Frequently Asked Questions in Dam Decommissioning: Guidance for Data Collection, Analytic Needs, and Project Implementation

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Overview and Problem Scope

- 82,642 large dams (NID), ~2.5 million total (NAS)
- 3% of US land inundated
- Impounded water 76% (25-380%) of mean annual runoff
- Every non-AK river over 750 sq.mi. drainage fragmented
Overview and Problem Scope

- Sediments are leading cause of impairment in US. 6-12% of these are contaminated to Tier 1 or 2.
- Structural and economic obsolescence have condemned many smaller dams; that is less true of large structures, but 85% of large dams will have reached their design lifespan by 2020 (FEMA, 2011).
- Dams and their removal are emotionally charged subjects in which science and reasoned discourse have played minor roles.
Overview and Problem Scope

- Unobstructed river reaches have been reduced 91% in the North Atlantic region
Benefits and costs of dams

Benefits

• Water quality and delivery for domestic, agricultural, and industrial uses
• Hydropower
• Navigation, including canals
• Control of flooding and ice regime
• Control of invasive populations
• Flatwater recreation
• Waste, nutrient, or sediment trapping
• Archeological and aesthetic values

Costs

• Ecosystem impacts
• Water quality impacts
• Recreation dependent with unregulated hydrography and ecological integrity
• Impacts on T&E populations
• Legal and financial liability
• Safety
• Maintenance requirements for structure, headpond, associated erosion
• Archaeological and aesthetic impacts
Dam Life Concepts

- Engineering, design life spans
- Usable life (for original or altered purposes)
- Economic life (present value exceeds costs)
- Geomorphic life
- Overall value balance (including ecosystem effects, liability, and risk of catastrophic failure)
St. Francis Dam failure, CA, 1928

Chase Brook Bridge collapse caused by private dam failure, NY, 1996.

Teton Dam failure, ID, 1976

Rockfish Creek dam failure, NC, 2003
Dams and ecosystems

- Altered sediment, hydrologic, woody debris, and ice regimes
- Habitat fragmentation
- Nutrient cycling and flow impacts
- Water quality and thermal regimes
- Major impacts on T&E, anadromous, catadromous, and adfluvial populations
- Mix of lentic and lotic habitats alters predation regimes and other life history processes and supports exotics
- Dams encourage floodplain development and discourage spatial and temporal dynamism
Nutrient flows and cycling

- The Columbia River system once received about 200,000 tons of nutrients annually from salmon runs.
- ~60% of the carbon structuring the bodies of juvenile salmon and other species is marine in origin in anadromous rivers.
- As much as 18% of nutrients supporting riparian vegetation in salmon rivers is ocean-derived.
- Salmonid fry double their growth rate post-spawning in rivers with active runs, as opposed to control rivers.
- Hydrologic flux and woody debris budget changes
- Reservoirs can act beneficially as nutrient sinks in agricultural watersheds.
Dam removal and ecosystems

- New hydrology and hydraulics on sites and reaches that have adjusted, to some degree, to original alteration.
- Sediment pulse (often relatively short lived)
- Morphology and layering of deposition lens influences passive routing and magnitude, duration, and timing of suspended sediment impacts
- Risk of invasive plant communities on exposed substrate
- Risk of invasive aquatic populations (fragmentation, unfortunately, can be beneficial)
- Impacts on T&E populations
- Altered redox boundary
Cited reasons for removals

- Environmental -- 43%
- Safety -- 30%
- Economics -- 18%
- Failure -- 6%
- Unauthorized structure -- 4%
- Recreation -- 2%

(American Rivers et al., 1999)

Public safety and desire to save costs of repair usually drive removal, not restoration goals (Born et al., 1998)
Data and analytic needs


http://el.erdc.usace.army.mil/emrrp/techtran.html

44 different data needs, many with individual subcategories…
Sediment transport and fate ("It’s the sediment, stupid...")

- High turbidity
- Local widening and erosion due to slope increase
- Downstream aggradation of channels and floodplains
- Upstream headcutting and erosion
- Embeddedness
- Release of contaminants, nutrients
Case Study Analyses of Physical Responses

Doyle et al.’s studies:
• Sand-bed, high-transport channels
• Impoundment filled with sediment
• Channel evolution accomplished by erosion and channel widening, at almost any flow

Pizzuto et al.’s study:
• Gravel systems
• Impoundment not filled with sediment
• Channel evolution accomplished by deposition of new floodplains and channel narrowing during floods
Applied needs: a fate determination, sediment dynamics, and management FAQ

- Where is dam in life cycle
- Effects on ssc/discharge over time
- Sediment volume vs. transport capacity
- Morphology, sizing, sorting, and contaminant characteristics
- Where are likely depositional zones for fines and ungraded sediments? Over time?
- Effects on flooding
- Effects of temporary stabilization or induced deposition techniques
- Maximum lateral and vertical dynamism, infrastructure risks
- Are vertical or longitudinal sorting present and significant?
- T&E, invasives risks?
Sediment Management Options

- No action
- Bypass
- Mechanical removal
- Stabilization (temporary or permanent)
- Controlled release (spatial or temporal increments)
- River erosion
- Combination—remove fines, passively route coarse
- Design deposition
Cougar Dam Drawdown Impacts on South Fork MacKenzie River (provisional data)
Sediment Sources in Cougar Drawdown
Sources of Cougar Modelling Inaccuracies

• Initial submergence of dried lakebed deposits

• Mass wasting and slope failures caused by rapidly changing pool levels

• Active erosion of predominantly clay banks

• Lateral migration and downcutting of main inflow tributaries. **

** cause higher levels of turbidity
Milltown Dam Removal Issues
Clark Fork Channel Widening, 2008
Micropile Installation
Blackfoot River channel constraint
Conclusions and Needs 1

• Dam removal is a requisite tool for managing aging structures and restoring both aquatic and riparian populations and processes.

• We need to develop more empirical knowledge on the effects of dams and drawdowns to learn about dam removals and lend perspective to use of models.

• Analytic and communications requirements are demanding but scale-, goal-, and system-dependent.
Conclusions and Needs 2

- Projects can be difficult and expensive; prioritization and effective planning and implementation are sorely needed.
- Better models and case study documentation are needed, particularly for ecosystem responses. Physical, transport, and ecological models need linkage and dynamic capacity for temporal and spatial scaling. Physical responses, their consequences, and their attenuation can be rapid.
Conclusions and Needs 3

Needs:

• Refine techniques for incremental releases and design depositional for downstream reaches.
• Specify acceptable risks and dynamism to reduce hardening where possible and reallocate resources to sediment management, physical restoration, exotics management, and revegetation.
• For existing dams, route, harvest, and reduce inflow of sediment as part of ongoing O&M.
• Improve sediment routing design in new structures.