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USSD, as the United States member of the International Commission on Large Dams, is dedicated to:

ADVOCATE: Champion the role of dam and levee systems in society
EDUCATE: Be the premier source for technical information about dam and levee systems
COLLABORATE: Build networks and relationships to strengthen the community of practice
CULTIVATE: Nurture the growth of the community of practice.

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On the Cover: Thornton Reservoir is part of the $3.6-billion TARP Project in Chicago. It will be a featured stop on the 2019 USSD Annual Conference Field Tour on Thursday, April 11.

www.ussdams.org
President’s Message

As we begin to approach year end and the holiday season, I know you are all very busy with both work and family so I’ve kept this message brief in hopes that you will spend more time reading through some of the other articles included in this issue.

As many of you know, USSD has made a concerted effort in recent years to support young professionals by providing them with opportunities to showcase their professional work and encouraging them to take on leadership positions within USSD. Our Young Professionals have been particularly busy this year, and this issue of the Bulletin highlights some of their contributions:

- Outstanding Young Professional Paper, 2018 Conference
- Outstanding Poster Paper, 2018 Conference (the author is a YP)
- Research summaries from three 2018 scholarship recipients
- A compilation of short pieces from YPs describing personal and professional experiences (don’t miss the poem!)
- Sage advice from seasoned professionals
- An article summarizing recent and ongoing YP activities.

One way YPs contribute to USSD and the profession is by joining a USSD technical committee. This opportunity is for everyone — I encourage you to read the article on the benefits of becoming active in one or more of our technical committees (page 14).

I would also encourage you to have a look at Sharon’s piece regarding our 90th birthday on page 43. If you are not aware, USSD was formed 90 years ago as one of six original member countries to ICOLD. ICOLD now comprises 100 National Committees (countries) and continues to provide a forum for the exchange of information and experience that serves to enhance the state of practice and provide tremendous value to the community of practice. Visit the ICOLD website (www.icold-cigb.net) for more information.

I recently returned to Arizona from my trip to Quebec City where I attended the Canadian Dams Association (CDA) annual meeting. As most of you know, CDA is the Canadian National Committee to ICOLD and we have partnered with CDA on several initiatives in the last few years. I was glad to see several of our members in attendance including our Secretary-Treasurer Stuart Harris, Board Member Del Shannon and Board Advisor Paul Meeks. The conference was well attended by nearly 470 people, which is very close to if not the highest attendance they have experienced. As we are seeing here at home, the dam industry in Canada is very active and there is much interest among members in sharing their latest work and exchanging ideas for continued advancement of the state of practice.

You should have already received information on next year’s ICOLD Annual Meeting which is being organized by CDA and will take place June 8-14, 2019 in Ottawa. This offers a unique opportunity for USSD members to participate in an ICOLD Annual Meeting right next door. In addition to the ICOLD Annual Meeting, please also look for more information soon on the next Dam Safety in the Americas International workshop event in Paraguay during the fall of 2019. This meeting will be hosted by the ICOLD National Committees of the Americas (INCA), which includes USSD.

Thank you for your continued support of USSD. I look forward to continuing to work with all of you to strengthen the community of practice and enhance our collective commitment to dam safety.

Dean B. Durkee
President, USSD
An outstanding technical program, a new interactive exhibit hall, and a fun array of networking events await attendees of the 39th USSD Annual Conference and Exhibition. Plan to join your colleagues in Chicago, April 8-11, at the historic downtown Chicago Hilton. The Federal Energy Regulatory Commission is the local Host.

The 2019 USSD Conference theme is Second City, Second Chances: Stories of Rehabilitation, Modification, and Revitalization. Dams and levees continue to provide essential public benefits including flood control, water supply, renewable energy, recreation, navigation, and habitat and environmental enhancement. The need to maintain and improve our aging infrastructure has been well publicized, making it important to also share the great success stories of restoration and upgrades for dams and levees.

**Technical Program**

The technical program has been developed by the Conference Planning Committee, chaired by Rachael Bisnett, Stantec. More than 130 presentations were selected from abstracts submitted in response to the call for papers. Concurrent sessions will feature research and experience relating to the conference theme, or corresponding to topics addressed by USSD Technical Committees.

The conference will open Monday morning with the second in a series of Legacy Workshops, organized by the USSD Foundations Committee. The workshop will feature a technical presentation by Donald A. Bruce, President of Geosystems, L.P., along with a facilitated interview, and question and answer session.

Plenary Sessions will open the technical program on Tuesday and Wednesday mornings, and will include invited presentations addressing contemporary issues related to dams and levees. FERC Commissioner Cheryl LaFleur will speak during the Wednesday Plenary Session.

**Committee Meetings**

Committee meetings are scheduled for Monday and Tuesday afternoons, allowing the opportunity for any conference attendee to participate. Committee meeting schedules will be posted on the conference website.

**Field Tours**

Half-day tours will be offered on Thursday morning and afternoon for an additional fee. Each tour will visit Thornton and McCook Reservoirs, features of the Tunnel and Reservoir Plan (TARP) project. See page 6 for more information on the project.

**New to the 2019 Conference**

Several changes and additions are in the works for the 2019 Conference. A new mobile event app will allow participants to contact other attendees, upload their conference schedule, participate in the USSD Gamification to earn points and win prizes, and post to social media. Attendees will also have the ability to complete feedback surveys on sessions attended. The exhibit hall will be a hub of activity with all general luncheons held in the hall to maximize networking opportunities. Beacons placed throughout the hall will alert users of important information and announcements. Exhibitors can also compete to win ‘Best in Show’ or ‘Most Creative Booth.’ The USSD Pavilion in the exhibit hall will be the place to meet colleagues, charge your devices, congratulate award winners, and take a break before the next session.

Sponsors that also exhibit will be able to display large ‘sponsor’ ribbons on their booths that show that they support USSD and the dam and levee industry.

**Thursday Workshops**

In addition to the Opening Session workshop on Monday morning, five workshops, organized by USSD Technical Committees, will be held on Thursday.
Introducing ICOLD Bulletin 177 on RCC
The USSD Committee on Concrete Dams is organizing a workshop to introduce a new ICOLD Bulletin on Roller-Compacted Concrete, finalized in 2018. During the workshop, primary authors of the Bulletin chapters will give presentations on design and construction of RCC dams. Thursday morning.

Threshold and Action Levels
When used effectively, threshold and action levels can help dam owners and engineers identify instrument readings outside the expected range and trigger action when needed. To help workshop participants understand the various uses of threshold and action levels, this workshop will include presentations, case studies and panel discussion from four federal agencies, dam owners and consulting engineers. Thursday morning.

Flood Consequence Estimation with HEC-LifeSim
Risk is estimated through the combination of the probability of an event, the performance of the structure, and the consequences of failure. Quantifying consequences can be done in varying levels of detail and there are several tools available to perform these estimates, including the USACE model, HEC-LifeSim, which provides a detailed look at flood impacts and evacuation. All day Thursday.

Seismic Evaluation of Concrete Dams
Seismic analyses of concrete dams are becoming more dependent on advanced modeling techniques as the needs of the industry advance. The relative scarcity of data related to the performance of dams subjected to extreme seismic events limits verification of analytical tools and analysis results. Recognizing this constraint, solicitation of opinions among researchers and practitioners about the current state-of-practice in seismic analysis of concrete dams is warranted. It is essential to verify the consistency of the analysis results for the considered potential failure modes. Thursday afternoon.

Emergency Communication Primer
Through presentations, discussions, and a group activity, this workshop aims to refine communication skills which may ordinarily be taken for granted but become crucial in emergencies, when judgment can be hampered by stress and urgency. Participants will learn and exercise the best practices for communication of critical, precise information under emergency conditions to ensure public safety. This workshop offers an opportunity to practice what we all hope never to do. Thursday afternoon.

Hotel Reservations
The conference hotel is the beautiful Hilton Chicago, 720 South Michigan Avenue, in the heart of the city. Committee meetings, technical sessions, the exhibition, and most networking events will take place in the Hilton. The USSD conference rate is $229, plus tax. A limited number of rooms are available at the prevailing government rate. Online: https://book.passkey.com/go/USSD19. Phone: 877-865-5320, group USD.

The cutoff date is March 15, or until the room block fills, whichever is earlier.

Alternate Hotel
A limited number of rooms has been reserved at the nearby Congress Plaza Hotel, 520 South Michigan Avenue. The room rate is $120. Online: https://bit.ly/2LnStL6. Phone: 800-635-1666.

5K FUNds Run/Walk
USSD will host its fifth annual 5K FUNds Run during the Annual Conference and Exhibition in Chicago. Nearly 100 people participated in the 2018 event in Miami last April. Thanks to our sponsors and runners, we were able to raise close to $10,000 for the scholarship program! Help USSD cultivate our next generation of dam and levee professionals by participating in the 2019 5K FUNds Run. Walk, jog, dance or run across the finish line with colleagues, family and friends, or be a cheerleader on the sidelines; together we can make a difference. Let’s see which company and which USSD technical committee has the most participants!

Individual registration cost is $40 and all proceeds go to the USSD Scholarship Fund. Can’t make it to Chicago? Sign up to be a virtual runner.

Walk/Run Logistics. Wednesday, April 10, 2019. Race start time: 6:30 am. The event will begin and end at the Chicago Hilton; the course will travel through Grant Park, just across the street from the Hilton.

Partners in Education. For a minimum contribution of $350, your logo/name will be included as an event sponsor on the FUNds Run poster, to be displayed on the conference website, the mobile app and at the conference. You’ll also receive a free registration for one runner.
The $3.6-billion Tunnel and Reservoir Plan (TARP) project in Chicago is a mega-project — one of the largest civil engineering projects ever undertaken in terms of scope, cost and timeframe. TARP was conceived to reduce pollution and flooding in the metropolitan Chicago area, and to reduce the harmful effects of flushing raw sewage and other contaminated water into Lake Michigan by diverting storm water and sewage (combined sewer overflow, CSO) into temporary holding reservoirs until it can be pumped to existing plants for treatment. Commissioned in the mid-1970s, the project is managed by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC).

Completion of the system is not anticipated until 2029, although substantial portions of the system have already been opened and are currently operational. The overall system includes 210 kilometers of conveyance tunnels, constructed 55 to 90 meters below ground surface and varying in size from 2.7 to 10.9 meters in diameter; 252 drop shafts; four underground pumping plants; and 3 surface reservoirs. The reservoirs are being developed in a joint effort of the MWRDGC and the U.S. Army Corps of Engineers. The 2019 USSD Conference field tour will visit the Thornton Composite Reservoir (TCR) and McCook Reservoir.

The TCR is located in the former north lobe of the Thornton Quarry and is estimated to provide $40 million per year in flood damage reduction benefits to 556,000 people in 56 communities. This 7.9 billion gallon capacity CSO reservoir serves the Calumet System south of Chicago and has been in operation since November 2015. A 2,700-foot-long and 300-foot-high Rock Dam separates the north lobe from the active portion of the quarry and supports Interstate I-80/294, a key highway within the Tri-State region. In the center of the Rock Dam is a 109-foot-high roller compacted concrete gravity dam, called the Gap Dam. The RCC Gap Dam spans a former haul route through the Rock Dam to complete the full height water barrier between TCR and the active main lobe of the quarry. A double-row grout curtain was constructed around the perimeter of the TCR to prevent exfiltration of reservoir waters into the surrounding areas.

McCook Reservoir is being developed in two phases to serve the Mainstream and Des Plaines Systems, approximately 252 square miles of Chicagoland surface area. Phase I was completed at the end of 2017 and Phase II is under construction with mining underway to form the reservoir. The total capacity of the reservoir will be 10 billion gallons and will bring an estimated $90 million per year in flood damage reduction benefits to 3.1 million people in 37 communities.
Reclamation's International Affairs Program

The Bureau of Reclamation has had a significant impact on the landscape of the American West. However, it is not widely known that Reclamation has also left a sizeable imprint internationally and is known worldwide for its expertise in dam safety, dam construction, water resources management, desalination, and sedimentation. Reclamation has also played a pivotal role in helping others to establish governmental water agencies so that they could develop and better manage their water resources.

Reclamation provides reimbursable technical assistance, training, seminars/workshops, visitor programs, and technology exchange to foreign governments and international organizations through authority delegated by the U.S. Department of State.

Technical Assistance: Technical assistance programs typically entail the assignment of Reclamation experts overseas on a short-term basis. Each program is designed to address the specific needs of the requesting agency and all costs are fully reimbursable.

Technical Training and Visitors: Reclamation provides reimbursable technical training and technical visitors’ programs for foreign visitors. Training programs are tailored to fit each request and vary in length from two days to one-year, usually combining office assignments and field visits or study tours to Reclamation’s Denver, regional, and area offices.

Technical Cooperation and Technology Exchange: Reclamation periodically seeks to improve the technical capabilities of its personnel by participating in formal cooperative science and technology exchange programs with other countries, and more often through informal activities, such as attendance by Reclamation employees at various meetings, conferences and other forums. These activities are generally non-reimbursable.

Reclamation’s International Affairs Program, with staff in both Denver and Washington, D.C., serves as the point of contact for all international activities and serves as a liaison between foreign and international entities and Reclamation’s technical and subject matter experts. Throughout the years, Reclamation has worked in more than 70 countries, trained more than 6,000 professional staff from approximately 100 countries and welcomed more than 20,000 visitors from nearly every country in the world.

The 30th Safety Evaluation of Existing Dams International Technical Seminar and Study Tour will take place June 3-12, 2019.

For more information, visit www.usbr.gov/international/.

Apply Now for USSD 2019 Scholarships

USSD is now accepting applications for the 2019 Student Scholarship Program. USSD annually awards scholarships to students whose academic program and research studies have the potential to develop practical solutions to design and construction challenges related to dams and levees. USSD Members are encouraged to spread the word by contacting their alma mater or local universities.

Award Overview

Up to four finalists will be invited to present their research at the annual conference. In addition to covering conference registration and travel costs for the finalists, USSD will award up to a combined total of $20,000 at the 2019 conference, with a minimum individual award of $2,000 to each finalist. All finalists are invited to participate in the full conference, providing an opportunity to meet and interact with the industry experts in dams and levees.

The annual conference is April 8-11, 2019, in Chicago. Finalists will present their research to the Board of Directors and conference attendees during the technical sessions on Tuesday, April 9. The results will be announced during the conference on Wednesday, April 10.

Application

Applications are due by January 21, and must be submitted online at: http://www.ussdams.org/about/scholarships/. Applications must include the following:

- Personal, school, and work information (resume-type information)
- Research paper/proposal (6 pages maximum) describing a specific research topic and highlighting the innovative aspects of the proposed research work
- Two letters of recommendations (one from academic advisor)

Scholarships are open to junior or senior undergraduate students and graduate students pursuing a Masters or PhD. Applicants will be judged based on expectations commensurate with their current education level, in order to provide equal opportunities.
Dam Engineering

Licensing and Relicensing
Dam Safety
Hydropower
Hydraulics and Hydrology
FERC Part 12D Safety Inspections
Subsurface Explorations
Seismic Stability Analysis
Remedial Design
Agency Coordination
Local Connections, **Global Ideas**

Our clients face tough decisions with limited resources. That’s why we support leading water associations—like USSD—to help make great things possible for our industry.
America’s Water Infrastructure Act of 2018
Keith Ferguson, Chair, USSD Committee on Advocacy, Communication and Public Affairs

The Water Infrastructure Act, commonly referred to as the Water Resources Development Act of 2018, was signed by President Donald Trump on October 24. Among other things, the legislation reauthorizes the National Levee Safety and National Dam Safety Programs. The following is a summary of dam and levee related provisions. The full legislation can be seen here: https://bit.ly/2JAcIlj.

Title 1 — Water Resources Development

SEC 1101 Congress to consider a water resources development bill not less often than once every Congress.

SEC 1105 Non-federal Engagements and Review: Requires the issuing of guidance to implement each covered provision of the Act including Public notices, stakeholder engagement, reporting to the Congress and Senate on input and recommendations received from stakeholder engagement, and requirements for stakeholder input related to development of new guidance.

SEC 1119 Local Government Reservoir Permit Review: For a period of 10 years from enactment of the Act, the Secretary shall expedite review of applications for covered permits if the applicant is a local government with jurisdiction over an area for with any portion of the water resources available to the area served by the local governmental entity is polluted by chemicals used at a former defense site under jurisdiction of the DOD that is undergoing or schedule to undergo environmental restoration under chapter 160 of title 10, USC or if mitigation is ongoing. A covered permit means a permit to be issued by the Secretary to modify a reservoir owned or operated by the Secretary to which not less than 80 percent of water rights are held for drinking water supplies serving an area with a population less than 80,000.

SEC 1123 Levee Improvements: The Secretary of the Army is authorized, at the request of a local government to provide technical services on a reimbursable basis to assess the reasons a federally constructed levee owned or operated by the local government is not accredited by FEMA.

SEC 1126 Purpose and Need Statements: Not later than 90 days after the date of receipt of a complete application for a water storage project, the District Engineer shall develop and provide to the applicant a purpose and need statement that describes –
• Whether the District Engineer concurs with the assessment of the purpose of and need for the water storage projects, and
• If the District Engineer does not concur, an assessment by the District Engineer of the purpose of and need for the project.

No environmental impact statement or environmental assessment required under NEPA of 1969 shall substantially commence with respect to a water storage project until the date on which the District Engineer provides to the applicant a purpose and need statement as outlined above.

SEC 1132 Rehabilitation of Corps of Engineers Constructed Dams: Subsection e and f of Section 1177 of WRDA 2016 are modified to increase funding from $10,000,000 to $40,000,000.

SEC 1144 Levee Safety Initiative Reauthorization: Sections 9005(g)(2)(E)(i) and 9008 have been modified to extend from 2019 through 2023.

SEC 1146 Reservoir Sedimentation: the date of enactment has been changed to the Water Resources Development Act of 2018, eliminating the pilot program requirements and requiring a report to congress no later than 3 years after the date of enactment of the Water Resources Development Act of 2018.

SEC 1152 Study of Water Resources Development Projects by Non-Federal Interests – Requires expedited review of feasibility studies (no more than 180 days) and report to the Senate and Congress the results of the Secretary's review including feasibility determination, recommendation by the Secretary, or conditions the Secretary may require for construction of the project. Review may not be delayed as a result of consideration being given to changes in policy or priority.

SEC 1163 Dam Safety – Section 14 of the National Dam Safety Program Act (33 U.S.C. 467)) has been extended from 2019 through 2023.

SEC 1204 GAO Study on Benefit-Cost Analysis Reforms – benefit-cost procedures of the Secretary of the Army and Director of the Office of Management and Budget including:
Benefits and costs that are, or are not included in benefit-cost calculations including minimum, local and regional economic benefits.

SEC 1206 Identification of Non Powered Dams for Hydropower Development – Corps has not more than 18 months to develop a list of existing non-powered dams owned and operated by the Corps that have the greatest potential for hydropower development.

SEC 1217 Maintenance of High-Risk Flood Control Projects – each project classified as Class III under the Corps Dam Safety Action Classification systems for which the Secretary has assumed responsibility for maintenance shall be assessed to identify:
• The anticipated effects of the Secretary continuing to be responsible for project maintenance for 15 years after the date of enactment of this Act.
• Anticipated effects of the Secretary not continuing to be responsible for maintenance of the project during the same 15-year period
A report shall be submitted no more than 90 days after completion of the assessment and submitted to both the Congress and Senate.

**Title III — Energy**

**SEC 3001**  
Authorities for Necessary Hydropower Approvals – modifies Section 5 of the Federal Power Act (16 U.S.C. 798) to:

- increase preliminary permits to 4 years,
- allows extension of a preliminary permit once for not more than 4 additional years beyond the initial 4-year period, and
- allows the Commission to issue an additional permit to the permittee if it is determined that there are extraordinary circumstances that warrant the issuance of the additional permit.

The time limit for construction of project works has been amended to allow a construction extension from 2 additional years to not more than 8 additional years.

**SEC 3003**  
Promoting Hydropower Development at existing Nonpowered Dams – Requires the FERC (Commission) within 180 days of enactment of the Act to issue a rule establishing an expedited process for issuing and amending licenses for qualifying facilities.

- Establishes an interagency task force of appropriate Federal and State agencies and Indian Tribes to coordinate the regulatory processes associated with the authorizations.
- The task force shall develop procedures that to the extent practicable, will not result in any material change to the storage, release or flow operations of the associated nonpowered dam existing at the time an applicant files its license application.
- The expedited process will result in a final decision on an application for a license by not later than 2 years after receipt of a completed application for the license.
- Dam Safety – Before issuing any license for a qualifying facility, the FERC shall 1) assess the safety of existing non-Federal dams and other non-Federal structures related to the qualifying facility (including possible consequences associated with failure of such structures), 2) ensure that the Commission’s dam safety requirements apply to such qualifying facility and the associated qualifying nonpowered dam, over the term of such license, and 3) effectively and without conflict participate in cooperation related to the preparation of environmental documents under NEPA of 1969.

Not later than 12 months after the date of enactment of the ACT, the FERC, in cooperation with the Secretary of the Army, Secretary of the Interior, and the Secretary of Agriculture, shall jointly develop a list of existing nonpowered Federal dams that the Commission and the Secretaries agree have the greatest potential for non-Federal hydropower development.

**SEC 3004**  
Closed-Loop Pumped Storage Projects – The Act provides for a new rule within 180 days of enactment establishing an expedited process for issuing and amending licenses for closed-loop pumped storage projects. The expedited process shall be established by an interagency task force, with appropriate Federal and State agencies and Indian Tribes to coordinate the regulatory processes associated with the authorizations. The FERC shall seek to ensure that the expedited process will result in final decisions on an application for a license by not later than 2 years after receipt of a completed application for such a license. Other notable elements of this section:

- Dam Safety – Before issuing a license, the FERC shall assess the safety of existing dams and other structures related to the project (including possible consequences associated with failure of such structures).
- Exceptions may be issued under the expedited process provided the FERC consults with the USFWS, NMFS, and State agencies exercising administration of the fish and wildlife resources of the State in which the closed-loop pumped storage project is or will be located in a manner provided by the Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.)
- The FERC, to facilitate development of a closed-loop pumped storage project may 1) add entities as joint permittees following issuance of a preliminary permit, and 2) transfer a license in part to one or more nonmunicipal entities as co-licensees with a municipality, if the municipality retains majority ownership for which the license was issued.
- Interagency communications and cooperation shall effectively and without conflict participate in the preparation of environmental documents under NEPA of 1969.
- FERC shall establish criteria that a pumped storage project shall meet in order to qualify as a closed-loop project eligible for the expedited process. This criteria will include 1) cause little to no change to existing surface and ground water flows and uses, and 2) is unlikely to adversely affect species listed as a threatened species or endangered species under the Endangered Species Act of 1973.

**SEC 3005**  
Considerations for Relicensing Terms – The Act provides amendments to Part I of the Federal Power Act (16 U.S.C. 792 et seq.) by expanding considerations for relicensing terms:

- Project-related investments by the licensee under the new license, and
- Project-related investments by the licensee over the term of the existing license.

**Title IV — Other Matters**

**SEC 4314**  
Indian dam safety reauthorization – Section 3101 of the Water Infrastructure Improvements for the Nation Act (25 U.S.C. 3805) has been amended to extend it from fiscal year 2017 through 2030.
Grouting Conference to be Held in Austin

The 40th annual short course on Grouting Fundamentals & Current Practice will be hosted by The University of Texas at Austin’s Cockrell School of Engineering from March 4-8, 2019. The event will be attended by professionals worldwide to learn the latest and best in the field of grouting. Since 1979 this unique course on geotechnical grouting materials, methods and applications has educated over 2,000 grouters and filled a wide gap in traditional university education. Although theory and calculations are an integral part of competent grouting work, practical experience is essential to success in the very critical situations grouters are called to fix.

An incredible breadth and depth of subject matter will be covered by a renowned course faculty that included experts from seven countries, many of whom maintain active leadership and membership on the ASCE G-I Grouting Committee. The 2018 course included 70 delegates representing engineering design firms, specialty geotechnical contractors, hydropower facility owners, equipment manufacturers and material suppliers. As is common, the majority of delegates were from throughout the U.S. and Canada, with significant overseas attendance based on major upcoming geotechnical construction works. The recent course included such delegates from Australia, Albania, Bolivia, Uganda, and throughout Europe.

An integral part of this course is the half-day Field Demonstration that facilitates direct hands-on learning. The Field Demo included high shear mixing, QC testing of fluid grout, slab jacking, penetration of microfine cements, tube-a-manchette grouting, methods for nondestructive quantification of ground improvement, along with a broad spectrum of grout materials (cementitious, chemical, and cellular).

The 2019 course will again be hosted by UT Austin. The University of Texas host invites you to come join them for some good times in Austin and their wonderfully warm spring weather. For course details visit: https://executive.engr.utexas.edu/epd/grouting19.php.

U.S. Levee Safety Coalition Announces Webinar Series

The U.S. Levee Safety Coalition in cooperation with the U.S. Army Corps of Engineers and the Federal Emergency Management Agency is pleased to present a series of webinars on levee safety in the United States. Following the successful rollout of the International Levee Handbook, we are excited to announce our next series of bi-monthly webinars designed to share best practices, disseminate information and to facilitate a dialogue between federal partners and levee stakeholders, consultants, contractors and others in the levee safety industry.

The first webinar was U.S. Army Corps of Engineers, Levee Portfolio Report and was presented by Eric Halpin, Deputy Dam Safety Officer/Levee Safety Officer USACE, and Noah Vroman, Director, Levee Safety Center USACE. This webinar was presented on September 24, 2018 and October 9, 2018.

Managing risks associated with levees in the United States will require diligence and cooperation among all levels of government, the private sector and the public. As progress toward the establishment of a National Levee Safety Program continues, the U.S. Levee Safety Coalition webinars and the presentation of the USACE Levee Portfolio Report provide an opportunity to start this conversation. The webinars are brought to you by ASDSO on behalf of the Levee Coalition.

To register for these FREE live webinars please visit https://bit.ly/2PJjET3.

About the U.S. Levee Safety Coalition: The U.S. Levee Safety Coalition is a group of national professional organizations that have joined together to support and advance levee safety in the United States of America. Coalition members include the American Council of Engineering Companies (ACEC), the American Society of Civil Engineers (ASCE), the Association of State Dam Safety Officials (ASDSO), the Deep Foundations Institute (DFI), the National Association of Flood and Stormwater Management Agencies (NAFSMA), and the United States Society on Dams (USSD).
Modifying a dam to add reliable, renewable energy

The Red Rock Dam in Iowa was originally constructed in the 1960s for flood control and recreation. Now it is being upgraded to produce hydropower. Our design maximizes energy generation while safeguarding the integrity of the existing dam throughout construction.

Design with community in mind
stantec.com/water
An Open Letter on the Value of Technical Committee Membership and How to Get Involved

Dear Members and Colleagues,

It is well recognized by USSD leadership and many of our members that the strength of USSD lies in the strength of our committees. The technical committees provide direct benefits to our industry as advocates for the current state-of-the-practice through the publication of white papers and workshop presentations. As a committee member, you have the opportunity to share a professional network with many of the leaders and rising stars of our industry. Committee membership is open to all USSD members; however, growing the number of members that are actively involved in technical committees has been a persistent challenge.

USSD’s leadership has taken various steps to increase the percentage of USSD members that join a Technical Committee. Two recent steps are the efforts to increase the number of young professional members in USSD and to increase the visibility of the technical committees. For the April 2019 Conference in Chicago, we’re also going to modify the schedule slightly to make the committee meetings more accessible to all attendees. Everyone is invited, and we encourage you to attend — and to actively participate!

Organizational and Sustaining member companies can increase the value of their membership by designating young professional members and encouraging their designated members to become active in one of the technical committees. Committee visibility increased when formal Charters were developed and published on the USSD website. The charters serve as an electronic landing page for members to learn more about each committee and who to contact for more information.

Young Professional Initiatives

The Young Professionals (YP) Committee has been spearheading involvement of members age 35 and under across USSD since 2013 and has gained momentum in recent years. On first blush it may seem that this committee’s primary focus is on social events, but the broader intention of the committee is to increase YP involvement across all facets of the organization, including technical participation. Initially the YP Committee did this with conference technical agendas by 1) soliciting participation among YPs as contributors; 2) creating YP tracks within the technical sessions; 3) highlighting YPs in technical programs; and 4) aiming for at least one YP paper and YP moderator per technical session. As YP membership and conference participation has increased, the committee also sought ways to expand YP representation in organizational leadership. This led to the creation of both the YP Board Advisor role as well as YP Vice Chair positions for all committees. The YP Vice Chair positions, particularly for technical committees, serve as an entry point for motivated YPs to advance within their chosen specialty without having to wait out the departure of senior leaders. The success of these roles has been demonstrated by the nearly full panel of YP Vice Chairs and advancement of these chairs to more senior chair positions within their committees, not to mention the positive feedback many chairs have expressed regarding their YP cohorts.

And most recently, the YP Committee has begun teaming with technical committees to organize workshops for the annual conference. The first such workshop will be hosted in conjunction with the Committee on Public Safety and Security for Dams, and will cover Emergency Communication at USSD 2019 in Chicago.

Benefits of Membership in a Technical Committee

While these approaches have accomplished their goals in some respects, the percentage of USSD members that are actively involved in a technical committee hasn’t increased significantly. Perhaps it is because these approaches fall in the category of “leading a horse to water.” Our goal in this short piece is to “get the horse to drink.” Or, help answer the question, “What’s in it for me?” So why would you benefit from being a member of a technical committee?

1. Technical committee membership takes the burden out of networking. Unlike many networking events, we don’t have to learn any conversation starters. The topic for conversation has been established, and chances are it’s something that interests you.

2. Technical committee membership is automatic entry to a peer network that gives us the ability to understand what others are thinking and doing in our field. For all you owner’s representatives, it also offers the opportunity to help guide the conversation to address issues being faced by your organization.
3. Technical committee membership offers the opportunity to have insightful, energizing conversations with other people who understand our professional lives. This is where we find our professional peers. That common interest peer group spans all ages and stages in their career, and comes from all parts of the country and sometimes the world.

4. Technical committee meetings are opportunities for more open and candid technical conversations. Eventually, even new members develop a sense of belonging. This is hastened when you take the next step in membership and agree to step up and champion an initiative.

5. “I’m going to make a bold prediction: richer, more frequent discussions with peers would help your career.” (James Millar, Building Bridges: The Case for Executive Peer Networks)

ICOLD Affiliation
More importantly, USSD technical committees are not alone. USSD is the United States member organization of the International Commission on Large Dams. We are one of 100 member nations to ICOLD. As a USSD member, whether you realize it or not, you are a member of ICOLD. Just as the technical committees within USSD are where much of our organization’s work gets done, ICOLD also has similar technical committees which meet during the Annual Meeting. There are many similarities between USSD and ICOLD committees, in that both are great networking opportunities and both study issues related to their topic and produce reports.

USSD currently has 22 committees and ICOLD has 31. Both totals include the Board of Directors as a committee and ICOLD’s total includes the Regional Clubs. Many of the committees have the same name, with the difference being national or international scale. For example, both have Dam Safety, Embankment Dams, and the relatively new Levees Committees. In other cases, the names are not identical, but the committee intents are the same. For example, USSD has the Monitoring of Dams and Their Foundations Committee and ICOLD has the Dam Surveillance Committee; and USSD has the Earthquakes Committee and ICOLD has the Seismic Aspects of Dam Design Committee. ICOLD also has some committees which do not have a parallel within USSD, such as Sedimentation of Reservoirs and Resettlement Due to Reservoirs. You can find the complete USSD Committee list here https://www.ussdams.org/about/ussd-committees/ with a copy of the charter and links to contact the committee chair. You can find the full list of ICOLD committees here http://icold-cigb.net/GB/icold/technical_committees.asp and can contact the USSD committee chair to gain more information on the corresponding ICOLD committee.

USSD committee meetings are open to all members, and so are ICOLD committee meetings. However, ICOLD is a bit more formal. Each country is allowed no more than one official representative on each committee, and not all countries have representation on each committee. Anyone who wants to attend an ICOLD committee meeting can do so as an observer. Two ICOLD committees — Hydromechanical Equipment and Resettlement Due to Reservoirs — are currently looking for representatives from the United States. If these (or any other) committees are of interest to you and you will be at the 2019 ICOLD meeting in Canada, you are encouraged to attend the committee meeting as an observer. If after attending the meeting, you would like to become more involved, contact USSD leadership for assistance with the next steps.

Get Involved
If you are interested in attending a committee meeting during the 2019 USSD Conference and Exhibition, we recommend you contact one of the committee leaders and let them know you plan to attend. As an alternative, you can just show up. The committee meeting schedule will be posted on the conference website at www.ussdams.org prior to the event, and all committee meetings will occur on Monday afternoon or Tuesday afternoon during the conference. Once you are in the room, take advantage of the opportunity and consider ways you can contribute your experience and skill set to further or expand the committee’s goals. We are confident that you’ll find personal and professional benefits to participating!
Introduction

Dams are undoubtedly one of the many brilliant innovations of humans, used to harness the flowing energy of Mother Nature and store life-giving water. Dams have played a vital role in providing service and protection to our communities and economy throughout the ages, and their significant role continues in the modern history of the world. The number of dams has rapidly increased with rapid growth of population and community development over the past century. Safe dam operation and appropriate maintenance are vital to sustaining the benefits and mitigating the associated risks. Dam safety is currently receiving more attention because of the increasing overall public awareness about large infrastructure elements (FEMA 2013).

Spillways are one of the most critical components of any dam structure, responsible for safely passing flood flow without endangering the dam structure itself. An appropriately designed and constructed spillway structure is required to reduce the likelihood of potential failure modes (PFMs) developing. Unlike outlet works typically used to release service discharges, spillways are generally operated during relatively large hydrologic events. Therefore, many spillways are not operated regularly and in some cases have never been required to. The infrequent operation of spillways in some instances has led to false impressions regarding the importance of the spillway's purpose, sometimes resulting in a lack of enough attention paid to spillway soundness. Most defects and damages to spillway structures develop progressively, leading to incidents with a wide range of hazard potential. Therefore, to reduce the risk of PFMs developing, detailed routine inspections and assessment of the spillway, as part of dam safety practices, are necessary to identify existing or potential issues and remedy deficiencies accordingly.

The general dam safety guidelines and procedures developed by federal agencies such as the U.S. Army Corps of Engineers (USACE), U.S. Bureau of Reclamation (USBR), Federal Energy Regulatory Commission (FERC) and others are recommended to be regularly implemented by the owners/operators. However, spillway inspections and review of associated PFMs have not always been fully and regularly integrated into the practice of inspection, particularly those spillways that only receive infrequent or emergency use. The recent incident at the Oroville Dam in California has heightened concerns regarding spillway safety. Following the incident, FERC requested that owners/operators of high and significant hazard dams, in which dam failure may result in loss of life and/or significant economic losses, perform a detailed spillway-focused inspection and assessment and complete a spillway-focused PFM analysis (FERC 2017a).

Spillway inspection, PFM identification, assessment, and remedial actions determined to be necessary can vary depending on the type, structural, geotechnical, drainage and hydraulic characteristics of the spillway, its age and historical operation and maintenance actions. Hence, a spillway-focused generalized programmatic and integrated inspection and assessment framework encompassing the variety of spillway types, issues, PFMs, and potential solutions would provide a useful tool for establishing a strategy toward a safer dam infrastructure. This paper is intended to present such a spillway focused programmatic assessment plan, providing the reader with a guide for preparing and performing a hands-on spillway assessment, determination of the spillway vulnerabilities, and reduce the risk of spillway
associated PFMs. This programmatic framework is intended to be used as general guidance; however, each spillway has unique characteristics to which inspection and evaluation efforts need to be tailored, considering project setting, design, construction, historical operation and maintenance, and applicable dam safety requirements.

**Spillway Assessment**

Spillways are typically described based on their expected priority and frequency of operation, control condition, and linings. Primary spillways (aka principal or service spillways) are designed to pass most large flood flow releases from the dam, and are often the only spillway provided. They are typically designed to provide what was considered conservative and safe operation at the time of design, and reflect the understanding of hydrologic conditions and construction materials at the time. Conversely, auxiliary or emergency spillways are generally intended to be operated very rarely, only during very large flood events. They are designed to provide additional protection against dam overtopping during extreme conditions if the normal outlet works and/or service spillway cannot provide sufficient capacity (USBR 2004). Spillways can be differentiated into controlled crests, where mechanical equipment such as gates, flashboards or fuse panels are used to manage outflows, and uncontrolled crests, where flow passes voluntarily over the crest with no control. Spillways can be further divided into lined chutes, where concrete slab and side slope or vertical walls contain most or all of the discharge passing through the spillway, and unlined chutes that rely on excavated natural channels to carry the flow. Lined chutes are typically used where the spillway is in regular use or the unit flow capacity requirements are large and the foundation materials are not resistant to erosion. Lined chutes increase the reliability of the structure. Unlined spillways generally rely on the natural foundation material with limited improvement. Often, primary spillways are lined, while emergency spillways may be unlined. Since the spillway-associated PFMs differ between lined and unlined spillways, this distinction was utilized in developing the programmatic spillway inspection and assessment procedures presented in this paper.

Generally spillway assessment and inspection efforts include six main steps: 1) initial PFM identification, 2) document review, 3) hands-on condition assessment, 4) data analysis, 5) PFM assessment and development, and 6) action plan development. Each of these steps is vital to the evaluation of the safety of spillway, determine issues and associated risks and develop a plan to remedy deficiencies.

**Potential Failure Modes Identification**

According to FERC (2017b), a PFM is defined as “the chain of events leading to unsatisfactory performance of the dam or a portion thereof.” This includes any events resulting in uncontrolled and/or unintended release of water. However, past events (e.g. Oroville spillway failure) demonstrate that even if an event does not lead to uncontrolled/unintended release of water, the consequences of that event can be significant and should also be considered. Therefore, the first important step in a generalized framework for spillway inspection is to establish a good understanding of spillway vulnerabilities and associated PFMs. This step would identify what deficiencies to look for during a document review and hands-on condition inspection. A list of general considerations that would increase the spillway vulnerability and may lead to PFMs developing is presented in Table 1.

**Lined spillways**

Concrete-lined chute/tunnel spillways usually consist of a weir to direct reservoir outflows into the chute or tunnel conveying the water to downstream and often some form of energy dissipation to reduce the high energy of the flow before entering the downstream natural flow path. The PFMs to consider when inspecting concrete lined spillways can be summarized in the five main categories below.

- **Spillway lining overtopping**: The spillway walls can be overtopped when the spillway discharge exceeds the design capacity, air bulking increases the volume of mixed flow greater than design capacity, or spillway capacity within the chute is decreased due to blockage (e.g., debris, side slope failure). If this occurs, the materials above and behind the lining that are not resistant enough will be eroded by the overtopping high velocity flow. Erosion could potentially progress rapidly
beneath the concrete lining and lead to spillway failure.

- **Lining deterioration, instability and erosion:** Significant lining deterioration (e.g., cracks, spalls, and delamination) can result in spillway system failure through different mechanisms such as lining structural failure, foundation exposure, and increased pore pressure under the lining. Unrelieved uplift pressure under the spillway chute lining can also overstress the concrete slab and lead to chute lining failure. The uplift pressure build-up can be caused by hydraulic stagnation at the upstream edge of displaced slabs at joints or increase in pore water pressure due to lack of functional underdrain system. Lining erosion resulting from cavitation or abrasion could also cause lining failure over time. Failure of the chute lining slab or walls and resulting exposure of the foundation material to high velocity flow can quickly worsen the situation.

- **Foundation erosion:** The foundation erosion process is necessary for a number of PFMs to fully develop. If the spillway foundation is vulnerable to erosion, internal seepage through cracks, holes, damaged or deteriorated joint sealant or water stops could introduce erosive flows under the slab and initiate foundation erosion. Failure of, or lack of a functional underdrain system, could also initiate internal seepage erosion beneath the slab. Foundation material erosion can progress under the lining to such an extent that unsupported slab or sidewall lining could crack or collapse, leading to failure of the spillway system.

- **Seismic loading:** Seismic loading in excess of design consideration could initiate cracking in the spillway structure concrete lining. Significant cracks in the concrete could lead to failure of spillway crest, gates and piers, as well as chute lining. This could result in unintended release of water if the spillway crest fails or expose the foundation to high velocity flow, increasing the risk of foundation erosion if the lining fails. Also, failed/dislodged concrete lining may block the spillway and lead to overtopping of the lining. These failures can be further exacerbated by liquefaction of granular foundation material due to seismic loading.

- **Slope instability:** Increased pore pressures in the chute side slope foundation (e.g., within the spillway side slope foundation or on unprotected slopes above the spillway) can potentially lead to slope failure. Slope failure in the spillway sidewall foundation could result in concrete lining failure and exposure of the embankment to further erosive forces. Slope failure above the spillway chute could result in spillway lining overtopping due to flow restrictions from material blocking the chute. It could also divert water to a new flow route that could threaten the embankment or undermine the dam foundation. This could cause embankment and foundation erosion and threaten the safety of both the spillway and dam. Additionally, increased pore pressure behind spillway walls with blocked drains could potentially overstress the wall reinforcing.

**Unlined Spillways**

Since there is no lining in unlined spillways the characteristics of the foundation rock or soils are critical when considering the PFMs. The PFMs to consider when inspecting unlined spillways can be summarized in the following four main categories.

- **Open channel erosion:** Operation of an unlined spillway may initiate open channel erosion/incision at vulnerable locations where the bed material is not strong enough to resist the erosive energy of spill flow. Significant erosion/incision could lead to head-cutting or slope instability processes and threatens the integrity of the structure.

- **Seepage/internal erosion:** Internal erosion would start when the hydraulic gradient of seepage flow through weak areas such as faults reaches the critical gradient. Subsequently, materials will be plucked and transported away, creating an erosion feature. If the material has sufficient cohesion a pipe can form, eroding material progressively further into the foundation. The internal erosion, regardless of simple erosion feature or forming a pipe, would carry the same risk as open channel erosion.

- **Headcutting:** A headcut, sudden change in bed elevation at the upstream edge of a gully, in earthen material progressively moves upstream in the opposite direction of the flow towards the source. Headcutting can be initiated by open-channel erosion. A breach may occur if headcutting reaches the spillway crest, creating the potential for a catastrophic failure in unlined spillways.

- **Slope instability:** Slope stability can be compromised by either toe erosion undermining the slope or increased pore pressure reducing stability. Both spillway toe erosion and an increase in pore pressure within the foundation or on adjacent slopes that could potentially increase the vulnerability of the unlined spillway.

**Spillway Flow Control Systems**

Often, spillways are equipped with mechanical control systems such as gates and valves. In this case, operational failure of the spillway control system may decrease the spillway outflow capacity and consequently raise the reservoir elevation. If the spillway is the only flood release structure or if alternative reservoir outlet works are not operational and the issue cannot be fixed in a timely manner this could lead to a dam overtopping PFM. Some dams have at least a few different ways of discharging the flow.
(e.g., emergency spillways, outlet works, low level outlet, and powerhouse). Sometimes, controlled spillways are equipped with multiple independent and redundant controlled outlets (e.g., multiple gates). Therefore, the number, capacity and vulnerability of the all flow release systems should be considered when identifying and developing PFM.

**Document Review**

Reviewing the available documents pertaining to a particular dam and spillway provides essential information necessary for a successful spillway assessment, so its importance cannot be emphasized enough. The information would guide the inspection effort and prepare the team for the hands-on inspection and testing. This would also allow them to identify any potential problematic areas beforehand, which require more attention during the hands-on inspection. A general list of the type of documents that may provide valuable information for spillway assessment is provided in Table 2.

**Hands-on Assessment**

Prior to scheduling a date for the hands-on assessment, enough time must be allowed for preparation and to perform a preliminary PFM identification and review available documents. The inspection planning should also take into account the operational, seasonal, and environmental considerations pertaining to the spillway. The inspection team must work closely with other groups such as dam operation staff and technicians, and consider access difficulties that may require specialists such as rope access engineers and/or divers for safe access to parts of the facility. Also, the team may need to attend special training sessions such as confined space training, depending on the project specifications. The hands-on assessment encompasses different techniques, including visual inspection, non-destructive, and destructive testings to assess the spillway condition.

**Visual Inspection**

The visual inspection must be performed by individuals with adequate training and background familiar with dam and hydraulic structures. If engineering evaluations are included, a professional engineer, licensed in the appropriate jurisdiction is also required. The experience and knowledge level of the inspection team, with regards to operation, safety, structural, geotechnical and hydraulic aspects of dams, is a key factor to a successful assessment effort. The visual inspection must be conducted by carefully observing the spillway condition and looking for abnormal features and possible deficiencies. This encompasses a wide range of features and deficiencies related to hydraulic, structural, geotechnical, and operational characteristics of the system. A general list of features to look for during visual inspection of spillways is presented in Table 3. It is necessary to accurately document and record the observed features during visual inspection. Documenting spillway condition and observed features with photographs taken from similar vantage point.

| Design/ construction drawings | Geotechnical exploration program | x  | x |
| As-built drawings | Construction details (compare with as-built to examine differences between original design and as-built) | x  | x |
| As-built drawings | Foundation characterization | x  | x |
| As-built drawings | Excavation objectives | x  | x |
| As-built drawings | Connection between slabs, expansion joints, water stops | x  | --- |
| As-built drawings | Anchors, reinforcing | x  | --- |
| As-built drawings | Drains, weepholes (materials, location, accessibility, outlets) | x  | x |
| Construction records | Project modifications | x  | x |
| Construction records | Issues with lining materials | x  | --- |
| Construction records | Concrete mix design and testing, placement tolerances and curing | x  | --- |
| Construction records | Foundation issues | x  | x |
| Construction records | Observations | x  | x |
| Construction records | Foundation preparation | x  | x |
| Construction records | Anchors | x  | x |
| Construction records | Lining reinforcement | x  | --- |
| Geotechnical | Seismicity assessment | x  | x |
| geology studies | Characterization of geotechnical setting relevant to spillway foundation and surrounding slopes | x  | x |
| Geotechnical | Earthfill material embrittlement | x  | x |
| geology studies | Faults and discontinuities | x  | x |
| Hydrological studies | Flood analysis (duration, magnitude, frequency) | x  | x |
| Hydrological studies | Flood routing | x  | x |
| Hydraulic | Spillway design capacity | x  | x |
| design | Hydraulic characteristics for a range of flows (e.g., depth, velocity, stream power, cavitation index) | x  | x |
| Hydraulic | Energy dissipation | x  | x |
| Hydraulic | Tailrace channel | x  | x |
| Operational and historical records | Operational plan | x  | x |
| Operational and historical records | Past spill events (spill flow discharge and duration) | x  | x |
| Operational and historical records | Inspection and maintenance records | x  | x |
| Operational and historical records | Project modifications | x  | x |

*Probable Maximum Precipitation
**Probable Maximum Flood

<table>
<thead>
<tr>
<th>Features</th>
<th>Lined Spillways</th>
<th>Unlined Spillways</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reservoir condition in the spillway approach (e.g., vortices and waves)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Debris condition and debris management system</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Slope stability (e.g., steep slopes, evidence of movement, drainage concerns on side slope and at toe)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Erosion in spillway approach and/or tailrace channel</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Crest displacement</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Lining damages and deficiencies (e.g., transverse and longitudinal cracks, delamination, spalling, scaling, pop-outs, abrasion and exposed rebar)</td>
<td>x</td>
<td>---</td>
</tr>
<tr>
<td>Cavititation damage</td>
<td>x</td>
<td>---</td>
</tr>
<tr>
<td>Slab condition (e.g., deformation, distortions, and displacement)</td>
<td>x</td>
<td>---</td>
</tr>
<tr>
<td>Reinforcement corrosion or damage</td>
<td>x</td>
<td>---</td>
</tr>
<tr>
<td>Joint condition (e.g., gap, offset, and filler material)</td>
<td>x</td>
<td>---</td>
</tr>
<tr>
<td>Rock condition (e.g., cracking, joint set, and weathering)</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>chute scours/erosion/incision</td>
<td>---</td>
<td>x</td>
</tr>
<tr>
<td>Wall condition (e.g., displacement, tilting, and alignment)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Efflorescence (with or without staining)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Sepsage</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Skidwall and under-drains condition</td>
<td>x</td>
<td>---</td>
</tr>
<tr>
<td>Control structures and operation (e.g., valves and gate leaf, frame, lifting assembly)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Vegetation</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Animal activities</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Previously repaired areas</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>As-built conformity</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

Table 2. Useful Documents and Information for Spillway Assessment and Inspection.

Table 3. General List of Features to Look for During General Inspection.
A general list of equipment that may be needed to efficiently perform the inspection is provided in Table 4.

It should be noted that the condition of energy dissipation structures such as stilling basins, plunge pools, and downstream channel is crucial to the overall functionality of the spillway and should be inspected along with the spillway structure.

**Non-destructive Testing**

Non-Destructive Testing (NDT) methods are used to evaluate structures without causing damage. They are becoming more popular in different fields of science and engineering because of relatively low cost and high data-gathering efficiency. They can provide valuable information about the properties and condition of spillway lining, foundation, and structural members which cannot be achieved during visual inspection. They use different scientific theories to indirectly evaluate the spillway condition. The tests must be conducted by a team of professionals because the quality of evaluation greatly depends on the experience and knowledge level of operators. The results should be analyzed and interpreted by the NDT team in conjunction with the inspection team to achieve reliable evaluation. The limitations of NDT methods should be evaluated when planning the inspections. Table 5 presents a list of some of common NDT methods that can be used in spillway evaluation.

### Table 4. List of Useful Equipment for Visual Inspection.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notebook and pen/pencil</td>
<td>Documenting observations</td>
</tr>
<tr>
<td>Site specific inspection checklist</td>
<td>Helping with consistency and completeness of inspection effort</td>
</tr>
<tr>
<td>Prepared inspection notes</td>
<td>Documenting all joints, slab numbering/lettering for easy tracking</td>
</tr>
<tr>
<td>As-built drawing set</td>
<td>Reference for documentation</td>
</tr>
<tr>
<td>Heavy-duty brush</td>
<td>Small debris and vegetation removal</td>
</tr>
<tr>
<td>Tape measure</td>
<td>Determine size, geometry and location of observed features</td>
</tr>
<tr>
<td>Laser measure</td>
<td>Quick measuring from wall to observed features</td>
</tr>
<tr>
<td>Survey wheel/tape</td>
<td>Determine location of observed features</td>
</tr>
<tr>
<td>Crack page</td>
<td>Determine size of cracks</td>
</tr>
<tr>
<td>Waders/boots</td>
<td>For access to wet areas</td>
</tr>
<tr>
<td>Flashlight</td>
<td>Light source for dark areas</td>
</tr>
<tr>
<td>Spray paint</td>
<td>Mark observed features for better visibility and future reference</td>
</tr>
<tr>
<td>Survey flags</td>
<td>Mark location of observed features</td>
</tr>
<tr>
<td>Camera</td>
<td>Take photos and videos of the observed features</td>
</tr>
<tr>
<td>GoPro/push cameras/ROV*</td>
<td>Monitoring underdrain system</td>
</tr>
<tr>
<td>Hammer</td>
<td>Debri removal, manual hammer impact testing for qualitative identification of material strength and voids under concrete lining</td>
</tr>
<tr>
<td>Metal rods</td>
<td>Probing joint gaps</td>
</tr>
<tr>
<td>Heavy chain</td>
<td>Chain drag testing for identifying voids under concrete lining</td>
</tr>
<tr>
<td>Plumb body/level</td>
<td>Check deflections of walls or slabs</td>
</tr>
<tr>
<td>Borescope</td>
<td>Investigate drains for potential blockage</td>
</tr>
<tr>
<td>Access equipment</td>
<td>To access difficult/accessible areas (e.g., fall protection, rope access, diving equipment)</td>
</tr>
</tbody>
</table>

*Remotely Operated Vehicle

### Table 5. Common Non-destructive Testing Methods for Spillway Evaluation.

<table>
<thead>
<tr>
<th>Non-destructive Testing</th>
<th>Technology</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photographic Records</td>
<td>Digital Photography</td>
<td>Take numerous photographs of the structure and compare with as-built drawing for conformity and with previous or future photographs to determine any changing condition</td>
</tr>
<tr>
<td>LIDAR</td>
<td>Laser light</td>
<td>Scan the structure and compare with as-built drawing for conformity and with previous or future scans to determine any changing condition</td>
</tr>
<tr>
<td>Sonar Scan</td>
<td>Sound wave</td>
<td>Perform underwater scan of approach channel or stilling basin</td>
</tr>
<tr>
<td>Ground Penetrating Radar (GPR)</td>
<td>Electromagnetic waves</td>
<td>Determine/locate the depth of materials within a material (e.g., rebar within concrete)</td>
</tr>
<tr>
<td>Schmidt Hammer</td>
<td>Spring rebound</td>
<td>Measure existing thicknesses of members (slabs)</td>
</tr>
<tr>
<td>Impact Echo (IE)</td>
<td>Sound waves</td>
<td>Determine voids within or behind/below structural members such as walls/slabs</td>
</tr>
<tr>
<td>Slab Impulse Response (SIR)</td>
<td>Sound waves</td>
<td>Determine the support conditions of slabs-on-grade pre- and post-repair and, in particular, determining subgrade voids</td>
</tr>
<tr>
<td>Half Cell Corrosion Mapping*</td>
<td>Electrical resistance</td>
<td>Locate areas of delamination or voids within concrete slabs within shallow depths</td>
</tr>
<tr>
<td>Thermal Imaging</td>
<td>Infrared radiation</td>
<td>Determine the corrosion potential of a reinforced concrete member</td>
</tr>
<tr>
<td>Ultrasonic Pulse Velocity (UPV)</td>
<td>Ultrasound waves</td>
<td>Map potential areas of deficiencies within the structure (e.g., large air voids, cracks, and delamination)</td>
</tr>
<tr>
<td>Seismic Reflection and Refraction</td>
<td>Geophysics</td>
<td>Map potential areas of deficiencies within the structure (e.g., large air voids, cracks, and delamination)</td>
</tr>
</tbody>
</table>

*May require exposing the rebar, causing some damage to the structure.


**Destructive Testing**

Unlike the NDTs, the Destructive Testing (DT) methods require destruction of a portion of spillway to evaluate the structure. The DT methods are usually less complex and easier to interpret but will provide more information compared to NDTs. Because of their destructive nature, they are usually performed only when additional information is required for justification and future repair planning. Table 6 presents a list of some of common DTs that can be used in spillway evaluation.

<table>
<thead>
<tr>
<th>Destructive testing</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boring</td>
<td>Allows for investigation into subsurface conditions, verification of slab depth, creating a path for borescopes to be inserted beneath the slab in order to determine the size of voids</td>
</tr>
<tr>
<td>Coring</td>
<td>Verification of slab depth, creating a path for camera to be inserted beneath the slab in order to determine the size of voids, can be used to determine in-place concrete properties and reinforcement size</td>
</tr>
<tr>
<td>Geotechnical testing (e.g., drilling, rock coring, Becker hammer, cone penetration testing)</td>
<td>Determine geotechnical properties of the foundation material</td>
</tr>
<tr>
<td>Petrographic Analysis</td>
<td>Comprehensive evaluation of concrete to determine potential issues (e.g., durability, low strength, surface distress, etc.)</td>
</tr>
</tbody>
</table>
Data Analysis and Assessment

Following the completion of hands-on assessment, the collected data, information and observations must be analyzed and interpreted. Effective data compilation and presentation is the critical path to accurate analysis and interpretation. The compilation of data is crucial in developing a baseline that can be used for future inspections to measure against and identify changing conditions. The observed features and testing results must be looked at both as a whole and individually to determine their potential source and the spillway vulnerability. Integrated presentation of various observed features would help to readily identify any existing pattern important to assessment. Developing a map of the spillway and presenting observed features is an effective approach to integrate and analyze the observations. For example, a concrete deficiency map of a lined spillway is a useful tool to identify pattern of cracks and areas of concern that indicate the existence of a systematic problem with the structure.

Often, analytical analysis or modeling simulation based on the hands-on assessment information would be required to support the observation and help with the PFM analysis and future planning. This could include hydrologic, hydraulic, structural, and geotechnical analysis. For example, if evidence of cavitation is observed in the spillway chute, hydraulic analysis of the flow must be performed to support the observation and determine the risk of cavitation leading to a PFM. Currently, there are number of available software and modeling tools which can be used to perform the supporting analysis, a list of which is presented in Table 7.

<table>
<thead>
<tr>
<th>Type</th>
<th>Analysis</th>
<th>Candidate tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrologic</td>
<td>Capacity, flow, cavitation, uplift and scour, erosion, and headcutting analysis</td>
<td>Capacity and flow (e.g., HEC-RAS, CFD modeling), cavitation and uplift (e.g., analytical spreadsheet), erosion and headcutting (e.g., HEC, WinDam, Erosion Index method)</td>
</tr>
<tr>
<td>Hydraulic</td>
<td>Structural stability analysis</td>
<td>SAP2000, ANSYS, LS-DYNA</td>
</tr>
<tr>
<td>Structural</td>
<td>Geotechnical</td>
<td>GeoStudies ~ Slope W, SEEP W, FSAC</td>
</tr>
</tbody>
</table>


Potential Failure Mode Analysis and Development

After all the information about the spillway is gathered, analyzed and interpreted, only then should the analysis and development of spillway-related PFMs proceed. The PFM analysis and development entails rationalizing the potential processes and sequence of events leading to unsatisfactory performance of spillway, including uncontrolled and/or unintended release of water from the reservoir. Typically, PFM analysis (PFMA) sessions are performed as part of the FERC Part 12 Dam Safety process for FERC-regulated dams, and similar processes are used for other federal projects. For projects that are not subject to federal regulations, PFM analysis and development would provide greater understanding of the spillway and the potential for associated failure modes. The PFMA is conducted by a team of qualified (by experience and/or education) participants and usually includes representatives from the inspection team, dam owner’s personnel, and related regulatory agencies. During a FERC spillway-focused PFMA session, the general potential failure modes previously identified will be reconsidered in more depth. The gathered information and analysis will help to classify the PFMs into different categories, based on the probability of occurrence and associated risk. It should be noted that the PFM classification is based on the engineering judgment of PFMA session participants. The PFMs classification is intended to help with future inspection effort and prioritizing actions needed to be taken to lower the vulnerability of project in the future. The outcome of the PFMA session must be accurately documented for future reference. Detailed information about the PFMA procedure and consideration for FERC-regulated dams is presented in FERC (2017b).

Action Plan

Upon completion of the PFMA session, development of a surveillance and monitoring program and an action plan is recommended for high risk and probable PFMs. The program should identify the type and frequency of future inspections, evaluate the current instrumentation and visual surveillance program, and discuss priorities to lower the vulnerability of the dam and the risk of PFMs and appropriate recommendations (FERC 2017b). To lower the risk of spillway-related PFMs, several actions (major or minor) may be recommended, depending on the nature and level of the deficiencies. Table 8 presents some of common actions to improve the spillway deficiencies. It is important

<table>
<thead>
<tr>
<th>Type</th>
<th>Action Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrologic</td>
<td>Improve debris management protocols</td>
</tr>
<tr>
<td>Geotechnical</td>
<td>Improve slope/foundation stability (e.g., anchors, grouting, retaining walls)</td>
</tr>
<tr>
<td>Hydraulic</td>
<td>Reduce pore pressure and seepage flow (e.g., seal the joints, improve drain efficiency)</td>
</tr>
<tr>
<td>Structural</td>
<td>Repair joints (e.g., eliminate significant joint offsets and large gaps, install water stops)</td>
</tr>
<tr>
<td>Erosion and Energy Dissipation</td>
<td>Improve erosion resistance of spillway (e.g., resistant lining, riprap, grouted riprap)</td>
</tr>
<tr>
<td>Operational</td>
<td>Improve physical and operational state of the control system</td>
</tr>
</tbody>
</table>

Table 8. Common Actions to Remedy Spillway Deficiencies.
that the owner/operator appropriately implements the
developed action plan to reduce the likelihood of spillway
associated PFMs.

Summary
A recommended framework for periodic spillway inspection
and assessment to identify changing conditions and spillway
vulnerability is presented. This programmatic inspection
and assessment plan is intended as a guide for inspection
and assessment of spillways and a tool which can be adopted
for individual projects as appropriate. Various means and
methods of inspection were described and referenced, along
with typical or necessary supporting analysis, potential
failure mode analysis and common action plan items to
remedy existing deficiencies and lower the risk of PFMs
developing.

The programmatic spillway assessment and PFM analysis
and development presented herein follows this typical
procedure below:

1. Initial consideration and identification of PFMs

2. Review of existing documents

3. Selecting the most appropriate assessment methods
to acquire the most information, plan and execute the
inspection and assessment

4. Synthesize the collected data and perform supporting
analysis if needed

5. Conduct a PFM analysis and development

6. Develop an action plan

References
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Engineering Guidelines for the Evaluation of Hydropower Projects
– Chapter 14.
USBR. 2004. Inspection of Spillways, Outlet Works, and Mechanical
Leaders in Innovative Dam Engineering Solutions

Bel Air Water Impoundment Project, Maryland

Excellence Delivered As Promised
Spotlight on Young Professionals

Introduction

Young professionals from around the globe are working to advance the state of our practice. Some bring an interest in emerging technologies, while others seek to engage the community through various social media platforms. Most are too busy trying to glean wisdom, grasp knowledge, and hoard experience, while also trying to find time to stop and smell all those youthful roses. In any case, all of them share a passion for water: how to move it, how to predict it, and how to store it in mass quantities safely.

In this issue of the bulletin, USSD recognizes the efforts of our younger members by inviting them to tell a tale, explain a technical project they are involved in, or simply to write some rad dam slam poetry. Now that you’ve googled “slam poetry,” we invite you to kick back, relax, delve into the progress of our young professionals, and reflect upon your own youthful endeavors.

On the Role of Advanced, AI-Based Technologies in Dam Engineering

M. Amin Hariri-Ardebili, Post-Doctoral Research Associate and Lecturer, University of Colorado, Boulder, Colorado

The role of dam engineers has greatly changed over the last three decades. In the past, dams were mainly designed by trial-and-error methods, and once built, dam engineers had to collect and write down instrumentation results using pen and paper. This data then had to be interpreted by an experienced engineer, and the probability of human error was relatively high.

Thanks to new technologies, the surveillance and monitoring tasks involved in this process have significantly improved. Satellite imagery, LIDAR, drone inspections, distributed fiber-optic temperature sensors, 3D scanning for dam deformability, underwater cameras, and smart phones are only a few of the technologies dam engineers are now adopting to assist in their roles.

The question is, how can we effectively utilize all the data these digital tools are collecting? I have been working for the past three years to address this question through my post-doctoral studies. I found there are several innovative solutions developed by computer scientists at a high level of maturity that have great potential for application in dam engineering, including artificial intelligence (AI) and machine learning (ML).

These technologies have been employed, to some extent, over the last decade to predict future dam responses using recorded geodetic measurements from past dam responses; however, they have never been used in the context of finite element simulations or probabilistic risk analysis.

I have been combining AI-based models with traditional nonlinear finite element (FE) simulations to perform risk analysis of dams subjected to multiple hazards, such as earthquakes, floods, and aging. This is shown schematically in the figure above, where the FE results are fed into an AI technology to develop a Monte Carlo-based meta-model, and consequently to quantify the existing uncertainties. These results are published in several peer-reviewed journals and prove the applicability of this idea in general. This work opens the door for relatively low-cost, quantitative risk analysis of dam portfolios across the US and provides a metric for systematically prioritizing repair and rehabilitation costs.
Spotlight on Young Professionals

USSD Young Professionals Committee
Aimee Corn, Gannett Fleming, Inc., Greenwood Village, Colorado; and Emily Schwartz, Black & Veatch, Austin, Texas

As the holiday season appears on the horizon, it seems a good time to review the many successes enjoyed by the YP Committee this year. The 2018 conference saw the largest YP participation yet as well as many firsts for our committee. In addition to our annual Networking Social, we introduced our first Mentoring Luncheon, coordinated by vice chair Aimee Corn. This luncheon joined YPs and Seasoned Professionals (SPs) for casual networking and knowledge sharing. Due to its resounding success, expect another luncheon in Chicago, with a new round of SPs who have enthusiastically volunteered beyond our wildest expectations. Want to hear from the SPs in their own words? Be sure to read their advice section on page 27.

Student Outreach

In Miami we formally created the Student Outreach Subcommittee and elected Rachael Brooks as subcommittee chair. The primary initiatives of this subcommittee are 1) to garner student interest in USSD by coordinating with local universities in advance of our annual conference and 2) to meet that student interest by securing funding for student registrations through sponsorships. As with its parent committee, this subcommittee will need support from the broader organization, so keep an eye out for sponsorship solicitations to boost student attendance in Chicago. Have a contact at a university near Chicago? Reach out to YP leadership to help coordinate.

Workshops

The YP Committee also hosted our first workshop in Miami, focused on honing communication strategies towards various target audiences within the industry. The half-day workshop was well received and well attended, leaving us with the motivation to take on another workshop. We are happy to announce that for 2019 we have teamed with the Committee on Public Safety and Security for Dams to present a workshop on Emergency Communication. Consider signing up when you register for USSD 2019.

Outstanding YP Award

Last but certainly not least, we are proud to announce Board approval of the Outstanding YP Award. In the coming months we will finalize the nomination form and begin soliciting nominations. Consider which YP you will nominate for recognition in April; we know it’s going to be a tough decision.

We’ve enjoyed a dramatic growth in YP participation across USSD during the last several years, with more YP contributions to technical programs and committees than ever before. But there’s still plenty of work to be done, with further initiatives under development, so stay tuned for more exciting announcements from your YP Committee. If you’re a YP looking to get more involved in USSD, don’t hesitate to reach out to a YP Committee Chair or Vice Chair.

YP Committee Leadership

Brandan Vavrek, Chair
(brandan.vavrek@seattle.gov)

Emily Schwartz, Vice Chair
(schwartz@bv.com)

Aimee Corn, Vice Chair
(acorn@gfnet.com)
Spotlight on Young Professionals

Aqueduct to Aquatic Aspirations
Ali Reza Firoozfar, HDR, Hydraulic Engineer, Seattle, Washington

I grew up in Meymeh, Isfahan, a small town in arid, central Iran. My parents were teachers and our relatives and neighbors were farmers. The farmers irrigated with groundwater delivered by ancient man-made tunnels called Qanat. As I grew up, water became increasingly scarce due to extended drought periods. Water disputes became frequent, sometimes even resulting in physical altercations between neighbors. Observing good people struggle led me to wonder how I might be part of the solution. This experience propelled me to study water engineering. During my undergraduate studies, I became interested in hydraulics and entered graduate school to pursue a MSc degree in Hydraulic Structures.

In the spring of 2009, my uncle returned to Iran after 30 years of living in Arizona. He saw in me a young, motivated engineer in graduate school with high aspirations, and suggested I go to the U.S. to continue my education. I was intrigued by pioneering work in hydraulics performed at the Iowa Institute of Hydraulic Research at the University of Iowa. This seemed to be the best place for me to further my studies. I decided to journey to Iowa to become a hydraulician and do anything to make it happen. After several months of hard work, tests and paperwork, I received an email from the University of Iowa. My dream had come true; I was accepted at IIHR for a PhD candidate position.

I received my admission letter late and with the impending fall semester, I had only a few months to obtain a visa and travel to Iowa. There is no U.S. Embassy in Iran, and U.S. Embassies in most neighboring countries repeatedly turned me away due to timeline or political reasons. It became apparent that if I wanted to obtain a U.S. visa, I would need to use unconventional measures; I decided to travel to the U.S. Embassy in Afghanistan, an active war state, telling only my father so someone would know where to look for me, just in case.

I gathered my passport and an Afghanistan visa and hopped a weekly flight from Tehran to Kabul where an acquaintance, Raheem, picked me up. He arranged my hotel and took me around Kabul. The next morning, I had my interview at the embassy, and flew back to Mashhad, Iran, where I caught a 12-hour bus ride back to Tehran after a harrowing week.

The following day I received an email from the embassy saying my visa was ready! This quick turnaround was unexpected because the visa process for Iranian nationals can take up to 18 months. I needed to find an alternate route to Kabul because there were no direct flights for another week. After another 12-hour bus ride to Mashhad, I managed to find a cab to the border town of Taybad, Iran, where I met an Afghani who lived in Iran and traveled to Afghanistan weekly for business. Once across the border he put me in a sedan with six other passengers travelling to Herat, and strongly advised me not to say a word until I was in Herat for fear the Taliban may abduct me due to my nationality. I awoke in Herat, happy to not be a hostage! Raheem, who happened to be on vacation in Herat, picked me up, and took me to his family’s home to dine with their relatives as an honored guest. They fed me more than I could possibly eat and after dinner insisted I sleep in their bed while the family retired to the floor. Such is Afghan hospitality.

The next morning, I had to catch the daily flight to Kabul, over the Taliban controlled ground. The airport check-in area had four bullet ridden walls and no roof. I weaved through the other travelers to a man seated at a folding table with a book. As I got to him, he shut the book and shouted, “the flight is full.” I told him I had already purchased my ticket but he didn't care. Fortunately, Raheem had a friend in airport security who told the pilot that I must present to the ministry of communication by noon and needed to be on that plane! They found me a seat and I was on my way to Kabul. The next day I retrieved my visa and headed home to bid farewell to my family. The following week I flew to the U.S. to join a renowned hydraulic institute and follow my dreams.
Spotlight on Young Professionals

Sage Advice from Seasoned Professionals
Aimee Corn, Gannett Fleming, Inc., Greenwood Village, Colorado

The Young Professionals/Seasoned Professionals lunch was a big hit in Miami. We’re looking forward to another successful lunch in Chicago! The seasoned professionals can be our strongest allies, so we reached out to get their advice for this edition of the Bulletin. Below is advice great for anyone, in any stage in their career:

• It’s easy to get along with people you like. The real test of your character is how you interact with people you don’t particularly care for.

• Written and verbal communication skills are as important as technical skills to career advancement. More often than not, those who rise to leadership positions are skilled communicators.

• Listen to others and seek their advice and counsel. Depend on multiple mentors, and remember the most seasoned professionals are very approachable and interested in talking with young professionals.

• Don’t get “pigeon-holed” into doing one thing early in your career. Try different things, volunteer to do investigations or construction observations, and get as much field experience as possible early in your career. Look for opportunities to work outside of your comfort zone and learn something new.

• Anytime you have a question for someone, develop two answers yourself prior to contacting the person. The answers may or may not be wrong, but the thought process is important to develop and the person you are consulting with will have a better opinion of you.

• If you fail to plan, you plan to fail. Having a goal and a road map for where you want to go in your career is important. Even if it’s a high-level career plan, with little detail, it still points you in a direction and lets others know that you have a particular interest or direction you would like your career to take. Letting your mentor and those around you know that you have a career plan can open doors that you did not know existed.

• Don’t simply mirror the skills of someone else. Develop your own unique skills and stay true to them. Trust your unique solutions even when the solutions are challenged by those “above” you.

• You don’t need to know everything, rather, it’s more important to have a desire for continued growth, appropriate humility, and an attitude of lifelong learning. Take advantage of all opportunities to learn. Yes, you are busy, but finding time to take advantage of all these opportunities will be tremendously beneficial.

Thank you to the following individuals for sharing some insights with us: Del Shannon, Alex Grenoble, John France, Dan Wade, Dan Johnson, and Stuart Harris.

The Way of the Spill
Precip downpoured with intensity
Twitterers tweeted the emergency
But this flood was a cinch
For the spillway labyrinth
The day was saved by this Auxiliary

Micah Smidt, Project Engineer, RJH Consultants, Inc.
Denver, Colorado
Spotlight on Young Professionals

Floodplain Interagency Coordination

David L. Silvertooth, Chief, Emergency Management Branch, and Southern California Silver Jackets Coordinator, U.S. Army Corps of Engineers, Los Angeles, California

Over the past 12 months, I have had the opportunity to lead a Silver Jackets Floodplain Management Services Interagency project in coordination with the USACE Dam and Levee Safety Programs, the Emergency Management Branch, the State of California, Counties of Los Angeles and Orange, and multiple cities located downstream of the Whittier Narrows Dam to develop a regional flood response evacuation plan and execute multiple flood scenario tabletop exercises.

The Whittier Narrows Dam in Los Angeles County, California, is one of the highest risk dams in the U.S. and is located in a densely populated urban environment. There are over 20 cities and approximately 1 million people at risk downstream of the dam. The dam is currently classified as a Dam Safety Action Classification 1, very high urgency. The risk is primarily driven by identified potential failure modes combined with a very high and densely populated downstream community; however, an on-going USACE study revealed the lack of and need for flood risk awareness and comprehensive flood focused emergency planning in the communities downstream of the dam.

Utilizing a previously developed Evacuation Plan, created through another Silver Jackets effort by the City of Pico Rivera, California (a city with the highest risk associated with the dam) the project is addressing this risk by: (1) Coordinating with the communities to develop a comprehensive plan that identifies all the tasks and funding necessary to develop plans for each community; (2) Compiling relevant USACE data into a package that will aid emergency planning; and (3) Developing a multi-city flood Evacuation Plan.

In addition to leading the coordination and development of the plan, I’ve helped develop, coordinate, and facilitate flood scenario tabletop exercises to ensure that the developed plans are functional and people are ready to appropriately respond to flooding near dams in southern California.

These efforts have been a great opportunity to engage with federal, state, and local partners, while helping reduce risk associated with the dam through valuable interagency coordination, plan development, and readiness exercises. It’s been a rewarding experience that has reinforced the value of communication and the role that professional relationships play in preparedness planning and reducing risk.

Hurricane Florence and Social Media

Katie Leigh Ward, Senior Meteorologist, MetStat Inc., Fort Collins, Colorado

When major precipitation events occur, it becomes apparent there are many misconceptions with precipitation frequency and questions about the validity of these studies given the changing climate. One common misconception is that frequency estimates are derived solely from extrapolating gauge records; but they are actually derived from regional L-moment statistics which address many of the limiting factors of general extrapolation methods. Another common misunderstanding is that a 1,000-year event only happens once in 1,000 years. However, Average Recurrence Interval (ARI) is a probability, which means a 1,000-year event has 0.1% chance of occurring in any given year at the same location; possible but relatively improbable.

Hurricane Florence produced record-breaking tropical cyclone precipitation in the Carolinas in September 2018. After translating multiple gridded precipitation forecasts to ARI maps, it was evident this storm, with ARIs exceeding 1000-year values, was going to cause devastating flooding. These maps were provided in a blog post and shared on social media to supply the public with a metric on the severity of this forecasted event.
As the storm made landfall and progressed inland, ARI maps were continually updated using gauge-adjusted quantitative precipitation estimates to determine where the most extreme precipitation occurred. Although the precise location of the rarest precipitation was slightly askew, the spatial extent and magnitude was verified from the forecasted ARI. After the storm moved northward beyond the Carolinas, an update to the blog was posted that provided the public with preliminary maps of the ARI of observed precipitation such as the one presented on the figure below. These maps were subsequently shared on Twitter, which is the ideal platform to share with many people quickly, but some of the key information gets dropped off given the limited character allotment.

The bottom line is: in an era of information overload and complex statistics it’s easy to get lost in or overlook the details. What is important is to present data in a clear yet thorough way. For example, it’s not enough to call a storm a 1 in 1000-year event, but rather an event that has a 0.1% probability of occurring in any given year, at that location. It’s also suggested to direct readers to background information on how the underlying frequency estimates were calculated, to mitigate ambiguities and misconceptions. Communicating more concisely is paramount in enabling the public to understand and leverage the information that is disseminated.

**USSD Conference — Worth a Dam?**

Suzanne Grix, Business Development Manager, Great Lakes Environmental & Infrastructure, Sacramento, California

Cory Fournier (coach, author, and speaker) once gave a presentation at a conference that forever changed how I view choices in business and personal life. Her colorful presentation, which was meant to highlight how some individuals climb the ladder and some don’t, included a lesson about differentiators which began by pointing out the five common threads of every general contracting company’s marketing message — “We’ll do the job: 1. On time, 2. On budget, 3. Given this experience, 4. With these people, and 5. We’ll get it done safely.” Every website, every brochure, every proposal — no matter what company it was — the same five things. So who wins the job? The one smart enough to answer the most important question — “What else?”

There’s no shortage of high quality conferences delivering on a few basic requirements: 1. Great content, 2. Solid attendance, 3. Networking, 4. Marketing, and 5. A location you get onboard with. Despite having never been to USSD and knowing few, if anyone, in attendance, I was immediately enthusiastic. Half- and full-day workshops on a variety of topics, a field trip to the Herbert Hoover Dike, Marlins baseball game, roof-top YP networking social, and YP-only luncheon — all included in the conference fee! And, to top it off, a 5k FUNds run and free t-shirt. I made more lasting connections (and great friends) at USSD 2018 than any conference I’ve attended. If it’s a choice of where to spend your conference dollars, make sure your choices meet your basic needs and dare to ask the question — “What else?”
Impact of In-Situ Soil Conditions on SCCB Cutoff Walls

Jared Williams, Project Manager, Great Lakes Environmental & Infrastructure, Centennial, Colorado

Slag Cement-Cement-Bentonite (SCCB) cutoff walls are designed for applications that contain limited work pads, protect in-place utilities, or scenarios that require a backfill with some structural integrity. Industry standard specifications for flood control projects require a pre-construction mix design process that includes analyzing a variety of mix proportions, selecting the most appropriate for the application, and then running a final analysis on the selected mix considering the impact of site-specific sands. Common belief is that sands suspended in the SCCB trench slurry creates a worst-case condition with respect to hydraulic conductivity due to the understanding that sands by nature have medium to low permeability and clays are several orders of magnitude less permeable.

Great Lakes Environmental & Infrastructure has experience constructing SCCB cutoff walls in geotechnical conditions differing from cobbles to clays. Because cobbles, gravels and coarse sands will not suspend in the slurry, this discussion will be limited to differences between fine sands and silts / clays. E&I recently completed a 200,000 square foot SCCB cutoff wall that allowed for analysis of different soil types and their corresponding average hydraulic conductivity and unconfined compressive strength. The table below shows a summary of our findings.

<table>
<thead>
<tr>
<th>Soil Type</th>
<th># of Samples</th>
<th>Avg. Hydraulic Conductivity (28 days)</th>
<th>Avg. UC Strength (28 days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sands</td>
<td>40</td>
<td>8.0x10-08 cm/sec</td>
<td>111 psi</td>
</tr>
<tr>
<td>Silts/Clays</td>
<td>33</td>
<td>7.0x10-07 cm/sec</td>
<td>81 psi</td>
</tr>
</tbody>
</table>

Based on our data, the test results for SCCB cutoff walls constructed in areas containing in-situ silts/clays resulted in the worst-case soil condition with an average strength reduction of 30 psi and an average hydraulic conductivity increase of 6.2x10-07 cm/sec. The effect of the particle size on permeability presented by this data is counterintuitive and could be the result of many different factors. As a result of these findings, specifications should not only require an analysis of in-situ sands during the preconstruction process, but also the in-situ silts / clays to truly develop an understanding of the site specific worst-case condition.

Performance-Based Testing of Double-Curvature Thin Arch Dam

Jeremy Begley, Civil/Structural Designer, Gannett Fleming, Inc., Greenwood Village, Colorado

Over the past year and a half, I have been engaged in performance-based testing (PBT) on a large concrete double-curvature thin arch dam. Dr. Ziyad Durón of Harvey Mudd College, who is a recognized expert in PBT of dams, partnered with Gannett Fleming to conduct two independent field tests. I had the privilege of being extensively involved on both tests working with Dr. Durón.

The purpose of the PBT was to estimate the natural frequencies of the dam for use in seismic evaluations. In both field tests, data were collected using highly sensitive accelerometers, which were used to estimate the natural frequencies of the dam. The first test was flow-induced monitoring (FIM) that consists of obtaining accelerometer readings of the dam during normal spilling operations in late spring. For this test, the ambient flow provided the energy to excite the dam. The second test was impulse testing performed in late summer, which consists of using a cold gas thruster (CGT) to provide an impact force to the dam system. Both tests resulted in the same natural frequencies.

Following the field tests, I developed a 3D numerical model using ANSYS according to the industry standards. After performing a modal analysis of the initial model, the frequencies in the analytical model did not match the frequencies obtained from the PBT. Upon months of further refinement and simplification of the numerical model, the first few natural resonances were matched to that of the field tests. This is only the beginning and has opened the doors for further analysis work to validate numerical models with field studies.

Field testing is imperative to create models that accurately simulate the true characteristics and behavior of a dam.
Focus on Young Professionals

By developing numerical models backed by measured field data, engineers can have greater confidence in the results of their seismic evaluations. Increased confidence results in dam owners that are equipped with better information to understand the risk of their assets. Also, PBT is useful in identifying nuances of a structure that are otherwise unattainable with visual inspection and typical instrumentation.

I look forward to seeing PBT implemented more extensively on future projects across the dam industry because this project has opened my eyes to innovative ways to handle the crippling problem of aging infrastructure!

Women of USSD

Zahra Amini, Project Engineer, Geosyntec Consultants, Huntington Beach, California

You are with your colleagues and meeting with a client to discuss the project. You happen to be the only female engineer at the meeting. The client addresses your colleagues almost the entire time, asking questions and looking for recommendations. Your colleagues respond, never redirecting questions to you. You sit silently, thinking, “Wait a minute! I did all these analyses, I’m the technical lead on this task. The project manager is promising things that are completely out of scope because he does not understand the model. Why am I even here?” Enough is enough. You pull together all your courage to chime in. Upon doing so, the client looks at you, nods and turns back to your colleagues. The conversation goes on as if you don’t even exist. Sigh!

Despite recent progresses, these sorts of unconscious biases against female engineers are still alive and well. Practically every woman in the industry has experienced the effects of bias at some point in her career, whether she realizes it or not. The fact is women tend to naturally have strong intuition and collaboration skills that can potentially make them great leaders. Women’s approaches to problem solving and managing are often different from men, but different from the norm does not mean worse. An alternative perspective could see their approach as creative, out of the box thinking, an opportunity to counter stagnation and improve the industry as a whole. As leaders, women are strategic, laser-focused and resilient, but above all they bring empathy to the table, which is a superpower in its own right.

When I walked into my first USSD conference planning meeting I was immediately drawn by the number of women at the table. They were serving in many different roles: executive director, conference chair, technical committee leader, and board of directors member. This was refreshing and made me proud of this organization. At USSD it is ok to be feminine! You don’t need to change who you are or assume masculine traits to gain respect as an engineer. The men and women of USSD have created a positive environment where women take charge in key leadership roles while supported by their male peers. Particularly for early career women, the Young Professionals committee provides plenty of support, mentorship and opportunities to get involved. We are setting a great precedent in this industry, and the community is reaping the benefits. If you are a woman in engineering, I urge you to get more involved. Go for it, we are here for you!
Sedimentation Prize Challenge

The Bureau of Reclamation is launching a new prize challenge seeking new or improved techniques to remove sediment from reservoirs in a cost-effective manner.

This is a theoretical challenge where solvers can provide ideas on sediment collection, transport, or delivery to the downstream river. In a theoretical challenge the only thing required is a white paper. Solvers are asked to submit their idea with detailed descriptions, drawings, illustrations, specifications, supporting data or literature, and any other things that would be needed to bring the idea to practice.

In this first stage, a total prize pool of $75,000 is available. The minimum full amount award is $15,000. If this first stage produces winning concepts and Reclamation determines a second stage is beneficial, it will launch a subsequent challenge where participants will be asked to present their proposal and provide a working prototype. In addition to an anticipated higher monetary award, Reclamation will invite industry, non-profit organizations, and venture capital representatives to the Stage 2 presentations and testing.

Submissions for this competition must be submitted by 11:59 p.m. EST on January 4, 2019.

Reclamation is partnering with the U.S. Army Corps of Engineers, Federal Energy Regulatory Commission, Natural Resources Conservation Service and American Rivers on various aspects of this prize competition.

To learn more about this prize competition, please visit https://www.usbr.gov/research/challenges/index.html.
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USSD: Advocate • Educate • Collaborate • Cultivate
Fall 2018
Advocacy, Communication and Public Awareness

Keith Ferguson, Committee Chair

With the approval of the Board of Directors, the Committee has initiated a program to develop position statements on important industry-related topics that can be used by members of USSD to represent a consensus position when discussing these issues in various professional, communication and education settings.

Each position statement will include a summary of the USSD position, background information, and rationale for the USSD position. Position statements will be developed by the ACPA and peer-reviewed by expert individuals or agencies prior to approval by the USSD Board. A position statement on Evaluation of Incidents and Failures was recently approved by the Board, and an additional six position statements are in various stages of development. Position Statements are posted under the “About” tab at www.ussdams.org.

The ACPA is also working to increase USSD’s exposure on various social media platforms. Thanks to the efforts of Yulia Zakrevskaya and Merry Dang, USSD now has approximately 550 followers on Twitter and LinkedIn.

Third Workshop on Case Histories in Dam Safety Risk-Informed Decision Making

David Bowles, Workshop Coordinator

The USSD Committee on Dam Safety organized this workshop, held during the 2018 USSD Annual Conference. The workshop was the third in a series, following similar workshops held in 2010 and 2014. The purposes were:

- To present risk assessment case histories that illustrate how actual applications have been conducted and how their results have been used in decision making.
- To make the concepts and theory of risk assessment more understandable to dam safety practitioners.

All case history presenters were requested to follow a standard outline, which included the following components:

- Purpose, context and scope
- Baseline risk assessment
- Risk reduction assessment
- Limitations, decisions, risk communication and lessons learned

As with the 2010 and 2014 workshops, there was diversity in the presentations including in their: purposes (design, construction risk, existing, risk reduction measures, portfolio management); approaches/levels of detail (uncertainties, limitations); owners (federal, state, private); regulated; self-regulated and regulator; locations (throughout U.S., Australia); types of dams; levels of risk assessment (PFMA, SQRA, range of QRA); and failure modes.

Brian Becker, Chair of the Committee on Dam Safety, welcomed the group; and David Bowles, Chair of the Risk Subcommittee, provided an introduction. The morning session was moderated by Douglas Boyer, FERC, and included four cases histories:

- Detailed PFMA for the Design of New Glades Reservoir, Jennifer Williams, AECOM
- Tellico Dam Semi-Quantitative Risk Analysis, Husein Hasan and Caleb Douglas, TVA
- Preliminary Quantitative Risk Assessment and FERC Pilot Study for Alcona Dam, David Bowles, RAC Engineers and Economists and Utah State University
- Construction Risks at Stampede Dam, Jennifer Huggins, Bureau of Reclamation

The afternoon session was moderated by Nate Snorteland, USACE, and included four more case histories:

- Coffe Dam Design, Greg Hammer, USACE
- Seqwater Dams Portfolio Risk Assessment, Barton Maher, Seqwater, Australia
- A Scaled and Efficient Semi-Quantitative Risk Analysis for a Portfolio of 22 High Hazard Dams, Daniel Osmun, HDR
- Victoria’s dam safety — the risk management journey: A Risk-informed Regulatory Approach, Siraj Perera (State Regulator), State of Victoria, Australia (presented by David Bowles)

You may download the presentations as pdf files from the USSD website at https://www.ussdams.org/resource-center/publications/proceedings/.
Abstract

Appurtenant hydraulic steel structures such as spillway gates are subject to deterioration over time from influences such as corrosion, fatigue, and damage. Similar asset deterioration occurs on construction equipment, vehicles, bridges and building components. Asset management tools based on Markov Decision Processes (MDP’s) that assist in evaluating optimum inspection and maintenance schedules have been in existence for several decades (AASHTOWare BrM - formerly PONTIS for example). This paper extends the use of MDP’s for hydraulic steel structures and adds partial observability. The primary intent of this paper is to determine whether an optimum policy for inspection intervals and actions taken for hydraulic structures such as spillway gates could be approximated by a Partially Observable Markov Decision Process (POMDP). This work is a follow-on to the Master of Science Report work performed in 2017 at University of Colorado by Travis Ford, P.E.

This work explores the application of algorithms born in the reinforcement learning branch of artificial intelligence (AI) industry and applied to hydraulic steel structure asset management. Specifically, the use of a Partially Observable Markov Decision Process applied to deterioration of radial (Tainter) gates on dams. The fundamentals of the problem include structural inspection, structural deterioration, maintenance activities, maintenance intervals, and condition states. Optimizing inspection intervals depends on much more than just the condition of the structure. It can also be influenced by the level of risk, design features, maintenance practices and of course financial constraints. Recent advances in both computing power and algorithms for AI has provided significantly better tools to solve these large intractable infrastructure problems.

The primary conclusions of this research include: regional deterioration, spike in cracking damage between 1945 and 1960 due to advent of welding, economy of scale for inspection and retrofit, tradeoff between inspection methods, strategies for structure longevity, sensitivity with discount factors, and cost vs. risk tradeoff.

Introduction

This work follows a similar process to that of Dr. Mingxiang Jiang and his dissertation in part directed Dr. Ross Corrotis (Jaing, M 1995). A good summary of their work is published in a paper with Hugh Ellis in the Journal of Infrastructure Systems titled Inspection Maintenance and Repair with Partial Observability (Ellis, H. 1995). Both the PhD work and the research behind the paper were early iterations of Markov Decision Processes (MDP’s) with partial observability. Computing power has limited the research in this area until recently.

The most relevant publications found as a guide for this work included a series of three papers written in the Journal of Reliability Engineering and System Safety by Papakonstantinou, K.G., and Shinozoka, M, in 2014. The papers built up a similar model to this work using bridge inspection data and then applying dynamic programming in POMDP’s for planning optimal inspection and maintenance policies (Papakonstantinou, K.G. 2014 a, b and c). This paper will review the current gate inspection practice, modeling basics for MDP and POMDP’s (Theory), developing POMDP model parameters for spillway gates and the spillway gate model results.
The research in support of this paper involved gathering and processing data, creating input file and testing a steel spillway gate POMDP model. Seventy two dams (800 gates) were evaluated for various condition states of corrosion, fatigue and damage. Probability matrices for model input and deterioration curves were generated showing the timeframe during which a structure may transition condition states. Additionally, factors such as cost, discount rates and level of risk were incorporated. The data was then combined to create a model into which an individual, real world, spillway gate could be entered producing repair-inspection Action Plans. This enables asset owners to determine the most efficient inspection types, intervals and repair methods. Condition states of a simulated, single high-hazard dam spillway gate were entered into the model and an optimum inspection and repair policy generated.

Current Gate Inspection Practice

Inspector Scope and Interval

The typical hydraulic structure inspection scope typically depends on hazard classification such as a high hazard dam requiring 10 year inspections or not at all for low hazard. Often the dams receive annual inspections but specific detailed inspections are conducted on appurtenances such as gates at longer intervals. A variety of guidelines exists with different regulators and there is not a consistent standard for frequency of radial gate inspections. Table 1 lists federal requirements in use today.

Rating systems

Bridge rating systems such as those developed by the national bridge inventory (NBI) or element level (Fig. 1) are used nationally. There are nuances in how each state prefers the data but overall the idea was to gather data that could be used in deterioration models and asset management systems. Element level inspection is specific to the material in which it is made.

Table 1. Required Radial Gate Inspection Intervals.

<table>
<thead>
<tr>
<th>Owner/Regulator</th>
<th>High and Medium Hazard</th>
<th>Low Risk</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal Energy Regulatory Commission</td>
<td>10 years</td>
<td>None</td>
<td>FERC Tainter Gate Initiative - Rev 1</td>
</tr>
<tr>
<td>U.S. Army Corps of Engineers</td>
<td>5 years</td>
<td>5 years</td>
<td>ER 1110-2-8157</td>
</tr>
<tr>
<td>U.S. Bureau of Reclamation</td>
<td>6 years (max)</td>
<td>6 years</td>
<td>Reclamation Manual : Directives and Standards During Comprehensive and/or Periodic Facility Reviews (3 year)</td>
</tr>
</tbody>
</table>

Inspector Qualifications

Hydraulic structure inspectors are not required to have any specific qualifications and do not have similar definitions as those that are used for federally mandated bridge inspectors. State inspectors are typically trained in multidiscipline civil between geotechnical, hydraulic and structural but are not often structural engineers and do not have structural inspection specific training. They must have a wider range view of dam safety. The ASCE Gate Guidelines (Water Control Gates ASCE, 2012) does give some recommendations for qualifications and intervals based structure usage including qualified inspector or engineer but only gives general recommendations on when those inspections should occur.

Current practice in Dam Safety is setup well for a multicomponent feature and risk best practices attempt to evaluate each. When considering specific structural components however, it is often helpful for the owner to track deterioration over time and plan for replacement. Typically earthen or rock dams are not evaluated for deterioration in the same way a structural (Steel, Concrete or other) component would be. The MDP and POMDP can be useful strategies for estimating the structural component life cycle.
Developing POMDP Model Parameters For Spillway Gates

The following sections describes the radial gate model inputs which each required a separate (ongoing) research effort. States, Actions Transitions, Observations, Observation Probabilities, and Rewards are all developed from either available data or a Formsite Survey.

Deterioration Modeling and Condition States

A Formsite survey was sent to owners and other industry professionals asking for data that included rating an existing structure based on the most recent inspection providing the age and opinions about inspection types. Several agencies and private owners responded to the anonymous survey questions and most stated that they were unable or unwilling to share inspection or deterioration data due to the high security and risk with releasing information. In total, 72 dams (~800 individual gates) were used in this study for the deterioration modeling. Figure 2 shows the basic age of the structure.

![Figure 2. Number of Structures in Each Age Group Reported in Formsite Survey and Used in the Analysis.](image)

Each structure was reviewed by a structural inspection expert who in turn provided a condition state rating based on states 1-6 after ERDC/ITL TR-09-4. Condition state 1 is good condition and 6 is failed condition. Within each defect (Corrosion, Fatigue, and Damage) there are 6 condition states. Table 2 shows an example.

<table>
<thead>
<tr>
<th>Name</th>
<th># of Structures, Dimension and Type</th>
<th>Corrosion Condition State</th>
<th>Fatigue Condition State</th>
</tr>
</thead>
<tbody>
<tr>
<td>LO</td>
<td>L: 15'h high by 20'h wide Radial Gages</td>
<td>Corrosion: 2</td>
<td>Fatigue: 2</td>
</tr>
<tr>
<td>BR</td>
<td>L: 10'h high by 20'h wide Radial Gages</td>
<td>Corrosion: 2</td>
<td>Fatigue: 3</td>
</tr>
</tbody>
</table>

![Table 2. Example Formsite Survey Results with All Dam Names Removed.](image)

When the corrosion-fatigue-damage model in the equation below is multiplied by itself every year with no maintenance intervention all states reach >90% probability of failure within 100 years.

Deterioration is a driving factor and impacts the decision to inspect, rehabilitate, or replace a structure. The deterioration curves generated in this study are converted into transition probabilities within a matrix and used in the POMDP. The derivation of transition probabilities followed (Riveros, 2010) using a Weibull Distribution. Figures 3A and 3B are an example of this process showing the synthetic corrosion deterioration model. Random number generation was used at each 10 year interval using a Latin Hypercube Simulation.

Fatigue/Cracking and Damage are wild cards. It may not only cause a transition from one condition state to the next, it is entirely possible that a fatigue/cracking or damage failure in the right member (i.e. fracture critical member) could lead to the structure dropping several condition states instantaneously or potentially failing structurally or failing to operate. A brittle failure like this would imply that at every condition state transition there should be some probability of converting to condition state 6.

Adding in a possible failure for every change in conditions state in the model also makes the models run faster. This is because the longer the agent keeps looking for solution the more possibility there is to fall into condition state 6. The equation below shows the combined corrosion-fatigue/cracking transition matrix converted to include the possibility of a brittle failure. The probability of failure was estimated using Table VII-1-7 – Gate Failure Response Curve from (USBR Risk Best Practices, 2015) starting with 1% at Condition State 1 and incrementally increasing by 1% until Condition State 5.

When the corrosion-fatigue-damage model in the equation below is multiplied by itself every year with no maintenance intervention all states reach >90% probability of failure within 100 years.

Actions

Actions include activities performed by the agent on the system such as inspect or repair. This hydraulic structure model uses maintenance actions including inspection and repair efforts. Actions were chosen based on the most likely inspection practices for hydraulic steel structures and based on the inspection reports reviewed. The following annual actions for inspection and repair are detailed below.
Repair-Inspection Action Pairs
The following repair-inspection actions represent the policy pairs used for this study. Note that the higher the number the more conservative the maintenance policy. The inspection types are distributed throughout. 20 action pairs are possible based on the repair and inspection actions and shown in Figure 4.

Possible Observations and Detectability
The Formsite survey included an opinion section rating the detectability of each method based on personal experience. The arms reach visual observation matrix used for this model is shown below and shows a probability of detection of 0.75. The other probabilities of detection included no inspection (0.00), walking inspection (0.33), drone inspection (0.46) and ultrasonic+arms reach (0.86) respectively.

The rewards (costs) for this study (shown below) were gathered for both the anticipated maintenance and inspections. Cost data were gathered from the survey and industry tracking spreadsheets for retrofit as well as new designs. All costs are input into the optimization model in $1k increments, so a $43,000 inspection would be input as -43 into the rewards vector.

Inspection and Maintenance Costs
Inspection costs are based off responses from the survey and from industry data. The bulk of the modeling costs are estimated based on the available data (Planck, S. 2017 with Ford, T. additions) and converted to present value. Cleaning and painting can almost be as much as painting and strengthening due to the large mobilization costs. The costs in the rewards vector also include operational costs of that asset for that year.

Spillway Gate Model Results
For this study, a single simulated 40 ft high by 40 ft wide radial gate was chosen as a test structure. The POMDP solver used is called Perseus (Spann 2005). Perseus proved to be the most user friendly academic software as it has a Matlab Linux interface and the output studies proved to have the most consistent and expected trends. The simulated project includes only a single gate and is assumed to have been newly constructed. An optimal policy graph is shown in Figure 4. The vertical axis shows the inspection/repair action pairs and is read horizontally to match up with the policy for that structure age. It primarily uses walkabout visual inspections with drone and arms-reach inspections spaced at about 4 and 8 years respectively. It also illustrates 3 strengthening projects over the first 100 years as pointed out in Figure 4. The initial replace action in year 3 is considered a starting point, replacing a structure that early or often is not considered feasible.

Summary and Conclusions
The purpose of this study was to explore the Partially Observable Markov Decision Process and its application to hydraulic steel structure asset management. The publicly available Perseus software run in Matlab was used for the primary modeling. The solver is approximate like all POMDP solvers and finds a solution based on randomized version point-based value iteration.

1. More detailed inspections cost more but the benefit of a higher probability of detection can outweigh added cost.
2. The modeling showed that early rehabilitations on structures can help curb the deterioration model early. This is opposite from what many asset owners often do but if done early on the deterioration curve, the structure benefits through its entire remaining life cycle vs. just the last few years. Early retrofit work pays off in the long run more than waiting.
3. The higher the cost of an activity the less likely the agent will choose it. If a failed condition state has a large negative value the agent will take actions that keep it away from the expensive place. The higher the cost the more conservative the agent will be in its avoidance.
4. The deterioration on structures with private owners was
faster compared to government due to maintenance and operational policies.

5. There is a spike in fatigue/cracking deterioration between 60 and 70 years old which corresponds with the advent of welding technology. A large percentage of the deterioration for fatigue/cracking on radial gates is related to tack weld cracking. Riveted hydraulic structures show less fatigue damage than welded structures.

6. The inspection costs per gate and per square foot of projected area varied depending on quantities. The more gates or structures to inspect the lower the cost per item.

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ICOLD and USSD Celebrate 90 Years
Sharon Powers, Executive Director, U.S. Society on Dams

The origins of ICOLD came as a result of French engineers who had the idea of creating an international forum devoted entirely to dams. In 1925, the French Association for the Advancement of Science at its 49th Session in Grenoble declared its intent to support the creation of a permanent international technical commission specifically concerned with large dams. Later in 1926, the French delegation to a Sectional Meeting of the World Power Conference in Basel, Switzerland, accepted a proposal for setting up an International Commission on Large Dams (ICOLD), together with a draft constitution. The proposal was again supported by the World Power Conference Executive Council at its meeting in Cernobbio, Italy, in 1927. A French Committee on Large Dams was created near the end of 1926 with the support of the Société Hydrotechnique de France. Proposals were drawn up and a draft Constitution dated December 22, 1927, was created for circulation through diplomatic channels to interested governments.

During the July 6, 1928 constitutive meeting of the International Commission on Large Dams in Paris, six nations were represented: United States, France, Italy, Romania, UK and Switzerland. The move to create ICOLD was approved at the closing session of the International Congress of Electricity Producers and Distributors UNIPEDE on July 10, 1928. On October 3, 1928, at a meeting in London the Executive Council of the World Power Conference voted unanimously to recognize the International Commission on Large Dams. The National Committee of the United States, known then as USCOLD, established itself during that same year as a founding member of ICOLD. In 2001, it incorporated in the State of Colorado and became known as the United States Society on Dams (USSD). As such, USSD also celebrates its 90th birthday as an original member of ICOLD.

The International Commission on Large Dams held its first Congress on Large Dams in 1933 in Stockholm as part of the World Power Conference. It was the first public event organized by ICOLD. During this Congress, ICOLD consisted of 21 Member States and reviewed 47 reports. ICOLD operated as an autonomous body within the World Power Conference until 1967, when it became an international independent nongovernmental organization. Initially the focus of ICOLD was on advancing technology in planning, design, construction and operation of dams. In the 1960s ICOLD placed emphasis on dam safety, reanalysis of older dams, effects of aging on dams and environmental impacts. Today, it also is a forum to exchange knowledge and experience in dam engineering.

ICOLD is comprised of National Committees from 100 countries and currently has 31 technical committees, and USSD holds seats on many.


ICOLD 2019 Set for Ottawa, Canada

The Canadian Dam Association will host the 87th Annual Meeting of the International Commission on Large Dams in Canada’s capital city of Ottawa, June 9-14, 2019. An International Symposium will be held during the Annual Meeting week, with the theme, Sustainable and Safe Dams Around the World. Workshops organized by ICOLD Technical Committees will be featured, as well as local technical tours. In addition to a number of networking and cultural events, the program will include an exhibition with technical seminars. Several post-meeting study tours within Ontario, Québec and British Columbia are also planned.

CDA Short Courses
CDA will offer optional short courses on the weekend before the ICOLD event for an extra fee. These classroom sessions are eligible for professional development credits as required in many jurisdictions. The program of short courses is expected to include: Dam Safety Reviews; Mining and Tailings Dam Topics; Public Safety Around Dams; and Emergency Management for Dam Safety.

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Research Summaries, 2018 USSD Scholarship Recipients

Editor’s note: The following articles describe research projects of the 2018 USSD scholarship recipients. The research of El Hachemi Bouali, winner of the $8,000 scholarship, was featured in the Summer 2018 issue of Dams and Levees.

Effectiveness of a Glycerol Sealant to Reduce ASR Expansion

Johnathan Blanchard, University of Arkansas

The exact mechanism for Alkali-Silica Reaction (ASR) expansion is not understood, but it has been determined that ASR requires 1) sufficient reactive silicate, 2) sufficient alkali, and 3) sufficient water (Thomas et al., 2013). The control of alkali and silica has been the primary focus for the prevention of ASR. Conversely, controlling the amount of water available has been the way in which ASR has been managed. Many research studies have utilized relative humidity as a means of quantifying the amount of water within the concrete; these researchers agree that when the internal relative humidity is below 80 percent ASR expansion will stop. Different sealers (silane, low viscosity epoxies, and high molecular weight methacrylic) have been noted to be effective at reducing ASR expansion by controlling water infiltration into the concrete. However, these sealers are only short-term solutions, and have variable effectiveness.

The aforementioned sealers primarily operate by restricting water infiltration; however, in some applications, like dams, water is able to infiltrate from other sources. However, utilizing a sealant that not only prevents external infiltration, but also actively reduces the internal relative humidity of the concrete could improve our ability to control ASR expansion. Specifically, glycerol is a soluble desiccant that could be used in conjunction with other sealants to further reduce ASR expansion. A research project is currently being planned at the University of Arkansas to evaluate if a glycerol coating would actively reduce the relative humidity within the concrete.

In the proposed research project, the effectiveness of a glycerol sealant to reduce ASR expansion will be evaluated in a laboratory setting utilizing concrete cylinders. Specifically, concrete cylinders utilizing Jobe sand, Arkansas River sand from Arkansas (ARS-A), and Arkansas River sand from Oklahoma (ARS-O) will be evaluated. The Jobe sand has been noted to be very susceptible to ASR attack and will be used to determine early results (0-6 months). ARS-A was recently determined to be reactive with high silicate concrete and will be utilized to determine long term results (6 months to 2 years). ARS-O was determined to be inert and will be used as a master control. Additionally, each type of concrete will be utilized in testing cylinders, which will be treated with different concentrations of glycerol and different types of sealants, and at least one control cylinder, which will be untreated. The concrete cylinders will be cast with heat dissipation sensors and will be implemented with strain gauges to continuously monitor relative humidity and expansion of the cylinders.

Johnathan Blanchard is a second year PhD student at the University of Arkansas. Once Johnathan obtains his doctorate, he plans to work in industry as a consultant engineer. He also has an interest in policy making, and hopes to pursue this interest after obtaining his PE.

Understanding Backwards Piping Erosion by Inverting Pore Pressure Data

Carolyne Bocovich, Colorado School of Mines

This research aims to advance the use of observations and monitoring data to understanding the process of backwards piping erosion (piping) in earthen dams and levees (EDLs). EDLs are critically important but often overlooked pieces of infrastructure. Internal erosion, including piping, is a leading cause of failure in EDLs and a major contributor to flood risk. Piping initiates downstream of the EDL due to high hydraulic gradients and progresses backwards toward the upstream reservoir. The following questions will be pursued in this research.

1. Can inversion of pore pressure estimate spatial changes in hydraulic conductivity?
2. What can estimates of hydraulic conductivity, derived from inversion of pore pressure, indicate about piping progression?
3. What can estimates of hydraulic conductivity, derived from inversion of pore pressure, indicate about the effectiveness of a geotextile to impede piping progression?

Data from the Ijkdijk 2009 test 2 and Ijkdijk 2012 experiments will be used to address these questions. The
Ijkdijk experiments were a series of full scale experiments conducted in the Netherlands to study failure mechanisms of EDLs (Flood Control Ijkdijk, 2016). In 2009 and 2012 experiments were conducted to study piping progression and mitigation of piping progression using a geotextile. During both experiments densely spaced piezometers captured the spatial and temporal changes in pore pressure. Parekh et al. (2016) discussed the changes in observed temporal and spatial pore pressure signatures during these experiments.

To address the first question, a finite element model was created using dimensions and parameters of the Ijkdijk 2009 test 2 experiment (van Beek et al., 2010). Spatial anomalies of high hydraulic conductivity were modeled to mimic a progressing pipe. Calculated spatial and temporal pore pressures were shown to correlate with those observed during the Ijkdijk 2009 experiment, discussed in Bocovich et al. (2017).

Inversion is a method used to estimate unknown parameters from observations connected by a physical relationship, referred to as the forward model. Linear regression is an example of inversion. However, this research inverts pore pressures to estimate hydraulic conductivities in a 3-dimensional finite element model, which is a much more complicated because it is non-linear and non-unique. In order to address these challenges assumptions about piping progression must be included in a more complicated inversion analysis. Once an inversion is tested to understand its capabilities and limitations, spatial pore pressures from consecutive time steps collected during the Ijkdijk 2009 and Ijkdijk 2012 experiments will be inverted to better understand the changes of hydraulic conductivity during piping progression. The Ijkdijk 2009 experiment will provide a better image of how piping progresses in space and in time, while the Ijkdijk 2012 experiment will demonstrate the effectiveness of the geotextile to mitigate piping.

By advancing the use of observations and monitoring data through inverting pore pressure to estimate changes in hydraulic conductivity as piping progresses, this research will improve our understanding of EDL failure due to piping.

References
van Beek, V.M., H. T. J. de Bruijn, J. G. Knoeff, A. Bezuijen, and U. Foster. 2010. “Levee Failure Due to Piping: A Full Scale

Monitoring Water Infrastructure from Space
Sean Salazar, University of Arkansas

The Central Valley, California is home to one of the most productive agricultural regions in the world, providing over half of all the fresh produce and nuts grown in the United States. A network of reservoirs and canals provide irrigation to the valley; however, the water infrastructure continues to be affected by widespread land subsidence that has occurred beginning in the 1920s, due to groundwater extraction. To monitor the rate of ongoing subsidence on a large scale, a stack of 42 radar images spanning from October 2016 to March 2018, gathered from the European Space Agency’s Sentinel-1 satellite mission, were analyzed. The radar images covered an area of 16,000 square miles, focused around the San Joaquin Valley region of the Central Valley, where the worst subsidence is occurring. Using an interferometric synthetic aperture radar (InSAR) persistent scatterer analysis technique, approximately 5 million stable ground targets were tracked over the 1.5-year period to establish a time-series of the surface deformation. Due to the high resolution of the images, critical infrastructure affected by the sinking land, like the Friant-Kern Canal, were able to be identified and quantified in the analysis. Results were shown to correlate well with the findings of a recent NASA Jet Propulsion Laboratory study (Farr et al. 2016), indicating that recent drought had contributed to accelerated subsidence, with unsustainable pumping operations outpacing natural and assisted aquifer recharge.

Reference

Sean Salazar earned his B.S. and M.S. degrees in civil engineering from the University of Arkansas. Sean is in the final year of his Ph.D. program under a National Science Foundation Graduate Research Fellowship. In 2017, Sean spent a year at the Norwegian Geotechnical Institute in Oslo. Following graduation, Sean plans to enter engineering consulting.
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Walter (Pete) Pierce of USACE HQ presented about successful media management (see Figure 1). He stated that when preparing for a media interview, consider: the points you want to make; the topics you want to cover; illustrations you might want to include; and that everything is “on the record.” He described the “27/9/3” format wherein you should limit your discussion of any single topic to 27 words to be stated in 9 seconds in 3 messages. He stated that you should be consistent in your messages, and to repeat them as necessary to get your points across. He related that you should: provide facts but restrict use of technical information; never criticize or speak for another agency/organization/entity; and request assistance from your entity’s public affairs or public information office, if there is one.

Stacy Langsdale of the USACE Institute for Water Resources presented about risk communication, which she defined as open two-way exchange of information and opinion regarding project risk. She noted that risk should be discussed with not only those who are affected by the risk, but also decision makers who can affect the risk. She pointed out that risk can be considered a combination of hazard probability and outrage over consequences, and that outrage can only be tolerated up to a certain point by society. She presented a quadrant diagram of hazard versus outrage, with different communication techniques to use for each quadrant (see Figure 2). She discussed low-stress situations (such as emergency exercises) versus high-stress situations (such as emergency operations). She described the “three M’s of communication” — message, messenger, and media — and that the message should be tailored to the audience.

Chuck Smith of the Sutter County, California, Office of Emergency Management presented about facing “imminent catastrophic failure” at Oroville Dam. He noted that the incident resulted in the largest non-hurricane evacuation in U.S. history despite refusal by many residents to evacuate. He described the incident timeline to express the point of view from the emergency management personnel of a potentially-affected area downstream of the dam. Approximately 188,000 people were ordered to evacuate from the three counties. This resulted in clogging of all main roads; uncertainty over where to evacuate to; and fear of drowning in your vehicle. Some of the lessons learned were that: the county had only one computer-generated emergency announcement, and it did not match the incident (spillway flow only); and better communication needs to occur between the dam owner and the county EMAs.

Jason Needham of the USACE Hydrologic Engineering Center presented about the Oroville Dam warning and evacuation incident. This presentation delved deeper into the details of the delays experienced. He described three types of delays: 1) Warning Delay Time, which is the time between detection of a problem and the decision to provide a warning; 2) Warning Diffusion Time, which is the time between the decision to provide a warning and receipt of the warning by the entity that would take protective action; and 3) Protective Action Initiation Time, which is the time between receipt of the warning by the entity that would take protective action and actual initiation of the protective action. He stated that lessons learned included that: the computer-generated emergency announcement software took 34 minutes to send the evacuation order message to 160 contacts; some downstream counties that were supposed to evacuate were receiving an influx of evacuees from other counties; sleep deprivation of decision makers might have contributed to the delays; communication issues occurred between the dam owner and the county EMAs; and the location of the incident command center had to be moved.

Frank Blackett of the Federal Energy Regulatory Commission presented about additional information on the Oroville Dam incident as well as an update on its remedial construction. He noted that meteorological
assessments have indicated that more Pacific Ocean atmospheric rivers ("Pineapple Express") occurred in the year prior to the spillway incident than in any single year prior. This caused the reservoir level to rise 60 feet by December 2016, an additional 60 feet by January 2017, and an additional 50 feet by February 2017. FERC was allowed full access to the site by the dam owner, the California Department of Water Resources. He related the aspect of the federal regulator during the incident, and noted that a lesson learned by FERC was to consider project component failure and not just failure by uncontrolled release of water. He stated that immediate measures taken following the incident were to remove the 1.8 million cubic yards of material that was eroded from the hillside and deposited in the river, and to add grouted riprap as a temporary protection. The final remediation cost is expected to be at least $800 million. Remediation of the service spillway is being performed in several reaches with different methods in each reach, and the remediated emergency spillway weir will include a roller-compacted concrete (RCC) splashpad.

Jonathon Garton of the Iowa Department of Natural Resources presented a concise version of the forensic effort following the Oroville Dam incident. He stated that FERC required an independent forensic team, and California DWR asked the Association of State Dam Safety Officials and the U.S. Society on Dams (USSD) to select the forensic team. The selected team was led by John France of AECOM. California DWR paid for the forensic effort, but otherwise had no interaction with the team. Mr. Garton related that early indications of concerns with the service spillway chute (as far back as 2006) as well as the lack of performance of a potential failure modes assessment for the spillway (considered in 2014) were due to the ongoing misunderstanding of the spillway foundation geology. DWR memoranda in 2005 and 2009 also stated that the spillway discharge area is competent bedrock and resistant to erosion.

Dusty Myers of the Mississippi Department of Environmental Quality presented about the 2012 incident at Percy Quin Dam. He noted that the state-owned dam is in the southwest portion of Mississippi, and the waterway downstream of the dam drains into Louisiana. This necessitated coordination between the two states during the incident.

Figure 3. Temporary stabilization measures for the Guajataca Dam spillway, which was damaged during Hurricane Irma.

Jose Miguel Bermudez Diaz of the Puerto Rico Electric Power Authority presented on the Guajataca Dam spillway incident. He described the modification history of the dam since its construction in the 1920s, including adding and fortifying a stabilization berm, and replacement of part of the spillway. He related that Hurricane Irma caused the spillway structure to collapse on September 22, 2018, and by September 25, PREPA was concerned about full collapse of the dam. Fortunately, that did not occur. FEMA then assigned USACE to develop and coordinate the implementation of an Interim Risk Reduction Measures Plan.

Dusty Myers of the Mississippi DEQ returned to present about the 2004 failure of Big Bay Dam. He prefaced the presentation by noting that there were no fatalities due to the incident occurring during the daytime as well as due to effective evacuation measures by county EMAs. There had been distress indicators that had not been taken seriously by the dam owner. He described the timeline of the event: a seepage boil was detected by project maintenance personnel on March 11; muddy flow was observed in the stilling basin during the morning of March 12; flow from the boil increased and became turbid by noon; the downstream slope began to erode by 12:30pm; the embankment breached and the conduit moved downstream just after 1pm; the breach widened to about 385 feet by 1:30pm; and the lake was completely drained by 3:40pm. Investigations following the incident noted that: the design had not included a filter drain; seepage into the conduit had been observed in 1995; modifications had been performed on the dam without notifying the Mississippi DEQ; a sinkhole in line with the conduit had been observed in 2001 or 2002; and a sinkhole had also been observed on the upstream face. He stated that it was apparent that this incident was due to internal erosion with a long "continuation" phase and a rapid "progression" phase. He listed lessons learned as: 1) the dam owner did not realize the distress indicators; and 2) inspectors need to be well-trained and informed about previous deficiencies and repairs.

The Technical Seminar concluded with a panel discussion intended for participants to direct any remaining questions to the presenters. Highlights from the discussion were that: inundation mapping needs to include more scenarios in the modeling effort; real-time inundation mapping can assist with emergency operations; and modelers should try to tie the inundation mapping to real-time flow gage data.
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In Memorium

Frank Kresse died April 26, 2018, in Petaluma, California. He enjoyed a 55-year career as an engineering geologist.

Membership Updates

The USSD Board of Directors has approved the following committee appointments:

Advocacy, Communication and Public Awareness — YP Vice Chair Karl Tingwald; Social Media subcommittee — Vice Chair, Merry Dang; YP Vice Chair, Micah Smidt

Dam Decommissioning — YP Vice Chair, Johnathon Atkins

Dam Safety — YP Vice Chair, Mohammad Amin Harir-Ardebili

Foundations — YP Vice Chair, Dmitri Ivanov

ICOLD Congress Papers — Chair, Grady Hillhouse; Vice Chair, Arun Parsons

Tailings Dams — YP Vice Chair, Benjamin Schmidt

Young Professionals — Student Outreach subcommittee — Chair, Rachael Brooks

Education and Training Ad Hoc Committee — Chair, Rodney Eisenbraun

Website Updates

Several updates have been made to ussdams.org:

- Rotator banners on home page updated with important USSD information monthly
- Membership Directory format updated and moved to home page under Membership tab. This change provides increased visibility for USSD members and for those looking for products and services
- Alert box added to notify users of important news
- Current and past monthly E-News emails added under Resource Center tab
- Benefits of membership have been updated

News of Members

Brian M. Crookston, Schnabel Engineering, is a 2018 recipient of the ASDSO Young Professional Award, which recognizes members under 40 years of age working in the dam safety field who have made outstanding contributions to the Association, their respective organization, and/or the dam safety industry in general.

Brian Gettinger has joined Freese and Nichols, Inc. as a Tunneling Services Leader, Southeast Texas region.

Bruce R. Rogers is the Levee Safety Program Manager, USACE, North Atlantic Division.

WSP USA has announced that Douglas Oliver is now mine water services leader, and Zach Youngerman has been named planning and resilience lead for water and environment. Three water and environment experts — James Miller, Rasheed Ahmad and Connor Wraight — have joined the Atlanta office of WSP USA. Elisabetta Natale was selected to join the 2018 class of the Water Leadership Institute, a program of the Water Environment Federation.

Yulia Zakrevskaya is now a Hydraulic Engineer at Stantec in Walnut Creek, California.

Awards Nominations

Nominations will open in January for three annual awards:

- Lifetime Achievement Award
- Excellence in the Constructed Project Award
- Public Safety Recognition

Begin preparing your nominations now!

Dues Notices

For those members with January 1 renewal dates, dues notices have been e-mailed. You may pay online with a credit card, or mail a check.

Board Updates

The following is a partial list of actions taken at the August and October meetings:

- Approval of 2019 annual budget, including 2019 conference registration fees.
- The immediate Past President will now be a non-voting member of the Executive Committee.
- Revisions to the Bylaws and the Operations Manual were approved and are posted on the USSD website, under the "About" tab.
- Charleston, South Carolina has been selected as the site of the 2021 Annual Conference and Exhibition.

Balloting will begin in January for the 2019 Board of Directors.
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