RECLAMATION Managing Water in the West

Fall 2014
Research and
Development Office
Newsletter 2015-01

The Knowledge Stream

Ecohydraulics and River Restoration Issue

Rod Wittler, Mid-Pacific Region Science Liaison, Ph.D., P.E.

Rod Wittler is the Mid-Pacific Region Science Liaison to the Research and Development Office. Science liaisons serve all of the regions offering expertise in various disciplines. Rod specializes in river restoration issues related to hydraulics, fisheries management, and adaptive management.

Rod served as the Senior Scientist of the Trinity River Restoration Program from 2004 to 2008. For 15 years prior, he was a Research Hydraulic Engineer in the Hydraulic Investigations and Laboratory Services Group in Reclamation's Technical Service Center.

Rod has 30 years of general and research engineering experience in hydraulic models, river mechanics, flow measurement, sediment analysis, temperature modeling, and river restoration.

Rod earned a Bachelors of Science, Masters of Science, and Doctor of Philosophy degrees from Colorado State University and is a registered professional civil engineer in the State of Colorado.

In this issue. . .

We ask our rivers to do more and more every year: water supply, wastewater treatment, recreation, aesthetic values, habitat for fish and wildlife, and many others. But rivers can only support so much, begging the question, "How do we manage our rivers in an environmentally sustainable fashion?"

Reclamation's projects exist within an ecosystem and have impacts on that ecosystem. Our mission is to manage water resources in an environmentally sound manner. River restoration is central to that management. Ecohydraulics combines many disciplines, including biology and engineering. Research in ecohydraulics focuses on developing tools for managers, such as computer models, designs for habitat restoration, and fish passage. We use these tools to analyze options for operating in the most restorative manner. This covers a broad range from flow magnitude, flow timing, and water quality to the shape of the river with sedimentation, geomorphology, and bank stabilization to habitat, vegetation, and even animal behavior.

Research into ecohydraulics enhances the set of tools managers use to answer these questions. In this issue, we cover determining ecological health in reservoirs, improving analysis through better snow models and choosing the right dataset, designing rehabilitation structures such as large wood and automatically adjusting fish ladders.

Chuck Hennig, Deputy Chief of Research

Large wood conference, "Technical Workshop on Large Wood Applications and Research Needs in River Restoration," February 2012.

Rod Wittler, Mid-Pacific Region Science Liaison, served as principal editor for this issue.

About *The Knowledge Stream. . .*

The Knowledge Stream is the Bureau of Reclamation's Research and Development Office's quarterly newsletter bringing you news and information on Reclamation research and science: projects, events, innovation, results, publications, and more.

Help Us Write *The Knowledge Stream*: Send Us Your Content and Ideas

We welcome and encourage content from our readers. Please send your Recent and Upcoming Events, Innovation Around Reclamation, or any other content ideas to: research@usbr.gov.

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1. Follow the link below to our "Sign Up" form: http://goo.gl/e4MlEu
2. Text "ResearchUSBR" to 22828

Regional Science and Technology Coordinators Contact Information

Whether you are a regional researcher, Reclamation partner or customer, or just have an idea for a project that can help your region, the Regional Science and Technology Coordinators can help you with your research ideas, proposals, and projects.

Region	Coordinator	Email	Telephone
Pacific Northwest (PN)	Jennifer M. Johnson	jmjohnson@usbr.gov	208-378-5225
Mid-Pacific (MP)	Jobaid Kabir	jkabir@usbr.gov	916-978-5091
Lower Colorado (LC)	Nathaniel Gee	ngee@usbr.gov	702-293-8029
Upper Colorado (UC)	Mark McKinstry	mmckinstry@usbr.gov	801-524-3835
Great Plains (GP)	Collins Balcombe	cbalcombe@usbr.gov	512-899-4162

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This document is designed to be read either electronically via PDF or printed in color or black and white. Please forward it to your colleagues and friends.

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1. Print individual Research Updates on one sheet of paper, double-sided.
2. Print the whole document double-sided, corner stapled on 8.5- x 11-inch paper.
3. For magazine-style, instruct your print professional to print the whole document double-sided, head-to-head, saddle-stitched on 11- x 17-inch paper.

Your suggestions for improvements are always welcome. Please email them to jakervik@usbr.gov.

Thanks,

Jake Akervik, Communication and Information Systems Coordinator
Research and Development Office

Contents

Research and Development Office Contact Information

Website:
www.usbr.gov/research

Address:
PO Box 25007
Building 56, Room 1017
Denver Federal Center
Denver, Colorado 80225-0007
303-445-2125, research@usbr.gov

Chuck Hennig
Deputy Chief of Research
303-445-2134, chennig@usbr.gov

Curt Brown
Outgoing Chief of Research
303-445-2098, cbrown@usbr.gov

Miguel Rocha
Science and Technology Program Manager
303-445-2841, mrocha@usbr.gov

Jake Akervik
Communication and Information Systems Coordinator
303-445-2136, jakervik@usbr.gov

Janet Montano
Administrative Assistant
303-445-2133, jmontano@usbr.gov

Research Coordinators

Levi Brekke
Water and Climate
303-445-2494, lbrekke@usbr.gov

Yuliana Porras-Mendoza
Advanced Water Treatment
303-445-2265,
yporrasmendoza@usbr.gov

Erin Foraker
Renewable Energy
303-445-3635, eforaker@usbr.gov

Joe Kubitschek
Invasive Mussels
303-445-2148, jkubitschek@usbr.gov

Samantha Zhang
Technology Transfer
303-445-2126, szhang@usbr.gov

Rod Wittler
Mid-Pacific Region Science Liaison
530-262-3670, rjwittler@usbr.gov

Research Updates

Research Updates

Recent and Upcoming Events

The list of events below is intended for informational purposes only and does not necessarily constitute an endorsement by Reclamation. These events may be of interest to the science, research, and related communities and are not necessarily hosted by Reclamation. A list of recent and upcoming events can also be found at: www.usbr.gov/research/events.

The Northwest Hydroelectric Association (NWHA)—Workshops and Tour

NWHA provides a regional voice for the hydropower industry, representing the needs of its membership since 1981. NWHA is dedicated to the promotion of the region's waterpower as a clean efficient energy, while protecting the fisheries and environmental quality that characterize the Northwest Region.

The NWHA technical workshops offered engineers, electricians, mechanics, operators, and technicians servicing the hydroelectric industry a forum to discuss and learn about the arts and issues of their work, which is fundamental to the Northwest Region quality of life.

2014 Small Hydro Workshop
September 4 - 5, 2014 | Sisters, Oregon

2014 Fall Workshop & Tour
October 29 - 30, 2014 | Spokane, Washington

Additional NWHA information and presentation archive: www.nwhydro.org/default.htm

National Hydropower Association (NHA)—NHA Southwest Regional Meeting

September 8 - 10, 2014 | Golden, Colorado
NHA presented the NHA Southwest Regional Meeting. Based on new incentives and increased interest in renewable energy, the United States hydropower industry is primed for growth. Numerous opportunities are available to expand the region's hydropower base, while at the same time providing responsible environmental stewardship of the region's rivers. Additional meeting information:
www.hydro.org/news-and-media/events/details/nha-southwest-regional-meeting/

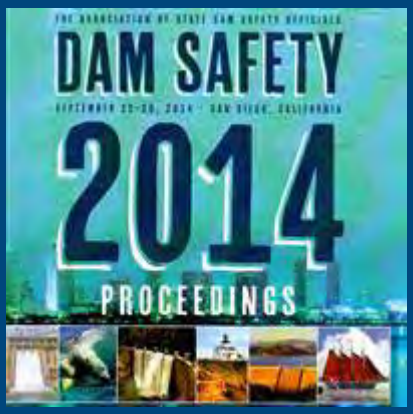
NHA—Hydropower Finance Summit

October 2, 2014 | New York, New York
This exclusive 1-day event brought together key leaders in the hydropower and financial sectors. Sessions examined project opportunities, financing options, and growth forecasts for the Nation's largest renewable energy resource. Additional summit information:
www.hydro.org/news-and-media/events/details/hydropower-finance-summit/

NHA—Hydraulic Power Committee Fall Retreat

October 6 - 8, 2014 | Holyoke, Massachusetts
This 3-day meeting focused on hydro operations, dam safety and security, and best practice sharing. The retreat was open to all NHA member companies and invited guests, including owners and operators of hydro projects and service and equipment providers. Additional retreat information:
www.hydro.org/news-and-media/events/details/nha-hydraulic-power-committee-fall-meeting-3/

Recent and Upcoming Events



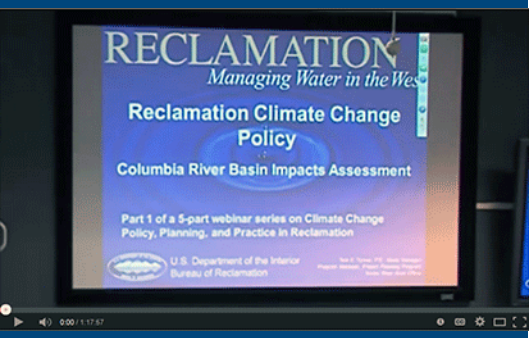
The Association of State Dam Safety Officials (ASDSO)—Dam Safety 2014 Conference

September 21 - 25, 2014 | San Diego, California

ASDSO's annual conference is one of the leading conferences in the United States (U.S.) dedicated to dam safety engineering and technology transfer. The conference and field trips continue to be the annual event to showcase dam safety in the U.S., with over 1,050 industry professionals attending.

This year's field trip was to the University of California-San Diego (UCSD) Large Outdoor Shake Table Facility. UCSD's large outdoor shake table is the largest facility of its kind in terms of footprint and payload capacity of any in the world.
Additional conference information:
www.damsafety.org/conferences/?p=8faca187-a4b0-406d-b9d6-f71c8ba9d192

A Five-Part Webinar Series on Policy, Planning, and Practice in the Pacific Northwest (PN) Region



Reclamation Climate Change Policy

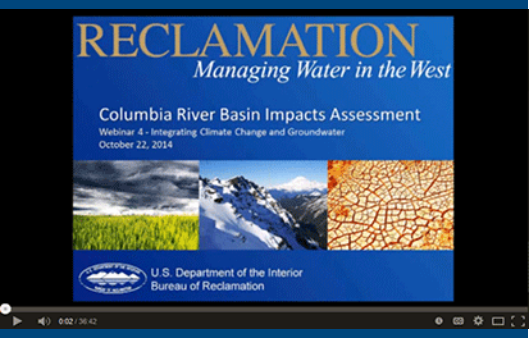
September 4, 2014

Climate change policies and legislation that have resulted in Reclamation-wide activities addressing climate change were presented. An overview of U.S. Department of the Interior, Reclamation, and PN Region actions were also presented.

Project Future Flow Estimates Using Climate Change Models

September 25, 2014

Understanding the steps necessary to generate future climate change hydrology (flow) using meteorological data from Global Climate Models were presented. The Hood River Basin Study was used as a case study.



Using Projected Future Climate Change Flows

October 8, 2014

Understanding how future climate change flow is used in a network model like MODSIM-DSS to evaluate the potential impacts of climate change on reservoir operations, storage volume, flow, and other metrics were presented. The Henry's Fork Basin Study was used as a case study. Bob Lounsbury, a hydraulic engineer in Reclamation's PN Region, presented.

Integrating Climate Change and Ground Water

October 22, 2014

Understanding how meteorological data or flow data generated in the climate change process can be used to evaluate the impacts of climate change on ground water was presented. A MODFLOW ground water model from the Hood River Basin Study was presented.

Finding Climate Change Information and Data Sources

November 5, 2014

Understanding how to access climate and hydrology data that will be generated in the PN Region was presented. GIS staff presented information on links, available data, and downloading data.

Contact and additional webinar information:
Toni E. Turner, (208) 383-2207, tturner@usbr.gov
Rochelle Ochoa, (208) 378-5212, rochoa@usbr.gov

View these recent recorded webinars at:
https://www4.gotomeeting.com/register/916514615

Midwest Hydro Users Group—Fall Regional Meeting

November 12 - 13, 2014 | Wausau, Wisconsin

The Midwest Hydro Users Group held their annual fall regional meeting, an owners-only meeting, and a full membership meeting. Additional meeting information: www.midwesthug.org/activities.html

Renewable Energy World Conference & Expo North America 2014 Conference

December 9 - 11, 2014 | Orlando, Florida

With an unwavering history, the Renewable Energy World Conference & Expo North America is returning for its ninth year and will provide the perfect venue to gather and exchange information about the latest in technology, opportunities, and funding in today's changing world. The conference and expo will also, once again, be co-located with Power Generation Week, providing networking opportunities with more than 20,000 professionals and key decisionmakers.

The Renewable Energy World Conference & Expo North America is recognized as the leading platform for information exchange, networking opportunities, and new business development covering all sectors in renewable energy and hot topics such as large-scale renewables, distributed generation, utility integration, renewables and the global market, and innovative energy partnerships. Additional conference and exhibition information:

www.renewableenergyworld-events.com/index.html

The Northwest Hydroelectric Association (NWHA)—Annual Conference and Technical and Operations Seminar

NWHA provides a regional voice for the hydropower industry, representing the needs of its membership since 1981. NWHA is dedicated to the promotion of the region's waterpower as a clean efficient energy, while protecting the fisheries and environmental quality that characterize the Northwest Region.

The NWHA technical workshops and seminars offer the engineers, electricians, mechanics, operators, and technicians servicing the hydroelectric industry a forum to discuss and learn about the arts and issues of their work, which is fundamental to the Northwest Region quality of life.

2015 Annual Conference
February 17 - 19, 2015 | Portland, Oregon
See www.nwhydro.org/events_committees/AnnnualConference.htm

2015 Technical & Operations Seminar—Machines, Maintenance, and Management: Keeping Hydro Facilities Up and Running
May 7 - 8, 2015 | Hood River, Oregon
See www.nwhydro.org/events_committees/tech_operations_conference.htm

Additional NWHA information: www.nwhydro.org/default.htm

Innovation Around Reclamation

Gravity foundation being installed on the Salmon River in Oregon. Photograph courtesy of Sean Welch/Reclamation.

Backfilling a large wood structure with native gravel material to increase stability.

Custom made concrete deadman anchor attached to a chain and a key wood member to resist buoyant forces in a high risk location.

Wood pins being installed to connect pieces of a large wood structure.

Large Wood – Risk-Based Design Guidelines

While large wood structures may be required to achieve habitat complexity and function, there are no official design or construction standards. Yet these structures pose risks, from failure to safety risks for recreationalists and others (see Research Update on page 52).

Reclamation and the U.S. Army Corps of Engineers (USACE) are currently drafting national standards for designing and placing large wood (see Research Update on page 46). In addition, Reclamation, Bonneville Power Administration, and USACE are designing and implementing projects now to improve salmonid habitat in the Pacific Northwest (PN) Region to help meet commitments stipulated in the *2010 Supplemental Federal Columbia River Power System (FCRPS) Biological Opinion*.

Thus, Reclamation's PN Region has drafted interim guidelines to provide design guidance until national or agency-developed guidelines are endorsed. The guidelines cover questions to ask, who to ask, and what to do with the results. Using these guidelines, Reclamation and project partners can provide a repeatable methodology for designing individual projects that document and present the inherent risks of large wood structures. The results of each of these risk assessments become part of the final work product that is agreed upon by all involved stakeholders documenting the acceptable risk factors in the design.

Indeed, Reclamation's PN Region is partnering with many Federal, state, local, and Tribal agencies, as well as non-profit organizations, to use large wood to an amazing extent already. Reclamation provides the technical designs for completed projects such as:

- Middle Fork of the John Day River, Oregon—Placed approximately 1,000 pieces of wood, with plans for a total of 2,000 pieces in a 2-mile-long project of newly constructed river meanders.
- Catherine Creek, Oregon—Installed approximately 500 pieces in a mile of stream, and are currently planning on an additional 5 miles of full creek restoration.
- Methow River, Washington—Completed two projects in 2012 that each had approximately 600 pieces of wood.
- Entiat River, Washington—Installed approximately 1,000 pieces of wood (collaborating with others) for a 2-mile project, and currently planning another project with approximately 2,000 pieces of wood over a 4-mile reach.
- Yankee Fork of the Salmon River, Idaho—Completed log structures with approximately 150 pieces of wood, and are planning to restore meanders along with approximately 500 pieces of wood.

Contact: Michael (Mike) Knutson | Reclamation's Pacific Northwest Region
208-378-5031, mknutson@usbr.gov

Tessel Web Mapping

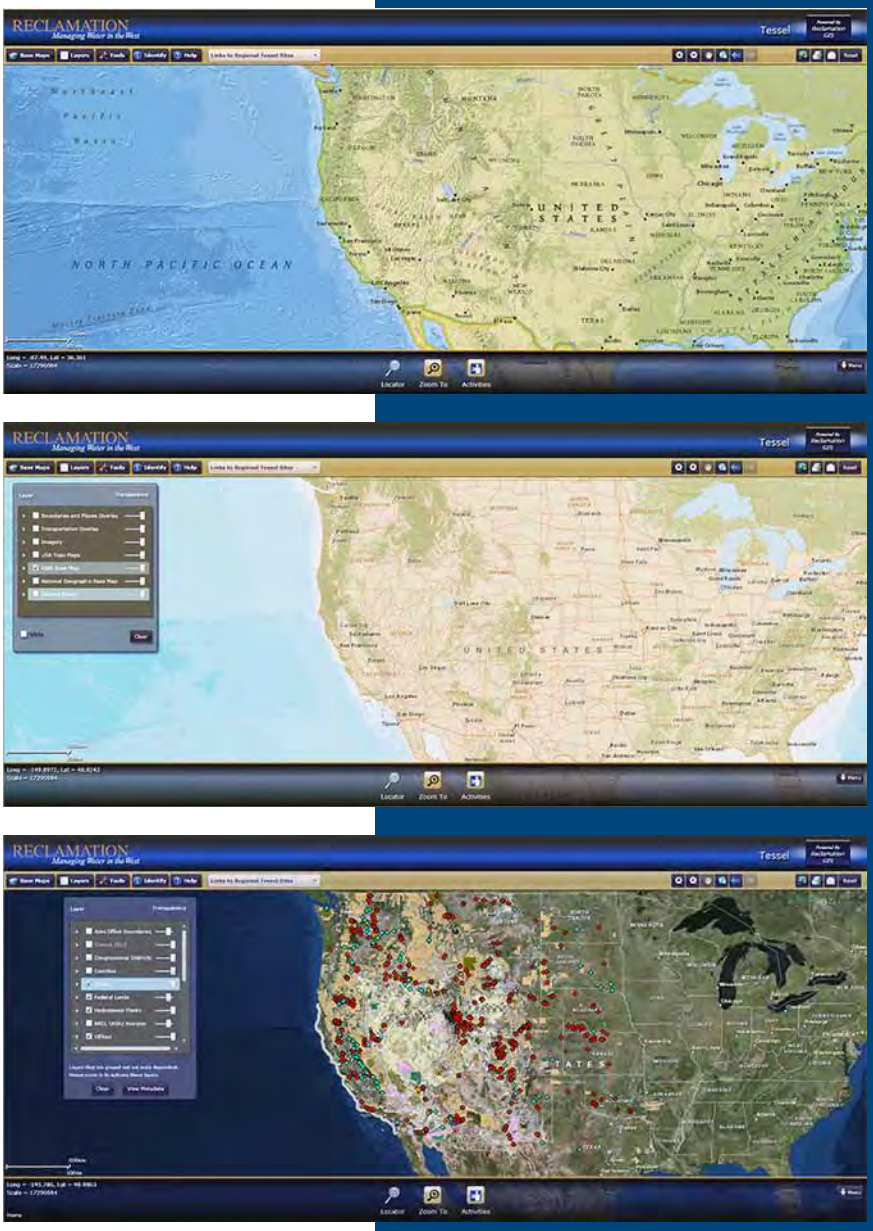
Web mapping has made great strides in recent years, and it is currently available within Reclamation. Even Reclamation employees who do not use the ArcGIS mapping platform can now create maps and perform spatial queries to support decisionmaking with online, in-house web mapping. A bureau-wide Intranet web mapping application, Tessel8, lets all Reclamation employees access a variety of geospatial data, like critical habitat, land use, land ownership, etc., which can be overlaid with locations of Reclamation's facilities. This is powered by Reclamation's geographic information system (GIS) database and programming system, commonly known as BORGIS.

Ecosystem and river and reservoir restoration projects can use Tessel to help inform and support decisions for operations and maintenance or explore feasibility of proposed projects. Where data are available, other potential uses include:

- Finding future streamflow projection data for use in hydraulic modeling to determine the effects on large wood or other river and restoration activities
- Locating construction resources (e.g., aggregate) close to a construction project
- Identifying opportunities for new power generation where canal drops are near existing transmission lines

A new HTML5/JavaScript (markup/programming language) design is being developed to further enhance this capability integrating Reclamation web services with public web services. Somewhat like smartphone applications, the "new" Tessel will support custom applications that leverage core Tessel function (e.g., zooming, navigation, base maps, printing, saving maps, and map markup). This also provides specific custom tools or analytic processes to enhance workflows of Reclamation program operations and activities. Web mapping and other interactive web applications should be considered in this process. If you are interested in beta testing the new Tessel, please contact Greg Gault (contact information below).

Reclamation's Tessel8 (current Tessel) can be found at: http://gis.bor.doi.net/Tessel8.



Screenshots from Tessel8.

Contact: Gregory (Greg) Gault | Reclamation's Pacific Northwest Region
208-378-5325, ggault@usbr.gov

Multimedia Around Reclamation

River Restoration Videos

Reclamation's many river restoration and recovery programs offer compelling stories of improving habitat and returning fish to rivers. These videos include:

Glen Canyon Dam, Arizona

- The U.S. Department of the Interior triggered the first high flow experimental (HFE) release since 2008 from Glen Canyon Dam on November 19, 2012, based on the new science-based protocol for conducting more frequent HFE releases. The goal is to determine the effectiveness of multiple HFE releases in rebuilding and conserving sandbars, beaches, and associated backwater habitats that have been lost or depleted since the dam's construction and operation. Published on November 20, 2012.
  See: https://www.youtube.com/watch?v=p5AvmNxBWK4

- Anne Castle, Assistant Secretary of the Interior for Water and Science shares her perspective on the ongoing cycle of scientific experimentation, learning through doing, and improvement over time at Glen Canyon Dam (known as the Adaptive Management Program). This program has set the stage for the new multiyear protocol for conducting HFE releases to benefit downstream resources. Published on November 13, 2012.
  See: https://www.youtube.com/watch?v=ic_oWDEEcr8

More Information and Other Media Resources: www.usbr.gov/uc/rm/gcdHFE

Trinity River Restoration Program, California

The Trinity River Restoration Program (TRRP) produced a video showing an overview of its restoration program. Enjoy the great shots of anadromous fish and learn about the importance of the Trinity River and the restoration projects. This multiagency partnership is rehabilitating 40 miles of fish habitat downstream from the Lewiston Dam to the North Fork of the Trinity River in California. Published on November 14, 2013.
Download Full Resolution Video (lower resolution video for streaming):
http://odp.trrp.net/Data/Documents/Details.aspx?document=2162

More Information/TRRP Website: www.trrp.net/

Bull Trout Activities in Boise River Basin, Idaho

Reclamation works cooperatively with the U.S. Fish and Wildlife Service, U.S. Forest Service, and the State of Idaho to study bull trout and their habitat in the Boise River Basin. Published on February 27, 2013.
See: www.youtube.com/watch?v=RilsQYv42ys&feature=youtu.be

More Information: www.usbr.gov/pn/snakeriver/esa/bulltrout/index.html

Tyee Ranch, Washington

By breaching a 40-year-old levee, engineers reconnect historic Entiat River side channels and develop valuable salmon and steelhead habitat. The Tyee Ranch Habitat Restoration Project in north-central Washington State has gigantic wood structures that mimic natural logjams. The intent is to create scour holes and deep cover for fish. Published on April 5, 2013.
See: www.usbr.gov/pn/fcrps/habitat/projects/uppercolumbia/tyeeproject/index.html

PS3 Side Channel Project, Idaho

Gold dredging re-shaped the Yankee Fork of the Salmon River in central Idaho and affected fish populations. New side channel habitat will attract juvenile Chinook salmon to the area. The PS3 Side Channel Project is the successful result of a team of private landowners, engineers, and natural resource agencies. Published on April 5, 2013.
See: http://tinyurl.com/PS3-side-channel

Yankee Fork, Idaho

Just 6 months after construction, over a half dozen adult steelhead have found new side channel habitat along the Yankee Fork of the Salmon River. The nesting areas, called redds, will nurture tiny fry during the summer. The PS3 Side Channel Project was built by a team of private landowners, engineers, and other natural resource agencies in fall 2012 to bring salmon, steelhead, and bull trout back to the Yankee Fork. Published on June 4, 2013. See: http://tinyurl.com/yankee-fork

More Information: www.usbr.gov/pn/fcrps/habitat/projects/uppersalmon/yankeeforkproject/index.html

Elwha River, Washington

- A series of six video movie clips were taken of the Elwha River and surrounding areas during a site visit after the removal of the Elwha and Glines Canyon Dams. Filmed/Published on February 25 through 27, 2014. See: www.usbr.gov/pmts/sediment/projects/ElwhaRiver/ElwhaGlinesCanyon.htm

- A series of webisodes (five webisodes total), produced by Wings over Watersheds, chronicle the removal of the Elwha and Glines Canyon Dams—the largest dam removal project in United States history. Published on June 1, 2011, through November 21, 2013. See: www.nps.gov/olym/naturescience/restorationoftheelwha.htm

Surveying for Salmon in the Grande Ronde Basin, Oregon

In the summer of 2013, Student Conservation Association interns spent 8 to 10 hours a day mapping hundreds of river reaches in Oregon's Grande Ronde River Basin in an effort partnered with the Oregon Department of Fish and Wildlife, Reclamation, and others. The data collected will help Reclamation and its Grande Ronde Basin partners develop tributary habitat improvement projects like the Catherine Creek Restoration Project. Published on December 19, 2013. See: http://tinyurl.com/survey-salmon

More Information: www.usbr.gov/pn/fcrps/habitat/

North Fork, Boise River, Idaho

Watch a time lapse of the fish weir installation on the North Fork of the Boise River. The weir allows fish biologists to collect data on the life histories and health of the bull trout population. Published on September 25, 2013. See: http://tinyurl.com/fish-weir-north-fork

Partnerships Videos

Models of Fish Movement

Reclamation and the U.S. Army Corps of Engineers-Engineer Research and Development Center (USACE-ERDC) are partnering to develop models to track how fish respond to various flows and barriers. Published on August 7, 2010. See: http://el.erdc.usace.army.mil/emrrp/nfs/fishpassage.html.

More Information: See article on page 20.

Partnering With the U.S. Army Corps of Engineers

Get a sense of USACE-ERDC as an innovative problem solver in this 5-minute introduction to their diverse capabilities, cutting-edge facilities, and leading experts. Published on January 17, 2014. See: www.erdc.usace.army.mil/About.aspx

Featured Faces

D.J. Bandrowski

www.usbr.gov/research/projects/researcher.cfm?id=2322

D.J. Bandrowski three-dimensional scanning large wood on the Trinity River near Junction City, California.

David Bandrowski, Implementation Branch Chief, B.S., P.E.

David (D.J.) Bandrowski is the Implementation Branch Chief of the Trinity River Restoration Program, a part of the Northern California Area Office in Reclamation's Mid-Pacific Region. D.J. is a civil engineer with over 16 years of experience planning, designing, and implementing restoration projects across the United States (U.S.) and overseas.

D.J., who is a Licensed Professional Engineer, graduated from Michigan Technological University in Marquette, Michigan, in 1998, with a bachelor's degree in civil engineering, specializing in water resources and hydraulics. He first developed a passion for civil engineering and water resources while he was living abroad in Bolivia, where he saw firsthand the need for sustainable solutions for water related issues and the degradation of once pristine rivers from impacts due to lack of resource stewardship.

Before joining Reclamation, D.J. was a watershed engineer at the U.S. Department of Agriculture's Natural Resources Conservation Service, in northern Michigan, where he worked with both farmers and municipalities on river and wetland restoration projects. He also participated in many international details to Central and South America, where he performed post-hurricane watershed assessments for various entities including the U.S. Agency for International Development, the U.S. Department of Agriculture's Foreign Agricultural Service, and the U.S. Department of State. In addition, D.J. served as a science fellow to the U.S. Embassy in La Paz, Bolivia, where he researched and assessed impacts to cocaine production and narcotic interdiction within Bolivia's rivers and watersheds.

D.J. joined Reclamation and the Trinity River Restoration Program in 2008, and served as a design engineer and project manager until 2011, when he was promoted to Implementation Branch Chief. He currently oversees the planning, design, and construction of the salmon rehabilitation projects on the Trinity River. Many other engineers and scientists in the program compliment his expertise, and together they form a strong multidisciplinary team carrying out an adaptive management framework on the Trinity River. Over the last few years, D.J. has participated in several of Reclamation's Science and Technology Program research projects, collaborating closely with the U.S. Army Corps of Engineers and the Sedimentation and River Hydraulics Group in Reclamation's Technical Service Center. D.J. is currently managing a Reclamation Science and Technology Program research project developing the *Large Wood National Manual* that will be published in early 2015 (see Research Update on page 46).

D.J. is passionate about rivers and loves boating, fishing, and camping with his wife and three children. He enjoys coaching baseball and soccer with community youth and leading children's activities at his church. D.J. loves to explore wild places and can often be found hiking or hunting in remote regions of northern California's Trinity Alps Wilderness.

Jennifer Bountry, Hydraulic Engineer, B.S., M.S., P.E.

Jennifer Bountry is a hydraulic engineer with the Sedimentation and River Hydraulics Group, which is part of the Water and Environmental Resources Division of Reclamation's Technical Service Center. Jennifer has 16 years of experience in evaluating river hydraulics and sedimentation processes for river restoration and reservoir projects, primarily in the Pacific Northwest.

Jennifer, who is a Licensed Professional Engineer, graduated from Colorado State University in Fort Collins in 1998. She holds a master's degree in civil engineering, a bachelor's degree in civil engineering, and a bachelor's degree in business marketing. Jennifer first became interested in water resources while living along the Mississippi River in her hometown of Alton, Illinois, as well as during college trips to Germany, France, and Italy, where she examined centuries-old water infrastructure still in use today.

Jennifer joined Reclamation in 1998 and has participated in numerous projects related to interdisciplinary fluvial process evaluation, river restoration evaluation, numerical modeling, and workshops designed to generate new ideas in ecohydraulics. She has been involved for many years in Reclamation's Technical Assistance to Tribes Program in the Pacific Northwest, where she works with teams to promote further understanding of physical processes and help inform restoration planning for salmonid habitat.

Jennifer's Reclamation Science and Technology Program research projects have focused on development of sediment analysis guidelines for dam removal projects, water temperature numerical modeling, and development of hydraulics at a reach and watershed scale for salmonid trophic models. In recent years, she has spent a large portion of time serving on an adaptive management team to assist with sediment management on the Elwha Dam Removal Project in northwest Washington State. Jennifer received the John W. Keys, III, Award for participating in the Pacific Northwest Region Tributary Habitat Program in the Columbia Basin.

Jennifer spends her free time in the outdoors with her family and friends, where she enjoys hiking, biking, and skiing. She volunteers with science experiments, assists in the classroom, and participates in a parent-run school garden at her children's elementary school, which encourages seed-to-table learning opportunities.

Jennifer Bountry

www.usbr.gov/research/projects/researcher.cfm?id=1571

Jennifer Bountry hiking down a trail at the Elwha River to measure the incision resulting from the recent removal of Elwha and Glines Canyon Dams.

Featured Faces

Julia Pierko

www.usbr.gov/research/projects/researcher.cfm?id=2175

Julia Pierko displaying a rainbow trout in the course of data collection during bull trout trap and transport activities below Arrowrock Dam, Boise Project.

Julia Pierko, Pacific Northwest Region Liaison Officer, P.E., CFM

Julia Pierko is the Pacific Northwest (PN) Region Liaison Officer to the Commissioner's Office in Washington, D.C. When she joined Reclamation, she had 20 years of experience providing professional services to local government and private consulting, as well as leading and participating in public water resource planning, design, and construction projects. In 2010, Julia began working at the Snake River Area Office in Reclamation's PN Region, where she helped develop collaborative solutions to water management issues involving planning, legal, environmental, and engineering challenges.

Julia earned her bachelor's degree in civil engineering from the University of Akron–Ohio, and her master's degree in environmental and water resources engineering from the University of Texas–Austin. She is a registered professional engineer (civil engineer) in Nevada, California, South Dakota (retired), and Idaho. She is also a Certified Floodplain Manager and is seeking certification as a Project Management Professional. Additionally, Julia recently served as a Sunset Fire District Commissioner and an Ada County Planning and Zoning Commissioner.

While working in the PN Region, Julia became involved in Reclamation's Science and Technology Program by participating in partnerships with outside entities to develop proposals and project execution phases for various projects in support of Reclamation's mission. For example, in fiscal year 2013, she served as the project manager for the "Evaluation and Standardization of Seepage Repair Methodologies" research project. This Reclamation Science and Technology Program research project is vital because Reclamation's operating entities currently use a wide variety of methods to repair seepage at canal embankments and/or foundations. The research project involved a survey of the various seepage repair methods used by Reclamation's operating entities. She also assisted in a fiscal year 2014 project, "Canal Inspection Methods Literature Review," which is an important first step in compiling and assessing existing knowledge about void and seepage detection methods for application to urban canals. The ultimate goal is to use the information gleaned from the research projects to improve the safety of Reclamation's canals.

An additional project Julia helped execute was the ecohydraulics research roadmap, where she worked with basic and applied researchers who broadly represent Reclamation's ecohydraulics work. She has also been involved in numerous other Reclamation efforts in the PN Region that have benefited from the support of the Reclamation Science and Technology Program, including numeric modeling tool development. Due, in part, to her outstanding research and leadership skills, Julia was recently selected as the PN Region Liaison Officer to the Commissioner's Office.

Julia is married and has a son and daughter who are both attending college in the PN. While she is greatly enjoying the urban experience offered by Washington, D.C., she misses her garden and seeing a sky full of stars at night.

Donald E. Portz, Fisheries Biologist, B.S., M.S., Ph.D.

Donald (Don) Portz is a fisheries biologist with the Fisheries and Wildlife Resources Group in Reclamation's Technical Service Center (TSC). He began working with the TSC in 1998, as a graduate student and government contractor, before becoming a Federal employee in 2000. Don has spent his entire professional career working for Reclamation. Currently, he serves as the TSC's fisheries project manager for three large programs in California: San Joaquin River (SJR) Restoration Program, Tracy Fish Facility Improvement Program, and Delta Cross Channel Fish Barrier Project.

Don grew up along the banks of the Hudson River in upstate New York and has always enjoyed water. At an early age, he expressed interest in conservation and fisheries management, which became a focus of his educational and professional pursuits. After obtaining a bachelor's degree from the State University of New York–Albany, Don took a break from college to sail the Caribbean as a first mate on a sailboat. He spent many days on the open ocean, pondering his future life direction and studying for the Graduate Records Examination. Then, he returned to dry land, took the exam, and moved to Colorado to pursue a master's degree at the University of Colorado–Boulder.

Don's journey brought him to Reclamation when he needed a flume to conduct tests for his master's thesis on the study of hydrodynamics of endemic Colorado River fish body forms. The opportunity to perform research in a one-of-a-kind facility like TSC's hydraulics laboratory, as well as to collaborate with experienced researchers on studies, was very alluring.

After graduating in December 1999, Don began working for TSC as a fisheries biologist, where he spent 2 years traveling all over the Western United States, tackling Reclamation's fisheries issues. In 2002, he had the opportunity to further his education with Reclamation's support, so he enrolled in a doctoral program at the University of California–Davis. His dissertation focused on research to improve the health and survival of salvaged fishes at Reclamation's Tracy Fish Collection Facility. He finished his Ph.D. while still working for Reclamation and then became very involved with fisheries concerns in Central Valley, California.

Since moving back to Denver, Colorado, and joining his TSC colleagues, Don has remained committed to working with the Tracy Fish Facility Improvement Program and has expanded his technical fisheries support to the SJR Restoration Program, Central Valley Project Improvement Act fisheries projects, and the Interagency Ecological Program. Don also interacts with the Research and Development Office on various projects and helps foster the partnership with the SJR Restoration Program and technology development to solve fisheries monitoring challenges. In addition, Don worked extensively with Reclamation's Science and Technology Program in developing the SmeltCam, an underwater trawled submersible that uses a video imaging system to identify and enumerate fish without capture, as well as improving Passive Integrated Transponder (PIT) technology for use in monitoring fish movements in the SJR and making improved management decisions for the river's restoration.

While Don's passion for fish and wildlife conservation occupies much of his waking hours, he realizes that a healthy home life is important. Don met his wife, Ana, while attending graduate school at the University of California–Davis, and they have been married for more than 3 years. Along with their dog, Nube, they enjoy traveling, hiking, fishing, hunting, home improvement projects, gardening, and making delicious meals fresh from their organic garden and from Don's fishing and hunting adventures.

Don Portz

www.usbr.gov/research/projects/researcher.cfm?id=1277

Don Portz releasing an adult female Chinook salmon in Reach 1 of the San Joaquin River Restoration Program. These are the first salmon to be translocated from downstream sections of the river to spawn below Friant Dam in over 60 years.

Technology Challenges

Well-designed prizes, integrated into a broader innovation strategy, have enabled Federal agencies to:

- **Pay only for success**
- **Establish ambitious goals without having to predict which team or approach is most likely to succeed**
- **Reach beyond the "usual suspects" to increase the number of solvers tackling a problem**
- **Identify novel approaches without bearing high levels of risk**
- **Bring other perspectives from many disciplines to bear**
- **Increase cost-effectiveness to maximize return on taxpayer dollars**

***Implementation of Federal Prize Authority: Fiscal Year 2013 Progress Report,* A Report From the Office of Science and Technology Policy, May 2014**

Research Office Contact

Chuck Hennig
Deputy Chief of Research/ Technology Transfer Manager
303-445-2134
chennig@usbr.gov

Challenge Update

Federal agencies have a new way to use the creative capacity of both the American public and private sector to help solve problems and the ability to financially reward the successful problem solvers. The Prize Competition section of the America COMPETES Reauthorization Act of 2010 provides agencies with authority to conduct prize competitions to spur innovation, solve tough problems, and advance their core missions.

Meeting new water needs and balance the multitude of competing uses of water in the West, Reclamation's core mission, poses many challenges. Beginning in 2015, Reclamation's Research and Development Office (through the Science and Technology Program) plans to launch several nationwide prize competitions to solve specific problems in the following Reclamation mission-critical areas:

Infrastructure Sustainability for more efficient operations and more affordable and effective maintenance and repairs. Reclamation's mission is to assist in meeting the increasing water demands of the West, while protecting the environment and the public's investment in Reclamation's extensive inventory of water storage, water delivery, and hydropower generation infrastructure.

Ecosystem Restoration to help recover threatened and endangered fish and the prevention of new listings under the Endangered Species Act. Effective solutions will help Reclamation comply with the environmental laws and regulations that sustain healthy aquatic ecosystems, while continuing to meet its water delivery obligations.

Water Availability to better conserve existing water supplies, create new sources of useable supplies, and forecast and manage water supplies to meet competing water needs under a variable and changing climate. Reclamation places great emphasis on fulfilling its water delivery obligations, water conservation, and water recycling and reuse; developing partnerships with its customers, states, and Native American Tribes; and in finding ways to bring together the variety of interests to address the competing needs for its limited water resources.

Challenge Ideas

Help Reclamation's Federal Challenge Management Teams identify candidate problems that might be suited to solve through a prize competition challenge. Submit a problem for consideration that is aligned with Reclamation's mission-critical areas (noted above) at: https://docs.google.com/forms/d/1j8Q3wzpCKjR5uq_uTvKtrmc6aqt9EZxTsfo3hWq_j-k/viewform?usp=send_form.

Enter or submit a prize competition challenge on the Challenge.gov website at: www.Challenge.gov. (Reclamation's prize competition challenges should be posted during the first or second quarter of 2015.)

Problems that are typically better suited for solving through a prize competition challenge are where:

1. An adequate or strong solution has been evasive or expensive.
2. Market forces may not provide appropriate incentives to solve, or solve well.
3. Agencies would like to reach beyond the usual sources of potential solvers and experts that commonly work in their domain.
4. Agencies would like to reach those that have developed, or are developing, technologies to solve other problems that may be transferable to their problem.

Determining Which Problems to Tackle

Reclamation is planning to collaborate with other Federal agencies with Federal Challenge Management Teams to identify prize competition problems that address its shared priorities. The Collaborative Federal Challenge Management Teams will work together to define the problem(s) selected for prize competitions, and design and manage the challenge in way that makes the best use of Federal capabilities. Federal collaboration will also enable Federal agencies to leverage Federal capabilities and find solutions that have a broader impact across the mission of multiple Federal agencies, the stakeholders they collectively serve, and overall public good.

A Federal Fish Recovery Challenge Management Team has been established that includes representatives from:

- Reclamation
- U.S. Geological Survey (USGS)
- U.S. Fish and Wildlife Service
- National Oceanic and Atmospheric Administration (NOAA) Fisheries
- U.S. Army Corps of Engineers (USACE)

Reclamation and USACE are contacting other Federal agencies to form an Infrastructure Challenge Management Team.

The existing Climate Change and Water Working Group (CCAWWG) will help develop a Federal Water Availability Challenge Management Team. Reclamation also intends to incorporate other agencies and subject matter experts aligned with the broad scope of this challenge area. CCAWWG agencies include Reclamation, USGS, NOAA, USACE, National Aeronautics and Space Administration, U.S. Environmental Protection Agency, and the U.S. Department of Agriculture's U.S. Forest Service and Agricultural Research Service.

"These '21st-century moon shoots' are audacious yet achievable goals that will allow us to harness the public's imagination and solve big problems."

Cristin Dorgelo
Assistant Director for Grand Challenges at the White House Office of Science and Technology Policy

May 21, 2014, interview with BBC News Magazine.

www.bbc.com/news/magazine-27492970

More Information

More information on CCAWWG can be found at:

www.ccawwg.us/index.php

Partnerships

The U.S. Army Corps of Engineers-Engineer Research and Development Center helps solve the Nation's most challenging problems in civil and military engineering, geospatial sciences, water resources, and environmental sciences for the U.S. Department of Defense and its U.S. Army, civilian agencies, and for the Nation's public good.

USACE-ERDC's vision is to become the world's premier public engineering and environmental sciences research and development organization.

Partnering for Priorities in Ecohydraulics Research

Reclamation and the U.S. Army Corps of Engineers -Engineer Research and Development Center (USACE-ERDC) have been working together on high-priority issues including restoring our rivers and researching ecohydraulics. Collaboration ranges from simply sharing information to working together on shared goals. The partnering agencies are communicating with other agencies, universities, and private industry to pull together knowledge and fill the gaps.

By exchanging science and technology research and identifying high-priority areas for collaboration on research, testing, demonstrations, and technology transfer, this collaboration can help increase the certainty of operations by addressing environmental concerns.

The two agencies met in March 2014 to identify potential areas of research collaboration, noting many areas for collaboration on research, testing, and technology transfer in ecohydraulics. In the months following, subject matter experts have been meeting to develop detailed descriptions of opportunities and paths forward, and to identify top priorities. The top five priorities for this coordinated effort are noted below:

1. Using Large Wood Structures

Re-establishing large wood features is frequently recommended as a component in river restoration projects to re-establish flow patterns, enhance habitat, and help recover species. Reclamation developed a large wood research roadmap in 2012 (see Research Update, *How Large Woody Debris in Streams and Rivers Can Help Habitats*, which can be found at: www.usbr.gov/research/docs/updates/2013-26-large-wood.pdf). One of the identified gaps is developing models of large wood and engineered logjams. This modeling work is critical for planning and designing effective structures. It includes three-dimensional models that are now available for field installations for prototype analysis and calibration (see Research Update on page 48). Linking modeling with fish tracking and habitat modeling are also important future steps.

The *Large Wood National Manual*, which brings many agencies and experts together, is scheduled to be completed by spring of 2015 (see Research Update on page 46).

2. Modeling Fish Movement, Computation Fluid Dynamics, Telemetry

Hydraulic and water quality models can create a "virtual reality" of the aquatic environment associated with an engineering design or operational alternative for civil infrastructure. An Eulerian-Lagrangian-Agent Method (ELAM) is useful to analyze and reproduce fish swimming behavior that underlies trajectory and distribution patterns by recursively reducing differences between simulation and field observations.

— continued

— continued

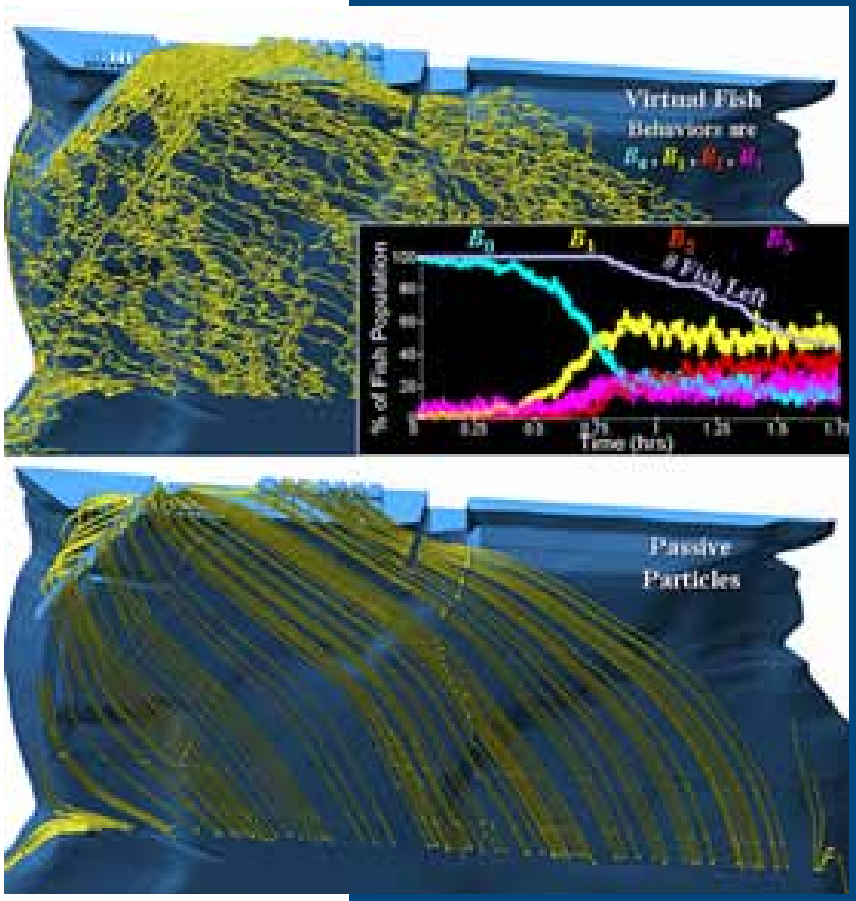
Ongoing collaboration in Reclamation's Mid-Pacific Region can help address research gaps in this developing technology. Many agencies and entities at the local, state and Federal levels are interested in the outcomes to illuminate operational decisions related to fish movement.

3. Gauging the Impact of Restoration Actions on Fish Populations

What is success in wildlife and fisheries management and how is it valued? Evaluation factors, performance measures, economic valuations (ecosystem services) are all important factors in determining the return on investment for these actions.

Many small projects need to be combined into an overall picture of an ecosystem or river basin. How can accumulating the impacts of all the small projects be done in order to make a statement about the overall basin impact on valued ecosystem components?

Reclamation and USACE-ERDC have begun research and are both working to develop methods to address these questions on the same geographic scale. As there are needs for data and analyses are similar, this type of research will leverage research dollars.



ELAM simulated fish versus passive particles (flow lines) approaching a dam. Photograph courtesy of USACE- ERDC.

4. Addressing Sediment for Reservoir Sustainability

Reservoirs fill with sediment, losing storage and operational capabilities. This is already a serious problem for many geographical areas within USACE-ERDC's jurisdiction, with smaller dams on rivers with larger sediment loads. However, this is now a growing concern for a small number of Reclamation facilities. Reclamation developed a reservoir sustainability research roadmap in 2012, and Reclamation and USACE-ERDC are now revising and augmenting this research roadmap. These research projects are in their beginning stages (see Research Update, *Sedimentation and River Hydraulics Modeling*, which can be found at: www.usbr.gov/research/docs/updates/2013-27-srh-model.pdf).

5. Going the Next Step for the Ecohydraulics Research Roadmap

Reclamation has developed an ecohydraulics research roadmap (see article on page 24). Phase 2 of the ecohydraulics research roadmap will include participation with USACE-ERDC and other agencies. Including the technical experts from USACE-ERDC and other agencies will provide a more comprehensive identification and prioritization of ecohydraulics knowledge gaps.

More Information

See the "Multimedia Around Reclamation" segment in this issue for videos regarding the partnership between Reclamation and USACE-ERDC.

Partnerships

The Federal Interagency Sedimentation Project partnering sponsors.

The Federal Interagency Sedimentation Project (FISP) was created in 1939 to unify and standardize the research and development activities of Federal agencies involved in fluvial sediment studies.

Currently, the FISP is represented by partnering agencies consisting of:

- **U.S. Department of the Interior's**
  - ◊ **U.S. Geological Survey**
  - ◊ **Bureau of Reclamation**
  - ◊ **Bureau of Land Management**
- **U.S. Department of Agriculture's**
  - ◊ **Agricultural Research Service**
  - ◊ **U.S. Forest Service**
- **U.S. Department of Defense's**
  - ◊ **U.S. Army Corps of Engineers**
- **U.S. Environmental Protection Agency**

Federal Interagency Sedimentation Project

River restoration and recovery depends on the interactions between a river's flow and sediment movement—both in the water (suspended sediment) and along the riverbed (bed load). Sediment movement reshapes rivers, causes water quality issues, and impacts all of the facets of our water system (navigation, aquatic habitat, agriculture, flood control, recreation, and hydropower). Yet measuring how much sediment is in the water and tracking its movements is notoriously difficult. Sediment characteristics vary with stream location and over time. Moreover, bed load moves mostly in floods or high flows, making it difficult to physically access the river and measure changes.

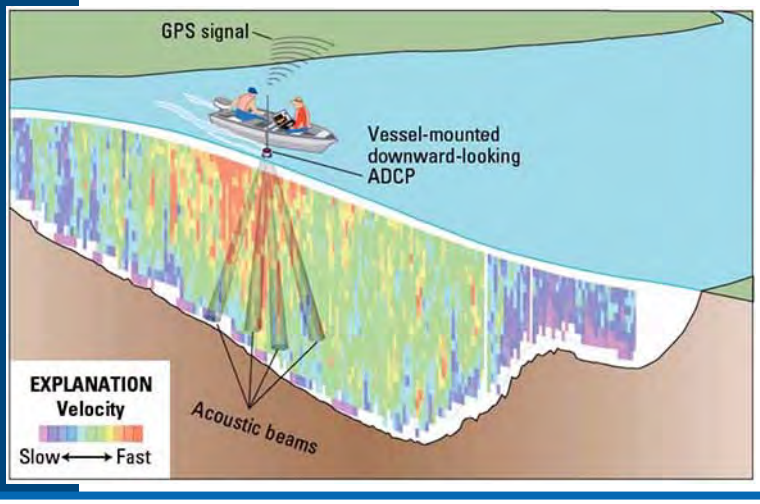
Federal agencies are working together to develop and deliver standardized instruments and protocols to provide sediment data that are accurate, comparable, and collected using best practices. To carry out its mission, the Federal Interagency Sedimentation Project (FISP) supports research into sediment, and supplies quality assured physical sampling equipment and training.

Fiscal Year 2014 Projects

The FISP worked on many projects in fiscal year 2014. Two recent research activities addressed very different aspects of acoustics. One activity used sounds underwater to track sediment movement; another helped improve physical sampling methods.

Searching for Sediment Movement Using Sound

Equipment, such as sonar, sends out a signal and then software evaluates the return signal sent back from sediment suspended in the water column. For example, the FISP project, "Acoustic Response to Suspended Sediment Concentration and Grain-Size Variation in Large, Sand-Bed Rivers" is improving methods for measuring suspended sediment concentrations using downward-looking acoustic Doppler current profilers (ADCP). The acoustic system is sensitive to the grain-size distribution. Thus, a better understanding of the temporal and spatial variation of suspended sediment concentrations and grain-size distribution in large, sand-bed rivers will help researchers evaluate the best approach for using ADCP for sediment monitoring.



ADCP cross section. Graphic courtesy of David Mueller, U.S. Geological Survey.

To verify the results, the study is using physically collected samples of suspended sediment concentration. Those sediment samples can also be used to analyze the effect of grain-size distribution on the acoustic signal.

This is a multinational effort, partnering with researchers in Argentina, South America, on the Parana River system.

Listening to Sediment Movement

Equipment listens to the noise created by sediment as it moves along the riverbed. The acoustic bed load measurements depend on the range of the hydrophone. Determining this range is a large unknown, but knowing the range is key to ensuring that the field sites are instrumented and the data analyzed properly to estimate field-scale bed load movements.

It is unknown how different the signal propagation will be over rough beds of gravel, cobbles, or boulders or how acoustic energy will be reapportioned in the frequency domain. Without this knowledge, it is not possible to arrive at a reasonable estimate of the measurement volume of a hydrophone submerged in a stream. This research involves conducting a series of laboratory experiments where sound is propagated over beds of varying roughness, recorded after passing over known distances, and compared to spreading models such as cylindrical spreading for shallow-water environments. Under these controlled conditions, amplitude relative to distance for a known range of frequencies will be recorded over beds of different roughness. This information will be combined with other parameters to begin developing a method for measuring self-generated noise.

Sediment and water recirculating flume at the National Sedimentation Laboratory, Oxford, Mississippi, to measure sound.

The FISP supports research studies to identify, develop, or test emerging sediment surrogate technologies or further improve instruments and methods for physical sampling.

The FISP issues an annual call for proposals and typically funds about four studies that leverage its small research budget to conduct relevant research. The FISP also conducts in-house research to advance these goals.

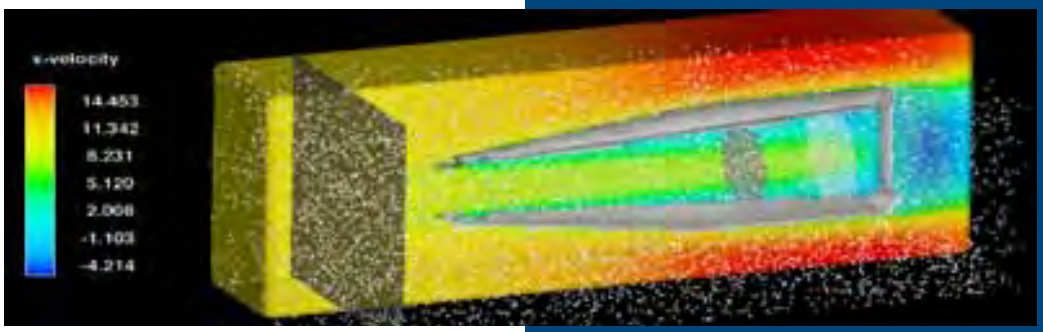
Results from FISP projects are documented in reports, papers, and/or presentations.

Modeling Sediment Samplers

Since its formation, the FISP has worked to develop standard and scientifically valid equipment and methods for collecting sediment samples. To take accurate representative physical samples, the velocity through the physical sampler's opening must match the local river velocity. Otherwise, too slow or too fast sampling rates will not accurately portray the concentration of suspended sediment in the water column. However, ensuring this velocity match over a wide range of stream conditions (e.g., depth, velocity, temperature, and transit rate for depth-integrating samplers) is a challenge and research is needed.

Computation fluid dynamics (CFD) modeling has a greater upfront cost, but then the numerical model can be used rather than constructing physical models for each condition. This research involves developing CFD for a sediment sampler nozzle. Simulations will be run to evaluate the effect of turbulence, sediment size, and ambient velocity to determine how to configure the nozzle for various conditions. Once this model is developed, it can be used in future evaluations of the effect of variable temperature, design tolerances, and other characteristics.

Three-dimensional simulation output of downstream velocity with particles.



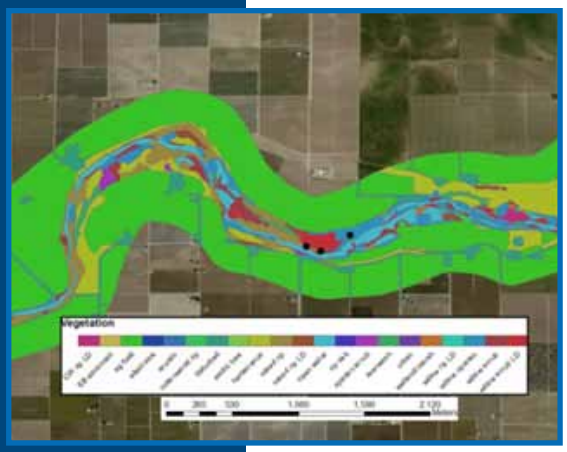
Getting the Data: Ecohydraulics Modeling and Data

Filling in the Ecohydraulics Research Roadmap

A core team comprised of representatives from Reclamation's Research and Development Office, Technical Service Center, and regional offices has developed an ecohydraulics research roadmap to prioritize ecohydraulics research needs for Reclamation. This research roadmap identifies gaps in Reclamation's technical capabilities and prioritizes research dollars to fill these gaps. The core team has completed phase I, an initial scoping of ecohydraulics research gaps and prioritization.

Priority topics for Reclamation's Science and Technology Program (S&T Program) research proposals are:

- **Data:** Develop improved techniques for data measurement and collection and determine the appropriate scale for management standards.
- **Metrics:** Establish structural and functional measurements for restoration projects to resolve predictability and understanding of physical and biological mechanisms. Cross program and interregional utility are particularly important.
- **Lifecycle Requirements**: Identify and document lifecycle requirements for development of conceptual lifecycle models, with the potential to evaluate and verify limiting factors.
- **Substrate Habitat**: Determine processes and mechanisms operating in the substrate environment and the interaction between physical and biological outcomes and resources. The substrate environment is broadly defined due to the diversity of river systems in which Reclamation operates.
- **Models for Physical-Biological Linkages:** Develop or refine analytic or numerical tools that simulate the linkages among ecohydraulic resources to estimate environmental responses to Reclamation management actions.
- **Feedback Loop/Communication:** Construct tools for adaptive management, structured decisionmaking, and facilitating transparent communication and understanding between internal and external stakeholders. The S&T Program seeks large-scale, Reclamation-wide, or interagency applications.



Testing of Dynamic Vegetation Roughness Routines for the Sedimentation and River Hydraulics–Two-Dimensional Model (SRH-2D).

Top: Stem diameter being measured with precision calipers.

Middle: Vegetation stems being counted and recorded in field book.

Bottom: Vegetation classes near fieldsite 3, indicated by black dots.

Future Plans

The next phase is to work with other resource management agencies to leverage research. Plans are currently in the works with USACE-ERDC and other agencies (see article on page 20).

Other Current Projects

- Passive Acoustic (Hydrophone) Measurement of Coarse Bed Load
  www.usbr.gov/research/projects/detail.cfm?id=4864
- Scoping Tools for Water Conflict Management
  www.usbr.gov/research/projects/detail.cfm?id=1380
- Effects of Climate Change and Reservoir Operations on Riparian Vegetation
  www.usbr.gov/research/projects/detail.cfm?id=1596
- Aquatic Species Surveillance Using Environmental DNA
  www.usbr.gov/research/projects/detail.cfm?id=2105
- Downstream Fish Passage for Large Storage Dams
  www.usbr.gov/research/projects/detail.cfm?id=3544
- Discounting for Long-Lived Water Resource Investments
  www.usbr.gov/research/projects/detail.cfm?id=3574
- Basin-Scale Real-Time Flow and Salt Load Visualization for TMDL Compliance
  www.usbr.gov/research/projects/detail.cfm?id=3942
- Quantitative Modeling Tools of Scour and Morphological Impact Due to Large Wood Debris Structures
  www.usbr.gov/research/projects/detail.cfm?id=4495
- Scoping the Potential Use of Ecosystem Service Accounting Protocols in Environmental Analysis
  www.usbr.gov/research/projects/detail.cfm?id=4942
- Validation and Improvement of SRH-1D for Dam Removal and Sediment Sluicing Projects
  www.usbr.gov/research/projects/detail.cfm?id=5325
- Development of Full-Duplex Passive Integrated Transponder (PIT) Antenna System for Deep River/Canal Systems
  www.usbr.gov/research/projects/detail.cfm?id=5437
- Maximizing the Benefit of Smaller Engineered Log Jams
  www.usbr.gov/research/projects/detail.cfm?id=5796
- Developing Guidelines for Formulating Reservoir Sustainability Plans
  www.usbr.gov/research/projects/detail.cfm?id=6080
- Continued Field Measurement of Riparian Evapotranspiration, Lower Colorado River Basin
  www.usbr.gov/research/projects/detail.cfm?id=6224
- Building Capacity for Incorporating Uncertainties and Communicating Results in Reclamation's Long Term Planning and Decisionmaking Processes
  www.usbr.gov/research/projects/detail.cfm?id=6262
- Predicting Vertical and Lateral Sediment Erosion in River and Reservoir Settings
  www.usbr.gov/research/projects/detail.cfm?id=7356
- Compilation and Assessment of River Restoration Evaluation Metrics
  www.usbr.gov/research/projects/detail.cfm?id=7592
- Exploring Methods to Predict, Manage, And Control Alluvial Material Transport
  www.usbr.gov/research/projects/detail.cfm?id=7796
- Generalized Streamflow Depletions Model for Historic and Projected Future Climate Scenarios
  www.usbr.gov/research/projects/detail.cfm?id=8013
- Predicting the Ecological Consequences of Hydrologic and Thermal Modification in Wadeable Streams: The Climatic Context
  www.usbr.gov/research/projects/detail.cfm?id=8224
- The Efficiency of SandWand Technology as a Habitat Restoration Tool for Native Salmonids in Small Tributaries
  www.usbr.gov/research/projects/detail.cfm?id=8351
- Ecological Costs of Streamflow Regulation
  www.usbr.gov/research/projects/detail.cfm?id=8721
- Valuing Flow and Water Dependent Ecological Resiliency Under the Secure Water Act
  www.usbr.gov/research/projects/detail.cfm?id=8737

Current Projects in This Issue

RECLAMATION Managing Water in the West

Fall 2014
Research and
Development Office
Bulletin 2014-17

The Knowledge Stream
Research Update

Assessing the Ecological Health of Reclamation's Reservoirs

Using physical, chemical, and biological parameters to assess general ecological conditions for Reclamation reservoirs within a region

Bottom Line

This research project developed reservoir health assessments to help characterize the current conditions for reservoirs in Reclamation's Snake River area, Idaho, that support bull trout.

Better, Faster, Cheaper

Developing and applying ecological health assessments for reservoirs will help indicate conditions that can cause environmental concerns if left unnoticed. A consistent set of indicators, data collection, and assessments can provide comparable rates by time and site, as well as ecological health status trends. Without this consistency, project information and data collection cannot provide a true picture of trends over a long period of time within a region.

Principal Investigator

Dmitri Vidergar
Fisheries Biologist
Snake River Area Office
Pacific Northwest Region
208-383-2216
dvidergar@usbr.gov

Research Office Contact

Miguel Rocha
Science and Technology
Program Manager
303-445-2841
mrocha@usbr.gov

Problem

Reservoirs are complex ecosystems with fish, birds, algae, and insects coexisting in a bewildering array of influences from water quality parameters (such as water temperature, dissolved oxygen, and components) and water quantity (such as changes in levels). Understanding the overall ecological health of Reclamation's reservoirs and trends over time is vital to efficient and environmentally sound management. Using "spot checks" to evaluate ecological health of a reservoir may miss seasonal trends and provide an inconsistent picture of overall health. Data needed to establish an ecological health assessment trend may be available by using datasets already being managed by different groups.

Reclamation performs many investigations using physiochemical parameters (e.g., water temperature, dissolved oxygen, and water quality) or biological parameters (e.g., chlorophyll *a*, macroinvertebrates, and fish). But understanding and comparing these parameters poses major challenges:

- Temporal and spatial characteristics of the hydrologic and thermal regimes vary. Assessments are not conducted at similar times or in similar locations. Some have been conducted in short- and long-term periods and others periodically at established monitoring intervals.
- Parameters are not consistent between studies. Most investigations have described measured or mean values on physiochemical parameters and lists of fauna species with individual numbers and catch rate statistics in the results. However, parameters vary depending on the natural conditions at the time of sampling (e.g., fluctuation of precipitation, inflow, water level, and temperature with climate change).
- Data are put on the shelf and not tracked. These data have been mostly used and stored separately when projects were completed. Thus, assessments may not consider or recognize long-term changes.

Therefore, it is difficult to compare individual data points and parameters and assess a general ecological condition of reservoirs.

In 1990, the Tennessee Valley Authority (TVA) began a systematic monitoring program with 12 reservoirs to:

- Provide information on reservoir "health"
- Determine if conditions are changing
- Target detail assessment studies
- Report results

The monitoring program currently includes 69 sites on 31 reservoirs throughout the Tennessee River Valley, and each site is sampled every other year unless a substantial change in the ecological health occurs during a 2-year cycle. Reclamation could use a similar program.

Palisades Dam, Idaho

Solution

To help assess, rate, and compare ecological condition of Reclamation's reservoirs, this Reclamation Science and Technology Program research project first examined the TVA's monitoring program and adapted these ideas for the Snake River Area Office in Reclamation's Pacific Northwest Region, including:

- A standardized list of parameters (subset) from a larger list of commonly sampled parameters that can be used for an Ecological Health Assessment. Variables include: physical (water temperature), chemical (dissolved oxygen and sediment quality), and biological (chlorophyll *a*, benthic macroinvertebrates, and fish communities).

- A "theoretical" web-based database that can be used to help managers and analysts apply an Ecological Health Assessment for a reservoir. This database can be used to describe baseline conditions for future reporting and, coupled with literature reviews, to design more specific studies when necessary. Data were used from the Laboratory Information Management System database in Reclamation's Pacific Northwest Regional Office Water Laboratory, which stores water quality data from both fisheries and water quality monitoring projects. It would be possible to incorporate data from sources outside Reclamation.

Future Plans

The conceptual idea of the work helps increase the awareness of consistency in data collection of certain parameters during routine work for the Snake River Endangered Species Act group. Now Reclamation has a foundation for a database to collect data from across disciplines. These data will be very important sources for determining long-term trends and can provide a foundation for operational decisions.

Reclamation is hopeful that other offices and/or programs will join in the collaboration of future efforts. This research warrants further applications, such as developing programs for other watersheds and making data available for researchers and analysts.

"Developing a web-based tool for tracking the ecological health of a reservoir could be a valuable tool for the general characterization of aquatic ecosystems and making comparisons among Reclamation's reservoirs."

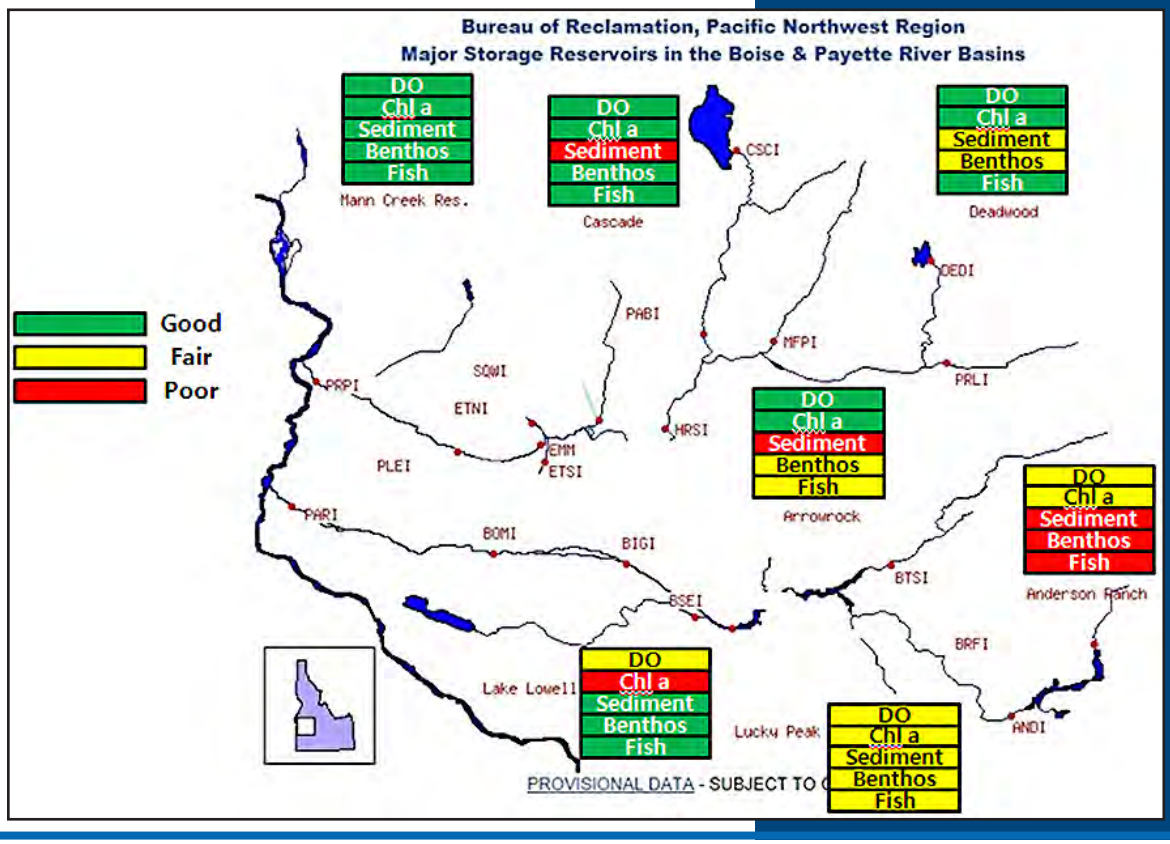
Dmitri Vidergar
Fisheries Biologist, Reclamation's Pacific Northwest Region

Collaborators

University of Idaho

More information

www.usbr.gov/research/projects/detail.cfm?id=5163



Theoretical example of an ecological health assessment summary using centralizing information with web-based data (not based on actual data).

RECLAMATION Managing Water in the West

Fall 2014
Research and
Development Office
Bulletin 2014-18

The Knowledge Stream
Research Update

Measuring Biological Effects of Altered Flows

Understanding how flow and water temperature relate to stream health

Bottom Line

Aquatic invertebrates are important ecological indicators of flow and temperature alterations because of their rapid response to environmental changes. This research project examined the degree of alteration in macroinvertebrate communities to help evaluate the relationship between the severity of hydrological alteration (including flow and temperature) and the biological integrity of the ecosystem.

Better, Faster, Cheaper

Using aquatic invertebrates as indicators provides an accurate, low-cost method for environmental assessment and evaluation that is directly related to important resources. These insights could help develop models that would aid researchers and managers in predicting the ecological consequences of streamflow alteration expected under various scenarios of climate change.

Principal Investigator

S. Mark Nelson
Research Aquatic Biologist
Environmental Applications and Research Group
Technical Service Center
303-445-2225
snelson@usbr.gov

Research Office Contact

Miguel Rocha
Science and Technology Program Manager
303-445-2841
mrocha@usbr.gov

Problem

Regulated flows need to meet the needs of both ecosystems and society. Understanding ecosystem requirements, however, has been hindered by an inability to quantify the relationships between stream health indicators and hydrologic alteration.

Alteration of natural streamflows is a multidimensional phenomenon affecting frequency, duration, and timing of various streamflow magnitudes. In addition, altered flows affect stream ecosystems through habitat modification, temperature modification, desiccation, and sheer stress. Changes in aquatic macroinvertebrate communities may occur because of altered habitat, changes in sediment input, water quality, thermal regimes, and flow patterns. Aquatic invertebrates also play a role in transferring energy to higher trophic levels since they are a major part of the food resource for fishes. Changes in invertebrate communities may result in changes in condition of fish communities. Further, many aquatic invertebrates have nonaquatic phases leading to their importance to other predators, including birds.

This quantification of flow/thermal alteration in simple terms and biology in terms of condition will provide valuable ecological information for decisionmakers.

Sampling aquatic invertebrates in a Sierra Nevada (California and Nevada) stream.

Study and Results

This Reclamation Science and Technology Program research project expands a preliminary exploration of the range of biological integrity as represented by macroinvertebrate communities encountered over a wide range of hydrological alteration (see research project "Assessing the Ecological Costs of Streamflow Regulation," which can be found at: www.usbr.gov/research/projects/detail.cfm?id=6188).

This effort is among the first to quantify the relationships between biological integrity and hydrological alteration. This research project conducted macroinvertebrate community assessments in a set of regional rivers in the Sierra Nevada mountain range (California and Nevada) with varying degrees of hydrological alteration and provide quantitative relationships between measures of invertebrate community integrity and hydrological/thermal alteration.

Aquatic invertebrate samples were collected and hydrological information obtained from U.S. Geological Survey Sierra Nevada gaging stations that varied in flow alteration. Hourly water temperatures were measured for about a year with site-deployed temperature loggers. Hydrological and thermal alterations at each site were computed relative to reference site values, both observed and expected.

March streamflows and summer water temperatures were important predictors of invertebrate communities. Temperature alterations did not necessarily covary with streamflows, possibly because of variability in dam flow management. Hydrology and temperature may be differentially important to macroinvertebrates at some damsites. Macroinvertebrate taxa were identified that increased or decreased in response to dam operations and some of these responses were found to be consistent with other studies.

Future Plans

While the previous study in this area focused on flow, this research project's results point to the additional importance of temperature in modification of biotic communities. Although the exact mechanisms remain unclear, these relationships are still a useful guide to decisions about the tradeoff between flow depletion and stream health. The ability to generalize this relationship to other mountain streams, such as Rocky Mountain streams, also remains unclear and needs corroboration by similar studies in other subregions. It is also unclear how far downstream modifications in macroinvertebrate communities are continued. These data would be useful in assessing the full impacts of flow/temperature alterations on aquatic communities.

Future studies should focus on these other dimensions of natural streamflows, as well as the mechanisms that affect biological communities and their habitats as hydrological characteristics are altered by water management activities.

"The nation's waterways are called upon to serve many purposes and populations. Each use adds physical and biological stress to the river that the ecosystem must bear. Managing our part of each river's course is key to Reclamation's mission. Techniques like those in this study are useful for indicating the status and trend of waterways, based on the lowest level biologic building blocks. If the bugs, water temperature, habitats, and other basic components are prospering, theory says that the conditions for sustaining or recovering higher level ecosystem components are positive."

Rod Wittler
Mid-Pacific Region Science Liaison, Research and Development Office

More Information

Carlisle, D.M., S.M. Nelson, K. Eng. 2012. *Macroinvertebrate Community Condition Associated With the Severity of Streamflow Alteration*. River Research and Applications.

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RECLAMATION Managing Water in the West

Fall 2014
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Bulletin 2014-19

The Knowledge Stream
Research Update

Using Unmanned Aerial Systems to Monitor Sediment Flow

Collaborating with the U.S. Geological Survey to test unmanned aerial systems for mapping sediment flow at a dam removal site

Bottom Line

Researchers tested the feasibility of using unmanned aerial systems (UAS) to map sediment flow on the Elwha River post dam removal in Washington. Although the data gathered did not have the quality needed to track sediment flow, modern platforms and sensors show great promise for high quality mapping.

Better, Faster, Cheaper

Using updated UAS platforms and sensors will allow for multiple passes over small areas, such as reservoirs that will produce high resolution imagery capable of being used for excellent quality mapping that can be used to monitor changing typography and sediment flow.

Principal Investigator

Douglas Clark
Physical Scientist
Emergency Management and Geographic Information Systems Group
Technical Service Center
303-445-2271
drclark@usbr.gov

Research Office Contact

Miguel Rocha
Science and Technology Program Manager
303-445-2841
mrocha@usbr.gov

Problem

Dam removal began on the Elwha River, Washington, in mid-September 2011. Currently, Elwha Dam and over 50 percent of Glines Canyon Dam have been removed, Lake Mills and Lake Aldwell Reservoirs have drained, and the Elwha River flows freely from its headwaters in the Olympic Mountains to the Strait of Juan de Fuca for the first time in nearly 100 years. This restoration project is unique as it encompasses an entire watershed (i.e., 320 square miles from the Olympic Mountains to the Strait of Juan de Fuca) of predominantly pristine wilderness, historically home to all runs of Pacific Northwest salmon.

These two reservoirs were filled with sediment, and removing these dams represents the largest controlled release of sediment in the history of North America—an "end member case" for dam removal. Because this is the first dam removal on such a large scale, there are uncertainties about how rapidly, and in what patterns, sediment will erode from the reservoirs and move downstream. Monitoring the changing topography as the approximately 24 million cubic yards of sediment are being eroded and redistributed downstream is a critical component of the science of dam removal.

Many of those uncertainties can be answered by using aerial over flights, including those from unmanned aerial systems (UAS), to monitor changes in the reservoirs and river channels. But conventional aerial photography is expensive and not justified unless it is for large surveys over wide areas. This Reclamation Science and Technology Program research project sought to test whether UAS could be used to monitor sediment transport on the Elwha River as two dams were being removed.

UAS imagery captured Lake Aldwell Reservoir on the Elwha River, Washington, with a GoPro Hero2 Camera mounted on a Raven A in September 2012.

Solution

The researchers tested UAS to determine if this could be used for repeated and frequent monitoring in such a dynamic environment. The research showed that UAS could indeed be used for this purpose, however, newer platforms and sensors would be required to obtain high quality mapping. This research project used old military surplus technologies that were not designed for high resolution mapping.

Application and Results

This research project was conducted on the Elwha River on Lake Mills and Lake Aldwell Reservoirs. A 10-year-old military surplus Raven RQ-11A platform with a 0.5-megapixel electric-optical sensor system was used. Results were suboptimal. Subsequently, the native sensor system was replaced by a GoPro Hero2 Camera with 11 megapixels, which produced substantially better results. However, the quality was still insufficient for the high quality mapping necessary to track sediment flow.

Future Plans

Researchers will continue to test UAS to determine how they can best be used to serve Reclamation's mission requirements. Reclamation personnel have expressed interest in testing the feasibility of using UAS for wildlife surveys, water quality studies, water management, vegetation mapping, telemetry surveys, reservoir surveys, operations and maintenance planning, restoration monitoring, ineligible lands monitoring, surveys of inaccessible areas, monitoring encroachments/ trespasses, monitoring boundaries, habitat surveys, flow surveys, crop surveys, archeological surveys, and endangered species protection.

Raven RQ-11A launch at the Aldwell Reservoir on the Elwha River, Washington.

"Unmanned aerial systems hold promise for making it possible to conduct frequent missions to gather high resolution imagery over small areas."

Douglas Clark
Physical Scientist, Reclamation's Technical Service Center

Collaborators

- **U.S. Geological Survey's National Unmanned Aircraft Systems Project Office**
- **National Park Service**

More information

www.usbr.gov/research/projects/detail.cfm?id=3734

U.S. Geological Survey information:

http://rmgsc.cr.usgs.gov/UAS/WA_BORRiverSedimentMonitoring.shtml.

www.youtube.com/watch?v=5KKtjGVZFkw

RECLAMATION Managing Water in the West

Fall 2014
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Bulletin 2014-20

The Knowledge Stream
Research Update

Choosing the Right Meteorological Dataset for Hydrologic Simulations

How meteorological datasets affect model simulations and portrayal of climate sensitivity

Bottom Line

This research project determined that spatially distributed meteorological datasets affect calibration of the Variable Infiltration Capacity (VIC) model and corresponding streamflow simulations and may also affect characterization of runoff changes due to climate change.

Better, Faster, Cheaper

Federal natural resource management and conservation agencies, including Reclamation, have mandates for incorporating climate change into long-term planning. Greater understanding of the implications associated with using a particular meteorological dataset in hydrologic modeling is important, not only for historical hydrologic studies, but also for characterizing the uncertainty associated with projected future hydrologic conditions.

Principal Investigators

Subhrendu Gangopadhyay
Hydrologic Civil Engineer
Water Resources Planning and Operations Support Group
Technical Service Center
303-445-2465
sgangopadhyay@usbr.gov

Marketa Elsner
Hydrologic Civil Engineer
Water Resources Planning and Operations Support Group
Technical Service Center
303-445-2455
melsner@usbr.gov

Problem

For water and environmental management decisions, understanding the uncertainty associated with various underlying modeling application choices is critical. Sophisticated physical process models informed by climate change scenarios are increasingly becoming an integral part of long-term natural resources planning. Studies using these models are often the best available science to be used for decisionmaking. For example, the proposed listing of the North American wolverine in 2013 as threatened under the Endangered Species Act relied on evaluations of climate change impacts on this distinct population, which depends heavily on contiguous snowpack.

Choices in conducting a study to support environmental and water management decisions may include historical and projected future meteorological datasets and a hydrologic modeling framework, which involves choice of model structure and calibration methods. In short, choosing a historical meteorological dataset is one of many modeling application decisions to be made that affects the water budget.

Shasta Lake on the Sacramento River, a case study watershed that compared streamflow simulations based on four meteorological datasets. Photograph courtesy of Mid-Pacific Regional Office.

Understanding the methods, assumptions, and analyses going into developing these datasets is vital to using these applications for subsequent analysis. Moreover, understanding uncertainty associated with various underlying modeling applications is critical for environmental management decisions. Thus, to better determine the implications of using a particular historical dataset and to characterize the uncertainty associated with projections of future hydrologic conditions, the following questions need to be answered:

- Is there an optimal distributed meteorological forcing dataset to be used in simulating streamflow through a hydrological model, specifically the Variable Infiltration Capacity (VIC) model?
- How does the choice of distributed meteorological data affect hydrologic model calibration and sensitivity analysis, particularly for changes in climate?

Solution

This Reclamation Science and Technology Program research project compared four meteorological forcing datasets commonly used in natural resources planning studies. It compared precipitation and temperature (maximum, minimum, and diurnal range) from these datasets over a common time period (water years 1980 - 1999), spatial resolution (1/8 degree), and domain. Domains generally covered the United States portions of four major western hydrologic regions, including: the Pacific Northwest

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(Columbia River Basin plus coastal drainages in Oregon and Washington), California, the Great Basin, the Colorado River Basin, and the Missouri River Basin (west of 93 degrees west longitude).

These direct comparisons allow better understanding of the implications of these datasets with respect to long-term planning studies. Hydrologic model calibrations (using each of the four compared datasets) and resulting simulations were examined on seven case study watersheds (see map) to answer:

- Does a model calibrated to one meteorological dataset yield significantly different calibration parameters than a model calibrated using a different meteorological dataset?
- Do results from a model calibrated to one meteorological dataset differ significantly when the model is run with a different meteorological dataset?
- How sensitive is runoff to changes in climate (as represented by differences between calibration and validation periods)?

Map of basins covered, along with seven case study watersheds: 1–Animas River, Durango, CO; 2–Dolores River, Cisco, UT; 3–Green River, Green River, UT; 4–Missouri River, Toston, MT; 5–Sacramento River, Red Bluff, CA; 6–Salt River, Chrysotile, AZ; 7–Snake River, Heise, ID.

This study found that, of the four commonly used datasets considered, each meteorological dataset differs, particularly in forecasting minimum and maximum temperatures in high elevation regions such as the Rocky Mountains. However, this study also found that no single dataset stands out as the best for simulating streamflow—each was developed for a specific purpose and set of applications and used different approaches. Key findings in the context of various uncertainties in long-term natural resources planning studies included:

- Evaluating runoff sensitivity to changes in climate indicates that the choice of meteorological dataset may be as important in characterizing potential changes in runoff as climate change itself.
- The choice of meteorological forcing dataset will influence statistical downscaling of projected climate scenarios from coarser scale (in space and time) global climate models, thereby influencing the uncertainty associated with climate projections downscaled to forecast local conditions.
- Although there are substantial differences among these datasets, no single dataset is superior to the others with respect to VIC model simulations of streamflow.
- There is no apparent relationship between optimal calibration parameter values and meteorological dataset or watershed, suggesting that the quality of the datasets is comparable or there is enough flexibility in the model parameters to compensate for differences among forcing datasets and potential biases in process representation.

Future Plans

Further studies exploring the sensitivity of other hydrologic variables beyond streamflow (e.g., snowpack, evapotranspiration) to the particular meteorological forcing dataset, changes in runoff sensitivity due to hydrologic model calibration, as well as studies using ensembles of approaches and techniques (including additional hydrologic models), will enhance understanding of uncertainties and are critical for identifying best practices for applications.

"This work supports previous findings, demonstrating that we need to consider many facets of datasets and ways to analyze them, as all of these factors play a role in how climate change impacts are portrayed in long-term natural resources planning studies."

Marketa Elsner
Hydrologic Civil Engineer, Reclamation's Technical Service Center

Research Office Contact

Miguel Rocha
Science and Technology Program Manager
303-445-2841
mrocha@usbr.gov

Collaborators

National Center for Atmospheric Research, Research Applications Laboratory

More Information

www.usbr.gov/research/projects/detail.cfm?id=675

Elsner, M., S. Gangopadhyay, T. Pruitt, L. Brekke, N. Mizukami, and M. Clark. 2014. *How Does the Choice of Distributed Meteorological Data Affect Hydrologic Model Calibration and Streamflow Simulations?* Journal of Hydrometeorology, 15, 1384–1403. DOI: http://dx.doi.org/10.1175/JHM-D-13-083.1.

RECLAMATION Managing Water in the West

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Bulletin 2014-21

The Knowledge Stream
Research Update

Improving Water Management With a State-of-the-Art Snow Model

A physically based, high resolution snow model for enhanced streamflow predictions in a changing environment

Bottom Line

Traditional river forecasting tools based on historical trends are struggling to cope with today's evolving climate. Models based on physical principles can handle such non-normal patterns. This research project helps determine their suitability for river management.

Better, Faster, Cheaper

This modeling approach can answer the vital questions faced by water managers throughout the snow season: how much water remains in the snowpack, how susceptible it is to melt, and when and where that melt water will enter the river system—no matter what the weather conditions.

Principal Investigator

Ted Day
Hydraulic Engineer
River and Reservoir Operations Office
Pacific Northwest Region
208-378-5273
tday@usbr.gov

Research Office Contact

Miguel Rocha
Science and Technology Program Manager
303-445-2841
mrocha@usbr.gov

Collaborators

U.S. Department of Agriculture's Agricultural Research Service

Problem

Current operational snowmelt-driven streamflow forecasts are largely derived from models based on statistical analyses of historic trends, such as the relationship of point observations of snow water equivalent to streamflow volume. Up until now, the reasoning has been that the computational demands of modeling over large basins required simpler, parameterized models. Often, a temperature-index melt model based solely on air temperature and historic melt patterns is used to forecast or analyze snowmelt rates. This simplified method is employed because it is computationally fast and air temperature data are readily available.

However, these statistically based models lack a strong physical basis. Snowmelt is a product of many physical processes such as sun, wind, and heat that depend on more than just air temperature. It has been shown that models without a physical basis become unreliable when non-normal conditions are encountered. Recent unseasonably warm winters have exposed the inadequacies of current modeling tools and clearly demonstrate the need for modernization.

Physically based distributed snow models (PBDSM) are founded on the physical processes governing snow accumulation and melt. PBDSMs require little to no calibration and are based on current and predicted conditions. The physical basis means that all mass and energy fluxes that affect the snow cover are numerically calculated based on the governing physics. These models readily adapt to changing conditions and are ideal tools for evaluating streamflow responses to short-term extreme events such as rain-on-snow; the extended effects of unseasonable wet, dry, warm, or cold periods; and the long-term effects of climate warming.

A lack of driving data (for example, mountain weather observations) for PBDSMs has also been seen as an impediment to more complex solutions. Today, however, computational capabilities have increased exponentially, efficient techniques for distributing limited observations have been developed, and gridded weather forecasts are readily available.

Solution

iSnobal is a PBDSM that has been successfully applied and tested in research basins throughout the world. The model independently resolves all the mass and energy fluxes affecting snow accumulation and melt while tracking the snowpack state (e.g., how susceptible is the current snowpack to melt). The model was designed for hydrologic applications and is forced with commonly measured or modeled meteorology.

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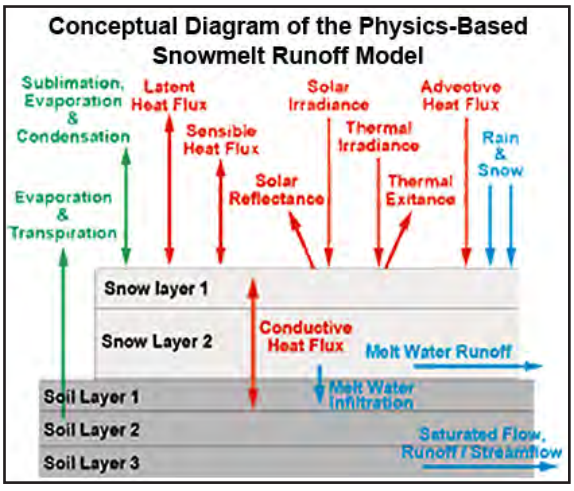

Schematic of the physical processes considered in iSnobal.

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This Reclamation Science and Technology Program research project applies iSnobal in an operational setting for the first time ever. The test application is in the Boise River Basin, Idaho, covering a model domain of 13,000 square kilometers (km^2). Three major reservoirs capable of storing close to a million acre-feet of water are located in the basin. Snow accumulation and melt is simulated with 0.01 km^2 resolution (100 x 100 meters)—100 times finer than the current SNODAS snow model from the National Weather Service. Project goals are to assess the feasibility of PBDSM applications in operational settings, determine how applications might be improved, and outline how water managers can best leverage modeling capabilities.

Application and Results

In 2013 and 2014, up-to-date iSnobal products were distributed to Reclamation on a weekly basis throughout the snowmelt season. Products included gridded snow distribution across the Boise River Basin, summations of snow storage above each of the three reservoirs by elevation, and maps of melt susceptibility. It was demonstrated that sufficient forcing data were available and that iSnobal products could be generated in a timely fashion compatible with operational needs.

Future Plans

Work is nearly complete on coupling a hydrologic routing model to iSnobal to convert simulated snowmelt and precipitation to streamflows entering the reservoir network. In 2015, short-term weather forecasts generated by the Weather Research and Forecasting (WRF) model will be input to the combined snow-routing model. These final steps will produce the most sophisticated modeling framework in the world for predicting snowmelt-generated streamflow on an operational basis.

Reservoir managers will have an advanced, modern tool for predicting inflows, optimizing water management, and increasing flood protection in all possible conditions. These modeling tools are not just specific to the Boise River Basin—the physical principles they are based on make them directly applicable to snow-fed basins throughout North America and beyond.

"We have already been able to use model results to support real-time operations for the Boise River Basin. The graphics and numerical products depicting distribution and amount of available snowmelt water were very useful in confirming our suspicions that runoff in both 2013 and 2014 would be less than forecasted, and less than what Snotel data alone would indicate."

Mary Mellema
Hydrologist, Reclamation's Pacific Northwest Region

More Information

www.usbr.gov/research/projects/detail.cfm?id=2264

Lucky Peak Dam and Reservoir, Idaho (a U.S. Army Corps of Engineers facility operated as a system with Reclamation's upstream Arrowrock Dam and Reservoir).

Anderson Ranch Dam and Reservoir, Idaho.

RECLAMATION Managing Water in the West

Fall 2014
Research and
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Bulletin 2014-22

The Knowledge Stream
Research Update

Understanding How Recharge Cycles and Dissolved Nitrate Affect Selenium

Using geochemical modeling and laboratory testing to track selenium and salinity

Bottom Line

This research project investigated the processes controlling selenium loading in the lower part of the Uncompahgre River Basin in western Colorado.

Better, Faster, Cheaper

These results identify recharge conditions and nitrate concentrations that promote and/or deter selenium and salinity mobilization, which will assist Reclamation in implementing best management practices for irrigation in the Western United States (U.S.). As the project evaluated generic geochemical processes rather than site-specific processes, results are directly transferrable to other locations in the Western U.S. where selenium-bearing shales lurk under waterways.

Principal Investigator

Terence L. Stroh
Chief, Environmental and Planning Group
Western Colorado Area Office
Upper Colorado Region
970-248-0608
tstroh@usbr.gov

Research Office Contact

Miguel Rocha
Science and Technology Program Manager
303-445-2841
mrocha@usbr.gov

Problem

Selenium concentrations can lead to serious environmental problems. Selenium is a major contaminant of concern in surface water in many Western States where Cretaceous marine shales naturally contain selenium. Selenium is leached to ground water and surface water by limited natural runoff, agricultural and domestic irrigation, and leakage from irrigation canals. In some areas, concentrations exceed levels that are deemed safe for sensitive aquatic life, including endangered fish. In the early 1980s, selenium contamination from irrigation wastewater caused deaths and severe deformations in waterfowl at the Kesterson National Wildlife Refuge in central California. Resource managers and policy makers have been addressing the potential for widespread selenium contamination at other sites since then.

However, to implement the best practices for managing selenium depends on understanding how selenium moves from the shale into and through water systems—and these processes are not fully understood. This is apparent in the Gunnison River Basin, Colorado. In the 2009 Programmatic Biological Opinion for the Gunnison River Basin, the U.S. Fish and Wildlife Service determined that "Colorado pikeminnow, humpback chub, bonytail, and razorback sucker are being harmed from continued discharge of selenium related to the Uncompahgre Project and other water uses in the Gunnison Basin. . .." The Gunnison Basin Selenium Management Program was developed as part of a broad-based cooperative effort to provide water security, environmental compliance, and regulatory certainty for water users in the Gunnison Basin.

Solution

This Reclamation Science and Technology Program research project investigated two ways that selenium can leach from shales and be transported through water systems:

1. Recharge and Water Table Fluctuations (Wetting and Drying). As stream and ground water levels fluctuate throughout the year, selenium can cycle between dissolved and solid phases. When water levels rise, selenium-bearing salts can be dissolved, mobilized, and flushed to streams. When water levels fall, salts can be left behind in deposits as water evaporates.

2. Dissolved Nitrate in Ground Water. In irrigated agricultural areas, dissolved nitrates in recharge and ground water have been statistically related to elevated ground water selenium concentrations.

Drillers and the rig obtaining core samples.

Application and Results

Reclamation and the U.S. Geological Survey (USGS) worked together to quantify the effects of selenium on water quality, aquatic wildlife, and birds in the Upper Colorado River Basin. The processes influencing selenium mobilization were examined with laboratory studies to determine geochemical mass balance and develop conceptual models using field data collected from the Lower Uncompahgre River Basin. Work included:

- Testing soil and sediment samples from the study area using sequential extractions to identify the forms of selenium present in solid phases
- Characterizing the form of selenium in non-irrigated and irrigated soils from agricultural sites and sediments from a wetland formed by a leaking canal
- Conducting laboratory leaching experiments and geochemical modeling
- Developing a conceptual model of selenium weathering to explain seasonal variations in the surface water chemistry of Loutzenhizer Arroyo, a major tributary contributor of selenium to the lower Uncompahgre River

The technical results of this study were published in the Applied Geochemistry Journal in August 2014.

Future Plans

A phase II investigation has been funded by the State of Colorado and USGS to characterize the occurrence, distribution, and spatial variability of selenium in soils in shallow aquifer sediments derived from Mancos Shale and associated soils. Ultimately, this information will assist in making land- and water-use decisions to decrease effects of selenium contamination.

Implications for Best Management Practices

During the irrigation season, most of the irrigation water is contacting soils that have been leached by decades of irrigation and have a relatively low capacity to release selenium. Deep percolation of irrigation water and leakage from canals promotes ground water flow through shallow bedrock along bedding planes and weathering fractures, dissolving selenium and nitrates from secondary salts.

Dissolved nitrates from the dissolution of soluble salts plays an important role in keeping ground water selenium concentrations elevated by inhibiting selenate reduction.

Nitrates in winter baseflow can be derived from naturally occurring salts in the Mancos Shale rather than leaching from fertilizers, although nitrate loading from irrigated fields is another potential source in surface water.

More Information

www.usbr.gov/research/projects/detail.cfm?id=6623

Mast, M.A., T.J. Mills, S.S. Paschke, G. Keith, J.I. Linard. 2014. *Mobilization of Selenium From the Mancos Shale and Associated Soils in the Lower Uncompahgre River Basin, Colorado.* Applied Geochemistry Journal, 48 16-17.

"These research results will provide important tools to assist in our understanding of selenium mobilization leading to more efficient, targeted approaches to control selenium loading in the basin."

Brent Uilenberg
Manager, Technical Services Division, Reclamation's Upper Colorado Region

Collaborators

- **U.S. Geological Survey**
- **Colorado River Water Conservation District**
- **Gunnison Basin Selenium Management Program**

Analyzing core samples.

RECLAMATION Managing Water in the West

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The Knowledge Stream
Research Update

Managing Datasets for Monitoring, Evaluating, and Decisionmaking

Improving data stewardship processes to meet decisionmaker needs, ensure data quality, and facilitate data sharing

Bottom Line

Data are valuable national assets for Reclamation, its partners, the U.S. Department of the Interior, the Federal Government, and the public. Managing data as assets and making them available, discoverable, and usable (now and in the future)—in a word, open—not only fosters transparency but also promotes institutional efficiency and effectiveness.

Better, Faster, Cheaper

Good data management promotes good science and engineering, fosters sound decisionmaking, and ensures that the agency and the public get the greatest return out of the investment in data collection and analysis.

Principal Investigator

Douglas Clark
Physical Scientist
Emergency Management and Geographic Information Systems Group
Technical Service Center
303-445-2271
drclark@usbr.gov

Research Office Contact

Miguel Rocha
Science and Technology Program Manager
303-445-2841
mrocha@usbr.gov

Problem

Stewardship of resources is a core part of Reclamation's mission, including water conservation, river restoration, water reuse, environmental protection, and invasive species control, to name only a few. To manage critical resources such as water and power, Reclamation must also manage the data and information associated with them. The scientific and technical data that Reclamation collects in these areas are also critical resources that require stewardship. These "mission-critical" data are difficult, costly, and/or impossible to recreate, if lost. Data damage or loss can actually compromise Reclamation's ability to accomplish its mission.

Numerous challenges presently face those charged with managing Reclamation's data assets, including time pressures and the lack of funding, policy, data standards, and efficient data management tools.

Solution and Results

To address these challenges, this Reclamation Science and Technology Program research effort assembled an interregional team to investigate the requirements of quality data stewardship. The Reclamation Data Stewardship Team held Reclamation-wide meetings, interviewed data management subject matter experts, took data stewardship training, compared data management systems, and conducted surveys. Among the findings were:

1. Above all, good data stewardship requires comprehensive planning. Data stewardship is the management of data through its entire lifecycle (from design through archiving). The Reclamation data lifecycle is a series of phases through which data progress to inform Reclamation's decisions or provide information to the public. Each phase of the lifecycle is related to, and driven by, the information requirements that pertain to the decision at hand.

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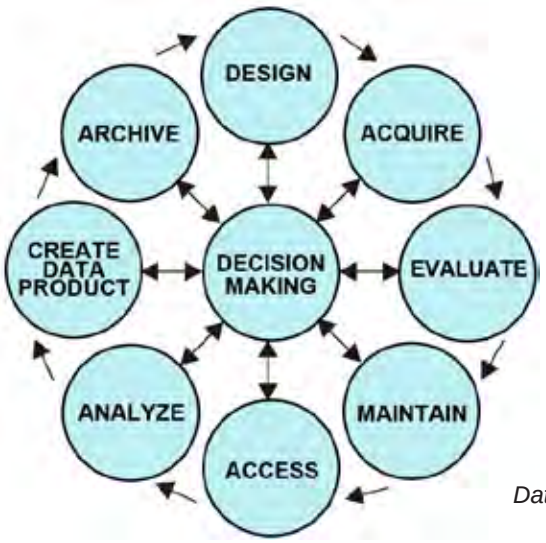


Data lifecycle.

— continued

2. In a survey of data stewards for 16 river restoration projects the team learned that collaboration and technology are viewed as being the most important building blocks for successful data stewardship.

Another survey, this one of Reclamation researchers, found that a number of challenges exist:

- Metadata stored with original data is shown to be the exception rather than the rule
- Data are generally not readily discoverable
- Storage redundancy is not always practiced
- Poor speed of access is shown to be a significant drag not only on storage, but on productivity overall
- Data stewardship policy and procedures are rare

Future Plans

This research helps lay the groundwork for implementing the May 2013 Executive Order 13642 making open and machine readable data the new default for government information. This order declares that federally generated data are valuable national assets whose value is amplified when they are made accessible. In response to that order, the U.S. Department of the Interior is developing related policy documents with the assistance of the Reclamation Data Stewardship Team.

The team is also evaluating a variety of data management initiatives in other agencies to determine best practices. Armed with this information, the team is currently heavily engaged with the Water Data Initiative, organized by the Lower Colorado Regional Director, Terry Fulp, to "establish and implement within Reclamation a process to publish water and other mission-related data, in support of Federal open data policy and making Reclamation resources data more comparable and sharable." If the water data initiative is successful, it will be but the first step in rationalizing other mission-critical data assets such as power, lands, infrastructure, and species at risk.

Data loss can be devastating (top right).

Working together to develop and preserve data (bottom left).

"Reclamation makes critical decisions based upon the data the agency collects and manages. Data are, therefore, valuable assets. Good data management is essential to ensure the quality, currency, and integrity of these information assets."

Curt Brown
Outgoing Chief of Research, Research and Development Office

Collaborators (Reclamation Data Stewardship Team)

- **Research and Development Office**
  - ◊ **Curt Brown, Outgoing Chief of Research**
- **Policy and Administration**
  - ◊ **Arthur Coykendall, Environmental Specialist**
- **Information Resources Office**
  - ◊ **James Nagode, Information Technology Specialist**
- **Technical Service Center**
  - ◊ **Bruce Whitesell, Physical Scientist**
- **Mid-Pacific Regional Office**
  - ◊ **Julie Eldredge, Quality Assurance and Data Management Branch Chief**
  - ◊ **Barbara Simpson, Geographer**

More Information

www.usbr.gov/research/projects/detail.cfm?id=3760

RECLAMATION Managing Water in the West

Fall 2014
Research and
Development Office
Bulletin 2014-24

The Knowledge Stream

Research Update

Looking at Bed Load 24 Hours a Day

Using acoustics to continuously measure coarse bed load movement in a river

Bottom Line

This research project is the first in North America to install bed load impact plates on a riverbed, which is a new method to measure gravel transport in stream channels, also known as bed load.

Better, Faster, Cheaper

Long-term monitoring of bed load movement will provide invaluable data for studying bed load transport during and after dam removal. This permanent installation saves time and money by automating bed load measurements and provides continuous measurement under all flow conditions. Furthermore, this reduces the risk of sending staff to collect measurements during high riverflows, when most bed load moves.

Principal Investigator

Robert C. Hilldale
Hydraulic Engineer
Sedimentation and River Hydraulics
Technical Service Center
303-445-3135
rhilldale@usbr.gov

Research Office Contact

Miguel Rocha
Science and Technology
Program Manager
303-445-2841
mrocha@usbr.gov

Collaborators

- **National Center for Physical Acoustics (University of Mississippi)**
- **Graham Matthews & Associates**
- **U.S. Geological Survey**
- **National Park Service**

Problem

Hard to Measure Bed Load Transport. Moving sediment on or near the bed of a river (by rolling, sliding, or "saltating"—like skipping or jumping along the bottom) is vital to a river's health. However, quantifying that motion is difficult because bed load moves only during high flow events, perhaps once a year under normal conditions. Measuring bed load transport using classical means, with pressure-difference bed load samplers, only provides snapshots (1 to 2 minutes) of data at discrete times and locations across the channel and is dangerous during floods. To truly understand bed load transport, a reliable way to continuously measure its movement is needed.

Challenges to bed load transport measurements have prevented a thorough understanding of the physical processes responsible for bed load motion, from initiation to sustained transport. Data collected with the bed load impact plate system will increase our understanding of the transport of coarse bed load in gravel-bed rivers.

Measurements Are Critical to Understanding Impacts From Dam Removal. Sediment has accumulated behind the Elwha and Glines Canyon Dams for nearly a century, and nearly 10 million cubic yards of sediment have been released from the two reservoirs. Removing the dams has re-established the natural flow of sediment from the Olympic Mountains down to the Strait of San Juan de Fuca, restoring the estuary, beaches, and shellfish beds along the mouth of the river.

This sediment underlies the entire ecosystem and is critical for building aquatic and riparian habitat. As the dams were removed, sediment that accumulated behind the dams was transported down the river creating high sediment loads in the lower river, significantly impacting the river and nearshore ecosystems.

Because this impact plate installation is just downstream from these two dam removal projects, bed load transport during and after dam removal will also be better understood. Monitoring bed load movement during and after dam removal is critical for many reasons, primarily for the implications that bed load has on channel morphology (form). Sediment erosion from reservoir delta deposits, and its ensuing transport and fate, has not been previously well documented or understood.

Graham Matthews & Associates personnel using classic methods to measure bed load for calibration.

This sedimentation monitoring program involves many Federal agencies, such as Reclamation, U.S. Geological Survey (USGS), and the National Park Service. Monitoring and interpreting sediment transport along the river from the former dams to the ocean will provide key data to manage the Elwha River Restoration Project, and it will provide a better understanding of the impacts of large-scale dam removal on downstream ecosystems.

Solution

This Reclamation Science and Technology Program research project has installed and is calibrating an innovative bed load impact plate system, the first permanent installation of its kind in North America. The impact plate system consists of a series of 72 plates (approximately 20 inches by 14 inches) mounted adjacently, providing continuous measurement along the riverbed at one cross section. Forty-six plates are equipped with a geophone and 26 plates with an accelerometer. This instrumentation measures the deformation of the steel plate as sediment contacts it, but the geophones and accelerometers provide different electrical signals. Three streamside computers manage the continuous data collection, pre-process, and store the data. The computers can be accessed remotely to manage the data collection parameters and download data.

Application and Results

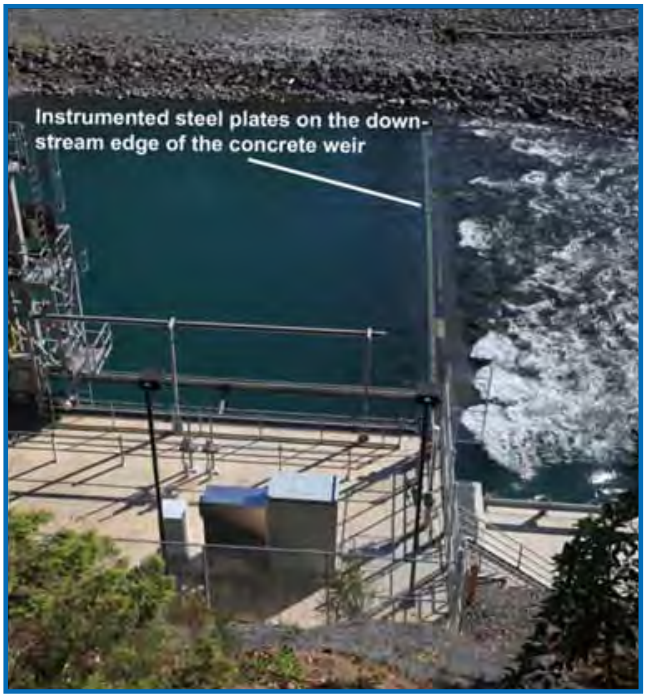
Before obtaining reliable sediment measurements from the bed load impact plates, the system must be calibrated. To compare the performance of the 46 geophone plates to traditional measurements, bed load was measured with a TR-2 pressure-difference bed load sampler (suspended from a crane mounted on the raft). These data are being compared in this ongoing calibration process. Four separate bed load measurement campaigns have been completed and more are planned.

Using this preliminary calibration, approximations of bed load being released from both reservoirs during the first 2 years of dam removal have been made. USGS is continuously measuring suspended sediment transport at the same cross section, providing a picture of sediment transported in the water column. Combined, these data provide a nearly complete picture of all sediment being transported past this measurement cross section, one of only a few such data collection sites in the world.

Future Plans

Electrical signals produced by the geophones are reasonably well understood, although the same understanding of the signals generated by an accelerometer and calibrating these measurements on site still need to be developed. Reclamation is partnering with the U.S. Department of Agriculture's Agricultural Research Service and will place a two-plate impact system equipped with accelerometers in a gravel and water recirculating flume at the National Sedimentation Laboratory in Oxford, Mississippi, to determine appropriate measurement algorithms with which to measure bed load transport. The accelerometers produce a richer signal, providing more detailed information about the sediment transport process.

After a complete system calibration, the computer management system will be automated, where data are completely processed, backed up, and published on the web. This will greatly decrease the involvement of Reclamation's Technical Service Center personnel in managing the system and processing the data, further reducing cost.



Photograph of the bed load impact plate system on the Elwha River, Washington. Photograph courtesy of Graham Matthews & Associates.

"The installation and operation of the bed load impact sensors on the Elwha River near Port Angeles, Washington, are a cutting edge achievement in the continuous monitoring of gravel transport. This installation is the first of its kind in North America and Reclamation should be proud."

Tim Randle
Manager, Sedimentation and River Hydraulics Group, Reclamation's Technical Service Center

More Information

www.usbr.gov/research/projects/detail.cfm?id=115

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RECLAMATION Managing Water in the West

Fall 2014
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Bulletin 2014-25

The Knowledge Stream

Research Update

Predicting Erosion in Rivers and Reservoir Settings

Are complex channel processes during dam removal ready to be simulated?

Bottom Line

Using the erosion of the Lake Mills Delta (behind Glines Canyon Dam on the Elwha River, Washington), new geofluvial modules of the SRH-2D model were tested for predicting both vertical and lateral erosion in reservoir sediment deltas. It was found that the current state-of-the-art models can be used to simulate simultaneous vertical and lateral erosion of a reservoir sediment delta during reservoir drawdown or dam removal. However, further research is needed to improve the accuracy of simulations regarding the timing and extent of sediment erosion.

Better, Faster, Cheaper

Numerical modeling that incorporates the hydraulic complexities of reservoirs and rivers, such as bank erosion, can more accurately predict potential sediment impacts and provide critical information for species recovery and river restoration projects, as well as other analyses.

Principal Investigators

Yong Lai
Hydraulic Engineer
Sedimentation and River Hydraulics Group
Technical Service Center
303-445-2560
ylai@usbr.gov

Jennifer Bountry
Hydraulic Engineer
Sedimentation and River Hydraulics Group
Technical Service Center
303-445-3614
jbountry@usbr.gov

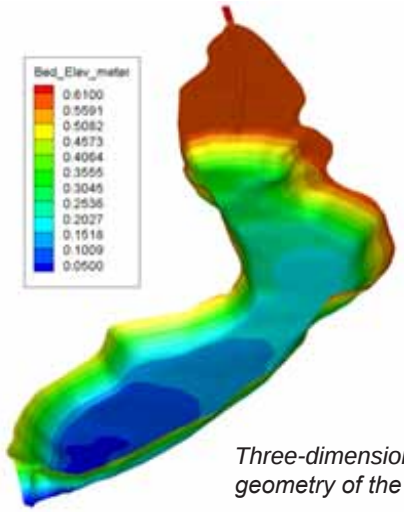
Problem

Erosion of riverbanks and reservoir sediment deltas could lead to temporary increased sediment loads, decreased instream habitat, and risks to downstream infrastructure. When high flows occur or when reservoir levels drop, high velocity flows cut through the sediment (vertical incision) and laterally erode into the banks. Modeling both these erosion processes is critical to predicting how much sediment will be released into the downstream system and how long these releases will last.

As many complex physical processes are involved in reservoir delta and river channel morphological development, many projects rely on qualitative measures rather than quantitative predictions. For some projects, such a qualitative approach is adequate; for others, a more accurate quantitative prediction is needed to reduce uncertainty in designing or operating infrastructure such as pumping plants or for river restoration projects.

The Sedimentation and River Hydraulics–Two-Dimensional Model (SRH-2D) that Reclamation's Technical Service Center developed has been widely used for both hydraulic and sediment modeling for engineering and river restoration projects since 2006. While sediment transport models can predict vertical bed elevation changes numerically, the many complex processes involved in lateral bank erosion have made such modeling elusive. Now, new bank erosion modules have been developed to simulate both vertical and lateral stream erosion processes.

Although SRH-2D has been used to predict dam removal sedimentation processes (for example the Klamath River; the Colorado River in the reservoir pool behind Palo Verde Dam, Arizona/California; and a sediment plug on the Rio Grande River), the model adequacy is yet to be demonstrated for complex channel processes occurring in dam removal scenarios. Determining if SRH-2D, a current state-of-the-art multidimensional sediment and morphological model, can predict both vertical and lateral sediment erosion and deposition processes during dam removal is crucial for using this in future analyses.



Three-dimensional view of the initial geometry of the specific model run, 3xC.

Solution

The large amount of physical model and field data available from the Elwha River Restoration Project near Port Angeles, Washington, provided a unique opportunity to test and verify the Reclamation model. This Reclamation Science and Technology Program research project applied the new SRH-2D model, including bank erosion modules, to simulate the delta processes during the removal of Glines Canyon Dam in the former Lake Mills on the Elwha River.

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Removing two dams on the Elwha River exposed roughly 27 million cubic yards of sediment and wood trapped in the reservoirs. Both vertical and lateral sediment erosion processes were very important during the lowering of the reservoir.

A physical model dataset was compared against the new geofluvial SRH-2D model, which coupled bank erosion modules with the mobile-bed model, to simulate the delta erosion and deposition characteristics when dam notches are removed.

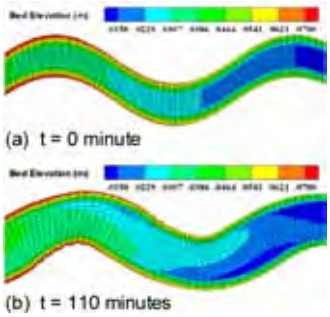
Results and Conclusions

The University of Arizona tested the numerical model against data from a field drawdown case when Lake Mills behind Glines Canyon Dam was lowered 18 feet during April 1994. Comparing the two methods reached these conclusions:

- When erosion processes include both lateral and vertical erosion, modeling bank erosion is critical to incorporate for accurate overall predictions of erosion patterns.
- The Lake Mills test case showed that SRH-2D predicts qualitative erosion and deposition patterns well.
- The new geofluvial SRH-2D model achieved limited success—it can simulate simultaneous vertical and lateral erosion of the delta. However, the model still misses some of the details (e.g., timing and extent) of the lateral erosion.

Looking upstream at sediment terraces left behind from dam removal notching and tree stumps where the river has cut tens of feet down through sediment deposits into the pre-dam floodplain.

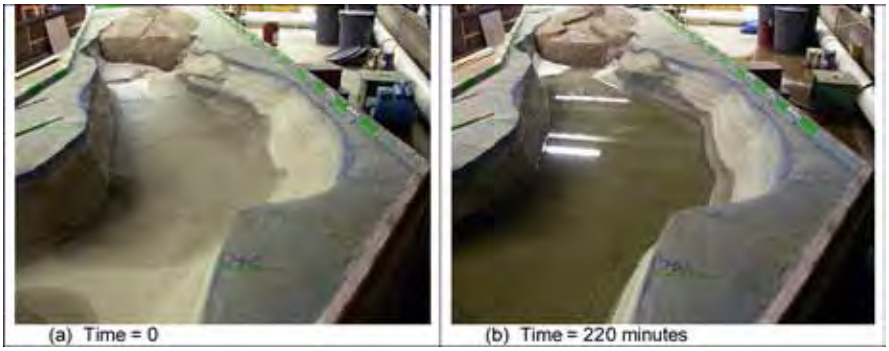
After 3 years of dam removal, the Elwha River has carved a new landscape resulting from multiple phases of vertical and lateral erosion by riverflows.



Initial and final meshes for simulation Run 3 with the moving mesh (contours are bed elevation).

Future Plans

Reclamation can use this new model now on river erosion cases and reservoir deltas to show relative trends related to alternative scenarios for decisionmaking. Additional model research and development are needed to further develop and refine a bank erosion module that can track the region of the channel bank, or bank toe point, in a robust and stable way, particularly for the field situation.



Initial terrain and terrain after 220 minutes during the physical model test. Photographs courtesy of Chris Bromley, University of Nottingham, England.

"The determination of a river channel width has been a problem for centuries. Engineers and scientists have had to simulate river hydraulics with a known channel width. This research advances our understanding of how to simulate streambank erosion and channel width changes over time."

Tim Randle
Manager, Sedimentation and River Hydraulics Group, Reclamation's Technical Service Center

Research Office Contact

Miguel Rocha
Science and Technology Program Manager
303-445-2841
mrocha@usbr.gov

Collaborators

- **Reclamation's Pacific Northwest Region**
- **University of Arizona**
- **National Park Service**

More information

www.usbr.gov/research/projects/detail.cfm?id=7356

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RECLAMATION Managing Water in the West

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The Knowledge Stream
Research Update

Quickly Determining Pools and Riffles Stability in Gravel-Bed Rivers

Evaluating the use of a rapid assessment tool that could help design sustainable pool-riffle habitat

Bottom Line

This research project evaluated simple measurements representing a ratio of averaged cross section flow velocities at a pool and riffle sequence. These measurements may be an indicator that determines the self-sustainability of pools and riffles—even with changes in annual streamflows from climate change, anthropogenic uses, or watershed disturbances.

Better, Faster, Cheaper

This rapid assessment tool may be a cost-effective way to determine if a pool and riffle will be self-sustaining with further field evaluation. This could help identify and develop self-sustaining habitat features and minimize maintenance costs in retaining these features, as well as ascertain where more detailed analyses are warranted. This can save project dollars in both design and maintenance.

Principal Investigator

Sharon Parkinson
Program Manager
Design Group
Pacific Northwest Region
208-378-5210
sparkinson@usbr.gov

Research Office Contact

Miguel Rocha
Science and Technology
Program Manager
303-445-2841
mrocha@usbr.gov

Problem

Gravel-bed rivers are an important habitat for salmonids. Pools and riffles in gravel-bed rivers are particularly critical for spawning and other life stages. Pool-riffle sequences comprise two distinct features. Pools are streambed depressions that occupy the main portion of the channel with a near horizontal water surface slope and lower velocities than riffles under low flow conditions. Riffles usually have steeper water surface slopes and higher velocities at low flow conditions.

The goal for many restoration projects is to create habitat features that will behave like natural systems, with as little intrusive maintenance as possible. This involves balancing natural stream dynamics—the combination of water flows and the available range of sediment sizes. Typically, designing sustainable pools in a restoration project requires either empirical analyses or full three-dimensional hydrodynamic and sediment transport models. But few projects have the budget to conduct a thorough modeling approach.

However, using simple measurements of physical conditions and respective ratios may provide a rapid assessment tool. This tool builds on the hypothesis of "velocity reversal" when the cross section averaged velocity becomes greater within the pool with respect to the riffle. This then assumes that sediment from the pool will scour and settle on the riffle, thus maintaining these sustainable pools and riffles without outside intervention. This tool is a simple one-dimensional criterion used to determine whether sustainable pools and riffles will be retained over time.

If river restoration designers use this tool, they could then determine which pools and riffles are likely to be stable, build features with the self-sustaining ratio properties, and focus efforts on those reaches where additional engineering design may be necessary to protect infrastructure and property.

Collecting data on the Red River Wildlife Management Area, Idaho.

Solution and Results

This Reclamation Science and Technology Program research project evaluated this simple set of measurements to find out if this rapid assessment would predict the stability of pools and riffles. These simple measurements can easily be collected in the field (using a tape for measuring channel widths and survey rod for measuring bottom depths) to determine whether a particular feature within a restoration reach should be left untouched, so efforts can focus on features that may require engineered features to create stable conditions. This information could supplement or replace more detailed numerical modeling used to design habitat restoration projects.

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First, the hypothesis was tested using the one-dimensional criterion by collecting and analyzing field measurements at the Red River Wildlife Management Area. The Idaho Department of Fish and Game manages this area, which is in the Lower Red River Meadow near Elk City, Idaho. Based on work to date:

- Field data support the hypothesis that velocity reversal may be a mechanism for the long-term sustainability of unforced pools.
- This measurement appears to be a reasonable indicator of whether pool-riffle sequences will persist.

Constructed large wood jam on the Trinity River. Ground photograph (left) compared to Light Detection and Ranging (LiDAR) scan (right).

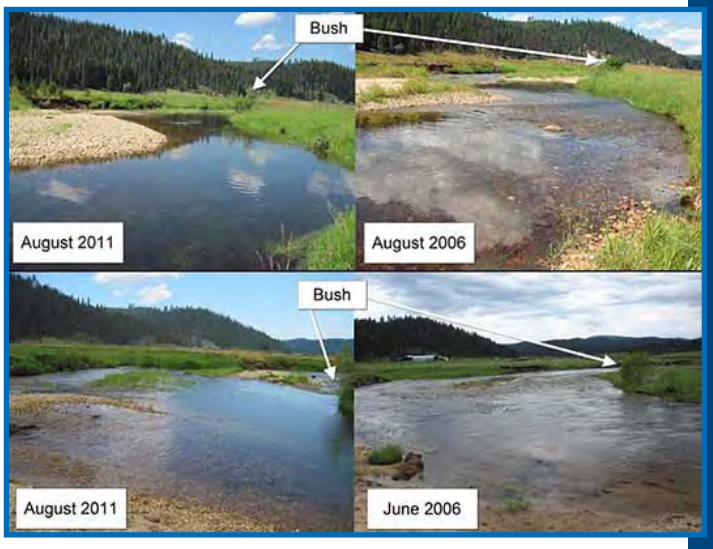
Next, to further understand how sediment transport influences how pools and riffles can be sustainable, laboratory experiments were conducted to replicate field conditions that are typically too dangerous and technically difficult to conduct safely in the field. Examinations of sediment transport processes found that while this rapid assessment tool is a cost-effective approach, it is a simplistic representation of complex hydraulic, sediment transport processes. For example, sediment overload of the pool may restrict self-recovery.

Future Plans

Using this rapid assessment tool means that simple measurements can easily be collected in the field and results have shown the usefulness of the approach in rapidly assessing the vulnerability of pool habitat for the Red River in north-central Idaho.

More testing is needed to:

- Determine the effectiveness of this rapid assessment tool over long periods of time and in other rivers. Monitoring the features in the Red River as the features evolve and move over time in natural systems should also continue.
- Determine how this tool is limited by sediment processes. Further plans are to collect pool-riffle dimensions in Reclamation's ongoing and proposed restoration projects. In addition, these will be applied to other restoration efforts to determine if this predictor can be modified and applied in other ways based on other sediment, hydrologic, or other physical reach conditions (for example, slope gradient).



Before and after—a dual pool-riffle sequence became a single pool-riffle sequence on the Red River Wildlife Management Area, Idaho.

"These physical measurements can be easily collected in the field and may be used in the monitoring and design of sustainable pool-riffle habitat features in gravel-bed rivers. These study results and guidelines could be applicable to instream habitat restoration projects throughout Reclamation."

Ferron (Jeff) Peterson
Habitat Program Manager, Reclamation's Pacific Northwest Region

Collaborators

- **Reclamation:**
  - ◊ **Pacific Northwest Regional Office**
  - ◊ **Pacific Northwest Region's Columbia/Snake River Salmon Recovery Office**
- **University of Idaho, Center for Ecohydraulics Research**
- **State of Idaho Experimental Program to Stimulate Competitive Research**
- **National Science Foundation**

More Information

www.usbr.gov/research/projects/detail.cfm?id=4362

RECLAMATION Managing Water in the West

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Bulletin 2014-27

The Knowledge Stream
Research Update

Large Wood National Manual

Developing a National Manual for Planning, Designing, and Implementing Large Wood Projects

Bottom Line

Reclamation and the U.S. Army Corps of Engineers (USACE) are jointly developing a Large Wood National Manual to help establish more consistent methods to assess, design, and manage wood projects intended to restore streams and rivers throughout the United States.

Better, Faster, Cheaper

By more comprehensively understanding the detailed biology, geomorphology, hydraulics, and engineering aspects of a large wood design, practitioners will now be able to apply these guidelines on various river restoration projects across a range of geographic regions. This manual will also help provide a consistent process for project design and offer various techniques for applying wood as a restoration method.

Principal Investigator

David (D.J.) Bandrowski
Implementation Branch Chief
Trinity River Restoration Project
Mid-Pacific Region
530-623-1811 or 530-784-3234
dbandrowski@usbr.gov

Research Office Contact

Miguel Rocha
Science and Technology
Program Manager
303-445-2841
mrocha@usbr.gov

Problem

Wood is not just debris that rivers carry to the sea, but rather are important elements that alter channel shape and form (morphology), create habitat, store sediment and organic matter, and change landscapes. The role of wood in creating aquatic and riparian habitat has led many regulatory agencies and fisheries advocates to recommend the re-introduction of large wood structures in rivers and streams.

Various Federal and state agencies are increasingly advocating that more wood be used as a "softer," more cost-effective, and ecologically beneficial engineering approach in restoration and mitigation projects to meet environmental mandates and endangered species requirements, while maintaining traditional agency missions. The term "softer" only implies that wood is a natural part of a river and, thus, better fits within the context of restoring natural conditions.

Yet there is nothing soft about the analysis and design of wood projects—they should be conducted with the same scientific and engineering rigor as any river project. Natural resource management professionals need practical information on how to use large wood in restoration practices and understand how to manage wood that naturally enters rivers and streams. This manual provides river and stream restoration professionals with comprehensive guidelines for the planning, design, placement, and maintenance of large wood in rivers and streams with an emphasis of restoring ecosystem process and function.

Solution

This Reclamation Science and Technology Program research project partners with the U.S. Army Corps of Engineers (USACE) and brings universities, private industries, and government entities together to develop a manual to:

- Serve as a practical resource for planners and help practitioners in the restoration industry to understand the roles of wood and how it should be re-introduced and managed in fluvial ecosystems using both active (placement) and passive (recruitment and transport) methods
- Develop comprehensive guidelines for the planning, design, placement, maintenance, and assessment of large wood in rivers and streams with an overarching emphasis of restoring ecosystem forms, processes, and functions, given the current states of science and practice

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- Provide guidance to states, territories, Native American Tribes, local governments, watershed organizations, and the general public regarding technical tools and sources of information for the planning, design, placement, and maintenance of large wood in rivers

The manual covers:

- The need and purpose of large wood in rivers
- Large wood planning processes
- Geomorphic and hydrologic considerations
- Ecological considerations
- Risks associated with wood placements
- Regulatory compliance, tradeoffs, and uncertainties
- Design and engineering considerations
- Fisheries considerations
- Flood events and related considerations
- Project implementation and construction

Large wood structure under construction at the Sawmill Rehabilitation Project (2009) on the Trinity River, near Lewiston, California.

In fields as fast-changing as restoration ecology and practice, this material will be improved with additional knowledge and experience. However, the basic elements of the manual will hold true long into the future—particularly the underlying premise that wood is a critical component of fluvial systems and will become more appreciated with additional research. Thus, Reclamation and USACE hope that this manual provides guidance and acts as a catalyst to drive further innovations and improved benefits for aquatic ecosystem restoration.

Future Plans

Four chapters are complete and have been peer reviewed by approximately 20 regional experts. The next four chapters will be out for both internal and external review in November 2014 with the final version slated for completion in May 2015, which will include two additional chapters bringing the total chapter count to 10. The *Large Wood National Manual* will be disseminated electronically and is designed to allow for future chapter developments and new scientific literature to be added annually.

Large Wood Conference, "Technical Workshop on Large Wood Applications and Research Needs in River Restoration," February 2012.

"This manual will provide the common set of guidelines for using wood in restoration efforts. This will serve as a foundation for future planning, design, implementation, and regulatory review to help restore ecosystem forms, processes, and functions."

D.J. Bandrowski
Implementation Branch Chief, Reclamation's Mid-Pacific Region

Collaborators

- **Reclamation:**
  - ◊ **Research and Development Office's Science and Technology Program**
  - ◊ **Pacific Northwest Region's Columbia/Snake River Salmon Recovery Office**
  - ◊ **Mid-Pacific Region's Trinity River Restoration Program**
- **U.S. Army Corps of Engineers-Engineer Research and Development Center (USACE-ERDC)**
- **Utah State University**
- **ICF International**
- **Natural Systems Design**
- **Shields Engineering**
- **Fox Environmental**

More Information

www.usbr.gov/research/projects/detail.cfm?id=2754

RECLAMATION Managing Water in the West

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The Knowledge Stream
Research Update

Modeling How Large Woody Debris Structures Affect Rivers

Modeling river changes from large wood structures and other instream structures

Bottom Line

This research project analyzed a number of existing state-of-the-art modeling tools for their suitability to predict the flow and morphological changes caused by large wood and instream structures so that the tools may contribute to the design.

Better, Faster, Cheaper

While several Reclamation regions have used large wood structures for river restoration, their use has been challenged due to a lack of general design guidelines that address the risk, safety, and morphological impacts. Providing a numerical model that can predict these impacts will allow Reclamation to use this river restoration technique responsibly and effectively. Moreover, these modeling tools, once verified, could also be used for a wide range of Reclamation projects (e.g., design guidelines for instream structures and fish habitat studies).

Principal Investigator

Yong Lai
Hydraulic Engineer
Sedimentation and River Hydraulics Group
Technical Service Center
303-445-2560
ylai@usbr.gov

Research Office Contact

Miguel Rocha
Science and Technology Program Manager
303-445-2841
mrocha@usbr.gov

Problem

Providing large wood features in a stream can help restore rivers and recover endangered species by re-establishing flow patterns and enhancing habitat. However, these large woody structures may cause scour and change the shape of the river—and these processes and risks are not well studied or understood.

Methods and guidelines for determining risk, designing structures that effectively provide habitat and restore rivers, and predicting the river's response to large wood structures are not available. Traditional methods to measure and predict scour mostly rely on data from flumes, which suffers from scale problems. Field data for scour are scarce and expensive to obtain.

Moreover, large wood structures' irregular forms make laboratory or field studies difficult. Large wood in rivers is usually in a chaotic form, with logs, branches, roots, and slash materials in various sizes and at different angles—forming an array of interwoven geometries. This collection of geometries presents a challenge when trying to replicate as a three-dimensional (3D) solid model.

However, accurate scour and morphological predictions for these complex forms are becoming feasible as more numerical modeling tools become available. These

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Logjam on the lower Trinity River. Photograph courtesy of the Trinity River Restoration Program.

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tools need to be evaluated and tested for large woody structures to determine their risk, safety, and scour and morphological impacts.

Computational fluid dynamics (CFD) modelling is an attractive alternative. However, CFD modelling for large wood structures has its own challenges—the difficulty of mesh representation and lack of reliable and practical 3D flow and mobile-bed models.

Solution

This Reclamation Science and Technology Program research project evaluated models and potential field work to determine what could be used to understand the flow field around large wood structures and the morphological changes that these structures may cause.

Test cases on the Trinity River were selected and constructed wood jams were studied by collecting high resolution terrestrial and bathymetric topography to establish a monitoring baseline.

Engineered logjam on the Trinity River under floodflows. Photograph courtesy of the Trinity River Restoration Program.

Future Plans

This study determines that some models could become the primary quantitative prediction tools for scour and morphological impacts related to large wood structures. Collecting repeat data after high flow releases to capture any morphological changes over time is proposed. In addition, unique tools will be deployed to capture the underwater vertical face of the constructed wood jams. These data collections will pose the most challenges due to the logistics of dealing with swift current and limitations with marine equipment applied to a complex riverine environment. These data will be used to evaluate and compare against the predicted results of the 3D hydraulic modelling output. A number of collaborators could help to evaluate models, including:

- U2RANS: A 3D numerical model developed at the University of Iowa and modified and improved for realistic riverflows at Reclamation
- SRH-2D: A 2D hydraulic and sediment transport model developed by, and widely used at, Reclamation and by external universities, research institutions, and consulting companies
- OpenFOAM: An open source CFD model

"State-of-the-art computational fluid dynamics modelling could help us understand how large wood structures work and interact in a river environment."

Yong Lai
Hydraulic Engineer, Reclamation's Technical Service Center

Collaborators

- **Reclamation's Trinity River Restoration Program**
- **Penn State University**
- **U.S. Army Corps of Engineers**
- **Taiwan Water Resources Agency**

More Information

www.usbr.gov/research/projects/detail.cfm?id=5772

Recovering Species and Restoring Ecosystems

America's Great Outdoors

Source: Saginaw Bay Resource, Conservation, and Development.

www.saginawbayrcd.org/outdoors.shtml

America's Great Outdoors (AGO) is an initiative to establish a community-based, 21st century agenda for conservation, recreation, and reconnecting Americans to the outdoors.

AGO brings together many Federal agencies to work together with state and local partners across the country.

Reclamation's river restoration work directly supports the President's AGO initiative by:

- **Protecting and renewing rivers, enhancing recreational opportunities**
- **Conserving and restoring Federal lands and waters**
- **Engaging young people in conservation**

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Research Builds the Foundation for Reclamation's Recovery and Restoration Programs

Reclamation conducts extensive species recovery and river restoration activities on many of its projects throughout the Western United States. These programs are essential to Reclamation's core mission of delivering water and generating power. They also help Reclamation meet its tribal trust responsibilities and comply with applicable legal requirements such as those under the Endangered Species Act and the Clean Water Act.

While both recovery and restoration programs are conducted to ensure that Reclamation can continue water and power deliveries, there are some key differences:

Recovery Programs	Restoration Programs
To recover threatened or endangered species so that they can be "down-listed" or de-listed.	To restore and maintain fish and wildlife populations and habitat.
Typical actions: • Rearing and stocking fish • Inspecting fish for disease • Removing non-native fish • Protecting instream flows and designated habits • Screening canals and other infrastructure • Providing fish passage • Modifying habitat	Typical actions: • Providing variable flows • Rehabilitating channels • Managing sediment • Restoring riparian vegetation • Constructing wetlands • Installing water temperature control devices • Addressing water quality issues
	
Saving the razorback sucker in the San Juan River Basin Recovery Implementation Program. Source: San Juan River Basin Recovery Implementation Program, FWS (www.fws.gov/southwest/sjrip/photo_gallery.cfm?PL=3).	*Trinity River Restoration Program constructed the Sven-Olbertson Side Channel.*

Recovery programs are conducted with the U.S. Fish and Wildlife Service (FWS) as "Reasonable and Prudent Alternatives" outlined in Biological Opinions. River restoration programs often take a watershed and ecosystem view as water supplies are less variable and more certain in restored river systems. Often, both recovery and restoration programs take an adaptive management approach, continually assessing the environment and making program decisions based on these data and ongoing research. By partnering with other Federal, state, and local agencies; tribes; and various non-profit environmental conservation organizations and stakeholders, Reclamation's recovery and restoration programs benefit fish and wildlife and their habitats.

Developing Research Roadmaps

Coping with the very large geographic scales of species recovery and river restoration, as well as the lengthy time scales for program implementation and species response, requires careful coordination for research priorities. The Research and Development Office (Research Office) supports these efforts to prioritize research and coordinate data. For example:

- Large wood research roadmap (see Research Update, *How Large Woody Debris in Streams and Rivers Can Help Habitats*, which can be found at: www.usbr.gov/research/docs/updates/2013-26-large-wood.pdf)
- Ecohydraulics research roadmap (see article on page 24)
- Trinity River Restoration Program online data portal (see Research Update, *Trinity River Restoration Program's Online Data Portal*, which can be found at: www.usbr.gov/research/docs/updates/2012-11-online-data-portal.pdf)

Tracking Fish

The Research Office supports research into the latest technology in transducer development and radio communications to track fishes. Adult and juvenile tracking require different technologies, due to their physiological differences, making tracking complex. The Reclamation Science and Technology Program has assisted with several projects for recovery programs, including assisting in developing a floating Passive Integrated Transponder (PIT) tag antenna system, evaluating the effectiveness of fish screens and weirs, and testing the effects of electrofishing and non-native fish removal on endangered fish. A device was also developed to track fish in turbid water at Sack Dam, California.

Understanding Flows

Determining flows for the environment is the interface between Reclamation's recovery and restoration programs and flow and power operations. For example, the Trinity River Restoration Program designs the hydrograph for the river and the Central Valley Project implements the hydrograph. Designing environmental flows takes into account a variety of factors, such as the habitat, riverflows and sediment, and life-cycle requirements of the fish. The Research Office has partnered in years of research to develop the ecohydraulic tools for designing environmental flows, such as fish swimming performance, sediment transport, geomorphology, benthic production, fish tracking, and more. Other programs, such as the Grand Canyon and San Joaquin River programs, operate in a similar manner and also depend on these research tools.

Restoring Habitat

Initial restoration strategies relied on larger flows to initiate sediment transport and scour riparian vegetation, resulting in geomorphic complexity that—in terms of ecohydraulics—may equate to aquatic habitat. As insights into flows and habitat restoration have increased, this strategy has evolved via adaptive management processes. Now, based on more research, adaptive management includes elements such as extensive flood plain lowering and large wood structures to 'jumpstart' the habitat creation/ sustaining processes.

Understanding Sediment Transport

Developing sediment transport models and ways to track sediment is critical in designing channel rehabilitation projects and analyzing annual restoration flow regimes.

America's Great Outdoors continued

AGO takes as its premise that lasting conservation solutions should come from the American people—that the protection of the Nation's natural heritage is a non-partisan objective that is shared by all Americans.

Reclamation incorporates AGO goals of protecting and renewing rivers, enhancing recreational opportunities, conserving and restoring Federal lands and waters, and engaging young people in conservation into all its operations.

Research Is Key

These recovery and restoration programs use a diverse set of ecohydraulic tools in a wide array of circumstances and situations.

The Research and Development Office provides funding to develop and evolve these tools to meet emergent needs in both recovery and restoration programs.

More Information

See the "Multimedia Around Reclamation" segment in this issue for videos of recovery and restoration projects, as well as the Trinity River Restoration Program.

A more comprehensive list of river restoration projects and programs at Reclamation can be found at:

www.usbr.gov/river/.

RECLAMATION Managing Water in the West

Fall 2014
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The Knowledge Stream
Research Update

Improving Public Safety of Large Wood Installations

Designing and installing safer large wood structures

Bottom Line

This scoping-level research project identified specific research gaps on safety issues and determined the best way to address these gaps to design and install safer large wood structures.

Better, Faster, Cheaper

Ensuring the safety of the public is paramount to Reclamation's efforts. Concerns over public safety and liability of large wood projects in Reclamation's restoration programs need to be addressed.

Principal Investigators

Connie Svoboda
Hydraulic Engineer
Hydraulic Investigations and Laboratory Services Group
Technical Service Center
303-445-2152
csvoboda@usbr.gov

Christopher Cuhaciyan
Hydraulic Engineer
Regional Office
Pacific Northwest Region
208-378-5143
ccuhaciyan@usbr.gov

Sean Kimbrel
Hydraulic Engineer
Sedimentation and River Hydraulics Group
Technical Service Center
303-445-2539
skimbrel@usbr.gov

Problem

Large wood installations are an important component of Reclamation's overall river restoration strategy. However, large wood structures can pose a public safety hazard to river recreational users such as boaters, swimmers, fisherman, and children. Installing large wood structures in rivers can produce what are known in the boating community as "strainers." Flow through or flow underneath the structure can pin boaters or swimmers against the structure or pull them under the water surface. Large wood structures also produce an attractive location for fishing, playing, and climbing.

A multilog large wood structure placed in the center of the Green River, a tributary of the Colorado River.

Design features such as structure porosity, structure orientation, log submergence, percent river obstruction, and use of cables and metal bars affect the safety of the structure. Large wood installations can become structurally unstable and fail, such that part or all of the structure moves downstream. Liability associated with large wood installations has become a widely discussed topic within the river restoration community.

While public safety is typically considered during the design process, there is a lack of cohesive information on this topic. A Large Wood Conference, "Technical Workshop on Large Wood Applications and Research Needs in River Restoration" hosted jointly by Reclamation and the U.S. Army Corps of Engineers in February 2012 identified the need for design criteria to improve the safety of structures as a high priority.

Solution

Researchers identified four major topics relating to safety issues of large wood structures:

1. Public Safety: Public safety involves the dangers of human interaction with the structure. People can be pinned against a wood structure by the force of approaching water, entrapped under or against the structure, or snagged on branches. American Whitewater's paddling accident database shows that wood is among the leading factors contributing to paddling deaths (see "More Information" on next page). Many factors to minimize this risk should be examined, including:

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- Porosity of the large wood structure
- Flow under the structure
- Orientation of wood
- Structure placement/percent of river obstruction
- Anchoring
- Visibility
- Ability to avoid structure
- Limiting access

2. Structural Stability: The loss of stability of large wood structures can cause damage at and downstream from the structure. This can become a hazard to life and property during large flood flows, or can lead to the loss of habitat enhancement goals at the site. One of the challenges of installing large wood structures is that they tend to not be static over time. Wood recruitment from natural or free floating logs in a river may alter an initially safe structure.

3. Liability: Liability associated with large wood structures has grown as a topic of discussion in recent years. Often, there are multiple agencies, funding sources, designers, installation contractors, landowners, and others involved in a project. A common question then is, "Who is responsible for accidents and damage related to large wood structures?"

4. Risk Analysis: A risk assessment approach would be valuable for large wood installations. This type of approach would help designers and project managers determine how to design and secure large wood structures and where to place installations to minimize risk based on potential consequences at the site.

Future Plans

Future research may focus on developing physical and numerical models and a guidance document. The research paths that would benefit the four major topics from a technical perspective are:

- Developing a risk assessment approach for large wood structure installations
- Developing a traffic engineering framework for identifying reaction time to avoid large wood structures
- Determining the best configuration of logs in a logjam structure for specific project goals
- Developing application methods of implementing smaller large wood structures, while minimizing risk and maximizing habitat benefits
- Creating a database of information on installed projects showing how installations change over time
- Researching safe ways to anchor large wood structures that do not require cable, chains, anchors, or other non-natural or non-degradable materials
- Providing design guidance to help understand how structures may fail so in the event of failure they are designed to fail as safely as possible
- Improving design elements for safer large wood structures such as porosity, flow through, and log orientation
- Assessing habitat performance of stable versus mobile wood

"Large wood structures are an important part of Reclamation's overall river restoration strategy. It is our responsibility to ensure that they are designed and installed as safely as possible."

Connie Svoboda
Hydraulic Engineer,
Reclamation's Technical Service Center

Research Office Contact

Miguel Rocha
Science and Technology Program Manager
303-445-2841
mrocha@usbr.gov

Collaborators

Reclamation's Pacific Northwest Region

More Information

www.usbr.gov/research/projects/detail.cfm?id=8952

www.americanwhitewater.org/content/Accident/view

RECLAMATION Managing Water in the West

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Bulletin 2014-30

The Knowledge Stream
Research Update

Placing Half Log Structures in Reservoir Drawdown Zones to Help Endangered Fish

Constructing onsite habitat structures in reservoir drawdown zones for endangered fish

Bottom Line

This research project developed inexpensive habitat structures that provided immediate habitat benefits in a section of a tributary that flows through a reservoir drawdown zone, as well as recommending design improvements for durability in certain applications.

Better, Faster, Cheaper

Meeting Endangered Species Act requirements for fish and fish habitat within the migratory corridor of Reclamation reservoirs can be done in an inexpensive manner without changing operations in some cases.

Principal Investigator

Dmitri Vidergar
Fisheries Biologist
Snake River Area Office
Pacific Northwest Region
208-383-2216
dvidergar@usbr.gov

Research Office Contact

Miguel Rocha
Science and Technology Program Manager
303-445-2841
mrocha@usbr.gov

Collaborators

Idaho Department of Fish and Game

Problem

Migratory fishes that inhabit reservoirs, including the Endangered Species Act-listed bull trout, often travel through portions of tributaries that flow through drawdown zones in reservoirs.

Bull trout. Source: Western Native Trout Initiative through the U.S. Fish and Wildlife Service (http://westernnativetrout.org).

Drawdown zones provide "lake" or "river" habitat, depending on seasonal water operations. Finding an appropriate mechanism for improving habitat in a drawdown zone is difficult because of the dynamic nature of the interface between a tributary and a reservoir. (The interface between a tributary and reservoir may be referred to as a drawdown or transition zone, delta, or varial zone.)

Habitat structure in Trail Creek, a tributary to Deadwood Reservoir, Valley County, Idaho. Initial placement (left) and 1 year later (right).

These areas often lack complex habitat because of the characteristic fluctuations in reservoir levels. Traditional habitat improvements (boulder or large woody debris placement, construction of plunge pools, or planting of riparian vegetation) often become buried as sediment is deposited and re-distributed within this area.

Solution

This Reclamation Science and Technology Program research project started in 2008 to develop and test a method to improve habitat diversity for migratory fishes within drawdown zones. Work included:

- Exploring design options for habitat structures to be placed in stream-like habitat within a drawdown zone of a reservoir

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- Deploying prototype structures in a variety of drawdown zone habitats
- Evaluating effectiveness of the structures after 1 year of deployment
- Providing recommendations for future implementation

Prototype log structures were developed consisting of two "feet" and a "deck" that was secured to the top of each foot. To evaluate the most durable and functional design, each structure varied slightly.

Each structure needed to be:

- Inexpensive and installed by a two-person crew with the use of tools that could be carried up to a half mile over rough terrain. Excluding the initial investment of tools, the cost of installing each structure equaled approximately $180.00 in parts and 4 to 6 hours of staff time for two people.
- Constructed with logs found near the study site and be no larger than what a crew of two people could safely move. (The U.S. Forest Service required the use of dead trees. However, live wood may prove more durable.)
- Assembled on the shore at the study site then pushed or carried into the channel and anchored in place.
- Durable enough to withstand complete inundation for most of the year and maintain its functionality during low water when the habitat returned to stream-like conditions.

Application and Results

In 2009, six structures were placed: three in the Deadwood Reservoir on the Deadwood River and three in the Arrowrock Reservoir on the Middle Fork of the Boise River, both in Idaho. Study locations were selected to evaluate structures in a variety of habitat conditions (sandy and cobble substrate, shallow and deep water, and a small and large tributary).

The structures' performance was analyzed by comparing water velocities and depths at the location of each structure (quantitative) and durability between designs (qualitative). The maximum inundation depth for each structure was also recorded by comparing the elevation at the installed structure to the full pool elevation.

Four of the six habitat structures remained intact after 1 year; however, only two remained in the wetted channel and were functional. (The deposition of sand and fine sediment within the delta causes the channel to change course year to year; two structures became buried in sediment.)

Picture of habitat structure in Middle Fork of the Boise River, Idaho. Initial placement (top) and 1 year later (bottom).

The initial evaluation demonstrated that each structure provided some type of cover including one or more of the following: overhead, shading, velocity, or depth. Initial results varied depending on water velocity and attributes of the existing channel.

"The instillation of fabricated habitat structures in a reservoir's drawdown zone can improve fish habitat at a minimum expense. The methods used in this study would work best in habitats with a well-defined channel and low amounts of sediment."

Dmitri Vidergar
Fisheries Biologist, Reclamation's Pacific Northwest Region

Future Plans

Based on the results of this pilot study, these inexpensive log structures do improve habitat conditions and, in some situations, are durable enough to remain functional for 1 or more years. However, further testing is recommended before wide-scale implementation. Additional testing should include:

- **Increased anchor size**
- **Orientation within the channel**
- **Use of synthetic material instead of wood**

More Information

www.usbr.gov/research/projects/detail.cfm?id=5149

RECLAMATION Managing Water in the West

Fall 2014
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Bulletin 2014-31

The Knowledge Stream
Research Update

Testing Nitrogen Fertilizer to Help Restore Mature Cottonwood Trees

Determining if fertilizing cottonwood trees might help restore lost productivity in dryland riverine ecosystems

Bottom Line

This research project examined the hypothesis that mature cottonwood trees are generally limited by the amount of nitrogen in the soil. However, no effect or trend from fertilizing with nitrogen was detected on either river studied.

Better, Faster, Cheaper

A greater understanding of the role nitrogen plays in dryland riparian systems will help water resource managers adaptively manage restoration projects more effectively.

Principal Investigator

S. Mark Nelson
Research Aquatic Biologist
Environmental Applications and Research Group
Technical Service Center
303-445-2225
snelson@usbr.gov

Research Office Contact

Miguel Rocha
Science and Technology Program Manager
303-445-2841
mrocha@usbr.gov

Problem

Riverine forests in the world's semiarid and arid regions (drylands) are threatened by flow regime changes linked to river regulation, increasing human demands for water, and climate change. Restoring lost riparian forest productivity is a common management goal in dryland riverine ecosystems. If nutrient deficiency is a factor in how many trees can grow in an area, then mature trees at these sites may be especially sensitive to nutrient supplement in sandy or coarse alluvium areas where soil nutrients, particularly nitrogen, are sparse.

In the Western United States, cottonwoods (*Populus fremontii*) dominate many dryland river ecosystems. Cottonwoods provide habitat for many organisms, including threatened and endangered species. The stress that flow alterations cause in these trees is well documented, but managing resilience to reduced water availability requires understanding other potential stressors, such as low soil nutrient concentrations.

Study and Results

This Reclamation Science and Technology Program research project studied two areas in Colorado—one along the Green River in the Browns Park National Wildlife Refuge and the other along the Yampa River in the Deerlodge Park at Dinosaur National Monument. These rivers originate in the Rocky Mountains and are characterized by a snowmelt-driven spring flood. Study trees from multiple locations on each floodplain were systematically selected, with the intention of having two sets of trees at each subsite, matched by size, to serve as treatment and control groups. In 1999, one tree in each pair received granular urea at the rate of 20 grams of nitrogen per square meter.

If cottonwood growth is limited by lower levels of nitrogen in the soil, then radial growth would increase in response to fertilization. To quantify this expected increase, this work:

- Calculated a ratio (R_G) of the 1999 - 2001 cumulative growth increment (the three growing seasons after fertilization) to the 1996 - 1998 cumulative growth increment (the three growing seasons before fertilization) for each tree. Comparing R_G values circumvented the potential problem of variation among trees in their radial growth rates as each tree effectively served as its own control.
- Compared related growth during the 3-year (1999 - 2001) post-fertilization period to a 10-year pre-fertilization period. This addressed the potentially confounding effects from size and spatial variability in a different manner, and included fertilized and unfertilized trees excluded from the growth ratio analysis because they lacked a matching tree for pairing.

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Cottonwoods along the Green River, Colorado.

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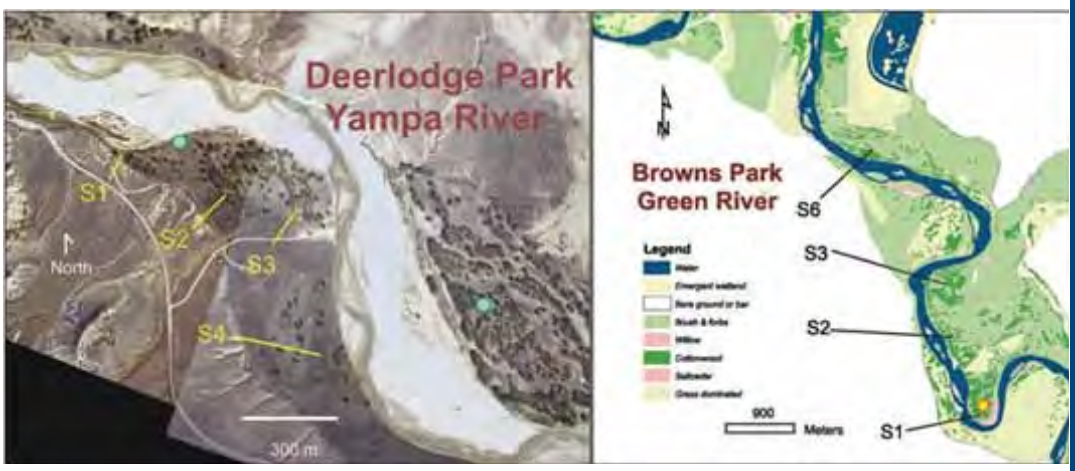

Locations of the subsites containing the study trees at the Deerlodge Park (DLP) (Yampa River) and Browns Park (BP) (Green River), Colorado, study areas. Flow in the Yampa River is from right to left; the Green River flow is from left to right. The two dots at DLP and single dot at BP are locations where microclimates and ground water levels were monitored.

Cottonwoods at both sites showed strong variation in annual increments, reflecting year-to-year variation in environmental conditions. However, no effect from nitrogen fertilization was detected in either site. Also, no effect was detected when examining the radial growth of trees at either site, based on growth during the 10-year period prior to the date of fertilization to standardize subsequent growth. The failure to find a fertilization effect on radial growth was surprising and can be interpreted several ways:

- Growth of mature cottonwood trees is not limited by nitrogen levels in the soil.
- Trees are limited of nitrogen, but the fertilizer dose was too small or the application needed to be repeated in multiple years to elicit the expected response.
- The response might have been in an unmeasured way, such as root biomass or reproductive output.
- Other mechanisms, such as precipitation, restricted nitrogen uptake by trees.

In summary, these data suggest, but do not conclusively show, that mature cottonwood trees are not limited by the amount of nitrogen in the soil at the study sites.

Implications for Best Management Practices

Restoring dryland riverine forest productivity lost as a result of reduced soil water availability, or increasing resilience of established restoration tree plantings to water stress in dryland riparian areas through nitrogen fertilization, needs further study.

Until future studies reveal general patterns, local testing for soil nutrient constraints on tree productivity is needed to inform water resource managers about the efficacy of fertilization as a means to enhancing productivity of degraded dryland riparian forest.

Future Plans

Before dismissing fertilization as a practical management option to increase cottonwood productivity in degraded systems, or to enhance resilience in dryland riparian ecosystems, additional testing using different application rates is warranted. Positive confirmation of adequate soil nitrogen at these and other dryland riparian sites would bolster the argument that flow management is necessary and sufficient to achieve high levels of productivity in degraded desert riverine cottonwoods.

"While this study did not show that the availability of nitrogen in the soil increases cottonwood growth, it provides guidance for best management practices."

S. Mark Nelson
Research Aquatic Biologist, Reclamation's Technical Service Center

Collaborators

- **U.S. Geological Survey**
- **Rubenstein School of Environment and Natural Resources, University of Vermont**
- **Department of Ecosystem Science and Sustainability, Colorado State University**
- **Natural Resource Ecology Laboratory, Colorado State University**

More Information

www.usbr.gov/research/projects/detail.cfm?id=15

Andersen, D.C., E.C. Adair, S.M. Nelson, and D. Binkley. 2014. *Can Nitrogen Fertilization Aid Restoration of Mature Tree Productivity in Degraded Dryland Riverine Ecosystems?* Restoration Ecology. DOI:10.111/rec. 12104.

RECLAMATION Managing Water in the West

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The Knowledge Stream
Research Update

Designing Fish Ladders to Automatically Adjust to Varying Water Surface Levels

Self-regulating articulated fish ladders use a constant flow with varying water surfaces

Bottom Line

This research project helped develop and test a fish ladder for small diversion dams that uses a constant amount of water, even when reservoir levels vary. This provides a constant fish ladder discharge without adversely affecting the hydraulics in the fish ladder.

Better, Faster, Cheaper

This fish ladder can operate automatically at remote locations, saving staff time and travel expenses. Moreover, as this prevents the fish ladder from discharging more water than needed, irrigators can divert their allotted water without impacting the fish ladder. This avoids costly operations and maintenance issues for rural fish ladders.

Principal Investigator

Dale Lentz
Hydraulic Engineer
Hydraulic Investigations and Laboratory Services Group
Technical Service Center
303-445-2143
dlentz@usbr.gov

Research Office Contact

Miguel Rocha
Science and Technology Program Manager
303-445-2841
mrocha@usbr.gov

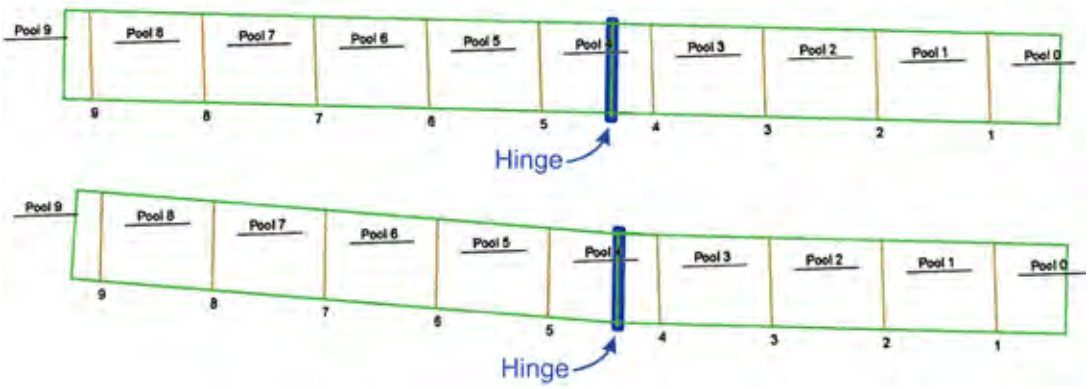
Problem

Fish ladders constructed on small diversion dams may take on more water than they need for fish passage if the water elevations change. In very low head dams with reservoir water surface elevations that fluctuate by less than 3 feet and with limited instream flows, a small reservoir rise could double or triple the amount of flow in the fish ladder (for example, rising from 2 to 8 cubic feet per second [cfs]). With these small dams, when the irrigators only divert 2 to 3 cfs, any change in flow diversions becomes problematic for irrigators. This often results in the fish ladders being shut down during high diversion periods or weir boards placed in the fish ladder to restrict flows—and also fish passage.

The Klamath Basin Area Office in Reclamation's Mid-Pacific Region and the Oregon Department of Fish and Wildlife (ODF&W) need to develop a fish ladder suitable for endangered sucker species and other native fish indigenous to the highly regulated streams in the Western United States. For effective fish passage, these fish ladders need to be able to pass a constant flow over a range of headwater elevations. They also need to work remotely without close supervision.

Solution

This Reclamation Science and Technology Program research project designed a fish ladder that can be installed at low head diversion structures where the reservoir water surface elevation fluctuates regularly. The fish ladder automatically adjusts to the change in water surface elevation, providing a constant fish ladder discharge without adversely affecting the hydraulics in the fish ladder.



Elevation view of the articulated fish ladder. The hinge in the middle allows the upstream half of the fish ladder to rotate up and down with the changing upstream water surface elevations.

In a typical fish ladder, the upstream end where fish exit has a fixed elevation. Therefore, when the upstream headwater increases, the flow through the fish ladder also increases. In this self-regulating articulated fish ladder design, the downstream

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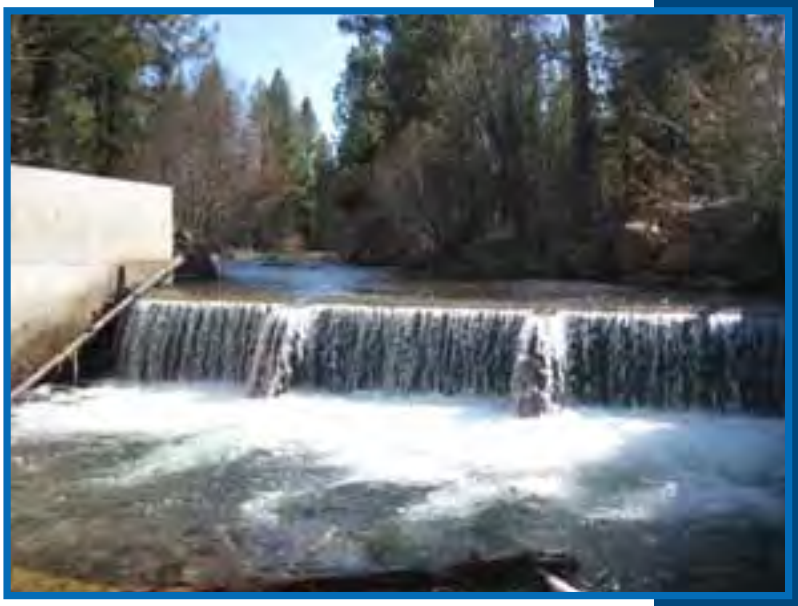
half of the fish ladder is at a fixed elevation and the upstream half can pivot around a hinge in the middle of the fish ladder. Thus, when the water level in the reservoir rises, the upstream half of the fish ladder rises, maintaining a constant inflow in the fish ladder. As the water elevations in these diversion dams vary by only 1 to 3 feet, a slope change of less than 6 degrees is sufficient to maintain the constant flow needed for fish passage without diverting more water than needed.



Irrigation Diversion in Whychus Creek, Oregon.

Application and Results

This fish ladder was evaluated in the laboratory to investigate the hydraulic conditions when the fish ladder is bent in the middle, creating two different slopes within the same fish ladder. A dual vertical slot technical fish ladder with nine pools was tested in the hydraulics laboratory. The fish ladder was 2 feet wide and 1.5 feet deep, and each pool within the ladder was 2 feet long. This model can be scaled up to larger sizes of fish ladders. In this study, the downstream half of the fish ladder was kept at a constant slope of 3 degrees for all tests, and the upstream half of the fish ladder was tested at slopes ranging from 0.2 to 5.7 degrees. Pool water surface elevations were measured, velocity through the slot and Energy Dissipation Factors were calculated, and each test configuration was visually observed.

Results from the laboratory study indicated that fish could navigate the dual slope of the fish ladder—there were no adverse hydraulic conditions that would hinder fish passage.

Future Plans

This type of a fish ladder will only be successful if it can self-regulate as the upstream water surface changes. The next research steps are to investigate effective ways for the upstream part of the fish ladder to move automatically with changing water surface elevations (for example with an automatic hoist using an associated water level sensor or with large floats attached to the sides of the upstream end of the fish ladder). In the laboratory, small floats were added to the fish ladder in an attempt to self-regulate. Given the fish ladder setup location in the laboratory, it was not possible to attach large floats. Attaching large floats (55-gallon drums) to the sides of the fish ladder could be a successful way to self-regulate.

Reclamation is also working with ODF&W to identify a test site and install this for field evaluation. After installation, research will be required to determine the efficacy of the test site and then to determine the most effective installation configurations for other locations. This fish ladder could be used Reclamation-wide on diversion dams in small rivers, and it is recommended that Reclamation planners work with local and state resource agencies to identify opportunities to build these fish ladders.

"A standard design for a fish ladder that automatically adjusts to changing headwater elevations to control flows could help provide fish passage for endangered sucker species and other native fish indigenous to highly regulated streams in the West."

Brent Mefford
Hydraulic Engineer, Retired
Employee From Reclamation's Technical Service Center

Collaborators

- **Reclamation's Klamath Basin Area Office**
- **Oregon Department of Fish and Wildlife**

More Information

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RECLAMATION Managing Water in the West

Fall 2014
Research and
Development Office
Bulletin 2014-33

The Knowledge Stream
Research Update

Using Electric Barriers for Returning Adult Salmonids

Can electric barriers be used to redirect upstream migrating adult salmon back to their natal stream?

Bottom Line

For this scoping-level research project, a literature review was conducted on the use of electric barriers for returning adult salmonids. The effectiveness of electric barriers at deterring migrating adult salmon; the effects of electricity on adult salmon health, stamina, and reproductive capability; and the effects of electricity on delta smelt and sturgeon were investigated.

Better, Faster, Cheaper

Based on the literature review, an electric barrier may be effective at diverting upstream migrating adult salmon in the Mokelumne River that might otherwise pass through the Delta Cross Channel into the Sacramento River. For this application, physical barriers are not feasible as they would restrict fish movement throughout the year and impede recreational activities. Other non-physical barriers may not be enough to deter adult salmon.

Principal Investigators

Connie Svoboda
Hydraulic Engineer
Hydraulic Investigations and Laboratory Services Group
Technical Service Center
303-445-2152
csvoboda@usbr.gov

Jarod Hutcherson
Fish Biologist
Fisheries and Wildlife Resources Group
Technical Service Center
303- 445-2011
jhutcherson@usbr.gov

Problem

Manmade diversions provide unnatural routes between river systems that may cause adult salmon to move away from natal spawning grounds. In these instances, poor hatchery return numbers or undesirable genetic mixing may occur.

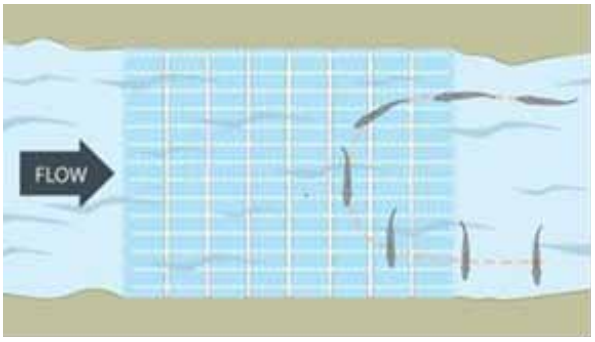
An electric barrier may be one possible alternative to redirect upstream migrating adult salmon back to their natal stream. An electric barrier has been proposed to prevent upstream migrating adult Chinook salmon (*Oncorhynchus tshawytscha*) in the *Mokelumne* River from moving into the Sacramento River when Delta Cross Channel gates are open in the fall. Electric barriers may also be considered for returning adult salmon at other locations in Reclamation's Mid-Pacific and Pacific Northwest Regions.

To determine if an electric barrier may be a safe and effective way to deter migrating adult salmon, a targeted literature review was needed to answer:

- Have electrical barriers been installed for this purpose?
- How were the barriers designed?
- Were the barriers effective? If not, what were the problems?
- Does electricity affect adult salmonid health, stamina, or reproductive capability?
- How does electricity affect delta smelt (*Hypomesus transpacificus*) and sturgeon (in particular, green sturgeon—*Acipenser Medirostris*), since these federally protected species may be present in locations where electric barriers are installed to guide adult salmon?

Solution

Electric fish barriers are commercially available and have been used in a variety of situations including the restriction of fish movement during upstream passage. When carefully designed, electric barriers can be effective for a wide range of channel widths and water depths and for a range of target fish species. If an upstream moving fish is stunned by the barrier, water velocities must be high enough to move the fish downstream from the barrier to recover. Deterred fish should have a clear path back to the preferred migration route.



Schematic of a graduated electric field fish barrier where a fish is immobilized, swept downstream, and recovers movement. Image created by, and courtesy of Smith-Root, Inc. (www.Smith-Root.com).

Alternating current was used in early fish barriers, but this has since been found to be injurious to fish. Direct current (DC) or pulsed DC is typically used in recent fish barrier applications. When pulsed DC is used, peak voltage, peak current, pulse width, and frequency are adjusted to elicit the desired fish response. Electrodes can be flush-

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mounted on the river bottom, installed as vertical drops suspended from a cable, attached to pilings, attached to buoys at the water surface, or suspended mid-depth in the water column. Large fish are generally more susceptible to electrical fields than smaller fish because more power is transferred for a given voltage gradient (volts per unit distance) over the length of the fish. Maintaining field intensity low enough to avoid tetanus in larger fish should also allow smaller fish to pass through the field unharmed.

Smith-Root, Inc. (Vancouver, Washington) has developed a graduated field fish barrier. To redirect upstream migrating fish, the voltage gradient progressively increases as the fish moves upstream through the barrier. This design allows fish to turn away from the field while experiencing minimal discomfort, but causes significant discomfort as fish progress through the barrier. Since fish of concern may come in contact with the barrier from the upstream side, it may be appropriate to graduate the voltage gradient on the upstream end as well.

Electric barriers pose certain safety risks to commercial vessels, recreational boats, and people in the water in the vicinity of the barrier. However, electric barriers can be designed to be non-lethal to humans and fish by using low frequency pulsed DC. Boats can safely pass through barriers without harm to occupants when safety requirements for each specific site are followed.

Delta Cross Channel gates in the open position, California.

Electric barrier with bottom flush-mounted electrodes at Quinault National Fish Hatchery, Washington.

The literature review search did not uncover any studies with the same application as the project at the Delta Cross Channel. Several fish hatcheries in the Pacific Northwest use some type of electric barrier to divert adult salmon towards the hatchery. Although electric barriers are likely successful at obtaining return numbers to the hatcheries, published information regarding their efficacy as an exclusion barrier is limited. In various situations, DC barriers have been shown to reduce upstream migration of sea lamprey, common carp, and grass carp and a hanging electrode alternating current (AC) array has been shown to reduce upstream migration of salmon.

Few studies are available regarding the effects of electrical exposure to sturgeon. Some injuries were recorded, but voltage and frequency levels were higher in literature than what would be used in a graduated field fish barrier. Soft-start pulsing to disperse fish near electrodes should be considered if sturgeon are expected near the proposed barrier location. Additionally, no information is readily available regarding effects of electric barriers on delta smelt. However, the electrical settings necessary to divert larger fish such as salmon and carp without injury should not cause adverse effects to smaller fish such as delta smelt. Electrical exposure to the eggs of sturgeon and delta smelt could reduce viability; however, unless sturgeon or delta smelt are spawning in the vicinity of the electrical barrier, it is unlikely that their eggs would be affected. Regulatory agencies should be contacted to determine if federally listed fish and their eggs or larvae will be present in the proposed location of the electric barrier during the operation period.

"Electric barriers may be an effective alternative to redirect upstream migrating adult salmon if a clear path back to the preferred migration route is provided."

Connie Svoboda
Hydraulic Engineer, Reclamation's Technical Service Center

Research Office Contact

Miguel Rocha
Science and Technology Program Manager
303-445-2841
mrocha@usbr.gov

Collaborators

Central Valley Project Improvement Act Program in Reclamation's Mid-Pacific Region

Future Plans

This literature review can be used by personnel considering the installation of an electric barrier for their project. Although no studies were found where a DC electric barrier was used as an exclusion barrier for upstream migrating adult salmon, this literature review indicates that an electric barrier could be successful at achieving project goals for the proposed Delta Cross Channel barrier. Installing an electric barrier to divert upstream migrating adult Chinook salmon away from the Delta Cross Channel should be further investigated.

More Information

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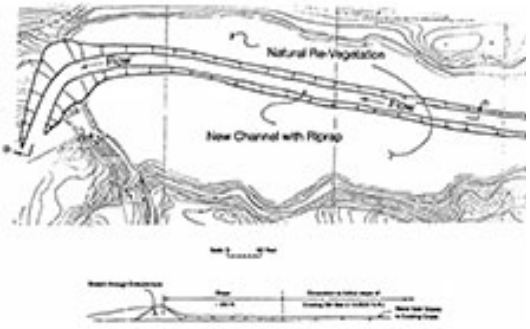

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Before and after photographs of the continued restoration at the Elwha Dam site and the removal of Glines Canyon Dam. Photographs by John Gussman, Doubleclick Productions.

River-mile 194

River-mile 30

River-mile 65

Before and after photographs of the first of several planned floods. The U.S. Department of the Interior ordered the deluge, released in a gush from the Glen Canyon Dam starting November 19, 2013, to rebuild habitat along the Colorado River.

"It really is humbling to be part of a process much bigger than any one person. To meet so many others who share the same vision and passion, many who have substained this dream over decades. In the end this story is about change, and how it is possible to do the right thing. We cannot only save nature, we can repair it."

John Gussman
Professional Photographer/Filmmaker
Doubleclick Productions
Return of the River, 2014