BUREAU OF RECLAMATION

R&D Office Research Updates

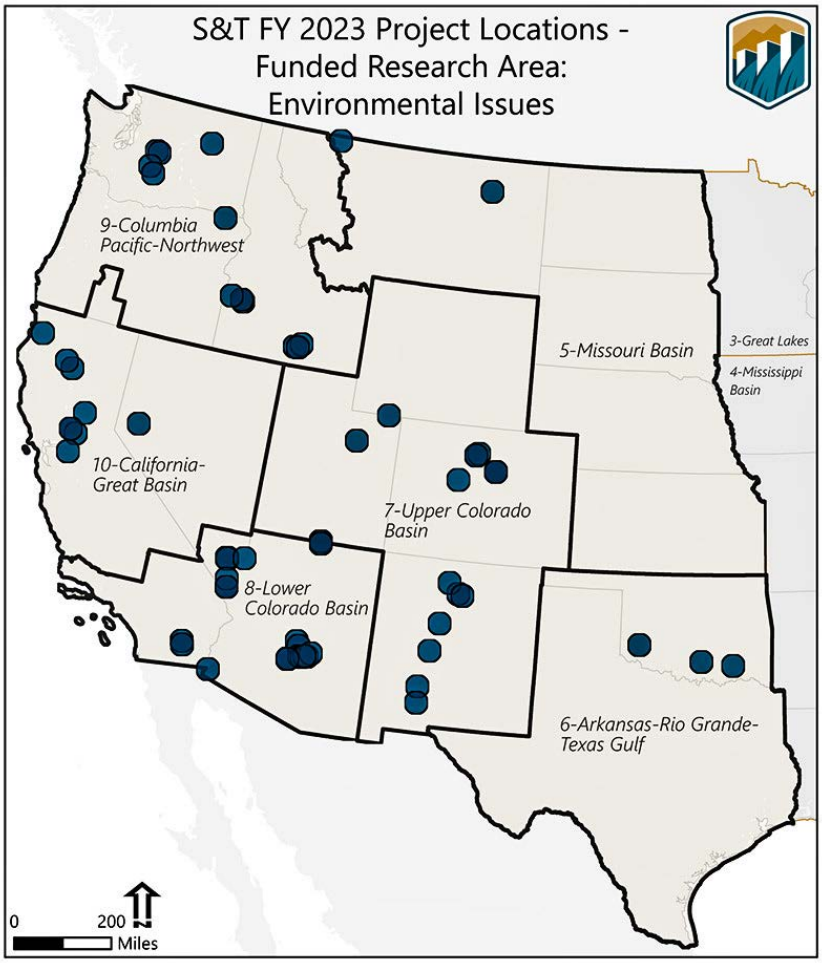
Environmental Issues for Water Management and Delivery

U.S. Department of the Interior

January 2023

Executive Summary

The Environmental Issues in Water Management and Delivery (EN) Research Area of the Science and Technology Program (S&T) examines research in the following categories: Water Delivery Reliability, Invasive Species, Water Quality, Sediment Management, and River Habitat Restoration. In FY23, S&T funded 42 EN Projects approximately totaling $2.1M: 12 were new totaling $1.1M and 30 were continuing totaling $1.0M. EN research is extremely valuable to Reclamation, both by development of new methods and techniques, as well as by learning about technologies that could be adopted by Reclamation Programs to assist with environmental compliance.



Reclamation's Research and Development Office (R&D) manages the Science and Technology Program (S&T) and is focused on providing innovative solutions for Reclamation water and power facility managers and its western customers and stakeholders, primarily through competitive funding opportunities to Reclamation employees.

The S&T Program has five research areas (listed below) directly related to Reclamation's mission. For more information, visit: www.usbr.gov/research/st/needs_priorities/index.html.

S&T Research Areas and Categories

Water Infrastructure (WI)
Dams, Canals, Pipelines, and Miscellaneous Water Infrastructure

Power and Energy (PE)
Hydro Powerplants, Energy Efficiency, Pumping Plants, and Non-Hydropower Renewable

Developing Water Supplies (WS)
Advanced Water Treatment, Groundwater Supplies, Agricultural and Municipal Water Supplies, and System Water Losses

Environmental Issues in Water Delivery and Management (EN)
Water Delivery Reliability, Invasive Species, Water Quality, Sediment Management, and River Habitat Restoration

Water Operations (WP)
Water Supply and Streamflow Forecasting, Water Operations Models and Decision Support Systems, Open Data, and Climate Change and Variability

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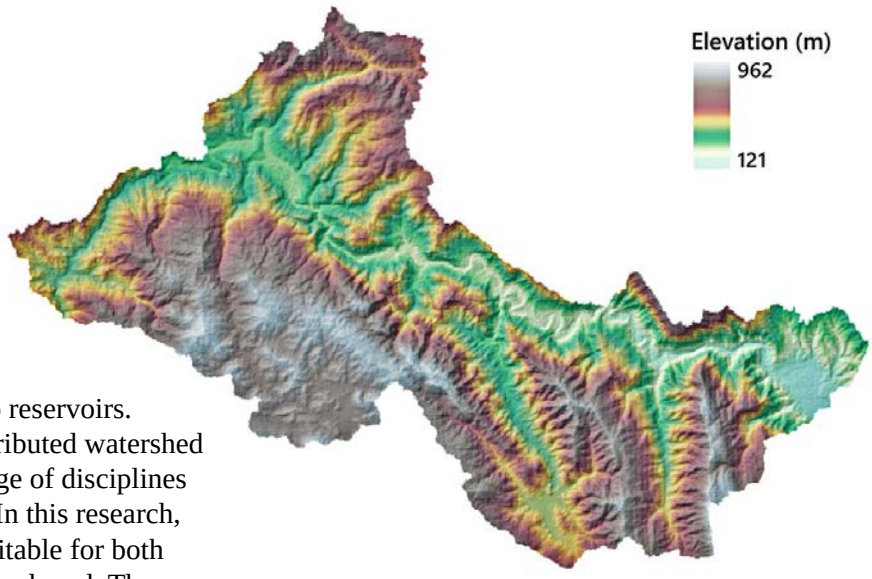
Environmental Issues for Water Delivery and Management

FY22 Completed Projects

1809: Mercury Loading to Streams and Reservoirs: A Process-Based Approach – Yong Lai



Terrain elevation ranges of the Upper Cache Creek overlaid on a hillshade of the sub-watershed modeled in the study.

Heavy rainfall and subsequent sediment and mercury movement from watersheds have serious economic, environmental and social impacts on communities around the world. Hydrological models have become useful decision support tools for flood warning, watershed management and mercury delivery to reservoirs. The development of a process-based, mesh-distributed watershed model, however, is complex as it involves a range of disciplines and spans multiple spatial and temporal scales. In this research, a process-based and mesh-distributed model, suitable for both event-based and continuous simulations, was developed. The watershed is conceptualized in three distinct zones: a surface region and two subsurface zones representing the unsaturated soil and groundwater. Overland runoff is governed by the 2D diffusive wave equation with an optional 1D channel network solver; water in the unsaturated zone is modeled through mass conservation assuming dominant vertical processes; and the saturated groundwater flow is governed by the 2D Dupuit approximation. Soil erosion and sediment transport are governed by multi-size non-equilibrium equations incorporating the processes of soil entrainment, deposition and transport. The mercury is routed using also the mass conservation equation. The model is driven by meteorological input, taking into account vegetation characteristics to compute evaporation and plant transpiration, and land use and soil type properties. The new model represents a generalization of the existing models in an attempt to overcome some of the current model shortcomings.

20057: Modeling effects of wildfire and fire retardant on nutrients downstream in a watershed scale – Jun Wang

The goal of this project was to improve understanding of the effects of wildfire and fire retardants on soil nutrients and how wildfires impact the export of nutrients from burned landscapes. Additionally, this project helped to identify the effects of fire retardant on land and water quality and how to describe and simulate the effects of wildfire and fire retardants on soil nutrients and water quality. The PFHydro computer program was successfully applied to this problem, providing a benefit to resource managers. Modeling application results in the upper Cache Creek (CA) watershed, using estimated post-fire soil nitrogen and phosphorus concentrations, confirms the conclusions of a thorough literature review. The theoretical increase in nutrient export due to addition of ammonium-phosphate-based fire retardant (such as PHOS-CHEK®) is exceedingly small compared to the measured post-fire nutrient loads, indicating that the contribution from fire retardants from the 2015 Rocky Fire and Jerusalem Fire was likely insignificant in this watershed.

Fire retardants such as PHOS-CHEK® are commonly deployed by aircraft to combat wildfire in the Western United States.

Image of exposed Salton Sea playa.

21013: Stakeholder Outreach and Exploration of Dust Mitigation and Suppression Strategies for Exposed Playa at the Salton Sea – Meghan Thiemann

The Salton Sea is a 350-square mile terminal (closed basin) desert saline lake in southern California. A combination of naturally occurring evaporation and reduced inflows due to the Quantification Settlement Agreement mitigation flows ending in 2017 has resulted in declining water surface elevations. As the Salton Sea recedes, exposed playa is anticipated to become emissive and contribute to negative public health impacts in the region. Stakeholder outreach is a critical component before field testing new dust suppression strategies on exposed playa due to the complexity of issues at the Salton Sea, the various landowners and jurisdictions, and the many stakeholders required to implement projects and solutions. S&T 21013 gathered feedback from Salton Sea stakeholders on dust suppression strategies to field test, and in particular enzyme-induced carbonate precipitation (EICP) and microbially-induced carbonate precipitation (MICP), which will be field-tested under S&T 21016. Stakeholders were supportive of field testing EICP and MICP and did not have concerns that would alter the field testing plans. This project also compared dust suppression strategies across various objective categories and summarized findings in a matrix table included as Appendix A of the final report.

8101: Measuring Gravel Bar Mobility in Large Rivers with Tracer Gravel – Nate Bradley

The Bureau of Reclamation deployed 600 tracer clasts labeled with Passive Integrated Transponder (PIT) tags on gravel bars in the Methow River in the vicinity of the Sugar Levee near Twisp, WA in October 2018. The purpose of the experiment was to test a hypothesis that the Sugar Levee is disrupting sediment transport dynamics through the study reach and causing 'excess' deposition on a gravel bar downstream of the levee, resulting in bank erosion and property loss on the opposite bank. Searches for the tracers in 2020 and 2021 recovered and surveyed the locations of 448 (75%) and 356 (59%) of the rocks installed. Many rocks remain on the bar where they were installed, but a few have traveled more than a mile. Rocks installed on two bars adjacent to the levee are much more mobile than tracers installed further upstream. This is likely due to an increase in channel slope caused by incision adjacent to the levee.

A tracer stone on a gravel bar in the Methow River. The small white spot on the rock at the center of the photo is the epoxy used to seal the PIT tag inside the rock.

19112: Monitoring the Movements of Juvenile Pacific Lamprey in the Yakima River using Acoustic Telemetry – Patrick Monk

Juvenile Pacific Lamprey implanted with an acoustic transmitter.

Barriers to migration contribute to declining populations of Pacific Lamprey (Entosphenus tridentatus) throughout the West, but little is known about their migration patterns and effects of dams and water diversions. Telemetry has been used to describe dampassage routes and survival of juvenile salmon and steelhead for decades. Juvenile The Dept. of Energy-Pacific Northwest National Laboratory has been developing a micro-transmitter specifically for use in juvenile lampreys, eels, and other small fishes. Through a collaborative research approach, we used prototype transmitters to do a pilot-level evaluation of tagged lamprey movements in the Yakima and Columbia Rivers. We partnered with an ongoing telemetry study being conducted by the U.S. Geological Survey (USGS), the Bureau of Reclamation (Reclamation), and Yakama Nation Fisheries (YNF). Our study goals were to (1) release tagged lamprey high upstream in the study area to maximize our ability to detect them at several sites as they traveled downstream, (2) release lamprey under different hydrologic conditions, and (3) evaluate tag performance and test some survival model assumptions in preparation for future studies. Detections of migrating lamprey during the study were lower than that of salmon suggesting lamprey have different migratory behaviors than salmon. Tag life was about 18 days and surgically-implanted tags did not appear to affect juvenile lamprey. Future studies should consider unique aspects of lamprey behavior during study design.

FY23 New Projects

23015: Reintroduction of Anadromous Fish to the Blocked Areas of the Upper Columbia River: Downstream Movement and Survival of Juvenile Salmon in the Upper Columbia River Basin – Sue Camp

Stakeholders exploring the feasibility of anadromous fish passage and reintroduction in the upper Columbia River are seeking a reduction in Life Cycle Modeling uncertainty. This project focuses on testing critical uncertainties associated with reservoir and downstream passage survival, such as site-specific migration and passage survival data. The resulting survival estimates generated from this study will guide decision making regarding the need for, and location of, juvenile fish passage facilities at Chief Joseph Dam and Grand Coulee Dam.

23022: Food for Fish: A 2-Dimensional Fate and Transport Model for Zooplankton with Implications for Juvenile Salmon Growth and Water Management Efficiency – Jenna Paul

The objective of this research is to develop and test a zooplankton fate and transport solver to address the following: how zooplankton distributes in the river when released from an outfall, how far downstream it persists as a food source, and how many flooded acres are needed to augment the food supply to create a population-level increase in juvenile salmon growth. The product of this research will be a new module in Reclamation's two-dimensional hydrodynamic model, Sedimentation and River Hydraulics – Two-Dimensional, that can simulate the spatial and temporal distribution of zooplankton on any river.

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FY23 New Projects *-continued*

23025: Quantification of Accuracy Improvements Related to Multibeam Data per Quantification of Accuracy Improvements Related to Multibeam Data Processing – David Varyu

The purpose of this research is to identify the degree of processing of multibeam bathymetry data necessary to reach diminishing returns. That is, can we reduce the time and cost required for data processing without reducing the quality/accuracy of area-capacity curves, and if so, by how much?

23026: Tracing Salinity through the Southern Sacramento-San Joaquin River Delta, California Using Continuous Salinity Monitoring, High-speed Salinity Transects, and Ion Fingerprinting – Grace Windler

Water from the Sacramento-San Joaquin River Delta (Delta) in California supports over 3.5 million acres of agricultural land across California and a diverse ecosystem in what is the largest estuary in western North America. Reduced carry-over reservoir storage during multi-year droughts leads to low flow rates and elevated temperature and salinity downstream in the Delta. In partnership with the California Department of Water Resources, this project will utilize recently improved spatial and temporal coverage of salinity data in the Delta to characterize salt fluctuations in the southern channels and develop strategies for more efficient salinity management practices.

23039: Boulder Cluster Design Guidance for River Restoration – Melissa Shinbein

The purpose of this proposal is to create a boulder cluster design guidance document to assist river restoration practitioners in meeting fish habitat objectives. The guidance will incorporate previous physical and numerical modeling results for the Los Angeles River and qualitative boulder cluster design information.

FY23 Active Projects

ID	Final Year	Title	Lead
20057	2023	Modeling Effects of Wildfire and Fire Retardant on Nutrients Downstream in a Watershed Scale	Jun Wang
20069	2023	Monitoring Suspended Sediment: An Investigation Coincident with the Cherry Creek Reservoir Annual Flush	Daniel Dombroski
1792	2023	Using Beryllium-10 Derived Erosion Rates as a Proxy for Reservoir Sedimentation	Melissa Foster
19105	2023	Fish Passage at River Diversion Juncture: A Science-Based Approach	Yong Lai
19266	2023	Side Channel Evolution and Design: Achieving Sustainable Habitat for Aquatic Species Recovery	Nathan Holste
19290	2023	Improving Predictions of Scour in the Vicinity of Vegetation in Habitat Rehabilitation Areas	Daniel Dombroski
19306	2023	Side Channel Evolution, Geomorphic Diversity, and Sediment Transport on the Bighorn River Following Larger Dam Releases Between 2008 and 2018	Melissa Foster
20031	2023	The Potential for Restoring Thermal Refuges in Rivers for Cold-water Salmonids	Aaron Hurst
20042	2023	Threat Assessment and Evaluation of Burrowing Crayfish in Reclamation Canals	Aaron Murphy
20052	2023	Quantifying the Development and Dynamics of Reservoir Delta and Related Backwater Vegetation in the Context of Physical Drivers	Nathan Holste
20060	2023	River Restoration Interactive Geospatial Database to Inform Future River Rehabilitation Design	Melissa Shinbein
20064	2023	Monitoring Detritus Deposition and Scour Downstream of Minidoka Dam with Implications to Snake River Physa Snail Habitat and Irrigation Canals.	Daniel Dombroski
20091	2023	Determining the Capabilities and Limitations of Unmanned Aircraft Systems (UAS) Equipped with Light Detection Ranging (LiDAR) Sensors when Applied to Hydrologic Studies, Infrastructure, Mapping, and General Land Data Collection	Meyer Jay

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FY23 Active Projects *-continued*

ID	Final Year	Title	Lead
21008	2023	Resolving Spatiotemporal Distribution of Suspended Sediment Concentration over the Columbia and Snake River Using Remote Sensing	Michael Poulos
21016	2023	Laboratory and Field Testing of Enzyme and Microbially Induced Carbonate Precipitation for Mitigation of Fugitive Dust at the Salton Sea	Angel Gutierrez
21054	2023	Abrasivity of Slurry-Transported Sediment: Development of a Laboratory-Based Test System	Evan Lindenbach
21075	2023	Modeling Riverine Pool Temperature Stratification and Reservoir Selective Withdrawal for Fish Spawning and Rearing Habitat	Yong Lai
21077	2023	Predicting Reservoir Drawdown Flushing to Improve Reservoir Sustainability	Victor Huang
21078	2023	Chemical Fingerprinting of Delta Smelt for Sensitive Detection in the Environment	Daniel Deeds
21084	2023	Cost Estimating Guidelines for Dam Decommissioning Alternative	Jennifer Bountry
21088	2023	Sediment Effects on River Restoration Habitat Features: Physical Processes and Guidelines for Effective and Sustainable Design, Planning, and Maintenance	Drew Baird
21092	2023	Utilizing Hydrophones to Detect Streambed Mobilization in the Wild and Scenic Reach of the Rio Chama	Rebecca Braz
22008	2023	The Use of a Multi-Sensory Behavioral Barrier as a Fish Deterrent to Reduce Entrainment at the St. Mary Diversion Dam, Milk River Project, Montana	Lauri Teig
22066	2023	Recent Advances in Selenium Treatment Technologies, Application to Emerging Wetlands, and Pilot Project Implementation Plan in the Salton Sea, California	Meghan Thiemann
22088	2023	Evaluation of Mercury Release from Sediment and Dredging to Lahontan Reservoir Waters	Dan Deeds
20045	2023	A Methodology for Rockwad Velocity and Predator Habitat	Jenna Paul
20094	2024	Cyanophage Treatment Development for Mitigating Freshwater Harmful Algal Blooms Caused by Cyanobacteria	Christopher Waechter
21015	2024	Physical and Surrogate Data Collection of Sediment Transport in Ephemeral Systems	David Varyu
22015	2024	Nuisance Aquatic Vegetation (NAV) Control in Water Delivery Systems: An Automated Metering System for Accurate and Consistent Herbicide Application	Kevin Kelly
22019	2024	Potential Impacts of Phosphorous Loading from Wildfire-fighting Retardants Related to the East Troublesome Fire on Surface Water Quality in Willow Creek and Willow Creek Reservoir	Lindsay Bearup
22065	2024	Investigating the Physical Processes that Impact Reservoir Delta Fish Passage and Evaluating Potential Solutions	Colin Byrne
22067	2024	Evaluation of Shallow Acoustic Sub-Bottom Profiling Technologies for Measuring Reservoir Sedimentation Thickness and Stratigraphy – Englebright Lake, California	Daniel Dombroski
22077	2024	Enhancing Reclamation's Watershed Model to Predict Post-Fire Sediment Delivery to Reservoirs and Assess Management Actions.	Benjamin Abban
22097	2025	Evaluating Watershed Response and Increases in Sediment Loading to Willow Creek and Willow Creek Reservoir Due to East Troublesome Fire	Kent Collins
23025	2024	Quantification of Accuracy Improvements Related to Multibeam Data Processing	David Varyu
23039	2024	Boulder Cluster Design Guidance for River Restoration	Melissa Shinbein
22025	2025	Leveraging the Results of an Invasive Saltcedar Leaf Beetle Impact Monitoring Study to Create a Risk Assessment and Restoration Prioritization Tool on the Middle Rio Grande, New Mexico	David Moore