BUREAU OF RECLAMATION

FY 2023 Science and Technology Research Projects

Refurbishment of Small Diameter Embedded Pipes in Powerplants and Dams, Year 1 Funding: $29,536

This scoping-level research will identify and evaluate potential refurbishment solutions for small diameter embedded pipes that have suffered extensive corrosion in powerplants and dams. Small diameter metallic pipes were typically installed uncoated, and their condition is not assessed during comprehensive or periodic facility reviews. Now that the age of much of Reclamation's infrastructure exceeds 70 years, corrosion has compromised many of these small pipes, which are notoriously hard to repair or reline. John Keys Pump-Generating-Plant awarded a contract in fiscal year 2020 to reline the 10- to 12-inch diameter bypass filling, air vent, and drain pipes. However, water leaking back into the pipes made them impossible to reline. Potential solutions need to be identified as soon as possible for this active, multi-year contract. A TSC team has been assembled with funding support from John Keys to investigate the refurbishment options, and initial investigations found no solution.

Investigating Rubberized Polysiloxane Coating Formulations to Improve Durability and Long-Term Performance, Year 1 Funding: $130,952

The United States Army Corps of Engineers and the Bureau of Reclamation began a collaboration in 2015 to investigate alternative corrosion-resistant coatings to vinyl for impacted immersion service of hydraulic infrastructure. Reclamation recently found several polysiloxane coating products to have excellent corrosion-prevention properties in water immersion service. However, the durability, impact resistance, flexibility, and erosion resistance of polysiloxanes were inferior to that of vinyl. These mechanical properties are essential for long-term corrosion protection of Reclamation's immersed infrastructure. The goal of the proposed research is to find a durable polysiloxane formulation that is suitable for field trials through a focused Reclamation effort in collaboration with the United States Army Corps of Engineers Paint Technology Center, which has committed to providing substantial cash funding for this research.

Investigation of Innovative Exposed Lining Systems, Year 1 Funding: $72,640

Geomembrane liners have been in use dating back to the 1960's, primarily in canals, reservoirs, ponds, and landfills. Today, the liner type that is overwhelmingly specified in exposed liner applications is HDPE. Although HDPE is a very durable and high performing, no one has conducted long-term field or laboratory studies comparing HDPE to any of the new technologies available to us today. This study will evaluate new advanced liner technologies,

including a flexible Geo-Form Ethylene Propylene Diene Monomer, a polyurea impregnated geotextile, a bitumous geomembrane, and a reinforced polyethylene. The expected outcome of this research consists of determining whether HDPE is still the preferred exposed liner material or if there are other more durable and economical options for the end user.

Long-Term Coatings Lab Testing Data Analysis for Service Life Correlations and Evaluation of New Testing Methods, Year 1 Funding: $87,000

Reclamation and other water agencies have been working to find replacement coatings for the long service lifetimes provided by coal tar enamel and solution vinyl coatings. Analysis of existing coatings laboratory data is needed to determine which laboratory tests best predict field performance, and new or improved test methods are also needed to fill gaps left by traditional testing approaches. The goal is to enhance the predictive power of laboratory testing without increasing test durations to help ensure that specified coatings will provide a long field service life of corrosion protection of Reclamation's steel infrastructure. The research team will analyze existing large datasets to identify correlations and statistical significance, utilizing coatings testing data from Reclamation's Materials and Corrosion Laboratory and the U.S. Army Corps of Engineers Paint Technology Center. The large dataset analysis results will help to identify and perform new laboratory testing methods. The research outcome is improved coating laboratory evaluation techniques and increased correlation of laboratory performance to field performance.

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, Year 1 Funding: $95,000

At the turn of the 20th century, salmon runs into the upper Columbia River watershed supported the culture and livelihood of indigenous peoples and provided an immeasurable ecological benefit throughout the region. Upon completion of multiple hydroelectric facilities, including Grand Coulee Dam in 1941 and Chief Joseph Dam in 1961, salmon runs were extirpated from the upper Columbia. Stakeholders in the region have been exploring the feasibility of anadromous fish passage and reintroduction into the blocked areas. The project to be undertaken is focused on testing critical uncertainties associated with reservoir and downstream passage survival, such as site-specific migration and passage survival data. This will reduce Life Cycle Modeling uncertainty and help to confirm resultant conclusions regarding anadromous reintroduction feasibility and success. 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.

Ground Modification using Microbially Induced Desaturation (MID) for Liquefaction Interim Risk Reduction, Year 1 Funding: $105,000

Microbially induced desaturation and microbially induced desaturation/precipitation (MID/P) are emerging technologies that offer the potential for sustainable, cost-effective liquefaction

mitigation for existing structures. Liquefaction refers to an increase in pore pressure in saturated, loose sand or gravel deposits that results in a loss of shear strength; typically, this type of loading occurs during an earthquake, and can result in a catastrophic failure of a dam or canal. Many of Reclamations' dams and canals are founded on potentially liquefiable materials and will require further investigation, and potentially modification. This project will evaluate benefits associated with MID/P technology and provide a draft risk analysis of the implementation of MID/P as a long-term liquefaction mitigation method. To investigate MID/P, a bio-geotechnics testing program will be developed at Reclamation's Technical Service Center Geotechnical Lab, specifically aimed at testing liquefaction resistance of MID/P treated soils.

Food for Fish: A 2-Dimensional Fate and Transport Model for Zooplankton with Implications for Juvenile Salmon Growth and Water Management Efficiency, Year 1 Funding: $75,000

The Sacramento River floodplain once provided an abundant source of food to rearing and migrating juvenile salmonids. Flood control measures and agricultural development now limit fish access to the floodplain. As a result, feeding opportunities may be fewer, perhaps resulting in unrealized growth potential and potentially lower survival rates at out-migration. 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.

The Effect of Large Earthquake Loading on Fine-grained Foundation Materials: Determining Residual Undrained Strengths at Large Strains and Corresponding Embankment Deformations, Year 1 Funding: $130,000

Deformation analysis due to earthquake loading relies on well-defined residual undrained strengths. However, there is not an industry-accepted standard to determine this value, meaning no clear method to incorporate these strengths into deformation analyses. This results in large uncertainties and very conservative (overly designed) embankments. This research utilizes laboratory tests and numerical modeling to: 1) determine earthquake induced residual undrained strengths (the reduced strength of soil as it is deformed) of fine-grained embankment and foundation soils and 2) inform deformation analyses of embankments. It is relevant to all Reclamation dams with fine-grained material in the foundation or embankment, and which are subjected to strong earthquake loading with the potential of large deformations. Recent and ongoing examples include Boca Dam, Howard Prairie Dam, Conconully Dam, BF Sisk Dam, Ochoco Dam, El Vado Dam, Glen Elder Dam, Steinaker Dam, Keene Creek Dam, and Starvation Dam (among others). Results from this research will allow for increased confidence in geotechnical design and has the potential to greatly decrease the amount of time, material and funding required for seismic modifications.

Quantification of Accuracy Improvements Related to Multibeam Data Rrocessing, Year 1 Funding: $47,232

Multibeam bathymetric surveys are necessary to determine sedimentation trends and to update area-capacity tables for Reclamation's reservoirs. The time currently budgeted for processing multibeam data is approximately two days for each day of data collection. The purpose of this research is to identify the degree of processing necessary to reach diminishing returns. That is, can we reduce the level of effort in data processing without reducing the quality/accuracy of area-capacity curves, and if so, by how much? There is a Directive and Standards currently in review related to the requirement that Reclamation's Regional Offices develop sediment management plans for each reservoir under their purview. It is reasonable to assume that a reservoir survey would be one aspect of a sediment management plan for many of Reclamation's reservoirs. Therefore, the processing of bathymetry survey data needs to be as efficient as possible such that the data processing does not become a bottleneck (timewise or funding wise) to the objective/intention of the Directive and Standard.

Tracing Salinity Through the Southern Sacramento-San Joaquin River Delta, California Using Continuous Salinity Monitoring, High-speed Salinity Transects, and Ion Fingerprinting, Year 1 Funding: $87,375

Water from the Sacramento-San Joaquin River Delta (Delta) supports over 3.5 million acres of agricultural land across California and supports a diverse ecosystem of over 750 plant and animal species in what is the largest estuary on the west coast of North America. The Bureau of Reclamation and the California Department of Water Resources must operate in a way to meet water quality objectives designed to protect human health and safety, threatened or endangered species, and agricultural water users. Severe droughts not only stress a limited water supply, but also increase the tension between these beneficial uses of water in the Delta. Reduced carry-over reservoir storage during multi-year droughts leads to low flow rates and elevated water temperature and salinity downstream, thus posing risks to native fish species, drinking water, and salt-sensitive crops. This project will package high-resolution data that will directly improve the calibration and validation of hydrological models widely used throughout California. It will also provide a way to test regional representation of fixed water quality stations and identification of local point sources of salinity. Understanding the dynamics of salinity in the southern Delta will allow for strategies for more efficient salinity management practices, potentially directly benefitting Reclamation by conserving water supply.

Developing a Robust Planning Framework for Climate Change in California, Year 1 Funding: $51,588

In California, the historical hydrology is characterized by periodic shifts between wet and dry, however climate change is expected to exacerbate the frequency and intensity of these shifts. Most evaluations of climate change effects within Reclamation commonly use the output of Global Climate Models (GCMs) as a starting point for developing model inputs and forcings (Reclamation, 2021). As it is often not possible to simulate each of these potential futures for

every project due to resource limitations (e.g. budget, computational), representative GCMs are often selected based on performance over the historical period (Pierce, 2021) or to represent a range of the variability seen in climate projections (Reclamation, 2016). Decision makers are left with the question of how to interpret and communicate future performance across a wide range of climate futures for multi-sector objectives. This study will include two components: 1) use existing data from the Merced River study to develop a planning framework, and 2) adapt and apply this framework to the larger-scale Central Valley Project/State Water Project (CVP/SWP). Applications of this tool to both the watershed scale and the larger scale CVP/SWP system will serve as proofs of concept for the generalizability of the methodology, as well as support the development of guidance for broader Reclamation-wide implementation.

Automated In Situ Repairs of Damaged and Aging Infrastructure, Year 1 Funding: $105,161

The need for in situ or 'in place' repair of Reclamation's aging infrastructure has been repeatedly identified by field personnel as a critical area of need and development. This proposed research investigates the use of 3D scanning and automated welding to perform repairs to equipment. Two applications are proposed: 1) cavitation repair of turbine runners, and 2) a proof of concept for repair of damaged steel components. The first application will select 1-2 suitable Reclamation field locations for final prototype development and testing of an automated cavitation weld repair robot for Francis and Kaplan style hydroelectric turbines. The cavitation repair robot will help alleviate personnel exposure to safety and health hazards and ultimately decrease outage time and repair costs by providing a faster, easier, and safer method for turbine draft tube and runner cavitation damage repair. The second application will continue the investigation of additive manufacturing methods for in situ repairs of other types of damage. This work will investigate existing technologies and utilize three-dimensional scanning to map a repair area geometry and print the repair area directly onto the native part.

Evaluating the Feasibility of Sequential Tank Aeration and Re-chlorination for Removal of Disinfection Byproducts Under Extreme Water Age in Support of the Navajo Gallup Water Supply Project Design, Year 1 Funding: $183,084

The Navajo Gallup Water Supply Project is Reclamation's largest treated water supply project, totaling $1.5 billion in investments. Extreme distribution system water age in the Navajo Gallup Water Supply Project systems require effective design to mitigate contaminants of concern, specifically disinfection byproducts. The impacts of successive aeration and re-chlorination cycles on disinfection byproduct formation, removal, and speciation will be evaluated using a bench scale San Juan Lateral water treatment plant and San Juan Lateral distribution system. The bench-scale distribution system will be designed to evaluate the water quality and disinfection byproduct characteristics after successive aeration and re-chlorination events. The results of this work will inform the Navajo Gallup Water Supply Project system design to meet current disinfection byproduct regulations at point of use. The data from this work will inform designers on placement of tank aeration systems and will provide the means to improve overall project technical effectiveness and feasibility through responsible design.

Developing and Testing an Engineered Biological Control for Iron Oxidizing Bacteria in Water Wells, Year 1 Funding: $100,600

The Yuma Area Office manages 111 groundwater pumping wells, which primarily serve to lower the regional groundwater table for productive agriculture. Water pumped from these wells provides supplemental benefits by augmenting water supply and managing salinity in the Colorado River. The leading cause of premature failure of these wells is Iron Oxidizing Bacteria (FeOB). This research will carry out a series of chemical, microbiological, and solid-state characterizations of FeOB to identify the primary factor(s) causing the clogging problem, develop biological mitigation strategies, conduct laboratory testing of treatment variants, and conduct field testing of select treatment variants. The research is expected to demonstrate that a biological control can be engineered as a viable, low-cost treatment to mitigate the proliferation and adverse impacts of FeOB on water wells. Results are expected to influence water well maintenance strategies not only within the Bureau of Reclamation, but could also be applied worldwide throughout the industry. This strategy could also provide a framework for mitigating bacteria in other industries (sanitation, medicine, etc.).

Stochastic Streamflow Generation: A Complementary Approach for Hydroclimate Projections in Hydrologically Complex Basins, Year 1 Funding: $69,640

As Reclamation works toward operationalization of climate-change planning across all of the agency's mission areas, we will need a generalized approach for developing representative streamflow estimates under a non-stationary climate in all of our service areas, including hydrologically complex basins. In addition, we will need methods for development of weather and streamflow timeseries that are compatible with techniques developed under the practices of decision-making frameworks such as Decision Scaling and Decision-Making under Deep Uncertainty (DMDU). The goal of this proposal is to develop a generalized stochastic streamflow generation approach to complement Reclamation's present methodological practices that is applicable across all of Reclamation's river basins, and that is consistent with decision-making frameworks such as DMDU. The aim is to build on previous work to develop a tool with applicability across Reclamation and the broader water resources planning community.

System Commissioning for Topical Concrete Coatings used for Algae Resistant Linings for Canals, Year 1 Funding: $60,668

The purpose of this proposal is to confirm if products identified in S&T Research Final Report "Algae Resistant Linings for Canals and Other Water Resource Structures" are capable of reducing algae growth when applied to full-size concrete canal lining panels that are in-service over multiple irrigation seasons. Several products trialed in the previous study demonstrated the potential to reduce algae growth. These products would be trialed on full-size concrete canal lining panels within the Quincy-Columbia Basin Irrigation District that are in-service. The research strategy will include dewatering several canals, if not already dewatered during off-season, cleaning panels by pressure washer and applying the proposed products to the concrete

panels. The canal will then but in-service as planned and the panels will be observed and photographed monthly to track algae growth.

Exploring Frameworks for Simulating Historical and Future Hydrology in the Upper Deschutes River Basin, Year 1 Funding: $28,336

The Deschutes River basin is hydrologically complex due to highly connected surface and groundwater systems. In water supply studies incorporating climate change, frameworks for estimating streamflow commonly include hydrologic modeling because tools may be developed in a consistent way to simulate historical and projected future climate conditions. However, these models have been so far unsuccessful in reproducing historical observed unregulated streamflow in the Deschutes River basin. Model deficiencies can result in unreliable historical and future water supply information on which to base management decisions. The objective of this scoping proposal is to identify an effective approach for developing historical and future streamflow scenarios that meets the needs for future water supply studies, and then submit a full conducting proposal next cycle to develop the approach. This scoping proposal research strategy will include exploration of two approaches that have been applied in other complex watersheds.

Boulder Cluster Design Guidance for River Restoration, Year 1 Funding: $50,000

Aquatic species, such as endangered fish, rely on a diverse range of depth, velocity, and cover to provide habitat at different flow rates. Rivers that suffer from a lack of geomorphic diversity and complexity have experienced habitat degradation because there is little opportunity for fish to seek refuge from high velocities that occur during runoff flow events. Installing boulder clusters is one technique employed by river restoration designers to provide lower velocity refuge that improves fish habitat in uniform river systems. However, there is little guidance available for design practitioners to implement effective boulder cluster configurations. The purpose of this proposal is to create boulder cluster design guidance to assist river restoration practitioners in meeting fish habitat objectives. The guidance will be created by incorporating previous physical and numerical modeling results for the Los Angeles River and qualitative boulder cluster design information. Formal documentation is needed to preserve lessons learned and provide technology transfer.

Climate Change Impact Analysis on Groundwater Availability and Managed Aquifer Recharge in California, Year 1 Funding: $59,000

This project will assess the likely effects of projected climate change on groundwater availability. A range of future climate scenarios for California will be considered that represent potential future conditions with a focus on the Central Valley in California and in particular the Delta-Mendota subbasin . The analysis of climate change impacts on groundwater availability performed in this study will provide a tool that can assist the Delta-Mendota subbasin with implementation of their groundwater Sustainability plans. Additionally, this study will yield an analytical framework that may be applicable to other regions throughout Reclamation. The

analytical framework developed in this project will be built on the linkage of a suite of models that allow for the representation of climate forcings driving the interrelated governing processes of rainfall-runoff into reservoirs, reservoir operations, crop water demands, and conjunctive use of groundwater and surface water deliveries to meet the crop water demands.

Reducing Reclamation's Carbon Footprint Through Modernizing Concrete Materials, Specifications and Construction Practices, Year 1 Funding: $74,739

The objective of this project is to collaborate with other high-level concrete industry leaders and to develop guidance on best practices for reducing Reclamation's carbon footprint as it relates to concrete materials and construction. The concrete industry has been targeted for its contribution to global warming due to the high levels of carbon emitted by cement production and the overall concrete construction process. Many teams are currently being formed (with and without government partners) to look for ways to improve the concrete industry while maintaining strong, durable, and long-lasting infrastructure. There is a great push for the concrete community to become carbon neutral by the year 2050. This research plans to review, in entirety, the many recently published documents related to concrete carbon neutrality, attend meetings and workshops of various organizations and government or non-government teams, identify new research areas related to sustainable concrete, perform outreach on the subject to our Regional engineering and construction staff, and develop a written technical report summarizing the issues and potential solutions that relate to reducing Reclamation's carbon footprint through modernizing concrete materials, specifications and construction practices.

Assessing Satellite Remote Sensing Products to Improve Spatial and Temporal Resolution of Snow Water Equivalence (SWE) Measurements in the San Juan - Chama Project's Source Watersheds, Year 1 Funding: $112,000

Current climate stressors have caused snowpack accumulation amounts and melt patterns to increase in interannual variability, which has made streamflow forecasting more difficult in areas dependent on mountain snowpacks for water supply. To improve runoff forecasting from snowmelt, the accuracy of snowpack measurements, primarily snow water equivalence (SWE), needs to improve at the spatial and temporal scales. This can be done by increasing the resolution of snow data collection to the basin scale using satellite remote sensing techniques. This proposal will assess the measurement accuracy and frequency of satellite remote sensing products to determine how they may be used, in conjunction with ground-based measurements, to produce a SWE product that can improve water supply estimates from annual spring snowmelt runoff in the headwaters of Reclamation's San Juan-Chama Project. This assessment will also identify any conditions or periods during the snow season where the accuracy of this method might break down, whereby the fusion of this method with snow depth from stereo satellite imagery may be utilized to bridge this limitation. The goal of this proposal is to refine the temporal and spatial scale of SWE measurements that are currently available to Reclamation to improve the accuracy of snowmelt runoff estimates.