RECLAMATION

Managing Water in the West

FY 2011 Science and Technology Program

Research and Development Office

U.S. Department of the Interior
Bureau of Reclamation

February 2011

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

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

Cover photo: Using floating Passive Integrated Transponder (PIT) tag antenna on the San Juan River to count fish without harming them. Contact: Mark McKinstry mmckinstry@usbr.gov

Science and Technology Program

The Science and Technology (S&T) Program is managed by the Research and Development Office within the Technical Resources Directorate of the Bureau of Reclamation. The S&T Program is a Reclamation-wide competitive merit-based applied research and development program addressing the challenges faced by Reclamation water and facility managers, and our western stakeholders. Over the past 7 years, the R&D Office has provided over $50 million for over 800 research projects that have led to many important tools, solutions, and improvements in the way we manage our water and power infrastructure and related resources. Many of the solutions from previous research projects are summarized in Western Water and Power Solution Bulletins as well as highlights of activities and a description of each research project are on our Web site at <http://ww.usbr.gov/research/>.

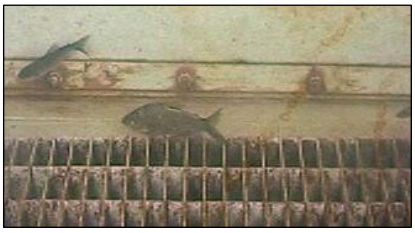

Figure 1. Electronic Fish Identification System

Priority Areas

While the Program addresses the full range of challenges faced by project operators, the S&T Program has the flexibility to shift priorities to address emerging problems. For fiscal year (FY) 2011, particular emphasis is given to addressing challenges associated with **climate impacts** and invasive **zebra and quagga mussels**. Climate impacts research includes not only improving our ability to understand and define climate impacts on Western water resources, but also developing a portfolio of tools for adapting water management to these climate impacts. Adaptation solutions include: improved means for conserving water and improving efficiency of use; expanded water supplies through desalination and reuse; better ways to use groundwater storage and conjunctive management; increased efficiency of hydropower generation; and tools for environmental management under climate stresses. These areas have been the focus of intensive work both within Reclamation and with other agencies. Critical gaps in knowledge and tools have been identified, and studies have been initiated to address those gaps.

Fiscal Year 2011 Program Summary

The Science and Technology Program FY 2011 budget request is $11,486,000. Table 1 is the spending plan for the budget request. Nearly 50 percent of the budget is allocated to climate related research. Additionally, a portion of the budget is reserved to provide flexibility within the program pending the final appropriation bill.

In FY 2011, 158 funding requests totaling $12.4 million were received in response to a Reclamation-wide call for proposals. The proposals were reviewed by Reclamation staff for relevancy to Reclamation's mission and by non-Reclamation technical experts for validity. Review committees, including regional office S&T Coordinators, evaluated the reviews and recommended projects for funding. The Director, Research and Development, prepared the proposed list of FY 2011 projects based on those recommendations.

Table 1. FY 2011 Science and Technology Spending Plan

Program	Amount ($)	Budget (%)
Climate Impacts	1,775,000	15%
Renewable Energy	1,120,000	10%
Advanced Water Treatment	1,367,000	12%
Zebra and Quagga Mussels	1,933,000	17%
Environmental Issues in Water Delivery and Management	1,095,000	10%
Water and Power Infrastructure Reliability	560,000	5%
Water Operations Decision Support	762,000	7%
Conserving or Expanding Water Supplies	640,000	6%
Technology Transfer	628,000	5%
Collaboration, Regional Office Participation, and Program Efficiency Improvements	639,000	6%
Continuing Resolution Reserve	969,000	8%
FY 2011 Total Budget Request	**$11,488,000**	

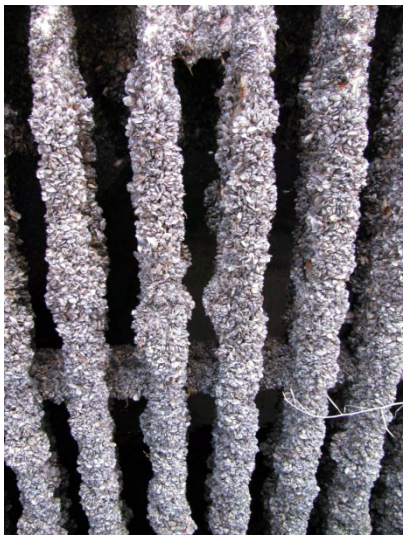

Figure 2. Lake Mead, Nevada Intake Trash Rack

The final draft list of Science and Technology projects consists of 137 projects and activities that total $9.7 million. The final draft list also includes $1.5 million for 14 projects and activities pre-funded at the end of FY 2010.

Table 2 lists the awarded funds for each Reclamation region. The majority of funding was awarded to principal investigators in the Technical Service Center (TSC). Nearly 80 percent of the proposals originated from principal investigators in the TSC. The Great Plains Region is not listed because no proposals were received from that region. Not included in the table is $700,000 set aside for managing the zebra and quagga mussel research and climate change research portfolios.

Table 2. Award Identified By Regional Office

Region	Proposed Award ($)
Lower Colorado	218,000
Mid-Pacific	486,000
Pacific Northwest	336,000
Technical Service Center	7,899,000
Upper Colorado	133,000
Grand Total	**$9,072,000**

Figure 3. Generator winding insulation testing

Chart 1 provides another perspective on the proposed awards. This chart shows where data are collected for each research project. For example, in most cases, even though a Technical Service Center employee receives funding, the work is being undertaken with an area office. For example, although the GP Region did not submit any proposals, as shown, fifteen percent of the projects are focused on Reclamation Projects within the Great Plains Region.

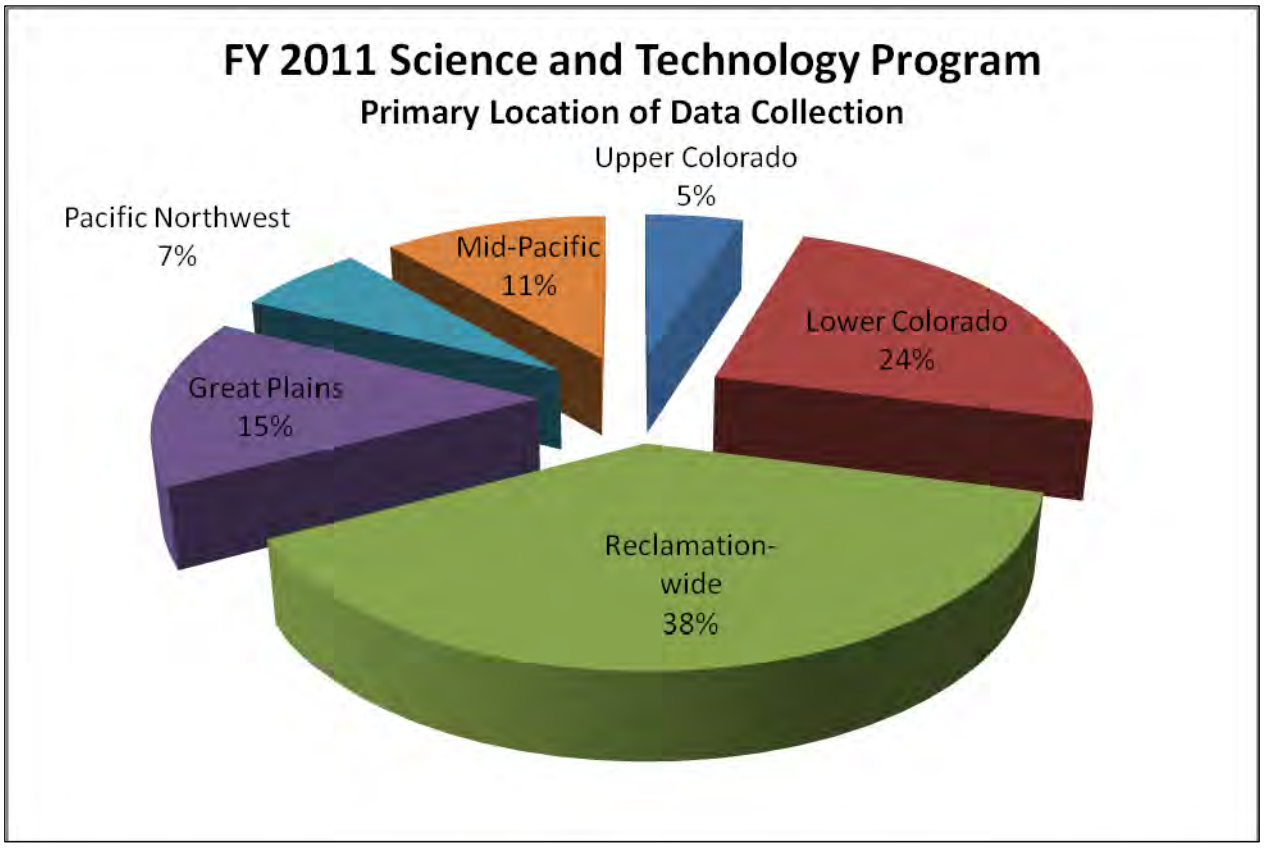

Chart 1. Funding by Data Collection

Individual Projects

Individual projects are described in the rest of this briefing book under the subject tabs. Where we have not identified or solidified partnerships, this heading is left blank. Descriptions are not provided for climate change and zebra and quagga mussel management or reserve. These funds are set aside to address emerging issues, pursue promising new research topics, establish priorities, identify needs, provide technical review of other research, assist researchers, and to generally coordinate activities associated with the priority areas.

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310 Effects of Climate Change on Riparian Vegetation Structure, Water Uptake, and Dependent Pollinators along Mainstem Rivers in the Colorado River Basin

Summary: Will climate change affect native pollinators?

Contact: Mark Nelson, snelson@usbr.gov

Research Question:

- Can potential effects from climate change on water management operations exacerbate negative effects from climate change on riparian plants and habitats that support pollinators?
- How might water management operations be adjusted to optimize water delivery and potentially benefit riparian pollinators?

Riparian habitats along regulated rivers are important providers of native insects to pollinate nearby irrigated orchards and crop fields. Commercially managed bees are suffering serious declines due to introduced parasites and pathogens (National Academy of Sciences [NAS] 2007), increasing the importance of native pollinators in agricultural production (Winfree et al. 2007). The populations of native pollinators relying on riparian habitats, in turn, are tightly coupled to the status of riparian plants and on the processes that ensure plant population persistence. Both of these factors are strongly linked to river hydrology.

We will conduct a literature review, examine the potential consequences of climate-induced reduced flows to riparian plant flower production, and initiate a pilot study of riparian plant species response to changes in soil temperature. These changes are likely to be produced as a result of a shift in timing of spring water management operations. Results from all tasks will be communicated to managers, modelers, and others through presentations, reports, and in-house data sharing.

Need and Benefit: Climate change will affect Reclamation-managed water in the decades ahead, but the exact nature of those changes is uncertain. Riparian habitats along both regulated and unregulated rivers are increasing in value as habitat is reduced through instreamflows and land use changes. Climate change, by reducing precipitation levels in some headwater areas, may accelerate any increase in the habitat value. The NAS study found convincing evidence of local and regional declines in wild pollinators from habitat degradation and loss and the NAS study recommended protection. Maintenance of native pollinator populations become a national priority. Reclamation needs to understand how its water management operations may be affecting native riparian pollinator populations and how those effects may be modified as a result of operation changes undertaken in response to climate change. The proposed work will benefit Reclamation by providing information of use in the development of both current and future water management scenarios that include environmental benefits and costs.

Partners: U.S. Geological Survey (USGS), U.S. Fish and Wildlife Service (USFWS), Southern Nevada Water Authority

Keywords: riparian pollinators, riparian habitat, climate change, soil temperatures, bees

507 Evaluating Water Management Responses to Global Climate Change Using Coupled Hydrologic and Economic Models

Summary: Using economic models to help Reclamation manage water in response to global climate change.

Contact: Jennifer Johnson, jmjohnson@usbr.gov

Research Question:

- What Reclamation water management strategies are most appropriate for addressing changes in water supply and demand likely to result from global climate change?

Water management strategies can address water supplies (e.g., increasing reservoir storage) and/or water demand (e.g., conservation, regulation, and market-based water trading). Coupled hydrologic and economic models are essential tools for addressing questions of where and when supply management and/or demand management approaches are most appropriate for meeting the challenges of global climate change.

We will build on the S&T Program research project 5330, Boise Valley spatial water allocation modeling, which combined a conjunctive groundwater model with a partial equilibrium economic model. This research will identify water management options associated with Reclamation's operation of the Boise River and reservoir system. The project will develop the links between selected river and reservoir models and the partial equilibrium economic model and apply the fully developed Boise Basin spatial water allocation model. Evaluation will include scenarios representing the Pacific Northwest (PN) Region's water supply and demand conditions likely to result from climate change, including decreased precipitation, decreased streamflow, reduced aquifer recharge, and increased competition among water users. Various Reclamation strategies for dealing with the impacts of climate change will also be considered, including construction of new reservoir storage, new water conservation measures, water rights re-distribution, and market-based water management. The Boise Basin model will serve as a prototype for the development of spatial water allocation models in other Reclamation regions.

Need and Benefit: Partial equilibrium models can incorporate the relative economic value of water to different economic sectors and un-priced economic impacts ("externalities" such as increased drain returns, improved wildlife and aquatic habitat) into Reclamation's decisionmaking process.

The magnitude of projected warming for the PN Region and the region's strong reliance on mountain snowpack for water supply warrants consideration of climate impacts in water resource management.

Partners:[1]

Keywords: partial equilibrium economic models, water management, climate change

[1] Note that where we have not identified or solidified partnerships, this heading is left blank.

675 Understanding How Different Versions of Distributed Historical Weather Data Affect Hydrologic Model Calibration and Climate Projections Downscaling

Summary: Reclamation researches weather datasets to improve climate change predictions for water management studies.

Contact: Subhrendu Gangopadhyay, sgangopadhyay@usbr.gov

Research Question:

- How different are the presently available distributed weather datasets for precipitation, temperature, and spatial patterns?
- How sensitive is the hydrology model response when calibration is carried out with one of the presently available distributed weather datasets and forced with the other datasets?
- What are the implications of the climatology differences from the distributed weather datasets for statistical downscaling of Global Climate Model (GCM) outputs?

We will analyze datasets using two measures:

1. Spatial similarity of the distributed precipitation and temperature fields of the study datasets
2. Implications on hydrologic modeling

We will then provide guidance on the choice of datasets for statistical downscaling of GCM outputs used in different types of scale-dependent planning assessments.

We will evaluate these differences from a hydrological standpoint at specific Reclamation basins: Animas at Durango, Colorado; Snake at Heise, Idaho; Sacramento at Redding, California; Salt at Chrysotile, Arizona; Yellowstone River at Billings, Montana; and Colorado River at Lees Ferry Utah and Arizona. The analysis will indicate whether the choice of forcing a dataset makes a difference in the quality of the hydrologic simulations.

Need and Benefit: Water agencies will continue to face decisions about which downscaled data to use and implicitly which downscaling method and spatial resolution to rely upon. Understanding the assessment uncertainties introduced by these choices is needed for decisionmaking. However, quantitative information on such uncertainties is limited, setting up the need for evaluations such as this proposed effort. This research will guide choices of datasets for future Reclamation studies and identify inadequacies in forcing datasets that may warrant improvements as a preliminary step to future studies.

Partners: The proposed collaboration with the National Oceanic and Atmospheric Administration (NOAA) (in-kind cost share partner) is advantageous to leverage NOAA's hydrologic modeling expertise.

Keywords: climate change, hydrologic modeling, dataset, downscaling, Global Climate Model (GCM), weather, precipitation, spatial analysis, precipitation, temperature

1158 Physiological Tolerances of Fishes of the Sacramento-San Joaquin Delta, California

Summary: To help fish in the Sacramento-San Joaquin Delta, Reclamation is compiling physiological data on dozens of species.

Contact: Zak Sutphin, zsutphin@usbr.gov

Research Question:

- How do fish respond to changes in their environment?

An understanding of how fish respond to changes in their environment is necessary when restoring habitat to support native fish and to predict future species assemblages, likely outcomes for important native and non-native species, and the potential for invasion. We will review existing literature and summarize the temperature-dependent physiological tolerances and metabolic responses of fish resident in the Sacramento-San Joaquin Delta (SSJD) to water quality parameters likely to be impacted by water management facilities and global climate change. The review will cover 58 species of fish (23 native). Each species account will be organized into adult, juvenile, larval, and egg tolerances. The water quality variables we intend to include are temperature, dissolved oxygen, carbon dioxide, pH, ammonia, nitrite and nitrate, and salinity (upper lethal tolerance). The report will also include graphical summaries for physiological tolerances: critical dissolved oxygen minima, thermal preference, critical thermal minima and maxima, incipient upper and lower lethal temperatures, and standard oxygen consumption rates.

Need and Benefit: Over the last century, the physical habitat of the SSJD and the chemical composition of its water have been greatly modified as a result of water management practices; the development of dams, canals, and water pumping facilities; increased agricultural, domestic, and industrial development; and global climate change. These changes have coincided with considerable population declines in most native fishes and alterations in species composition that have favored the expansion of non-native organisms. A thorough review of the effects of temperature on the physiological tolerances and preferences of fishes of the SSJD will provide both Reclamation and non-Reclamation managers and scientists a single source when developing project and species management plans, working on threatened and endangered species consultation efforts, or when considering effects of current or future Reclamation projects on the fishery.

Partners: Sutphin is a co-author of the planned monograph with Christopher Myrick of Colorado State University. In-kind support is also expected from the California Department of Fish and Game and from personnel of Reclamation's Tracy Fish Facility in Tracy, California.

Keywords: Sacramento-San Joaquin Delta, fish, SSJD, physiological tolerance, water quality, climate change, temperature

1646 Sensitivity of Hydrologic Impacts Assessment to Downscaling Methodology and Spatial Resolution

Summary: Reclamation partners with NCAR and USACE to find best methods for incorporating downscaling climate projections into long-term water planning.

Contact: Levi Brekke, lbrekke@usbr.gov

Research Question:

- Does portraying hydrologic impacts under climate change depend on the chosen downscaling method (i.e., dynamical downscaling using regional climate simulation versus non-dynamical downscaling using statistical or empirical methods)?
- At what space and time scales does portraying impacts begin to be sensitive to methods class, and for what types of hydrologic metrics?
- How do the responses to these questions vary with the spatial resolution of dynamical downscaling and the adequacy of process representation in atmospheric and hydrologic models?

Need and Benefit Non-dynamically generated datasets are often rich with scenarios, allowing planners to characterize climate projection uncertainty and plan assumptions within that uncertainty. However, questions remain about the veracity of downscaled data produced by such non-dynamical methods, particularly when land-atmosphere interactions are important for defining local climate and when non-dynamical methods assume such interactions will remain static even as larger scale climate changes might influence such interactions (U.S. Geological Survey [USGS] Circular 1331).

Water agencies will continue to face decisions about which downscaled data to use and implicitly which downscaling method and spatial resolution to rely upon. As decisions are made, there will be interest in understanding the assessment uncertainties introduced by these choices. However, quantitative information on such uncertainties is limited. We will build from earlier intercomparisons, separately addressing how downscaling methods and resolution affects the portrayal of weather or hydrologic impacts under historical and climate changed conditions. As a result, this project could provide information that might guide the scoping decisions about the downscaling methods and data to use for different types of scale-dependent planning assessments (e.g., flood risk assessments at local scales versus water supply assessments at regional scales).

Partners: Reclamation has experience applying non-dynamical downscaling techniques, but not dynamical techniques. Proposed collaboration with the National Center for Atmospheric Research (NCAR) and U.S. Army Corps of Engineers (USACE) (as a cost-share partner) helps leverage expertise to explore best methods for incorporating downscaling climate projection information into longer-term water resources planning and subsequently conducting hydrologic evaluations under climate change (USGS Circular 1331). This project will also provide postdoc support with University Corporation for Atmospheric Research (UCAR) Advanced Studies Research Program.

Keywords: climate change, dynamical downscaling, non-dynamical downscaling, Colorado Headwaters Project, hydrologic metrics

5891 Biological Impacts on Reclamation Operations from Climate Change

Summary: Reclamation investigates how climate change could affect fish and invasive species, and potential responses.

Contact: Mark Bowen, mbowen@usbr.gov

Research Question:

- What Reclamation operations will be affected by climate change's impact on biological resources?
- How great will the effects be?
- How can Reclamation respond to ensure water supply reliability?

We will identify regional and area office partners within Reclamation to use available downscaled climate projections, translate projections into biological forecasts for projected changes to populations and habitat, conduct probabilistic scenario planning, and recommend management actions. The research will also identify strategic basins to work in, find personnel to conduct the work, and locate external funding and in-kind services (e.g., non-governmental organizations, State agencies, and other Federal agencies).

We will identify fisheries population and fish physiology effects as well as invasive species effects from climate change in Reclamation-managed systems. We will concentrate on effects on species of interest**:** zebra mussel, quagga mussel, and plant species identified by management. We will determine how best to translate predicted hydrologic inputs for biological models. This is a phased approach. In Phase 1, we will identify personnel, determine management needs, and write a S&T proposal for fiscal years 2012-2015.

Need and Benefit: Climate change could produce new operational constraints for Reclamation water managers. Thorough comprehension and management of biological resources in the presence of climate change could benefit Reclamation by facilitating stable fish populations, allowing understanding of fish's physiological processes that can limit production, determining maintenance schedules necessary to minimize biofouling, and reducing water delivery losses from invasive plant obstructions. These actions can save water, reduce operational constraints, and allow us to improve water supply reliability for meeting Reclamation's mission. This research will ensure that biological effects will not impair Reclamation's ability to meet its delivery schedules in the face of climate change.

Partners: Research agency partners include National Oceanic and Atmospheric Administration (NOAA) Fisheries (formerly National Marine Fisheries Service [NMFS]), U.S. Geological Survey (USGS), U.S. Forest Service (USFS), and Trout Unlimited

Keywords: fish, climate change, mussels, invasive species, water delivery, biofouling

6507 Evaluating Climate-Induced Runoff and Temperature Change on Stream Habitat Metrics for Endangered or Threatened Fish

Summary: Developing a model framework to evaluate climate impacts on fish.

Contact: Jennifer Bountry, jbountry@usbr.gov

Research Question:

- How will climate change alter the hydrologic runoff and water temperature inputs to stream and flood plain reaches used by endangered or threatened fish species?

- How are runoff and temperature changes linked to fish habitat within a stream reach?

We will develop a set of linked models to help predict the effects of climate change on rivers and endangered species. These will include watershed- and reach-scale models to predict streamflow, water temperatures, and other fish habitat metrics under various climatic scenarios for the reaches used by species listed under the Endangered Species Act (ESA), plus a combined bioenergetics and life-cycle model (to be done by the U.S. Geological Survey [USGS]) to assess the impact of these factors on fish growth, reproduction, and survival. We propose to test the model framework at a site on the Methow River, Washington, to explore additional opportunities for collaboration and model development.

Need and Benefit: Despite decades of stream rehabilitation projects, salmonid populations have declined to levels that warranted listing under the ESA. Most of the rehabilitation actions are engineering-based and aim at altering stream channels to provide velocities, depth, and sediment sizes known to be preferred by the fish species of interest. However, it is not clear if these actions actually improve the quality of the habitat, if the habitat generated is sustainable, and whether it will ultimately be used by fish. Salmonids, in particular, require adequate availability of food, but linkages between altered hydraulics and the food web are almost never evaluated. To further complicate matters, climate change has become an increasing concern in ESA salmon programs because many streams are already believed to be at an upper threshold of tolerable water temperatures during low-flow, late summer, and fall periods.

The model framework will help Reclamation and its partners develop river rehabilitation projects that will improve conditions for listed salmonids with consideration for habitat response to climate change.

Partners: Columbia Cascades Area Office, the Yakama Nation, Idaho State University, TerrAqua, USGS, the Wild Fish Conservancy, and the University of Washington

Keywords: climate change, modeling, endangered species, salmonids, fish habitat, stream rehabilitation, food web

7855 Back to the Future: Innovative Tree Ring Analysis to Reconstruct Paleoclimate and Streamflows for Improved Urban Water Planning Under Climate Change

Summary: Examining tree rings to create paleoclimate records for better future planning in Salt Lake City, Utah.

Contact: Fred Liljegren, fliljegren@usbr.gov

Research Question:

- Can past precipitation and streamflow data be re-created from a suite of tree ring chronologies since these tree species represent different habitats and lend themselves to strengthening a particular climate signal?

The Salt Lake City, Utah, region has a climate record dating from the mid-1800s that can be used to calibrate a tree ring record to climate and streamflows. A number of good candidate species for tree ring analysis include indigenous coniferous species that are signature species in tree ring analysis because their growth is sensitive to drought. However, these species represent different habitats.

We will conduct controlled field studies to define the relationship between a suite of tree species native to the Wasatch range and drought stress and air temperature as well as to use tree ring data to understand and explain paleoclimate drought cycles and reconstruct streamflows in an innovative way.

The research will help increase prediction accuracy and extract nuanced climate information such as air temperature and counterintuitive weather patterns such as dry winters combined with cool, wet summers.

Need and Benefit: Reclamation and other water agencies can use these nuanced climate insights to understand potential drought cycles and evaporative demand, thus enabling us to plan for extreme drought under climate change rather than suffering the negative impact of drought events. Understanding the long-term hydrology will help project future potential scenarios to help plan for water shortage events.

Partners: Water districts in northern Utah and northern Colorado as well as the Utah State University

Keywords: ecophysiological studies, tree ring analysis, Utah juniper limber pine, doug fir, mountain mahogany, Logan River watershed, Cache Valley climate, climate change, urban water planning, paleoclimate

8990 Investigation of Climate Change Impact on Reservoir Capacity and Water Supply Reliability

Summary: How will climate change affect reservoir sedimentation and storage?

Contact: Paula Makar, pmakar@usbr.gov

Research Question:

- How is projected climate change expected to affect watershed sediment yield?
- How would changes in sediment yield affect rate of reservoir sedimentation and associated lost storage capacity?
- How might these latter effects interact with hydrologic (water supply) impacts to ultimately affect water delivery reliability?

We will investigate methods to assess the effects of climate change on reservoir sedimentation, which affects the life expectancy of a reservoir. Such impacts, in conjunction with climate change impacts on reservoir inflow patterns, could affect future operations and water delivery reliability. This research will parallel a U.S. Army Corps of Engineers (USACE) study to provide a period change climate and hydrologic analysis in selected study basins. Reclamation reservoir selections are (a) Bighorn Lake in Montana and Wyoming and (b) Elephant Butte Reservoir in New Mexico. Preliminary USACE reservoir selections are (a) Garrison Reservoir in North Dakota and (b) Cochiti Reservoir in New Mexico.

Both research projects will apply existing water operations models to assess how projected hydrology and reservoir sedimentation would impact water delivery reliability under otherwise existing operating conditions.

Need and Benefit: Climate change and reservoir sedimentation can each act to reduce the reliability of the reservoir water supply. Increased hydrologic variability will lead to more floods and droughts, even if the long-term mean reservoir inflow remains the same. The increased flood intensity will deliver more sediment to the reservoir. The increased drought severity and reservoir sedimentation will result in less reservoir storage capacity. Increases in sedimentation rates could seriously affect the users of the reservoirs. The decrease in available reservoir storage over time could reduce the ability of Reclamation and USACE to provide a firm annual yield to users each year. This could affect the repayment contracts with the districts and all other facets of reservoir use.

Comparisons of results can be used to help predict the life of a reservoir and to apply better management of the reservoir to extend its life expectancy under climate change. These comparisons may also assist in decisions on whether additional analysis is needed, such as better forecasting of variable hydrologic loading or changes in operating rules and upstream sediment management, to maintain or even increase water supply reliability under changing climate conditions.

Partners: U.S. Army Corps of Engineers (USACE)

Keywords: sedimentation, climate change, hydrologic models, reservoir sedimentation, reservoir storage, water operations

Directed: Climate Change and Economics

Summary: What are the economic implications of climate change for Reclamation?

Contact: Dave Harpman, dharpman@usbr.gov

Research Question:

- What are the economic implications of climate change for Reclamation?

Changes in climate affect all of Reclamation's activities, and these changes have economic implications. Science and Technology Program research projects are still being defined and could include:

- Climate Change in the Colorado River Basin—A Case Study of Agricultural Response.
- Conceptual Approach for Identifying Consumptive Water Use in Hydropower Production
- Agricultural Demand for Irrigation Water with Climate Change
- General Economic Support for River Basin Studies
- Advanced Optimization Algorithms for Hydropower Dispatch

Need and Benefit: Reclamation needs an understanding of the potential economic consequences of climate change to better prepare, adapt, and plan.

Partners:

Keywords: climate change, economics, agricultural demand, water supply, water demand, hydropower

Directed: Climate Change Downscaling

Summary: Expanding archive of downscaled climate projections to include new techniques and hydrologic projections.

Contact: Tom Pruitt, tpruitt@usbr.gov

Research Question:

- Can we generate more relevant downscaled information for ecosystem and flood frequency studies?
- Can we define how different downscaling techniques lead to uncertainty in portraying hydrologic impacts?

Need and Benefit: Reclamation's existing archive contains projections of monthly temperature and precipitation for the contiguous United States. The archive has served requests from roughly 700 users since November 2007, supporting various planning and research activities. Reclamation has used these to characterize future supplies and reservoir operations. On the matter of exploring future impacts to ecosystems and flood frequency, the current archive has limitations. To address these limitations, Reclamation collaborated to apply a new technique that downscales daily weather patterns from global climate simulations (relevant to storm and flood frequency assessments) and also daily temperature range (relevant to ecosystem studies). This Science and Technology Program research project will develop Web services to make this new dataset publically available, and to conduct hydrologic investigations to assess how future hydrologic portrayal differs depending on use of the archive's two downscaled datasets.

Partners: Lawrence Livermore National Laboratory – Green Data Oasis, Santa Clara University, Climate Central, Scripps Institute of Oceanography, U.S. Geological Survey (USGS), U.S. Army Corps of Engineers (USACE) Institute for Water Resources

Keywords: downscaled climate projections, hydrologic projections, climate change

Directed: Climate Change Training

Summary: Coordinating climate-related research and capacity-building activities.

Contact: Levi Brekke, lbrekke@usbr.gov

Research Question:

- How can Reclamation work with other agencies to leverage limited resources and develop a curricula designed to train tomorrow's practitioners on how to conduct climate change impacts and risk assessments for various water and environmental resources?

We will help coordinate activities to develop training programs and materials.

Need and Benefit: This question is being explored through Reclamation's involvement with the Climate Change and Water Working Group (CCAWWG), and in collaboration with the University Corporation for Atmospheric Research (UCAR) and U.S. Fish and Wildlife Service's (USFWS) National Conservation Training Center (NCTC). Objectives include

1. Provide an authoritative, effective university-based venue for the research community to translate new climate change knowledge and capabilities into practical applications with the water resources community of practice
2. Provide an effective forum for the exchange of information on new needs, knowledge, and capabilities as they emerge

Partners: U.S. Army Corps of Engineers (USACE), Federal Emergency Management Agency (FEMA), U.S. Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA), U.S. Geological Survey (USGS), UCAR, and USFWS NCTC

Keywords: climate change, training, water resources, knowledge sharing

Directed: Evaluating Power and Uncertainty Associated with Sample Size in Non-Parametric Approaches to Hydrologic Variables for Streamflow Forecasts and Simulations

Summary: Using flexible parameters to examine data for streamflow forecasts and simulations.

Contact: Subhrendu Gangopadhyay, sgangopadhyay@usbr.gov

Research Question:

- How can we characterize uncertainty associated with non-parametric statistical analyses relevant to floods and droughts?

We will use mathematical procedures for statistical hypothesis testing which, unlike parametric statistics, make no assumptions about the probability distributions of the variables being assessed. The model structure is not specified *a priori* but is instead determined from data. The number and nature of the parameters are flexible and not fixed in advance.

Traditional techniques require estimates of parameters for location and scale, which may not be reflected in actual climate data. Nonparametric approaches are much more flexible and less affected by data that lies outside the estimated parameters. Therefore, these techniques are useful to account for abrupt changes in climate and errors in data recording or transmission.

Need and Benefit: There is considerable scientific uncertainty regarding the precise nature of how a changing climate may affect Reclamation's river basins, and thus water and power operations. This research will help evaluate this uncertainty and provide for more accurate streamflow forecasts and simulations for Reclamation decisionmaking.

Partners: University of Colorado, Boulder

Keywords: statistical analysis, non-parametric approaches, climate change, streamflow forecasts

Directed: Groundwater and Surface Water Interactions

Summary: Integrating groundwater–surface water management in a changing climate.

Contact: Subhrendu Gangopadhyay, sgangopadhyay@usbr.gov

Research Question:

- How will groundwater and surface water interactions be affected by climate change?

This Science and Technology Program research project will result in:

- A white paper listing issues with groundwater and surface water interactions and climate change
- A Groundwater Hydrology Work Group comprised of academics, the Water Research Institute, and Federal agencies to translate white paper issues into a technology development strategy
- Model intercomparison to explore management-hydrology model integration with simple/complex hydrology models

Need and Benefit: Understanding the potential issues with groundwater and surface water interactions form climate change is crucial for Reclamation's water management and power operations decisions.

Partners: Partnerships will include universities, agencies, and other research institutions.

Keywords: climate change, groundwater, surface water

Directed: Facilitating Lessons Learned on Climate Change

Summary: Applying lessons learned from other disciplines to climate change and water resource planning and management.

Contact: Jade Soddell, jsoddell@usbr.gov

Research Questions:

- How can we share our knowledge and experience about climate change issues that are unique to water resource planning practitioners and/or decisionmakers? Can lessons learned from other disciplines (e.g., emergency management) be employed in climate change and water resource management?
- Are there already established methods and techniques available that are appropriate for use in climate change information sharing and development of common terminology guidelines?
- How can applying these lessons learned benefit planning decisions in water resource management?

Need and Benefit: We need to leverage all of the existing information and research to provide the best information possible for climate change issues. While other research associations exist, we need a specific venue for sharing information on issues unique to water resource planning.

Examples may include exploring how to emulate information-sharing structures on Emergency Management Web sites (e.g, Federal Emergency Management Agency's [FEMA] Lessons Learned and Information Sharing Web site <https://www.llis.dhs.gov/index.do> and the Homeland Security Information Network <http://www.dhs.gov/files/programs/gc_1156888108137.shtm>).

Partners: This research project will explore coordinating with other researchers, Landscape Conservation Cooperatives (LCC), Climate Science Centers (CSC), Federal agencies, and others to determine the needs for and develop a plan for a related joint information center. Partners will include research institutions, academic institutions, and government agencies.

Keywords: climate change, water resource planning, research coordination, lessons learned, information sharing

Directed: Literature Synthesis on Climate Change Implications for Reclamation's Water Resources

Summary: Developing region-specific literature syntheses.

Contact: J. Mark Spears, jspears@usbr.gov

Research Question:

- How can Reclamation effectively develop, maintain, and deploy region-specific literature summaries on climate change implications for water resources for use in Reclamation's environmental compliance and other documentation efforts?

Need and Benefit: Given that Reclamation has multiple environmental compliance efforts being conducted at any given time within each of its regions, and given that climate change now must be addressed in such documentation efforts, it is in Reclamation's interests to have a consistent portrayal of climate change literature within each of these documents. Further, Reclamation can alleviate the burden on project-specific scoping efforts to include development of such narratives by instead developing and maintaining region-applicable narratives. Fiscal year (FY) 2010 involved releasing the first version of "Literature Synthesis on Climate Change Implications for Reclamation's Water Resources" <http://www.usbr.gov/research/docs/climatechangelitsynthesis.pdf>. FY 2011 involves completing and releasing the first annual update of this document, once again working with current and former National Oceanic and Atmospheric Administration (NOAA) Regional Integrated Sciences and Assessments (RISA) to provide content review. Also, FY 2011 involves tracking literature and initiating review and synthesis updates during 4th quarter FY 2011.

Partners: Four NOAA-RISAs (i.e., California Applications Program, Climate Assessment of the Southwest, Southern Climate Impacts Planning Program, and Western Water Assessment), and the University of Washington Climate Impacts Group (former NOAA-RISA)

Keywords: climate change, literature, water resources, environmental compliance

Directed: Postdocs Applying Climate Expertise Fellowship Program—Climate Change Flood Potential

Summary: Assessing the potential for changes in warm season extreme precipitation events across the Colorado Front Range in future climates.

Contact: Jade Soddell, jsoddell@usbr.gov

Research Question:

- What sort of changes can we expect to see in Colorado Front range warm season extreme precipitation events in future climates (i.e., changes to the elevation of precipitation thresholds and intensity, amount, and spatial distribution of extreme precipitation events)?
- Will simulating extreme events with a higher resolution provide more detailed information on the influence of regional climate-scale environmental changes on storm-scale processes affecting the generation of precipitation?
- Can we use fine-resolution atmospheric modeling to explore this question and others related to summer season storm potential along the Colorado Front Range?

Need and Benefit: We will examine warm-season extreme precipitation events in the Western United States using climate model projections of past and future periods. Extreme precipitation events are of great importance to both the general public and water resources managers, particularly in the complex terrain of the Western United States. Safety issues pertaining to flash flooding, river dam design, and reservoir operations depend strongly on accurate assessments of the potential for heavy rainfall events over a given region. As many of the environmental factors that drive precipitation generation are predicted to change in future climates, understanding the potential for changes in extreme precipitation events thus becomes an important issue for future planning and adaptation. Results are ultimately intended to be applied to the needs of water resources managers in the Western United States, and more specifically to Reclamation's dam safety and flood risk assessment needs.

Partners: Postdocs Applying Climate Expertise (PACE), National Oceanic and Atmospheric Administration (NOAA)'s Earth System Research Laboratory (ESRL), Federal Emergency Management Agency (FEMA), Reclamation's Eastern Colorado Area Office

Keywords: climate change, Colorado Front Range, extreme precipitation, Weather Research and Forecast Model (WRF), post docs

Directed: Vulnerability Analysis of Western Water Resources to Climate Variability and Change

Summary: Apply probabilistic methods to characterize future impacts on supplies, demands, and associated vulnerability to water scarcity.

Contact: Levi Brekke, lbrekke@usbr.gov

Research Question:

- How might we characterize climate change implications for water supplies, water demands, and associated vulnerability?

- How can we use this understanding on landscape vegetation response to climate change in efforts to characterize watershed hydrologic impacts?

Need and Benefit: The overarching objective of this Science and Technology Program research project is to develop and implement a probabilistic framework for assessing regional-scale vulnerability of western water resources to climate variability and change that incorporates ecologic and economic factors. The effort involves:

1. Developing and introducing a probabilistic definition of vulnerability

2. Implementing a new statistical-dynamical hydrologic model that incorporates an ecological optimality hypothesis governing the long-term and short-term evolution of transpiration efficiency and vegetation cover

Partners: Colorado State University

Keywords: drought, flood, water supplies, climate change, climate, water supply, water demand, vegetation response to climate change, hydrology model, transpiration, vegetation cover

Directed: Decisionmaking Methodologies Analysis—Scenario Planning Comparisons

Summary: How do different ways to analyze climate change scenarios compare?

Contact: Chuck Hennig, chennig@usbr.gov

Research Question:

- How do various methods to analyze climate change and project future scenarios compare?

Decision Support Planning Methods (DSPMs) are new techniques to help water utilities use climate change projections for planning. While more sophisticated models and methods are being developed, it could be years before the range of projections—and uncertainties about these projections—are narrowed. Comparing the strengths, weaknesses, and applicability of various models can help Reclamation make the decisions needed now.

We will inventory and compare the DSPMs available and those being developed.

Need and Benefit: With knowledge of the various DSPMs and a guide to which methods apply to certain situations, Reclamation can use these methods to then assess the impacts from potential climate changes on our operations, reservoirs, and watersheds. These analyses can then form the basis for planning and decisionmaking to implement adaptation strategies.

Partners:

Keywords: Modeling, climate change, projections, decision support, scenarios

Contents

486 Advanced Optimization Algorithms for Hydropower Dispatch

Summary: Finding the most economic way to operate hydropower plants.

Contact: David Harpman, dharpman@usbr.gov

Research Question:

- How can we determine the most economic combination of generator units to operate and set their generation level (the economic dispatch problem)?

Most supervisory control and data acquisition (SCADA) systems at Reclamation hydropower plants do not contain an optimization package to assist with dispatch decisions. Powerplant operators use professional experience and judgment to achieve powerplant efficiency, often relying on the "equal loading" rule of thumb.

The SCADA systems at a few of Reclamation's larger and more modern hydropower plants have been retrofitted with optimization software. Experience has shown that these programs can result in increased power revenues and potentially reduced maintenance and mechanical equipment repairs since operation within rough zones and start and stop cycles are minimized. This Science and Technology research project's algorithms can be embedded in a plant's SCADA system and help guide the dispatch decision process.

Need and Benefit: Substantial gains can be realized from even small improvements in dispatch efficiency. For example, increasing the generation efficiency at Glen Canyon Dam by 2 percent would yield over $4,000,000 (2004 dollars) annually. New optimization heuristics do not rely on traditional calculus-based approaches, but instead are based on innovative search techniques drawn from biological and physical processes. Although computationally intensive, these methods can solve difficult constrained optimization problems, like the economic dispatch problem, quickly and reliably.

Partners: This proposed research project will enjoy significant value added through a mutual and ongoing collaborative relationship with researchers based at Argonne National Laboratory (ANL).

Keywords: Energy dispatch problem, optimization algorithms, hydropower, generators, SCADA

548 Power System Diagnostics

Summary: New diagnostic techniques could save millions in maintenance and downtime costs at Reclamation powerplants.

Contact: Eric Eastment, eeastment@usbr.gov

Research Question:

- What can be learned from demonstrated problems in Reclamation's electrical facilities and from the research-oriented requests of staff at these facilities that will allow us to improve diagnostic techniques and to develop new methods for reducing maintenance costs and equipment downtime?

We will address high-voltage insulation, rotating machine protection, and maintenance testing and diagnostics. Tasks will be targeted to:

- Solve repetitive problems
- Address common Reclamation needs
- Broaden and diversify facility equipment maintenance expertise
- Mitigate the impact and assist with the integration of renewable energy technologies with Reclamation's existing hydroelectric infrastructure

As this research relies heavily on assistance from power facility staff, some of it cannot be reliably scheduled; research priorities may shift to take advantage of opportunities that arise to study particular problems at particular power facilities.

Need and Benefit: Reduction in facility operation and maintenance costs and improved power system reliability require new methods to diagnose abnormal equipment operation, address effects of aging and wear, and minimize costly downtime. Much of this research will result in developing new test methods and equipment for field diagnostics of high-voltage rotating machines, power transformers, and associated high-voltage auxiliary equipment.

With improved equipment testing methods, more reliable plant operation is possible with less downtime required for failure diagnostics or misoperation analysis. The resulting reduction in maintenance costs and lost revenue will contribute to improved plant operating efficiency. Diagnostics that prevent a transformer or generator failure could be worth $1 million to $50 million per incident, depending on the powerplant.

Partners: Technical Service Center (TSC) researchers will conduct this project in partnership with the Power Resources Office and with power operations staff from Reclamation regional, area, and field offices. Field testing will be conducted on generators at available Reclamation plants with in-kind service assistance and co-funding. Results will be reviewed by electrical engineering staff at the Colorado School of Mines and shared with members of the Western Electricity Coordinating Council (WECC).

Keywords: hydroelectric power, diagnostics, operation and maintenance, generators, transformers, high-voltage equipment

661 Power System Stability Improvement

Summary: Increasing hydropower system stability and performance while reducing maintenance.
Contact: J. Agee, jagee@usbr.gov
Research Question:

- Can we increase power system stability and reliability and better assess generator controller performance while reducing our maintenance effort through analysis of data acquired by plant monitoring equipment?

This 7-year Science and Technology Program research project is in its last year. We are developing and implementing new methods to identify structure, dynamic parameters, and performance of generator controllers used in Reclamation powerplants. Now, engineers travel to the generation site with specialized equipment to get this information. This is time-consuming, labor intensive, and costly.

We will develop identification methods to replace manual methods for verifying and maintaining controller performance. New analysis methods based on data acquisition and parameter identification will determine the impact of generator controllers on power system stability in a more efficient way while adding the ability to monitor long-term power system operations. We are developing software to identify controller characteristics, dynamic parameters, their effects on the power system, and any unusual operation that may be occurring. We are using existing and new plant condition monitoring equipment at several Reclamation facilities. We are testing our concepts in the laboratory with our real-time simulation computer running a single-machine-infinite-bus model. This year, we will complete the project by documenting past work with a peer-reviewed technical journal paper on generator small-signal testing analysis and Reclamation reports on our new frequency transducer and our new plant condition monitoring schemes.

Need and Benefit: The final product will serve to reduce engineering costs by reducing the amounts of field testing and efforts required for parameter tuning and computer model validation. Benefits will improve commissioning and periodic field testing efficiency of generator controllers, resulting in less travel for engineers and savings of up to 50 percent for each commissioning or field test (up to $200,000 annually for Reclamation). This can benefit Reclamation power facilities, and it could benefit other Federal and non-Federal entities. Additional benefits will include accurately identifying and maintaining adequate stability margins, which can save hundreds of millions of dollars in avoided costs by eliminating the need for additional transmission lines. The potential fruits of this research project can benefit all generation owners by decreasing the engineering effort and costs to derive this information. The alternative is that an increasing number of power generating entities will provide erroneous information or no information at all.

Partners:[1]

Keywords: powerplant, optimization, operation and maintenance, condition monitoring, controller performance, generator controllers

[1] Note that where we have not identified or solidified partnerships, this heading is left blank.

1088 Optimization of Energy Recovery in Brackish Water Reverse Osmosis Desalination Systems

Summary: How low can energy costs go for brackish water desalination?

Contact: Steve Dundorf, sdundorf@usbr.gov

Research Question:

- What is the minimum energy cost possible for brackish water desalination using existing energy recovery technologies in an optimized total system?
- Is pilot-scale system performance directly scalable to full scale?
- What are the costs associated with membrane desalination?

We will optimize existing energy recovery technologies to produce the most cost-effective membrane desalination system. The goal for this pilot test is to reduce energy use by 15 to 30 percent for treating brackish water by using a pressure exchanger and some innovative flow regimes to increase recovery. The research approach will be to conduct the pilot tests using the most energy efficient commercially available reverse osmosis (RO) treatment equipment, including pumps, membranes, and energy recovery devices.

Testing will have two phases. Phase 1, from November 2009 to June 2010, involved a series of tests to find the most energy-efficient operating point using a standard flow configuration. Phase 2, from June 2010 to January 2011, used an innovative flow scheme that includes reconfigured piping and an interstage booster pump.

Need and Benefit: Cost effectively treating brackish water sources will help alleviate water shortages in areas that have run out of fresh water sources and potentially reduce the demand for already water-stressed sources such as the Colorado River. When energy and equipment use are optimized, this provides the most cost-effective and environmentally sound solution.

A part of ensuring advanced treatment options are used and high quality water is produced at a more affordable cost is ensuring that those involved in water treatment know the actual costs of the technology. We will also analyze and publish the costs associated with membrane desalination known to the water treatment community.

Partners: The research will be conducted through the Affordable Desalination Collaboration (ADC). ADC is a non-profit organization comprised of a group of industry leading companies, Federal and State government agencies, and water districts to reduce the overall cost of membrane desalination processes. Experiments will be conducted by the City of El Paso, Texas Water Utilities (a non-biased entity) at their new brackish groundwater desalination plant (Kay Bailey Hutchison Desalination Plant).

Keywords: brackish water, desalination, water treatment, pilot plants, membrane desalination costs

1411 Power System Stability Enhancement in the Digitally Controlled Power System

Summary: Preventing blackouts by integrating generator governors with other system controllers.

Contact: J. Agee, jagee@usbr.gov

Research Question:

- How can Reclamation generator controllers be more effectively integrated with powerplant and power system area controllers to provide added power system reliability (preventing blackouts)?
- How can individual generator governors be better integrated with powerplant and area generation controllers and power marketing agency Automatic Generation Control (AGC) systems, and how can individual generator voltage regulators be better integrated with area voltage controllers?

We will address these questions.

Need and Benefit: Better integration of generator governors can lead to better efficiencies in hydropower control and marketing. Substantial gains can be realized from even small improvements in hydropower plant efficiency.

This section contains Intellectual Property and it cannot be displayed. If you wish to view this content, contact J. Agee to request additional information.

Keywords: generators, governor, hydropower, power reliability, intellectual property

1482 North American Electric Reliability Corporation and Western Electricity Coordinating Council Generator Testing and Modeling Requirements

Summary: Increasing the efficiency in obtaining data and validating powerplant models.

Contact: Kyle Clair, kwclair@usbr.gov

Research Question:

- Can we increase the efficiency in obtaining data and validating powerplant models, thereby saving Reclamation a significant amount of money and resources?
- How accurate does a powerplant model need to be for most system studies?
- What tests or events yield the best data for powerplant model validation?
- What is the optimal and most efficient set of measurements and simulations to provide adequate computer models?
- What new data collection equipment and software can be developed to increase the efficiency of obtaining the data?

We will determine how to increase efficiency in obtaining data and validating powerplant models using a series of tests and measurements of the response of the equipment, followed by a computer simulation of the measured event and adjustments to the model until the model produces similar results. The project will have a full report, with recommended procedures, and technical papers submitted to the industry journals and conferences. As interim results become available, they will immediately be put to practice.

Need and Benefit: Studies showed that many generation plant models were inaccurate, which resulted in the inability to predict the type of system instability that led to the blackouts of 1996. To correct this inaccuracy, WECC requires generator owners to regularly validate the computer models representing their plants. Reclamation could spend close to $1.5 million in the next 5 years to validate computer models of its powerplants. Although computer model validation has been shown to significantly improve the accuracy of system simulations, there is very little quantitative evidence that it can be used to base guidelines or procedures for obtaining data, performing the validations, or determining the quality of the resulting model. There are no uniform benchmarks for measurement of model accuracy. Increasing the efficiency in obtaining data and validating models could save Reclamation a significant amount of money and resources.

Partners:

Keywords: powerplant, model, efficiency, data collection, validation, generators

3107 Affordable Self-Cleaning Trash Rack

Summary: Developing a low-energy, solar-powered, self-cleaning trash rack system for irrigation canals.

Contact: Tom Gill, tgill@usbr.gov

Research Question:

- Can a self-cleaning, low-head, solar-powered, low-energy trash rack system be developed that can effectively remove debris from irrigation canal systems?
- Can this system be widely applied and be cost effective for irrigation districts?

Floating debris accumulation can require hourly attention from ditchriders. Developing a self-cleaning trash rack will reduce time, labor, and money invested in canal maintenance.

We will develop and test a self-cleaning trash rack system that can be solar powered and that effectively clears debris from the trash rack. We will develop and test a prototype system at the Water Resources Research Laboratory in Denver, Colorado. It will then implement a prototype self-cleaning trash rack at one field site with significant debris accumulation for demonstration testing. The prototype self-cleaning trash racks will then be implemented at other field sites for demonstration testing.

Need and Benefit: Existing trash rack cleaning systems can be equipment intensive and well out of the range of affordability for many irrigation systems. Other systems, such as travelling screens, may be damaged by large debris that periodically may enter canal systems and can reduce flows and create head loss. Developing this system will benefit many irrigation districts that depend on Reclamation for support. Operational and economic improvement to irrigation systems is essential as agriculture is vital to Reclamation and to the American public.

Partners: Tom Green County Water Control and Improvement District 1, Angostura Irrigation District

Keywords: trash rack, renewable energy, water delivery, irrigation districts, operation and maintenance

4850 Solar Photovoltaic Desalination

Summary: Treating brackish water with solar power in rural areas and on reservations.

Contact: Mitchell Haws, mhaws@usbr.gov

Research Question:

- Can we treat impaired or brackish water sources to potable standards in areas outside of the traditional water and electrical power infrastructure grid?
- Can we use renewable energy treatment systems to treat these marginal water supplies?
- Can concentrating solar panels be used in a desalination treatment train to produce potable water supplies in these off grid locations?

This Science and Technology Program research project will result in a desalination treatment train using concentrated solar photovoltaic panels as the power and heat source to operate a multi-effect distillation system. The desired system will be portable and adaptable to the local conditions. We envision a stand-alone unit that could operate outside the traditional water and power infrastructure grid. This would be an economical and sustainable treatment system. We seek to enlist the financial and technical resources of multiple partners to develop an off-grid water and power system by examining the possibilities of using concentrating solar photovoltaic (PV) panels to generate off grid electricity to operate a desalination treatment train and then capturing and using waste heat produced by the solar photovoltaic concentrating process as the heat source for the desalination process.

Need and Benefit: Accessing water and power from traditional sources is cost prohibitive in many rural areas and on reservations because of the great distances to existing infrastructure. The “Implementation of the National Desalination and Water Purification Technology Roadmap” suggests adopting alternative energy and energy saving solutions when considering advanced water treatment.

This research identifies a system that may provide onsite renewable electricity and potable water desalination for remote water and power users. Results obtained from this research could be transferrable to many locations in the southwest with favorable solar radiation to meet needs of a variety of uses and users. Other methods of desalination require large amounts of energy to produce water and require a great deal of technical skills for operation and maintenance. The proposed method of using solar energy and distillation would need less energy and less technical skill to operate the system.

Partners: University of Arizona

Keywords: desalination, advanced water treatment, renewable energy, solar energy, rural water, Native American**,** reservations

5021 Reduced Cost Hydropower Maintenance

Summary: Reducing hydropower operation and maintenance costs while enhancing reliability.

Contact: Nathan Myers, nmyers@usbr.gov

Research Question:

- How does Reclamation reduce its largest expense (operation and maintenance [O&M] costs) while simultaneously ensuring and enhancing plant sustainability and reliability?

We address innovative developments to reduce hydropower operation and maintenance costs while enhancing reliability.

Need and Benefit: Substantial gains can be realized from even small improvements in hydropower efficiency.

This section contains Intellectual Property and it cannot be displayed. If you wish to view this content, contact Nathan Myers to request additional information.

Keywords: hydropower, operation and maintenance, reliability, intellectual property

6144 Renewable Integration and Small Hydro

Summary: Adapting Reclamation's hydropower plants to support wind energy.

Contact: Nathan Myers, nmyers@usbr.gov

Research Question:

- How will Reclamation and the hydropower industry adapt to support the successful integration of wind energy?

Need and Benefit: The electric power industry in the United States is in the midst of some profound changes that will change the way it produces, transmits, and controls electric energy. High energy prices, national security, supply uncertainties, and environmental concerns are driving public policies and utilities to develop renewable energy sources. As a result, the United States' wind energy industry is growing rapidly. Various scenarios have been proposed and studied regarding the new electrical generation profile. Recently the Department of Energy (DOE) released a comprehensive and detailed report documenting one of these studies entitled "20% Wind Energy by 2030."

Hydroelectric generation is uniquely positioned to facilitate the integration of wind energy. Hydropower is the only renewable source of electricity presently available that can support wind energy by providing the capacity and reserve needs of the power system. Hydropower is the preferred method to provide system reserves, and—unlike gas turbines, another source of reserves—it has zero emissions and zero fuel cost.

This section contains Intellectual Property and it cannot be displayed. If you wish to view this content, contact Nathan Myers to request additional information.

Keywords: renewable energy, wind energy, hydropower, intellectual property

7014 Renewable Power Generation for Water Transmission

Summary: Finding places for renewable energy on Reclamation lands.

Contact: Mitchell Haws, mhaws@usbr.gov

Research Question:

- Are there opportunities to install solar technologies on Reclamation project land and rights-of-way?
- Can we better use Reclamation project lands by using alternative power generation capabilities?

We will:

- Examine various renewable energy methods (e.g., solar photovoltaic, concentrated solar photovoltaic, solar thermo, sterling engines).
- Determine the best locations on Federal property to tie into existing transmission infrastructure.
- Explore the possibilities of covering Reclamation project canals with solar panels to produce power and reduce evaporation. Solar panels could also be located on project right-of-ways in order to best used project lands.
- Perform engineering and cost estimate analyses.
- Provide results and recommendations.

Need and Benefit: We will first focus on the Navajo Power Generation Station (NGS), Arizona. If the Environmental Protection Agency (EPA) and the National Parks Service (NPS) require more stringent standards or reduce power generation from the NGS, there will be a significant economic impact to Reclamation, along with many of Reclamation's partners. This research will help**:**

- Provide clean energy alternatives for powering pumping stations and renewable energy credit
- Provide potential replacement power for losses
- Minimize evaporation from open canals
- Fulfill future system power requirements
- Provide additional power for the future

Partners: Navajo Power Generation Station in Arizona

Keywords: power generation, solar, solar over canals, rights-of-way, evaporation, renewable energy

8301 Enhancement of Hydroturbine Operational Flexibility for Powerplant Cost Optimization

Summary: Optimizing operations and improving overall hydropower plant efficiency with rough zone management.

Contact: Ted Bechtel, tbechtel@usbr.gov

Research Question:

- What modifications can be made to powerplant controls to optimize operations and improve overall plant efficiency based on exclusion zone management?

This Science and Technology Program research project will develop methods for improved redefinition of hydroturbine exclusion zones in terms of operational range and maintenance costs. (Exclusion zones are defined as generation ranges producing rough operation and cavitation.)

Based on historical data obtained on site and discussions with appropriate power marketing staff, we will determine the tradeoff between increased revenue associated with greater regulation/reserves and maintenance costs from expanded operations in the vicinity of exclusion zone boundaries.

Need and Benefit: This research will help improve Reclamation's powerplant efficiency and operations.

This section contains Intellectual Property and it cannot be displayed. If you wish to view this content, contact Ted Bechtel to request additional information.

Keywords: exclusion zone, rough operation and cavitation, powerplant efficiency, optimization cost model, intellectual property

9608 Generator and Supervisory Control and Data Acquisition Controls Modification for Wind Integration

Summary: Improving hydropower plant controls to integrate wind and solar power.

Contact: J. Agee, jagee@usbr.gov

Research Question: Can Reclamation change generator speed governor and SCADA controls to improve the integration of wind and solar power into the Western United States' power system?

This Science and Technology Program research project develops improvements in hydropower controls.

Need and Benefit: Using all of our nation's renewable energy supplies is the key to providing power for the next generation. As second largest producer of hydroelectric power in the Western United States, Reclamation needs to remain on the cutting edge of integrating wind and solar power into the grid.

This section contains Intellectual Property and it cannot be displayed. If you wish to view this content, contact J. Agee to request additional information.

Keywords: wind, solar power, hydroelectric power, renewable energy, intellectual property

9629 Power System Safety

Summary: Preventing personnel injuries and reducing or eliminating potential damage to equipment.

Contact: Eric Eastment, eeastment@usbr.gov

Research Question:

- What are effective ways to address personnel safety topics?

Power system safety is formulated to develop solutions for personnel safety in Reclamation power generation and other supporting facilities (switchyards, battery rooms, other non-power generating facilities, tunnels, etc.).

Need and Benefit: We will address personnel safety topics related to arc flash prevention and control, power system apparatus grounding, and personal protective grounding issues. The broad approach is designed to encompass safety issues that compromise employee safety within Reclamation facilities. The research is aimed at preventing personnel injuries and reducing/eliminating potential damage to equipment.

This section contains Intellectual Property and it cannot be displayed. If you wish to view this content, contact Eric Eastment to request additional information.

Keywords: safety, personnel, safety equipment, intellectual property

9933 Effective Cavitation Detection Techniques for Hydraulic Turbines

Summary: Effectively detecting cavitation damage in hydropower generators to better manage hydropower.

Contact: John Germann, jgermann@usbr.gov

Research Question:

- Can Reclamation effectively reduce scheduled outages, improve machine performance, and reduce repair time and maintenance costs on its generating units by using new and improved cavitation detection techniques?

Cavitation is the formation of vapor bubbles in a liquid when the pressure of the liquid falls below its vapor pressure. Cavitation damages hydraulic machinery by eroding machine parts and decreasing turbine performance. We will continue to test and improve Reclamation's cavitation detection and monitoring techniques.

In 2004, Reclamation tested commercially available cavitation monitors, but they did not work well and could not distinguish damaging cavitation from non-damaging cavitation. This new detector uses a shaft mounted Acoustic Emissions (AE) sensor to wirelessly transmit high frequency signals from the turbine shaft. Wireless technology has advanced in the last 2 years to where it can be used for this purpose. We will continue to develop and test this cavitation detection system.

Need and Benefit: Turbine outages to inspect and repair cavitation damage result in lost revenue during unit downtime. For example, the Grand Coulee Power Office at Grand Coulee Dam can spend up to $400,000 per year per unit for cavitation repairs on the third powerplant units. Production losses for these extended outages are very expensive, and lost power revenue due to repair outages can run into the hundreds of thousands of dollars per day for these units.

Integrating wind power into the power system increases the need for cavitation detectors. A wide range of a generator output was prohibited because cavitation may occur within this "cavitation zone." As more wind power is added to the system, hydropower will need to provide additional regulation and large "cavitation zones," so prohibited operations will become very costly and limit Reclamation's ability to support wind power.

Reclamation's goal is to extend its machine condition monitoring capabilities by measuring and analyzing erosive cavitation in cavitation-prone units. A long-term goal is to be able to predict erosive cavitation so that it is possible to quantify dollars associated with damage from operating in cavitation prone areas.

Partners: Reclamation's Wyoming Area Office will make the cavitation prone units at Fremont Canyon, Wyoming, available.

Keywords: hydropower, Fremont Canyon Powerplant, cavitation, machine conditioning, wind power, hydroelectric turbine, wireless technology

Directed: Pump Storage Study-Energy/Water Nexus under Climate Change

Summary: Finding ways to get more pumped generation.

Contact: Joe Kubitschek, jkubitschek@usbr.gov

Research Question:

- What opportunities does Reclamation have for pumped generation at our existing facilities?

We will:

- Identify opportunities for retrofit/conversion for pumped generation at existing Reclamation facilities, including technical considerations and requirements
- Develop a screening process for candidate facilities that integrates technical, environmental, and economic considerations
- Select and develop alternatives for the most favorable candidate facility
- Perform economic analyses for these alternatives
- Report findings

Need and Benefit: Pumped storage flattens out load variations on the power grid, helping hydropower plants continue operating at peak efficiency, while reducing the need for "peaking" powerplants that use costly fuels. However, capital costs for purpose-built hydrostorage are high. Determining ways to retrofit our existing facilities could provide an economical and environmentally sound way to provide power.

Partners:

Keywords: hydropower, pumped storage

Contents

400 An Analysis of Nanofiltration Treatment Applications on Recycled and Potable Water Supplies

Summary: Examining nanofiltration to treat recycled water for use in cooling towers.

Contact: Erik Jorgensen, ejorgensen@usbr.gov

Research Question:

- Can nanofiltration (NF) provide water of sufficient quality while consuming less energy and at lower expense than reverse osmosis (RO)?

Recycled water is often too saline for use in certain applications, such as providing feed water for cooling towers and energy generation facilities. Its high salt content may shorten the life of such facilities through increased scaling and corrosion. As a result, recycled water used in these applications usually requires treatment for salt removal, and RO is the most commonly used method for this treatment. We will perform a literature review and analyze the applicability of NF technology to replace RO, culminating in a research report and a preliminary work plan for a future pilot project (if applicable).

Need and Benefit: Recycled water is a growing water resource that, with proper treatment, can be used in a variety of non-potable ways. Using recycled water for cooling towers and energy production can alleviate stress on many water utilities, reduce the need for them to seek out additional sources of water, reduce the amount of water that must be treated to potable water standards, and conserve existing water supplies. Demonstrating the feasibility of using NF rather than RO to treat recycled water for these applications should reduce both the cost and the environmental impact of such treatment and lead to greater use of recycled water nationally and globally.

Partners: The Texas Water Development Board, Dallas Water Utility, the San Antonio Water System, and the City Public Service Energy have provided written letters of commitment for in-kind services to support this Reclamation study.

Keywords: Water recycling, water treatment, nanofiltration (NF), reverse osmosis (RO), desalination

536 Membrane Pretreatment with Ion Exchange for Natural Organic Matter Removal

Summary: Improving desalination membrane cleaning times to save money and provide cleaner water.

Contact: Steve Dundorf, sdundorf@usbr.gov

Research Question:

- How can we improve desalination membrane cleaning times?

Natural Organic Matter (NOM) fouls membrane in pretreatment and desalination systems. Removing a fraction of NOM with an ion exchange pretreatment system from water treatment membranes saves costs and provides water quality.

We will investigate ways to substantially reduce membrane fouling reduction by using a proprietary ion exchange pretreatment system (MIEX), which has substantially lowered membrane cleaning times. Reclamation is partnering with Orica, and we hope to determine what fraction of organic matter needs to be treated to reduce membrane fouling by using NOM removal fractionation techniques.

Need and Benefit: Removing a certain fraction of NOM may be more desirable and less expensive and a cost savings for all Reclamation clients using a membrane filtration process for water treatment.

Partners: Orica

Keywords: ion exchange pretreatment system, natural organic matter, NOM, MIEX

3195 Evaluation of Hybrid Pulsed-Power Electromagnetic/Reverse Osmosis System

Summary: Investigating scaling and fouling reduction in membrane systems by electromagnetic devices.

Contact: Katherine Guerra, kguerra@usbr.gov

Research Question:

- What is the chemical/physical mechanism associated with scaling/fouling potential reduction when using an electromagnetic/reverse osmosis (EM/RO) system?
- What is the best process configuration for the EM/RO system?
- Should the EM device be placed on the feed or concentrate stream?
- Should the EM device be placed on the pretreatment system?
- Would more than one EM device be beneficial?

Preliminary research suggests that EM devices may reduce scaling and organic fouling in RO membrane systems. We will test an electromagnetic device to address those questions. Currently, scale formation is one of the largest issues for RO desalination of brackish water. If successful, the EM device will prove to reduce scale formation, resulting in operation and maintenance cost savings for RO water treatment systems.

Need and Benefit:

The benefits of reduced scale formation include:

- A decrease in scale inhibitor chemical requirements for RO systems
- An increase in feedwater recovery, which equates to a smaller volume of concentrate for disposal

Both of these benefits are in line with the National Research Council (NRC) report on desalination and support the strategic research agenda to lower the cost of desalination.

Partners: University of Colorado and GE Osmonics

Keywords: electromagnetic/reverse osmosis, EM/RO, scaling, organic fouling, electromagnetic

3259 Treatment and Beneficial Use of Produced Water in the Western United States

Summary: Can beneficial use of oil and gas produced water be cost effective and environmentally sustainable?

Contact: Katie Guerra, kguerra@usbr.gov

Research Question:

- Can produced water quality, geographic location, and treatment requirements be matched with local beneficial uses of produced water to identify economically favorable produced water re-use projects?

In many areas of the Western United States, produced water, from oil and gas operations, can serve as a drought-proof water supply, relieving the stress on conventional water supplies. Water exists naturally in subsurface formations along with oil and gas. The oil and gas extraction process commonly generates large quantities of water, referred to as "produced water." Estimates for the volume of water extracted are roughly 5 billion gallons per day from onshore operations in the United States. Produced water is considered a waste byproduct by the oil and gas industry. Generally, the produced water is either injected back into the formation to wash out more oil or discharged to the surface, where it causes environmental problems.

However, in many cases, especially in the Rocky Mountain region, oil and gas production occurs in areas where there is a need for additional water supplies. If treated to appropriate standards or managed properly, produced water could serve as a "new" water supply and reduce the cost and environmental impact of energy production. We will help identify ways to treat that water supply.

Need and Benefit: This work combines Geographic Information System (GIS) mapping of produced water occurrence and potential beneficial uses of produced water to identify practical produced-water projects. Reclamation will benefit from this research through identifying projects that could augment water supplies for the Western United States. This work also considers the geographic distribution of water quality in terms of the water quality requirements for different types of beneficial use, including irrigation and livestock watering, streamflow augmentation, and municipal and industrial applications.

Partners: The Division of Economics and Business at the Colorado School of Mines as well as other industrial partners

Keywords: produced water, beneficial use, management strategies, coal bed methane, oil and gas operations, water resources, water treatment

3464 Concentrate Management Modeling, Design, and Optimization

Summary: Can computerized modeling help us reduce the waste in reverse-osmosis desalination?

Contact: Saied Delagah, sdelagah@usbr.gov

Research Question:

- Can reverse-osmosis (RO) concentrate streams be further dewatered to cost effectively reduce the volume of concentrate that needs disposal and to recover additional water contained in the concentrate?

- Can state-of-the-art process-simulation software accurately model concentrate handling unit operations that will be encountered in concentrate minimization and water reuse?

The OLI software model is used in the oil and gas industry and is highly regarded for its electrolyte modeling capabilities. We will investigate whether this model can adequately predict complex aqueous behavior in concentrate streams.

Need and Benefit: Membrane processes are becoming a technology of choice for the water purification industry. Purification of sea and brackish water creates new sources of water that enhance the nation's conventional water supplies. The concentrate generated from membrane desalination contains the particulates and salts that were removed from the feed water. The volumes of concentrate can be anywhere from 15 to 50 percent of the total feed water. The management of these concentrate streams represents a significant waste disposal cost and the loss of additional valuable water contained in the concentrate stream.

Minimizing the concentrate stream depends on being able to predict which processes will achieve optimal results. Currently, no tool has been verified that can model concentrate streams comprehensively and be able to predict their behavior as they are further dewatered. We plan to develop and evaluate tools for performing virtual process design, thus reducing the likelihood that costly experimentation may be conducted under unpromising conditions.

Partners:[1]

Keywords: reverse osmosis, desalination, water purification, concentrate management, modeling, concentrate disposal

[1] Note that where we have not identified or solidified partnerships, this heading is left blank.

4141 Assessment of Low-Pressure Membrane Technology to Reduce the Cost of Desalination

Summary: Optimization of low-pressure membrane technology for desalination pretreatment.

Contact: Katie Guerra, kguerra@usbr.gov

Research Questions:

- What material properties affect membrane solute rejection and water productivity?
- What feed water characteristics are important to consider when selecting a membrane product?
- What are the operating conditions that affect membrane solute rejection and treated water productivity?
- What are the conditions under which ceramic membranes are more economically favorable than polymeric membranes?
- How is the flux of ceramic membranes affected by water quality parameters, operating conditions, and cleaning conditions, and how does this compare to polymeric membranes?
- How do changes in operational and water quality parameters affect the overall cost of operation for a low pressure membrane system?

We will conduct a literature review and experiments, develop a life-cycle cost model for low pressure membrane systems, and demonstrate the benefits of using a mixed-integer non-linear programming approach to minimize the life-cycle cost model for low pressure membrane systems.

Need and Benefit: Water treatment applications using low pressure membranes for bacteria, viruses, organics, and particulate removal can be used in place of expensive, labor-intensive conventional treatment processes. Effective use of low-pressure membranes can also significantly decrease the cost of desalination and traditional water treatment and substantially reduce the energy demand for water production. However, there is little guidance to help membrane users select the most efficient low-pressure membrane pore size, material, and process operating conditions; this research will help to fill that gap in knowledge. Reclamation has access to operating plant data, research reports not available to the general public, and laboratory equipment and facilities to conduct this work. Therefore, Reclamation can play a crucial role in reducing the cost and carbon footprint of this technology.

Partners: We will be seeking industry partners to provide materials and knowledge on full-scale membrane plant operation.

Keywords: desalination, advanced water treatment, membranes, low-pressure membranes, life-cycle cost model

5840 Slowsand Filtration for Reducing Costs of Desalting Surface Waters

Summary: Slowsand filtration can save municipalities 75 percent of water treatment costs and 20 percent of water desalting costs.

Contact: Chuck Moody, cmoody@usbr.gov

Research Question:

- Does slowsand filtration (SSF) effectively remove particulates from water so that reverse osmosis (RO) desalting equipment can operate with little or no fouling?

For desalting surface waters, this study evaluates SSF and RO to achieve breakthrough cost savings of 20-30 percent compared to conventional treatment and RO and microfiltration (MF) and RO.

Two recent Reclamation studies have produced exciting results: *Alternatives for Using Central Arizona Project Water in the Northwest Tucson Area* (2000) and the Science and Technology research project ID: 361: *Slowsand Filtration for Reducing Costs of Desalting Surface Waters*, which sponsored the Pilot Investigation of Slowsand Filtration and Reverse Osmosis Treatment of Central Arizona Project Water (2002). These studies estimate that, at the Yuma Desalting Plant, SSF costs 75 percent less than conventional water treatment or MF water treatment. For pretreatment filtration to RO desalting equipment, the studies estimated that with SSF, SSF-RO can reduce total desalting costs (including concentrate disposal by a low-volume Central Arizona Salinity Interceptor [CASI] through Yuma) by a breakthrough 20 percent compared to conventional treatment with RO and MF with RO.

Need and Benefit: Desalting offers "drought-proof" water supplies to communities with brackish waters or seawater. By reducing the cost of desalting surface waters (including seawater), SSF-RO expands the use of desalting for providing drought-proof water supplies. To save municipalities 75 percent of surface water treatment costs and 20 percent of surface water desalting costs, Reclamation can perform a valuable public service by developing SSF-RO and conducting pilot tests evaluating the SSF-RO combination on Colorado River water as it simultaneously evaluates SSF-RO for the Yuma Desalting Plant. Reclamation is best positioned to conduct the research and implement the results because**:**

1. Reclamation operates the state-of-the-art pilot-scale Water Quality Improvement Center (WQIC) in Yuma, Arizona
2. Reclamation engineers are familiar with SSF-RO

Further, Reclamation has no vested interests marketing SSF because it offers no commercial incentive to private companies.

Partners:

Keywords: desalination, advanced water treatment, slowsand filtration, SSF, reverse osmosis, RO, Yuma Desalting Plant, Water Quality Improvement Center, WQIC

7251 Groundwater Reliability Improvement Program through Indirect Potable Reuse

Summary: Can nanofiltration and reverse osmosis be used to recover wastewater?

Contact: Greg Krzys, gkrzys@usbr.gov

Research Question:

- Will an integrated nanofiltration/reverse osmosis (NF/RO) water purification system increase overall recovery to greater than 90 percent through operation of the NF membranes at higher fluxes and recoveries at lower pressure?

We will construct a demonstration-scale wastewater treatment system in the Los Angeles area incorporating NF for primary treatment and RO for secondary treatment. We will then evaluate, separately, the performance of each of the two system components. The study will be conducted over 1 year, with approximately 6 months of actual testing.

Need and Benefit: Water supply reliability in the Los Angeles Basin is growing unpredictable due to continued population growth, drought, climate change, and growing environmental water needs. Tapping into alternative sources of water is becoming a necessity. One alternative has been implemented by the Orange County Water District, which has demonstrated that treated wastewater can be used to replenish groundwater aquifers and withdrawn later for potable use. Recharge of the aquifer also reduces the potential for subsidence and improves water quality.

This research will demonstrate the use of an NF/RO process to treat up to 54.5 million gallons per day of effluent from the Los Angeles County Sanitation District. The demonstration, if successful, would achieve a higher recovery rate than other existing treatment technologies and also reduce the capital and operation and maintenance costs. The product water (up to 46,000 acre-feet per year) would be used to recharge the Central and Main San Gabriel groundwater basins east and south of Los Angeles.

Partners: California Department of Water Resources, City of San Bernardino Water Department, City of San Diego Water Department, County Sanitation District of Los Angeles County, Inland Empire Utilities Agency, Los Angeles Department of Water and Power, Metropolitan Water District of Southern California, Orange County Sanitation District, Otay Water District, Rancho California Water District, San Diego County Water Authority, Santa Ana Watershed Project Authority, Southern California Salinity Coalition, Western Municipal Water District

Keywords: wastewater treatment, nanofiltration, NF, reverse osmosis, RO, groundwater recharge, water recycling

7720 West Basin Ocean Water Desalination Demonstration

Summary: Desalting seawater while saving energy and managing concentrates.

Contact: Saied Delagah, sdelagah@usbr.gov

Research Question:

- What is the effectiveness and energy savings of a demonstration study of an isobaric energy recovery system that uses high-efficiency pumps and energy efficient reverse osmosis (RO) membranes?

West Basin Municipal Water District (West Basin MWD), California, will be conducting an ocean water desalination demonstration study that builds on the 6-year pilot study completed in 2008. Reclamation helped this pilot through the Desalination and Water Purification Research (DWPR) program. The upcoming demonstration plant will study:

- The plant's energy usage to minimize energy consumption and carbon footprint. The proposed energy reduction study will focus on the implementation of an isobaric energy recovery system as well as the use of high-efficiency pumps and energy efficient RO membranes. The study will evaluate the effectiveness of the above strategies as well as the overall energy savings gained from the implementation of the above strategies.

- Concentrate management and the effects of high salinity discharge of concentrate produced in ocean water desalination plants on aquatic environments surrounding the discharge.

We will aid future sea water desalination plants and help establish regulatory limits for concentrate discharge. Reclamation will be involved in designing the plant, developing the research test plan, providing quality assurance/quality control, and assisting in possible onsite operation of the demonstration plant. This project will also aid in oversight of West Basin MWD's study.

Need and Benefit: Environmental regulations associated with concentrate discharge to the ocean pose a serious challenge to successful full-scale coastal desalination. Studies such as this must prove the safety of concentrate disposal to the ocean to overcome regulatory and environmental hurdles. Otherwise, all the membrane advancement in the world would be moot, as no viable concentrate disposal exists to deal with the large quantities of concentrate generated from desalination plants.

Partners: West Basin MWD

Keywords: desalination, water treatment, demonstration plant, concentrate disposal, concentrate management, sea water, energy reduction, isobaric energy recovery system

8380 Developing the Next Generation Chlorine-Resistant, High Flux, and High Salt Rejection Polyamide Desalting Membrane to Increase Water Supply

Summary: Building a better polyamide membrane for desalination.

Contact: Yuliana Porras Mendoza, yporras@usbr.gov

Research Question:

- Can we achieve both chlorine stability and membrane performance within the polyamide system?
- If this is possible, how can we best synthesize the next generation chlorine-resistant desalting membrane?

This Science and Technology Program research project builds on chemical studies from previous research project 526, *Developing the Next Generation Polyamide Desalting Membrane to Increase Water Supply*. This research will also improve ways to prevent fouling and biofouling of the new membrane.

Need and Benefit: Significant advances in these areas would increase the water supply by lowering the overall costs for desalting operations by increasing membrane life and minimizing downtime due to cleaning and/or membrane replacement.

This section contains Intellectual Property. Contact Yuliana Porras Mendoza to request additional information.

Partners: Reclamation is currently seeking partners to license and commercialize this technology.

Keywords: desalination, polyamide, membrane, water treatment, biofouling, fouling, license, commercialize, intellectual property, reverse osmosis, RO

8944 Forward Osmosis Water Purification

Summary: Improvements to FO membranes and process can significantly reduce capital and energy costs for membrane separation plants.

Contact: Chuck Moody, cmoody@usbr.gov

Research Question:

- To reduce desalting costs, can we develop Forward Osmosis (FO) to purify water at lower cost than reverse osmosis?

FO employs a membrane similar to RO, but the saltwater is not pressurized to force it through the membrane. If two solutions are placed on either side of a semi-permeable membrane, water will move toward the side with the higher concentration of solutes. Thus, if a concentrated solution of water and fertilizer (the "driving solution") is placed opposite a volume of seawater (the "source water") the natural force of osmosis will pull pure water out of the seawater and thru the membrane, resulting in a larger volume of fertilizer-charged irrigation water ("the FO product").

Need and Benefit: Efficient membranes and an engineered 2-stage FO process offer the potential for low-cost seawater desalination. As desalination plants become more affordable, FO may be a new alternative to the drinking-water shortages in many areas. The next steps consist of developing improved FO membranes and integrating and pilot testing the 2-stage FO process at Reclamation's Water Quality Improvement Center (WQIC) in Yuma, Arizona.

This section contains Intellectual Property. Contact Chuck Moody to request additional information.

Keywords: forward osmosis, FO, WQIC

9000 Cellulose Acetate Membrane Improvements

Summary: Building a better cellulose acetate membrane for desalination.

Contact: Saied Delagah, sdelagah@usbr.gov

Research Question:

- Is it possible to make relatively minor modification(s) during the synthesis of the polymer to achieve a superior cellulose acetate (CA) desalting membrane?

CA membranes make up a significant percentage of the desalting membranes used around the country. Although the intrinsic transport properties of membranes can exceed 99.5 percent salt rejection, this has not been the case in practice, due to irregularities with the CA polymer.

This ongoing Science and Technology Program research project is showing tremendous results in displaying a superior CA membrane with increased salt rejection, and the research team is investigating the Reclamation-created membrane's performance at higher pH. This membrane can operate at a higher pH without much damage to the membrane. Further investigation is needed to improve this membrane based from the lessons learned on this project.

This project contains Intellectual Property and it cannot be displayed. If you wish to view this content, contact Saied Delagah to request additional information.

Need and Benefit: Superior CA membranes can increase water production tenfold. For example, if feed water at 3,500 milligrams per liter (mg/L) is desalted with a CA membrane with 95 percent salt rejection, the product would be 175 mg/L. If a superior CA membrane existed with 99.5 percent salt rejection, the product would be 17 mg/L.

A CA membrane operating within an increased pH range improves overall desalting costs by lowering pretreatment chemical costs. The Yuma Desalting Plant, which is a CA-based membrane plant, would benefit greatly from a CA membrane could operate at higher pHs with a superior performance than commercially available membranes.

Partners: Reclamation is currently seeking partners to license and commercialize this technology.

Keywords: cellulose acetate, CA, desalination, membrane, water treatment, intellectual property, reverse osmosis, RO, commercialize, license

9316 Strategies for Treating Variable Source Water

Summary: Treating brackish water and seawater with the same desalting system.

Contact: Michelle Chapman, mchapman@usbr.gov

Research Question:

- Can a process be devised to adapt a desalting facility to treat highly variable sources of water that would allow high recovery of water when treating brackish water plant and recovery of energy when treating seawater?

Utilities may want to treat multiple sources of water with one treatment system, for example:

- The Texas Gulf Coast where brackish surface or groundwater is available for much of the year but only seawater is available during dry seasons
- South-central California where the character of the irrigation drainage water changes with the intensity of irrigation
- Inland desert areas where the composition of brackish surface and groundwater is significantly different when augmented with storm water

Reclamation assisted the U.S. Office of Naval Research in developing and demonstrating the Expeditionary Unit Water Purifier system that can produce 100,000 gallons per day of potable water from any liquid source water with up to 60 gallons per liter or total dissolved solids (TDS) under 35 °C. The system was tested under the Environmental Technology Validation (ETV) program overseen by NSF International for the U.S. Environmental Protection Agency (EPA). Test water sources were seawater, turbid surface water, and tertiary wastewater. As a complete system, it performed well with each source. However, it is only capable of 50 percent recovery of water no matter which source is used. Because of this, the system has been turned down for potential emergency applications due to the excessive loss of water. A flexible system that could achieve high water recovery when the feed source allows while still maintaining the capability of recovering energy when treating more concentrated sources (e.g., seawater) is needed.

Need and Benefit: As the variability in the climate increases, it is critical that treatment of new sources of water be developed. While energy and recovery efficiencies for systems designed for one particular water type are close to their theoretical limits, there are still efficiencies to gain for systems treating variable sources. This Science and Technology Program research project can still make a big difference in desalination cost by developing unique treatment strategies for multiple sources of water that conserve energy and water resources.

Partners: We will work with the partner water supply entities, Texas Water Development Board, Brownsville Public Utilities Board, and San Patricio Municipal Water District, to identify the composition of potential source waters that would serve as feed waters for the test system.

Keywords: desalination, variable source waters, brackish water, seawater, membranes, energy conservation

Contents

1417 Investigation of Molybdenum Disulfide and Tungsten Disulfide as Additives to Coatings for Foul Release Systems

Summary: Using Molybdenum Disulfide or Tungsten Disulfide to control biofouling from invasive mussels

Contact: David Tordonato, dtordonato@usbr.gov

Research Question:

- Is it possible to use Molybdenum Disulfide or Tungsten Disulfide as an additive for foul release coatings?

Molybdenum Disulfide and Tungsten Disulfide are used as lubricants for machinery and other tools. When in powder form, these materials are known for exhibiting very low coefficient of friction values. We will perform a literature review to evaluate the potential of using Molybdenum Disulfide or Tungsten Disulfide to create a durable coating to deter the attachment of zebra and quagga mussels (dreissenids).

Need and Benefit: This project is part of a larger coatings study to evaluate potential foul release coatings to control zebra and quagga mussel infestation on Reclamation infrastructure. Zebra and quagga mussels have the potential to cause a decreased operational reliability at Reclamations facilities due to increase head losses and potential flow blockages in cooling lines, trashracks, and other equipment. Foul release coatings are one possible solution to control fouling.

Partners:[1]

Keywords: zebra mussels, quagga mussels, dreissenids, Molybdenum Disulfide, Tungsten Disulfide, Foul release coatings, fouling, biofouling

[1] Note that where we have not identified or solidified partnerships, this heading is left blank.

1740 Resistance of Protective Coatings and Pipe Linings to High Pressure Water Jets Used for Invasive Mussel Removal and Cleaning

Summary: Can you strip invasive mussels off hydraulic equipment using water jetting without removing protective coatings?

Contact: Joshua Mortensen, jmortensen@usbr.gov

Research Question:

- What are the optimal operating criteria for high-pressure water jets that will successfully remove colonies of invasive mussels (dreissenids) from hydraulic equipment (pipelines, trash racks, gates, etc.) without damaging protective coatings on the equipment?

We will test the durability of a variety of coatings, including existing coatings, common linings used in pipelines as well as new coatings developed in Reclamation's Technical Service Center's (TSC) Materials Engineering and Research Laboratory. We expect that methods of water jet nozzle operation developed in this research will be widely applicable to hydraulic equipment and infrastructure throughout Reclamation. We also expect that determining the resistance of protective coatings to high-pressure water jets will provide criteria that are directly applicable to a variety of high-pressure cleaning systems.

Need and Benefit: Since early 2007, invasive mussels have been found in Reclamation waters, significantly impacting many areas of the water infrastructure. Colonies of mussels have caused degradation of dam facilities, spillways, power turbines, pumps, and many other components of the infrastructure. They have been particularly detrimental to water pipelines, where they have caused fouling and decreased flow capacity. To remedy this problem, researchers recently developed a high-pressure water jetting nozzle that removes mussels from inner pipeline walls. When operated from 5,000 to 10,000 pounds per square inch (psi), the water-jetting nozzle was very successful in removing mussels from pipes, but it also has been found to remove valuable coatings and linings which protect the pipes from corrosion and other degradation. The effectiveness of high-pressure jetting nozzles can be greatly increased by determining, through additional research, the optimal jetting pressures for pipe linings and protective coatings used on various other hydraulic structures.

Partners: Partnerships for this project include Reclamation's Lower Colorado Region, which is expected to provide in-kind services of facility use, implementation of field testing, and help for application to other facilities.

Keywords: zebra mussels, quagga mussels, invasive species, dreissenids, high-pressure water jets, jetting nozzle, protective coatings, pipe linings

2358 Ecological Impacts of Dreissenids on Cyanobacteria-Producing Toxins in Western Reservoirs

Summary: Is there a relationship between invasive mussels and algal blooms?

Contact: Davine Lieberman, dlieberman@usbr.gov

Research Question:

- Do zebra and quagga mussel (dreissenids) infestations in Reclamation reservoirs result in increased cyanobacteria (blue-green algae) blooms, as well as increased cyanobacteria (blue-green algae), producing algal toxins?

Algal toxins can be detrimental to human health and cause animal deaths, including cattle and dogs. Ingestion of significant levels of the algal toxin Microcystin can cause liver damage and dysfunction in humans and animals. Cyanobacteria must be present for the commonly occurring algal toxin, Microcystin LR to be present, but not all cyanobacteria produce algal toxins. Lakes and reservoirs have been closed as a result of Microcystins exceeding World Health Organization guidelines for drinking water (1 micrograph per liter [µg/L]) and recreation (20 µg/L).

Now we are discovering that dreissenids are invading waters first, followed by greater cyanobacteria blooms, and, therefore, cyanobacteria-producing algal toxins.

This research project will build on the Science and Technology research project (4939, *Managing for Algal Toxins in Reclamation's Reservoirs*). Over 300 reservoirs will be surveyed for both zebra/quagga mussels and cyanobacteria producing algal toxins. This sampling effort will be continued in 2011 and beyond. This research will map algal toxin data for Reclamation reservoirs, and investigate how dreissenids may cause problems that affect animal and human health.

Need and Benefit: Dreissenids can cause millions of dollars of damage to Reclamation’s infrastructure, and algal toxins can potentially shut a reservoir down to prevent human and animal health risks. Most of Reclamation reservoirs have never been examined for algal toxins. Now with zebra/quagga mussels infesting our reservoirs, there is a real need to investigate the influence of dreissenids on cyanobacteria producing algal toxins. Increases in algal toxins in association with dreissenids could be financial disaster, causing changes in dam operations and delivery of water.

Partners: We have worked closely with Dr. Greg Boyer's lab at the State University of New York (SUNY), New York for quality assurance and quality control on our algal toxin technique.

Keywords: zebra mussels, quagga mussels, dreissenids, algal toxin, health, water quality, algal blooms, cyanobacteria

2647 Natural Biocide Coatings

Summary: Using natural biocide coatings for invasive mussels.

Contact: Allen Skaja, askaja@usbr.gov

Research Question:

- Can we use a natural biocide on coatings for zebra and quagga mussels? Is there a way to incorporate biocides into an antifouling coating?

We will investigate ways to improve antifouling coatings.

Need and Benefit:

This section contains Intellectual Property and it cannot be displayed. If you wish to view this content, contact Allen Skaja to request additional information.

Keywords: zebra mussels, quagga mussels, dreissenids, biocide, intellectual property

2675 Modernization of Trashrack Raking Systems to Manage Quagga Mussel Settlement

Contact: Bryan Heiner, bheiner@usbr.gov

Research Question:

- Can Reclamation develop new ways of cleaning trashracks to manage quagga mussels settlement?

Many sites that contain large amounts of fouling are also concerned with increasing aquatic weeds and other debris. In particular, trashracks that experience mussel colonization have reduced open space and capture more debris than they otherwise would. Now, trashracks need to be disassembled and removed to be cleaned. We will investigate more efficient methods to clean trashracks.

Need and Benefit: Quagga mussels (*Dreissena rostiformis bugensis*) have a detrimental impact on Reclamation facilities. This invasive species can completely shut down and prevent facilities from operating as they were designed. Removing mussel fouling from infrastructure in such a way that facility operations can continue is vital to Reclamation's mission to deliver water and power in an economically and environmentally sound manner.

This project contains Intellectual Property and it cannot be displayed. If you wish to view this content, contact Bryan Heiner to request additional information

Keywords: zebra mussels, quagga mussels, dreissenids, trashracks, fouling, intellectual property

3104 Study to Determine the Feasibility of Overcoating Coal Tar Enamel with Foul Release Coatings

Summary: Overcoating coal tar enamel coatings to control biofouling from invasive mussels.

Contact: David Tordonato, dtordonato@usbr.gov

Research Question:

- Is it possible to overcoat coal tar enamel coatings with a foul-release type coating to prevent the attachment and infestation of zebra and quagga mussels (dreissenids)?

We will test and evaluate a complete overcoat system consisting of a coal tar primer, epoxy primer, and foul-release topcoat. This research builds on previous Science and Technology research with Reclamation's Materials Engineering Research Lab (MERL) which identified materials that could be used to perform repairs on coal tar enamel. The study showed that 100% solids epoxies exhibited acceptable adhesion to the coal tar and could be used for repairing coal tar enamel coatings. The proposed study will build on previous research by testing the 100% solids epoxies as primers for foul release coatings.

Need and Benefit: Reclamation commonly used coal tar enamel as a coating on penstocks, scroll cases, outlet works and other infrastructure until the late 1970s. The coating contains known carcinogens and proper precautions must be taken for removal and disposal. Furthermore, experience has shown that under ideal conditions, an existing coal tar system may last over 100 years. Therefore, it is preferable to leave the existing system intact. However, some equipment coated with coal tar may be susceptible to dreissenid infestation where water velocities are below 6 foot per second (ft/s), causing increased head loss reducing overall efficiency. The proposed investigation may help to create an economically viable method for controlling mussel infestation where coal tar enamel is currently present.

Partners:

Keywords: zebra mussels, quagga mussels, dreissenids, coal tar, coal tar enamel coatings, coatings, foul release coatings, biofouling, epoxy, primer, topcoat

3318 Impact of Quagga Introduction on Reservoir Water Quality

Summary: Studying the ecological impacts of quagga mussels in Lake Mead, Nevada.

Contact: Mike Horn, mhorn@usbr.gov

Research Question:

- What are the ecological impacts of quagga mussels?

We have a good idea of when quagga mussels entered in Lake Mead, Nevada, the first Reclamation system to have been invaded—and now dominated by quagga mussels. Moreover, a nearly 20 year dataset exists for Lake Mead and the Las Vegas Wash inflow area. This dataset includes a comprehensive set of nutrient data, chlorophyll, zooplankton, phytoplankton, secchi depth, and water quality profile. Analyzing this unique long-term dataset should allow us to identify specific quagga mussels impacts on the reservoir community. This information would significantly help advance the science of understanding the consequences of this species as it spreads to other areas.

We will take the entire time series data set and overlay the appearance of quagga mussels. We will then correlate the appearance of quagga mussels to any changes being observed to have taken place over that time period.

Need and Benefit: The long-term datasets may increase our ability to separate changes associated with quagga mussel introduction from those changes associated with short-term climatic events.

Analyzing this dataset to determine if changes have occurred over time to the Lake Mead ecosystem will provide valuable insight as to what might be expected to occur should this species successfully colonize other Reclamation facilities.

Partners:

Keywords: zebra mussels, quagga mussels, dreissenids, ecological impacts, Lake Mead, water quality

3997 Impact of Quagga Mussel Introduction on Particulate Organic Matter Drift, Ecosystem Level Impacts

Summary: How do quagga mussels affect particulate organic matter and water quality in the lower Colorado River?

Contact: Mike Horn, mhorn@usbr.gov

Research Question:

- How do quagga mussels affect Particulate Organic Matter (POM) and water quality in the lower Colorado River?

POM supports the base of the food web in aquatic systems, and is one of the many factors determining the makeup of aquatic communities in riverine ecosystems. Quagga mussels efficiently filter POM from the water column. Quagga mussel infestations can lead to changes in the entire food chain, potentially impacting sport fisheries, native and endangered species, and water quality in reservoirs and downstream areas. An effort is currently underway to determine changes occurring within Lake Havasu. This research will complement that ongoing study.

We will closely replicate the previous study "Limnology and Drift of Particulate Organic Matter through the Lower Colorado River" Davine Lieberman, Thomas Burke REC-REC-91-1, April 1991, Denver Office, which sampled a series of stations from Davis Dam, Arizona and Nevada, downstream to near the Mexican border. At each site, basic water quality data (e.g., temperature, dissolved oxygen, specific conductance, ph and turbidity and flow) will be recorded. POM will be collected using drift nets and size fractionated into <25micrometers (µm), >25-505µm, and >505µm. Based on changes detected, predictions can then be made as to potential larger scale impacts to water quality and/or fisheries issues on the lower Colorado River.

Need and Benefit: These results can then be expanded to make predictions for other drainages where Reclamation projects exist and where Reclamation has significant investment in specific fisheries or other habitat related issues as a result of ongoing operations. This research project will provide valuable information for predicting impacts in other areas and help identify issues that may be impacting ecosystem health in the lower Colorado Rivers.

Many Reclamation projects have significant investment in helping maintain or restore sport fisheries, and/or native species whose survival has been impacted by ongoing operations. Without the types of studies being proposed here, it will be very difficult for managers to develop new plans ensure Reclamation still meets the terms of agreements it has reached with other regulatory agencies.

Partners:

Keywords: zebra mussels, quagga mussels, dreissenids, particulate organic matter, ecosystems, POM, ecological impacts, lower Colorado river, sport fisheries, native species

4111 Investigating New Fish Screening Technology and Modification of Existing Infrastructure to Reduce Impacts of Invasive Quagga and Zebra Mussels on Reclamation Facilities

Summary: New fish screening and operation technologies resistant to zebra and quagga mussels.

Contact: Cathy Karp, ckarp@usbr.gov and Brent Mefford, bmefford@usbr.gov

Research Question:

- What new fish screening and operations technologies are available that are resistant to mussel attachment and can be successfully operated in waterways with high densities of mussels?

We will investigate new technologies, including screen materials (plastics, fabrics, and alloys), cleaning techniques (scrapers, shakers, and high pressure jets), screen coatings and differing screen types (traveling screens, conical, circular). There may be ways of combining these technologies to shorten the study time or prioritize techniques that show the most promise.

Need and Benefit: The testing and determination of technologies to be able to allow water delivery in mussel-infested areas must be developed prior to infestation. This research allows evaluations and tests to be performed ahead of potential problems that could cost Reclamation a substantial amount of money and reduced ability to deliver water.

Partners:

Keywords: zebra mussels, quagga mussels, dreissenids, invasive mussels, trashracks, trashrakes, new materials, cleaning methods, screen coatings, screen types, screen materials

4442 Environmental Effects and Spread of Zebra and Quagga Mussels in Flowing Water Systems in the Western United States

Summary: What problems are invasive mussels causing in Reclamation waters?

Contact: Mark Nelson, snelson@usbr.gov

Research Question:

- How do Dreissenid mussels (*Dreissena polymorpha/bugensis*) and other benthic organisms interact and how do these interactions affect the mussel infestations in Reclamation waters?

We will use a combination of sampling methods to study effects of mussel invasion on benthic communities and will include sampling lotic environments with both kick-net and colonization samplers. Each of these methods has its strengths and weaknesses, and data will be collected in a complementary manner.

Along with examining potential impacts to aquatic macroinvertebrate sources, we will examine the role that streams might play in invasion of other reservoirs by zebra mussels. In most studies, zebra mussel populations are attenuated in a downstream direction. It is unclear whether this might differ in western states and information would be collected to determine whether this secondary dispersal method could allow from invasion of downstream reservoirs.

Need and Benefit: Reclamation operates numerous reservoirs and associated structures in the Western United States which may be impacted by Dreissenid mussels. In some cases, operations depend on management guidelines that prevent adverse impacts to fisheries.

Study of effects of Reclamation facilities on biology is a very specialized area with little expertise developed outside of Reclamation. Information from Reclamation's studies will help regional natural resources management staff reduce the risk of Reclamation water facilities in receiving violation notices under Federal or State laws that could negatively impact water deliveries. Information on the secondary spread of mussels in systems with multiple reservoirs would be helpful to operations and maintenance and natural resources management staff in predicting the probability of further infestations. These mussels may severely impact water delivery systems.

Partners:

Keywords: zebra mussels, quagga mussels, dreissenids, invasive mussels, water delivery, benthic organisms

4601 Are there Similarities between Water Quality Parameters in Western Reclamation Reservoirs Infested with Dreissenids: Database Analysis

Summary: Why do invasive mussels occur where they do?

Contact: Davine Lieberman, dlieberman@usbr.gov

Research Question:

- Are there similarities between water quality parameters in Reclamation reservoirs infested with zebra/quagga mussels (dreissenids)?
- Why do dreissenids occur where they do?

Dreissenids may expand throughout Reclamation's reservoirs. We do not understand the limnology of many of our reservoirs, a foundation for investigating the similarities of dreissenid infestations. We will examine water quality data being compiled by the American Recovery and Reinvestment Act of 2009 (ARRA) zebra mussel project. Water quality data being compiled from each reservoir where veligers are being collected can lead to a wealth of knowledge, if data are used. Much of the database information will be new, since many of the 300 reservoirs have never been sampled for physical, chemical, or biological parameters (e.g., dissolved oxygen, pH, water temperature, specific conductance, complete ions, nitrogen and phosphorus, chlorophyll, phytoplankton, zooplankton, and algal toxins).

The database contains frequency, densities, and location of dreissenids to date, but at present, these data have not begun to be placed in graphs or tables with corresponding water quality data. This research project will expand and use this database to examine the water quality data for up to 300 reservoirs across the Western United States.

Need and Benefit: Millions of dollars are spent to be able to continue operating Reclamation dams and facilities with dreissenid infestations. Examining even the reservoirs without any dreissenids will add to our understanding of the potential of dreissenids to infest these waters. Using the database as a tool in finding similarities in water quality parameters between reservoirs may help in providing management strategies for dreissenids.

All of this information can lead to better management practices of Reclamation-wide reservoirs. Information gathered from the database will greatly add to zebra mussel program by providing a snapshot of each reservoir, and similarities that exist between dreissenids-infested waters.

Partners:

Keywords: zebra mussels, quagga mussels, dreissenids, water quality

5091 Biochemical and Biomechanical Characteristics of Invasive Mussel Adhesion

Summary: How do invasive mussels adhere to infrastructure?

Contact: Allen Skaja, askaja@usbr.gov

Research Question:

- What are the chemical and physical source processes, composition, and properties of adhesion for zebra and quagga mussels?

We will review literature to determine the state of knowledge for invasive mussel adhesion characteristics and properties (physical and chemical) to identify knowledge gaps, future research needs, and opportunities for development of new settlement prevention technologies (e.g. coatings and/or alternative adhesion inhibitors). This will help guide future research on mussel settlement prevention and facilities protection strategies and technologies.

Need and Benefit: Dreissenids can cause millions of dollars of additional maintenance to Reclamation's infrastructure. Reclamation is perusing economical and environmentally sound methods to protect the wide variety of infrastructure by preventing mussels from settling on infrastructure. Reclamation needs to find economical and environmentally sound methods to protect the wide variety of coatings used on its infrastructure by preventing mussels from settling on infrastructure under water. Thus, mussel biochemical and biomechanical adhesive properties need to be investigated. There is a lot of information available on bioadhesives, but we do not know the extent of information for zebra and quagga mussels adhesives.

Partners:

Keywords: zebra mussels, quagga mussels, dreissenids, bioadhesives

6138 Control of Dreissena Biofouling using Carbon Dioxide

Summary: Using CO_2 to control invasive mussels in Reclamation reservoirs.

Contact: Kevin Kelly, kkelly@usbr.gov

Research Question:

- Can carbon dioxide (CO_2) be used as an environmentally benign and cost effective treatment to eradicate and prevent Dreissena mussels (dreissenids) colonization within closed water conduits (pipes)?

Unlike most aquatic species, Dreissena species cannot tolerate an increase in the concentration of dissolved carbon dioxide (pCO_2). Studies have shown that small amount of CO_2 in the water can result in 100 percent mortality and colonization inhibition. Water entering or held within the impacted area could be treated with CO_2, for a short exposure period and then naturally stripped of CO_2 by rapid equilibration with the atmosphere, leaving no trace residual. To demonstrate the practical and cost-effective use of CO_2, we will carry out a small scale study at the Willow Beach Fish Hatchery, which has quagga mussels. After an acclimatization period, insulated pipes charged with quagga mussel adults and long term veliger settlement plates will be treated at five levels of free CO_2 (from control to 500 milligrams per liter [mg/L]) via separate carbonation towers.

Need and Benefit: Reclamation reservoirs in four of the five Reclamation regions are currently infested. Dreissenids can impede the flow of water, harming water and hydropower delivery at Reclamation facilities. Reclamation needs new economical and environmentally safe control strategies for dreissenids in pipes. For example, the fire suppression system at Hoover Dam is a critical system. However, since Lake Mead is infested with quagga mussels, the fire suppression system could fail if quagga mussels block the pipes.

Other methods are either very expensive, do not work well, or can have environmental affects. CO_2 is a natural chemical that does not require a separate or specialized production (e.g., fermentation), is already produced in large quantities, is recycled from initial combustion waste streams for good environmental stewardship, has an indefinite shelf life, is nonflammable, is easy to handle and store, does not require electrical or mechanical power to deliver, and can be distributed easily and evenly in water (including hard-to-reach confined water). Adding CO_2 also reduces the bioavailability of calcium in the water, thereby inhibiting shell growth. Once the water is freely exposed to the air at the outlet, purged, or the CO_2 is stripped and reused, so that it will not affect the downstream water ecology.

Partners:

Keywords: zebra mussels, quagga mussels, green chemistry, carbon dioxide, CO_2, dreissinids

6407 Effects of *Pseudomonas fluorescens,* a Biological Control Agent for Quagga and Zebra Mussels, on Growth, Health, and Survival of Fish

Summary: Using *Pseudomonas fluorescens* to control invasive mussels.

Contact: Zak Sutphin, zsutphin@usbr.gov

Research Question:

- Can a simple bacterium control invasive mussels (without harming anything else)?

The most ecologically responsible agents for controlling invasive dreissenid mussels (i.e., quagga and zebra mussels) are likely to be biological control agents, which are naturally occurring species that suppress expansion of other species through predation, competition, parasitism, and other means. One particular agent, *Pseudomonas fluorescens* (Pf), a bacterial strain proven lethal to dreissenid mussels, is currently in the developmental stages of research and shows promise as a biological control agent. Because Pf would be applied to infested water infrastructure at levels higher then normally observed in natural systems, and there is potential for the product to seep out of such structures and accumulate, it is necessary to investigate the effects of Pf on the aquatic community. Therefore, we will quantify the effects of Pf on health, growth, and survival of fish and macroinvertebrates.

Need and Benefit: Invasive dreissenid mussels have caused devastating ecological and economic impacts in aquatic systems in the eastern United States. The recent and persistent expansion of these species into western states, including but not limited to California, Nevada, Arizona, and New Mexico poses a further threat to new ecosystems and to Reclamation's water management/treatment infrastructure. Dreissenid mussels disperse rapidly**:** their pelagic free-swimming veliger larvae drift with moving water, and all life-stages function as "hitchhikers," traveling on watercraft and on fishing equipment. Both mussels are polymorphic and prolific breeders, and they efficiently colonize onto nearly any available hard surface, rapidly clogging water pumps and intake pipes upon invasion, costing owners millions of dollars in maintenance. Preventing the spread and controlling colonization of these mussels has ecological and economic implications and merits further exploration.

Partners:

Keywords: Invasive species, biological control, Dreissenidae, zebra mussels, quagga mussels, *Pseudomonas flourescens*, Pf, dreissenid

7095 Antifouling Coatings for Invasive Mussel Control

Summary: Testing coatings for invasive mussel control.

Contact: Allen Skaja, askaja@usbr.gov

Research Question:

- What coatings will provide excellent corrosion protection, durability, and deter mussel attachment?

We will investigate coatings for mussel control.

Need and Benefit: Coatings need to be prescreened to determine the likelihood of success for mussel control. Many times, the companies have no experience relative to using coatings for mussel control since the products are developed for ship going vessels. Suppliers of coatings need to provide data to show that their materials have some chance of providing fouling control before we perform testing. Metropolitan Water District of Southern California (MWD) and Reclamation are the only two agencies within the United States and Canada that are testing coatings in dynamic exposure conditions.

Without mussel control strategies, maintenance costs will increase drastically, and affect the delivery of water or hydropower production.

Partners:

Keywords: coatings for mussel control, deter mussel attachment, zebra mussels, quagga mussels, dreissenid, corrosion protection

9508 Fish Predation on Quagga Mussels

Summary: Fish predators that may help control invasive mussels.

Contact: Cathy Karp, ckarp@usbr.gov

Research Question:

- Which fish species in the Western United States are consuming mussels (quagga and zebra forms)?
- Do redear sunfish readily consume mussels that are attached to vertical and horizontal surfaces?
- Do redear sunfish consume both mussels and snails (e.g., New Zealand mud snail) when offered both?

We will examine redear sunfish and other fish's ability to consume invasive mussels.

Need and Benefit: Establishment and spread of quagga mussels in the Western United States has the potential to severely impact Reclamation's ability to deliver water. Reclamation needs to aggressively respond to the mussel invasion while it's still in the early stages. Fish predation on invasive mussels is one type of biological control that may contribute to slowing the establishment of mussels in Reclamation canals and other water delivery structures.

Partners: Reclamation's Lower Colorado Region

Keywords: quagga and zebra mussels predators, redear sunfish, biological control, invasive mussels.

9640 Production and Testing of Antibodies for Dreissena Mussels

Summary: Using antibodies to control invasive mussels in Reclamation reservoirs.

Contact: Kevin Kelly, kkelly@usbr.gov

Research Question:

- Can we produce and isolate primary antibodies that can used to control, capture, and monitor dreissinids?

Antibodies are proteins produced by the immune system to identify and neutralize foreign invaders, usually bacteria and viruses. The recognition of an antigen by an antibody is highly specific. We will produce and select antibodies by**:**

1. Collecting Dreissena spp. tissues and veligers
2. Producing antibodies via a custom antibody service
3. Screening candidate antibodies for further study

Need and Benefit: Zebra and quagga mussels have the ability to impede the flow of water, thereby impacting water and hydropower delivery at Reclamation facilities. Other methods are either very expensive, do not work well, or can have environmental affects. Antibodies are commercially available. Using antibodies to detect veligers under the microscope makes automated veliger counting possible, efficient and accurate via conventional flow cytometry. Conjugated antibodies may deliver toxins to dreissenids (similar to human monoclonal antibody therapy for cancers). The toxin can be attached to the antibodies which target specific cell types, such as cells found only within quagga and zebra mussels. Releasing these conjugates at low levels would have no effect—only when these conjugates are concentrated enough on the target cells would they reach the minimum dosage level required to cause mortality.

Partners: Metropolitan Water District of Southern California (MWD), Water Research Foundation (WaterRF), and Reclamation

Keywords: zebra mussels, quagga mussels, dreissenids, cytometry, antibodies, cells, toxins, antibody, detection

9829 Creating Turbulence to Prevent Invasive Mussel Colonization within Pipelines

Summary: Flow conditions could create turbulence to kill invasive mussel veligers.

Contact: Joshua Mortensen, jmortensen@usbr.gov

Research Question:

- Can zebra and quagga mussel fouling in pipelines be reduced by developing inlet flow conditions that create turbulent eddies in a range that will kill mussel veligers as they enter a pipe?

Water distribution, transmission, and utility pipelines are a major part of Reclamation's infrastructure that has been significantly impacted by invasive mussels. Developing a specialized pipe retrofit that would kill mussel veligers as they enter a piping system will be a valuable control against the colonization of mussel species within a piping system. Development of such a retrofit would be widely applicable to Reclamation's infrastructure where mussel removal is difficult, time consuming, expensive, and dangerous. We will develop a pipe retrofit that would create turbulence small enough to significantly impact the mortality and/or growth of mussel veligers as they enter a pipe.

Need and Benefit: The long-term objective of this research is to develop a specialized pipe inlet that will be applied to a wide range of Reclamation's piping facilities to protect existing piping infrastructure from mussel invasions. It is expected that the development of such a retrofit will result in formation and acquisition of intellectual property. This section contains Intellectual Property. Contact Joshua Mortensen to request additional information.

Keywords: zebra mussels, quagga mussels, dreissenids, veligers, turbulence, pipe inlet, intellectual property

Directed: Use of Endothall for Management of Invasive Mussels in Canals

Summary: Can Endothall be used to control invasive mussels in irrigation water?

Contact: Scott O'Meara, someara@usbr.gov

Research Question:

- Can Endothall be used to control invasive mussels in irrigation water?

Endothall is the common name of the active ingredient of general use aquatic herbicides under the trade names Aquathol and Hydrothal-191. These products are labeled for control of aquatic pest plants, but until recently Endothall was not registered for irrigation water. Research conducted over the last several years has lead to a re-evaluation of crop tolerance levels for Endothall, and the aquatic herbicide products are now labeled for use in irrigation water. Endothall is also the active ingredient in a general biocide under the trade name EVAC, which is labeled for control of mussels in water systems but not for irrigation water. Endothall has proven to control invasive mussels and is safe for irrigation water, but current product registration does not cover both the target species and use area under a single label. We will investigate using Endothall for mussel control.

Need and Benefit: Mussels can severely impact water delivery canals through increased roughening and accelerated corrosion. The few available management tools for mussels in these situations are limited logistically or economically, or they may pose certain environmental detriments. Having access to Endothall as an additional "tool in the toolbox" for invasive mussel control would benefit Reclamation and other agencies and irrigation districts that will inevitably be faced with the problem in the future. This research will also serve as a primer for future investigations of further benefits for integrating Endothall into other control methods and application circumstances.

Partners: Potential partners include United Phosphorus Inc., Central Arizona Project**,** Coachella Valley Water District

Keywords: zebra mussels, quagga mussels, dreissenids, Endothall, Aquathol, Hydrothal, chemical control

Directed: Evaluating High pH for Controlling Invasive Mussels

Summary: Using elevated pH to control invasive mussels in powerplant raw water systems.

Contact: Joe Kubitschek, jkubitschek@usbr.gov

Research Question:

- Can increased pH effectively control mussels to protect critical water resources related infrastructure?

Mussels are currently thought to have a pH threshold for survival somewhere between 9.3 and 9.5. Other pH levels may prevent mussels from settling on infrastructure.

This Science and Technology Program research project will be conducted under a recently awarded indefinite delivery/indefinite quantity (ID/IQ) contract with RNT Consulting, Inc., the leading invasive mussel experts in North America. This project will first identify pH thresholds for quagga and zebra mussels under site-specific conditions where both these species are already impacting Reclamation facilities**:** Lake Havasu, in Colorado and Arizona, and San Justo Reservoir, in central California. The project will vary pH levels to establish pH requirements that prevent settlement. Finally, alternatives will be developed for practical application to hydropower cooling water systems including cost comparisons with other conventional control options and initial identification of environmental issues and regulatory requirements.

Need and Benefit: Reclamation needs a wide arsenal of tools to control invasive mussels. pH has been used to control golden mussels in South America and is viewed as a promising new approach to controlling invasive mussels in critical raw water systems at Reclamation facilities.

Partners: Reclamation's Research & Development Office, Technical Service Center, Lower Colorado Region – LC Dams Office, and RNT Consulting, Inc.

Keywords: zebra mussels, quagga mussels, dreissenids, pH, acidity, water quality, infrastructure

Directed: Evaluating Pulsed-Pressure Technology for Control

Summary: Using pulsed-pressure devices to control invasive mussel fouling on water intake structures.

Contact: Joe Kubitschek, jkubitschek@usbr.gov

Research Question:

- How effective and practical are pulsed-pressure devices for control of invasive mussel fouling on water intake structures with potential future application to water delivery pipelines?

Pulsed-pressure technologies have been in use for many years and have various applications ranging from oil exploration and military marine defense systems to control of invasive fish species. In the context of invasive mussel control, this technology is expected to provide and environmentally acceptable alternative since it does not involve introducing chemicals into raw water systems (a conventional means of controlling mussels). The primary methods for generating underwater pulsed pressures include sparkers and hydroguns. Preliminary testing in FY2010 indicated that sparker technology is not yet sufficiently mature for this application. However, hydroguns, which use air or water for high-speed actuation of a piston to generate a pressure pulse, appear promising.

We will conduct field evaluations of pulsed-pressure devices. As a follow on to preliminary evaluation of sparker technology, hydroguns will be deployed at a suitable field site for evaluation and demonstration.

Need and Benefit: Zebra and quagga mussels can clog intakes, trashracks, strainers, pipes, fire control systems, cooling water systems, and fish screens, resulting significant costs to protect water and hydropower systems. Pulsed pressure devices have the potential to protect these systems by removing attached mussels or preventing settlement.

Partners: U.S. Geological Survey, Northern Rocky Mountain Science Center and the U.S. Fish and Wildlife Service

Keywords: zebra mussels, quagga mussels, dreissenids, pulsed-pressure devices, water delivery pipelines, water intake structures, hydroguns, sparkers

Directed: Zebra and Quagga Test Facility Planning

Summary: Reclamation is planning a field-based invasive mussel research facility.

Contact: Joe Kubitschek, jkubitschek@usbr.gov

Research Question:

- What are the requirements for future design of a field-based invasive mussel research facility?
- What concepts will work to meet these requirements?

We will bring invasive mussel research experts together to identify research facility needs and capabilities, develop alternatives, select the preferred field site for mussel research, and organize and interface with Reclamation's Technical Service Center (TSC) design team in the initial planning process for design.

Need and Benefit: Mussel infestations are a growing concern among water management organizations throughout the Western United States. Zebra and quagga mussels can harm almost every aspect of water and related resources. While Eastern experiences provide a valuable guide, what works in the East may not always work in the West where the vastness and intricacies of water distribution systems compound the problem. Water resources managers in the West need updated information and improved methods, solutions, and strategies to assess and minimize the impacts to our Western water resources infrastructure. Thus, Reclamation needs a field based research facility to research ways to control invasive mussels that are specific to the conditions in the Western United States.

Partners: Reclamation Research and Development Office, Technical Service Center, Regional Offices, other agencies, private industry, and academia

Keywords: zebra mussels, quagga mussels, dreissenids, field-testing facility, design, planning

Directed: Evaluation of Ultraviolet (UV) Light Treatment to Minimize Facility Impacts from Invasive Mussels

Summary: Using UV light treatment to control invasive mussels.

Contact: Fred Nibling (fnibling@usbr.gov), Denise Hosler (dhosler@usbr.gov), Leonard Willett (lwillett@usbr.gov)

Research Question:

- Can we use light treatment to control mussel settlement in drinking water supply lines and power plant cooling water systems?

Free-swimming, planktonic larvae of quagga and zebra mussels (veligers) may enter into facilities through water intakes, settle, and grow to maturity within the structure. This can block flows and lose system function with serious consequences to system components. For example, if this were to occur unabated in a cooling water line to a hydropower generator, shutdowns from overheating may occur—resulting in loss of power or damage to the unit.

For this research project, Reclamation's Technical Service Center researchers will use sampling ports and flow-through aquaria mesocosms to collect veligers (and adults) for quantification and observe settlement response to treatments.

Need and Benefit: If demonstrated effective for control of mussels, UV treatment is expected to have broad application across Reclamation and throughout the Western United States. This treatment method is that it would eliminate the need for discharge permitting and represents an environmentally safe alternative to conventional oxidants. UV is also an effective treatment for waterborne disease organisms in drinking water systems.

Partners: Reclamation's Lower Colorado Region – Hoover Dam

Keywords: zebra mussels, quagga mussels, dreissenids, ultraviolet, UV, aquaria mesocosms, veligers

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35 Assessment of Potential Effects of Operation of Reclamation Facilities on Pacific Lamprey in Major Tributaries of the Columbia River Basin

Summary: Reclamation investigates devices to guide Pacific lamprey away from irrigation canals.

Contact: Jennifer Beardsley, jbeardsley@usbr.gov

Research Question:

- How do Reclamation facilities affect Pacific lamprey in major tributaries of the Columbia River basin?

Columbia River basin populations of Pacific lamprey (*Entosphenus tridentatus*) have declined markedly from historic levels in recent years, and there is widespread concern among Federal and State management agencies and Columbia River basin tribes about their continued existence.

We will document the present distribution of lamprey in relation to Reclamation projects. We will determine, where possible, the historic and current distribution of lamprey in relation to Reclamation projects in these basins. An integral aspect of the project will be to determine whether existing water storage projects or irrigation diversions have screens and, if so, whether they were constructed to National Oceanic and Atmospheric Administration (NOAA) Fisheries criteria, and whether these screens are adequate to reduce or eliminate impacts to lamprey. Next, we will estimate or determine the potential effects of the diversions on juvenile lamprey. We also propose to assess the condition of upstream passage for lamprey at Reclamation projects and the potential effect these structures may have on adult lamprey. Results from this assessment will provide the basis for future laboratory or field studies.

Need and Benefit: This research project will allow Reclamation to identify water storage and diversion projects that may affect Pacific lamprey and to develop management actions or recommended structural modifications to address these issues. the 2008 Memorandum of Agreement (MOA) with lower Columbia River tribes includes identifying all Reclamation projects in the Columbia River basin that may affect lamprey, focusing initially on the Umatilla and Yakima projects and related facilities, and then jointly develop a lamprey implementation plan.

Although the initial study area for this proposal is major tributaries of the Columbia River basin, any information generated regarding criteria for screening or passage improvements would be applicable to Reclamation projects wherever lamprey occur in proximity to Reclamation projects. This proposal would improve the reliability of Reclamation water deliveries by producing effective solutions that Reclamation water managers can use to prevent water conflicts with the environmental demands on water supplies.

Partners: Confederated Tribes of the Umatilla Indian Reservation and the Yakama Nation

Keywords: lamprey, fish passage, water deliveries, Pacific lamprey, *Entosphenus tridentatus,* Columbia River basin

295 Monitoring the Effectiveness of Gravel Augmentations Downstream from Dams for Habitat Improvements

Summary: Recording the benefits of gravel augmentation for rivers and fish habitats.

Contact: David Gaeuman, dgaeuman@usbr.gov

Research Question:

- How far downstream from a gravel augmentation point will habitat benefits be realized?
- How long will it take to achieve downstream habitat benefits?
- How long will habitat benefits at a specific location persist?
- How much added gravel is needed to achieve habitat benefits at specific downstream locations?

We will track gravel placed in a creek along with small gravel augmentations using electronic tags.

Need and Benefit: This research will allow managers to better predict what will happen to downstream stream reaches when they add large quantities of gravel below dams. Numerous gravel augmentation programs are currently being implemented in the Western United States. These programs are typically managed by Reclamation and funded through Reclamation or its constituents. For example, several augmentation programs in California are implemented with funds derived from the Central Valley Improvement Act. However, basic characteristics of the long-term behavior of coarse sediment slugs needed to optimize augmentation design and management remain poorly understood. Habitat restoration and environmental mitigation downstream from dams is a Reclamation responsibility where dams were constructed and are managed by Reclamation. Reclamation has a further responsibility to achieve required habitat restoration objectives efficiently and at least cost to its water-user constituency.

Partners: New Albion Geotechnical and Oregon State University

Keywords: gravel augmentation, habitat restoration, sediment slugs, PIT tags

1368 Predicting the Interactions between Flow, Sediment, and Riparian Vegetation

Summary: Reclamation simulates flow, sediment, and vegetation interactions to predict establishment and survival of riparian species.

Contact: Blair Greimann, bgreimann@usbr.gov

Research Question: Reclamation has developed a computer model tool to predict the interactions of flow, sediment, and vegetation to model the establishment and survival of a broad range of riparian species to answer a range of questions:

- What impact does riparian vegetation have on local flood conditions (water surface elevation), and how can vegetation be incorporated into restoration projects without increasing flood risks?

- What set of reservoir operations can be used to encourage successful native vegetation recruitment and survival, and can reservoir operations be used to control invasive species?

We will develop methodologies and a tool to predict the effect of vegetation on river flood stage. A literature review will help provide parameters to suggest how the parameters for major species in the Western United States. Invasive species will also be addressed. The final product will be computer modules that can be used by SHR-1D and SRH-2D to predict the:

1. Riparian processes of seedling establishment, growth, and mortality as a function of vegetation species and hydrologic condition

2. Influence of the aging process on vegetation characteristics including plant size, flexibility, and density

3. Impacts of vegetation on water surface elevations and vegetation washout by high flows during floods

Need and Benefit: Managing river systems in a way that sustains or restores healthy riparian zones is a challenge on many rivers (e.g., the Rio Grande, Lower Colorado, Sacramento, Truckee, and Platte Rivers). This model will help efforts in many basins to restore rivers to a more natural state through physical improvements or flow management (e.g., Platte, San Joaquin, and Sacramento Rivers). This set of tools would help quantify several Reclamation actions for which we currently do not have quantitative methods. Reclamation is the most logical agency to pull this information together into a functional tool that can apply this knowledge to real conditions.

Partners: Partners include the Technical Service Center (TSC), the Mid-Pacific Region (MP), the Stockholm Environmental Institute (SEI), University of California at Davis (UCD) and the Desert Research Institute (DRI).

Keywords: climate, flow, sediment, riparian vegetation, adaptive management, river restoration, hydrologic models, vegetation models, giant reed, *Arundo donax*, salt cedar, tamarisk, cottonwoods, *Populus fremontii*, black willow, *Salix gooddingii*, narrow-leafed willow, *Salix exigua*

2249 Removal of Non-Native, Invasive New Zealand Mudsnails Using an Innovative Stream Restoration Tool

Summary: Can we jet and suction New Zealand mudsnails out of streams?

Contact: Juddson Sechrist, jsechrist@usbr.gov

Research Question:

- Can a new stream restoration tool, called the SandWand, remove New Zealand mudsnails (NZM) (*Potamopyrgus antipodarum*) from large amounts of in-situ streambed in an economical and efficient manner?
- What, if any, is the recolonization rate/density of NZMs within treated sections over time?

Abundant populations of NZM, an invasive species, in infested Reclamation systems can have serious ecological and economic effects. There is currently no efficient method recognized to control, remove, or prevent range expansion of NZMs.

We will investigate the efficiency of NZM removal in the mainstem of Bear River, Idaho by using a SandWand developed by Streamside Technologies (Findlay, Ohio) and quantify this removal effort's success, NZM recolonization rate, and effects on salmonids (e.g., abundance, habitat preference, health/condition, and diet). The SandWand uses a combination of jetted water and pump suction to first expose and loosen interstitial fines and NZMS and then suctions and removes them from the treated area. We will treat the study portion of the river in late summer 2011 with the SandWand. Substrate along the transects will be cleaned to a depth of approximately 12 inches or to bedrock if framing gravels are sparse. We will conduct pre- and post-treatment monitoring based on recommendations from the Bear River Environmental Coordination Committee.

Need and Benefit:

NZMs affect the fitness of imperiled species and complicate recovery efforts often funded by Reclamation. This applied research will provide Reclamation managers and stakeholders a case study to help find innovative means to manage aquatic systems to avoid future listings under the Endangered Species Act (ESA) and remove species that are currently listed.

NZMs are likely to contribute significantly to biofouling (e.g., clogging pumps, intake lines, louvers), resulting in financial loss for cleaning, maintenance, treatment, and replacement. This research will facilitate development of scientific and technical NZM control.

Partners: Partnering with14 affiliations, including Federal, State, tribal, and various non-governmental organizations associated with the Bear River Environmental Coordination Committee.

Keywords: New Zealand mudsnails (NZM), *Potamopyrgus antipodarum*, SandWand**,** Bear River Environmental Coordination Committee, Bear River, water jet, invasive species

2408 The Effects of Electrofishing on the Reproductive and Developmental Health of Razorback Suckers in the Colorado River Basin

Summary: How does electrofishing affect razorback suckers?

Contact: Mark McKinstry, mmckinstry@usbr.gov

Research Question:

- What are the indirect effects of repeated electrofishing on nonnative fish suppression on survival, gametogensis and growth and development in adult and larval razorback suckers (*Xyrauchen texanus*)?

Because of intensive non-native removal efforts and monitoring, native fish, including razorback sucker, may be exposed to up to 13 electrofishing passes in a single year. Limited studies have documented the negative impacts of electrofishing in ripe adult and embryo razorback suckers. However, no studies have looked at the impacts or effects of repeated exposure to electrofishing throughout the year on the reproductive health of adult razorback suckers. We will determine the:

1. Effects of electrofishing on gametogenesis and fish health in razorback sucker broodstock

2. Effects of electro-shocking on razorback sucker fertilization, embryogenesis and larval survival and development

3. Critical period of susceptibility for adult razorback sucker fitness to electro-shocking

The study will retain 240 hatchery-reared adult razorback suckers, split equally by sex, to test the effects of electrofishing on ripe male and female razorback suckers, on egg-hatching success, and subsequent embryo survival. This three-year research would culminate in guidelines for electrofishing to protect reproductive health of razorback sucker in the Colorado River Basin.

Need and Benefit: Razorback sucker is a federally endangered fish species endemic to the Colorado River Basin. Reclamation funds and manages three major Programs concerned with the management of razorback suckers. Information on effects of electrofishing would greatly assist Reclamation and its multiple partners in making better management decisions to manage and monitor endangered fish and ultimately to deliver water and power.

Partners: Uvalde National Fish Hatchery (UNFH), US Fish & Wildlife Service, Bozeman Fish Technology Center, USGS, Northern Rocky Mountain Science Center, San Juan Recovery Implementation Program

Keywords: Endangered Species Act, ESA, razorback suckers, *Xyrauchen texanus*, electrofishing, electroshocking

2440 Quantification of Temperature Change to a Water Body Influenced by Subsurface Return Flow

Summary: Reclamation is studying how subsurface return flows affect water temperatures in streams.

Contact: Sharon Parkinson, sparkinson@usbr.gov

Research Question:

- Can we develop a model to quantify changes in river temperature resulting from subsurface water returns?

We will focus on improving an existing model and deriving methodology to quantify the potential temperature change in the hyporheic zone and its influence on the thermal regime of a stream. The ultimate goal is to be able to quantify the thermal effects of surface water management decisions on resulting subsurface return flow conditions and its influence on a receiving water body. As part of this study, instrumentation will be installed at a test site for the collection of data intended for a simple analytical model.

Need and Benefit: Increasingly, Reclamation is being required to monitor temperature within rivers and below projects to comply with environmental regulations. By investigating the thermal benefit of returning irrigation drains via wetlands or subsurface pathways, and in turn quantifying the benefit, Reclamation can demonstrate compliance with stipulated water quality standards and also effectively satisfy its water delivery obligations. This type of analysis would be valuable for predicting the effectiveness of a proposed mitigation measure for achieving compliance with temperature requirements.

Developing advanced surface water and groundwater management tools is paramount to Reclamation's ability to reliably deliver water and generate power as effectively as possible. Reclamation is responsible for understanding the impacts of its project operations and resulting water quality to the surrounding system in meeting standards. Typically, groundwater and surface water processes are viewed and managed separately. In many situations, surface water and groundwater processes constitute a single system that must be understood and managed together if the resources are to be used effectively. The ability to operate models that can simulate groundwater–surface water interactions with models that can incorporate water quality constituents will allow Reclamation to analyze various water delivery management scenarios by analyzing the potential thermal regime change to the streambed.

Partners: Idaho Power has committed to provide in-kind services in support of the study, and technical assistance is also expected from the University of Idaho.

Keywords: river, temperature, models, thermal, groundwater, surface water, water quality

3253 Passive Hydro-Acoustic Monitoring of Gravel-Bed Material Sediment Load for Management of Gravel-Bed Rivers, including Gravel Augmentation to Improve Endangered Fish Habitat Downstream from Dams

Summary: Reclamation develops hydrophones as a cheaper and better way to monitor gravel bed material.

Contact: Drew Baird, dbaird@usbr.gov

Research Question:

- How can we extend existing passive hydro-acoustic technology for monitoring bed material load in gravel bed rivers into a viable new tool that can consistently provide a greater amount of data and more economical data to better manage gravel bed rivers?

We will:

- Form strong partnerships with Federal, university, and hydro-acoustic/remote sensing industry personnel
- Perform literature searches to establish the state-of-practice and needs
- Develop a plan to take passive hydro-acoustic technology from the current basic research stage (which has shown promising results) to reliable and field deployable instrumentation

This Science and Technology Program research project will result in a brief written summary of the state-of-practice and needs, formation of a development team, contributions to the project, and a complete product development plan.

Need and Benefit: Gravel bed material transport is difficult and costly to measure. Current technology, bedload sampling, is labor intensive and costly and, thus, rarely accomplished. Flows with the greatest effect upon the channel, structures, and habitat suitability are almost never measured. These samplers typically measure less than 1 percent of the total load. There is high uncertainty in transport estimates from measured data even under the best circumstances.

This research provides an opportunity to use recent technological developments in passive hydro-acoustics (hydrophones) technology and develop hydrophones to become viable for field applications. This will provide more economical and vastly improved data to manage sediments, flow, and infrastructure. Passive hydro-acoustics is much cheaper, so bedload monitoring can be possible in places where it is not currently being done.

Partners: The project is complex and will require developing strong partnerships with universities, other Federal agencies, and private industry.

Keywords: passive hydro-acoustic technology, gravel riverbeds, flow management, sediment transport, bedload, riverbed, hydrophones

3618 Improving Fish Species Recognition and Tracking Algorithms to Identify Fishes in Turbid Water

Summary: Underwater video imaging systems can identify and count fish species to monitor abundance and distribution.

Contact: Donald Portz, dportz@usbr.gov

Research Question:

- Can towed video imaging systems provide a non-lethal, supplemental method to examine pelagic fish distribution and abundance of patchy or rare species?

We have developed an intelligent system capable of counting fish-sized objects, and we are working to provide an improved algorithm for that system to determine types of pelagic fishes in real-time. Turbidity is the primary limiting factor for performing video analysis in many rivers and lakes. We have determined the best lighting and image configurations, along with the applicable video imaging technology, for identifying numbers and species of fishes in turbid waters. The software currently in use has difficulties with similar-looking species. Algorithms incorporating species-specific morphometrics need to be developed for recognition and identification.

We will develop and investigate the effectiveness of several algorithms to determine the fastest real-time solution for identifying pelagic Sacramento-San Joaquin Delta species.

Need and Benefit: Trawls and other types of netting presently form the foundation of fish monitoring in many rivers, lakes, and reservoirs. Although these gear types have proved exceptionally useful, they are not very effective with patchy or rare species. Moreover, the recent decline in some fish populations has led to concern over the lethal "take" by trawling methods. Recent progress in towed video imaging systems may provide a supplemental non-lethal method that could be used to examine pelagic fish distribution and abundance.

Partners: SureWorks, LLC

Keywords: fish tracking, underwater video imaging, turbidity, delta smelt, SmeltCam

3837 Characterization of Cyanobacterial Biomass in a Reclamation Reservoir

Summary: Is it economically viable to remove and harvest cyanobacterial algae?

Contact: Chuck Korson, ckorson@usbr.gov

Research Question:

- Is it economically viable to remove and harvest cyanobacterial algae (blue-green algae)?

Research has shown there are chemicals in Upper Klamath Lake cyanobacteria that have potential commercial value, including oils, pigments, proteins, and potential pharmaceuticals. We will explore the use of cyanobacterial biomass in Upper Klamath Lake for potentially biomass-based fuels and other commercially marketable products. It may become economically viable to remove algal biomass from Reclamation reservoirs or downstream receiving waters in quantities sufficient to remediate ecosystem impacts. Commercially valuable products may potentially be derived from cyanobacterial algae.

Need and Benefit: Biomass removal would eliminate a significant pool of nutrients in the entire Klamath River system. Benefits could accrue to the environmental resource and allow Reclamation to meet its Clean Water Act and Endangered Species Act (ESA) responsibilities without major changes in project operational features.

Partners: Klamath Tribes, Oregon Institute of Technology, and U.S. Geological Survey (USGS)

Keywords: cyanobacterial algae, cyanobacterial biomass, blue-green algae, water quality

4362 Identifying Indicators and Guides for Sustainability of Pools in Gravel-Bed Rivers

Summary: Designing habitat features for sustainable pools for salmonids.

Contact: Sharon Parkinson, sparkinson@usbr.gov

Research Question:

- Can pool-riffle velocity reversals be verified and measured for a broader range of field conditions in gravel-bed rivers?

Gravel-bed rivers are important habitat for salmonids. The pool-riffle morphology in gravel-bed rivers is important as the diversity in physical habitat is critical for salmonids at spawning and other life stages. If pool-riffle velocity reversals could be verified and measured for a broader range of field conditions, this would develop useful equations and establish guidelines for designing restoration projects that would allow rapid assessment of pool habitat vulnerability. These parameters could also be useful in lieu of or as a supplement to a more detailed modeling exercise of restoration alternatives.

Need and Benefit: Criteria and knowledge gained from the design of specific habitat features for various lifestages of salmonids in various streams or rivers has the potential to provide design guidelines, assess the need for engineered features as well as a means of determining design success metrics. The Columbia Snake Salmon Recovery Office (CSRO) supports this research project to establish guidelines that can be used in the design of sustainable pools in gravel-bed rivers. The results of this investigation would have wide reaching applicability for instream habitat projects in subbasins funded by CSRO a well as Reclamation-wide habitat projects.

Partners: CSRO

Keywords: riffle morphology, velocity reversal, pool sustainability, gravel-bed rivers

5086 Impact of Invasive Species Water Use on Lower Colorado River Operations

Summary: Remote sensing may tell us how much water transpires through invasive tamarisk plants.

Contact: John Osterberg, josterberg@usbr.gov

Research Question:

- How much water does tamarisk (saltcedar) transpire?

We will estimate the changes of tamarisk evapotranspiration (ET) and resulting changes in demand for river water, as the tamarisk beetle progresses down the Colorado River system, through a combination of remote sensing and spatial modeling of river/flood plain groundwater interactions.

We will use airborne and satellite remote sensing methods to estimate spatial ET from the Colorado River riparian corridor from Lake Mead southward to the Mexican border and also along the Virgin River, north of Lake Mead, to the mouth of the Virgin River canyon. Utah State University's airborne multispectral system will be used to acquire high-resolution imagery of sections of the riparian zones of these rivers to obtain data for estimating spatial ET and to compare with estimates based on Landsat thematic mapper images from the last decade.

Need and Benefit: Invasive vegetation species such as tamarisk and Russian olive have spread throughout the Western United States' water systems and rivers, outcompeting and replacing native species of trees and shrubs. Tamarisk, in particular, is a significant water user. In the Lower Colorado River basin, it grows in medium to dense stands covering large areas of the generally broad flood plains. This poses operational challenges for the management of the river due to the reduction of riverflows that can result when ET demands from riparian vegetation cause a flux of river water into the flood plain groundwater system.

The rate of ET from riparian zone vegetation is relatively unknown, as is the manner in which the rate is impacted by water quality and salinity, depth to the water table, and vegetation density. Models of riparian ET need to take these aspects into account, as well as estimates of the groundwater flux from the river to the riparian groundwater system for supplying the riparian ET demand. Improvements in these estimates through modeling will improve river management and optimize upstream releases.

Partners: Utah State University

Keywords: invasive species, tamarisk, evapotranspiration, remote sensing, multispectral imaging, saltcedar

5524 Impacts of Saltcedar and Saltcedar Control on Wildlife in the Southwestern United States: Publishing Research Results

Summary: Examining how wildlife responds to saltcedar control measures.

Contact: Susan Broderick, sbroderick@usbr.gov

Research Question:

- How do wildlife species respond to various types and scales of saltcedar (*Tamarix ramosissima*) control measures?

This research will complete the recently conducted Science and Technology Program research project 9331, *Management Guidelines to Reduce Endangered Species Conflicts from Saltcedar Control at Reclamation Water Projects,* which collected and partially analyzed data on three taxa of wildlife from Reclamation saltcedar control projects on the Pecos, Canadian, Rio Grande, and Arkansas Rivers and the Las Vegas Wash over 3 years. A final report was not produced due to lack of funding.

We will complete analysis of our data and present data and management recommendations to Reclamation managers in the Lower Colorado River Regional Office and the Technical Service Center and peer-reviewed journals as funds allow.

This can form the basis to develop management guidelines that could be implemented by Reclamation resource managers conducting saltcedar control and riparian restoration programs for endangered species recovery, as well as provide access at water management facilities for inspection, maintenance, and recreation in areas of heavy saltcedar infestations.

Need and Benefit: Saltcedar is considered an undesirable species in riparian areas of the Southwestern United States. Reclamation removes saltcedar in a large number of riparian restoration projects. These projects are typically related to water delivery, water salvage, or avoiding impacts to endangered species. Questions, however, remain as to the value of these high-dollar restorations for wildlife resources. In many cases, very little in the way of quantifying results has occurred.

Data and management guidelines developed from this research would provide Reclamation resource managers with the knowledge and tools to implement saltcedar control projects designed to minimize impacts to endangered species (e.g., Southwestern willow flycatcher) as well as candidate species (e.g., yellow-billed cuckoo and least Bell's vireo). Such knowledge would also help to avoid adverse impacts to neotropical migratory songbirds (under protection of the Migratory Bird Treaty Act) and other wildlife species.

Partners:[1]

Keywords: saltcedar, tamarisk, wildlife, riparian restoration, endangered species recovery

[1] Note that where we have not identified or solidified partnerships, this heading is left blank.

5683 Salmon Spawning Gravels as a Critical Indicator of Restoration Potential, San Joaquin River, California

Summary: Restoring a salmon fishery may depend on conditions down in the gravel, not just in the stream.

Contact: Mark Nelson, snelson@usbr.gov

Research Question:

- How will restoration efforts that rely on changing dam operations impact the target environments and organisms?

Recently, restoration flows to the San Joaquin River have been implemented as a first step towards developing a Chinook salmon fishery. Spawning gravel and water quality assessments are considered important components in this restoration effort. During spawning activity, eggs are buried in the substrate, often at depths from about 30 to 45 centimeters. This relatively deep substrate region is often within the hyporheic zone, where surface water and groundwater interact. Hyporheic conditions in the redd environment may differ markedly from those found at the surface and can differ in water quality, sediments, and invertebrate communities. All of these elements may impact the success of salmon egg survival and could be considered appropriate endpoints for measurement. This Science and Technology Program research project will collect information on these disparate elements and provide guidance into the potential quality of this environment for spawning.

Need and Benefit: Re-regulation of rivers below dams has been promoted as a way to sustain the natural attributes of rivers; however, actual tests of flow restoration and altering temperatures by selective withdrawal have not demonstrated any unambiguous successes.

Often impacts below dams are multivariate in nature. Changes to a single attribute, like flow, may not positively alter temperature or sediment availability or transport. Much of the present literature suggests that we are unable to control flows to the degree necessary for biological improvement. The potential for limited success in progress towards biological goals below dams through management of flow changes indicates that the biological aspects of these operations should be thoroughly studied.

Partners: U.S. Fish and Wildlife Service and California Department of Fish and Game

Keywords: Chinook salmon, stream restoration, endangered species, surface water-groundwater interactions, stream gravels

6188 Assessing the Ecological Costs of Streamflow Regulation

Summary: Evaluating the severity of hydrological alteration and biological integrity.

Contact: Mark Nelson, snelson@usbr.gov

Research Question:

- What is the relationship between the severity of hydrological alteration and biological integrity?

Biological integrity is how community composition and native species richness in a particular stream segment differ from regional reference conditions. Similarly, hydrological alteration is the degree to which various streamflow characteristics (e.g., characteristics of annual minimum flows) differ from expected natural conditions (usually based on regional or nearby unregulated streams). Regional scales and measurements are necessary to establish goals for water management that balance ecosystem and societal needs.

We will conduct a preliminary exploration of the range of biological integrity—as represented by macroinvertebrate communities—encountered over a wide range of hydrological alteration. Alteration of natural streamflows is a multidimensional phenomenon affecting frequency, duration, and timing of various streamflow magnitudes. In addition, altered flows affect stream ecosystems through habitat modification, temperature modification, desiccation, and sheer stress. Future studies should focus on these other dimensions of natural streamflows as well as the mechanisms by which biological communities and their habitats are subsequently affected as hydrological characteristics are altered by water management activities.

Need and Benefit: Information gained would aid researchers and managers in predicting ecological consequences of streamflow alteration expected under various scenarios of climate change. Studies will provide information to stakeholders on integrating and enhancing aquatic system attributes during water management.

Partners: U.S. Geological Survey, Ecological Synthesis Team

Keywords: hydrological alteration, biological integrity**,** streamflows, biological communities, ecosystems

6606 Prediction of Bank Erosion to Improve River Restoration Strategies and Reservoir Sediment Management

Summary: Predictive procedures to determine bank erosion of river channels and reservoirs.

Contact: Blair Greimann, bgreimann@usbr.gov

Resarch Question:

- Can we develop a predictive procedure of bank erosion in river channels and reservoirs to improve the design of river restoration strategies and the management of reservoir sediment?

Bank erosion is a critical process in the erosion of sediment in reservoirs resulting from dam removal or from the sluicing of sediment from reservoirs. The SRH-2D- BSTEM model could be used to predict the erosion of sediment following dam removal or during reservoir sluicing.

We will develop a practical procedure to predict bank erosion by combining the bank erosion technologies developed by the Agricultural Research Service (ARS) with the mobile-bed technologies developed by Reclamation.

Need and Benefit: Bank erosion is important to the design and sustainability of fish habitat. Several restoration projects, such as the Trinity River Restoration Project, San Joaquin Restoration Project, and the restoration projects on the tributaries to the Columbia Basin identify off-channel, side-channel, or the channel margins as habitat important to the success of juvenile anadromous fish. Several upcoming dam removal projects will also benefit from the better prediction of bank erosion processes, including the proposed removal of four PacifiCorp dams on the Klamath River and Matilija Dam on the Ventura River.

Knowing how flow releases will affect bank erosion and habitat formation along these rivers is critical to the specification of flow releases. The best available science needs to be applied to specifying these flow releases because these decisions affect large amounts of water, power production, and irrigation delivery.

Partners: ARS is a leading Federal agency in the data collection, parameter estimation, analysis, and prediction of bank erosion in streams. Reclamation is a recognized expert in sediment transport mobile-bed modeling. The collaboration of the two agencies will build upon the strengths of both agencies, and it will be possible to develop a practical tool that will benefit both agencies.

Keywords: riverbank erosion, river sediment management, fish habitats, riparian habitats, flow release

7432 Predation on Listed Fishes at Reclamation Facilities and Ways to Reduce its Impact

Summary: Determining severity of predation issues in all Reclamation regions.

Contact: Cathy Karp, ckarp@usbr.gov

Research Question:

- How widespread is predation at Reclamation facilities?
- Does predation significantly impact Reclamation operations?
- What are some methods (e.g., fish behavioral barriers, flushing flows, habitat manipulation to move predators out) Reclamation can employ to reduce such predation?

We will determine the extent and severity of the predation issue and review on-site programs that seek to reduce impacts of predation (i.e., move predators, create refugia for target fishes, structurally modify predator habitat). We will use these results to design a study to test ideas to reduce incidence of predation at Reclamation sites.

Need and Benefit: Fish predation occurs at some Reclamation facilities due in part to blockage of fish movements and creation of predatory fish habitat. Reclamation needs to understand how widespread this problem is and whether there are some common methods that can be used to reduce predation. This understanding will help Reclamation address fish restoration and other environmental concerns at our facilities.

Partners:

Keywords: fish predation, fish behavior, flushing flows, habitat

7622 Evaluating the Cost Effectiveness of Data Collection Techniques and Relative Improvements in Modeling Reservoir Production

Summary: Modeling reservoir food bases to help predict fish production.

Contact: Allyn Meuleman, gmeuleman@usbr.gov

Research Question:

- How much better will model resolution and reservoir production results be characterized if taxonomic analysis is performed on the primary and secondary production components of the food base?

We will include taxonomic data, comprising the reservoir food base, in modeling reservoir processes to improve hydrodynamic models that analyze reservoir production. Ultimately, with this model output, fish production can be linked using a food web to trace energy transfer from primary production under varying operational scenarios.

We will use the model and instrumentation in a test case, Deadwood Reservoir, Idaho, to analyze bull trout production potential in the system and its links to ecosystem management in accordance with a recent U.S. Fish and Wildlife Biological Opinion. The output of these model runs will be analyzed to compare the primary productivity estimates with the ELCOM-CAEDYM model, generated with and without the phytoplankton and zooplankton taxonomy information. We will also test the model outputs for other parameter sensitivities to discern if the differentiated taxonomic groups are driving the potential improvements to modeled results.

Ultimately, this model output, under varying operational scenarios, can be linked quantitatively to fish production using a food web model. This research will help Reclamation determine the sensitivity of model outputs to the taxonomic inputs when compared to the simpler models for phytoplankton. It will also provide insight into what level of detail and cost are appropriate in satisfying the objectives of this type of study.

Need and Benefit: Reservoir operations can influence primary production that can influence growth and production of bull trout. This research will link several tools into a holistic description of physical and biological factors that may limit or otherwise influence or affect bull trout production in the river and the reservoir under various reservoir operational scenarios. Also, these models will help us make quantitative comparisons of the potential effect of reservoir operational changes on physical habitat conditions as well as describe the implications for primary and secondary production in the reservoir.

These tools provide scientists and resource managers throughout Reclamation a way to explore ecosystem responses to actions that are a result of operational or outside system changes.

Partners:

Keywords: ecosystem responses, food web, bull trout, reservoir production, reservoir operations, phytoplankton, isotopes, energy transfer, water quality, zooplankton

7707 Evaluating Innovative Swim-Thru Fishway Valve Lock System for Medium Head Applications

Summary: Making fish passage easier and less expensive at medium and high head dams.

Contact: Jennifer Johnson, jmjohnson@usbr.gov

Research Question:

- Can we find and evaluate an effective and cost-effective upstream passage fishway?

We will test a Swim-Thru, a new patented fish passage system. This patented system has two sequenced slow opening and closing valves. It is similar to a fish lock, but it attracts fish in the tailwater into the fishway and then directs them up a discharge line to the dam forebay.

Need and Benefit: The only other alternatives (i.e., trap and haul, or trap and elevator, or Borland Fish lock systems) are very expensive to build and operate. Reclamation does not have a product with similar capabilities or cost effectiveness to permit fish to pass over medium and high head dams where presently we have few provisions for upstream fish passage. This patented Swim-Thru fishway system promises to be a very cost-effective alternative. If proven successful, this could be used to provide fish passage at a number of Reclamation's higher head dams where fish passage presently is not considered feasible.

Partners: Bonneville Power Administration (BPA) funded much of the previous testing, and National Oceanic and Atmospheric Administration (NOAA) Fisheries were advocates and technical reviewers of the last prototype test. Oregon State University provides adult hatchery steelhead in a controlled setting for a real-time test of the Swim-Thru system.

Keywords: Swim-Thru, fish passage, high head dam, medium head dam, fish lock, fishway

8351 The Efficiency of SandWand Technology as a Habitat Restoration Tool for Native Salmonids in Small Tributaries

Summary: Can fine sediments just be jetted and suctioned away to restore fish habitat?

Contact: Zak Sutphin, zsutphin@usbr.gov

Research Question:

- Can fine sediments just be jetted and suctioned away to restore fish habitat?

In response to habitat degradation, a multitude of restoration efforts have been conducted on behalf of the Bonneville cutthroat trout (BCT), and continued restoration efforts are recommended for management. This Science and Technology Program research project is a multi-year pre- and post-treatment monitoring program. In year 1–2, we will complete study site selection (2–3 tributaries) and collect baseline data on habitat and on the macroinvertebrate and fish communities. After year 2, we will remove fine sediments, and then we will quantify changes in habitat, macroinvertebrates, and the fishery in years 3–4. For sediment removal, we will use a new technology, the SandWand™ system (Streamside Environmental, Findlay, Ohio), which is manually operated and uses jetted water and pump suction to expose and loosen interstitial fines, then suction for removal. If sediment removal efforts result in restoring runs of BCT, we propose riparian habitat restoration at the end of year 4 and continued monitoring in years 5–6.

Need and Benefit: Removing interstitial fines from framework gravels on spawning beds is beneficial, but until recently, it has not been possible to do this cost effectively. Now, however, Reclamation could use SandWand technology to take advantage of private-sector expertise and resources that complement Reclamation's mission-driven research and development.

Imperiled anadromous fish in Reclamation river basins are confronted with a lack of spawning habitat caused by dams or by anthropogenic alteration or contamination as they return to rivers to spawn. This proposal seeks to combine existing and emergent technologies to significantly increase juvenile survival in rivers impacted by water withdrawals, logging, mining, or by biological, bacterial, or viral contaminants. Reclamation is responsible for recovery efforts of threatened and endangered species, and these costs amount to millions of dollars each year. Should this restoration tool prove effective at increasing redd densities and survival of anadromous fishes, then Reclamation stakeholders, the environment, and American taxpayers will all benefit.

Partners: Streamside Environmental and the U.S. Forest Service

Keywords: cutthroat trout, anadromous fish, habitat restoration, sediment removal, SandWand™

8370 Design Guidelines for New Technology, Low-Cost Bank Stabilization Features

Summary: What are the engineering and hydraulic performance properties of new methods of bank stabilization?

Contact: Drew Baird, dbaird@usbr.gov

Research Question:

- What are the engineering and hydraulic performance properties of new methods of bank stabilization (both a fixed bed bend and a mobile bed flume) in the laboratory and at documented field sites? These are also used for river restoration.

Since 2001, we have built physical hydraulic models of new methods of bank stabilization (e.g., bendway weirs, root wads, J-Hooks, native material bank protection, stone toe protection, and deformable bank lines) to test these transverse features.

We will conduct detailed laboratory measurements of structure performance, conduct field investigations for a range of geomorphic conditions and structure types, compile and document successful design criteria used in the field, perform a literature review, and synthesize the laboratory testing, field performance data, documented criteria, and literature review.

Need and Benefit: New methods of bank stabilization are being used in lieu of traditional riprap revetments for their cost savings and habitat benefits. They can also be used for reducing sediment deposits in front of fish screens, intake structures, and bypass structures, as well as for river restoration actions.

Existing design methods rely upon anecdotal information, individual professional experience, or incomplete methods that do not account for the near-bank flow processes. From 2001 to now, the physical model has been used to measure performance of these structures relative to channel hydraulic properties, structure geometry, and spacing. The laboratory work uniquely represents near-bank flow processes for bendway weirs, spur dikes, and native material features.

Reclamation owns and operates/maintains in-channel diversion and water delivery and riverside facilities that need to be protected from bank erosion. Reclamation also has river restoration requirements as a result of the presence of endangered species.

Partners: Reclamation's Albuquerque Area Office and Yuma Area Office, Colorado State University, U.S. Army Corps of Engineers Engineering Research and Development Center National Engineering, Design Center of the Natural Resources Conservation Service

Keywords: bank stabilization, fixed bed bend, mobile bed flume, bank erosion, bendway weirs, spur dikes, riprap

8462 Decision Framework to Determine Potential Sediment Impacts and Analyses for Reservoir Sediment Sluicing and Dam Decommissioning

Summary: Predicting the potential sediment impacts from sediment sluicing and dam decommissioning.

Contact: Jennifer Bountry**,** jbountry@usbr.gov

Research Question:

- What are the potential sediment impacts from sediment sluicing and dam decommissioning?
- How does the size of the reservoir and sediment load affect the level of modeling and data collection needed to address sedimentation questions associated with sediment sluicing and dam decommissioning projects?
- How does reservoir size and sediment volume influence the ability of current data collection methods and analysis tools to detect and quantify impacts of downstream sediment redistribution following sluicing or dam decommissioning?

We will conduct two workshops with scientific panels to produce a decision tree to guide the level of sediment analysis and modeling needed for reservoir sediment management, and the level of predictive capability (uncertainty analysis). We will then validate the decision tree developed by the workshop panel with field analysis and experience from workshop participants, including pre- and post- reservoir sediment management actions. Field analysis at dam removal project locations will include a mixture of reservoir and riverbed surveys, turbidity measurements, bed-material sampling, and repeat photo documentation.

Need and Benefit: Reclamation designers, reservoir operators, permitting agencies, and stakeholders need a tool to match the level of reservoir sediment analysis and certainty needed for a given project with the scale of the sediment issue. This research will benefit projects involving prediction of sediment erosion and transport related to reservoir sluicing and flushing as well as projects predicting sediment levels associated with design of pumping plants or other water intake structures downstream of Reclamation reservoirs (releasing sediment either in conjunction with reservoir sluicing or dam removal).

Reclamation manages a large number of reservoirs and reduced capacity due to sedimentation is a continuing challenge. This decision tree would work for the full range of reservoir sizes managed by Reclamation—the steps would be applicable for a range of dams with small and large sediment accumulations.

Partners: Over 50 scientists and practitioners involved in dam removal work from across the country have collaborated on this effort with Reclamation. This tool is being sponsored by the National Committee on Sedimentation. The Subcommittee on Sedimentation reports to the Federal Advisory Committee on Water Information See <http://acwi.gov/sos/index.html> for more information.

Keywords: sediment, decision tree, sediment load, dam decommissioning, sluicing

9320 Assessing and Reducing the Uncertainty of Predictions from Hydraulic and Hydrologic Models

Summary: Reclamation assesses and reduces model uncertainty.

Contact: Blair Greimann, bgreimann@usbr.gov

Research Question:

- What is the uncertainty of predictions from hydraulic, sediment transport, and hydrology models?

Predictions from these types of models include some degree of uncertainty from simplifying the real system for the model, errors in the estimated values of model parameters, and other sources. However, the magnitude and origins of the uncertainty are not well understood in most applications. This project is to develop and implement a framework to quantify and ultimately reduce the uncertainty associated with predictions from hydrologic and hydraulic models. The method combines Global Sensitivity Analysis (GSA) and Generalized Likelihood Uncertainty Estimation (GLUE). It focuses primarily on characterizing how well a model calibration method has constrained model parameters and how the uncertainty in the parameter values translates into uncertainty in forecasts obtained from a model.

We will build on previous efforts with the same name to evaluate and improve the current GSA-GLUE methodology and extend the method and streamline it to apply to real-world systems.

Need and Benefit: Model uncertainty can add significant costs to Reclamation projects. If the uncertainty in the model predictions can be reduced, then the range of possible outcomes would also be reduced, which would ultimately increase the efficiency of project designs. The methodology and software tools developed in this Science and Technology research project would benefit data collection, Reclamation and its project partners' decisionmaking, and improve other computer models.

Partners: We are building on this existing work by partnering with experts who are leading the development of these tools and are knowledgeable about the modeling tasks commonly confronted by Reclamation, including Dr. Jeffrey Niemann at Colorado State University.

Keywords: hydraulic models, hydrologic models, sediment transport, model uncertainty, Global Sensitivity Analysis, GSA, Generalized Likelihood Uncertainty Estimation, GLUE

Contents

772 Demonstration Project to Implement Electro-Osmotic Pulse Technology to Stop Water Leaks through Concrete

Summary: Can electro-osmotic pulses stop water leaks?

Contact: Daryl Little, dlittle@usbr.gov

Research Question:

- Will electro-osmotic pulse (EOP) technology be effective in stopping water leaks through concrete?

We will develop a repair technique for existing Reclamation structures to stop water leaks through concrete walls. The strategy is to demonstrate whether EOP technology is an effective solution. We will install and adjust an EOP system at a test site. This system will be closely monitored over the course of 3 years. A final report will be drafted, reviewed, and distributed at the end of the project. This report will be distributed throughout Reclamation, regional, area, and field offices.

Need and Benefit: Due to the cracks and leaks in the concrete, water migrates through the concrete and can lead to calcium carbonate deposits. These deposits can interfere with gate operations, plug drains, result in standing water in chambers, and cause significant corrosion problems.

This is a common, Reclamation-wide problem. Existing methods for these types of repairs are very expensive and limited in application. To date, in many cases, the only solution is continual maintenance of leaking structures. The continual repair and maintenance is difficult and expensive due to the location and materials.

Although this technology seems promising, facility managers and operators are reluctant to try it until its effectiveness is better understood. This research will help to determine if this technology is a viable solution to this problem. If so, it will be useful all throughout Reclamation. If this technology is effective for these kinds of leaks, repair costs will be greatly reduced, since repairs would be a one-time fix versus continuous repairs.

Partners: U.S. Army Corps of Engineers

Keywords: electro-osmotic pulse, EOP, water leaks, concrete, operation and maintenance, O&M

919 Water Resistant Concrete

Summary: Waterproofing concrete to prevent freeze-thaw.

Contact: Kevin Kelly, kkelly@usbr.gov

Research Question:

- Can commercially available and upcoming cementitious capillary waterproofing products be used by Reclamation to prevent concrete damages due to freeze-thaw action and undesirable chemical reactions from water intrusion?

- Can candidate waterproofing products be driven into the concrete matrix via electrokinetic transport?

Freeze-thaw is probably the mode of action that caused the most damage to concrete at Reclamation facilities. This problem also affects other concrete structures such as parking garages, buildings, and bridges. In freeze-thaw, water expands by freezing and contracts by thawing within the concrete. Concrete expansion may also occur due to undesirable crystallization reactions caused by reservoir water intrusion, such as gypsum formation ("sulfate attack") and alkali-silica reaction. Undesirable crystallization reactions result in crystals larger than concrete crystals, resulting in enormous pressure buildup that may also lead to fractures. Preventing or reversing water intrusion and undesirable water-intrusion crystallization reactions can result in a longer concrete life.

Need and Benefit: Many of Reclamation facilities are made out of concrete and are situated in regions where temperature extremes annually reach below and above the freezing point of water. For older facilities, there is a need to protect the concrete from the physical weathering process of freeze-thaw. These methods of concrete protection would add more years to the durability of our older Reclamation concrete structures and save costs associated with repairs and maintenance.

Partners: U.S. Army Corps of Engineers Research and Development Center (West Point, New York)

Keywords: concrete, infrastructure, freeze-thaw, water damage, weathering, operation and maintenance, electrokinetic transport, water-proof

1540 Three-dimensional Slope Stability Analysis of Embankment Dams

Summary: Using 3D modeling to improve slope stability assessment.

Contact: Ashok Chugh, achugh@usbr.gov

Research Question:

- How can three-dimensional (3D) modeling improve slope stability assessment?

Slope stability analysis plays a significant role in assessing in-service performance of earth dams under static, seismic, and hydrologic loading conditions. Generally, these analyses are performed using two-dimensional (2D) models. But 3D modeling may provide insights into the effects of valley form (e.g., steep or flat abutments, flat or undulating floor, narrow or wide valley) on the computed factor of safety results of an earth dam of given geometry (i.e., height and alignment). However, it is not known for what proportions of dam geometry, with respect to valley form, the 3D effects become significant and a 3D analysis should be carried out.

This Science and Technology Program research project will address use of the FLAC3D computer program to address inter-related considerations:

1. Effects of valley form (shape and size with respect to dam height) on stability of an embankment dam

2. Effects of material degradation (strength loss, pore pressure build up) during seismic events on the first consideration

3. Reliability of 3D computer software (based on limit-equilibrium and continuum-mechanics principles) for the first two considerations

Need and Benefit: The three research considerations on likely performance of an embankment dam during a seismic event routinely come up in risk-based decision meetings with Reclamation staff as well as in meetings with consulting review boards members. At present, estimates on these effects are based on individuals' experience and judgment. Assessing the magnitude of 3D effects based on proposed numerical models would provide better estimates of the 3D effects on slope stability.

Even though the questions during risk deliberations concern likely performance of a dam during a seismic event, static analysis of the dam is necessary as it provides the stress state in the dam prior to the application of seismic load. For this reason, the research will include static and seismic loading conditions.

Partners: University of Illinois

Keywords: risk assessment, dams, three-dimensional modeling, 3D, valley floor, slope stability analysis

1597 Evaluation of Protective Coatings

Summary: Evaluating coatings is essential to cost containment and long lasting maintenance

Contact: Allen Skaja, askaja@usbr.gov

Research Question:

- Is Reclamation using the best coatings for corrosion protection?

We will investigate coating system performance.

Need and Benefit: Evaluating and using the highest performance coating systems will reduce the maintenance and down time of a structure, thus increasing water availability and reducing maintenance costs. If products are selected that are not evaluated this could result in a difference between a 15-year service life to a 30-year service life. An improperly selected coating that prematurely fails could have severe adverse consequences on a major recoating job. Costs of $1 million or more in recoating work would have negative impacts on project funding and hydroelectric generation or water delivery revenues.

Partners: [1]

Keywords: coatings and corrosion, high performance coatings, coating evaluations

[1] Note that where we have not identified or solidified partnerships, this heading is left blank.

1898 Investigation of Coatings Containing Tremolite Non-Asbestiform to Determine if Abrasive Blast Fragments Contain Asbestos

Contact: Allen Skaja, askaja@usbr.gov

Research Question:

- Do coatings that contain tremolite non-asbestiform break down into fragments considered asbestos during the removal process?

We will investigate this issue.

Need and Benefit: These byproducts from the coating removal process would be a safety issue since tremolite non-asbestiform is used on almost every project across Reclamation.

Partners: U.S. Geological Survey

Keywords: tremolite, non-asbestiform fragments, material removals

1966 Long-term Performance of Cut-off Walls to Prevent Seepage in Dams

Summary: Do cut-off walls prevent seepage in dams in the long term?

Contact: Kurt Von Fay, kvonfay@usbr.gov

Research Question:

- What are the long term performance characteristics of cut-off walls used to prevent seepage in dams?

Cut-off walls are frequently used to slow down or prevent seepage of water through and around dams. Construction techniques of cut-off walls, including concrete, cement-bentonite slurries, and cement grouting, are thought to be a long-term solution to blocking seepage, but new information may suggest they are not as effective as once thought.

We will study the long-term performance of cut-off walls used to prevent seepage in dams by:

1. Identifying a number of dams that have had cut-off walls installed
2. Documenting pre-installation and post-installation seepage rates
3. Drawing conclusions about the effectiveness of different cut-off techniques

Need and Benefit: Because Reclamation has such a large inventory of dams, the results of this study could have tremendous impacts on Reclamation and its structures. Identifying those techniques which are most effective for seepage prevention will help Reclamation improve the performance of its structures.

Partners:

Keywords: dams, seepage, cut-off walls, including concrete, cement-bentonite slurries, cement grouting

2411 Terrestrial Photogrammetry: Deploy Reclamation-wide, Develop Capabilities, Explore Applications for Three-dimensional Measurements

Summary: Photogrammetry now provides rapid, accurate, inexpensive measurements and models of almost everything.

Contact: Rebecca Heisler, rheisler@usbr.gov

Research Question:

- Can Reclamation take advantage of photogrammetry technology and establish a multi-discipline team to speed up and improve the quality of data acquisition?
- Can close-range (terrestrial) photogrammetry technology be deployed throughout Reclamation so all offices can benefit from it?
- Can terrestrial photogrammetry methods for geologic mapping and characterizing rock structures help reveal the potential for rock erosion and improve estimates of stream power at Reclamation structures?
- Can terrestrial photogrammetry obtain volume measurements for in-place density calculations for various types of soils?
- Can relatively inexpensive software process photographs and generate 3D models for measurement data?

We will obtain photographs and generate models from real situations that present themselves every year to help answer these questions.

Need and Benefit: Terrestrial photogrammetry is a powerful data-gathering tool applicable to any situation that requires a measurement. Within the past year, photogrammetry techniques were successfully deployed for the first time in the Hydraulics Laboratory to rapidly obtain accurate models and measurements. The Flood Hydrology Group had great success using a camera mounted on a helium balloon to develop models for streamflow effects. Terrestrial photogrammetry was successfully used in a tunnel for the first time to obtain a scale model and to accurately measure concrete erosion volumes. Terrestrial photogrammetry is revolutionizing how measurements are made in the field. Reclamation now is poised to use this technique for virtually every construction job to obtain as-excavated and as-built geology and topography, to monitor ongoing changes at dam sites using difference-calculation modules in the software, and to expose and expand these measurement and modeling capabilities to other disciplines. From geologic mapping to estimating stream power, there are myriad applications in which terrestrial photogrammetry can provide rapid, inexpensive, highly accurate information.

Partners: Great Plains and Pacific Northwest Regions have both expressed interest in a demonstration of this technology. Also, the recent transfer of a leading photogrammetry researcher from Reclamation to the U.S. Army Corps of Engineers (USACE) provides a significant opportunity for developing a partnership with them.

Keywords: terrestrial photogrammetry, topography, data acquisition

4490 Electrochemical Paint Stripper for Removal of Lead Based Paints and other Hazardous Coatings

Summary: Electrochemical paint stripper may be safer than chemical, power tool or hand tool removal methods.

Contact: Allen Skaja, askaja@usbr.gov

Research Question:

- Can Reclamation use electrochemical paint strippers to remove hazardous coatings?

Need and Benefit: This electrochemical stripper would be preferred over chemical strippers, power tool cleaning and hand tool cleaning. These other modes of cleaning have health hazards associated with removal of caustic solutions or highly carcinogenic chemicals, production of fine particulates that can enter the respiratory system, and limited removal of only loose paint chips.

Partners:

Keywords: electrochemical paint stripper, coatings, paint, lead paint, cleaning, operations and maintenance

4925 Improving the Range of Hydraulic Performance of Type III Stilling Basins

Summary: Installing ramps may improve stilling basin performance.

Contact: Connie Svoboda, csvoboda@usbr.gov

Research Question:

- Can we improve the hydraulic performance of Reclamation Type III stilling basins over a broader range of flow conditions by installing a ramp in between the baffle blocks?

During a physical hydraulic model study funded by the U.S. Army Corps of Engineers (USACE) in 2008, the performance of a modified Reclamation Type III stilling basin unexpectedly improved with the installation of a 3H:1V sloped ramp between the baffle blocks. The ramp, which was installed to reduce cavitation potential on the stilling basin floor, allowed the basin to be more stable over lower tailwater elevations. The modeled stilling basin contained a stepped spillway with no chute blocks at a 2.5H:1V slope. It is unclear whether the stepped chute or spillway slope contributed to the success of the ramp, so we need further research. We will build a Froude-scale physical hydraulic model to test two configurations:

1. Smooth spillway chute with chute blocks, baffle blocks, and endsill
2. Stepped spillway chute without chute blocks, baffle blocks, or endsill

Need and Benefit: Improving the acceptable range over which Reclamation Type III stilling basins can successfully operate will improve infrastructure reliability. Improving the performance of Reclamation Type III stilling basins at low tailwaters has broad application within Reclamation, within the Federal Government, and in the private sector. Reclamation has the experience to further research on stilling basin designs and the responsibility to document potential enhancements of its guidelines. The Hydraulics Laboratory at the Technical Service Center (TSC) has the facilities and instrumentation needed to provide quality data to answer this research question.

Partners:

Keywords: stilling basins, tailwater, chutes, ramps, baffles

6330 Scoping Study on New Technologies to Halt Concrete Shrinkage and Cracking

Summary: Reducing or eliminating concrete cracks.

Contact: Kurt Von Fay, kvonfay@usbr.gov

Research Question:

- What technologies are available to help reduce or eliminate concrete shrinkage and cracking during concrete curing?
- Are there any potential issues with the use of these technologies?
- Which of these technologies could be successfully used in Reclamation structures?

Concrete is a very useful material, but virtually all concrete cracks. Cracks can be repaired, but these repairs can become expensive and labor intensive. This Science and Technology Program research project will begin to evaluate relatively new technologies that may help reduce or completely eliminate concrete shrinkage and cracking. The project will:

1. Perform a research review to identify promising technologies
2. Identify technological issues that may be preventing wide-scale acceptance of the technologies
3. Identify those technologies that could help in construction or rehabilitation of Reclamation facilities

Need and Benefit: Reclamation has many facilities with unique needs. These facilities encompass a wide variety of concrete construction materials and techniques that are not common to other areas of the large civil structures community. The Materials Engineering and Research Laboratory in the Technical Service Center (TSC) is responsible for providing more reliable, better quality, better performing concrete materials, and eliminating shrinkage and cracking in Reclamation structures would be of enormous benefit.

Partners:

Keywords: concrete, shrinkage, cracking, construction

6629 Moisture Content Requirements for Effective Concrete Repairs

Summary: Ensuring long-term success for concrete substrates.

Contact: Kurt Von Fay, kvonfay@usbr.gov

Research Question:

- What is the optimum moisture content for the concrete substrate for different concrete repair materials to ensure successful long-term performance?

There is much contradictory speculation about the optimum moisture conditions for various repair systems. We will address this issue for a wide variety of repair methods by developing a field test to quickly and easily evaluate the moisture condition of a concrete substrate, the optimum moisture content of the substrate at the time of repair for different repair materials, and performance criteria for surface preparation, including recommendations about moisture conditioning ("how to" and "why to").

The research will investigate the:

- Factors affecting bond behavior and durability in overlays/repairs
- Test method to evaluate in-situ concrete moisture content instantaneously
- Influence of repair material on optimum moisture condition (with respect to tensile bond) of the substrate prior to repair/overlay
- Effect of moisture condition on repair/overlay shear bond strength

Need and Benefit: The success of concrete repairs and overlays is lower than desired and hard to predict. Many times, they crack prematurely, reducing the service life of the repair and requiring expensive repairs much sooner than originally planned. This problem with repairs and overlays is not unique to Reclamation. However, the problem is more significant to Reclamation because the age and quality of many of our older concrete structures makes repairs even more difficult.

This research brings a direct benefit to Reclamation and our stakeholders that would not otherwise occur. Our applied research is solution-oriented and combines our key engineering and scientific problem-solving expertise with strong basic research contributions from others with whom we have developed long-standing relationships.

Partners: U.S. Navy, Naval Facilities Engineering Command

Keywords: infrastructure, concrete, concrete repair, overlays, moisture condition, concrete substrate

8442 Physical Hydraulic Modeling of Canal Breaches

Summary: Physical hydraulic models used to study erosion and breaching processes for canal embankments.

Contact: Tony Wahl, twahl@usbr.gov

Research Question:

- How can we use small-scale physical models to study the breaching processes of typical canals?

Canal flow rates and cross sections will be scaled down to allow testing to take place in the hydraulics lab. Materials whose erodibility characteristics are well known will be used for the testing, which will allow the development of relationships for predicting canal breach outflow rates as a function of canal and embankment geometry and geotechnical characteristics.

The products of this Science and Technology Program research project will promote our long-term objective of developing a canal-specific numerical model for simulating erosion and breaching of canal embankments, or the incorporation of canal-specific features into existing embankment dam breach models. This future canal breach model would be valuable for detailed analysis of specific cases and could also be used to develop simplified appraisal-level tools.

Need and Benefit: To classify the hazard potential of Reclamation canals and reduce flooding risks, predictions of the breach outflow rate from a canal failure are needed. Breaching of traditional embankment dams has been widely studied and tools for predicting dam breach outflow rates are reasonably well developed. However, breaching of canal embankments has not been studied extensively, and there are important differences between the canal situation and the embankment dam scenario. Most notably, the flow of water past the developing breach and limitations on the ability of the canal to convey water to the breach site may significantly affect the mechanics of the erosion process and the resulting breach outflow rate.

Reclamation has constructed more 7,300 miles of canals since 1902. When in operation, these embankments can erode and fail (breach) due to seepage through animal burrows, failure of canal lining materials, or overtopping flow during floods or due to misoperation or failure of canal control equipment. Although they pose threats to life and property that are similar to traditional dams, canal embankments are not regulated by the Dam Safety Program. Failures of canals embankments on Reclamation projects have occurred with some frequency throughout our history. The last significant failure of a Reclamation canal was the Truckee Canal failure in January 2008. Before this most recent failure, the Truckee Canal had experienced as many as eight previous failures. Although no lives were lost in this case, property damage was extensive. Loss of life during embankment failures is becoming a greater possibility as urban development takes place near Reclamation canals.

Partners: Lower Colorado Regional Office, Agricultural Research Service

Keywords: canal failure, embankments, canal breaches, outflow hydrographs, inundation levels, flooding, hydraulic modeling

9541 The Application of Light Detection and Ranging Technology to Improve the Management and Protection of Heritage Assets in the American Falls Archaeological District, Idaho

Summary: Using LiDAR to monitor our historic heritage.

Contact: Jennifer Huang, jhuang@usbr.gov

Research Question:

- What are the natural forces and human activities that speed the erosion of archaeological sites in the American Falls Archaeological District (listed on the National Register of Historic Places)?
- How can we provide for more well-informed management decisions to manage and preserve these invaluable cultural resources under Reclamation's control and jurisdiction, a responsibility required both by national law and Reclamation policy?

New technologies could provide an extremely high quality and quantity of quantifiable data. These data could then be analyzed and compared to a baseline of data to detect changes over time, greatly reducing subjectivity and furnishing management with information that would promote better decisionmaking processes.

We will collect fine elevation data annually for 3 years by using aerial Light Detection and Ranging (LiDAR) equipment and ortho-imagery of the 4,494 acres of Reclamation and Bureau of Land Management (BLM) lands in the American Falls Archaeological District along the Snake River below American Falls Dam in southeast Idaho. A final report will be written and disseminated, and a presentation of results will occur at the national meeting of the Society for American Archaeology, introducing LiDAR as a new, viable tool for archeological site condition assessment (thanks to Reclamation's innovation).

Need and Benefit: A very important Reclamation-owned archeological area is in immediate danger from several erosional factors. This area lies within the American Falls Archaeological District, a bounded area that is listed on the National Register of Historic Places. The district contains 158 contributing archeological sites (131 on Reclamation land and 27 on BLM land) and represents almost continuous human occupation spanning more than 12,000 years. Reclamation needs to provide better protection of the heritage assets under its control and jurisdiction as directed by several legislative authorities.

Applying LiDAR to ascertain archeological site condition assessment has not been attempted, according to our background research, either within or outside the Department of the Interior (DOI). This study would represent a revolutionary step in cultural resources management and could be an enormous boon for Reclamation in both its fiscal and legal responsibilities to heritage preservation.

Partners: Bureau of Land Management

Keywords: Light Detection and Ranging, LiDAR, American Falls Archaeological District, cultural resources

9750 Hydraulic Modeling with Abrupt Changes in Reynold's Number

Summary: Determining ways to use the same physical models to study downstream hydraulic effects.

Contact: Leslie Hanna, lhanna@usbr.gov

Research Question:

- How do we continue to provide state-of-the-art solutions to problems in hydraulics involving structures that include areas where the Reynolds number (R#) drops abruptly in magnitude?

Physical models of dams, spillways and outlet works are often necessary to solve design challenges in hydraulics. The laws of similitude using Froude scaling can usually be applied to study these structures because the R# is high enough to ignore viscous effects. However, it is also often desirable to study the flow conditions downstream from these structures where stilling action causes the R# to drop considerably. In this case, the R# may no longer be high enough to match the friction/shear of the prototype to accurately simulate sediment transport and shear characteristics. If a correlation can be made between the drop in R#, and the operations required to compensate for this drop, the same model can be used to study the downstream hydraulic effects of the structure.

Need and Benefit: This research will facilitate our ability to use the same model to study and solve a multitude of problems associated with the implementation of these designs. Several physical models of spillways, dams, and outlet works have already been constructed in the Hydraulic Investigations and Laboratory Services Group for previous or ongoing studies. As a result, we have already-constructed models that can be used for this research as well as existing data from the studies that have been completed thus far. The existing models can be used for further investigations (so that new model construction may not be necessary); and the existing data will reduce the quantity of investigations that must be performed for this study.

Partners:

Keywords: Reynolds number, R#, flow models, physical models

9818 Laboratory Evaluation of Metallized Coatings for Use on Reclamation Infrastructure

Summary: Metallizing could increase the service life of protective coatings.

Contact: David Tordonato, dtordonato@usbr.gov

Research Question:

- Could a metallizing process increase service life and fill the void in Reclamation's assortment of coatings caused by changing regulations?

Metallizing could increase the service life of protective coatings while providing greater flexibility during application. However, more testing is needed to optimize alloy compositions and application parameters.

We will apply a test matrix consisting of several conventional metallizing alloys and galvanizing to test substrates. One or more metallizing topcoats or sealcoats will also be tested using different surface preparation techniques. Triplicates of each coating system will be subjected to accelerated weathering for approximately 5,000 hours. Cost and practical issues associated with performing metallizing will also be evaluated. Applicable environmental and safety regulations will also be considered with the use of metallized coatings on Reclamation infrastructure.

Need and Benefit: Regulations on volatile organic compound (VOC) emissions have become more strict in recent years, so many coating systems that Reclamation previously used are now unavailable. Vinyl resins were used extensively when service conditions required a durable protective coating that was subjected to immersion and ultraviolet (UV) light. Metallizing could potentially be used as a substitute for vinyl resins for this specific type of service environment. Furthermore, metallizing can be applied under a variety of environmental conditions, whereas most polymer coatings specify humidity and temperature conditions for proper curing. A recent report produced by Reclamation concluded that metallizing has life cycle costs similar to those of conventional coatings while potentially providing a greatly increased service life.

Partners:

Keywords: metallizing, thermal spray, alloys, coating, seal coat, top coat, service

Contents

1010 Adaptive Water Operations and Planning Decision Support Using Reliability-Based Global Optimization and HydroGeoSphere Integrated Hydrologic Model

Summary: Improving HydroGeoSphere to simulate complex hydrologic systems for better water management.

Contact: George Matanga, gmatanga@usbr.gov

Research Question:

- Can decision support tools using global optimization, stochastic simulations, and integrated hydrologic modeling be developed to help water managers objectively select the optimal strategy for managing water-resource system operation and planning while coping with complex hydrology, uncertainties, and regulatory and physical constraints?

We will develop a decision support system to determine this. Reclamation's Mid-Pacific Region is currently applying HydroGeoSphere in a variety of problems to realistically simulate various surface-water and groundwater physical/thermal processes in a fully integrated manner. It relates hydrologic and environmental response to different water system operations and planning strategies. We will provide an integrated hydrologic system simulation module based on the HydroGeoSphere code, a general water system operation and resources management module, a module for evaluating performance and objective functions, an optimization module using the differential evolution algorithm, a stochastic simulation module based on Monte Carlo realizations to represent uncertainty and variability, and a Geographic Information System (GIS) based visualization module that serves as the communication platform.

Need and Benefit: Fully integrated surface water and groundwater systems are complex. Water resource managers traditionally make decisions on water system operations and planning based on their experience, consideration of a limited number of decision alternatives, and a few scenarios of future conditions (such as water availability, water demand, and weather/climate change). In addition, such decisions are typically made on an administrative schedule—instead of adaptively as new information is collected. Decision support tools are needed to assist water managers in assimilating water resources data, simulating the response of fully integrated surface and subsurface water systems, coping with uncertainties, and making optimal decisions.

Partners: Amec, Oakland, California; University of Waterloo, Waterloo, Ontario, Canada; University of Hong Kong, Hong Kong

Keywords: HydroGeoSphere, global optimization, fully integrated water systems**,** decision support software, adaptive management, future scenarios, differential evolution, Geographic Information Systems, GIS

1741 Using Data on Threatened Steelhead to Effectively Manage Water Operations and Minimize Impacts

Summary: Analyzing data to save the steelhead trout in California's Central Valley.

Contact: John Hannon, jhannon@usbr.gov

Research Question:

- How can we use existing data on the threatened steelhead trout to more effectively manage water in the Central Valley Project, California?

Threatened steelhead trout constrain Federal and State of California water operations, yet existing data on the species have not been adequately analyzed. These existing data likely contain valuable information that could be used to more effectively manage water operation for all affected species in California's Central Valley.

We will analyze these data to help develop operational criteria.

Need and Benefit: Existing steelhead data could be more effectively used to develop operational criteria that protect the species while liberating water for other beneficial uses. The ongoing Bay Delta Conservation Plan (BDCP), to which Reclamation is devoting considerable resources, would benefit from the analyses conducted using this existing data. The BDCP proposes considerable changes in water operations in an attempt to minimize the effects of climate change on operations, so this research is timely and needed and could save considerable money.

Partners:[1]

Keywords: steelhead trout, lifecycle, Bay Delta Conservation Plan, BDCP, Water operations, Central Valley

[1] Note that where we have not identified or solidified partnerships, this heading is left blank.

2321 Evaluation of the Enhanced Snowmelt Runoff Model to Assist in Water Management Operations and Decision Support

Summary: Combining satellite imagery with snowpack telemetry may improve snowmelt runoff predictions.

Contact: Allyn Meuleman, gmeuleman@usbr.gov

Research Question:

- Can recently developed methods improve the predictability of streamflows based on short- to medium-term downscaled weather forecasts to assist in Reclamation's water-management decisions?

We will collaborate with the Natural Resources Conservation Service (NRCS) and with private industry to calibrate and run the enhanced Snowmelt Runoff Model (SRM) for five basins starting in the 2011 runoff season.

Five basins in the Snake River basin will be examined. They were selected because they have varying rates of snowfall and precipitation, the University of Idaho has conducted research in these basins, and the headwater streams in these basins are primarily snow dominated.

The enhanced model uses satellite spectroradiometer data from the National Aeronautics and Space Administration (NASA), improved snow probability mapping algorithms to see under clouds, and downscaled 15-day weather forecasts for NRCS's snowpack telemetry (SNOTEL) temperature and precipitation data. The satellite images provide useful information about the receding snow cover in parts of the basins not monitored by the SNOTEL network and, hence, could improve the accuracy of streamflow and snowmelt runoff predictions.

Need and Benefit: More than 80 percent of the water supply in the Western United States' results from the melting mountain snowpack. Many local, State, and Federal agencies' operations depend on knowledge of the runoff from the mountains, including those interested in agriculture, power generation, tourism, fire prediction, and protection of fish and wildlife. Reclamation, in particular, requires accurate and timely predictions of water supplies in order to manage these resources to meet complex and often competing demands. These predictions depend on accurate estimates and forecasts of snow-cover extent, snow water equivalence, and snowmelt. Through sound science, these products are now available for use in models to improve streamflow forecast results.

Partners: NRCS has committed to provide significant in-kind services. Technical support is also expected from Aniuk Consulting, LLC.

Keywords: snowmelt runoff, streamflow forecasting, Natural Resources Conservation Service, NRCS, SNOTEL, satellite imaging, National Aeronautics and Space Administration, NASA, MODIS

2582 A Method for Developing Daily Flow Data from Monthly Model Output that can be Used for Risk Assessment

Summary: Converting monthly flow data to shaped daily data to use for risk assessment.

Contact: Jennifer Johnson, jmjohnson@usbr.gov

Research Question:

- Is there an efficient and effective method for converting monthly flow data to shaped daily data that can be used for risk assessment?

Often, flow data from Reclamation's planning model output are in monthly increments. However, risk assessments, such as determining flood risk or meeting minimum flows for fish, require that data be in daily increments and that the minimum and maximum flow rates be estimated.

This Science and Technology Program research project will develop and analyze a method to convert monthly data to daily output data by using a surrogate dataset. The research result will be a tool that incorporates the developed statistical method using either Excel or the statistical package R, or a combination of the two. The tool will be transparent so that users can understand the techniques involved in developing the new dataset.

Need and Benefit: Reclamation needs an accepted method in which to calculate daily flow data from monthly model output to be used for such studies. Long-term planning and environmental studies are used to determine operating procedures under changing conditions, such as new environmental regulations, site structural changes, or global climate change.

Numerical models allow Reclamation hydrologists to determine the impact of changes to the system and to evaluate possible reactions to changes in the system. Since a large number of planning studies are now asking for risk assessments of statistical probabilities such as exceeding flood stage, filling reservoirs, and going below minimum flow requirements for fish, we need to develop daily data that capture the statistical likelihood of these events.

Partners:

Keywords: risk assessment, numerical models, monthly data, daily data, flow data, planning studies, operating procedures

2846 Geographic Information System-based Decision Support for Wetland Drainage Salinity Management

Summary: Creating models to manage salinity in wetlands.

Contact: Charles Johnson, cjohnson@usbr.gov

Research Question:

- Can seasonal wetland hydrology be generalized within a GIS-based decision support modeling framework with sufficient rigor to meet wetland manager needs for salt management?

We will develop a GIS-based decision support system based on a flow and salinity simulation model that constructs water and salt mass balances for each modeled area. Questions that the model may be able to answer include:

- What is an appropriate level of aggregation of individual wetland impoundments that captures spatial heterogeneities while providing a manageable interface for a decision support system?
- What level of aggregation is appropriate for current and future sensor network configurations?
- What are the factors that promote and potentially impede technology transfer of a decision support system to wetland managers?
- Can the decision support system be generalized for application to agricultural and wetland salinity management projects Reclamation-wide?

The research project will first develop a level of simulation model aggregation that integrates well with the current real-time flows and water quality monitoring network, is logical to wetland managers, and is easy to simulate. Once this is agreed upon among all wetland entities and project proponents, data collection and analysis will begin in earnest—yielding a system that delivers water to each unit and keeps track of daily outflow, seepage, evaporation, and moist soil plant transpiration to continually update water storage and salt load storage.

Need and Benefit: This research will improve wetland managers' ability to coordinate and schedule saline return flows to the San Joaquin River and to improve compliance with State regulations for salinity. The final work product will be generalized so that it can be extended to other Reclamation users. It should be applicable to both wetland and agricultural applications where saline return flows must be managed to meet salinity (or other contaminants) total maximum daily load (TMDL) limits. Reclamation has an obligation to supply drainage service to its water supply contractors and to assist water districts to comply with downstream water quality objectives. This research could provide a way to monitor our obligations through simulation—as a watershed of 170,000 acres could never be adequately monitored by a sensor network alone.

Partners: KISTERS International, Inc.

Keywords: salinity management, modeling, water quality, wetlands

3625 Integrated Information Management System, Development of Web Interface

Summary: Finding data for water management should be easier with Trinity River Restoration Program new system.

Contact: Erik Peterson, ebpeterson@usbr.gov

Research Question:

- How can we better deploy the Integrated Information Management System (IIMS) in Reclamation?

This Science and Technology Program research project will implement IIMS on the Web. As requested, this will provide a two-stage rollout of Web capabilities:

1. Base implementation of existing IIMS capabilities on the Web. Geospatial capabilities will be handled through a simple query of data on the Web originating from ArcGIS Desktop, and the Time Series Analyst (TSA) will add viewing capabilities for depth, bedload, or cross-sectional data. Additionally, data stewardship tools will be enhanced with this first stage.

2. Enhanced implementation of IIMS capabilities, including a Web-based geospatial interface; TSA enhanced to visualize depth profiles, bedload, and cross-sectional data; and provision of an IIMS manual.

Need and Benefit: Managing Reclamation dams, rivers, and water resources increasingly requires rigorous scientific analysis of physical and biological responses to management actions. A science-based approach to river system management requires collecting, disseminating, analyzing, and reporting large volumes of physical and biological measurements. Without an integrated information management solution, Reclamation scientists, managers, and policy makers are left to gather what information they can from many different sources. Much of this information has been stored on individual computers or databases that are isolated, remote, and poorly coordinated, leading to poor data provenance, inadequate quality control, data duplication, and territorialism.

Unfortunately, initial attempts at deployment of IIMS within Reclamation have proven problematic. Challenges center around using a desktop application as the primary interface. We now seek to build upon the foundation of IIMS initial development by fully implementing the Web interface in place of the desktop application. This interface will provide data integration, viewing, and sharing tools needed by Reclamation for wise water management in today's collaborative environment.

Partners: ESSA Technologies

Keywords: information management, Web interfaces, water resources management

3789 Data Management and Data Stewardship in Reclamation

Summary: Reclamation investigates data stewardship best practices.

Contact: Douglas Clark, drclark@usbr.gov

Research Question:

- How can Reclamation effectively introduce and implement data management/stewardship best practices?

Teams and sub-teams from all Reclamation Regions, the Washington Office, and the Denver Technical Service Center, including a technical team of Information Technology (IT) personnel and subject matter experts will develop:

- Information on a possible organization structure for the implementation of data management/stewardship in Reclamation
- Data acquisition and management plan (DAMP) template for the stewardship of data throughout the entire data lifecycle and data stewardship teaching materials
- Best practices for data acquisition and management and recommended principles, roles, responsibilities, and authorities for data stewardship within Reclamation
- Information for the development of future Directives and Standards (D&S) and handbooks on biological and geospatial data
- Recommendations for writing, reviewing, and adopting a data standard and for a data stewardship umbrella policy

Need and Benefit: Reclamation is responsible for acquiring, managing, and analyzing resources data. We must ensure that the value of mission critical data is carefully maintained. At present, many data gathering efforts take place in isolation without the benefit of protocols, quality standards, maintenance procedures, or archival processes. Mission-critical data in Reclamation must be managed with rational collection, processing, maintenance, and disposition processes.

Partners: A team of data management experts from other agencies such as the US Park Service, the Bureau of Land Management, the Fish and Wildlife Service, the US Geological Survey, and NatureServe will serve on an advisory board.

Keywords: Data management, data stewardship, IT, best practices, geospatial data, biological data, archives, records, data lifecycle, data processing, data maintenance, data disposition, information technology, data quality, data protocols, subject matter experts

6769 Three-Dimensional Visual Reservoir Sediment Modeling and Animation

Summary: Modeling sedimentation to determine reservoir capacity.

Contact: John Carlson, jcarlson@usbr.gov

Research Question:

- What techniques are best used to calibrate the sediment model to historic data from reservoir sedimentation surveys?
- Based on historic rates of sedimentation, when will sediment levels reach critical facilities such as water intakes, dam outlets, and other important facilities such as boat marinas?

This Science and Technology (S&T) Program research project continues from a S&T research project in Fiscal Year 2010, which developed the model showing the accumulation of sediment over time as a succession of surfaces. The model functions as intended. At Bighorn Lake, Montana, the research will extend the model to include significant side channel deposition and visualize deposition farther downstream toward the dam where facilities are located. We will calibrate the model more closely with measured reservoir bottom elevations, including adding variable sediment deposition rates over time to the model equations (which now assume a constant rate per year averaged). At Elephant Butte Reservoir, New Mexico, we will gather, format, and input existing reservoir bottom elevation data and perform the sediment accumulation computations to input data to the model.

Need and Benefit: Reservoir operators need to know how the current water surface area and storage capacity changes with water surface elevation and how this information will change in the future. Predictions of sedimentation at dam intakes and other facilities would greatly aid in planning either sediment removal efforts or alternate courses of action such as dam decommissioning and removal, installation of alternate water intakes, sediment bypasses, etc.

Results from this research will give Reclamation managers information on the timing and location of reservoir sedimentation impacts. Future investigations could then be conducted to develop local solutions for specific reservoirs. In addition, model results will suggest how much time is available to implement actions to mitigate impacts.

Having this information presented visually (rather than numbers presented in a table) makes it easier for Reclamation managers, irrigation district officials, and other stakeholders to grasp and displays a greater sense of urgency for dams with faster sediment accumulation rates. Managers could prioritize reservoir sediment surveys and sediment removal such that dams with those intakes clogging the soonest could be the first candidates for dredging, etc.

Partners:

Keywords: sediment, dam decommissioning, dam removal, reservoir impacts, sedimentation, ArcGIS, ArcScene, Elephant Butte Reservoir, Bighorn Lake

Contents

60 Development of a Multi-Aquifer Hydrologic Modeling Package to Support Reclamation Water Use Planning in Rural/Urban Landscapes

Summary: Combining models to better answer conjunctive water management questions.

Contact: Jennifer Johnson, jmjohnson@usbr.gov

Research Question:

- Is there a way to develop a non-proprietary hydrologic modeling package that combines a multi-layer analytic element model (TimML), a finite-difference model (MODFLOW), and a data management tool (ArcGIS) to address management issues?

We will focus on Reclamation's need for hydrologic modeling tools that can address conjunctive ground water and surface water management issues at the interface between rural and urban landscapes.

Separately, analytic element method (AEM) and finite-difference (FD) models provide answers to some conjunctive water management questions. However, combining the capability of these models would provide a powerful decision-making tool for ground water hydrologists and water managers. We will develop an ArcGIS extension that will act as a pre- and post-processor for model input and output data and transfer the data to TimML. The extension will also have the capability to control TimML model calculations and will be able to communicate with regional MODFLOW models.

Test cases for each stage will be located in the Boise Valley. The development of the extension will be completed in three stages**:** developing a proof-of-concept tool, refining that tool, and incorporating the existing MODFLOW model of the Boise Valley into the ArcGIS extension package. This portion of the research and development will most likely be the most time consuming and complicated, due to the fundamental differences between finite difference models and AEM models.

Need and Benefit: Combining TimML and MODFLOW with ArcGIS will increase the efficiency by which Reclamation can answer questions about regional and local scale conjunctive surface and groundwater management issues. Other government agencies do not have the need to answer the types of questions that are often posed to Reclamation groundwater hydrologists and the private sector is not interested in developing a non-proprietary hydrologic modeling tool.

Partners: Idaho Department of Water Resources Research

Keywords: TimML, MODFLOW, ArcGIS, hydrologic modeling, rural, urban, ground water, surface water, water management

216 Database for Field Performance of Electronic Water Level Sensors

Summary: Developing an impartial performance database for water level sensor performance.

Contact: Tom Gill, tgill@usbr.gov

Research Question:

- What water level sensors provide accurate measurements over a sustained period of time in field conditions?

We will install and monitor the field performance of several water level sensing technologies at Reclamation-related field sites. The research will build on perspectives from previous Science and Technology research projects and will focus on a critical and most failure-prone component of canal modernization technologies—water level sensors. Research results will be an unbiased database documenting performance over time of each instrument included in the study.

Direct communication between Reclamation researchers and cooperating irrigation districts will allow a detailed dataset to be collected without risking logistic impairments.

Need and Benefit: Water level sensor reliability—or lack thereof—represents a huge potential liability for virtually any entity using electronic control technologies to help manage an open channel water system. Damage liabilities faced by an irrigation district from water level sensor failure can readily represent a greater cash outlay than the cost of a supervisory control and data automation (SCADA) system.

Water level sensors used directly by Reclamation and entities that receive water from Reclamation projects represent a major share of the electronic water level sensor market. Available information is largely limited to manufacturer's promotional literature and to "word of mouth" recommendations from other users. Developing an impartial performance database would provide users an alternative to a first-hand "trial and error" process for selecting water level sensors.

Partners: This research will be conducted in cooperation with selected irrigation districts and area offices across the Reclamation service area.

Keywords: canal modernization technology, water level sensors, supervisory control and data automation, SCADA systems, irrigation districts, canal operations

414 Effectiveness of Conservation Pricing in Reducing Water Demand, Evidence from Increasing Block Rate Structures

Summary: Determining the best way to price water to conserve urban water.

Contact: Steven Piper, spiper@usbr.gov

Research Question:

- What is the effect of conservation pricing structures on residential and commercial water use?

We will evaluate the effectiveness of using an increasing block rate pricing structure to reduce municipal and industrial water demand. Different types of increasing block rate structures would be expected to have varying levels of effectiveness in reducing water demand. This research will evaluate the influence of various marginal water prices on the quantity of water demands and determine the most appropriate rate structure for meeting water conservation goals.

We will develop a model of water demand that includes variables (price and non-price) expected to influence demand (e.g., marginal price, average price, home size, lot size, household size, climatic variables, income) for various rate structures and to estimate the price elasticity of demand for each type of rate structure. The price elasticity of demand measures the influence of price on the quantity demanded for a good or service. A greater price elasticity of demand implies greater effectiveness of price as a conservation tool.

We will use:

- Individual household/business data to estimate a municipal and industrial demand model for each water supplier or for all water suppliers combined

- Aggregated average data for various water suppliers, which could then be used to estimate an aggregated demand model for all suppliers

Need and Benefit: This research will help Reclamation understand how conservation pricing structures can best be implemented to help accomplish water efficiency goals. Knowing the effects of these pricing structures can help determine the optimal/least cost mix of conservation approaches that meet conservation goals.

Partners: This research proposal will continue a cooperative relationship between Reclamation and the Metropolitan Water District of Southern California (MWD).

Keywords: pricing structure, economics, water supply, water demand, water conservation

485 Evaluation and Use of Alternative Sealants to Reduce Seepage Losses in Canals

Summary: Finding effective bio-based sealants for earth-lined canals.

Contact: John Osterberg, josterberg@usbr.gov

Research Question:

- How effective are bio-based sealants in reducing seepage losses from earthen canals?

These sealants have shown promise to substantially reduce seepage rates and are much less expensive than traditional canal lining alternatives. Two different types of sealants will be tested in the Arkansas River Valley in Colorado: flocculants (like polysaccharide, or polysaccharide-polyacrylamide compounds) and oil/water emulsions.

We will:

- Estimate seepage losses by the inflow-outflow technique using acoustic Doppler current profilers (ADCP) and acoustic Doppler velocimeters (ADV)
- Apply canal sealant to each of the selected canal reaches
- Acquire topographic and hydrographic data to describe the hydraulic geometry and water level elevations along the treated canals
- Analyze data to estimate rates of seepage loss along the tested canal reaches using conservation of mass

Need and Benefit: Reclamation has over 300 irrigation districts, and most have earth-lined canals. These canals lose large amounts of water during the irrigation season. Most districts do not have the repayment capability to line canals with concrete, use membranes, or convert to pipe. Canal sealants show great promise at reducing seepage at a substantially lower cost. These products could save large amounts or water throughout the Western United States.

Partners: Colorado State University

Keywords: canal sealants, irrigation, water conservation, earthen-lined canals, seepage loss, flocculants, oil/water emulsions, bio-based sealants, Doppler

2319 Design Refinement and Construction Drawings for Overshot Gates that Irrigation Districts can Construct Themselves

Summary: Refining designs for overshot gates that irrigation districts can build themselves.

Contact: Tom Gill, tgill@usbr.gov

Research Question:

- Can an overshot gate designing system be developed that could be used for a common range of gate sizes while maintaining basic format so users with a limited technical background could construct the gate cost effectively?

This Science and Technology (S&T) Program research project follows the S&T research project 6890, *Development and Testing of an Overshot Gate Design that Irrigation Districts Can Self-Construct and Maintain,* which designed an inexpensive overshot gate that irrigation districts could build themselves. We will provide technical assistance to install already constructed gates and to evaluate their performance. We will compare this performance with alternate means of operating the gates used by the cooperating districts. Monitoring field performance of the existing prototype gate will be crucial for studying alternative gate lifting mechanisms. We will also examine alternatives for sealing flow around gate edges for the existing prototypes.

Need and Benefit: Replacing stop log control with overshot gates represents a significant upgrade in flow control capability. Where overshot gates have been installed, whether commercially or locally constructed, districts have achieved improved capability to manage flows.

Overshot gates are a popular means of upgrading control at a stop log structure, but the cost of commercially produced overshot gates can be prohibitive for many districts to consider. Primary beneficiaries of the products of this project will be irrigation districts, most of which operate Reclamation projects, thereby improving water delivery.

Partners: Buford-Trenton Irrigation District, North Dakota; Bostwick Irrigation District, Nebraska; and South Platte Ditch Company, Colorado.

Keywords: overshot gates, irrigation, stop logs, water delivery, irrigation districts

2597 Flow Calibration of Submerged Sluice Gates

Summary: Software aids flow calibration of canal check gates.

Contact: Tony Wahl, twahl@usbr.gov

Research Question:

- How can we improve calibration algorithms for canal radial gate structures?

To achieve efficient operation and management of open channel irrigation delivery systems, accurate flow measurement is needed. The greatest need is at canal check structures where flows are regulated and divided to meet the needs of downstream users. By using canal check gates themselves as flow measurement devices, the need for constructing dedicated flow measurement devices (e.g., flumes) is reduced. This Science and Technology Program (S&T) research project builds upon previous S&T Program research (project 1281, *Flow Measurement with Canal Radial Gates*) that developed the WinGate software used to develop flow calibrations for canal radial gate and slide gate check structures. WinGate replaces the RADGAT software previously developed by Reclamation in the early 1980s. We will promote the application of WinGate to operating canal systems and will use new findings from researchers in Spain to further improve WinGate's calibration algorithms for canal radial gates and slide gates.

Need and Benefit: Reclamation will benefit from this research with more accurate flow measurements at canal check gates and more accurate gate settings to target flow rates.

Partners: U.S. Department of Agriculture Agricultural Research Service

Keywords: WinGate, water measurement, flow measurement, canal, check structure, radial gate, slide gate

4292 Reinforced Concrete Pressure Pipe Stress Distribution

Summary: Designing reinforced concrete pressure pipe for reduced load factors

Contact: Tedd Calhoun, tcalhoun@usbr.gov

Research Question:

- What are the appropriate coefficients to use for the design of reinforced concrete pressure pipe (RCPP) in light of recent code trends of reduced load factors?

Concrete pipe design is based upon assumed stress coefficients for moment, shear, and thrust loadings. The coefficient values and the location of the stresses for typical loadings on buried installations were developed in the 1950s. Modern installation techniques, including Standard Installation Direct Design (SIDD), provide additional support which result in reduced reinforcement requirements.

RCPP is subjected to unusual concrete design loading conditions because the pipe often carries high internal pressure which results in axial (circumferential) tension. Professional society committees are re-evaluating design parameters for this type of pipe because the stresses are not well understood. We will:

- Install stress/strain gauges and temperature thermo-couples in the pipe to monitor pipe behavior
- Record soil foundation and vertical/lateral loading information at several intervals around the pipe circumference
- Measure stress/strains during concrete curing to assist in determining shrinkage cracking of the concrete (which affects reinforcement stresses)

Information will be collected during concrete curing, fabrication, earth backfilling, pipe pressurization, and for a period thereafter. The information will be correlated to predicted and computed values to determine the degree of reduced reinforcement that may be used.

Need and Benefit: RCPP is commonly used in Reclamation projects for cross drainage structures, in-line siphons, pipeline distribution systems and other features. Refined design approaches can reduce construction costs. Traditional ultimate strength concrete design load factors used by several standards (Reclamation, ASTM, American Water Works Association [AWWA]) are larger than modern codes and standards (American Concrete Institute [ACI] building code, American Society of Civil Engineers [ASCE], American Association of State Highway and Transportation Officials [AASHTO]). The reduced factors will result in significant reinforcement and concrete cost savings while retaining adequate structure durability and safety. This research is needed to help Reclamation maintain durable and safe facilities.

Partners: Simpson Gumpertz & Heger, Inc.

Keywords: concrete pressure pipe, pipe pressurization, load factors, building codes, design, concrete

5505 Measurement Device Calibration with Light Detection and Ranging and Flow3D

Summary: LiDAR or photogrammetry can increase flow measurement accuracy.

Contact: Bryan Heiner, bheiner@usbr.gov

Research Question:

- Can Light Detection and Ranging (LiDAR) or photogrammetry be combined with computation fluid dynamics to create custom ratings at aged or inaccurate open-channel flow measurement structures throughout Reclamation's water distribution systems?

Many transmission canals and channels currently operate with limited flow measurement accuracy making water distribution difficult. We will determine ways to use LiDAR and photogrammetry to obtain accurate as-built dimensions at sites that need to achieve accurate flow measurements. This will prevent unnecessary water release or disruption of water delivery and increase the accuracy and reliability of water distribution quickly and efficiently.

Need and Benefit: It becomes difficult for Reclamation to manage and distribute the water they wholesale as flow measurement accuracy decreases. LiDAR and photogrammetry can help Reclamation obtain more accurate flow measurements.

Partners: [1]

Keywords: LiDAR, photogrammetry, flow measurement accuracy, computational fluid dynamics

[1] Note that where we have not identified or solidified partnerships, this heading is left blank.

6578 Evaluation of Low-Cost Ultrasonic Flow Meters

Summary: Are the new, low-cost irrigation flow meters as good as more expensive flow measurements?

Contact: Bryan Heiner, bheiner@usbr.gov

Research Question:

- Are relatively low-cost Doppler flow meters a reliable and cost-effective means to accurately measure flow in open-channel and closed-conduit irrigation water delivery systems?

We will purchase several meters of this type and perform measurements in the Water Resources Research Laboratory to compare the accuracy of each meter to a calibrated measurement standard, such as a venturi meter, weir, or flume. We will evaluate their performance over a range of flow conditions and study the effect of varying water quality factors (i.e., scattering particle concentration and its effect on acoustic signal strength). We will then conduct field tests at locations where accurate flow measurement structures are already in place that can provide a direct comparison for the test meter. All tests will be documented in a Hydraulic Laboratory (HL-series) report.

Need and Benefit: Irrigation project managers are constantly seeking low-cost methods for accurately measuring irrigation deliveries. Acoustic Doppler flow meters are an attractive option because they cause no head loss, are easily installed, provide supervisory control and data acquisition (SCADA)-compatible outputs, and can be applied to a wide variety of flow situations. Reclamation's hydraulics laboratory in Denver has fielded numerous questions in the last few years from area office personnel and irrigation districts regarding the accuracy and suitability of these meters. Anecdotal evidence from Australian applications suggests that devices of this sort could fill an important niche in the United States, but the devices' relatively simple technological approach to flow measurement may also create limitations.

By conducting a non-biased evaluation of several low-cost meters, Reclamation engineers can help irrigation districts and Reclamation field personnel identify low-cost ultrasonic meters that can be used with confidence.

Partners: In-kind contributions are expected from Greyline Instruments, Inc.; Mace USA, LLC; and Reclamation's Nebraska-Kansas Area Office.

Keywords: flow meters, ultrasonic, Doppler, irrigation water measurement, acoustic

7645 Research and Development of a Comprehensive Guide of Tools for Management of Diverging Science in Reclamation Water Allocation Decisions

Summary: What to do when scientific findings conflict?

Contact: Douglas Clark, drclark@usbr.gov

Research Question:

- What tools are currently being used in Reclamation to manage conflicting or diverging science?
- What tools are effective, and which have proven ineffective?
- What tool gaps exist?
- What promising, but unused, tools could be successfully implemented?

This Science and Technology Program research project identifies available tools for managing conflicts over science and examines the strengths and limitations of each tool. We will survey Reclamation managers, scientists, and engineers to learn what techniques and tools are currently used to manage diverging science within Reclamation and what gaps exist. After conducting an initial Reclamation-wide electronic survey, we will conduct in-depth, intensive interviews and case studies and then develop a guide to describe each tool (strengths and limitations) to help the water manager to understand when and under what conditions each approach to managing conflict over science might be the appropriate one to use.

Primary deliverables will be a report of current practices, an analysis of the strengths and weaknesses of various conflict management tools, a manual, training, and a workshop to disseminate best practices.

Need and Benefit: During focus groups devoted to understanding the genesis of water conflict in Reclamation, an area office biologist reported that the only fact that scientists could agree to was that a particular endangered fish (the bluntnose shiner) “needed water.” Managers told us they regularly spent 50-100 percent of their time managing water conflict and that conflict over divergent scientific claims represented a significant portion of the overall conflict management picture. Reclamation needs to document those tools that have been successfully used, investigate other potentially useful tools, develop a guide describing each tool’s optimal use, and provide training on best practices for choosing and using appropriate tools.

Partners: U.S. Geological Survey (USGS)

Keywords: water conflict, decision processes, water management, workshops, scientific recommendations, conflict management

8944 Forward Osmosis Water Purification

Summary: Improvements to FO membranes and process can significantly reduce capital and energy costs for membrane separation plants.

Contact: Chuck Moody, cmoody@usbr.gov

Research Question:

- To reduce desalting costs, can we develop Forward Osmosis (FO) to purify water at lower cost than reverse osmosis?

FO employs a membrane similar to RO, but the saltwater is not pressurized to force it through the membrane. If two solutions are placed on either side of a semi-permeable membrane, water will move toward the side with the higher concentration of solutes. Thus, if a concentrated solution of water and fertilizer (the "driving solution") is placed opposite a volume of seawater (the "source water") the natural force of osmosis will pull pure water out of the seawater and thru the membrane, resulting in a larger volume of fertilizer-charged irrigation water ("the FO product").

Need and Benefit: Efficient membranes and an engineered 2-stage FO process offer the potential for low-cost seawater desalination. As desalination plants become more affordable, FO may be a new alternative to the drinking-water shortages in many areas. The next steps consist of developing improved FO membranes and integrating and pilot testing the 2-stage FO process at Reclamation's Water Quality Improvement Center (WQIC) in Yuma, AZ.

This section contains Intellectual Property. Contact Chuck Moody to request additional information.

Keywords: forward osmosis, FO, WQIC, intellectual property

8969 Wireless Automated Control of Surface Irrigation Systems for Improved Irrigation Efficiency

Summary: Developing cost-effective automated surface irrigation systems using wireless communications.

Contact: Tom Gill, tgill@usbr.gov

Research Question:

- Can a cost-effective system be developed to enhance surface (or flood) irrigation systems efficiency and reduce surface runoff?

We will investigate a system using increasingly affordable wireless technologies to communicate irrigation water advancement rates to identify appropriate timing for changing water applications from one field section to the next. This follows a similar ongoing Science and Technology research project 3877, *Programmable Logic Control of Automated Surface Irrigation Systems for Improved Water Use Efficiency*, that developed prototype automated surface irrigation systems in southern Arizona and southern California using hard-wired links between a central control point and all canal gate and canal measurement structures. It will install a prototype system using wireless communications along with solar-charged individual stations that can perform stand-alone functions if communications are interrupted.

Need and Benefit: Despite the growing conversion from surface to alternative application systems (e.g., sprinkler and subsurface drip), a vast portion of the irrigated acreage in Reclamation projects is—and is likely to remain for the foreseeable future—irrigated using surface irrigation systems. Developing a technology that improves the accuracy of the relationship between water applied and the infiltration capacity of the crop root zone in surface irrigation systems would benefit all water users in Reclamation projects.

Partners: University of California Extension Service Desert Research and Extension Service near El Centro, California

Keywords: surface irrigation, irrigation districts, wireless communication, renewable energy