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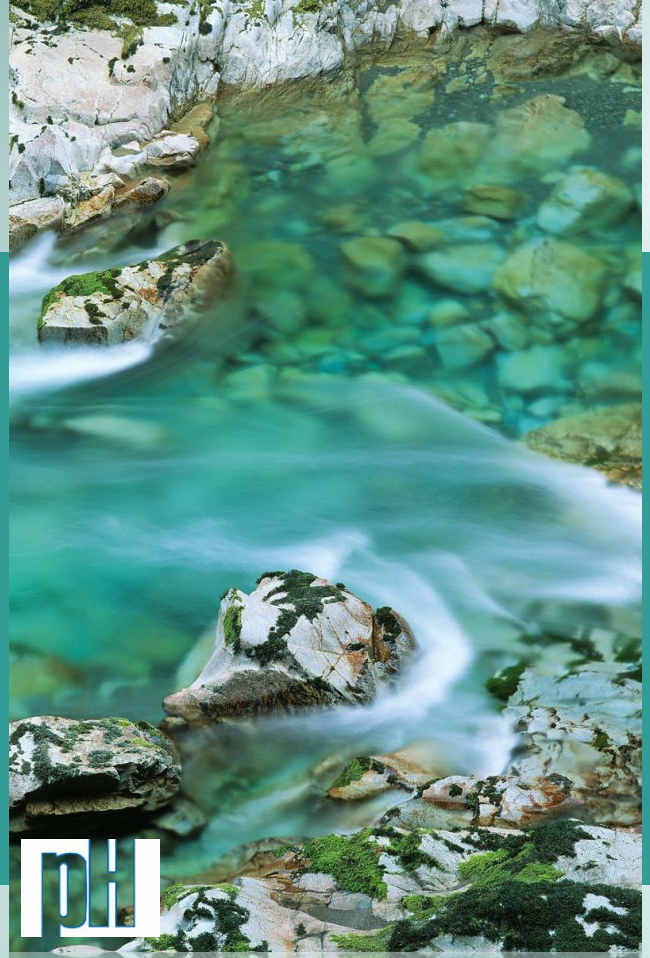
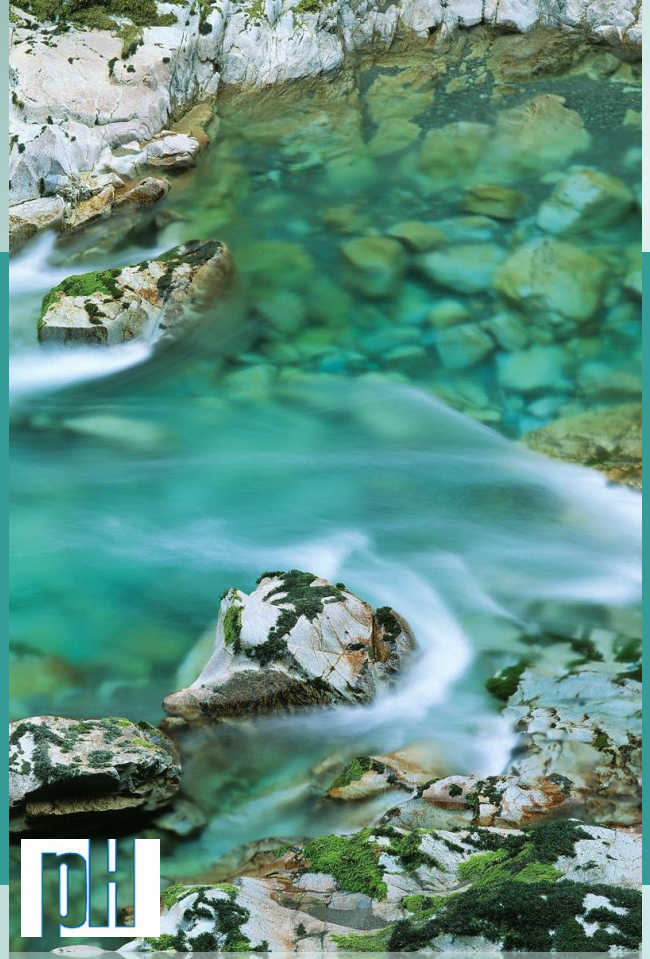
50min talk & 10min Q&A



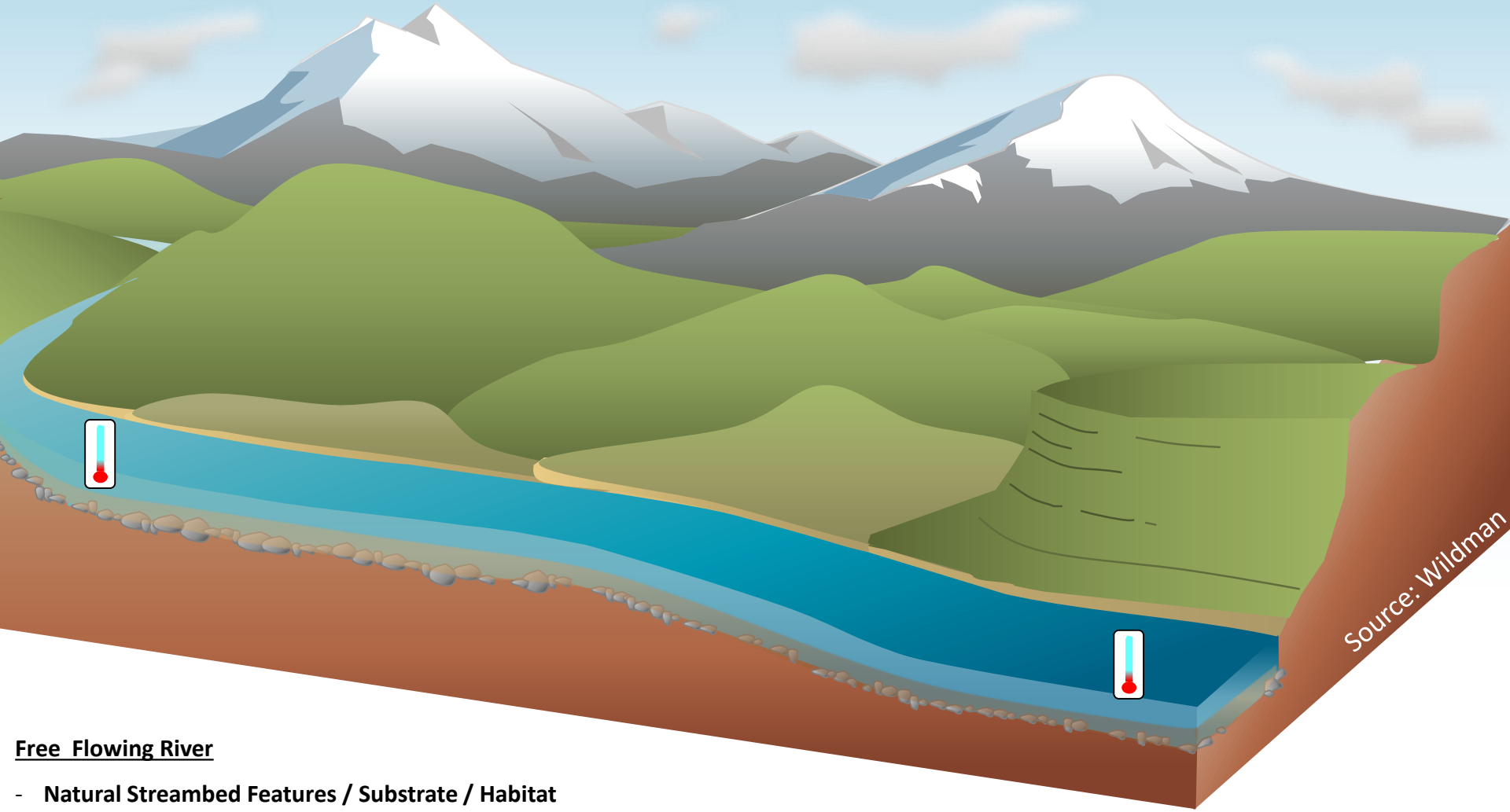
DAM REMOVAL
STEP BY STEP

- Impacts of Dams & Dam Removal
- How We Analyze Dams for Removal
- What We are Learning Through a Wide Diversity of Case Studies



IMPACTS of DAMS and DAM REMOVAL

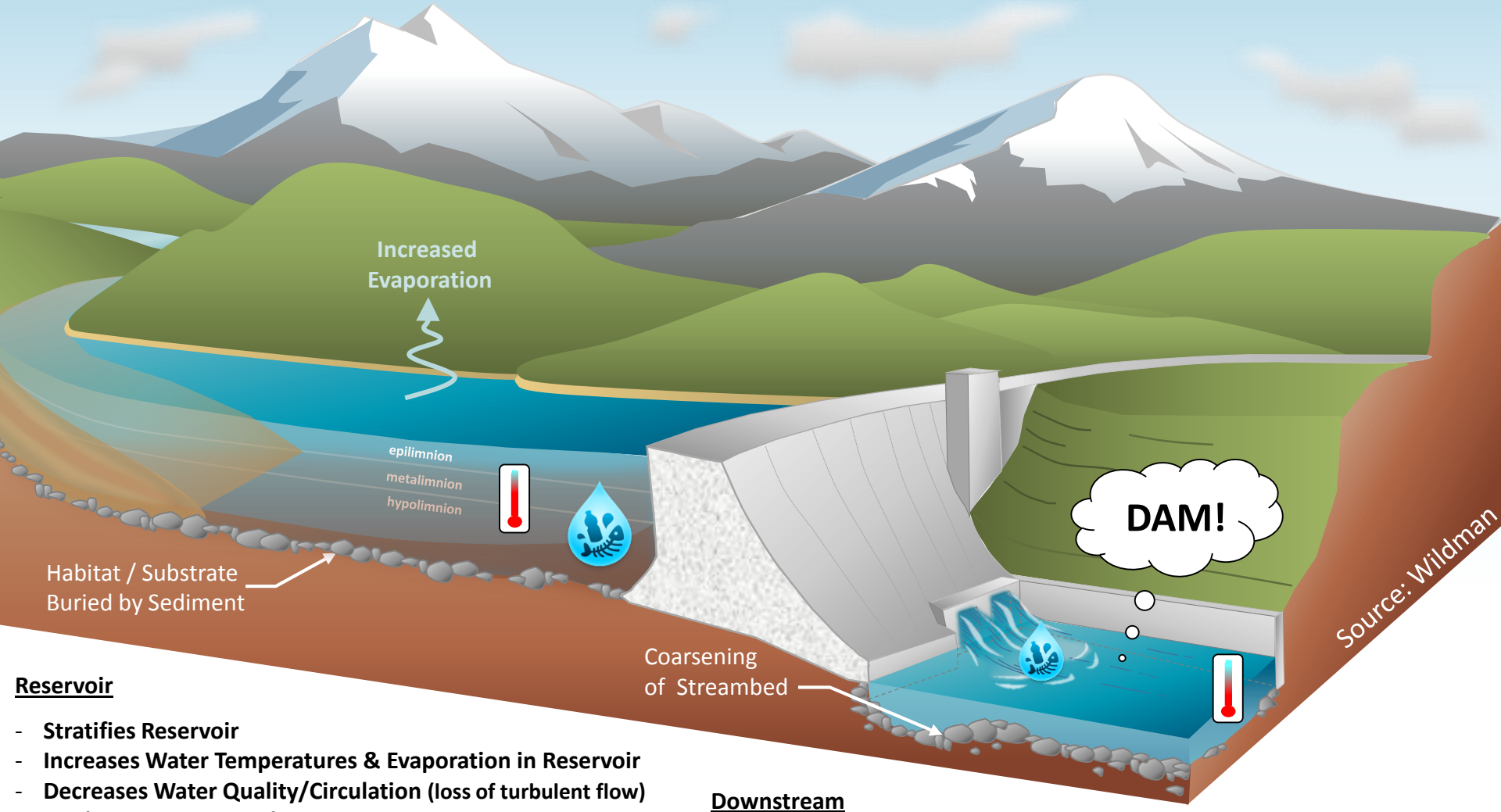
IMPACTS OF A DAM



Free Flowing River

- **Natural Streambed Features / Substrate / Habitat**
- **Turbulent Flow Patterns**
- **Natural Temperature & Flow Regime**
- **Natural Transport of Sediments (suspended and bed load)**
- **Natural Transport of Debris & Nutrients**
- **Fish / Aquatic Organism Passage**

IMPACTS OF A DAM



Reservoir

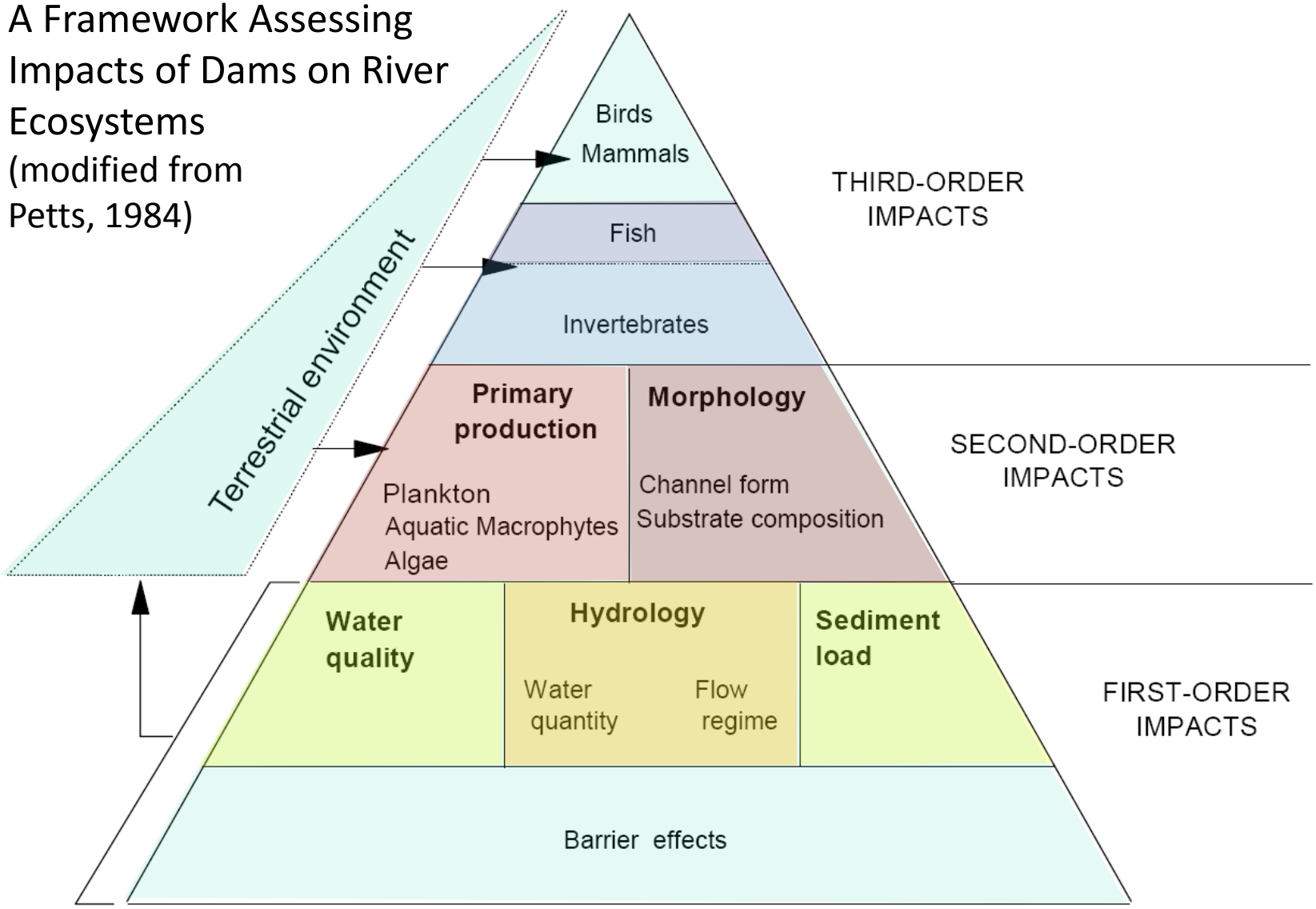
- **Stratifies Reservoir**
- **Increases Water Temperatures & Evaporation in Reservoir**
- **Decreases Water Quality/Circulation (loss of turbulent flow)**
- **Depletes Oxygen Levels (may become anoxic)**
- **Creates Algae Blooms**
- **Blocks Nutrient & Debris Transport**
- **Traps Sediment**
- **Pollutants Accumulate in Sediment**
- **Blocks Fish Passage**

Downstream

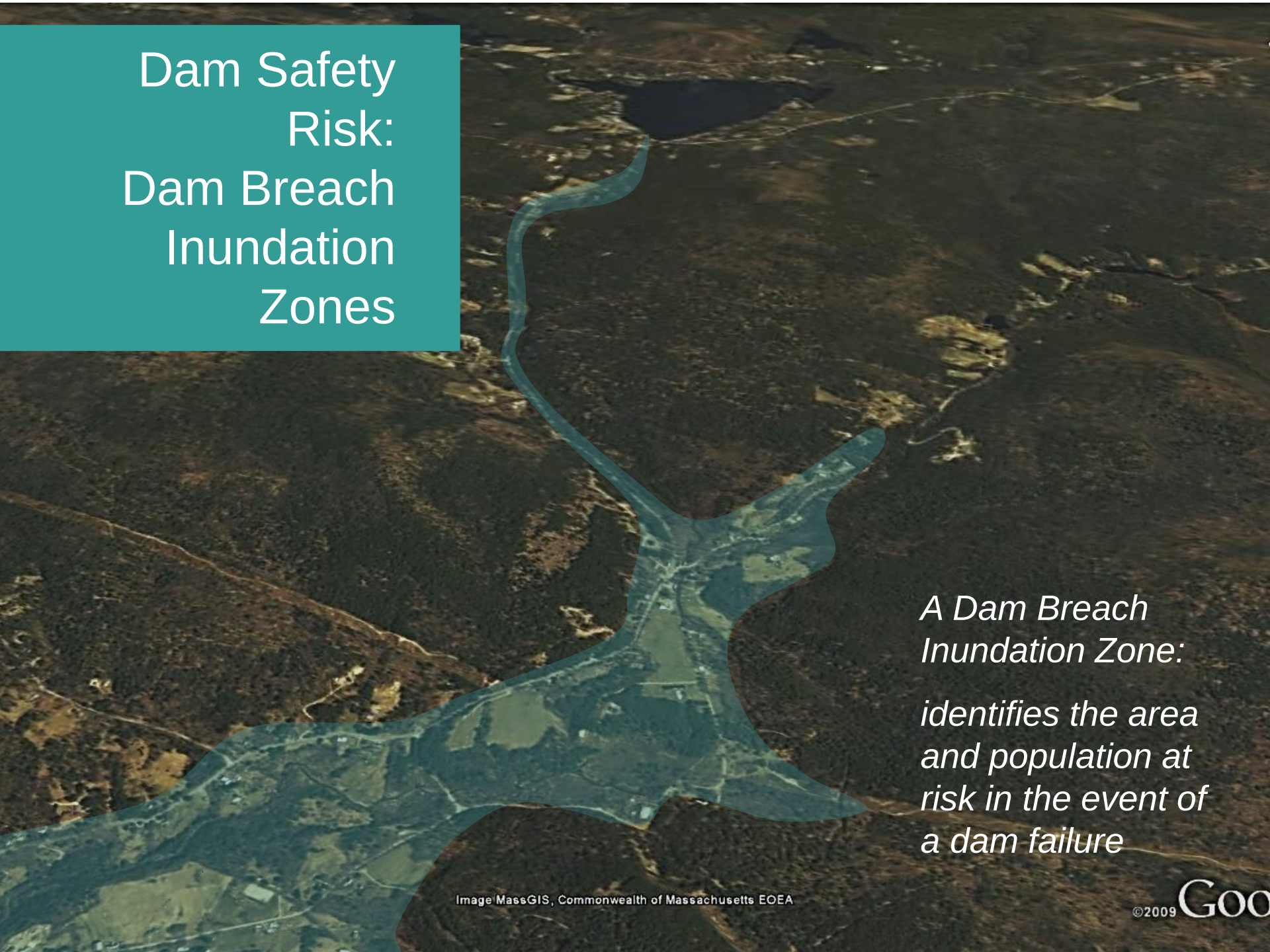
- **Modifies Water Temperatures**
- **Decreased Water Quality**
- **Creates Nutrient Starved Conditions Downstream**
- **Alters Downstream Flow Regime**
- **Creates Sediment Starved Conditions Downstream / Riverbed Degrades**

CASCADING ENVIRONMENTAL IMPACTS OF DAMS

A Framework Assessing Impacts of Dams on River Ecosystems (modified from Petts, 1984)



Dam Safety Risk: Dam Breach Inundation Zones



A Dam Breach Inundation Zone:

identifies the area and population at risk in the event of a dam failure

Dam Safety Risk: Dam Breach Inundation Zones

Iowa – 2010 Dam Failure

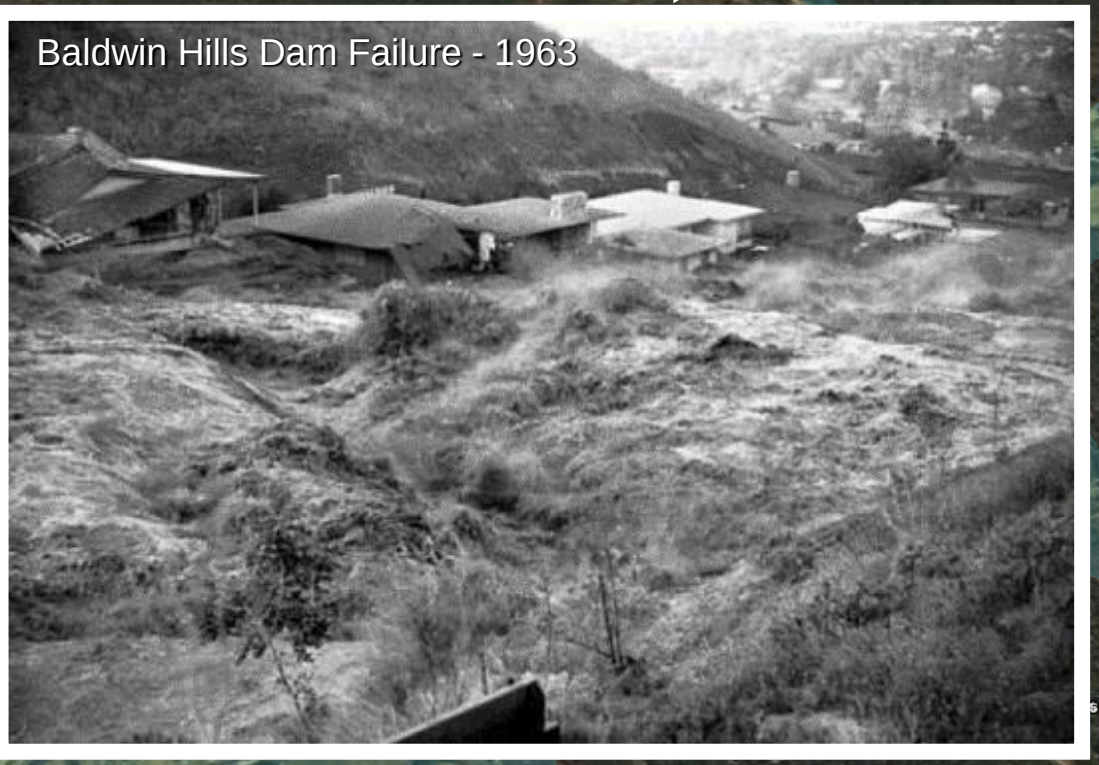
A Dam Breach Inundation Zone:

identifies the area and population at risk in the event of a dam failure

Image MassGIS, Commonwealth of Massachusetts EOEA

©2009 Goo

Dam Safety Risk: Dam Breach Inundation Zones



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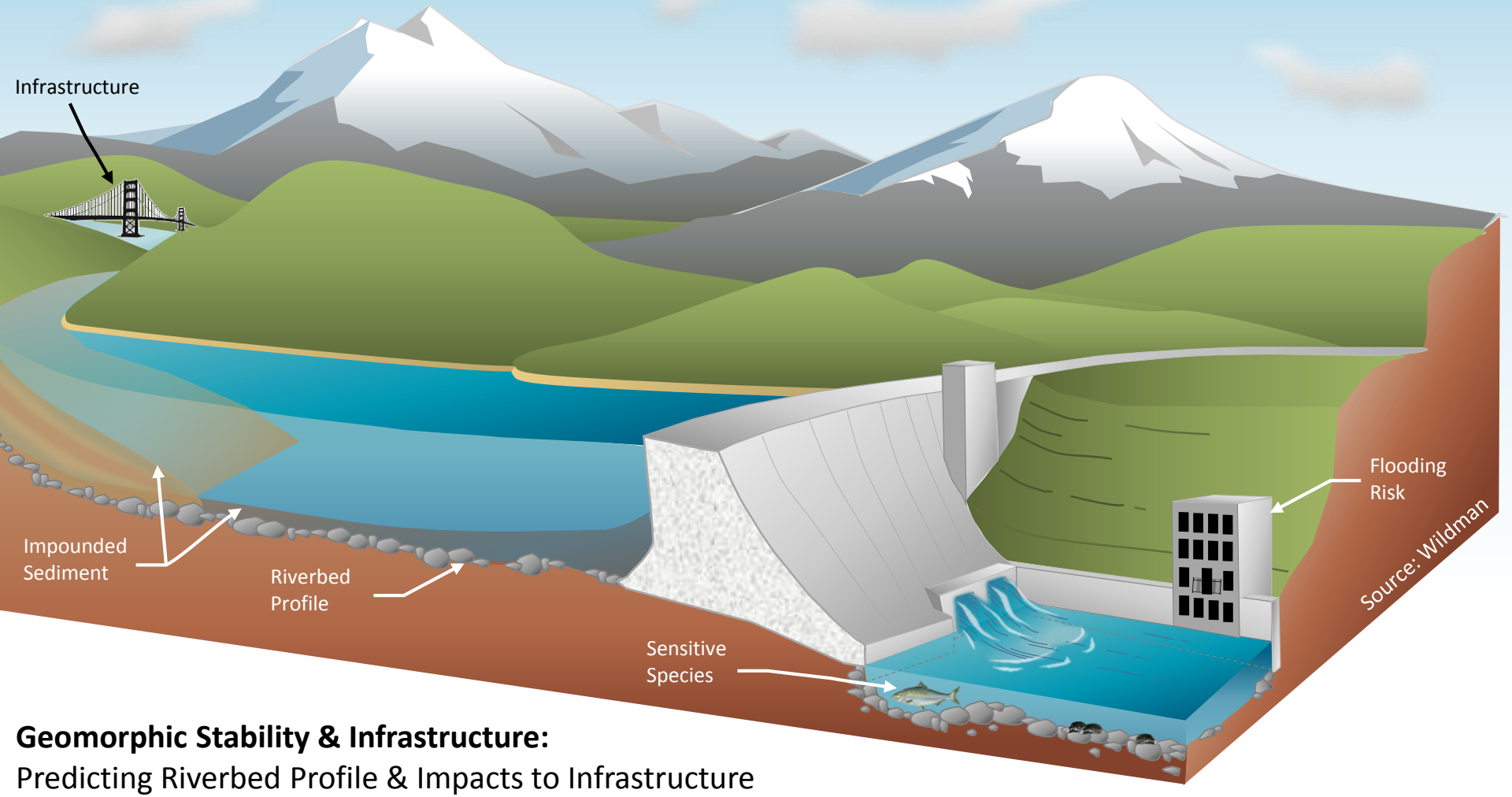
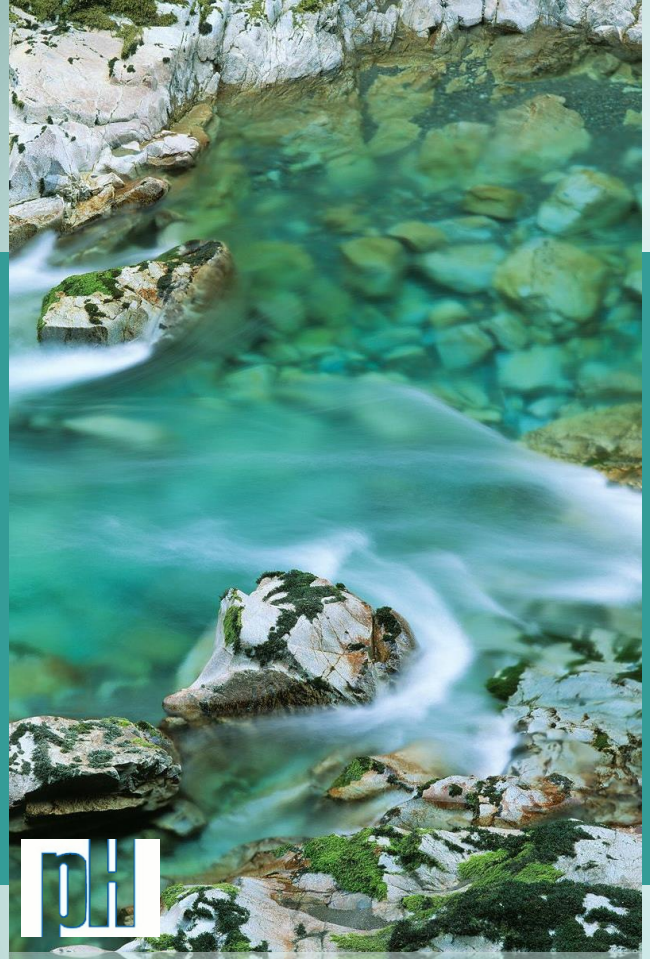
identifies the area and population at risk in the event of a dam failure

KEY IMPACTS OF DAM REMOVAL



Geomorphic Stability & Infrastructure:
Predicting Riverbed Profile & Impacts to Infrastructure
Impounded Sediment: quality and quantity
System Sensitivity: sensitive species, invasive species, downstream flooding
Current Use: replacing or balancing uses (i.e. hydro vs environmental impact)
Historic & Sentimental Value
Unknowns



ANALYZING DAMS FOR REMOVAL

Step 1: Planning/Feasibility Phase

START

Selection of Project
- Prioritization/Optimization Plan, Opportunistic, or Decision Point for Dam
- Determine Funding Options

Identify Project Goals
- Fish Passage
- Dam Safety
- Water Quality
- Etc.

Will the owner consider removal?

yes

no

Consider Alternatives
- Repair/Replace
- Lower
- Fishway

Identify Key Issues
- Refer to Checklist*
- Select Design Firm**

Collect Available data for Site
- T&E Databases
- Infrastructure/ Utilities at Risk
- Historic/Archeological Consultation

Field Investigation
w/ Geomorphic assessment

Sediment Investigation
- Physical Characteristics
- Quantity (probes)
- Quality (approved sampling plan, sampling & testing)
- Configuration (dewater or survey)

Consultation with Regulators

Are there any show stoppers?

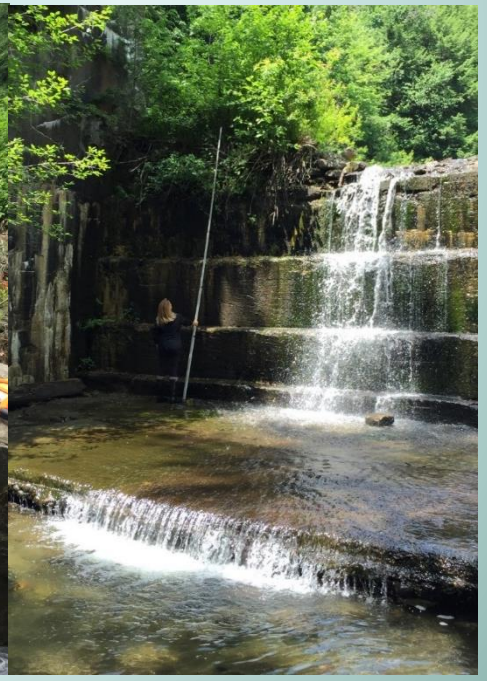
yes

Stakeholder/Public Input Meeting(s)

Review key issues

Top Key Issues:

- *Sediment*
- *Infrastructure/utility impacts*
- *Current use (& economic value of dam)*
- *Environmental concerns & benefits*
- *Geomorphic equilibrium*
- *Public health & safety*
- *Flooding & hydrologic impacts*
- *Aesthetic & sentimental value*
- *Historic/archeological*
- *Community concerns*
- *Sensitive or invasive species*
- *Water rights*
- *Cost & funding availability*



* Separate attachment

** Depends on how complicated the project is

Step 1: Planning/Feasibility Phase

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Are there any show stoppers?

yes

no

Review key issues

Stakeholder/Public Input Meeting(s)

Public Meeting

Alternatives Analysis
- Dam Removal Options only
- Select a Design Firm**

Secure Funding
- For Design & Permitting

Develop Sediment Management Plan
- **Passive Release**
- **Staged Release**
- **Excavation** (full or partial; mechanical or hydraulic dredge)
  - **Relocate On-site** (possible capping or stabilization)
  - **Export Off-Site** (determine disposal/reuse options)
- **Combination of Methods**

Consultation with Regulators

Can downstream channel/ecosystem handle it?

yes

no

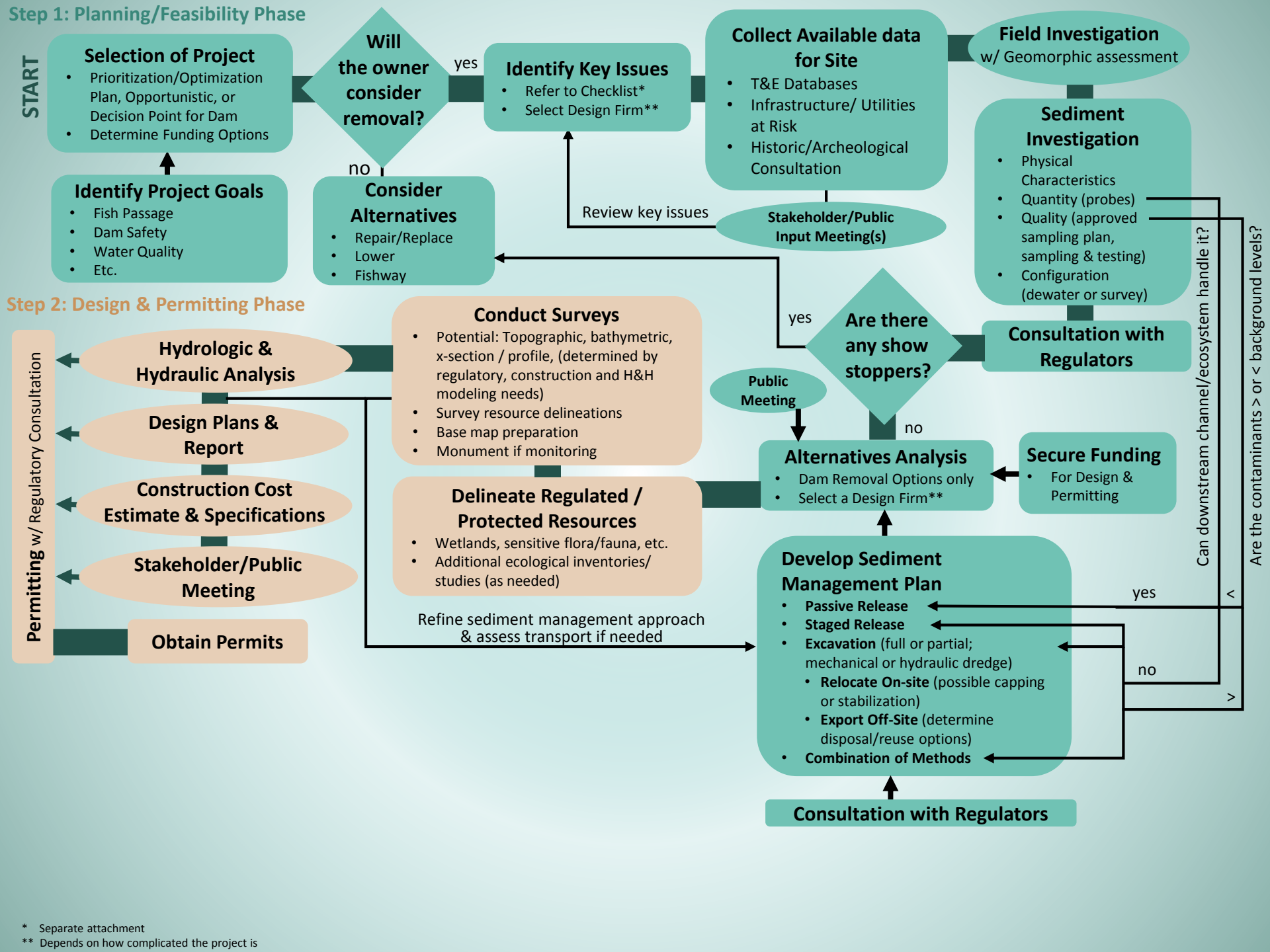
Are the contaminants > or < background levels?

<

>

* Separate attachment

** Depends on how complicated the project is



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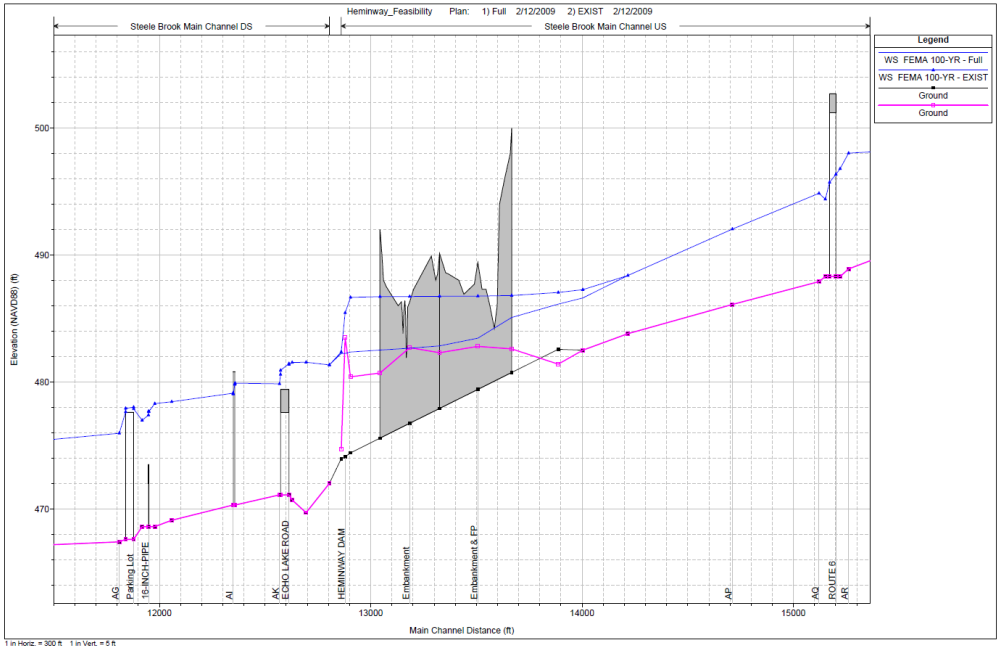
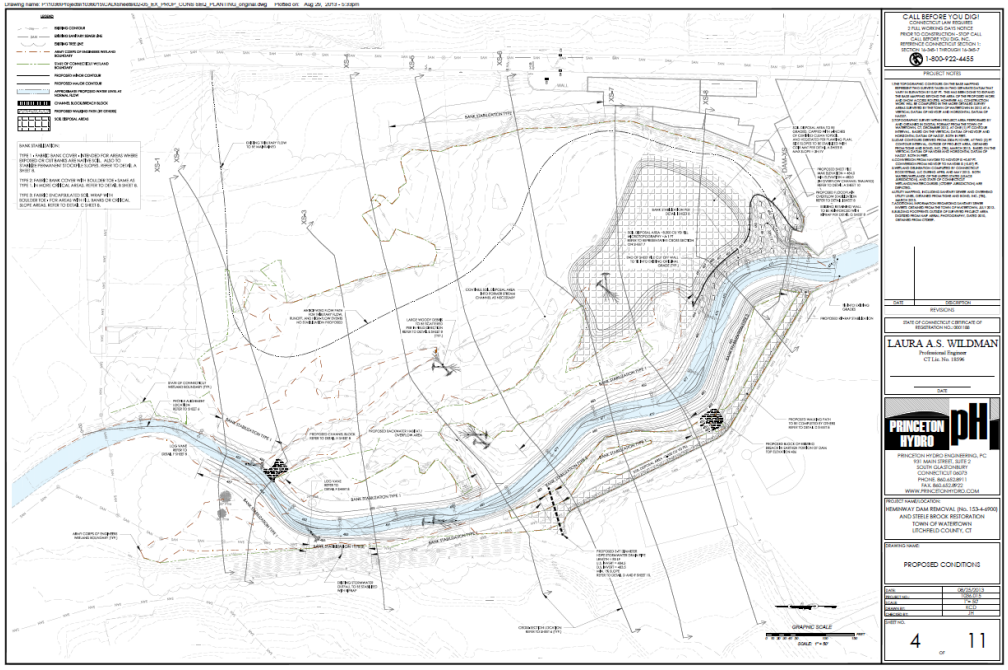
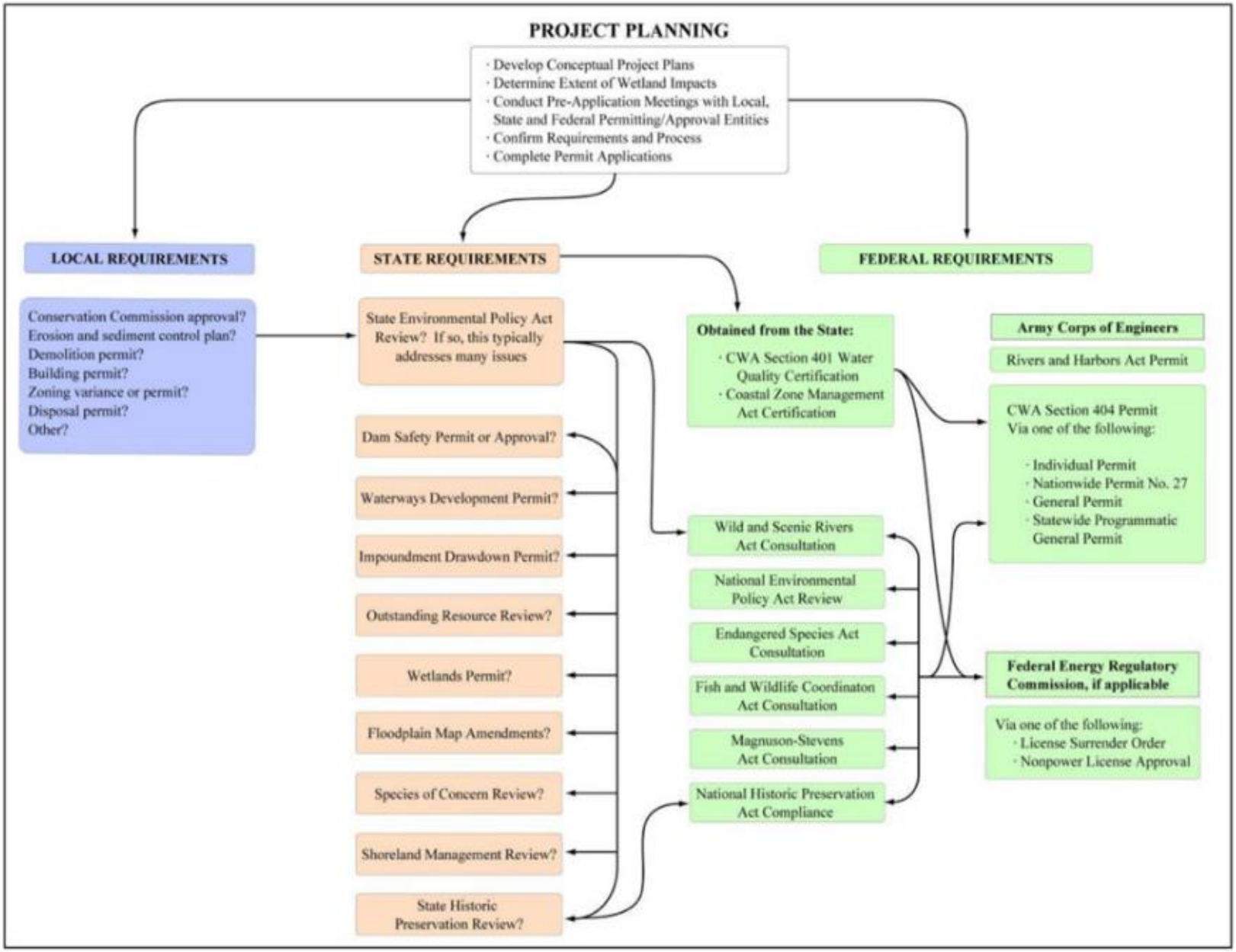
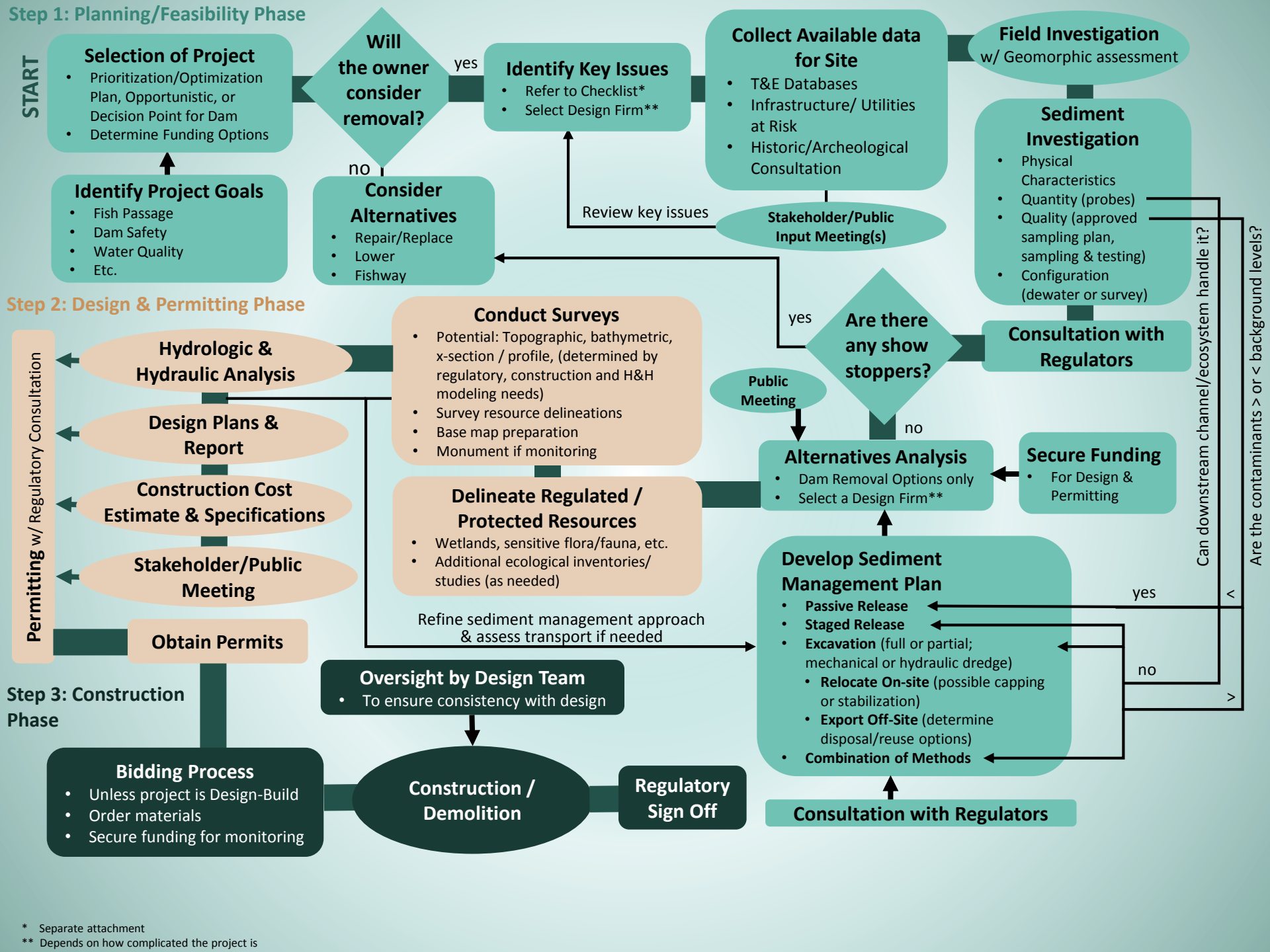

Heminway_Feasibility Plan: 1) Full 2/12/2009 2) EXIST 2/12/2009
Steele Brook Main Channel DS
Steele Brook Main Channel US
Legend
WS FEMA 100-YR - Full
WS FEMA 100-YR - EXIST
Ground
Ground
Elevation (NAVD88) (ft)
500
490
480
470
AG
Parking Lot
16-INCH-PIPE
AI
AK
ECHO LAKE ROAD
HEMINWAY DAM
Embankment
Embankment & FP
AP
AQ
ROUTE 6
AR
12000
13000
14000
15000
Main Channel Distance (ft)
1 in Horiz. = 300 ft 1 in Vert. = 5 ft


CALL BEFORE YOU DIG!
1-800-922-4455
PROJECT NOTES
LAURA A.S. WILDMAN
Professional Engineer
PRINCETON HYDRO
PROJECT NAME/LOCATION:
HEMINWAY DAM REMOVAL (NO. 153-4-WQ)
AND STEELE BROOK RESTORATION
TOWN OF WATERTOWN
LITCHFIELD COUNTY, CT
DRAWING NAME:
PROPOSED CONDITIONS
SHEET NO.
4 11

Conceptual Permitting Flow Chart





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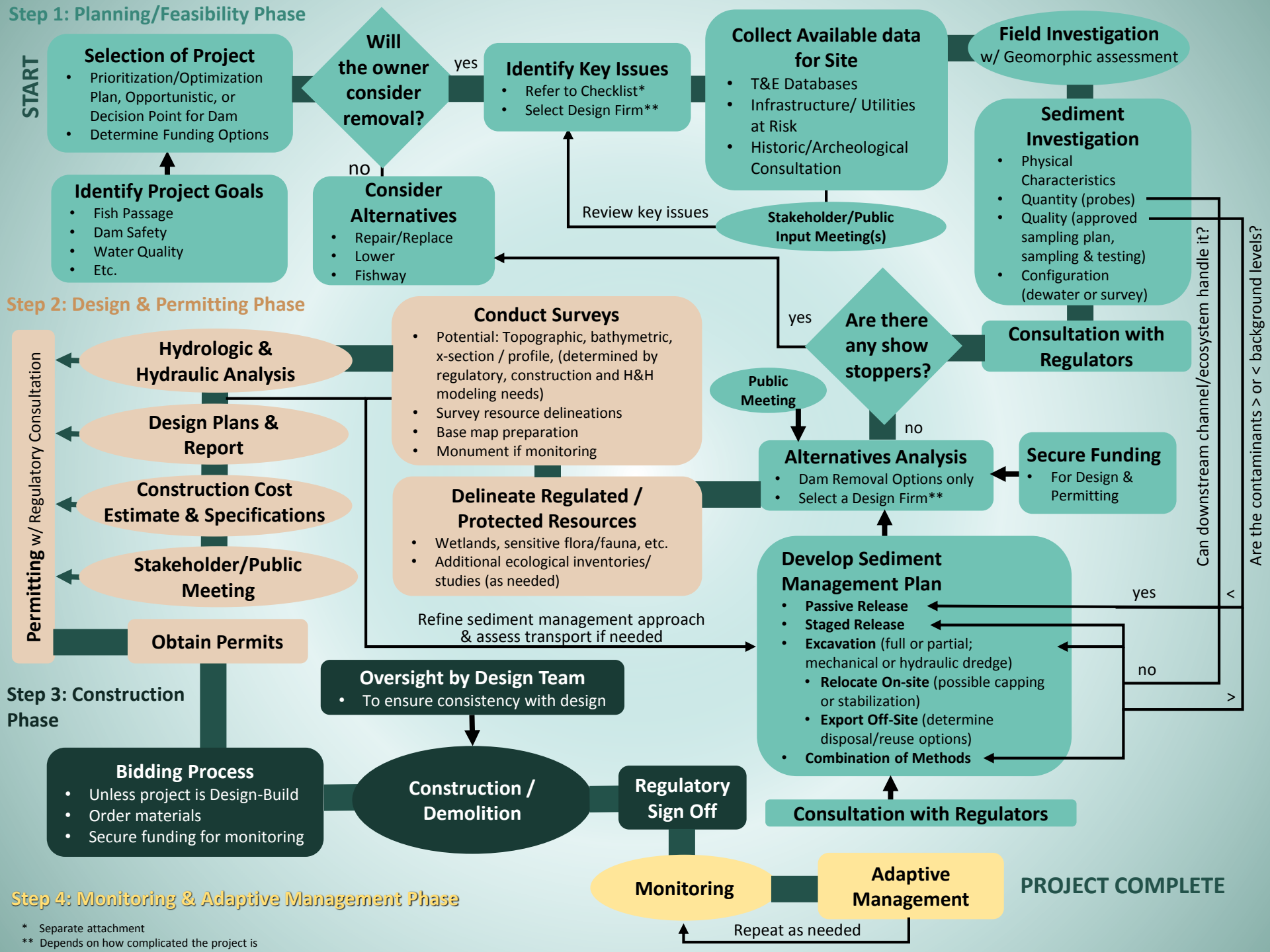
Step 1: Planning/Feasibility Phase
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Fish Passage
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Water Quality
Etc.
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yes
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Fishway
Identify Key Issues
Refer to Checklist*
Select Design Firm**
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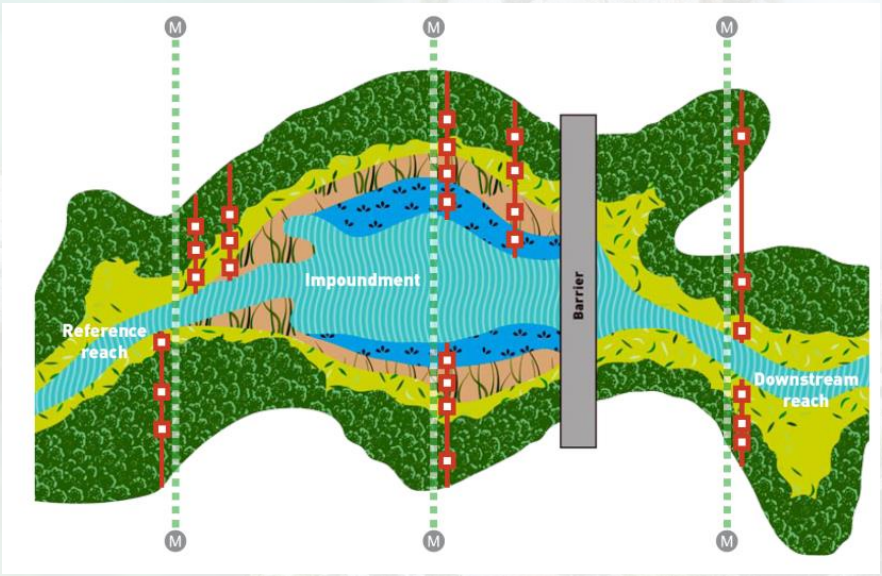
Field Investigation
w/ Geomorphic assessment
Review key issues
Stakeholder/Public Input Meeting(s)
Sediment Investigation
Physical Characteristics
Quantity (probes)
Quality (approved sampling plan, sampling & testing)
Configuration (dewater or survey)
Step 2: Design & Permitting Phase
Conduct Surveys
Potential: Topographic, bathymetric, x-section / profile, (determined by regulatory, construction and H&H modeling needs)
Survey resource delineations
Base map preparation
Monument if monitoring
Are there any show stoppers?
yes
no
Consultation with Regulators
Public Meeting
Hydrologic & Hydraulic Analysis
Design Plans & Report
Construction Cost Estimate & Specifications
Stakeholder/Public Meeting
Permitting w/ Regulatory Consultation
Delineate Regulated / Protected Resources
Wetlands, sensitive flora/fauna, etc.
Additional ecological inventories/ studies (as needed)
Alternatives Analysis
Dam Removal Options only
Select a Design Firm**
Secure Funding
For Design & Permitting
Develop Sediment Management Plan
Passive Release
Staged Release
Excavation (full or partial; mechanical or hydraulic dredge)
Relocate On-site (possible capping or stabilization)
Export Off-Site (determine disposal/reuse options)
Combination of Methods
Refine sediment management approach & assess transport if needed
Can downstream channel/ecosystem handle it?
Are the contaminants > or < background levels?
yes
no
Obtain Permits
Step 3: Construction Phase
Oversight by Design Team
To ensure consistency with design
Bidding Process
Unless project is Design-Build
Order materials
Secure funding for monitoring
Construction / Demolition
Regulatory Sign Off
Consultation with Regulators
Step 4: Monitoring & Adaptive Management Phase
Monitoring
Adaptive Management
Repeat as needed
PROJECT COMPLETE
* Separate attachment
** Depends on how complicated the project is

THE ENGINEERING DATA CAN THEN BE USED AS THE PRE-REMOVAL DATA SETTING US UP FOR POST-REMOVAL MONITORING

DETAILED: When funds are available

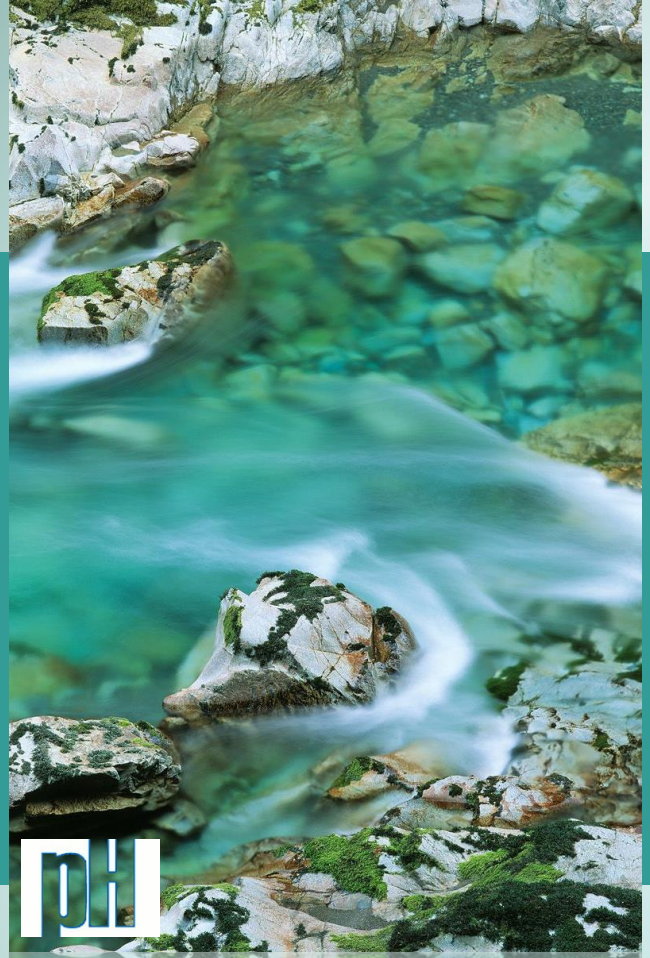
RESOURCE MANAGEMENT FOCUSED: When funds are not available



8 Critical Parameters

- Monumented cross-sections
- Longitudinal profile
- Grain size distribution
- Photo stations
- Water quality
- Riparian plant community structure
- Macroinvertibrates
- Fish passage assessment

http://www.gulfofmaine.org/streambarrierremoval/



LEARNING THROUGH A WIDE

DIVERSITY OF CASE STUDIES

NO TWO DAM REMOVALS ARE THE SAME

Type of Dam

- Earth
- Gravity
- Stone Masonry
- Timber Crib
- Arch
- Stop Log
- Concrete
- Reinforced or Not
- Slab and Buttress
- Inflatable Rubber
- Other

Use

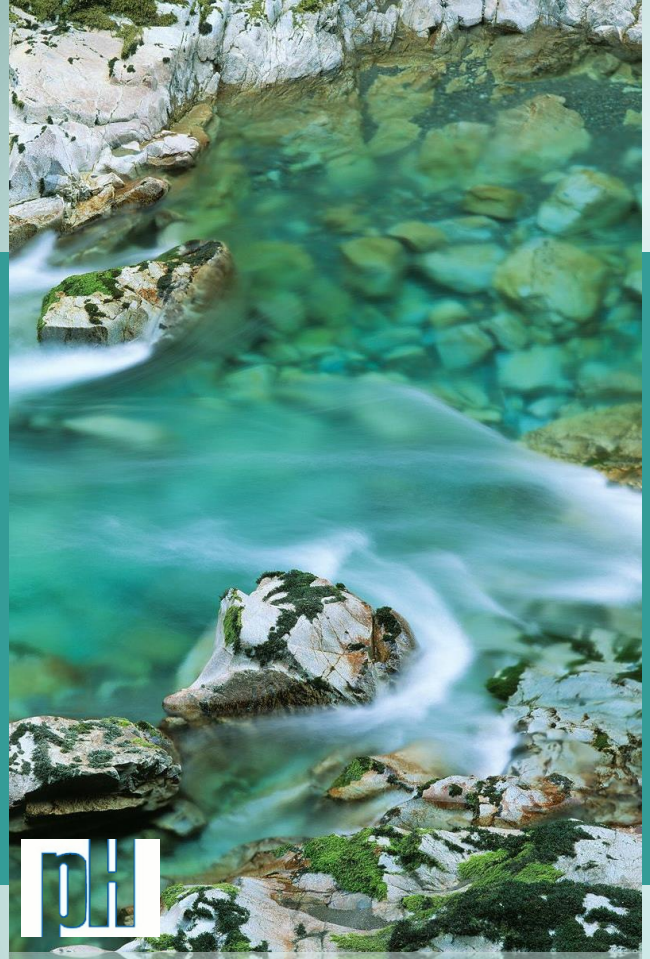
- Water Supply
- Navigation
- Water Level Control
- Flood Control
- Fire Suppression
- Recreational
- Hydro Electric
- Irrigation
- Tailings
- Grade Stabilization
- Fish & Wildlife
- No Use
- Other

Site Specific Issues

- On a Canal (not River)
- Wide/Narrow Reservoir
- Urban or Rural
- Highly Managed
- Delta Deposited
- Quantity of Sediment
- Historic Operation
- Legacy Thalweg
- Quality of Sediment
- Layered Deposit
- Legacy Dam
- Coarse or Fine Grained
- Bedrock or Vegetation
- Infrastructure Impacted

Issues Associated with Impacts

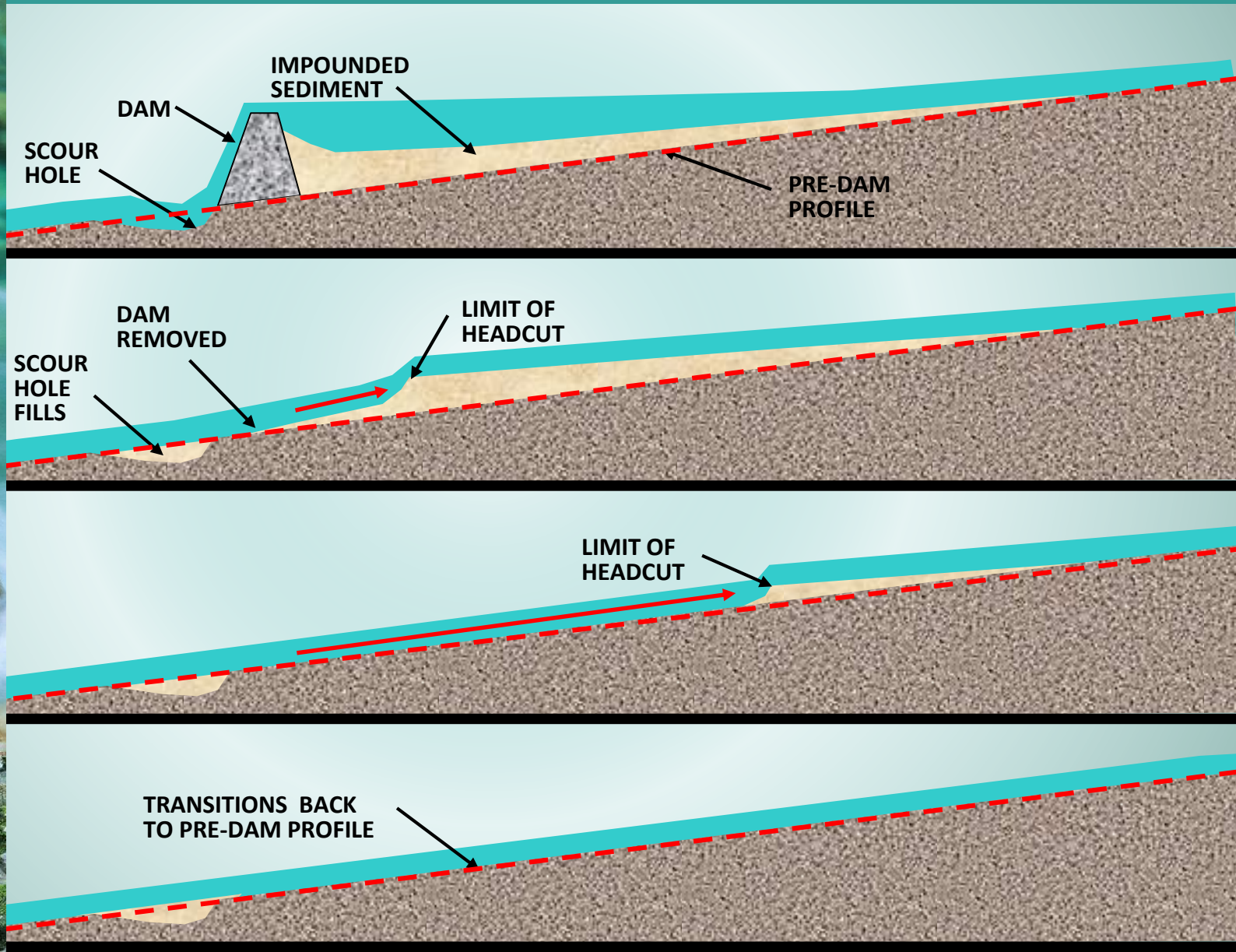
- System Sensitivity
- Interconnected Impacts
- Sensitive Species
- Entrenched
- Water Quality
- Transport Capacity
- Social Perception
- Scale
- Historic
- Cost/Funding



GEOMORPHIC STABILITY & INFRASTRUCTURE

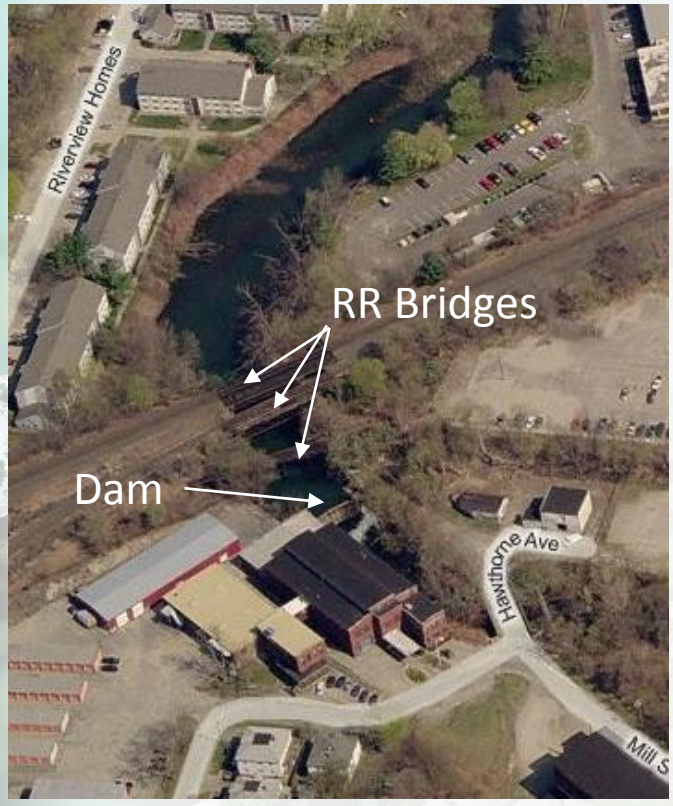
RIVERBED PROFILE

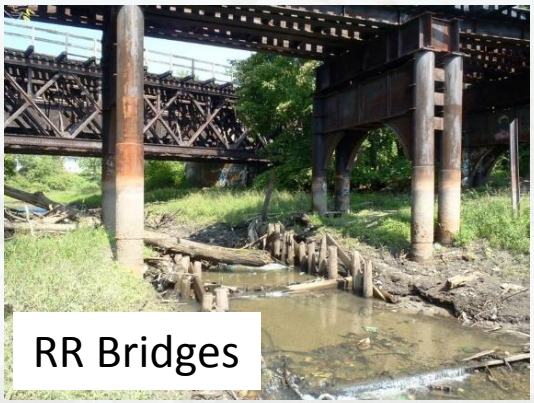
Simple Example



Tel-Electric Dam, Massachusetts

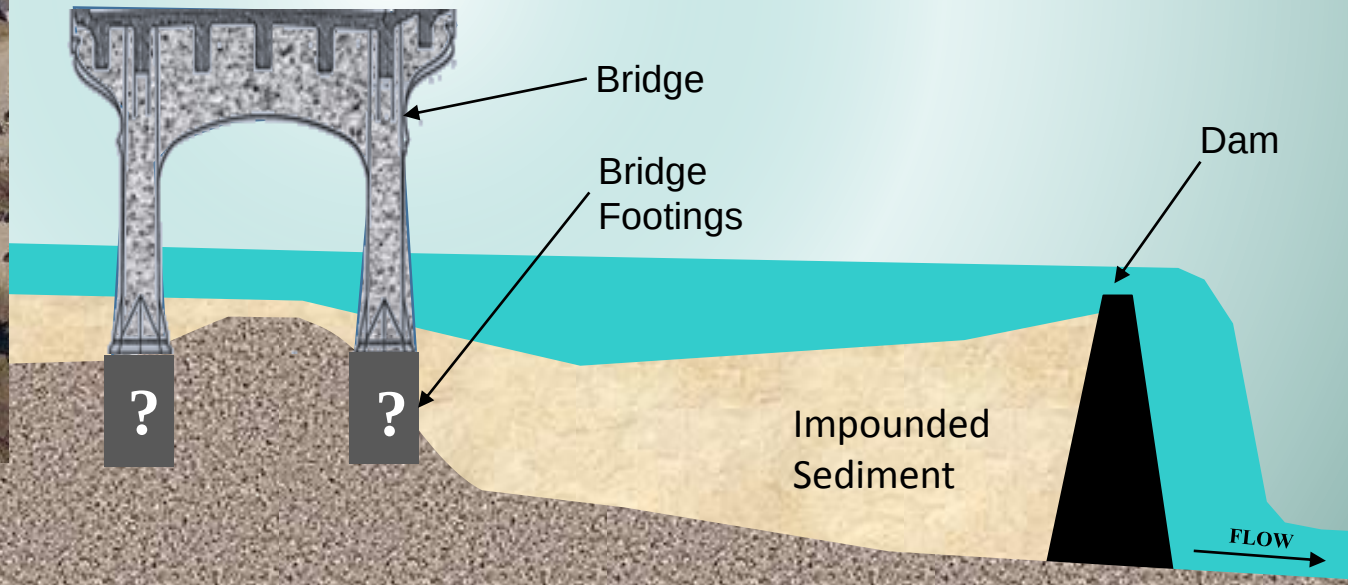
- 5m concrete capped stone masonry dam
- Significant infrastructure: 2 active railroad bridges; 1 abandoned railroad bridge to be removed, factories, retaining walls, etc.
- Contaminated sediments throughout river
- 1 recent death





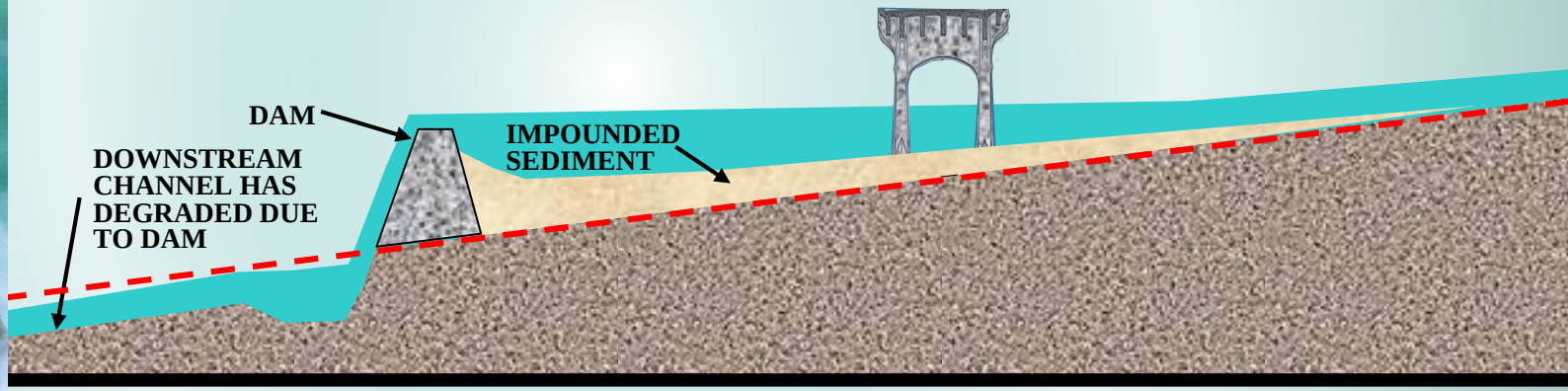
TEL-ELECTRIC AM REMOVAL

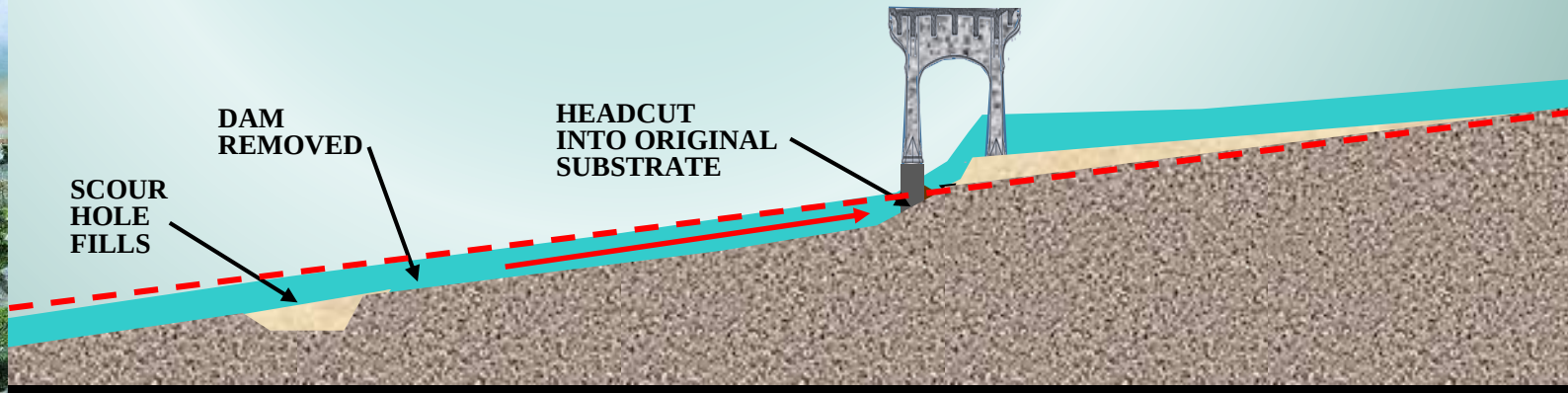
Potential for Headcut & Undermining



GOLDSBOROUGH DAM REMOVAL

Potential for Headcut & Undermining

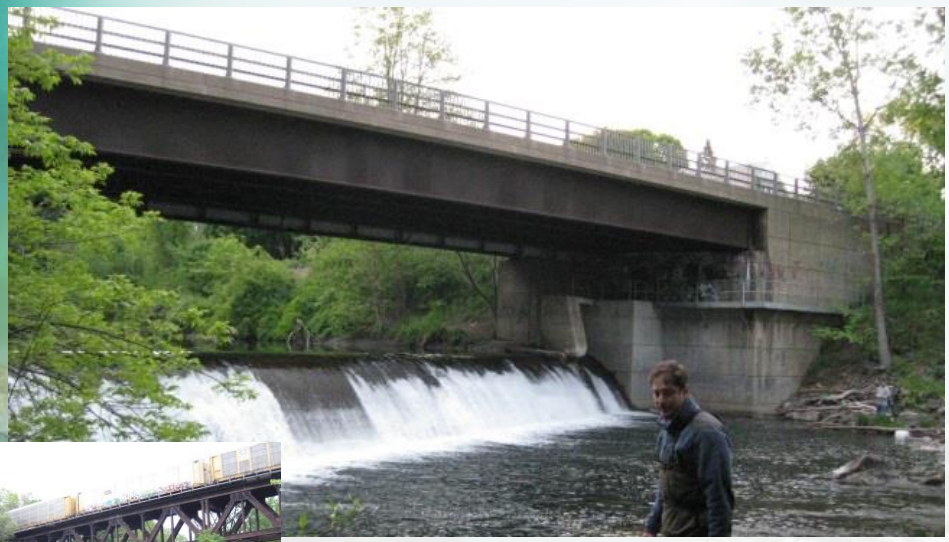


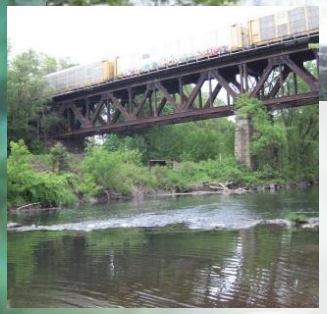


Green River Dams, Massachusetts

- Cascading infrastructure impacts due to geomorphic instabilities
- Timber crib dam, not what it appeared to be
- Submerged knickpoint due to river avulsion per-dam construction

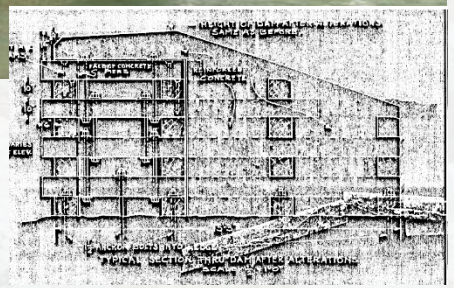
Mill Street





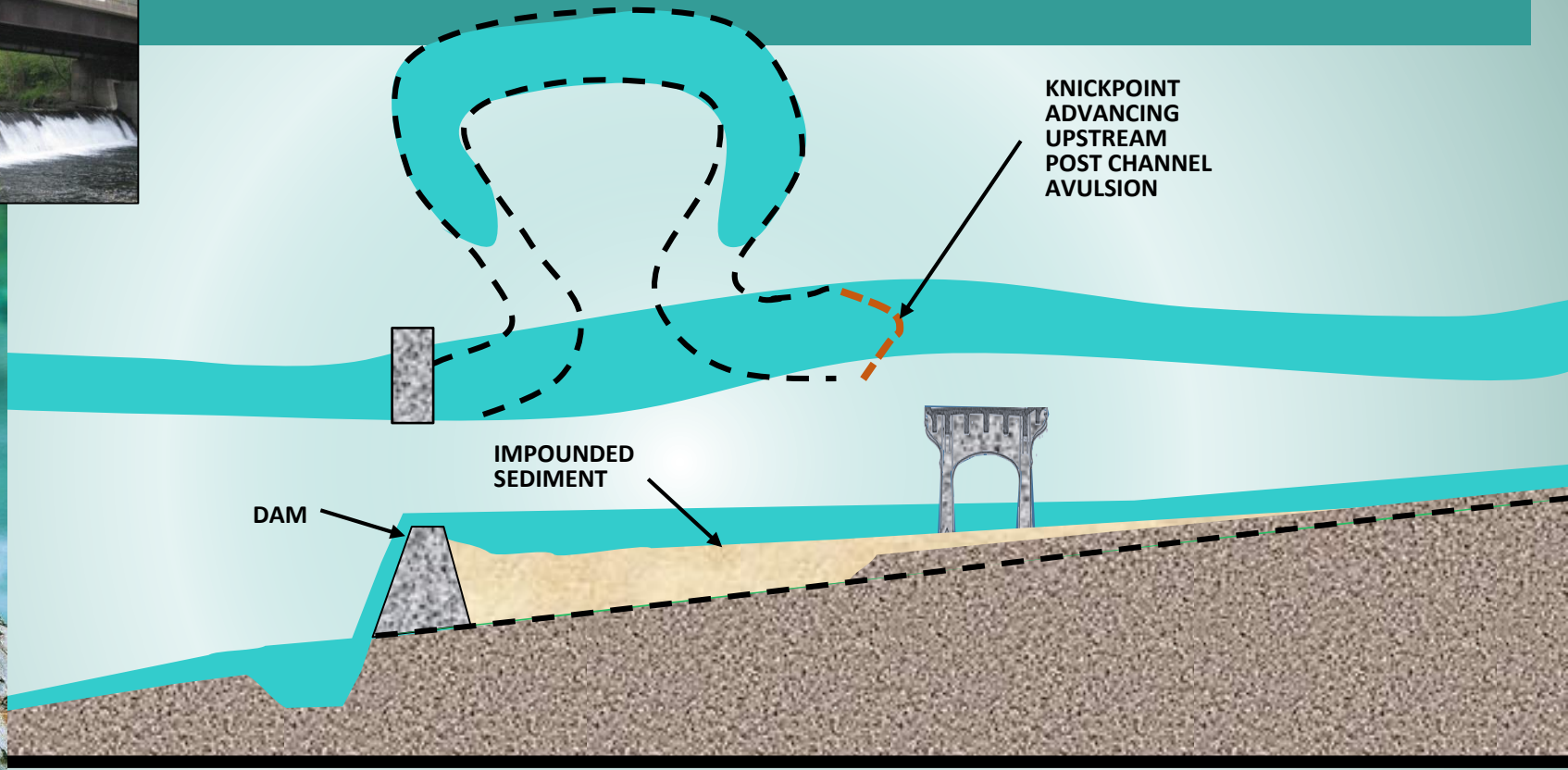
Mill Street Dam

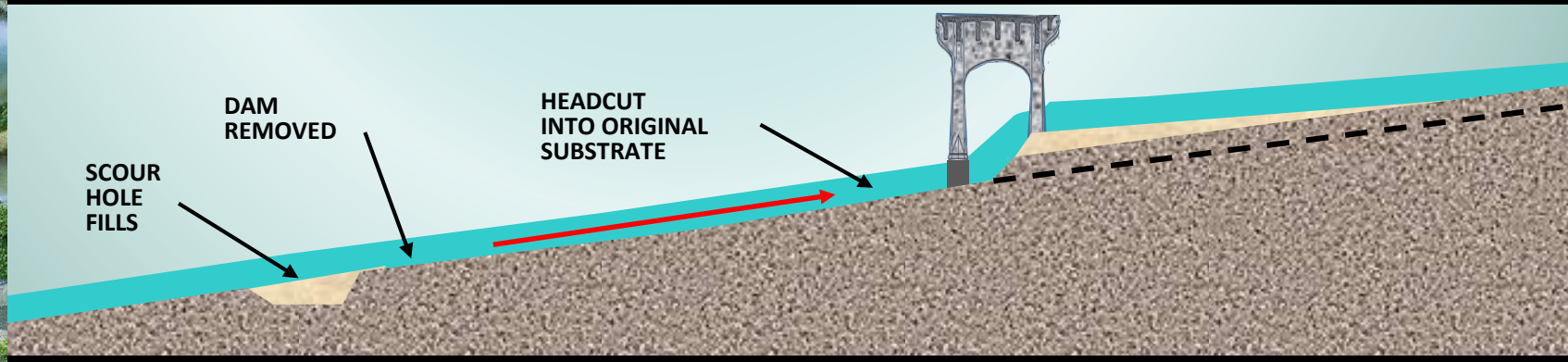
Winchell Smith Dam



GREEN RIVER DAMS

SUBMERGED KNICKPOINT (Mill Street Dam, MA)



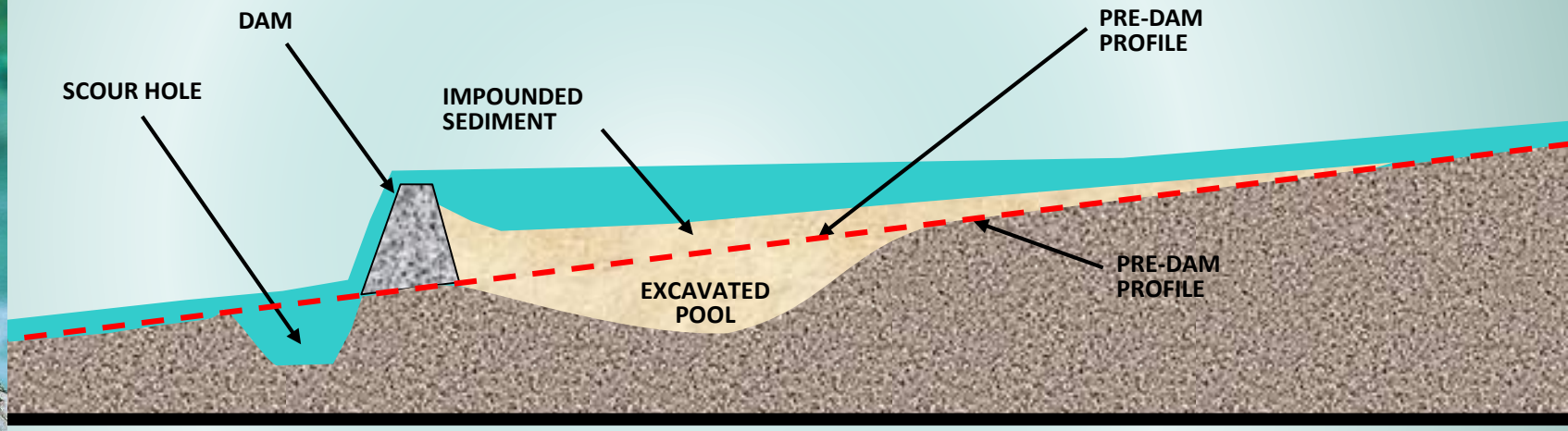


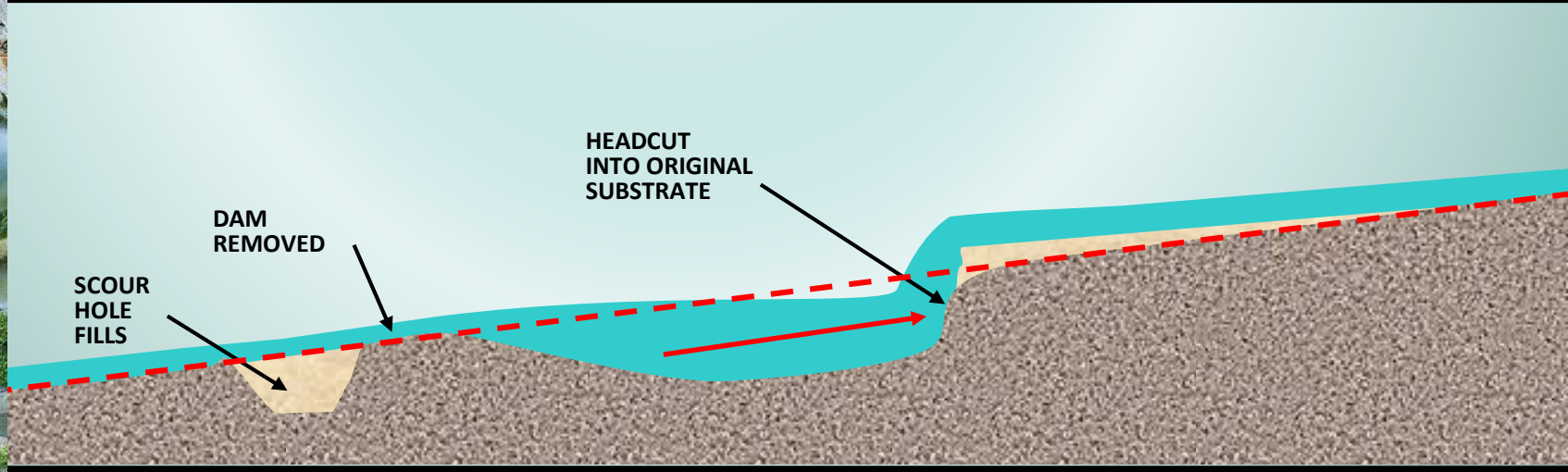
Heminway Dam, Connecticut

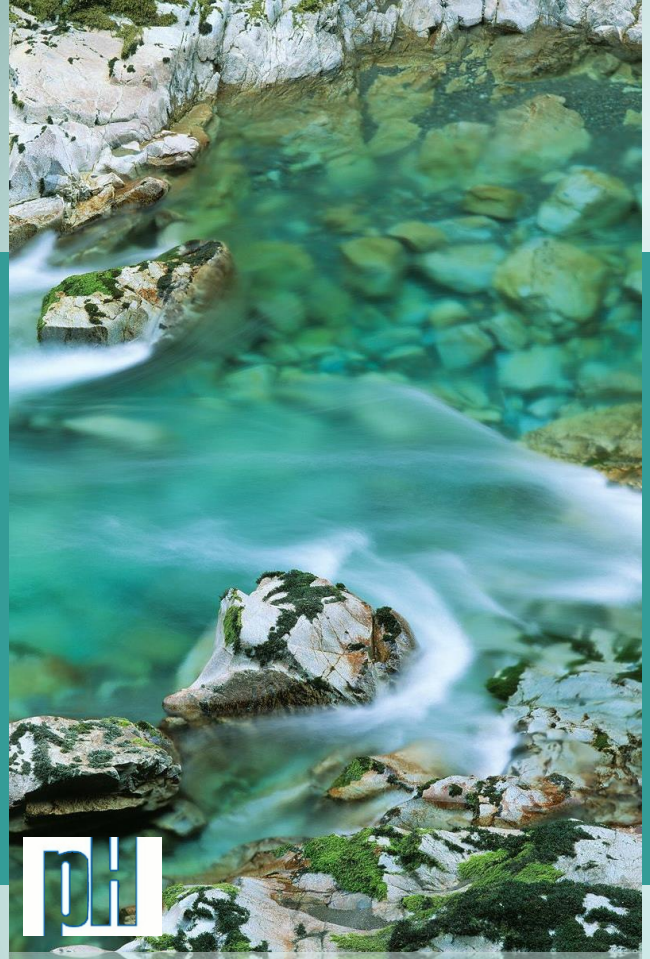
- Originally dredged impoundment
- Sediment filled impoundment now considered wetland
- Difficult permitting sediment relocation within former impoundment

HEMINWAY DAM

Dredged Impoundment







CONSECUTIVE DAMS

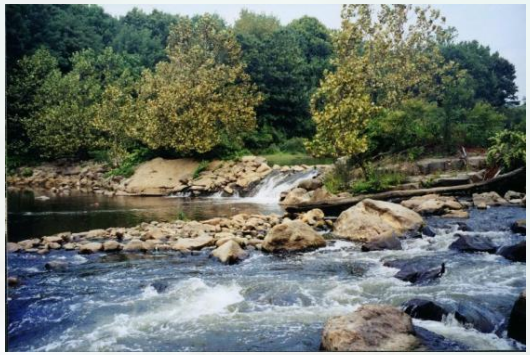
5 Dams on the Naugatuck River, Connecticut

Chase Brass

Concrete Dam
height = 2m length = 53m

Platts Mill

Stone Rubble / Timber Crib
height = 3n length = 77m

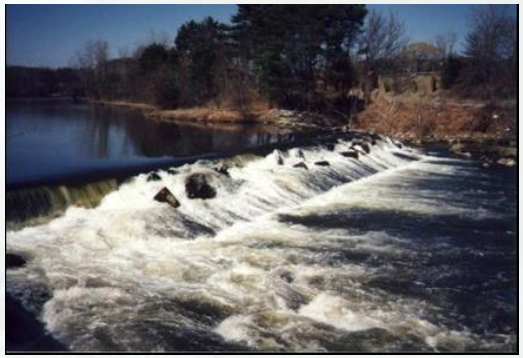


Anaconda

Timber crib / Sheetpile Dam
height = 4m length = 109m

Union City

Timber Crib Dam
height = 2.5m length = 63m



Freight Street

Concrete / Sheetpile Dam
height = 1m length = 53m

- 5 Dams Removed
- 70% of Watershed now free flowing
- Revival of an industrial river

5 Dams on the Naugatuck River, Connecticut

Chase Brass

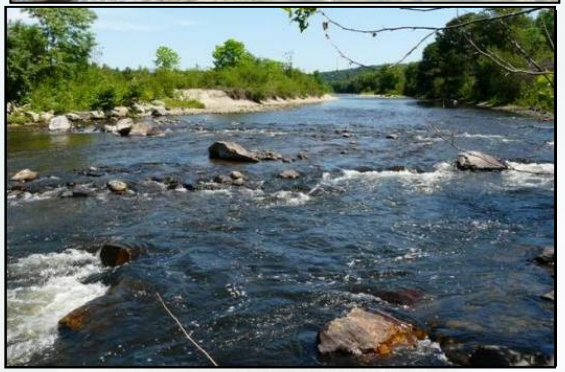
Concrete Dam
height = 2m length = 53m

Platts Mill

Stone Rubble / Timber Crib
height = 3n length = 77m

Anaconda

Timber crib / Sheetpile Dam
height = 4m length = 109m



Union City

Timber Crib Dam
height = 2.5m length = 63m

Freight Street

Concrete / Sheetpile Dam
height = 1m length = 53m

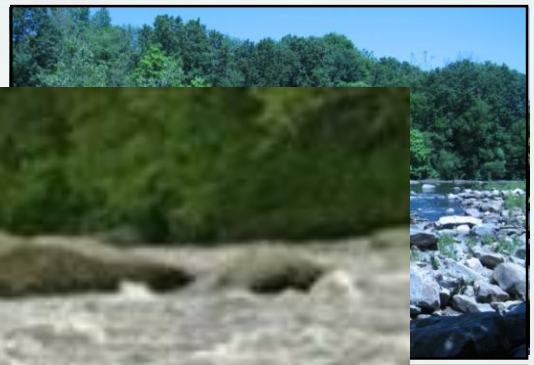
- 5 Dams Removed
- 70% of Watershed now free flowing
- Revival of an industrial river

5 Dams on the Naugatuck River, Connecticut

Chase Brass

Concrete Dam
height = 2m le

Platts Mill



Ana

Timber crib / She
height = 4m leng

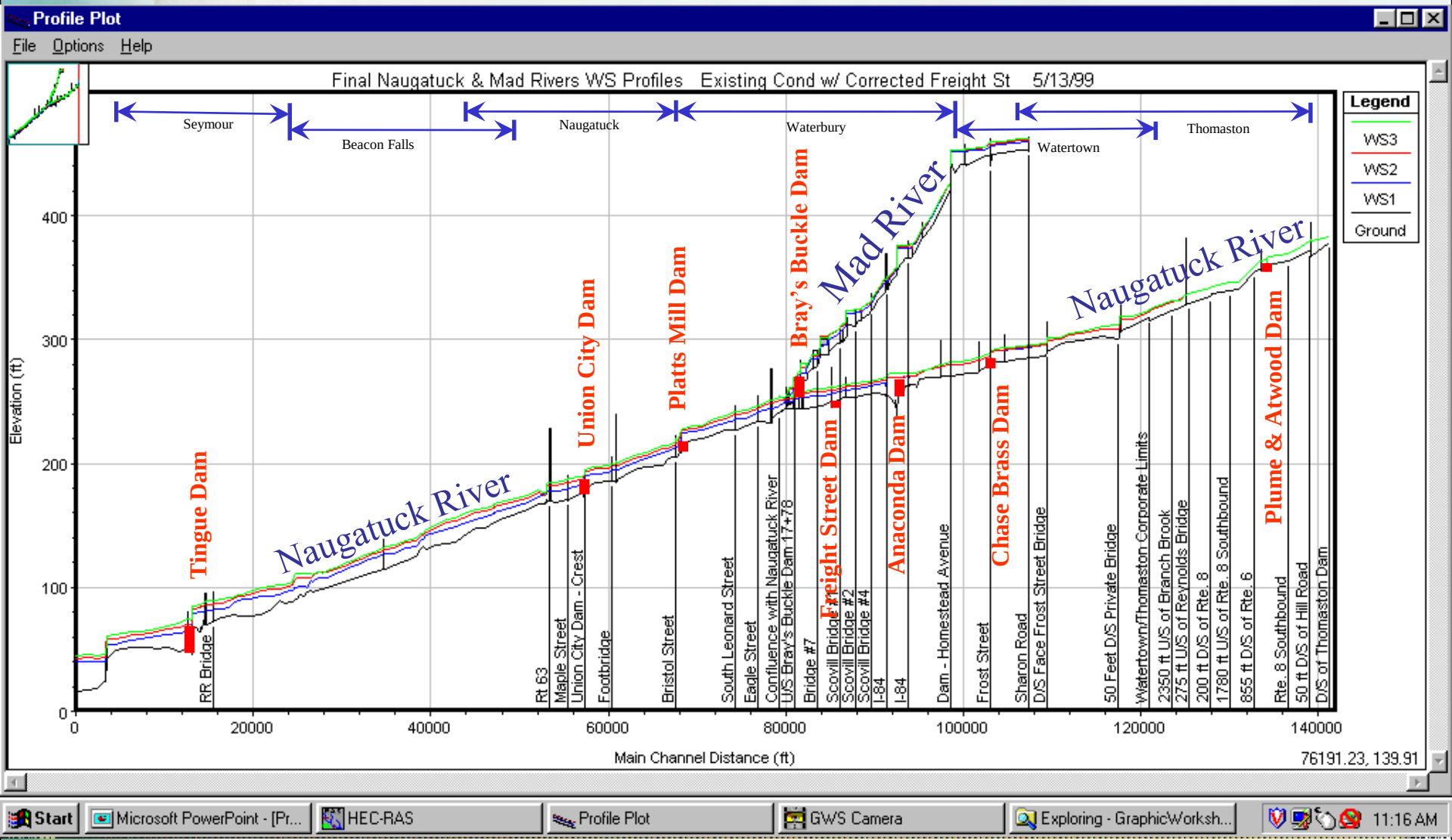
Freight

Concrete / She
height = 1m le

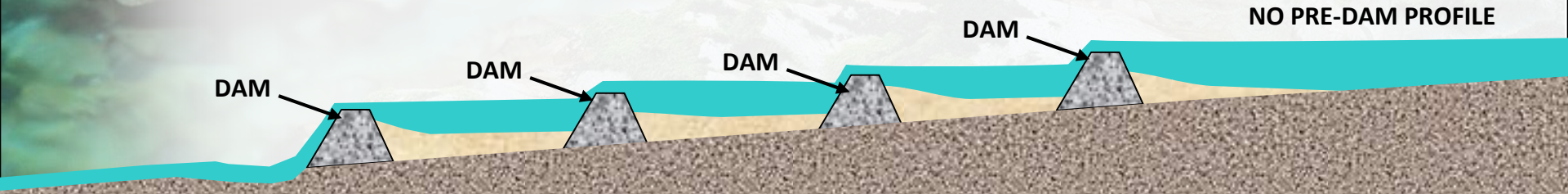
ee

- Revival of an industrial river

5 Dams on the Naugatuck River, Connecticut

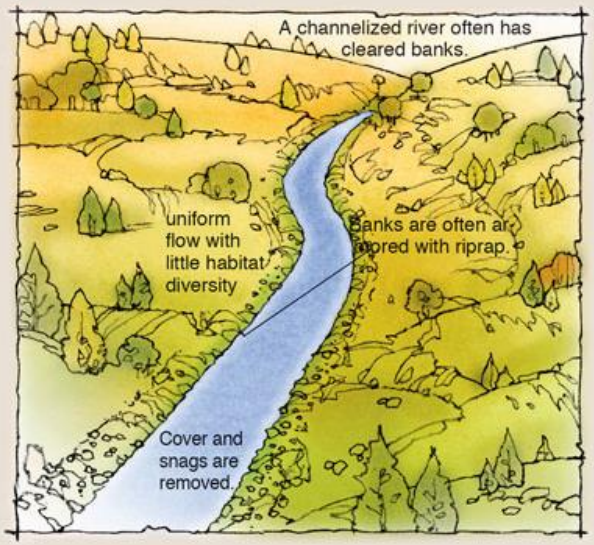


Canals vs Rivers

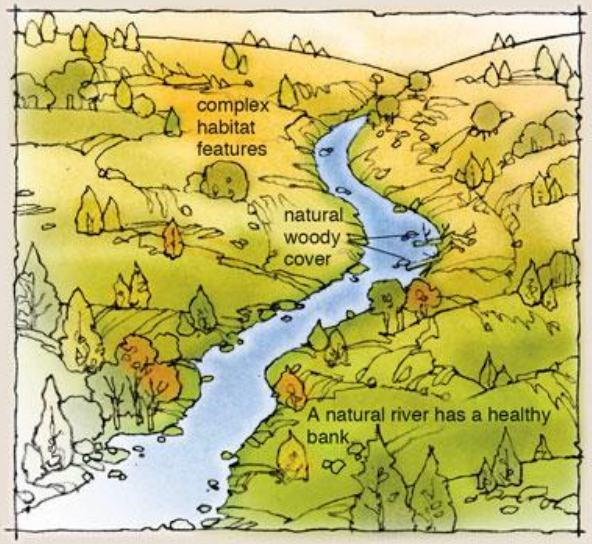


Canals vs Rivers

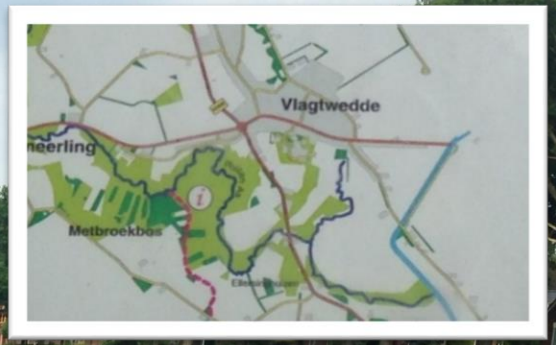
Channelized River

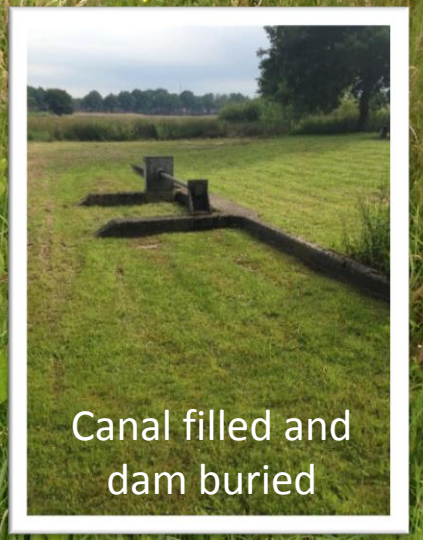


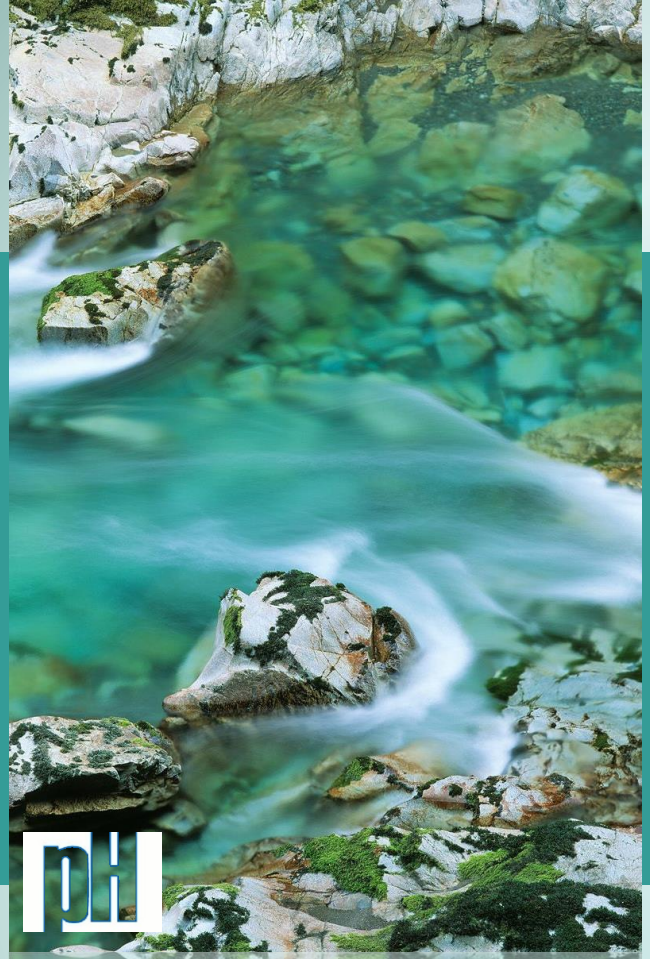
Natural River



River & Floodplain Restoration Project in the Netherlands, where the canal was dechannelized and rerouted. However the water for this "river" is pumped 12 ft uphill from a different watershed.







PASSIVE VS ACTIVE SITE RESTORTION

ACTIVE SITE RESTORATION

Puddin' Head Branch Dam Removal, FL

Puddin'Head Branch Dam Removal, FL

Source: Steve Herrington/TNC

ACTIVE SITE RESTORATION

Puddin' Head Branch Dam Removal, FL

PASSIVE SITE RESTORATION

Tannery Brook Dam, New Hampshire

- 8.5m earthen dam
- Wide impoundment
- Little impounded sediment
- Passive channel treatment

PASSIVE SITE RESTORATION

Tannery Brook Dam, New Hampshire

- 8.5m earthen dam
- Wide impoundment
- Little impounded sediment
- Passive channel treatment

PASSIVE SITE RESTORATION

Tannery Brook Dam, New Hampshire

- 8.5m earthen dam
- Wide impoundment
- Little impounded sediment
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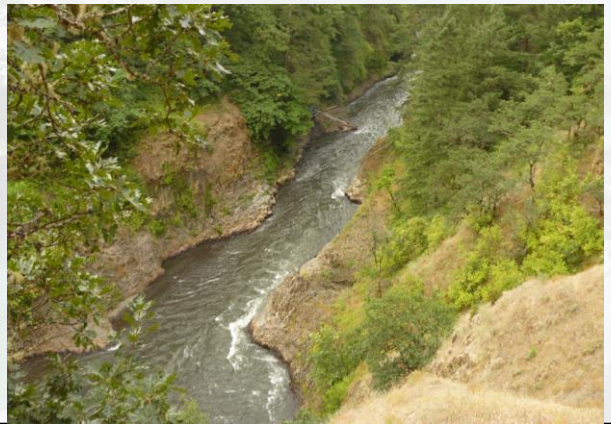
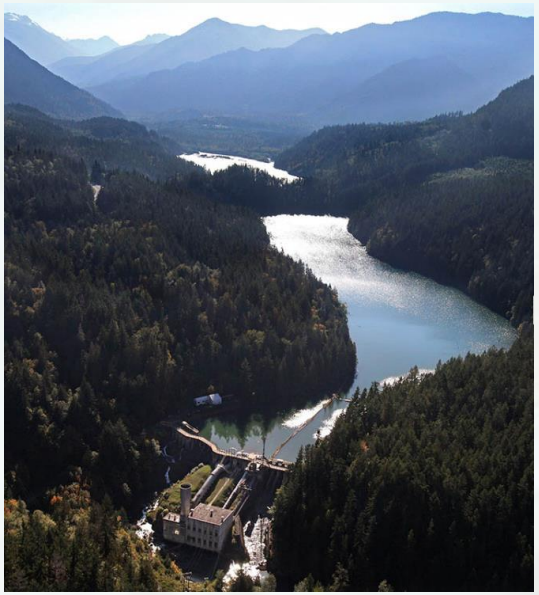
PASSIVE SITE RESTORATION

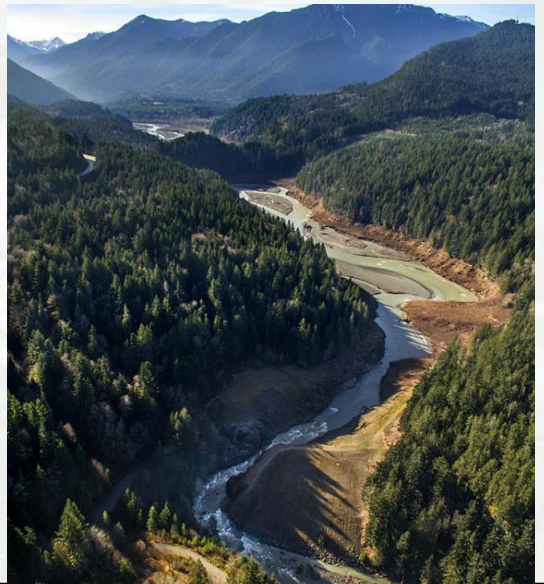
Large Scale

CONDIT DAM, WA



GLINES CANYON DAM, WA

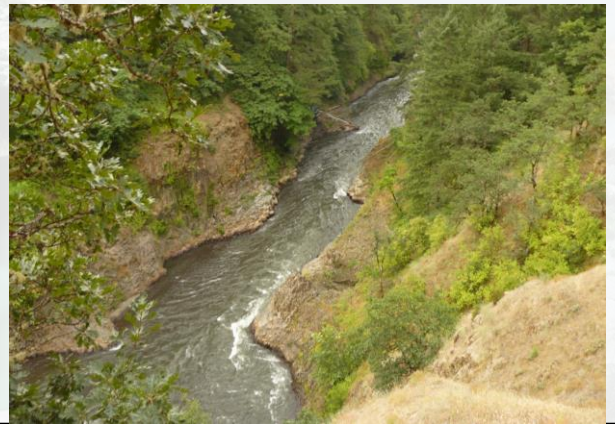




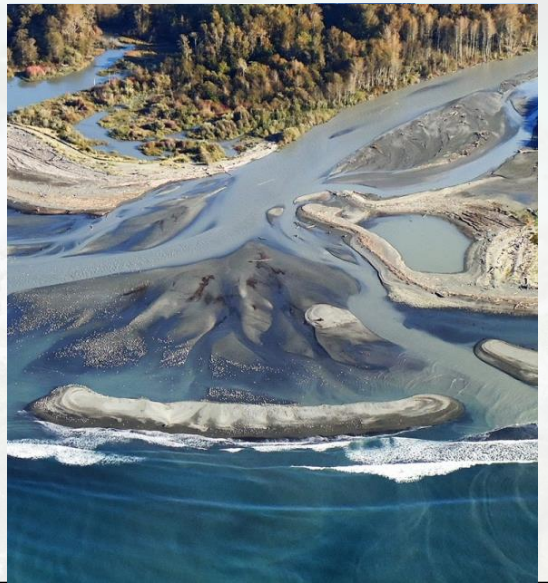
PASSIVE SITE RESTORATION

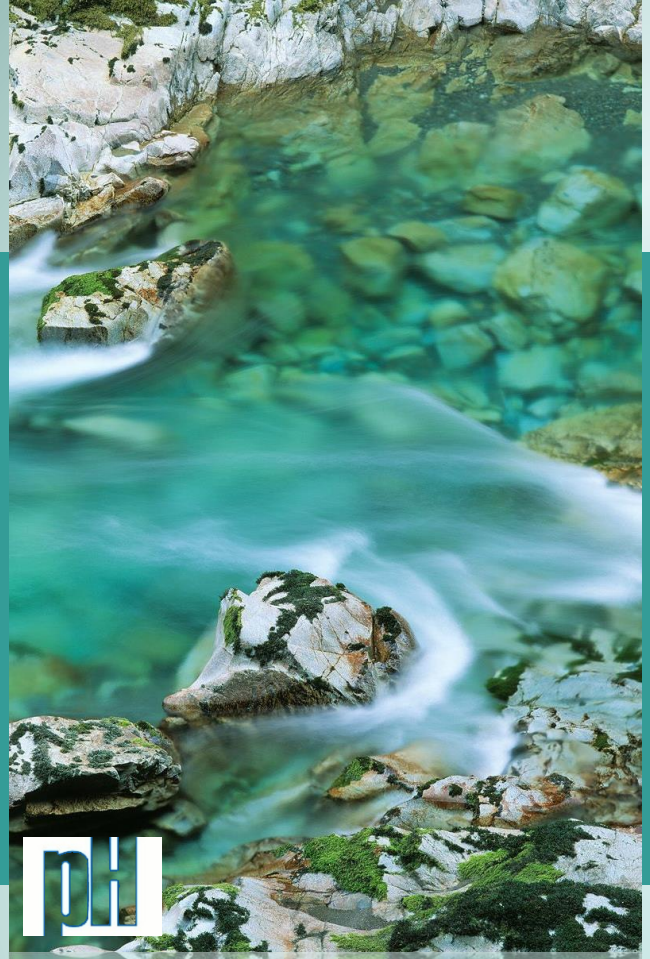
Large Scale

CONDIT DAM, WA



GLINES CANYON DAM, WA





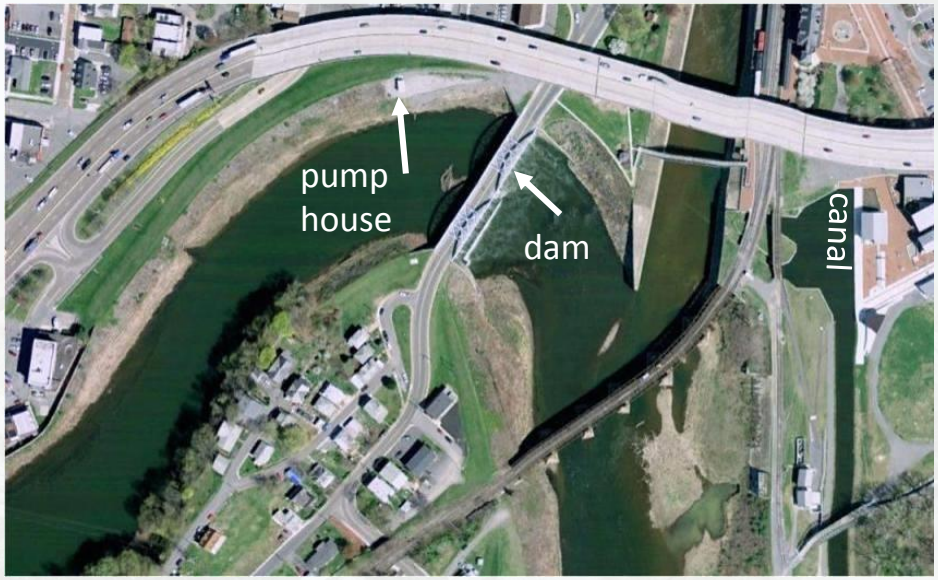
CONTAMINATED SEDIMENT

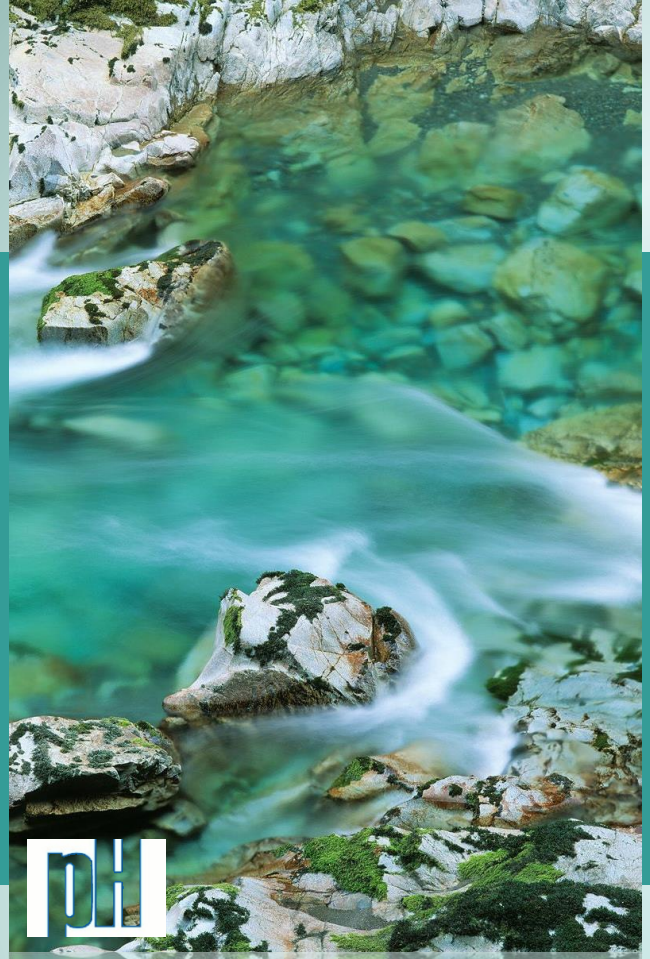
Milltown Dam, Montana

- 10m high timber crib and concrete, hydroelectric dam
- Superfund site
- 5 million m^3 of contaminated sediment
- Much of the sediment relocated on site and capped in place

Cumberland Dam, Maryland

- Historic bridge & canal
- Need to modify 5.2 MGD water intake for historic canal ($200-$500K)
- Dioxins in sediment





SYSTEM SENSITIVITY

Pizzini Dam, Connecticut

- 1m high stone masonry dam
- No sediment
- Threatened mussel species downstream
- 3 years to permit
- 10 min to remove

9:00AM

9:15AM

9:30AM

10:00AM

Lamprey & mussel relocation post removal

Rouge River Dam, Michigan

Invasive: Round Goby - (*Neogobius melanostomus*)

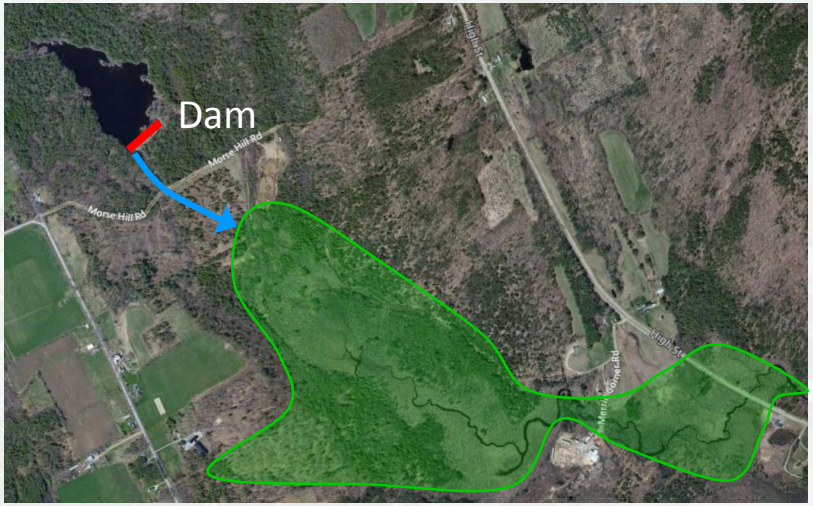
Invasive species outcompetes native species

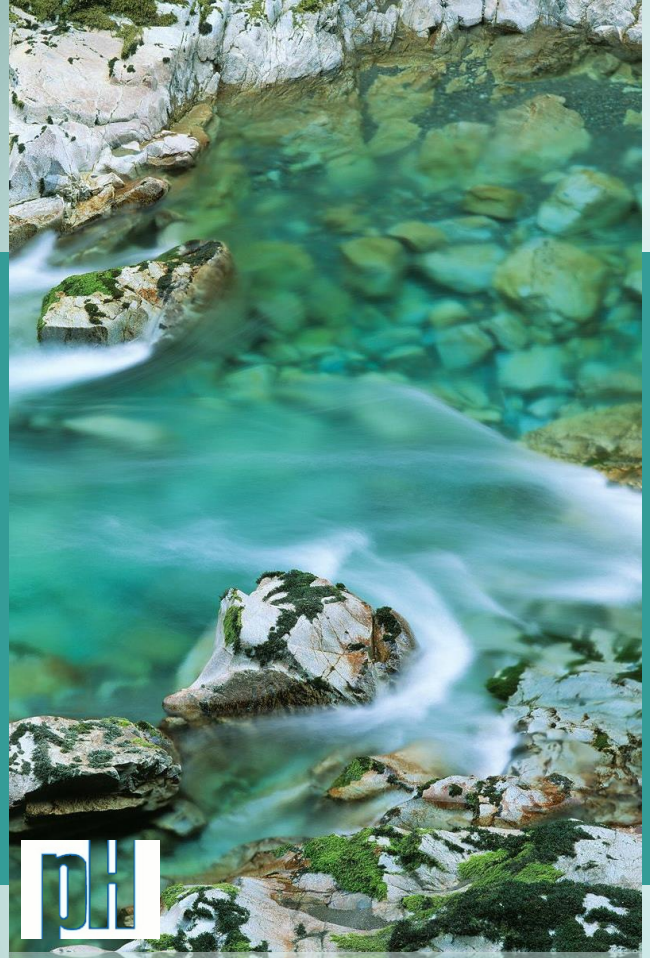
Native: Johnny Darter - (*Etheostoma nigrum*)

Potential for Downstream Flooding

Heminway Pond Dam, CT

Tannery Dam, NH

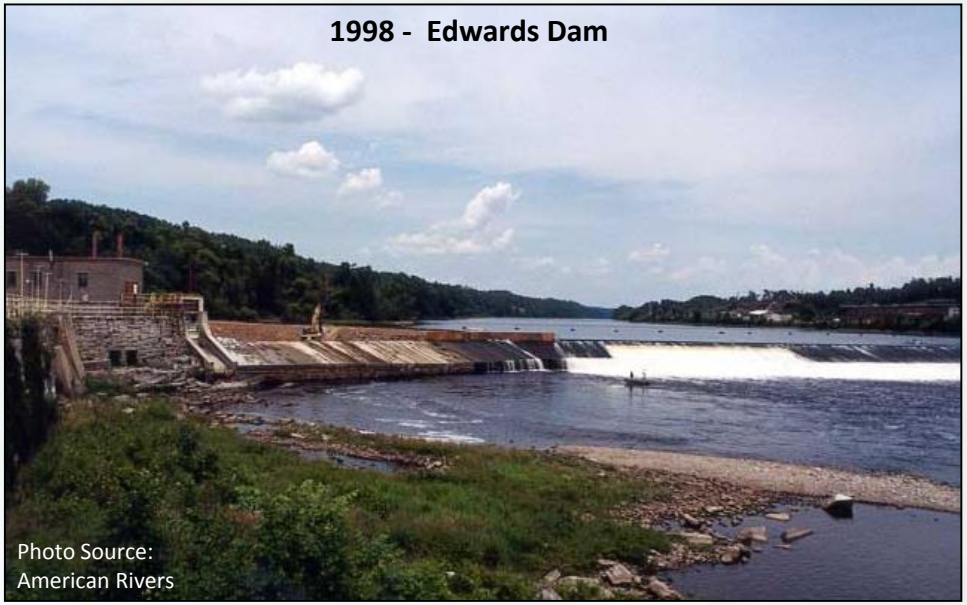


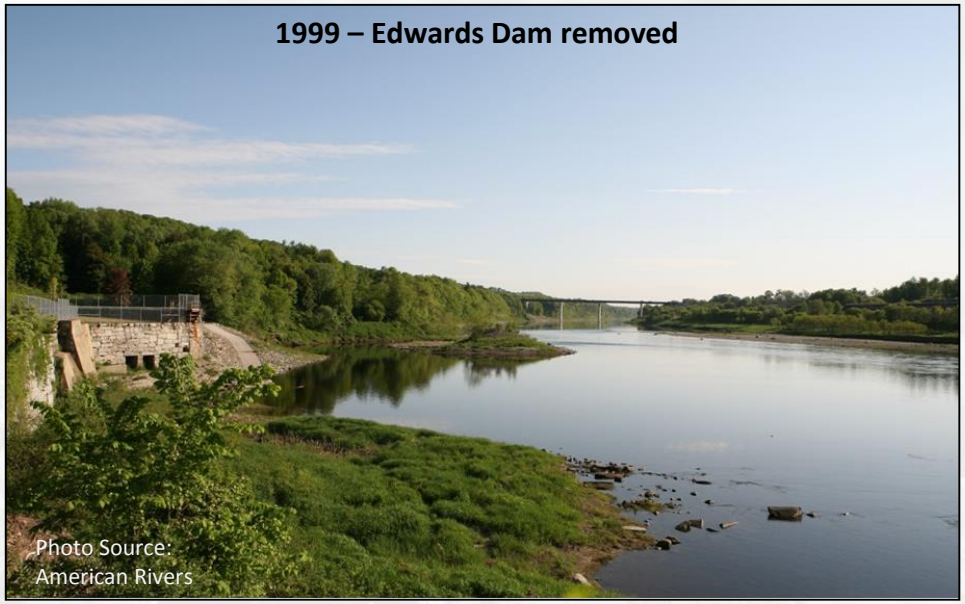


BALANCING HYDRO AND THE ENVIRONMENT

Edwards Dam, Maine

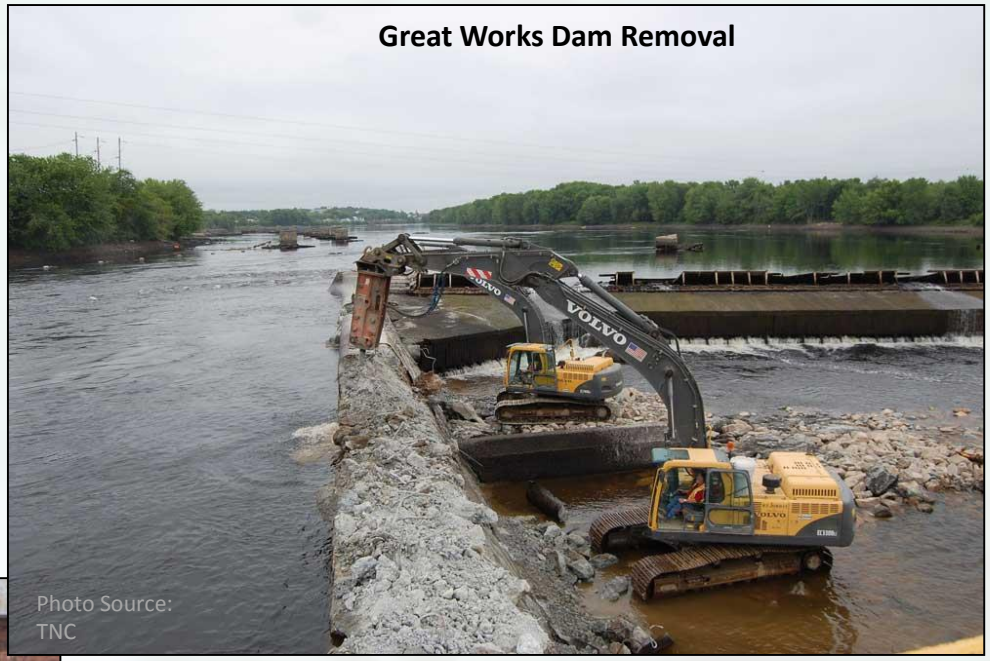
- **7.3m high hydropower dam**
- **1997:** Edwards Dam marked the first time that FERC had ever denied an application for relicensing and set a precedent for FERC's authority to remove dams that pose greater harm than good. One year after removal in 1999 alewife returned by the millions for the first time in 160 years.

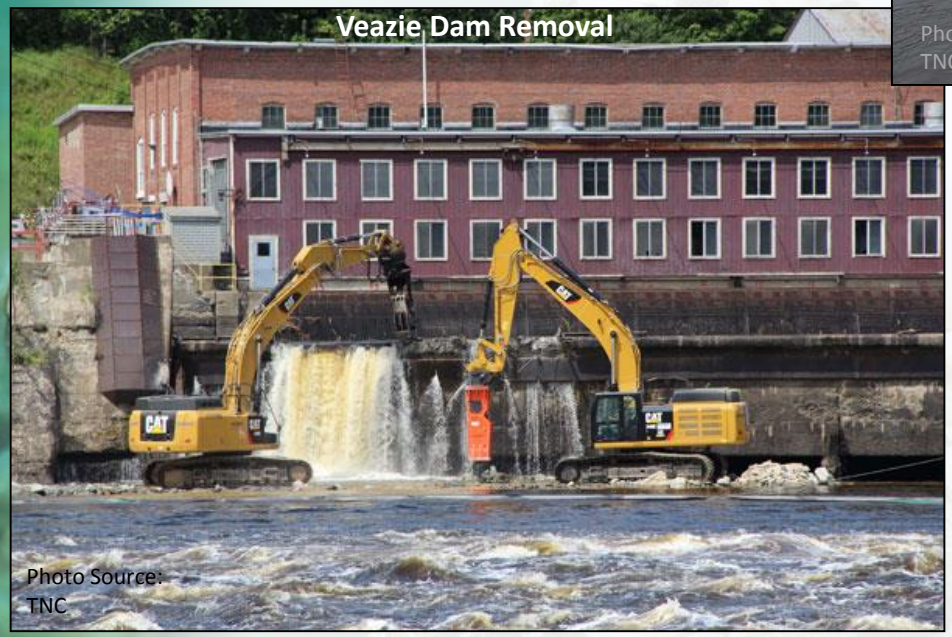


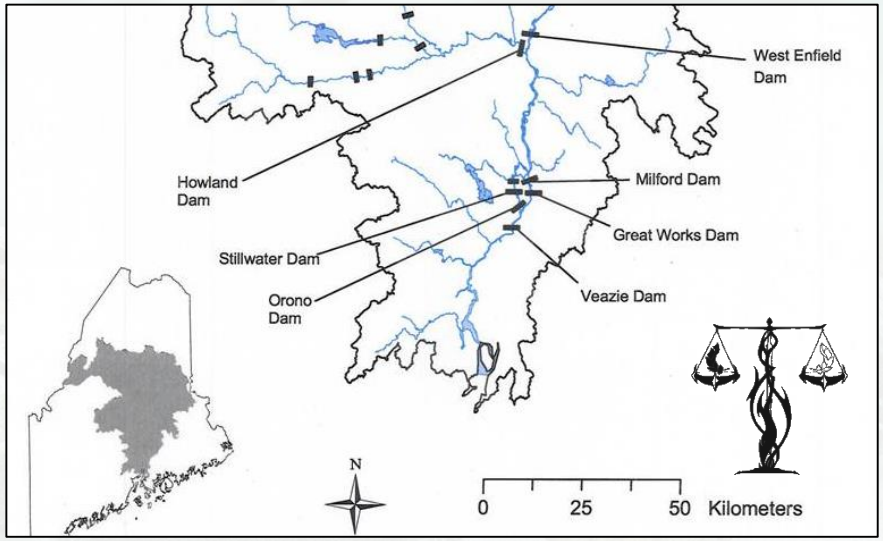


Penobscot River Dams, Maine

- FERC Settlement
- Hydro & Environmental Balancing: removed 2 dams increased power on two others







Penobscot River Dams, Maine

before

Veazie Dam Removal

after

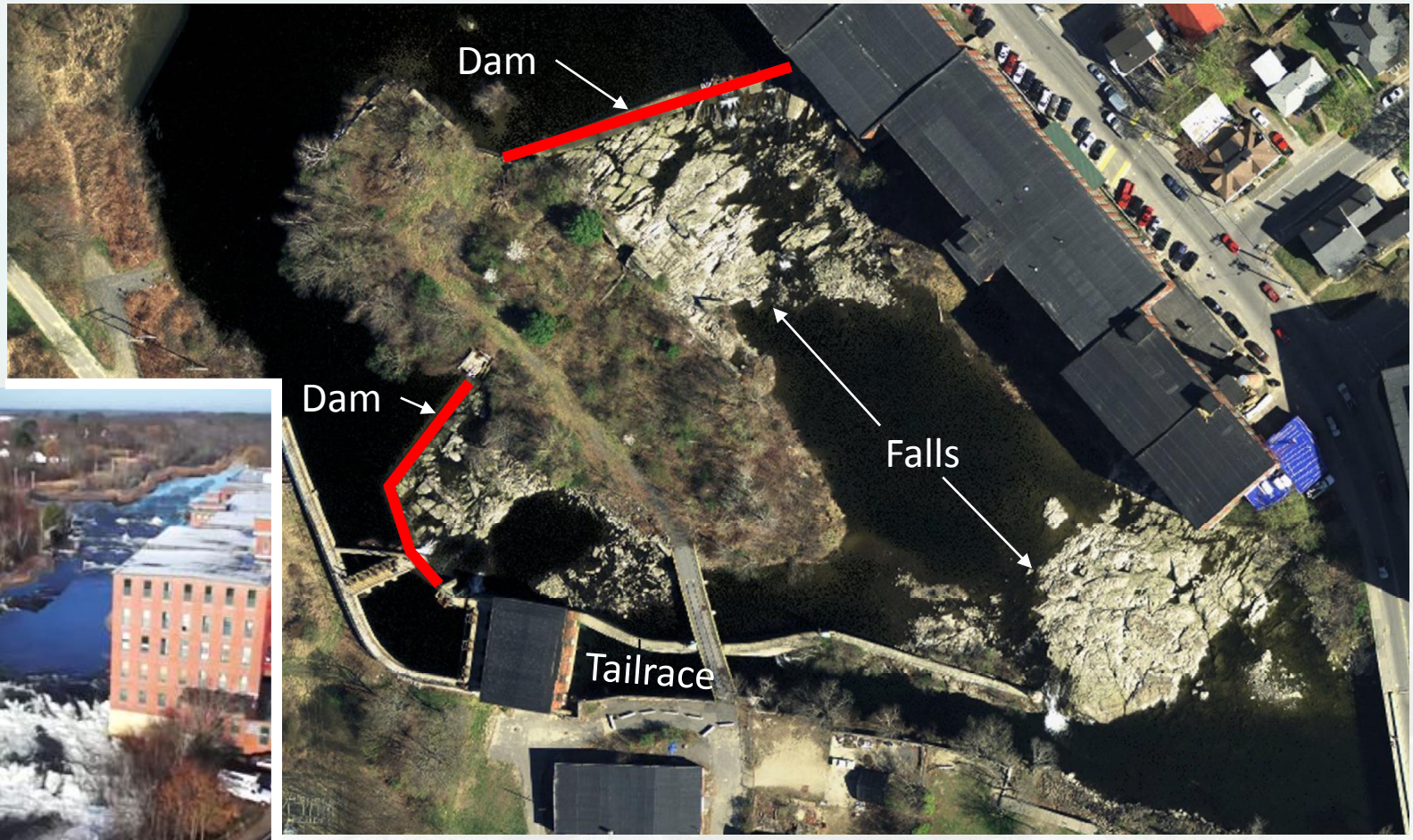
Great Works Dam Removal

before

after

Saccarappa Dam, Maine

- Active hydro-electric; economically infeasible w/ fish passage prescription
- 2 concrete spillways with bedrock excavated tailrace; 2 bedrock falls; significant site modification
- Removal ≠ Fish Passage – The key will need to be Adaptive Management



San Clemente Dam, California

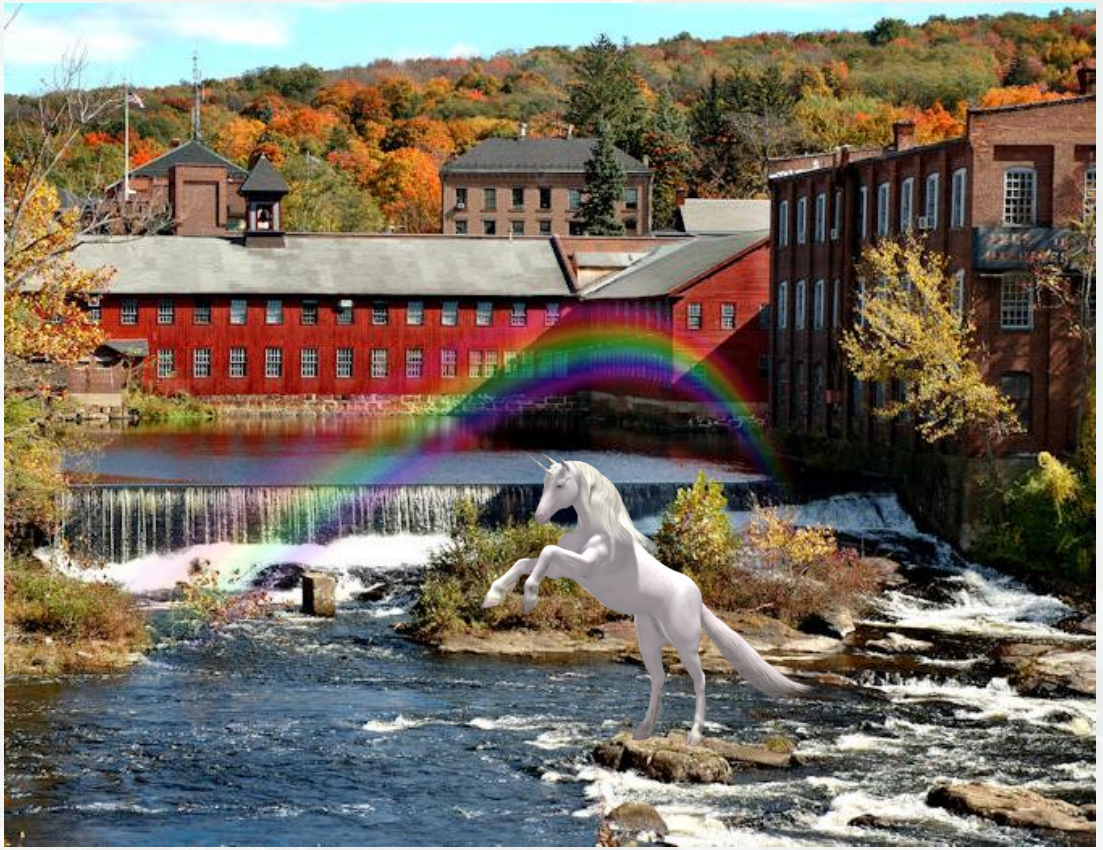
- Hydropower Dam: 158m, economically infeasibly to repair seismic and hydrologic deficiencies
- Unique bypass alternative to deal with sediment

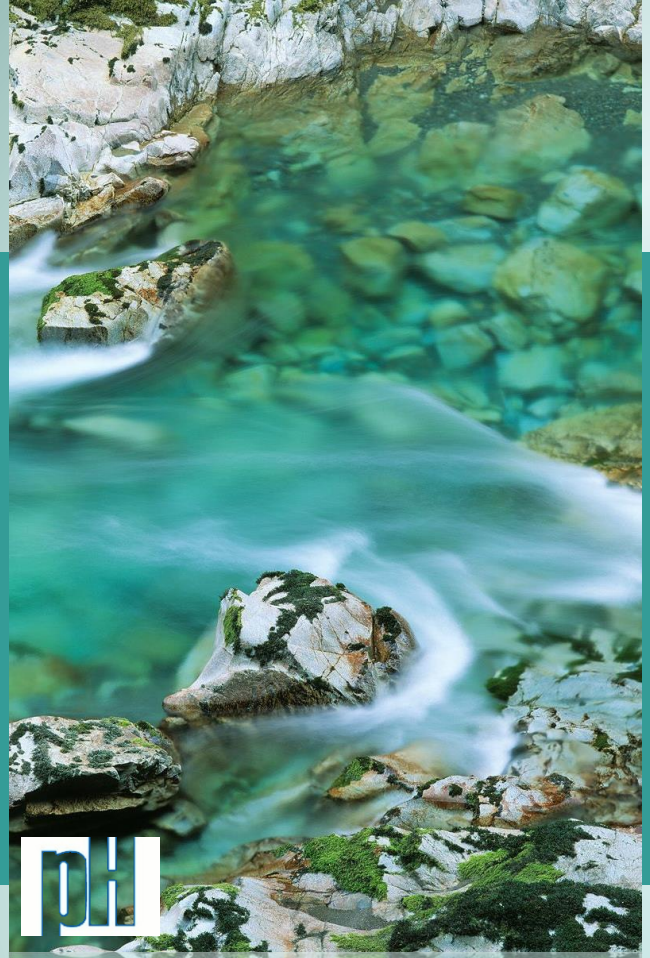
Post Removal

Canton Dam, Connecticut

- Dam removal not considered due to future desire to develop small hydro – decades into process
- Is there potential to look into other micro-hydro options?

In-Conduit Turbines





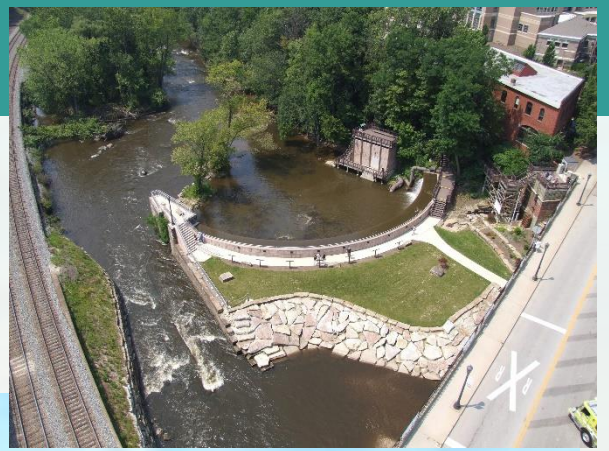
HISTORIC & SENTIMENTAL VALUE

(i.e. unicorn habitat)

Kent Dam, Ohio

- Historic Site
- Creative solution: portion of dam retained to create falling water aesthetic

Kent Dam, Ohio



- Historic Site
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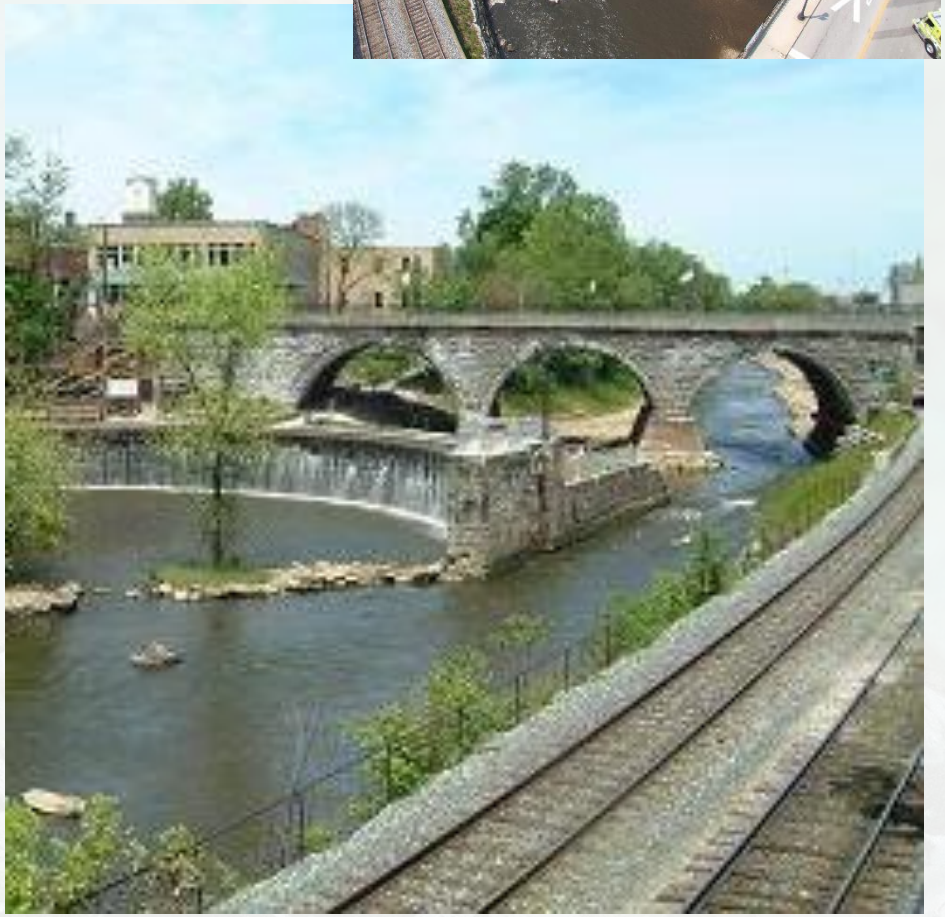
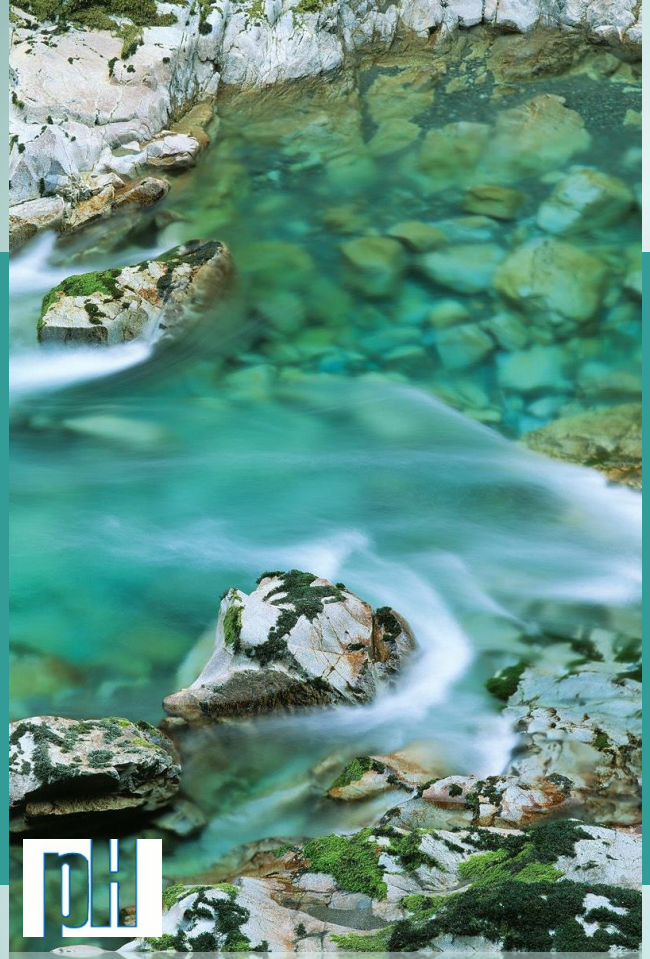


Final Design: CDM



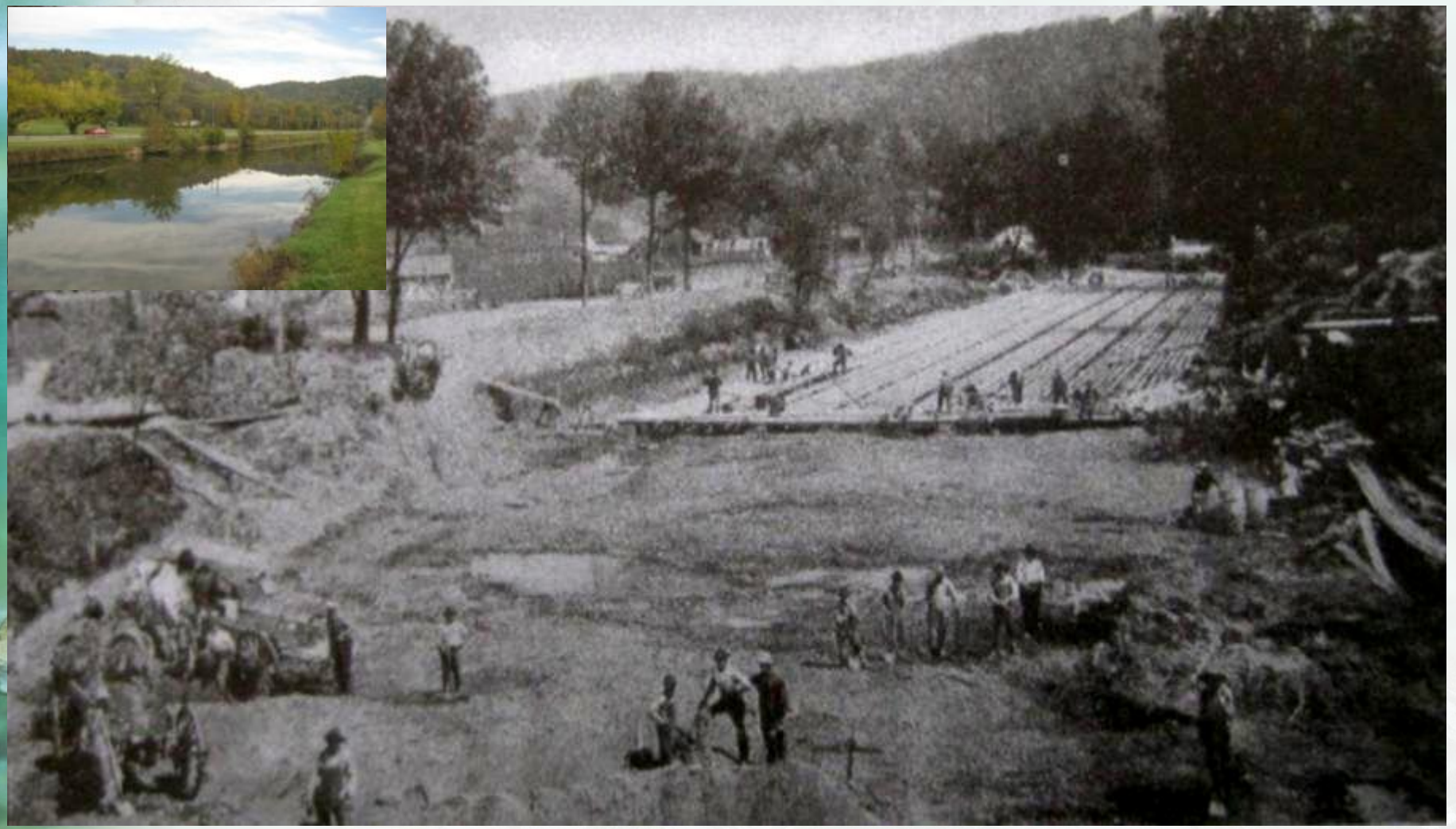
PREPARING FOR UNKNOWNS

Brave Dam, Pennsylvania

A typical impoundment?

Brave Dam, Pennsylvania

~~A typical impoundment?~~ No, the worlds largest radiator!



Dunkard Creek Dam, PA - Turn of the century cooling systems for a gas pumping station

Laura Wildman, PE
Princeton Hydro LLC
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lwildman@princetonhydro.com