetlands and 1,760 linear feet of shoreline)

Large Mosaic – Side Channel Restoration: Schodack Island Park

- Side channel and tidal wetland corridor (8.5 acres)
- Tidal wetland restoration (19.1 acres)

Tributary Connectivity: Moodna Creek (collectively reconnect 7.8 miles of habitat)

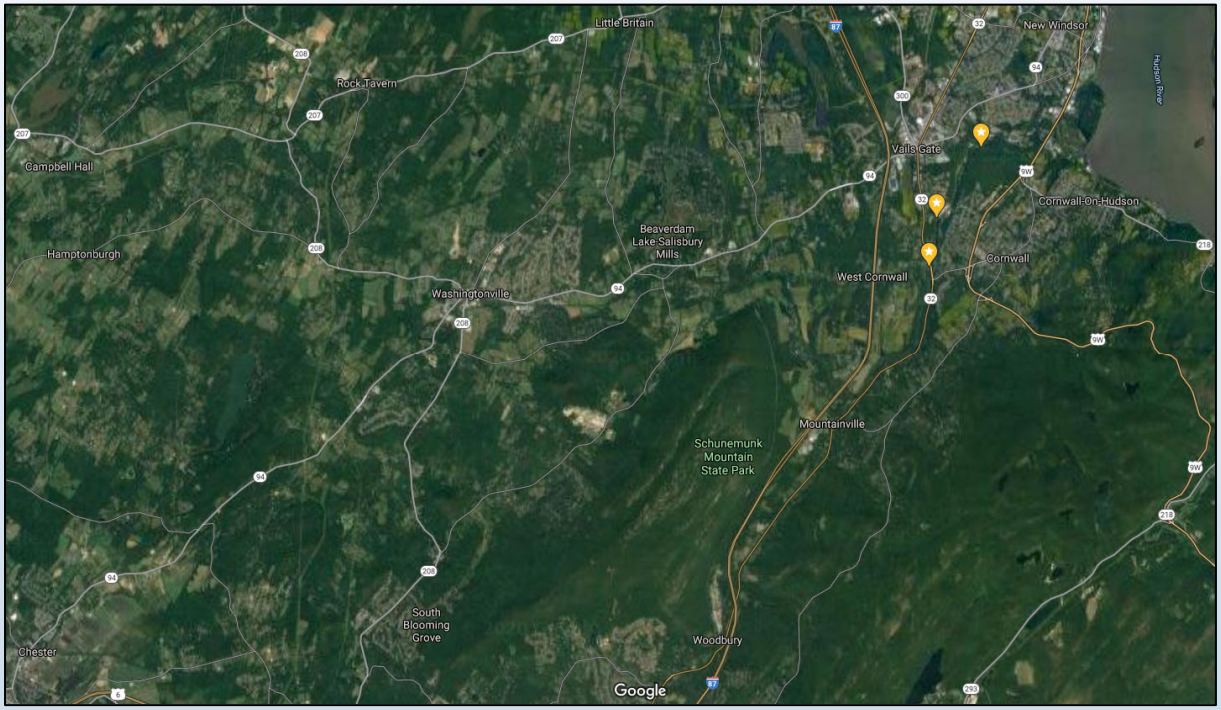
Utility Pipe (Removal)

Firth Cliff Dam (Removal)

Orr's Mill Dam (Partial Removal)

Moodna Creek Watershed

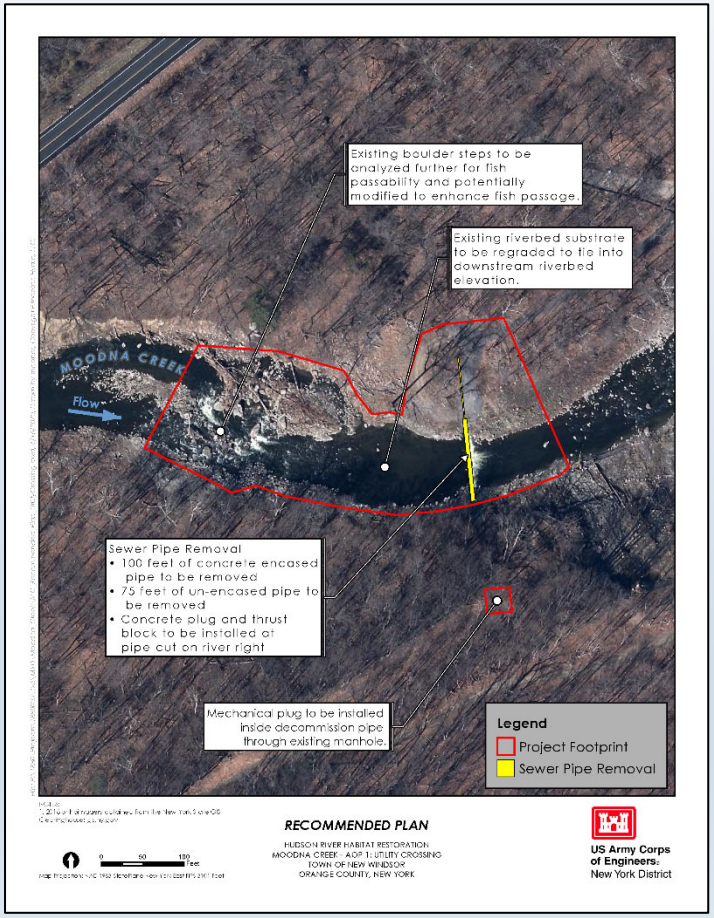
- Drainage area = 168 mi^2
- Natural Land Cover ~ 63%
  - 2011 National Land Cover Dataset (NLCD)
  - Open water + forests + grasslands + wetlands
- Minor water quality issues
  - EPA's 303d listing
  - Nutrients, dissolved solids, flow alteration,…
- Three barriers in series near the Hudson River confluence



Data summarized from:
Colorado State University's
Environmental Resource Assessment and Management System (eRAMS)
Watershed Rapid Assessment Program (WRAP)
http://www.erams.com/wrap

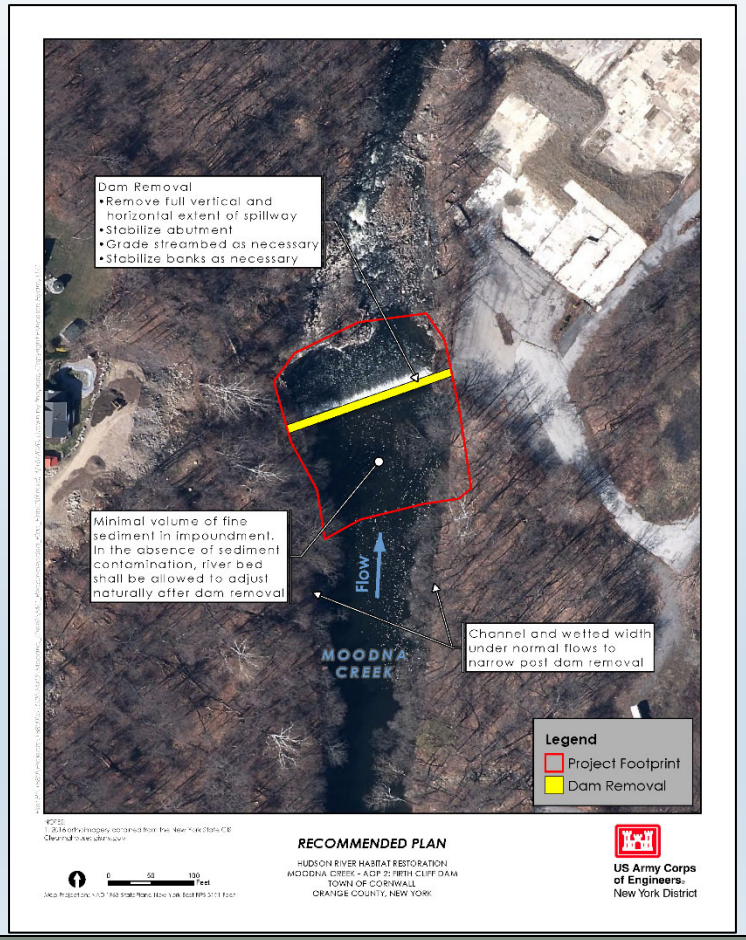
Barrier #1 Summary: Utility Crossing

- Structure height ~ 2 ft
- Max reservoir width ~ 65 ft
- Avg river width ~ 44 ft
- Description
  - Encased concrete sewer line (dormant)
  - Forms a weir with ~ 2 ft vertical drop
  - Full removal



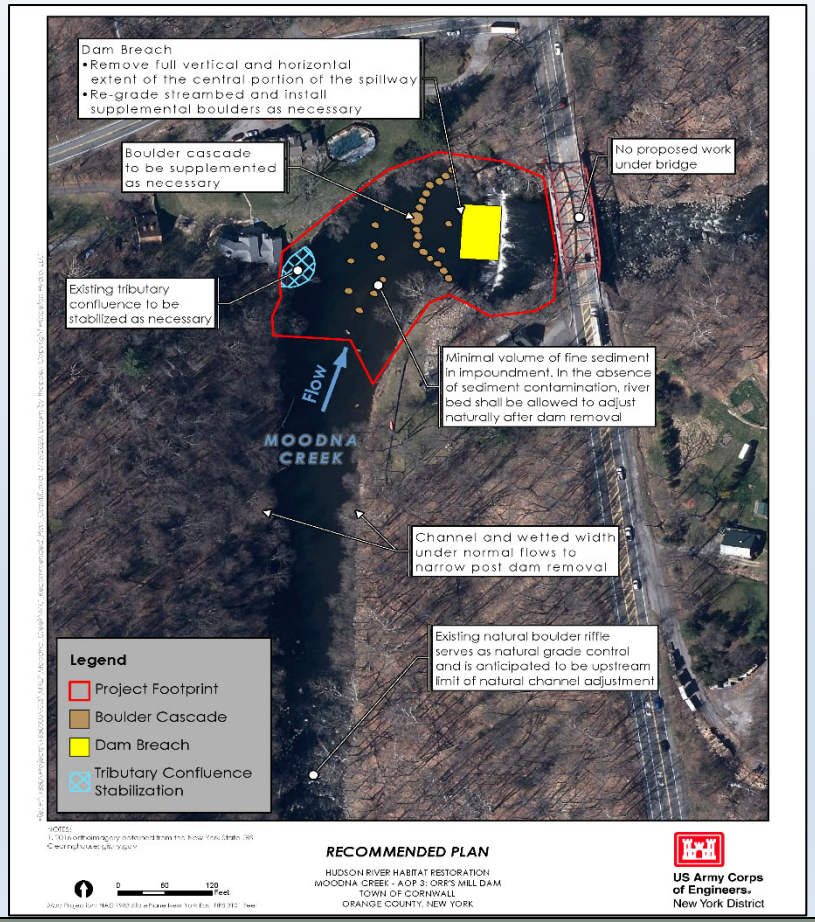
Barrier #2 Summary: Firth Cliff Dam

- Structure height ~ 9 ft
- Max reservoir width ~ 150 ft
- Avg river width ~ 41 ft
- Description
  - Class A - Low Hazard Dam
  - Former textile manufacturing site
  - Full removal



Barrier #3 Summary: Orr's Mill Dam

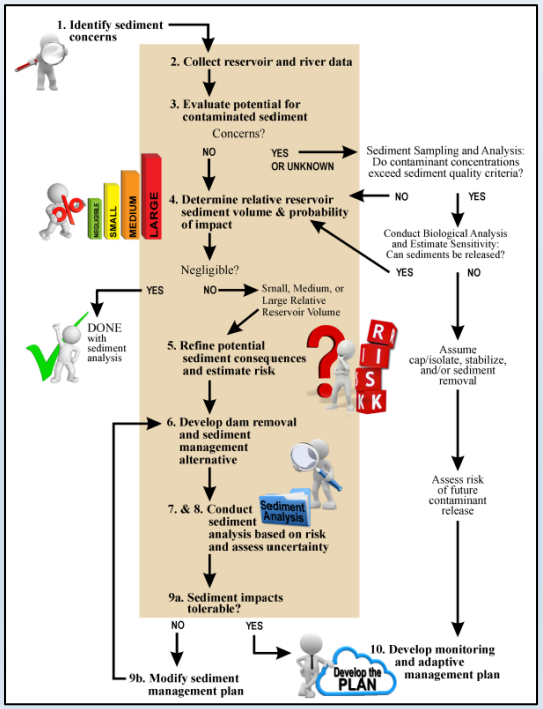
- Structure height ~ 10 ft
- Max reservoir width ~ 87 ft
- Avg river width ~ 60 ft
- Description
  - Concrete encased cobble-filled crib structure
  - Prior NYSDEC inspections characterized as being in a state of disrepair, structurally unsound, and "could fail at any time."
  - Partial removal



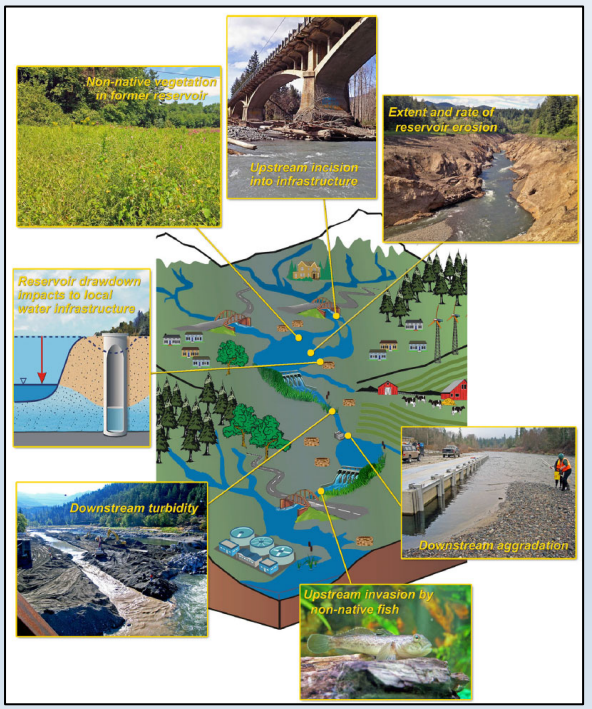
Rapid sediment analyses
(led by Princeton Hydro)

- Rapid screening of potential feasibility-level challenges
  - Aligning with risk-informed decision making
  - Informing permitting process
- Basic approach
  - Review key metrics from literature (See Part 2)
  - Rapid analyses informed by limited data collection

Sediment Risk Assessment Framework
(Randle and Bountry 2017, BOR)

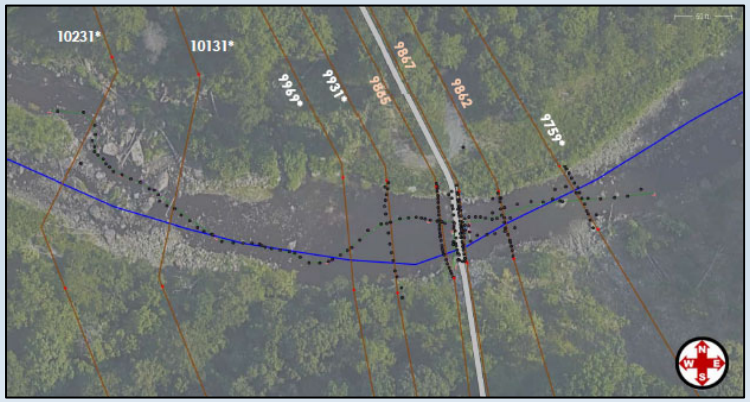


Common Management Concerns in Dam Removal Projects
(Tullos et al. 2016, JAWRA)



Data Compiled

- Field observations
  - Geomorphic assessment
  - Grain size analysis
  - Site-properties and constraints
  - Photographs
- Limited topographic survey
  - RTK-GPS
  - Cross-sections + Longitudinal profile
  - Sediment volume



- HEC-RAS model (flood levels only)
  - Existing model for Orange County
  - Input flows: median, bankfull, and 1% AEP (StreamStats)
- Watershed sediment yield assessment
  - Erosion and Sedimentation Manual (Randle et al. 2006)
  - Higher and lower ratings for "bookends"

List of drainage basin characteristics and possible range of numerical ratings (modified from Pacific Southwest Interagency Committee, Water Management Subcommittee, 1968; Table 2.9 Published in Randle, T.J., Yang, C. T., Daraio, J., 2006. "Chapter 2, Erosion and Reservoir Sedimentation" in Erosion and Sedimentation Manual. U.S. Department of the Interior, Bureau of Reclamation, Denver, CO, 94 pp.)

Drainage basin characteristic	Sediment yield levels			Site Assessment		
	High rating	Moderate rating	Low rating	Site Conditions	Lower Rating	Upper Rating
Surface geology	10: marine shales and related mudstones and siltstones	5: rocks of medium hardess moderately weathered and fractured	0: massive hard formations	Moderate hardness, mostly metamorphic, moderately weathered and fractured	5	7
Soils	10: fine textured and easily dispersed or single grain salts and fine sands	5: medium textured, occasional rock fragments, or caliche crusted layers	0: frequent rock fragments, aggregated clays, or high organic content	Medium textured, moderate organic content	4	6
Climate	10: frequent intense convective storms	5: infrequent convective storms, moderate intensity	0: humid climate with low intensity rainfall, arid climate with low intensity rainfall, or arid climate with rare convective storms	Humid climate but occasional moderate intensity storms	4	6
Runoff	10: high flows or volume per unit area	5: moderate flows or runoff volume per unit area	0: low flows or volume per unit area or rare runoff events	Moderate flows or runoff volumes per unit area	5	6
Topography	20: steep slopes (in excess of 30%), high relief, little or no flood plain development	10: moderate slopes (20%), moderate flood plain development	0: gentle slopes (less than 5%), extensive flood plain development	Gentle to moderate slopes (5-20%), moderate to extensive floodplain development	8	12
Ground cover	10: ground cover less than 20%, no rock or organic litter in surface soil	0: ground cover less than 40%, noticable organic litter in surface soil	-10: area completely covered by vegetation, rock fragments, organic litter with little opportunity for rainfall to erode soil	Mostly covered by vegetation; MUCH FORESTED/MOUNTAINS WITH STATE PARKS	-8	-5
Land use	10: more than 50% cultivated, sparse vegetation, and no rock in surface soil	0: less than 25% cultivated, less than 50% intensively grazed	-10: no cultivation, no recent logging, and only low intensity grazing, if any	Little agricultural; residential/commercial development; undeveloped areas are forested, not logged	-8	-6
Upland erosion	25: rill, gully, or landslide erosion over than 50% of the area	10: rill, gully, or landslide erosion over about 25% of area	0: no apparent signs of erosion	Limited upland erosion	1	5
Channel erosion	25: continuous or frequent bank erosion, or active headcuts and degradation in tributary channels	10: occasional channel erosion of bed or banks	0: wide shallow channels with mild gradients, channels in massive rock, large boulders, or dense vegetation or artificially protected channels	Bank erosion and channel incision are common	12	22
				Total	23	53
				Sediment yield classification (ac-ft/mi2) (Randle, 1996)	0.2	0.54

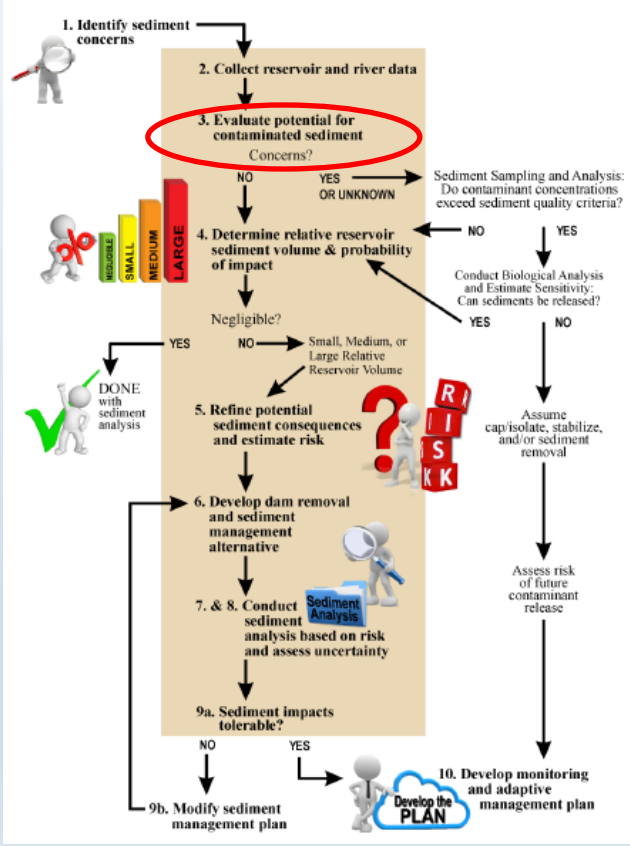
Table 2.10. Drainage basin sediment yield classification (Randle, 1996)

Drainage basin classification number	Total rating	Annual sediment yield (ac-ft/mi²)
1	> 100	> 3
2	75 to 100	1.0 to 3.0
3	50 to 75	0.5 to 1.0
4	25 to 50	0.2 to 0.5
5	0 to 25	<0.2

Is sediment quality a potential concern?

- No "reason to believe" contaminants are present
  - Watershed history, site uses, etc.
  - Sediment is predominantly compact gravel and cobble with interstitial sand
- Sediment quality sampling deferred to pre-construction engineering and design (PED)
  - Standard measure of due diligence
  - Required by NY DEC

	Sediment Type
AOP #1 Utility Line	Gravel, some cobble, and interstitial sand
AOP #2 Firth Cliff Dam	Gravel and cobble, numerous large boulders, interstitial sand
AOP #3 Orr's Mill Dam	Cobble, numerous large boulders, interstitial sand and gravel

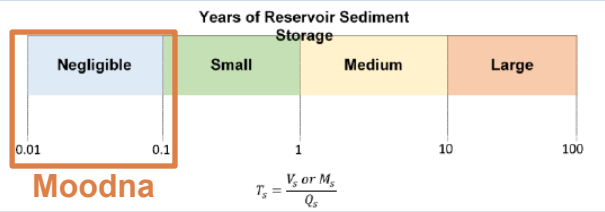


Sediment analysis steps for dam removal (Randle and Bountry 2017).

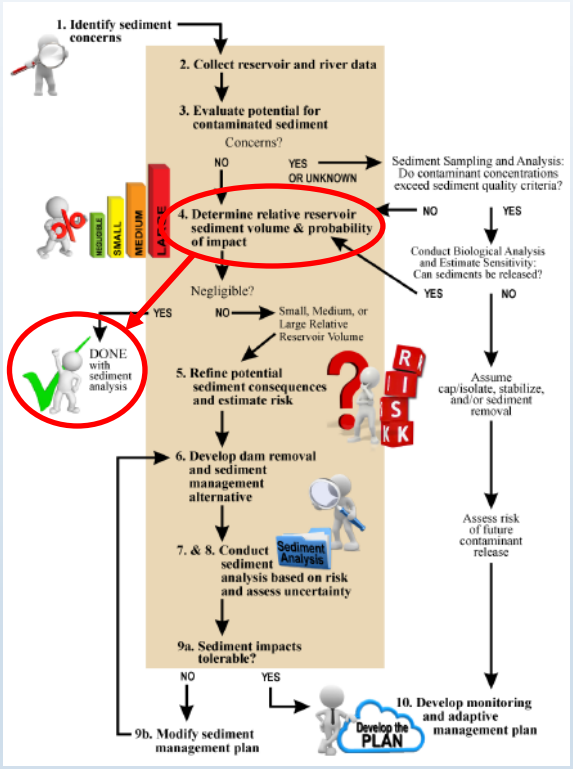
How much sediment is stored?

- Relative reservoir sediment volume
  - $T_s = V_s$ (or M_s) / Q_s
  - Number of years of sediment load stored
- Moodna Creek structures = "negligible"

Variable	Barrier #1: Utility Crossing	Barrier #2: Firth Cliff Dam	Barrier #3: Orr's Mill Dam
Approximate sediment volume (yd^3)	240	5,500	5,100
Avg annual sediment load (yd^3/yr)	54,531-147,233	53,240-143,748	51,949-140,263
Relative sediment volume (yr)	0.001 - 0.004	0.03 – 0.10	0.04 – 0.10



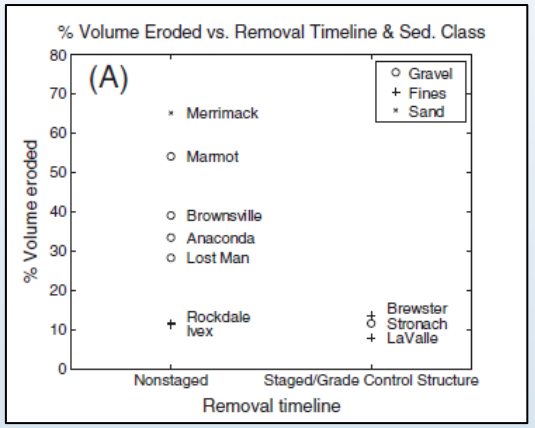
(Randle and Bountry 2017)

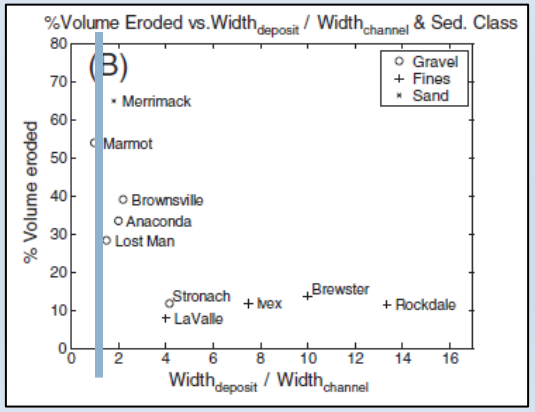


Sediment analysis steps for dam removal (Randle and Bountry 2017)

CMC1: Degree and rate of reservoir sediment erosion

- Low % fine grained sediment
  - Sediment is predominantly compact gravel and cobble with interstitial sand
- Deposit width / Channel width > ~2.5
  1. Utility Crossing ~1.4
  2. Firth Cliff ~ 2.0
  3. Orr's Mill ~ 1.2
- Phased vs. rapid removal
  - Small structures facilitate rapid removal
- **Conclusion**: No anticipated problems

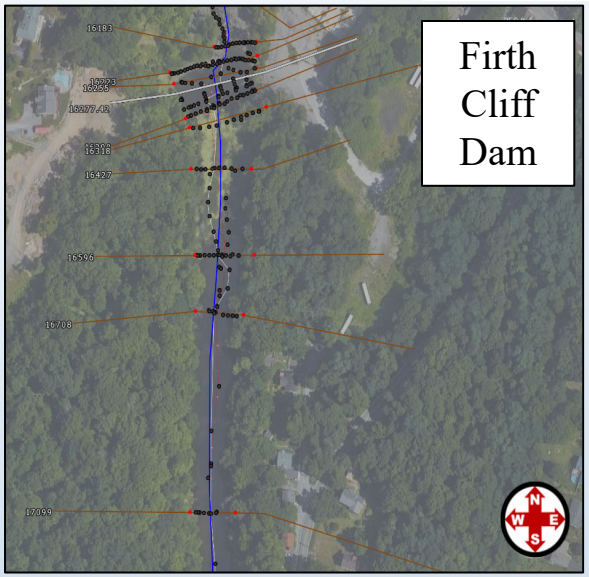


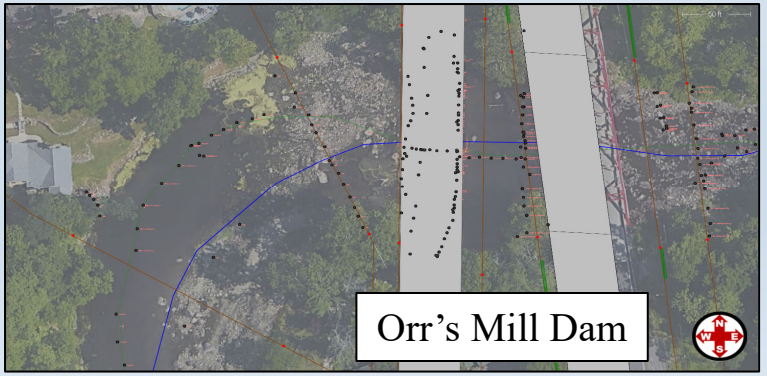


Sawaske and Freyberg (2012, Geomorphology)

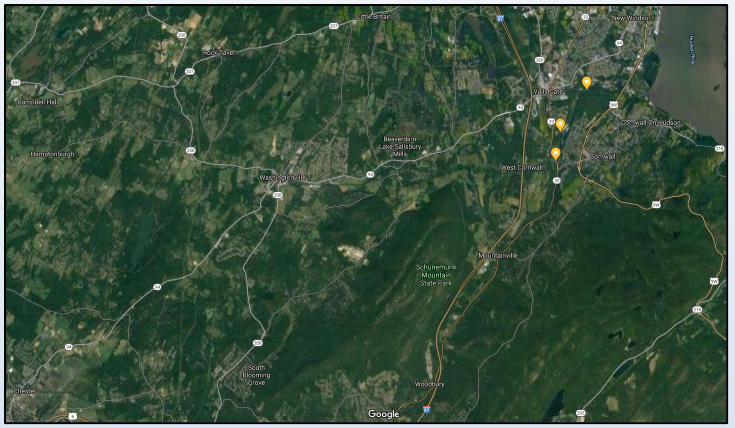
CMC2: Excessive channel incision upstream of reservoirs

- Confined valley geometry
  - Anticipated rapid progression through channel evolution model phases
  - Home and bridge at Orr's Mill may require minor changes and adaptive management
- Low % fine grained sediment
  - Sediment is predominantly compact gravel and cobble with interstitial sand
  - Likely to mobilize quickly and completely
- Channel slope
  - Bedrock grade control upstream of all dams
- **Conclusion**: No anticipated problems
  - Adaptive management at Orr's Mill





CMC3: Downstream sediment aggradation

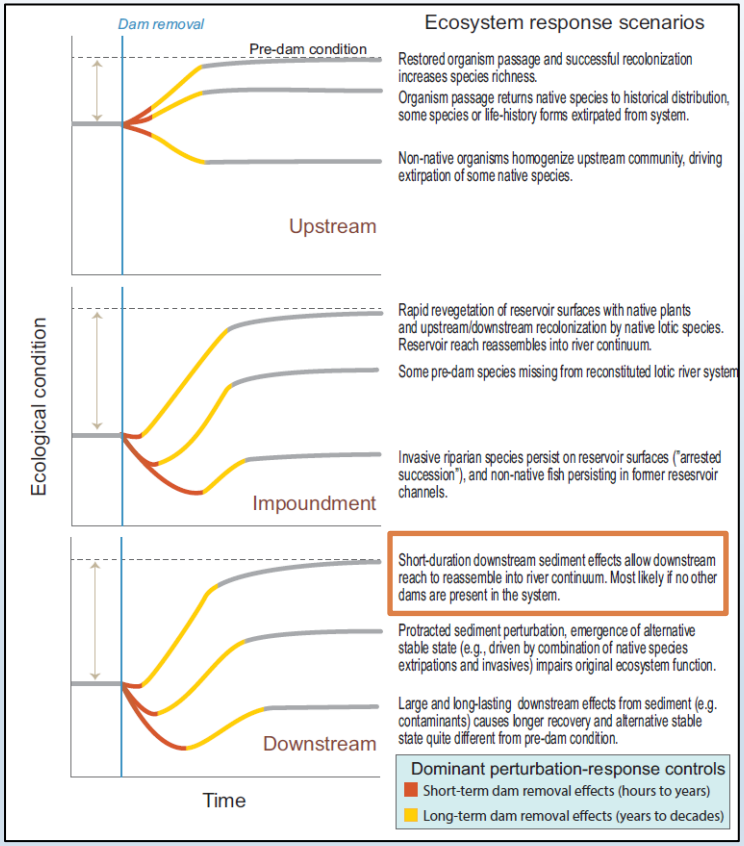


- Proximity to dam
  - Structures in series
  - Less than 3 river miles from Hudson River
- Relative sediment volume
  - Largely insignificant relative to background yield
- Channel slope and confinement
  - Well-vegetated banks and narrow valley walls indicate little potential for lateral channel adjustment or meandering
- Coarse grain size
  - May alter some riffles and bars downstream, but effect would be temporary and largely negligible
- **Conclusion**: No anticipated problems

CMC4: Elevated turbidity

- Fine grained sediment
  - Impounded sediments are largely coarse
  - Interstitial sands and silts
- Low relative sediment volume
  - Anticipated erosion in less than 1 year at all sites
- Low background turbidity levels in Moodna
  - However…grain size and relative sediment volume indicate low potential for problems
- **Conclusion**: No anticipated problems

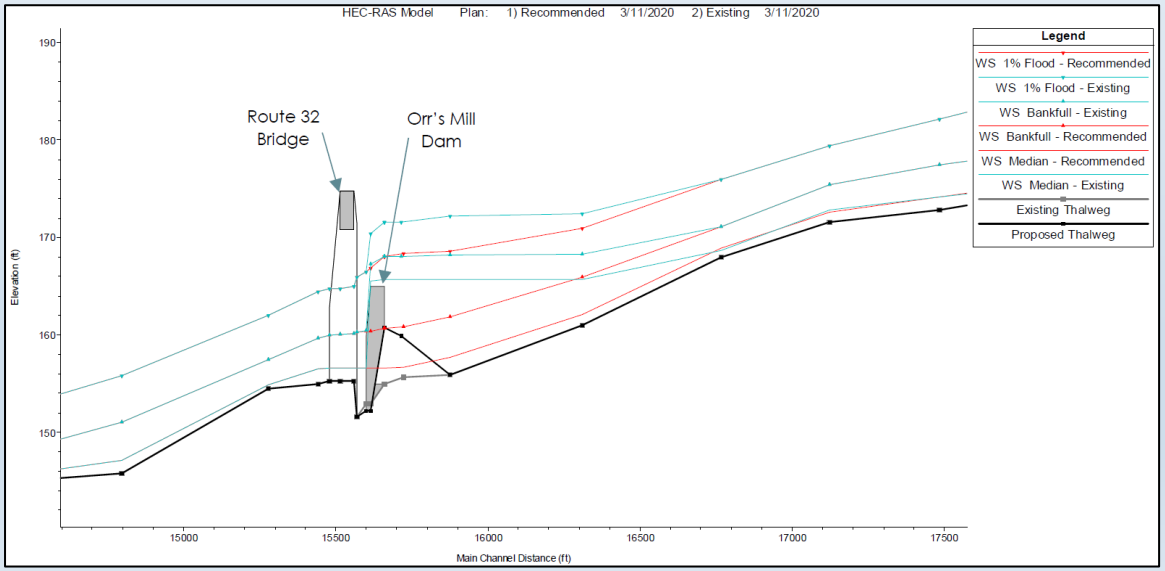
"Short-duration downstream sediment effects allow downstream reach to reassemble into river continuum. Most likely if no other dams are present in the system."
-Bellmore et al. (2019, *Bioscience*)



Is there potential for affecting flood stage?

- Relative change in flood stage
  - 1% Annual Exceedence Flood, bankfull, and median
- Potential for flow constriction at Orr's Mill
  - Further investigation recommended in PED
- **Conclusion**: No anticipated problems.

Barrier	Change in 1% AEP (ft)
1. Utility Crossing	-0.8
2. Firth Cliff Dam	-3.8
3. Orr's Mill Dam	-3.5



Summary of Sediment Analyses for Moodna Creek

Common Management Concern	Barrier #1: Utility Crossing	Barrier #2: Firth Cliff Dam	Barrier #3: Orr's Mill Dam
Relative sediment volume	✔	✔	✔
Sediment quality	PED	PED	PED
Degree and rate of reservoir sediment erosion	✔	✔	✔
Excessive channel incision upstream of reservoirs	✔	✔	✔ (PED)
Downstream sediment aggradation	✔	✔	✔
Elevated turbidity	✔	✔	✔
Increase flood levels	✔	✔	✔ (PED)

Take-away Messages

- Used a growing body of dam removal science and literature-based summaries from other sites to rapidly screen potential problems
  - Randle and Bountry 2017, Tullos et al. 2016, Foley et al. 2017, Major et al. 2017, USGS's Dam Removal Information Portal,...
- Rapid methods were chosen to align with USACE risk-informed planning approaches (and timelines)
  - Qualitative and semi-quantitative methods were key
- No analyses indicated major problems, but did identify key issues to be aware of in design
  - Sediment quality to be monitoring in PED
- Keep the easy projects easy

Questions and Acknowledgements

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https://www.nan.usace.army.mil/Missions/Environmental/Environmental-Restoration/Hudson-River-Habitat-Restoration/