Data Needs and Case Study Assessment for Dam Fate Determination and Removal Projects; A Checklist

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By Jock Conyngham[1]

Complexity

Low Moderate High

Environmental Value

Low Moderate High

Cost

Low Moderate High

PURPOSE

Dam removal represents an increasing focus for U.S. Army Corps of Engineers (USACE) planning and regulatory staff and overarching missions for civil works activities and ecosystem restoration. Though no comprehensive inventory of removals exists, the Corps has implemented numerous projects under a variety of authorities, including Continuing Authories Projects (CAP), Support for Others (SFO), and General Investigations (GI). Nearly every dam removal requires Corps review and permitting under Section 404 of the Clean Water Act. These jurisdictions require public interest reviews and an array of analyses on potential environmental, ecological, economic, navigational, and cultural resource effects, benefits, and possible mitigation measures. Efficient, focused, and thorough data collection can facilitate these processes and mandates. The Ecosystem Management and Restoration Research Program (EMRRP), a GI-funded technology transfer program administered by the Engineer Research and Development Center's Environmental Laboratory, supported the development of a comprehensive data needs inventory with simple guidelines for application to aid Division and District personnel tasked with assessing or undertaking dam removals.

OVERVIEW

A concordance of various factors has brought dam removal, retrofitting, and repair into high relief in recent years. These include high dam densities (Figure 1), relatively poor condition (American Society of Civil Engineers (ASCE) 2009), the high cost of dam repair, liability concerns, the filling of impoundments by sediments, the fading or cessation of an individual

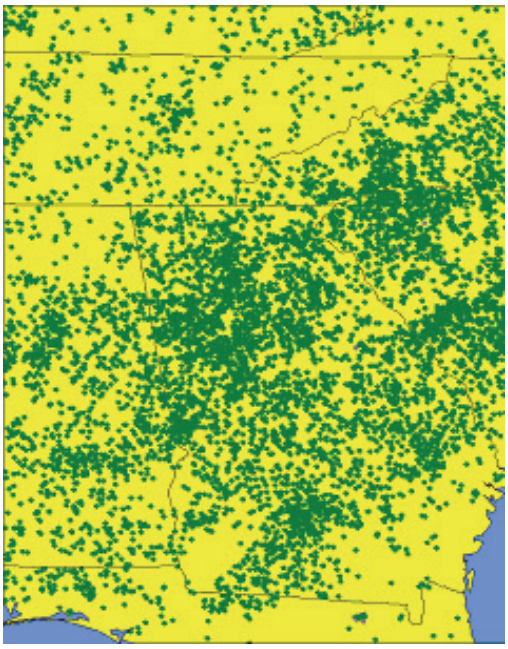

Figure 1. Densities of large dams in the southeastern United States (USACE National Inventory of Dams)

[1] Environmental Laboratory, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

structure's original purpose, and, finally, recognition of the environmental impacts of dams (American Institute of Bjological Sciences (AIBS) 2002; Heinz Center 2002). Infrastructure and legal concerns, combined with restoration goals or mandates and the appearance of new funding mechanisms, have led to a large recent cohort of more than 500 removals—in large part because of the economic advantages of removal as compared to repair (Born et al. 1998).

Decisions regarding individual dam fate or dam-related restoration alternatives involve significant economic, social, and environmental costs. Many removals to date have received little analytic attention; impending structural failure, enthusiasm for restoration, or brief project and funding cycles led to rapid action and uneven analytic rigor applied to assessment of risks, site conditions, alternatives, benefits, and responses. The same holds largely true for many repair or maintenance decisions.

The opposite has also occurred, particularly in the case of large, expensive, or high profile projects. A case in point is the thermal retrofit structure recently installed by the US Army Corps of Engineers, Portland District, in Cougar Dam on the South Fork McKenzie River subbasin of the Willamette River system, in which extensive analyses failed to accurately estimate the timing and magnitude of turbidity episodes related to drawdown and refilling. Other removal and retrofit projects have been slowed or made far more expensive than necessary due to unneeded or misconceived analyses. Guidance for requisite data collection to support improved project implementation and varying levels of trade-off analyses as well as improved case study assessment is required.

THE DIVERSITY OF DAMS AND DAM EFFECTS

Dams, their effects and benefits, and options for their fate can be viewed through a number of contextual or analytic lenses. These include:

1. **Financial and legal contexts.**Treaty obligations, financial and ownership rights, legal and permitting mandates, and operations and management costs can represent absolute "green light/red light" factors in dam fate determination.
2. **Original and current purpose(s) of structure and its operational hydrology.** Many dams were constructed to provide mechanical power in an age of manufacturing mill industry long gone. Reservoirs for water supply may have been replaced by underground sources, or those for flood control or other purposes may have filled with sediment. These cases are distinct from structures that still provide significant hydroelectric or flood control benefits that clearly outweigh their evident costs.
3. **Size relative to watercourse.** A small dam can have a significant effect on a small stream or river, and even a large one if it limits keystone populations or prevents fish passage to critical habitat. In general, however, small structures cannot store sediment in the requisite volumes or affect hydrology to a degree sufficient to cause the fundamental physical and ecological alterations that large structures can.
4. **Presence, distribution, and nature of contaminants**. Dams can be major storage points of contaminants, ranging from nutrients in agricultural run-off areas to persistent heavy metals in reservoirs located in watersheds that supported mining or certain other industries.
5. **Safety and longevity issues**. Dam structure characteristics, condition, geologic setting, and liability concerns span a broad range of permutations. Many, particularly recently constructed larger dams, periodically inspected by owners and state safety inspectors, are sound and pose little threat. Others pose acute threats to downstream

populations and infrastructure or chronic threats to the recreating public. For every deficient, high hazard dam repaired from 2003 to 2008, almost two more were added to the deficient list (ASCE 2009). Dams also effectively trap ice and woody debris that can increase risks of flooding and damage downstream when their transport to downstream reaches is restored by a removal.

6. **Invasive or threatened and endangered species**. The presence of threatened and endangered species in a river system often weights decisions for connectivity or necessitates additional studies to assess potential impacts from a removal or modification. Habitat fragmentation may be viewed as either undesirable or the preferred alternative given the presence of T&E populations or those of unwanted exotic species.
7. **Archaeological value**. Dams represent archaeological sites of great interest to many groups, academics, and agencies. Occasionally, a dam site represents a nested or layered collection of structures and objects, necessitating sequential review or analyses by specialists during various points of a removal.
8. **Public perceptions, opinions, and goals**. Dams, their headponds, and their effects create strong emotions and charged debate. A technically straightforward removal or modification can be delayed or made far more expensive in the face of sufficient controversy.

In an ideal world, good data collected with robust and efficient methods and communicated effectively can:

- focus discourse and facilitate the resolution of controversy
- lead to more rapid and effective decision-making
- allocate resources to greatest needs
- save money
- optimize benefits
- provide needed documentation and opportunities to advance the states of science and practice.

Good data analyzed and shared with multiple project partners and stakeholders become particularly important as resource managers move from decisions on smaller, older dams to those that address larger structures and projects of greater economic, social, and ecological consequence.

Figure 2. Varying data demands in dam removal: Stimson and Milltown Dams, Bonner, Montana

Figure 2 contrasts two dam removal projects with very different characteristics, implications, and data requirements, though they were located within a mile of one another at the junction of the Blackfoot and Clark Fork Rivers in northwest Montana. Stimson Dam (upper photo) was a low head wooden structure providing no current services and trapping a small amount of clean sediments. It was failing rapidly. Milltown Dam was a high head hydropower dam trapping 6 million yd of contaminated sediments, with a large amount of

infrastructure just upstream and major effects on local wells and groundwater flow paths. The latter removal, recently completed with complementary restoration work still underway, required orders of magnitude more data collection and analyses than the recently completed Stimson removal.

RELEVANT DATA FOR DAM FATE DETERMINATION AND REMOVAL PLANNING

As discussed above, data needs vary by scale, potential consequences, contentiousness, risk of failure (imminent or long-term) or broader liability, and other issues. However, most removal decisions and implementations will require some subset of the following considerations to some degree. Many of the following subjects should be assessed in both with- and without-dam scenarios, and, in cases of potential partial removal, degrees in between.

Policy, economic, and legal data needs, contexts, and concerns

- ☐ Ownership
- ☐ Dam condition and risk hazard in event of failure
- ☐ Liability related to dam structure, intake, flume, or hydraulic jumps
- ☐ Liability related to dam removal implementation
- ☐ Value of dam services at present and projected into future
- ☐ Dam licensing or safety mandates (e.g., fish passage, short-term repairs)
- ☐ Operations and maintenance costs
- ☐ Legal, hydraulic, and physical implications for nearby infrastructure
- ☐ Implications for adjacent and downstream landowners through land creation or restoration of normative hydrograph, including flooding, debris, and ice regimes
- ☐ Tribal rights
- ☐ Water rights and flow mandates
- ☐ Recreational and other ecosystem service economic and non-economic analyses
- ☐ Permitting for dam removals
- ☐ Agency jurisdictions and mandates
- ☐ Funding opportunities
- ☐ Monitoring of project effects and consequences

Engineering and ecological data needs, contexts, and concerns

- ☐ Implications for threatened and endangered species
- ☐ Implications for invasive biota
- ☐ Implications for recreationally or commercially significant species
- ☐ Ecological community effects analysis, particularly for keystone prey species or system drivers
- ☐ Channel network analyses in large rivers for habitat and life history needs in order to prioritize removal sequencing. Occasionally, conflicts between individual species restoration goals or scaled goals (species, guild, community, aquatic/riparian, estuarine, etc.) may appear
- ☐ Site, reach, and system effects of altered and restored sediment, hydrologic, ice, and woody debris regimes
- ☐ Wetlands distribution and dynamics
- ☐ Riparian dynamics
- ☐ Groundwater flux, levels, and interactions with surface water
- ☐ Sediment storage volumes, particle size distribution, contamination levels, vertical and longitudinal heterogeneity, and deposition lens morphology. Compare with upstream and downstream reaches
- ☐ Bedrock influence
- ☐ Hydrology and hydraulics (H&H) analyses for sediment transport capacity relative to deposition lens and background supply through all affected reaches under varied hydrologic regimes
- ☐ H&H analyses for likely erosional and depositional zone identification
- ☐ Analyses of effects and mitigation options for affected infrastructure (water intakes, well levels, bridge piers, etc.)

- ☐ Identification and subsequent analyses of various modification and removal options (repair in place, time-sequenced incremental removal, spatially incremental grade control for stability and fish passage, total removal, passive sediment management using river power, active sediment management using slurry, dredging, or dry removal techniques)
- ☐ Related bank and bed stability needs
- ☐ Related ecosystem restoration needs and opportunities
- ☐ Sediment disposal options, including design depositional zones in downstream reaches and floodplains
- ☐ In the event of repair or continued operations, determination of options for operational hydrology, fish passage, thermal regimes, riparian management, sediment and woody debris amendments or sluicing schedules, or basin restoration for increased ecological integrity and productivity
- ☐ Project sequencing, ingress and egress, and staging options
- ☐ Turbidity and other water quality changes (short-term and mid-term), including dissolved oxygen and temperature
- ☐ Monitoring of physical, hydrologic, chemical and biological responses for adaptive management and project documentation

Other social data needs, contexts, and concerns

- ☐ Archaeological values
- ☐ Public opinion, perceptions, and questions—adjacent landowners, affected communities, and advocacy groups
- ☐ Determination of optimal avenue(s) for effective public participation and communications
- ☐ Aesthetics
- ☐ Monitoring of project effects and consequences on relevant economies, job opportunities, recreational patterns, and opinions
- ☐ Collection and content analyses of media coverage

PROJECT INVENTORY EFFORTS AND DATA UTILIZATION

Rigorous documentation and analyses of dam removal decisions and case studies are in their infancy (Pohl 2001). The foremost effort to initiate such work resides at the University of California at Berkeley's Clearinghouse for Dam Removal Information (http://www.lib.berkeley.edu/WRCA/ damremoval/index.html), hosted by the university's Water Resources Center Archives. The clearinghouse currently contains nearly 1000 records, often in the form of case-specific gray literature difficult to locate and archive, covering a wide array of economic, permitting, monitoring, hydrology and hydraulics, geomorphic, and biological subjects. Relevant symposia and conference proceedings are also stored there.

SUMMARY

Each dam removal or major retrofit is an experiment specific to that project's history, operational characteristics, and geomorphic, hydrologic, ecological, economic, and social environments. Requisite data needs have to be carefully identified, data collection must be implemented, analyses must be undertaken, and findings must be communicated, often in a time-constrained context, as efficiently as possible. Certain characteristics such as project size, legal issues, or risk of imminent failure usually determine the actual subset of subjects considered and the degrees to which they are investigated. However, an exhaustive checklist can speed and reduce costs of project implementation by ensuring that important data needs are agreed upon and identified at the project's outset and by improving implementation for both project-specific and broader engineering and scientific excellence.

POINTS OF CONTACT

For additional information, contact the author, Jock Conyngham (406-541-4845, Jock.N.Conyngham@usace.army.mil), or the manager of the Ecosystem Management and Restoration Research Program (EMRRP), Mr. Glenn Rhett (601-634-3717, Glenn.G.Rhett@usace.army.mil).
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REFERENCES

American Institute of Biological Sciences. 2002. *BioScience—A Special Section on Dam Removal and River Restoration* 52(8): 643-750.

American Society of Civil Engineers (ASCE). 1997. *Guidelines for retirement of dams and hydroelectric facilities.* New York: ASCE.

American Society of Civil Engineers (ASCE). 2009. Report card for America's infrastructure, 2009. http://www.asce.org/reportcard/

Born, S.M. K. D. Genskow, T. L. Filbert, N. Hernandez-Mora, M. L. Keefer, and K. A. White. 1998. Socioeconomic and institutional dimensions of dam removals: the Wisconsin experience. *Environmental Management* 22(3):359-370.

Heinz Center. 2002. *Dam removal: Science and decision making.* Washington, DC: H. John Heinz III Center for Science, Economics and the Environment.

Pohl, M. 2001. Constructing knowledge on American dam removals. In *The future of dams and their reservoirs.* Denver: US Society on Dams.