BUREAU OF RECLAMATION

# Research Area Summary
# *Developing Water Supplies*
# Research and Development Office

U.S. Department of the Interior

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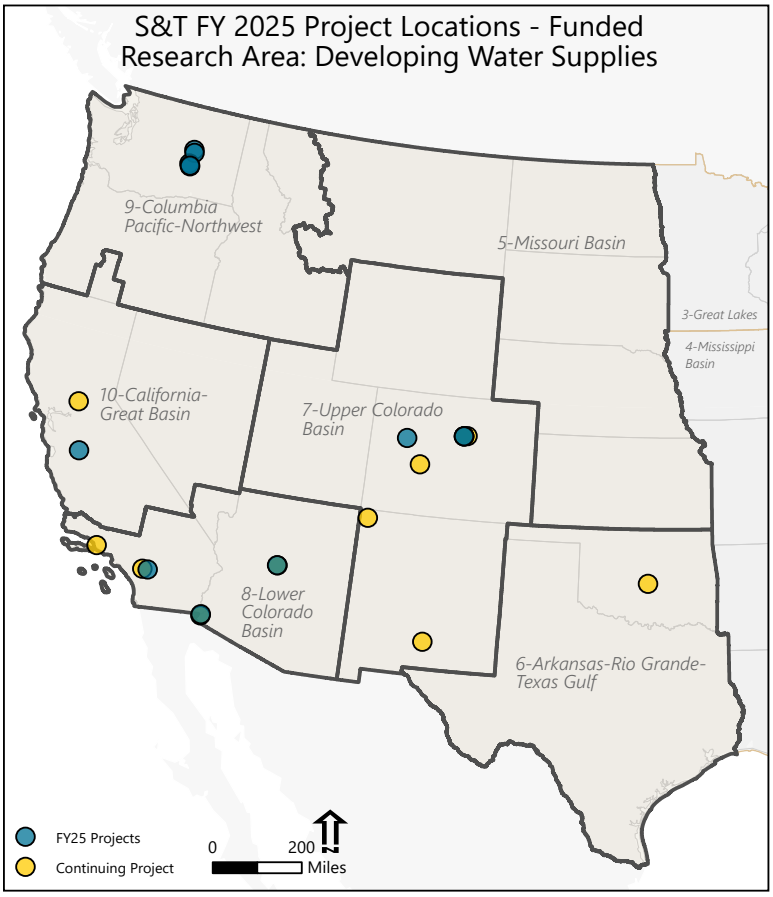
# Executive Summary

The Developing Water Supplies (WS) Research Area of the Science and Technology Program (S&T) examines research in the following categories: Advanced Water Treatment, Groundwater Supplies, Agricultural and Municipal Water Supplies, and System Water Losses. In FY25, the S&T Research Program funded 9 WS Projects approximately totaling $1 M. Six new projects received $0.7 M, and 3 continuing projects received $0.3 M in FY25. Advanced water treatment is an enormous field of study spanning a wide range of technology types, a diverse group of water users, and a complex landscape of water types. This year, Benefit Cost Ratio calculations were estimated for one WS project to demonstrate the value of this research. The benefit cost ratio for project 1855: Scaling Resistant Reverse Osmosis/Nanofiltration Membranes was calculated to be several times the investment of the project. The membranes used in this project allow for an additional recovery process at desalination plants that is more efficient and requires less feed water to produce the same amount of product water. Additionally, the process results in less brine concentrate for disposal. As demonstrated, WS research is extremely valuable to Reclamation in expanding and enhancing our valuable water supplies.




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: https://www.usbr.gov/research/st/index.html

## S&T Research Areas and Categories

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

**Power and Energy (PE)**
Hydro Powerplants and Pumping Plants

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

**Environmental Issues for 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 Hydrologic Variability

**Developing Water Supplies:**
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# Developing Water Supplies

## FY24 Completed Projects

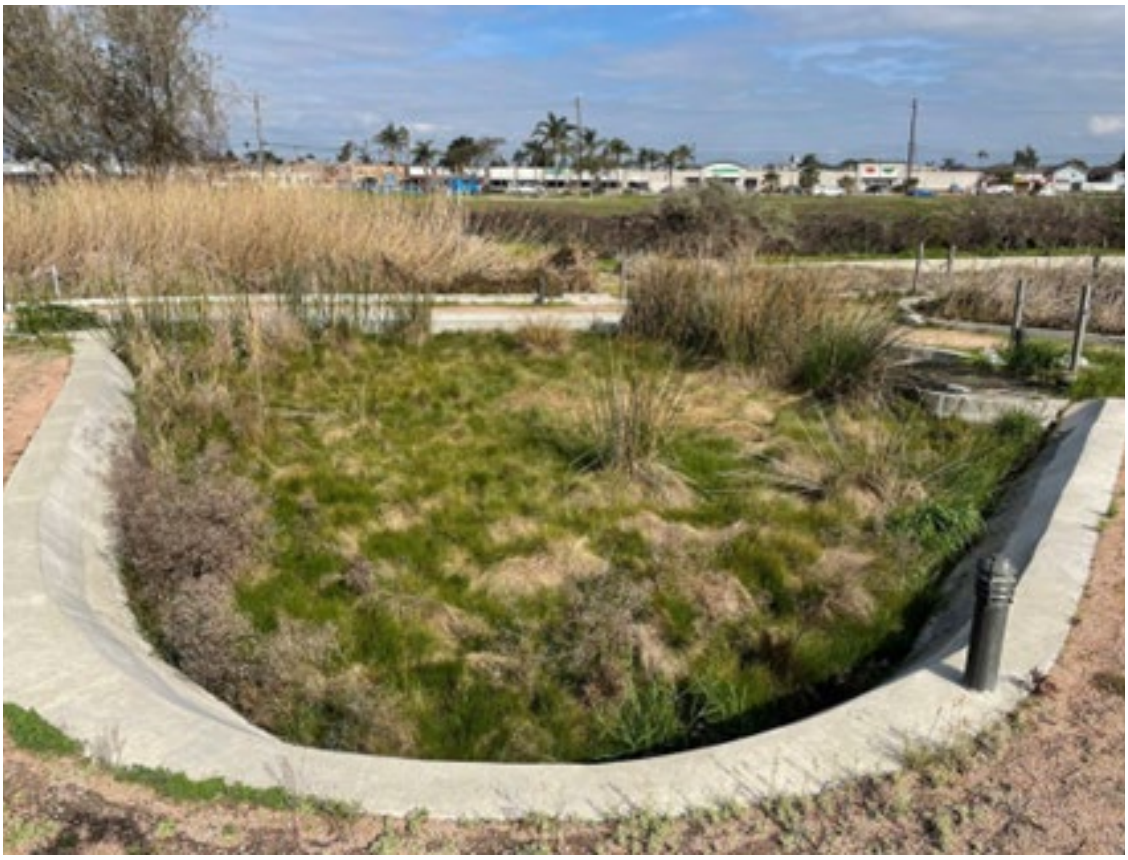
### 1877: Cost Modeling of Membrane Desalination Processes Using Reclamation's WaTER Model – Leah Flint

Reclamation routinely funds and partakes in early-stage and applied research projects to benefit the overall mission of the organization. This project utilized Reclamation's Water Treatment Estimation Routine (WaTER) model, an existing cost model previously developed by Reclamation in conjunction with the National Institute of Standards and Technology, to evaluate the utility of WaTER to quantify the cost/benefit of laboratory scale research. WaTER is an order-of-magnitude cost estimating tool based on cost curves developed by the Environmental Protection Agency and process calculations to size systems. The project team evaluated the cost-benefit tradeoffs of two alternative treatment trains for treating water from Foss Reservoir in Oklahoma at the Foss Reservoir Master Conservancy District (FRMCD) Water Treatment Plant (WTP), which currently uses a novel electrodialysis reversal (EDR) process to treat brackish surface water to potable water standards. The alternative treatment scenarios evaluated using WaTER were based on work under Desalination and Water Purification Research (DWPR) project (# R16AP00006) by Dr. Chellam of Texas A&M University that evaluated the fouling control and water quality improvements of an electrocoagulation (EC) and microfiltration (MF) process compared to MF alone as pre-treatment to Nanofiltration (NF) on brackish surface water collected from Foss Reservoir. Dr. Chellam's DWPR project indicated that addition of EC allowed for higher flux (e.g., smaller systems) in downstream MF and NF processes. Therefore, this work evaluated if the additional capital and operational costs of EC offset the operational and maintenance (O&M) savings from MF (and NF), relative to a MF-NF process without EC. In order to complete the analysis, a new EC module was added to the existing WaTER model. Then, using data generated under the existing DWPR agreement, and additional data using the same equipment at Texas A&M, the current baseline EDR process was modeled and compared to the two alternative treatment scenarios. Results indicated that the EC-MF-NF process was more expensive than the MF-NF process. Both alternative processes evaluated (EC-MF-NF and MF-NF) were less expensive than the baseline Coagulation-Media Filtration-EDR process currently used at FRMCD WTP. However, these results should be interpreted conservatively as WaTER is an order-of-magnitude cost estimating tool and does not consider all contingencies and auxiliary processes associated with a WTP. Furthermore, coagulation provides additional benefit to a surface water treatment plant, including targeted total organic carbon removal to manage variable seasonal water quality variations.

*Membrane and spacer stacks for electrodialysis.*

## 7134: Analysis of Microbial Communities in Constructed Wetlands – Yale Passamaneck

Water reuse is becoming a subject of growing interest as pressure on existing water sources increases and many surface water sources are less reliable. Many water reuse technologies produce concentrate with inorganic and organic contaminants that require further treatment or disposal. Introduction of concentrate to wetlands, and in particular constructed wetlands, has gained attention as a strategy for the biological treatment by ecosystems that are adapted to process the contaminants present in concentrate. The present study analyzed the microbial communities of a constructed wetlands designed to treat reverse osmosis concentrate generated by an advanced water treatment facility in Oxnard, CA. DNA sequencing and analysis of the V3-V4 hypervariable region of the 16S rRNA gene was used to characterize the bacteria present in samples from soil, sand, and water substrates. Sampling was performed over a period when operations moved from feeding entirely freshwater to the wetlands to increasing additions of reverse osmosis (RO) concentrate. All the substrate samples were found to have complex bacterial communities. Measurable changes in bacterial communities occurred during the study period, but large-scale changes in community structure were not observed. A small number of microbial taxa were identified as having undergone significant changes in their relative frequency of occurrence associated with changes in the RO concentrate fed to the wetlands. The present study was limited by operational challenges that limited the partner's operation of the water treatment facility and the feed of concentrate to the constructed wetlands. The original study design was to follow the wetlands from an initial feed of only freshwater through increasing addition on RO concentrate until only 100% RO concentrate was being fed to the wetlands. During the study period the proportion of RO concentrate fed to the wetlands did not increase above 40%. This likely limited observed changes in the microbial communities that were evaluated. Future studies would benefit from following microbial conditions fed higher concentrations of RO concentrate. Environmental transcriptomic or genomic sequencing approaches could also aid in identifying the microbial metabolic approaches occurring in constructed wetlands.



*Constructed wetland at an advanced water treatment facility in Oxnard, CA.*

# FY25 New S&T Projects

## Research Program

### 25004: A Comparison of Reverse Osmosis and Carbon-Based Treatment Trains for Implementing Direct Potable Reuse of Wastewater for Existing Facilities – Miguel Arias-Paic

With periods of prolonged drought, the American West is impacted by water scarcity with an ever-increasing demand. Diverse water portfolios will be required to sustain community water demands. Drought impacted communities are looking to utilize advanced water treatment to further treat municipal wastewater, a readily available local source, to augment potable water supplies. This is known as direct potable reuse (DPR). Arizona is working towards implementing regulations for DPR and understanding technological capabilities to meet achievable water quality goals. DPR is the purification and treatment of reclaimed water to a level suitable for drinking, highlighting its potential as a safe and reliable drinking water source. This project will conduct bench-scale process testing of two advanced water treatment methods to inform the selection of which treatment train will best satisfy the proposed DPR regulations for Arizona that will take effect in 2025.

### 25031: Concentrate Minimization Pilot Using Novel In-Line Precipitator to Reduce Cost of Inland Water Treatment – Saied Delagah

Water supplies can be augmented by treating impaired and unusable sources. These sources have salinities that make them unsuitable for consumption, irrigation, recreation, industrial and/or municipal uses. These unusable sources require desalination to create additional water supplies. Desalination technologies today use membrane and can recover 50 to 85% of the feedwater as pure water, with the remaining discharged as the concentrate stream containing the minerals, contaminants, and salts. This remaining concentrate stream is an expensive barrier to wide scale adoption of inland desalination. Impaired waters containing salts can crystalize and form “scale” on the membranes during desalination, thus impeding high water recovery and increasing the cost of treatment. This project will demonstrate a novel in-line precipitator that controls the point of crystallization which will reduce the cost of concentrate management, inland desalination, and create additional usable water supplies.

### 25033: Investigation of Relationships among Water Resource Management Adaptation Strategies – Saied Delagah

Some water resource management (WRM) adaptation strategies (namely conservation, water reuse/recycle, and desalination) are increasingly used to address water scarcity and water quality issues. These strategies can affect the volume and composition of watershed waters. For example, while some degree of conservation is beneficial in lowering water needs, conservation results in less water accompanying the solids coming into wastewater treatment plants. Also, as the level of conservation increases, there will be less frequent turnover in reservoir and storage tank water that may affect water quality, particularly with regard to disinfection by-product formation and microbiological activity. This research will investigate the effects of implementing WRM adaptation strategies on watershed waters and on how these effects may influence the feasibility of using and/or processing the affected waters. The proposed effort addresses a subject that has not been widely recognized in the literature nor addressed in published studies. The study will identify various effects, gather information, and develop a water balance model to aid in WRM planning.

### 25034: Multiple Approaches to Managing Salinity Accumulation in California’s Central Valley – Grace Scarim

Salt is accumulating in California’s Central Valley due to concentration of agricultural (ag) drainage. The Central Valley, a national hub for food production, is experiencing more impacts to land each year due to the importation and accumulation of salt. Salt has fallowed 250,000 acres and limited farming productivity for an additional 1.5 million acres due to crop sensitivities. There is currently no solution for salinity importation. This project aims to test several treatment options, including a “minimal selenium removal” option to understand the necessary water quality to feed a passive constructed wetland to manage ag drainage. Water quality will be compared to other successful wetlands fed by agricultural drainage, such as the Ciénega de Santa Clara in Mexico. This work looks to limit salinity impacts while providing safe water for wildlife and decreased communal financial burden. This research is applicable to saline ag drainage / water that is not being managed.

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## 25036: Novel Potable Reuse Treatment Process to Lower Cost and Energy Requirements and Increase Contaminant Removal – Saied Delagah

Water reclamation and reuse has become an important part of water portfolios as a response to current demands and challenges that communities face throughout Reclamation's regions, other parts of the US, and the world. Direct and indirect potable reuse (potable reuse) is becoming an increasingly popular means for communities to extend their water resources. Two major issues for expanding reuse projects exist: first, water reuse has relatively high energy demand; and second, there are concerns about health risks due to increasing organics and a number of contaminants of emerging concern (CECs) ubiquitous in water sources today. This study will further test and develop a resilient and more energy efficient way to produce sustainable water and help address the growing need to find solutions to remove organics and CECs from the environment. If successful, the novel treatment approach could be applied at wastewater treatment plants considering potable reuse.

## 25041: Using Cloud-Seeding Simulations to Understand Precipitation and Streamflow Impacts in the East River Basin of Colorado – Lindsay Bearup

This project aims to understand how cloud seeding affects the annual precipitation and streamflow in the East River Basin, Colorado. Pre-existing WRF-WxMod simulations of cloud seeding will drive WRF-Hydro simulations of hydrology under varying initial land-surface (i.e. soil moisture) states to quantify how cloud seeding could affect different components of the water budget. Comparison with field campaign data from SAIL/SPLASH will help to constrain WRF-WxMod to produce more accurate simulations of cloud seeding and its impacts in an area of complex terrain. Such analysis will benefit water managers in this region by using new capabilities to assess the potential for weather modification to enhance snowpack, streamflow, and soil moisture in a drought-prone region of the Upper Colorado River Basin.

## New and Continuing Projects*

| ID | Final Year | Title | Lead |
|---|---|---|---|
| 20008 | 2026 | Navajo-Gallup Water Supply Project - San Juan Lateral Source Water Blending and Corrosion Studies | Caitlin Kodweis |
| 20058 | 2025 | Concentrate Minimization through Development of an Innovative In-line Static Mixer | Saied Delagah |
| 20092 | 2025 | Ion Exchange Pretreatment for Desalting Membrane Processes to Maximize Clean Water Production | Miguel Arias-Paic |
| 21026 | 2025 | Cost and Performance Evaluation of Electrodialysis Reversal (EDR) Desalination of Brackish Agricultural Drainage Water and Groundwater | Luis Cruzado |
| 22006 | 2025 | Integrating Water Reuse and Stormwater Management into Constructed Wetland Designs to Enhance Water Supply and Multi-Purpose Project Benefits | Alissa Aligata |
| 22068 | 2025 | Investigating the Potential of Cloud Seeding to Enhance Precipitation in the East River Basin of Colorado | Lindsay Bearup |
| 22078 | 2025 | Increasing the Effectiveness and Simplicity of Potable Water Reuse with a Multi-Benefit Ferrate Treatment Process | Catherine Hoffman |
| 22102 | 2025 | Long-Term Arid Region Reservoir Usability Evaluation due to Salinity Induced Degradation of Water Quality | Neal Gallagher |
| 23032 | 2025 | Developing and Testing an Engineered Biological Control for Iron Oxidizing Bacteria in Water Wells | Andrew Scott |
| 24007 | 2025 | Impacts of Large-Scale Stormwater Recharge on Aquifer Salinit in Arid Lands | Edward St Pierre |
| 25004 | 2027 | A Comparison of Reverse Osmosis and Carbon-Based Treatment Trains for Implementing Direct Potable Reuse of Wastewater for Existing Facilities | Miguel Arias-Paic |
| 25031 | 2027 | Concentrate Minimization Pilot Using Novel In-Line Precipitator to Reduce Cost of Inland Water Treatment | Saied Delagah |
| 25033 | 2027 | Investigation of Relationships among Water Resource Management Adaptation Strategies | Saied Delagah |
| 25034 | 2027 | Multiple Approaches to Managing Salinity Accumulation in California's Central Valley | Grace Scarim |
| 25036 | 2026 | Novel Potable Reuse Treatment Process to Lower Cost and Energy Requirements, and Increase Contaminant Removal | Saied Delagah |
| 25041 | 2027 | Using Cloud-Seeding Simulations to Understand Precipitation and Streamflow Impacts in the East River Basin of Colorado | Lindsay Bearup |

**Continuing projects include those that received no-cost extensions.*

**Front cover:** Research equipment at Reclamation's Brackish Groundwater National Desalination Research Facility

**Back cover:** Solids contact clarifier at Foss Water Treatment Plant