



2023 National Dam Safety Research Summit Report

August 2023



FEMA

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Message from the Director

July 12, 2023

Hosted by the Federal Emergency Management Agency's (FEMA) National Dam Safety Program (NDSP), the research summit had 55 attendees from 39 different federal and state agencies and industry partners in attendance. The National Dam Safety Program Research Summit took place Wednesday, February 8th & Thursday, February 9th, 2023, at FEMA Headquarters in Washington, DC.



The mission of the Research Summit was to evaluate near-term industry needs for dam safety and to outline a path forward for the future. This event provided a venue to bring the key dam safety industry research leaders from across the United States and from all sectors (federal, state, academia, and industry partners). The objectives lined out prior to the summit were as follows:

- Identify firm and defined research deliverables funded by the Infrastructure Investment and Jobs Act (IIJA) that must be completed in a three-year cycle.
- Identify and forecast future research needs for long-term execution. For each research need, develop a description, justification, and pathway to move those ideas forward.

As a result of the research summit, NDSP selected 31 projects to begin in FY23-25. This report summarizes each phase of the process taken to identify these priorities.

FEMA and NDSP would also like to thank and acknowledge the contributions of the NDSP Research Workgroup and Chairs, the Summit moderators and participants, and the National Dam Safety Review Board members to the 2023 National Dam Safety Research Summit.

Sincerely,

Kayed Lakhia
Director – National Dam Safety Program



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1. Overview

DATE AND LOCATION

Wednesday, February 8th &
Thursday, February 9th, 2023
**FEMA Headquarters in
Washington, D.C.**



ATTENDEES

55 members
of the dam
safety industry



39 total federal and state
agencies, academia, and
industry partners



TOPIC GROUPS

Members were
divided into
three tracks:

- 1. Hydrological & Hydraulic**
- 2. Geotechnical and Structural**
- 3. Safety and Security**



31

draft project
scopes were
produced



31

projects were
selected to
begin FY23-25

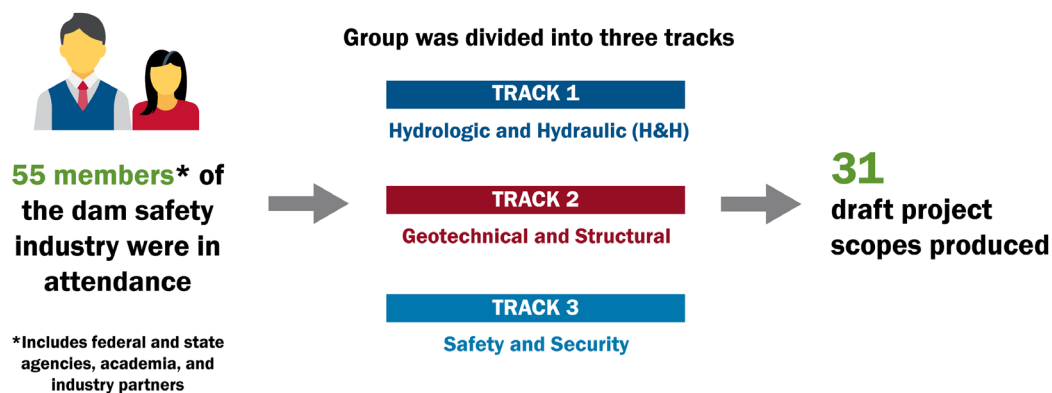


2. Introduction

The National Dam Safety Program Research Summit took place Wednesday, February 8th & Thursday, February 9th, 2023, at FEMA Headquarters in Washington, DC. The mission of the Research Summit was to evaluate near-term industry needs for dam safety and to outline a path forward for the future. This event provided a venue to bring the key dam safety industry research leaders from across the United States and from all sectors (federal, state, academia, and industry partners).

The objectives lined out prior to the summit were as follows:

- Identify firm and defined research deliverables funded by the Infrastructure Investment and Jobs Act (IIJA) that must be completed in a three-year cycle.
- Identify and forecast future research needs for long-term execution. For each research need, develop a description, justification, and pathway to move those ideas forward.



The Research Summit had 55 attendees from 39 different federal and state agencies as well as industry partner organizations. Attendees were divided into three tracks, and within these groups, they collaborated and presented amongst each other on which research projects they believed should move to the final presentations. Once everyone rejoined and the final presentations were completed, each attendee was given 8 votes to decide which research projects they wanted to see pushed forward.

After the summit, the Research Work Group members met and made recommendations to the National Dam Safety Review Board (NDSRB), who in turn voted on their final suggestions to FEMA. As a result of the Research Summit efforts, FEMA National Dam Safety Program selected 31 projects to begin in FY23-25. This report summarizes each phase of this process as well as next steps.

3. Phase 1: Summit Planning

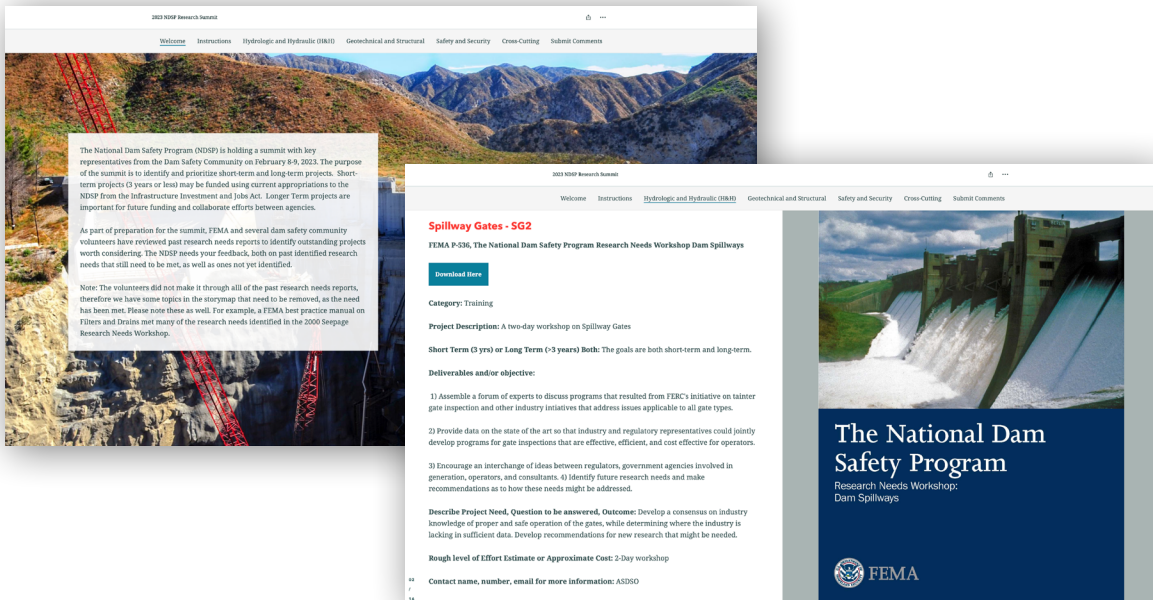
On November 6th, 2021, President Biden signed the Infrastructure Investment and Jobs Act (IIJA) into law. This Act contained significant increases in funding for the National Dam Safety Program, \$67M of which is earmarked for operations. The operations budget primarily focuses on funding activities such as research and technical guidance, training, safety assessments, emergency action planning, and public safety outreach. Based on this opportunity, the National Dam Safety Review Board Research Workgroup decided to convene the summit to prioritize dam-related research needs.

The mission of the National Dam Safety Program Research Summit was to evaluate near-term industry needs for dam safety and to outline a path forward for the future. This year’s Summit theme was Short-Term Priorities and Long-Term Planning.

The purpose of the summit was to identify and prioritize short-term and long-term projects. Short-term projects (3 years or less) may be funded using current appropriations to the NDSP and IIJA. This summit report will be used to guide the NDSP research objectives for the next five years.
























In preparation for the Summit, FEMA and several other dam safety community volunteers met between 5-10 times over the year prior to the summit’s convening. During this time, the working group reviewed past research needs reports to identify outstanding projects worth considering. After their investigation the working group determined that there were areas of research that were missing from the reports. These research topics were divided into three main tracks: **Hydrological and Hydraulic (H&H), Geotechnical and Structural, and Safety and Security.**

After the tracks were decided, the working group moved to identify industry partners (federal, state, academia, and private industry) to work with during the summit. The attendees were invited based on expertise and proficiency to ensure that the missing areas of research would be adequately examined. *For a complete look at the story map that was used to develop the tracks please visit, [this page](#).*



4. Phase 2: Research Summit

The research summit had 39 different federal and state agencies, and industry partners in attendance. On the first day of the two-day event, the attendees were divided into the 3 different tracks – Hydrologic and Hydraulic (H&H), Geotechnical and Structural, and Safety and Security. The participating agencies are as followed:

- | | | | |
|-------------------------------------------------------------------------------------|-----------------------------------------------------------------|--------------------------------------------------------------------------------------|----------------------------------------------------------|
|  | ▪ AECOM |  | ▪ Federal Energy Regulatory Commission (FERC) |
|  | ▪ American Rivers Association |  | ▪ Freese-Nichols, Inc. |
|  | ▪ Argonne National Laboratory |  | ▪ Gannett Fleming |
|  | ▪ Association of Dam Safety Officials (ASDSO) |  | ▪ Georgia Department of Natural Resources |
|  | ▪ Association of State Floodplain Managers (ASFPM) |  | ▪ Maryland Department of the Environment |
|  | ▪ Atkins Global |  | ▪ National Oceanic and Atmospheric Administration (NOAA) |
|  | ▪ Brigham Young University |  | ▪ Oklahoma State University |
|  | ▪ CEATI International |  | ▪ Stanford University |
|  | ▪ Colorado State University |  | ▪ Tennessee Valley Authority (TVA) |
|  | ▪ Columbia University |  | ▪ University of Colorado at Boulder |
|  | ▪ Department of Homeland Security (DHS) |  | ▪ University of Mississippi |
|  | ▪ DHS Cybersecurity & Infrastructure Security Agency (DHS CISA) |  | ▪ University of Missouri Columbia |



- University of Puerto Rico



- U.S. Fish & Wildlife Services (USFWS)



- U.S. Army Core of Engineers (USACE)



- U.S. Society on Dams (USSD)



- U.S. Bureau of Reclamation (USBR)



- Utah State University



- U.S. Department of Agricultural Research Service (USDA ARS)



- Veenstra & Kimm, Inc.



- U.S. Department of Agriculture Forest Service (USDA FS)



- Virginia Department of Conservation and Recreation



- West Virginia Conservation Agency



- U.S. Department of Agriculture Natural Resource Conservation Service (USDA NRCS)



- William Sale Partnership Ltd.

The moderators began the break out sessions where each track worked together as a group to brainstorm and presenting new project ideas or worked off existing project ideas. The attendees defended the project ideas that they thought were necessary to keep and push forward to presenting to the entire summit.

The following shows which agencies and industry partners were participating in each track and the summaries from each proposed research project that was discussed from the session. To read the full scopes of work for the proposed research projects, see the Appendix.

4.1. Hydrological and Hydraulic (H&H)

Participating agencies:

- Argonne National Laboratory
- American Rivers Association
- ASDSO
- Atkins Global
- Bureau of Reclamation
- Columbia University
- USDA NRCS
- Colorado State University
- Veenstra & Kimm, Inc.
- Utah State University
- University of Mississippi

4.1.1. Assessment and Use of Climate Cycle Information for Dam Safety Decision Making

Project Description: Understanding climate phenomena and how they may influence decision-making for floods with recurrence intervals of less than 100 years could help prioritize risk reduction actions. The project will develop an assessment of identified cyclical climate variations at inter-annual to multi-decadal time scales that provide descriptions of those variations, summarizes the current ability to forecast these variations, and recommends strategies for using this information to prioritize risk reduction actions at dams.

4.1.2. Climate Change PMP and Design Rehab

Project Description: This proposal would a) complement the ongoing work related to the probable maximum precipitation (PMP) through an investigation of the historical data on extreme precipitation events to assess trends over the last century, to identify regions where specific mechanisms and their change needs further study; b) review the literature to identify how Intergovernmental Panel on Climate Change (IPCC) and re-analysis model projections indicate regional changes to PMP in the context of the dominant types of regional events that are identified; and c) develop regionally specific recommendations to update PMP and PMF estimates along with narrative discussions and quantification of the sources and magnitude of uncertainty in the projections.

4.1.3. Developing a Modern Collaborative Research Network for the Design and Analysis of Hydraulic Structures

Project Description: The project will address the need for further collaboration of hydraulic designers by forming a Hydraulic Modeling Consortium for Hydraulic Structures. The consortium will identify the gaps in research related to hydraulic design and then implement a systematic research program to develop updated design guidance.

4.1.4. Guidance on Non-standard Peak Rate Factors/Unity Hydrography and Research Whether These Factors Would be Influenced by Climate Change

Project Description: This project will acquire a contractor to prepare a hydrologic study to establish consistent federal guidelines on how to apply these non-standard factors and synthetic methods. The project includes technical reviews of existing publications and other resources modeling hydrographs. These studies will then inform a best practice document that encourages the use of proven and researched hydrologic methods from subject matter experts to promote more rigorous and defensible hydrologic practices nationally at dams.

4.1.5. Guidance on Unlined Spillway Erosion Estimation

Project Description: As more extreme hydrologic events increase, the potential for erosion and scour of unlined (soil and rock) spillways will also increase. The project would obtain spillway erosion case studies from industry experts and focus on the initiation, continuation, and progression of the erosion/scour process to plot the variability of erosion rates with geologic material and hydraulic mechanism. The research will be completed upon creating the Unlined Spillway Erosion Estimation guidance document adopted and used by the dam safety community.

4.1.6. Guidelines for Hazard Potential Classification

Project Description: There is a need to create consistent guidelines to conduct hazard potential classification studies. This project requests funding to prepare technical guidance to establish consistent federal guidelines on how to conduct hazard potential classification studies to create consistency in how the states report hazard potential classification in the NID, including performing a technical review of existing guidance. This consistency will impact the number of dams eligible for HHPD funding and assist states in consistently assessing and assigning hazard potential classification across their regulated inventory.

4.1.7. Improvements for a National Web-based Dam-break Flood Inundation Mapping and Consequences Analysis Decision Support System

Project Description: There is a need to improve the highly used National Web-based Decision Support System for Water Infrastructural Security (DSS-WISE Lite), which is an integrated flood modeling environment. The project will improve the system by conducting a new survey to compile interests in future improvements, address recommendations that have not been made since the survey three years ago, and address newly identified recommendations from the survey results.

4.1.8. Land Use Change Information for Dam safety Decision Making

Project Description: A process is needed for addressing land use changes that have occurred since the construction of an existing dam and project changes over some future period. The project will address the need by developing a recommended policy for identifying actual and projected land use changes and using that information in dam safety assessments and planned risk reduction actions.

4.1.9. Modernization of SITES and WinDAM Computational Models for Prediction of Earthen Spillway and Embankment Dam Erosion and Breach

Project Descriptions: Modernization of the USDA Sites and WinDAM models base code (upgrade from 32bit to 64bit), graphical user interface (GUI), and supporting user guides are critically needed.

The project will request funding through an interagency agreement between USDA-ARS and FEMA to modernize and transform the SITES and WinDAM software packages to a cloud-based environment to meet today's user needs while maintaining compliance with federal cybersecurity and 508 policies and regulations. All user manuals will be upgraded to reflect the new SITES and WinDAM versions.

4.1.10. Quantification of Embankment Breach Parameters

Project Description: The importance of accurately modeling an embankment breach is to provide realistic scenarios for use in emergency planning, evaluating consequences to the surrounding communities, and targeting repairs. This project will conduct research to eliminate knowledge gaps. At the end of the proposed effort, the primary deliverable will be a (user-friendly) web-based program based on the results from both laboratory and field tests that will far more effectively predict and therefore provide an assessment of embankment breaches.

4.1.11. Update to FEMA P-946

Project Description: This proposal requests funding to hire a contractor to prepare the second edition of the Federal Guidelines for Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures (FEMA P-946). The project includes performing a literature review of guidelines from federal and state regulators and interviewing industry experts. It is expected that the document will include a new discussion on 2D modeling, using dam breach analysis in risk-informed decision-making, and estimating dam breach parameters with physically-base methods. The document will promote consistency across the industry.

4.2. Geotechnical and Structural

Participating agencies:

- AECOM
- Bureau of Reclamation
- CEATI International
- University of Colorado at Boulder
- FERC
- Freese-Nichols, Inc.
- Maryland Department of the Environment
- USDA ARS
- USSD
- USACE
- University of Missouri Columbia
- TVA

4.2.1. Dam Lifecycle Development

Project Description: Research is required to understand the anticipated lifespan of a dam better in order to help facilitate appropriate decisions related to it. This project will develop the framework for using an asset management approach to begin the development of the lifecycle of a wide range of dams. The project's outcomes include the lifecycle framework and models to demonstrate the value of maintenance, rehabilitation, and modification on the service life of individual structures.

4.2.2. Development of an Approach to Identify and Characterize Seismic Failure Modes

Project Description: Earthquakes pose a unique threat to the stability and safety of dams. This project aims to support an effort to develop guidance for the identification and evaluation of seismic failure modes of dams, explicitly focusing on embankment dams.

4.2.3. Establish Risk Prioritization of Poor/Unsatisfactory Condition Dams

Project Description: There are currently estimated to be between 1500 and 2000 high-hazard dams eligible for the High Hazard Potential Dam (HHPD) grant and are rated as poor or unsatisfactory. This project will perform screening-level risk prioritization for these poor and unsatisfactory dams and train the states on how to perform their own screening-level risk assessments.

4.2.4. FEMA NDSP Guidance Document Update

Project Description: This project will review existing FEMA NDSP guidance documents and identify which ones need to be updated. Upon completion of this review, documents that are determined to not be up to date will be updated with current best practices. Additionally, an appropriate review cycle will be determined for each document to continue to be reviewed in the future to determine if the documents continue to represent current best practices.

4.2.5. Geotechnical Characterization of Embankment Dams

Project Description: There is no standard of practice for the geotechnical characterization of embankment dams and foundations. This project will conduct a literature review of related documents and work with a group of industry experts to develop a best practices manual that can be used to develop educational training seminars and serve as a future resource.

4.2.6. Integrating System-Level Thinking into Dam Engineering and Management

Project Description: There is a need to understand the impacts on other facilities connected to a network due to changes at a dam within the network and integrate new knowledge into facility management. The project seeks to compile best practices currently implemented by other federal agencies and distribute guidance to dam owners and operators to increase the scope of emergency action planning and response. This project would establish a framework for prioritizing systems and communication between dam owners within each system.

4.2.7. Internal Erosion Processes for the Prediction of Dam Embankment Performance

Project Description: Information regarding internal erosion needs to be consolidated into a reference. This project will update the dam failure database to conclude internal erosion failure, update the FEMA P-1032 Manual, and conduct regional training workshops to educate engineers, owners, and regulators.

4.2.8. Leverage Dam Performance to Support Dam Safety

Project Description: In dam safety, there is a need to gather, archive, and evaluate information on the performance of dams and the consequences of their unsatisfactory performance to support an evidence-based approach to policy, communication, and engineering management of dams. To fill the need, the two-pronged project will first establish a foundation for a dam safety information system and secondly take a long-term view of the information needs in dam safety and develop an infrastructure, database system, communication products, and other critical features.

4.2.9. Static Liquefaction: Develop Short-term “Screening” Guidance for Dam/Levee Owners and Regulators and Identification of Research Needs

Project Description: Current PFMA Best Practices for water dams have not considered static liquefaction failure modes. This project will better define project needs, develop interim guidance for screening existing dams for susceptibility, a roadmap for research needs, and develop a best practice document for water dam owners and professionals. The research will also include evaluating the use of existing empirical relationships for post-liquefaction residual strength based on common field investigation methods and the results of post-seismic stability analyses to evaluate the potential for static liquefaction.

4.2.10. Validation, Verification, Calibration, and Uncertainty Quantification for Numerical Models for Embankment and Concrete Structures

Project Description: Current engineering design and analysis practice and risk-informed decisions rely on numerical analysis methods to simulate dam performance, despite these models often having uncertain validity and reliability. This project will conduct studies directed toward enhancing the accuracy and reliability of numerical models for embankment and concrete dams to quantify the uncertainties of these models. The outcome will be a comprehensive technical guide and best practices for the numerical analysis of dams.

4.3. Safety and Security

Participating agencies:

- ASDSO
- ASFPM
- Brigham Young University
- DHS
- FEMA
- Oklahoma State University
- USDA ARS
- Virginia Department of Conservation and Recreation

4.3.1. Cyber Dependencies Affecting Dam Safety and Operations

Project Description: There is a need to identify and evaluate the role of information technologies and operation technologies on dam safety and operations. This project aims to develop identification templates to assist owners in evaluating their cyber dependencies. The effort will research and leverage current best practices and any applicable Federal guidance to develop a consistent and standard approach to cyber asset identification that will then help to develop a minimum set of data fields to efficiently identify critical components, potential vulnerabilities, and overall impacts on safety and operations.

4.3.2. Dam Safety Public Relations Campaign

Project Description: The project will address the need for an increased level of the general public's understanding and awareness of dam safety. This project will request funding for a 5-year strategy to develop and implement an educational plan for increasing public understanding of dams and public safety at dams. The educational plan will include creating a public outreach plan, conducting the plan, and developing products such as videos, handouts, imaging, and more.

4.3.3. Enhancement and Maintenance of the ASDSO Dam Safety Toolbox

Project Description: The project will fill the need for a single-location resource for guidance related to small and medium-sized embankment dams by creating a website with a long-term maintenance and funding plan. The website's material will be crowd-sourced from subject matter experts and be able to be used to share information between engineers, state regulatory programs, and more.

4.3.4. FEMA National Dam Safety Program Guidance Document Library – Update Existing Guidelines and Add New Guidelines

Project Description: Since the National Dam Safety Program (NDSP) was started, several important guidelines have been created; however, many of these documents have never been updated or are outdated. In addition, as new issues and technical topics have emerged over time, there is a need to create new guidelines. This project aims to review all existing guidelines, update documents, identify topical gaps, and develop new guidance documents to create a comprehensive library of current National guidance documents for practitioners.

4.3.5. First Responder Dam Hazard Training Program

Project Description: There have been many first responder fatalities performing rescues and body recoveries at dams, especially low-head dams, because they were unaware of the hazards. This project will address the increasing dam safety risks to First Responders in conducting rescue or recovery operations by developing best practice guidance, education, and training resources and enhancing risk and hazard awareness notification services for First Responders.

4.3.6. HMP and FPMP Guidance Training Development

Project Description: Guidance is needed to help State Dam Safety Programs, dam owners, and project sponsors meet the Floodplain Management Plan requirement of FEMA's High Hazard Potential Rehabilitation Grant Program (HHPD). This project would research existing Hazard Mitigation Plans and Floodplain Management Plans and identify any existing guidance incorporating dam hazards. The deliverables would be guided to develop these plans, which would be scalable based on the extent of the dam's impact on the community(ies) and examples of existing plans.

4.3.7. Low-Head Dam Inventory

Project Description: Currently, there is no national low-head dam inventory despite these dams being able to create dangerous currents downstream that have resulted in many more fatalities than from dam failures over the last several decades. The purpose of this project is to create the beta version of the national inventory of low-head dams that is peer-reviewed and can be viewed as a publicly available map and simple database.

4.3.8. Project Screening Tool for Low-Head Dams

Project Description: The national inventory of low-head dams will educate the public about these structures' location, especially those with dangerous currents downstream. The primary project task is to create and test a screening tool that will determine the occurrence of submerged hydraulic jumps at low-head dams that then informs a map-based product that shows for which low-head dams a submerged hydraulic jump can occur.

4.3.9. Proximity Alarm for the Recreating Public Approaching a Low-Head Dam

Project Description: The project will address the increasing dam safety risks to the general public by developing new innovative solutions for automated public notification of dam safety risks and hazards. The project will conduct a landscape analysis and technology scouting to develop an open technology architecture and prototype capability. This analysis will later help develop a technology transition and sustainment plan to reduce public safety accidents.

4.3.10. Public Safety Incidents Database

Project Description: An official database of public safety and work safety incidents at dams is needed to help identify trends. This project involves creating a national database of incidents at dams that tracks accidents and fatalities to reduce the number of incidents, identify and monitor trends, and evaluate current practices' effectiveness.

4.3.11. State-led Dam Removal Funding Programs - Best Practices

Project Description: There is a regular need for dam removal or rehabilitation funds, leading to a more straightforward path to grants that would fund removal. The project will focus on best practices to develop state-led dam removal funding programs, compile a resource library, and identify current federal funding opportunities.



5. Research Summit, Final Presentations, and Voting Process

When the research summit attendees finished brainstorming and presenting within their own groups, they decided on who would champion each research project. Each project was given two champions, and those champions then presented their proposal to the entire summit. The champions had an allotted time to go through their proposal and pitch their ideas to the whole group.

After every track finished their presentations, the attendees were given the opportunity to vote on which projects they wanted to see pushed forward. The project titles were written on easel pads and were posted along the walls of the conference room. Each attendee was given 8 stickers to vote on their favorite proposals. After the voting closed, the summit moderators went around the room tallying up all of the stickers and informed the group which projects received the highest number of votes and concluded the summit.



6. Phase 3: Post-Summit Reviews, Refinement, and Voting

After the summit, the Research Work Group members met to discuss and make their official recommendations to the National Dam Safety Review Board (NDSRB) over the research projects that were voted on during the summit. A handful of work group members recused themselves from the voting process if they thought their company or organization may bid on some of the proposals. Afterwards, the NDSRB voted again on their final suggestions to FEMA. As a result of the Research Summit efforts and the post-summit reviews, FEMA's National Dam Safety Program selected 31 projects to begin in FY23-25.



7. Phase 4: Summit Priorities, Implementations, and Next Steps

As a result of the research summit, the National Dam Safety Program selected 32 projects to begin in FY23-25. The projects were reviewed and voted on by the NDSRB research group, the voting was based on the estimated project duration and cost. These projects consist of updates to existing guidelines, new publications, new databases, geotechnical and structures, hydrologic and hydraulic, safety and security, and cross-cutting.

Planned start dates for the contracts are September/October 2023 and they must be completed by September 2027 (funding limitations).

Note: While the proceeding tables outline the projected projects for FY23-25, FEMA and the NDSRB reserve the right to make changes as needed in alignment with the strategic goals, objectives, priorities, and available funding of the NDSP.

FY23 Projects

Publication Update	Description	Estimated Duration
Many FEMA NDSP Guidance Documents have not been reviewed to determine if the material in them is still current best practice	This project will review existing FEMA NDSP guidance documents and identify which ones need to be updated. Upon completion of this review, documents which are determined to not be up to date will be updated with current best practices. Additionally, an appropriate review cycle will be determined for each document to continue to be reviewed in the future to determine if the documents continue to represent current best practices.	3 years

<p>Update to FEMA P-946 Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures</p>	<p>The first edition of the Federal Guidelines for Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures (FEMA P-946) was published in July 2013. The guidelines document the history of inundation mapping, causes of dam failures, dam breach analysis study approaches, hydrologic analyses, downstream routing analysis, the estimation of breach parameters and analysis tools for dam failure modeling. The guidelines are frequently used by state and federal dam safety regulators to establish acceptable study approaches and mapping standards. The guidelines are also frequently referenced by hydrologic and hydraulic engineers during the completion of dam break inundation studies.</p>	<p>21 months</p>
<p>Update to Selecting and accommodating Inflow Design Floods for Dams FEMA P-94</p>	<p>The first edition of the Federal Guidelines for Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures (FEMA P-94) was published in August 2013. It needs to be updated with following considerations: 1. Research and tabulate overtopping related failures and incidents (ASDSO database and others) in US. Try to identify the reason for incidents (capacity issue, blockage or gate malfunction, settlement, other).</p> <ul style="list-style-type: none"> ▪ For the capacity issues, review the precipitation data for main events (multiple dam incidents or high profile cases): Was this a 500 year event or PMP event? Were there shoulder events that saturated the soil before the extreme precipitation event? Tabulate data, summarize information, draw conclusions. Is there a trend? ▪ Can we identify common reasons for why some dams perform well under high precipitation conditions (maybe based on dam condition assessment before the event)? ▪ Summarize spillway requirements for each state and for each dam hazard category. Also summarize agency (FERC, USACE, BOR, TVA, etc) requirements are a reference ▪ Provide best practice suggestions based on observations from 1, 2 and 3 and other agency practices. ▪ National Academy of Science and NOAA will update the PMP atlas in the near future. What is the most efficient way to incorporate this information for the states? What should be include in a FEMA spillway design/rehabilitation guideline when NOAA atlas is released? 	<p>2 years</p>

New Publications	Description	Estimated Duration
FEMA National Dam Safety Program Guidance Document Library – Update Existing Guidelines and Add New Guidelines	The FEMA library of technical guidelines needs to be updated. In addition, existing gaps need to be identified and new guidance documents developed based on those gaps. The specific need for new guidance includes: A practitioner’s guide to Risk-Informed Decision-Making (RIDM); A facilitators guide to Potential Failure Mode Analysis (PFMA)	1 years
State-led Dam Removal Funding Programs – Best Practices	There is a regular need for funds for dam removal or rehabilitation. State-led grant or loan programs can meet this need and solve dam safety problems through removal or rehabilitation of dams. In addition, match requirements for Federal grants to remove dams can be outside the capacity of a dam owner. State-led grants can provide these funds and open up the federal grants to allow for removing bigger or more expensive projects. More than 2,000 dams have been removed around the country and dam removal has become a common approach to remedy dam safety issues with uneconomical dams.	2 years
Static Liquefaction: Develop short-term “screening” guidance for dam/levee owners and regulators, and identification of research needs	Recent dam failures attributed to “Static Liquefaction”, a failure mode that has not been historically considered in water dam PFMAs. The Edenville case history will be analyzed using different post liquefaction residual strength relationships to identify whether the existing seismic evaluation framework would have captured the potential for this static liquefaction case history.	1.5 years

Database	Description	Estimated Duration
Leverage Dam Performance to Support Dam Safety	A fundamental need in managing critical infrastructure is the development and maintenance of an information system that monitors the performance of these systems. Information systems exist for some elements of the nation’s physical infrastructure (e.g., bridges, transportation systems, pipeline systems, among numerous others), and in other critical fields such as health care (e.g., The Johns Hopkins University COVID-19 resource center and dashboard, Centers for Disease Control), law enforcement (e.g., FBI Crime Data), etc. These systems monitor, archive, and evaluate information at varying levels of detail to support a range of information needs, are intended to support data-driven decisions in technical areas and in public policy, and provide information that supports fact-based communication with the public.	4 years
Geotechnical and Structural	Description	Estimated Duration
Gravel and Rockfill Characterization for Seismic Analyses	The main objective of this research will be to gain knowledge on gravel and rockfill material characterization for seismic analyses for design and evaluation of new and existing embankment dams and levees.	4 years
Cracking of Embankment Dams Due to Earthquake Shaking	A thorough, rigorous, fundamental reexamination of case histories of embankment dam cracking will be performed. Data from the recent February 6, 2023 Türkiye earthquake will be collected as part of the project with collaboration with the US and Turkish researchers. This process will be similar to that used for the vetting of case histories used to develop the widely used earthquake-induced liquefaction and post-liquefaction residual strength case relations. For each case history, the geology, geomorphology, construction, and geotechnical aspects of case history will be reevaluated, as well as the magnitude, and other characteristics of the seismic loading (duration, type of faulting, ground motions, etc.). Different types of cracking, as well as crack-like features such as fissures or voids will be clearly distinguished. Dam design and construction documents will be reviewed where possible to identify and report particular design features potentially important for embankment cracking. The case history data base will be curated, with each case history being assigned a set of quality rankings based on the information available. Finally, a set of suggestions will be developed for best practices for crack mapping, characterization and data collection in future earthquake reconnaissance field surveys	2 years

Hydrological and Hydraulic	Description	Estimated Duration
Screening tool for determining occurrence of submerged hydraulic jumps at low-head dams	Screening tool for determining probability and frequency of occurrence of submerged hydraulic jumps at low-head dams	3.5 years
Improvements for a National Web-based Dam-break Flood Inundation Mapping and Consequences Analysis Decision Support System (DSS Wise Lite)	A new survey to compile users' interests in future improvements for DSS-WISE Lite. Integrating near-real time publicly available hydrographs from watershed and land surface models as boundary conditions for hydrologic events. Develop the capability to model tailings dam failures by including mixtures of water and sediment into simulations. Develop a web-based external Application Programming Interface (API) for serving DSS-WISE Lite results.	21 months
Safety and Security	Description	Estimated Duration
First Responder Dam Hazard Training Program	First responder education of hazards at dams and how to safely conduct river rescue or recovery at dams. There have been a significant number of first responder fatalities performing rescues and body recoveries at dams, especially low head dams, because they were not aware of the hazards or properly educated and trained on how to perform rescues and recoveries under such conditions (ASDSO 2019, Tschantz 2014). The rate of fatalities is 8-times more for accidents compared to dam failures. This trend is increasing with the growth of population living or recreating near dams and the rise in extreme water sports. First responders represent about 1/3rd of those fatalities (Kern and Hotchkiss 2015).	4 years
Proximity alarm for the recreating public approaching a low-head dam	Technology innovation to improve public awareness of dam safety risks and hazards. The rate of fatalities is 8-times more for accidents compared to dam failures. This trend is increasing with the growth of population living or recreating near dams and the rise in extreme water sports. (Kern and Hotchkiss 2015). The general public lacks awareness of these risks and hazard and capabilities that would automatically notify them that they are approaching and/or in proximity of a high hazard area.	3.5 years

Low-head dam inventory	There is no national low-head dam inventory. These structures, though not designed for water storage, can create dangerous currents downstream that have resulted in many more fatalities than from dam failures and incidents over the last several decades. Low-head dams are generally not part of formal state inventories, are not subject to inspection or attention, and therefore are nonjurisdictional.	1 year
Cross-cutting	Description	Estimated Duration
Dam Lifecycle Development	The anticipated lifecycle of dam is currently poorly understood. Research is required to better understand the anticipated lifespan of a dam in order to help facilitate appropriate decisions related to it planning, design, construction, operation, maintenance, potential upgrade, and decommissioning.	4 years
Enhancement and maintenance of the ASDSO Dam Safety Toolbox	There is a need for a single-location resource for guidance related to small to medium sized embankment dams. ASDSO has developed the Dam Safety Toolbox, a wiki-style website, as a solution however there is no long-term plan / funding source for maintenance & expansion.	4 years

FY24 Projects

Project Name	Description	Estimated Duration
Cyber Dependencies Affecting Dam Safety and Operations	There is a clear need to identify and evaluate the role played by information technologies and operation technologies on dam safety and operations. Cyber threats continue to grow and represent one of the most serious operational risks facing modern organizations. Numerous cyber intrusions across different types of infrastructures, both domestic and overseas, demonstrate the urgent need for assessing digital dependencies and eventually promoting and sustaining enhanced cybersecurity awareness. This is particularly essential for those situations where the control of physical processes and operations relies on digital information and communication systems.	3 years
New Training Aids for Dam Safety (TADS) Update	Update and Revise the Training Aids for Dam Safety (TADS): A Self-Instructional Study Course in Dam Safety Practices (FEMA 609DVD). The outcome would be a publicly available, modern set of workbooks and videos that have incorporated all the relevant work completed by FEMA over the last few decades.	3 years

<p>Integrating System-Level Thinking into Dam Engineering and Management</p>	<p>This project seeks to compile best practices currently implemented by other federal agencies and distribute guidance to dam owners and operators to increase the scope of emergency action planning and response. Current practice sees dam facilities as a silo, whereas they are intertwined as part of a larger network. One facility could be impacted by changes in operations, maintenance, and emergency action planning at another. This project would establish a framework for prioritizing systems as well as communication between dam owners within each system. Project implementation would see dams as part of a network, and lead to better emergency management and planning for all dams within each network.</p>	<p>3 years</p>
<p>Developing a modern collaborative research network for the design and analysis of hydraulic structures</p>	<p>Currently, much of the federal hydraulic design guidance for hydraulic structures, including spillways, is based upon project-specific model studies and generalized design guidance from decades past. Today, with modern construction techniques, new materials, and technologies, there is a pressing need for collaboration between key players for new studies and to updated guidance. Recent project-specific physical and numerical modeling efforts have generated innovative designs and data resources, but a focused, collaborative effort is required to produce modern hydraulic design guidance that meets federal needs and promotes effective design of hydraulic structures by the U.S. water resources industry. Figures 1-4 herein illustrate current needs and recent research efforts due to challenges with current federal design guidance.</p>	<p>3 years</p>
<p>Modernization of SITES and WinDAM Computational Models for Prediction of Earthen Spillway and Embankment Dam Erosion and Breach</p>	<p>This proposal requests funding through an interagency agreement between USDA-ARS and FEMA to modernize and transform the SITES and WinDAM software packages to a cloud-based environment to meet today's user needs while maintaining compliance with federal cybersecurity and 508 policies and regulations All user manuals will be upgraded to reflect the new SITES and WinDAM versions.</p>	<p>3 years</p>

<p>Guidance on Unlined Spillway Erosion Estimation</p>	<p>The spillway erosion/scour project is intended to provide dam owners, the spillway design and risk assessment community, case studies of unlined (soil and rock) spillway erosion/scour and further guidance on the estimation of erosion potential and erosion rates for design and risk assessments.</p>	<p>1 - 1.5 years 2 - 1.5 years</p>
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FY25 Projects

Project Name	Description	Estimated Duration
<p>Public safety incidents database</p>	<p>There is no official database of public safety and worker safety incidents at dams for the United States. This information is needed to help identify trends and focus efforts where they are needed most.</p>	<p>+1 year(s)</p>
<p>Geotechnical Characterization of Embankment Dams</p>	<p>There is no standard of practice for the geotechnical characterization of embankment dams and foundations. Federal and State regulators provide suggested methods which leads to confusion in implementation between Owners and Engineers. The lack of geotechnical data for projects leads to construction and dam safety risks.</p>	<p>2 years</p>
<p>Guidelines for Hazard Potential Classification</p>	<p>This proposal requests funding to prepare technical guidance to establish consistent federal guidelines on how to conduct hazard potential classification studies to create consistency in how the states report hazard potential classification in the NID. This consistency will impact the number of dams eligible for HHPD funding and will assist states consistently assess and assign hazard potential classification across their regulated inventory.</p>	<p>2 years</p>
<p>Develop guidance to help States, project sponsors and Dam owners develop Hazard Mitigation Plans and Floodplain Management Plans that reflect dam risk in a community</p>	<p>The most pressing need is that FEMA’s High Hazard Potential Rehabilitation Grant Program (HHPD) has a specific requirement in the legislation for a Floodplain Management Plan (FPMP) “to reduce the impact of future flood events in the area protected by the project.” Guidance is needed to help State Dam Safety Programs, dam owners and project sponsors meet this requirement.</p>	<p>1 year</p>

<p>Development of an approach to identify and characterize seismic failure modes of dams</p>	<p>The purpose of this project is to support an effort to develop guidance for the identification and evaluation of seismic failure modes of dams. This project will be focused on embankment dams. The guidance that is developed can later be expanded in a similar project to concrete dams. This proposal requests funding to conduct a comprehensive study to identify, understand, and evaluate seismic failure modes of embankment dams. The study will involve a systematic review of available literature, data from existing studies (performed by others), and the performance of case studies for selected projects. The review of existing studies and the new case studies will involve seismic response analyses and the identification of potential failure modes. The information generated from these sources will provide a basis to develop a framework and guidance for evaluating the seismic performance of embankment dams and the identification and characterization of potential failure modes.</p>	<p>2 years</p>
<p>Validation, verification, calibration, and uncertainty quantification for numerical models for embankment and concrete structures</p>	<p>This proposal requests funding to conduct studies directed toward enhancing the accuracy and reliability of numerical models for embankment and concrete dams. The project aims to quantify the uncertainties of these models through a comprehensive technical review and analysis. The project will compare and evaluate the case history results of those of numerical models. These evaluations will provide a basis for quantifying uncertainties associated with numerical modeling practices. Different sources of uncertainties will be discussed in numerical simulation and effective actions will be proposed to mitigate and reduce them. The outcome of this project will be a comprehensive technical guide that provides guidance and best practices for numerical analysis of dams and estimates of uncertainty in numerical models for embankment and concrete structures.</p>	<p>2 phases of 2 year 2 year total</p>

<p>Internal erosion processes for the prediction of dam embankment performance</p>	<p>Internal erosion is documented in multiple recent publications from USSD, FEMA, USBR, FERC, and the COE. This information needs to be consolidated into a reference for Engineers, Owners, and Regulators. This also includes updating dam failure databases to include internal erosion failures for Federal, State, Municipal, and Private dams to understand the importance of internal erosion in the evaluation of dams. Development of an education program will increase the overall understanding of the importance of internal erosion considerations in the design, and assessment, and mitigation for embankment dams.</p>	<p>1.5-2 years</p>
<p>Land Use Change Information for Dam Safety Decision Making</p>	<p>Land use in the vicinity of a dam will be dynamic over time. Changes in land use can significantly alter both inflows and consequences for consideration in dam operation and/or dam failure analysis. Changes in land use can also lead to restrictions on the operation of a dam to protect people and property from more frequent events at the expense of poor performance for extreme events. A process is needed for addressing both land use changes that have occurred since construction of an existing dam and project changes over some future period.</p>	<p>1 - 6 months 2 - 90 days 3 - 90 days</p>
<p>Establish risk prioritization of poor/unsatisfactory condition dams</p>	<p>There are currently estimated to be between 1500 and 2000 high hazard dams which are eligible for the High Hazard Potential Dam (HHPD) grant and are rated as poor or unsatisfactory. As grant funding is not available to upgrade or remove all of these dams, it is important that the dams within each state can be prioritized based on its risk. Many states struggle with determining appropriate risk prioritization for their inventories. This project will perform screening level risk prioritization for these poor and unsatisfactory dams and provide training to the states in how to perform their own screening level risk assessments. A method of screening has previously been developed for FEMA and has been piloted. It is anticipated that this screening process will be used to perform these risk assessments.</p>	<p>6-9 months</p>

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National Dam Safety Review Board Workgroup Chairs

- Sherry Hunt, Federal Chair, USDA
- Jason Sheeley, Federal Co-Chair, USACE
- Michele Lemieux, Non-Federal Co-Chair, MT Dept. of Natural Resources & Conservation
- Joanne Brandani, Non-Federal Co-Chair, CalOES
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Project & Procurement Management

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9. Appendix

Track 1: Hydrologic and Hydraulic (H&H)

Title: Assessment and Use of Climate Cycle Information for Dam Safety Decision Making (H4a)

Need: Climate studies have shown patterns of behavior (El Nino, La Nina, Atlantic Oscillation, etc.) that have the potential to influence dam safety decision making and prioritization. Understanding these phenomena and how they may influence decision making for floods with recurrence intervals of less than 100 years could help prioritize risk reduction actions.

Project Description: Develop an assessment of identified cyclical climate variations at inter-annual to multi-decadal time scales that provides descriptions of those variations, summarizes the current ability to forecast these variations, and recommends strategies for using this information to prioritize risk reductions actions at dams.

Project Task:

- Perform a literature review to identify documented cyclical climate variations.
- Describe each documented cyclical climate variation concisely.
- Provide an assessment of the industry's ability to forecast these cycles.
- Identify Seasonal to Sub-Seasonal and Season-to-Decade forecast products that are available from NOAA and other sources.
- Recommend strategies that dam owners could use to prioritize dam safety studies.
- Recommend strategies that regulators could use to prioritize regulatory actions.
- Recommend strategies that entities providing funding for dam safety risk reduction actions could use to most effectively allocate funds.
- Recommend software enhancements.

Product/Outcome: A best practice document providing guidance for incorporating known climate variation cycles into dam safety decision making at both local and national levels.

Research Category: Best Practice Document

Project Benefits:

- Provides tangible recommendations for incorporating known climate variation cycles into dam safety decision making.
- Supports effective/efficient allocation of risk reduction funding.

Measure of Success: A completed best practice document adopted and used by both dam owners and regulators to demonstrate that dam safety decision making is taking climate variability into account.

Project Schedule: Total duration - 360 days; Phase I is 180 days, Phase II and III are 180 days total

Title: Climate Change and Design/Rehab

Need: The probable maximum precipitation (PMP) and the associated probable maximum flood (PMF) have been used as “conservative” design criteria for dams. There are some open questions as to whether or not the PMP estimates should be revised to reflect current climate conditions, as well as to project them for likely future climate conditions. Given that precipitation mechanisms, the seasonality of precipitation and available moisture pathways, including tropical moisture export dynamics influent into a region vary significantly, a regionally specific approach to update PMP estimates is needed. In this environment of significant investment in our dam infrastructure, dam owners and regulators need guidance on whether designs should incorporate changed estimates in PMP.

Project Description: This proposal would a) complement the ongoing work through an investigation of the historical data on extreme precipitation events to assess trends over the last century, to identify regions where specific mechanisms such as hurricane dynamics and their change need further study, and to refine our understanding of the mechanisms that lead to regional PMP events; b) review the literature to identify how Intergovernmental Panel on Climate Change (IPCC) and re-analysis model projections indicate regional changes to PMP in the context of the dominant types of regional events that are identified; and c) develop regionally specific recommendations as to the need to update PMP and PMF estimates along with narrative discussions and quantification of the sources and magnitude of uncertainty in the projections.

Project Task: Five main tasks are anticipated: 1) Literature review to identify the main mechanisms for PMP (and extreme precipitation over different durations) change under climate change addressing the regional precipitation dynamics and their projected change. 2) Data analysis to identify extreme precipitation and flow events and to develop regional envelope curves for these events. 3) Repeat the data analysis with retrospective and future projections from the IPCC CMIP6 and other climate model simulations. 4) Synthesize a set of recommendations for the need and methods for updating PMP and PMF. 5) Develop a data base and a software that makes it accessible that allows users to access the historical data and future projections.

Product/Outcome: Defensible Guidance for practical strategies for updating these extreme event design criteria based on climate changes that have already occurred and for a future updating schedule based on the potential projections. Climate science may also improve to reduce the uncertainty of the projection for each scenario. The tools developed by the project would be designed to leverage these changes by automatically updating the associated data sets and hence providing a platform on which users can rely for the next few decades to update their analyses.

Research Category: Applied Research Project, Best Practice Document, Software, Database

Project Benefits: Quantitative guidance for Dam Safety relative to climate change.

Measure of Success: Adoption of the guidance and tools. Peer Reviewed articles.

Project Schedule/Phases: Total duration - 36 months

Title: Developing a modern collaborative research network for the design and analysis of hydraulic structures

Need: Much of the federal hydraulic design guidance for hydraulic structures, including spillways, is based upon project-specific model studies and generalized design guidance from decades past. Today, there is a pressing need for collaboration between key players for new studies and to updated guidance. Recent project-specific physical and numerical modeling efforts has generated innovative designs and data resources, but a focused, collaborative effort is required to produce modern hydraulic design guidance that meets federal needs and promotes effective design of hydraulic structures by the U.S. water resources industry.

Project Description: This proposal requests funding to form a consortium spanning multiple U.S. laboratories and subject-matter experts. This project would be a collaborative, coordinated effort to prioritize critical design gaps, define testing scopes and objectives, design and construct specialized modeling facilities for testing and data collection, and produce high quality, peer-reviewed design guidance. Results would be shared with the dam safety community via publications; development of decision support tools, computational models, comprehensive standardized databases; and training workshops and webinars.

Project Tasks:

- Phase 1 – Set up a Hydraulic Modeling Consortium for Hydraulic Structures aimed at identifying the gaps in research relative to design, performance, analysis, and risk assessment of structures.
- Phase 2 – Implementation of a systematic research program to develop updated design guidance relating to areas identified in Phase 1, with iterative review to adapt to evolving needs.

Product/Outcome: Provide new hydraulic structure design guidance and development of training sessions.

Research Category: Applied Research Project, Best Practices Document, Educational Project, Database

Project Benefits: Improve and modernize hydraulic design guidance of spillways and approaches for model verification; increased efficiency in completing research through collaborative efforts.

Measure of Success: Published Consortium’s annual report, formulation and completion of systematic model studies, publishing scientifically sound and peer-reviewed findings and results, adoption of generalized design guidance into federal design guidance documents, number of trainings completed and number of participants engaged in the trainings, number of students actively involved in related research projects, and feedback from the dam safety community.

Project Schedule/Phases: 3 Years, 1 year for each phase

Title: Guidelines for Hazard Potential Classification

Need: There is a need to create consistent guidelines to conduct hazard potential classification studies. FEMA 333 dated 2004 provides definitions for hazard potential classification. ACER 11 was published in 1988 and the BOR stopped supporting it in 1998. As an example if we take a few dams in different states and conduct hazard potential classification studies based on their specific state criteria we will get inconsistent potential hazard classification results.

Project Description: This proposal requests funding to prepare technical guidance to establish consistent federal guidelines on how to conduct hazard potential classification studies to create consistency in how the states report hazard potential classification in the NID. This consistency will impact the number of dams eligible for HHPD funding and will assist states consistently assess and assign hazard potential classification across their regulated inventory. The project includes performing a technical review of existing state and federal guidance and other resources to develop guidelines and potentially update FEMA 333.

Project Tasks:

- Collect and review of all states/federal hazard potential classification guidelines, interview dam safety office staff to determine how they apply guidelines across their regulated inventory.
- Identify existing guidelines that could potentially be the foundation of the national guidelines.
- Develop a draft guidance that establishes an advisory group comprised of 5 states and select federal agencies and informs guidances that will be pilot tested in 5 states. Revise the guidance and formally review it. Peer review, finalize, and publish the document.

Product/Outcome: Development of guidance that can stand alone or part of the update of FEMA 333. The outcome will be consistent identification of hazard potential classification of dams across the US.

Research Category: Best Practice Document

Project Benefits: Provides consistent and correct identification of a hazard potential of a dam to states for reporting to the NID. Promotes consistent guidance to state dam safety offices across the country in conducting hazard potential classification studies. Provides states consistent identification of hazard potential classification that established the appropriate level of design standard for the dam.

Measure of Success: A completed best practice document that is adopted and used by the dam safety community.

Project Schedule: This project should be completed within 24 month period.

Title: Guidance on non-standard peak rate factors/Unit Hydrographs and Research whether these factors would be influenced by climate change

Need: The unit hydrograph is a technique for modeling the transformation of excess precipitation to runoff at the watershed scale. When the watershed is ungaged, the unit hydrograph relationship cannot be derived directly; therefore, many synthetic unit hydrograph methods have been developed to help with ungaged watersheds. After addressing the state of the practice and where they are currently applied – a subsequent phase of the project could address the role of climate change.

Project Description: This proposal requests funding to hire a contractor to prepare a hydrologic study to establish consistent federal guidelines on how to apply these non-standard factors and synthetic methods. The project includes performing a technical review of existing publications and other resources modeling hydrographs. The project would occur in 3 phases. The first phase would include the literature review, methodology review and development and a pilot application. The second phase would expand to include other coastal and non-coastal regions that are similarly flat in topography. The third phase would look for recent climatic trends and if appropriate investigate whether these methods remain applicable under a climate change regime.

Project Tasks: Perform a literature search of available resources. Research and develop draft best practice document that includes the following: an assessment of available state and federal approaches to using non-standard methods and synthetic hydrographs, appropriate testing methods for alternative hydrographs, discuss the physiographic regions where applicable, and provide calibration and verification of areas where the non-standard peaking factors would apply. Peer review, finalize, and publish each phase that includes recommendations, focuses on expanded regions, and climate change implications.

Product/Outcome: A best practice document for this aspect of hydrology that encourages the use of proven and researched hydrologic methods.

Research Category: Best Practice Document

Project Benefits: The project will provides consistency of approach and a federal basis for states to adopt the approach. Promote cost effective hydrologic designs. Fill a void in current Federal and State guidance on the topic.

Measure of Success: A completed best practice document that is adopted and used by the dam safety community.

Project Schedule: This first phase project should be completed within an 18 month period. Phase 2 would take 2 years and phase 3 would add one year for a total performance period of 4.5 years.

Title: Guidance on Unlined Spillway Erosion Estimation

Need: The spillway erosion/scour project is intended to provide dam owners, the spillway design and risk assessment community, case studies of unlined (soil and rock) spillway erosion/scour and further guidance on the estimation of erosion potential and erosion rates for design and risk assessments.

Project Description: As the potential for more extreme hydrologic events increases, the potential for erosion and scour of unlined (soil and rock) spillways will also increase, particularly those unlined spillways that have never operated or experienced an erosion-inducing event. The research would obtain as many spillway erosion case studies as possible from industry and focus on the initiation, continuation, and progression of the erosion/scour process with the intent of plotting the variability of erosion rates with geologic material and hydraulic mechanism. The potential erosion rates would allow dam owners to better understand the potential for erosion and rate of erosion at their sites, particularly for those spillways that have never operated.

Project Task:

- Phase 1: Submit an industry call (national and international) for spillway erosion case studies to populate a database to create an Unlined SpillWay Erosion guidance document that is peer-reviewed and will be published.
- Phase 2: Hydraulic modeling to further the understanding of erosion/scour mechanisms, update the Unlined Spillway Erosion guidance document, peer review, and publish it.

Product/Outcome: The product outcomes would be a report that documents includes: Spillway case study data, estimated erosion rate, hydraulic mechanism, graphical and tabular erosion rates based on geologic material (soil and rock), comparison to existing erosion methodologies, identification of future needs for Phase 2.

Research Category: Database, applied research project, educational project

Project Benefits: The research would provide dam owners with new understanding of the potential for erosion/scour at their sites. Application would be for erosion extent estimation for design and risk assessments. The research would especially benefit those dam owners where the spillway has never operated.

Measure of Success: A completed Unlined Spillway Erosion Estimation guidance document that is adopted and used by the dam safety community.

Project Schedule: Phase 1 – Completed within 18 months, Phase 2 – Completed within 18 months

Title: Improvements for a National Web-based Dam-break Flood Inundation Mapping and Consequences Analysis Decision Support System

Need: Improving the highly used National Web-based Decision Support System for Water Infrastructural Security (DSS-WISE Lite), which is an integrated flood modeling environment that combines a two-dimensional numerical model with GIS-based decision support tools for consequence analysis. Some of these improvements have been identified and recommended by users through a survey that was done ~3 years ago based on an older version of the web-based system. In light of the newly released DSS-WISE 3.0 and new developments of additional capabilities of the web-based system, a new poll/survey is warranted to compile users' interests in future improvements to this web-based system and develop/integrate these improvements accordingly.

Project Description: Since the DSS-WISE™ Lite service became available on the NCCHE server on November 8, 2016, it has handled more than 57,400 simulations from over 1,730 active users in over 70 federal, state and local-level groups across the United States. In light of the newly released DSS-WISE 3.0 and new developments based on a survey that was done 3 years ago, a new poll/survey is warranted to compile users' interests in future improvements to this web-based system and develop/integrate these improvements accordingly. Also, the development of some of the pending improvements that were identified and recommended by DSS-WISE users as part of the older survey can take place through this new funding opportunity, and listed below are the time-phased tasks for these developments.

Project Task(s):

- Phase 1: A new survey to compile users' interests in future improvements for the Web-based DSS-WISE Lite.
- Phase 2: Address already identified users' recommended improvements by adding a damage assessment tool, adding hydrographs from watershed and land surface models, integrating machine learning algorithms, and more.
- Phase 3: Address newly identified users' recommended improvements from the new survey of Phase 1.

Product/Outcome: Survey results and analysis that will be used to identify and rank the priorities of the users' suggested improvements for Phase 3. Integration of already identified improvements/capabilities. Development of a technical proposal to address the highly prioritized improvements recommended and further integration of these new capabilities into the web-based DSS-WISE Lite system.

Research Category: Software, Applied Research.

Project Benefits: Supporting NDSP's efforts to continue providing dam safety research. Enhancing the highly used web-based DSS-WISE Lite capabilities and usage by addressing users' requested needs and recommendations. Expanding the potential applications and users pool. Better facilitation of emergency management.

Measure of Success: Identification of actionable items from users' survey results. Completed integration of users' identified modeling capabilities and improvements into web-based DSS-WISE Lite. Increased usage, applications and users' pool.

Project Schedule: Phase 1- short-term, 6 months-1 year; Phase 2 - mid-term, 1-3 years; Phase 3 - long-term, 3-5 years

Title: Land Use Change Information for Dam Safety Decision Making (H4b)

Need: Land use in the vicinity of a dam will be dynamic over time. Changes in land use can significantly alter both inflows and consequences for consideration in dam operation and/or dam failure analysis. Changes in land use can also lead to restrictions on the operation of a dam to protect people and property from more frequent events at the expense of poor performance for extreme events. A process is needed for addressing both land use changes that have occurred since construction of an existing dam and project changes over some future period.

Project Description: Develop a recommended policy for identifying actual and projected land use changes and using that information in dam safety assessments and planned risk reduction actions.

Project Task:

- Perform a literature search to identify current land use planning concepts and principles.
- Summarize the key practices/principles that would be applicable to assessing land use impacts for dam safety.
- Conduct a workshop with Federal and State representation to brainstorm potential policy recommendations that could be broadly implemented.
- Provide recommended policy for addressing current and planned land use changes in dam safety assessments and risk reduction actions.
- Recommend software enhancements that would facilitate implementation of the recommended policy.

Product/Outcome: A documented policy recommendation for addressing land use changes in dam safety assessments and risk reduction actions.

Research Category: Policy

Project Benefits:

- Would provide a consistent method for addressing land use changes in dam safety decision making.
- Enhances the current limited approach of looking at land use changes through the lens of hazard classification.

Measure of Success: A completed policy document proposed to NDSRB addressing land use changes.

Project Schedule/Phases:

- Phase I – 180 days – Completion of draft report addressing tasks 1 and 2
- Phase II – Additional 90 days – Workshop to explore potential policy recommendations
- Phase III - Additional 90 days – Review and finalize policy recommendation(s)

Title: Modernization of SITES and WinDAM Computational Models for Prediction of Earthen Spillway and Embankment Dam Erosion and Breach

Need: Modernization of the USDA Sites and WinDAM models base code (upgrade from 32bit to 64bit), graphical user interface (GUI), and supporting user guides are critically needed. Further, upgrading the models to a USDA cloud-based environment that has and approved federal authority to operate (ATO) is critically needed to support today's users while maintaining compliance with current federal cybersecurity guidelines. The SITES computational model for predicting earthen spillway erosion and breach was developed. The last release of this software was in 2005. Field observations during the development of SITES revealed cases where earthen dams had experienced overtopping or internal erosion events. Thus, USDA-ARS initiated embankment overtopping and internal erosion physical modeling research that led to the development of WinDAM, a software to predict embankment dam erosion processes and breach due to overtopping or internal erosion. The computational routines in these software packages have been routinely maintained and updated, but no major revisions have been completed since their original development.

Project Description: This proposal requests funding through an interagency agreement between USDA-ARS and FEMA to modernize and transform the SITES and WinDAM software packages to a cloud-based environment to meet today's user needs while maintaining compliance with federal cybersecurity and 508 policies and regulations All user manuals will be upgraded to reflect the new SITES and WinDAM versions.

Project Tasks:

- Transform the SITES and WinDAM software to a modern programming language that is optimally structured for cloud computing.
- Develop user-friendly GUIs for SITES and WinDAM that are 508 compliant.
- Update all user guides.
- Host SITES and WinDAM in a USDA cloud environment that has an approved ATO.

Product/Outcome: Modernized versions of SITES and WinDAM with updated user guides.

Research Category: Software

Project Benefits: Increase the functionality and user friendliness of the SITES and WinDAM software packages. Addressing stakeholder needs, who include federal agencies, state dam safety offices, and industry. Increased adoption of the software packages will assist in new earthen dam design, analysis of aging dams, and the prioritization of dams for rehabilitation.

Measure of Success: Monitoring user statistics in the cloud-environment, user testimonials, and customer surveys and feedback.

Project Schedule/Phases: 3 years

Title: Quantification of Embankment Breach Parameters

Need: Prolonged overtopping during extreme flood events erodes earthen embankments and leads to breaching and catastrophic flooding. Accurate prediction of breaching is crucial to the evolution of risk assessment, confidence in design, and the development of effective emergency plans. Many commonly used models for assessing an embankment breach do not yet depict an accurate assessment of the mechanistic processes occurring before, during, and after a breach, which is a major shortcoming in engineering analyses and subsequent risk assessment.

Project Description: Many empirical equations have been inherited from dam failure analysis, based on data from a few actual prototype dam failures and limited physical modeling, however parameters used to define numerical methods are not well defined. Given the lack of actual data to support breach models and even the lack of uncertainty within the models, the engineering community does not have a model with the refinement to accurately predict the occurrence of a breach, to evaluate the severity of such a breach, or one with a breach repair option that provides a realistic number of hours for repair.

Project Task: The research and development proposed under this partnership will eliminate knowledge gaps in understanding the overtopping and breaching of earthen embankments. Specifically, project products (models and supportive information) will be developed by means of prototype and near-prototype flume tests involving embankment models constructed at multiple geometries, compositions and hydraulic loadings. Research will provide data and insight necessary to evaluate the following points regarding overtopping of embankments: rates of erosion; Effects of velocity, flow conditions, and overtopping duration on the mechanisms of failure; Roles and extents of geotechnical mechanisms in breach modeling; applicability of excess-shear-stress equations to the erosion of coarse-grained materials; Additional resiliencies gained by well-maintained vegetation.

Product/Outcome: The main deliverable will be a web-based program based on the results from both laboratory and field tests. Developing state-of-the-art design and providing the ability for risk assessment founded in quantifiable results of the research program. To facilitate application of project results, design and monitoring tools will be created to improve embankment dam and levee design and failure prediction.

Research Category: Applied research project.

Project Benefits: Dissemination of project results and products will serve to improve embankment sustainability by giving engineers, specifiers and practitioners the ability to adequately design and assess risk of embankment failure, thereby significantly reducing the loss of life and catastrophic damage to critical infrastructure.

Measure of Success: Effective project management, ITR team, number of project meetings, and project deliverables.

Project Schedule/Phases: Total duration - 3+ years

Title: Update to FEMA P-946

Need: The first edition of the Federal Guidelines for Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures (FEMA P-946) was published in July 2013. The guidelines document the history of inundation mapping, causes of dam failures, dam breach analysis study approaches, hydrologic analyses, downstream routing analysis, the estimation of breach parameters, and analysis tools for dam failure modeling. The guidelines are frequently used by state and federal dam safety regulators to establish acceptable study approaches and mapping standards. The guidelines are also frequently referenced by hydrologic and hydraulic engineers during the completion of dam break inundation studies.

The standard of practice for dam break inundation studies has advanced significantly since 2013. Specifically, due to the availability of high-quality digital terrain data, faster computing time and the accessibility of 2D hydraulic models, 2D hydraulic modeling for dam break inundation studies has become more commonplace. With the transition to risk-informed decision-making, probabilistic dam breach analysis is another emerging trend. Physically-based breach parameter estimation software has also advanced. Regulators need these topics and other emerging topics to be discussed within FEMA P-946 to allow for these advances to be easily embraced within their programs.

Project Description: This proposal requests funding to hire a contractor to prepare the second edition of the Federal Guidelines for Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures (FEMA P-946). The project includes performing a literature review of guidelines from federal and state regulators and interviewing industry experts. It is expected that the document will include new discussion on 2D modeling, using dam breach analysis in risk informed decision making and estimating dam breach parameters with physically-base methods. The document will promote consistency across the industry.

Project Task: Conduct a literature review and data collection. Develop a draft second edition of FEMA P-946. Perform a peer review of the document. Finalize and publish the document.

Product/Outcome: Second edition of FEMA P-946

Research Category: Best Practice Document

Project Benefits: Provides needed guidance for regulators. Promotes consistency in dam breach analysis nationally. Promotes the use of best available information and technology for the industry.

Measure of Success: An updated document that is adopted by the dam safety community.

Project Schedule/Phases:

Task 1: 9 months, Task 2: 9 months, Task 3: 3 months

Track 2: Geotechnical and Structural

Title: Dam Lifecycle Development

Need: The anticipated lifecycle of dam is currently poorly understood. Research is required to better understand the anticipated lifespan of a dam in order to help facilitate appropriate decisions related to it planning, design, construction, operation, maintenance, potential upgrade, and decommissioning.

Project Description: The dam community simply doesn't know the true lifecycle of a dam. Regardless of the actual design service life of a dam, their owners are now beginning to spend considerable funds in maintaining these structures as problems begin to arise. If a better understanding of a dams design life and lifecycle were known it would allow owners, regulators, planners, designers and contractors make more efficient decisions about the future of individual structures. This project will develop the framework for using an asset management approach to begin the development of the lifecycle of a wide range of dams. We anticipate the ultimate development of a strategy to understand, assess, and implement guidance on all phases of a dams lifecycle. This will include planning, design and construction, operation and maintenance and decommission phases.

Project Task:

- Data Gathering and Documentation
- Data Gathering to build dam asset inventory
- Develop dam lifecycle key factors for different structures and their purpose.
- Publish key dam lifecycle key factors.

Product/Outcome: Framework for dam owners to help assess and understand the lifecycle of individual dams and where dams currently exist within their lifecycle. Asset in the decision making process related to operation, maintenance and decommissioning. Models to demonstrate present value of maintenance, rehabilitation, and modification on the service life of individual structures.

Research Category: Applied Research Project, Educational Project

Project Benefits: Development of lifecycle graphical projections for dam assets. Framework for evaluating cost/benefit decision making related to dam assets as viewed through the lens of lifecycles. Education of stakeholders that advance their understanding of making appropriate decisions related to maximizing the service life of their structures, but also educating these same entities that the end of a dams service life will, at some point, be reached.

Measure of Success: Establishment of planning tools for dam asset retirement. Development of guidelines demonstrating dam asset lifecycle curves and trends. Development of guidelines demonstrating appropriate dam safety measures intended to safely extend dam service life.

Project Schedule/Phases: 5 years

Title: Development of an approach to identify and characterize seismic failure modes of dams

Need: Earthquakes pose a unique threat to the stability and safety of dams as there have been numerous instances of significant damage. Generally, the assessment of failure modes is carried out by subjective assessment of subject matter experts. With respect to the identification of seismic failure modes, the results of detailed evaluation of dams suggest the identification of potential failure modes depends on the details of a dam's design and construction and the specifics of the seismic response of a dam, which can vary significantly depending on factors such as earthquake magnitude, level of ground motion, time and frequency domain details of input motions, etc. Experience from detailed studies of dams suggests that subjective, non-quantitative identification of seismic failure modes can fall short of the potential vulnerability of a dam. There is a need to develop a process to guide dam engineers in the identification and evaluation of seismic failure modes.

Project Description: The purpose of this project is to support an effort to develop guidance for the identification and evaluation of seismic failure modes of dams. This project will be focused on embankment dams. This proposal requests funding to conduct a comprehensive study to identify, understand, and evaluate seismic failure modes of embankment dams. The study will involve a systematic review of available literature, data from existing studies, and the performance of case studies for selected projects. The review of existing studies and the new case studies will involve seismic response analyses and the identification of potential failure modes. The information generated from these sources will provide a basis to develop a framework and guidance for evaluating the seismic performance of embankment dams and the identification and characterization of potential failure modes.

Project Task: Tasks to be carried out in this project will include: a literature review, new case studies, forming a panel of seismic evaluation experts, conduct potential failure mode evaluation, develop a framework and guidance for identifying and characterizing seismic failure modes of embankment dams.

Product/Outcome: The final outcome of this project will be a comprehensive technical report that summarizes the findings of the study, including the different types of seismic failure modes of dams, their causes and mechanisms. Report that provides a framework and guidance for evaluating seismic failure modes of embankment dams.

Research Category: Applied Research Project, Best Practice Document

Project Benefits: Improved understanding of seismic failure modes. Enhanced seismic safety of dams. Increased resilience of communities. Advancement of seismic engineering knowledge.

Measure of Success: The successful completion of a comprehensive literature review on seismic failures of dams. Development of guidelines for conducting potential failure mode evaluation of embankment dams.

Project Schedule/Phases: The estimated period of performance of this project is 24 months.

Title: HHPD Screening Level Risk Assessments

Need: Establish risk prioritization of poor/unsatisfactory condition dams.

Project Description: There are currently estimated to be between 1500 and 2000 high hazard dams which are eligible for the High Hazard Potential Dam (HHPD) grant and are rated as poor or unsatisfactory. As grant funding is not available to upgrade or remove all of these dams, it is important that the dams within each state can be prioritized based on its risk. Many states struggle with determining appropriate risk prioritization for their inventories. This project will perform screening level risk prioritization for these poor and unsatisfactory dams and provide training to the states in how to perform their own screening level risk assessments. A method of screening has previously been developed for FEMA and has been piloted. It is anticipated that this screening process will be used to perform these risk assessments.

Project Task: Perform risk prioritization of approximately 500 dams eligible for the HHPD grant which are rated as poor or unsatisfactory. This list will be determined in conjunction with the state dam safety programs. Develop training and guidance for states to use in development of future risk assessments. Determine ways that FEMA can assist the state programs with outreach to high priority dam owners.

Product/Outcome: The product of this project will be a database of the risk prioritization of dams eligible for the HHPD grant which are currently in poor or unsatisfactory condition. These identified dams will be prioritized within each state and provided to the state dam safety programs. Additionally, training will be made available to state dam safety programs to assist in continuing to develop prioritization with the state. Finally, state dam safety programs will be able to work with FEMA to determine best methods of outreach to HHPD owners.

Research Category: Applied Research Project, Educational Project.

Project Benefits: The primary benefits of this project will be assisting state dam safety programs in prioritizing dams within their inventory and providing outreach to dam owners.

Measure of Success: The success of the project will be measured based on completion of screening level risk assessments for approximately 500 dams. Additionally success will be measured by number of state dam safety programs trained in the risk assessment process and outreach methods.

Project Schedule/Phases:

- Phase 1: Duration: 1 year
- Phase 2: Duration: 6-9 months
- Phase 3: Duration: 6-9 months

Title: FEMA NDSP Guidance Documents Update

Need: Many FEMA NDSP Guidance Documents have not been reviewed to determine if the material in them is still current best practice.

Project Description: This project will review existing FEMA NDSP guidance documents and identify which ones need to be updated. Upon completion of this review, documents which are determined to not be up to date will be updated with current best practices. Additionally, an appropriate review cycle will be determined for each document to continue to be reviewed in the future to determine if the documents continue to represent current best practices.

Project Task: Review existing FEMA NDSP guidance documents for compliance with current best practices. Update guidance documents which have been identified in Phase 1 as outdated to current best practices. Determine an appropriate review cycle for each document so that all documents are kept in line with current best practices.

Product/Outcome: The product of this project will be updated FEMA NDSP guidance documents. Additionally, a schedule of future document reviews will be developed to guide FEMA in future review cycles. These documents could then be made widely available through FEMA and its partners.

Research Category: Best Practice Document

Project Benefits: This project will update FEMA NDSP guidance documents for use by the dam safety community. This will help ensure that current best practices are presented to the dam safety community.

Measure of Success: The project will be successful if all FEMA NDSP documents are reviewed and updated as necessary. Additionally, developing a schedule for future reviews will help lead to the documents continuing to represent current best practices.

Project Schedule/Phases:

- Phase 1: Review existing FEMA NDSP guidance documents for compliance with current best practices. Determine an appropriate review cycle for each document so that all documents are kept in line with current best practices. Duration: 6 months.
- Phase 2: Update guidance documents which have been identified in Phase 1 as outdated to current best practices. Duration TBD.

Title: Geotechnical Characterization of Embankment Dams

Need: There is no standard of practice for the geotechnical characterization of embankment dams and foundations. Federal and State regulators provide suggested methods which leads to confusion in implementation between Owners and Engineers. The lack of geotechnical data for projects leads to construction and dam safety risks.

Project Description: This project will develop an educational manual/best practices manual to:

- Explain geotechnical characterization techniques.
- Provide guidance for the scale of the investigation based on geology, dam type, and size.
- Provide guidance for the type of investigation based on the analysis needed.
- Alert the user to limitations and errors associated with testing techniques.

Project Task:

- Literature Review of textbooks, ASTM standards, Federal, State Dam Safety Guidance Documents to consolidate information.
- Identify a group of industry experts and conduct a brainstorming session to develop the content of the best practices manual.
- Develop and Peer review Best Practices Manual.
- Develop and Educational training seminar for young engineers, dam owners, and regulators.

Product/Outcome: A best practices document for the geotechnical characterization of new and existing embankment dams that includes: Qualifications for geotechnical engineers and drillers; Drilling techniques and abandonment procedures; Testing and sampling procedure with error and limitations; Installation and abandonment of instrumentation; Recommendations for the type and size of investigations based on dam type, analyses; Seminars on geotechnical characterization for junior engineers and dam regulators.

Research Category: Best Practice Document, Educational Project

Project Benefits: Consolidation of investigation techniques from Federal, State, and Dam State Agencies into one document. Development of a Best Practices Document for the Site Characterization of Embankment Dams. Education of new engineers and dam safety regulators.

Measure of Success: FEMA Manual on Site Characterization of Embankment Dams. Regional Training Workshops using updated training materials (USSD/ASDSO National Conference; ASDSO Regional Conferences).

Project Schedule: 24 months

Title: Integrating System-Level Thinking into Dam Engineering and Management

Need: There is a need to better understand impacts to other facilities connected to a network due to changes at a dam within the network and integrate new knowledge into facility management.

Project Description: This project seeks to compile best practices currently implemented by other federal agencies and distribute guidance to dam owners and operators to increase the scope of emergency action planning and response. Current practice sees dam facilities as a silo, whereas they are intertwined as part of a larger network. One facility could be impacted by changes in operations, maintenance, and emergency action planning at another. This project would establish a framework for prioritizing systems as well as communication between dam owners within each system. Project implementation would see dams as part of a network, and lead to better emergency management and planning for all dams within each network.

Project Task:

- Phase 1: Identify current best practices for systems integration. Identify and prioritize “systems.” Establish a framework for communication and collaboration on emergency management (i.e., best practices document). Communication framework and systems-based approach outreach).
- Phase 2: Evaluate effectiveness of systems framework. Continue to assess gaps in understanding.

Product/Outcome: The primary outcome will be a document that incorporates (1) a prioritization framework for “systems” nationwide; (2) best practices for dam owners on communicating with other operators in their “system”; and (3) guidance on collaborating on emergency management and other system level impacts.

Research Category: Applied Research, Best Practice Document, Educational Project

Project Benefits: Improved emergency preparedness. Will allow for collaboration on impacts due to upstream incidents/failures/releases, emergency action planning/response, and other impacts (e.g., environmental, recreational)

Measure of Success:

- Improved emergency action plans.
- Increase in alert times for the public in case of failure/release.
- Publication of best practices document for systems evaluation for dam management.
- Education of dam owners on potential impacts in relation to other facilities.

Project Schedule/Phases: Total duration - 3 years with ongoing upkeep

Title: Internal erosion processes for the prediction of dam embankment performance

Need: Better understanding (education) of the initiation and progression of internal erosion of embankments

Project Description: Internal erosion is documented in multiple recent publications from USSD, FEMA, USBR, FERC, and the COE. This information needs to be consolidated into a reference for Engineers, Owners, and Regulators. This also includes updating dam failure databases to include internal erosion failures for Federal, State, Municipal, and Private dams to understand the importance of internal erosion in the evaluation of dams. Development of an education program will increase the overall understanding of the importance of internal erosion considerations in the design, and assessment, and mitigation for embankment dams.

Project Task:

- Updating Dam Failure Database to include Federal, State, Municipal, Privately Owned dams for Internal Erosion failures.
- Literature Review of Existing Sources (FEMA, USSD, USBR, COE, FERC).
- Update FEMA P-1032 to include failure modes and best practices from sources (FEMA, USSD, USBR, COE, FERC). Needs to better define exit gradient calculation procedures and how the seepage modeling influences the results.
- Develop Multi-tiered Education Program for geotechnical/dam engineers and dam owners/regulators.

Product/Outcome:

- Updated dam failure database that encompasses internal erosion failures from Federal, State, Municipal, and Privately Owned Dams.
- Updated FEMA P-1032 to include failure modes and best practices from sources (FEMA, USSD, USBR, COE, FERC).
- Training Materials to better educate engineers, owners, and regulators. Training materials should be multi-tiered to provide detailed education by the user.

Research Category: Best Practice Document, Educational Project, Database

Project Benefits: Database will quantify internal erosion risks at embankment dams. Enhanced internal erosion knowledge base will help in the design, assessment, and mitigation planning for dams. Updated FEMA P-1032 Manual. Better educated engineers, owners, and regulators.

Measure of Success: A database categorizing internal erosion failures by region (geology?). Updated FEMA P-1032 Manual. Regional Training Workshops using updated training materials (ASDSO Regional Conferences, State Emergency Management Agencies).

Project Schedule/Phases: This project can be completed within 18-24 months.

Title: Leverage Dam Performance to Support Dam Safety

Need: A fundamental need in managing critical infrastructure is the development and maintenance of an information system that monitors the performance of these systems. However, these systems do not currently exist in the dam safety arena. In dam safety there is a broad based need to gather, archive and evaluate information on the performance of dams and the consequences of their unsatisfactory performance to support an evidence-based approach to policy, communication, and engineering management of dams.

Project Description: We envision a two part project. The first part establishes a foundation for a dam safety information system, building on existing resources, that creates a baseline of dam performance, consequence and modification/repair data for the dam safety profession. The second part of the project takes a long-term view of the information needs in dam safety and develops an infrastructure, database system, communication products, and other critical features, that supports a broad range of dam safety needs. These needs include the advancement of engineering methods unique to dam engineering, dam safety practices and standards, public policy, and communication in the U.S.

Project Task: Part 1: Establish a Foundation for Dam Performance Information System by identifying available data sources, establish an architecture and framework for a database, migrate data, publish the database online, create an annual report, and publish the report. Part 2: Long-term development for the dam performance information system will include the development of a dam safety implementation strategy, build on existing systems, create tools for increased dam safety communication, and figure out long-term viability of a dam safety information system will require ongoing support.

Product/Outcome: There are a number of products that will be generated by this project: Online, publicly accessible dam safety information system (database and library); Annual database and library growth; Annual dam safety summary on the performance of dams and the consequences of unsatisfactory performance in the U.S.; Results of focused topic-specific data evaluations.

Research Category: Database, technical and educational resource.

Project Benefits: The data collected will: help with engineering advancement, help better inform dam safety professionals, be used to advance our knowledge of dam lifecycles, grow the educational foundation for future decisions regarding dam safety, and provide vital information to help guide policy recommendations.

Measure of Success: Level of participation of the profession involved in contributing information to this system. Completeness in reporting of dam failures and incidents. Number of database users. Number of engineering topical areas that are supported.

Project Schedule/Phases: Total duration will last 2 years with an annual program maintenance for a 5 year period.

Title: Static Liquefaction: Develop short-term “screening” guidance for dam/levee owners and regulators, and identification of research needs

Need: Recent dam failures attributed to “Static Liquefaction”, a failure mode that has not been historically considered in water dam PFMA.

Project Description: Three dam failures since 2019 are attributed to static liquefaction. The presence of videos documenting the initiation led to the characterization of the initiation as static liquefaction rather than a more traditional slope instability failure or overtopping failure. Current PFMA Best Practices for water dams have not considered static liquefaction failure modes. This project will include a workgroup of industry experts, academicians, and federal experts to help better define the project needs, developing interim guidance for screening existing dams for susceptibility, a roadmap for research needs, identify research needs, and developing a best practice document for water dam owners and dam safety professionals. The research will take advantage of pertinent studies performed for tailings dams and develop comparative parameters for use in water dams. The research will include evaluating the use of existing empirical relationships for post liquefaction residual strength based on common field investigation method, and the results of post-seismic stability analyses, to evaluate the potential for static liquefaction. The Edenville case history will be analyzed using different post liquefaction residual strength relationships to identify whether the existing seismic evaluation framework would have captured the potential for this static liquefaction case history.

Project Task:

- Evaluate the current state of practice regarding static liquefaction in tailing dam industry.
- Utilization of post liquefaction residual strength relationships and analysis.
- Methods of field investigation and laboratory testing for static liquefaction evaluation.
- Best practices publication.

Product/Outcome: Static liquefaction related PFMs for water dams informed by the tailing dam experience and seismic liquefaction procedures (or best practices) publication.

Research Category: Best Practice or Procedure Document

Project Benefits: Better develop understanding of the mechanisms, and identification of conditions that lead to a failure initiated due to static liquefaction and communicate a consistent evaluation methodology for the dams/levee/mining industry. Dam safety community will have a best practices document.

Measure of Success: Interim guidance for screening while additional research is completed. Static liquefaction failure mode procedures document for consistent implementation by the dam/levee safety community.

Schedule/Phases: Total duration - 1.5 year

Title: Validation, verification, calibration, and uncertainty quantification for numerical models for embankment and concrete structures

Need: Current engineering design and analysis practice and risk-informed decision rely on numerical analysis methods to simulate of dam performance. However, the validity and reliability of these models is often uncertain. There is a general need to validate numerical modeling methods and practices and to quantify the uncertainties of these models to ensure their reliability and increase the confidence in their use.

Project Description: This proposal requests funding to conduct studies directed toward enhancing the accuracy and reliability of numerical models for embankment and concrete dams. The project aims to quantify the uncertainties of these models through a comprehensive technical review and analysis. The project will compare and evaluate the case history results of those of numerical models. These evaluations will provide a basis for quantifying uncertainties associated with numerical modeling practices. Different sources of uncertainties will be discussed in numerical simulation and effective actions will be proposed to mitigate and reduce them. The outcome of this project will be a comprehensive technical guide that provides guidance and best practices for numerical analysis of dams and estimates of uncertainty in numerical models for embankment and concrete structures.

Project Task: Conduct a thorough literature review of the current state of the art in numerical modeling for embankment and concrete structures. Develop case study numerical models for embankment and concrete structures. Collect the detailed information about the material properties, environmental loading, and instrumented response of dams. Validate and verify the numerical models. Provide recommendations on how to effectively calibrate the numerical models. Quantify the uncertainties in numerical modeling.

Product/Outcome: A comprehensive report summarizing the findings of the research in the form of best practice document is expected. A summary of previous USSD and ICOLD benchmarks with specific recommendations for the practitioners is expected. A set of validated and verified numerical models including the results that can be used with confidence in dam analysis. Quantification of model uncertainty. A framework for performing validation, verification, calibration, and uncertainty qualification for embankment and concrete structures, which can serve as a guide for future research in this area.

Research Category: Applied Research Project, Best Practice Document

Project Benefits: Improved accuracy and reliability of numerical models. Better understanding of structural behavior. Better design and analysis of dams. Improved safety and performance of dams.

Measure of Success: The quality of the final report can be measured by the comprehensiveness and clarity of the information presented. User Adoption.

Project Schedule/Phases: Each phase will take 24 months long each for total of 4 years.

Track 3: Safety and Security

Title: Cyber Dependencies Affecting Dam Safety and Operations

Need: There is a clear need to identify and evaluate the role played by information technologies and operation technologies on dam safety and operations. Cyber threats continue to grow and represent one of the most serious operational risks facing modern organizations. Numerous cyber intrusions across different types of infrastructures, both domestic and overseas, demonstrate the urgent need for assessing digital dependencies and eventually promoting and sustaining enhanced cybersecurity awareness. This is particularly essential for those situations where the control of physical processes and operations relies on digital information and communication systems.

Project Description: The effort will initially focus on developing identification templates to assist owners in evaluating their cyber dependencies. The effort will research and leverage current best practices and any applicable Federal guidance to develop a consistent and standard approach to cyber asset identification. As a second phase, the effort will develop a minimum set of data fields to efficiently identify critical components, potential vulnerabilities, and overall impacts on safety and operations. In particular, this approach will address, as a minimum, those systems supporting monitoring and operations in real-time.

Project Task:

- Phase 1: Develop Cyber Identification Template, Pilot Cyber Identification Template, Select minimum set of data fields recommended for inclusion in the National Inventory of Dams, Recommend approaches for long-term data collection.
- Phase 2: Develop a Cyber Dependency Assessment Template/Tool. Pilot Cyber Dependency Assessment Template/Tool. Develop process to assess collected data and recommend (simple) approach to characterize cyber dependencies and cyber maturity (e.g., low/medium/high) based on information and data fields identified in previous phase.
- Phase 3: Develop outreach campaign to promote available cybersecurity services and products (i.e., resources, tools, and training). Augment Cyber Dependency Assessment Template/Tool with recommendations and linkages to best practices tailored to the level of maturity.

Product/Outcome: Cyber Identification Template. Data Collection Recommendations. Cyber Dependency Assessment Template/Tool. Education, Training, and Outreach Resources.

Research Category: Database, Best Practice, Education

Project Benefits: Ability to assess the cyber landscape. Consistent and streamlined approach to assess and address cyber dependencies relevant to dam safety and operations.

Measure of Success: A simple approach to quantify the cyber landscape and mitigate potential risks associated with cyber dependencies that is adopted and used by the dam safety community.

Project Schedule: This project should be completed within a 36-month period.

Title: Dam Safety PR Campaign

Need: The general public needs to be educated on the Nation's dams to gain understanding and awareness of safety.

Citizens should:

- Be aware of their surroundings.
- Have a plan in place if an evacuation becomes necessary.
- Receive for public education on dam removal/decommissioning.
- Understand risks of recreating at low-head dams.

Project Description:

This proposal requests funding for a 5-year strategy to develop and implement a plan for increasing public understanding of dams and public safety at dams. The contractor should be supported by a nationally recognized public relations firm.

Project Task: In meeting the objective of this effort, the following tasks will be completed:

- Task 1. The contractor will work with FEMA to write a request for proposal (RFP) and identify potential public relations companies. The contractor will coordinate the RFP and proposal review and award procedures.
- Task 2. The contractor will identify subject matter experts to work with the consultant on development of the 5-Year Strategy.
- Task 3. Implementation of strategy. Plan may include printed materials, presentations, tv/radio placements, PSAs, social media, and other channels.

Product/Outcome: Creation of a public outreach plan. Implementation of a plan that could include products, such as videos, handouts, imaging, etc.

Research Category: Educational Project

Project Benefits: Increase public understanding of dams /public safety at dams. Prepare citizens for emergency evacuation. Public will better understand potential benefits of dam removal. Save lives at low-head dams – both recreators & first responders.

Measure of Success: Completed plan. Successful release of content. Number of people who saw PSA/Ad/ post ect. Surveys.

Project Schedule/Phases: Phase 1 – 18 months, Phase 2 – 3.5 years

Title: Develop guidance to help States, project sponsors and Dam owners develop Hazard Mitigation Plans and Floodplain Management Plans that reflect dam risk in a community

Need: The most pressing need is that FEMA's High Hazard Potential Rehabilitation Grant Program (HHPD) has a specific requirement in the legislation for a Floodplain Management Plan (FPMP) "to reduce the impact of future flood events in the area protected by the project". Guidance is needed to help State Dam Safety Programs, dam owners and project sponsors meet this requirement.

Project Description: Ideally, dam hazards should be identified every state and community Hazard Mitigation Plan (HMP) and all communities would have a Floodplain Management Plan that would recognize the role that dams have in the overall flood risk and potential risk mitigation activities. This project would research existing HMPs and FPMPs and identify any existing guidance that incorporate dam hazards. The deliverables would be guidance to develop these plans which would be scalable based on the extent of the impact of the dam in the community(ies) and examples of existing plans.

Project Task:

- Review existing materials (manuals, guidance, white papers, etc.) for developing HMPs and FPMs.
- Develop guidance and sample documents.
- Develop training materials to help.

Product/Outcome: Guidance including sample documents and training materials.

Research Category: Best practice document

Project Benefits: Help states and project sponsors meet the requirements of the HHPD program. Provide communities information to best assess the flood risk in communities.

Measure of Success: Initially, success would be seen in the abilities of HHPD sponsors to develop the plans that satisfy the HHPD grant requirements. The project would also be useful to Silver Jacket teams, watershed coalitions, individual communities, etc.

Project Schedule/Phases:

- Research
- Development
- Training

Title: Enhancement and maintenance of the ASDSO Dam Safety Toolbox

Need: There is a need for a single-location resource for guidance related to small to medium sized embankment dams. ASDSO has developed the Dam Safety Toolbox, a wiki-style website, as a solution however there is no long-term plan / funding source for maintenance & expansion.

Project Description: Enhancement and maintenance of the ASDSO Dam Safety Toolbox.

Project Task:

Beta Phase

- Task 1: Recruiting and training Subject Matter Experts & website moderations. (ASDSO Dam Design and Construction Committee – “DDAC”).
- Task 2: Resolve any technical/ user experience issues identified during beta phase.

First Year Support

- Task 3: Development of new topic pages from scope development to content development and developing state specific pages.
- Task 4: Administrative tasks including: User Management (Single Sign-on); Back-end Database Management (ASDSOs website development contractor); Database updates by Web Developer
- Task 5: Content Management (DDCC) including reviewing editorial suggestions, updating best practice documents, adding newly developed training, facilitating adherence to style guides, and explore and advice on funding options.

Long Term Support

- Repeat tasks 4 and 5 yearly

Product/Outcome: Long-term maintenance / expansion for a website that will provide a single-location resource for guidance.

Research Category: Webpage / Database

Project Benefits: Advance the industry toward the use of standard practices. Create a resource to educate and support regulators. Create an authoritative reference. Create a resource for expert consultants who are submitting designs to regulators who may not have experience with the issue being addressed. Aid dam owners in identifying qualified engineers. Aid in information sharing between state regulatory programs.

Measure of Success: Creation of new content by contracted & crowd-sourced contributors. Website visits, time spend per visit, additional website analytics. User feedback.

Project Schedule/Phases: Total Duration - 1.5 years with yearly updates

Title: FEMA National Dam Safety Program Guidance Document Library – Update Existing Guidelines and Add New Guidelines

Need: The FEMA library of technical guidelines needs to be updated. In addition, existing gaps need to be identified and new guidance documents developed based on those gaps. The specific need for new guidance includes:

- A practitioner’s guide to Risk-Informed Decision-Making (RIDM)
- A facilitators guide to Potential Failure Mode Analysis (PFMA)

Project Description: One of the objectives of the National Dam Safety Program (NDSP) is to support the training and education of dam safety engineers, dam owners and operators, emergency managers and responders, policy makers, and others who have a role to play in reducing the risks associated with dams. Since the NDSP was started, several important guidelines have been created; however, many of these documents have never been updated or are outdated. In addition, as new issues and technical topics have emerged over time, there is a need to create new guidelines.

The first objective of this project is to review all existing guidelines, , create a schedule for updating documents, and recommend a plan for peer review. A second objective is to identify topical gaps and to develop new guidance documents to fill the gaps. Initial focus for new guidelines should include:

- A Practitioner’s guide to RIDM—with examples from multiple organizations on how to use RIDM to assess risk, in addition to resources to help stand up a RIDM program.
- A Facilitators guide to PFMA—with examples of how to prepare a PFMA, catalog of example potential failure modes (PFMs), tips on how to assess if they are likely or not, and basics on qualitative ranking.

Project Task: Establish a team of experts to review existing library and create a gaps analysis. Establish a system for peer reviewing each new guideline. Develop new guidelines based on the gaps. Coordinate with FEMA POC to get each updated or new document approved and finalized. (e.g. 508 compliant, FEMA number, posted with FEMA online library, marketing/communications distro list).

Product/Outcome: All FEMA NDSP guidance documents reviewed and updated, as needed. Gaps analysis report. New guidance documents created based on identified gaps.

Research Category: Best Practice, Educational Project

Project Benefits: A comprehensive library of current National guidance documents for practitioners on all relevant dam engineering and awareness topics.

Measure of Success: Updated existing guidelines. Completed new guidelines.

Project Schedule: Total Duration - 1-4 years

Title: First Responder Dam Hazard Training Program

Need: First responder education of hazards at dams and how to safely conduct river rescue or recovery at dams. There have been a significant number of first responder fatalities performing rescues and body recoveries at dams, especially low head dams, because they were not aware of the hazards or properly educated and trained on how to perform rescues and recoveries under such conditions (ASDSO 2019, Tschantz 2014). The rate of fatalities is 8-times more for accidents compared to dam failures. This trend is increasing with the growth of population living or recreating near dams and the rise in extreme water sports. First responders represent about 1/3rd of those fatalities (Kern and Hotchkiss 2015).

Project Description: This project will address the increasing dam safety risks to First Responder in conducting rescue or recovery operations by developing best practice guidance, education and training resources, and enhance risk and hazard awareness notification services for First Responders. Initial use case will focus on low head dams, additional use cases may be considered such as unregulated or orphan dams that have not been adequately maintained. Risks and hazards to be covered include water flows, intakes, human activities, or other structural and environmental factors. Note: This project has a dependency on the accuracy and availability of foundational data on dams and can be a catalyst in support of national dam safety data needs and priorities.

Project Task: Research the current state of practice including education and training resources supporting the First responder community. Update existing or develop new best practice documentation, education and training resources, or risk and hazard notification services for the First Responder community. Develop a national approach for coordinating, delivering, and sustaining these resources to the National Dam Safety Program.

Product/Outcome: Key deliverables would include: Literature review and report of findings on current state of practice; Best Practice Documentation; Education and Training Resources; First Responder Dam Safety Risk and Hazard notification services; National Coordination and Sustainment Plan.

Research Category: Best Practice Document, Education and Training Resources, Other – Risk and hazard notification services; National coordination and sustainment plan.

Project Benefits: Reduction in first responder injuries and fatalities, improved response and recovery operations for dam related accidents.

Measure of Success: Noticeable trend in reduction in first responder injuries and fatalities over 5-year period upon rollout of materials. Number of First Responder organizations adopting best practices and completing new education and training.

Project Schedule: 36 months for total work effort.

Title: Low-head dam inventory

Need: There is no national low-head dam inventory. These structures, though not designed for water storage, can create dangerous currents downstream that have resulted in many more fatalities than from dam failures and incidents over the last several decades. Low-head dams are generally not part of formal state inventories, are not subject to inspection or attention, and therefore are nonjurisdictional.

Project Description: A National Task Force has been compiling an inventory of low-head dams showing only latitude and longitude using volunteers from ASDSO, ASCE, USSD, American Rivers and American Whitewater and a limited number of engineering students. Supplemented by the efforts of the Southeast Aquatic Resources Partnership (SARP), the Task Force work is about 50% complete on what we would describe as an alpha version. This alpha version will be complete in Fall 2023 but will not contain several thousand more low-head dams that we know exist but have not had the volunteer workforce to identify. The purpose of this project is to complete the second iteration (beta/draft final) of a national inventory. Proceeding from an alpha version to a beta/draft final version requires more time and effort than is represented by the Task Force volunteers; recruiting professionals to check and extend our work has not been successful after several attempts. Our beta/draft final version will greatly speed the U.S. Army Core of Engineers work, or if funding is not appropriated, serve the nation well within six months of funding this project.

Project Task: Expand the alpha version of the national inventory on low-head dams including quality control checking of work performed to date.

Product/Outcome: A national inventory of low-head dams that show latitude and longitude that has been peer-reviewed and is all inclusive to the knowledge of the National Task Force. The product will be viewed as a map and simple database and made publicly available.

Research Category: Database and Educational Project

Project Benefits: The completed inventory by the national task force and the performing contractor of this project will document the number and location of low-head dams in the U.S. that will inspire further work to ultimately reduce the number of drownings at these structures. Getting this completed quickly will enable additional work to be performed by interested agencies and institutions and will greatly improve communication with the public about these structures.

Measure of Success: Publication of the map and database within 6 months of project inception.

Project Schedule: Total Duration 6 months.

Title: Proximity alarm for the recreating public approaching a low head dam

Need: Technology innovation to improve public awareness of dam safety risks and hazards.

The rate of fatalities is 8-times more for accidents compared to dam failures. This trend is increasing with the growth of population living or recreating near dams and the rise in extreme water sports. (Kern and Hotchkiss 2015). The general public lacks awareness of these risks and hazard and capabilities that would automatically notify them that they are approaching and/or in proximity of a high hazard area.

Project Description: This project will address the increasing dam safety risks to the general public by develop new innovative solutions for automated public notification of dam safety risks and hazards. Initial use case will focus on low head dams, additional use cases may be considered such as unregulated or orphan dams that have not been adequately maintained. Similar capabilities exist and have been deployed by local authorities in relation to boat ramps, these types of innovative solutions have not been developed or deployed to support the dam safety community. Note: This project has a dependency on the accuracy and availability of foundational data on dams and can be a catalyst in support of national dam safety data needs and priorities.

Project Task: Conduct a landscape analysis and technology scouting. Develop an open technology architecture and prototype capability, field deploy and test the capability, develop technology transition and sustainment plan.

Product/Outcome: Key deliverables would include

- Technology scouting analysis report
- Open architecture documentation
- Prototype capability
- Field experimentation and validation report
- Technology transition and sustainment plan

Research Category: Applied research, Software – Technology Innovation, Other – open architecture documentation.

Project Benefits: Reduction in public safety accidents and or injuries/fatalities, enhanced public awareness of dam safety related risks, hazards and accidents.

Measure of Success: Noticeable trend in reduction of public safety accidents and/or injuries and fatalities over 5-year period as technology is deployed and adopted. Number of responses, downloads/installs and social and geographically diverse areas.

Project Schedule: 36 months for total work effort.

Title: Public safety incidents database

Need: There is no official database of public safety and worker safety incidents at dams for the United States. This information is needed to help identify trends and focus efforts where they are needed most.

Project Description: This project involves creating a national database of incidents at dams that include all persons interacting at a damsite include maintenance workers, contractors, operators, the recreating public and trespassers. The database will include accidents as well as fatalities. Common incidents currently include drowning at low head dams, being trapped in a “strainer”, going over spillways, falling from walls and other heights, divers becoming trapped, confined-space entrapment and toxic atmosphere, etc. The database will need to be maintained by adding new incidents as they occur, doing QA/QC, and publishing meaningful information to the dam safety community. Access permissions, who will be responsible for maintaining the database, and how it will be funded also need to be established.

Project Task:

- Inventory existing databases:
 - Tony Bennett’s (Ontario Power) private database (probably best of its kind in the world, ASDSO media tracking database (See ASDSO website), BYU low head dam incidents database, OSHA?, FERC?
- Determine database format, content and features.
- Determine how data will be obtained:
 - Media searches and alerts, new industry reporting systems (FERC regulated), reporting system for federally owned dams, reporting system for State regulated dams
- Determine where database will be housed.
- Establish a regular publishing of meaningful information.

Product/Outcome: A database to make information available to researchers and dam safety professionals to help track trends and measure the effectiveness of existing practices and policies and the need for new practices and policies.

Research Category: Database

Project Benefits: Reduce the number of accidents and fatalities at dams. Identify and monitor trends. Evaluate the effectiveness of current practices and identify where changes are needed.

Measure of Success: Accurate meaningful data is being collected that is used by the dam safety community to improve public safety around their dams.

Project Schedule/Phases: Total duration: 12 months and ongoing upkeep.

Title: Screening tool for determining occurrence of submerged hydraulic jumps at low-head dams.

Need: Screening tool for determining probability and frequency of occurrence of submerged hydraulic jumps at low-head dams.

Project Description: The national inventory of low-head dams will educate the public about the location of these structures. An obvious question is what to do next. The “killer” current at low-head dams is created when the water level downstream submerges the hydraulic jump (whitewater) at the base of the dam. This does not occur at all low-head dams. Decisionmakers need tools to help prioritize actions, whether they include low-head dam removal, rehabilitation, or public safety actions.

Project Task:

To create and test a screening tool that will determine the occurrence of submerged hydraulic jumps at low-head dams, including how often such conditions might persist.

- Task 1: Develop the screening tool to predict the occurrence and persistence of submerged hydraulic jumps at low-head dams.
- Task 2: Test the screening tool using the database of fatalities at low-head dams to refine the tool.
- Task 3: Produce the visual tool and accompanying report and documentation.

Product/Outcome: A map-based product that shows for which low-head dams a submerged hydraulic jump can occur and a statement of its probable frequency and persistence.

Research Category: Applied research, software, database.

Project Benefits: This screening tool will help decisionmakers prioritize actions related to public safety at low-head dams. Since submerged hydraulic jumps do not occur at all low-head dams, knowing which structures present the greatest danger will allow efficient allocation of resources to address public safety.

Measure of Success: Actions take to reduce dangers at low-head dams where submerged hydraulic jumps are most prevalent.

Project Schedule/Phases: Task 1: months 1-12, Task 2: months 6-15, Task 3: months 15-18

Title: State-led Dam Removal Funding Programs – Best Practices

Need: There is a regular need for funds for dam removal or rehabilitation. State-led grant or loan programs can meet this need and solve dam safety problems through removal or rehabilitation of dams. In addition, match requirements for Federal grants to remove dams can be outside the capacity of a dam owner. State-led grants can provide these funds and open up the federal grants to allow for removing bigger or more expensive projects. More than 2,000 dams have been removed around the country and dam removal has become a common approach to remedy dam safety issues with uneconomical dams.

Project Description: Determine best practices to develop and manage state-led dam removal funding programs and provide information on federal funding for dam removal or rehabilitation. Compile a resource library on existing state-led dam removal funding programs. This can include funds for rehabilitation, and the funds can be in the form of grants or loans. Determine the best practices and policies from these programs and use this to develop recommendations for states looking to set up their own funding program. Identify current federal funding opportunities that can be applied to dam removal or rehabilitation and highlight those whose grant funding match requirement can be met by state funding.

Project Task:

Part I: Identify current state-led funding programs for dam removal. These may also include rehabilitation but must include removal. Put this information into a publicly accessible resource library.

Part II: Utilize information from Phase I to develop best practices and program recommendations for states to use to start their own funding programs. Include information on dam removal funds available from federal grants and how the state grants can be paired with federal or private grants to fund larger projects. These best practices will be shared out in a whitepaper as well as a recorded webinar that will be publicly available and published on the resource page or in the resource library for this overall project.

Product/Outcome: Resource library on existing programs, white paper on how to set up a state-led dam removal/rehabilitation grant/loan program, webinar for interested parties.

Research Category: Database (resource library), white paper, recorded webinar

Project Benefits: Improve dam safety by increasing availability of funds for dam removal and rehabilitation, with a focus on dam removal, especially opening up funding that may not be currently accessible to dam owners.

Measure of Success: Multiple states set up a new state-led dam removal/rehabilitation funding program. Current programs utilize the report to optimize their existing programs and enact best practices. Federal dam removal funding is moved to more projects in the timeline outline.

Project Schedule/Phases: Part I - 6 months, Part II - 12 months