Association of State Dam Safety Officials Annual Conference (Dam Safety 2018)

Seattle, Washington, USA 9 - 13 September 2018

Volume 1 of 2

ISBN: 978-1-5108-7211-0

Printed from e-media with permission by:

Curran Associates, Inc. 57 Morehouse Lane Red Hook, NY 12571



Some format issues inherent in the e-media version may also appear in this print version.

Copyright© (2018) by Association of State Dam Safety Officials All rights reserved.

Printed by Curran Associates, Inc. (2018)

For permission requests, please contact Association of State Dam Safety Officials at the address below.

Association of State Dam Safety Officials 239 S. Limestone Lexington, Kentucky 40508 USA

Phone: 859/550-2788

info@damsafety.org

Additional copies of this publication are available from:

Curran Associates, Inc. 57 Morehouse Lane Red Hook, NY 12571 USA Phone: 845-758-0400 Fax: 845-758-2633 Email: curran@proceedings.com Web: www.proceedings.com

Table of Contents

MONDAY, SEPTEMBER 10

Opening General Session

90th Anniversary of the St. Francis Dam Failure: Lessons Learned, and Still to be Learned1 Nathaniel Gee, P.E., Group Manager, Bureau of Reclamation; Jon Wilkman, Wilkman Productions, Inc., and Irfan Alvi, President and Chief Engineer, Alvi Associates

Concurrent Session: 1 - Communications (Communicating with Non-Engineers)

What was the Value of Flood Control during Last Week's Storm? Use the New NRCS Watershed Benefits Model to Find Out3 Larry Caldwell, P.E., Watershed Specialist (Retired), Gary Utley, P.E., Hydraulic Engineer, and Jim Henley, GIS Specialist (Retired), USDA – NRCS

An Improved Approach to Explaining Dam Breach Information to First Responders22 Benjamin Israel-Devadason, Senior Hydraulic and Hydrologic Engineer, and Paul Schweiger, Vice President, Gannett Fleming, Inc.

Dam Ownership Risks and Burdens: Raising Public Awareness through Educating Real Estate Agents23 Emma Moradi, Staff Engineer, and Yohanes Sugeng, Engineering Manager, OK Water Resources Board

Concurrent Session: 2 - Seepage

First secant pile dam repair in Sweden30 Ingvar Ekström, Project Manager, and Magnus Ljunggren, Project Manager, Sweco Energuide

Considerations for Embankment Dam Toe Drain Design: An Inspection and Maintenance Perspective47 Brian Hart, Resource Group Supervisor, Grand Coulee Power Office, Mike Freeman, Civil Engineer, Provo Area Office, Ryan Proctor, Supervisor, Force Account, Provo Area Office, and Nathan Lowe, Civil Engineer, Great Plains Regional Office, Bureau of Reclamation; and Mark Pabst, Private Consultant

Oroville Dam Vegetated Area Study77 Ryan Matthew Abernathy, Water Resources Engineer, CA Department of Water Resources; and Les F. Harder, Jr., Senior Professional Associate, HDR

Concurrent Session: 3 - Hydrologic Modeling

Risk-Based Forecasting to Support Operational Decision Making in the Eastern Sierras95 Nicole Novembre, President, Brava Engineering; Bruce Barker, Principal Engineer, MGS Engineering; Jason Caldwell, Principal Hydrometeorologist, Weather & Water, Inc.; Blake Allen, Meteorological Programmer, MetStat, Inc.; and Matthew Muto, Senior Dam Safety Engineer, and John Dong, Dam Safety Engineer, Southern California Edison

SSPMP, RIDM, Climate Uncertainty, and U.S.96 Michael McMahon, Senior Hydro-meteorologist/Climate and Resiliency Lead, HDR

Using a Distributed Hydrologic Model for a Dam Safety Study in a Small Ungauged Basin97 Chandler S. Engel, Research Civil Engineer, Meghan C. Quinn, Research Geotechnical Engineer, Shaun R. Stanton, and Jeffery D. Ellis, US Army Engineer Research and Development Center (ERDC)

NRCS-DamWatch, Lessons Learned and Looking Ahead117

Stephen Durgin, P.E., National Design Engineer, and Larry Caldwell, P.E., Earth Team Volunteer (Retired), USDA – NRCS; and Joseph Scannell, President/CEO, USES Corp.

Concurrent Session: 4 - Concrete Arch Dams

Methods to Better Understand Seismic Behavior of Concrete Arch Dams136 Aimee Laura Corn, Civil/Structural Engineer, and Guy S. Lund, Principal Engineer, Gannett Fleming, Inc.; and Erin K. Gleason, Dam Safety Engineer, and Darren Brinker, Engineering Manager - Dam Safety, Denver Water

In Situ Stress Measurements and Instrumentation Installation – Duke Energy Walters Dam, Waynesville, North Carolina150

Andy Shaffer, Associate & Field Services Manager, Leo J. Gilbride, P.E., P.Eng., Vice President and Principal, Erik Hemstad, Senior Engineer, and Benjamin Haveman, Rock Mechanics Technician, Agapito Associates, Inc.; Clinton Forsha, P.E., PMP, Geotechnical Engineer, HDR of the Carolinas; and Brad Keaton, P.E., Chief Dam Safety Engineer, Duke Energy Carolinas, LLC

Waterproofing a Multiple Arch Dam in a Cold Mountainous Environment with PVC Geocomposite Membrane163

John Wilkes, P.E., President, and Bobby Blankinship, P.E., Engineer, Carpi USA, Inc.; Bahram Safavi, Ph.D., P.E., Dam & Public Safety Manager, Jennifer Fernandez, Senior Project Manager, and Nicolas von Gersdorff, P.E., Chief Dam Safety Engineer, Southern California Edison

Concurrent Session: 5 - Seismic Issues

Seismic Evaluation of Gatun Dam - Panama Canal174

Lelio Mejia, Geosyntec Consultants; Maximiliano De Puy and Antonio Abrego, Panama Canal Authority; and Erik Newman and Rajendram Arulnathan, AECOM

A Centrifuge Study on the Effects of Soil Gradation on Liquefaction Potential and Dynamic Response188 Alexander Sturm, Graduate Student, Gregory Shepard, Graduate Student, Jason DeJong, Professor, and Dan Wilson, Associate Director of the Center for Geotechnical Modelling, University of California, Davis

Case Studies of the Seismic Performance of Levee Segments on Peat Foundation Soil198 Yi Tyan Tsai, Student, Scott Brandenberg, Professor, and Jonathan Stewart, Professor, University of California - Los Angeles; and Atsushi Mikami, Professor, Tokai University

Concurrent Session: 6 - Big Data

One Hurricane After Another.... So, Are My Dams OK? – Rapid Assessment of Potential Dam Failures in Puerto Rico following Hurricanes Irma and Maria199

Jonathan Keeling, P.E., CFM, Senior Dam Safety Engineer, Stantec Consulting Services Inc. (part of STARR II); Edward Beadenkopf, Principal Project Director/Vice President, ATKINS (part of STARR II); Alan Springett, Senior Engineer, Risk Assessment Lead, James Demby, Jr., P.E., Senior Technical and Policy Advisor, National Dam Safety Program, and Shudipto Rahman, Civil Engineer, Risk Analysis Branch, Federal Emergency Management Agency

The Power of GIS in the Regulation of Dams200

Dusty Myers, P.E., Chief, Dam Safety Division, and Josh Watts, GIS Analyst, MS Department of Environmental Quality

The Big Year - 2,000 Dam Inspections Later!201

Stephen L. Whiteside, P.E., Vice President, Patterson X. Gambill, P.E., Danielle K. Neamtu, P.E., and John D. Boyer, P.E., CDM Smith; and John M. McCain, Manager, Dam Safety Program, SC Department of Health and Environmental Control

Digitizing field data collection and facilitating inspections – our experience218 Emma Hill, Geological Engineer, and Prabeen Joshi, Geotechnical Engineer, Klohn Crippen Berger

Concurrent Session: 7 - Breach Modeling

A Comprehensive Approach to Inundation Analysis for the Baker River Hydroelectric Project224 Kevin J. Ruswick, P.E., CFM, Senior Associate, Alex Rutledge, P.G., P.E., Associate, Loring W. Crowley, Project Engineer, and Ali Tabrizi, Ph.D., Senior Staff Professional, Schnabel Engineering; and Joshua Gile, EIT, Senior Engineer Puget Sound Energy

Cost Effective Evacuation Mapping: DSS-WISE Vs. HEC-RAS 2D; When to go the Extra Mile225 Chadrick Douglas Hill, Civil Engineering Specialist, Marc E. Pitman, P.E., Civil Engineering Specialist, and Mike Mahowald, Civil Engineering Specialist, MT Department of Natural Resources & Conservation

Concepts for Probabilistic Dam Breach Modeling241 Christopher Goodell, Principal Consultant, Kleinschmidt Associates

Concurrent Session: 8 - National Levee Program Update

What we know today about our nations levees: The Levee Portfolio Report242 Eric C. Halpin, P.E., Deputy DSO/LSO, US Army Corps of Engineers

Status of Inventory and Review Activities with Non-federal Levee Systems251 Jamie L. McVicker, P.E., Levee Safety Program Manager, US Army Corps of Engineers

The Challenges of Non-Program Levees252

Andrew J. Orlovsky, P.E., Civil Engineer Manager, PA Department of Environmental Protection; and Almur S. Whiting IV, P.E., Dam Safety Program Manager, US Army Corps of Engineers

Federal Levee Safety Guidelines260 Noah D. Vroman, P.E., Director - Levee Safety Production Center, and Michael K. Sharp, Ph.D., P.E., US Army Corps of Engineers

TUESDAY, SEPTEMBER 11

General Session

Discussion of Lessons to be Learned from the 2017 Oroville Dam Spillway Incident261 Moderated by John W France, P.E.

- Ted E. Craddock, P.E., California Department of Water Resources, O&M Division
- David E. Capka, Federal Energy Regulatory Commission
- Sharon K. Tapia, P.E., California Division of Safety of Dams
- Roger L. Raeburn, Pacificorp
- Bill McCormick, P.E., P.G., Colorado State Engineer's Office
- Darren Brinker, P.E., Denver Water

Concurrent Session: 9 - Spillway Condition Assessment

Observations and Lessons Learned from FERC's Spillway Inspection Initiative262 Douglas Johnson, Regional Engineer, Portland Office, Justin Nettle, Senior Engineer, and Eric Kennedy, Senior Engineer, Federal Energy Regulatory Commission

Observed Trends during Spillway Assessments271

Katherine Maher, Project Engineer, Cory Miyamoto, Project Engineer, and David Gutierrez, Senior Geotechnical and Water Resources Engineer, GEI Consultants, Inc.

Iron Gate Stilling Basin Rehabilitation278

Kelcy T. Adamec, Civil Engineer, Federal Energy Regulatory Commission; and Nathan Higa, Civil Engineer, and Roger L. Raeburn, Chief Dam Safety Engineer, PacifiCorp

Concurrent Session: 10 - Levees

Use of Fat Clays in Design of Levees286

Ray E. Martin, Owner, REM, LLC; George Sills, Manager, George Sills Geotechnical Engineering Consultant, LLC; and David Williams, President, David T. Williams and Associates

Deformation-based versus Limit Equilibrium Analyses to Assess the Effect of Repeated Rise and Fall of Water Level on the Stability of Princeville Levee299 Rowshon Jadid, Graduate Student, Brina Montoya, Assistant Professor, and Mo Gabr, Professor, North

Carolina State University; and Victoria Bennett, Assistant Professor, Rensselaer Polytechnic Institute

Applying New Probabilistic Framework to Capture Extreme Uncertainty in Risk Management for Levee System Safety307 Azadeh Mostofi, PhD Candidate, University of Texas at Austin

Concurrent Session: 11 - Post Tensioning

Installation and Verification Monitoring of High Capacity Multi-Strand Tendons for Dam Anchoring318 Mark Sinclair, Manager Engineering & Technical, Traylor SRG LLC

Post-Tensioned Anchor Load Distribution for Gated-Spillway Lift Joint Stabilization335 Matthew W. Drewek, Ph.D., P.E., Senior Structural Engineer, and William H. Walton, P.E., S.E., F.ASCE, D.GE, Vice President / Senior Practice Leader, GEI Consultants, Inc.; and David R. Tripp, P.E., Dam Safety Engineer / Generation Engineer, Upper Peninsula Power Company

3D Geologic Modeling and Probabilistic Stability Analyses Support a Rock Face Stabilization Project at Boundary Dam, Pend Oreille River, Washington State342

Robert Cannon, P.G., Senior Vice President, Frederic Snider, P.G., Associate Scientist, Alex Rutledge, P.G., P.E., Associate Scientist, and John Gagnon, P.G., Senior Staff Scientist, Schnabel Engineering; and Andre Ball, P.E., Dam Safety Engineer, and Kimberly Pate, P.G., P.E., Chief Dam Safety Engineer, Seattle City Light

Concurrent Session: 12 - Don't Just Sit There! Let's Talk About Dam Security

Research Update on Dams Sector Topics: Following the Trail of Innovation.....355 Yazmin Seda-Sanabria, Program Manager, Critical Infrastructure Protection and Resilience Program, and Michael K. Sharp, Ph.D., Technical Director for Civil Works Infrastructure, U.S. Army Engineer Research and Development Center Dam-Induced Flooding: Scenarios, Consequences, and Difficult Choices for NRCS Dam Rehabilitation Projects356 Stephen Durgin, P.E., National Design Engineer, USDA – NRCS

WinDAM, A Dam Safety Engineering Tool for Breach and Non-Breach Flood Events357 Sherry L. Hunt, Research Leader and Research Civil Engineer (Hydr), Darrel M. Temple, Research Leader (Retired), and Ronald D. Tejral, Agricultural Engineer, USDA - ARS; Stephen Durgin, P.E., National Design Engineer, and Karl Visser, Civil Engineer (Hydr), USDA - NRCS; and Abdelfatah Ali, Post-doctoral Research Associate, ORISE/ORAU

Innovation in Colorado: High Hazard Dam Release - Downstream Floodplain Impacts Database and Tools360 Amanda J. Hess, H&H Group Manager, Gannett Fleming, Inc.; and Bill McCormick, Chief, Dam Safety, and Kallie Bauer, Dam Safety Engineer, CO Division of Water Resources

Concurrent Session: 14 - Geologic Issues

Assessment of Rock Mass Failure Modes Related to Block 18/19 Movement, Upper Baker Dam, Puget Sound Energy366

Rex Whistler, Geological Engineer, Robert Clark, Senior Associate Civil Engineer, and Will Hultman, Vice President, Geological Engineer, Shannon & Wilson, Inc.; and Robert Romocki, Chief Dam Safety Engineer, Puget Sound Energy

Geologic and Geotechnical Considerations for Condition Assessments of Unlined Granitic Spillways in the Sierra Nevada, California368

Robert A. McManus, Principal Geotechnical Engineer, PG&E; and Drew Kennedy, Principal Geologist, SAGE Engineers, Inc.

3D Geological Modeling as a Tool for Evaluating Dam Foundations391 Cameron Bartsch, P.Geol, Structural Geologist, Terrane Geoscience Inc.; Robert Romocki, Chief Dam Safety Engineer, Puget Sound Energy; Todd R. Kincaid, Ph.D., Hydrogeologist, GeoHydros; and William Hultman, P.E., Vice President, Shannon & Wilson Inc.

Concurrent Session: 15 - Applying Practical Knowledge/Lessons Learned

Colorado's Comprehensive Dam Safety Evaluation process uncovers long history of dam safety concerns and prompts immediate action at Marshall Lake Dam.....392 Ryan Schoolmeesters, P.E., Dam Safety Engineer, and John Hunyadi, P.E., Dam Safety Engineer, CO Division of Water Resources

Practical Experience with Development and Implementation of Effective Construction Monitoring Plans415 Joseph Kudritz, P.E., Water Resource Engineer, Brian Afek, P.E., Project Manager, and Jacob Bench, E.I., Civil Associate, Michael Baker International

A Review of the Historical Design of Concrete Dams Holding the Middle Third424 Kevin Griebenow, Civil Engineer, Federal Energy Regulatory Commission

Concurrent Session: 16 - Risk

How Joining Asset and Dam Safety Risks Provides Greater Insight into Management Decisions -Assessment of Nine Dams on the Waikato River, New Zealand437 M. Jonathan Harris, National Practice Leader for Dam Safety and Risk, Schnabel Engineering; Will Oxley, Strategic Asset Planner, Mercury; and Murray Gillon, Senior Consulting Engineer, Damwatch Engineering Ltd.

Third Time's the Charm: South Carolina's Dam Safety Program's experience with Hurricane Irma, the state's third significant storm event in three years.443 Jill Stewart, P.E., Director, Dam Safety and Stormwater Permitting Division, John McCain, P.E., Manager, Dam Safety Section, and Shawn Frazer, Associate Engineer, SC Department of Health and Environmental Control

Inches of Flood Risk Reduction, Miles of Community Benefits – Balancing Goals & Interests Through a String of Dam Removal Projects on the Pawcatuck River444 Nils S. Wiberg, P.E., CFM, Associate/Chief Water Resources Engineer, Fuss & O'Neill, Inc.

Concurrent Session: 17 - Decade Dam Failures Part One

110th Anniversary of Hauser Dam Failure, Montana.....476 Stephen Durgin, P.E., National Design Engineer, USDA – NRCS

A Review of the September 23, 1938 Fort Peck Dam Construction Slide477 Charles Redlinger, Senior Geotechnical Engineer, and Laila Berre, Dam Safety Program Manager, Northwest Division, US Army Corps of Engineers; and Keith Ferguson, Vice-President, HDR

Hold Back The Dam, Boys! -The Story of the Minnedosa Spillway Failure495 Jonathan Pittman, P.E., Senior Associate, Schnabel Engineering

Concurrent Session: 18 - Get Out! - CS18

Is It Time to Update Federal Guidelines for Dam Safety, FEMA 64 EAPs503 Robert Beduhn, Director, Dams, Levees and Civil Works, HDR

The Human Element: Warning and Evacuation During the Oroville Dam Incident504 Gregory Richards, P.E., CFM, Project Engineer, and Jesse Pope, P.E., CFM, Hydraulic & Hydrologic Engineer, Gannett Fleming, Inc.; and Jason T. Needham, Consequence Specialist, US Army Corps of Engineers

A Comparison of Risk and Resilience Interpretations of the Crisis at Oroville514 Lucien Hollins, Undergraduate Researcher, Daniel Eisenberg, Ph.D., and Thomas Seager, Associate Professor, Arizona State University

Concurrent Session: 19 - Hydrology/PMP - CS19

My 23-year Perspective of PMP and Precipitation Frequency Estimates for Dam Safety Applications in the United States527

Tye W. Parzybok, President/CEO and Chief Meteorologist, MetStat, Inc.

Hydrologic Analysis Used to Update the Rainfall from the July 1942 "Smethport" Storm-Important Applications for Dam Safety and Design533

Bill Kappel, President/Chief Meteorologist, and Doug Hultstrand, Senior Hydrometerologist, Applied Weather Associates; and Joe Bellini and Peter Masopust, Aterra Solutions

Uncertainty in Hydrologic Estimates547 Arthur C. Miller, Science Practice Leader, AECOM

Concurrent Session: 20 - Seepage and Grouting

A DAM Innovative Solution: Cutoff Walls and Pressure Grouting at Georgia's Richland Creek Dam564 Brian D. Barkauskas, P.E., Business Development Director, Raphael Delhaye, Assistant Project Manager, and Eloy Ramos, P.E., Project Manager, Nicholson Construction Company; and H. Craig Robinson, P.E., Piedmont Geotechnical Consultants

Grouting in Dams and Levees: The Fundamentals575 Dr. Donald A. Bruce, President, Geosystems, L.P.

Using Technology to Better Understand Seepage at the Laurel Bed Dam in Virginia585 Thomas I. Roberts P.E., C.F.M, Regional Dam Safety Engineer, VA Department of Conservation and Recreation; Don Sipher, P.E., F.A.C.E.C., President, Froehling & Robertson, Inc.; Ryan Blanchard, Vice President of Business Development, Keith Wall, Director of Business Development, and David Bierman, Staff Geophysicist, Willowstick Technologies

WEDNESDAY, SEPTEMBER 12

Concurrent Session: 21 - Public Safety and Outreach

Low Head Dams - Addressing Safety AT Dams594 Manuela Johnson, State of Indiana Silver Jackets Lead, Indiana Department of Homeland Security

How Multiple Dam Table Top Exercises is a Win-Win Situation595 Natalie Rogers, P.E., CFM, Water Resources Engineer, and Marc Johnson, P.E., CFM, Principal Water Resources Engineer, FTN Associates Ltd. Implications of updating inundation mapping for use in Emergency Action Plans: Sutherlin Dams600 Edward George Robison, Senior Project Manager, and Nathan Cox, Hydraulic Engineer, McMillen Jacobs Associates; and Meghan Walter, State Hydraulic Engineer – Oregon, USDA - NRCS

Concurrent Session: 22 - Spillway Rehabs

The Floating Bulkhead: A Practical, Flexible, and Economical Approach to Dewatering Gates607 Christopher T. Goodwin, P.E., Water Resources Manager, and Todd M. Rudolph, Water Resources Engineer, Ayres Associates

Lake Delhi Dam Reconstruction – A Good Dam Story616 William Holman, Senior Project Manager, Stanley Consultants, Inc.

Fine Tuning a Piano Key Weir617 Randall P. Bass, P.E., Principal, Schnabel Engineering LLC

Concurrent Session: 23 - Internal Erosion

Hyatt Dam - Challenges of Modifying a 96-Year Old Embankment Dam to Address Internal Erosion Risk.....636 Elizabeth Ouellette, P.E., Geotechnical Engineer, Brandt Demars, P.E., Regional Construction Engineer, and Tara Schenk McFarland, P.E., Program Manager, Bureau of Reclamation

Embankment Breach Research: Observed Internal Erosion Processes653 Abdelfatah K. Ali, Post-doctoral Research Associate, ORISE/ORAU; Sherry L. Hunt, Research Leader and Research Civil Engineer, Ronald D. Tejral, Agricultural Engineer, and Darrel M. Temple, Research Leader (Retired), USDA - ARS

Concurrent Session: 24 - PMP

Use of Stochastic Storm Transposition Methods for Developing the PMF for FERC-regulated Bear River, Utah Hydroelectric Project657

Alyssa Hendricks Dietrich, Senior Hydrometeorologist, Victoria Sankovich Bahls, Senior Hydrometeorologist, and Tye Parzybok, President/CEO, Chief Meteorologist, MetStat, Inc.; Christopher Bahner, WEST Consultants, Inc.; and Roger Raeburn, Chief Dam Safety Engineer, PacifiCorp

Temporal Distribution of Probable Maximum Precipitation669 Joseph Wilson, Civil Engineer, Dam and Reservoir Safety Program, MO Department of Natural Resources

Updating PMP Analysis Through Collaboration-The Colorado-New Mexico Regional Extreme Precipitation Analysis, Setting a new Standard of Practice.....670 Bill Kappel, President/Chief Meteorologist, Doug Hultstrand, Senior Hydrometeorologist, and Geoff Muhlestein, Senior GIS Analyst, Applied Weather Associates

Concurrent Session: 25 - Spillway Assessment

"You Don't Know What You Don't Know" - Inspecting Spillways and Assessing Potential Failure Modes671 Paul Schweiger, Vice President, Manager of Dams and Hydraulics Section, and Robert A. Kline, Vice President, Gannett Fleming, Inc.

Application of a Systematic Integrated Framework for Spillway Inspection and Assessment672 Ali Reza Firoozfar, Hydraulic Engineer, Kenwarjit S. Dosanjh, Hydraulic Structures Section Manager, Keith C. Moen, Northwest Hydropower Engineering Manager, Edwin T. Zapel, Dam, Hydro, Civil Works, Hydraulic Design Lead, and William R. Fiedler, Dam Safety/Risk Senior Technical Advisor, HDR

Folsom Dam Auxiliary Spillway and Oroville Flood Control Outlet Spillway – How the Offspring Differs from the Parent678

Cecily M. Nolan, P.E., Civil / Structural Engineer, Ethan Thompson, P.E., Lead Hydraulic Engineer, Kenneth R. Pattermann, P.E., G.E., Geotechnical Engineer, and Michele K. Louie, P.E., Civil / Structural Engineer, US Army Corps of Engineers; and Nathan C. Cox, P.E., Hydraulic Engineer, McMillen Jacobs Associates

Concurrent Session: 26 - Levees

Zero to Thirty in Sixty Days - Critical Levee Repair Sites Rehabilitation Effort, Central Valley, California698 Richard Millet, P.E., G.E., Vice President, Water Resources, Rob Nixon, P.E., G.E., Loren Murray, P.E., and Armando Lopez, Project Manager/Construction Manager, AECOM; Kent Zenobia, P.E., Supervising Engineer Specialist, Division of Flood Management, and David Wheeldon, P.E., Supervising Engineer, Division of Flood Management, CA Department of Water Resources

Where's the Risk? An Analysis of the Sacramento-San Joaquin Delta Levee Risks708 Hollie Ellis, Senior Vice President, Shannon & Wilson, Inc.; Larry Roth, ARCADIS; and Erin Mullin, P.E., Delta Stewardship Council

Hurricane Harvey: analyzing and preventing floods inside a levee720 Phil Martin, Asst. General Manager, Fort Bend County Levee Improvement District No. 2

Concurrent Session: 27 - Monitoring and Inspection

Scanning Sonar Applications for Dam Inspections and Bathymetric Surveys721 Tracy B. Vermeyen, Hydraulic Engineer, Bureau of Reclamation

Dam Drone Inspections – Low Cost, High Value Data The New Exchequer Dam Story727 George Meister, P.E., Senior Engineer/UAS Coordinator, and Chad Masching, P.E., Senior Engineer, GEI Consultants, Inc.

Preserving Instrumentation at New Waddell Dam.....731 Aaron L. Ashcroft, Sr. Civil Engineer, Reliability, Central Arizona Project

Concurrent Session: 28 - Cracking and Blasting

Designing Geotextiles to Span Open Cracks in Embankments733 Benjamin C. Doerge, Geotechnical Engineer, M & E Consultants/USDA - NRCS (Retired); and Karl K. Visser, Hydraulic Engineer, USDA – NRCS

Will My Filter Crack? Testing 1, 2, 3. Evaluation of the Suitability of Sand Material for Filters in Dams749 Daniel Frechette, Principal Geotechnical Engineer, Wood Environment & Infrastructure Solutions, Inc.; and Stephen Brown, Senior Geotechnical Engineer, Flood Control District of Maricopa County - Dam Safety Branch

Criteria for Controlled Close Proximity Blasting at the Oroville Dam Spillways and Flood Control Structure768 John Lemke, President, Geodaq, Inc.; Mike Driller, Mark Schultz, Supervising Engineer, Division of Safety of Dams, and Amin Islam, Engineer, CA Department of Water Resources; and Gordon Revey, Revey Associates Inc.

Concurrent Session: 29 - Soapbox Session: Toward Industry-Wide Use of Best Technical Practices780 Facilitated by: Mark E. Baker, P.E., Dam and Levee Safety Officer, National Park Service

Concurrent Session: 30 - Zoned Embankments and Deformation

Use of FLAC Modeling and Other Factors for Assessing Operational Risk at Ritschard Dam781 Don Meyer, P.E., Senior Water Resources Engineer, and Ray Tenney, P.E., Deputy Chief Engineer, Colorado River Water Conservation District; and Tiffany Adams, Ph.D.., P.E., Geotechnical Engineer, AECOM

Design of a High Hydraulic Asphalt Core Rockfill Dam for Colorado.....798

Donald Montgomery, Principal Engineer, Taylor Scott, P.E., Civil Engineer, and Dr. Christine Weber, Senior Associate, Stantec; and Joe Donnelly, Project Manager - Water Resource Engineer, Northern Colorado Water Conservancy District

Evaluation of Liquefaction Resistance of Gravelly Soil Using the Dynamic Cone Penetrometer818 Kyle M. Rollins, Professor, and T. Leslie Youd, Professor Emeritus, Brigham Young University; and Michael Talbot, Project Engineer, US Bureau of Reclamation

Concurrent Session: 31 - Risk and Hydrology

Risk-Informed Hydrologic Design using Stochastic Models.....835 Joseph Wright, Supervisory Hydraulic Engineer, and Amanda Stone, Hydrologic Engineer, Bureau of Reclamation, Technical Services Center

Improving Watershed Precipitation Frequency Estimates for Risk-Informed Decision-Making836 Debbie Martin, Senior Hydrometeorologist, Katie Ward, Senior Meteorologist, and Jason Caldwell, Chief Hydrometeorologist, MetStat, Inc.; and Mel Schaefer, MGS Engineering Consultants, Inc.

Concurrent Session: 32 - Decade Dam Failures Part Two

70th Anniversary of the Columbia River Dike Failure837 Stephen Durgin, P.E., National Design Engineer, USDA – NRCS

The Mud Pond / Lake Lee Dam Failures – A Story of Mistakes in Two Centuries838 R. Lee Wooten, P.E., Principal, GEI Consultants, Inc.; William C. Salomaa, Director, Paul Marinelli, P.E., Dam Safety Engineer, and Edward M. Connor, Dam Safety Engineer, Office of Dam Safety, MA Department of Conservation and Recreation; and Alon Dominitz, P.E., Section Chief – Dam Safety, NY Department of Environmental Conservation;

40th Anniversary of the Palagnedra Dam Failure863

Alon Dominitz, P.E., Chief, NY Department of Environmental Conservation; and Johnathon Atkins, Dam Safety Division, MS Department of Environmental Quality

See What's New at DamFailures.org!871 Gregory Richards, P.E., CFM, ASDSO DamFailures.org Subcommittee Chair, Gannett Fleming, Inc.

Concurrent Session: 33 - Regulatory Guidance

Environmental Consequence Classification of Mine Dam Failures: Updating the Canadian Classification System872

Lee Nikl, Principal/Senior Environmental Scientist, and Julia Steele, Golder Associates Ltd.; Lindsay Robertson, Klohn Crippen Berger; Scott Davidson, New Gold Inc.; and Rob Schryburt, Ontario Ministry of Natural Resources and Forestry

Introducing NRCS Design Guidance for Articulated Concrete Block Armored Spillways884 Jon Fripp, Stream Mechanics Civil Engineer, Karl Visser, Hydraulic Engineer, and Stephen Durgin, P.E., National Design Engineer, USDA-NRCS

FEMA Public Assistance (PA) Disaster Funding for Dams885 Preston W. Wilson, Civil Engineer, and Lujuana Richardson, Section Chief, Federal Emergency Management Agency

Concurrent Session: 34 - Hydraulic Modeling

Physical Modeling of Air Demand at Cedar Cliff Dam Using 1:8 and 1:19 Scale Models900 Dan Gessler, Vice President, Andy Johansson, Director, Hydraulic Modeling, and Chris Miller, Engineer II, Alden Research Laboratory, Inc.; John Eddy, PMC Hydro Program Engineer, and Brad Keaton, Chief Dam Safety Engineer, Duke Energy; and Hasan Kocahan, Manager, Hydroplus Inc.

What Happens When Spillway Gates Can't be Opened910

Damian M. Gomez, Water Resources Engineer, and Kevin Miller, Civil/Water Resources Engineer, Gomez and Sullivan Engineers, DPC

Quantification and Mitigation of Uplift on a Non-Ogee Shaped Spillway Crest: Numerical and Physical Hydraulic Modeling of Mathis Dam921

Joe Orlins, Director, Hydraulic Modeling and Consulting, Zach Taylor, and Dan Gessler, Vice President, Alden Research Laboratory, Inc.; and Todd Barber, Senior Engineer – SCG Hydro Services, Southern Company

Posters & Lightning Talks

Critical Infrastructure and Flood Risk Management Innovation for Dam Safety Monitoring922 Glen Alexander, Dam Safety and Floodplain Compliance Supervisor, Kentucky Division of Water; and Katherine Osborne, Project Manager, Stantec

20th Anniversary of the Archusa Dam Failure923 Johnathon Atkins, E.I.T, MS Department of Environmental Quality

Probabilistic Flood Hazard Assessment for Risk Analysis of a Rockfill Dam using SEFM924 Bruce Barker, Principal, MGS Engineering Consultants, Inc.; Matthew Muto and John Dong, Southern California Edison; Jason Caldwell and Katie Ward, MetStat, Inc; and Nicole Novembre, Brava Engineering

Electric Lake Dam – Physical Modeling of the Morning Glory Outlet Works937 Kirsten Blezy, P.Eng, Hydraulic Engineer, and Brian Hughes, P.Eng., Principal, Northwest Hydraulic Consultants Ltd.; and Roger Raeburn, P.E., Chief Dam Safety Engineer, PacifiCorp

Use of Fragility Analyses on Dams for use in Informing Design952 Michael Boone, Geotechnical Engineer, Black & Veatch; and Alidad Hashemi, Structural Engineer, Bechtel Corporation

Eastvale Dam Emergency Repair: A Collaborative Approach953 Jared Deible, Technical Manager, Pete Logsdon, Civil Engineer, and Scott Zang, Technical Expert -Geotechnical, Michael Baker International; and Jonathan Conville, Acting Chief of Dam Safety, PA Department of Environmental Protection

Lessons Learned from Over 53 NRCS Dam Breach Analyses Using HEC-RAS 2D954 Sunit Deo, Senior Water Resources Engineer, and Kelley Rich, Water Resources Engineer, HDR

The use of 2D High-Resolution Dam Break Flood Maps on the Implementation of Emergency Action Plans956 Reinaldo Garcia, Director of Model Development and Applications, Hydronia LLC; and Pully Torres and Rafael Rosa, Torres-Rosa Consulting Engineers

Inexpensive Model Dam Building Provides a Wealth of Firsthand Experience968 Megan G. Garrett, P.G., Dam Safety Program Manager, and Thomas Child, P.E., Civil Engineer, US Army Corps of Engineers

Trunnion Transition Plate Modeling Techniques and the Resulting Strut Behavior in Radial Gate Finite Element Analyses974

Kevin Gerst and Christopher Buller, Peterson Brustad Inc.; and Roger Raeburn, Chief Dam Safety Engineer, PacifiCorp

A Review of the Historical Design of Concrete Dams Holding the Middle ThirdN/A Kevin Griebenow, Civil Engineer, Federal Energy Regulatory Commission

Assessment of Potential Tree Root Impacts on the 2017 Oroville Dam Spillway Incident986 Leslie F. Harder, Senior Professional Associate, HDR Geotechnical Applications of Unmanned Aerial System Surveys for Inspection and Investigation1032 Michael Hughes, Senior Project Manager, Ty Moyer, Commercial UAS Director, and Rob Nixon, Senior Project Manager, AECOM

Labyrinth Weir Foundation Design on Highly Expansive Soil1043 Shawn Hutcherson, Geotechnical Engineer, Marc T. Miller, and Dustin Mortensen, Freese and Nichols, Inc.

Harris County Flood Control District (HCFCD) Disaster Recovery Program1044 Kevin Kiniry, Engineer, and Rolando Ayala, Engineer, Freese and Nichols, Inc.; Alan Black, Director of Engineering Division, and Jason Brock, Director of Maintenance Engineering, Harris County Flood Control District; and Chris Fenner, Vice President, Stuart Consulting Group, Inc.

Lower Baker Dam – 2: Evaluating Erodibility, Mitigating Leakage, and Addressing Potential Failure Modes at a Concrete Arch Dam through Groundwater Modeling1053 Todd Kincaid, Ph.D., President, GeoHydros, LLC; Robert Romocki, Chief Dam Safety Engineer, Puget Sound Energy; Brent Meyer, Hydrogeologist, EA Engineering, Science, and Technology, Inc., PBC; George Annandale, Dr.-Ing, P.E., Consultant, George W. Annandale, Inc.; Henry Falvey, Dr.- Ing, President, Henry

Modernization of a Dam Safety Inspection and Instrumentation Program1067 Benjamin Phillips, Dam Safety Civil Inspection Engineer, Tennessee Valley Authority,

T. Falvey & Associates, Inc.; and William Hultman, P.E., Vice President, Shannon & Wilson, Inc.

Opportunity to Restore Fish Passage at a Small Coastal Dam1068 Matthew Prociv, P.E., Civil Engineer, HDR; and Darrin Raines, CityAdministrator, City of Cosmopolis

New Case Studies with Texas' New PMP Tool - Small and Large Dam Watersheds, Comparisons to HMR 51/52, and Dilemmas1069

Kelley Rich, Water Resources Engineer, Cris Parker, Senior Water Resources Engineer, and Sunit Deo, Senior Water Resources Engineer, HDR

Uncertainty Analysis of Dam Breach Flooding Extents Using FEMA DSS-WISE Lite1071 Hui-Ming (Max) Shih, Senior Water Resource Engineer, CDM Smith; and Charles Thompson, Bureau Chief, and James D. Head, Dam Safety Engineer, NM Office of the State Engineer, Dam Safety Bureau

Zoned Earthen Embankment Dam Construction Techniques and Approaches1079 Benjamin Toby Sisco, Project Engineer, EIT, Phillips & Jordan, Inc.

Hard Rock vs. Heavy Metal – an Innovative Sediment Bypass Tunnel Armoring Solution1080 Richard E. Smith, Dam Safety Program Manager, and Ellen Engberg, Civil Engineer, US Army Corps of Engineers; and Terry Gilliland, Senior Project Manager, Garney Companies, Inc.

The influence of the reservoir geometry input approach on the dam breach outflow hydrograph La Plata Dam Breach Analysis, Toa Alta, PR1081

Pully A. Torres, Co-Founder, and Rafael Rosa, Co-Founder, Torres-Rosa Consulting Engineers, PSC

Striking a Better Balance: Value Engineering of Native American Dams Throughout the U.S.1082 Matthew Young, P.E., CFM, Safety of Dams Engineer, Flood Hydrology Coordinator, and Lee Mauney, P.E., CFM, Safety of Dams Engineer, Early Warning Systems Coordinator, U.S. Bureau of Indian Affairs; and Allison Knaak, Ph.D., Technical Writer, Managed Business Solutions, LLC (Contractor to U.S. Bureau of Indian Affairs)

Earthen Levee Breach Analyses in South Florida Everglades Protective Areas1089 Sheng Yue, Civil Engineer, IMC/US Army Corps of Engineers