RECLAMATION Managing Water in the West

November/December 2011
Research and
Development Office
Newsletter 2012–01

The Knowledge Stream

Research Awards and Updates

"The key to our success—as it has always been—will be to compete by developing new products, by generating new industries, by maintaining our role as the world's engine of scientific discovery and technological innovation. It's absolutely essential to our future."

White House Strategy for American Innovation, 2011.

"We build partnerships among Reclamation's scientists, project managers, outside experts, and industry to shorten the path between research and its application to address the manifold challenges of water management in the West."

Curt Brown, Director, Research and Development

Director's Message

Reclamation manages hundreds of dams, reservoirs, powerplants, and distribution canals to bring water to more than 31 million people, to provide irrigation water for 10 million acres of farmland and to generate more than 40 billion kilowatthours of power—enough electricity for 3.5 million homes each year. Of the top six challenges that the U.S. Department of the Interior recently announced, four are central to Reclamation's mission:

- Energy management
- Water programs
- Climate change
- Operational efficiencies

As climate change and drought threaten water supplies, and as the economic and environmental cost of fossil energy increases, Reclamation's ability to produce renewable energy and sustainable water supplies under changing conditions will be vital.

In making our awards for FY2012 Science and Technology projects, we have been guided by these challenges. Our top priority research areas, Climate Change and Variability, Mitigating the Impact of Invasive Mussels on Water and Power Operations, and Using Advanced Water Treatment Technology to Stretch Water Supplies, reflect these critical priorities for our Nation—and the world. Furthermore, we have added a focus on Expanding the Generation of Renewable Energy.

Each research project goes through a rigorous review to ensure technical merit and relevance to Reclamation's mission. This year's review team is featured below, and the next few pages list the 2012 research awards.

Curt Brown, Director, Research and Development

The Science and Technology Program Review Committee

Top left to right: Rod Wittler-Mid-Pacific Region (MP), Gary Davis-Great Plains Region, Jobaid Kabir-MP, Kevin Price-Research and Development Office (R&D), Miguel Rocha-R&D, Mark McKinstry-Upper Colorado Region, Chuck Hennig-R&D, Curt Brown-R&D.

Bottom left to right: Amy Porter-Lower Colorado Region, Erin Foraker-Power Resources Office, Jennifer Johnson-Pacific Northwest Region, Lisa Krosley-Dam Safety Office.

Print Options and Instructions

You have three options for printing parts or all of this document:

1. Print individual research updates on one sheet of paper, print double-sided for the two-page updates.

2. Print the whole document double-sided, corner stapled on 8.5” x 11” paper.

3. For magazine-style, instruct your print professional to print the document double-sided, head-to-head, saddle-stitched on 17” x 11” paper.

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

Thanks.

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

Contents

Research and Development Office and Contacts

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

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

Kevin Price, Advanced Water Treatment Research Coordinator, 303-445-2066, mprice@usbr.gov

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

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

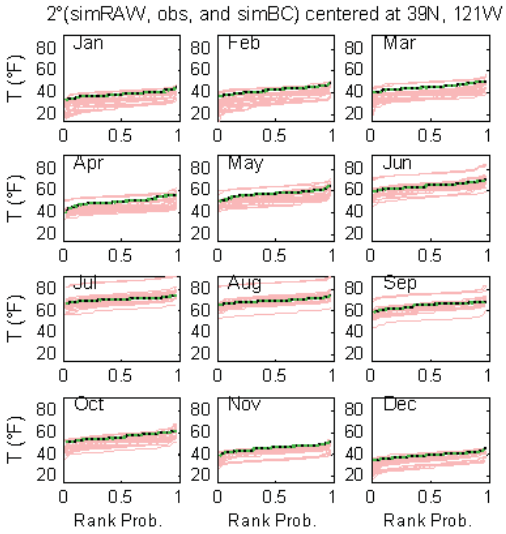
FY 2012 Research Awards

This fall we will fund 134 ongoing and new research projects. We also fund technology transfer, collaboration, workshops, and other outreach efforts to help ensure our innovative solutions reach Reclamation managers; other Federal, state, local, tribal, and non-governmental entities, and the public.

Activity	Funding
Environmental Issues in Water Delivery and Management	$ 1,725,396
Climate Change and Variability	$ 1,650,000
Invasive Zebra and Quagga Mussels	$ 1,650,000
Renewable Energy	$ 1,353,700
Advanced Water Treatment	$ 876,658
Water and Power Infrastructure Reliability	$ 801,787
Water Operations Decision Support	$ 437,002
Conserving or Expanding Water Supplies	$ 277,001
Research Projects Subtotal	**$ 8,771,544**
Collaboration, Regional Office Participation, and Program Improvements	$ 550,000
Technology Transfer	$ 450,000
Other Activities Subtotal	**$ 1,000,000**

Climate Change Variability and Adaption

- Sensitivity of Hydrologic Impacts Assessment to Downscaling Methodology and Spatial Resolution, Tom Pruitt, tpruitt@usbr.gov
- West-Wide Drought Assessment Using Paleoclimate and BCSD Climate Projections, Subhrendu Gangopadhyay, sgangopadhyay@usbr.gov
- Diagnose CMIP5 Projections for Credibility, Strengths and Weaknesses in Water Resources Planning Applications. lbrekke@usbr.gov
- Climate Science and Water Resources Distance Learning Efforts and Customized Workshop, Levi Brekke, lbrekke@usbr.gov
  Methodology and Data for Quantifying Extreme Precipitation Events in a Changing Climate, John England, jengland@usbr.gov
- Ingredients-Based Climatology and Future Projections of Extreme Precipitation Events Using a Numerical Weather Prediction (NWP) Framework, Raymond Caldwell, rcaldwell@usbr.gov
- Linking Extreme Precipitation and Floods: Implications for Climate Change Scenarios, Jeanne Godaire, jgodaire@usbr.gov
- Development of Forecast and Decision Calendars to Facilitate Improved Forecast Applications by Reclamation Decision Makers, Ian Ferguson, iferguson@usbr.gov
- Back to the Future: Innovative Tree Ring Analysis to Reconstruct Paleoclimate and Streamflows for Improved Urban Water Planning Under Climate Change, Fred Liljegren, fliljegren@usbr.gov
- Understanding How Different Versions of Distributed Historical Weather Data Affect Hydrologic Model Calibration and Climate Projections Downscaling, Subhrendu Gangopadhyay, sgangopadhyay@usbr.gov
- Quantifying the Benefits of Integrated Surface Water-Groundwater Modeling for Climate Impact Analyses, Ian Ferguson, iferguson@usbr.gov
- Comparing Methods for Simulating Agricultural Evapotranspiration and Crop Yields under Changing Climate Conditions, Michael Tansey, mtansey@usbr.gov
- Effects of Climate Change on Riparian Vegetation Structure, Water Uptake, and Dependent Pollinators along Mainstem Rivers in the Colorado River Basin, Mark Nelson, snelson@usbr.gov
- Evaluating Climate-Induced Runoff and Temperature Change on Stream Habitat Metrics for Endangered or Threatened Fish, Jennifer Bountry, jbountry@usbr.gov
- Evaluating Water Management Responses to Global Climate Change Using Coupled Hydrologic and Economic Models, Jennifer Johnson, jmjohnson@usbr.gov
- Robust Long-Term Streamflow Forecasting, Roger Hansen, rhansen@usbr.gov
- Cumulative Uncertainties Assessment and Evaluation of Relative Influence on Output Uncertainties, Levi Brekke, lbrekke@usbr.gov
- Vulnerability Analysis of Western Water Resources to ClimateVariability and Change (J. Ramirez), Levi Brekke, , lbrekke@usbr.gov
- Pilot Demonstration of Hydroeconomic Model Development and Application in the Lower Colorado River Basin, Levi Brekke, lbrekke@usbr.gov
- Literature Synthesis on Climate Change Implications for Reclamation's Water Resources, Mark Spears, jspears@usbr.gov



The new "Bias Correction and Downscaled WCRP CMIP3 Climate and Hydrology Projections" are available at: http://gdo-dcp.ucllnl.org/downscaled_cmip3_projections.

Levi Brekke, Climate Change and Hydrology Coordinator, 303-445-2494, lbrekke@usbr.gov

FY 2012 Research Awards

Zebra and Quagga Mussels

- Resistance of Protective Coatings and Pipe Linings to High Pressure Water Jets Used for Invasive Mussel Removal and Cleaning, Joshua Mortensen, jmortensen@usbr.gov
- Modernization of Trashrack Raking Systems to Manage Quagga Mussel Settlement, Bryan Heiner, bheiner@usbr.gov
- Impact of Quagga Mussel Introduction on Particulate Organic Matter Drift, Ecosystem Level Impacts, Mike Horn, mhorn@usbr.gov
- Investigating New Fish Screening Technology and Modification of Existing Infrastructure to Reduce Impacts of Invasive Quagga and Zebra Mussels on Reclamation Facilities, Cathy Karp, ckarp@usbr.gov
- Fish Predation on Quagga Mussels, Cathy Karp, ckarp@usbr.gov
- Production and Testing of Antibodies for Dreissena Mussels, Kevin Kelly, kkelly@usbr.gov
- Zebra and Quagga Mussels: Environmental Effects and Spread of Quagga and Zebra Mussels in Flowing Water Systems in the Western United States, Mark Nelson, snelson@usbr.gov
- Solutions to Mussel Infestation Issues in Fire Protection and Other Systems at Reclamation Facilities, Ron LeBlanc, rleblanc@usbr.gov
- Effects of *Pseudomonas fluorescens*, a Biological Control Agent for Quagga and Zebra Mussels, on Growth, Health, and Survival of Fish, Zak Sutphin, zsutphin@usbr.gov
- Antifouling Coatings for Invasive Mussel Control, Allen Skaja, askaja@usbr.gov
- Research and Development of Durable Foul Release Coatings, Allen Skaja, askaja@usbr.gov
- Creating Turbulence to Prevent Invasive Mussel Colonization within Pipelines, Joshua Mortensen, jmortensen@usbr.gov
- UV Evaluations at Hoover and Davis Dams, Denise Hosler, dhosler@usbr.gov
- Endothall Technical Support and Oversight, Scott O'Meara, someara@usbr.gov
- Sparker Testing, Joe Kubitschek, jkubitschek@usbr.gov
- CDOW Database, Denise Hosler, dhosler@usbr.gov

Quagga mussels on the intake trashracks at Hoover Dam.

Joe Kubitschek, Zebra and Quagga Mussel Research Coordinator, 303-445-2148, jkubitschek@usbr.gov

Advanced Water Treatment

- Effects of Recharge and Dissolved Nitrate on Selenium and Salinity Mobilization Using Geochemical Modeling and Laboratory Testing, Terry Stroh, tstroh@usbr.gov
- Concentrate Minimization via Pellet Softening - Process Evaluation and Pilot Study, Saied Delagah, sdelagah@usbr.gov
- Treatment and Beneficial Use of Produced Water in the Western United States, Katherine Guerra, kguerra@usbr.gov
- Strategies for Treating Variable Source Water, Michelle Chapman, mchapman@usbr.gov
- Municipal Water District of Orange County Sea Water Pilot Desalination Study Quality Assurance/Quality Control and
- Peer Review, Saied Delagah, sdelagah@usbr.gov
- Assessing Low-Pressure Membrane Technology to Reduce the Cost of Desalination, Katherine Guerra, kguerra@usbr.gov
- Oxnard Saline Treatment Wetlands, Amy Witherall, awitherall@usbr.gov
- A Water Footprint Analysis Tool To Assess the Value of Water, Darlene Tuel, dtuel@usbr.gov
- Membrane Pretreatment with Ion Exchange for Natural Organic Matter Removal, Steve Dundorf, sdundorf@usbr.gov
- Slowsand Filtration for Reducing Costs of Desalting Surface Waters, Chuck Moody, cmoody@usbr.gov

Seawater demonstration facility; Long Beach, California.

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FY 2012 Research Awards

Advanced Water Treatment – *continued*

- West Basin Ocean Water Desalination Demonstration, Saied Delagah, sdelagah@usbr.gov
- Developing the Next Generation Chlorine-Resistant, High Flux, and High Salt Rejection Polyamide Desalting Membrane to Increase Water Supply, Yuliana Porras Mendoza, yporras@usbr.gov
- Single Well Brackish Groundwater Recovery and Brine Disposal, Kevin Black, Sr., kblack@usbr.gov
- Forward Osmosis Water Purification, Chuck Moody, cmoody@usbr.gov
- Innovative Constructed Wetlands for Removing Endocrine Disrupting Compounds from Reclaimed Wastewater, Michelle Chapman, mchapman@usbr.gov

Kevin Price, Advanced Water Treatment Research Coordinator, 303-445-2260, mprice@usbr.gov

Renewable Energy

- Phase 2–Advanced Optimization Algorithms for Hydropower Dispatch, David Harpman, dharpman@usbr.gov
- Solar Photovoltaic Desalination, Mitchell Haws, mhaws@usbr.gov
- Renewable Energy Evaluation for Zero Liquid Dischage Processes, Michelle Chapman, mchapman@usbr.gov
- Reduced Cost Hydropower Maintenance, Nathan Myers, nmyers@usbr.gov
- Power System Diagnostics, Eric Eastment, eeastment@usbr.gov
- Renewable Integration and Small Hydro, Nathan Myers, nmyers@usbr.gov
- Effective Cavitation Detection Techniques for Hydraulic Turbines, John Germann, jgermann@usbr.gov
- Renewable Power Generation for Water Transmission, Mitchell Haws, mhaws@usbr.gov
- Signal Processing Techniques for Determining Powerplant Characteristics, Kyle Clair, kwclair@usbr.gov
- Multi-Area Benefits from Co-location of Energy Production Facilities, Greg Krzys, gkrzys@usbr.gov
- Power System Safety, Eric Eastment, eeastment@usbr.gov
- Increased Hydrogeneration while Improving Environmental Conditions, Merlynn Bender, mbender@usbr.gov
- Affordable Self-Cleaning Trash Rack, Tom Gill, tgill@usbr.gov
- Pumped Storage, Dave Harpman, dharpman@usbr.gov
- Demand Management Study, Miguel Rocha, mrocha@usbr.gov

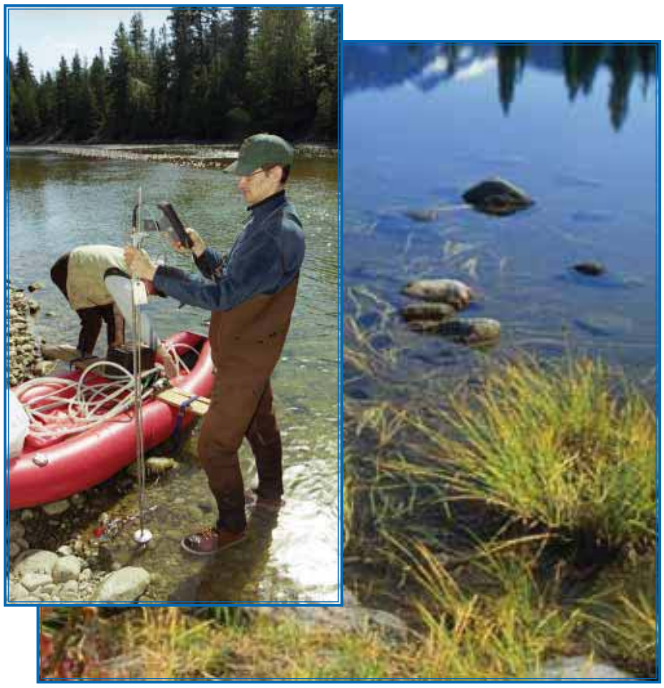
Solar panels, wind turbine, and Hoover Dam—all sources of renewable energy.

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

FY 2012 Research Awards

Environmental Issues in Water Delivery and Management

- Predicting Vertical and Lateral Sediment Erosion in Rivers and Reservoirs, Jennifer Bountry, jbountry@usbr.gov
- Investigation of Fish Predation Refugia Concepts at Hydraulic Structures, Connie Svoboda, csvoboda@usbr.gov
- Fish Predator Reduction Using Fish Traps with Bait Attraction, Joshua Mortensen, jmortensen@usbr.gov
- Underwater Curtain Technology for Downstream Fish Passage in Reservoirs, Dale Lentz, dlentz@usbr.gov
- Fish Tags—the Old/New Tool for Assessing Impacts of Reservoir Operations on Migratory Fish and Critical Habitat, Dmitri Vidergar, dvidergar@usbr.gov
- Technical Workshop on Large Wood Applications and Research Needs in River Settings, Jennifer Bountry, jbountry@usbr.gov
- Achieving Reservoir Sustainability, Kent Collins, kcollins@usbr.gov
- The Effects of Electrofishing on the Reproductive and Developmental Health of Razorback Suckers in the Colorado River Basin, Mark McKinstry, mmckinstry@usbr.gov
- Engineering Log Jam Design Standards, Aaron Kopp, akopp@usbr.gov
  Cone Screen Riverine Baffle Design, Leslie Hanna, lhanna@usbr.gov
- Quantification of Temperature Change to a Water Body Influenced by Subsurface Return Flow, Sharon Parkinson, sparkinson@usbr.gov
- Monitoring the Effectiveness of Gravel Augmentations Downstream from Dams for Habitat Improvements, David Gaeuman, dgaeuman@usbr.gov
- Modeling Changes in Water Quality Resulting from Sediment Delta Interactions, Nick Williams, nwilliams@usbr.gov
- Predicting the Interactions between Flow, Sediment, and Riparian Vegetation, Blair Greimann, bgreimann@usbr.gov
- Evaluating Innovative Swim–Thru Fishway Valve Lock System for Medium Head Applications, Steve Montague, smontague@usbr.gov



Fish biologists on the Yakima River

- Stream Flow and Nutrient Constraints on the Productivity and Habitat Quality of Desert Riparian Ecosystems in the West, Mark Nelson, snelson@usbr.gov
- Calibration of Bed Load Impact Sensors for Surrogate Sediment Measurement, Robert Hilldale, rhilldale@usbr.gov
- Bedload Adaptation Length for Modeling Bed Evolution in Gravel-Bed Rivers, David Gaeuman, dgaeuman@usbr.gov
- Identifying Indicators and Guides for Sustainability of Pools in Gravel-Bed Rivers, Sharon Parkinson, sparkinson@usbr.gov
  Impact of Invasive Species Water Use on Lower Colorado River Operations, John Osterberg, josterberg@usbr.gov
- Passive Acoustic (Hydrophone) Measurement of Coarse Bed Load, Robert Hilldale, rhilldale@usbr.gov
- Predicting Bank Erosion to Improve River Restoration and Reservoir Sediment Management, Blair Greimann, bgreimann@usbr.gov
  Evaluation of Salmonid Smolt Survival at Roza Diversion Dam and the Downstream 11–Mile Reach, Cathy Karp, ckarp@usbr.gov
- Elwha Dam Removal Science Symposium and Field Trip, Jennifer Bountry, jbountry@usbr.gov
- The Efficiency of SandWand Technology as a Habitat Restoration Tool for Native Salmonids, Zak Sutphin, zsutphin@usbr.gov
- San Joaquin River Restoration Program Geophysical Analysis for Seepage Management and Channel Capacity Improvement, Katrina Harrison, kharrison@usbr.gov
- Assessing and Reducing Uncertainty from Hydraulic and Hydrologic Models, Blair Greimann, bgreimann@usbr.gov
- Salmon Spawning Gravels as a Critical Indicator of Restoration Potential, San Joaquin River, California, Mark Nelson, snelson@usbr.gov
- Evaluation of Embryo Reintroduction Methods to Facilitate Reintroduction of Spring–run Chinook Salmon into the San Joaquin River Restoration Program, Donald Portz, dportz@usbr.gov
- Design Guidelines for New Technology, Low–Cost Bank Stabilization Features, Drew Baird, dbaird@usbr.gov
- Ecological Costs of Streamflow Regulation, Mark Nelson, snelson@usbr.gov
- Research in partnership with the San Joaquin Recovery Program, Alicia Forsythe, aforsythe@usbr.gov

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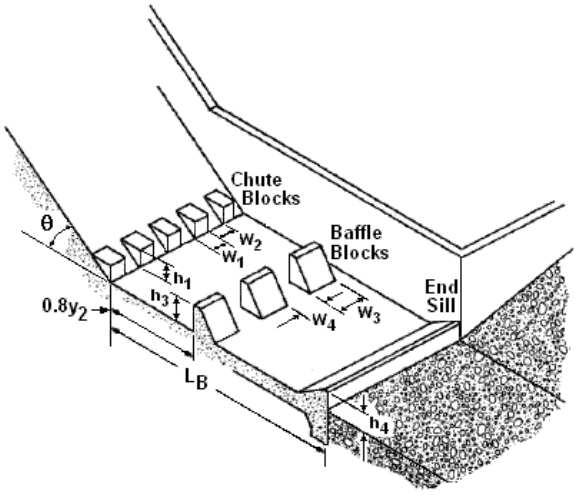
FY 2012 Research Awards

Water and Power Infrastructure Reliability

- Improving the Range of Hydraulic Performance of Type III Stilling Basins, Connie Svoboda, csvoboda@usbr.gov
- Detecting and Monitoring Internal Erosion using Acoustic Emission Technology, Robert Rinehart, rrinehart@usbr.gov
- Leaching Lithium, John Robertson, jrobertson@usbr.gov
- Moisture Content Requirements for Effective Concrete Repairs, Kurt Von Fay, kvonfay@usbr.gov
- Testing/Verifying Rope Access Anchors, Shaun Reed, sreed@usbr.gov
- Laboratory Evaluation of Metallized Coatings for Use on Reclamation Infrastructure, David Tordonato, dtordonato@usbr.gov
- Demonstration Project to Implement Electro–Osmotic Pulse Tech, Daryl Little, dlittle@usbr.gov
- Physical Hydraulic Modeling of Canal Breaches, Tony Wahl, twahl@usbr.gov
- Terrestrial Photogrammetry: Deploy Reclamation–Wide, Develop Capabilities, Explore Applications for Three–Dimensional Measurements, Rebecca Heisler, rheisler@usbr.gov



Schematic for a Type III stilling basin.

- Measuring Erodibility of Embankment Soils Containing Gravel, Tony Wahl, twahl@usbr.gov
- Identify Primary Noise Sources in the Powerplant and Implement Noise Engineering Controls to Reduce Exposures to Employees, Theresa Gallagher, tgallagher@usbr.gov
- Evaluation of Intelligent Compaction Technology Based on Correlations to Relative Density, Robert Rinehart, rrinehart@usbr.gov
- The Application of Light Detection and Ranging Technology to Improve the Management and Protection of Heritage Assets in the American Falls Archaeological District, Idaho, Jennifer Huang, jhuang@usbr.gov

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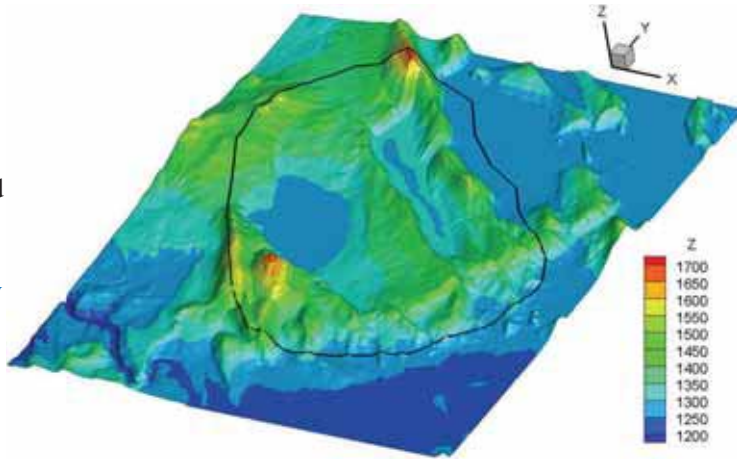
Water Operations Decision Support

- Optimizing Surface Model Techniques for Digital Representation of River Channels, Kurt Wille, kwille@usbr.gov
- Adaptive Water Operations and Planning Decision Support Using Reliability-Based Global Optimization and HydroGeoSphere Integrated Hydrologic Model, George Matanga, gmatanga@usbr.gov
- Geographic Information System-Based Decision Support for Wetland Drainage Salinity Managemen, Nigel Quinn, nquinn@usbr.gov
- Estimating Unmetered Groundwater Irrigation Demand with High-Resolution Remote Sensing Data, Eve Halper, ehalper@usbr.gov
- A Method for Developing Daily Flow Data from Monthly Model Output that can be Used for Risk Assessment, Jennifer Johnson jmjohnson@usbr.gov
- Exploring Potential Uses of Near Remote Sensing and Unmanned Aerial Vehicle (UAV) Technologies in Reclamation Science, Engineering, and Operations, to Reduce Costs, and Add Capabilities, Douglas Clark, drclark@usbr.gov
- Potential Reclamation Applications of the Gasoline Micro Air Vehicle (gMAV), Jade Soddell, jsoddell@usbr.gov



HydroGeoSphere screenshot. *Shaded relief map (3 times vertical exaggeration), ground surface elevation (color fill) and flow domain boundary (black line)*

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FY 2012 Research Awards

Water Operations Decision Support – *continued*

- Selective Filtering of Light Detection and Ranging (LiDAR) Data for Enhanced Surface Representation of River Geomorphology, Lanie Paquin, mpaquin@usbr.gov
- Data Management and Data Stewardship in Reclamation, Douglas Clark, drclark@usbr.gov
- Enhancing the Institutional Capacity of Reclamation to Manage Water Resource Conflicts in the Western United States, Douglas Clark, drclark@usbr.gov

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

Conserving or Expanding Water Supplies

- Flow Calibration of Submerged Sluice Gates, Tony Wahl, twahl@usbr.gov Evaluation of Low-Cost Ultrasonic Flow Meters, Bryan Heiner, bheiner@usbr.gov
- Effectiveness of Rebate Programs in Reducing Household and Commercial Water Use, Steven Piper, spiper@usbr.gov
- Database for Field Performance of Electronic Water Level Sensors, Tom Gill, tgill@usbr.gov
- Wireless Automated Control of Surface Irrigation Systems for Improved Irrigation Efficiency, Tom Gill, tgill@usbr.gov
- Design Refinement and Construction Drawings for Overshot Gates that Irrigation Districts Can Construct Themselves, Tom Gill, tgill@usbr.gov
- Developing a Multi-Aquifer Hydrologic Modeling Package to Support Reclamation Water Use Planning, Jennifer Johnson, jmjohnson@usbr.gov
- Reinforced Concrete Pressure Pipe Stress Distribution, Steve Robertson, srobertson@usbr.gov

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Overshot gate installed at Bostwick Irrigation District near Red Cloud, Nebraska

RECLAMATION Managing Water in the West

November 2011
Research and Development Office
Bulletin 2012–03

The Knowledge Stream
Award Announcements

Desalination and Water Purification Research Program

Facilitates partnerships to develop more effective, environmentally sensitive ways to increase water supplies.

"By investing in alternative water treatment technology research we are working to find ways to stretch the nation's current water supply, use less energy and reduce impacts to the environment. The research we are funding has the potential to unlock efficiencies that ensure future water supplies, strengthen our economy, and create jobs."
Commissioner Connor

Bottom Line

Under the DWPR Program, Reclamation cost shares research and studies with non-Federal entities. A competitive, merit-reviewed process is used to make awards with a recommended cost-share of 25 to 50 percent Federal contribution.

The 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

Project Awards

In fiscal year 2011, Reclamation awarded $1.5 million under the Desalination and Water Purification Research Program to further research advanced water treatment technologies. This funding will be leveraged to support $2,771,752 in research. Five new projects are:

Design and Testing of a Pressure Regulation Subsystem for a Wave-Driven Desalination System: Resolute Marine Energy, Boston, Massachusetts ($37,000), with with Atlas Water Systems. Olivier Ceberio, oceberio@resolutemarine.com. This project is to design, build, and test a pressure and flow rate regulation system. This system will be used in conjunction with a seawater reverse osmosis system powered by ocean wave energy to create a clean and cost-effective alternative to diesel-driven desalination systems.

Pilot-Scale Evaluation of High Recovery Desalination of Agricultural Drainage Water with Smart Integrated Membrane Systems: University of California at Los Angeles, Western San Joaquin Valley, California ($199,809). Yoram Cohen, yoram@ucla.edu. This is a pilot test of the smart integrated membrane system (SIMS) technology of autonomous/self-adaptive ultrafiltration /reverse osmosis operation for desalination of agricultural drainage water. Operation is scheduled for two field sites in the western San Joaquin Valley where agricultural drainage management is a major challenge. The project aims to demonstrate the ability to continuously desalt brackish water attaining the maximum feasible recovery with a system operation that adapts in real-time to varying water quality scaling or fouling potential.

Combining Electrodialysis Reversal and Slurry Precipitation and Recycle Reverse Osmosis Technologies to Increase Recovery at Inland Desalters: Carollo Engineers, Corona, California ($197,968). Graham Juby, gjgjuby@carollo.com. This new treatment approach aims to decrease the volume of concentrate, thus making disposal easier at utilities where methods like ocean discharge are not feasible. This is a one-year pilot test to be carried out at the Temescal Desalter site in Corona, California.

Optimization of Desalination Diffusers Using Three-Dimensional Laser Induced Fluorescence: Georgia Institute of Technology, Atlanta, Georgia ($101,968). Philip Roberts, proberts@ce.gatech.edu. Designs of multi-port concentrate diffusers require predictions for dilution and environmental impacts. Predictions will be made by measuring and mapping tracer concentration profiles in the jets and the spreading bottom layer using an innovative three-dimensional Laser-Induced Fluorescence system. The results will be detailed data on the three-dimensional concentration distributions.

Studies on Presence, Influence and Control of Biofilms on Desalination Membranes: University of Toledo, Ohio ($115,420.) Isabel Escobar, isabel.escobar@utoledo.edu. This project will investigate making membranes resistant

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Denver, Colorado 80225-0007

— continued

to biofoulants by charging the surface with copper. The project will focus on specific metal chelating ligands to bind the metal to the membrane. This work follows successful results on similar treatment of spacers in membrane equipment.

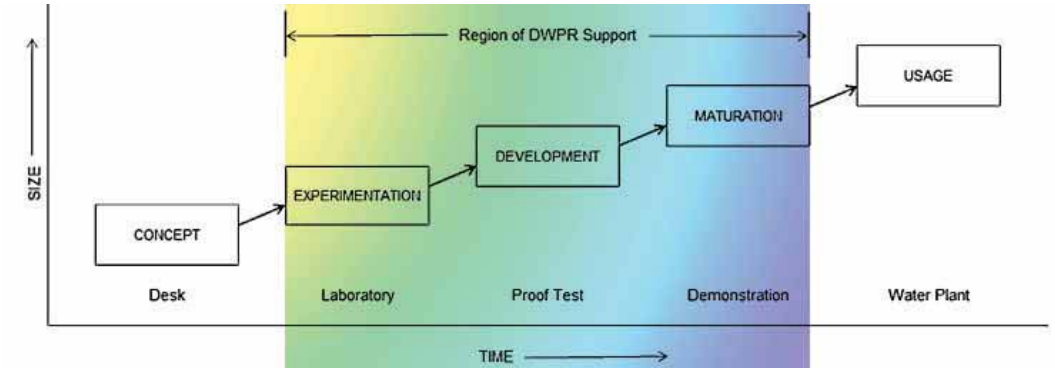
Guidelines for the Use of Stainless Steel in the Water and Desalination Industries: Eastern Municipal Water District, Perris, California ($86,572). Erin Mackey, emackey@carollo.com and Thomas Seacord, tseacord@carollo.com. Stainless steel is widely used in water and desalination systems. There are six major types of stainless steel and over 150 compositions. This project is developing guidelines to properly specify the type of stainless steel and construction standards used and to identify appropriate operating conditions to avoid corrosion.

Installation and Operation of a Full Solar Distillation Desalination Unit at the Brackish Groundwater National Desalination Research Facility: Suns River, Many, Louisiana ($84,703). Hill Kemp, hillk@suns-river.com. $84,703. Previously developed solar stills suffer from low productivity that limits the application of this technology. The unit to be tested has several novel features: a tilted adsorption surface almost normal to the incident sunlight and falling film evaporation, which are expected to materially increase the rate of evaporation and a modified surface to provide improved condensation. Initial efforts will concentrate on small production units.

Two projects are receiving continuing funding for the second phase:

Demonstration of Zero Discharge Desalination at the Brackish Groundwater National Desalination Research Facility at Alamogordo, New Mexico: University of Texas at El Paso with Veolia Water Solutions and the City of Alamogordo. ($499,996). Malynda Cappelle, mcappelle@utep.edu. The Zero Discharge Desalination process offers the potential to maximize the volume of product water from a brackish source while minimizing the amount of waste to be disposed. Recovery is progressively increased to very high values (about 97 percent) by removing gypsum (calcium sulfate) and silica. This work will build on pilot tests at various locations. The primary goal is to move towards commercialization and regulatory acceptance of this process.

Osmotically Assisted Desalination: A Low Energy Reverse Osmosis Hybrid Desalination System: University of Nevada, Reno ($186,492). Amy Childress, amyec@unr.edu. This will be a pilot-scale test of a hybrid system combining reverse osmosis with pressure retarded osmosis. The system will be used as a proof-of concept investigation to verify the bench-scale results and optimize the operating parameters necessary for developing a highly efficient reverse osmosis desalination system. The system will be field tested at the Brackish Groundwater National Desalination Research Facility in Alamogordo, New Mexico.



Desalination timeline. DWPR supports projects from the laboratory to demonstration.

"Through this program, Reclamation is forming partnerships with private industry, universities, water utilities, and others to address a broad range of desalting and water purification needs."

Kevin Price, Advanced Water Treatment Research Coordinator

Better, Faster, Cheaper

DWPR research has led to building desalination systems with innovative ways to save energy, reduce concentrate waste, and reduce costs—extending our water supplies around the world. We have researched and applied ways to build bigger plants more economically, and to facilitate industry-developed standards, thus reducing costs even further.

Web site

www.usbr.gov/research/AWT/DWPR

Reclamation R&D Office Contact

Kevin Price mprice@usbr.gov Advanced Water Treatment Research Coordinator, 303-445-2260

FY 2011 Year in Review

We've got over 200 partnerships involved in river restoration activities, so this conference helps bring people together and once again, to help educate each other, highlight the benefits of what we are doing, and be more successful . . . Given the importance of river restoration overall to Reclamation and some of the programs we have on-going, it is certainly my goal that over the next decade, Reclamation becomes as well known for its expertise in river restoration as it is for building dams, maintaining dams, and building and taking care of other water supply infrastructure.

Michael L. Connor, Commissioner

Research Projects

In FY 2011, we awarded $9.7 million for 137 research projects, focusing on our priority areas:

- Climate Change and Variability Research: $1.8 million
- Zebra and Quagga Mussels: $1.9 million
- Advanced Water Treatment: $1.4 million
- Renewable Energy: $1.1
- Other mission related research: $3.5 million

The next section (pages 18 - 36) provide one-page summaries of just some of the innovative solutions. The last section (starting on page 37) lists even more research products.

Workshops

We have conducted many workshops to share new tools and understand the challenges Reclamation faces.

River Restoration

We funded and helped plan and implement the conference, River Restoration: Exploring Institutional Challenges and Opportunities at the University of New Mexico Albuquerque, New Mexico, on September 14, 2011. Reclamation and the University of New Mexico Law School cohosted the conference. Participants included 50 Reclamation staff involved in managing river restoration programs and 50 outside experts, stakeholders, and non-governmental organizations.

The program to restore the San Joaquin River as part of the Central Valley Project Improvement Act resulted in restoration of interim flow releases from Friant Dam beginning in 2009. The photos show the San Joaquin River before interim flow releases and after it was reconnected to the Sacramento-San Joaquin Delta in 2010, a stretch of 330 miles Except for flood releases, this has not happened in more than 60 years.

See www.usbr.gov/river for more information on this conference and our river restoration projects.

FY 2011 Year in Review

Partnerships

We have forged partnerships and interagency agreements to tap into the vast reservoir of knowledge and expertise to address water operation challenges.

National Renewable Energy Lab Cooperative Agreement

We developed an Interagency Agreement with the Department of Energy to contract with the National Renewable Energy Laboratories (NREL) to investigate renewable energy on Reclamation lands. NREL is performing a West-wide utility scale analysis, West-wide facility scale analysis, and site specific utility and facility scale evaluations on the Central Arizona Project and at other sites within Reclamation's service area.

Tasks include:

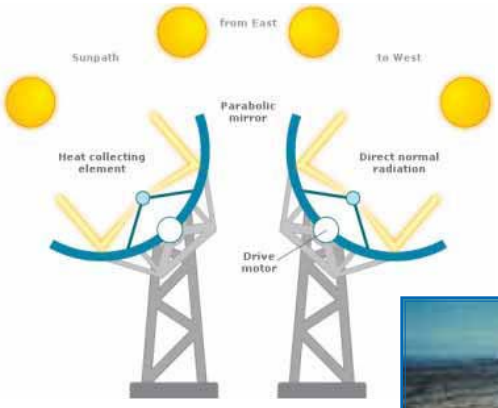
- Assessing facilities and analyzing sites throughout Reclamation to determine potential renewable energy generation
- Participating in the Renewable Energy Opportunity Study for Navajo Gallup Water Supply Project.
- Providing training about renewable energy development for Reclamation leadership, management, and staff.
- Assisting Reclamation with reviewing proposals from industry for installing and developing renewable energy on Reclamation lands or facilities.
- Providing technical, economic, and policy analysis for renewable energy technologies and topics.

A draft of the first report, covering the two West-wide analyses and the first facility and utility scale analyses (for the Central Arizona Project) was received October 2011.

Bureau of Reclamation, Irrigation
Artist: Michael Frary

Bottom Line

Reclamation scientists and engineers with a broad array of outside partners, undertake innovative research and technical investigations to address a wide range of challenges.



Parabolic Troughs are aligned N-S and track the sun from East east to west, Arizona Trough Plant near Tucson, AZ

8 Megawatt Single Axis tilt PV System in Alamosa, CO

Aerial View of CSP Trough Plants at Kramer Junction, CA (In operation for 30 years)

RECLAMATION Managing Water in the West

October 2011
Research and Development Office
Bulletin 2012–01

The Knowledge Stream
Research and Innovation Update

Downscaled Climate and Hydrology Projections Web Site

New daily climate and Western U.S. hydrology projections are now available

Bottom Line

New climate and hydrology projections help users answer local questions about daily climate, streamflow, and water resources.

Projections Web Site

"Bias Correction and Downscaled WCRP CMIP3 Climate and Hydrology Projections" available at: http://gdo-dcp.ucllnl.org/downscaled_cmip3_projections/

Better, Faster, Cheaper

Via the web site, Reclamation makes downscaled climate and hydrology projections available to scientists and engineers quickly and easily. Use of this web service reduces assessment costs and supports risk-based climate adaptation planning.

Reclamation R&D Office Contact

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Collaborators

Reclamation (Science and Technology Program, WaterSMART Basin Studies Program), Santa Clara University, LLNL Green Data Oasis, Climate Central, Scripps Institution of Oceanography, and the U.S. Geological Survey.

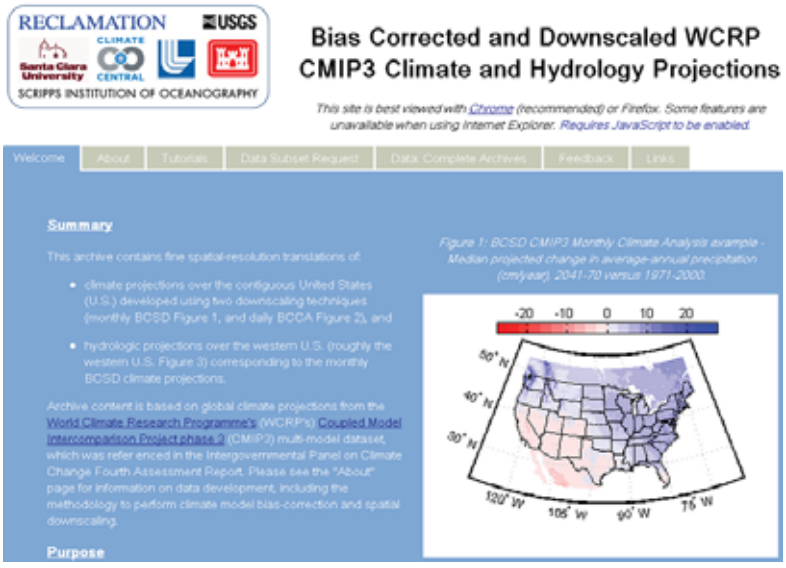
What Was the Problem?

Global climate models (GCM) are used to simulate future climate responses to scenario increases in atmospheric greenhouse gases (GHGs). Climate responses include changes in surface temperature and precipitation. However, GCM outputs are spatially coarse and not adequate for evaluating local climate impacts.

Users need to quickly and easily access GCM output translated spatially to locally relevant resolution (i.e., "downscaled"). They also need this output to be finely resolved in time so that they may address monthly to daily climate questions (e.g., precipitation amounts, reoccurrence of wet and dry weather patterns, daily temperature range). Users also need (1) a way to account for the GCM's tendencies to simulate climate that is too warm or cool and/or too wet or dry, which varies by location; (i.e., model "bias") and (2) understanding of what these climate projections mean for local hydrology (e.g., streamflow, snowpack, water supplies).

Initial Solution

In 2007, Reclamation collaborated with U.S. Department of Energy's National Energy Technology Laboratory (DOE NETL), Santa Clara University, Lawrence Livermore National Laboratory (LLNL), and University of California's Institute for Research on Climate Change and Its Societal Impacts (IRCCSI) to apply a proven technique called "Bias Correction Spatial Disaggregation" (BCSD, see "About on the Web site" to 112 contemporary global climate projections made available through the World Climate Research Program Couple Model Intercomparison Project, Phase 3 (WCRP CMIP3). These projections represent 16 GCMs simulating climate responses to three GHG scenarios from multiple initial climate system conditions. The effort resulted in development of 112 monthly temperature and precipitation projections over the continental U.S. at 1/8º (12 kilometers) spatial resolution during a 1950–2099 climate simulation period. These projections were the first information resources on the Web site.



Web site screenshot.

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New Needs, New Solutions

Daily Climate Projections

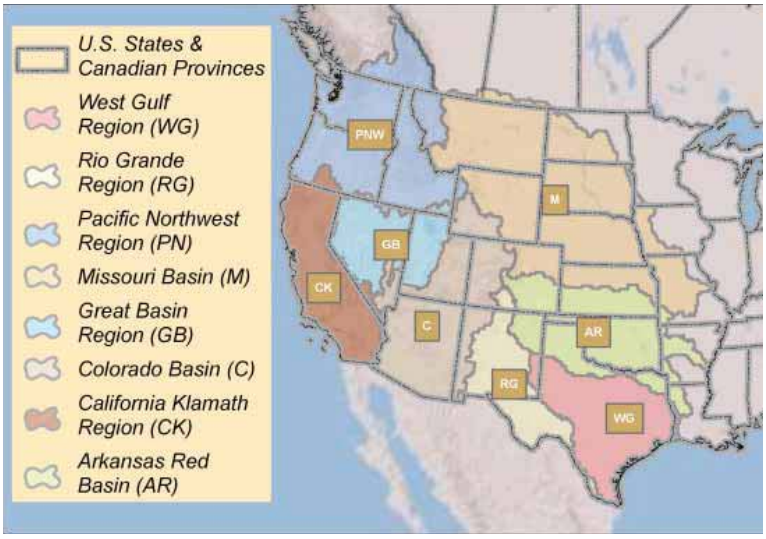
Since 2007, about 1,000 users have downloaded the monthly climate projection information from the Web site for various educational, research, and planning uses. However, the monthly climate projections do not address potential changes in daily temperature range (important for ecological studies) nor potential changes in daily precipitation conditions and wet/dry spell reoccurrences. To address this, the collaboration expanded in 2010 to leverage a new technique developed at Scripps Institution of Oceanography, U.S. Geological Survey, and Santa Clara University, "Bias Correction Constructed Analogs" (BCCA). The technique operates on daily GCM output, producing daily projections of minimum temperature, maximum temperature, and precipitation at the same spatial resolution as BCSD information. Based on available daily CMIP3 information reported at PCMDI (see "More Information" on the Web site), and through additional support from U.S. Army Corps of Engineers and Climate Central, BCCA was applied to 53 of the 112 BCSD projections for periods 1961–2000, 2046–2065, and 2081–2100. These new projections are now available to support a variety of studies, including those related to ecological and flood-related impacts.

Western U.S. Hydrologic Projections

Translating downscaled climate projections into associated hydrologic projections requires considerable time and effort. As hydrologic model tools to support such assessment are often not readily available, local analysts have been forced to conduct their own hydrologic model development and application exercises. These are often done inconsistently, making regional impact assessments or intercomparison and prioritization difficult.

Motivated by an interest in addressing both the challenges of interregional assessment and providing access to hydrologic projections for local planning efforts, Reclamation collaborated with the University of Washington's Climate Impacts Group (CIG) and the National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) Colorado Basin River Forecast Center to generate hydrologic projections over the Western United States, corresponding to the monthly BCSD climate projections contained at this Web site. These 112 hydrologic projections were developed through support from the Reclamation WaterSMART Basin Studies Program as part of the West-Wide Climate Risk Assessments activity.

This web site provides hydrologic projections in monthly and daily form. Monthly projections can be flexibly accessed using a new interface that permits tributary basin identification above a "pour cell," and then retrieval of monthly climate and hydrology projections above that location. Monthly projections include: precipitation, mean daily maximum and minimum temperatures, wind speed, evapotranspiration (actual and potential), soil moisture, snow water equivalent, and runoff. Daily projections include the four weather variables plus runoff.



BCSD CMIP3 Hydrologic Projections—Geographic Extent of Hydrologic Modeling.

"Through July 2011, this web site has served projections to about 1,000 users, collectively issued through approximately 11,000 downloads. The requests have covered the contiguous U.S. and parts of southern Canada and northern Mexico."

Levi Brekke, Water and Climate Research Coordinator, Reclamation

Who Can Benefit?

Researchers and decision-makers can use these projections to evaluate potential future climate and hydrology, assess societal impacts, and explore adaptation options.

Future Development Plans

In 2012, archive collaborators plan to apply both downscaling techniques to new global climate projections (CMIP5) and also to develop hydrologic projections associated with the daily BCCA CMIP3 projections.

More Information

CMIP3:
http://www-pcmdi.llnl.gov/ipcc/about_ipcc.php

CMIP5:
http://cmip-pcmdi.llnl.gov/cmip5/

Hydrology Projections:

www.usbr.gov/WaterSMART/docs/west-wide-climate-risk-assessments.pdf

RECLAMATION Managing Water in the West

October 2011
Research and Development Office
Bulletin 2012–02

The Knowledge Stream
Research and Innovation Update

Zebra and Quagga Mussels

Preventing the spread and addressing the impacts from invasive mussels in Western U.S. waters

Bottom Line

As a high priority since 2008, Reclamation has focused invasive mussel research activities on improving early detection methods; identifying, developing, demonstrating, and implementing facilities protection technologies and strategies; and assessing ecological impacts.

For More Information

See http://www.usbr.gov/mussels/research/current.html

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Researchers are engaged in a number of mussel-related research activities through Reclamation's Research & Development (R&D) Office, Lower Colorado (LC) Region, LC Dams Office, and Technical Service Center (TSC).

Many of these activities involve collaborating with other Federal agencies, Reclamation's managing partners, and private industry.

Mussels in a cooling pipe.

Improving Monitoring and Detection

Reclamation researchers are investigating the potential of isolating and producing primary antibodies to improve detection of mussel larvae and explore the potential for other uses in controlling mussels. With Metropolitan Water District of Southern California (MWD), Reclamation continually works to improve early detection methods. Under a Cooperative Research and Development Agreement (CRADA) with Fluid Imaging Technologies, researchers also have helped identify improvements for automated mussel detection in water samples using FlowCAM® technology. Reclamation also recently provided MWD with golden mussel (*Limnoperna fortunei*) tissue samples for DNA sequencing to help develop future screening capability for this species—another invasive mussel now in South America.

Developing Zequanox™

Reclamation's R&D Office, LC Dams Office, and TSC are collaborating with Marrone Bio Innovations, Inc. (MBI) under a CRADA to develop a promising environmentally friendly treatment product derived from dead *Pseudomonas fluorescens* bacteria. Closed system field trials at Davis Dam began in 2009, and results have shown promise. In 2010, Reclamation received approval from the U.S.Environmental Protection Agency (EPA) to use Zequanox™ at impacted Reclamation facilities along the lower reaches of the Colorado River. The environmental compliance process for using this treatment in cooling water subsystems at Reclamation's Davis Dam has been completed with the environmental assessment (EA) and finding of no significant impact (FONSI). MBI has applied for EPA Section 3 Registration under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), and approval of latest formulations is under review.

Evaluating Filtration and Ultraviolet (UV) Technologies

Reclamation is testing ballast filtration technology for cooling water system protection at Reclamation's Parker Dam. Initial results indicated near 100 percent exclusion of mussel larvae larger than 100 microns (using 40-micron filter media) and 95 percent exclusion of mussel larvae larger than 200 microns (using 80-micron filter media). We are evaluating long-term performance and operation and maintenance requirements. We also began evaluating UV treatment for cooling water system protection at Reclamation's Hoover Dam. Study plans include evaluating mussel larvae response to UV exposure and further expanding testing at Davis Dam.

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Assessing Ecological Impacts

Reclamation is continuing to assess the long-term ecological impacts related to mussel infestations, including overall post-infestation changes in water quality and interactions with other aquatic organisms in Western water bodies.

Trashrack fouling.

Testing Coatings

Since 2007, Reclamation researchers have conducted ongoing field testing of various commercially available coatings at Reclamation's Parker Dam. We have identified certain coatings systems that inhibit mussel fouling. However, the durability appears low, and we are continuing to explore technologies to improve durability. We are considering the physiochemical characteristics of mussel adhesion to further identify and develop durable coatings solutions with the desired antifouling or foul release performance features.

Other Related Activities

Monitoring and Detection Program – Reclamation's R&D Office was provided $4.5M in American Reinvestment and Recovery Act (ARRA) funding for monitoring and detection at more than 350 priority water bodies in the Western United States. In collaboration with various State resource agencies, this program uses multiple detection methods and the data serve to update the extent of known presence and obtain environmental suitability information proximate to Reclamation facilities. Early detection can provide valuable lead time (perhaps 3-5 years) to plan, budget, and implement actions to respond, mitigate, and protect facilities before being overwhelmed. Reclamation is continually exploring ways to maintain this program into the future.

Facility Vulnerability Assessments – To further assist Reclamation's regional, area, and project offices as well as our managing partners and other agencies (including the U.S. Army Corps of Engineers), staff from Reclamation's Technical Service Center and Lower Colorado Region have conducted more than 75 facility vulnerability assessments throughout the Western United States. This effort, in conjunction with early detection, has been geared toward providing site-specific information on potential mussel-related impacts to key facility features that are intended to help project management and staff anticipate and plan for those impacts should a future infestation occur.

Collaboration and Outreach – Reclamation is continually exploring collaboration opportunities with Federal and State agencies, private industry, and academia to identify, evaluate, develop, and implement new mussel management and control technologies and strategies. In addition to hosting the 17th International Conference on Aquatic Invasive Species in San Diego, California, and the 2009 Western Invasive Mussel Management Workshop in Las Vegas, Nevada, Reclamation continues to pursue technical exchange opportunities with our managing partners and the scientific community.

"Quagga mussels pose serious threats to Reclamation's infrastructure and operations at Hoover, Davis, and Parker Dams' hydroelectric generation facilities. Intakes, pipes, and strainers are becoming clogged with these creatures, reducing the abilities of these structures to pump and deliver water and generate hydropower."
- Reclamation Lower Colorado Region News Release on quagga mussels at Davis Dam, June 13, 2011

Developing Alternative Control Technologies

We are exploring several other technologies,including:

- **Pulsed pressure devices to remove mussels and/or prevent settlement on water intake structures and within pipelines**
- **Turbulence generating devices to prevent settlement within water distribution systems**
- **Fish predation as a means of supplemental mussel control where predatory species are already resident**
- **Elevated pH control strategies**
- **The potential for using certain herbicides to control mussels in irrigation systems**
- **Retroffiting trash raking systems to remove mussels**
- **Alternative fish screening technologies to maintain hydraulic and biological performance in the presence of mussels.**

Research Updates

Western Water and Power Solution Bulletin

Research and Development Office — Denver, Colorado

Bulletin No. 30
September 2011

Bioreactors Remove Selenium from Water at Reduced Cost

Bioreactor cells reduce selenium without requiring attendance—improving water quality and saving money

What Is The Problem?

Waterfowl deformities and mortalities at several Reclamation projects have been linked to selenium contamination of irrigation drain water. Selenium occurs naturally in certain Cretaceous and Eocene age marine shale derived soils throughout the Western United States. When mobilized by irrigation, selenium from these soils can contaminate water bodies and adversely impact fish and wildlife. Failure to remediate selenium contamination, in some cases, could result in violations of the Endangered Species Act and/or the Migratory Bird Treaty Act. Remediating selenium-contaminated areas has been problematic, in part because it is difficult to treat selenium-contaminated water. Conventional filtration type methods are expensive, inefficient, and generate large amounts of secondary waste.

What Is The Solution?

Reclamation's Western Colorado Area Office (WCAO) is working with Mesa State College, Golder Associates, Inc., and United Companies to develop a passive, low-tech bioreactor selenium removal process. We used existing bioreactor technology that successfully treats acid mine drainage to the challenge of selenium contamination. The bioreactor is constructed in a manner to create a favorable environment for microorganisms that consume selenium. Based on test results so far, it appears passive selenium-reducing bioreactors offer an efficient, cost-effective treatment method.

A bench-scale test was conducted in 2007 that demonstrated selenium removal rates of 92 to 98 percent. During the bench-scale tests, pretreatment concentration selenium ranged from 20 to 70 micrograms per liter. The pilot-scale test was conducted in 2008–09, and its primary objective was to achieve high selenium removal efficiency and determine the relationships between selenium removal efficiency, detention time, and ambient air temperatures for potential use in a larger scale project. The ongoing pilot-scale test cell covered a 60- by 60-foot area and contained 114 cubic yards of varying proportions of sawdust, hay, wood chips, limestone, and manure to grow the microorganisms. The pilot-scale bioreactor operated over a range of flow rates between 3 and 15 gallons per minute to determine the optimal detention time. The highest removal rates occurred when the water was detained in the cell for 12 hours.

Who Can Benefit?

Selenium-reducing bioreactors could be used at many locations where selenium-impaired surface waters are impacting fish and wildlife. The technology also could be applied to drainages and natural waterways where State and Federal regulatory agencies are advocating for the reduction of selenium loading. However, due to its low treatment (flow) rates, the best use likely would be where high-selenium concentration drainage could be isolated from cleaner waters. Pilot-scale testing showed that this concept will work for small seeps (2–24 gallons per minute). As larger volumes would require large amounts of land, this treatment would be most effective in treating smaller amounts in targeted areas such as tributaries.

Where Have We Applied This Solution?

The location of the bench- and pilot-scale test sites is at a gravel mining operation adjacent to the Colorado River near Grand Junction, Colorado. The site was chosen because of high selenium concentrations in discharge waters and the willingness of concerned parties to cooperate to address the problem.

Pilot-scale selenium passive bioreactor cell.

Future Development Plans

Reclamation will consider using this technology for small point sources of selenium. This technology would allow local entities to undertake remediation, which would benefit Reclamation and project water users. Using this technology could help avoid future water conflicts with the potential for significant cost savings over other treatment methods.

More Information

A report of findings is available at http://www.seleniumtaskforce.org/images/Se_Pilot_Bioreactor_Final_Report.pdf

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Collaborators

Reclamation's Science and Technology Program and Western Colorado Area Office, Mesa State College, Golder Associates Inc., and United Companies

Research Updates

Western Water and Power Solution Bulletin

Research and Development Office — Denver, Colorado

Bulletin No. 32
September 2011

Hydropower Turbine Retrofit Improves Dissolved Oxygen Levels

Retrofitting turbine air venting systems to increase dissolved oxygen levels can prevent downstream fishery impacts

What Is The Problem?

Adequate dissolved oxygen in reservoirs and rivers is critical to aquatic ecosystems and may be required to avoid impacts on both endangered species and recreational fish stocks. In some cases, dam releases through hydroelectric powerplants can contribute to reduced dissolved oxygen downstream as they release water from levels in the upstream reservoir that are oxygen depleted. Low dissolved oxygen-related issues are estimated to occur in 8 percent of Reclamation reservoirs. However, many factors affect dissolved oxygen, including the time of year, especially warm summer months. Although needs vary by species, dissolved oxygen levels of 5 milligrams per liter (mg/L) or more are necessary to support most fish species.

Numerous approaches have been tested for raising dissolved oxygen levels in hydroelectric powerplant discharges, including: in-structure aeration, selective intake depth, forebay gas injection, downstream aeration weirs, spillway operation, and penstock air or oxygen injection.

What Is The Solution?

General Electric (GE) Hydro and Reclamation's Montana Area Office have collaborated to develop a method to retrofit existing hydroelectric turbines to inject sufficient air into the water to raise downstream dissolved oxygen levels. The air is injected/sucked into the flow passing the turbine as the water falls down the draft tube walls. In-structure aeration is typically most efficient because a smaller volume of water is treated relative to treating the reservoir. GE Hydro has a proprietary method of modifying the existing turbine vacuum breaker components to accept large quantities of air into the bottom portion of the turbine. Depending on flow conditions and dissolved oxygen levels, one or more turbines can be modified to significantly raise downstream dissolved oxygen levels.

Who Can Benefit?

This technology may be used at hydroelectric powerplants where low dissolved oxygen problems exist in the tailwater, and where other solutions are cost prohibitive. The owners and managers of these facilities can benefit by using this cost-effective solution to low dissolved oxygen conditions, which could avoid potential fines and/or disruptions to power generation associated with adverse effects to fisheries.

Where Have We Applied This Solution?

In 2005, one of the three turbines at Reclamation's Canyon Ferry Powerplant near Helena, Montana, was retrofitted with an air pump to alleviate fishery impacts due to periodic downstream low dissolved oxygen levels. Air is injected at a rate of about 6,000 cubic feet per minute into a turbine flow rate of 1,750 cubic feet per second. Summer dissolved oxygen levels have been raised from an average of 4.6 to 6.0 mg/L.

Reclamation's installation cost for retrofitting the turbine air venting system was approximately $175,000, and the ongoing operating cost is about $21,600 per year. Fishery impacts have been significantly reduced after installing the air venting system.

Turbine air injection blower at Canyon Ferry Powerplant.

Future Development Plans

There are no specific future development plans for turbine air injection retrofit installations at Reclamation facilities. Potential future applications will be evaluated case-by-case as dissolved oxygen problems are identified. Reclamation will continue to collect additional dissolved oxygen and turbine performance data at Canyon Ferry Powerplant.

More Information

A report documenting dissolved oxygen conditions before and after the Canyon Ferry Powerplant application is available at http://www.usbr.gov/research/science-and-tech/research/results/canyon ferry DO.pdf

Contact Information

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Paul Backlund, Facility Operations Specialist, Canyon Ferry Field Office, mailto: pbacklund@usbr.gov, 406-475-3923

Collaborators

Reclamation's Science and Technology Program, Montana Area Office and Canyon Ferry Field Office as well as General Electric Hydro

Research Updates

Western Water and Power Solution Bulletin

Research and Development Office — Denver, Colorado

Bulletin No. 44
February 2011

Using Stream Water Temperature Measurements for Habitat Rehabilitation

Fiber optic cable system measures water temperatures through the length of a stream to understand stream interactions

What Is The Problem?

Water temperature data provide information about the general health of a stream and aquatic species that require certain temperature ranges to survive and thrive. Documenting the ground water and surface water exchange throughout the length of the channel, including the location for cold water sources, is crucial to channel restoration or habitat enhancement work. Locating cold ground water upwelling in rivers is difficult because point temperature sensors generally are spaced large distances apart. Knowing the cold water source locations could help in designing channel reconstruction and habitat features (e.g., woody debris, boulders, or other materials). These habitat features provide cover for fish, increase food production, and provide resting areas while fish move along the stream.

What Is The Solution?

Reclamation and Oregon State University (OSU) researchers have collaborated to develop and test a fiber optic Distributed Temperature Sensing (DTS) system to measure the interaction between ground water and surface water along the stream channel. The system measures temperature at one-meter intervals along the cable, resulting in a more complete temperature profile. The system's records this data at a user-specified frequency, from seconds to hours. Data on air temperature and solar radiation also are recorded. The data are analyzed using a numerical modeling tool to identify ground water and surface water interactions relative to effects of air temperature and solar radiation. Results are considered relative to the stream's physical, biological, and chemical makeup, thus increasing the chances for successfully siting rehabilitation or restoration projects.

Who Can Benefit?

Stream temperature is a key determinant of habitat for salmonids and other aquatic species throughout the Western United States. Restoration professionals can benefit from the DTS system to guide restoration of critical fish habitat and to pinpoint restoration strategies that will provide the greatest returns in habitat creation and enhancement.

Where Have We Applied This Solution?

Staff from Reclamation's Columbia Snake Recovery Office (CSRO) recently collaborated with OSU to use DTS information for the Big Boulder Creek Restoration Project in Oregon. This project involved relocating a stream to its historical location, including design and construction of numerous habitat enhancement features. The DTS system was installed to document the stream channel temperature characteristics and changes in the existing and new channels. The DTS system was installed in the existing channel to measure temperatures prior to and after stream reconstruction in 2008. The DTS system was installed in the new channel again in 2009. A final report documenting the successful application of the DTS system on the Big Boulder Creek Project will be published by the end of fiscal year 2011.

Determining the location of a ground water source after river restoration (Huff 2009, used with permission).

Future Development Plans

The DTS system could be used where water temperature data are required along a continuous path in nonstream settings such as bore holes or reservoirs. For example, the DTS could be used vertically in a reservoir to monitor temperature gradients to guide discharge temperature adjustments by a selective withdrawal intake structure.

Reclamation and OSU plan to continue to develop the DTS technology to further refine field techniques and improve data analysis and modeling for future rehabilitation projects.

More Information

Huff, J.A. 2009. John Day Project: Monitoring river restoration using fiber optic temperature measurements in a modeling framework. Oregon State University, MS thesis. <http://ir.library.oregonstate.edu/xmlui/handle/1957/13847>

Contact Information

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Collaborators

Reclamation's Science and Technology Program and CSRO, as well as OSU Department of Biological and Ecological Engineering.

Western Water and Power Solution Bulletin

Bulletin No. 56
September 2011

Research and Development Office — Denver, Colorado

Sustaining Habitat Health and Salt Balances in Wetlands

Developing optimal wetland management strategies in response to salinity discharge limits

What Is The Problem?

The Grasslands Ecological Area (GEA) in western Merced County, California, contains the Grassland Water District, San Luis National Wildlife Refuge Complex, and the Los Banos Wildlife Management Area Complex, with nearly 140,000 acres of wetlands, grasslands, riparian habitats, and conservation easements on private lands. These managed wetlands constitute most of the remaining wetlands in California's Central Valley and are extremely important to Pacific Flyway waterfowl.

In 2003, the California Regional Water Quality Control Board (Board) released a total maximum daily load (TMDL) standard for salinity in the San Joaquin Basin. Managed wetlands that release water to the San Joaquin River are subjected to the same salt load discharge limits as agricultural operations under this TMDL. However, the Board allows a waiver of strict waste discharge requirements for basin dischargers if they demonstrate coordinated salt management under a real-time water quality management program. We are meeting this challenge by researching and developing innovative wetland salinity control practices and decision support tools.

What Is The Solution?

The Science and Technology Program sponsored some of the first field-based research in the GEA to develop telemetered sensor networks for wetland hydrology. These monitoring systems included technologies to estimate wetland evapotranspiration, seepage, and salt loading into and out of the ponds. This initial research was supplemented by more than $2 million in non-federal competitive research grants thathelped build the current web-based real-time flow and water quality monitoring network of almost 60 stations. These stations are used to characterize the current system and for future operations. Data are used to meter and schedule salt loads from the combined wetlands to fall within the salt load assimilative capacity in the San Joaquin River assigned to these wetlands.

Real-time telemetered flow and salinity monitoring stations.

Water and salinity balances are an important first step in developing a wetland simulation and forecasting model. Quantifying wetland hydrology is technically difficult because water and salinity balance data are lacking, because water uptake by the diversity of wetlands plants is hard to predict, and because soil seepage is highly variable due to differences in soil texture. Further, evaporation rates can deviate by more than 20 percent from theoretical estimates. Accurately quantifying seasonal wetland hydrology is essential to assess the effectiveness of seasonal wetland management practices needed to comply with the salinity objectives.

Who Can Benefit?

Managers have been improving their understanding of wetland hydrology—developing better understanding between water deliveries, moist-soil plant water requirements, and habitat response to manage these wetlands effectively. Many of these technologies and implementation techniques can be adopted in wetlands across the Reclamation service area.

Where Have We Applied This Solution?

The current monitoring network includes sites in private, Federal, and state —all three entities will need information on salt loads contained in their ponds to permit collaborative scheduling for wetland drainage as mandated under the TMDL and real-time water quality management program. In 3 years, the telemetered, real-time flow and salinity monitoring network has had a profound effect: encouraging more quantitative wetland water management, innovation, and an understanding of the relationship between wetland water and salt management.

Future Development Plans

Full implementation of real-time wetland salinity management in the San Joaquin Basin likely will take more than a decade.

More Information

Quinn et al., 2010. Use of environmental sensors and sensor networks. Env. Mod. and Software., 25, 1045-1058.

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Collaborators

Wetland staff within Grassland Water District and the California Department of Fish and Game and scientists at Berkeley National Laboratory and University of California, Merced have been active supporters.

Research Updates

Western Water and Power Solution Bulletin

Bulletin No. 65

Research and Development Office — Denver, Colorado

September 2011

Assessing Spatially Distributed Temperatures for Water Suitability and Habitat

Better representation of temperature processes leads to increased accuracy and higher confidence.

What Is The Problem?

Reclamation dam operations need to meet specified temperatures for dam discharges or downstream river reaches, based on habitat and biological criteria on many rivers. Thus, managers need to have accurate forecasts and models of how water and power operations might influence temperatures.

To predict how dam releases will affect downstream river habitat, we must understand the temperature variations in river features such as tributaries and agricultural returns, gravel pits, ground water upwelling, side channel activation, streamside vegetation, and topographical shading. Flows and temperatures within these features behave differently than that in the main channel and are not captured in the existing low-order models. Existing tools based on low-order modeling show river temperatures as a simple line with limited spatial distribution of flow and temperature inputs and poorly represent the physics of the river processes.

What Is The Solution?

This Science and Technology Program project improves the representation of spatial features that affect temperature to better model temperatures for a river. We developed a temperature model into the existing two-dimensional (2D) hydraulic model (SRH-2D). This model is spatially distributed, so it incorporates temperature data both across the river surface and below the surface. A multidimensional representation provides a more complete description of temperature impacts using the same dimensions as are significant for biology. Spatially distributed sources of heat and cooling (ground water, solar, wind, vegetation) are directly transferable to the model and do not require grouping by reach.

The new model takes the existing thermal modeling to a new level—tributary and agriculture returns, side channel activation, and channel spills can be modeled based on their physical processes. Physical processes modeled include solar radiation, terrain and vegetation shade, atmospheric radiation, water back radiation, heat exchange between water and river bed, as well as water surface evaporative and conductive losses.

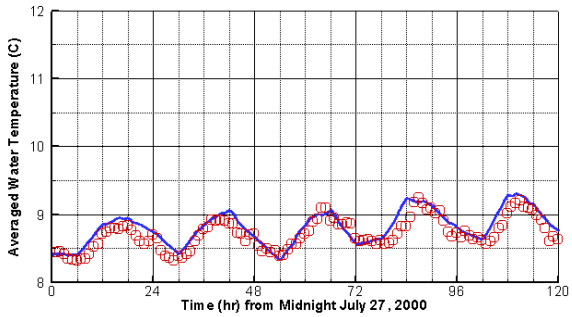
Accurate flow hydraulics eliminates the need for abstract travel time coefficients and flow routing parameters. In lateral splits, such as gravel pits or side channels, flow moves at different speeds along different paths, and heats or cools at different rates as a result. The difference in flow velocities between the river centerline and banks also is captured, eliminating calibration for cross-section averaging.

Who Can Benefit?

The new model can help planners identify zones in the river that will retain acceptable temperatures even when overall river temperatures might be undesirable or when “hot spots” persist in spite of good average temperatures. Representing these physical processes better also leads to simpler model formulation, increased accuracy, and higher confidence. Thus, this model can benefit river managers who have the need to project downstream temperatures for operational consideration or environmental concerns.

Where Have We Applied This Solution?

We verified the model using test cases with analytical solutions and with data from the McKay Creek downstream of the McKay Dam, Oregon.



Comparison of temperature near McKay Dam from 7/28 through 8/1/2000; solid line: simulated; circles: measured.

Future Development Plans

We are further developing and applying the 2D temperature model to the Methow River, in Washington, to predict the stream temperature and its impact to the salmonid population. We are also applying the model to the San Joaquin River to address temperature issues around gravel pits. Once the model is verified through these further studies, we plan to publish the model on our Web site for public use.

For More Information

Lai, Y.G. and D. Mooney, (2009). “On a Two-Dimensional Temperature Model: Development and Verification,” ASCE World Environmental and Water Resources Congress, Kansas City, Missouri, May 17-21, 2009.

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Collaborators

Reclamation’s Mid Pacific Region and the Science and Technology Program

Research Updates

Western Water and Power Solution Bulletin

Research and Development Office — Denver, Colorado

Bulletin No. 71
September 2011

Floating PIT Tag Detection System

New Passive Integrated Transponder (PIT) tag antenna system detects fish in waterways while floating over them

What Is The Problem?

Reclamation funds and manages several programs concerned with the recovery of endangered fish species. Accurate fish counts are an important aspect of these programs. Yet, accurately detecting fish moving through rivers and streams is difficult and costly. Capture by electrofishing or trapping is typically required, involving large amounts of personnel and equipment. Also, capturing can lead to mortality or changes in behavior and movements.

Existing systems that detect tagged fish are only effective for species with predictable movement patterns that can be funneled past the tag antennae. Improvements to these systems are needed to detect other species without involving their capture to reduce costs and cause less disruption to the fish.

What Is The Solution?

Reclamation and Utah State University (USU) researchers have developed a system to detect fish as an antenna network floats over them. The fish are captured and tagged with Passive Integrated Transponder (PIT) tags to allow researchers to track their movements and survival. PIT tags resemble a grain of rice and function similarly to bar codes used to scan goods in stores. The researchers developed an innovative floating antenna system that allows us to remotely detect fish that have been PIT tagged but that do not have predictable movement patterns (such as salmon). Unlike other PIT tag systems that require fish to travel through a detection device, this system floats on the river and does not disturb the fish.

The system's antenna modules are 3 feet wide by 10 feet long, made of polyvinyl chloride (PVC) and foam with internal antennae, and float on the surface of the water. This system is patent pending (U.S. Patent Application Number 61/431,622). The entire system consists of a raft to provide a platform for the floating antenna modules, a multiplexer to operate the antennas, battery power supply, an integrated global positioning system (GPS), and data recorder to record tag number, date, time, and location of the PIT tag in the river. This floating antennae system can be mounted to a moveable or stationary raft.

Who Can Benefit?

Reclamation programs, as well as other programs for detecting fish, can benefit from this technology. Better data on fish populations would assist numerous Reclamation programs in managing fish species and give Reclamation more information to manage its facilities in an efficient manner. For example, if the successful use of this system allowed better estimates of fish populations, progress toward recovery would be improved through better-informed stocking goals, flow recommendations, and management activities. PIT-tagged fish would not have to be individually captured and handled, thus reducing mortality.

Where Have We Applied This Solution?

An early prototype of the system was constructed and tested in 2008. The system's efficiency at detecting endangered fish that were free swimming in the San Juan River was proven and documented. It was floated over a 19-mile reach of the river and was able to detect 76 tags, including 22 that were in a side channel inaccessible by electrofishing boats. An electrofishing effort that was running concurrently with the test detected approximately the same number of fish at a much higher cost.

Raft deployed floating PIT tag antennae system on the San Juan River.

This comparison effectively demonstrated that fish can be detected with the floating antennae system and that it is less harmful to the fish and much cheaper to operate.

Future Development Plans

The Reclamation-USU collaborative project was completed in November 2010. Plans are underway to construct a stationary floating antenna in tributaries of the San Juan River as well as a large stationary floating system in the lower river above a large waterfall. The results of this research project have generated considerable interest, and BioMark, Inc. is potentially interested in commercial development of the system.

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Collaborators

Reclamation, Utah State University, and the San Juan River Recovery Implementation Program

Research Updates

Western Water and Power Solution Bulletin
Research and Development Office — Denver, Colorado
Bulletin No. 41
January 2011

LiDAR Assists in Archaeological Site Preservation and Protection

A tool for improved analysis and preservation of archaeological features that saves time and money

What Is The Problem?

Locating, documenting, analyzing, and protecting archaeological sites, petroglyphs, pictographs, and other cultural features have long been a challenge for archaeologists and resource managers. Monthly, semi-annual, or annual surveys, usually in remote locations, are necessary for archaeological features in one location or over vast areas employing such traditional approaches as on-the-ground surveys, grid drawings, and photographs that are labor intensive, time consuming, and that do not capture all aspects of the objects and sites. Geographic Information Systems (GIS), another approach, uses layers of spatial information to display patterns at a large scale with information already available and, generally, does not provide new information on a finer scale. Scale issues also are experienced with aerial photography.

What Is The Solution?

LiDAR (light detection and ranging), a relatively new technology, has had very limited archaeological and historic preservation applications during the past decade, most notably analyzing Stonehenge in England and restoring fresco paintings in European churches. With advances in LiDAR technology and reduced costs, a variety of archaeological features now can be more efficiently surveyed in concentrated or larger areas. LiDAR also provides visual information in addition to geospatial accuracy.

A high-speed pulsed laser beam is sent from the LiDAR device measuring up to 50,000 points per second at "survey grade" accuracy. The high-resolution sets of measurement points then are processed to depict accurate three-dimensional (3-D) images. This automated process is much faster than previous methods. Using LiDAR to collect archaeological data not only saves time and money compared to traditional methods, but the data can be captured to submillimeter accuracy depending on the instrument used. Savings are estimated to be 50–70 percent compared with traditional methods.

Traditional methods of creating grids, renderings, and photographs of numerous inscriptions, artifacts, and sites miss the fine detail that a 3-D laser image captures. LiDAR digitally represents all angles of a subject with artificial lighting that produces 3-D images, allowing archaeologists and land managers to capture features previously unseen and view changes sooner for more efficient site restoration and protection. Another capability of some LiDAR units is the ability, under certain conditions, to penetrate through openings in vegetation and use algorithms to depict ground surface features.

Who Can Benefit?

Archaeologists, tribes, land resource managers, and others seeking to preserve or reveal new archaeological sites can benefit from incorporating LiDAR into their field work.

Where Have We Applied This Solution?

Reclamation used terrestrial LiDAR for petroglyph panels in the Cedar Bluff Reservoir area in Kansas during three field seasons (2008–2010) to record changes caused by vandalism and erosion, examining inscriptions with a Leica High Definition Scanning ScanStation 2 unit to create 3-D images that allows us to pinpoint panels needing treatment. A field laptop operated the ScanStation 2, capable of measuring 50,000 points per second, and controls were plotted with Global Positioning System (GPS) for placement into a State coordinate system. A FugroViewer was used to view LiDAR data collected by Leica software. In 2010, a mobile version of the ScanStation 2, the hand-held Z scanner, recorded data at the submillimeter level.

Examining panels using a Leica ScanStation 2.

Future Development Plans

Airborne LiDAR is being tested in the American Falls Archaeological District in Idaho.

More Information

Using terrestrial LiDAR to conduct archaeological surveys is a relatively new development. Information about 3-D LiDAR archaeological research in the American Falls Archaeological District can be found at: http://www.usbr.gov/research/science-and-tech/projects/detail.cfm?id=9541.

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Collaborators

Reclamation's Science and Technology Program, Great Plains Regional Office, Snake River Area Office, and Pacific Northwest Regional Office

Research Updates

Western Water and Power Solution Bulletin

Research and Development Office — Denver, Colorado

Bulletin No. 42
September 2011

Protecting Infrastructure by Predicting Coating Service Life Span

Using Electrochemical Impedance Spectroscopy (EIS) to select the most durable protective coatings

What Is The Problem?

Industrial coatings are the primary means of controlling metal corrosion in water conveyance and storage structures. Various types of protective coatings are used in new installations and for re-coating existing structures. Water managers rely on accurate predictions of coating service longevity to select those that will minimize maintenance costs, maintain structural integrity over time, and maximize water availability by avoiding downtime for coating removal and application. Many new coating products are entering the market place, some of which have little or no track record in field applications. Without a proven track record, new materials must be tested in an attempt to determine the expected service life. Without this testing, the coating could risk poor corrosion protection, and we might have to re-coat more frequently.

Traditional laboratory methods for evaluating coatings simulate field exposure and include: cathodic disbondment, water immersion (including sea water), high humidity, burial, prohesion, ultraviolet light (UV), alternating fog and UV, adhesion, abrasion, and impact resistance. The problem is that when most coatings surpass the testing period with little or no visual deterioration, the extent of future service life is still unknown.

What Is The Solution?

To test coatings for Reclamation use, Reclamation's Materials Engineering and Research Lab is using a highly sensitive test method that supplements traditional coating inspections and can rapidly (within 30 minutes) measure the effectiveness of coating resistance to corrosion by recording the impedance value over time. Electrochemical Impedance Spectroscopy (EIS), also known as impedance spectroscopy, measures coating impedance (resistance to alternating current [AC]) over a range of frequencies with corresponding responses that include varying energy storage and dissipation properties in the test circuit.

By observing the rate of impedance variance, it is possible to extrapolate to a point in time when the barrier properties fail, marking the expected service life. Although higher impedance levels generally correlate to better corrosion protection, it is the rate of impedance change that is the best predictor of coating service life. The EIS method allows for direct comparisons among different coating systems and degrees of changes over time. Although most coatings can be evaluated using the EIS method, the approach works best for such barrier coatings as epoxy, polyurethane, polyurea, moisture-cured urethanes, and coal tar epoxy.

Who Can Benefit?

Owners of infrastructure that include components requiring protective coatings can benefit when appropriate coatings are selected to maximize time in service and reduce costs. Testing and selecting cost-effective durable protective coatings is critical for protecting such water storage and conveyance structures as canals, gates and valves, and pipelines.

Electrochemical Impedance Spectroscopy test cell.

Where Have We Applied This Solution?

Coatings tested with EIS have been applied to a multitude of structures for various projects, including: Platoro dam outlet works, Enders dam outlet works, Flatiron Powerplant penstocks, Carr Powerplant penstocks, Grand Coulee Third Powerplant mechanical overhaul, Palisades mechanical overhaul, and many others.

Future Development Plans

Reclamation is using the EIS method to evaluate new quagga and zebra mussel antifouling, foul-release, and fluorinated powder coatings that are crucial for controlling rapid mussel spreading and destruction to water infrastructure.

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Collaborators

Reclamation's Science and Technology Program, Materials Engineering and Research Laboratory, Denver Technical Service Center, and Northern California Area Office.

Research Updates

Western Water and Power Solution Bulletin

Bulletin No. 57

Research and Development Office — Denver, Colorado

September 2011

Preparing concrete before repairs and overlay

New surface preparation guide for concrete repairs saves time and money and leads to longer-lasting repairs

What Is The Problem?

The primary goal of a concrete repair is to bond the damaged substrate and the new repair layer so that they act together for the life of the structure. This prolongs the useful service life of a deteriorated structure—restoring the load-carrying capacity and strengthening the structure. However, the success of thin repairs (less than 6 inches thick) is difficult to predict. Most repairs last only 2–5 years. Many times, these repairs crack prematurely, requiring expensive re-working much sooner than planned. The problem with thin repairs and overlays, while universal, is a particular issue for Reclamation due to the age and condition of our older concrete structures.

One approach to improving the success of thin repairs is to make the repair layer thicker by first removing more of the underlying structure. However, this is a time-consuming and costly approach. By developing better methods for thin repairs, significant money and time can be saved. A key factor is to effectively prepare the substrate surface before applying repair materials—no matter what repair material and application method is used.

What Is The Solution?

In this Science and Technology Program project, we developed performance criteria for successful surface preparation of existing concrete prior to a repair or overlay. We considered a number of factors: roughness, porosity, absorptivity, strength of the substrate's skin, chemical status, moisture content, temperature, and the hydration dynamics of the repair material. We then prepared concrete slabs, installed repair overlays, and conducted pull off tests to test the bond between the repair and substrate. We found that:

- Using International Concrete Repair Institute profile chips to assess surface textures before repairing is the most effective method. This method is as effective as digitally matching surfaces—and costs significantly less.
- Rougher surfaces are slightly stronger in shear than smoother surfaces; thus, repairs for shear loads should use rougher surfaces.
- Tests using pull offs are not affected by slight variations in the test apparatus' alignment.
- Surfaces do not need to be treated again within 24 hours of repair because carbonation of the surface does not affect repairs, as originally believed.

Who Benefits?

A guide specification, replacing the current Concrete Repair Manual, will be issued soon. Reclamation managers and operations and maintenance staff can use these results to save time and money and to streamline repair schedules. Moreover, the concrete repair industry will also benefit from these findings to more effectively repair concrete while saving time, labor, and money.

Concrete replacement repairs to damaged concrete surfaces removed by hydroblasting.

Future Development Plans

These findings will be incorporated into our guide specifications. We plan to issue a general report summarizing all the results and recommendations by the end of the year and a new concrete repair manual within the next 2 years.

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Partners

To help address and quantify these factors, Reclamation joined with Laval University, Quebec, Canada; University of Liege, Liege, Belgium; Warsaw University of Technology, Warsaw, Poland; Vaycon Consulting, Baltimore, Maryland and U.S. Navy/Port Hueneme to develop performance standards for the surface preparation of concrete prior to repair or overlay.

Research Updates

Western Water and Power Solution Bulletin

Research and Development Office — Denver, Colorado

Bulletin No. 49
September 2011

Determining the Potential for Cavitation in Stepped Channels

Laboratory tests show that new spillway designs can call for higher specific discharge without risking cavitation damage

What Is The Problem?

Stepped channels have been used for centuries as efficient and effective ways to dissipate energy in spillways and other water channels. In the late 1980s, dam construction began featuring roller-compacted concrete, which has a stepped lift process, producing stairstep-shaped dams. This technique spurred designers to choose stepped channels for spillways. Stepped spillway designs can have high hydraulic heads, resulting in high-velocity flows on the spillway. These high flows make the potential for cavitation a major design consideration.

When water is subjected to localized pressure reductions below the vapor pressure of water, vapor bubbles or cavities can form. As the vapor cavities travel with the flow and the local pressure conditions rise, these cavities implode. Repeated implosions near a solid boundary, such as the spillway surface, can erode the surface materials. Researchers have studied many topics associated with stepped channels, including air entrainment, velocity and pressure distributions, and energy dissipation. Still, the uncertainty on whether cavitation damage would be possible on stepped spillways has resulted in recommending limited specific discharges (discharge per unit width) and using aeration slots or ramps to reduce cavitation. These design limits can significantly increase the width of the spillway structure, resulting in higher construction costs.

However, new spillway designs have stretched these recommended limits particularly on discharge capacity. We need to understand how cavitation forms on stepped spillways to determine if these large discharges may result in conditions that risk cavitation damage.

What Is The Solution?

We conducted tests at Reclamation's Denver laboratory to investigate the cavitation potential of a novel stepped spillway designed for the Joint Federal Project (JFP) at Folsom Dam, California. While no existing stepped spillway installations have reported cavitation damage, the design parameters for the JFP spillway call for specific discharges much higher than any stepped spillway currently in service.

These tests were performed in our low ambient pressure chamber where ambient pressures are lowered close to the vapor pressure of water, allowing local pressures to drop below the vapor pressure at much reduced water velocities. This allows us to visualize cavitation in a controlled setting to predict what will occur under normal operating conditions.

The test program revealed a good correlation between the critical cavitation condition and the roughness of the stepped configurations that we tested. A range of slopes were investigated, and actual damage in non-aerated flow conditions was verified and found to be slope-dependant. Thus, stepped spillway designs can pose risks for cavitation damage, especially on spillways of slopes less than 1 to 1. Thus, this risk needs to be considered in the spillway design.

Who Can Benefit?

Designers of new spillways can now use these results to determine safe operating limits for their stepped spillways.

Where Have We Applied This Solution?

We used these tests originally for the JFP spillway. However, the test program showed good potential to provide generalized data for stepped spillways, and Reclamation's Dam Safety Office and Science and Technology Programs have provided additional funds to extend the analysis to a broader range of designs.

Cavitation appearing on a steep sloped stepped spillway.

Future Development Plans

We plan on refining our study to focus on damage from cavitation on stepped spillway designs. We found that there was a difference in damage based on slope—even with similar levels of cavitation. While we now know the potential for cavitation, and that damage can occur (particularly at mild slopes), we need to systematically investigate the conditions where the onset of damage occurs, as this is generally well beyond the conditions where cavitation first forms.

More Information

Publications are forthcoming.

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Collaborators

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Research Updates

Western Water and Power Solution Bulletin

Research and Development Office — Denver, Colorado

Bulletin No. 27
September 2011

Pisces Software Program

A tool for more efficiently analyzing hydrology model time series data for users from novices to modelers

What Is The Problem?

In water resource management projects and studies, it is often necessary to manage and analyze large amounts of hydrology data. For example, time series output data from numerical modeling tools are used to compare multiple scenarios or alternatives. Even with a small number of scenarios or alternatives, organizing, comparing, evaluating, and presenting the data can be difficult. Some hydrology models have output management features, but only those licensed and trained to operate these models can use them. Alternatively, speadsheet or database tools can be used to compare, evaluate, and present. This can be a cumbersome and labor-intensive process that also requires specialized computer skills.

What Is The Solution?

Reclamation's Pacific Northwest Regional Office has developed an easy-to-use computer program called Pisces to manage, organize, and analyze time-series data. It does not require special computer skills or modeling experience to operate. Pisces accepts output data from common hydrologic models. With Pisces, users can access data immediately—simultaneously and independent from the hydrologic model. Users can easily graph any portion of the time-series data. Pisces provides convenient access to time-series model results and the ability to easily compare many different scenarios or alternatives. Pisces has specialized features that allow users to analyze and compare any combination of scenarios/alternatives. For example, a biologist can evaluate the difference in impacts to fish habitat (flows, temperatures, etc.) between multiple dam release scenarios for a specific river reach. The software has successfully evaluated over 100 sets of model output data.

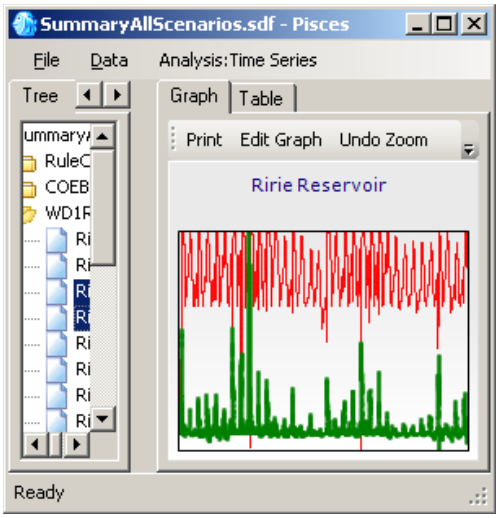
Pisces is currently configured to work with output data from MODSIM, RiverWare, Bonneville Power Hydsim model, and the U.S. Army Corps of Engineers HEC-DSS format from hydrologic computer models. A scenario selector unique to Pisces converts massive amounts of output data into a summary form for each time series by scenario or alternative. Pisces can also be used to organize, graph, and analyze observed natural resource time series data. It is configured to accept data from Reclamation's Hydromet, AgriMet, and Hydrologic Database river and weather conditions , U.S. Geological Survey's National Water Information System, and other sources. Data in other formats can be entered as text files or as Microsoft Access and Excel files.

Who Can Benefit?

Pisces is most commonly used by participants and stakeholders in water resources planning projects and studies, including water and natural resource managers, hydrologists, engineers, biologists, irrigation district staff, and various others. It can also be used by anyone needing to manage and/or analyze any type of time series data sets.

Where Have We Applied This Solution?

Pisces has been used extensively for Reclamation-sponsored studies and planning efforts on the Columbia, Rio Grande, and Snake Rivers. It is also used frequently by Reclamation staff and others for managing Hydromet and AgriMet data.



Pisces screenshot.

Future Development Plans

Since its inception in 2001, the software has been modified slightly as needed for specific project needs. It is expected that the software will continue to evolve as needed by particular users for their projects.

More Information

The software, user manual, and video demonstrations can be downloaded at: http://www.usbr.gov/pn/hydromet/pisces

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Collaborators

Reclamation's Science and Technology Program, Grand Coulee River Bank Stability Programs, Pacific Northwest Regional Office, and the Snake River, Yakima, Albuquerque. and Ephrata Area Offices.

Research Updates

Western Water and Power Solution Bulletin

Research and Development Office — Denver, Colorado

Bulletin No. 52
September 2011

Determining the Effects of Terracing and Small Reservoirs on Water Supplies

New understanding of how these conservation practices impact water supplies improves Reclamation's water operations

What Is the Problem?

Land terraces control runoff to prevent erosion and allow water to soak into the ground. Small reservoirs or stock ponds catch and store water for use by livestock and wildlife. These conservation projects directly impact surface water supplies, but they can also affect ground water recharge and have a resulting impact on surface flows for years into the future. Construction of land terraces and small reservoirs over the last 30–40 years has had a significant but unmeasured impact on river basin water supplies. A complete accounting of water use in a river basin may need to include depletions due to land terracing and small reservoirs.

In the Republican River Basin, about 2.2 million acres of terraced fields and several thousand small water impoundments are depleting the natural water supply of the basin. The Republican River Compact Settlement requires a study to determine their impact on streamflow depletion in the basin. Although the design of terraces and reservoirs and their estimates of water capture is well understood, the "as built and operating" impacts basin wide have not been studied. Moreover, the actual magnitude, timing, and location of these depletions is not well understood—thus, a crucial piece of water use information is missing.

What Is the Solution?

This Science and Technology Program research project partnered with the States of Colorado, Kansas, and Nebraska to provide new insights and tools to assess impacts on surface water supplies from the development and operation of land terraces and small reservoirs.

The study collected up to 5 years of field data from specific terraces, including precipitation, inflows and outflows from terrace channels, temperatures, and soil moisture changes. Water levels in reservoirs were also monitored. This 5-year period covered wet, dry, and average water years. We used the data to understand how these conservation practices changed the water balance. Based on this, we built a water balance model that we could apply to the entire basin. The data and the basin model suggest that these water conservation practices increase net evapotranspiration by an average of 36,000 acre-feet annually, decrease streamflow by an average of 63,000 acre-feet annually, increase recharge by an average of 88,000 acre-feet annually, and decrease stream transmission loss by an average of 61,000 acre-feet annually. These are average data over a 59-year period.

Who Can Benefit?

Information gained from this study will assist with improving overall water management of the limited water supply in the basin and ensure a more appropriate allocation of water among the States of Colorado, Nebraska, and Kansas.

Furthermore, terraces, small reservoirs, and other upstream depletions are issues common to other Reclamation watersheds. Water managers can leverage this increased understanding and modeling for these water supply impacts in other basins.

Where Have We Applied This Solution?

Knowledge of the depletion effect of these water conservation practices will lead to better overall water management—including the management of existing and future conservation practices for an increased basin-wide benefit.

Operating terraces in the Republican River watershed.

Future Development Plans

The information about the study was presented to the Republican River Compact Administration at their annual meetings in Burlington, Colorado on Aug 30 and 31, 2011. The States of Colorado, Kansas, and Nebraska are considering ways to apply this new understanding of terraces and reservoir water balances to other watersheds within their respective states.

For More Information

Publications and dissertations from our partner universities summarize the methods used to develop these findings. Republican River Compact Administration Conservation Committee 2011. Summary Report of Preliminary Findings to the Republican River Compact Administration summarizes the findings.

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Collaborators

Reclamation's Great Plains Region; the states of Colorado, Nebraska, and Kansas; University of Nebraska at Lincoln, Nebraska; and Kansas State University at Manhattan Kansas

Research Updates

Western Water and Power Solution Bulletin

Research and Development Office — Denver, Colorado

Bulletin No. 35
September 2011

The Western Water Information Network (WWIN)

Enterprise GIS brings baseline geospatial data to the water scientist's fingertips

What Is The Problem?

Geographic data related to water supply and demand exist in many locations within Reclamation and in other agencies such as the U.S. Geological Survey (USGS), the Census Bureau, and the Department of Transportation. How can Reclamation consolidate these geospatial data to deliver them to water scientists and engineers?

What Is The Solution?

This Science and Technology Program project helps ensure that current, consistent, well-documented geospatial data and related resources are available to geographic information system (GIS) users across Reclamation in a form that can be readily used. We developed a pilot, proof-of-concept enterprise geospatial library that assembled base data layers relevant to GIS projects undertaken to serve Reclamation's mission—the Western Water Information Network (WWIN). During the last months of the WWIN project, a full-blown enterprise application, DataSpace Console, was initiated. It is currently available to any ArcGIS user. See the "primer" link under "More Information," below.

Who Can Benefit?

DataSpace Console serves as a data access tool for GIS personnel using the ArcGIS Desktop (ArcMap) application that simplifies finding and retrieving geospatial data and imagery managed in Reclamation GIS (BORGIS) distributed data repositories. DataSpace has substantially reduced the number of hours that ArcGIS users spend looking for commonly used geospatial data and services. Virtually eliminating the need for employees to locate the most commonly used spatial data sets saves from 1 to 2 days of staff time per employee for an average mapping project. In addition, DataSpace developers:

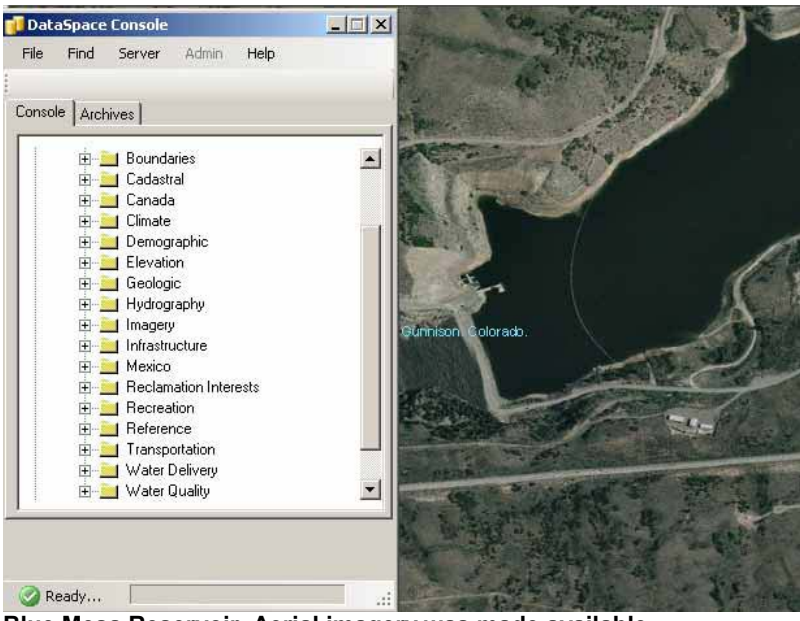
- Contributed to development of a bureau-wide policy on data stewardship and management
- Coordinated with programs like Facilities Operation and Maintenance and Dam Safety to develop and validate the names, locations, and completeness of an inventory of Reclamation dams
- Worked with a variety of programs and projects to facilitate Reclamation's ability to share geospatial and other types of data with external partners and stakeholders

Where Have We Applied This Solution?

Water scientists, managers, and project planners across Reclamation have all benefited from the DataSpace Console.

Future Development Plans

The Reclamation GIS community is currently working with other U.S. Department of the Interior agencies to make DataSpace available to them.



Blue Mesa Reservoir. Aerial imagery was made available through DataSpace.

More Information

A primer for DataSpace is at:
http://ibr1pnrapgis001/sites/GISCommunity/Data%20Management/BORGIS_DataSpace_Console_User_Guide_v2.0.pdf

All of the enterprise GIS applications are on our intranet site:
http://ibr1pnrapgis001/sites/GISCommunity/default.aspx

Contact Information

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Research Updates

Western Water and Power Solution Bulletin

Research and Development Office — Denver, Colorado

Bulletin No. 40
September 2011

Measuring Flow Rate through Canal Check Gates

New methods give canal operators more flow control

What Is The Problem?

Irrigation canals have typically been operated to maintain steady water levels in each canal pool. However, to improve water delivery efficiency, today operators are also often asked to control flow rates at key check structures. Typically, this requires constructing dedicated flow measurement structures or purchasing flow metering equipment—often at significant cost.

What Is The Solution?

When dedicated flow measurement devices are not practical, canal regulating gates themselves can be calibrated to serve as flow measurement devices. However, traditional gate calibration methods have had poor accuracy in some flow conditions. Now, new software is improving the accuracy of flow rate calibrations for both radial gates (also called tainter gates) and vertical slide gates commonly used to regulate large irrigation canals.

Laboratory testing has led to improvement of the calibration methods incorporated in the new software, increasing flow measurement accuracy for several challenging flow conditions:

- Transitional and submerged flow
- Gates discharging into downstream canals that are much wider than the gate itself
- Nonuniform operation of multiple gates located beside one another in a single check structure

With these improvements, the measurement accuracy obtained from calibrated gates can approach that of dedicated flow measurement devices. This saves money and also provides flow measurement capability to canal operators at exactly the most useful location in the canal system, the point of flow control.

Who Can Benefit?

The new WinGate software will be useful to operators of open-channel water delivery systems controlled by check structures containing radial gates or vertical slide gates. Gates may need to be improved by adding gate position sensors and upstream and downstream water level sensors. However, in many cases, this equipment is already installed. Some field investigations may be needed to account for the type and condition of the gate seals, which can affect the flow measurement calibration.

Check structure on the Amarillo Canal, Farmington, New Mexico

Where Have We Applied This Solution?

Early versions of the WinGate software have been used during field testing for canals and radial gates on the Navajo Indian Irrigation Project (Farmington, New Mexico). Beta testers of the software have used it effectively on the Coachella Canal and the All-American Canal. Researchers in Spain have also applied the gate calibration method in WinGate (the Energy-Momentum, or E-M method) to vertical slide gates.

Future Development Plans

Recent laboratory scale model test data for radial gates are being used now to make further improvements to the Energy-Momentum calibration method, and those improvements are being incorporated into WinGate at this time. A journal article describing the latest work was submitted for review in the summer of 2011.

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Collaborators

The Salt River Project co-funded this work.

Research Updates

Western Water and Power Solution Bulletin

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Research and Development Office — Denver, Colorado
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Framework for Understanding Ground Water Model Uncertainty

A standardized approach for applying statistics and methods to improve model output reliability and use

What Is The Problem?

Increasing demand for limited water supplies has intensified the need for effective information and tools to help water resource managers investigate ground water and surface water interactions. Managing complex surface and subsurface water systems requires efficient application of ground water models to explain how the system behaves and might react to change. Water managers need this information as they plan additional storage, manage water operations and conjunctive use, or assess the impact of climate change and other system stressors.

Uncertainty is inherent in all models, and uncertainty must be understood by both modelers and decisionmakers. Many approaches exist for quantifying model uncertainty, thus choosing the most appropriate approach for a given model and application is difficult. Also, effectively communicating model results to managers has been challenging because uncertainty implies an "error in the results," which is not accurate.

Reclamation does not have a standard for quantifying uncertainty, a standard process, or even tools to communicate ground water model uncertainty. Because of this, deciding whether existing ground water data are adequate to answer water management questions can be difficult. Modelers and managers are often faced with a dilemma: either accept given levels of uncertainty in the analysis or undertake expensive additional well drilling and data collection.

What Is The Solution?

We developed a Framework to apply statistics and methods for quantifying and communicating ground water model uncertainty. The approach guides reducing uncertainty by guiding users to understand the quantity and locations of data that are needed to provide a desired range of certainty and to avoid additional resource expenditures on unnecessary data collection. The Framework is unique in that it serves as a reference and communication tool among modelers, especially within Reclamation, as well as a tool for modelers to effectively communicate uncertainty to managers, resulting in better ground water management decisions.

The Framework document describes the most appropriate methodologies and how best to use them for common problems at the four main points in the modeling process where uncertainty arises: 1) defining the behavior of the system, 2) model inputs (hydrogeology, rainfall, evapotranspiration, irrigation, etc.), 3) calibration (modifying raw data inputs until outputs match observed data), and 4) the model's predictive abilities.

Who Can Benefit?

Ground water modelers and managers can use the Framework to apply a standard, proven approach to defining and characterizing uncertainty that, in turn facilitates communication between technical and managerial staff and reduces the costs of ground water studies.

Where Have We Applied This Solution?

We applied the Framework in the Minidoka Dam Raise Study, simulating the region surrounding and beneath Lake Walcott. We may also apply the Framework during the Henry's Fork Special Study in the Upper Snake River Basin and the Treasure Valley Ground Water Model for the Boise River Basin (both in Idaho).

Minidoka Dam and Lake Walcott.

Future Development Plans

As new techniques emerge, they will be investigated and incorporated into the Framework document. We intend to continue discussing uncertainty with management to improve the Framework as a communication tool.

More Information

A copy of the Framework document is available at: http://www.usbr.gov/research/docs/GroundwaterModelUncertainty_2010.pdf.

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Collaborators

Reclamation Science and Technology Program and Pacific Northwest Regional Office.

Research Updates

Western Water and Power Solution Bulletin

Bulletin No. 69

Research and Development Office — Denver, Colorado

September 2011

Finding Ways to Solve Water Conflicts in the West

Analysts researched conflicts to determine ways to work together effectively.

What Is The Problem?

Water is a critical resource in the Western United States, and often a source of conflict, owing to growing populations and new water demands, including water needed to address Native American water rights, endangered species habitat needs, and new recreational uses. All of this is complicated by drought and increasing climate variability. For water managers, understanding and dealing with conflict is a central part of the job.

What Is The Solution?

By analyzing a large array of water disputes, this Science and Technology Program research project has helped Reclamation to understand how water conflicts grow and develop. It has also provided Reclamation with institutional tools to use to help solve these conflicts.

During this research, focus group sessions were conducted in Reclamation area offices to understand local sources of water conflict. In addition, over 8,000 media reports pertaining to water conflict were scored by a panel of conflict analysts as to the amount of conflict or cooperation each embodied. We then related the level of conflict against biophysical and social variables to produce profiles of environments and conditions likely to create water conflict. The results suggest that biophysical factors appear to be less important in predicting conflict than the absence of existing institutional capacity to manage conflict, such as stakeholder networks and watershed groups.

In addition, we prepared case studies for individual water conflicts to understand their genesis and resolution in detail. Repeatedly we found that that the chances for conflict grow when the rate of change outpaces the institutional capacity of an organization to manage that change.

As a result of all these efforts, we have developed a set of teaching modules for building capacity to prevent and manage water conflict. The modules help students understand the general context of Western water, the stages of water conflict, and the skills required to manage conflict. Interactive sessions help to build these skills, including listening, identifying needs and interests, joint fact-finding, systems assessment, problem framing, and network construction, amongst others.

Who Can Benefit?

Reclamation managers can access these workshops and request training for employees, stakeholders, and partners to help develop conflict-resolution skills.

Where Have We Applied This Solution?

We have conducted training and workshops for Reclamation staff and stakeholders in Salt Lake City, Albuquerque, Sacramento, Billings, Bismarck, and Phoenix. These workshops have been enthusiastically received and students have said that they have taken home skill sets that helped them solve real problems.

Dr. Aaron Wolf conducting a conflict management workshop.

Future Development Plans

A train-the-trainer program will be examined for its feasibility. This research strives to create a permanent water conflict training capability for Reclamation personnel and Reclamation stakeholders.

For More Information

Sharing Water, Building Relations: Managing and Transforming Water Conflict in the US West. The final version of this manual will be completed in late 2011. Contact Douglas Clark at the TSC.

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Collaborators

The Western Water Institutional Solutions research project is a joint effort between the Upper Colorado Region Adaptive Management Group in the Environmental Resources Division, the Department of Geosciences at Oregon State University, and Reclamation's Research Office, Technical Services Center, North Dakota Area Office, Montana Area Office, Albuquerque Area Office, Phoenix Area Office, and the Upper Colorado Region.

Research Updates

Western Water and Power Solution Bulletin

Research and Development Office — Denver, Colorado

Bulletin No. 70
September 2011

Managing Diverging Science in Reclamation Water Allocation Decisions

A comprehensive guide for tools to manage conflicts over science that impede water allocation decisions

What Is The Problem?

Reclamation managers, engineers, and scientists sometimes become involved in internal or external disagreements over technical data, methods, or findings, which are sufficiently serious to impede a water resource management decision. For instance, two scientists might disagree about how much water an endangered species of fish really requires or how much water yield will grow if tamarisk is removed from a river corridor. These disagreements can sometimes disrupt water deliveries.

Tamarisk on the Colorado River. Scientists dispute how much water yield will increase if the invasive tree were removed from the watershed. Photo courtesy of Dr. Subramania Sritharan of Central State University.

Our aim is to investigate what methods Reclamation has used to resolve disputes over science, and how effective the various methods were in resolving those disputes.

What Is The Solution?

This research examined the tools Reclamation uses to manage conflicting or diverging science to determine:

- What tools have worked best in specific situations?
- What tools have proven ineffective?
- What tool gaps exist?
- What promising, but unused tools could be successfully implemented?

In FY2011, the researchers launched a Reclamation-wide electronic survey to determine how disputes over science are currently managed. The survey asked Reclamation scientists, engineers, and managers what techniques they have used and to what effect. The results are being compiled and will be available at the end of 2011.

Who Can Benefit?

Reclamation managers will be able assess what tools might be of use to them. These would include joint fact-finding among stakeholders and scientists, Blue Ribbon panels, conducting new scientific experiments ("more science"), "science courts," adaptive management processes, and collaborative modeling, among others).

Future Development Plans

From these investigations and follow-up case studies we will put together a manual of tools that are available to water managers to handle disputes over science.

- What lessons have our managers learned as they have used various tools?
- What are the relative strengths and weaknesses of each tool used to manage disputes over science?

Continued research, which will include in depth case studies, are needed to understand these strengths, limitations, and applicability of each dispute resolution approach.

For More Information

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Collaborators

Reclamation's Research Office, Reclamation's Technical Services Center, and U.S. Geological Survey (USGS) Policy Analysis and Science Assistance Branch

http://www.usbr.gov/research/science-and-tech/research/results/70-managing%20diverging%20science09-07-11-del.pdf

Research Updates

Western Water and Power Solution Bulletin

Research and Development Office — Denver, Colorado

Bulletin No. 55
September 2011

Venturi Solution for Measuring Flow at Flumes under Risk of Submergence

New measurement system provides accurate measurements for flat, open canals under a range of water level conditions

What Is The Problem?

The ability to measure flow throughout a delivery system is key to managing water. Much of these flows are carried in open canals designed with flat slopes. Conventional structures, such as weirs or flumes, that measure these flows require a significant drop in water surface elevation from above to below the structure to provide accurate measurements. This water level drop can not be created at many locations where flow measurements are needed—without reducing the flow capacity.

Minimal gradients for canals maximize the area that water can be delivered under gravity flow. The energy required to move water in a canal is derived from the slope of the canal. The flatter the canal, the lower the low flow velocities with limited erosion potential and lower energy losses in transit (as there is less friction). However, with these minimal gradients, conventional flumes or weirs often become excessively submerged (where the downstream water depth is over an allowable proportion of the upstream depth) and, thus, can not provide measurements.

Historically, stream gauging techniques have been used where conventional structures are not viable. Stream gauging can be a comparatively time-intensive process where flow velocity is determined for multiple segments of a cross-section location. A number of products (including acoustic-doppler technology) have become available to measure flows where conventional flumes and weirs cannot. Cost-effectiveness for agricultural water systems of the high-end products and observed inconsistent performance with some of the less costly products are concerns with these devices.

What Is The Solution?

This Science and Technology Program project used long-throated flumes with a two-level measurement system to obtain flow measurements even under highly submerged conditions. The approach section, reduced cross-section area, and throat section of a long-throated flume must be shaped like a prism for enough distance so that flow lines become parallel. This enables flow measurements to be obtained by accurately measuring flows at both the approach and throat sections of the flume. This two-level measurement uses the same solution that is used for measuring flow with pipe venturi meters. The “venturi solution” is the simultaneous solution of the equations for conservation of mass and for conservation of energy.

The water level differential between the approach and throat sections of a highly submerged long-throated flume may be as little as a few hundredths of a foot. The comparatively complex computations required for the venturi solution coupled with this high need for a high degree of resolution to measure water levels prompted Reclamation engineers to develop an electronic system for level measurement and flow calculations.

Field tests using this measurement system were initiated at four sites in the Yuma, Arizona, vicinity in 2008. As field test data have verified, flow calculated using the venturi solution will be valid whether a flume is excessively submerged or not.

A field test site at the Unit B Irrigation District near Yuma.

Who Can Benefit?

This measurement method for long-throated flumes could be used on practically any open channel conveyance system. It can be particularly cost-effective at existing long-throated flumes subject to occasional excessive submergence.

Where Have We Applied This Solution?

The four field test sites near Yuma, Arizona remain in operation. Three new venturi solution flumes were installed in 2009 at the Mohave Valley Irrigation District in western Arizona. A paper on this study was presented at a U.S. Committee on Irrigation and Drainage conference in Sparks, Nevada, in June, 2009.

Future Development Plans

Interested irrigation managers can view the laboratory submerged venturi flume facility at the Technical Service Center’s (TSC) Hydraulics Lab or in the field. This technology is incorporated into TSC’s Modern Methods of Canal Operations and Control and the Basic Principles and Developments in Flow Measurement courses.

More Information

http://www.usbr.gov/pmts/hydraulics_lab/pubs/PAP/PAP-0987.pdf

Contact Information

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Research Products

To get information generated by research quickly into the hands of end users and the broader public, our researchers publish their results in peer reviewed journals, technical memoranda, research reports, and other venues. We also present our results at conferences and workshops. Access these documents electronically at www.usbr.gov/research/docs/2011.html.

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Bank protection using car bodies.

Bank materials showing fine grained over bank sediment, capping gravelly alluvium.

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Research Products

Environmental Issues in Water Delivery and Management – *continued*

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Research Products

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Water Operations Decision Support – *continued*

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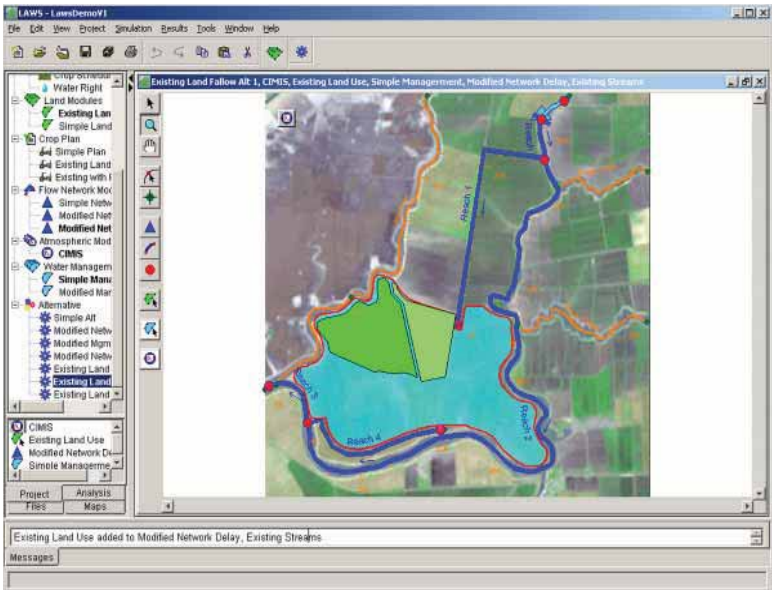

LAWS screenshot.

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