RECLAMATION

Managing Water in the West

Synthesis of Ecological and Physical Effects of Dam Removal Projects

Research and Development Office
Science and Technology Program
(Final Report) ST-2015-1666-1

U.S. Department of the Interior
Bureau of Reclamation
Research and Development Office

September 2015

Mission Statements

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Reviewer TIMOTHY RANDLE (Signature)

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Executive Summary

An effort to synthesize existing dam removal studies and data, thereby providing scientists and managers better knowledge of likely outcomes of future dam removals, was sponsored by the U.S. Geological Survey's John Wesley Powell Center for Analysis and Synthesis. Discussions and presentations revealed the tremendous growth of information from dam removals over the last few years, and pointed to several common patterns of physical and biological responses. For example, reservoir size and sediment characteristics, in conjunction with the type and rate of dam decommissioning, appear to lead to predictable relations between processes eroding reservoir sediment and the downstream sediment transport and channel response, which in turn affect biological conditions and trajectories. We participated in the overall synthesis of dam removal findings into a publically available database and a paper synthesizing common management concerns associated with dam removal.

Contents

Overview

Dam decommissioning is rapidly emerging as an important river restoration strategy in the United States. Over one thousand dams have been removed in the last few decades, including several large ones in recent years, such as Condit Dam and the Elwha River dams in Washington State. These removals and the studies associated with them provide, for the first time, an opportunity to evaluate the far-reaching benefits and consequences of these significant river perturbations and watershed restoration efforts. Understanding dam-removal response not only improves fundamental understanding of rivers—in particular landscape and ecosystem response to fluvial aquatic reconnection and profound sediment pulses—they also provide valuable lessons for managing river restoration and reservoir sedimentation for long-term sustainability.

Through interagency collaboration and authorization by Congress, Reclamation technical staff have provided engineering analysis, water quality design, economic evaluation, and sediment analysis and adaptive management for several dam removals in the past two decades. Example projects include Savage Rapids and Gold Hill Dam removals on the Rogue River in Oregon, Chiloquin Dam removal on the Sprague River in Oregon, Matilija Dam in California, Elwha and Glines Canyon Dam in Washington, Klammath Dam in California, Battle Creek Dams in California, and smaller dams such as the Methow Valley Irrigation Dam in Washington. As dams continue to age in the U.S., it is expected that dams that no longer serve their purpose or can be easily replaced by other more economic means will continue to be removed. Additionally, the interagency Subcommittee on Sedimentation has endorsed a sediment analysis dam removal guideline that Reclamation is leading.

An effort to synthesize existing dam removal studies and data, thereby providing scientists and managers better knowledge of likely outcomes of future dam removals, was sponsored by the U.S. Geological Survey's John Wesley Powell Center for Analysis and Synthesis. The 20-member working group convened meetings, June 2014 and June 2015, at the Powell Center facility in Fort Collins, Colorado. The group consisted of federal-agency and academic biologists, hydrologists, geomorphologists, and engineers from throughout the United States along with representation from American Rivers, a non-profit leader in dam removal studies and implementation. Discussions and presentations revealed the tremendous growth of information from dam removals over the last few years, and pointed to several common patterns of physical and biological responses. For example, reservoir size and sediment characteristics, in conjunction with the type and rate of dam decommissioning, appear to lead to predictable relations between processes eroding reservoir

sediment and the downstream sediment transport and channel response, which in turn affect biological conditions and trajectories. Reclamation staff participated in the overall synthesis of dam removal findings into a publically available database and a paper synthesizing common management concerns associated with dam removal.

Dam Removal Database

This research effort contributed funding for a “living” database of dam removal demographic data, that is being led by USGS scientists and reviewed by Reclamation staff. The database was based on an extensive literature search aimed at identifying documents relevant to the emerging field of dam removal science. In total the database contains 179 citations that contain empirical monitoring information associated with 130 different dam removals across the United States and abroad. Data includes publications through 2014 and was supplemented with the U.S. Army Corps of Engineers National Inventory of Dams database, U.S. Geological Survey National Water Information System, and aerial photos to estimate locations when coordinates of dam locations were not provided. Publications were located using the Web of Science, Google Scholar, and a University of Berkley Clearinghouse for Dam Removal Information. The purpose of this dataset is to provide a publicly available database of dam removal literature and associated meta-data, such as the character of removed dams, types of monitoring designs employed, and response metrics measured. The creation of this meta-knowledge database provides managers, stakeholders, and the public with the information necessary to help make informed decisions about dam decommissioning.

Management Concerns Paper

Managers make decisions about if and how to remove dams in spite of uncertainty about likely physical and ecological responses. Stakeholders opposed to dam removal often raise concerns about negative effects, regardless of if they are warranted at a particular site. We used a newly-available dam removal science database and other information sources to explore seven of these frequently-raised concerns, noted as “Common Management Concerns” (CMCs), to investigate their occurrence and the contributing biophysical controls. The CMCs addressed were: degree and rate of reservoir sediment erosion; excessive reservoir channel incision; downstream sediment aggradation; elevated turbidity; drawdown impacts on local water infrastructure; colonization of reservoir sediments by non-native plants; and expansion of invasive fish. Biophysical controls emerged for some of the concerns, providing managers with information to assess whether further analyses are warranted to evaluate CMCs at their

sites. We show how many CMCs have one or more controls in common, facilitating the identification of multiple risks at a site, and demonstrate why CMC risks should be considered in the context of other important factors like natural watershed variability and disturbance history. A journal paper has been submitted as of August 2015 with the following citation:

Tullos, D., Collins, M., Bellmore, J., Bountry, J., Connolly, P., Shafroth, P., and Wilcox, A. Submitted August 7, 2015. "Common management concerns associated with dam removal", Journal of the American Water Resources Association.

Workshop Summary

Funding from this research effort was provided to attend the second of two workshops that contributed toward the development of the research products: the dam removal database and journal paper on management concerns related to dam removal. The workshop was hosted by the USGS Powell Center, which serves as a catalyst for innovative thinking in Earth system science research by providing the time, creative space, and computational, data manipulation and data management resources to promote synthesis of existing information and emergent knowledge. The Powell Center is a scientist-driven institution where leveraging existing research efforts produces powerful new insights and moves scientific understanding and its inclusion into management forward at an accelerated pace (https://powellcenter.usgs.gov).

The workshops combined group discussions to strategize prioritization of topics, assignment of working teams, small working groups targeted at reviewing and writing components for identified papers, and periodic "check in" presentations to get peer review from the larger group. The workshop also served the role of forming a peer network in the field of dam removal. This network has continued to collaborate, sharing new information and dam removal experiences from which each member can continue to learn and benefit from. A list of workshop organizers and participants is listed below for reference.

Workshop Principal Investigators:
James E O'connor (*Oregon Water Science Center*)
Jeff Duda (*Western Fisheries Research Center*)
Amy East (*Pacific Coastal and Marine Science Center*)
Chauncey W Anderson (*Oregon Water Science Center*)

Workshop Participant:
Patrick J Connolly (*Columbia River Research Laboratory, WFRC*)
James Ryan Bellmore (*U.S. Geological Survey*)

Jonathan Warrick (*Pacific Coastal and Marine Science Center*)
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Andrew Wilcox (*University of Montana*)
Francis Magilligan (*Dartmouth College*)
Timothy J Randle (*Bureau of Reclamation*)
George Pess (*National Oceanic and Atmospheric Administration*)
Laura Craig (American Rivers)

Data Sets

A database that contains dam removal information was published as a USGS data series, and can be downloaded (along with associated meta-data) on the web at: http://doi.org/10.5066/F7K935KT

The citation for this database is:

Bellmore JR, Vittum KM, Duda JJ, and Greene SL. 2015. USGS Dam Removal Science Database. US Geological Survey. http://doi.org/10.5066/F7K935KT.

Appendix A: USGS Memo

United States Department of the Interior
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To: Jennifer Bountry, Sedimentation and River Hydraulics Group, Technical Service Center, Denver, Colorado.

Re: Progress Report Memo[1]

Dear Dr. Bountry,

This memo serves as a summary of progress and products produced under the BoR-USGS Interagency Agreement # R15PG00041. This IA provided funding to support on-going efforts to identify, extract, compile and analyze dam removal science information across the United States. Four tasks were outlined in the original IA. Below, we list each task, provide a description of what was done, and cite any products associated with completing the task.

Task 1. *Conduct an extensive literature search to identify documents related to the science of dam removal.*

> We identified dam removal studies published through 31 December 2014 using ISI Web of Science, Google Scholar, and the U.S. Geological Survey (USGS) Publication Warehouse. In total, we identified 170 documents on dam removal in the United States.

Task 2. *Extract and compile meta-data from citations identified as relevant, including information on: monitoring design, environmental characteristics, method and timing of dam removal, and the type of physical and biological response data collected.*

> From the 170 documents we identified we extracted information on: (1) characteristics of the dam and its removal (e.g., dam height, location, year of removal); (2) physical, water-quality, and biological response metrics that were measured; and (3) the type of

[1] **The content of this memorandum is deliberative and predecisional, so it must not be disclosed or released by recipients. Because any draft findings herein have not yet been approved for publication by the U.S. Geological Survey (USGS), it does not represent any official USGS finding or policy*.

experimental design employed, as well as the duration and frequency of sampling.

Task 3. Organize this meta-data into a relational database.

A database that contains all of extracted information was published as a USGS data series, and can be downloaded (along with associated meta-data) on the web at: http://doi.org/10.5066/F7K935KT

The citation for this database is:
Bellmore JR, Vittum KM, Duda JJ, and Greene SL. 2015. USGS Dam Removal Science Database. US Geological Survey. http://doi.org/10.5066/F7K935KT.

Task 4. Utilize the information in the database to summarize the dam removal monitoring information that currently exists.

The information contained with the USGS Dam Removal Science Database was summarized into a manuscript, which is currently undergoing peer review for publication in the journal *Frontiers in Ecology and the Environment*.

A copy of this draft manuscript is attached to this memo.
File Name: Bellmore_etal_Frontiers_IN_REVIEW_BOR_Memo

If you have any questions about any of the information, please feel free to contact at us.

Kind Regards,

Ryan Bellmore & Jason Dunham