BUREAU OF RECLAMATION

Research and Development Office
Science and Technology
Research Program

FY 2027 Innovation Strategy Annual Implementation Plan



U.S. Department of the Interior

June 2026

Mission Statements

The U.S. Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its trust responsibilities or special commitments to American Indians, Alaska Natives, Native Hawaiians, and affiliated 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 - Shasta Dam, about nine miles northwest of Redding, California, on the Sacramento River.

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1. Introduction

The Innovation Strategy Implementation Plan (ISIP) is developed annually to set priorities for the Science & Technology (S&T) Program annual Call for Research Proposals, as well as planning for future prize competition activities. The ISIP promotes both administration priorities and technical needs of Reclamation. The R&D Office engages leadership and subject matter experts to update the ISIP. This process offers agility to address current priorities and emerging needs.

Regarding the former, the S&T Program invites administration leadership to identify and refine priorities in the ISIP each year. For technical needs, the Program relies on subject matter experts to refine categories within each research area and identify technical needs for those categories. Consistent research areas across years provide stability in support of program administration while research categories and needs provide granularity and specific needs.

2. Administration Priorities

This ISIP is responsive to administration and leadership priorities each year as outlined below. In addition to the following Department of the Interior and Reclamation priorities, a special emphasis is placed on research related to developing and integrating artificial intelligence (AI) into Reclamation processes.

2.1. Department of Interior Priorities

- Advancing Energy Dominance
- Protecting Our People and Borders
- Effectively Managing Our Land and Water Resources and Expanding Outdoor Access
- Upholding America's Trust and Insular Responsibilities
- Reducing Costs for Hardworking Americans
- Optimizing the Federal Workforce and Management of Real Property

2.2. Reclamation Priorities

- Prioritizing Western Water Deliveries for People and Agriculture
- Energy Security and Domestic Energy Dominance
- Colorado River Water
- Fulfilling Federal Commitments to Indian Water Rights

2.3. Commissioner's Focus Areas

- Colorado River Water Supply, Resiliency, and Reliability
- Water Supply and Conveyance in the Central Valley Project
- Opportunities to Increase Hydropower Generation across Reclamation
- Opportunities to expedite NEPA Compliance, with an emphasis on projects contributing to increased hydropower generation, or impacting water supply in the Colorado River and Central Valley Project

2.4. Reclamation Director Needs

Each year, prior to the Call for Proposals, S&T solicits Regional Directors for a list of their highest priority research needs for a given year. This year, the S&T Program has also included needs for the Denver Directorates. We now refer to these as "Reclamation Director (RD) Needs". These needs evolve year-to-year and are published in a stand-alone document as part of the annual Call for Proposals. S&T works to be responsive and address these needs by developing a combination of solicited and brokered proposals. The FY 2027 S&T Program Reclamation Director Needs can be found at this link.

3. Technical Needs

The S&T program organizes research into five topic areas: Water Infrastructure, Power and Energy, Environmental Issues for Water Delivery and Management, Water Operations and Planning, and Developing Supplies. These areas are reviewed every four years as part of updating the S&T Program Innovation Strategy. Research areas have remained consistent since 2018, demonstrating their continued effectiveness in representing the breadth of Reclamation's innovation needs.

Each year, the S&T Program uses expert input, coordination, and existing research roadmaps to update research categories and identify technical needs (see Figure 1). This approach enables flexibility to respond to new priorities, emerging requirements, and completed projects. The ISIP is primarily highlighted in the annual Call for Research Proposals but also informs the plan for near and long-term prize competitions through coordination across program elements.

3.1. Research Roadmaps

Research Roadmaps are an intensive effort to elicit and illuminate the needs within a research Category. Road mapping may be done within a Research Area, Research Category, or research needs that require a deeper dive to discover specifics. S&T sponsors these efforts and involve bureau-wide input. Roadmaps typically require six months to one year to complete. Roadmaps can be accessed on this website, then by clicking on the desired Research Area on the menu located on the right side

of the page. The roadmaps are located at the bottom of each "Research Area" page. Roadmap links are also provided within this document in the Research Area or Category descriptions

3.2. Partnerships

S&T maintains partnerships with a variety of federal, state, and local government agencies, as well as non-profits, universities, and private entities. During coordination opportunities with these partners, collaborative research opportunities are identified. This allows S&T to share the funding burden of the project and expand the knowledge base by contributing to the project.

3.3. Prize Competitions

Since the Prize Program's inception in 2015, multi-agency collaborations have been formed in three areas central to Reclamation's mission: water availability, infrastructure sustainability, and environmental compliance. These theme areas are well aligned with the S&T research areas of water infrastructure, power and energy, environmental issues for water delivery and management, water operations and planning, and developing supplies. Table 1 crosswalks the central prize competition theme areas with S&T strategic research areas. Moving forward, beginning with this Innovation Strategy, the prize competition program fully integrates and adopts the S&T research areas, aiding data-driven program management such as tracking trends in types of projects funded.

To date, 38 prize competitions launched and closed with over 750 solutions submitted and 150 winning ideas. Many of the solutions are in the form of idea descriptions or theoretical solutions that essentially serve as fresh starting points for new research and development activities. Other solutions are more mature and are ready for technology demonstration to further reduction-to-practice.

A summary matrix of the completed prizes and solutions can be viewed here (access to this document is for DOI employees only). Additional prize information can be accessed at this website and by coordinating with the Prize Contact listed in the summary matrix linked above. The following sections identify research needs that are associated with completed prize competitions and competitions that are ongoing. Research needs that have a prize activity ongoing or completed are noted by a "++" at the end of the description.

Researchers with interest in advancing prize solutions from completed competitions are strongly encouraged to coordinate with the Prize Contact listed in the summary matrix linked above and associated Research Coordinator identified below.

Prize Competition Program Administrator: Christine VanZomeren (cvanzomeren@usbr.gov).

3.4. Research Area Coordinators:

Power and Energy (PE)

Erin Foraker, eforaker@usbr.gov, 303-445-3635

Water Infrastructure (WI)

Erin Foraker, eforaker@usbr.gov, 303-445-3635
Bobbi Jo Merten, bmerten@usbr.gov, 303-445-2380

Environmental Issues for Water Delivery and Management (EN)

Jennifer Bountry, jbountry@usbr.gov, 303-445-3614 (except Invasive Species)
Sherri Pucherelli, spucherelli@usbr.gov, 303-445-2015 (Invasive Species)

Water Operations and Planning

Chris Frans, cfrans@usbr.gov, 720-967-9793 (except Open Data)
Allison Odell, aodell@usbr.gov, 720-672-5107 (Open Data)

Developing Water Supplies

Andrew Tiffenbach, atiffenbach@usbr.gov, 303-445-2393

4. Fiscal Year 2026-2029 Science Priorities

The table and narrative descriptions below represent S&T's priority Research Areas and Categories for Fiscal Year (FY) 2026-2029.

Prize Theme Area	S&T Research Area	S&T Research Category
Infrastructure	**Water Infrastructure (WI)**	• Dams • Canals • Pipelines • Miscellaneous Water Infrastructure
Infrastructure	**Power and Energy (PE)**	• Hydro Powerplants • Pumping Plants
Environment	**Environmental Issues for Water Delivery and Management (EN)**	• Water Delivery Reliability • Invasive and Nuisance Species • Water Quality* • Sediment Management • River Habitat Restoration
Water	**Water Operations and Planning (WP)**	• Water Supply and Streamflow Forecasting • Water Operations Models and Decision Support Systems • Open Data* • Hydrologic Variability
Water	**Developing Water Supplies (WS)**	• Water Treatment • Water Supply Augmentation • Groundwater Supplies • Agricultural and Municipal Water Supplies • System Losses

Note: Safety is integrated into the Water Infrastructure and Power and Energy S&T areas.
**Cross-cutting Research Areas*

Table 1 - Relationships between Research and Development Prize Theme Areas, S&T Research Areas and Categories

5. FY 2027 Research Needs

This section outlines short lists of research needs by Research Area and Category.

5.1. Water Infrastructure (WI)

Improve the reliability of Reclamation water storage, water delivery, and facilities by producing or advancing effective solutions, tools, and practices that Reclamation facility managers can use to cost effectively maintain, modernize, and extend the life of Reclamation's aging infrastructure. These should be related to Reclamation's operations and maintenance responsibilities.

Categories:

5.1.1. Dams:

Examine and develop tools, methods, practices, and strategies to improve condition assessment, repair and maintenance, reliability, service life, and safety.

Coordination Contacts: Erin Foraker and Bobbi Jo Merten

Source of Research Needs

Research Priorities to Enhance Dam Infrastructure

Geotechnical Research Roadmap

Concrete Research Roadmap

Needs Statements

1. Investigate economical, safe, and effective methods to remove medium to large debris accumulating on storage and diversion dam intake structures, in support of budgetary constraints and the increasing wildfires exacerbating the issue in the western states.

2. Investigate methods to detect erosion of material under spillway slabs and into spillway underdrains, as well as methods and materials, e.g., lightweight/cellular concrete, to repair voids under spillway slabs (cross cutting with Canals), specifically high hazard potential dams which have potential failure modes that are estimated to lie in the low probability, high consequence region of the Dam Safety risk portrayal chart.

3. Investigate and implement improved concrete mix design standards, including natural pozzolan replacements for fly ash, thermal studies using modern materials. Reduce construction costs

and schedules via improved concrete protection guidelines for acceptable temperature gradients in relation to developed concrete strength.

4. Develop modeling tools to predict the rate of deterioration and strength loss in concrete, such as alkali aggregate reaction, freeze thaw, etc.

5. Develop consistent guidelines for seismic analyses of concrete dams to serve as a reference for analysts and dam owners, including advice on input loads for finite element (FE) analysis techniques, procedures for calibrating the FE models at different complexity levels and verification and interpretation of the analysis results considering various input parameters.

6. Research innovative design criteria, standards, and materials for new construction or major modifications; include historical analyses and "lessons learned" investigations as appropriate.

7. Identify internal erosion risk assessments, including improved methods to model field conditions in a laboratory setting and improved integration of field observations and laboratory testing (cross-cutting with Canals). ++

8. Advance geotechnical laboratory and field-testing practices, with emphasis on characterization of cyclic and post-cyclic soil behavior and soil modulus, erodibility of earth materials as related to structure reliability and sediment removal, characterization of engineering properties of gravelly and cobbly soil, including liquefaction susceptibility and internal erosion (cross-cutting with Canals Research Category).

9. Enhance science and engineering to close the gaps between laboratory testing and numerical modeling and between numerical modeling and field performance (cross-cutting with Canals). Investigate the use of innovative downhole or in-situ testing equipment including improvements to typical drilling practices.

5.1.2. Canals:

Examine and develop tools, methods, practices, and strategies to improve condition assessment, repair and maintenance, reliability, efficiency, and service life.

Coordination Contacts: Erin Foraker and Bobbi Jo Merten

Source of Research Needs

Research Priorities to Enhance Canals Infrastructure Sustainability

Needs Statements

1. Enhance science and engineering understanding of observations to determine quantifiable thresholds for action, particularly as they relate to risk assessment (cross-cutting with Pipelines Research Category). Examples include encroachments within or outside rights-of-way, seepage progression, consequences due to failure, or changes due to operations.

2. Evaluate methods and materials to detect and fill or repair voids under canal linings (cross cutting with Dams Research Category).

3. Develop underwater canal lining repair materials and methods for cracked, buckled, or bulged linings (underwater crack sealants, grouts, etc.) or underwater canal panel placement materials or methods.

4. Develop improved, less expensive canal lining, cover, and repair materials and methods++.

5. Identify improved inspection methods to reduce siphon pipe failure rates and develop less expensive repair methods to repair pipe in lieu of replacement and associated costs (cross cutting with the Pipelines Research Category)++.

6. Investigate methods, technologies, and approaches to reduce the incidence of canal drownings by improving physical aspects, sensing, or response techniques ++.

7. Identify economical methods and techniques to improve impacts due to subsidence.

5.1.3. Pipelines:

Examine and develop tools, methods, practices, and strategies to improve condition assessment, repair and maintenance, reliability, efficiency, and service life.

Coordination Contacts: Erin Foraker and Bobbi Jo Merten

Source of Research Needs

Research Priorities to Enhance Pipeline Infrastructure Sustainability

Needs Statements

Improve pipeline and tunnel condition assessment techniques and repair methods. Determine cost-effectiveness and constructability of alternatives.

1. Evaluate remotely operated vehicle (ROV) instrumentation and faster data analysis for assessing pipe condition (visual and quantitative) such as coatings and linings, pipe material, obstructions, and detecting leaks++.

2. Demonstrate low- or no-power technologies or sensors for detecting and monitoring metallic corrosion when embedded in concrete pipes including prestressed concrete cylinder pipes (cross cutting with Canals Research Category).

3. Enhance science and engineering understanding of observations to determine quantifiable thresholds for action, particularly as they relate to risk assessment (cross cutting with Canals). Examples include pipe leaks, consequences due to failure, or changes due to operations.

5.1.4. Miscellaneous Infrastructure:

Examine and develop tools, methods, practices, and strategies to improve condition assessment, repair and maintenance, reliability, efficiency, and service life.

Coordination Contacts: Erin Foraker and Bobbi Jo Merten

Source of Research Needs

There is no research roadmap currently available for this Category.

Needs Statements

1. Data standards – Evaluate standardized data collection approaches for inspections to facilitate improved data processing for predictive or condition-based maintenance. Develop approaches to better document as-built conditions at time zero, i.e., baseline conditions.

2. Data processing and access – Develop solutions, tools, and practices to improve analysis of large datasets, such as from photogrammetry or other detection methods, including 3D data visualization and digital twins. Improve data accessibility and streamline design processes through incorporation of real-time data. ++

3. Predictive maintenance – Research machine learning and artificial intelligence algorithms or other solutions, to develop a predictive or condition-based maintenance approach for assets (cross cutting with Power and Energy Research Area). ++

4. Safety – Improve the safety of the public, personnel, and operations, including but not limited to robotics or ROVs, wearable devices, hearing protection, hazardous energy detection, hazardous atmosphere monitoring, repetitive strain injury prevention, musculoskeletal disorders prevention, hazardous materials exposure prevention, and other occupational illness/injury prevention.

5.2. Power and Energy (PE)

Improve safety, reliability, resiliency, and efficiency by developing or advancing operations and maintenance and regulatory compliance solutions, tools, and practices of Reclamation's hydropower, pumping, and pump-storage facilities in order to reduce costs and increase energy supplies, and add value, ensuring Reclamation's hydropower remains a long-term, cost-competitive energy resource with quickly changing energy markets.

Categories:

5.2.1. Hydro Powerplants:

Examine, develop, and deploy tools, methods, practices, and strategies to improve safety, operations and maintenance, reliability, efficiency, outage time, and output, including pump-storage plants.

Coordination Contact: Erin Foraker

Source of Research Needs

For additional details regarding hydropower protection system related research needs, please reference the Research Priorities for Mechanical Components of Hydropower Units.

Needs Statements

1. Increase hydropower equipment reliability and performance for the hydroelectric generation powertrain from water to wire, including but not limited to, generator insulation systems, excitation, turbines, control, maintenance strategies, Supervisory Control and Data Acquisition (SCADA), and machine condition monitoring—such as to develop or improve existing tools to recommend effective operational limits that can distinguish erosive (damaging/ metal or material loss) cavitation from non-erosive cavitation.

2. Develop and implement data science techniques, including but not limited to advances in data sharing and analysis, networks, and accessibility, to reduce cost, improve reliability, and increase efficiencies (cross cutting with Water Infrastructure Section).

3. Improve the safety of the public, personnel, and operations, including but not limited to, robotics or ROVs, wearable devices, hearing protection, hazardous energy detection, hazardous atmosphere monitoring, repetitive strain injury prevention, musculoskeletal disorders prevention, hazardous materials exposure prevention, and other occupational illness/injury prevention (cross cutting with Water Infrastructure Section).

4. Develop inspection tools that advance data quality and reduce costs and time for inspecting equipment with limited access, identify alternatives for inspections and operational tests that cannot easily be performed, including but not limited to, large pipes and penstocks with difficult-to-access or dangerous geometries (e.g., complex geometry, steep slopes, drops, etc.), submerged equipment (e.g., bulkheads, trash racks, gates, valves, etc.), and auxiliary systems

(e.g., cooling water; heating, ventilation, and air conditioning [HVAC]; fire protection; oil piping, and other auxiliary equipment.

5. Evaluate, investigate, and develop Maintenance Improvement Initiatives resulting in cost-effective, less invasive, and less labor-intensive maintenance tasks, automated techniques, and online tools, e.g., new sensor technologies, data sampling strategies, system integration, digitization, and data science tools, related to hydropower protection and control systems, excitation, governor systems, and other hydropower equipment, that improve maintenance practices outlined in Facilities, Instructions, Standards, and Techniques Manuals. Integrate artificial intelligence and machine learning techniques, where applicable.

6. Develop methods to authenticate and improve hydropower value to support sustainable, cost-competitive hydropower resource within quickly changing energy markets, including but not limited to, new energy storage technologies, evaluation of ancillary services, operational improvements, and constraints on hydropower generation.

7. Improve materials or find alternative techniques for preventing corrosion, cavitation, and erosion damage that are cost effective, minimize outage time, and are durable and repairable, including but not limited to, coatings in high velocity environments, coating application in low temperatures and humid or wet conditions, and cavitation repair methods for turbine runners.

8. Investigate best practices and repair techniques for mitigating generator rotor arm cracking, rotor rim float, and pole connection failure issues.

9. Improve equipment shaft, bearing, and seal reliability, including but not limited to, oil level measurement accuracy and robustness for unsteady oil reservoir depths, hydraulic conditions, or difficult applications during unit operation, oil quality standards and performance (viscosity, temperature, moisture, contaminants), oil containment and leak detection for different oil systems, and greaseless technologies and environmentally friendly lubricants.

10. Conduct a comprehensive review of emerging motor design innovations, such as axial flux and other high-efficiency architectures, and quantify their performance benefits (e.g., power density, thermal management, material utilization). Investigate pathways to integrate these advancements into generator design (cross cutting with Pumping Plants Research Category) to improve overall system efficiency, optimize structural and electromagnetic parameters, and increase nameplate capacity while maintaining reliability and cost-effectiveness.

5.2.2. Pumping Plants:

Examine and develop tools, methods, practices and strategies to improve safety, operations and maintenance, reliability, efficiency, and outage time.

Coordination Contact: Erin Foraker

Source of Research Needs

Research Priorities to Enhance Pumping Plant Infrastructure Sustainability

Needs Statements

1. Improve pump operation and maintenance, including but not limited to, monitoring techniques related to pump starts, improved philosophy to ensure long term sustainability, and identify, demonstrate, and enhance pump storage attributes that make it a cost- effective utility scale option for grid energy storage that supports an increasing amount of variable generation. Investigate nondestructive inspection tools, such as ultrasonic testing, to improve efficiency and effectiveness of inspections in hard to access areas, and research and develop longer service life interior pipe coatings (cross-cutting with Hydropower Plants).

2. Evaluate pump economics, including but not limited to, investigate the economics of repairing versus replacing pumps and pump impellers (Reclamation's Technical Service Center [TSC] has a pumping plant assets inventory data file); investigate the economics of variable frequency drives regarding operational parameters, equipment and installation costs, and future utility costs; identify and modify machine condition monitoring techniques used for powerplants to be applicable for pumping plants, investigate composite materials for intake equipment, such as structural fiberglass, including lifecycle cost and benefit-cost analyses.

3. Develop methods for vibration testing of exposed pipe in pump discharge basins (not in roadmap).

5.3. Environmental Issues for Water Delivery and Management (EN)

Improve the reliability of Reclamation water deliveries by producing effective solutions, tools, and practices that Reclamation water managers can use to carry-out Reclamation's mission in an environmentally sound manner.

Categories:

5.3.1. Water Delivery Reliability:

Improve the reliability of Reclamation water supplies by finding innovative means to address aquatic and terrestrial ecosystem and species needs while still meeting water delivery contracts.

Coordination Contact: Lindsay Bearup and Jennifer Bountry

Source of Research Needs

Environmental Issues for Water Delivery and Management Research Roadmap

Needs Statements

1. Explore management approaches (e.g., nature-based solutions, adaptive management, temperature management) to improve ecological resilience to natural and human-caused disturbance.

2. Identify operational strategies to support aquatic organisms during low and high flows or under unsuitable water quality conditions.

3. Develop approaches to improve representation of environmental processes in decision support systems.

5.3.2. Invasive Species:

Investigate the impacts of invasive and nuisance species on Reclamation's infrastructure and assets and develop effective prevention, detection, and control methods to mitigate those impacts.

Coordination Contact: Sherri Pucherelli

Source of Research Needs

Environmental Issues for Water Delivery and Management Research Roadmap

Needs Statements

1. Prevention

   a) Optimize prevention methods such as watercraft inspection and decontamination (WID), by investigating methods to prioritize WID locations.

   b) Develop technologies to prevent the transportation of invasive/nuisance species from one location to another.

2. Early detection and monitoring

   a) Optimize existing sample collection and analysis methods and develop new methods for invasive/nuisance species detection, including molecular methods, automation, and machine learning.

   b) Investigate new methods for remote, rapid detection and mapping of invasive/nuisance species.

3. Control

   a) Evaluate and develop physical, cultural, chemical, biological, and genetic control methods for the management of invasive/nuisance species.

   b) Conduct social science studies to support the development and implementation of innovative control methods.

   c) Develop tools and protocols that support coordinated rapid response to new invasive/nuisance species populations.

4. Impact assessment

   a) Increase the knowledge and understanding of ecological and economic impacts of invasive/nuisance species in the western United States.

   b) Develop invasive/nuisance species risk assessments to prioritize management efforts.

5.3.3. Water Quality:

Develop and advance tools and practices that Reclamation has the mission, responsibility, and authority to use in managing water quality issues that are (1) linked to Reclamation operations and (2) could impact the reliability of Reclamation water deliveries if not addressed.

Coordination Contact: Kristin Mikkelson and Jennifer Bountry

Source of Research Needs

Environmental Issues for Water Delivery and Management Research Roadmap

Needs Statements

1. Improve understanding of operational effects on water quality in flow releases, and in reservoir or downstream processes.

2. Develop or improve methods to predict, manage, and monitor effects of hydrologic variability on water quality.

3. Understand impacts of external natural and anthropogenic influences such as fires on reservoir water quality.

4. Explore the causes and timing of harmful algal blooms and how Reclamation can detect and mitigate them through operational strategies or new technologies.

5. Improve our ability to predict turbidity episodes in reservoirs.

5.3.4. Sediment Management:

Develop and improve sediment management solutions and tools that improve the reliability and sustainability of water deliveries from Reclamation reservoirs and associated river systems and improve habitat conditions for threatened and endangered species.

Coordination Contact: Jennifer Bountry

Source of Research Needs

Environmental Issues for Water Delivery and Management Research Roadmap

Needs Statements

1. Develop guidance for sediment sampling plans in reservoirs and downstream river reaches to understand when to apply data collection and how to utilize it in a sediment management plan.

2. Improve capability of numerical models to predict responses from sediment management options in reservoirs.

3. Develop indirect methods to estimate reservoir sedimentation. ++

4. Improve data collection and quantification tools for estimating effects from large scale fires on sediment and debris production and associated river morphology or reservoir sedimentation response. Applies to water quality impacts (e.g., turbidity) from fires as well.

5. Develop a geo-spatial screening tool to characterize probability of reservoir sedimentation impacts or suitable management options for resource managers.

5.3.5. River Habitat Restoration:

Develop and improve aquatic habitat management solutions and tools that improve the ability to comply with regulatory requirements or mitigation measures assigned to Reclamation programs, including channel improvements, floodplain connectivity, channel complexity, fish passage and protection, and riparian vegetation enhancement.

Coordination Contact: Connie Svoboda and Jennifer Bountry

Source of Research Needs

Environmental Issues for Water Delivery and Management Research Roadmap

Needs Statements

1. Improve fish screen performance or develop alternative methods for fish exclusion.++

2. Improve methods for upstream and downstream fish passage.++

3. Improve detection and tracking of movement and migration of individuals and/or species.++

4. Evaluate post-project performance of rehabilitation projects through engineering and fisheries assessments.

5. Better understand effects of eco-hydraulics on habitat availability, connectivity, and food webs for species of concern.

6. Explore the influence of riparian or aquatic vegetation in relation to salmonid habitat and food webs using predictive hydraulic or sediment models.

5.4. Water Operations and Planning (WP)

Develop solutions and tools that help Reclamation water managers make effective reservoir and river system operational and planning decisions. Improve the integration, evaluation, understanding, and presentation of critical data and information.

Categories:

5.4.1. Water Supply and Streamflow Forecasting:

Develop and improve solutions and tools to forecast and monitor water supplies, including hydrologic events, and water demands.

Coordination Contact: Chris Frans

Source of Research Needs

Short Term Water Management Decisions

Needs Statements

1. Develop techniques to extend or improve skill of temperature and precipitation forecasts at the seasonal time frame. ++

2. Investigate new technologies and methods for monitoring/modeling snowpack conditions (e.g., snow water equivalent [SWE], snow depth, and snow extent) to improve water supply forecast skill. This may include investigations of new measurement technologies (e.g., satellite and building capacity for working with such data), processing or modeling of datasets, and evaluation of water supply forecast skill improvement.

3. Develop techniques and workflows to automate basin monitoring and forecast data acquisition and usage.

4. Enhance and evaluate emerging short-term streamflow and seasonal runoff volume forecasting methods, including their benefit to operational decision-making. ++

5. Explore and develop methods to improve the quantification and forecasting of the influences of diversions/depletions on reservoir inflows.

6. Explore and develop practices and workflows for developing and/or using forecast hindcasts in modeling/planning activities.

7. Develop techniques and assessments that quantify the economic value of forecast skill attributed to specific forecasting and monitoring technologies.

5.4.2. Water Operations Models and Decisions Support Systems:

Develop and improve reservoir/river system operations and planning models and decision support systems to optimally manage water delivery and use for Reclamation. This would include investigations and methods for water supply losses through evaporation.

Coordination Contact: Chris Frans

Source of Research Needs

There is no research roadmap currently available for this Category.

Needs Statements

1. Develop approaches and tools to support and optimize real-time operations in response to competing objectives and other constraints.

2. Develop approaches, tools, and supporting datasets to efficiently evaluate benefits (e.g., economic) gained from alternative operational paradigms as compared to current practices (i.e., a testbed).

3. Develop or explore decisions support tools and operational paradigms that leverage or pair with ensemble or probabilistic forecast products.

4. Develop tools and datasets to support an enhanced representation of hydrological variability in planning applications.

5. Explore opportunities for improved planning and operations that can leverage increasing access to high performance computing and cloud-based resources.

6. Explore opportunities to link or better integrate models and decisions support systems (e.g., operations, hydropower, sediment, and water temperature).

7. Develop or explore opportunities for artificial intelligence methods (e.g., large language models, machine learning) to increase the efficiency of analyzing and presenting data products of observation-based datasets, inputs to decisions support models, or outputs of decisions support models.

8. Improve evaporation and evapotranspiration estimation technologies to improve the quantification of water supply losses.

5.4.3. Open Data:

Develop methods and tools to improve management of Reclamation's water and related data to make it more comparable across locations, more easily found, and more shareable, both within Reclamation and with other agencies, stakeholders, and the public.

This includes expanding applicability and use of the Reclamation Information Sharing Environment (RISE, available at https://data.usbr.gov/), a platform for publishing Reclamation's mission-related data.

Coordination Contact: Allison Odell

Source of Research Needs

There is no research roadmap currently available for this Category.

Needs Statements

1. Develop and demonstrate visualization and/or analysis tools that leverage RISE data and could be hosted on the RISE website in support of decision-making, engagement, communication, and collaboration among Reclamation staff, partners, customers, stakeholders, other agencies, and the general public.

2. Investigate methods to facilitate adoption and expand utilization of RISE and/or contribute to expanding RISE data publication capabilities. This may include investigation of methods for publishing data types that are not currently represented in RISE (e.g., large, complex, multi-dimensional, or novel datasets) or for which RISE could provide better data services. This could also include development of data standards, data formatting tools, or data management methods to enable or expand compatibility with the RISE system.

3. Identify and evaluate how emerging technologies and trends related to data discovery, integration, and use (e.g., generative AI/LLMs, knowledge graphs, semantic web/semantic metadata, natural language processing, machine learning, graph databases/graph analytics, etc.), can be effectively applied in Reclamation data management and dissemination.

5.4.4. Hydrologic Variability

Develop methods and tools to increase adaptive management and flexibility in the planning, design and operations of Reclamation's facilities under a wide range of hydrological conditions, including management of droughts and floods.

Coordination Contact: Chris Frans

Source of Research Needs
There is no research roadmap currently available for this Category.

Needs Statements:

1. Develop tools and resources to support informed use of model simulations in water management applications.

2. Develop methods and basis for estimating extreme meteorological and hydrologic event possibilities, deterministically or probabilistically.

3. Identify risks posed by variable hydrology and extreme weather to efficient and continuous

operation of water and power infrastructure, and potential adaptation strategies.

4. Develop tools, methods, or resources for assessing observed hydrologic variability and appropriately considering historical data, including paleo-reconstructed data, in planning, maintenance, operations, and other aspects of Reclamation's mission.

5. Explore and develop adaptation techniques and tools that focus on understanding system vulnerability and resilience (e.g., DMDU [Decision Making Under Deep Uncertainty], decision scaling, etc.).

5.5. Developing Water Supplies (WS)

Develop, enhance, and protect water supplies for Reclamation stakeholders with new technologies, solutions, and practices that expand, create, or conserve water supplies.

Categories:

5.5.1. Advanced Water Treatment:

Develop technologies, methods, tools, processes and approaches to advance the treatment of impaired water sources that allow Reclamation to better utilize existing supplies, or to develop new supplies from non-traditional water resources such as brackish groundwater, seawater, municipal wastewater, produced waters from oil and gas extraction activities, and other impaired sources.

Coordination Contact: Andrew Tiffenbach

Source of Research Needs
Developing Water Supplies Needs

Needs Statements

1. Novel water treatment processes:

   a) Investigation of novel water treatment processes that treat impaired / non-traditional water sources producing beneficial water supply.

   b) Evaluate the use of artificial intelligence to improve existing or emerging water treatment technologies or processes.

2. Concentrate / residual management (generated by a prior process or highly concentrated source water):

   a) Investigate concentrate residual waste disposal options including beneficial reuse and selective precipitation with potential for valorizing precipitant solids.

   b) Develop and evaluate technologies such as novel membrane processes, non-steady- state membrane processes, enhanced evaporation, precipitation processes, phase separation, adsorption processes and advanced thermal processes to reduce concentrate and/or residual waste volume.

   c) Investigate concentrate management challenges associated with water reuse treatment.

   d) Develop techniques that use targeted removal/management of sparingly soluble inorganics, organics or other constituents to increase overall treatment system beneficial water recovery while considering the potential for separating or producing constituents that can be valorized.

3. Decision support tools for research and/or process performance:

   a) Develop metrics and tools for comparing/evaluating the performance and/or economics of emerging water treatment technologies.

   b) Develop a technology primer for emerging water treatment technologies and/or applications.

4. Selective pollutant/constituent characterization and treatment:

   a) Develop and/or optimize technologies or processes for the characterization, detection, monitoring and sensing of regulated contaminants, Contaminants of Emerging Concern (CEC), regulated or unregulated per/poly-fluoroalkyl substances (PFAS), or other constituents preventing the beneficial use of an impaired water source.

   b) Develop and/or optimize technologies or processes for the separation and treatment of CEC, PFAS, or other constituents preventing the beneficial use of an impaired water source.

   c) Develop and/or optimize technologies focused on the destruction of CEC, PFAS, or other constituents preventing the beneficial use of an impaired water source.

5. Water reuse research:

   a) Develop membrane and/or non-membrane-based technologies and treatment trains for non-potable and potable reuse.

   b) Investigate the potential to valorize and/or reuse constituents in non-potable and potable reuse concentrate/residual streams.

6. System optimization research:

   a) a. Develop sensors or other monitoring approaches to support system optimization in areas such as increasing beneficial water production optimized to influent water quality, real-time fouling/scaling detection, identify system upsets, real-time troubleshooting, etc.

5.5.2. Water Supply Augmentation:

Develop and improve processes, resources, and/or technologies to augment water supplies for Reclamation projects by utilizing water sources such as stormwater; natural treatment systems such as wetlands; or management approaches such as cloud seeding or hydrologic investigations.

Coordination Contact: Andrew Tiffenbach

Source of Research Needs

There is no research roadmap currently available for this Category.

Needs Statements

1. Perform research to understand winter orographic cloud seeding effectiveness and impacts.

2. Identify needs where natural treatment systems such as wetlands can be utilized for water supply augmentation.

3. Identify needs and challenges for the use of stormwater across the western United States to be utilized for water supply augmentation.

5.5.3. Groundwater Supplies:

Develop and improve solutions and tools that advance and optimize groundwater supplies for either storage and/or further understanding of surface water's impact on groundwater supplies that can be of use for Reclamation projects. Projects under this Category should not focus on the treatment of groundwater, those types of projects belong under the water treatment Category.

Coordination Contact: Chris Frans

Source of Research Needs

Brackish Groundwater in the United States

Needs Statements

1. Groundwater quality data needs:

   a) Occurrence and distribution of groundwater

   b) Hydrogeologic characterization

   c) Geochemistry

   d) Brackish groundwater use

   e) Brackish groundwater sustainability

2. Groundwater-surface water interaction:

   a) Summarize relevant data and overcome data gaps.

   b) Models and processes used to evaluate groundwater-surface water interaction in regulated river systems.

5.5.4. Agricultural and Municipal Water Supplies:

Develop and improve technologies, methods, tools, and approaches to augment water supplies for agricultural and municipal water demands at a lower cost and/or reduced environmental impact for Reclamation stakeholders and projects.

Coordination Contact: Andrew Tiffenbach

Source of Research Needs

There is no research roadmap currently available for this Category.

Needs Statements

1. Process development for selective constituent removal and recycle/reuse of agricultural drainage water.

2. Develop decision support tools for comparing and evaluating the performance and/or economics of technologies treating agricultural drainage water.

3. Develop decision support tools on how to augment water supplies from the treatment/reuse of agricultural drainage water.

5.5.5. Water Losses:

Develop and improve processes, technologies, and tools that conserve water and/or reduce water losses in Reclamation water storage and delivery systems.

Coordination Contact: Andrew Tiffenbach

Source of Research Needs
There is no research roadmap currently available for this Category.

Needs Statements

1. Develop new and innovative ways to reduce evaporative losses at reservoirs and evaluate the efficacy of these technologies or approaches.