RECLAMATION *Managing Water in the West*

Summer 2015
Research and Development Office
Newsletter 2015-03

The Knowledge Stream

Sustainable Water Infrastructure and Safety Issue

In this issue. . .

For employees working inside or near powerplants, harmful noise levels can cause problems . . .

. . .View the ***Noise Engineering Controls: Hydropower Plants – Sound Dampening*** video and hear how Reclamation has uncovered some surprising results. . .

see pages 8, 11, and 25

Challenges Update—The Desal Prize! . . .

Reclamation's Desal Prize Team

. . .see page 15 and back cover

Then . . .

Now . . .

Derby Dam, constructed under specification number 1 and drawing number 1 of the U.S. Reclamation Service, now the Bureau of Reclamation, shows just how old Reclamation's infrastructure is.

Work started on the dam on October 2, 1903, and finished May 20, 1905. Operational water diversions began in 1906.

"Fourth Annual Reclamation Research Jam Results". . .

. . .See the top 10 innovative ideas submitted in the Reclamation Research Jam 2015 on page 12

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- **Research Roadmaps for Dams, Canals, and Powerplants**
- **Infrastructure and Safety Projects Initiated in Fiscal Year 2015**
- **Innovation and Multimedia Around Reclamation**

. . . and More!

U.S. Department of the Interior
Bureau of Reclamation

This newsletter is available at:
www.usbr.gov/research/docs/ks-2015-03.pdf
To subscribe to this newsletter, see options on page 51.

Chief's Message

Chief, Research and Development

Levi Brekke became Chief, Research and Development, in February 2015, after serving as the Research and Development Office's Water and Climate Research Coordinator since 2011.

Levi previously served in Reclamation's Technical Service Center for 6 years and in the Mid-Pacific Region for 2 years.

Bobbi Jo Merten, Chemist/Acting Science and Technology Program Manager and Erin Foraker, Renewable Energy Research Coordinator served as principal editors for this issue.

Greetings and welcome to this edition of *The Knowledge Stream*. In this issue, you can learn about Research and Development Office (Research Office) efforts to address water and power management challenges facing Reclamation and its customers and stakeholders. You will find articles covering a variety of program activities, including research, prize competitions, and technology transfer.

This issue spotlights sustainable water infrastructure and safety, a Science and Technology Program priority area for research. Innovation around maintaining and replacing our existing infrastructure will help Reclamation and our partners extend the viable life of our facilities with increased effectiveness and reasonable costs. The emphasis on safety research is motivated by accidents in 2014 and ensuing discussions with both Reclamation's Pacific Northwest Regional Director and Safety Manager. Through these efforts, we aim to ensure a safe workplace and to reflect Reclamation's focus on "Safety First!"

This issue also has information about the "Fiscal Year 2016 Science and Technology Program Annual Call for Proposals," which opened on April 15th and closes on June 30th. We encourage researchers to review our revised Proposal Guidance document provided with the internal call for proposals memorandum. This is a combined resource for Reclamation researchers and partners, as it points to research roadmaps (research needs), proposal development guidance, and key contacts. Furthermore, we encourage researchers to continue partnering with other agencies and across disciplines to develop solutions for our enduring challenges.

Lastly, I would like to acknowledge "transition" as a key theme for the Research Office during this fiscal year. For the first time in 7 years, the Research Office will be without the leadership of Dr. Curt Brown, who served as Chief, Research and Development, and retired this past fall. It is my privilege to accept the challenge (and daunting responsibility) of succeeding him in this position. Also, Science and Technology Program Manager, Miguel Rocha, and Communication and Information Systems Coordinator, Jake Akervik, have moved on to new opportunities after years of service. To help with this transition, the Research Office has received a number of invaluable contributions from acting chiefs and program managers, including Chuck Hennig, Denise Hosler, Allen Skaja, Erin Foraker, Jennifer Johnson, Bobbi Jo Merten, Ken Nowak, and Saied Delagah—thanks to all of them for such excellent work! Moving forward, the Research Office will greet several new staff additions, the first of which I am pleased to announce is our new Budget Analyst, Jennifer Arends, who joins Reclamation after years of service with the U.S. Army III Corps in Fort Hood, Texas.

Levi Brekke, Chief of Research

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

Dave Raff
Reclamation Science Advisor
202-513-0516, draff@usbr.gov

Levi Brekke
Chief of Research
303-445-2494, lbrekke@usbr.gov

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

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

Research Coordinators

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

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.

Federal Laboratory Consortium (FLC)—National Meeting

April 28 to 30, 2015 | Denver, Colorado

This year's theme, "Reaching New Peaks With Technology Transfer," proved that technology transfer continues to be the key element of our Nation's initiative. The Research and Development Office had an exhibit on their Water Prize Competitions.

Additional meeting information:

www.cvent.com/events/2015-flc-national-meeting/event-summary-64c9e5ff32114bcaa2d3fba3dd4b4cea.aspx

Corrosion and Protective Coatings—Hands-On Training

May 5 through 7, 2015 | Denver, Colorado

The Materials Engineering and Research Laboratory in Reclamation's Technical Service Center hosted and presented a "Corrosion and Protective Coatings Hands-On Training." This 3-day training course familiarized participants with the issues relating to corrosion of metal and corrosion protection.

Contact and additional training information:
Allen Skaja | 303-445-2396 | askaja@usbr.gov

National Hydropower Association Midwest Regional and Midwest Hydro Users Group —Spring Meeting

May 19 and 20, 2015 | Duluth, Minnesota

Additional meeting information:

www.hydro.org/news-and-media/events/details/2015-nha-midwest-regional-and-hydro-users-group-meeting/ and www.midwesthug.org/activities.html

Structure From Motion Photogrammetry—Community of Practice Workshop

June 23 through 25, 2015 | Weaverville, California

The Trinity River Restoration Program in Reclamation's Mid-Pacific Region will be hosting and presenting a "Structure From Motion Photogrammetry Workshop" to help further establish a community of practice in this area. This research project workshop is being funded through Reclamation's Science and Technology Program (www.usbr.gov/research/projects/detail.cfm?id=3835).

Contact and additional workshop information:
Eric Peterson | 530-623-1810 | ebpeterson@usbr.gov
See article in the "Infrastructure Research" segment on pages 22 and 23.

HydroVision International—Conference and Exhibition

July 14 through 17, 2015 | Portland, Oregon

The HydroVision International Conference and Exhibition is the largest gathering of hydro professionals worldwide. Highlighting perspectives on the role of hydropower, exploring issues affecting hydro resources, and helping participants develop a vision to meet challenges and ensure the future sustainability of hydropower.

Additional conference and exhibition information:

www.hydroevent.com/index.htm

Innovation Around Reclamation—
Applying Photogrammetry Research

Using Terrestrial Photogrammetry for Geological Engineering

The Engineering Geology Group in Reclamation's Technical Service Center uses terrestrial photogrammetry methods—and the insights gleaned from previous Science and Technology Program research projects—to geologically map for foundation acceptance of Reclamation's structures (such as spillways, abutments, embankment placements, etc.). This work is completed so that the geology is well understood and is actually what the feature designers assumed it would be.

Digital photographs from an off-the-shelf camera are taken of the geology exposed within the structure foundation areas. A variety of methods can be used to take the digital photographs, including hand-held, tripod, survey rod, balloons and, in the future, unmanned aerial systems. Oriented stereo images, three-dimensional (3D) point clouds, accurate digital elevation models, and orthophotos can be created from these photographs. These data tools are useful for a variety of project types, including geologic mapping, rock slope stability, tunnel mapping, difference modeling, generation of topographic maps, or to accurately measure any object.

Photogrammetric mapping not only applies to existing dams, but also to new construction to ensure the details of the geology, concrete structures, and embankments are quickly and accurately documented for current and future use. With photogrammetric models, it can be very practical to obtain remarkably accurate data, and these methods have many advantages over traditional surveys. The software available to construct 3D models using ordinary digital images is being developed and improved at a rapid rate.

Advantages to using photogrammetry include:

- Field work that used to take many days can now be performed in hours
- Hundreds of discontinuities can be measured instead of just a few
- Statistical confidence improves greatly
- Rope access can be minimized, improving safety
- Topography can be developed at the same time
- Surfaces can be added to the model to see where they intersect
- Geologists can quickly evaluate multiple projections and see the result on the 3D photograph to compare with outcrops, etc.

Some of the project areas using photogrammetry include:

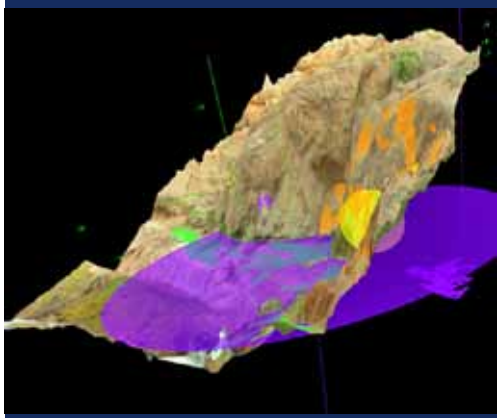
- Grand Coulee Forebay Dam Study, Washington – 2008
- Pathfinder Dam New Spillway, Wyoming – 2011
- Glendo Dam New Spillway, Wyoming – 2013
- Minidoka Dam New Spillway, Idaho – 2013
- Clark Canyon Proposed Powerplant, Montana – 2014
- Black Canyon Proposed Powerplant, Idaho – 2014
- Glendo Dikes Modification, Wyoming – 2014
- Big Thompson Diversion Structure Proposed Tunnel, Colorado – 2014
- Keechelus to Kachess Proposed Tunnel, Washington – 2015
- Wymer Proposed Dam and Dike Foundation, Washington – 2016

Contact: Bryan Simpson | Technical Service Center | 303-445-3094 | bksimpson@usbr.gov

"Photogrammetry is a useful tool, saving time and money for geologic mapping. The potential applications for photogrammetry at Reclamation are limited only by our imagination."

Bryan Simpson
Engineering Geologist
Reclamation's Technical Service Center

Using a balloon to take photographs.



Photogrammetric three-dimensional model showing geological features.

Innovation Around Reclamation—
Using Tablets for Field and Lab Work

Smart phones, tablets, and more are taken everywhere, so why not into the field and laboratory for research?

Two recent Reclamation Science and Technology Program research projects, which evolved from gathered innovative ideas from the 2013 Reclamation Research Jam, examined the versatility of tablet apps and devices.

Providing data straight from the field saves time, helps ensure accuracy, and creates a consistent basis for collecting and analyzing data.

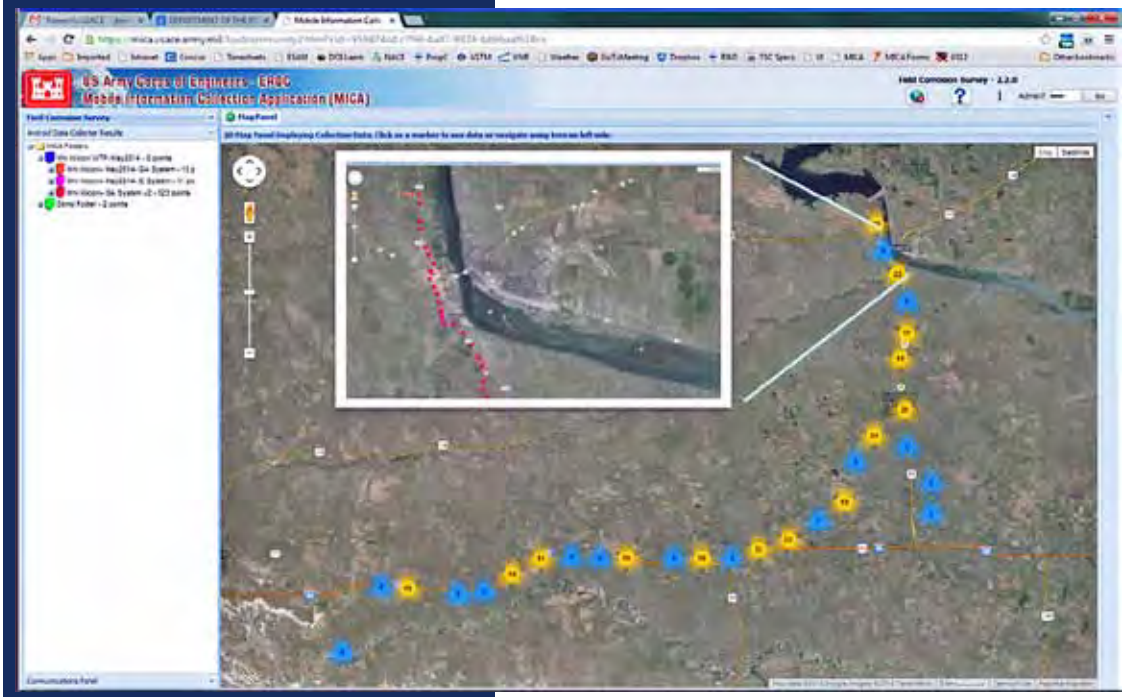
Concrete Core Logging Tablet App

Concrete core logging involves taking photographs, making sketches, measuring cores, and recording other pertinent data according to American Society for Testing and Materials (ASTM) C856. Personnel with varying degrees of experience tackle this complex process. The original goal was to write a tablet app for Reclamation personnel to be able to consistently log concrete cores. However, a few off-the-shelf apps already provide the functions needed. This Reclamation Science and Technology Program research scoping project reviewed 15 existing tablet apps to determine if they could be used to log concrete cores. Experienced loggers should be able to use existing apps as noted in this research scoping project's final report. An in-house app that prompts inexperienced loggers may also be useful and should be developed to improve the logging process efficiency and ensure compliance with procedures.

Reclamation Science and Technology Program Research Project ID 5481
Contact: Audrey Rager | Technical Service Center | 303-445-2377 | arager@usbr.gov

Mobile Information Collection Application

Custom apps to collect global positioning system (GPS) locations, form data, photographs, videos, and notes on a single device offer an effective technology for tasks ranging from field inspections of infrastructure to emergency responses. This Reclamation Science and Technology Program research project field tested a tablet app, "Mobile Information Collection Application" (MICA), developed by the U.S. Army Corps of Engineers. The app proved both efficient and extremely functional, combining the tasks of a GPS location; form data collection; and photograph, video, and note capturing all into one device. By eliminating paper forms and collecting all relevant information digitally, data, photographs, videos, and notes can be automatically organized to a given GPS point, which can then be updated in real-time to a central web-based server and mapped. Information can then be analyzed and decisions made much more quickly than previous methods that involved transcribing data manually.



MICA web interface showing GPS-located test stations of a cathodic protection system on the Mni Wiconi Core Pipeline in Pierre, South Dakota.

Reclamation Science and Technology Program Research Project IDs 7876 and 6816
Contact: Jessica Torrey | Technical Service Center | 303-445-2376 | jtorrey@usbr.gov

Innovation Around Reclamation—
Establishing a Plan for Geospatial Services

Standardized Geospatial Data and Services Address Open Data and Interoperability

Nearly every data point Reclamation gathers—from riverflows to snowpack, from flood control to hydropower releases—is "geospatial" as data are tied to a certain location. Reclamation is working on a Geospatial Services Strategic Plan (RGSSP) to develop a framework that supports the expanded, effective use of geospatial technology to advance the mission of Reclamation. This plan will help all Reclamation activities to access and use relevant geospatial information. The plan does not stop at data collection or identification, but goes beyond to embrace people and policy for an overall technology environment. The plan's goals are to:

- Ensure that geospatial information and associated analytical products needed to carry out Reclamation's mission are available and accessible to all levels of the organization
- Ensure accountability and effective development and management of Reclamation's geospatial resources
- Strengthen collaborative partnerships to advance the use of geospatial technology
- Sustain a technology environment that allows geospatial information to be easily and effectively used by all Reclamation and U.S. Department of the Interior activities that could benefit from it

Developing and implementing an overarching plan for geospatial services (such as geographic information systems [GIS], remote sensing, photogrammetry, aerial photography, global positioning systems [GPS], cartography, cadastral survey, modeling, and engineering services) will improve Reclamation's ability to contribute to national datasets for water, hydropower, and infrastructure.

Tessel is a web mapping site Reclamation employees use to visualize and query location and general reference information about projects, facilities, and other geospatial data that Reclamation collects and maintains.

Reclamation is working within the agency and reaching out to other agencies to develop services and solutions for sharing and reusing geospatial data for better analyses, decisionmaking, and operations.

Contact: Stephen Jalbert | Pacific Northwest Region | 208-378-5257 | sjalbert@usbr.gov

More Information

Reclamation GIS Community of Interest SharePoint site at:

https://borsp/corp/GIS/SitePages/Home.aspx

Multimedia Around Reclamation

Noise Engineering Controls: Hydropower Plants – Sound Dampening

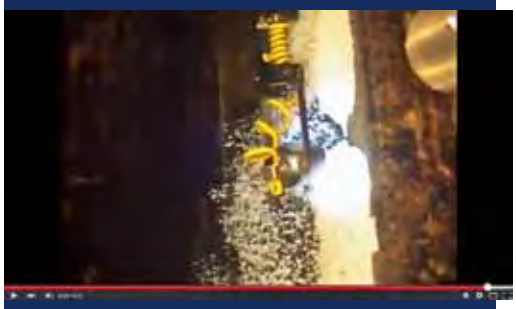
Hydropower plants generate lots of power and sometimes excessive noise. For employees working inside the powerplants, harmful noise levels can cause problems. The Research and Development Office is working with the Office of Naval Research and a private acoustic design firm to deploy noise dampening technologies to reduce powerplant noise levels. The pilot project, begun in 2013, aims to isolate sound and improve the environment for powerplant workers. They have uncovered some surprising results.
Published on April 7, 2015
See: www.youtube.com/watch?v=IEHyWdQcO08
More Information: See articles in the "Featured Faces" and "Safety Research" segments on pages 11 and 25, respectively.

Revitalizing and Managing the Nation's Powerhouse

Generators in Grand Coulee Dam's Third Power Plant (Washington) are undergoing a $100 million upgrade to bring the 40-year-old powerhouse into the 21st century and ensure another 40 years of clean, renewable, low-cost hydropower for the Pacific Northwest.
Published on February 13, 2014
See: www.youtube.com/watch?v=2O8UFThR8NA&list=PLvHsnLEo5Rt5blnQPG6s8TGgLZQ1O0U63&index=1
More Information: www.usbr.gov/pn/grandcoulee/tpp/index.html

Protecting Critical Infrastructure

Security Guard Dustin Busse describes his work at Reclamation's Grand Coulee Dam (Washington). To keep this valuable resource safe, Reclamation employs a number of well-trained and well-tested security guards.
Published on February 27, 2013
See: www.youtube.com/watch?v=vVYTWutAYBI&index=9&list=PLvHsnLEo5Rt5blnQPG6s8TGgLZQ1O0U63



Grand Coulee Waterstop

Reclamation's Grand Coulee Dam in Washington has a contraction joint where the leaks have been steadily increasing. In this video, the particles are a hydrophilic material that reacts with water and expands three times in size. A progressive cavity pump was used to force a water/particle slurry from the top of the dam down 250 feet. The particles entered the contraction joint and expanded, slowing the flow of water. The process was monitored by a remotely operated underwater vehicle and a downhole inspection camera. This process resulted in a 63-gallon-per-minute flow reduction inside the galleries.
Published: May 29, 2015
See: www.youtube.com/watch?v=U3hn_LaJZW4&feature=youtu.be.
More Information: See article in the "Infrastructure Research" segment on pages 20 and 21.

Photogrammetry Counterfort Wall Model

Photogrammetry uses many pictures to create data points, which can then be modeled. This short video shows the model results for a concrete counterfort wall.
Published: May 29, 2015
See: www.youtube.com/watch?v=aLi7ujc-1xk&feature=youtu.be.
More Information: See article in the "Infrastructure Research" segment on pages 21 and 22.

Featured Faces

Jessica Torrey, Materials Engineer

Jessica Torrey is a materials engineer working with the Corrosion Team in the Materials Engineering and Research Laboratory (MERL) at Reclamation's Technical Service Center (TSC) in Denver, Colorado. Jessica has a Bachelors of Science in Ceramic Engineering from Alfred University, Alfred, New York. She also earned a doctorate in materials science and engineering from the University of Washington in Seattle. After earning her Ph.D., Jessica spent time as a post doctoral research fellow and visiting scientist at the University of Erlangen and Bavarian Center for Applied Energy Research (ZAE Bayern) in Erlangen, Germany; the National Institute of Materials Science (NIMS) in Tsukuba, Japan; and the National Institute of Standards and Technology (NIST) in Boulder, Colorado.

In 2012, Jessica joined Reclamation, where she began applying her research background. She became active in Reclamation's Science and Technology Program, winning the People's Choice Award for Most Votes in the 2013 Reclamation Research Jam. She is currently collaborating with researchers from NIST and the U.S. Army Corps of Engineers on projects in composite materials, novel corrosion monitoring systems, corrosion in concrete, and tablet apps for field and laboratory work. Jessica is a member of the Infrastructure Sustainability Prize Challenge Team and is co-organizing a joint research symposium with NIST for summer 2015. Jessica is also active in the National Association of Corrosion Engineers and chairs a session in Degradation of Non-Metallic Materials at the annual Materials Science and Technology Conference.

In addition to her research projects, Jessica is a team member on a variety of TSC projects that involve designing cathodic protection systems for Reclamation infrastructure. She coordinates Reclamation's laboratory corrosivity testing and performs field testing and inspections of corrosion monitoring and cathodic protection systems. Jessica also coordinates the semiannual Corrosion Webinar Series and teaches portions of the MERL Coatings and Corrosion School. She has also mentored TSC college and high school interns. In 2014, Jessica organized the very first Reclamation Intern Poster Contest.

Jessica enjoys traveling to Reclamation sites, as well as traveling in her free time. Most recently, she visited Thailand. When at home in Boulder, Colorado, she is fond of gardening and taking walks with her dogs, Meatball and Scotch.

Jessica Torrey

http://www.usbr.gov/research/projects/researcher.cfm?id=2352

Installing a cathodic protection system at Mesa Verde National Park, Colorado.

Featured Faces

Matthew Klein

http://www.usbr.gov/research/projects/researcher.cfm?id=2676

Matthew Klein performing quality control tests for the roller-compacted concrete mix designs at Minidoka Dam Spillway and Headworks Replacement Project near Burley, Idaho, October 2013.

Matthew Klein, Civil Engineer

Matthew Klein began his path toward a career in structural/materials engineering early in life. As a teenager, he drew structural and civil plans on sheets of paper and taped them together to create blueprints. Then, after high school, he worked in residential and commercial construction, which eventually led to owning his own roofing company. It was during a general contractor's training program that Matthew first discovered what an important role the structural engineer has in the field of design.

Matthew earned a Bachelors of Science in Civil Engineering from Walla Walla University, Washington, in 2008, and then he accepted an assistantship from Rutgers University, New Jersey, to pursue a master's degree and a doctorate in structural and materials engineering. Matthew's Ph.D. dissertation focused on inorganic polymer repair of concrete structural elements. While at Rutgers University, Matthew also worked on the Rutgers Center for Advanced Infrastructure and Transportation Long-Term Bridge Performance Program, the Automated Nondestructive Evaluation and Rehabilitation System funded by the National Institute of Standards and Technology, and other projects in conjunction with the Federal Highway Administration.

In summer 2013, Matthew began working as a civil engineer with the Concrete Team in the Materials Engineering and Research Laboratory (MERL) at Reclamation's Technical Service Center in Denver, Colorado. His areas of interest include concrete inspection, testing, and repair. In this focus, he is specifically interested in classification and detection of concrete deterioration mechanisms and how to repair the deterioration to a functional state. Given the aging infrastructure in Reclamation, this direction is especially crucial for long-term performance and operation.

Matthew has several projects funded by Reclamation's Science and Technology Program, including the use of photogrammetry to detect and characterize concrete deterioration using visible and infrared light spectrums above and below water. The photogrammetric, three-dimensional models can also serve as a digital record of the as-built or as-inspected state of the structure for future reference. (See the "Infrastructure Research" segment in this issue for the article, *Photogrammetric Tools for Condition Assessment*.) In addition, Matthew is researching methods to repair concrete deterioration in challenging environments, such as underwater applied chemical grouts. The goal of these projects is twofold: 1) to allow quantifiable data collection for deterioration detection and monitoring in order to make condition assessments quicker and less costly to obtain, and 2) to provide reliable, inexpensive repair methods that can extend the service life of current structures. Matthew is also a member of the Infrastructure Sustainability Challenge Design Team.

Matthew is a member of the American Concrete Association (ACI) and American Society of Civil Engineers, and he has made presentations at the ACI Strategic Development Council on what photogrammetric condition assessments can do. He also holds certificates from ACI in concrete strength testing and concrete field testing and recently became a certified Concrete Construction Special Inspector.

One of Matthew's hobbies is playing the classical violin and Scottish fiddle. This was one of the interests that connected him with Laura, his wife of 8 years, who is a professional pianist. Matthew and Laura have an energetic 2-year-old daughter, Alyssa, and they enjoy spending time together exploring the natural beauties of Colorado. Some of Matthew's other hobbies include photography, building and modifying computers and remote-controlled aircrafts, and making home improvements using the large assortment of construction tools he has retained from his building days.

. . .Highlighting People That Contribute to Reclamation Research and Development

Theresa Gallagher, Industrial Hygienist

Commander (CDR) Theresa Gallagher has been a United States Public Health Service Commissioned Officer for over 18 years. She spent 12 of those years working for the Indian Health Service in Fairbanks, Alaska, and Rhinelander, Wisconsin. In 2009, Theresa was detailed to Reclamation in Denver, Colorado.

Theresa was born in Barbourville, Kentucky. Her employment history began at age 16, when she was hired as a cashier for Winn Dixie Supermarket. Later, while attending college, she was employed as a bank teller and worked at an outdoor fruit market.

In spring 1996, Theresa was accepted into the Commissioned Officer Student Training and Extern Program (COSTEP), where she worked with the Navajo people in Gallup, New Mexico, and Fort Defiance, Arizona. Theresa found the work, people, and culture so enjoyable that she decided to continue her environmental health pursuits. She earned a Bachelors of Science in Environmental Health from Eastern Kentucky University in December 1996. In 1997, she moved to Fairbanks, Alaska, and then in 2004, she moved to Rhinelander, Wisconsin. In 2006, she earned a Masters of Science in Public Health (with an industrial hygiene emphasis) from Tulane University in New Orleans, Louisiana.

In 2009, Theresa began working for Reclamation as an industrial hygienist and the principal bureau staff advisor for public and occupational health. In 2014, she became a Certified Occupational Hearing Conservationist. Theresa also is the Deputy Branch Director for Public Health Service Rapid Deployment Force –Team 1, Preventive Medicine. Through the years, she has also served in several deployments, including those for Hurricanes Katrina, Wilma, Rita, and Ike; the Jefferson Parish schools mission; and United States Naval Ship Mercy: Philippine Islands Response mission.

In 2012, Theresa became involved in Reclamation's Science and Technology Program noise engineering controls research project, which was initiated to install engineering controls in powerplants and demonstrate their effectiveness in reducing noise levels. To date, demonstrations have taken place in Green Springs (Ashland, Oregon), Roza (Yakima, Washington), and Chandler (Benton City, Washington) powerplants, with successful outcomes. Overall noise levels were reduced by 3 to 16 decibel A-weighted (dBA), to below 85 dBA. As a result, hearing conservation programs are no longer required where the engineering noise controls were installed at these powerplants, and the need for employees to use hearing protection has been decreased or eliminated. In fiscal years 2015 and 2016, the noise engineering controls research project is expanding to involve larger powerplants in more diverse areas. (See the "Multimedia Around Reclamation" segment on page 8 in this issue for a video regarding noise engineering controls/sound dampening at hydropower plants. In addition, see the "Safety Research" segment in this issue for the article, *Reducing Noise From Sandblasting*.)

In her spare time, Theresa enjoys spending time with friends and her dog, Krueger.

Theresa Gallagher

http://www.usbr.gov/research/projects/researcher.cfm?id=2182

Theresa Gallagher featured in "Noise Engineering Controls: Hydropower Plants – Sound Dampening" video.

See the "Multimedia Around Reclamation" segment in this issue on page 8.

Reclamation Research Jam 2015

Reclamation Research Jam logo.

The Research and Development Office (Research Office) hosted the Fourth Annual Reclamation Research Jam internal online crowdsourcing event to gather innovative ideas from March 2 through March 27, 2015.

The Reclamation Research Jam is the unofficial kickoff of the Research Office's annual project selection and funding cycle. The official kickoff begins in April, when the Research Office begins accepting proposals via their online proposal management system, PropC (www.usbr.gov/research/propc), and runs till the end of June.

The gathered Reclamation Research Jam ideas will be shared with Reclamation researchers for possible submission as research project proposals during the upcoming fiscal year 2016 funding cycle and are considered by the Science and Technology Program Review Committee when reviewing projects (see "S&T Program Call for Proposals" on next page).

Top 10 Reclamation Research Jam 2015 Ideas

Net Votes	Idea Title
25	Comprehensive Book-Length History of Desalination Research, Development, Technology, and Applications
23	Drones for Communications Tower, Dam Inspections, and More. . .
20	Geotechnical Explorations With AMS PowerProbe 9500VTK
19	Basalt Fibers for Use in Concrete in Corrosive Environments
14	Self-Healing Coatings
12	Unmanned Aerial Vehicles and Remotely Operated Vehicles
12	Reclamation-Wide Lessons Learned and Best Practices Site
11	Using SEM and XRD to Analyze Composition of Corrosion Byproducts
11	Three-Dimensional Printing Technology
11	Basin-Wide Real-Time Data Collection

Research Office Contact

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

Levi Brekke, Chief, Research and Development, presenting Jim Bailey with the People's Choice Award for Most Votes for his winning idea, "Comprehensive Book-Length History of Desalination Research, Development, Technology, and Applications" in the Reclamation Research Jam 2015.

Reclamation Research Jam 2015 by the Numbers

Total Votes:	406
Up Votes:	394
Down Votes:	12
Ideas:	45
Comments:	55

Science and Technology Program Call for Proposals

What Is the Science and Technology Program?

Reclamation's Science and Technology Program is the primary research and development arm of Reclamation. It is a Reclamation-wide, competitive research and development program focused on innovative solutions to benefit Reclamation water and power facility managers, as well as its stakeholders. Only efforts proposed and led by Reclamation staff are eligible for funding. The program seeks solutions that can be widely applied across the agency.

Science and Technology Program Call for Proposals

During the spring to early summer, the Research and Development Office (Research Office) accepts proposals from Reclamation employees to research solutions to Reclamation's many mission-related challenges. While proposals are only accepted from Reclamation employees, external entities and individuals can team up with a Reclamation employee to submit a joint proposal. The proposals are being solicited by June 30, 2015, for funding in Federal fiscal year 2016.

How Are Science and Technology Program Proposals Reviewed?

Reclamation offices review the proposals for relevance to Reclamation's overall mission and current priorities. Proposals are also reviewed for technical merit by a team of Reclamation and external experts to determine the technical soundness, contribution to the field of investigation, and the reasonableness of the budget. A multidiscipline Reclamation-wide committee then reviews, incorporating the previous two reviews and any additional criteria to prepare a final list of research projects.

Collaboration

Although only Reclamation employees can apply for Reclamation Science and Technology Program funding, the program encourages collaboration with external partners from:

- Universities
- Local, State, Federal, and Tribal Governments
- Non-Governmental Organizations
- Private Entities

Fiscal Year 2016 Research Activities

- Advanced Water Treatment*
- Climate Change and Variability*
- Invasive Zebra and Quagga Mussels*
- Renewable Energy and Energy Conservation*
- Sustainable Water Infrastructure and Safety*
- Regional Director Research Needs
- Water Operations and Decision Support
- Environmental Issues in Water Delivery and Management
- Conserving and Expanding Water Supplies
- Water and Power Infrastructure Reliability

*Indicates priority area.

Submission and Review Schedule

April to June:
Proposal preparation; full proposals are due June 30, 2015.

July to Mid-August:
Reclamation relevancy and technical reviews.

Mid-August to September:
Multidisciplinary Reclamation-wide committee meets for Program Review; recommends research projects for funding; Research Office prepares awards recommendation package for Washington, D.C., office concurrence.

October:
Funding decision; awards are announced.

Research Office Contact

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

More Information

More information and lists of previously funded research can be found at: www.usbr.gov/research

Desalination & Water Purification Research Program

The Desalination and Water Purification Research Program (DWPR Program) has three major goals:

1. Augment the supply of usable water in the United States.

2. Understand the environmental impacts of desalination and develop approaches to minimize these impacts relative to other water supply alternatives.

3. Develop approaches to lower the financial costs of desalination so that it is an attractive option relative to other alternatives in locations where traditional sources of water are inadequate.

Research Office Contact

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

The Desalination and Water Purification Research Program (DWPR Program) invites private industry, universities, water utilities, and others to partner with Reclamation to address a broad range of desalting and water purification needs.

The DWPR Program covers a wide range of advanced water treatment technology and methods. Fiscal year (FY) 2014 funded projects in multiple areas such as concentrate management, membrane development, and renewable energy-powered desalination systems.

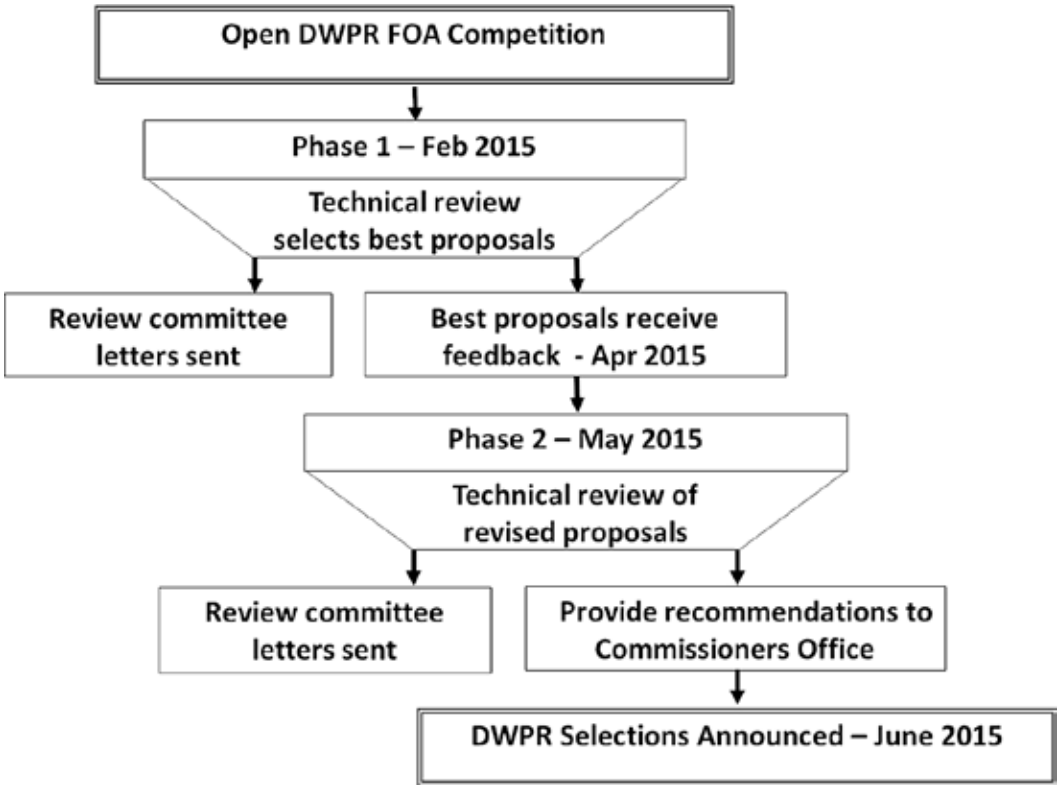
For FY 2015, Reclamation expects to award around $1.5 million in research laboratory- and pilot-scale studies. This year, DWPR instituted a two-phase system for proposal applications thus removing the previous pre-proposal process.

The DWPR Program priorities in FY 2015 are:

1. Overcoming technical, economic, and social barriers for direct and/or indirect potable reuse treatment

2. Novel processes and/or materials to treat impaired waters

3. Concentrate management solutions leading to concentrate volume minimization for inland brackish desalination



The DWPR Program's newly instituted two-phase system and schedule for proposal applications.

Challenges Update—The Desal Prize

Reclamation and the U.S. Agency for International Development (USAID), in partnership with the Swedish International Development Cooperation Agency and the Ministry of Foreign Affairs of the Kingdom of the Netherlands, announced the winners of the Desal Prize on April 22, 2015. The week of April 7, 2015, five finalist innovator teams competed for $200,000 in prize funds in head-to-head demonstrations at Reclamation's Brackish Groundwater National Desalination Research Facility (BGNDRF) in Alamogordo, New Mexico.

The Desal Prize competition judges at Reclamation's BGNDRF, Alamogordo, New Mexico.

The Desal Prize competitors' demonstration system setups at Reclamation's BGNDRF, Alamogordo, New Mexico. See additional photographs on back cover.

First place went to the Massachusetts Institute of Technology (MIT) and Jain Irrigation Systems with their photovoltaic-powered electrodialysis reversal (EDR) system. Second place went to the University of Texas at El Paso (UTEP) Center for Inland Desalination System with their zero discharge desalination technology.

The Desal Prize is a three-phase, incentivized competition that challenged worldwide innovators to create cost-effective, energy-efficient, and environmentally sustainable desalination technologies that can provide potable water for humans and water for crops in developing countries. The two winning teams, and a team that received honorable mention, will be eligible to receive grant funds totaling $400,000 to implement pilot projects in late summer or early fall with small-holder rural farmers in a USAID mission region.

First Place: MIT and Jain Irrigation Systems designed a photovoltaic-powered EDR system that desalinates water using electricity to pull charged particles out of the water and further disinfects by using ultraviolet rays. The system was designed for low energy consumption, limiting costs—especially in off-grid areas.

Second Place: UTEP Center for Inland Desalination System designed a Zero Discharge Desalination (ZDD) technology that reduces water waste in the desalination of groundwater by conventional processes. Electrodialysis uses voltage to remove undesirable ions from water.

Honorable Mention: Green Desal, a team comprised of the Asian Institute of Technology & Management, National Center for Agricultural Research and Extension, State University of Ponta Grossa, Technion-Israel University of Technology, and the University of North Texas, developed a high-percent recovery system that integrates proven technologies in reverse osmosis, ion exchange, nano-filtration, re-mineralization, and disinfection.

"The Bureau of Reclamation was proud to host this international competition at the Brackish Groundwater National Desalination Research Facility, which included 68 applications from 29 countries.

Providing a sustainable water supply is important for the West, the country, and the world. The knowledge gained from this competition will not only assist in the goals of the prize competition, it will inform brackish groundwater treatment technologies here in the United States."

Estevan López
Commissioner, Bureau of Reclamation

More Information

Reclamation's News Release:

http://www.usbr.gov/newsroom/newsrelease/detail.cfm?RecordID=49201

About Reclamation's BGNDRF:

http://www.usbr.gov/research/AWT/BGNDRF/

About the Desal Prize at USAID's Securing Water for Food: A Grand Challenge for Development Website:

http://www.securingwaterforfood.org/the-desal-prize/

About the Desal Prize Winners at USAID's Securing Water for Food: A Grand Challenge for Development Website:

http://www.securingwaterforfood.org/blog/2015/4/22/desal-prize-winners-announced

Infrastructure Research

Developing Research Roadmaps

The Research and Development Office started to develop research roadmaps to ensure continued reliability of Reclamation's infrastructure in 2013. Research roadmaps answer:

What are the common reasons for reduced service life, extraordinary maintenance, or failure of Reclamation's infrastructure components?

What mitigation practices are currently used by Reclamation to address these failures or extend the working life of the infrastructure components?

What additional tools, measures, and technology, or improvements in existing technology, might allow us to extend the service life for all reserved and constructed Reclamation infrastructure components?

Research Office Contacts

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

Bobbi Jo Merten
Chemist/Acting Science and Technology Program Manager
303-445-2380
bmerten@usbr.gov

Infrastructure Research Roadmapping

Roadmapping identifies and analyzes research gaps—unmet needs. Prioritized roadmaps of research, development, demonstration, or testing will help Reclamation fill gaps in its current toolbox and thereby extend the useful life of its critical infrastructure. They provide a comprehensive description of the research need, including the adverse outcome, currently used mitigation practices, and the outstanding needs for tools, technology, etc.

Canals

Reclamation has well over 8,000 miles of canal and almost 25,000 miles of laterals, with many going through areas that were once farmland but are now housing developments. Research is needed to maintain these canals and diversion dams ensure safe water deliveries. A draft research roadmap was completed in fiscal year 2014.[1] A few examples of needs identified during this preliminary phase are:

- Effective canal seepage detection methods or technologies for use by engineers or field staff to more clearly define seepage paths
- Tools to control or prevent animal burrowing in canals (nonhazardous)
- Effective methods for repair of animal burrows in canals
- Improved, less expensive canal lining, cover, and repair materials and methods (which districts can install themselves—low tech)
- Methods and materials for underwater placement of canal linings

Dams

Reclamation's approximately 471 dams [and dikes][2] provide a vital infrastructure for the West, storing water, providing flood control, and generating hydropower. A draft research roadmap was completed in fiscal year 2014. A few examples of needs identified during this preliminary phase are:

- Remote sensing or inspection method to detect seepage or material transport paths
- Methods and materials to detect and fill or repair voids under spillway slabs
- Modeling tools to predict the rate of concrete deterioration
- Developing improved correlations between laboratory grout characterization tests and actual field performance
- Improving understanding of chemical interactions that adversely affect the performance of embankment dam filter material
- Developing methods or tools to measure the health of a gate beginning with historical causes of nonperformance

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[1]Diversion dams are included in the canals research roadmap, because they tend to be maintained by the same personnel as those maintaining an associated canal.

[2]Congressional Research Service. December 2010. "Terrorism and Security Issues Facing the Water Infrastructure Sector." CRS Report for Congress. Congressional Research Service, 7-5700, www.crs.gov, RL32189, p. 2.

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Powerplants

Reclamation's 53 powerplants generate power from the water held behind reservoirs. They provide more than 40 billion kilowatt hours a year—enough electricity to serve 3.5 million homes. As powerplants are complex, a number of research roadmaps will be developed to provide a more comprehensive look at powerplant systems and equipment issues.

Glen Canyon Dam (Arizona) outlet works in operation.

Hydropower protection systems, the first powerplants research roadmap, was drafted by the Hydropower Diagnostics and SCADA Group in Reclamation's Technical Service Center. A few examples of needs identified during this preliminary phase are:

- Improving test methods including less invasive protection system test methods, online monitoring, and broad approaches to improvements, which minimize outage times, reduce operations and maintenance costs, and improve reliability and protection
- Relay logic review software allowing verification of logic diagrams, testing, and improved reliability
- Evaluating and improving training techniques specifically related to protection systems within the organization
- Maximizing testing intervals to reduce human-introduced errors while ensuring the highest level of reliability
- Improving equipment design, including test switch configurations to increase efficiency and safety of testing, optimizing lockout relay functionality and reliability, addressing maintenance in future designs, and investigating impacts of non-standardized equipment

Future Research Roadmaps

Future research roadmapping efforts to strategically identify Reclamation's infrastructure research needs include:

- Pumping Plants: Scheduled to be completed in fiscal year 2015.
- Powerplants: Mechanical systems research roadmap scheduled to be completed in fiscal year 2016.
- Pipelines: Scheduled to be completed in fiscal year 2016.

How Are Research Roadmaps Developed?

Reclamation field personnel, engineers, and policy specialists provide data for each research roadmap. Once the data are analyzed, a committee of subject matter experts ensures that the final results (the roadmap) provides an accurate and comprehensive representation of Reclamation's research needs. The committee's analysis incorporates the size of the research gap and the overall value of the research results. This ensures that the highest priority and impact research needs are identified.

Quality Control

Vetting is an important process to ensure Reclamation's research efforts extend into other communities of use. This process provides awareness, feedback, and buy-in for the identified research needs. Each research roadmap is being vetted individually to best target internal and external representatives for each type of infrastructure.

More Information

Non-Hydropower Infrastructure Roadmapping:

http://www.usbr.gov/research/projects/detail.cfm?id=151

Hydropower Roadmapping:

http://www.usbr.gov/research/projects/detail.cfm?id=9488

Infrastructure Research

Our aging infrastructure constantly presents new maintenance, replacement, and modification challenges. Reclamation must maintain water and power deliveries in a cost effective and environmentally sound manner. Infrastructure research strives to improve technology and find innovative repair and construction processes to cost effectively keep our infrastructure running for the next century. The projects previewed here were initiated in fiscal year 2015.

Detecting Corrosion on Rebar in Concrete

Corrosion costs over $275 billion a year in the United States, and 25 to 30 percent of these costs could be saved if optimum corrosion management practices were employed. Advanced life prediction and performance assessment tools are key to developing accurate forecasts of remaining service life and designing appropriate corrosion mitigation for Reclamation's infrastructure, including infrastructure built with reinforced concrete.

This Reclamation Science and Technology Program research project aims to apply novel techniques for nondestructive testing of corrosion of metal in reinforced concrete. Working with collaborators, novel techniques will be studied to quantify the degree of corrosion at a metal-concrete interface for use in site inspections and continuous monitoring. These techniques will be compared to a traditional corrosion measurement technique. The potential advances in sensitivity and location specificity of the new techniques would allow Reclamation corrosion specialists to pinpoint problem areas at an earlier stage where corrosion mitigation methods might be used rather than repair or replacement.

Reclamation Science and Technology Program Research Project ID 1943
Contact: Jessica Torrey | Technical Service Center | 303-445-2376 | jtorrey@usbr.gov

Monitoring Corrosion Mitigation Systems With the U.S. Army Corps of Engineers

Reclamation has over 1,000 cathodic protection (CP) systems on hundreds of projects. This includes both galvanic and impressed current CP systems on aging structures valued well above a billion dollars, such as pipelines, tanks, dams, gates, trashracks, and fittings. Proper design and installation followed by routine testing and maintenance of a corrosion mitigation system are key to protecting Reclamation's infrastructure.

Researchers at the U.S. Army Corps of Engineers (USACE) are developing a modeling tool to maximize the efficiency and protected area of a CP system upon installation. In addition to this design tool, they are investigating sensors to monitor the health of the coating and CP system through the lifetime of the structure. Due to the similarity of missions and infrastructure, researchers at Reclamation are joining with their counterparts at USACE in this effort to document structures of priority concern for corrosion issues at both agencies, identify critical components of these structures, and provide guidance for designing and installing corrosion mitigation systems for improved efficiency. As the research progresses, researchers hope to collaborate on a pilot study of the CP design model and remote sensor array.

Reclamation Science and Technology Program Research Project ID 4108
Contact: Jessica Torrey | Technical Service Center | 303-445-2376 | jtorrey@usbr.gov

Samples of corrosion on steel panels and with panels embedded in concrete.

Surveying Elephant Butte Dam With Unmanned Aerial Vehicles

Reclamation's Elephant Butte Dam in New Mexico is nearly a century old. To inspect for signs of aging, inspectors must now scale the face of the dam using ropes. But could remotely controlled unmanned aerial vehicles (UAV) photograph and scan the dam? If so, then inspections could be more frequent and more thorough, pointing to early signs of problems to address them quickly and more easily.

Using UAVs may prove to be an expedient, economic, and safe way to conduct inspections. If so, then this could be applied to many more of our aging dams as they exceed their design life and thus provide more information for Reclamation's Safety of Dams Program.

Investigators in the El Paso Field Division in Reclamation's Upper Colorado Region are exploring the above question, focusing on Elephant Butte Dam. At the same time, another Reclamation Science and Technology Program research project (Project ID 9612) will apply photogrammetry to the aerial survey data. Doing so would be the first full sight survey using a UAV.

Historic photograph of the first project manager's car (a 1915 Cadillac Touring Car) parked on Elephant Butte Dam, New Mexico, in the early 1920s. Note: A modern UAV (Aeryon Scout) has been added.

Reclamation Science and Technology Program Research Project ID 6015
Contact: Mike Landis | Upper Colorado Region | 915-534-6307 | mlandis@usbr.gov

Erosion of Cracks in Canals and Dam Embankments

Embankment failures in urbanized areas could result in loss of life, significant property damage, environmental impacts, loss of project benefits, litigation, and a decrease in Reclamation's credibility. Better understanding the potential for internal erosion and embankment failure due to cracking is critical to maintaining our infrastructure. The University of New South Wales (UNSW) created a Hole Erosion Test (HET) to determine the initial hydraulic shear stress required to initiate erosion. From this research, Reclamation, U.S. Army Corps of Engineers (USACE), UNSW, and URS Corporation created tables for designers to use when evaluating the potential for internal erosion to initiate through a cracked embankment.

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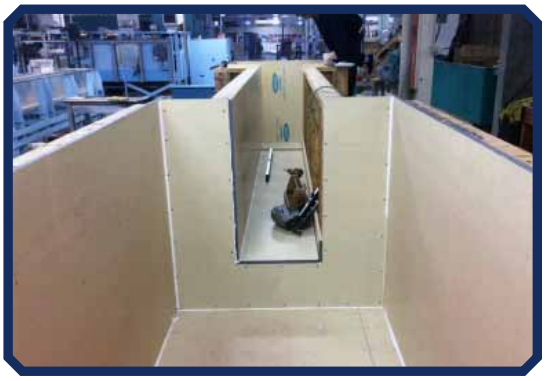
Almost complete model, looking upstream.

Model under construction—on the left is the reservoir, tail box is on the right.



Photograph taken looking upstream, standing in the tail box.

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However, Reclamation and USACE are concerned that the HET may not accurately evaluate the probability of erosion initiating within a cracked embankment. The Crest Embankment Erosion Test (CEET) will help Reclamation and USACE determine if HET results should be used in the risk-based evaluation process that USACE has adopted for much of their dam and levee inventory and that Reclamation has adopted for their dam embankments, and canals in some cases.

This research will test particular soil types to see how flaws or cracks in embankments can erode under different conditions. The new model is under construction and preliminary tests will begin this summer. Results from each test will be drafted in a report containing photographs and video of each test, material properties, CEET and HET erosion rates, and a comparison of the CEET and HET results. A final report co-authored between team members from Reclamation's Technical Service Center, as well as USACE, is anticipated to be completed in fiscal year 2017.

Reclamation Science and Technology Program Research Project ID 8284
Contacts: Peter Irey | Technical Service Center | 303-445-3033 | pirey@usbr.gov
Ted Howard | Technical Service Center | 303-445-3042 | thoward@usbr.gov

Going Under Water to Seal Cracks With Chemical Grouts

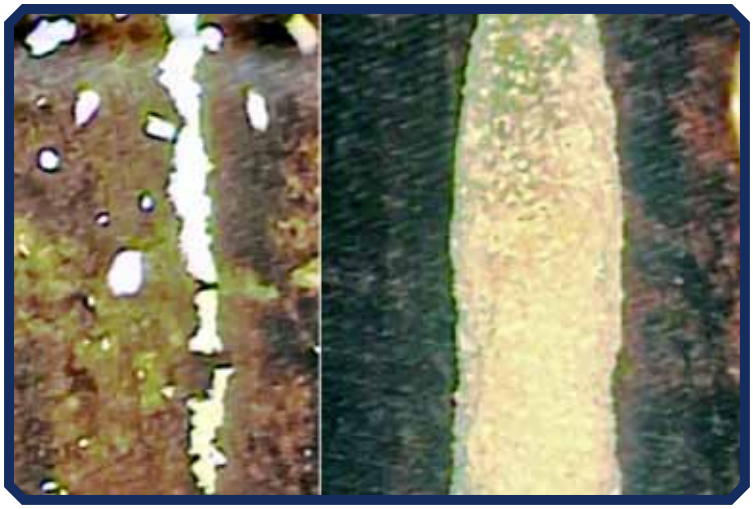
Reclamation's concrete structures play vital roles and cannot always be taken out of service for repairs. Yet they may need repairs as they age. Polyurethane grouts can cure under water and provide a waterproof seal in the concrete. In addition, the grout remains flexible, which can accommodate some concrete movement.

Testing in the Materials Engineering and Research Laboratory in Reclamation's Technical Service Center will occur this summer. Concrete cylinders will be broken into two pieces and placed into a test bed. Grout will be applied under water to seal these cracks as water moves through it to simulate in an in-service application. Different sizes of cracks and types of underwater sealers will be tested.

This Reclamation Science and Technology Program research project will also examine ways to deliver the sealing material for cracks. These machines could be operated above the surface of the water (from the crest of the dam or the canal embankment, or even in a boat) to repair these cracks. Thus, a diver would not be needed.

Reclamation Science and Technology Program Research Project ID 2398
Contact: Matthew Klein | Technical Service Center | 303-445-2368 | mjklein@usbr.gov

Evaluating Methods to Seal Leaking Contraction Joints in Dams



Ground polyurethane pumped to a leaking contraction joint. The left figure shows a close up of the particles being pulled into the joint and the right figure shows the particles completely plugging the joint.

Many of Reclamation's concrete dams were constructed with contraction joints that contain metal waterstops to prevent water from leaking through the joints. While these waterstop materials worked well for many years, as the contraction joints flex and move, some of the waterstops are failing. In some cases when they fail, they can allow large amounts of water into galleries and equipment rooms within the dam, causing significant maintenance and safety issues. This could lead to millions of dollars of increased maintenance costs across numerous facilities.

One way to repair these leaks is to core a hole and place hydrophilic rubber compounds behind the failed waterstop. Grand Coulee Dam in Washington has a contraction joint where the leaks have been steadily increasing. Holes cannot be cored here, so the project's researchers ground up the rubber and

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pumped it 200 feet deep into the reservoir water near the leaking joint's opening. The flowing water pulled the rubber particles into the joint, reducing water flows through the joint significantly.

The initial scoping project (Reclamation Science and Technology Program Research Project ID 3191) demonstrated that the concept was sound. One of the shortcomings of this approach, however, is that the rubber particles are not adhering to one another. When the joint or crack moves, some of the particles can become dislodged, reducing the effectiveness of the seal. This Reclamation Science and Technology Program research project will investigate methods to make the particles adhere to each other and the sides of the joint or crack once they have swelled. This should improve the long-term performance of the repair method. If this effectiveness can be improved, the method offers a relatively inexpensive solution to sealing leaking joints and cracks in hard-to-access locations.

More Information: See the "Multimedia Around Reclamation" segment in this issue on page 8, for a video regarding the Grand Coulee Waterstop.

Reclamation Science and Technology Program Research Project ID 7688
Contacts: David (Warren) Starbuck | Technical Service Center | 303-445-2317 | dstarbuck@usbr.gov
Kurt Von Fay | Technical Service Center | 303-445-2399 | kvonfay@usbr.gov

Determining When to Replace Wire Ropes

Wire ropes are everywhere in Reclamation's facilities and are used for personnel elevators, gate hoists, and the various cranes throughout Reclamation. They have a useful service life of 15 to 20 years. Extending their useful life and avoiding replacing still suitable ropes could reduce capital expenses. This Reclamation Science and Technology Program research project is examining using nondestructive testing to accurately estimate the residual strength of wire ropes to determine the remaining useful life of the rope. This research project will result in an operational manual to recommend ways of using nondestructive testing to determine when to replace wire ropes.

This clamp-on device can apply a magnetic flux leakage method to a wire rope in-situ to detect corrosion damage.

Reclamation Science and Technology Program Research Project ID 3973
Contact: Daryl Little | Technical Service Center | 303-445-6341 | dlittle@usbr.gov

Photogrammetric Tools for Condition Assessment

Photogrammetry can create three-dimensional (3D) images and models from photographs. However, models create complex files that need advanced computer hardware to process and view. In January 2015, Agisoft updated their PhotoScan photogrammetry package to include a standalone viewer. This allows a client to download and install a free viewer on their standard configured computer. The 3D model can be exported from PhotoScan and sent to the client for comment.

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Infrastructure Research

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Moreover, photogrammetry can be conducted in a series of time intervals to measure flows or even to monitor structures over long periods of time. These time-based pictures can be used to create a dynamic 3D model that changes over time (see the "Multimedia Around Reclamation" segment in this issue for a video regarding a concrete counterfort wall). In April 2015, this Reclamation Science and Technology Program research project will involve taking time interval pictures of a canal embankment breach test. A video will be created showing the 3D model and how it fails allowing measurements and analysis after the test has been completed.

A 3D photogrammetric counterfort wall model with photograph-realistic texture.

Actual counterfort wall model

At the moment, photogrammetry requires a special camera and setup. But what if a dam operator or ditchrider could just use a cell phone to take photographs? This research project is also comparing the quality difference and determining how much error is introduced by using a smaller sensor. If accurate results can be obtained by more casual photographs, then photogrammetry could have an even larger impact. Results from this research project will greatly enhance Reclamation's knowledge and application of photogrammetry's unique process to its diverse and specialized infrastructure.

Reclamation Science and Technology Program Research Project ID 493
Contact: Matthew Klein | Technical Service Center | 303-445-2368 | mjklein@usbr.gov

Structure From Motion Photogrammetry

The project described above includes use of "Structure from Motion" (SfM) or related techniques. SfM is a type of photogrammetry that uses a suite of algorithms to extract 3D point clouds from ordinary photographs. This can automatically match features between multiple photographs of the same subject taken from different angles and create 3D spatial positions. While precision and the quantity of points may not equal laser scanning technologies, the flexibility and low cost of SfM has several advantages:

- Collect data as needs arise, such as in the middle of construction, an emergency situation, or to fill in gaps. Collection can even be from a cell phone camera (though precision may be reduced with small lenses and sensors).
- Collect data that laser scanning or photogrammetry that require more precise photographs cannot access, or require customized equipment. Enables collection of data from a river raft in motion, an unmanned aerial vehicle, or even under water.
- Allows frequently repeated collections where scheduling of laser scanning may not be practical, affordable, or even possible.

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One of 46 raw photographs taken in modeling detailed riverbank topography (next page). Photographs were taken with a digital single-lens reflex (DSLR) camera while floating past the banks on an inflatable river raft.

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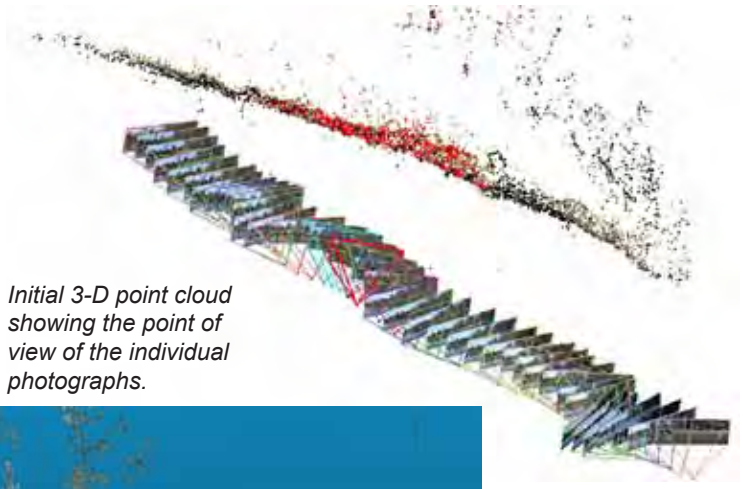
To promote strong knowledge and proper application of SfM, Reclamation's Science and Technology Program is developing a community of practice within Reclamation and other U.S. Department of the Interior agencies. An SfM workshop is planned for summer 2015 (see the "Recent and Upcoming Events" segment in this issue for details).

Reclamation Science and Technology Program Research Project ID 3835
Contact: Eric Peterson | Mid-Pacific Region | 530-623-1810 | ebpeterson@usbr.gov



Initial 3-D point cloud showing the point of view of the individual photographs.

Final ("densified") 3-D point cloud of riverbank. Data have not been cleaned of reflections from the water surface.

Considering Substrate Moisture Content in Concrete Repairs

Concrete repair and rehabilitation commonly involves removing unsound concrete before placing a repair material on it. Surface preparation of the existing concrete for repair affects the strength and durability of the bond between the existing concrete and new repair material. A very dry "thirsty" concrete surface tends to "suck" water from the repair material, which can reduce bond strength because of insufficient moisture for proper hydration of the repair material at the substrate surface. Conversely, too much moisture can reduce bond strength because excess water will leave excess porosity at the bond line and can prevent penetration of repair material hydration products into the substrate surface.

Most repair specifications and repair job requirements simply say that for cementitious repairs, the substrate surface should be "saturated surface dry." This roughly means the substrate is saturated, but starting to "look" dry. Yet there is no defined way to measure this in the field—and no comprehensive data available to support whether this is the best surface moisture condition or not.

This Reclamation Science and Technology Program research project will expand on work from a previous study. The previous study determined appropriate methods to measure surface moisture content and examined the effect of a range of moisture conditions on early age bond strength (about 28 days) of repair mortars. This study will look at bond strengths over time for slabs conditioned at three different moisture conditions prior to the application of a repair mortar and stored outside. Numerous pulloff tests will be performed over a period of time to determine the effects of moisture content and time on bond strength. Data generated from both of the experiments will be analyzed to determine correlations between moisture content, bond strength, overlay material, and age of bond strength testing.

Reclamation Science and Technology Program Research Project ID 6629
Contacts: John (Bret) Robertson | Technical Service Center | 303-445-2316 | jrobertson@usbr.gov
Kurt Von Fay | Technical Service Center | 303-445-2399 | kvonfay@usbr.gov

Safety Research

Reclamation is responsible for a multitude of facilities that form a significant part of the water resources infrastructure for the Western United States. Reclamation personnel also conduct a significant number of laboratory- and field-based work, research, studies, and investigations related to its projects and infrastructures. As the owner of these facilities, Reclamation is committed to providing the public, the environment, and its staff with adequate protection from risks which are inherent to this work and its infrastructures.

The need for more confidence becomes more prevalent as Reclamation infrastructure ages and innovation and technology grows. As Reclamation moves forward, it is imperative that employee safety continues to be a strong consideration. Any renovations or updated operational and maintenance processes must consider impacts to employee health.

Fish surveys underscore the need for safety.

Improving Methods for Predicting Air Demand in Penstocks and Outlet Pipes

Penstocks and low-level outlet pipes have air vent systems to provide efficient hydraulic operations and to protect the pipe in the case of an emergency closure. Emergency operations without proper air venting could, in some cases, cause the pipe to collapse, which would threaten the safety of the facility, personnel, and even the public. Original air vent systems on Reclamation facilities were sized using the best analytical methods available at the time. Due to uncertainties in predicting air demand, vents were sized conservatively to ensure safe operation.

For many facilities, operational requirements have changed for a variety of reasons, including environmental considerations, water delivery changes, and hydropower upgrades. Existing pipes (which may have aged significantly) are required to operate at higher flow rates than the original design, often putting the air vent system in question. Analytical methods for sizing air vent systems with more certainty will be needed to assess existing and new systems. This Reclamation Science and Technology Program research project is using physical data from laboratory and field tests to improve analytical methods and numerical models. This will help ensure that model outputs have greater certainty and more realistically predict air demand for air vent sizing and design.

Reclamation Science and Technology Program Research Project ID 5710
Contact: Josh Mortensen | Technical Service Center | 303-445-2156 | jmortensen@usbr.gov

Safety Practices and Protocols for Natural Resources Field Investigators

Reclamation personnel conduct many investigations in the field to survey and analyze natural resources related to Reclamation projects. Field-based investigations have inherent safety issues associated with weather, terrain, water (moving or stationary), disease, animal interaction, boating, wading, etc. Consolidated safety practices/protocols for natural resources field investigators to follow when conducting field-based investigations and monitoring are needed to keep personnel safe.

To develop safety practices/protocols, safety and natural resources specialists from Reclamation's Pacific Northwest and Mid-Pacific Regions, along with the Denver Safety Office, are working together on this Reclamation Science and Technology Program research project to plan and develop safety practices/protocols that natural resources specialists and technicians throughout Reclamation can use. Identifying potential hazards and developing mitigation practices/protocols will help natural resources personnel to do their jobs safely.

Reclamation Science and Technology Program Research Project ID 7949
Contact: Gay (Allyn) Meuleman | Pacific Northwest Region | 208-383-2258 | gmeuleman@usbr.gov

Reducing Noise From Sandblasting

Noise is often overlooked as a hazard because there are no obvious indicators of acute or chronic exposure. However, noise-induced hearing loss (NIHL) is one of the highest workers compensation expenses agencies have for non-traumatic injuries.

Sandblasting equipment such as gates and stop logs for dams, powerplants, and pumping plants is very noisy—with a median time-weighted average exposure for all blasting at 92 decibel-weighted average (dBA) and with short-term exposures easily exceeding 115 dBA. How can Reclamation use engineering controls to prevent noise exposure and possible hearing loss in high noise processes such as sandblasting and metal preparation?

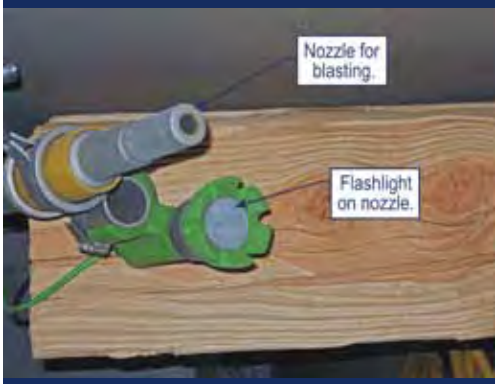
While personal protective devices are necessary to protect workers in this high noise environment (sandblasting noise measured at Grand Coulee Powerplant in Washington, ranged as high as 130 dBA), research and development focuses on achieving a longer term fix by reducing the noise at the source. Current research is focused on redesigning the sandblasting nozzle using a combination of experimental methods and advanced analysis techniques (which are also being used for jet engine noise reduction). The goal is to reduce noise by at least 10 decibels.

This Reclamation Science and Technology Program research project study will provide data to support the consideration of hazardous noise production as design criteria and will enable the engineers to focus energies toward redesign of those equipment or areas where the noises levels are the highest. The data from this study could result in new transferable technologies that could be used by all of Reclamation and all other agencies who perform large-scale sandblasting and other operations involving hazardous noise levels.

Research results so far have determined that noise reductions via nozzle modifications may be limited due to the geometry and size limitations of the nozzle. Therefore, investigators are modifying the nozzles to improve blasting efficiency to limit the blasting time and noise exposure for a sandblasting operator. A local machine shop will manufacture a prototype of a more efficient nozzle that uses the same inlet air pressure as the nozzle that Reclamation currently uses. The prototype will be tested at a local sandblasting facility this fiscal year.

Reclamation Science and Technology Program Research Project ID 9595
Contact: Christopher Andrews | Pacific Northwest Region | 509-633-9593 | candrews@usbr.gov

Personal protective equipment worn while sandblasting.



Sandblasting at Grand Coulee Powerplant, Washington.

Research Updates

Bulletin Title, Quote, and Website

Page

Polyurea Holds a Canal Together
"Wish we had enough money to coat all 12 miles of the RCC lining tomorrow! That Aqualastic® really works to seal the canal without reducing flows."
Mike Britton, General Manager
North Unit Irrigation District, Madras, Oregon
www.usbr.gov/research/docs/updates/2015-07-polyurea.pdf

Measuring Erodibility of Embankment Soils Containing Gravel
"This research increases our confidence in measurements of soil erodibility for many soils that we previously could not test."
Tony Wahl, Hydraulic Engineer
Reclamation's Technical Service Center
www.usbr.gov/research/docs/updates/2015-08-soil-erodibility.pdf

Eco-Friendly Cement for Green Construction
"This research is a great opportunity to assess a so-called "green" construction material for use at Reclamation. The sophisticated technology of TiO_2 photocatalysis is incorporated into a common building material—cement. This cement can be applied to structures such as retaining walls, office buildings, dam crests, and walkways. The white color is preserved with little maintenance, and it provides local air-purification."
Jessica Torrey, Materials Engineer
Reclamation's Technical Service Center
www.usbr.gov/research/docs/updates/2015-09-cement.pdf

Taking Cues From the Ancient Romans
"Examining these ancient techniques could help improve concrete strength, durability, and longevity while reducing global carbon emissions."
Audrey Rager, Geologist
Reclamation's Technical Service Center
www.usbr.gov/research/docs/updates/2015-10-roman-concrete.pdf

Managing Disputes Over Science: Contested Factors
"In focus groups held in regional and area offices, members of Reclamation's leadership told us they routinely spend 50 to 75 percent of their time managing conflict. Development of collaborative competencies among our employees is, therefore, vital to the future of this agency."
Douglas Clark, Physical Scientist
Reclamation's Technical Service Center
www.usbr.gov/research/docs/updates/2015-11-science-disputes.pdf

Research Update

Summer 2015
Bulletin 2015-01

Bottom Line

This research project helped develop HydroSense, a publically available modeling code that allows users to conduct hydro-economic analyses of water management alternatives. Reclamation and the Idaho Water Resources Research Institute at the University of Idaho have been developing these methods over the past 8 years.

Better, Faster, Cheaper

Hydro-economic modeling provides a framework for integrating physical, ecological, economic, and social/cultural systems into a single valuation that more completely explains the costs and benefits of management alternatives.

Principal Investigator

Jennifer Johnson, P.E.
Hydraulic Engineer
River and Reservoir Operations Group
Pacific Northwest Region
208-378-5225
jmjohnson@usbr.gov

Research Office Contact

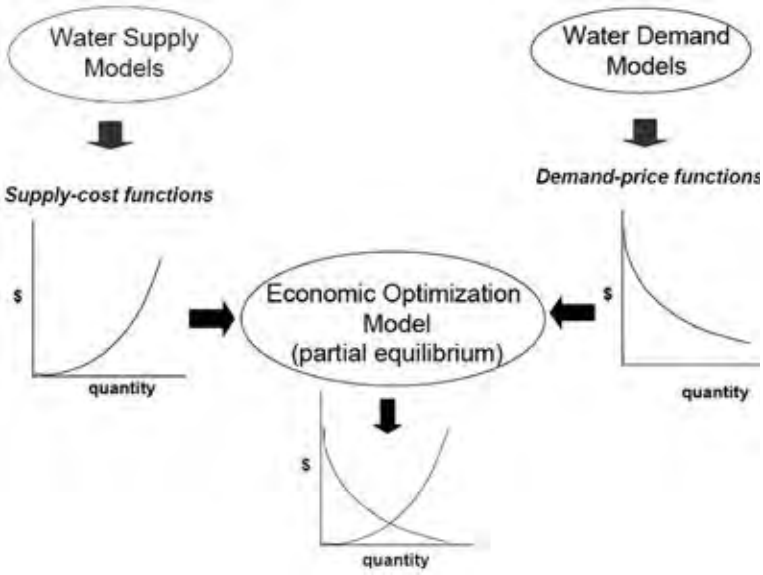
Erin Foraker
Renewable Energy Research Coordinator
303-445-3635
eforaker@usbr.gov

HydroSense: Publically Available Model for Evaluating Water Management Decisions

Making the hydro-economic modeling methodology available to the modeling community

Problem

Reclamation water management planning studies often require determining net benefits (benefits minus costs) or benefit-cost ratios (net benefits divided by net costs) for each alternative being considered.



Previous methods used to quantify benefits used a water supply management approach, which only tells part of the story and assumes that demand is static regardless of the cost of the supplied water. To provide a true picture, the changes in water demand that result from the changing cost of the supplied water need to be considered. Hydro-economic models consider both supply and demand to provide a framework for integrating physical, ecological, economic, and social/cultural systems into a single valuation that more completely explains the costs and benefits of water management alternatives.

Since 2006, Reclamation and the University of Idaho-Idaho Water Resources Research Institute hydrologists and economists have been collaborating to develop a hydro-economic model. The conceptual model and approach has been developed and proved in the Boise Basin, Idaho, resulting in a number of publications. However, applying the method in another basin was fraught with unknowns. How difficult would it be? Could other analysts not familiar with the model use the model to produce meaningful results? Since this method brings better valuations, making the model usable and accessible to future users in many basins is paramount.

Solution

To ensure that future Reclamation studies could use this hydro-economic model, this Reclamation Science and Technology Program research project entailed writing a generalized instruction manual for the hydro-economic modeling methodology

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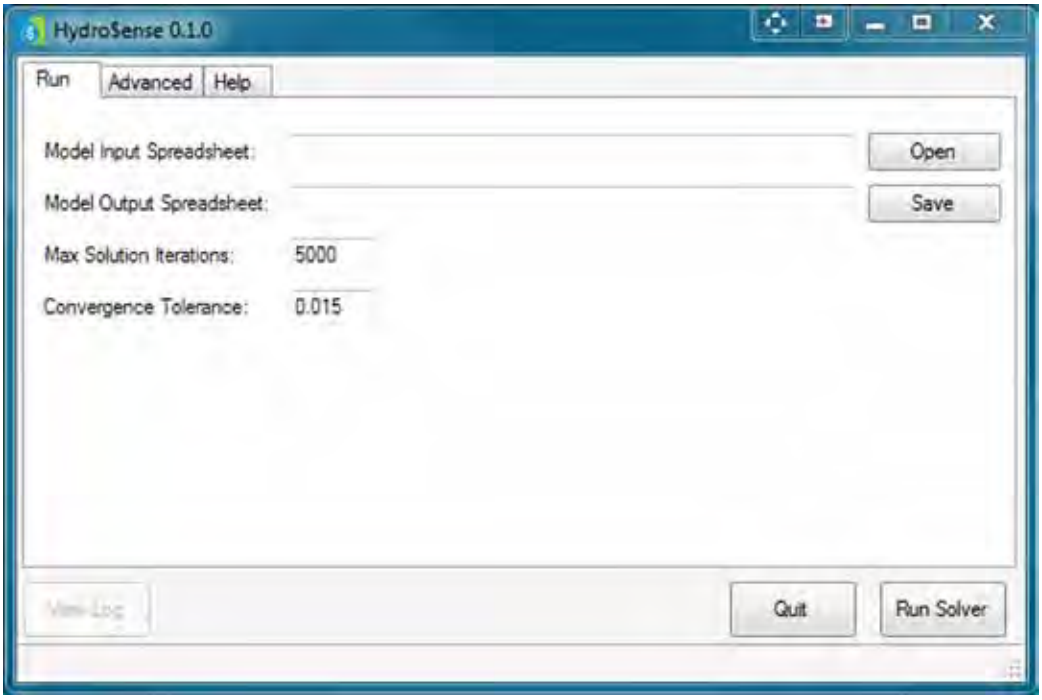
and developing HydroSense, an open source code that could be used to conduct hydro-economic analysis. To prove the model was useful in a basin other than the Boise Basin, this project applied the methodology to the Henrys Fork Basin in eastern Idaho.



HydroSense 0.1.0 interface, developed by Bob Lounsbury, Hydraulic Engineer, Reclamation's Pacific Northwest Region.

Future Plans

This methodology has been gaining recognition in the economic community and has proven to be useful in evaluating possible water management alternatives.

Now that it is publically available with a user's manual describing the methodology, it can be used by hydrologists and economists throughout Reclamation when evaluating water management alternatives. Others in Reclamation have expressed interest in adapting HydroSense for operational use.

Once technical staff are familiar and comfortable with the theory behind this methodology and application of the HydroSense tool through the proposed training and outreach, future potential uses by Reclamation could lead to project-level development of operational scenarios or other applications.

HydroSense logo created by Bobby Gaytan, Illustrator, Reclamation's Pacific Northwest Region.

"HydroSense is open-source code that can be used to conduct hydro-economic analysis using the methodology developed by Reclamation and University of Idaho-Idaho Water Resources Research Institute. It can provide a more complete valuation of water than the more traditional economic approaches, so it has the potential to lead to better, more informed water management decisions."

Jennifer Johnson
Hydraulic Engineer,
Reclamation's Pacific Northwest Region

Collaborators

- **Reclamation:**
  - ◊ **Pacific Northwest Regional Office**
  - ◊ **Snake River Area Office**
  - ◊ **Technical Service Center**
- **University of Idaho-Idaho Water Resources Research Institute**

More information

www.usbr.gov/research/projects/detail.cfm?id=8937

HydroSense code available at:

https://github.com/usbr/hydrosense

Research Update

Summer 2015
Bulletin 2015-02

Bottom Line

A generalized total dissolved gas (TDG) prediction tool is being collaboratively developed.

Better, Faster, Cheaper

Operators need a generalized model for predicting TDG to prioritize spills at dams to increase hydropower generation.

Principal Investigator

Merlynn Bender
Hydraulic Engineer
Water Resources Planning and Operations Support Group
Technical Service Center
303-445-2460
mbender@usbr.gov

Research Office Contact

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

Collaborators

- **Reclamation's Power Resources Office**
- **U.S. Department of Energy's Oak Ridge National Laboratory**
- **University of Iowa's IIHR—Hydroscience & Engineering**
- **University of Colorado Boulder's Center for Advanced Decision Support for Water and Environmental Systems**
- **Chelan County Public Utility District, Washington**

Predicting Total Dissolved Gas (TDG) for the Mid-Columbia River System

Classifying structural and operational parameters for a generalized TDG model

Problem

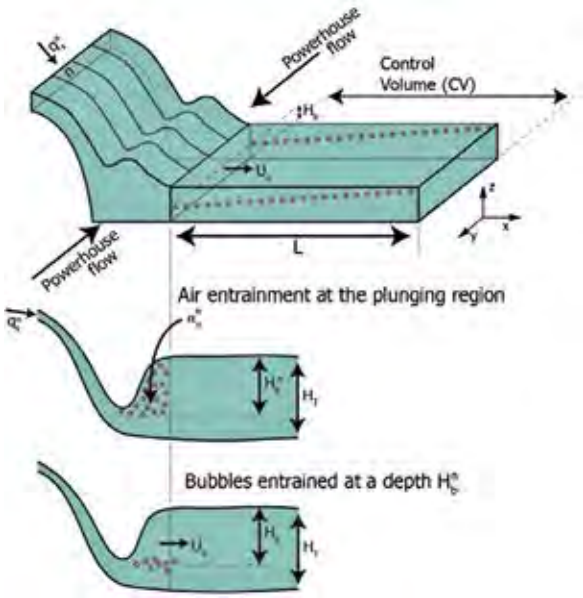
Total dissolved gas (TDG) supersaturation in tailwaters below hydropower dams can have significant effects on fish and downstream environmental conditions. Environmental constraints imposed in relation to TDG levels in tailwaters can further be a major limiting factor to operations and result in lost power generation. Yet there is no simple method for quantifying these TDG effects between or across a variety of hydropower facilities, dams, and/or water types due to the many degrees of varying conditions and operational scenarios.

Currently, no generalized predictive tools or guidelines are available to assess the effects of dam operations on downstream TDG minimization or reduction. Hydropower operators and planning groups need a generalized approach based on structural attributes to predict TDG at multiple dams based on readily available generalized parameters

Solution

Agencies are collaborating on developing a generalized TDG exchange method to predict TDG levels downstream from hydropower facilities with similar structural attributes. Steps include:

- Comparing dams where TDG is and is not a concern to identify a range of criteria needed for the predictive tool
- Determining a generalized set of parameters that affect TDG exchange (such as tailwater depth, spill discharge and pattern, project head, and entrainment of powerhouse releases)



Model parameters include plunge zone control volume, plunge point air entrainment, and bubble depth.

- Developing models based on fundamental mass, momentum, and energy conservation principles
- Using TDG data collected at Columbia River Basin dams to calibrate the generalized models using multiparameter regression analysis for various structural categorical classes

This resulted in simplified formulations to classify structural, operational, and environmental parameters to develop a predictive TDG exchange model.

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This generalized empirical approach helps develop TDG exchange formulations to apply to a whole class of projects while avoiding expensive data collection programs and complex project-specific model development formulations.

A one-dimensional model to predict TDG downstream from dams was developed based on mass, momentum, and energy conservation principles. The model consists of physically meaningful parameters including tailwater depth, powerhouse and spillway flow rates, unit spill, project head, and environmental variables such as atmospheric pressure and temperature.

Sensitivity analysis demonstrated that the most important parameters based on the variance of TDG are related to the maximum bubble depth and how the gas is vertically distributed above this depth. The model was implemented in a flexible framework to facilitate future introduction of additional processes or more comprehensive models.

Application

The network of dams throughout the Columbia River Basin are managed for irrigation, hydropower production, flood control, navigation, and fish passage that frequently result in both voluntary and involuntary spills. These dam operations are constrained by State and Federal water quality standards for TDG saturation, which balance the benefits of spill with the degradation to water quality associated with TDG saturation.

The capability of the model to predict TDG was evaluated by comparing model results against TDG data collected at Rock Island and Grand Coulee Dams on the Columbia River in Washington. The model accurately predicted TDG at Rock Island Dam; the more complicated structural and operational attributes of Grand Coulee Dam were more challenging.

Proposed Future Plans

Studies are needed to determine if generalized prediction of TDG is feasible for system operators and, if so, to develop the corresponding methodology and protocol for implementing a real-time water regulation modeling tool or guideline. Proposed future work would focus on:

1. Generically modelling the five remaining projects on the Mid-Columbia River
2. Incorporating the predictive generalized TDG equations into a real-time scheduling tool being developed by the Center for Advanced Decision Support for Water and Environmental Systems at the University of Colorado Boulder
3. Formulating a methodology for using a real-time scheduling tool for development of operational guidelines
4. Conducting an added-value analysis of a proposed real-time scheduling tool and operational guidelines
5. Disseminating information describing the generalized predictive TDG tool for development of spill priority guidelines for system operators

"Using a generalized model with other hydropower operations and planning efforts can help maximize hydropower generation while minimizing downstream TDG levels."

Merlynn Bender
Hydraulic Engineer,
Reclamation's Technical Service Center

More information

www.usbr.gov/research/projects/detail.cfm?id=9650

Rock Island Dam, Washington —a simpler project model.

Grand Coulee Dam, Washington—a more challenging project.

For printable version see: www.usbr.gov/research/docs/updates/2015-02-tdg.pdf

Research Update

Summer 2015
Bulletin 2015-03

Bottom Line

This research project developed initial guidelines for formulating reservoir sustainability plans to effectively manage inflowing sediment loads and in-situ deposits.

Better, Faster, Cheaper

Taking a proactive approach in developing a reservoir sedimentation management strategy for Reclamation reservoirs will help avoid loss of project benefits and expensive retirement options. The annual cost to manage inflowing reservoir sediment is much less than the cost to try to recover decades of past reservoir sedimentation.

Principal Investigator

**Kent Collins, P.E.
Hydraulic Engineer
Sedimentation and River Hydraulics Group
Technical Service Center
303-445-2549
kcollins@usbr.gov**

Research Office Contact

**Levi Brekke
Chief, Research and Development
303-445-2494
lbrekke@usbr.gov**

Dealing With the Inevitable: Sediment in Reservoirs

Developing effective guidelines for managing sediment in Reclamation's reservoirs

Problem

As time passes, reservoirs fill with sediment causing storage loss, reducing water supply reliability, and impacting infrastructure, particularly to marinas, boat ramps, outlet works, turbines, and water intakes. Also, reservoir deltas may extend upstream from the full reservoir pool and increase the frequency of flooding. Sedimentation will also reduce the surface area available for recreation. Reservoir sedimentation rates are very site-specific and vary across the world, ranging from an average annual storage loss of 2.3 percent in China to 0.2 percent in North America.

Reclamation's dams and reservoirs were designed to accommodate sedimentation over the first 100 years of operation. With many Reclamation reservoirs at or near their sediment design life, future sediment inflows will further decrease operational capabilities of these facilities along with the reservoir storage capacity. Half of Reclamation's reservoirs are over 60 years old, nearly 20 percent are at least 80 years old, and 7 percent are already older than the sediment design life of 100 years. By the year 2024, 31 (13 percent) of Reclamation reservoirs will be at least 100 years old and that number will increase to 46 (19 percent) by the year 2034. Current and new Reclamation facilities need to be designed, re-operated, and retrofitted for sustainable use to limit the loss of operational benefits and reservoir capacity due to sedimentation.

Solution

This Reclamation Science and Technology Program research project developed a proactive approach to managing sediment. This approach will change the management of reservoirs to provide project benefits indefinitely. A sustainable sediment management strategy would require upfront and continual operation and maintenance costs (including monitoring), but these continual costs can be feasible and less than the final costs associated with dam decommissioning if reservoir sedimentation is not managed.

Methods and alternatives identified by this research help determine the state of reservoir sedimentation in Reclamation facilities and provide Reclamation and other Federal agencies with ideas for taking a proactive planning approach to best manage dams and reservoirs in a sustainable manner.

Results

The preliminary reservoir sustainability guidelines provide the following information:

1. **Determine the magnitude of the sediment problem.** As the saying goes, "one cannot manage what one cannot measure." Direct ways to measure storage loss and the potential of sediment problems in a reservoir are to perform repeat hydrographic surveys of the reservoir and to measure sediment flux upstream and downstream from the reservoir. Determining the magnitude and rate of sedimentation helps predict when key reservoir and dam facilities will be impacted and helps prioritize reservoir sediment management activities.

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2. **Define preliminary sediment management options.** All methods to manage reservoir sedimentation can be placed into three reservoir sediment management categories: reduce sediment delivery, prevent sediment deposition, and remove deposited sediments. A combination of methods may be necessary to maintain reservoir capacity and achieve sustainability.

3. **Define stakeholders and constraints.** Most dams and reservoirs have a unique combination of site-specific constraints. Identifying site constraints and involving all stakeholders that benefit or may be impacted is critical to determine a reservoir's unique and potentially conflicting requirements.

4. **Assess feasibility, economic viability, and environmental considerations of options.** To assess the economic viability of various sediment management methods, a life cycle approach must be developed (either managing the reservoir sustainably or managing the reservoir as an exhaustible resource and funding dam decommissioning and developing new storage to maintain future benefits). Changes in operation to implement various sediment management methods are likely, requiring determination of water quality impacts from reservoir sediments and analysis of any potential contaminants to minimize adverse environmental effects.

5. **Develop and implement a sediment management plan**. Changes involving the dam and reservoir include a reservoir sediment monitoring plan, changes in operational and maintenance procedures, and any new implementation features, such as the possible design and construction of new infrastructure to pass sediments, a periodic dredging plan, and any agreements of funding and coordination with other stakeholders, public and private.

6. **Monitor and revise plan if necessary.** As with managing any resource, continued monitoring of reservoir sediments is necessary to track whether or not the implemented sediment management options are performing as predicted. If implemented options are not performing as predicted, revising the original plan may be necessary to extend the life of a reservoir and achieve reservoir sustainability.

Future Plans

Recommendations based on this research and findings include:

- Coordinate and perform pilot studies at Reclamation facilities to test the competency of the preliminary reservoir sustainability guidelines.

- Develop more detailed guidelines providing decisionmaking tools and key design information for the prediction and implementation of various sediment management methods.

- Develop additional Geographic Information System (GIS) data within Reclamation's DataSpace Console that include the storage capacity, drainage area, mean annual inflow, and mean annual sediment yield for all Reclamation reservoirs. These data would be valuable in further determining the relative impact of reservoir sedimentation in all Reclamation reservoirs, short of a comprehensive reservoir survey program for all Reclamation reservoirs.

- Refine and develop additional reservoir sedimentation distribution tools to estimate the spatial and temporal impacts of reservoir sedimentation to important features.

"This research will help Reclamation and other Federal agencies with methods and tools to best manage dams and reservoirs in a sustainable manner."

Sean Kimbrel
Hydraulic Engineer, Reclamation's Technical Service Center

More information

www.usbr.gov/research/projects/detail.cfm?id=6080

Sediment at Paonia Reservoir, Colorado.

For printable version see: www.usbr.gov/research/docs/updates/2015-03-sediment.pdf

Research Update

Summer 2015
Bulletin 2015-04

Bottom Line

This research project explored existing methods used by Reclamation, the industry, and other agencies to measure, capture, and control alluvial material.

Better, Faster, Cheaper

Controlling alluvial material before it reaches a main river channel is a potential best management practice and a step forward in avoiding damage.

Principal Investigator

Carrie Scott
Supervisory Civil Engineer
Yuma Area Office
Lower Colorado Region
928-343-8317
cmscott@usbr.gov

Research Office Contact

Levi Brekke
Chief, Research and Development
303-445-2494
lbrekke@usbr.gov

Predicting, Managing, and Controlling the Movement of River Rocks and Sand

How to control alluvial material before it is introduced into the Lower Colorado River

Problem

High flows in ephemeral streams can cause alluvial material (rocks and sand) to move. These materials have damaged Reclamation's infrastructure by depositing alluvial fans in the Colorado River channel, which reduce channel capacities and impact water deliveries. Bankline structures are compromised by erosion caused from the channel changes resulting from the wash fan depositions.

This is particularly critical on the Lower Colorado River. Flooding between 2003 and 2005 in the Gould and Mule Washes, tributaries to the Lower Colorado River, carried materials that washed out sections of Reclamation's roadways and structures and deposited thousands of cubic yards of alluvial material and debris into the river channel. In October 2011, Reclamation personnel found 10 large alluvial fans within the river channel from ephemeral tributary flows. These fans constrict the channel and erode and undercut bankline structures.

These problems are not unique to the Lower Colorado River. Throughout the American West, proactive and cost-effective solutions to control alluvial material are needed to ensure sustained water operations.

Solution

Alluvial material and ephemeral stream flows are worldwide issues and are being studied closely. This Reclamation Science and Technology Program research project conducted a literature review to explore ways to control alluvial material. The research team documented successes, problems, and potential gaps in science.

Research reiterated that sediment loads from ephemeral flows are natural occurrences and preventative measures are often costly to install and maintain. The Japanese have invested considerable efforts into testing measures to reduce the impact of these sediment-laden loads. However, as climate, geologic formations, and other considerations differ in the American West, Reclamation may not be able to adopt these measures. Some of the implementation measures, including screened basins, overflow stepped weirs, and staggered upland dikes, could be used.

Future Plans

The research team recommends that Reclamation's Yuma Area Office (YAO) in Yuma, Arizona, implement various designs of debris dams in critical ephemeral areas and test several upland mitigation measures. These structures should be studied for several years to examine the effectiveness and applicability of various combinations of sediment control structures upland of the depositional areas from

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the wash fans. The structures' effectiveness can be measured after each major storm with visual inspections, and instream depositional growth will be monitored through the annual Lower Colorado River Operations and Maintenance (O&M) Inspection.

Based on this research, YAO is now constructing structures. YAO has procured supplies and equipment and will build a structure in fiscal year 2016 at Mule Wash (river mile A110.1), on the Arizona side of the river. After each rainfall, this wash deposits a large amount of alluvial material into the Lower Colorado River. Structures to contain these materials will help alleviate problems in the river, saving O&M costs and preserving banklines on the California side of the river.

YAO is partnering with the Colorado River Indian Tribes Coalition to install structures at two future sites: Quien Sabe and Paradise Point on the California side of the river. This will also help to avoid bankline degradation, losing land to erosion, and navigational issues.

"Carefully choosing measures to control sediment-laden flows in critical ephemeral washes could help preserve banklines and avoid costly operation and maintenance issues."

Carrie Scott
Supervisory Civil Engineer, Reclamation's Lower Colorado Region

More information

www.usbr.gov/research/projects/detail.cfm?id=7796

Photograph taken from the California side of the Lower Colorado River observing the alluvial fan at Mule Wash, river mile A110.1.

The Quien Sabe Wash fan (facing north observing the north fan from the California side of the Lower Colorado River).

Photograph taken from the Arizona side of the Lower Colorado River observing the Paradise Point Wash fan.

The Quien Sabe Wash fan (facing west from the Arizona side of the Lower Colorado River).

Research Update

Summer 2015
Bulletin 2015-05

Bottom Line

This research project built a laboratory model of cracks and erosion to evaluate the effectiveness of three remote monitoring technologies.

Better, Faster, Cheaper

Continuously and remotely monitoring Reclamation's infrastructure will provide more timely alerts for potential problems, avoiding costly repairs, or even failures later.

Principal Investigators

Robert Rinehart
Civil Engineer
Materials Engineering and Research Laboratory
Technical Service Center
303-445-2395
rrinehart@usbr.gov

Justin Rittgers
Reclamation Pathways Program Intern
Seismology, Geomorphology, and Geophysics Group
Technical Service Center
303-445-3010
jrittgers@usbr.gov

Research Office Contacts

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

Bobbi Jo Merten
Chemist/Acting Science and Technology Program Manager
303-445-2380
bmerten@usbr.gov

Listening for Internal Erosion

Continuous, remote monitoring to detect problems early

Problem

Internal erosion (often called piping) can occur in embankments, dikes, abutments, foundations, and under spillways and is one of the most significant risks to Reclamation's structures and the people that live downstream from them. Internal erosion has resulted in several near failures of Reclamation facilities and in costly emergency responses and repairs. At the Arthur V. Watkins Dam in Utah, a local farmer happened to notice cloudy discharge near the toe of the dam and alerted the authorities. If this discharge had been noticed even 1 day later, it is possible the dam would not have been saved. At Red Willow Dam in Nebraska, Reclamation geologists and drillers fell into sinkholes on the downstream shell of the dam while looking for survey points.

Reclamation could monitor facilities continuously and remotely. This would augment its periodic comprehensive facility reviews. Continuous, remote monitoring could have alerted personnel to the onset of these internal erosion failure modes months or years in advance and could have saved significant amounts of taxpayer money.

Solution

This Reclamation Science and Technology Program research project investigated three techniques for suitability as long-term, continuous, and remote monitoring techniques for internal erosion and cracking of embankment dams.

This research project laboratory experiment built upon the large-scale embankment filter research that Reclamation and the U.S. Army Corps of Engineers have been conducting for several years. The primary purposes of the filter testing have been to gain a better understanding of cracked filter performance, conditions which cause a crack within a

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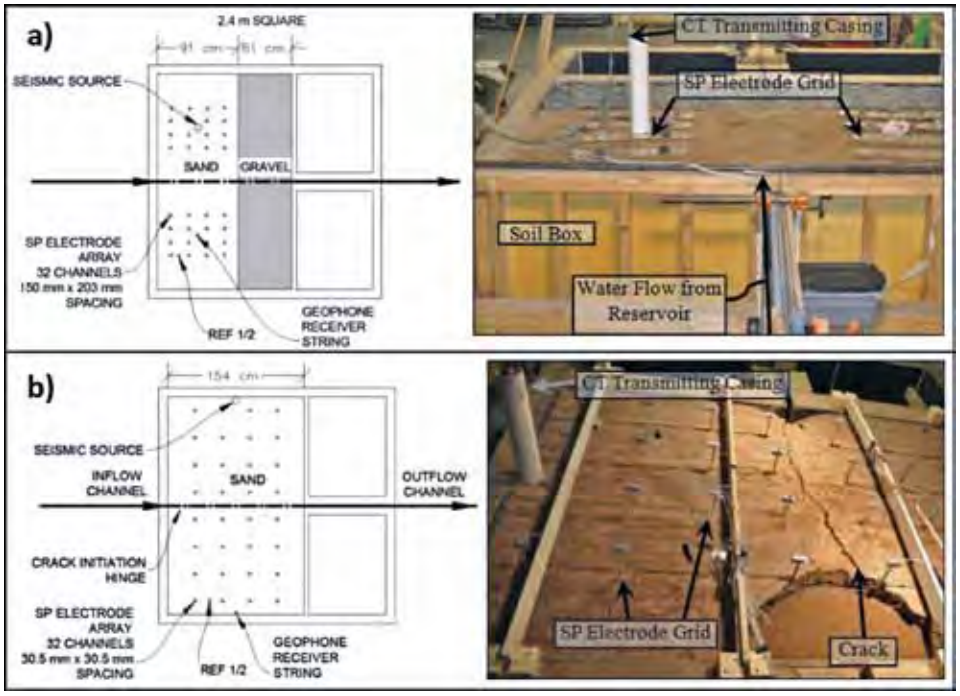

Top: Pre-crack photograph of filter geometry and instrumentation for T11 – two-stage filter.
Bottom: Post-crack photograph of filter geometry and instrumentation for T12 – single-stage filter.

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filter, ability of a filter to heal under flow conditions, and effectiveness of a filter to stop or control flow. The geophysical research presented here served as a complementary addition to the ongoing filter testing and has subsequently led to additional technology development work.

A laboratory model (a soil crack box) was constructed to simulate internal erosion. The box allows for the compaction of filter material in various configurations, subsequent cracking of the filter (i.e., to simulate differential settlement, desiccation, or seismically induced cracking), and impingement of reservoir water upon the cracked filter. As the model was forced to crack, geophysical data from the three monitoring techniques were collected during manually imposed cracking of granular filter materials. Data were collected during both self-healing and during continuing erosion.

Results and Applications

The three techniques tested were:

Passive Acoustic Emission (AE). Using acoustic sensors (e.g., geophones or accelerometers) to listen for noise from the dam. Just as houses creak, eroding infrastructure can make a noise. While many monitoring techniques require an external energy source and personnel onsite, AE relies solely on internal energy sources and is easily accomplished remotely. The only requirements for passive AE monitoring are robust, self-powered electromechanical sensors and a means to transmit the data to a remote monitoring computer. Unique AE signatures of filter collapse and self-healing were observed during these experiments, showing promise for the successful use of the AE method in monitoring applications for full-scale embankment structures.

Cross-Hole Tomography (CT). Tomography techniques (like X-ray) send signals between a transmitter in one borehole and a receiver in another borehole (or along the surface). While seismic tomography data collected between boreholes can offer better resolution of specific targets, one disadvantage is that the CT approach requires boreholes, and subsequent data images are limited to regions between borehole pairs. However, CT results from this research show promise for the applicability of seismic CT techniques for successful detection and imaging of embankment material cracking and self-healing phenomena associated with earthen embankment structure failure mechanisms.

Self Potential (SP). This passive geophysical method measures small variations in electric potential (voltage) that result from naturally occurring electric currents associated with seepage. The observed and expected relationship between SP data and the state of the filter material offers promise in the applicability of the SP technique towards full-scale embankment time-lapse monitoring efforts. Similar to passive seismic techniques, SP can be used to listen for anomalous or alarming changes in geophysical signatures associated with failure mechanisms. It can also be used to detect and image anomalous and concentrated seepage, helping to better characterize problematic seepage and focus remediation efforts at early stages.

Future Plans

This work has helped focus subsequent research for geophysical monitoring of embankment structures during induced failure, including instrumentation of Reclamation's Canal Breach Testing and passive geophysical monitoring of a full-scale embankment failure test that was carried out in the Netherlands during the fall of 2012. Work remains to further understand the link between identifiable cracking, healing, and flow events, as well as the risk of filter failure, in order to provide a complete picture for dam safety decisionmaking. Research in the cracked filter box is ongoing. However, this study serves as a preliminary proof of concept.

For a full-scale earth dam, directly monitoring with buried geophones, surface geophones, or other types of seismic transducers and/or surface SP electrodes can augment conventional instrumentation to enable a higher resolution (in time and space) response that might otherwise go unnoticed by traditional instrumentation and visual methods.

"This research shows that three monitoring technologies hold promise for cost-effective, continuous, and remote monitoring for Reclamation's infrastructure. Reclamation needs to take advantage of these to monitor for many different failure modes on many types of structures."

Justin Rittgers
Reclamation Pathways Program Intern, Reclamation's Technical Service Center

More information

www.usbr.gov/research/projects/detail.cfm?id=5500

Redlinger, C., C. Rudkin, D. Hanneman , and W. Engemoen. 2012. "Lessons Learned From Large-Scale Filter Testing." Manuscript submitted March 2012 to the 6th International Conference on Scour and Erosion, Paris, France, August 27-31, 2012.

Reinhart, R., M. Parekh, J. Rittgers, M. Mooney, A. Revil. 2012. "Preliminary Implementation of Geophysical Techniques to Monitor Embankment Dam Filter Cracking at the Laboratory Scale." Manuscript submitted March 2012 to the 6th International Conference on Scour and Erosion, Paris, France, August 27-31, 2012.

Research Update

Summer 2015
Bulletin 2015-06

Bottom Line

This scoping-level research project report investigated practical methods for canal inspections.

Better, Faster, Cheaper

Finding the most effective ways to inspect canals will help detect problems early, thus avoiding costly repairs and ensuring that Reclamation's canals continue to deliver water efficiently and effectively.

Principal Investigator

Nathaniel Gee
Supervisory Civil Engineer
Examination of Existing Structures/Safety of Dams Group
Lower Colorado Region
702-293-8029
ngee@usbr.gov

Research Office Contacts

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

Bobbi Jo Merten
Chemist/Acting Science and Technology Program Manager
303-445-2380
bmerten@usbr.gov

Inspecting Reclamation Canals in New Ways

Accurately predicting canal seepage

Problem

Reclamation is particularly concerned with identifying canals which have possible voids or active seepage that can potentially pose risks to urbanized areas. Some voids and seepage from canals can be detected by regular visual inspections, but methodologies are being researched that allow for identification and inspection of voids and seepage that cannot be detected by visual means alone.

Example of a canal of concern, highlighting that some of Reclamation's canals are above urbanized populations.

Solution

This Reclamation Science and Technology Program research project conducted a literature search to assemble and assess existing knowledge about void and seepage detection methods applied to canal channels. This compiles available field investigation methods useful for canal seepage and void detection and evaluation, including various geophysical survey techniques, and visual and other nondestructive inspection techniques. The techniques were evaluated for cost effectiveness, accuracy, practicality for large-scale use, and other factors.

Results

Methods to inspect canals and detect leaks or other potential problems include:

- **Traditional field seepage tests.** These tests help measure field seepage. Ponding and dye tracer tests are limited to small sections of canals and are best suited for situations when possible seepage locations have been identified and need to be further evaluated. Inflow-outflow tests help determine if a longer reach of a canal is losing or gaining water and are best suited to long sections of channel that contain apparent seepage.

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- **Geologic and hydrogeologic characterizations.** Using existing data (e.g., maps, well logs, and water levels) and drilling new wells can provide an understanding of the groundwater conditions near a canal. Data collected over time can be used to determine if elevated groundwater conditions are a result of canal seepage or other recharge sources.
- **Remote sensing.** Thermal imaging to measure heat, self potential to measure electrical potential, ground-penetrating radar to measure soil water content, electrical resistivity to measure how well the soil conducts electricity, and microwave radiometry to measure moist soil areas are all remote tools that can help paint a picture of water seepage and loss. Primary limitations include the presence of other structures or utilities that might interfere with readings. Further, most of these only note the presence of water and do not determine flow patterns.
- **Hydrochemical tracers.** Isotope and tracer investigations can be used in detailed studies to assess canal seepage. The difficulty with this method is that canal flows limit the time available for sufficient volumes of dosed water to seep into the aquifer and be detected. Another major disadvantage of this method can be the high costs of artificial isotopes and specialized expertise needed for application and evaluation, so this is generally not a practical solution for seepage location identification.
- **Fiber optic sensors.** These sensors detect leaks by monitoring temperature changes. A distributed sensor network supported by fiber optics is useful in harsh environments or along structures that span long distances. However, given the high costs of installation and assembly of a fiber optic thermal monitoring system, placing this technology on existing canals is likely to be limited to those reaches that may present potential flood hazards if breached.

All of these methods should be considered to be a set of tools, which can be selectively applied on a case-by-case basis for individual canal sections.

Future Plans

Methods and techniques that are cost effective, practical, and have not previously been demonstrated in the field will be field-tested at a critical reach of a Reclamation-owned canal. The plan will include scope of effort, preliminary design, cost estimates, any required regulatory requirements (i.e., National Environmental Policy Act [NEPA] and Endangered Species Act [ESA]). The plan may include additional laboratory-scale testing or modeling if the selected alternatives require further evaluation.

The ultimate objective of this research is to develop a practical and cost-effective single method or suite of methods to improve detection and evaluation of canal seepage sources and paths. Any method that is identified should be practicable for implementation by regional, area, and field office staff or their respective contractors.

"Determining the best methods to find and quantify the extent of seepage to ensure a breach does not occur on Reclamation's canals is a significant priority, with broader potential applicability to all canals."

Nathaniel Gee
Supervisory Civil Engineer, Reclamation's Lower Colorado Region

More information

www.usbr.gov/research/projects/detail.cfm?id=4861

Photographs below show the electrical resistivity test method being applied (mentioned under the remote sensing bullet above). The test is applied on the outer side of the embankment; the canal is at left. Stainless steel pins are pounded into the embankment at even spacings. The cable is connected to each pin and to the instrumentation to apply the method, which is further processed to provide a two-dimensional slice of the embankment's electrical resistivity.

Research Update

Summer 2015
Bulletin 2015-07

Bottom Line

This research project examined Aqualastic® spray-applied polyuria to repair degraded roller-compacted concrete (RCC) canal lining.

Better, Faster, Cheaper

Finding a thin, strong, easy-to-apply coating to stop deterioration will reduce ongoing maintenance costs. Moreover, patching concrete-lined canals with more concrete reduces the canal's capacity over time. Polyurea can seal canals without losing that capacity.

Principal Investigator

Katherine Kihara
Civil Engineer
Bend Field Office
Pacific Northwest Region
541-389-6541 x229
kkihara@usbr.gov

Research Office Contacts

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

Bobbi Jo Merten
Chemist/Acting Science and Technology Program Manager
303-445-2380
bmerten@usbr.gov

Polyurea Holds a Canal Together

Is polyurea a cost-effective way to seal and maintain concrete-lined canals?

Problem

Reclamation has many concrete- and shotcrete-lined canals in various stages of repair. Finding a material that is economical, results in a smooth surface, is relatively easy to apply, does not reduce channel capacity, and that will last for many irrigation seasons is critical for repairing Reclamation's and irrigation district partners' infrastructure.

The standard way to repair concrete-lined canals is to patch with more concrete. This process is labor intensive and costly. Shotcrete repairs vary between 2 to 4 inches of material over the existing shotcrete. This fills the channel with concrete rather than with water, reducing the channel capacity. It can also make the channel rougher, further reducing flows and channel capacity. To avoid this, the old shotcrete and/or concrete would need to be removed, but this increases the cost of repairs substantially. Reclamation needs to find cost-effective ways to repair and maintain these canals.

Solution and Results

Aqualastic® is a polyurea elastomeric coating that is sprayed onto a prepared surface. This product is similar to spray on bedliners commonly used in pickup trucks. Aqualastic® is currently applied to concrete canal linings as a crack sealer.

This Reclamation Science and Technology Program research project applied Aqualastic® over a section of canal about 75 feet long by 36 feet wide to measure its ability to reduce seepage and protect degraded or eroded sections of the lining. The tests are also determining how well the product adheres to roller-compacted concrete (RCC) and shotcrete substrate over time, over a large area. The product could also increase transmission efficiency by reducing the channel roughness as it provides a smoother surface.

Before: Deteriorating lining from dozer tracks and previous patchwork at the toe of the slopes is typical in this area of the North Unit Main Canal, Oregon.

After: The test section after one irrigation season and one winter season. Adhesion to the concrete substrate is excellent and there is no cavitation damage on the coated section.

Application and Results

The North Unit Irrigation District in Madras, Oregon, partnered to provide a test bed in the North Unit Main Canal. The canal is dewatered every winter and is subject to freeze-thaw damage. The RCC lining also had dozer trackmarks left in the concrete from construction, which are prone to cavitation damage during the irrigation season.

Different preparation methods were used on the RCC, including sandblasting to white and brushed. The two-part polyurea was applied to the test sections. The test sections were then inspected after the irrigation season and after a winter's non-irrigation season to check for freeze-thaw damage.

The test sections have had two irrigation seasons and one winter season to date. The test sections are doing well—no new cavitation damage, freeze-thaw damage, or direct sun exposure damage. Basic adhesion tests showed that the method of surface preparation did not show appreciable difference in the adhesion of the polyurea to concrete, based on attempts to pry the material's leading edge.

Future Plans

This project and future projects will check the test sections on a yearly basis to see how well the polyurea holds up over time. Followup reports in 1, 3, 7, and 10 years will document durability and ongoing maintenance costs (the 7- and 10-year reports will be completed under new Science and Technology Program research projects).

Aqualastic® can be a cost-effective repair method that does not reduce channel capacity and can also reduce seepage.

Many miles of concrete- and shotcrete-lined canals serve the American West. This technology should be easily transferrable to other irrigation districts and Reclamation offices with these types of canals.

Typical equipment used to apply Aqualastic® in cracks at Roza Canal, Washington, during annual maintenance. (Note that this was not part of the test research project.)

"Wish we had enough money to coat all 12 miles of the RCC lining tomorrow! That Aqualastic® really works to seal the canal without reducing flows."

Mike Britton
General Manager,
North Unit Irrigation District,
Madras, Oregon

Collaborators

- **Reclamation**
  - ◊ **Technical Service Center**
  - ◊ **Yakima Field Office, Pacific Northwest Region**
- **North Unit Irrigation District, Madras, Oregon**

More information

www.usbr.gov/research/projects/detail.cfm?id=786

For printable version see: www.usbr.gov/research/docs/updates/2015-07-polyurea.pdf

Research Update

Summer 2015
Bulletin 2015-08

Bottom Line

Canal embankments, levees, and dams are all susceptible to erosion and failure with potential for catastrophic damage and loss of project benefits. To address erosion issues, reliable methods for measuring soil erodibility are needed. Most embankments contain silt and clay, but many also include significant amounts of gravel, which makes erosion testing more difficult. This research project tested a new procedure for applying the submerged jet erosion test to these difficult soil types and confirmed the new method's effectiveness and accuracy for measuring soil erodibility.

Better, Faster, Cheaper

This research gives us confidence to use the jet erosion test to measure the erodibility of a broader array of embankment soils and this, in turn, enables better modeling of erosion processes that can lead to embankment failure.

Principal Investigator

Tony Wahl
Hydraulic Engineer
Hydraulic Investigations and Laboratory Services Group
Technical Service Center
303-445-2155
twahl@usbr.gov

Measuring Erodibility of Embankment Soils Containing Gravel

Procedure extends submerged jet erosion test to a wider range of soils

Problem

Reclamation is responsible for the safety of more than 8,000 miles of canals and 250 embankment dams in the Western United States. Risks of structure failure must be accurately assessed, potential affected areas identified, and mitigation measures put into place to protect downstream populations and property. Failure of embankments almost always involves soil erosion, so it is crucial that Reclamation has the ability to measure and rate the erodibility of embankment soils.

For several years, Reclamation has measured soil erodibility using a submerged jet erosion test device developed by the U.S. Department of Agriculture, Agricultural Research Service. This method was used in Reclamation's Science and Technology Program research project, "Physical Hydraulic Modeling of Canal Breaches" (Project ID 8442, 2010 through 2012) to rate soil erodibility, estimate length of time for failure to occur, and determine the magnitude of resulting floodflows. The jet device can be used in the laboratory or in the field and is designed specifically for the fine-grained silt and clay soils that are common in most embankments. However, some embankments also include significant amounts of gravel mixed with the silt and clay, and these soils are difficult to test with the submerged jet device.

The jet test erodes a soil specimen using a small, ¼-inch-diameter hydraulic jet. Rates of erosion are observed to categorize the erodibility of the soil. Unfortunately, with gravelly soils, the small-diameter jet is unable to completely erode the larger gravel particles, and the test scour hole becomes armored in a way that does not represent an actual large-scale erosion event.

Solution

This Reclamation Science and Technology Program research project tested a proposed method for applying the jet test to fine-grained soils that also contain gravel. It was hypothesized that removing the coarse material that interferes with the jet test could allow an accurate test to be performed on just the remaining soil. The research tested different size thresholds for the removal of gravel (No. 4 versus No. 40 sieve) and evaluated methods for adjusting the compaction of the soil specimens to account for the removal of the gravel particles.

Canal breach test underway in the Hydraulic Investigations and Laboratory Services Group in Reclamation's Technical Service Center.

Aerial view of the 2012 Central Arizona Project canal breach near Bouse, Arizona. About 50 miles downstream, on this same canal, the embankments contain gravelly soils similar to those considered in this research.

Testing and Results

To carry out the research, a quantity of soil was first prepared to represent the gravelly fine grained soils that are difficult to test. Erosion tests on this "parent" soil were accomplished using a unique, horizontal jet orientation that prevented armoring the scour hole. The second stage of the research involved screening the parent soil to remove gravel particles and then performing jet erosion tests on specimens of the remaining finer-grained soil. These tests could be performed in the traditional way because gravel was no longer present to interfere with the tests. The preparation and compaction of the finer-grained soil specimens were adjusted to ensure that they matched the compaction state of the finer-soil fraction in the original parent soil.

The results of the testing validated the hypothesis that erodibility could be determined by testing only the finer-grained fraction of the soil. Erodibility is always variable, so significant scatter existed in the individual test results. However, averages of multiple tests of the parent and finer soils were in reasonable agreement. Results were inconclusive in determining whether the soils should be separated using the No. 4 or No. 40 sieve, but it appears that screening at either size threshold would yield reasonable results. Screening at the No. 4 sieve would be easier in most cases.

Future Plans

It is recommended that additional testing be performed on a wider range of soils to confirm the initial test results obtained by this research project. In addition, this research could benefit other Reclamation activities; for example, the Seismology, Geomorphology, and Geophysics Group in Reclamation's Technical Service Center is using this test to determine the erodibility of soils in alluvial flood plains where gravel is often encountered.

"This research increases our confidence in measurements of soil erodibility for many soils that we previously could not test."

Tony Wahl
Hydraulic Engineer, Reclamation's Technical Service Center

Research Office Contacts

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

Bobbi Jo Merten
Chemist/Acting Science and Technology Program Manager
303-445-2380
bmerten@usbr.gov

More information

http://www.usbr.gov/research/projects/detail.cfm?id=4104

http://www.usbr.gov/research/projects/detail.cfm?id=8442

Wahl, T.L. 2014. *Measuring Erodibility of Gravelly Fine-Grained Soils.* Research and Development Office Science and Technology Program Final Report 2014-4104. Hydraulic Laboratory Report HL-2014-05.

For printable version see: www.usbr.gov/research/docs/updates/2015-08-soil-erodibility.pdf

Research Update

Summer 2015
Bulletin 2015-09

Bottom Line

This research project evaluated the durability of titanium dioxide (TiO_2)-based coating and bulk cement under the adverse weathering and freeze-thaw conditions at Reclamation structures.

Better, Faster, Cheaper

TiO_2-based cement products could provide Reclamation with a low maintenance option for architectural concrete with air-purification properties when used as part of a comprehensive air quality improvement plan at Reclamation. In addition to preserving the aesthetics of a structure with minimum maintenance, these products have been shown to reduce air pollutants such as volatile organic compounds, particulate matter, nitrogen oxides, and sulfur oxides.

Principal Investigator

Jessica Torrey
Materials Engineer
Materials Engineering and Research Laboratory
Technical Service Center
303-445-2376
jtorrey@usbr.gov

Eco-Friendly Cement for Green Construction

Evaluating titanium dioxide nanoparticle-based cement products with self-cleaning and air-purifying properties

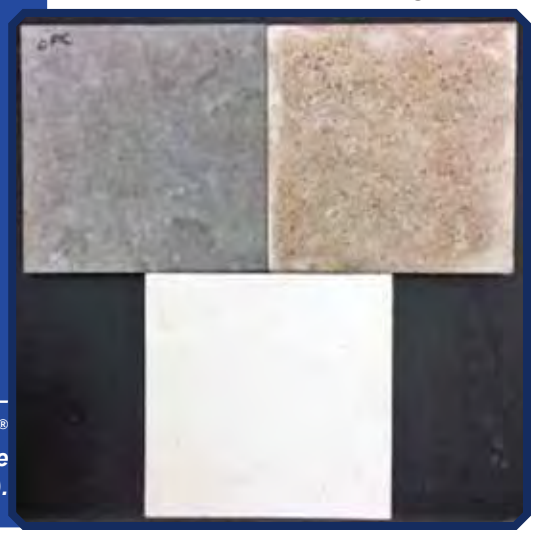
Problem

Environmentally friendly cement is critical to ensuring Reclamation can meet its commitments to sustainable design. In 2008, the U.S. Department of the Interior issued a Sustainable Buildings Implementation Plan (SBIP). Reclamation has committed to SBIP's vision to "reduce the negative economic, social, and environmental impacts of its buildings through sustainable planning, acquisition, siting, design, construction, operation, maintenance, leasing, and decommissioning." The 2011 Green Building Initiative further challenged Reclamation to design new construction with more energy and resource efficiency.

Moreover, Reclamation is often asked to provide architectural concrete to meet the aesthetic needs of new and existing building projects. A new "green cement" using titanium dioxide (TiO_2) may be able to satisfy those needs and even improve air quality in the vicinity of the structure. This cement could help reduce greenhouse gases and contribute to a healthier environment for the community through better building practices.

The Italian manufacturer of two TiO_2 nanoparticle-based photocatalytic green cement products (i.active COAT coating and TX Active® cement) has cited several instances where buildings in both the United States (U.S.) and Europe have used this product as part of a green building plan for Leadership in Energy and Environmental Design (LEED) certification. These products have been shown in the literature to purify air from pollutants such as volatile organic compounds (VOC), particulate matter up to 10 micrometers (PM10), nitrogen oxides (NO_x), and sulfur oxides (SO_x). The manufacturer and others report that these products can reduce NO_x by 45 to 91 percent and PM10 by 20 to 80 percent, depending on test conditions.

In addition, the cement is marketed as a self-cleaning product that helps to reduce maintenance costs and improve cosmetic appearance of structures. It could be used broadly across all Reclamation regions to comply with the SBIP guiding principles. However, while the TX Active® cement product has been employed in several locations in the Eastern U.S., there are little data available on the i.active COAT coating and how it may perform in the wet-dry, freeze-thaw conditions that Reclamation routinely services. Of primary concern, since Reclamation structures are often adjacent to sources of water, is to ensure that there is no release of nanoparticles from the product that could themselves contaminate Reclamation's water systems.



Panels for weathering testing—concrete control (top left), TX Active® concrete (top right), and i.active COAT-coated concrete (bottom).

Solution and Results

This Reclamation Science and Technology Program research project represented a unique opportunity for Reclamation to collaborate on evaluation of these products with Colorado Precast Concrete (CPC).

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CPC used these products on concrete pillar capstones at the Denver International Airport, Colorado. Reclamation's Technical Service Center, Materials Engineering and Research Lab tested the product.

Fiscal year 2014 experiments focused on two key areas:

- Ability of the product to resist nanoparticle leaching under various environmental exposure conditions
- Mechanical durability of the product under freeze-thaw conditions

Laboratory weathering tests were performed with the experimental setup exposing test coupons to cyclic "rain" and light/dark conditions. Samples were taken biweekly for testing of nanoparticle release. These samples were sent to research collaborators at the U.S. Army Corps of Engineers Environmental Laboratory; researchers there specialize in nanoparticle release and environmental toxicity studies. They will help analyze the Reclamation samples and use this as a case study for their ongoing effort to develop guidelines for nanoparticle use in the U.S. Army Corps of Engineers.

Additionally, freeze-thaw exposure tests, following American Society for Testing and Materials (ASTM) standards, were conducted on control concrete, i.active COAT-coated concrete, and TX Active® concrete bars. The i.active COAT coating showed very poor durability under freeze-thaw conditions. However, it is hypothesized that the sample geometry and test conditions were extremely harsh for coated samples; this setup is typically used for testing solid concrete blocks.

Future Plans

It is recommended that freeze-thaw testing be re-evaluated with a test setup specifically for cementious coatings. This would likely yield a more accurate prediction of the performance of i.active COAT coatings under these conditions.

Weathering test setup.

The i.active COAT-coated concrete bar after freeze-thaw testing.

Cross section of TiO_2-based cementitious coating on concrete.

"This research is a great opportunity to assess a so-called "green" construction material for use at Reclamation. The sophisticated technology of TiO_2 photocatalysis is incorporated into a common building material—cement. This cement can be applied to structures such as retaining walls, office buildings, dam crests, and walkways. The white color is preserved with little maintenance, and it provides local air-purification."

Jessica Torrey
Materials Engineer,
Reclamation's Technical Service Center

Research Office Contacts

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

Bobbi Jo Merten
Chemist/Acting Science and Technology Program Manager
303-445-2380
bmerten@usbr.gov

Collaborators

- **Reclamation**
- **Colorado Precast Concrete**
- **U.S. Army Corps of Engineers Environmental Laboratory**

More information

www.usbr.gov/research/projects/detail.cfm?id=7846

For printable version see: www.usbr.gov/research/docs/updates/2015-09-cement.pdf

RECLAMATION
Managing Water in the West

U.S. Department of the Interior
Bureau of Reclamation

Research Update

Summer 2015
Bulletin 2015-10

Bottom Line

This scoping-level research project study reviewed existing literature to unlock the secrets of Roman concrete properties and explored the possibility that Reclamation structures might be using a similar type of concrete.

Better, Faster, Cheaper

Manufacturing a more durable concrete and long-lasting concrete, would decrease the amount of concrete repairs and replacement.

When concrete lasts a long time less concrete needs to be produced, decreasing carbon dioxide emissions, thus lessening our impact on the environment. A manufacturing process that produced fewer carbon emissions would further help reduce carbon footprints.

Principal Investigator

Audrey Rager
Geologist
Materials Engineering and Research Laboratory
Technical Service Center
303-445-2377
arager@usbr.gov

Taking Cues From the Ancient Romans

Understanding and using the properties that allow Roman concrete to last over 2,000 years

Problem

Reclamation's infrastructure relies on concrete, and its durability and longevity are essential foundations for delivering water and power. While Reclamation's facilities are designed to last a single century, the Romans built with concrete that has lasted well over 20 centuries.

Modern concrete (Portland cement) consists of calcium, silicates, and hydrates (C-S-H) (water molecules that chemically bind to other molecules). This mix of limestone and clay needs to be heated to 1,450 degrees Celsius (2,642 degrees Fahrenheit). Both burning fuels and the heated limestone (calcium carbonate) release carbon dioxide. Portland cement used in concrete accounts for approximately 5 percent of annual anthropogenic carbon dioxide emissions.

In contrast, the Romans made concrete by mixing lime, volcanic rock, and a small amount of water and baking it to a lower temperature (only to 900 degrees Celsius or 1,652 degrees Fahrenheit). The water and lime reacted with the ash to create cement. According to surviving writings of Vitruvius, an engineer for the Emperor Augustus and Pliny the Elder, the best maritime Roman concrete was made with ash from the seaside town of Pozzuoli, Italy. Volcanic ash (or natural pozzolan) with similar mineral characteristics is found in many parts of the world, including the Western United States. Experts (e.g., Jackson et al., 2013) argue that Romans deliberately selected alkali- and alumina-rich ash for optimal performance of pozzolanic concretes. Roman concrete takes longer to cure, but the strength and durability may well compensate for that time.

Solution and Results

This Reclamation Science and Technology Program research project examined previous literature to determine potential avenues for further Reclamation research into ways to adapt Roman concrete techniques.

In theory, hydration of Portland cement resembles a combination of naturally occurring layered minerals including tobermorite. The ideal state would have a regular molecular structure resembling fibers. However, in reality, this ideal crystalline form of tobermorite is rarely found in modern concrete. Instead, tobermorite (C-S-H) occurs as an amorphous gel.

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The cement in Roman concrete contains more aluminum and less silicon than modern concrete, which may be the key to the longevity of Roman concrete. This resulting calcium-aluminum-silicate-hydrate (C-A-S-H) is an exceptionally stable binder. These natural substances formed structures (almost like cages) around sulfide and chloride ions that could cause concrete to deteriorate if these ions were free in the concrete.

Assessing some of Reclamation's structures to determine if they possess some of the properties similar to Roman concrete is also an important next step. Pumice deposits were used in historic concrete constructions in the West; in particular, the San Francisco peaks' pumice used in the construction of Glen Canyon Dam, Arizona. Reclamation's Upper Stillwater Dam, a roller-compacted concrete gravity dam about 31 miles northwest of Duchesne, Utah, might also use concrete with similar properties.

Upper Stillwater Dam, Utah.

Future Plans

Further research is needed to find out how to re-create the durability and low emissions in Roman concrete for future use in Reclamation and other industry concrete practices, including:

- Conducting similar studies that Jackson et al. (2013) conducted on other infrastructure using concrete samples from Reclamations' Upper Stillwater and Glen Canyon Dams (e.g., using a scanning electron microscope and X-ray diffraction) to determine if this concrete forms similar structures to Roman concrete
- Reverse engineering Upper Stillwater Dam construction methods and other Roman concrete manufacturing methods to determine effective ways to promote the growth of crystalline Al-tobermorite in modern concrete
- Developing ways to alter the chemistry (alkali and aluminum content) and physical form (pumaceous clasts) of commercial fly ash to resemble the volcanic ash used in Roman-style concrete
- Determining whether adding aluminum to a concrete mix reduces the chance of alkali-silica reaction
- Identifying sources of alkali- and alumina-rich volcanic ash (natural pozzolans) in the Western United States that might be used to reproduce Roman-style concrete

"Examining these ancient techniques could help improve concrete strength, durability, and longevity while reducing global carbon emissions."

Audrey Rager
Geologist, Reclamation's Technical Service Center

Research Office Contacts

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

Bobbi Jo Merten
Chemist/Acting Science and Technology Program Manager
303-445-2380
bmerten@usbr.gov

Collaborators

Dr. David Tordonato, P.E.
Materials Engineer
Materials Engineering and Research Laboratory
Technical Service Center
303-445-2394
dtordonato@usbr.gov

More information

http://www.usbr.gov/research/projects/detail.cfm?id=7137

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RECLAMATION
Managing Water in the West

U.S. Department of the Interior
Bureau of Reclamation

Research Update

Summer 2015
Bulletin 2015-11

Bottom Line

Analysis of survey data from Reclamation personnel yielded the following rank order for factors disputed in conflicts over science:

1. **Scientific inferences**
2. **Whether existing science addressed critical issues**
3. **Uncertainty in the science**
4. **Data quality**
5. **Perceived need for additional science**
6. **Whether science should be the basis for decisionmaking**
7. **The qualifications of the scientists**

Results also showed that those using collaborative processes had the fewest problems in these areas overall.

Better, Faster, Cheaper

By using collaborative processes (such as joint factfinding, collaborative modeling, and collaborative learning) to manage disputes over science, Reclamation personnel will likely experience fewer and less intense disputes over inferences drawn from the science, scientific uncertainty, data quality, perceived gaps in the science, adequacy of the science, and qualifications of scientists. Fewer disputes over science will result in reduced litigation and diversion of agency resources for the dispute management.

Managing Disputes Over Science: Contested Factors

Contested factors in disputes over science and their relation to the tools for managing them

Problem

According to focus groups held in Reclamation's regional and area offices, some of the most prevalent conflict management challenges the offices face are "disputes over science." For instance, a fish biologist might contend that an endangered species requires X amount of water to survive, and an ecologist might claim that it requires Y amount of water. These disputes are often further complicated when political constituencies adopt the views of one scientist or another.

This research effort focused on determining to what degree Reclamation personnel experience problems commonly associated with disputes over science, such as:

- Inferences drawn from the science
- Whether the science focused on the critical issues
- The quality of the data
- The level of uncertainty
- The adequacy of existing science (and whether additional science was required)
- Whether science should even be the basis for the management decision

Scientists often differ as to how wetlands should be classified, one scientific dispute that Reclamation's managers contend with.

- The competency of the scientists conducting the science

The research team also investigated whether any of the methods generally used to manage disputes over science resulted in fewer overall problems. The typical methods for managing scientific disputes are:

- Direct discussions amongst scientists
- Expert peer review panels
- Conducting additional science
- Public educational outreach
- Adaptive management processes
- Collaborative learning approaches

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Solution

This Reclamation Science and Technology Program research project conducted an electronic survey among Reclamation personnel who are directly involved in disputes over science to determine lessons learned from these disputes and the dispute resolution methods used to resolve them.

Application and Results

Survey results indicated that the most prominent factors disputed were (ranked in order):

- The inferences drawn from the science
- Whether the existing science addressed the critical issues
- The level of uncertainty
- The quality of the data

Issues of relatively less concern to survey respondents included whether there was a need for additional science, whether science should be the basis for water management decisions and, finally, the qualifications of the scientists. Among dispute resolution methods, collaborative approaches appeared to be the most trouble-free.

Based on this research, to reduce the number and intensity of disputes over science, it is recommended that Reclamation conduct its science with an eye towards the following:

- Making unbiased and objective scientific inferences
- Identifying and focusing on the most germane or critical issues in dispute or likely to be in dispute
- Determining and, to the extent possible, managing each of the sources and degrees of uncertainty
- Taking special precautions to ensure data quality

In addition, when the potential for conflict exists and it is feasible to do so, Reclamation scientists involved in dispute resolution should seriously consider using collaborative approaches.

Example of a dispute over science: To what extent does Tamarisk (salt cedar) deplete water supply in the Western United States? How can such disputes be managed?

Future Plans

Dennis Kubly (formerly of Reclamation's Upper Colorado Region) and Douglas Clark (Reclamation's Technical Service Center) are currently drafting a manual with Program and Administrative (P&A) funding that describes various methods for managing disputes over science.

"In focus groups held in regional and area offices, members of Reclamation's leadership told us they routinely spend 50 to 75 percent of their time managing conflict. Development of collaborative competencies among our employees is, therefore, vital to the future of this agency."

Douglas Clark
Physical Scientist, Reclamation's Technical Service Center

Principal Investigator

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

Research Office Contact

Levi Brekke
Chief, Research and Development
303-445-2494
lbrekke@usbr.gov

Collaborators

- **Dennis Kubly, Reclamation's Upper Colorado Region**
- **Curtis Brown, Reclamation's Research and Development Office**

More Information

http://www.usbr.gov/research/projects/detail.cfm?id=6641

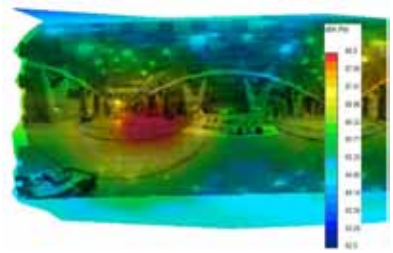
For printable version see: www.usbr.gov/research/docs/updates/2015-11-science-disputes.pdf

Recent Research Products

To get the information generated by research quickly into the hands of end users and the broader public, our researchers and partners publish their results in peer-reviewed journals, technical memoranda, research reports, and other venues.

Contact the authors/principal investigators for information about these documents or research projects. Use the Reclamation Science and Technology Program research project ID number to access contact information or the documents themselves at:
www.usbr.gov/research/projects/search.cfm.

Canal Inspection Methods Literature Review Final Peer Review
By Janet Montano
Project ID 7676
Upload Date 04-22-2015



Engineering Controls for Hydroelectric Powerplant Noise Reduction
By Theresa Gallagher and Jeffrey Komrower
Project ID 6433
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Hydrological, Chemical, and Biological Monitoring Plan
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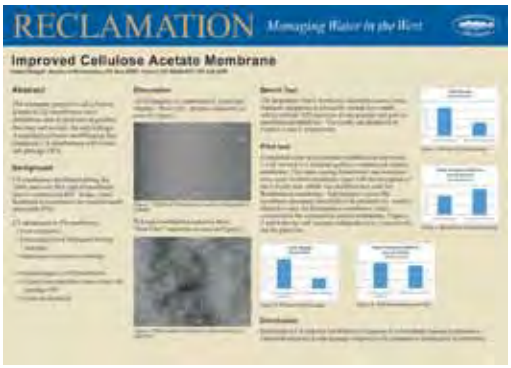

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Mid-Pacific (MP)	Jobaid Kabir	jkabir@usbr.gov	916-978-5091
Lower Colorado (LC)	Nathaniel Gee	ngee@usbr.gov	702-293-8029
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