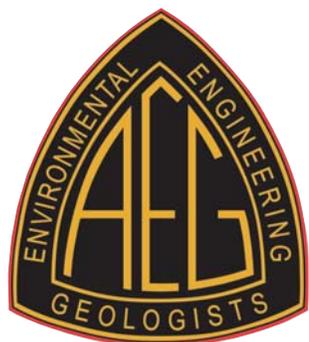


Vol. 62, No. 4 – September 2019



News



AEG2019
Asheville, NC
Program with
Abstracts



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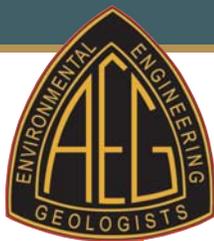
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News

AEG 62nd Annual Meeting – Program with Abstracts

AEG News (ISSN 0899-5788; USPS 954-380) is published five times a year by the Association of Environmental & Engineering Geologists (AEG). This includes three regular issues published in April (#2), July (#3) and December (#5) and two special issues: the Annual Report and Directory (#1) in March and the Annual Meeting Program with Abstracts (#4) in September (digital publication only). Digital copies of the Program with Abstracts are distributed at the AEG Annual Meeting. Association members receive an electronic copy of all five issues of the AEG News as part of their dues. Print subscription for Association members, which includes all three regular issues of the AEG News, is \$30 in addition to annual membership dues. Nonmember annual subscription is \$40 and includes only the three regular issues; the Annual Report and Directory issue is priced separately. Back copies of AEG News regular issues are \$12 each. Inquiries should be sent to AEG Headquarters: Association Manager, 201 East Main St., Suite 1405, Lexington, KY 40507 859-469-5800.

Periodical Postage paid at Lexington, KY, and additional mailing offices: POSTMASTER: Send address changes to AEG News, 201 East Main St., Suite 1405, Lexington, KY 40507, USA. AEG News is printed by Allen Press, Lawrence, KS, 66044, USA.

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Views expressed in this publication are not necessarily those officially representing the Association of Environmental & Engineering Geologists except where expressly stated.

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2. Images should be sent as high-resolution (250dpi at 4" wide or larger) jpeg or tiff files and should be named with a strong identifier such as HF-Texas-John Jones —NOTP204679.jpg. Corresponding photo captions should be included in the text along with an attribution of the source/photographer.
3. The policy of AEG News editorial staff is to limit the credentials of an individual to two. No effort will be made by the AEG News editorial staff to determine if individuals whose credentials are missing from the submitted copy actually have academic or professional credentials, nor will the staff verify the existence or correctness of the credentials submitted.

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On the Cover: North Fork Dam and Reservoir, Alex Rutledge, Schnabel Engineering

THE ASSOCIATION

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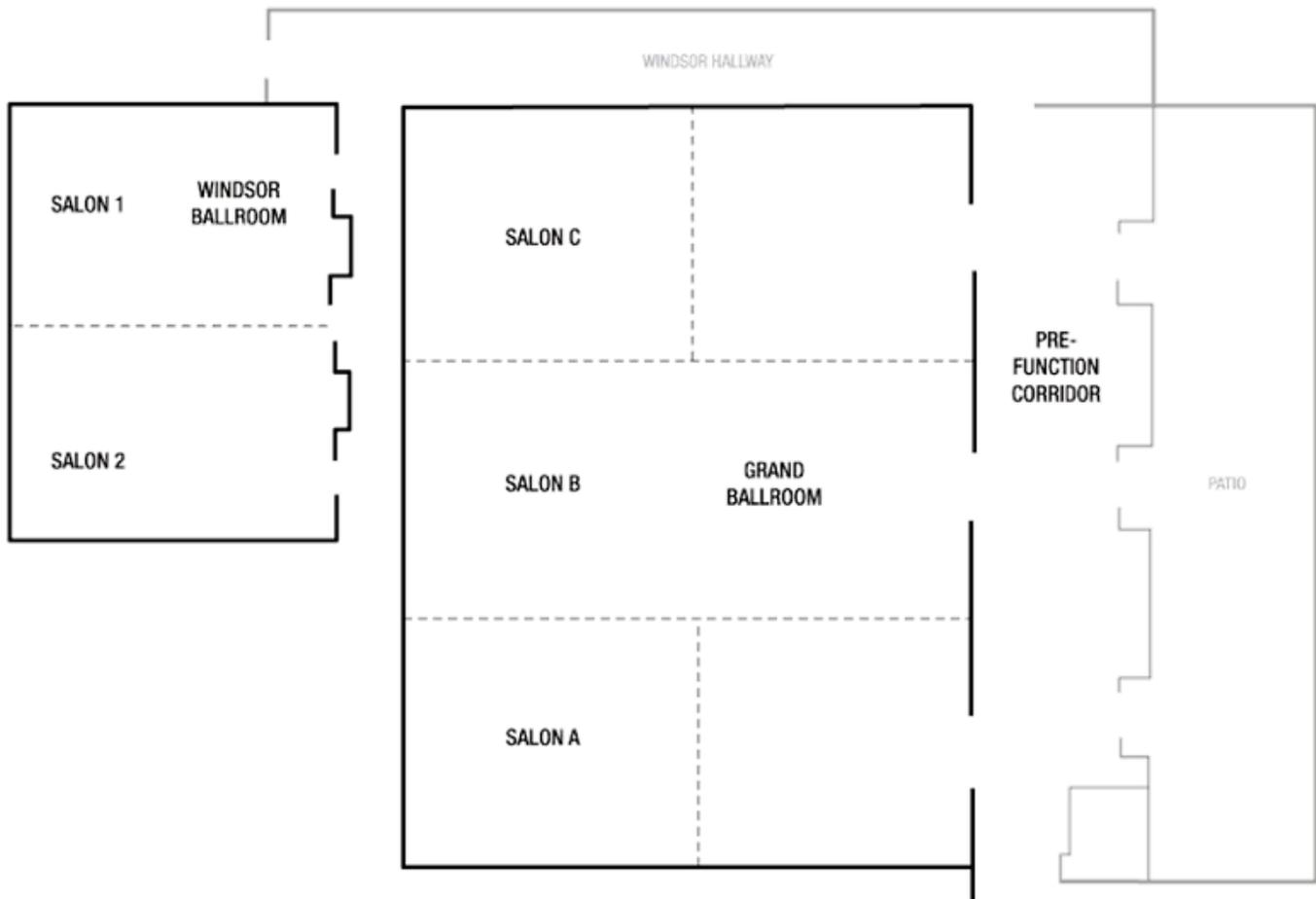
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Communications Director: RYAN MARSTERS, marsters.ryan@gmail.com

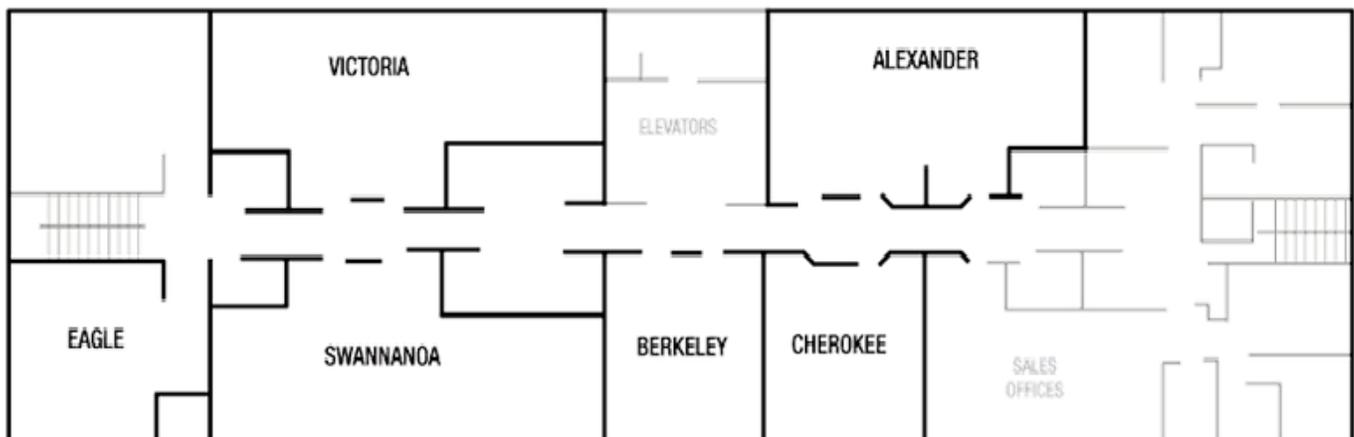
Hotel Layouts

See Schedules for Room Assignments for various sessions

LOBBY LEVEL



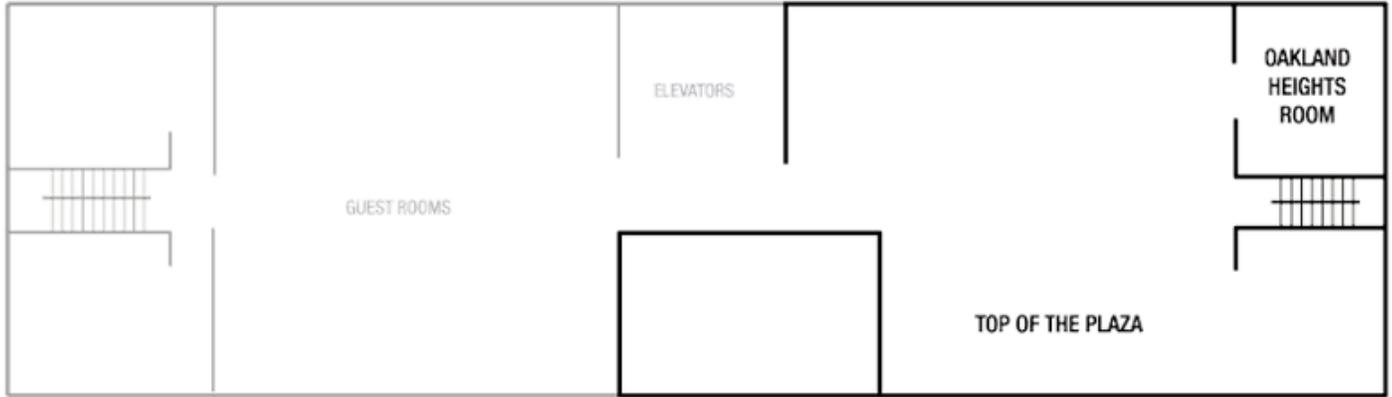
SECOND FLOOR



Hotel Layouts

See Schedules for Room Assignments for various sessions

12TH FLOOR



Be Sure to Stop by These AEG Booths in the Registration Area

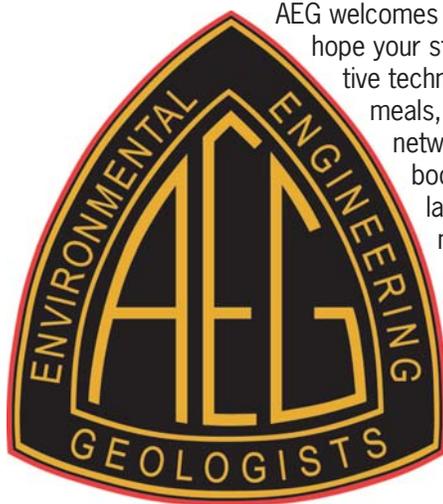
AEG Booth – Registration Area

201 E. Main Street, Suite 1405 Lexington, KY, US 40507

844-331-7867 x3229, Fax 740-452-2552

www.aegweb.org

Contact: aeg@aegweb.org



AEG welcomes you to Asheville! We hope your stay is filled with informative technical sessions, great meals, and of course lots of networking. Stop by our booth to see some of the latest publications and merchandise available. We will also have information on the various committees and what each has been working on to advance the AEG and the profession.

AEG 2020 Annual Meeting / Portland, OR – Registration Area

Contact: Mark Swank, Aspect Consulting LLC
AEG 2020 Annual Meeting Chair 971-865-5893
mSwank@aspectconsulting.com

Mark your calendar to join us for the 63rd AEG Annual Meeting in Portland, Oregon, September 20–26, 2020. Stop by our booth to get all of the details.

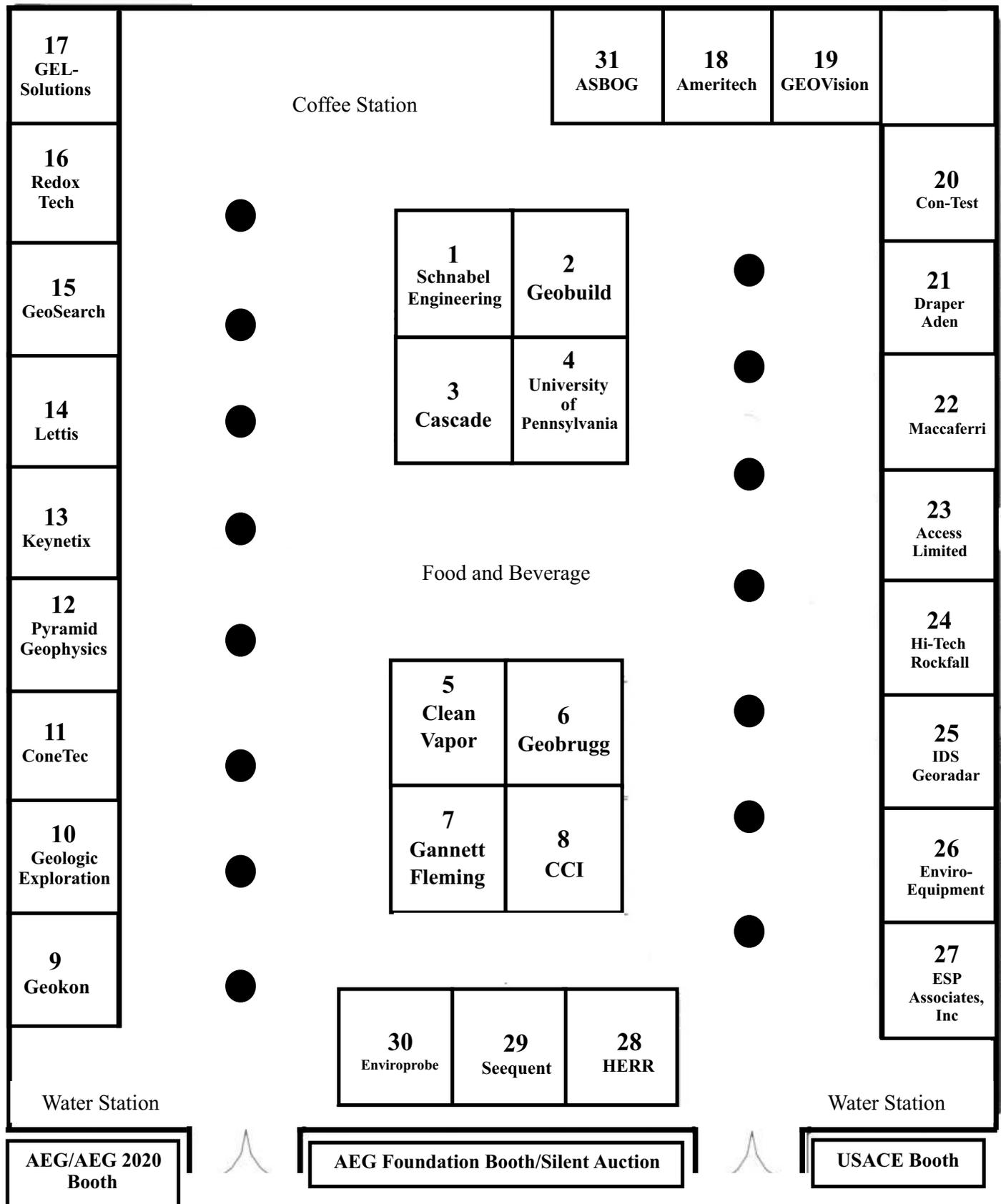
AEG Foundation Booth and Silent Auction – Registration Area

4123 Broadway #817, Oakland, CA, US 94611
www.aegfoundation.org

Contact: Alex Vazquez, vazquezam@gmail.com

Established by three Past Presidents of the Association of Engineering Geologists (AEG) in 1992, the AEG Foundation plays a key role in the success of our profession. The AEG Foundation's vision is to create a culture of giving back to the profession, and to instill complete confidence in donors that their money is well-invested and well-spent. Our core programs emphasize scholarship, research, and professional development to improve professional practice. We support outreach to increase the public's appreciation of environmental and engineering geology in geo-hazard evaluation and risk reduction.

Exhibit Hall Layout



Schedule of Events

This schedule is subject to change. Schedule updates will be listed in the Guidebook Mobile App.

EVENT	PLACE	TIME
TUESDAY, SEPTEMBER 17		
Registration/AEG Booth	Grand Ballroom Foyer	7:00am–7:00pm
Field Course #1: North Fork Dam Improvements – Making Asheville’s Water Supply More Resilient	Departs from the Hotel Lobby	12:00pm–4:45pm
Field Course #2: Breweries and Brownfields: The Environmental History of Asheville’s River Arts District	Departs from the Hotel Lobby	8:00am–12:00pm
Field Course #3: Debris Flows, Rock Slides, Rock Falls and Big Slow Movers: Who Could Ask for More? – <i>Sponsored by Subhorizon Geologic Resources LLC</i>	Departs from the Hotel Lobby	8:00am–5:30pm
AEG Executive Council Meeting	Oakland Heights	8:00am–5:00pm
AEG Foundation Board Meeting	Victoria	8:00am–5:00pm
Guest Tour #1: Biltmore House and Gardens	Departs from the Hotel Lobby	10:00am–4:00pm
Joint Luncheon – AEG EC and AEG Foundation (Invitation Only)	Cherokee	12:00pm–1:00pm
Exhibitor Move In	Grand Ballroom	12:00pm–5:00pm
Student/Professional Networking Reception – <i>Sponsored by University of Pennsylvania and EGIS</i>	Top of the Plaza	5:15pm–6:15pm
Welcome (Icebreaker) – <i>Sponsored by GeoBrugg North America</i>	Grand Ballroom	6:30pm–8:30pm
AEG Foundation Silent Auction	Grand Ballroom Foyer	6:30pm–8:30pm
Young at Heart Student/Professional Special Event (<i>Ticketed Event</i>) – <i>Sponsored by AEG Foundation, AEG Student Young Professional Support Committee, EDR, Prism Laboratories, Inc., SAEDACCO, and Rick Kolb</i>	Offsite – Pack’s Tavern	8:00pm–10:00pm
WEDNESDAY, SEPTEMBER 18		
Speakers’/Moderators’ Breakfast – <i>Sponsored by Rick Kolb</i>	Top of the Plaza	6:30am–7:30am
Registration/AEG Booth	Grand Ballroom Foyer	7:00am–5:00pm
Speaker Preparation Room	Berkeley	7:00am–5:00pm
Exhibitors	Grand Ballroom	8:00am–3:40pm
Committee Room	Eagle	8:00am–5:00pm
Poster Session Presentations	Windsor Foyer	8:00am–4:00pm
AEG Foundation Silent Auction	Grand Ballroom Foyer	8:00am–5:00pm
Guest Tour #2: Chimney Rock and Lake Lure Boat Tour	Departs from the Hotel Lobby	9:30am–3:00pm
Opening Session <i>Sponsored by Gannet Fleming</i>	Grand C	8:30am–12:00pm
Opening Session Welcome (AEG President Dave Fenster)	Grand C	8:30am–8:33am
Meeting Co-Chair Welcome (Paul Weaver and Briget Doyle)	Grand C	8:33am–8:35am
AEG Foundation Awards (AEG Foundation President William Flanigan)	Grand C	8:35am–9:00am
Keynote Speaker: Kenneth Taylor, State Geologist of North Carolina	Grand C	9:00am–9:30am
Keynote Speaker: Bart Cattnach, North Carolina Department of Environment and Natural Resources	Grand C	9:30am–10:00am
Morning Break – <i>Sponsored by Earthquake Insight, LLC</i>	Exhibit Hall	10:00am–10:30am
AEG Outstanding Environmental & Engineering Geologic Project Award: The Boone Dam Internal Erosion Remediation Project, Kingsport, Tennessee	Grand C	10:30am–11:00am
The 2018/2019 AEG/GSA Richard H. Jahns Distinguished Lecturer in Applied Geology: Deborah Green	Grand C	11:00am–11:20am
The 2019/2020 AEG/GSA Richard H. Jahns Distinguished Lecturer in Applied Geology: Scott Lindvall	Grand C	11:20am–12:00pm
Exhibitor Hosted Lunch – <i>Sponsored by Geobuild</i>	Exhibit Hall	12:00pm–1:30pm
Landslides Technical Working Group Meeting	Eagle	12:30pm–1:30pm
Get a Job and Make It Your Own	Swannanoa	12:30pm–1:45pm

AEG 62ND ANNUAL MEETING

EVENT	PLACE	TIME
WEDNESDAY, SEPTEMBER 18 ...continued		
Technical Session #1: Rockfall Mitigation	Grand C1	2:00pm–5:00pm
Technical Session #2: Symposium on Climate Resilience: Bringing Geoscientists and Climate Scientists Together	Grand C2	2:00pm–5:00pm
Technical Session #3A: The Profession of Geology	Windsor 1	2:00pm–3:00pm
Technical Session #3B: PFAS/GenX Symposium	Windsor 1	3:20pm–5:00pm
Technical Session #4: The Changing Times of Engineering Geology at Dams and Levees Symposium, Part I – TVA OEEG Project Award	Windsor 2	2:00pm–5:00pm
Volunteer Recognition Event	Eagle	2:45pm–3:30pm
Mid-Afternoon Break – <i>Sponsored by AEG St. Louis Chapter</i>	Exhibit Hall	3:00pm–3:20pm
Advocacy Committee	Eagle	4:00pm–5:00pm
Special Event – “A Night in the Mountains” (<i>Ticketed Event</i>)	Depart from the Hotel Lobby	6:00pm–10:00pm
THURSDAY, SEPTEMBER 19		
Speakers’/Moderators’ Breakfast	Top of the Plaza	6:30am–7:30am
Registration/AEG Booth	Grand Ballroom Foyer	7:00am–5:00pm
Speaker Preparation Room	Berkeley	7:00am–5:00pm
Exhibitors	Grand Ballroom	7:30am–3:40pm
AEG Foundation Silent Auction	Grand Ballroom Foyer	8:00am–3:40pm
Committee Room	Eagle	8:00am–5:00pm
Poster Session Presentations	Windsor Foyer	8:00am–4:00pm
Technical Session #5: The Changing Times of Engineering Geology at Dams and Levees Symposium, Part II	Grand C1	8:00am–12:00pm
Technical Session #6: Speaking Their Language: Communicating Science with Non-Scientists – Who, Why, and How Symposium, Part I	Grand C2	8:00am–12:00pm
Technical Session #7: NOA Symposium, Part I	Windsor 1	8:00am–12:00pm
Technical Session #8A: Hydrogeology, Groundwater and Karst	Windsor 2	8:00am–10:00am
Guest Tour #3: Explore the Spectacular Blue Ridge Parkway/Linville Caverns	Departs from the Hotel Lobby	9:30am–4:00pm
Technical Session #8B: Tunneling Symposium	Windsor 2	10:20am–12:00pm
Morning Break– <i>Sponsored by GeoEngineers, Inc.</i>	Exhibit Hall	10:00am–10:20am
Dams Technical Working Group Meeting	Eagle	12:00pm–1:00pm
Women in AEG/AWG Luncheon (<i>Ticketed Event</i>) – <i>Sponsored by Steele and Associates and Deborah Green</i>	Top of the Plaza	12:00pm–1:30pm
Lunch on your own for attendees		12:00pm–1:30pm
Licensure Committee Meeting	Eagle	1:40pm–3:00pm
Technical Session #9: The Changing Times of Engineering Geology at Dams and Levees Symposium, Part III	Grand C1	1:40pm–5:00pm
Technical Session #10: Speaking Their Language: Communicating Science with Non-Scientists – Who, Why, and How Symposium, Part II	Grand C2	1:40pm–5:00pm
Technical Session #11: NOA Symposium, Part II	Windsor 1	1:00pm–5:20pm
Technical Session #12: Environmental Characterization and Remediation, Part I	Windsor 2	1:40pm–5:00pm
Mid-Afternoon Break	Exhibit Hall	3:20pm–3:40pm
Exhibitor Move Out	Grand Ballroom	3:40pm–5:00pm
Editorial Board for the <i>Environmental and Engineering Geoscience</i> Journal Meeting	Eagle	4:00pm–5:00pm
Poster Reception and Happy Hour (all posters will be displayed) – <i>Sponsored by GEL-Solutions</i>	Grand Ballroom Foyer	5:00pm–7:00pm
Annual Banquet (<i>Ticketed Event</i>) – <i>Sponsored by Red Lab, Inc</i>	Grand Ballroom	7:00pm–10:00pm

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EVENT	PLACE	TIME
FRIDAY, SEPTEMBER 20		
Speakers'/Moderators' Breakfast	Top of the Plaza	6:30am–7:30am
Registration	Grand Ballroom Foyer	7:00am–1:30pm
Speaker Preparation Room	Berkeley	7:00am–3:00pm
Committee Room	Eagle	8:00am–5:00pm
Technical Session #13: Landslide Symposium: Evaluating and Managing Landslide Hazards at Local and Regional Scales	Grand C1	8:00am–12:00pm
Technical Session #14A: 3D Modeling and Risk-Based Methodology	Grand C2	8:00am–10:00am
Technical Session #15A: The Changing Times of Engineering Geology at Dams and Levees Symposium, Part IV	Windsor 1	8:00am–10:00am
Technical Session #16: Environmental Remediation and Geochemistry	Windsor 2	8:00am–12:00pm
Chapter Officers Advisory Panel	Swannanoa	9:00am–12:00pm
Guest Tour #4: Apple Country Wine Tour	Departs from the Hotel Lobby	9:30am–3:00pm
Morning Break	Grand Ballroom Foyer	10:00am–10:20am
Technical Session #14B: Geophysics	Grand C2	10:20am–12:00pm
Technical Session #15B: Transportation and Infrastructure	Windsor 1	10:20am–12:00pm
Past President's Luncheon (Invitation Only)	Top of the Plaza	12:00pm–1:00pm
Lunch on your own for attendees		12:00pm–1:00pm
Technical Session #17: Drones for Geologic Applications	Grand C1	1:00pm–3:00pm
Technical Session #18: Environmental Characterization and Remediation, Part II	Grand C2	1:00pm–3:00pm
Technical Session #19: Geologic and Geotechnical Site Characterization	Windsor 1	1:00pm–3:00pm
Technical Session #20: Geologic Hazard Mapping	Windsor 2	1:00pm–3:00pm
Technical Session #21: The 2019 Forum on the Geology of Industrial Minerals Symposium	Swannanoa	1:00pm–2:20pm
Afternoon Break	Grand Ballroom Foyer	3:00pm–3:15pm
AEG's Corporate Business Meeting and Closing Session – <i>Sponsored by Earth Consultants International, Inc.</i>	Grand B	3:15pm–5:00pm
Closing Beer/Wine Reception	Grand Ballroom Foyer	5:00pm–6:00pm
SATURDAY, SEPTEMBER 21		
AEG Board of Directors' Meeting	Top of the Plaza	8:00am–5:00pm
Field Course #4: These Rocks are Mined, But You Can Look at Them: Mining & Geology – <i>Sponsored by IDS GeoRadar, Subhorizon Geologic Resources LLC (SGR), and Vulcan Materials Company</i>	Departs from the Hotel Lobby	8:00am–5:00pm
Short Course #3: Geologic Mapping in the Digital Era: Data Collection and Rock Slope Stability Analysis	Oakland Heights	8:00am–5:00pm
SUNDAY, SEPTEMBER 22		
AEG Board of Directors' Meeting	Top of the Plaza	8:00am–12:00pm

STUDENT SESSION:

Get a Job & Make It Your Own: A Presentation Seeking Students' Comments and Discussion Wednesday, September 18, 2019 from 12:30-1:45pm

Greg Hempen, PhD, PE, RG

AEG Honorary Member, Past President & 2013–14 Jahns' Lecturer, Consulting Geophysicist, EcoBlast, LC

The talk seeks to gain students' involvement and discussion via a PowerPoint presentation. Attendees are encouraged to interrupt the presentation to comment or inquire. Three areas (Networking & Credentials, Acquiring a Job, & Career Development) are developed to touch on many concepts, chiefly to gain the comments, questions and discussions of students' concerns. The talk and response to inquiries attempt to provide the employer's perspective, so the new professionals may assess how their job applications and interviews might be evaluated by prospective employers. The presentation also makes a few recommendations on how one's career over time may be tailored to that individual's goals. Students may change the direction or develop a concern particular to that audience or to a particular industry or employment availability.

Technical Session Numbers and Names

See page 59 for full Technical Session listings.

SESSION	PLACE	TIME
WEDNESDAY, SEPTEMBER 18		
Poster Session Presentations	Windsor Foyer	8:00am–4:00pm
Opening Session – <i>Sponsored by Gannett Fleming</i>	Grand C	8:30am–12:00 pm
AEG Foundation Awards	Grand C	8:35am–9:00am
Keynote Speaker: <i>Kenneth Taylor, State Geologist of North Carolina</i>	Grand C	9:00am–9:30am
Keynote Speaker: <i>Bart Cattnach, North Carolina Department of Environment and Natural Resources</i>	Grand C	9:30am–10:00am
AEG Outstanding Environmental & Engineering Geologic Project Award: <i>The Boone Dam Internal Erosion Remediation Project, Kingsport, Tennessee</i>	Grand C	10:30am–11:00am
The 2018/2019 AEG/GSA Richard H. Jahns Distinguished Lecturer in Applied Geology: <i>Deborah Green</i>	Grand C	11:00am–11:20pm
Introduction of The 2019/2020 AEG/GSA Richard H. Jahns Distinguished Lecturer in Applied Geology: <i>Scott Lindvall</i>	Grand C	11:20am–12:00pm
Technical Session #1: <i>Rockfall Mitigation</i>	Grand C1	2:00pm–5:00pm
Technical Session #2: <i>Symposium on Climate Resilience: Bringing Geoscientists and Climate Scientists Together</i>	Grand C2	2:00pm–5:00pm
Technical Session #3A: <i>The Profession of Geology</i>	Windsor 1	2:00pm–3:00pm
Technical Session #3B: <i>PFAS GenX Symposium – Sponsored by Bryan Environmental Consultants, Inc.</i>	Windsor 1	3:20pm–5:00pm
Technical Session #4: <i>The Changing Times of Engineering Geology at Dams and Levees Symposium, Part I – TVA OEEG Project Award – Sponsored by Schnabel Engineering</i>	Windsor 2	2:00pm–5:00pm
THURSDAY, SEPTEMBER 19		
Poster Session Presentations	Windsor Foyer	8:00am–4:00pm
Technical Session #5: <i>The Changing Times of Engineering Geology at Dams and Levees Symposium, Part II Sponsored by Schnabel Engineering</i>	Grand C1	8:00am–12:00pm
Technical Session #6: <i>Speaking Their Language – Communicating Science with Non-Scientists – Who, Why, and How Symposium, Part I</i>	Grand C2	8:00am–12:00pm
Technical Session #7: <i>NOA Symposium, Part I</i>	Windsor 1	8:00am–12:00pm
Technical Session #8A: <i>Hydrogeology, Groundwater and Karst – Sponsored by Collier Consulting, Inc.</i>	Windsor 2	8:00am–10:00am
Technical Session #8B: <i>Tunneling Symposium</i>	Windsor 2	10:20am–12:00pm
Technical Session #9: <i>The Changing Times of Engineering Geology at Dams and Levees Symposium, Part III Sponsored By: RJH Consultants</i>	Grand C1	1:40pm–5:00pm
Technical Session #10: <i>Speaking Their Language – Communicating Science with Non-Scientists – Who, Why, and How Symposium, Part II</i>	Grand C2	1:40pm–5:00pm
Technical Session #11: <i>NOA Symposium, Part II</i>	Windsor 1	1:00pm–5:20pm
Technical Session #12: <i>Environmental Characterization and Remediation, Part I – Sponsored by SAEDACCO</i>	Windsor 2	1:40pm–5:00pm
Poster Reception (<i>All posters will be displayed and presenters available for questions</i>)	Grand Ballroom Foyer	5:00pm–7:00pm



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SESSION	PLACE	TIME
FRIDAY, SEPTEMBER 20		
Technical Session #13: <i>Landslide Symposium: Evaluating and Managing Landslide Hazards at Local and Regional Scales</i>	Grand C1	8:00am–12:00pm
Technical Session #14A: <i>3D Modeling and Risk-Based Methodology – Sponsored by Collier Geophysics, LLC</i>	Grand C2	8:00am–10:00am
Technical Session #14B: <i>Geophysics – Sponsored by GEOVSION</i>	Grand C2	10:20am–12:00pm
Technical Session #15A: <i>The Changing Times of Engineering Geology at Dams and Levees Symposium, Part IV Sponsored by Schnabel Engineering</i>	Windsor 1	8:00am–10:00am
Technical Session #15B: <i>Transportation and Infrastructure</i>	Windsor 1	10:20am–12:00pm
Technical Session #16: <i>Environmental Remediation and Geochemistry – Sponsored by EA Engineering, Science and Technology, Inc., PBC</i>	Windsor 2	8:00am–12:00pm
Technical Session #17: <i>Drones for Geologic Applications</i>	Grand C1	1:00pm–3:00pm
Technical Session #18: <i>Environmental Characterization and Remediation, Part II – Sponsored by SAEDACCO</i>	Grand C2	1:00pm–3:00pm
Technical Session #19: <i>Geologic and Geotechnical Site Characterization – Sponsored by GroundLogs</i>	Windsor 1	1:00pm–3:00pm
Technical Session #20: <i>Geologic Hazard Mapping</i>	Windsor 2	1:00pm–3:00pm
Technical Session #21: <i>The 2019 Forum on the Geology of Industrial Minerals Symposium</i>	Swannanoa	1:00pm–2:20pm

Women in AEG/AWG Luncheon Tickets Still Available!

Speaker:

Sarah Evans, Assistant Professor in the Department of Geological and Environmental Sciences at Appalachian State University

The university is primarily an undergraduate institution in Boone, North Carolina. Her expertise is in hydrogeology and numerical modeling with a focus on coupled heat transport and groundwater flow of cold regions. Sarah received her PhD in Hydrogeology at the University of Colorado Boulder in 2017, an MS in Terrestrial Hydrology at the University of Colorado Boulder in 2013, and a BA in Geology at Whitman College in Washington State in 2011. She grew up in Mukilteo, Washington.

Can't Take the Heat? The Hydrogeology of Cold Regions in a Warming World

Permafrost and seasonally frozen ground is found extensively at high latitudes and intermittently at high elevation areas at lower latitudes, underlying half of the exposed land surface in the Northern Hemisphere. In these cold regions, frozen ground acts as an aquitard, impeding downward groundwater flow while simultaneously enhancing groundwater-surface water interactions. As global air temperatures increase, frozen ground degrades. Frozen ground degradation alters groundwater recharge, groundwater contribution to streamflow, and consequently, vital freshwater supplies to lowland regions. In this talk, I will employ coupled heat transfer and groundwater flow numerical models in combination with field measurements to describe the effects of warming on groundwater discharge for a suite of cold region catchments, including sites on the Qinghai-Tibet Plateau, China, and in the Colorado Rocky Mountains, USA. Results highlight the difference in expected hydrologic changes for areas underlain with permafrost versus

those with seasonally frozen ground, such as the Pacific Northwest, and help anticipate future changes to water resources throughout the cold regions of the Northern Hemisphere.

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The Planning Committee

AEG's 62nd Annual Meeting would not be possible without the hard work and dedication of the following committee chairs and the many more volunteers that serve on these committees.

AEG Meeting Co-Chairs

Paul Weaver
ESP Associates, Inc.

Briget Doyle
University of South Carolina Upstate

Field Courses
Susan Avritt
Wood Environment & Infrastructure Solutions

Finance
Brian Smith
Bridgestone

Guest Tours
Sarah Montgomery
Radford University

Outstanding Environmental & Engineering Geologic Project Award
Gary Rogers
Schnabel Engineering

Poster Sessions
Maddie German
Municipal Engineering

Publicity
Rohit Warrior
Geosyntec Consultants

Short Courses
Cyrus Parker
North Carolina Department of Transportation

Special Event
Jennifer Bauer
Appalachian Landslide Consultants, PLLC

Sponsors and Exhibitors
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Duncklee & Dunham, PC
Eric Cross
Pyramid Geophysical Services

Student Coordination
Arpita Nandi
East Tennessee State University

Technical Program
Alex Rutledge
Schnabel Engineering

Meeting Management
Heather Clark
AEG Meeting Manager

AEG Headquarters – AMR Management Services
Kristy Howard
AEG Association Manager
Jessica Willhoite
AEG Association Administrator

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Special Thanks

AEG wishes to acknowledge the following companies for their support by allowing their employees to assist with the planning of the 2019 Annual Meeting:

Appalachian Landslide Consultants, PLLC
Bridgestone
Duncklee & Dunham
ESP Associates, Inc.
Geosyntec Consultants
North Carolina Department of Transportation
Pyramid Geophysical Services
Schnabel Engineering
The GEL Group
University of South Carolina Upstate
Wood Environment & Infrastructure Solutions

AEG wishes to thank the following individuals for their assistance with the planning of the 2019 Annual Meeting:

Andrea Ptak, AEG News Managing Editor/Production

Field Course Leaders:

Susan Avritt, Wood Environment & Infrastructure Solutions, Inc.
Jennifer Bauer, Appalachian Landslide Consultants, PLLC
Bart Cattanach, North Carolina Geological Survey
Aaron Collins, Schnabel Engineering, Inc.
Stephen Fuemmeler, Appalachian Landslide Consultants, PLLC
Jody Kuhne, North Carolina Department of Transportation
Mark Landis, Schnabel Engineering, Inc.
Zach Ostrum, Schnabel Engineering, Inc.
Chuck Pippin, Anchor QEA
Alex Rutledge, Schnabel Engineering, Inc.
Rick Wooten, North Carolina Geological Survey

Guest Tour Leaders:

Chris Patty
Amanda Rutledge
Jennifer Thomas

Symposium Conveners and Technical Session Moderators:

Mark Bailey, Asbestos TEM Labs
Jennifer Bauer, Appalachian Landslide Consultants, PLLC
David Bieber, Martin Marietta
Ned Billington, ESP Associates, Inc.
Patricia Bryan, Bryan Environmental
Hughbert Collier, Collier Consulting, Inc.
Visty Dalal, Maryland Department of the Environment
Casey Dowling, BGC Engineering
Hawkins Gagnon, Schnabel Engineering
Sallie Gaillard, USG
Deborah Green, Geologist Writer
Paul Headland, Aldea Services
Greg Hепен, Consulting Geophysicist, EcoBlast, LC
Ike Isaacson, Brierley Associates
Rick Kolb, Duncklee & Dunham
Thomas Lammons, Bunnel Lammons Engineering
Loren Lasky, New Jersey Department of Environmental Protection
Kevin McCoy, BGC Engineering
Holly Nichols, California Department of Water Resources
Mike Piepenburg, Mott MacDonald
Kevin Richards, U.S. Army Corps of Engineers Risk Management Center
Gary Rogers, Schnabel Engineering
Paul Santi, Colorado School of Mines
Bryan Simpson, Bureau of Reclamation
Gerry Stirewalt, Nuclear Regulatory Commission
Steven Stokowski, Stone Products Consultants
Cassandra Wagner, Bureau of Reclamation
Scott R. Walker, Tennessee Valley Authority
Rick Wooten, North Carolina Geological Survey

Get Involved...

Sign Up to Help with These Upcoming
 AEG Annual Meetings in YOUR Area...

AEG 2021
The Westin Riverwalk · San Antonio, Texas
September 21–26

AEG 2022
Las Vegas, Nevada
Location and Dates TBD

ROY COOPER
Governor

MICHAEL S. REGAN
Secretary

S. DANIEL SMITH
Interim Director



NORTH CAROLINA
Environmental Quality

June 2, 2019

Welcome to the Participants of the 62nd Annual Meeting of the Association of Environmental & Engineering Geologists

On Behalf of the State of North Carolina, the N.C. Department of Environmental Quality (NC DEQ), the Division of Energy, Mineral and Land Resources (DEMLR), and the North Carolina Geological Survey (NCGS), I am pleased to welcome all of you to the Old North State and to the lovely City of Asheville. This year is our 196th since the Survey was established by the Legislature in 1823.

Western North Carolina has many beautiful places where one can see the geology, biology, and ecology of our region. Unfortunately, as most of you know, there are also hidden dangers associated with this region. These include excessive rainfall associated with tropical cyclones or their remnants, which have triggered floods and debris flows such as those in 1916, 1940, 2004, and 2018. We also have the occasional earthquake in the State and sinkholes along the coast.

The presentations at this meeting will update everyone on the current state of knowledge on how to mitigate and/or avoid these hazards. Thank you for your contribution and again, welcome to Asheville!



Dr. Kenneth B. Taylor, P.G.

Dr. Kenneth B. Taylor, P.G. (NC #1835)
13th State Geologist of North Carolina



North Carolina Department of Environmental Quality | Division of Energy, Mineral and Land Resources
512 North Salisbury Street | 1612 Mail Service Center | Raleigh, North Carolina 27699-1612
919.707.9200



State of North Carolina
Office of the Governor

Roy Cooper
Governor

September 17, 2019

20301 Mail Service Center
Raleigh, N.C. 27699-0301

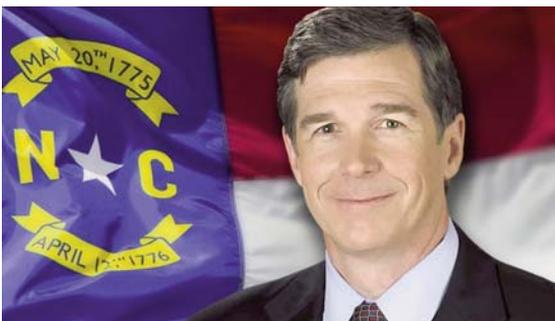
Dear Friends:

As Governor of North Carolina, it is my pleasure to welcome you to the 2019 Annual Meeting of the Association of Environmental & Engineering Geologists.

I sincerely appreciate the work you do to preserve and protect our natural resources. Your geological studies ensure that highways, bridges, utility plants and other types of structures do not damage our environment. This is vitally important for future generations.

I hope you will have time during your stay to enjoy the many historical, cultural and entertainment venues that Asheville has to offer. A visit to the beautiful Biltmore Estate is a must see for everyone.

With warm personal regards, I am



Very truly yours,

Roy Cooper

Welcome!

Location: The State Capital Building, Raleigh, N.C. 27602
Phone: 919-814-2100



City of Asheville
Office of the Mayor
P.O. Box 7148
Asheville, NC 28802
Phone: (828) 259-5600
www.ashevillenc.gov

April 22, 2019

Welcome to Asheville, Association of Environmental and Engineering Geologists!

Thanks for visiting us! We're glad you are here!

As Mayor, I am pleased to extend this official welcome to you on behalf of our citizens. We appreciate your patronage of our local businesses while you are here. Please know that your contribution to our local economy is deeply appreciated. Thank you for choosing to hold your annual meeting in Asheville.

While visiting Asheville I hope that you will find time to enjoy the sights and sounds of our unique mountain town. Asheville has many restaurants serving food grown right here in the mountains, eclectic shops with arts and crafts created by our local artisans, and entertainment venues featuring local and national performers.

Please accept my invitation to visit us again sometime.

Sincerely,

Esther E. Manheimer
Mayor



Old Mountains – New Beginnings –

The 62nd AEG Annual Meeting – Asheville, North Carolina

Using the Past to Map the Future

I'm very happy to welcome all of you to the beautiful Blue Ridge Province of Asheville, North Carolina. The Blue Ridge Province of the Appalachians is underlain by a variety of metamorphic and igneous rocks that are over one billion years old. The rocks in and around Asheville certainly reflect geologic processes that formed a very old mountain chain. However, as we look more closely we can see evidence that landslides have occurred repeatedly during recent geologic time on the slopes of those old mountains.

Many of our field courses and technical sessions address the theme of new beginnings. For example, Field Course #3 will show how mapping past landslides can help to identify and mitigate potential landslide hazards in similar settings. Participants on Field Course #2 will see how the results of an environmental mitigation project has resulted in innovative, constructive uses for an old industrial site.

As applied geologists, we focus on addressing issues that may affect our natural and built environments. Symposia and technical sessions on climate resilience, naturally occurring asbestos, and environmental remediation and geochemistry address some of our environmental challenges. Sessions on geologic hazard mapping, tunneling and site characterization will illustrate how understanding the geologic properties of a site can help mitigate hazards, leading to a successful project.

I want to thank those of you that volunteered the time necessary to make this meeting possible. The 2019 annual meeting organizing committee has met regularly and has worked tirelessly to schedule technical sessions, guest tours and special events to make this annual meeting a great success. The Student and Young Professional Support Committee has again put together programs that will help our younger members network with both younger and more seasoned professionals. Our Chapter Support Committee has organized the Chapter Officers Advisory Panel to encourage networking and sharing success stories among our various Chapters.

I also want to thank all the individuals and companies that have sponsored various aspects of the meeting or who are exhibitors. Without commitments like yours, these annual meetings would not be economically feasible or the quality would suffer. I also want to thank the many speakers, symposia organizers, course instructors and session moderators who have volunteered their time to prepare technical presentations, field and short courses.



Finally, I want to thank all of our attendees for your participation in what promises to be another outstanding annual meeting. Please take advantage of this opportunity in a beautiful setting to reconnect with old friends (our extended family), extend that family by meeting new friends (say hello to someone you don't know), and say hello to committee members, chapter officers, regional directors and members of the Executive Council. Please take advantage of this opportunity to learn more about AEG and all we have to offer our professional community.

David F. Fenster
AEG President, 2018–19

Welcome to Beautiful Asheville!

On behalf of the 2019 AEG Annual Meeting, we would like to welcome you to beautiful Asheville, North Carolina. We believe that you will find Asheville to be an eclectic city with plenty of things to do, see, and taste within a short walking distance of the Renaissance Hotel, Asheville.

Asheville is the largest city in Western North Carolina and is nicknamed the "Land of the Sky." For centuries before the arrival of Europeans, it was within the boundaries of the Cherokee Nation. The first European visitors to the area brought with them diseases that had a devastating effect on the population of the Cherokee people. Buncombe County was formed in 1792. The county seat, Morristown, was formed in 1793 on a plateau where two old Indian trails crossed. It was incorporated in 1797 and renamed "Asheville" in honor of North Carolina Governor Samuel Ashe.

Asheville is located in the Blue Ridge Mountains at the confluence of the Swannanoa River and the French Broad River. The city has a clear focus on sustainability and the development of a green economy. The Asheville City Council's goal is to reduce the overall carbon footprint of the city by with a reduction of 4 percent or more per year. To help accomplish this, each resident receives a "Big Blue" rolling cart in which they put all of their unsorted recycling materials. In addition, in 2009, the city installed over 3,000 LED streetlights, managed its water system under ISO 14001 standards for environmental management, and switched many of its employees to a four-day workweek to save on emissions from commuting. Asheville is recognized by the Green Restaurant Association as the first city in the U.S. to be a Green Dining Destination (meaning it has a significant density of green restaurants).

Live music is a very big thing in Asheville and the surrounding areas with numerous nightclubs and performance venues as well as seasonal festivals. There are constantly street musicians and performers around the downtown area as well as more organized events, such as the drum circle held in the small downtown park on the north end of the downtown area every Friday. Concerts organized by the city are also frequent events.

We hope that you get a chance while you are here to explore the area and discover some of the bounty of the Asheville area. However, don't miss out on the many opportunities provided by the meeting itself such as the exciting Field Courses, the "Night in the Mountains" Special Event, the numerous Technical Sessions and Symposia, and Poster Presentations.

We look forward to seeing "y'all" in Asheville!

“ ...
nicknamed
the 'Land of
the Sky.' ”



Paul M.
Weaver, PG
General
Co-Chair



Briget C.
Doyle, PhD
General
Co-Chair

AEG 2019 Awardees

Honorary Member



Scott Burns

AEG confers an honor of such high esteem that the distinction is recognized as a membership class: Honorary Member. This recognition is given to those persons whose careers have exemplified the ideals of AEG.

Karl and Ruth Terzaghi Mentor Award

Louis van Rooy

This award, established in 2008, recognizes outstanding individuals for their achievements as mentors throughout their career. The recipient should be an individual who has made lifelong efforts in providing professional, ethical, and technical mentoring for environmental and engineering geologists.



Schuster Medal

John Clague

A joint award from AEG and the Canadian Geotechnical Society that recognizes excellence in geohazards research in North America. Nominees must be residents of North America and meet at least two of the following criteria: professional excellence in geohazards research with relevance to North America; significant contribution to public education regarding geohazards; international recognition for a professional career in geohazards; influential geohazards research or development of methods or techniques; or teacher of geohazards students.



**The 2019 Awardees
will be honored
Thursday, September 19
at the
AEG Annual Banquet.**

Richard H. Jahns Distinguished Lecturer in Engineering Geology

Scott Lindvall



A joint committee of AEG and the Engineering Geology Division of the Geological Society of America selects the Richard H. Jahns Distinguished Lecturer. The Lecturer presents an annual series of lectures at academic institutions in order to increase awareness of students about careers in engineering geology.

Floyd T. Johnston Service Award

Rick Kolb

This award is presented to a member for outstanding active and faithful service to AEG over a minimum period of nine years to coincide with Floyd T. Johnston's tenure as Executive Director.



**NOMINATE a Deserving
AEG MEMBER
for One of Our
2020 AWARDS**

These are just a few of the AEG awards that recognize the contributions our members make to the Association and to the profession. It is our members that make the effort each day to provide public safety and protect property.

For a complete list of the awards and requirements for each, visit the awards page on our website:

<http://www.aegweb.org/?page=Awards>

AEG 2019 Awardees

In addition to honoring outstanding AEG Members, AEG also recognizes the following:

Advocacy Award

Jerome De Graff

Established in 2018, this annual award is to recognize and showcase the accomplishments of effective advocates for geological practice and for their advocacy and outreach work to promote the value of geological practice among the general public and/or a legislative body.



AEG Publication Award

This award was established by the Association in 1968 and is presented to the author(s) of the most outstanding paper published in any AEG publication during the fiscal year. Winning papers can be viewed online at GeoScienceWorld.

Challenging Geostatistical Methods to Represent Heterogeneity in CO2 Reservoirs under Residual Trapping

Environmental & Engineering Geology, Volume XXIV, Number 4
James R. Damico, Robert W. Ritzi, Naum I. Gerhenson, Roland T. Okwen

Environmental & Engineering Geoscience Journal Outstanding Reviewer Award

First presented in 2007, this award is given to an individual who has provided extended service by reviewing numerous manuscripts, including critical evaluations, detailed comments, corrections of grammar and syntax, thoughtful suggestions for changes to improve the quality of the manuscript, and guidance to the editors in making a decision regarding the manuscript.

Dr. Brian Bruckno

Virginia Department of Transportation

Outstanding Chapter Award

This award was established by the Board of Directors in 2001 to honor a Chapter of the Association judged to excel in a number of areas including professional activities, communications, membership, and networking.

To be Announced at the Annual Meeting

Outstanding Student Chapter Awards

The AEG Board of Directors established this award in 2001 to honor the AEG Student Chapter judged to have excelled over all others in a given year and to recognize a Student Chapter for its outstanding performance.

First Place – **University of Utah**

Second Place – **University of Alaska Fairbanks**



Open Faculty Positions

The Department of Mining Engineering at the University of Utah is seeking applications from outstanding individuals to fill two faculty positions at the rank of assistant or associate professor beginning no later than July 1, 2020.

Depending on the level of experience and qualifications of the successful applicants, the positions may be filled at either a tenure-track or a professor of practice level. We encourage applicants with a wide range of experiences and expertise to apply, including but not limited to various disciplines in mining engineering, economics, geomechanics, excavation, mine safety and health, mine design, ventilation, machine learning, automation, artificial intelligence, organizational culture enhancement, and stakeholder relations.

Those interested in applying must have a Ph.D. in mining engineering or a closely related field. Prior experience in industry, government, or academia are desirable. Other desired attributes for the position are as follows:

- Ability to utilize innovative approaches of effective teaching
- Ability to establish a sustainable, externally funded research group
- Ability to communicate well with students, colleagues, industry, and government personnel
- Commitment to participate in student recruitment, public and professional education, and outreach within rural and urban Utah communities
- Basic knowledge of issues and best practices around diversity and inclusion in higher education

To apply access the online application:

<http://utah.peopleadmin.com/postings/94649>

Review of applications will begin November 1, 2019 with the intent to fill the positions by July 1, 2020.

The University of Utah is an Affirmative Action/Equal Opportunity employer and does not discriminate based upon race, national origin, color, religion, sex, age, sexual orientation, gender identity/expression, status as a person with a disability, genetic information, or Protected Veteran status. Individuals from historically underrepresented groups, such as minorities, women, qualified persons with disabilities and protected veterans are encouraged to apply. Veterans' preference is extended to qualified applicants, upon request and consistent with University policy and Utah state law. Upon request, reasonable accommodations in the application process will be provided to individuals with disabilities.



AEG Foundation 2019 Scholars

Beardsley-Kuper Field Camp Scholarship



Caleb Ring
Colorado School of Mines



Kasey Buckley
Missouri
University of Science & Technology



Jennifer Stephens
Austin Peay State University

The Beardsley-Kuper Field Camp Scholarship Fund supports expenses for geology field camps with applied environmental and engineering geology components that will be useful to the students' future profession as an environmental or engineering geologist. The scholarship was established in 2009 by Cathryne Beardsley with her daughter Dorian Kuper and son-in-law Tom Kuper.

Carolinas Scholarship

Evan Miller

North Carolina State University

Established in 2015 with a gift from the Carolinas Chapter, this scholarship supports geologic studies by undergraduate students enrolled in a geology or geoscience program at an accredited university in North Carolina or South Carolina.



Marliave Scholarship



Andrew Graber
Colorado School of Mines

The Marliave Scholarship Fund was established in 1968 to honor the late Chester E. Marliave, Burton H. Marliave, and Elmer C. Marliave, outstanding engineering geologists and supporters of AEG. The funds are distributed as grants, which are intended to support academic activity and reward outstanding scholarship in Engineering Geology and Geological Engineering.

Christopher C. Mathewson Scholarship

Steven Follmer

University of Houston Clear Lake

Established in 2007 as the Texas Section Scholarship, the Scholarship was renamed in 2011 to honor Dr. Christopher C. Mathewson. Recipients of the scholarship are undergraduate or graduate students enrolled in an accredited Texas college or university, or graduate students conducting field studies in Texas.



Shlemon Quaternary Engineering Geology Scholarship

Nicholas Ferry

University of Cincinnati

The Shlemon Quaternary Engineering Geology Scholarship supports graduate geology students conducting Quaternary engineering geology research. Initial funding for the Scholarship was provided by a gift from Roy J. Shlemon, Honorary Member of the AEG.



Susan Steele Weir (Women of "Steele") Scholarship

Regan Wess

South Dakota School of Mines & Technology

The Susan Steele Weir Scholarship Fund was established by the AEG Foundation in 2017 in order to create a scholarship fund that promotes and supports the continued development and advancement of women in the profession of engineering geology.



Robert J. Watters Great Basin Chapter Scholarship

Justine Overacker

University of Nevada, Reno

The Robert J. Watters Great Basin Chapter Scholarship Fund supports geoscience studies by students at the undergraduate and graduate levels.



Martin L. Stout Scholarship

John Andrew Krone

University of Southern California

Undergraduate 1st Place



Audrey Woo

McGill University

Undergraduate 2nd Place



Sage Gandolfo

University of Nevada, Reno

Undergraduate 3rd Place



Matthew Tello

Colorado School of Mines

Graduate 1st Place



Ogochukwu Ozotta

University of North Dakota

Graduate 2nd Place



Dr. Martin L. Stout was Professor of Geology at California State University, Los Angeles from 1960 to 1990. He is remembered by his students for his passionate and insightful instruction in engineering geology. Dr. Stout was known for his expertise on landslides, his travels, his good humor, and his gracious manner. This scholarship supports his legacy.

Norman R. Tilford Field Study Scholarship

Lily Beth Bosworth

University of Utah

Undergraduate 1st Place



Astrid Garcia

University of California, Riverside

Undergraduate Tied-2nd Place



Judith Avila

California State University, Fullerton

Undergraduate Tied-2nd Place



Matthew Ellison

Utah State University

Graduate Division



The Tilford Scholarships are awarded to both undergraduate and graduate students for the summer field season, and were established in memory of Norman R. Tilford, who was a leader in engineering geology and a professor at Texas A&M University. Norm died in 1997 while flying his small aircraft to meet a student field trip. Norm was dedicated to teaching geology in the field and these scholarships support his legacy.

West-Gray Scholarship

Nicholas Ferry

University of Cincinnati



Established in 2014 with initial funding provided as a gift from AEG Past Presidents Terry R. West and Richard E. Gray, this fund supports undergraduate and graduate geology students studying in the eastern half of the United States.

**Student Scholarships
Are Available
through the AEG Foundation**

The AEG Foundation manages ten funds including four scholarships. Current applications and details are available at the AEG FOUNDATION website.

**DEADLINES FOR APPLICATIONS
ARE FEBRUARY 1, 2020.**

For more information about the AEG Foundation:
<https://www.aegfoundation.org/applications/>

Exhibitors

Our exhibitors offer an excellent platform to interact one-on-one with you and your company. Your active interest and participation during the exhibit hours will help to ensure that vendor support will remain strong during the years to come. Remember, without these exhibitors, the AEG 62nd Annual Meeting would not be successful.

Be sure to:

- Visit each and every booth
- Express your needs
- Ask questions and get answers
- Learn about new products and services

Access Limited Construction – Booth #23

Simon Boone, simon@alccinc.com
805-592-2230
www.accesslimitedconstruction.com

Access Limited Construction is a general contractor located in San Luis Obispo, California. An industry leader, we provide rock-fall mitigation, slope stabilization, and difficult drilling services for transportation, energy, mining and private sector clients. With our fleet of Spyder Excavators, we can access steep terrain and hard to reach projects throughout the United States from the East Coast to Hawaii.

Ameritech Slope Constructors, INC. – Booth #18

Roger Moore, bmackey@ameritech.pro
www.ameritech.pro

Ameritech Slope Constructors, Inc., is a contracting company specializing in civil/geotechnical construction projects, including rock and soil stabilization, rock scaling, rock bolting, high strength steel mesh drapes, and barriers as well as dry mix shotcrete. We also drill and break large boulders and overhanging ledges using nonexplosive rock removal methods and mechanical rock splitters.

Cascade – Booth #3

Jim McCombs, jmccombs@cascade-env.com
740-350-6611
Anthony Giannetti, agiannetti@cascade-env.com
267-304-0783
www.cascade-env.com

Cascade is the leading provider of environmental and infrastructure drilling, site characterization, and environmental remediation applications. We are the only nationwide integrated field services firm with expert technical capabilities and fleet to provide seamless environmental and geotechnical solutions, from concept to completion.

Exhibit Hall Hours:

Tuesday, Sept. 17 6:30am–8:30pm

Wednesday, Sept. 18 8:00am–5:00pm

Thursday, Sept. 19 7:30am–3:40pm

CCI – Booth #8

Justin Williams, justin.williams@cci-env.com
www.cci-env.com

CCI has been providing services ranging from remediation, abatement, and industrial services for over 30 years. CCI provides the most complete, quality-oriented environmental services in the market today, and strives for excellence in every service that we provide. Through sound remedial management methods, technical expertise, and regulatory awareness, CCI is able to provide our clients with the services needed and the confidence in knowing that their concerns are being met. Our staff's extensive environmental backgrounds and drive for innovation, allows CCI the expertise necessary to handle any Remediation project no matter the size or complications involved in the venture.

Clean Vapor, LLC – Booth #5

Lorine Barone, lbarone@cleanvapor.com
908-362-5616
www.cleanvapor.com

Clean Vapor, LLC, is a design-build vapor intrusion mitigation company with 30 years of experience with offices in New Jersey and North Carolina. We specialize in existing building and new construction mitigation. Our focus is on integrating advanced pressure field mapping as a foundation to efficient designs coupled with energy efficient dynamic controls and remote management technology.

Please stop by our AEG Foundation Silent Auction Booth in the Exhibitors' Hall.

Bid on one of our many items: vintage and classic geology books and other interesting books, rocks and minerals, geodes, and much, much more. **We can arrange shipping for those of you with limited luggage space.** To donate to the AEG Foundation, please visit www.aegfoundation.org.

Con-Test Analytical Laboratory – Booth #20

Adam Phillips, adam.phillips@contestlabs.com
www.contestlabs.com

Con-Test Analytical Laboratory is a full service environmental laboratory with the ability to analyze nearly all water, air, soil and solid materials. Established in 1987, Con-Test, Inc. was founded providing environmental consulting and testing services to a variety of clients throughout the Northeast. Over the years, Con-Test has expanded our services into the south-east, and internationally with our air specialty lab. Con-Test is highly certified including national accreditations and one of few independent laboratories with both the prestigious AIHA-LAP, LLC, ISO 17025 and NELAP accreditations. We are proud to state that we can offer the benefits of working with a small company, coupled with an expert depth of knowledge and analytical capabilities.

ConeTec, Inc. – Booth #11

Bruce Miller, bmiller@conetec.com
www.conetec.com

As an international full-service geotechnical and geoenvironmental site investigation contractor, ConeTec and California Push Technologies offer clients superior project management and site investigation services across the globe, with a large presence in North and South America. With one of the largest fleets of modern, purpose-built deployment equipment in the industry, the ConeTec Group provides in-depth geophysics, CPTu, in-situ testing, drilling, instrumentation, and final data reporting and analysis services. All field investigations are performed by specially trained personnel and supported by experienced site investigation professionals in order to provide the highest quality site investigation. This is the ConeTec difference— better information, better decisions.

Draper Aden Associates – Booth #21

Brandy Barnes, bmbarnes@daa.com
www.daa.com

In 1972, Virginia Tech graduates Joe Draper and Bill Aden formed Draper Aden Associates, a six-employee civil engineering firm in Blacksburg, Virginia. Today, it has grown into a full service consulting engineering firm with locations in Virginia and North Carolina and clients across the Mid-Atlantic region. Draper Aden is focused on creating a lasting positive impact through our work and strive to be a partner who helps municipalities, businesses, state agencies, and cultural institutions achieve their goals through expertise, collaboration and commitment. Our professionals and support staff provide a variety of services that range from site planning and engineering to surveying — both on the ground and in the air — to solid waste engineering consultation. And while we concentrate on engineering, surveying, and environmental services, we add value to just about any design or architectural project you are working on.

Enviro-Equipment – Booth #26

Rand Ratterree, rand@enviroequipment.com
www.enviroequipment.com

Enviro-Equipment, Inc., provides environmental monitoring instruments and supplies to professionals for groundwater monitoring and sampling, indoor air quality, industrial hygiene, wastewater sampling, confined space entry, soil screening, and more. Enviro-Equipment, Inc., also custom builds remediation systems to your specification and features an inventory of new, used and rental remediation equipment for soil and groundwater contamination.

Enviroprobe Service, Inc. – Booth #30

Matt McMillian, mattm@enviroprobe.com
856-858-8584
www.enviroprobe.com

Enviroprobe Service, Inc. is a state of the art geophysical exploration and drilling company offering modern approaches to investigative needs in civil, geotechnical, and environmental applications.

ESP Associates, Inc. – Booth #27

Ned Billington, nbillington@espassociates.com
www.espassociates.com

ESP Associates, Inc. is a multi-discipline engineering design and consulting firm providing our clients with civil engineering, surveying, planning/landscape architecture, geosciences, environmental, subsurface utility engineering, and construction engineering inspection.

Gannett Fleming – Booth #7

Brian Greene, bgreene@gfnet.com
412-922-5575
www.gannettfleming.com

Gannett Fleming is a planning, design, construction management, and alternative delivery firm. Our geotechnical and geological services include analysis, site characterization, geophysics, groundwater studies, digital photogrammetry, instrumentation and monitoring, ground modification, SPRAT Certified rope access for foundations, dams, levees, earth retaining structures, tunnels, and mining operations. As an ISO 9001:2015 Certified firm, we provide excellence delivered as promised.

Exhibitors' Luncheon

Wednesday, September 18
12:00–1:30pm in the Exhibit Hall.

Enjoy a delicious buffet lunch, connect with friends and associates, and make new contacts while browsing through our exhibitor booths

GEL-Solutions – Booth #17

Jeff Tallent, jeff.tallent@gel.com
www.gel.com

GEL Solutions of NC, Inc. DBA GEL Solutions (GEL), headquartered in Raleigh, NC, has seven offices and 70 employees strategically located throughout the Southeast. We provide subsurface utility engineering (SUE), surveying, utility coordination, and geophysical services to clients throughout the United States. GEL has extensive experience providing a variety of these services for Federal, state, municipal, and private entities. Projects we have supported include roadway improvements and widenings, bridge replacements, drainage improvements, and other infrastructure improvement projects. Our suite of up-front services is proven to be valuable prior to and during engineering design projects.

Geobrugg North America, LLC – Booth #6

Tim Shevlin, Tim.Shevlin@geobrugg.com
www.geobrugg.com

For over 65 years, Geobrugg has been producing solutions made from high-tensile steel wire to provide reliable protection against natural hazards. Intensive collaboration with industry, universities and research institutes has made Geobrugg a reliable partner when it comes to protection and safety solutions. Our systems are fully tested against rockfall, landslide, and debris flow.

Geobuild – Booth #2

Paul Hale, phale@geobuild.com
www.geobuild.com

Geobuild's mission is to protect people and infrastructure from geohazards through responsive and experienced geohazard mitigation services. We specialize in landslide repair, rockfall mitigation, excavation shoring, settlement control, and densification grouting; utilizing soil nails, micropiles, auger cast piles, and underpinning in some of the most difficult access applications that our clients are presented with.

Geokon – Booth #9

Joelle Lang, jlang@geokon.com
www.geokon.com

Geokon, Inc., manufactures a full range of high quality geotechnical instrumentation suitable for monitoring the safety and stability of a variety of civil and mining structures including dams, tunnels, foundations, mine openings, piles, etc. Geokon's sensors exhibit excellent long-term stability, accuracy and reliability even in the most adverse conditions.

Geologic Exploration, Inc. – Booth #10

Chris Schappell, cschappell@gexnc.com
704-872-7686
www.geologicexploration.com

Since 1990, Geologic Exploration, Inc., has provided regional environmental drilling and injection services at over 14,000 sites throughout the southeast and beyond. Based in Statesville, North Carolina, we provide clients with the tools for success through our modern drilling fleet, uncompromising safety and quality, expert training and experience, and superior customer service. Whether it is contamination assessment drilling, injection, geotechnical sampling, well rehabilitation, or abandonment services, Geologic Exploration has a full range of equipment with 12 late-model machines, including direct push, hollow stem auger, air and mud rotary, rock-coring, and sonic drills, to provide the ideal rig to meet your project needs. In addition to our top of the line equipment, we have experienced staff to complete your project in a safe, efficient and cost effective manner. Our team of project managers and drill operators have unparalleled expertise, safety training and field experience. Our safety program is designed to fully address the risks related to such services while meeting OSHA requirements and minimizing risk for both the client and our employees.

GeoSearch – Booth #15

Brian Morgan, brian.morgan@geo-search.com
980-389-0988
www.geo-search.com

GeoSearch provides customers with fast, accurate, constructive information to help assess and manage environmental risk. GeoSearch is a complete source for all of your environmental due diligence needs including ASTM environmental database reports, historical arials, city directory research, fire insurance maps, lien and tile search investigations, and more—all in one place!

GEOVision Inc. – Booth #19

John Diehl, jdiehl@geovision.com
951-549-1234
www.geovision.com

GEOVision Geophysical Services, a small California Corporation, offers state-of-the-art geophysical services using the most modern techniques and instrumentation to provide cost effective solutions to engineering and environmental problems. Our services include geophysical measurement, analysis, and monitoring. We specialize in non-invasive methods of investigation that often reduce the overall cost and liability in engineering and environmental projects. The use of geophysics can provide a better understanding of the source, location, and migration of subsurface contaminants; subsurface geologic and hydrologic conditions; subsurface infrastructure; engineering properties of soil and rock; and earthquake hazard.

Hazmat Emergency Response & Remediation, Inc – Booth #28

Alan King, Al.King@herrteam.com
910-640-2607
www.herrteam.com

Hazmat Emergency Response and Remediation, Inc. (HERR) is a privately-held, full-service environmental contractor with its corporate office based in Whiteville, North Carolina and an office in Thomasville, NC. HERR was formed in 2002 to serve eastern North Carolina and South Carolina by providing remediation, industrial, emergency response and waste management services. The company has maintained a consistent client base while expanding its service lines and coverage area over the years to include the entire states of North Carolina, South Carolina and southern Virginia.

HI-TECH Rockfall Construction, Inc. – Booth #24

Dane Wagner, dane@hitechrockfall.com
503-409-9180
www.hitechrockfall.com

HI-TECH Rockfall Construction, Inc., is a general contractor that provides natural hazard mitigation solutions, with focus on rockfall mitigation and slope stabilization systems. HI-TECH Rockfall founded in 1996, is located in Forest Grove, Oregon, USA. Our vast experience and innovative installation techniques allow us to work in limited access areas and overcome challenging situations, which all have made us the leader in the rockfall mitigation and slope stabilization industry.

IDS GeoRadar – Booth #25

John Metzger, john.metzger@idsgeoradar.com
303-726-6024
www.idsgeoradar.com

IDS GeoRadar is a world leader in designing and providing products for subsurface investigations, monitoring of structural, slope and geohazard ground movements and vibrations. IDS GeoRadar provides instruments in the Ground Penetrating Radar (GPR) and Ground Based Interferometric Radar (GbSAR) product sectors. Our solutions for GPR are developed for near-surface high-resolution and subsurface investigations of the earth. Ground Penetrating Radar uses radio wave reflections (frequency from 25 MHz to 3,000 MHz) to collect information of underground or within a structure such as buried pipes, underground cavities, subsurface cracks, voids and layers. IDS introduced the concept of multi-frequency, multi-channel ground penetrating systems. Our GPR products include Aladdin, Opera Duo, RIS Hi-BrigHT, RIS Hi-Pave, RIS MF Hi-Mod, RIS One & RIS Plus, SRS SafeRailSystem, Stream EM, Stream X. The IDS GeoRadar IBIS family of radar interferometers (GbSAR) that monitor structure movements and vibrations (bridges, buildings, dams, historical monuments, towers, etc.) and ground movements (mine walls, geohazards, glaciers, land

subsidence) are an increasingly important set of tools for today's construction, geotechnical, and transportation engineers. Our interferometric radar solutions, embodied by the IBIS range of products, provide innovative and unique solutions for remote, long-range, continuous near real-time inspection of at risk areas. IDS Interferometric radar products include the IBIS-FS, IBIS-ArcSAR, IBIS-FM, HYDRA-X/U/G, and the new RockSpot real-time rockfall monitor.

Keynetix – Booth #13

Hayley Maher, Hayley.Maher@keynetix.com
+44 (0) 1527 68888
www.keynetix.com

Keynetix prides itself on its data management expertise. Geotechnical and Environmental Data Management software is all they do—and they're good at it, which is why Autodesk chose them to be their worldwide geotechnical industry partner. HoleBASE SI is a state-of-the-art geotechnical knowledge management system that will help you stay in control of your geotechnical project data and archive. HoleBASE SI's extension for AutoCAD® Civil 3D allows quick and easy inclusion of all your geotechnical data in the BIM process and CAD drawings.

Lettis Consultants International – Booth #14

Hans AbramsonWard, abramsonward@lettisci.com
925-208-4359
www.lettisci.com

Lettis Consultants International, Inc. (LCI) offers high-technology, innovative Earth science consulting services to clients around the world. LCI geologists, seismologists, and engineers have comprehensive worldwide experience providing earthquake hazard analyses, engineering geology and geotechnical services, water resources expertise, and licensing and regulatory strategy and compliance.

Maccaferri – Booth #22

Justina Simmons, j.simmons@maccaferri.com
www.maccaferri.com

Maccaferri's extensive engineering capabilities and range of products help clients overcome challenges associated with geohazards, landslides, and other natural disasters. Maccaferri, known for its Double-Twist Wire Mesh Gabions, has developmental product lines for rockfall mitigation, retaining wall and soil reinforcement, natural disaster response, and other critical infrastructure needs. We are global engineers with 140 years experience, providing local solutions for complex projects around the world.

National Association of State Boards of Geology – ASBOG® - Booth #31

Deana Sneyd, dsneyd@asbog.org
678-713-1251
www.asbog.org

ASBOG serves as a connective link among the individual state geologic registration licensing boards for the planning and preparation of uniform procedures and the coordination of geologic protective measures for the general public. One of ASBOG's principal services is to develop standardized written examinations for determining qualifications of applicants seeking licensure as professional geologists. State boards of registration are provided with uniform examinations that are valid measures of competency related to the practice of the profession. Examination candidates are provided with a copy of the Professional Geologist Candidate Handbook, which delineates the format and outline for the exam.

Pyramid Geophysical Services – Booth #12

Eric Cross, eric@pyramidenvironmental.com
336-335-3174, ext. 137
www.PyramidGeophysics.com

Pyramid Geophysical Services is a consulting firm based in Greensboro, North Carolina, offering a full range of near-surface geophysical services. Our instrumentation includes ground penetrating radar (GPR), electromagnetics, electrical resistivity/IP, and seismic methods (refraction and MASW). Specific applications include geotechnical site characterization, geologic mapping (stratigraphy, karst, voids), environmental and hydrogeologic surveys, underground storage tank management, landfill delineations and a variety of other subsurface characterization techniques. Our services are available throughout the United States.

Redox Tech, LLC – Booth #16

John Haselow, jhaselow@redox-tech.com
919-678-0140
www.redox-tech.com

Redox Tech, LLC is a specialty environmental contractor that provides in situ remediation products and services. Redox Tech was founded in 1995 by Dr. John Haselow. Redox Tech provides laboratory testing (mainly oxidant demand), conceptual design, turnkey pilot-scale and full-scale applications. Redox Tech has completed over 2000 projects including activated, permanganate, persulfate Fenton's, chemical reduction with zero valent iron, aerobic (OBC and SBC) and anaerobic bioremediation (ABC, ABC+, ABC-Olé), steam injection and metals stabilization. Because of the diverse suite of remediation technologies that Redox Tech provides, the remediation approach that Redox Tech recommends will not be biased towards a particular solution. Redox Tech understands that successful remediation requires proper formulation and proper distribution. To provide proper delivery, Redox Tech maintains a fleet of 13

geoprobes and two custom designed soil blenders. We are partners with Carus Corporation to provide our products throughout Europe and the United States. For more information, please visit www.redux-tech.com.

Schnabel Engineering – Booth #1

Gary Rogers, grogers@schnabel-eng.com
336-274-9456
www.schnabel-eng.com

Schnabel is a leading provider of dam, tunnel and geotechnical engineering solutions nationally and abroad, with risk management rounding out a full-service approach. Our 300+ employee/owners in 19 locations have a passion for client service and tough technical challenges.

Seequent – Booth #29

Bart Jordan, bart.jordan@seequent.com
303-525-0108
www.seequent.com

Seequent is a global leader in the development of visual data science software. Our solutions enable people to create rich stories and uncover valuable insights from geological data. Our solution is designed to support all aspects of civil engineering and environmental projects—from 3D geological modelling with Leapfrog Works to model management and collaboration with Central.

University of Pennsylvania – Booth #4

Master of Science in Applied Geosciences,
lps@sas.upenn.edu
215-898-7326
www.sas.upenn.edu/lps/graduate/msag

The Master of Science in Applied Geosciences (MSAG) offers students a specialized degree that combines knowledge in theoretical areas of geology with technical expertise in geochemistry, geophysics, hydrogeology, and engineering geology with a focus on professional development. Students pursuing their MSAG at Penn may concentrate in one of three areas: Environmental Geology, Engineering Geology, and Hydrogeology.

US Army Corp of Engineers – Registration Area

US Army Corps of Engineers, Dam Safety Production Center
Coralie Wilhite, Coralie.P.Wilhite@usace.army.mil
916-215-7744

The program includes operational and production, which includes major repair/rehabilitation. Many great ideas for different program elements have been put in place to include new comprehensive dam safety policy that fully embraces USACE's risk-informed approach, as well as the establishment of production centers and an assortment of new management tools.

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Without the help and financial support of the following individuals and companies, it would be impossible to plan the quality meeting to which AEG members have become accustomed.

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740-350-6611

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267-304-0783

WWW.CASCADE-ENV.COM

Cascade is the leading provider of environmental and infrastructure drilling, site characterization, and environmental remediation applications. We are the only nationwide, integrated field services firm with expert technical capabilities and fleet to provide seamless environmental and geotechnical solutions, from concept to completion.

GIVEAWAY

Clean Vapor, LLC

Lorine Barone, lbarone@cleanvapor.com
908-362-5616

www.cleanvapor.com

Clean Vapor, LLC, is a design-build vapor intrusion mitigation company with 30 years of experience with offices in New Jersey and North Carolina. We specialize in existing building and new construction mitigation. Our focus is on integrating advanced pressure field mapping as a foundation to efficient designs coupled with energy efficient dynamic controls and remote management technology.

OPENING SESSION

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Brian Greene, bgreene@gfnet.com
412-922-5575

www.gannettfleming.com

Gannett Fleming is a planning, design, construction management, and alternative delivery firm. Our geotechnical and geological services include analysis, site characterization, geophysics, groundwater studies, digital photogrammetry, instrumentation and monitoring, ground modification, SPRAT Certified rope access for foundations, dams, levees, earth retaining structures, tunnels, and mining operations. As an ISO 9001:2015 Certified firm, we provide excellence delivered as promised.

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CCI

Justin Williams, justin.williams@cci-env.com
www.cci-env.com

CCI has been providing services ranging from remediation, abatement, and industrial services for over 30 years. CCI provides the most complete, quality-oriented environmental services in the market today, and strives for excellence in every service that we provide. Through sound remedial management methods, technical expertise, and regulatory awareness, CCI is able to provide our clients with the services needed and the confidence in knowing that their concerns are being met. Our staff's extensive environmental backgrounds and drive for innovation, allows CCI the expertise necessary to handle any Remediation project no matter the size or complications involved in the venture.

ICEBREAKER RECEPTION

Geobruigg North America, LLC

Tim Shevlin, Tim.Shevlin@geobruigg.com
www.geobruigg.com

For over 65 years, Geobruigg has been producing solutions made from high-tensile steel wire to provide reliable protection against natural hazards. Intensive collaboration with industry, universities and research institutes has made Geobruigg a reliable partner when it comes to protection and safety solutions. Our systems are fully tested against rockfall, landslide, and debris flow.

EXHIBITOR LUNCHEON

Geobuild

Paul Hale, phale@geobuild.com
www.geobuild.com

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TECHNICAL SESSIONS 4, 5, & 15A:

The Changing Times of Engineering Geology at Dams and Levees Symposium, Part I, Part II and Part IV

Schnabel Engineering

Gary Rogers, grogers@schnabel-eng.com
336-274-9456
schnabel-eng.com

Schnabel is a leading provider of dam, tunnel, and geotechnical engineering solutions both nationally and abroad, with risk management rounding out a full-service approach. Our 300+ employee/owners in 19 locations have a passion for client service and tough technical challenges.

STUDENT/PROFESSIONAL NETWORKING RECEPTION

University of Pennsylvania

Regina Cohen, cohenreg@sas.upenn.edu
215-746-1167
www.upenn.edu

The Master of Science in Applied Geosciences (MSAG) offers students a specialized degree that combines knowledge in theoretical areas of geology with technical expertise in geochemistry, geophysics, hydrogeology, and engineering geology with a focus on professional development. Students pursuing their MSAG at Penn may concentrate in one of three areas: Environmental Geology, Engineering Geology, and Hydrogeology.

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Jeff Tallent, jeff.tallent@gel.com
www.gel.com

GEL Solutions of NC, Inc. DBA GEL Solutions (GEL), headquartered in Raleigh, NC, has seven offices and 70 employees strategically located throughout the Southeast. We provide subsurface utility engineering (SUE), surveying, utility coordination, and geophysical services to clients throughout the United States. GEL has extensive experience providing a variety of these services for Federal, state, municipal, and private entities. Projects we have supported include roadway improvements and widenings, bridge replacements, drainage improvements, and other infrastructure improvement projects. Our suite of up-front services is proven to be valuable prior to and during engineering design projects.

ANNUAL BANQUET

RED Lab, LLC

Felecia Owen, fowen@redlabllc.com
919-278-8926
www.redlabllc.com

RED Lab, LLC, provides the most cost-effective solutions for on-site and in-lab analysis of environmental pollutants. With more than 20 years of environmental testing experience, we are focused on providing the latest developments in on-site technologies.

TECHNICAL SESSIONS 12 & 18:

Environmental Characterization and Remediation, Part I and Part II

Young at Heart Student and Young Professional Event

SAEDACCO

Peter Byer, pbyer@saedacco.com
803-548-2180
www.saedacco.com

South Atlantic Environmental Drilling and Construction Co. (SAEDACCO) maintains specialized equipment and trained personnel required to perform a wide range of environmental remediation services. Our auger, mud rotary, air rotary, air hammer and roto-sonic drill rigs are capable of deep drilling in all geological formations. Our drill rigs consist of both truck and track mounted all terrain carriers and our teams are composed of experienced drilling professionals capable of handling a wide range of drilling projects. There Is More To Us Than Meets The Eye. From Environmental Investigation Thru Remediation.

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SPONSORS

ALL-DAY COFFEES

Wednesday

HI-TECH Rockfall Construction, Inc.

Dane Wagner, dane@hitechrockfall.com
503-409-9180
www.hitechrockfall.com

HI-TECH Rockfall Construction, Inc., is a general contractor that provides natural hazard mitigation solutions, with a focus on rockfall mitigation and slope stabilization systems. HI-TECH Rockfall, founded in 1996, is located in Forest Grove Oregon, USA. Our vast experience and innovative installation techniques allow us to work in limited access areas and overcome challenging situations, which all have made us the leader in the rockfall mitigation and slope stabilization industry.

Thursday

Access Limited Construction

Simon Boone, simon@alccinc.com
805-592-2230
www.accesslimitedconstruction.com

Access Limited Construction is a general contractor located in San Luis Obispo, California. An industry leader, we provide rockfall mitigation, slope stabilization, and difficult drilling services for transportation, energy, mining and private sector clients. With our fleet of Spyder Excavators, we can access steep terrain and hard to reach projects throughout the United States from the East Coast to Hawaii.

Friday

AEG Sacramento Chapter

John Murphy, John.Murphy@Waterboards.ca.gov
<https://aegsacto.wordpress.com/>

The Sacramento Chapter of AEG was the original and founding section of AEG in 1957 and proudly supports the 2019 AEG Annual Meeting and the many dedicated members of AEG across the nation.

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YOUNG AT HEART STUDENT AND YOUNG PROFESSIONAL EVENT

AEG Foundation

Alex Vazquez, vazquezam@gmail.com
www.aegfoundation.org

Established by three Past Presidents of AEG in 1992, the AEG Foundation plays a key role in the success of our profession. The AEG Foundation's vision is to create a culture of giving back to the profession, and to instill complete confidence in donors that their money is well invested and well spent. Our core programs emphasize scholarship, research, and professional development to improve professional practice. We support outreach to increase the public's appreciation of environmental and engineering geology in geo-hazard evaluation and risk reduction.

AEG Student and Young Professional Support Committee (SYPSC)

Morley Beckman, MBeckman@kleinfelder.com
www.aegweb.org/page/OperationalComms

The SYPSC is responsible for the development and implementation of strategies related to supporting and increasing student and young professional members, and related goals in the Association's Strategic Plan.

EDR

Todd Elmore, telmore@edrnet.com
706-818-3310
edrnet.com

EDR is the leading information and technology provider to the real estate lending and property due diligence industries. We offer tools that help our clients increase efficiencies and better analyze and manage property-related risk. EDR's database contains over 4.1 billion historic property records, including the most comprehensive repository of environmental and land use information in the United States. Since 1990, EDR has supported environmental consultants on over 5 million Phase I ESAs.

Prism Laboratories, Inc.

Robbi Jones, rjones@prismlabs.com
803-448-6005
www.prismlabs.com

Since its inception in 1992, Prism Laboratories has been committed to providing the highest level of quality analytical services and technical support to our customers in the environmental monitoring, water quality and waste disposal market. Our team of highly qualified professionals is focused on ensuring on-time delivery of accurate and precise analytical results, while working one on one with our customers to provide customized service to suit each client's specific requirements.

Rick Kolb

rkolb@dunckleedunham.com

TECHNICAL SESSION BREAKS

Wednesday Morning

Earthquake Insight, LLC

Phyllis Steckel, psteckel@charter.net
636-239-4013

Earthquake Insight LLC is a small, woman-owned business whose mission is to increase awareness of earthquake hazards, earthquake risks, and earthquake mitigation options. Audiences include those in key, decision-making and policy-changing sectors, government, emergency professionals, as well as the general public.

Wednesday Afternoon

AEG St. Louis Chapter

Stephanie Kline-Tissi, klinestephaniej@gmail.com

AEG contributes to its members' professional success and the public welfare by providing leadership, advocacy, and applied research in environmental and engineering geology. Here within our St. Louis Chapter, we hold monthly meetings between September and December, February, and May, and hold a couple of social events throughout the year. We work with universities and colleges in Missouri and Illinois, advocating for the professional practice and help students with resumes, interview skills, and finding hands-on experiences to help them gain on-the-job skills.

Thursday Morning

GeoEngineers, Inc.

Mark Molinari, mmolinari@geoengineers.com
206-348-0200
www.geoengineers.com

We're GeoEngineers, Earth Science and Engineering Experts. You'll find us where soil meets foundation, water meets land, and humanity meets environment. We work with the earth, but people are the heart of what we do. Using earth science and engineering expertise, we help our clients find a balance between human needs and the earth's physical systems. Together we can build a better world.

SPEAKER/MODERATOR BREAKFAST

Wednesday

Rick Kolb

rkolb@dunckleedunham.com

WOMEN IN AEG/AWG LUNCHEON

Deborah Green

deb@geologistwriter.com

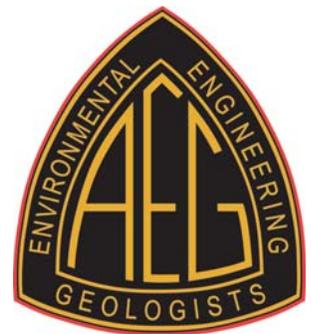
Geologist Writer, Deborah Green, rediscovered her love for creative writing after establishing herself in her professional career as an environmental and engineering geologist. Her first novel, tentatively titled *Inundation*, is loosely based on a period in her late husband's life when he was working as the Chief Foundation Geologist for a large dam in East Central Turkey. She is currently working on several short stories and essays as her agent begins submitting her novel to publishers. As the Geologist Writer, Deborah strives to understand and convey the wonder of the landscape and the complexity of earth processes while also exploring the mysterious terrain of the human heart. You can read some of her work on her website, www.geologistwriter.com.

Steele and Associates, LLC

Susan Steele Weir, steeleweir@aol.com
303-333-6071

Steele and Associates, LLC, is a small woman-owned engineering geologic consulting firm providing peer review of dam and tunnel construction projects and consultation on slope stabilization projects.

Calling
all
interested
volunteers!



Interested in volunteering some of your time to benefit AEG?

Join us for the **Volunteer Recognition Event, Wednesday, September 18** at 2:45 pm in the Eagle Room. Not only will we be recognizing current volunteers, but we will also be talking about current opportunities to volunteer and participate in AEG. We hope to see you there.

TECHNICAL SESSIONS

#3B: PFAS/GenX Symposium

Bryan Environmental Consultants, Inc.

Patricia Bryan, pbryan@bryanenv.com
708.922.9020
<http://www.bryanenv.com>

INDUSTRY EXPERTISE. RAPID RESPONSE. WOMAN OWNED. Founded in 2014, Bryan Environmental Consultants, Inc. provides full-service environmental consulting services to private clients and municipalities. With its deep industry and technical expertise, Bryan Environmental Consultants, Inc. provides quality, cost-effective environmental consulting services to its clients. We help advance your project with focused field investigations that keep your objectives in mind, clearly written reports that identify relevant environmental issues, expert regulatory advice and strategies, sensible recommendations, and realistic cost estimates.

#8A: Hydrogeology, Groundwater and Karst &

#14A: Risk / 3D modeling

Collier Geophysics, LLC

Collier Consulting, Inc.

Hughbert Collier, hughbert@collierconsulting.com
254-968-8721
www.collierconsulting.com

Collier Consulting is a woman-owned, geoscience and engineering firm. Our primary offices are in Stephenville, Texas, with satellite locations in Austin, Houston, Waco, Colorado, Ohio and Wisconsin. Founded in 1998, our mission is to provide our clients with the best solutions. We work hard to meet our clients' needs – with honesty, attention to detail, and a strong work ethic. This philosophy has allowed us to grow, but more importantly to develop and sustain long-term relationships with you – our clients.

#12 & #18: Environmental Characterization and Remediation, Part I and Part II

SAEDACCO

Peter Byer, pbyer@saedacco.com
803-548-2180
www.saedacco.com

South Atlantic Environmental Drilling and Construction Co. (SAEDACCO) maintains specialized equipment and trained personnel required to perform a wide range of environmental remediation services. Our auger, mud rotary, air rotary, air hammer and roto-sonic drill rigs are capable of deep drilling in all geological formations. Our drill rigs consist of both truck and track mounted all terrain carriers and our teams are composed of experienced drilling professionals capable of handling a wide range of drilling projects. There Is More To Us Than Meets The Eye. From Environmental Investigation Thru Remediation.

#14B: Geophysics

GEOVision Inc.

John Diehl, jdiehl@geovision.com
951-549-1234
www.geovision.com

GEOVision Geophysical Services, a small California Corporation, offers state-of-the-art geophysical services using the most modern techniques and instrumentation to provide cost effective solutions to engineering and environmental problems. Our services include geophysical measurement, analysis, and monitoring. We specialize in non-invasive methods of investigation that often reduce the overall cost and liability in engineering and environmental projects. The use of geophysics can provide a better understanding of the source, location, and migration of subsurface contaminants; subsurface geologic and hydrologic conditions; subsurface infrastructure; engineering properties of soil and rock; and earthquake hazard.

#16: Environmental Remediation and Geochemistry Symposium

EA Engineering, Science and Technology, Inc., PBC

Melissa Smith, masmith@eaest.com
410-329-5116
www.eaest.com

EA is a 100% employee-owned public benefit corporation that provides interdisciplinary environmental services to a wide range of public and private sector clients. Headquartered in Hunt Valley, Maryland, EA employs more than 500 professionals through a network of 26 commercial offices across the continental United States, as well as Alaska, Hawaii, and Guam. In business for more than 45 years, EA has earned an outstanding reputation for technical expertise, responsive service, and judicious use of client resources.

#19: Geologic and Geotechnical Site Characterization

GroundLogs

John Gobins, john.gobins@groundlogs.online
949-390-9699
www.groundlogs.online

GroundLogs helps geotechnical engineering and environmental consulting firms get their boring logs done quickly, consistently, and cost-effectively. We accomplish this by providing: 1) boring log drafting and data entry from handwritten field logs, 2) online boring log software for entering field notes on desktop computers or for field logging on tablet computers, and 3) tools and consultation for improving your logging and log preparation processes. Our delivered logs come in standard (GroundLogs, gINT, and LogPlot formats) and custom regulatory- and client-specific templates. Users can get started by registering on our website.

#9: The Changing Times of Engineering Geology at Dams and Levees Symposium, Part III

RJH Consultants, Inc.

Edwin Friend, efriend@rjh-consultants.com
303-225-4611
www.rjh-consultants.com

RJH Consultants, Inc. (RJH) is a geotechnical and water resources firm specializing in evaluation, civil design, and construction engineering for raw water supply systems; dams, reservoirs, and appurtenant facilities; and water conveyance infrastructure. RJH projects range from small geotechnical explorations to large embankment dam design and construction. RJH manages projects with overall costs ranging from several thousand dollars to in excess of \$200 million.

#s 4, 5, and 15A: The Changing Times of Engineering Geology at Dams and Levees Symposium, Part I, Part II and Part IV

Schnabel Engineering

Gary Rogers, grogers@schnabel-eng.com
336-274-9456
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Schnabel is a leading provider of dam, tunnel, and geotechnical engineering solutions both nationally and abroad, with risk management rounding out a full-service approach. Our 300+ employee/owners in 19 locations have a passion for client service and tough technical challenges.

AEG CORPORATE BUSINESS MEETING AND AWARDS CEREMONY

Earth Consultants International, Inc.

Tania Gonzalez, gonzalez@earthconsultants.com
714-412-2654
www.earthconsultants.com

Earth Consultants International is a small geological consulting business headquartered in Santa Ana, California. We specialize in characterizing and quantifying geologic hazards for planning and engineering mitigation, and are dedicated to helping our clients understand and overcome complex geologic issues all over the world. Now in our 23rd year, we have completed projects in 18 countries, in addition to hundreds of projects in southern and central California, and in Arizona, Washington, Nevada, New Mexico, and Texas. Our two Principal Owners, Mr. Eldon Gath and Ms. Tania Gonzalez, are well recognized experts in the profession. Services that Earth Consultants International provide include: Land-use planning and feasibility studies, Natural hazard assessments and hazard modeling, Earthquake geology, Geoarcheology, Environmental and ground-water studies, Mineral exploration and consulting, and Litigation and geoforensic support.

STUDENT PROFESSIONAL NETWORKING RECEPTION

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EGIS, PA is a North Carolina based geological consulting firm that specializes in down-hole geophysical and borehole video inspection services. Expertise is available in water well construction, development, and rehabilitation. By evaluating site specific concerns, we can design and implement cost effective solutions to your well problems.

FIELD COURSES

#3: Debris Flows, Rock Slides, Rock Falls and Big Slow Movers: Who Could Ask for More?

Subhorizon Geologic Resources LLC (SGR)

Jim Stroud, stroudjr@subhorizonresources.com
336-416-3656
www.subhorizonresources.com

SGR was formed in 2012 by Brett McLaurin and Jim Stroud. Not only does the SGR team offer extensive technical skills to its clients, SGR also brings together considerable expertise from over 30 years combined experience in the mining industry and academia. SGR's corporate headquarters is in Bloomsburg, Pennsylvania, with an office located in East Bend, North Carolina. Our clients are local and we can provide rapid response to their geological consulting needs. Our Services include: Geologic Exploration & Mapping, Economic Evaluation of Mineral Resources, Slope Stability Determinations, Environmental Assessments, Petrographic Services (aggregate and concrete), Geospatial Solutions (GIS and Remote Sensing), Natural Hazard Delineation, Medical Geology, and Forensic Geology.

#4: These Rocks are Mined, But You Can Look at Them: Mining and Geology

IDS GeoRadar

John Metzger, john.metzger@idsgeoradar.com
303-726-6024
www.idsgeoradar.com

IDS GeoRadar is a world leader in designing and providing products for subsurface investigations, monitoring of structural, slope and geohazard ground movements and vibrations. IDS GeoRadar provides instruments in the Ground Penetrating Radar (GPR) and Ground Based Interferometric Radar (GbSAR) product sectors. Our solutions for GPR are developed for near-surface high-resolution and subsurface investigations of the earth. Ground Penetrating Radar uses radio wave reflections (frequency from 25 MHz to 3,000 MHz) to collect information of underground or within a structure such as buried pipes, underground cavities, subsurface cracks, voids and layers. IDS introduced the concept

of multi-frequency, multi-channel ground penetrating systems. Our GPR products include Aladdin, Opera Duo, RIS Hi-Bright, RIS Hi-Pave, RIS MF Hi-Mod, RIS One & RIS Plus, SRS SafeRailSystem, Stream EM, Stream X. The IDS GeoRadar IBIS family of radar interferometers (GbSAR) that monitor structure movements and vibrations (bridges, buildings, dams, historical monuments, towers, etc.) and ground movements (mine walls, geohazards, glaciers, land subsidence) are an increasingly important set of tools for today's construction, geotechnical, and transportation engineers. Our interferometric radar solutions, embodied by the IBIS range of products, provide innovative and unique solutions for remote, long-range, continuous near real-time inspection of at risk areas. IDS Interferometric radar products include the IBIS-FS, IBIS-ArcSAR, IBIS-FM, HYDRA-X/U/G, and the new RockSpot real-time rockfall monitor.

Subhorizon Geologic Resources LLC (SGR)

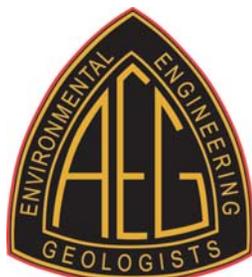
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Denise Hallett, hallettd@vmcmail.com
www.vulcanmaterials.com

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AEG 2019 ANNUAL MEETING MOBILE APP SPONSORSHIP

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Environmental Risk Information Services (ERIS) is a leading provider of detailed environmental property risk research. Leveraging our industry-leading research tools, we provide our clients and partners with in-depth property data for phase I site assessments, real estate due diligence, industry compliance information, and environmental hazard research. ERIS is the only company to provide comprehensive data to assess environmental risk throughout North America.

STUDENT MINI-GRANT PROGRAM

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Jane Gill-Shaler, janehgillshaler@gmail.com

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PanGEO is a full service geotechnical consulting firm based in Seattle, Washington. We provide geotechnical studies for infrastructure on public and private projects, including bridges, high-rise buildings, seismic retrofit and landslide stabilization efforts.

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Spotlight Geophysical Services provides innovative geophysical services for geotechnical and environmental applications. We have over 25 years of experience using geophysics to characterize complex subsurface conditions. We own and maintain an inventory of state-of-the-art geophysical tools, including micro-gravity, EM, land and marine seismic, GPR, and ERI. Spotlight Geophysical Services is available for projects throughout the United States and abroad. Based in South Florida, we are conveniently located for quick response to projects in the Southeastern U.S., the Caribbean, and Latin America.

2019 Technical Program

The 2019 Planning Committee has put together a technical program that is sure to provide an outstanding educational experience for attendees. PDHs will be available for all technical sessions and short courses. A speaker preparation room will be open from September 18–21, from 7:00am–5:00pm on Wednesday and Thursday and from 7:00am–2:30pm on Friday. A laptop and projector will be available for presenters to practice their presentations. AEG provides an open forum for the presentation of varying opinions and positions. However, opinions and positions expressed by speakers do not necessarily represent the views or policies of AEG.

TECHNICAL PROGRAM SPONSORS

Opening Session – Gannett Fleming*

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Technical Session #12 and #18: Environmental Characterization and Remediation Part I and Part II – SAEDACCO

Technical Session #14A: Risk/3D Modeling – Collier Geophysics, LLC

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Technical Session #16: Environmental Remediation and Geochemistry Symposium – EA Engineering, Science and Technology, Inc., PBC

Technical Session #19: Geologic and Geotechnical Site Characterization – Ground Logs

Technical Session #9: The Changing Times of Engineering Geology at Dams and Levees Symposium Part I and Part II – RJH Consultants

***Be sure to visit these Sponsors in our Exhibit Hall and thank them for helping to make this Technical Program possible.**

OPENING SESSION

Keynote Speakers



Kenneth Taylor
State Geologist
of North Carolina

Dr. Kenneth B. Taylor PG is the 13th person to serve as the State Geologist of North Carolina since the N.C. Geological Survey was authorized in 1823. His career has spanned 40 years, including 25 years in state government, a decade in academia, four years in

the private sector, and a short time in federal service. He has shared his experience in emergency planning, disaster response, hazard mitigation, risk assessment, loss estimation and geohazard analyses with other geoscientists and emergency managers in more than 60 abstracts and professional papers. As both a geologist and a geophysicist, he has responded to significant regional earthquakes to capture after-shock sequences for source analyses, worked in the Texas oil fields on secondary oil/gas recovery techniques, utilized geophysical methods to characterize geological problems, and analyzed energy and mineral resource potential. He was the 1991–92 Congressional Science Fellow from the Geological Society of America (GSA) and is a fellow of GSA.

Abstract: Natural Hazards – A Perspective from a Former State Emergency Planner, Emergency Manager, Director and the State Geologist

I have spent 25 years in state government and have worked in only 2 state organizations: the N.C. Division of Emergency Management and the N.C. Division of Land Resources. My background is in geologic hazards, including where the hazards are, how to avoid the impacts from those hazards, and how to make housing and infrastructure more resilient to these hazards. A hazard risk assessment is based on several factors: location, extent of impact, severity of impact, and probability of impact. In many cases, these factors are poorly known and/or difficult to quantify. Modeling has become the “what-if” method to plan for rare events. By running through a series of locations and levels of severity, the emergency planner can make order-of-magnitude estimates of potential impacts. Forecasting by the National Weather Service has given these planners the upper bounds on the potential impacts, and several states have used computer programs that can predict flood height and timing of peak flow for flooding events. Examples of modeling used by emergency managers from knowledge provided by scientists and engineers will be shared.



Bart Cattanach
North Carolina Department
of Environment and Natural
Resources

Bart Cattanach is a Licensed Geologist working for the North Carolina Geological Survey in their Asheville field office. He is the Senior Mapping Geologist for the Blue Ridge and western Piedmont and has spent the last 18 years working on a variety of geo-

logical projects in western North Carolina. He earned a BS in Geology from the University of North Carolina-Chapel Hill and a MS in Geology from North Carolina State University.

Abstract: The Geology of Western North Carolina: An Overview

Asheville is located within the Blue Ridge Physiographic province of the Southern Appalachian Mountains. The geology of surrounding western North Carolina records over a billion

years of Earth's history including evidence of three Wilson Cycles. Local basement gneisses are the product of Mesoproterozoic orogenesis. Failed and successful rifting of these gneisses in the Neoproterozoic deposited mixed volcaniclastic and sedimentary rocks within continental and oceanic basins along the new continental margin. In the early Paleozoic the active rift zone transformed into a passive continental margin with widespread sedimentary deposition on both continental and oceanic crust. Three major orogenic events affected the Grenville basement and younger cover sequences of western North Carolina during the Paleozoic: Taconic, Acadian/Neocadian, and Alleghanian. The Alleghanian orogeny culminated with the formation of Pangea. The metamorphism, plutonism, deformation, and faulting of these three mountain building events created and shaped the rocks we see at the surface today. Mesozoic rifting of Pangea created the Atlantic Ocean basin beginning the latest Wilson cycle. Brittle structures and diabase dikes extending into western North Carolina are evidence of this new chapter. It is believed that the mountains created during the Alleghanian orogeny were largely eroded and that the topography we see today is the result of relatively recent uplift and erosion during the Cenozoic.



BRIAN BAUER'S VIEW FROM BLUE RIDGE PARKWAY

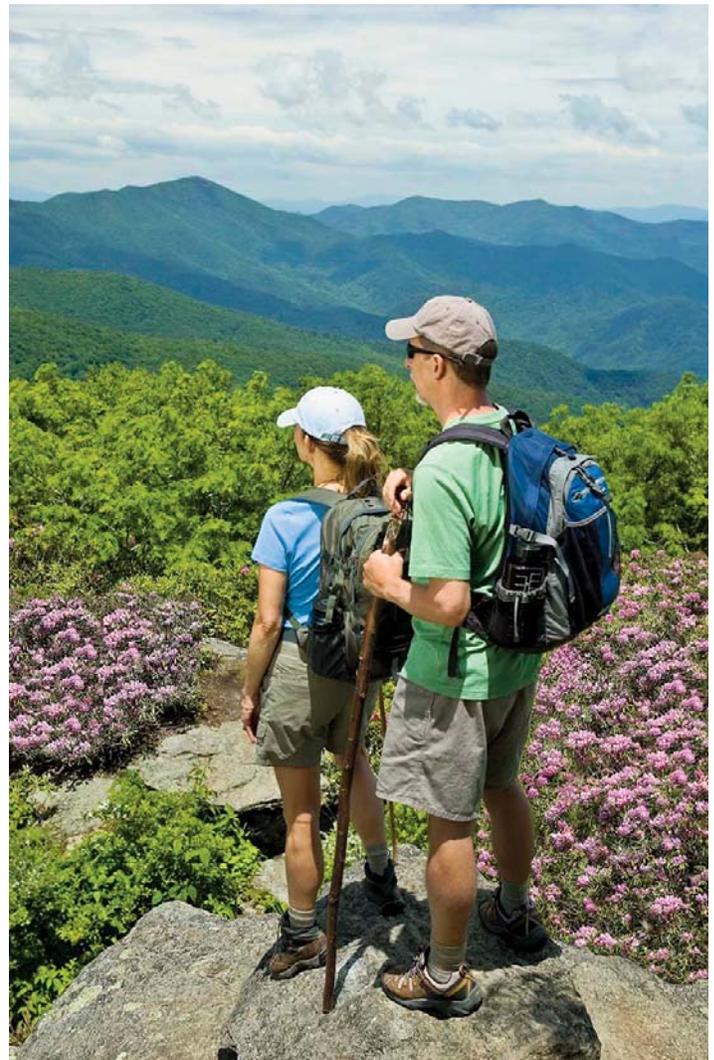


PHOTO COURTESY OF EXPLORE ASHEVILLE

The 2018/2019 AEG/GSA Richard H. Jahns Distinguished Lecturer in Applied Geology Deborah Green

I've been honored this year to serve as the 31st Jahns Lecturer. By the end of the Spring 2019 semester I had visited 43 colleges and universities in 19 states, giving more than 70 lectures, as well as meeting with students and faculty for informal discussions. I'm still answering emails from students who have sent questions and asked for mentoring since I spoke at their schools.

After the summer break I'll be traveling throughout September to complete my lectureship. I've been especially pleased to be the second woman Jahns Lecturer, and I'm gratified by the reception from students, particularly young women excited to talk about their own opportunities in the profession.



Deb Green (center) with NEIU students

The 2018/2019 Jahns Lectures included:

- How to Build a Geology Career You Love
- You Don't Look Like a Geologist – A Conversation on Diversity (or the Lack Thereof) in Our Profession
- Let's Talk – A Conversation on How We Communicate about Science
- A Tale of Two Waste Sites
- Always Book a Window Seat – The Lens Through Which We View the World as Geologists

"How to Build a Geology Career You Love" was requested more than twice as often as any of the other lectures, and both students and faculty seemed to appreciate hearing more about the career paths available in environmental and engineering geology. Too often we don't tell students what they can do professionally with the science they are so dedicated to learning. The two "conversation" format lectures also proved to generate rich interactions, with several schools and organizations specifically extending invitations to create those opportunities.

After attending the "Let's Talk" Jahns Lecture at an AEG Chapter meeting, Gerry Stirewalt, a long-time colleague asked me to co-convene "Speaking Their Language – Communicating Science with Non-Scientists – Who, Why, and How," a symposium for the 2019 AEG Annual Meeting. This symposium has a great slate of presenters, and I hope to see you there.

In addition to speaking with students, I also had the chance to address members of the general public about our work, and my life as an applied geologist, while participating in the Science in the City series at the Pacific Science Center in Seattle. The most unusual question of my lectureship came at the end of that presentation when someone asked what rock I would describe myself as.

With 35 years of professional experience in environmental and engineering geology projects across the United States, I have worked for a large consulting firm, in industry, and as an independent consultant. Now, semi-retired from geological consulting, I've written a novel whose protagonist is an engineering geologist working on a dam with a problematic foundation. Serving as the Jahns Lecturer has been one of the most rewarding experiences of my varied career, because of the time spent with future colleagues in the profession.

I hope I've helped the students I met this year see that working in environmental and engineering geology they can make a living and make a difference. Thank you to AEG and GSA for this honor and opportunity.

THE 2019/2020 AEG/GSA RICHARD H. JAHNS DISTINGUISHED LECTURER IN APPLIED GEOLOGY

Scott Lindvall

Scott Lindvall is a Certified Engineering Geologist in California with 35 years of experience working in the consulting industry performing seismic and geologic hazard analyses, fault investigations, and engineering geology studies for both existing and proposed critical facilities. He is particularly interested in advancing the state of the practice by incorporating recent research on active faults and seismic sources into the evaluation of dams, aqueducts, pipelines, nuclear facilities, and other infrastructure.



Scott received his BS in Geology from Stanford University in 1984 and his MS in Geology from San Diego State University in 1988. Dick Jahns was Scott's undergraduate advisor at Stanford, which makes this award especially meaningful to him. He has spent the majority of his career working for consulting firms specializing in seismic hazards and engineering geology. He currently manages the Lettis Consultants International Southern California office, and prior, worked many years at both William Lettis & Associates, and Lindvall, Richter & Associates.

His interest in geology came at a young age growing up in the Transverse Ranges of Southern California. His geologist father, Eric Lindvall, helped instill an appreciation of the outdoors (and therefore geology) and was later instrumental in shaping Scott's career. His interest in earthquakes was triggered at nine years old in the early morning hours of February 7, 1971, with the M6.6 San Fernando earthquake. Experiencing strong ground shaking from the main shock and several large aftershocks in the epicentral region, while dust was slowly rising from rock falls in the surrounding canyons, left a lasting impression.

Scott has performed detailed mapping of surface ruptures of earthquakes in southern California and Turkey, including the 1986 M6.6 Superstition Hills, 1992 M7.3 Landers, 1999 M7.4 Izmit (Kocaeli), 1999 M7.1 Düzce, and the 1999 M7.1 Hector Mine earthquake ruptures. Scott's experience in neotectonics, paleoseismology, and geomorphology has enabled him to pursue research projects designed to better quantify the timing of past events, slip rate, surface displacement, and style of deformation on active strike-slip and reverse faults throughout southern California. He has been awarded over a dozen research grants funded by the U.S. Geological Survey National Earthquake Hazards Reduction Program (NEHRP) and the

Southern California Earthquake Center (SCEC). Scott has directed geologic evaluations and seismic source characterizations in a variety of tectonic environments ranging from active plate boundaries to stable cratons. He served on the Technical Integration Team for a multi-year study sponsored by the U.S. Nuclear Regulatory Commission, U.S. Department of Energy, and the Electric Power Research Institute to develop the Central and Eastern United States Seismic Source Characterization for Nuclear Facilities, which has served as the regional seismic source model for hazard evaluations of nuclear facilities since its publication in 2012. Scott has also served on the advisory committee of the Earthquake-Induced Landslides Working Group for the California Geological Survey's (CGS) Seismic Hazards Mapping Program and, more recently, the CGS Special Publication 42 Advisory Panel to update the regulatory guidance on assessing fault rupture hazards in California.

Scott's lecture topics include:

- Crossing the San Andreas Fault: Improving the Resilience of the Los Angeles Aqueduct System
- The 1971 San Fernando Earthquake and Paleoseismology of the Sierra Madre Fault System
- A Tale of Three Dams Along the Owens Valley Fault System
- Characterizing Fault Displacement Hazards: Significant Progress and Significant Uncertainties
- Seismic Source Characterization for Evaluating Nuclear Power Plants in the Central and Eastern US
- Careers for Students in Applied Geology: Options to Consider

Scott is looking forward to this next year of the lectureship and the opportunities to meet and speak to geology students and colleagues on topics that have interested him throughout his career. Please email any speaking requests to lindvall@lettisci.com to schedule a presentation between October 2019 and September 2020.

Description of 2019/2020 Jahns Lecture Talks

Crossing the San Andreas Fault: Improving the Resilience of the Los Angeles Aqueduct System

This talk focuses on the Los Angeles Aqueduct crossing of the San Andreas fault in the Elizabeth Tunnel and describes the detailed surface and subsurface geologic investigations used to characterize the architecture of the fault zone at tunnel depth. Historic fault displacement data from world-wide strike slip faults are presented along with fault displacement hazard analyses performed to address the new 2019 performance-based seismic design guidelines for the Los Angeles Department of Water and Power.

The 1971 San Fernando Earthquake and Paleoseismology of the Sierra Madre Fault System

Experiencing the 1971 M6.6 San Fernando earthquake as a boy peaked my interest in earthquakes and I have continued to study the Sierra Madre fault system, which has uplifted the

San Gabriel Mountains to form the northern margin of the Los Angeles Basin. Incorporating tectonic geomorphic observations, paleoseismic trench studies, and age-dating research has continued to improve our understanding of past rupture behavior, slip rates, timing of events, and displacement per event on this significant north-dipping reverse fault system, that poses a significant hazard to the region.

A Tale of Three Dams along the Owens Valley Fault System

Three dams (Tinemaha, North Haiwee, and South Haiwee) in the Owens Valley are located on or adjacent to active faults, including the Owens Valley fault zone that produced a large surface-rupturing earthquake in 1872 (about 40 years prior to the construction of these facilities). These aging dams are being reassessed and rebuilt or rehabilitated by the Los Angeles Department of Water and Power to accommodate ground shaking, liquefaction, and fault displacement.

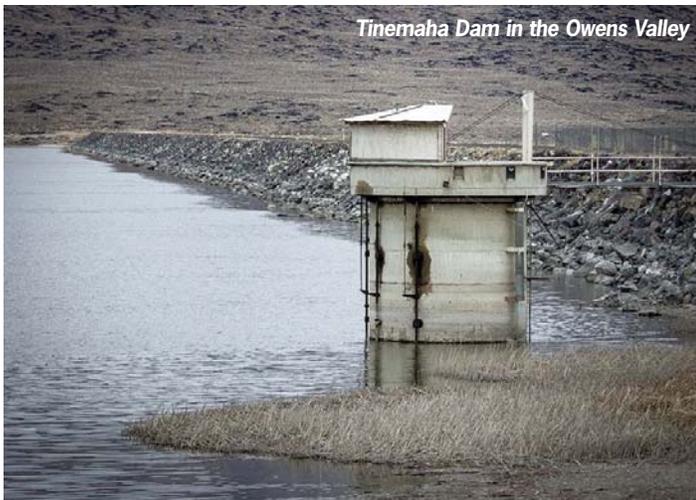


PHOTO BY DUSTIN BLAKEY – FLICKR CREATIVE COMMONS

Characterizing Fault Displacement Hazards: Significant Progress and Significant Uncertainties

This talk will focus on the different methods and underlying data used to develop probabilistic and deterministic fault displacement estimates and well as our understanding of fault behavior (slip rate, magnitude, and recurrence) and the uncertainties associated with fault behavior and observations of historic fault slip. The presentation will also raise critical questions regarding both methodologies and design criteria used for infrastructure projects in light of these uncertainties.

Seismic Source Characterization for Evaluating Nuclear Facilities in the Central and Eastern U.S.

This presentation will describe how seismic sources have been defined in the past two decades in the Central and Eastern U.S. (CEUS) to characterize safety of nuclear power plants in regions where little is understood about the causative faults of past earthquakes. East of the Rockies, the paucity of known active faults requires that seismic source characterization rely less on fault studies and more on spatial and temporal patterns of seismicity and evidence of strong ground shaking, such as paleoliquefaction, in the geologic record.

Careers for Students in Applied Geology: Options to Consider

Most of my engineering geology career has been working for small to moderate-sized consulting firms, however I have collaborated with other geologists and engineers at large engineering consulting firms, utilities, and government agencies. This talk will outline some of the different employment options for young geologists to consider as they begin their careers, by describing how roles, responsibilities, fields of study, and types of geologic investigations may differ.

AEG COMMITTEE MEETINGS in Asheville

LANDSLIDES

Technical Working Group Meeting
Wednesday, 9/18 – Cherokee
12:30–1:30pm

DAMS Technical Working Group Meeting
Thursday, 9/19 – Eagle
12:00–1:00pm

LICENSURE Committee Meeting
9/19 – Eagle
1:40–3:00pm

How to Schedule a JAHNS LECTURE

The individual Jahns Lecturer does almost all of their own scheduling and logistical coordination with the local Chapter. In addition, the Lecturer is conducting talks in other areas— all while trying to perform their "real" day-job back home."

Setting up a Jahns Lecturer takes patience and understanding on both ends, but the product is invaluable in its knowledge transfer, career guidance, and mentoring to students.

If your AEG Chapter would like a Jahns Lecturer's visit to your area, check out the helpful tips on our website at: www.aegweb.org/?page=LecturerVisit or www.aegweb.org/page/JahnsLecturer2019

AEG's Outstanding Environmental and Engineering Geologic Project Award – 2019

Boone Dam Internal Erosion Remediation Project

SCOTTIE L. BARRENTINE, PE; CHRISTOPHER L. SAUCIER, PE; SCOTT R. WALKER, PE, CEG



Introduction

The Tennessee Valley Authority (TVA) is the nation's largest publicly owned power producer, currently generating electricity for approximately 10 million customers in seven southeastern states (Figure 1). In support of its mission, TVA operates its 49 dams and reservoirs (Figure 2) as an integrated system for flood control, navigation, hydroelectric power, water supply, water quality, and aquatic ecology using a sophisticated real-time simulation of the Tennessee River and its tributaries. Constructed by TVA between 1950 and 1952, Boone Dam is an integral component of this system.

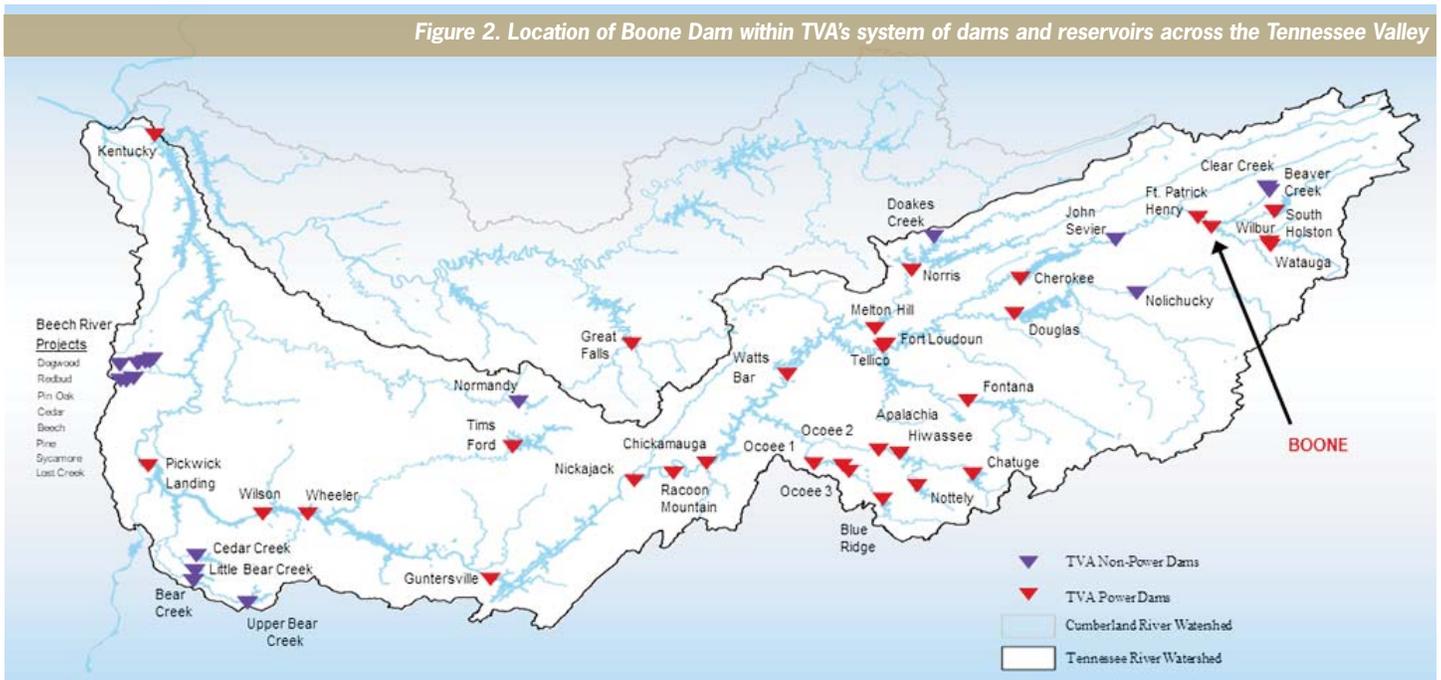
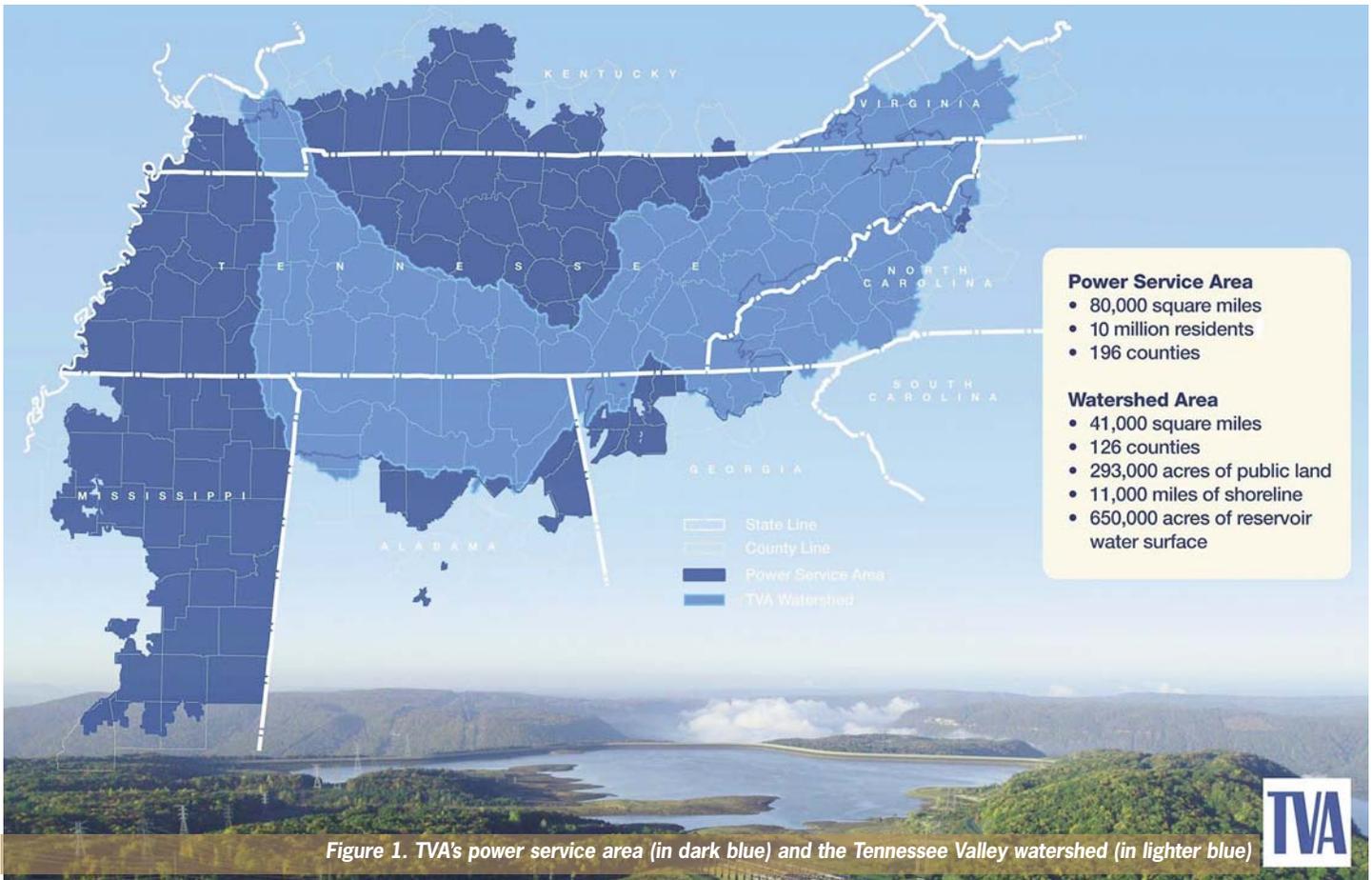
Located near the cities of Kingsport and Johnson City, Tennessee, at River Mile 18.6 on the South Fork Holston River, Boone Dam is 160 feet tall, and includes a 782-foot-long concrete gravity section with a gated overflow spillway, powerhouse with three generating units located downstream of and integral

to the concrete dam, and a 750-foot-long curved earthen embankment on the right abutment. At normal summer pool, Boone Lake has a total storage volume of 189,100 acre-feet.

Named for Daniel Boone, who was known to frequent the area in the 1760s, the dam and reservoir fulfill multiple elements of TVA's mission. Of primary importance is flood protection for public and private interests downstream of the dam, including a major population and industrial center at Kingsport, Tennessee. Several municipalities and industrial facilities utilize the reservoir for water supply, and recreation opportunities on Boone Lake provide important economic benefits to the region.

Project Overview

The purpose of the Boone Dam Internal Erosion Mitigation Project (Project) is to mitigate dam safety risks that TVA determined to pose an unacceptably high risk to the dam. Observations at the



site suggested that internal erosion had initiated and progressed; these observations were subsequently confirmed by additional investigation and analysis, including development of a hydrogeologic model. The selected mitigation option is a composite seepage and internal erosion barrier consisting of a new

concrete diaphragm wall and a new, deeper grout curtain. The diaphragm wall extends through the embankment dam, foundation materials, and into competent bedrock. The grout curtain extends farther into competent rock below the diaphragm wall. The barrier will be constructed in well-developed karst geology,

which is complicated by strong, steeply dipping limestone and dolomite bedrock, and the influence of local topography on the groundwater regime at the site.

Locally, the Project is important for its role in restoring a regionally important reservoir to full operation. Both within TVA and the broader engineering geology and dam safety communities, the Project is important for its contributions to the development of risk-informed decision-making (RIDM) practices, its unprecedented integration of geospatial data into design and construction of a composite barrier wall, and its tailored application of specialty underground construction techniques to extremely challenging geology and subsurface conditions.

First Indications of Trouble

TVA's normal operation of Boone Lake includes a seasonal fluctuation of 20 feet. The reservoir remains high through the summer for recreation, is drawn down to provide flood storage capacity over the winter, and then is refilled by spring runoff. In February 2012, while the reservoir was drawn down, a sinkhole was observed in the forebay approximately 75 feet upstream of the dam between the summer and winter pool elevations (Photo 1). When it was explored and dye tested, there was no evidence of connectivity



Photo 1. Sinkhole upstream of the dam in February 2012

either to the reservoir or downstream of the dam. The sinkhole was surveyed, backfilled, and marked for future inspection, but because it was far enough away from the footprint of the embankment it was not considered a serious threat to the dam.



Photo 2. Sinkhole in the control building parking lot on October 20, 2014

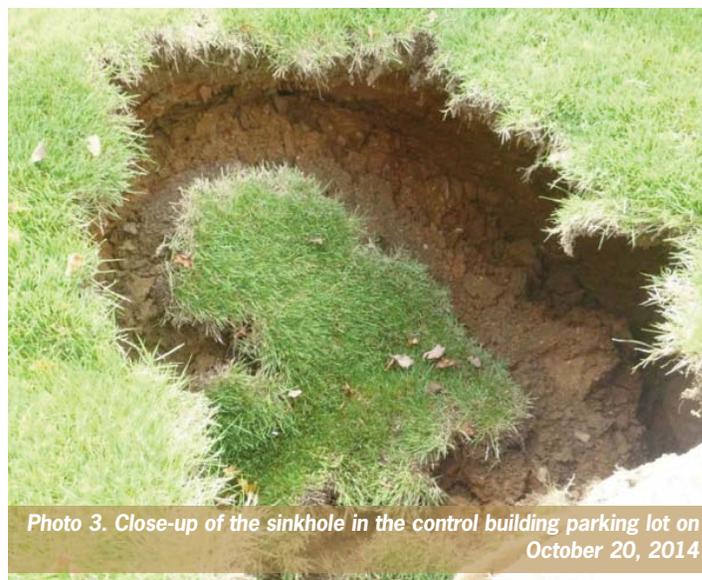


Photo 3. Close-up of the sinkhole in the control building parking lot on October 20, 2014

About two and one-half years later, on October 20, 2014, staff at the hydroelectric plant observed another sinkhole—this one located in the powerhouse parking lot near the downstream toe of the embankment portion of the dam (Photos 2 and 3). Sinkholes are relatively common in eastern Tennessee, and TVA has encountered sinkholes near dams that do not present a concern. However, to reach this conclusion, the cause needs to be investigated and understood. This sinkhole was explored and found to involve a block of soil approximately 6 feet square and about 6 feet deep. No clear exit from the sinkhole was evident. Over the subsequent week, inspections revealed cracks were opening in the surrounding pavement to a radial distance of approximately 15 feet from the center of the sinkhole.

On October 26, 2014, muddy seepage emerged from the right descending bank adjacent to the tailrace, approximately 20 feet downstream of the draft tubes for Unit 1 (Photo 4). This demonstrated that water moving through the subsurface



Photo 4. Muddy seepage exiting from the right bank of the tailrace on October 30, 2014. The concrete wall in the foreground is the downstream end of the draft tube discharge bay.

was carrying soil particles, which is an indication of a potentially serious internal erosion failure mode. Left unchecked, these processes (concentrated leak erosion and backward erosion piping) had the potential to lead to a breach, by progressing to the reservoir through the foundation under the embankment

and/or by stoping through the upstream embankment slope. From a dam safety standpoint, TVA judged that this failure mode posed a credible threat to the integrity of the dam.

Initial Response

In response to the muddy seepage, TVA initiated several activities and initial risk reduction measures. These included:

- 24-hour monitoring by dam safety engineers,
- reviewing and implementing portions of the Emergency Action Plan (EAP),
- accelerating drawdown to the winter pool elevation,
- staging heavy equipment and stockpiling filter and construction materials at the site,
- investigating possible causes of the muddy seepage, and
- installing a reverse-graded filter at the seepage exit point.

As the reservoir pool was lowered, the volume of muddy seepage decreased. Because of the influence of the reservoir on the observed internal erosion process, TVA decided to lower the reservoir an additional 10 feet below normal winter pool, which brought the water level to an elevation near the upstream toe of the embankment. Reducing the hydraulic load on the embankment also reduced the dam safety risk by reducing the volume of water that could be released by a breach. However, muddy seepage continued to be observed in the tailrace.

As an additional risk reduction measure, TVA constructed a reverse-graded filter at the seepage outlet. Construction of the filter required blocking the draft tube outlets for the Unit 1 generator turbine, which has reduced the generating capacity of Boone Dam by one-third. TVA also implemented a permanent operating restriction on Boone Lake, limiting the reservoir pool to an elevation between 7 and 12 feet below normal winter pool until the permanent mitigation solution is implemented. While necessary for dam safety, the decision was unpopular with local residents due to its adverse effect on recreation and the associated tourism industry.

Investigation

Once the initial risk-reduction measures were deemed effective, a team of TVA dam safety engineers initiated a formal investigation to find the source of the observed seepage and determine the degree to which dam safety was threatened. This investigation included subsurface exploration, geophysical surveys, and archival research. TVA and its partners drilled and sampled 97 borings, performed dye testing and water chemistry analysis, conducted televiewer and downhole camera surveys, and installed new instruments (including a network of more than 200 automated piezometers, and two robotic total stations to measure horizontal and vertical deformations). Geophysical techniques included microgravity, resistivity, seismic refraction, and spontaneous potential. Research included detailed review of the original geologic investigations, design documentation, as-built drawings, historical inspections reports, and construction photographs.

Environmental and Engineering Geologic Principles Applied

Background Information

The following sections provide background information about data that were ultimately incorporated into TVA's hydrogeologic model, which was an invaluable tool in both understanding the problem and developing a solution.

Topography

The site of the embankment dam consisted of a drainage slough with several tributaries cut into gentle slopes along the former river channel. The embankment portion curves downstream from the alignment of the concrete dam, which is oriented generally perpendicular to the original stream channel. The right end of the embankment dam ties into higher ground known as the "Right Rim." Additionally, fill was placed into the original stream channel downstream of the dam and generally downhill from the switchyard and control building. This fill material forms the right bank of the present-day tailrace channel.

Regional and Site Geology

The Boone Project is located within the Valley and Ridge physiographic province. The left non-overflow section, spillway section, and a portion of the powerhouse are underlain by Cambrian-age limestone (the Maynardville Member of the Conasauga Group) while the right non-overflow concrete section, the majority of the powerhouse, and embankment section are underlain by the Conococheague limestone and dolomite of the Cambrian-age lower Knox Group.

Geologic structure at the site is complex. The dam is founded on the southeast limb of an anticline that has been thrust completely over the next syncline to the northwest. Other structural features include a thrust-induced, bedding-parallel shear zone in the right abutment; a major inactive fault downstream; and four sets of bedrock discontinuities. Bedding of the underlying rock is steeply inclined, with a strike of N 25 E and a dip of 40 to 50 degrees to the southeast. The geologic structure has resulted in a network of interconnected discontinuities that provided preferential pathways for karst development. Karst features (including depressions, sinkholes, and springs) were evident at the site prior to dam construction.

Site Stratigraphy and Subsurface Conditions

As illustrated on Figure 3, the site stratigraphy below the compacted clay embankment includes surficial deposits, epikarst, and competent carbonate bedrock.

Surficial deposits consist of between 15 and 60 feet of alluvium and residual soil. Alluvial terrace deposits are highly variable, consisting of a poorly sorted mixture of clayey sand, sand and gravel, commonly with cobbles and boulders, many of which are comprised of quartzite. Residuum is primarily reddish-brown, highly plastic clay, with occasional embedded clasts of limestone, dolomite, and chert. The alluvium and

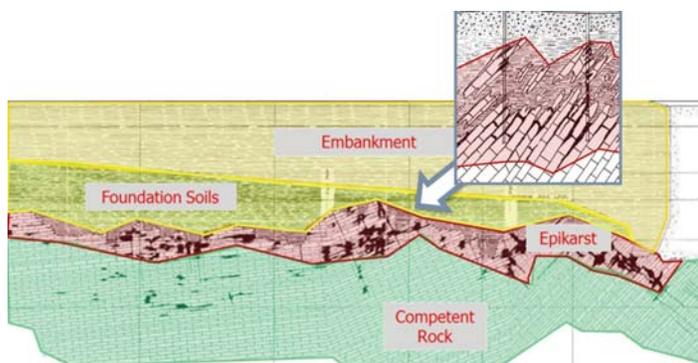


Figure 3. Schematic depiction of subsurface materials at the Project site

residuum are typically stiff and strong, with some notable exceptions as explained below. Where they underlie the embankment dam, they are referred to as foundation soils.

The combination of the structural geology and the karst activity (dissolution along joints and bedding planes) has created a well-developed epikarst zone above competent bedrock. The top of rock surface is highly irregular, with rock pinnacles, protruding ledges, and narrow, deep crevices. Weathering is highly variable; depending on karst development it extends as much as 10 to 30 feet deep where dissolution has created slots in the rock.

Pinnacles of slightly weathered rock extend up to 20 feet into the overlying surficial soils, and intervening slots (solution cavities) are most commonly filled with a mixture of residuum and alluvium. Because the pinnacles project upward at an angle (parallel to bedding), areas below the pinnacles are shielded from consolidation stresses (Figure 4). TVA's investigation found zones of very soft foundation soil between pinnacles near the contact with underlying rock, though these zones were generally of limited extent.

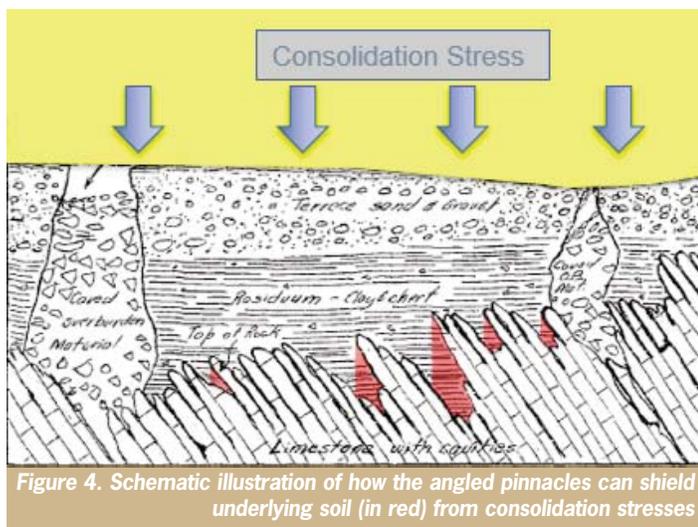


Figure 4. Schematic illustration of how the angled pinnacles can shield underlying soil (in red) from consolidation stresses

Competent rock at the site is typically light to dark gray limestone or dolomite, with calcite healed veins and/or vugs and cavities. Solution features exist within the competent rock, though these features are noticeably fewer than in the overlying epikarst zone.

The average unconfined compressive strength (UCS) of the rock is 22,300 pounds per square inch (psi), with a maximum of 34,300 psi. The rock has low abrasivity (based on the CERCHAR Abrasivity Index) and is brittle to very brittle based on the Brittleness Index (ratio of UCS to Brazilian tensile strength).

Hydraulic conductivity is generally low to very low in the compacted embankment fill and competent bedrock (exclusive of karst features), low in the residuum, and moderate in the alluvium. Hydraulic conductivity of the epikarst is highly variable, but generally higher than the other materials at the site. Open karst features (found primarily in the epikarst) often have very high hydraulic conductivity.

Original Dam Construction Details

The concrete portion of Boone Dam was founded directly on competent bedrock. However, with the exception of the cutoff trench, the earth portion of the dam was constructed as a homogenous, compacted clay fill embankment bearing on foundation soil that ranges from 20 to 50 feet thick. Figure 5 shows a cross-section through the embankment. A cutoff trench was excavated into the epikarst upstream of the dam centerline. This location improves slope stability of the embankment, but increases the hydraulic gradient across the trench. Bedrock pinnacles exposed in the trench were not removed (Photos 5 and 6), and in contrast to the foundation below the concrete dam, no dental concrete was used. Rather, the native foundation soils were excavated to the extent possible and then compacted back into the trench, around the rock pinnacles, using hand tools and light mechanical equipment (Photos 7 and 8). Pockets of soft residual and alluvial soils were noted between the pinnacles during excavation of the cutoff trench. To control settlement in these soft soils, consolidation grouting utilizing a 50-foot rectangular pattern was conducted after partial construction of the embankment. The consolidation grouting was intended to fill voids within the epikarst and stiffen the foundation soils.

Once the pinnacles were covered by clay fill and a level surface was achieved from manual placement and compaction of fill, circa August 1951, the ground surface outside the cutoff trench was stripped so that the entire footprint of the dam was prepared to receive machine-rolled fill. The lowermost third of the embankment was completed by November 1951. At this time, and roughly concurrent with the consolidation grouting program, a single row of vertical grout holes was drilled through the embankment fill along the centerline of the cutoff trench and injected with clay-cement grout. Holes extended to a depth of 10 feet below weathered rock and as much as 70 feet below top of rock, which corresponds to between 40 and 135 feet below the partially-completed embankment fill.

Groundwater Conditions

An extensive network of dissolution features exists at the site (Figure 6). Evidence of these features exists in the form of historical photographs and reports, which documented filling of open karst features with concrete and grout during construction

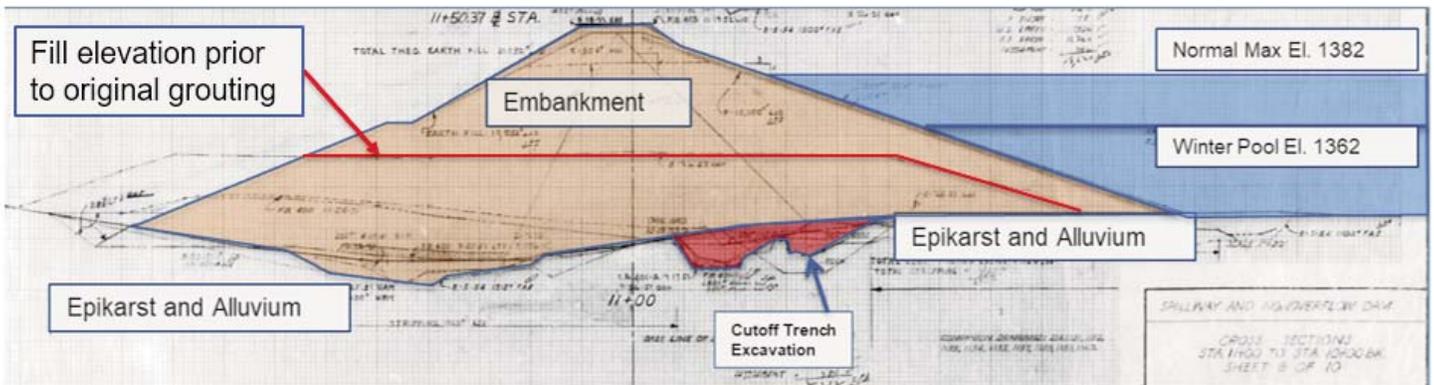


Figure 5. Annotated as-constructed drawing of the Boone Dam embankment. The original grout curtain (not shown) extends through the cutoff trench. Original consolidation grouting occurred under the entire embankment footprint.

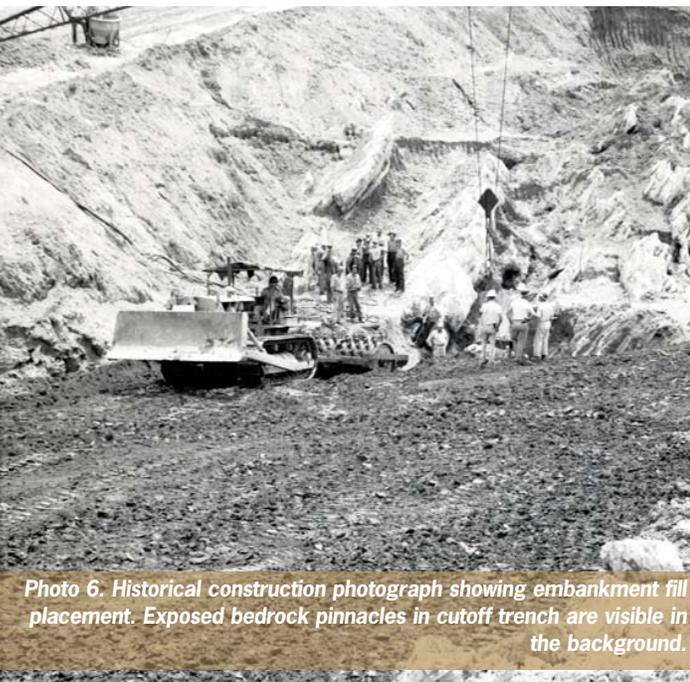
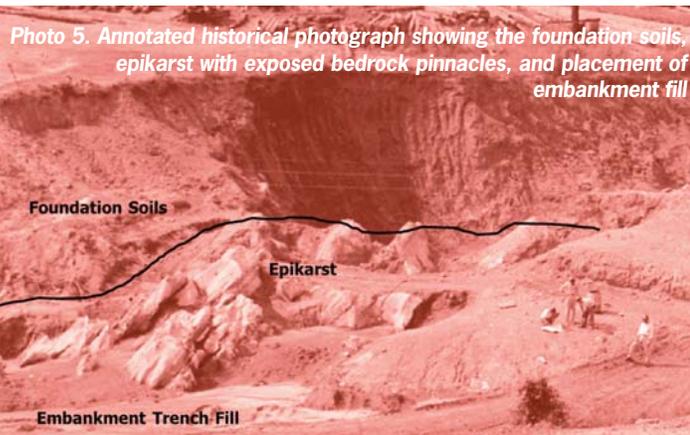


Photo 6. Historical construction photograph showing embankment fill placement. Exposed bedrock pinnacles in cutoff trench are visible in the background.

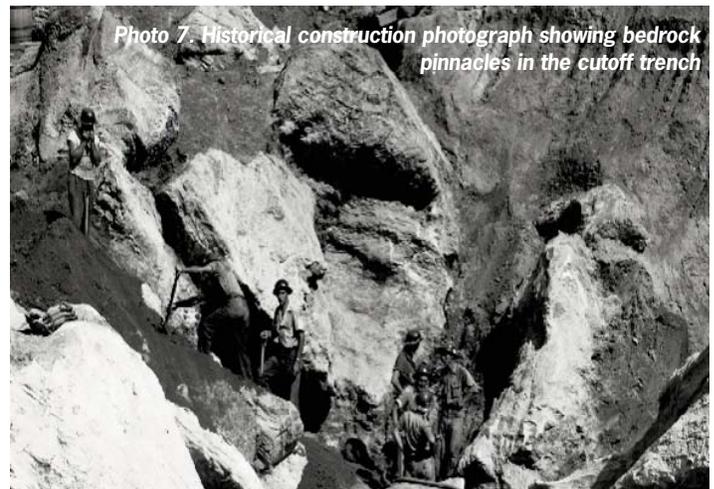


Photo 7. Historical construction photograph showing bedrock pinnacles in the cutoff trench

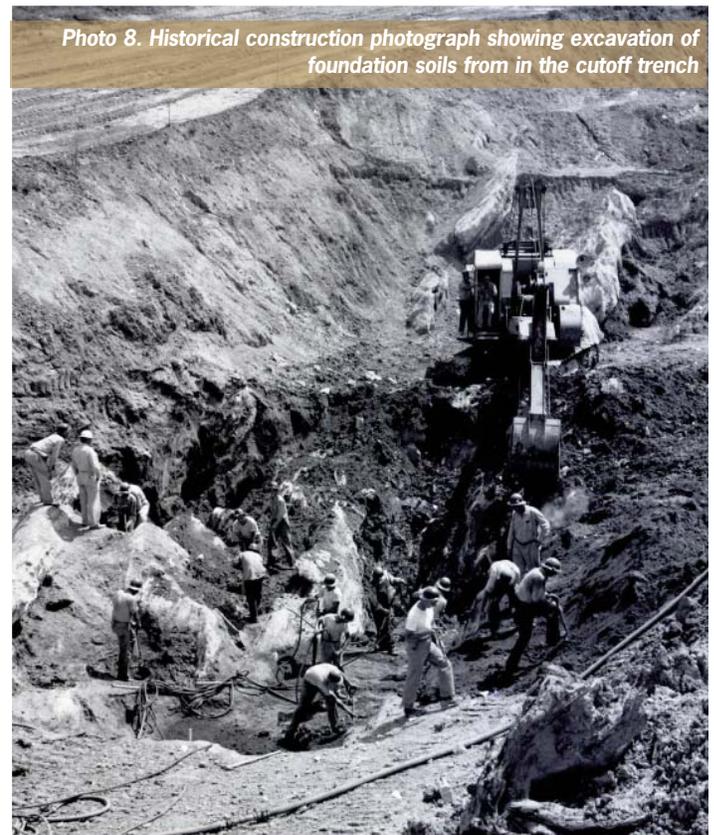


Photo 8. Historical construction photograph showing excavation of foundation soils from in the cutoff trench

of the dam. Preconstruction topographic maps identified several springs and sinkholes in the area. The Right Rim, a topographically high area beyond the right abutment of the dam, supplies a base flow of groundwater roughly parallel to the axis of the dam toward the South Holston River. Recent and historical explorations of the site indicate several open karst features

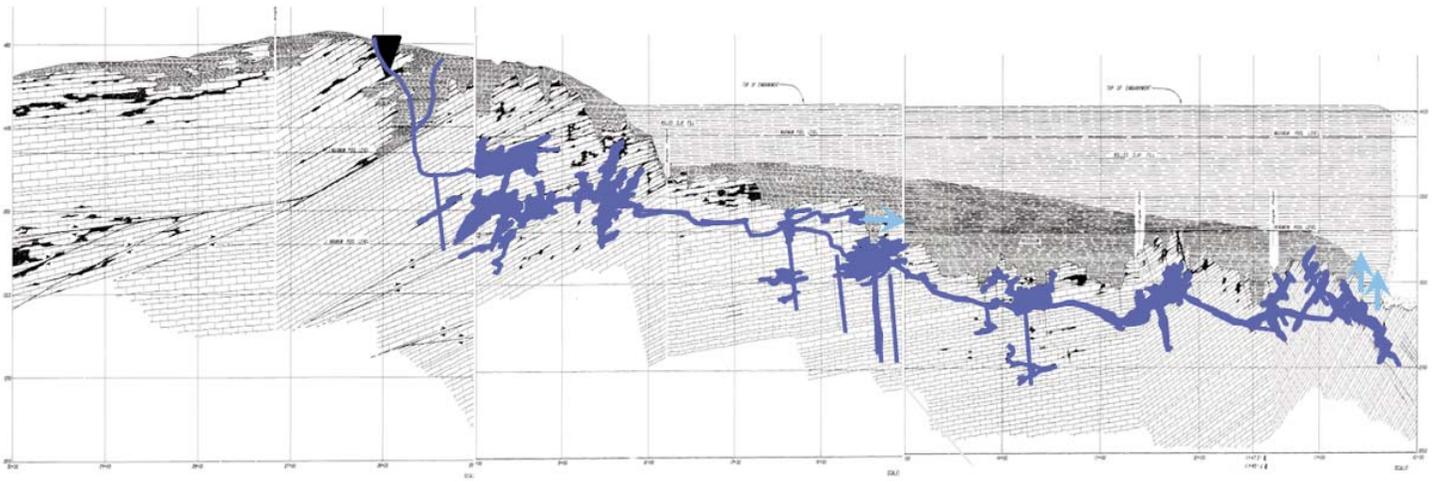


Figure 6. Schematic illustration of the mature karst system and interconnected voids in the epikarst below the right rim and embankment

are located immediately downstream of the embankment dam and likely serve as a drainage network to rapidly discharge groundwater from the Right Rim. A downhole video survey of one such feature identified near the downstream toe of the dam revealed that the groundwater flow is capable of carrying soil particles into cavities within the underlying rock.

Historic Observations

Annual inspections of the dam between 1954 and 1985 typically revealed no unusual signs of poor dam performance, with two exceptions. In 1955, a 30-foot-wide depression was identified in the riprap armoring along the upstream face of the dam. This depression was attributed to washout of the underlying crushed stone supporting the larger riprap, induced by the initial seasonal fluctuations of the pool. Later, in 1977, inspectors first noticed the appearance of wet spots along the lower third of the downstream face of the embankment and in along the downstream toe. These wet spots were only sporadic in their appearance and were not judged to be correlated to reservoir pools. Little dam monitoring instrumentation existed at the time to draw further conclusions regarding the dam's performance or the source of the wetting. In 1985, the wetting along the downstream toe was attributed to a leaking water supply line, which was subsequently replaced. However, occasional observations of wetting persisted after the water line was replaced. In the years preceding 2014, several small sinkholes were identified at the site, including in the area of the former beach (upstream and right of the embankment portion of the dam), the Right Rim, and the switchyard. None were judged to be dam safety threats.

Observations during and after the Investigation Program

Piezometers downstream of the compacted clay cutoff trench responded immediately to changes in reservoir elevation, but at a reduced magnitude. This type of behavior is indicative of open connections underneath the dam, which were later confirmed to exist.

Installation of a piezometer from the crest of the dam (downstream of the trench) into the foundation soil required an excessive volume of grout. Ultimately, a gray plume of grout was observed flowing into the reservoir near the upstream toe of the

embankment. Dye tracing from another exploration determined that the grout had likely traveled through the compacted clay in the cutoff trench to the reservoir. Additional borings drilled on the upstream slope of the dam encountered an approximately 3-foot-thick zone of very soft material within the compacted clay that had been placed around the pinnacles in the cutoff trench. The boring through this zone would not hold water, and dye injected in the cutoff traveled downstream within 45 minutes.

In the early spring of 2015, heavy snowfall was followed by substantial rain. With these conditions, water levels in piezometers at the toe of the dam and underneath the dam began to rapidly rise, some by up to 10 feet, and then slowly dissipate. In addition, muddy seeps were observed at the upstream toe of the dam into the reservoir. An abandoned well shallowly submerged by the reservoir approximately one mile upstream of the dam was observed to be flowing under artesian head—indicating a surcharge from the Right Rim at that location. Piezometric contours of the rise in groundwater and water chemistry testing indicated that infiltration of meteoric water into the karst system was causing surges in pore water pressures within the foundation at the downstream toe of the dam and underneath the embankment.

Hydrogeologic Model

Development

Early in the investigation of geologic conditions at the site, the design team recognized that a tremendous volume of data was being generated. Information included:

- drawings of the original site investigation,
- original design and construction drawings,
- historical inspection reports and photographs,
- records for historical and newly-installed instrumentation,
- logs of historical and recently-completed soil borings and rock cores,
- areal plots of geophysical testing,
- maps of sinkholes and site drainage patterns, and
- video investigations of conditions within site drainage pipes and within the dam's forebay and tailrace.

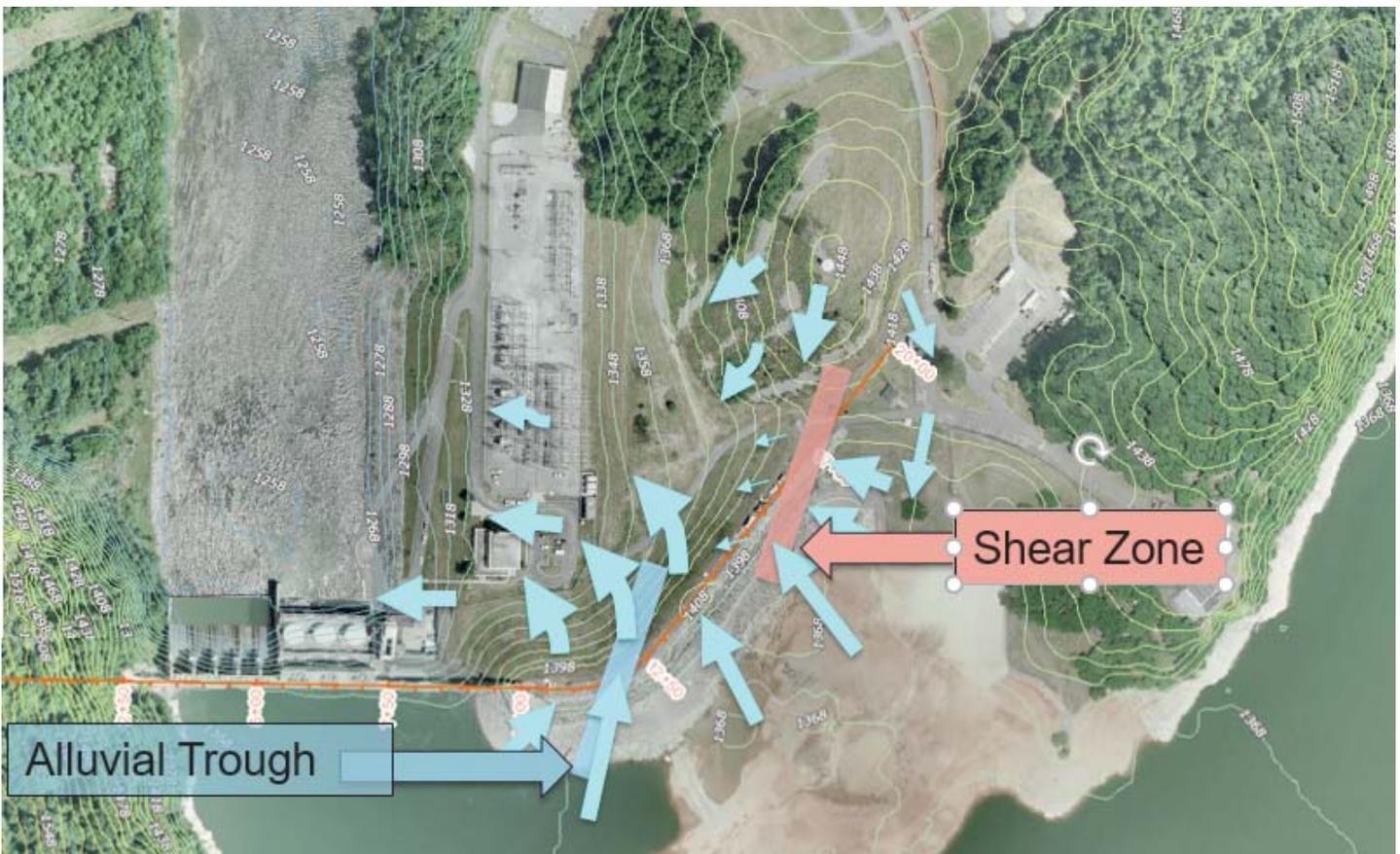


Figure 7. Schematic view illustrating groundwater pathways prior to 2015. Water from the right rim is bifurcated by the shear zone; most flows to the tailrace but some flows to the reservoir. Water from the reservoir seeps through the dam to the tailrace, with the alluvial trough providing a preferential pathway.

To aid in understanding the site's geologic and hydrogeologic conditions, all of these records were digitized and spatially referenced. In combination with computer modeling of the instrumentation readings, TVA incorporated the information into a 3D geographic information system (GIS) database. This proved to be a valuable tool for quickly visualizing and disseminating information. The ability to overlay multiple layers from the investigation program onto pre- and post-construction topography and aerial photographs permitted identification of connections between disparate data sets.

Interpretations

The hydrogeologic model illustrated how the combination of site topography, subsurface conditions, original design of the dam, and the original construction techniques explained the site observations and instrumentation readings. Historic groundwater flows were generally from the right abutment toward the original river channel—both upstream and downstream of Boone Dam—and these flows continue today. The shear zone in the right abutment acts as an aquitard, and bifurcates flows from the right rim to the reservoir and to the tailrace. The model showed that groundwater that would normally flow downstream of the embankment can be redirected into the reservoir, particularly at its reduced pool elevation, as illustrated on Figure 7.

The model also demonstrated that an extensive drainage network was well-developed in the karst at the site before the dam was constructed. During large rainfall infiltration events, sudden large increases in groundwater occur in the karst network and locally within the foundation soils. Subsurface information from the grouting program (discussed below) incorporated into the hydrogeologic model identified a buried channel filled with alluvium below the cutoff trench. Evident in the 3-D bedrock surface model (Figure 8), this “alluvial trough” is located under the curve in the embankment and is oriented roughly parallel to the shear zone.

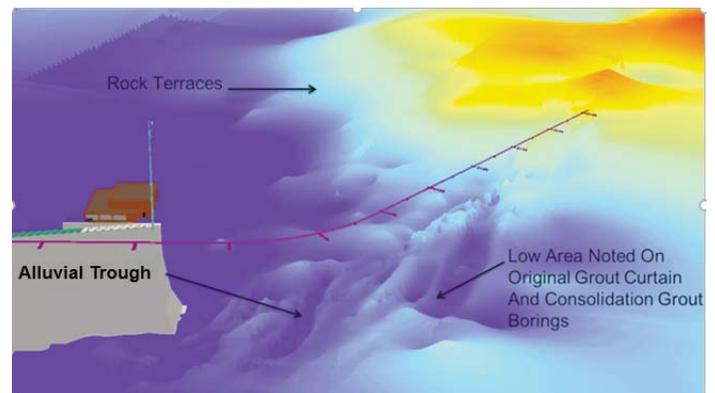


Figure 8. 3D model of the bedrock surface below the embankment dam showing the alluvial trough

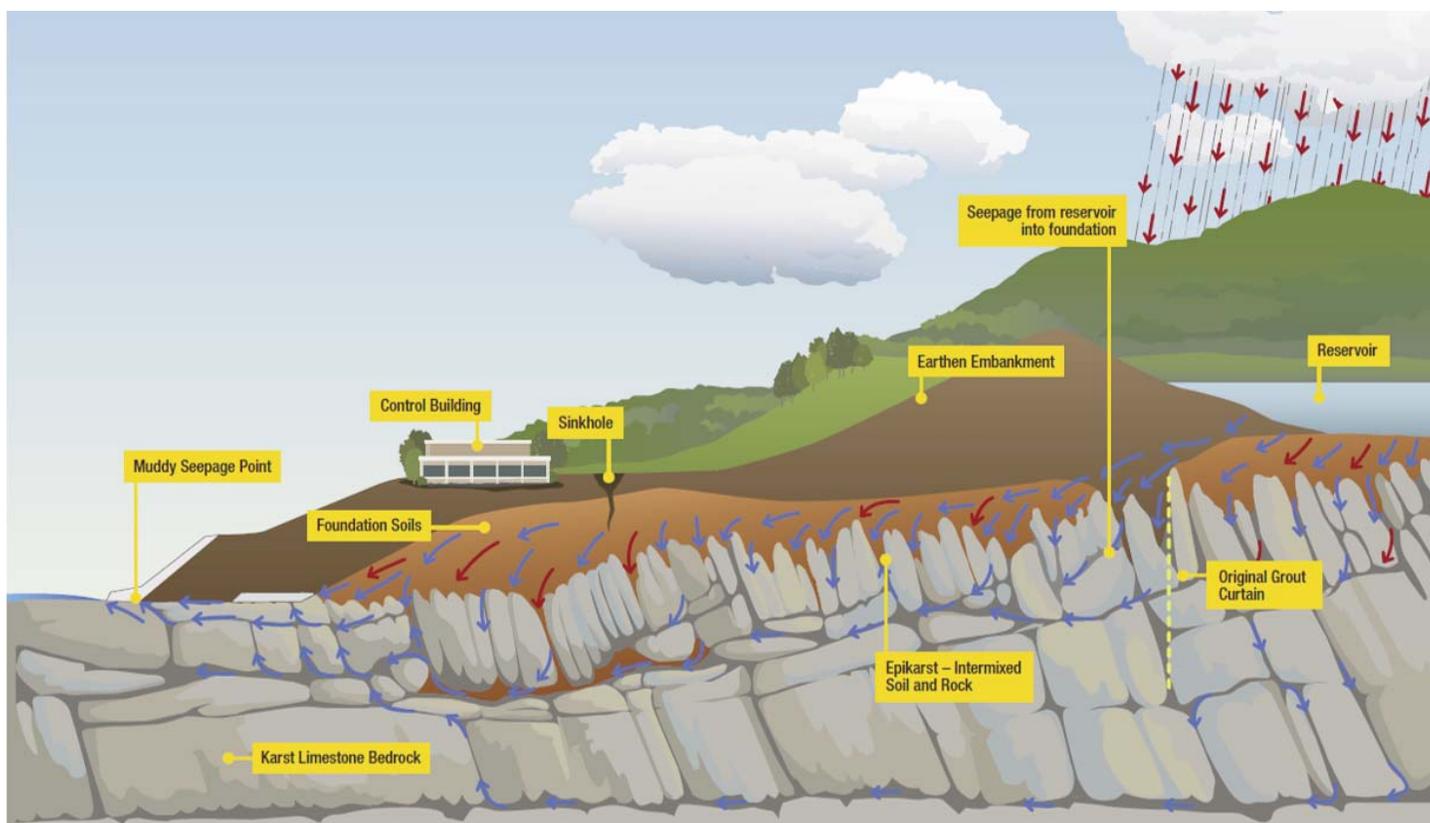


Figure 9. Conceptual schematic of the hypothesized failure mode. Note that the original grout curtain is assumed to be functional.

Using the model, TVA developed a hypothesis (illustrated on Figure 9) that the combination of the large drainage capacity of the karst network combined with the induced reservoir head created a high hydraulic gradient across the cutoff trench. (Modeling suggested a gradient of between 2 and 6 feet/foot was possible.) A gradient of this magnitude was judged capable of inducing backward erosion piping by exploiting weaknesses in the compacted embankment fill used to backfill the cutoff trench and/or the underlying foundation soils. The presence of the alluvial trough supported this hypothesis by providing a location for concentrated flow under the cutoff trench. Ultimately, the hydrogeologic model provided support for a conclusion that that the suspected failure mode was not only possible, but posed a credible threat to the safety of the dam.

Risk-Informed Decision-Making and Decisional Analysis

As a Federal corporation, TVA's Dam Safety Program is self-governed. In 2012, consistent with trends in the broader dam safety community—and prior to discovery of the seepage and internal erosion concerns at Boone Dam—TVA began the process of transitioning from a standards-based program to a risk-informed model. This transition was intended to aid in evaluating proposed dam safety modification projects, both for their overall effectiveness in reducing the TVA's overall risk exposure, and for the proper prioritization of risk reduction projects.

In the first years of the program, evaluations of dam safety risk within TVA's river dam inventory were largely confined to collecting "baseline" risk estimates posed by normal operation

of each reservoir so that the need for any future dam safety modification projects could be identified and prioritized. Following the discovery of seepage and internal erosion concerns at Boone Dam, application of RIDM at TVA shifted from high-level inventory evaluations of risk to evaluations of specific measures, which could reduce TVA's risk associated with a dam failure. To this end, the Boone project provided an opportunity for TVA to leverage RIDM to guide decisions about interim risk-reduction as well as the evaluation, selection, and design of mitigation options.

Risk Assessment at Boone Dam

TVA assembled a panel of engineering experts to assess and conduct a risk assessment related to the seepage at Boone Dam. Participants included geologists, engineers, power plant generation staff, river operations staff, and emergency management specialists. This assessment was conducted to evaluate the baseline risk at normal operations, and the risk at proposed interim reservoir pool elevations. The panel used the available project information to develop potential failure modes they considered the most credible threats to the dam. These included:

- internal erosion resulting in a conduit to the reservoir and rapid undermining of the foundation, resulting in collapse and overtopping of the dam,
- sinkhole development on the downstream slope of the dam, leading to instability and overtopping, and
- internal erosion resulting in increasing headwater pressure under the downstream slope, resulting in slope instability.

An experienced moderator elicited the opinions of the expert panel regarding the likelihood of each event along the progression of each potential failure mode toward breach, as well as the consequences which would likely result if the potential failure mode were fully realized. The process also captured the uncertainty band associated with the estimates. The expert panel represented a broad cross section of the dam safety industry, and this band highlighted differences of opinion regarding the internal erosion failure modes among the various members. The uncertainty in the results of the analysis also highlighted the need to have a sizable and diverse panel of experts, as the variety of experience and perspective of the group proved extremely valuable. Ultimately the risk assessment supported a recommendation to impose a restriction on the reservoir headwater elevation, provided guidance for selecting a risk-appropriate headwater operating range, and led to the conclusion that remediation would be required.

TVA also used RIDM to evaluate other significant issues related to the Project, including:

- selection of the remediation technique (from among roughly a dozen considered alternatives);
- the life safety risk and project-schedule risk imposed by various construction techniques;
- the threat imposed by temporary flooding events during the construction period;
- the need for redundancy in the design to mitigate effects from the Right Rim; and
- the need for additional dam safety modification projects beyond those required to mitigate seepage and internal erosion concerns (e.g., spillway bay or spillway gate modifications).

Of particular interest is the modification of common Semi-Quantitative Risk Analysis (SQRA) processes to evaluate threats which may be imposed upon the dam by construction activities. These evaluations added a level of detail to risk evaluation by considering the manner in which individual risk-driving potential failure modes progressed toward failure. The risk assessment teams identified those points in the event tree to which progression was most likely to occur prior to the potential failure mode being arrested by natural processes or human intervention. For the identified degree of progression of the failure mode, a “damage state” was described and the likelihood of arrival at that damage state was approximately quantified by expert elicitation. Finally, the cost and project delay associated with repairing the damage state was estimated. In this innovation, the usual SQRA process was expanded to provide estimates of both the life-safety risk imposed by a proposed construction technique, as well as the project schedule and budget risk that could be imposed by the technique.

Mitigation

Results of the risk analyses were used to inform the process of selecting a preferred mitigation alternative. The panel of experts developed remediation options and utilized decisional analysis matrix techniques to determine which of the options

would meet the requirements and objectives established by TVA Dam Safety and project stakeholders. Examples of these requirements and objectives include:

- return the reservoir to normal operations after remediation;
- maintain operations and minimum flows;
- arrest the active potential failure modes;
- do no harm;
- minimize interruption of normal operations;
- minimize environmental impacts;
- demonstrate robustness, redundancy, and reliability; and
- rely upon proven technologies.

The mitigation option selected was to install a diaphragm cutoff wall from the crest of the embankment dam through the foundation soil and epikarst and into competent bedrock, supplemented by a deep bedrock grout curtain below the wall. Additional supporting measures include modifications to the crest and a portion of the concrete dam gallery, injection of low-mobility grout (LMG) within the epikarst, and construction of rockfill berms.

Grouting

Both high mobility grout (HMG) and low-mobility grout (LMG) have been utilized as part of the Project. A total of 539 holes were drilled to inject LMG into the epikarst zone to consolidate zones of soft soil, and 335 HMG holes were drilled as part of curtain grouting in the competent bedrock. This represents about 22 miles of drilling and injection of over 2,000 cubic yards of LMG and HMG combined. The LMG and HMG grouting are illustrated of Figures 10 and 11.

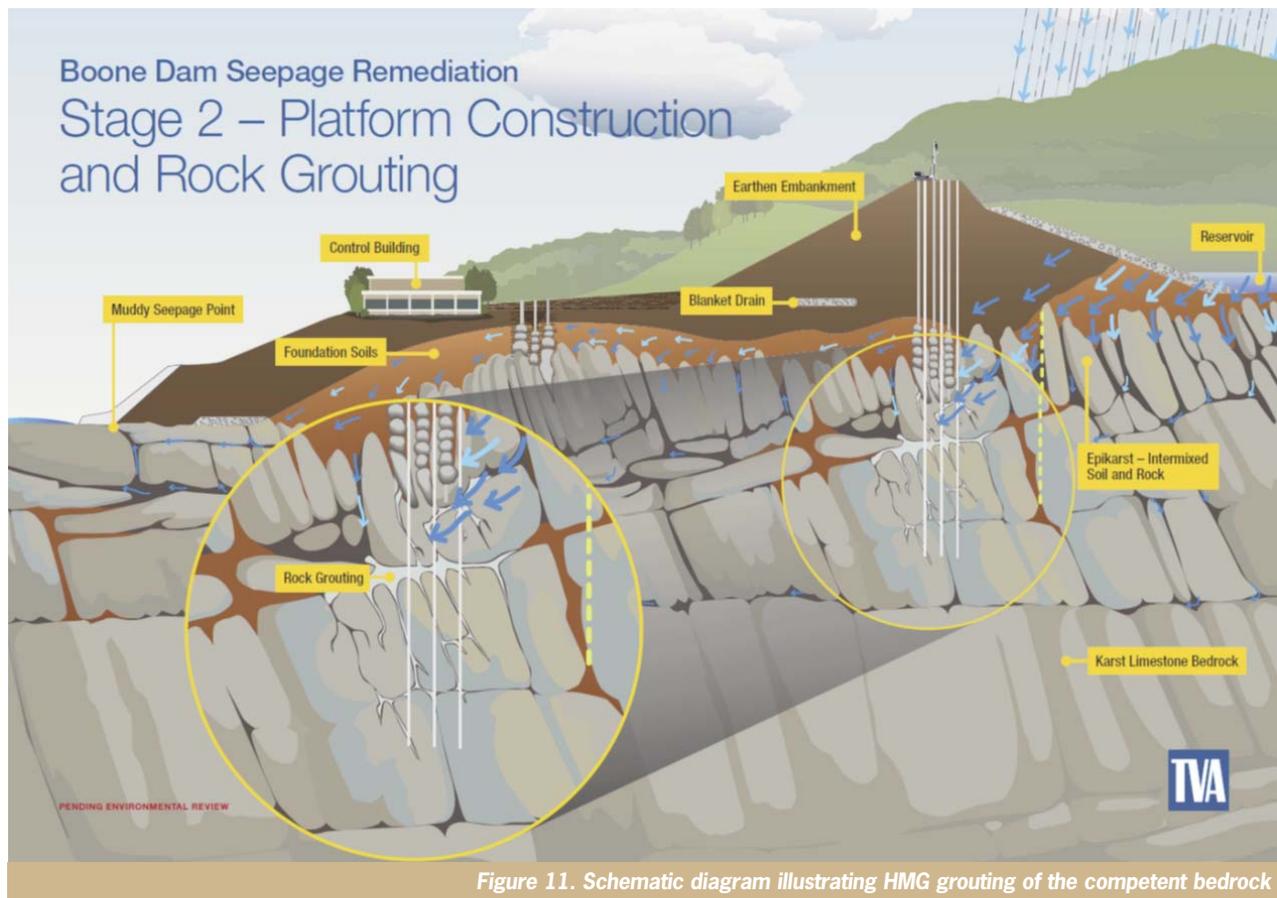
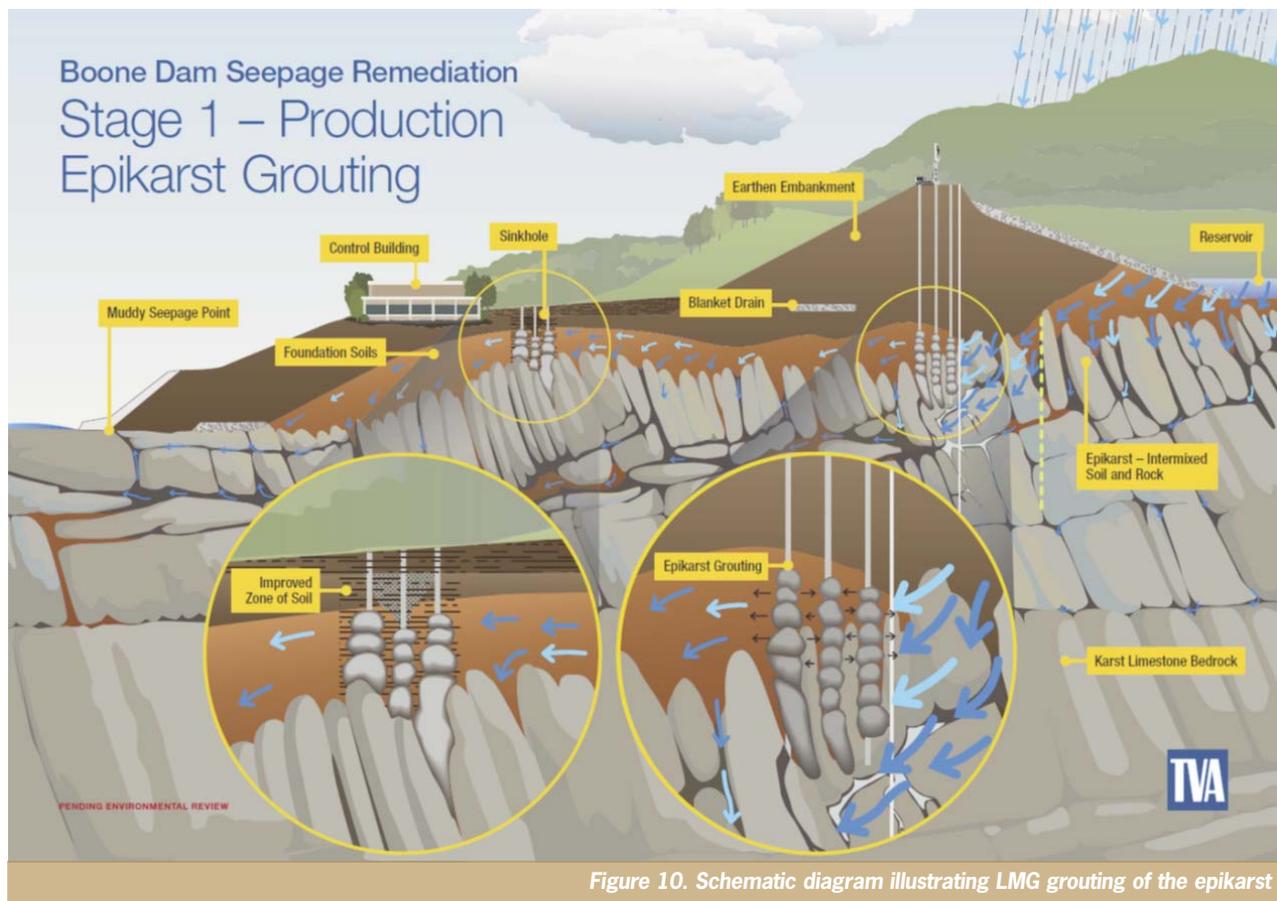
Sonic drilling techniques were used through the embankment fill, foundation soil, and epikarst; wireline coring and rotary percussion techniques were used in the bedrock. The depth at which rock was encountered was logged for each hole, and most bedrock holes were surveyed with an optical televiewer prior to grouting. Photo 9 shows rows of grout hole casings in the crest of the dam, and Photo 10 shows grouting activities in progress.

Crest Modification and Berms

To provide a wider working platform for grouting, the crest of the embankment dam was lowered by about 10 feet. Later, rockfill berms were placed against the original upstream and downstream slopes to provide additional stability for the embankment. The top of the upstream berm is level with the lowered crest, which also serves to provide a 125-foot-wide work platform to facilitate construction of the cutoff wall. A total of 220,000 tons of rock was placed to construct the berms. The berms are illustrated on Figure 12 and shown in Photos 11 and 12.

Diaphragm Cutoff Wall

TVA developed design criteria for the cutoff wall, including the depth (which varies from 109 to 169 feet in response to sub-surface conditions), minimum continuous thickness (24 inches),





Top Left-Photo 9. PVC grout casings installed through the dam crest and embankment fill
 Bottom Left-Photo 10. Deep bedrock grouting activities
 Top Right-Photo 11. Completed downstream rockfill berm
 Bottom Right-Photo 12. Completed upstream rockfill berm



Boone Dam Seepage Remediation

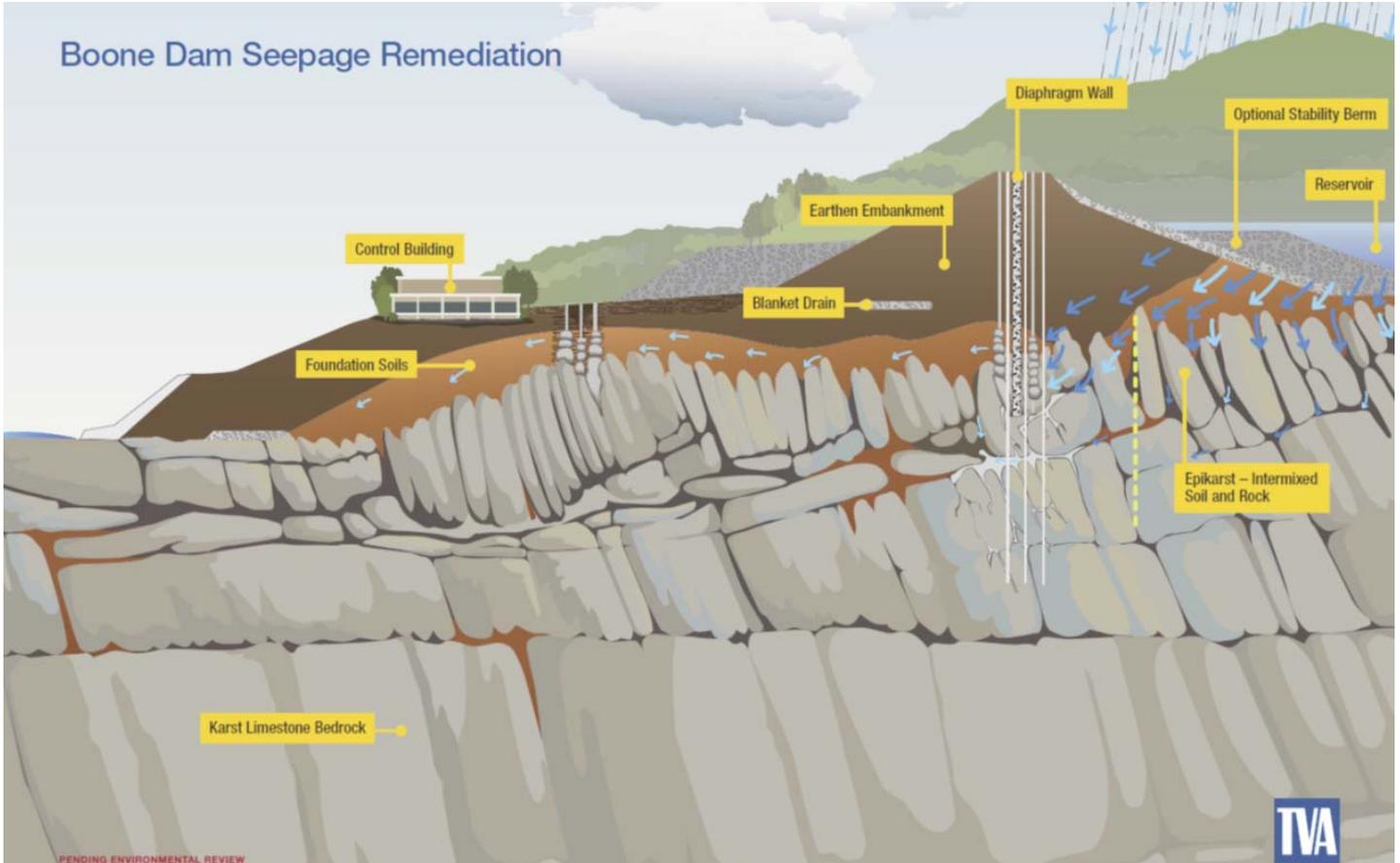


Figure 12. Schematic diagram illustrating the stability berms. Note that the as-constructed upstream berm extends to match the elevation of the crest.

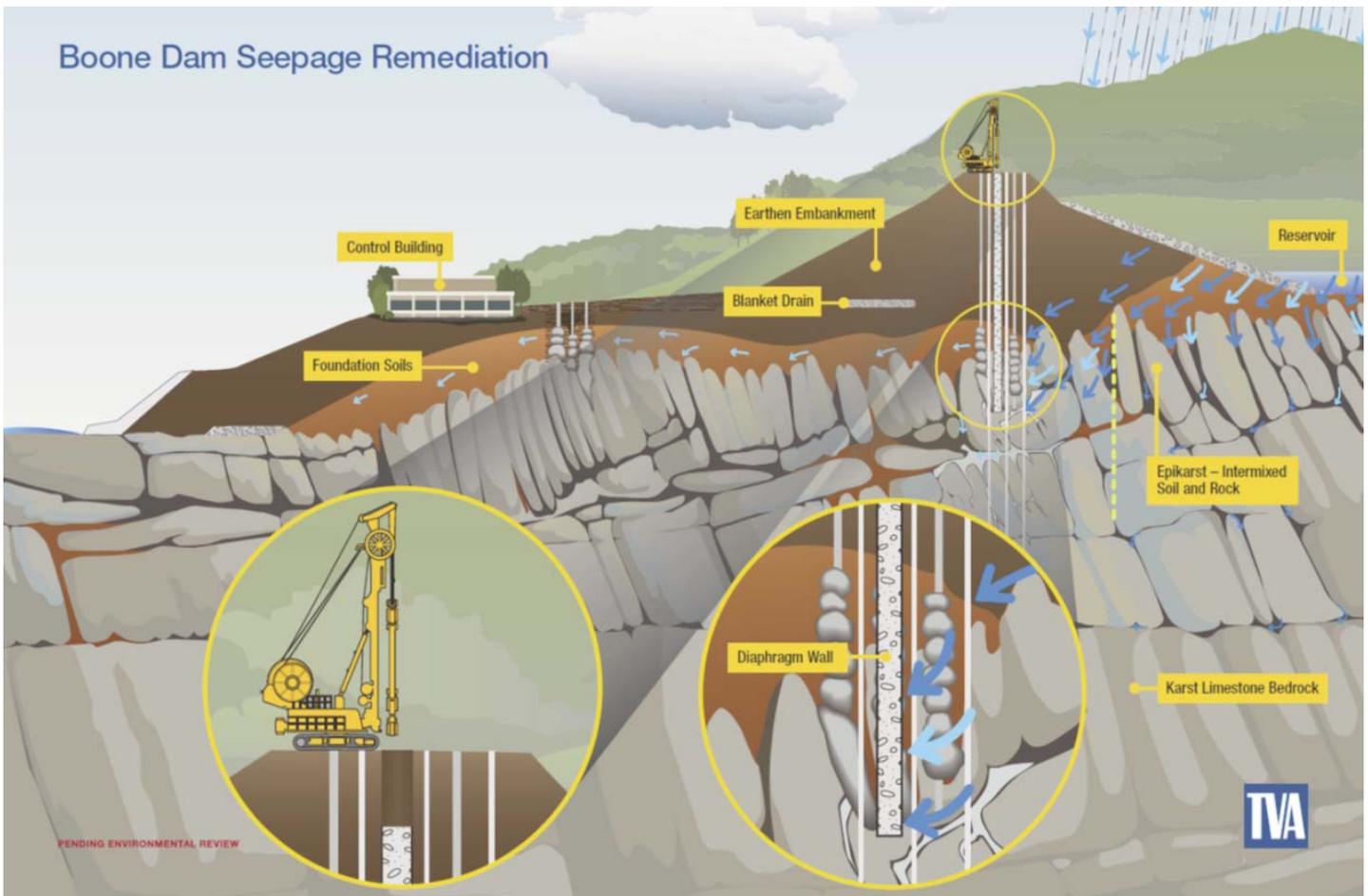


Figure 13. Schematic diagram illustrating construction of the concrete diaphragm wall with the new grout curtain extending below

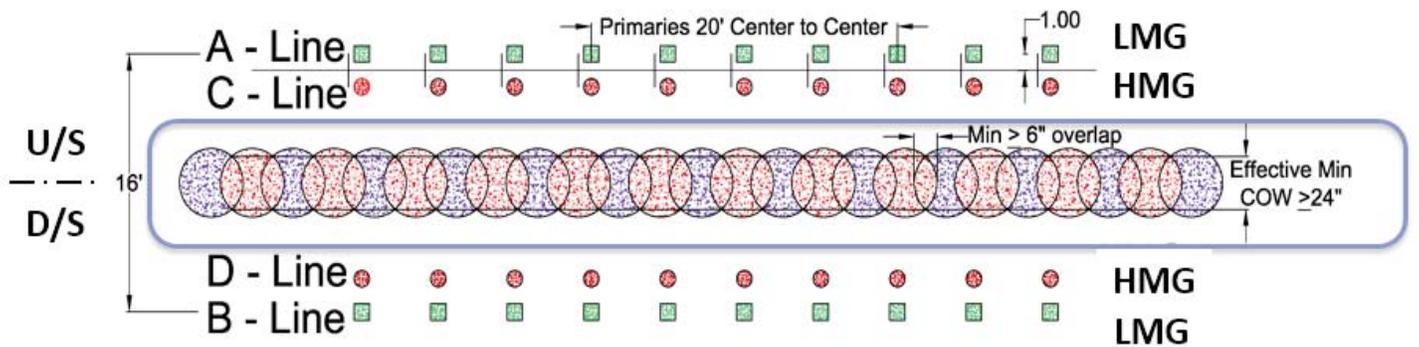


Figure 14. Schematic plan view of a portion of the secant pile wall elements bounded by the rows of HMG and LMG grout holes

compressive strength (3,000 psi), and acceptable construction techniques (hydromill panels, secant piles, or a combination of the two).

Wall design was finalized in partnership with the selected contractor, and includes the following details:

- Type: Secant pile wall
- Length: 836 feet
- Number of Elements: about 300
- Pile Diameter: 50 to 60 inches
- Pile Spacing: 31 to 35 inches

Figure 13 illustrates the wall in section, and Figure 14 is a schematic plan view of the layout of the wall elements along with the HMG and LMG grout lines. The left end of the cutoff wall will extend into the rightmost monolith of the concrete dam. To facilitate the tie-in, about 20 feet of gallery was back-filled with concrete.

Use of Hydrogeologic Model

Throughout the project, the model has been expanded and updated to provide more sophisticated graphical displays of the integrated data. Information from the grouting program provided additional information about subsurface conditions that

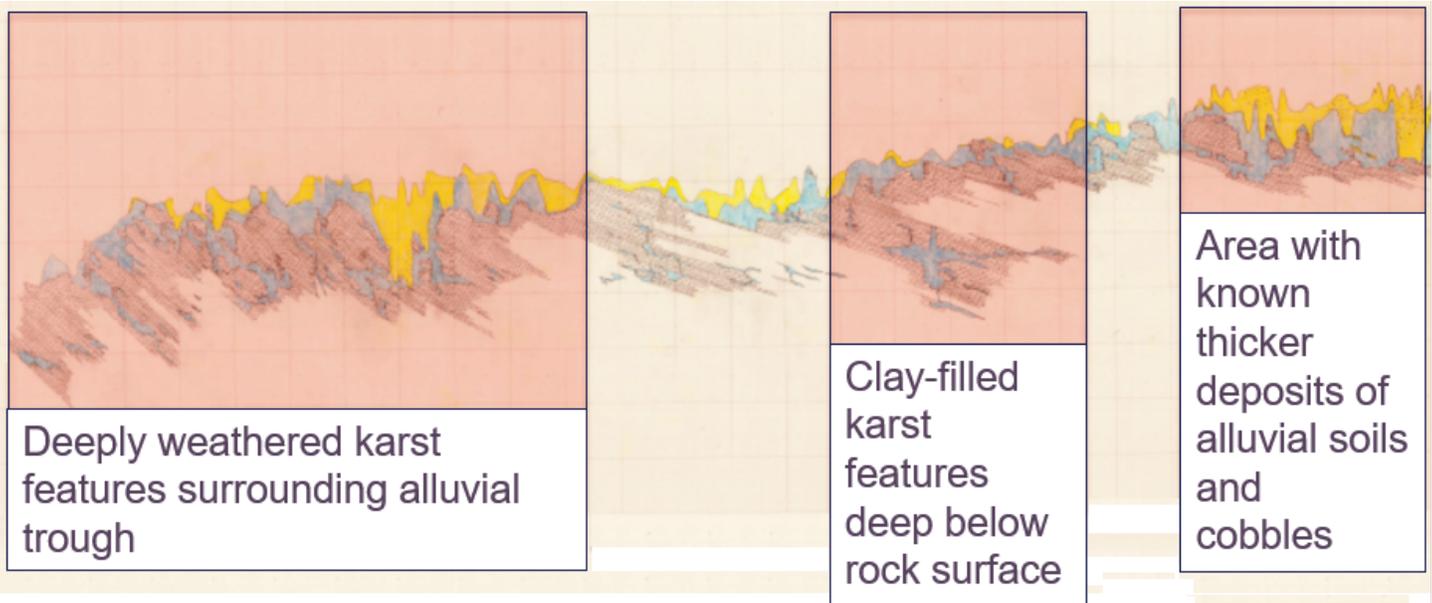


Figure 15. Longitudinal profile below the crest of the embankment dam illustrating alluvial soils (in yellow), residual soils (in blue) and carbonate bedrock (in gray). Data for the profile was derived largely from logs of the grout holes.

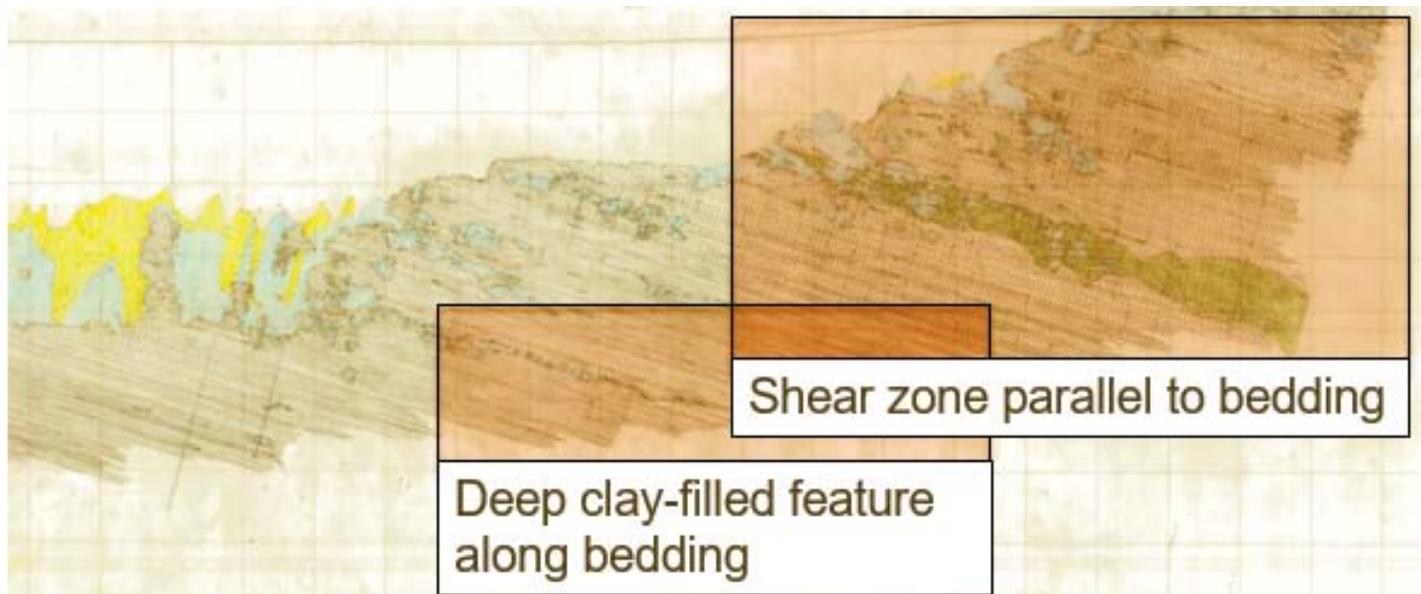


Figure 16. Longitudinal profile below the crest of the embankment dam illustrating alluvial soils (in yellow), residual soils (in blue) carbonate bedrock (in gray), and brecciated rock and clay associated with the shear zone (in green). Data for the profile was derived largely from logs of the grout holes.

was incorporated into the hydrogeologic model. Data about the elevation at which rock was first encountered allowed TVA to refine the bedrock surface profile, and hydraulic conductivity and grout takes along with information from the televiewer surveys provided information about the location and extent of defects in the generally more competent bedrock.

The hydrogeologic model was used extensively during development of the mitigation plan, and was the primary tool used to select the lateral and vertical extents of the composite barrier. The depth of the cutoff wall was selected to extend through clay-filled karst features, but it does attempt to intersect small fractures that accepted HMG (but not LMG). Figures

15 and 16 are longitudinal profiles below the crest of the embankment dam that illustrate many of the features that will be intersected by the cutoff wall. Laterally, based on the understanding subsurface geology and hydrogeologic conditions gained from the model, TVA determined that the design criteria would be met by terminating the right end of the cutoff wall after obliquely intersecting the shear zone.

As the project proceeds into construction, real-time data acquired from the extensive network of automated geotechnical instrumentation is integrated into the model. This allows a team of dam safety inspectors to perform rapid assessments of emerging threats to dam performance during construction.

Contributions to the Practice of Underground Construction

During development of the mitigation plan, TVA's design team leveraged the experience of several composite seepage barrier projects completed within the region, specifically projects recently executed by the U.S. Army Corps of Engineers at Wolf Creek and Center Hill Dams. However, modification of the work plans developed for these sister projects was necessary to accommodate important differences in site geology, variations in contracting and construction processes between the two agencies, and advances in technology which could be used to construct the remediation.

To date, these modifications have been most substantial during the execution of low-mobility and high-mobility grouting programs. The TVA conducted a pre-construction testing program of low-mobility grouting techniques that was unparalleled in its scope when compared to similar projects executed both within the U.S. and internationally. In addition, significant modifications to commonly employed grouting protocols were precipitated by the observation of embankment movements during grouting. These modifications to grouting processes involved the application of existing quality control tools at higher resolution (e.g., drilling energy measurements, borehole alignment survey tools), as well as the interfacing of these tools within the real-time geographic information database described above.

The high-mobility grouting program also provided significant advances to the state of practice. Innovation by TVA's contractor refined and improved the design of instrumented packers. Although the details are proprietary, the third generation of the instrumented packer accurately measures the grout pressure applied to the formation at depth, and use of this device identified differences between the predicted and actual grout pressures. While the reasons for the difference are not completely understood, this discovery will influence the evolution of grouting practice.

Other work undertaken by TVA as part of the project was intended to reduce construction risk by providing information to be used by prospective contractors when developing competitive bids for construction of the wall. Specific tasks included slurry cell testing, statistical analysis of drilling rates, and full-scale cutterhead testing.

Construction of the cutoff wall involves slurry-supported excavations. Slurry cell testing evaluated the potential for large slurry losses, and involved conducting 64 constant head tests and 72 falling head tests. These tests gave TVA confidence that the specifications for slurry loss were reasonable and achievable and also provided some evidence that the LMG and HMG grouting were successful in providing a degree of seepage resistance.

The extensive drilling for subsurface investigations and exploratory grouting utilized different drilling techniques and types of bits. TVA evaluated advance rates for three types of rotary bits, and determined that in the rock at the site, polycrystalline compact diamond bits performed better than impregnated and surface set bits, and that percussion drilling was typically faster than rotary drilling.

Finally, because the rock at Boone Dam is stronger (albeit more brittle) than the rock at sister projects (e.g., Wolf Creek Dam), an early question was whether cutoff wall elements could adequately penetrate the rock. To help alleviate this concern, TVA engaged the Colorado School of Mines to conduct full-scale cutter tests on large slabs of rock quarried from the site (Photo 13). This testing provided information about the effectiveness of different cutting tools that might be used to construct cutoff wall elements.



Photo 13. Full-scale cutter testing on a sample of bedrock from the site

Advancement of Public's Understanding of Geology and Engineering Geology

Due to the reliance of the local economy upon normal operation of the reservoir, the project has received a high level of scrutiny and inquiry from the public. In recognition of this fact, TVA established a long-term project communications plan within the first three months after the initiating events in October 2014. These plans include stationing of TVA Communications staff at the site for the duration of the project so that TVA can ensure a high level of interaction with the local community. Communications staff have coordinated over 250 presentations to local organizations, including high school students, community service organizations and churches, social clubs, and community activist groups. These presentations utilize a rotating roster of the project technical staff (geologists and engineers) so that each presentation has technical representation. Content related to the geology of the site (especially as it aids stakeholder understanding of the motivation for the project and difficulties that may be encountered during construction) is delivered by technical members of the design team during every single presentation, regardless of the audience. In addition to off-site presentations, TVA staff have conducted site tours for local media representatives and other interested parties (Photo 14). To date, TVA Communications staff estimate over 12,000 members of the public have learned about the geology of the dam site and the design and construction effort.

In addition to frequent public presentations, project communications staff are actively involved with local Science, Technology, Engineering, and Mathematics (STEM) initiatives. The



Photo 14. East Tennessee State University geology students on a tour of Boone Dam

project team develops classroom activities related to the operation of dams or the nature of geologic materials, to be delivered during day-long teaching sessions associated with STEM weeks at local middle schools and high schools. To date, these interactive classroom demonstrations have been delivered to several thousand students. The project has also developed a 3D laser printed physical model of the dam (Photo 15), which includes the cutoff wall remediation. TVA sponsors CareerQuest, a STEM educational event in Johnson City, and uses the model dam to educate some 4,000 students annually in grades 8 to 12. The model is also used during “Bring Your Daughter to Work Day” at TVA’s office complex in Chattanooga and other STEM events.

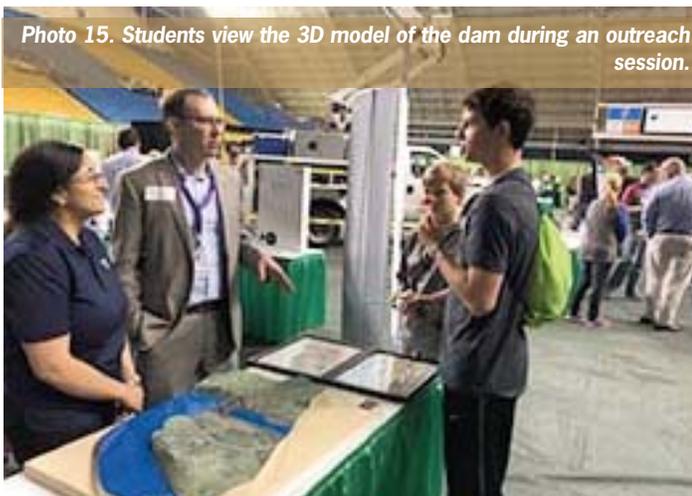


Photo 15. Students view the 3D model of the dam during an outreach session.

Protection of Environment and Enhancement of Cultural Understandings

The dam itself is recognized for its significance to the region’s history. Prior to initiation of the internal erosion remediation project, the TVA supported an application to place Boone Dam on the National Register of Historic Places. This application was granted in September 2016. In association with registration of the dam as a historic landmark, the TVA Office of Cultural Compliance and archaeologists from East Tennessee State

University created a blog for the Tennessee Council for Professional Archaeology entitled “30 Days of Archaeology.”

The opportunities for the project to foster an appreciation for the region’s culture and history extend beyond the history of the dam. As required by Federal law, the TVA conducted a comprehensive study to identify all significant archaeological sites and to monitor impacts from the project. Because the reservoir at Boone Dam will be operated below its normal pool levels for a sustained duration, TVA was aware that certain important Native American cultural sites may be exposed.

To support preservation of these valuable cultural resources, TVA engaged a team of local archaeologists at East Tennessee State University (ETSU). A team of researchers and graduate students from ETSU worked with the TVA Office of Cultural Compliance to identify which sites may be most vulnerable upon exposure. Local Native American representatives were engaged, and where supported by tribal interest, the team surveyed various sites for archaeological artifacts and worked to develop means for protecting these areas for future generations.

Cultural preservation efforts have identified 96 previously unknown archaeological sites around Boone Reservoir, ranging from the Paleo-Indian Era through to the Mississippian/protohistoric Cherokee and early historic Euromerican. Of greatest interest was the discovery of Native American pottery artifacts, which appear similar to Overhill Cherokee pottery previously identified in the region. These particular pottery fragments were dated to the 15th Century. This is significant, as prior fragments of Overhill Cherokee pottery have only been dated to the 18th Century, and the finding seems to indicate that Overhill Cherokee settlements existed in the area long before the dates previously associated with these populations. Through the “Thousand Eyes Program,” TVA has partnered with the local community and local tribal affiliates to train individuals to monitor and protect these sites (Photo 16).



Photo 16. TVA trains volunteers for the “Thousand Eyes” program to protect archaeological sites around Boone Lake.

Conclusion

LMG grouting was completed in 2017; the upstream and downstream rockfill berms were completed in 2018, and HMG grouting was completed in early 2019. Installation of the diaphragm wall elements began in mid-2019. TVA expects that the Internal Erosion Remediation Project will be fully complete and that Boone Lake will return to normal operation in July 2022.

TVA is grateful to the Association of Engineering & Environmental Geologists for its recognition of the Boone Dam Internal Erosion Remediation Project.

Technical Program Schedule

(Schedule changes can be found in the Guidebook Mobile App: <https://guidebook.com/g/aeg2019>)

Wednesday, September 18 – Afternoon

Technical Session #1

Rockfall Mitigation

Room: Grand C1

Moderator: Paul Santi

Time	Speaker	Title
2:00–2:20	Kuhne, Jody	Landslide Mitigation at MM 7.5, Interstate 40, Haywood County, North Carolina
2:20–2:40	Pippin, Chuck	Geologic Assessment of Bridal Veil Falls near Highlands, North Carolina
2:40–3:00	Keaton, Jeffrey	Suggested Refinements for the Enhanced Geologic Model Complexity Rating System
3:20–3:40	Duran, Robert	Rockfall Characterization, Analysis, and Mitigation Design for a Senior Living Community in Douglas County, Colorado
3:40–4:00	Graber, Andrew	Using Lichenometry to Evaluate Rockfall Rates and Talus Fan Development, Glenwood, Colorado
4:00–4:20	Brandon, Steve	Rock Slope Stabilization on the C&O Canal Near Paw Paw, West Virginia
4:20–4:40	Admassu, Yonathan	Rockfall Hazard Assessment Using Vehicle-Mounted Terrestrial Lidar Along US 33 Highway in Virginia
4:40–5:00	Gates, William	Emergency Response and Mitigation for a Rockslide on Snowshed #4, BNSF Stampede Subdivision, Washington

Technical Session #2

Symposium on Climate Resilience: Bringing Geoscientists and Climate Scientists Together

This session is intended to do just that. Oftentimes climate resilience and geohazards are discussed in separate silos. In order to make a true impact, these disciplines must be communicating with each other, and as a partnership to the public, corporate, and governmental end-users. Talks in this Symposium come from both sectors to encourage information exchange, interdisciplinary discussion, and create connections between the two groups.

Room: Grand C2

Convener: Jennifer Bauer

Time	Speaker	Title
2:00–2:20	Stevens, Laura	Highlights from the Fourth National Climate Assessments Volume II: Impacts, Risks, and Adaptation in the United States
2:20–2:40	Kunkel, Ken	Effects of Anthropogenically-Forced Global Warming on the Risks of Extreme Rainfall and Flooding
2:40–3:00	Gartner, Joseph	Effects of Climate Change and Extreme Weather on Geohazards in Colorado
3:20–3:40	Bessette-Kirton, Erin	A Long-Term Record of Rock Avalanches in Southeast Alaska with Implications for Landslide Hazards in a Changing Climate
3:40–4:00	Keaton, Jeffrey	Revisiting Insurance, Climate Change, and Landslide Mitigation: Thinking Outside the Shear Box
4:00–4:20	Tormey, Blair	Assessing Climate Change and Coastal Hazard Vulnerability in National Parks: Working towards Adaptation
4:20–4:40	Shuford, Scott	Planning for Changing Land Use Practices in Climate-Changed-Precipitation: A CASE Example of Climate and Geosciences Expertise
4:40–5:00	Hill, Michael	Climate Change Communication That Works

Technical Session #3A

The Profession of Geology

Room: Windsor 1

Moderator: Greg Hempfen

Time	Speaker	Title
2:00–2:20	Barnes, Brandy	Creating Opportunities and Growth as Young Professional Geoscientists
2:20–2:40	Bieber, Rebekah	The Danger of Silos: Three Case Studies That Illustrate Why Professions Working in Different Areas Need to Talk
2:40–3:00	Mathewson, Christopher	Professional Ethics vs. Political Correctness

Technical Session #3B**PFAS/GenX Symposium***(Sponsored by Bryan Environmental Consultants, Inc.)*

GenX, developed by DuPont spinoff Chemours as a safer replacement for some non-stick compounds in the PFAS family of chemicals, has emerged as the newest high-profile contaminant of concern in the environmental world. Experts from the North Carolina Department of Environmental Quality, NC State University, the EPA, and the legal community, will provide a first-hand look at the environmental impacts that GenX is having on communities both upstream and downstream of the Chemours Fayetteville plant, along the Cape Fear River in the Coastal Plains of North Carolina.

Room: Windsor 1**Convener: Rick Kolb**

Time	Speaker	Title
3:20–3:40	Scott, Michael	PFAS in North Carolina – State Regulatory Climate and Developments, Part I
3:40–4:00	Scott, Michael	PFAS in North Carolina – State Regulatory Climate and Developments, Part II
4:00–4:20	Behzadi, Harry	The Next Frontier on PFAS Contamination, Sediment, Surface Water and Fish Tissue
4:20–4:40	Pjetraj, Mike	Case Study on Atmospheric Deposition of GenX, Part I
4:40–5:00	Pjetraj, Mike	Case Study on Atmospheric Deposition of GenX, Part II
5:00–5:20	Gisler, Geoffrey	GenX Litigation in North Carolina (Presented By Kelly Moser)

Technical Session #4**The Changing Times of Engineering Geology at Dams and Levees Symposium, Part I – TVA OEEG Project Award***(Sponsored by Schnabel Engineering)*

The Tennessee Valley Authority (TVA) is honored that AEG selected the Boone Dam Internal Erosion Remediation Project to receive the 2019 Outstanding Environmental & Engineering Geologic Project Award. The first three presentations of this Symposium include an overview of how the site geology and decisions made during initial design and construction led to the creation of vulnerabilities to internal erosion and a description of how TVA developed a hydrogeological model to understand these complex interactions. The next three presentations will provide an in-depth look at some of the tools used in the process of developing and implementing the remediation concept, including 3D modeling, risk-informed decision making, and data management. Finally, the last two presentations will describe how the Boone Dam project has advanced the standard of practice for dam foundation grouting and discuss public outreach and communication of technical geologic (and other) information to a wide variety of stakeholders over the course of a long-duration megaproject. TVA looks forward to sharing this information about one of the most challenging dam construction projects ever undertaken in the Tennessee Valley.

Room: Windsor 2**Conveners: Scott Walker and Holly Nichols**

Time	Speaker	Title
2:00–2:20	Barrett, John	The Layers of the Onion: Identifying Internal Erosion Vulnerabilities in the Origins of Boone Dam
2:20–2:40	Barrentine, Scottie and Nate Bolles	Site Characterization Program for Design of the Boone Dam Remediation, Part I
2:40–3:00	Barrentine, Scottie and Nate Bolles	Site Characterization Program for Design of the Boone Dam Remediation, Part II
3:20–3:40	Meier, Dan	Boone Dam Internal Erosion Remediation Project: Integrated 3-D Modeling of Subsurface Conditions
3:40–4:00	Kiser, Patrick	Project-Level Execution of Risk-Informed Decision Making
4:00–4:20	Mohamadameen, Rozh	Boone Dam: A Comprehensive Workflow and Data Management System During Project Implementation
4:20–4:40	Ginther, Conrad	Observations of Instrumented Packer Performance during Grouting
4:40–5:00	Vinson, Sam	Public Outreach Experiences During a Major Dam Modification Project

Thursday, September 19 – Morning

Technical Session #5

The Changing Times of Engineering Geology at Dams and Levees Symposium, Part II

(Sponsored by Schnabel Engineering)

The session will open with the keynote address by Vanessa Bateman, Geotechnical, Geology and Materials CoP Lead Engineering & Construction, USACE, Washington, DC. Her topic will be Instrumentation Data from Dam Safety Monitoring During Construction-Recent USACE – Lessons Learned. Bateman's educational and interesting address will be followed by the most anticipated and equally educational post-construction update on the Oroville Dam Spillway retrofits by Holly Nichols and Nick Hightower, from the California Dept. of Water Resources (CDWR). Stephanie Briggs, Lettis International, will provide a glimpse of the hydraulic and geologic models that are used for improved unlined spillway erodibility assessment at the Oroville dam. While Jennifer Dean, CDWR, will provide a review of an engineering geologist's contribution to concrete gravity structures stability analyses. After the coffee break, the ever-intriguing presentations will be on the North Fork Dam makeover by Mark Landis and Loring Crowley, both from Schnabel Engineering, who will speak on Innovations in Dam Instrumentation Monitoring to Reduce Risk. After a span of two years, there will be an update on the The Dissolution Front: A Quantitative Geospatial Model Developed to Assist in Dam Safety Assessment at Mosul Dam, Iraq. Coralie Wilhite, USACE, will present results on Rock Mechanics and Its Effects on Spillway Modification Design. Last but not least, Visty Dalal, Maryland Dam Safety, will present a case study of a reluctant, private dam owner who ended up spending twice as much money on fighting the state and breaching the dam than they would have if the dam was repaired!

Room: Grand C1

Conveners: Gary Rogers and Visty Dalal

Time	Speaker	Title
8:00–8:40	Bateman, Vanessa	Keynote: Instrumentation Data from Dam Safety Monitoring during Construction – Recent USACE Lessons Learned
8:40–9:00	Nichols, Holly	The Oroville Dam Spillways: Wrapping up Construction and Moving forward
9:00–9:20	Hightower, Nicholas	Geologic Support for Foundation Preparation and Inspection at Oroville Dam Spillways Recovery
9:20–9:40	Briggs, Stephanie	Digging Deeper-Interating Hydraulic and Geologic Models for Improved Unlined Spillway Erodibility Assessment, a Case Study from Orville, California
9:40–10:00	Dean, Jennifer	An Engineering Geologist's Contribution to Concrete Gravity Structure Stability Analyses
10:20–10:40	Landis, Mark	North Fork Dam – A Major 65-Year Makeover
10:40–11:00	Crowley, Loring	Innovations in Dam Instrumentation Monitoring to Reduce Risk
11:00–11:20	Robison, Laurel	The Dissolution Front: A Qualitative Geospatial Model Developed to Assist in Dam Safety Assessment at Mosul Dam, Iraq
11:20–11:40	Wilhite, Coralie	Rock Mechanics and Its Effects on Spillway Modification Design
11:40–12:00	Dalal, Visty	Lessons Learned – Foster Dam Breach, Maryland



Happy
Geologist's
FRIDAY
Sept. 20, 2019 **Day!**

Geologists Day
is a professional holiday
of geologists, geophysicists,
and geochemists.



It's a perfect time to acknowledge and be proud of the contributions and accomplishments of our profession — and all the things that make geologists unique.

Almost everything in our modern life has been "touched" by geologists. Some examples are energy, agriculture, public safety, mineral resources, environmental quality, the built environment, communication, technology, transportation, healthcare and pharmaceuticals, and much more. Be sure to mark Sept. 20 on your calendar to celebrate the accomplishments and continuing work of the geoscience community.

Technical Session #6**Speaking Their Language – Communicating Science with Non-Scientists – Who, Why, and How Symposium, Part I**

Invited speakers for this timely symposium will discuss practical examples related to communicating science with non-scientists, including with whom we need to communicate, why we need to engage those audiences, and how to do so. Speakers with a broad range of scientific backgrounds and experience who work in government agencies, consulting, and academia will participate, as well as television and newspaper reporters, and political staff. In addition to topical presentations based on practical experiences, there will be a mini-workshop facilitated by reporters on how to provide the information needed to ensure that geoscience is reported accurately and effectively. Both the morning and afternoon sessions of the symposium will conclude with panel discussions in which the most important issues can be more deeply explored by all attendees.

Room: Grand C2**Conveners: Deborah Green and Gerry Stirewalt**

Time	Speaker	Title
8:00–8:20	Green, Deborah	Introduction to Speaking the Language – Communicating Science with Non-Scientist: Who, Why, and How
8:20–8:40	Bauer, Jennifer	Seeing Eye to Eye – Making Connections for Better Communication
8:40–9:20	Print and TV Reporters	Communicating Science with the Media – A Workshop
9:20–9:40	Burns, Scott	Communicating Geology to the Media – 25 Years of Experience
9:40–10:00	Bussell, Serin	Talk Dirty to Me, and Other Geologic Puns You Shouldn't Say when Running for Office (But You Should Run for Office)
10:20–10:40	Soileau, Suzanna	Why is the USGS Doing That!? – Establishing a Biological Identity in the Geological Survey
10:40–11:00	Shea, Eileen	Communicating Climate Science with Professional Practitioners in Multiple Sectors
11:00–11:20	Kreuger, Duane	A 6,000-Year-Old Earth and the Continued Devaluation of Professional Licensure – Ongoing “Lessons” from Missouri
11:20–11:40	Watts, Skip	Justifying Science to Non-Science Faculty and to the General Public in the Age of “Big Bang” TV
11:40–12:00	All Morning Speakers	Panel Discussion and Q&A

Technical Session #7**NOA Symposium – Naturally Occurring Asbestos (NOA)/Elongate Mineral Particles (EMP) Assessment, Monitoring and Mitigation, Part I****Room: Windsor 1****Convener: Mark Bailey**

Time	Speaker	Title
8:00–8:20	Bailey, Mark R.	Serpentine Covered Roadways and the Emergence of NOA Concerns in the US
8:20–8:40	Swanson, Sam	Geology of NOA Minerals in Southern Appalachian Mountains
8:40–9:20	Van Gosen, Bradley	Distribution and Geology of Natural Occurrences of Asbestos in the Eastern United States
9:20–9:40	Bailey, Mark R.	Investigation, Sampling and Identification for the Presence of Naturally Occurring Asbestos
9:40–10:00	Mischler, Steven	NIOSH Elongate Mineral Particle Research
10:20–10:40	Webber, James	Tales from the Muck: Airborne Asbestos Concentrations since the Late 1800s
10:40–11:00	Ray, Robyn	Staten Island Serpentine
11:00–11:20	Fitzgerald, Sean	Asbestos Content in Operational and Historic Aggregate Quarries in Virginia, Maryland, and Pennsylvania
11:20–11:40	Ennis, Jonathan	Natural Occurrence of Actinolite in Lynchburg, VA – Those Who Do Not Learn History Are Doomed to Repeat It
11:40–12:00	Hargrove, Glenn	Naturally Occurring Asbestos in the Virginia Appalachians-Impacts to Worker Health and Safety, Regulatory Compliance, and Economic Impacts

Technical Session #8A**Hydrogeology, Groundwater and Karst***(Sponsored by Collier Consulting, Inc.)***Room: Windsor 2****Moderator: Hughbert Collier**

Time	Speaker	Title
8:00–8:20	Hayes, Kevin	Hydrogeology of Two Reservoir Sites in the Indian River Lagoon – South Watershet, Florida
8:20–8:40	Torres, Eryn	Innovative Plume Stability Evaluation and Groundwater Monitoring Program Optimizations
8:40–9:00	Hall, Mike	Multi-Faceted Investigation to Locate a High-Capacity Production/Remediation Well in Karst
9:00–9:20	Voss, Stefanie	Honoring the Final Repose of America's Veterans: Karst Mitigation at Jefferson Barracks National Cemetery
9:20–9:40	Molinari, Mark	Karst in the Southern Highlands of Papua New Guinea
9:40–10:00		Discussion

Technical Session #8B**Tunneling Symposium**

The 2019 Tunneling Symposium features five presentations showcasing engineering applications in underground construction through a variety of differing rock types and ground conditions.

Room: Windsor 2**Conveners: Paul Headland, Ike Isaacson, and Mike Piepenburg**

Time	Speaker	Title
10:20–10:40	Parker Jr., Horry	Geologic Factors Affecting Starter Tunnel Construction along a Complex Weathering Front in Foliated Granitic Gneiss
10:40–11:00	Eisold, Eric	SEM Tunneling for the Utility Market
11:00–11:20	Pullen, Tom	Effects on Pre-Excavation Grouting Posed by Limestone Interbeds in Shale Bedrock
11:20–11:40	Krajnovich, Ashton	Assessing Structural Uncertainty in 3D Geologic Models of Mountain Tunnels
11:40–12:00	Sackett, David	Characterizing the Geology and Geotechnical Conditions of Soft Soils Surrounding Aged Water Tunnels in Detroit Using an Integrated Multi-Faceted Investigation Campaign

Thursday, September 19 – Afternoon**Technical Session #9****The Changing Times of Engineering Geology at Dams and Levees Symposium, Part III***(Sponsored by RJH Consultants)*

The session will open with the keynote address by Kathleen Bensko, Engineering Geologist, Dam Safety, FERC, informing us about the FERC's Dam Safety Program and the importance of engineering geology. Scott Walker, Tennessee Valley Authority (TVA), will provide a brief overview of the TVA and the geologic challenges at TVA projects. Thomas Terry, USACE will provide geologic input for Dam and Levee Risk Assessments; while Kevin Richards, USACE, will speak on site characterization for risk assessment of Cougar Dam, Oregon, and the preliminary results obtained in this project. Derek Morley from Geosyntec will talk about the changing times as it relates to the evolving role of engineering geology for considering resilience in Dam Safety Risk. Kevin Minger of RJH Consultants will guide on his topic "Where to Focus" – Using the PFMAAAA/SQRA Process to Manage Risk at a Single Dam or an Entire Portfolio. Lastly, Gary Rogers from Schnabel Engineering will present his talk on Risk-Based Approach and 3D Modeling Clarify Artesian Pressure Risk.

Room: Grand C1**Conveners: Gary Rogers and Visty Dalal**

Time	Speaker	Title
1:40–2:20	Bensko, Kathleen	KEYNOTE 2 – The FERC Dam Safety Program and the Important role of Engineering Geology
2:20–2:40	Walker, Scott	An Overview of the Tennessee Valley Authority and Geologic Challenges at TVA Projects
2:40–3:00	Terry, Thomas	Geologic Input for Dam and Levee Risk Assessments
3:20–3:40	Richards, Kevin	Site Characterization for Risk Assessment of Cougar Dam, McKenzie River, Oregon
3:40–4:00	Richards, Kevin	Preliminary Results – Risk Assessment of Cougar Dam, McKenzie River, Oregon
4:00–4:20	Morley, Derek	Changing Times: The Evolving Role of Engineering Geology for Considering Resilience in Dam Safety Risk
4:20–4:40	Minger, Kevin	"Where to Focus" – Using the PFMAAAA/SQRA Process to Manage Risk at a Single Dam or and Entire Portfolio
4:40–5:00	Rogers, Gary	Risk-Based Approach and 3D Modeling Clarify Artesian Pressure Risk

Technical Session #10**Speaking Their Language – Communicating Science with Non-Scientists – Who, Why, and How Symposium, Part II****Room: Grand C2****Conveners: Deborah Green and Gerry Stirewalt**

Time	Speaker	Title
1:40–2:00	Taylor, Kenneth	Coordinated Emergency Responses to Sinkholes and Mine Collapses by the North Carolina Geological Survey with Local Emergency Managers
2:00–2:20	Steckel, Phyllis	Earthquake Hazards Outreach to Those Who Need to Know about Earthquake Risks: Finding and Reaching Key Decision Makers
2:20–2:40	Wooten, Richard	Communicating with Stakeholders about Landslide Hazards: Go It Alone at Your Own Risk, and the Only Failure is to Stop Trying
2:40–3:00	McBride, Sara	Using Communication Science to Communicate about Science: A Case Study for Aftershock Forecasts
3:20–3:40	Ramsey, David	Communicating Volcano Hazards and Risk: Before, during, and after a Crisis
3:40–4:00	Gath, Eldon	Our Hills are Moving, and They Are Not Doing It Peacefully: How to Communicate Complex Geologic Issues to Real People
4:00–4:20	Juckett, Miriam	A (Literally) Hot Topic: The Critical Nature of Nuclear Communication
4:20–4:40	Stirewalt, Gerry	Communicating About Resolution of a Site Characterization Issue for a Nuclear Plant in a Mandatory Hearing at NRC
4:40–5:00	All Afternoon Speakers	Panel Discussion and Q&A

Technical Session #11**NOA Symposium – Naturally Occurring Asbestos (NOA)/Elongate Mineral Particles (EMP) Assessment, Monitoring and Mitigation, Part II****Room: Windsor 1****Convener: Mark Bailey**

Time	Speaker	Title
1:00–1:20	Hernandez, Dan	Managing NOA at a Large Construction Project: Lessons Learned from the Calaveras Dam Replacement Project Presented by Mark Bailey
1:20–1:40	Kalika, Sarah	Asbestos Dust Mitigation Plans: What to Consider when Preparing for Ground Disturbing Activities at an NOA-Containing Construction Site
1:40–2:00	Bailey, Kelly	A View from a Mining Industrial Hygienist
2:00–2:20	Clancy, Kate	A Critical Evaluation of Current Detection Limits and Testing Methods for Elongated Mineral Particles (EMPs)
2:20–2:40	Chatfield, Eric	What Sizes of Elongate Mineral Particles Should be Measured in Monitoring of NOA?
2:40–3:00	Harper, Martin	Applicability of Analytical Methods, Reference Materials and Proficiency Testing for NOA
3:20–3:40	Wylie, Ann	A Metrological Look at NOA
3:40–4:00	Bateson, James	Preliminary Screening of Historic Asbestos Mines, Prospects, and Natural Asbestos Occurrences in North Carolina
4:00–4:20	Frederick, Tim	Investigation and Risk Assessment of NOA in Sapphire Valley, North Carolina
4:20–4:40	Fitzgerald, Sean	Case Examples of NOA in North Carolina: Anthophyllite in the Blue Ridge Belt and Tremolite in the Murphy Belt
4:40–5:00	McGrath-Koerner, Monica	Analytical Problems of Analyzing Erionite Through the Paradigm of Asbestos Analysis
5:00–5:20	McNamee, Brittani	Development of National Database Evaluating Distribution of Natural Occurrences of Group One Human Carcinogen Minerals

Technical Session #12**Environmental Characterization and Remediation, Part I***(Sponsored by SAEDACCO)*

Geologists solving environmental problems, on land, sea and air.

Room: Windsor 2**Moderator: Loren Lasky and Patty Bryan**

Time	Speaker	Title
1:40–2:00	Snyder, Jay	Vapor Phase Source Area Loading at a Dry Cleaner Site
2:00–2:20	Bailey, Jim	Innovative Drilling for Emergency Characterization of Hydrostratigraphy
2:20–2:40	Lenz, Richard	The Breakdown of Indiana's Exceeds Liability Trust Fund (ELTF) System-What Went Right and What Went Wrong
2:40–3:00	Ercolano, Bettina	Legacy Landfills and Rising Sea Level in Southern Patagonia and Tierra Del Fuego (Presented by Patricia Bryan)
3:20–3:40	Johnson, Kelly	Vapor Intrusion: Assessment and Mitigation Options for Sites with Known or Suspected Chlorinated Solvent Contamination
3:40–4:00	Cork, Robert	Beneficial Use of Dredged Sediment to Create In-Lake Ecological Habitat
4:00–4:20	Carpenter, Alexis	Laboratory Development and Evaluation of Technologies for Groundwater Remediation (Presented By John Haselow)
4:20–5:00		Discussion

Friday, September 20 – Morning**Technical Session #13****Landslide Symposium: Evaluating and Managing Landslide Hazards at Local and Regional Scales**

Evaluating and Managing Landslide Hazards at Local and Regional Scales: This symposium will present case studies and field-based research of landslide processes and landslide hazard evaluation, management, mitigation and risk reduction at local and regional scales. Topics include field studies of landslide activity, morphology, and geometry; observations of post-fire landslide activity and preparation for ongoing post-fire hazards in a non-arid region; methods for and examples of regional susceptibility mapping; and updates on statewide hazard management efforts.

Room: Grand C1**Conveners: Casey Dowling and Kevin McCoy**

Time	Speaker	Title
8:00–8:20	Hilmar, Jerilynn	"Third Time's the Charm?" – History of Landslide Risk Reduction and the Current Path Forward at the Pine Flat Dam, California
8:20–8:40	Burns, Scott	Forest Fires and Slope Stability in a Rain Forest: Lessons Learned from the 1991 Forest Fire in the Columbia Gorge, Oregon, USA
8:40–9:00	Contreras, Trevor	Update on the Activities of the Washington Geological Survey's Landslide Hazard Program
9:00–9:20	Evans, Stephen	The Soos Creek Hatchery Emergency Landslide Repair
9:20–9:40	Hamel, James	Estimation of Long-Term Rock Slide Creep Movement from Tree Trunk Deformation
9:40–10:00	Kring, Katelyn	Exploring the Need for Improved Precipitation Measurements for Rainfall-Induced Landslide Hazard Characterization
10:20–10:40	Oommen, Thomas	Characteristics of Landslides from Idukki, Kerala, from the 2018 August Rain Events
10:40–11:00	Woodward, Jason	Landslide Geometry: Modeling Landslide Depths
11:00–11:20	Krupansky, Joseph	Landslide Vigilance-A Bird's-Eye View: I-68 at Haystack Mountain, Cumberland, Maryland
11:20–11:40	Cato, Kerry	Mapping Sediment Volumes to Assess Debris Flow Hazard of Low Activity Canyons at Forest Falls, California
11:40–12:00	Dowling, Casey	Landslide Susceptibility Mapping for Large Landslides in Saskatchewan

Technical Session #14A**3D Modeling and Risk-Based Methodology***(Sponsored by Collier Geophysics, LLC)***Room: Grand C2****Moderator: Paul Santi**

Time	Speaker	Title
8:00–8:20	Anderson, Scott	Augmented Reality: A New Tool for the Engineering Geologist
8:20–8:40	Gilman, Tony	3D Modeling as a Tool for Evaluating Foundations: A Case Study for the Lower Baker Dam, Washington, USA
8:40–9:00	Chandler, Dafydd	3D Subsurface Modeling to Reduce Risk in Geotechnical Design and Construction
9:00–9:20	Santi, Paul	Reliability Analysis in Engineering Geology
9:20–9:40	Christiansen, Cole	Risk-Informed Decision Making: Not Just Dam Safety (Presented By Scott Anderson)
9:40–10:00	Meyer, Brent	Using a Hybrid Flow Model for Evaluating Rock Erodibility and Mitigating Leakage in Fracture Flow Pathways around Lower Baker Dam, Washington

Technical Session #14B**Geophysics***(Sponsored by GEOVision)***Room: Grand C2****Moderator: Ned Billington**

Time	Speaker	Title
10:20–10:40	Vaughan, Johanna	Integration of Non-Invasive Geophysical Methods with Invasive Geotechnical Sampling for Optimized Karst Characterization
10:40–11:00	Knight, Michael	Karst, Geologic Mapping and Geotechnical Engineering in the State of Qatar
11:00–11:20	Bergstrom, Jorgen	Geophysical Borehole Logging in Fractured Rock for Hydrogeological Applications
11:20–11:40	Wilshaw, David	Advanced Continuous Surface Wave Testing (ACSW): Geologic and Geotechnical Site Characterization for the 21st Century
11:40–12:00	Keaton, Jeffrey	Innovative Seismic Refraction Survey Reveals the San Andreas Fault Zone from Inside the Elizabeth Tunnel

Technical Session #15A**The Changing Times of Engineering Geology at Dams and Levees Symposium, Part IV***(Sponsored by Schnabel Engineering)*

The session will be opened by Richard Gary, Digiogray Consults, who will share the work on Unexpected Ground Movements at Tyerson Station Dam. He will be followed by April Fontaine, USACE, who will speak on Sacramento Region Levee Rehab-2017 Event. The next two presentations by USACE's Michael Arles and Mark Elson will be on the Chickamauga Lock Replacement-Geologic Site Characterization before and after and Foundation Preparation and Verification for the Kentucky Lock Downstream Cofferdam, respectively. Malcolm Schaeffer, HDR Inc. will speak on Engineering Geology Investigations for the Cedar Cliff Auxiliary Spillway Upgrade Project, Southwest North Carolina, and, last but not least, Michael Nield, USCAE, will speak about Sliding Failures at Five Lock and Dam Projects – Dam and Cofferdam Failures within the Ohio River Basin.

Room: Windsor 1**Conveners: Kevin Richards and Cassandra Wagner**

Time	Speaker	Title
8:00–8:20	Gray, Richard	Unexpected Ground Movements at Ryerson Station Dam
8:20–8:40	Fontaine, April	Sacramento Region Levee Rehab – 2017 Event
8:40–9:00	Arles, Michael	Chickamauga Lock Replacement-Geologic Site Characterization before and after
9:00–9:20	Elson, Mark	Foundation Preparation and Verification for the Kentucky Lock Downstream Cofferdam
9:20–9:40	Schaeffer, Malcolm	Engineering Geology Investigations for the Cedar Cliff Auxiliary Spillway Upgrade Project, Southwest North Carolina
9:40–10:00	Nield, Michael	Sliding Failures at Five Lock and Dam Projects – Dam and Cofferdam Failures within the Ohio River Basin

Technical Session #15B**Transportation and Infrastructure****Room: Windsor 1****Moderator: Steven Stokowski**

Time	Speaker	Title
10:20–10:40	Abrams, Andy	Geotechnical Instrumentation at the Pullman-Moscow Regional Airport: Tracking Geotechnical Analysis to Guide Project Funding
10:40–11:00	Roman, William	A Proactive Approach to Addressing Potential Acid-Producing Rock, Potters Mills Gap Transportation Project
11:00–11:20	Bailey, Jim	Migrating Mud Pot-Emergency Responses to Protect Critical Transportation Infrastructure
11:20–11:40	West, Terry	Local Contractor Shows Lack of Knowledge About Cold Weather Deterioration of Exterior Concrete
11:40–12:00	Stokowski, Steven	Proposed Concrete Aggregate Classification

Technical Session #16**Environmental Remediation and Geochemistry Symposium***(Sponsored by EA Engineering, Science and Technology, Inc., PBC)***Room: Windsor 2****Convener: Kevin Finneran**

Time	Speaker	Title
8:00–8:20	Bang, Sangho	DNAPL Removal from a Fractured Bedrock by Surfactant Enhanced Aquifer Remediation (Presented By Gary Birk)
8:20–8:40	Pham, Kien	Comparing Use of Semi-Analytical and Dual-Domain Method as Matrix Diffusion Modeling Tools
8:40–9:00	Morris, Harry	Environmental Forensic Analysis of Data for Evaluation of a Statically Significant Increase (SSI) in Ground Water Monitoring Data at an Environmental Remediation Site
9:00–9:20	Das, Joy	A New Design Approach for Aquifer pH Adjustment During In-Situ Remediation (Presented by Brad Elkins)
9:20–9:40	Rogers, D. Brian	Investigating Sources of Heavy Metal Contamination in the Tri-State Mining District
9:40–10:00	Finneran, Kevin	Use of Rendered Animal Co-Products as Electron Donors in Environmental Remediation
10:20–10:40	Macbeth, Alec	Full-Scale Implementation: Arsenic Sequestration in Biogenic Iron Sulfides in Groundwater in Northwest Florida
10:40–11:00	Snyder, Jay	Biosparging in Confined Aquifer
11:00–11:20	Giannetti, Anthony	Implementation of In-Situ Remediation Injection-Communicating with Contractors to Improve Results
11:20–11:40	De Bacco, Gianluca	Case Study: Comparative Analyses of No-Purge and Low-Flow Groundwater Sampling Methods
11:40–12:00	Hall, Michael	Field Screening of Low Concentration Chlorinated Compounds in Groundwater

Friday, September 20 – Afternoon**Technical Session #17****Drones for Geologic Applications****Room: Grand C1****Moderator: Bryan Simpson**

Time	Speaker	Title
1:00–1:20	Kuhne, Jody	Buffalo Creek Road Landslide, Rutherford County, North Carolina, January 2019
1:20–1:40	Simpson, Bryan	DRONES! Geologic Discontinuity Mapping Using UAS (Unmanned Aerial System) Technology and Photogrammetric Methods for Rock Fall Mitigation
1:40–2:00	Bozkurt, Serkan	Utilization of UAV Technologies During Oroville Spillways Reconstruction
2:00–2:20	Kumar, Chandan	Lithological Mapping in Hutti-Maski Gold Mineralization Area of India Using AVIRIS-NG Hyperspectral Data and Machine Learning Algorithms
2:20–2:40	Ewing, Jordan	Terrain Strength Characterization Using Remote Sensing
2:40–3:00	Steckel, Richard	The Pros and Cons of Operating Drones In-House or Subcontracting

Technical Session #18**Environmental Characterization and Remediation, Part II***(Sponsored by SAEDACCO)***Room: Grand C2****Moderator: Thomas Lammons**

Time	Speaker	Title
1:00–1:20	Avritt, Susan	Electrical Resistance Heating: When Mother Nature Brings Challenges
1:20–1:40	Jones, Aaryn	EPA's Action Plan for PFAS
1:40–2:00	McMillan, Teresa	CSI Vapor Intrusion-Investigating a Source of TCE in a Residential Home Over a Large TCE Groundwater Plume
2:00–2:20	Behzadi, Harry	Remote Vapor Intrusion Air Sampling
2:20–2:40	McMillan, Teresa	Use of Passive Soil Gas Samplers to Scope Remedial Investigation and Accelerated Vapor-Intrusion Evaluation
2:40–3:00	Saindon, Rosanna	Abandonment-In-Place USTs at Complicated Sites

Technical Session #19**Geologic and Geotechnical Site Characterization***(Sponsored by GroundLogs)***Room: Windsor 1****Moderator: Hawkins Gagnon**

Time	Speaker	Title
1:00–1:20	Elson, Mark	Geotechnical Hole Logging: How we do it, and Why it Matters
1:20–1:40	Gagnon, Hawkins	Know Before You Go: Geologic Mapping in the Digital Age
1:40–2:00	El-Hussain, Issa	Updating the Probabilistic Seismic Hazard Model for Sultanate of Oman
2:00–2:20	Lyne, Bob	Shallow Landslide Characteristics and Solutions
2:20–2:40	Radach, Kyle	Characterization and Analysis of the Cedar Pass Landslide Complex, Badlands National Park, South Dakota
2:40–3:00	Minas, Shant	A Multi-Phase Fault Rupture Hazard Study in Century City, Los Angeles, California

Technical Session #20**Geologic Hazard Mapping****Room: Windsor 2****Moderator: Rick Wooten**

Time	Speaker	Title
1:00–1:20	Chakrapani Lekha, Vishnu	SAR Based Assessment of 2018 Kerala Floods
1:20–1:40	Raval, Joyata	Identifying and Mapping the Locations of Landslides after the 2018 Floods in Kerala, India Using Remotely Sensed Satellite Imagery
1:40–2:00	Rogers, Bruce A.	Geotechnical Investigation of a Landslide at the Howard Cemetery, Loyall, Kentucky – The Integration Dynamics of Regional and Stress-Relief Systems
2:00–2:20	Sharma, Mukta	A Catchment-Based Microzonation of Landslide Zone: A Case Study of the Sirobagarh Landslide Zone, Uttarakhand, Garhwal Himalayas, India
2:20–2:40	Das, Raja	Application of GIS-Based Kinematic Analysis to Evaluate Debris-Slide Initiation Zones
2:40–3:00	Carter, Richard	Machine-Aided Terrain Mapping Using Information Derived from Lidar Point Clouds

Technical Session #21**The 2019 Forum on the Geology of Industrial Minerals Symposium**

The 55th Forum on the Geology of Industrial Minerals (FGIM) is being held in Asheville, North Carolina, hosted by the Association of Environmental & Engineering Geologists' 62nd Annual Meeting. FGIM and the symposia encompasses all aspects of mining geology, mineral processing, and mining regulation within the industrial minerals field and heavily focuses on field trips to illustrate geology, mining techniques and processing facilities. This program showcases diverse issues in the industrial minerals community.

Room: Swannanoa**Conveners: David Bieber and Sallie Gaillard**

Time	Speaker	Title
1:00–1:20	Hagni, Richard	Mineralogy and Structural Control of Jamaican Bauxites Ores (Presented by Ann Hagni)
1:20–1:40	Santos, Vanessa	Securities and Exchange Commission S-K 1300 Rules-Understanding the Changes and Complexities
1:40–2:00	Orris, Greta	Greater Antilles Industrial Minerals – Geologic, Economic, and Environmental Issues Impacting Production and Development
2:00–2:20	Winn, Russell	When Worlds Collide
2:20–2:40	Elliott, Brent	Economic Potential of Industrial Minerals from Oilfield Brines in Texas

NOA Symposium Naturally Occurring Asbestos (NOA)/ Elongate Mineral Particles (EMP)

September 19, 2019 – 8:00am–5:20pm

Windsor 1

This symposium is being offered as part of the 2019 AEG Annual Meeting.

**Presenter Organizations**

Asbestos TEM Labs • Chatfield Technical Consulting • Cornerstone Earth Group • EMSL Analytical • Erskine Environmental Consulting • Froehling & Robertson • Kelly Bailey Consulting • NIOSH • North Carolina Division of Waste Management • Research Triangle Institute • Rescape Environmental • Scientific Analytical Institute • University of Maryland • University of Georgia • University of North Carolina, Asheville • US EPA • USGE • Webber Environmental Health Consulting • Zefon

Who Should Attend

Asbestos Consultants • Certified Industrial Hygienists • Environmental Consultants • Epidemiologists • Geologists • Geotechnical Engineers • Government Regulators • Heavy Construction Contractors • Mine and Quarry Operators • Risk Assessors • Testing Labs • Toxicologists

Accreditation: 1 CM

COST: The fee for this Symposium is included in the Full, Thursday One-Day, and Student Registrations to the AEG 2019 Annual Meeting.

Register at www.aegannualmeeting.org!

Poster Sessions

(See each poster for their available schedule. Schedule changes can be found in the Guidebook Mobile App:
<https://guidebook.com/g/aeg2019>)

Vote for Your Favorite Poster!

We will once again be holding a student poster competition. There will be three cash prizes (\$200, \$100, and \$50) for the top three vote recipients of the poster sessions. Voting will be conducted exclusively through the Guidebook Mobile App, so bring your mobile device to vote for your favorite. Winners will be awarded at the Poster Reception on Thursday evening.

Poster Reception

Thursday 5:00-7:00pm in the Grand Ballroom foyer. Cash Bar. Each Full, Thursday One-day and Student Registration receives one drink ticket.

Wednesday, September 18 – 8:00am–4:00pm

Speaker	Title
Akinrinmade, A.O.	Integrated Approach to Modern Landfill Siting Using Geo-Spatial, Geophysical, Geotechnical and Analytic Hierarchy Process
Cameron, Cortney	Spatiotemporal Patterns of Rainfall in West-Central Florida, 1940–2016
Cantando, Elizabeth	NNCI: The Virginia Tech National Center for Earth and Environmental Nanotechnology Infrastructure
Drummond, Jesse	Application of ESS and 3D Modeling to Evaluate Contaminant Migration Risk from a Proposed Earthen Containment Design (Presented By Jay Snyder)
Ferry, Nicholas	Developing Landslide Modeling Capabilities within LandLab to Evaluate Landscape Response and Recovery to Mega-Landslides
Gates, Jonathan	A Remote Sensing Approach to Map Water Tracks Identified Using Soil Hydraulic and Geophysical Properties
Jarvis, William	Soil Monolith Preparation and Associated Physico-Chemical Properties Analysis from the Gray Fossil Site, TN
Jeoung, Jaehyeung	A Study on the Weathered Granite Soils for the Prevention of Residual Subsidence of the Motorway
Leverett, Kelsi	Assessing Drainage Tile Efficacy Using Geophysical Techniques
Lindsey, Cassandra	Modifying Landslide Susceptibility Mapping Methods to Better Represent the Geology in Mesa County, Colorado
Markley, Dale	Former Mine Site Remedial Efforts in the Tri-State District – Progress of Efforts by Private Industry

Thursday, September 19 – 8:00am–4:00pm

Speaker	Title
Mirus, Benjamin	Community Effort to Develop an Interactive National-Scale Map of Landslide Occurrence across the United States
Montano-Soriano, Xochitl Ricardo	3D Groundwater Model of the District of Columbia and its Use to Assess the Effects and Environmental Impact of Construction Dewatering
Paul, Varun	Discerning Hydrogeochemical Properties in the Ground and Surface Waters of the Upper Pearl River Watershed in Mississippi
Shields, Sierra	Surface Water Quality in Missouri
Snyder, Jay	Construction of Multi-Level Monitoring Wells in Karst Environment
Snyder, Jay	The Use of Powdered Activated Carbon in Excavation Backfill to Sequester Residual Contamination and Enhance Bioremediation
Soller, David	Geoscience Information and Decision Making Support from the National Geologic Map Database
Vargo, Ana	Geology and Construction of Tibble Fork Dam Rehabilitation, Utah County, Utah
Young, David	Impacts of Design Characterization and Geological Characteristics on Remedial Strategy Optimization

Abstracts

Geotechnical Instrumentation at the Pullman-Moscow Regional Airport: Tracking Geotechnical Analysis to Guide Project Funding

Abrams, Andy, *GeoProfessional Innovation Corporation, aabrams@geoprocorp.com (TS #15B)*

The Pullman-Moscow Regional Airport Runway Realignment project requires moving 6.5-million cubic yards of earth to facilitate new runway and taxiway grades. Surface geology comprises compressible, moisture sensitive silt and clay loess underlain by basalt bedrock. The new alignment overlies fill embankments 60-feet-tall, constructed over the loess, and a stream channel lined with soft overbank deposits creating a potential for time dependent consolidation settlement to occur months to years after construction. Further, an electric power transmission line traverses the deepest fills where the most settlement-prone conditions exist. The transmission line cannot be realigned until the second year of construction. These factors combine to create a substantial series of challenges to project design and funding. Construction costs are estimated at over \$120 million; annual grants from the Federal Aviation Administration (FAA) fund the project at \$20 million per year. Therefore, civil designers established project phasing to accomplish specific portions of the work each year, while geotechnical design accounts for time-dependent embankment settlement to avoid impacts to runway paving and utility installations. Geotechnical design utilized finite element analysis, combined with traditional settlement estimating equations, to characterize the embankment settlement, to model time dependent aspects, and to establish project phasing to capitalize on annual FAA funding cycles while protecting work from settlement impacts. To validate design and settlement models, geotechnical engineers specified and installed a multi-phased instrumentation program to measure settlement magnitude and time rate at strategic and critical alignment locations, and at specific construction phases. Resulting instrumentation data guided and informed project phasing and FAA funding decisions for the project's success. This presentation outlines the problematic geologic conditions facing the project, geotechnical analysis and design used to estimate settlement, and details the geotechnical instrumentation program implemented to track actual settlement realized throughout construction and beyond.

Rockfall Hazard Assessment Using Vehicle-Mounted Terrestrial Lidar Data along U.S. 33 Highway in Virginia

Admassu, Yonathan, *James Madison University, admassyx@jmu.edu; Jacob Maser, maserjj@dukes.jmu.edu (TS #1)*

Rockfalls from cut slopes along highways are common types of slope failures. The Oregon Department of Transportation was the first to deploy a rockfall hazard rating system (RHRS) to evaluate rockfall hazard based on rating of geological and non-geological factors. The RHRS semi-quantitatively rates geological factors that include structural conditions, degree of interbedding, and degree of undercutting. A more robust quantitative evaluation of the geologic factors using digital surface models (DSMs) was put forward by Admassu (2019 - In Press) outlining four quantifiable parameters, Parameter A, B, C, and D. To test the proposed methodology, lidar data collected from a vehicle mounted lidar scanner along U.S. 33 is used. The formation exposed along the road is the Devonian age Hampshire Formation, which is a sub-horizontal fine to coarse-grained sandstone interbedded with shale, making it prone to releasing undercutting-induced rockfalls. The point cloud data was processed using SplitFx software to generate DSMs from which the relevant parameters were evaluated, resulting in Parameter B values ranging from as low as 2.5 to 334.5.

Shadow zones in the lidar scans and uneven distribution of points proved to be the main challenges to generating DSMs. DSM-derived quantitative geologic rockfall hazard ratings are easily reproducible. They are also easy for comparing results from lidar scans acquired at different times. More testing to evaluate DSM-based geologic rockfall hazard rating is needed, but its future is promising, as lidar data from various sources such as self-driving cars will become accessible.

Integrated Approach to Modern Landfill Sitting Using Geo-Spatial, Geophysical, Geotechnical and Analytic Hierarchy Process

Akinrinmade, A.O., *Department of Geology and Mineral Sciences, Kwara State University, Malate, adeolaonline@gmail.com; Olasehinde, P.I, piseinde@yahoo.com; Olasehinde, D.A., olasehinde.david@lmu.edu.ng; Awojobi, M.O., pastorawojobi@yahoo.co.uk; Olatunji, J.A., olatwise@yahoo.com (Poster)*

The prevailing trend of waste disposal site in many parts of sub-Saharan Africa is detrimental to the environment on a long term. Waste disposal sites are randomly selected and frequently incinerated, releasing harmful gases, which have negative impacts on the surrounding ecosystem and human life. The study area in Kwara State, Nigeria is a Microcosm of Africa's unique challenge. The research is aimed at the determination of suitable landfill sites that engender environment sustainability. The proposed landfill sites were investigated using Geographic Information System (GIS), Geological, Geophysical and Geotechnical techniques as tools to aid the decision-making processes. To achieve the objectives, 2017 IKONOS Satellite imagery was used to identify geological features, soil, topography, land use, roads network, river, surface water, infrastructure and settlement. Twenty (20) vertical electrical soundings (VES) were conducted using the Schlumberger configuration for geophysical investigations. Three to four layers were deduced: Topsoil/laterite, clay, weathered basement, moderate to fresh basement. An integration of IKONOS satellite imagery, geology, geophysics and geotechnical data were modelled with environmental geo-spatial model builder in ArcGIS 10.3 environment using Analytic Hierarchy Process (AHP). Weighted Linear Combination (WLC) and multi criteria analysis in which criteria such as distance from settlement, roads, highway, land use, water body, river, water table, elevation, and slope were used after geo referencing, reclassifying, weighting of criteria, data overlaid and finally suitability model map were developed. The whole area falls into two categories: moderately suitable (Sokoto2, Maleta) and not suitable (Sokoto1, Oke Oyi).

Augmented Reality: A New Tool for the Engineering Geologist

Anderson, Scott, *BGC Engineering, Inc., scanderson@bgcengineering.com; Gerald Magnusson, gmagnusson@bgcengineering.ca; Ivy Li, ili@bgcengineering.ca; Matthew Lato, mlato@bgcengineering.ca (TS #14A)*

Engineering geologists perform desk reconnaissance and travel to the field to gather three-dimensional information. A variable located in space is what explorations are all about. As new tools evolve and the ability to capture data from familiar and new sources increases abundantly, it becomes more challenging to interpret what the observations all mean, and what story they tell. It follows, then, that 3D visualization has an important place for the engineering geologist. The visualization can help geologists communicate with one another and communicate with non-technical stakeholders who are less likely to be familiar with "seeing" in 3D than the engineering geologist. Augmented reality, wherein a hologram is added to the real environment of people

working together, provides an opportunity to break down the barriers and get people seeing the same way. This paper tells a story, knit together from various projects, of how augmented reality helped engineering geologists convey their messages to one another, to office management, to the public and politicians, and to construction contractors needing to bid and build the work. It tells a story of improved understanding, and of saving money and time. It will be told and shown through The Ada Platform™ software and the lens of a Microsoft HoloLens.

Chickamauga Lock Replacement – Geologic Site Characterization before and after

Arles, Michael, U.S. Army Corps of Engineers, michael.a.arles@usace.army.mil; Sarah Wiles, sarah.g.wiles@usace.army.mil (TS #15A)

Chickamauga Lock, owned by Tennessee Valley Authority (TVA) and operated by U.S. Army Corps of Engineers (USACE), is currently undergoing construction for a lock replacement in Chattanooga, TN. The new \$757M 110'x600' lock chamber is being constructed by USACE and is located landward of the existing 60'x360' lock and downstream of Chickamauga Dam. The existing lock has major maintenance issues caused by alkali aggregate reactivity, also known as growing concrete. The new lock is founded in complex geology, with folded and faulted rock containing numerous bentonite layers that vary by a few inches to 30 feet in thickness. The project is being built in phases, with the majority of the excavation, having utilized controlled blasting techniques, being recently completed. The current contract will entail phased demolition of the spillway apron utilizing the checkerboard concept, preparation of foundations, drilled shafts, concrete for lock monoliths, gates and valves, and the control building resulting in the dry commissioning of the lock. The geologic site characterization has become further refined through the multiple investigations. The material excavated consisted of Middle Ordovician age limestones interbedded with shales and bentonite beds with adversely oriented joints and bedding, resulting in concerns over sliding and consolidation. The complex geology was accounted for in design and required inclined anchors and the installation of a secant pile wall. Further exploration during construction revealed that the bentonite is thinner or thicker in places, resulting in the refinement of the secant pile wall design at monolith L13 and adjustment of the drilled shaft lengths. The presence of bentonite resulted in an irregular foundation shape and in some places required rock bolting and shotcrete. Line drilling and precision presplitting were utilized to protect the bentonite from blasting gases and prevent over break. In some areas, blasting was abandoned and mechanical excavation was utilized.

Electrical Resistance Heating: When Mother Nature Brings Challenges

Avritt, Susan, Wood Environment & Infrastructure Solutions, Inc., susan.avritt@woodplc.com (TS #18)

The CTS of Asheville, Inc., Superfund Site is located in Asheville, North Carolina. Former manufacturing operations resulted in the release of chlorinated volatile organic compounds, primarily trichloroethene (TCE), and fuel oil. Direct sensing investigation techniques were utilized to delineate an approximate 1.2-acre area containing light non-aqueous phase liquid (LNAPL) comingled with TCE. In 2014, a vapor intrusion (VI) assessment was conducted at residential properties east of the Site. This area contains a groundwater discharge zone where contaminated groundwater from the Site emanates from a complex of springs. Results of the VI assessment indicated TCE concentrations in indoor air above EPA's applicable levels that are attributable to TCE volatilizing from the springs. Based on the results of the VI investigation, an

interim remedial action focused on significantly reducing TCE in the source area was proposed. A Focused Feasibility Study was completed in 2015 and proposed electrical resistance heating (ERH) for the 1.2-acre LNAPL area. A Consent Decree entered in March 2017 indicated a remedial action objective of 95 percent removal of TCE from saturated soil, groundwater, and LNAPL in the source area. An ERH system was designed to remediate the subsurface from the water table to bedrock. During ERH, an electrical current is passed through the subsurface via electrodes. The resistance to the current heats the treatment volume to steaming temperatures. Volatile compounds adsorbed to soil and in groundwater/LNAPL are volatilized and steam transports the vapor phase contaminants to vapor recovery points. The extracted vapors are then treated aboveground. ERH remediation was successfully implemented from June to November 2018. Restrictions from the power company lead the team to "fast-track" the project. Also, record rainfall experienced during implementation created operational challenges but produced some positive outcomes. This presentation will describe the ERH system design, installation and operation, as well as challenges and solutions.

Innovative Drilling for Emergency Characterization of Hydrostratigraphy

Bailey, Jim, Shannon & Wilson, jsb@shanwil.com; Steve Story (TS #12)

In early 2018, a naturally occurring mud pot began migrating toward a major rail line that runs on the east side of the Salton Sea in southern California. The Mud Pot was flowing at a rate of 40 gpm, eroding soils in the direction of the tracks. As the mud pot got closer, the railroad took actions to stop the migration. One action taken was to drill three exploratory borings to depths of 320 to 800 feet close to the Mud Pot. Because of the eminent risk to the rail line, Imperial County declared an emergency, and a drilling company was needed quickly that could advance three boreholes through several hundred feet of soft plastic clay into one or more highly pressurized water bearing zones. If possible, the driller must also be prepared to install a screened well. The difficult drilling conditions included high concentrations of CO₂ gas necessitating use of self-contained air, continuous gas monitoring, daytime temperatures up to 115 degrees Fahrenheit, and occurrence of high-pressure gas and water at depth. Three different drilling methods were used in sequence to prepare for encountering pressurized conditions, to protect the rig and site from a potential blowout, and to enable installation of a well screen. The drilling process was initially a 24-hour operation due to the urgency of the situation. Although the results of the drilling efforts are still being assessed, and the Mud Pot continues to migrate, the innovative drilling program was successful in overcoming some extreme subsurface conditions in a short time frame. This has provided for a better understanding of the subsurface hydrostratigraphy at the site and helped in developing solutions to protect the rail line long term.

Migrating Mud Pot – Emergency Responses to Protect Critical Transportation Infrastructure

Bailey, Jim, Shannon & Wilson, jsb@shanwil.com; Carolina Zamora, cz@shanwil.com (TS #15B)

The Salton Sea, located in southern California, is the southern terminus for the San Andreas fault and a locale for sediment hosted, low temperature geothermal features. Commonly known as mud pots, these features are believed to form in this area by decarbonation reactions involving sedimentary carbonate that generates carbon dioxide (CO₂) gas. As the gas rises through various water bearing sediments, likely along existing fault lineaments, they pull sediment and water toward the surface. In early 2018, one of these mud pots began

migrating toward a critical Union Pacific rail line (UPRR), a fuel pipeline, and California Highway 111 paralleling the east side of the Salton Sea. This was the first time a mud pot had been observed migrating. The mud pot produced a sediment slurry at approximately 30 to 40 gallons per minute, eroding soils in the direction of the railroad tracks. As the mud pot got closer to the tracks, the railroad took actions to stop or redirect the migration. Initial actions included multi-method geophysical surveys, dewatering of the mud pot caldera, and installation of a sheet pile wall. After Imperial County declared an emergency, three deep borings/wells were drilled to depths up to 800 feet deep. The borings were used to determine the feasibility of depressurizing one or more aquifers that might be contributing to the flow. Drilling conditions were challenging due to high concentrations of CO₂, H₂S, daytime temperatures up to 115° F, and occurrence of high-pressure gas and water. In late September of 2018, the mud pot breached the sheet pile wall and UPRR was forced to construct two temporary tracks. The fuel pipeline was rerouted in early 2019. Mud pot flow and movement is continuing to be monitored while several permanent engineering designs are developed to allow for repair of the original UPRR alignment.

A View from a Mining Industrial Hygienist

Bailey, Kelly, Kelly Bailey Consulting LLC, kfbcih@gmail.com (TS #11)

As a mining industrial hygienist, it is important to understand the potential hazards that may be encountered from the various products that come on to a mine site such as welding rods, solvents, fuels, etc. as well as what is being mined; coal, aggregates, sand and gravel, etc. In general, the mined product can present the most challenging exposure circumstances. When you take a bite out of Mother Nature she sometimes bites back. Understanding the mineralogy is an essential knowledge that a mining industrial hygienist must possess. In the case where natural occurrences of asbestos (NOA) may be encountered, an understanding of what is and is not asbestos or even more general, what is and is not a durable asbestiform amphibole or zeolite, is critical to performing a proper risk assessment. A reliable laboratory is an essential partner in this assessment. This presentation will outline some crucial elements that should be looked for with the laboratory that is selected to analyze the samples. What happens if your reliable laboratory reports that NOA was found in some of your samples? From the perspective of a mining industrial hygienist, several actions may be considered to address this circumstance. Each mine will need to be examined on a case-by-case basis. A single approach will likely not fit all mines. This presentation will outline some potential exposure assessment measures to consider.

Investigation, Sampling, and Identification for the Presence of Naturally Occurring Asbestos

Bailey, R. Mark, Asbestos TEM Labs, mark@asbestostemplabs.com (TS #7)

Identification of Naturally Occurring Asbestos (NOA) at a site begins with geologic map and field investigations to determine the potential NOA-containing lithologies and creation of an effective sampling plan to include both focused (veins, fractures, other suspect rocks observed in the field) and representative (composite or multi-increment) samples to fully characterize the site. Samples are then submitted to the lab where a choice of sample preparation and testing protocols must be made, focused on the type of information desired including: sample prep (drying, crushing, splitting, pulverizing, mixing/representative sub-sampling) and microscopical analysis (polarized light or electron microscopy) following one of a number of available methods (EPA, OSHA, CARB, ASTM...). Understanding the criteria used by the lab in the interpretation of elongate amphiboles particles is necessary in

assessing the test results received. Applying the information garnered from test results to understanding the potential risk to workers and the public will also be discussed.

Serpentine Covered Roadways and the Emergence of NOA Concerns in the U.S.

Bailey, R. Mark, Asbestos TEM Labs, mark@asbestostemplabs.com (TS #7)

The first regulations related to potential exposure from naturally occurring asbestos were promulgated in Montgomery County in 1976 due to dust emissions from serpentinite gravel-covered roadways using aggregate material from Rockville Quarry in Rockville, Maryland. While early in the 1970s when concern about health effects caused by the presence of asbestos in building materials was increasing, other "incidental" asbestos exposure sources were also considered for their potential health impact on the public and workers, chief among these were serpentine rock covered roadways and mining activities. Various studies were undertaken to determine the potential for unhealthy exposures from these sources, resulting in the recognition that roadways with NOA-containing aggregate or bedrock/soil cover can give rise to locally significant airborne asbestos fiber emissions. These studies included: a) Dr. Irving Selikoff's Maryland roadway study, b) UC Berkeley's study of the Atlas and Coalinga Asbestos Mine locale, and c) EPA's Copperopolis roadway study including Dr. Wayne Berman. These studies lead to the first ever NOA regulations being introduced in California in 1990 including CARB's Asbestos Air Toxic Control Measures (ATCMs) and the CARB Method 435 test method, which have become a model for many other states and local jurisdictions. While regulations have resulted in the paving of the most highly used NOA covered roadways, substantially reducing health exposure to many citizens, thousands of miles of lower-usage unpaved NOA gravel/bedrock covered roads still exist.

DNAPL Removal from a Fractured Bedrock by Surfactant Enhanced Aquifer Remediation

Bang, Sangho, Tersus Environmental, sangho.bang@tersusenv.com (Presented By Gary Birk) (TS #16)

Aquifer remediation of dense nonaqueous phase liquids (DNAPL) is challenging due to subsurface heterogeneity and stringent regulatory limits. Better understanding of geologic conditions is required to remediate DNAPL in porous media. Inter-well tracer tests were used to understand fluid flow patterns and NAPL presence in the subsurface. Typical examples of DNAPL contaminants include common degreasers, such as trichloroethylene (TCE) and tetrachloroethylene (PCE) which are denser than water and tend to travel vertically through the saturated zones (or into the water table) while Light Non-aqueous Phase Liquids (LNAPLs) move laterally within a capillary fringe on top of the water table. Also, heterogeneities of geology and hydrogeological conditions and variations in groundwater flow are other key considerations in remediation of DNAPL sites. Two general flushing approaches have been used to minimize the density contrast between the injected aqueous solution and the organic phases. Co-injection and partitioning of alcohols with surfactant flushing had been previously employed to reduce the density of mobile DNAPL. Another approach is surfactant flushing using the supersolubilization mechanism by decreasing the interfacial tension to a lower level (< 2 dyne/cm), instead of ultra-low range (< 0.01 dyne/cm), between the entrapped NAPL and aqueous solutions without significant mobilizing of the NAPL. The key objective of this field implementation is to clean up the contaminated source zones in a fracture bedrock formation largely impacted by the presence of DNAPLs. Since mobilization of DANPLs

with a surfactant flushing system could potentially cause the DNAPLs to migrate deeper into the uncontaminated zones, a proper neutral buoyancy control is deemed necessary to mitigate any uncontrolled vertical migration and ensure better contaminants recovery.

Creating Opportunities and Growth as Young Professional Geoscientist

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Upcoming young professionals can face a variety of obstacles when entering the workforce post-graduation. During career preparation, entry-level professionals can benefit from understanding geoscience industries, young professional opportunities, and the values and expectations of an employer. Geoscientists entering the workforce have resources readily available to assist in transitioning into a career and excelling as a professional. It is imperative that young geoscientists engage themselves in professional topics surrounding the geosciences and the impacts these topics have on industry, professionalism, and the geological community. Becoming an advocate for the profession reflects mentorship throughout a young professional career and strength within the geoscience community.

Site Characterization Program for Design of the Boone Dam Remediation (Parts I and II)

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In October 2014, a sinkhole was observed in near proximity to the downstream toe of the earthen embankment dam at the Boone Hydroelectric Plant near Kingsport, Tennessee. Within days, a turbid discharge was also observed flowing into the nearby tailrace. These observations were judged to be potential indicators of the development of internal erosion processes, which posed a credible threat to the integrity of the dam and the safety of the downstream public. These events initiated an extensive subsurface investigation and instrumentation program which included a review of historical documents, geophysical surveying, conventional drilling and sampling, downhole imaging, dye tracer testing, excavating of test pits, limited geochemical testing, and installing over 100 new geotechnical sensors. This investigation provided a wealth of information, which was used to develop a hydrogeological model of the site conditions including the various strata, their characteristics and properties, and how they relate to the performance of the structure. In total, the model verified the existence of a complex groundwater regime at the site, which was consistent with the postulated threat imposed by internal erosion. This presentation provides an overview of the development of the hydrogeological model for the Boone Dam site with an emphasis on the use of historical information, instrumentation and monitoring data, and geologic data to evaluate the performance of the structure. The resulting hydrogeological model underscores the need to consider the three-dimensional nature of subsurface water flows near dams in which regional groundwater, rainfall infiltration, abutments, and the reservoir function as an interactive system. Risk driving potential failure modes developed from the model are described, and the application of the model in choosing a remediation strategy is reviewed.

The Layers of the Onion: Identifying Internal Erosion Vulnerabilities in the Origins of Boone Dam

Barrett, John W, Geosyntec, jbarrett@geosyntec.com; Chris Saucier, clsaucier@tva.gov (TS #4)

In October 2014, a sinkhole was observed in near proximity to the downstream toe of the earthen embankment dam at the Boone Hydroelectric Plant near Kingsport, Tennessee. Within days, a turbid discharge was also observed flowing into the nearby tailrace. These observations were judged to be potential indicators of the development of internal erosion processes, which posed a credible threat to the integrity of the dam and the safety of the downstream public. Detailed studies of the site's history revealed the dam's construction in the early 1950s may have created inherent vulnerabilities that led to the subsequent development of internal erosion along several potential pathways through and beneath the dam, as well as near the embankment dam's connection with the adjacent concrete dam. The techniques used to construct the embankment dam and concrete dam are detailed through a photographic chronology of their construction. The chronology describes the interface created between these constructed elements and the site lithology, geologic structure, and groundwater regime to the degree these interfaces could have promoted the development of internal erosion during subsequent operation of the Boone Reservoir. The photographic chronology describes the history of dam performance observations from original construction to the present day, which supports conclusions regarding the development of internal erosion. The presentation provides context for companion presentations which detail geologic conditions at the site, the selection and design of a suitable internal erosion remediation, risk assessments and risk management strategies during selection of the remediation measure and its subsequent execution, and the tailoring of grouting approaches during the remediation to date.

Keynote – Instrumentation Data for Dam Safety Monitoring During Construction – Recent USACE Lessons Learned

Bateman, Vanessa, U.S. Army Corps of Engineers, Vanessa.C.Bateman@usace.army.mil (TS #5)

While the uses for a wide variety of instrumentation for long term dam safety monitoring are well understood, there are particular challenges that must be taken into account when designing and constructing a major dam safety modification. The stresses on the project become far more dynamic and significant upgrades to instrumentation systems may be needed. Instrumentation is frequently installed after a contract is let and a "baseline" condition before construction is not always established. Monitoring frequencies are increased from the before construction condition that may show a variability of instrument reaction that was not previously understood. Adding to the complexity, modern construction equipment is now equipped with instrumentation to monitor parameters, pressures and orientation in space of installed elements and some of these are being consistently used on Dam Safety Modification Projects such as pressure grouting and seepage barrier wall installations. Then there are the data generated by instruments used during the verification process (e.g. monitoring permeability and verticality). All these data need to be collected, collated, analyzed and understood during tight time windows in order to understand the effects on the dam both during and after construction. Recent USACE projects, including foundation pressure grouting and barrier wall installations have yielded some important lessons learned for the design, monitoring, data handling and analysis of dam safety projects using instrumentation for effective monitoring of construction quality and in protecting a project against developing potential failure modes.

Preliminary Screening of Historic Asbestos Mines, Prospects, and Natural Asbestos Occurrences in North Carolina

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In 2005 and 2006, the North Carolina Division of Waste Management and the U.S. Environmental Protection Agency Region 4 Superfund Division conducted preliminary environmental screening assessments of 50 historic asbestos mines, prospects, and occurrences in western North Carolina. Most of these are sites listed in the United States Geological Survey's Open File Report 2005-1189 (Van Gosen, 2005). The effort included archival research, aerial imagery inspection, visits to all 50 sites, and limited sampling and laboratory analysis, in order to determine which sites had greater potential for disturbance and resultant human exposure. The North Carolina Division of Public Health keeps a summary report and the 50 site reports available to the public on its Naturally Occurring Asbestos web page, along with the most recently available best management practices and risk communication materials. These materials need to be supplemented periodically with outreach efforts by both North Carolina agencies to local government health and planning agencies, and to the State Department of Transportation's regional offices.

Seeing Eye to Eye – Making Connections for Better Communication

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In today's world of non-stop news availability, and almost anything we want to learn about being just a click away, we, as scientists with a message, must be open to learning methods that have stood the test of time to not only reach, but truly connect, with our audience. These methods may not be in a typical scientists' comfort zone, but they will result in better connections within oneself (to help find the message that needs to be communicated) and with others (to communicate that message). The first method is to be present. Breathing techniques can be used to focus the mind on the present moment and prepare one for relating to others. Deep, intentional, "belly breaths" help to calm the central nervous system, activate the parasympathetic nervous system, and focus the mind, if only for a moment. Being present helps us better understand ourselves, our motives, and our desires to connect with others in order to share our knowledge with the world. The second method is to apply emotional intelligence, active listening, and body language to build a connection. One must first understand the audiences' own motivations, desires, and interests, in order to shape the scientific message in a way that will be received with understanding and interest. This talk will include examples of the techniques mentioned to connect to ourselves, literally see eye to eye, and actively listen to others, in an attempt to illustrate how to build connections and have important messages heard.

They're Still Moving:

Debris Flows and Debris Slides of the North Pacolet River Valley, Polk County, North Carolina in 2018 and 2019

Bauer, Jennifer, Appalachian Landslide Consultants, PLLC, jennifer@appalachianlandslide.com; Rick Wooten, rick.wooten@ncdenr.gov (TS #13)

The North Pacolet River Valley, near Tryon, Polk County in southwestern North Carolina, has a long history of landslides. Debris fans, large scale landslide deposits, talus slopes, and dormant debris slides can be found on the slopes of this valley, along the steep edge of the

Blue Ridge Escarpment. On May 18, 2018, at least 27 debris flows impacted this valley, damaging or destroying at least six homes, and causing one fatality. Roadways ranging from private driveways to interstates were covered by debris. 2018 proved to be a record rainfall year for parts of Western North Carolina, and the rains have continued to lead to landslides in 2019. Primarily, the 2019 landslides are partial reactivation of older, prior debris slides. The largest of the 2019 debris slides is impacting Howard Gap Road, a two-lane state maintained road, as well as the private property below. This paper will discuss the different landslide mechanisms, materials, slopes, and impacts of the 2018 and 2019 landslides in the North Pacolet River Valley vicinity.

The Next Frontier on PFAS Contamination of Sediment, Surface Water and Fish Tissue

Behzadi, Harry, SGS, harry.behzadi@sgs.com (TS #3B)

PFAS are a class of synthetic fluorinated chemicals used in many industrial and consumer products, including defense-related applications. They are persistent, found at low levels in the environment, and bio-accumulate. The sources which can release significant quantities of PFAS to the environment vary, from industrial and municipal wastewater treatment plants (e.g. textile industry, chrome-plating industry, among others), landfill leachate treatment plants, firefighting incidents and firefighting training areas (e.g., airports, fuel production and storage facilities) and landfills. Human exposure to PFAS is mainly by ingestion of contaminated food and water. These compounds are not metabolized, bind to proteins (not to fats), and are mainly detected in the blood, liver and kidneys. Elimination of PFOS, PFHxS and PFOA from the human body takes some years, whereas elimination of shorter chain PFAS is in the range of days, which is why the EPA is primarily concerned with long-chain PFAS compounds. Studies have shown these compounds being detected more often in surface water, sediments and/or bioaccumulated into fish tissue. Because of greater affinity for longer chain PFAS compounds for fish than other environmental matrices, certain compounds are often found in fish tissue, but not in the water or sediment. More generally, PFAS is the compound that has generated the most concern in fish due to its frequent occurrence in the environment, its bioaccumulation in fish tissue, its potential human health risk, and the availability of health effects information needed to develop fish consumption advisories. In summary, PFAS compounds are widely distributed in many bodies of waters all over the United States due to historic and current industrial activities, as well as the presence of military facilities. These compounds are of concern because they do not break down in the environment, bioaccumulate in humans and biota, and may pose risks to human health.

Remote Vapor Intrusion Air Sampling

Behzadi, Harry, SGS, harry.behzadi@sgs.com (TS #18)

When chemicals or petroleum products, such as gasoline or diesel fuel, dry cleaning solvents and industrial degreasers, are spilled or leak from underground storage tanks, they potentially emit gases or vapors that can seep into buildings through cracks in basements, foundations, sewer lines and other openings. These vapors pose an unseen, and sometimes odorless, health risk for residents or workers in those buildings. For monitoring situations that would benefit from the ability to capture intermittent vapor emissions, SGS Galson-Smart Sense allows you to get the job done remotely from wherever you are in the world. SGS Galson-Smart Sense, the only sampling initiation system available in the industry, tracks key parameters including VOCs, particle concentrations, O₃, NO₂, temperature, pressure and humidity, and other contaminants, with available sen-

sors. It can remotely or automatically, based on pre-set triggering concentrations, actuate switches that control sampling pumps and whole air solenoid valves. This allows for a sample to be collected in a Summa canister as a vapor is being emitted rather than collecting a diluted composite sample that may or may not accurately reflect the presence and/or concentration of a pollutant. This innovative technology can also be utilized for other air monitoring situations such as Fenceline Monitoring.

KEYNOTE 2 – The FERC Dam Safety Program and the Important Role of Engineering Geology

Bensko, Kathleen, Federal Energy Regulatory Commission, Kathleen.Bensko@ferc.gov (TS #9)

The Federal Energy Regulatory Commission, Office of Energy Projects (OEP) is comprised of five Divisions. The Division of Dam Safety and Inspections has the responsibility of developing and implementing policies, programs and standards for the dam safety of a jurisdictional inventory of approximately 2,500 hydropower producing dams. This includes the inspection and evaluation of the design, construction, operation and maintenance of the dams. Whether it is concerning a license application for developing a new hydropower project, overseeing modifications of an existing project to create one capable of producing hydropower, or maintaining the performance of a dam that has been in existence for a hundred years, our goal is to complete the mission while ensuring the safety of the lives and economic well-being of those at potential risk downstream of the project. So what is one of the main factors that is consistent in the safety equation of every water-retaining structure regardless of the type of design? It is the foundation...the site geology. The potential geologic risks encountered at FERC projects will be discussed, how we evaluate them and how we incorporate our findings into our Dam Safety Program. In the presentation, current case histories and on-going projects will be used to illustrate FERC's dedication to a successful program of dam evaluations.

Geophysical Borehole Logging in Fractured Rock for Hydrogeological Applications

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The first geophysical borehole logging survey in the world was a resistivity log conducted by the Schlumberger brothers in 1927. Since then, geophysical borehole logging has expanded and evolved to include a variety of methods for a wide range of applications. Many modern borehole logging tools are geared towards hydrogeological applications such as fracture mapping in rock, making the surveys very beneficial for both potable well water development and evaluation of sites with contaminated groundwater. These tools can be used to determine depth, dip, strike and aperture of fractures and fracture zones in open hole segments of wells drilled into rock. The most common logs for measuring fracture locations and features include optical and acoustic televiwer, caliper, single point resistance, spontaneous potential, fluid conductivity and fluid temperature. Fractures from which there is inflow into or outflow from the well are then further evaluated by measuring the vertical flow in the well with a heat pulse flowmeter (HPF) log or spinner flowmeter under low rate pumping and ambient conditions. Post processing of HPF data using the U.S. Geologic Survey Flow-Log Analysis of Single Holes (FLASH) program can estimate fracture transmissivities and far afield heads. Borehole logging information can be used to quickly determine suitable screening intervals without coring the holes or conducting packer tests. By analyzing the data in the field immediately following

data collection, driller standby cost or cost for additional mobilizations can be avoided. Results from the borehole geophysical logging also provides a greater understanding of fracture orientation, groundwater flow and contaminant transport, and confirms the relationship of large-scale geologic structures (lineaments) to local subsurface conditions, thus improving the site conceptual model. Combining geophysical borehole logging with other assessment techniques such as hydraulic head monitoring and natural stable isotope evaluation can confirm groundwater flow paths and identify hydraulic connection to groundwater end member sources.

A Long-Term Record of Rock Avalanches in Southeast Alaska with Implications for Landslide Hazards in a Changing Climate

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Glacial retreat and permafrost degradation resulting from rising global temperatures have the potential to impact the occurrence of landslides in glaciated environments. Several notable recent events, including the 2015 Taan Fiord landslide, which triggered a tsunami with one of the highest wave run-ups ever recorded, have called attention to the hazards posed by changes to landslide-conditioning processes in regions like Alaska. In the St. Elias Mountains of southeast Alaska, the presence of weakly lithified sedimentary rocks and active uplift resulting from the collision of the Yukatat and North American plates create landslide-prone conditions. To differentiate between the typical frequency of landsliding based on the geologic setting and active tectonics in this region and landslide processes that may be accelerated due to changes in climate, we conducted an inventory of rock avalanches in the St. Elias Mountains. The systematic examination of Landsat imagery from 1984-2018 allowed us to identify recent events and to understand how the current rates and characteristics of landsliding fit into a historical context. We compared climate data with observed rates of rock-avalanche activity, and with the size and locations of landslides. We also compared our landslide inventory with a catalog of $M \geq 4$ earthquakes to identify possible coseismic triggering events. Results show that the mean recurrence interval of rock avalanches in the St. Elias Mountains is nearly an order of magnitude shorter than that in a similar area near Glacier Bay, and that several periods of increased rock-avalanche activity exist. The most recent cluster of increased activity, which occurred between 2013–18, correlates with a six-year period of warmer than average winter temperatures, including the three warmest years on record in Alaska (2014–16). These findings highlight the need for hazard assessments that address changes in the frequency and magnitude of landslides that relate to fluctuating climate conditions.

The Danger of Silos: Three Case Studies That Illustrate Why Professions Working in Different Areas Need to Talk

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As professionals, we generally communicate with other professionals who do what we do. Three events illustrate why actively seeking out professionals working on related problems can potentially save lives and/or reduce property damage. The 1980 eruption of Mount Saint Helens in Washington killed 57 people and caused an estimated \$870-million in damage. One of the takeaways of the event was that better communication between seismologists, volcanologists, and slope stability experts might have reduced the death toll. The 1994 Northridge earthquake in California, which killed 57 people and resulted in an estimated \$20-billion in damage, occurred on a fault

that was well documented by petroleum geologists working in the area, but was relatively unknown to engineering geologists and seismologists. Pre-event knowledge regarding the fault by engineering geologists in Southern California might have led to changes in seismic hazard zonation in the area. The 2013 Manefay slide at the Bingham Canyon Mine in Utah did not result in any deaths or injuries because mining engineers recognized the slope failure hazard potential before the event. However, the slide did result in several million dollars in damage to equipment. The size of the slide was not anticipated, which resulted in considerable property damage. In post-event analysis, mining engineers realized that had they had better knowledge of research into natural landslides they would have been better able to predict the magnitude of the event and moved vulnerable equipment out of harm's way.

Utilization of UAV Technologies during Oroville Spillways Reconstruction

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The Oroville Dam, located on the Feather River in Northern California, is the tallest earth-fill dam in the United States, standing 770 feet high. In February 2017, the concrete-lined spillway chute and unlined emergency spillway sustained significant erosion damage while passing flows from Lake Oroville. Starting in May 2017, the Department of Water Resources (DWR) and its construction contractors began repairing and rebuilding Oroville's main and emergency spillways. As of November 1, 2018, the spillways have been successfully reconstructed, meeting DWR's public safety construction milestone. As part of this major repair effort, our GIS team has provided real-time mapping and visualization support services to streamline daily activities for the geology and engineering teams. We utilized UAV-acquired images, along with surveyed control points to create site-wide and task-specific base maps at various resolutions. In addition, we have used UAV-derived orthoimages of the site to create high-resolution digital elevation models to support site analyses and site monitoring efforts. This imagery was also heavily used for weekly reports, construction approvals, and other site documentation. This procedure has proven to be faster and more cost-effective than repeated aerial lidar surveys, and have allowed the Spillways Recovery team to track continuous modifications to the site and communicate progress at all stages of construction. During and immediately following the February 2017 spillway incident, geologists began mapping bedrock in fresh exposures created by erosion of the spillways. During construction, project geologists mapped bedrock in the newly cleaned foundations of the planned structures. Our GIS team processed UAV imagery on a daily basis to create up-to-date basemaps to facilitate the geologic mapping, and to allow the resulting maps to be overlaid on regularly updated high resolution site imagery. In total, project geologists mapped roughly 1 million square feet of rock foundation at a scale of 1:60 and 1.3 million square feet at 1:120.

Rock Slope Stabilization on the C&O Canal Near Paw Paw, West Virginia

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The Chesapeake and Ohio (C&O) Canal runs alongside the Potomac River from Cumberland, Maryland to Georgetown in Washington, DC, and spans three physiographic provinces over its 184.5 mile length, including the Piedmont, Valley and Ridge, and the Blue Ridge. Construction of the C&O Canal started in 1828 and was finally completed in 1850. One of the most ambitious features of the project was construction of a 3,118-ft-long tunnel near Paw Paw, West Virginia. Construction of the tunnel was deemed necessary to avoid five miles of loops along the Potomac River that had steep cliffs along which canal construction was nearly impossible. The north end of the tunnel includes an approximately 890-ft-long open cut rock slope approach to the tunnel portal. The tunnel and approach cut are located within Devonian-age shales and siltstones of the Brallier Formation. This portion of the C&O Canal follows the axis of a tightly folded anticline. As a result of the orientation of the anticline, the bedding dips into both slopes of the canal excavation at the project site. The east slope of the approach cut has been subject to planar failure rock slope instability since its construction. This presentation describes the construction limitations and the design and construction of rock slope remedial measures for this historic structure. Stabilization of the slope included scaling, rock dowels/bolts, pre-cast concrete shear keys, weep holes and rockfall protective mesh.

Digging Deeper – Iterating Hydraulic and Geologic Models for Improved Unlined Spillway Erodibility Assessment, a Case Study from Oroville, CA

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Scour of rock and soil from unlined spillways during spill events can contribute to a range of unintended environmental, safety, and reliability consequences for both downstream and upstream facilities. This presentation will describe a screening-level, site-specific study for an unlined emergency spillway. The study relied on iterating between geologic and hydrologic analyses to estimate the volume of materials that could be eroded from the unlined hillside during a range of potential hydrologic events. We integrated data from geologic mapping, boreholes, and exposed soil profiles to develop a 3D geologic model of the emergency spillway in GIS. A variety of field data and geotechnical laboratory tests developed the erodibility characterization for each modeled geologic unit. To evaluate potential erosion and channel evolution during hydrologic events, we modeled a series of flows that gradually increased from 6,000 cfs to the probable maximum flood (PMF), using HEC-RAS software from the U.S. Army Corps of Engineers. At each step, the locations and depths of scour and deposition were used to modify the site DEM prior to running the next HEC-RAS iteration. The resultant estimated volumes of eroded material for the range of modeled flows was used to inform the consequences of hydrologic loadings and yielded data critical to risk analyses and decision-making.

Communicating Geology to the Media – 25 years of Experience

Burns, Scott, Portland State University, burnss@pdx.edu (TS #6)

Communicating geology with the media is a very important job we as applied geologists have to help the community understand the geology and especially the geological hazards of the area where we live. I have had a chance to give 288 media interviews (TV, radio, newspaper) in the past 8 years and would like to pass on some guidelines to others who will do similar interviews in the future. First, each type of media will be different. Print media is low pressure, and they are looking for the basic facts of the subject and some anecdotes. They also usually like some graphics to use too. Radio is interested in similar things but not worried about graphics. With radio and TV, one has to ask if it is live (one has to be careful with what one says) or to be played later. If it is later, and you make a mistake, just ask the crew to allow you to repeat the last statement. For radio and TV, a couple of simple ideas: 1) Keep it simple and do not use jargon; 2) If you are giving two or three points, give the points rapidly and then describe them after you have listed them; 3) Show enthusiasm and passion in your speaking—a must!; 4) Always ask the angle of the story for the reporter; 5) They will usually mic you up and ask a series of questions and then find a sound bite, so build your story and use good examples; 6) Ask the reporter questions; 7) Have a theme that you keep coming back to; 8) Who is the listener going to be?; and, 8) Give short answers; In the end, have fun!

Forest Fires and Slope Stability in a Rain Forest: Lessons Learned from the 1991 Forest Fire in the Columbia Gorge, Oregon, USA

Burns, Scott, Portland State University, burnss@pdx.edu (TS #13)

In the late summer of 1991, there was an extensive forest fire in the Columbia Gorge, USA, on the Oregon side of the river that was started naturally by lightning. We learned from this fire that this steep terrain underwent three basic erosion/landslide processes in the next ten years as a result of the fire. After the fire was out in the autumn, the first rains brought abundant surface erosion of burnt soil and vegetation. A lot of this ended in the streams. Second, extensive enhanced rock fall occurred in the burned area. One classic area was next to Multnomah Falls where a Brugg cable fence had to be installed to protect the trail leading to Benson Bridge from rock fall onto hikers. Third, we learned that in a period of 5–10 years after the forest fire, areas of intensive burning of the forest would produce very large debris flows. It takes 5–10 years for the roots of the trees burned to disintegrate. Seven large debris flows in 1996 at Dodson and one large one near there in 2001 are examples of this delayed debris flow generation when a “Pineapple Express” would come into the area. This is a rain forest getting over 60 inches of precipitation per year. This differs from dry climate forest fires where debris flows are generated with the first major storm after the fire. After the 2017 Gorge fire—which also occurred on the Oregon side—was started by two teenagers, we noted the same things. First, there was extensive surface erosion for a week after the first rainfall. Also, all of the roads and trails were closed until checked for rock fall hazards. We now expect debris flows in the next 5–10 years to come down the following drainages that had extreme burning in the headwaters: Tanner Creek, Eagle Creek, Oneota Creek, and Horsetail Creek.

Talk Dirty to Me, and Other Geologic Puns You Shouldn't Say when Running for Office (But You Should Run for Office)

Bussell, Serin, Oregon House District 33 Candidate, serin@serin-forstaterep.com (TS #6)

Misinformation, conspiracy theories, and downright obstructionist views concerning science are rampant in the news, on social media, and some may be widely held among constituents. We see this in the vaccine debate, discussions of climate change, and, believe it or not, even whether the Earth is round or flat. To overcome this, critical thinkers need to occupy all levels of government—serving on school boards, water districts, planning commissions, parks boards, city councils, State government, and at the National level. We need scientists and engineers in office! We need public servants who will bring a scientific mindset to these positions and use fact-based evidence in formulating public policy. But who will step up? And how do you run a successful campaign? This talk will walk you through why you should run, how to put together a campaign, and what to expect when you're in office. Are you a professor, a lab technician, a student, or a parent? Great! You should be an elected official. Your community needs you, and if not you, who? Not convinced to run yourself? We'll also talk about how to be an effective advocate with elected officials, and how to bring science and engineering to those conversations. Whether speaking to local government leaders or State- and National-level politicians, we'll go over how to put together concise and compelling testimony and one-pagers in order to get important messages across.

Spatiotemporal Patterns of Rainfall in West-Central Florida, 1940–2016

Cameron, Cortney, Southwest Florida Water Management District, cortney.cameron@swfwmd.state.fl.us; Ron Basso (Poster)

In the Southwest Florida Water Management District, located in west-central Florida, relatively small changes in rainfall can result in relatively large changes in recharge, since recharge represents what remains of rainfall after evapotranspiration (which varies little year-to-year) and runoff. Many long-term rainfall and flow patterns observed in the District from 1940 to the present can be explained, in large part, by climatic cycles such as the AMO and ENSO, plus the frequency of tropical cyclone landfalls in the District. Comparing the current AMO warm phase to the last AMO warm phase, fewer tropical cyclone landfalls in the District, more La Nina months, and fewer El Nino months have led to decreased annual rainfall at most long-term stations. Thus, high flows that characterized the 1960s were unusually high as a function of higher rainfall caused by more El Nino months, fewer La Nina months, and more tropical cyclone strikes (on top of the warm AMO phase). Comparing the current warm phase to the last cool phase, wet season rainfall has generally increased, aligning with predictions of how the AMO impacts peninsular Florida rainfall. As a result of this increased wet season rainfall, most southern District stations have now exceeded their cool phase annual totals. At the same time, an increase in La Nina months and a simultaneous decrease in El Nino months have led to lower dry season rainfall at most stations. In the northern District, these ENSO-driven dry season decreases have completely cancelled out AMO-related wet season increases such that the current warm phase has experienced lower annual rainfall than the preceding cool phase. This reduced dry season rainfall in the northern District largely explains more recent low aquifer water levels, river, and spring flows that haven't recovered to those of the preceding warm AMO period prior to 1970.

NNCI: The Virginia Tech National Center for Earth and Environmental Nanotechnology Infrastructure

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NanoEarth at Virginia Tech is the leading destination for earth and environmental nanoscience research and discovery. Nanomaterials have unique chemical and physical properties that impact environmental and human health at local, regional, and global scales. However, the amount of natural and anthropogenic nanoparticles generated, released, and transported annually is largely unknown. Approximations based on flow models and self-reported industrial inventories yield at best order of magnitude estimates. Natural nanomaterial generation has been estimated to be hundreds of Tg per year, while incidental and engineered nanomaterial sources are believed to produce less than 10 percent of this amount. Anthropogenic contributions are expected to increase with time, while the mechanisms of nanoparticle interactions with cycles critical to maintain habitability remain poorly understood. The new scientific insights and technical developments afforded by the nanotechnology revolution have allowed scientists and engineers to begin to fill in the gaps in our understanding of the Earth system and better quantify the nanomaterial cycle. Toxicity, bioavailability, and the economic feasibility of recovery of nanomaterials are all important emerging areas of research. NanoEarth supports scientists across academia, government, and industry to enable critical discoveries at the nanoscale. We provide access to advanced tools and expertise to facilitate nanotechnology research and propel environmental solutions.

Laboratory Development and Evaluation of Technologies for Groundwater Remediation

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In situ soil and groundwater remediation is widely accepted and practiced in the United States. Both in situ chemical oxidation (ISCO) and in situ chemical reduction (ISCR) are mature technologies that have many variations in their implementation. Triad Growth Partners and Redox Tech are developing and evaluating chemistries for improving both ISCO and ISCR. On the ISCO side, we are testing new mixtures of slow release oxidants that can improve oxidation efficiency and reduce the potential for rebound. The slow release oxidants are patented products produced under intellectual property of Triad Growth Partners. The slow release oxidants currently being evaluated are sodium percarbonate and persulfate and mixtures of the two oxidants. On the ISCR side, recently there have been claims of improved efficiencies and reactivity of sulfidated zero valent iron (ZVI) versus traditional non-sulfidated ZVI. We completed side-by-side evaluations of the two ZVIs in terms of reaction efficiency, stoichiometry and rates. For both the ISCO and ISCR products, we will present results on treatment of prevalent chlorinated alkenes and alkanes.

Machine-Aided Terrain Mapping Using Information Derived from Lidar Point Clouds

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Terrain mapping is used to produce an understanding of the spatial distribution of surficial geology and geomorphology of a given area. The output is often used as a preliminary screening tool for identifying areas where further, more refined analysis may be required. Though the process is inherently interpretive and requires expert judgment, there are components that can be standardized and automated to increase efficiency and consistency within the process. In this study, a machine-learning exercise is carried out using hand-mapped terrain polygons as a training dataset and full feature airborne lidar data to derive classifier variables. The goal of the exercise is to determine how accurately a machine-learning algorithm can classify characteristics of surficial material, surface expression, and terrain-stability class. The results are compared to those of a conventional terrain mapping dataset. A secondary goal of the exercise is to determine how machine-aided terrain mapping can be used to augment the process, rather than replace the conventional process altogether. This presentation will show the results of machine-learning-based terrain mapping compared to the hand-mapped and provide a list of lessons learned and next steps.

Mapping Sediment Volumes to Assess Debris Flow Hazard of Low Activity Canyons at Forest Falls, California

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In the Transverse Range of California, recurrent debris flows are a significant hazard to the built environment of small residential neighborhoods that interface with steep canyon slopes prone to wasting of tectonically fractured and deeply weathered regolith. At Forest Falls in the San Bernardino Mountains, previous studies have focused on an unbuilt fan landform at Snow Creek Canyon (SCC) that has actively generated debris flows to study temporal and spatial patterns of flow pathways and deposition. Recent flow events at SCC are well documented by repeat aerial photography and field investigations of proxy-records of debris flow occurrences including tree-ring abrasion scars and surface age dates, and chronosequences of soil development. However, canyons to the west and east are poorly documented because few modern flows have been discharged onto the fan landforms and the fan surfaces have been extensively modified by residential developments. We hypothesize that the historical activity of debris-flows among neighboring low activity canyons (LACs) can be comparatively measured in reference to the active Snow Canyon. This approach uses lidar mapping to quantify relative measures of debris volumes deposited on canyon headwall slopes, in the canyon channels, and also from the volumes of fan landforms below LACs. Initial results provide a ranking of flow generation risk among the neighboring LACs, a potential range in volume of remobilized sediment production for LACs, and target further risk assessment to particular identified flow pathways in the LACs.

SAR Based Assessment of 2018 Kerala Floods

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Kerala, a state in south India, recorded 36% more rainfall than average during the southwest monsoon season of 2018 from June 1 to August 29. This led to catastrophic floods that peaked during the 17th to 21st of August, resulting in the death of 483 and substantial loss of infrastructure. In this study, satellite Synthetic Aperture Radar (SAR) data were used to map the flood inundation in the Pampa-Achankovil-Manimala watershed that covers parts of Pathanamthitta, Alappuzha, and Kottayam districts. Sentinel-1A data for August 21 was used to delineate flood extent. Another Sentinel-1A image from January 29 was used to characterize the pre-flood water extent. The pre-flood water extent was considered as the permanent water body. Low-lying areas in the coastal plains, corresponding to the Kuttanad wetland, were found to be most affected by the flood. Sentinel-1A data for August 21, 2019 shows that 116 square kilometers was flooded, which is more than six times the area of permanent water cover. Height Above Nearest Drainage (HAND) was computed for the watershed and was used to assess the flood water level rise. A water level rise of up to 5 meters was observed with a mean rise of 3.84 meters. These estimates are fairly conservative, as the flood had started receding by August 21.

3D Subsurface Modeling to Reduce Risk in Geotechnical Design and Construction

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The use of 3D ground models is a well-established practice within the oil and mining industries. This paper will present a discussion of why and how the geotechnical industry can use 3D ground models to greatly enhance understanding of ground conditions, streamline concept development, optimize detailed design, and inform construction contractors. Consider the typical standard of care for geotechnical investigations: a geotechnical investigation program consisting of boreholes on a 50-ft grid and 5-ft SPT sampling intervals can only recover 0.0003% [1/350,000] of the soil mass from investigation. This leaves the remaining 99.9997% open for interpretation and risk. This example is presented to emphasize the importance of intelligent geological interpretation. This process warrants the efforts of a skilled engineering geologist and the utilization of multiple recourses including borehole records, published literature, surface observations and local experience. A holistic and efficient data collation and interpretation tool is desperately needed. Modeling of geological conditions in three-dimensional visualization software has been shown to be a highly valuable method for increasing the validity and speed of the interpretation process. Performing the geological interpretation within a 3D visualization environment allows for the simultaneous consideration of numerous data sources. During the interpretation process, there is also an inherent appreciation for how the ground model confidence varies across a site and thus uncertainty risks can be understood and mitigated. This presentation will present a brief review of traditional ground interpretation methods and the potential resultant risks. The paper will then present methods and examples of 3D generated ground models and the resultant benefits for civil projects.

What Sizes of Elongate Mineral Particles Should be Measured in Monitoring of NOA?

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Monitoring of airborne elongate mineral particles (EMPs) in geological and mining operations where naturally occurring asbestos (NOA) is present is currently based on drawing a known volume of air through a membrane filter and counting of fibers longer than 5 μm by phase contrast microscopy (PCM). Analytical transmission electron microscopy (ATEM) is also now routinely used at a number of sites to identify elongate mineral particles and measure their concentrations in air samples and bulk materials. Current practice to interpret the ATEM results is to derive the concentration of PCM-equivalent fibers (fibers longer than 5 μm and thicker than 0.25 μm) for comparison with risk estimates. Separate ATEM fiber counts are currently being made for fibers 0.5 μm and longer, and also for fibers longer than 5 μm , of all fiber widths. New ATEM data derived from several different tremolite samples used in past intrapleural injection studies on rats show that the current measurement practice does not reliably track the mesothelioma risk. Also, the data show that much of the current analytical effort is devoted to measurements that have questionable predictive value, thereby compromising the ability to obtain reliable data for the fiber size categories that are widely acknowledged to be associated with mesothelioma risk. This issue appears to be related to the fact that the current risk factors were derived from exposures to commercial asbestos, whereas for NOA, the EMP width distribution varies widely from one source to the next, some of which are quite different from the width distributions exhibited by commercial asbestos.

Risk-Informed Decision-Making: Not Just for Dam Safety

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Risk-Informed Decision-Making (RIDM) is the name assigned to a process used more and more often in the United States to evaluate safety risk associated with dams and levees. It has a history of about 20 years with the U.S. Bureau of Reclamation, and 10 or so with the U.S. Army Corps of Engineers, and it is now required by the Federal Energy Regulatory Commission and many states. The process has some standardized approaches that are necessary for assuring a common product during a period of rapid implementation, and the Association of Environmental & Engineering Geologists has recently hosted training to share these approaches. Most of this RIDM work is based on the very important objective of safety. Oftentimes, however, infrastructure owners have more than safety to be concerned with, and they have explicit objectives such as environmental stewardship, sustainability, low life-cycle costs, and minimal service interruptions. This presentation demonstrates through case histories how the RIDM approach can be used to evaluate the risk associated with multiple performance objectives (other than safety) for highway projects. The RIDM approach is one of considering potential failure modes and decomposing a project into events that are easy enough for a panel of experts to assign an approximate probability of occurrence. Then, the principles of probability can be used to recombine the event nodes, and to compare alternatives. For dams and levees, the comparison would typically be of different projects with respect to the safety risk associated with each, though some water-resources agencies also look at other risks explicitly. For highways, the alternatives can be different potential alignments and the risks can be life-cycle cost and traffic interruption, for example, and as will be demonstrated.

A Critical Evaluation of Current Detection Limits and Testing Methods for Elongated Mineral Particles (EMPs)

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Asbestiform minerals and their nonasbestiform analogues share similar characteristics: dimensions, surface properties, fiber surface area, and chemical composition. These properties are major contributors to carcinogenicity. Mechanical crushing of asbestos-containing materials makes it extremely difficult to distinguish between asbestiform minerals and cleavage fragments of the same chemical composition and dimension. Based on the review of published studies, reliable methods for differentiating asbestiform fibers from cleavage fragments do not exist. The geologic definitions of elongated mineral particles (EMPs) commonly result in the mischaracterization of some asbestiform materials and exclude fibers that pose negative health effects in humans. Other current testing methods and counting rules attempt to exclude cleavage fragments by requiring higher fiber aspect ratios or longer fiber lengths; however, research shows that these criteria are not effective at differentiating asbestos minerals by habit and may result in false negatives for some asbestiform materials. Furthermore, growing evidence of cleavage fragment carcinogenicity suggests that there is no health basis for separating cleavage fragments from asbestiform fibers of the same dimensions. Reliable and reproducible testing methods are needed to accurately quantify toxic fibers, which can be done with thorough transmission electron microscopy analyses (TEM) and removing geological/morphological requirements of particle counting. Including cleavage fragments in current analytical methods is paramount for proper testing and mitigation of carcinogenic elongated respirable particles.

Update on the Activities of the Washington Geological Survey's Landslide Hazard Program

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The Washington Geological Survey's Landslide Hazard Program (LHP) was formed in response to the devastating 2014 SR530 Landslide near Oso, Washington. Currently, the program consists of five full-time geologists who map landslide hazards and respond to landslide emergencies. To date LHP has produced several publications, including a landslide inventory protocol detailing their method for mapping landslides. The program has also completed four lidar-based landslide inventories, mapping over 7,500 landslides in an area where 51 percent of the state's population lives. LHP also incorporates alluvial and debris fan mapping into the landslide inventory. To serve the public interest, LHP conducts community meetings and coordinates mapping with local cities, counties, and other stakeholders in addition to publishing final inventories on a website for viewing and downloading. LHP responds to landslide emergencies throughout the State, providing emergency managers and local jurisdictions with landslide expertise to evaluate landslide hazards. For instance, the Rattlesnake Hills landslide near Yakima started moving in 2017 and required coordination of multiple stakeholders to monitor the landslide, close roads, and evacuate residences. The landslide continues to move and LHP convenes regular technical calls to share monitoring data with multiple entities. During wildfire season, LHP evaluates post-wildfire debris flow potential for communities and infrastructure as part of Burned Area Emergency Response (BAER) teams in partnership with the U.S. Forest Service

and local jurisdictions. After four years of BAER work, the 2019 fire season will be the first time this type of evaluation is funded by the Washington State Legislature. The evaluation will include private lands and state-managed lands outside of National Forests. The Washington Geological Survey's website is an open repository for up-to-date landslide information throughout the State. LHP tracks recent landslides and displays them on the website, helping citizens, emergency managers, and the media to monitor landslide activity across Washington.

Beneficial Use of Dredged Sediment to Create in-Lake Ecological Habitat

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Identifying a cost-efficient and suitable location to place sediment removed from Polk County's Lake Adger has proven difficult over the past years. In 2018, after Polk County and the North Carolina Wildlife Resources Commission had considered several options, Anchor QEA proposed an innovative beneficial use solution that would create an in-lake ecological habitat from sediment removed from the lake's navigation channel during maintenance dredging. Anchor QEA completed pre-design investigations in 2018, and we are now moving into the design phase. At this time, it is anticipated that the 6,800 cubic yards of sediment will be used to enhance and create in-lake wetlands, and possibly islands or hammocks to provide greater capacity for sediment placement. Key engineering design features of the project include:

- Selection of a dredging and dewatering methodology that allows the efficient transfer of dredged material from the lake to the placement location, which has several feet of soft sediment and daily varying water levels.
- Engineering the design of the in-lake wetlands and hammocks to ensure that they remain stable during flood events, while establishing and maintaining suitable ecological habitat.
- Consideration of a construction option to modify braided channels as the Green River enters Lake Adger, to reduce future sedimentation of the navigation channel.
- Development of a HEC-RAS 2D model to simulate velocities, shear stresses, and water surface elevations over a range of flow conditions to assess the stability of the proposed sediment placement design and possible Green River modifications.

Anchor QEA anticipates completing the design and permitting in 2019, followed by dredging and construction in 2020. This presentation will cover several topics relevant to a variety of engineering projects, such as modelling of currents and sediment deposition, dredging and dewatering techniques, innovative engineering design to create ecological habitat, and options for navigating the permitting process.

Innovations in Dam Instrumentation Monitoring to Reduce Risk

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Aging dam infrastructure and uncertainty in understanding geologic features that affect structure stability necessitates enhanced monitoring to reduce the risk of adverse conditions affecting the integrity of a structure. In particular, monitoring systems are useful to detect anomalous behavior and, therefore, prompt further investigations and/or remedial measures to mitigate an undesirable event. Over the past decade, the technology for dam instrumentation monitoring has

greatly advanced allowing the owner and/or engineer to quickly identify data trends requiring subsequent action. One of these monitoring technologies is a Cloud-based Infrastructure Monitoring System (IMS) powered by sensemetrics. The IMS is a platform allowing instant remote data retrieval from the project site equipped with a data logger and transmittal device (THREAD). Once the raw data is captured and securely stored, the IMS platform provides access to various analytical tools. We highlight two water supply dam projects in North Carolina and IMS systems relevant to monitoring these dams. Lake Townsend Dam located in Greensboro, North Carolina, features thirteen vibrating wire piezometers located beneath the spillway and in the earthen embankment to monitor water pressure. These instruments were installed during a rehabilitation project completed in 2009 with data being logged locally at the dam. In 2019, the system was upgraded to the IMS and provides confidence that the structure is performing as intended. North Fork Dam located in Asheville, North Carolina, provides water supply to the City of Asheville and is in the construction phase of a major rehabilitation project to upgrade spillway hydraulic capacity and improve embankment stability. The IMS is proposed for the future monitoring of the dam and involves numerous piezometer and weir sensors. An alert system will be in place to identify anomalous and/or trending data behavior exceeding threshold levels that would prompt action. A field course to the North Fork Dam will be conducted as part of the 2019 AEG Annual Meeting and will highlight aspects of the instrumentation monitoring system.

Lessons Learned-Foster Dam Breach, Maryland

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The one-acre Foster pond with earthen embankment was built in 1987 for agricultural use. In February 2005, downstream residents complained to the Maryland Department of the Environment (MDE) regarding large volumes of sediments flowing from the Foster Pond into their backyard stream and ponds. MDE's Dam Safety and Water Compliance Divisions inspectors observed a deep scour (8-ft-deep, 25-ft-wide, 5-ft-long) on the Foster pond emergency spillway. Additionally, scouring had undercut the dam with less than 5 feet of embankment holding back the pond with seeps observed in the embankment. The principal spillway, constructed of corrugated metal pipe, was determined to be undersized with the 18-inch barrel and the 24-inch riser severely corroded with infiltrations. Evidently the pond had been built with inadequate spillway capacity that caused it to consistently overtop and incrementally erode the emergency spillway during frequent floods. The downstream heavily traveled two-lane county road and a residential home were in danger of flooding if the dam breached. Attempts by MDE and the Maryland Attorney General's Office did not yield any response from the owners who were reluctant to make repairs to their dam. Instead, they filled the scoured emergency spillway with recycled sidewalk concrete debris. In March 2005, MDE issued an "Administrative Order/Notice of Violation" (AO/NOV) to the owners and in April 2008 filed a court case in Baltimore County Circuit Court forcing the owners to either breach or repair the dam. In September 2008, the owners decided to breach the dam and pass the 100-year and above storms through the dam with a 3-foot retention pond. The 24-ft-wide breach with 2:1 side slopes were covered by 9-ft-long, 6-ft-wide, and 6-ft-tall gabion mattress stacked on geotextile fabric. Lessons learned—the cost of the breach, sediment pollution fines and the lawyers' fees amounted to a higher cost than repairing the dam.

A New Design Approach for Aquifer pH Adjustment During In-Situ Remediation

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Aquifer pH has a major influence on contaminant mobility and attenuation including precipitation/sorption of metals and biodegradation of chlorinated solvents. However, adjusting aquifer pH can be challenging due to strong buffering by clays, iron oxides and sorbed Al³⁺. Alkaline materials including hydroxides and carbonates are commonly added during enhanced reductive dechlorination (ERD) to adjust pH to greater than 6. There are few options available to site managers who need to calculate and design an approach for pH adjustment. Currently available design tools such as BUCHLORAC have limited capabilities. Recently SERDP/ESTCP published a base-addition design tool to help practitioners develop a comprehensive pH management plan utilizing a variety of common bases. After several years of research, EOS developed an injectable form of Mg(OH)₂ commercialized as CoBupHMg™. Laboratory studies demonstrated that the colloidal buffer suspension of Mg(OH)₂ was effectively transported through columns packed with aquifer sand without significant permeability loss. A subsequent field demonstration conducted in Virginia further proved that colloidal Mg(OH)₂ both transports well in the aquifer, as confirmed by measured concentrations in monitoring wells 20 feet away from the injection point, and could keep pH stable at near-neutral conditions for more than one year following injection. Determining the appropriate amount of alkaline material required can be challenging due to buffering by aquifer material and acidity produced during the remediation process. A case study will be presented demonstrating the use of the base-addition design tool developed for ESTCP and laboratory titration data for a challenging site in central North Carolina. Use of the design tool and CoBupHMg™ led to the successful remediation of this low pH site.

Application of GIS-Based Kinematic Analysis to Evaluate Debris-Slide Initiation Zones

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Debris-slides are one of the most important processes that transport sediments within mountainous regions. Often debris-slides initiate from slope instability caused by bedrock kinematic relationship of geological discontinuities and topographical slope. This study aims to develop a GIS-based kinematic model built on kinematic relationships to predict the debris-slides initiation zones in Southern-Appalachian hillslopes composed of weathered slate and phyllite bedrock. Two hundred fifty-six debris-slides initiation locations were mapped from aerial photographs and satellite imagery and were verified during the field survey. Topographical slope angle and aspect were extracted using Light Detection and Ranging digital elevation model. The orientations of geological discontinuities were determined in the field. The Rock Mass Rating (RMR) was determined using geotechnical data on uniaxial strength of rocks, rock quality designation (RQD), spacing and surficial condition of discontinuities and ground water flow condition collected in the field. Internal friction angle of the rock was estimated from the RMR evaluation. Four sets of discontinuities were revealed from stereonet pole plots formed by one set of bedding plane and joint-sets. Eleven possible arrangements of discontinuities were tentatively possible, of which nine combinations were kinematically feasible. Based on the criteria of the possible combinations, spatial probabilities for kinematic failure were calculated. The probabilities were then calibrated with 75% of the existing debris-slides location data and respective weightages were developed to evaluate possible combinations of

discontinuities based on their density of occurrence. A final kinematical debris-slides susceptibility map was produced using weighted overlay analysis in ArcGIS. The map was validated using the remaining 25% of the existing debris-slides locations using a Receiver Operating Characteristic (ROC). The area under the curve value was 0.67, indicating a valid result when compared to the occurrence of debris-slides. This study concluded that interrelation of topographic slope and bedrock discontinuities significantly contributed to the initiation of debris-slides in the study area.

Case Study: Comparative Analysis of No-Purge and Low-Flow Groundwater Sampling Methods

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Low-flow sampling methods are commonly used in routine sampling events, but can be impractical and inefficient when working on remote sites or with wells that are difficult to access, slow to recharge, or very deep. No-purge sampling methods present a cost-effective alternative because they have the potential to reduce sampling time and cost, require fewer personnel in the field, minimize the production of investigation-derived waste, and increase safety and other technical advantages. No purge methods have gained substantial credibility within the past several years, although regulatory agencies may still require site-specific demonstration of a no-purge method before allowing its routine use for groundwater monitoring at a given site. Anchor QEA of North Carolina, PLLC (Anchor QEA) has successfully implemented no-purge sampling pilot tests via HydraSleeve at two confidential sites, Site A and Site B. Both sites are contaminated with chlorinated solvents and have been historically sampled using low-flow methods. Comparative analysis of laboratory results and field parameters showed no significant difference in groundwater samples collected via HydraSleeve versus samples collected using traditional low-flow sampling methods. Use of no-purge methods at the two sites also resulted in substantial cost reduction for the clients. In addition to pilot test results, Anchor QEA will present advantages and disadvantages of available no purge sampling devices, field procedures, statistical methods used for data evaluation, cost comparison between sampling methods, and approaches to address regulatory compliance requirements.

An Engineering Geologist's Contribution to Concrete Gravity Structure Stability Analyses at Oroville Dam

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Since the Oroville Dam Spillway Incident in February 2017 in California, there has been an increase in public awareness of dam safety and increased scrutiny of dam industry standards for the evaluation of safety of dams. Specifically, safety issues inherent to the original design and construction of dams and spillways have been the subject of additional focus. The dam safety industry expects to see increased focus on review of as-built structure to confirm they meet the designer's intent and continue to do so over the life of the structure. Regulators need stability analyses based on clearly defined assumptions that have a demonstrable basis, input parameters and results. Engineers rely on engineering geologists to provide a clear understanding of the foundation of these structures, and the impact of

foundation conditions on their analyses and overall performance. Concrete gravity structure stability analyses rely on the engineering geologist's contribution. Stability analyses are sensitive to strength parameters of the underlying rock. Geologists need to provide appropriate shear strength estimates for sliding stability analysis of concrete gravity dams founded on rock. The appropriate shear strength could be the shear strength of: the intact rock, a highly fractured rock mass, discontinuities in the rock, the material infilling discontinuities within the rock, or the concrete-rock interface. A good understanding of the rock structure and properties of the foundation is critical in identifying the appropriate shear strength for stability analyses. This presentation will examine the selection of strength properties in additional detail in the context of ongoing dam inspection and analysis activities.

Landslide Susceptibility Mapping for Large Landslides in Saskatchewan

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Large landslides are widespread in the Western Canada Sedimentary Basin, which extends across the southern two thirds of the province of Saskatchewan. A novel approach was taken with the application of a standard bivariate statistical method (weights of evidence) for development of a landslide susceptibility map for large, deep-seated landslides at a nominal scale of about 1:50,000. Large landslides were inventoried within a 500 m buffer of every community in the province, and this inventory of communities plus buffers served as the basis for analysis. This approach is novel in that the landslide inventory and study area cover a very small proportion of the whole study area but comprise a relatively unbiased and statistically significant representation of the whole, as confirmed through validation by landslide identification in randomly selected locations outside the communities study area. A map like this needs to have its continuous range subdivided into meaningful bins to result in a useful product that presents information in a way suitable to support decisions. The end users of the map were closely involved in establishing thresholds for use in subdividing the map into four bins of Very Low, Low, Moderate, and High Susceptibility—each with different intended use in planning for future linear infrastructure.

Application of ESS and 3D Modeling to Evaluate Contaminant Migration Risk from a Proposed Earthen Containment Design

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A proposed dredged material containment design incorporated excavation into a confining formation to enable use of native clay in construction of perimeter dikes and as a natural liner. Geotechnical borings advanced by others at the site indicated the presence of "pockets of sand" within otherwise continuous clay. The project team recognized that this engineering-centric conceptual site model may have misinterpreted the scale and continuity of the sand units, which could have implications for construction and long-term operation. Our firm was contracted to provide additional hydrogeologic and stratigraphic evaluation for the project site. Our objectives were to evaluate: 1) the thickness of the confining unit to aid in assessment of the potential for bottom heave during excavation and potential impact to the aquifer below, and 2) the capacity of the sand units to transmit groundwater and serve as a preferential pathway for groundwater flow. Ten additional borings with continuous sampling were advanced to depths of 50–120 feet below grade to characterize the subsurface lithology in detail; three of the borings were converted into wells for aquifer testing. The ESS approach incorporated a literature review of the

regional geological history, interpretation of the comprehensive lithologic dataset, and comparison of the depositional environment to modern analogues. A three-dimensional lithologic model and cross-sectional diagrams were developed to more accurately portray the scale and continuity of the sand units of interest. Correlation of lithologic features including fining upward successions, distinctive sedimentary structures, scattered lignite, and benthic foraminifera fossils indicated muddy tidal flat and paleochannel depositional facies. Aquifer testing results validated the paleochannel geometry and indicated hydraulic conductivity of the paleochannel features within typical values for silt and fine sand. The findings were evaluated by the project team to determine whether the proposed design was satisfactory or if it should be modified based on the refined conceptual site model.

Rockfall Characterization, Analysis, and Mitigation Design for a Senior Living Community in Douglas County, Colorado

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Castle Rock, Colorado is one of the fastest growing cities in the United States and home to a nearly 500,000-square-foot open-air outlet mall. It is also home to areas of high rockfall hazard due to steep-sided mesas and a desire to develop these areas due to the rapid population growth. A new, state-of-the-art, retirement facility was proposed in one such area in 2017, to replace an outdated facility with no mitigation in place. K&A was contracted to perform rockfall hazard assessment and mitigation design for the redevelopment to comply with county regulations and to be reviewed by the Colorado Geological Survey (CGS). The assessment consisted of field mapping of outcrops and potential runout areas, historical aerial photograph interpretation, lidar-derived topographic analysis, and rockfall dynamics simulation (CRSP3D) modeling of potential rockfalls. Based on the modeled energies and bounce heights of potential rockfalls, a Geobruigg GBE100A-R flexible rockfall barrier was recommended to be placed just outside of the client's property line not to interfere with the already planned grading for the development. The CGS concurred with our analysis and approved the barrier strength and location. After the initial approval of the rockfall mitigation, numerous challenges to the implementation of the design were presented. These challenges included community opposition to the development, the need for additional modeling and clarification details, difficulty in obtaining easements from adjacent property owners, the Client's request to completely reposition the barrier (requiring new modeling, complete redesign, and re-approval by CGS and the County), and finally, the redesign of the project grading by the Civil Engineer to accommodate rockfall mitigation within the Client's property. This project provided great insight into working together with clients, state and local governments, communities, as well as the other project consultants. The project is going to construction shortly.

New Abstract: Can we fit this in somewhere?

SEM Tunneling for the Utility Market

Eisold, Eric D., Bradshaw Construction Corporation; Michael J. Wanhatalo, Matt Webb (TS #8B)

Between 1999 and 2019, Bradshaw Construction built six SEM tunnel projects from Georgia to Vermont through rock, mixed face and soft ground subsurface conditions. The jobs included sanitary sewer, CSO, storm drainage & pedestrian tunnels. Each undertaking incorporated unique conditions that led to the selection of SEM tunneling techniques as the best method. This presentation will focus on the elements and selection criteria for SEM tunneling on smaller projects.

Updating the Probabilistic Seismic Hazard Model for Sultanate of Oman

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The Earthquake Monitoring Center (EMC) at Sultan Qaboos University (SQU) evaluated the seismic hazard in the Sultanate of Oman in 2012. EMC produced the first probabilistic and deterministic seismic hazard maps for Oman in 2012 and 2013, respectively. In the current study, the probabilistic seismic hazard assessment (PSHA) is revisited to provide an updated assessment of the seismic actions on the Sultanate. The present study has several advantages over its predecessor: recently developed seismic source model; using an updated homogeneous earthquake catalogue; inclusion of epistemic uncertainties for the source models, recurrence parameters, maximum magnitude, and more recent and applicable ground-motion prediction equations (GMPEs). Epistemic uncertainties were treated using a combination of the best available databases within a properly weighted logic tree framework. Seismic hazard maps in terms of horizontal peak ground acceleration (PGA) and 5% damped spectral accelerations (SA) at the bedrock conditions ($V_S = 760$ m/sec) for 475, and 2475 years return periods were generated using the classical Cornell-McGuire approach. Additionally, Uniform Hazard Spectra (UHS) for the important population centers are provided. The results show slightly higher values at the northern parts of the country compared to the hazard values obtained in the previous study.

Economic Potential of Industrial Minerals from Oilfield Brines in Texas

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Recent geopolitical events have encouraged research and broadening our knowledge of domestic critical minerals and prospective resources key to industrial growth and resource independence. There has been significant research in the past decade on lithium resources and exploration of undiscovered deposits, primarily focused on pegmatites, continental brines and hydrothermally altered clays. Similar to continental brines, but distinctly different in terms of exploration and prospectivity, oilfield brines in Texas are being continuously produced as wastewater in oil and gas production, and can have 20%+ total dissolved solids as a mineralized solution. Lithium concentrations in some of these formations exceed 500 mg/L, and can be as high as 800 mg/L. Recent Advances in membrane technology and wastewater treatment processes allow us to create membranes specific to ion size and valence characteristics. Some of these membranes have been developed to concentrate Li^+ , for example, allowing for up to 8 times the initial concentration. Existing infrastructure, application of novel membrane technological advances, and significant critical element concentrations make oilfield brines an economical and untapped industrial mineral resource for the future of U.S. domestic mineral production.

Foundation Preparation and Verification for the Kentucky Lock Downstream Cofferdam

Elson, Mark, U.S. Army Corps of Engineers, mark.s.elson@usace.army.mil; Barney Schulte, Bernard.D.Schulte@usace.army.mil (TS #15A)

Construction of the Kentucky Lock Addition project's ongoing \$67 million downstream cofferdam presents safety, geologic, and construction method challenges. Approximately 500 linear feet of the cofferdam utilizes new lift-in, in-the-wet techniques to construct a concrete segmental wall—a cofferdam wall that will eventually be incorporated into the permanent wall of the new 1,200-ft × 110-ft navigation lock. The project site is at Kentucky Dam, the lowermost dam on the Tennessee River in western Kentucky. The contract design consists of a conventional sheetpile cofferdam at the downstream end with segmental, concrete boxes along the lock approach channel side. The foundation elevation of the segmental cofferdam section was to be approximately seven to eight feet below the top of rock in the approach channel. Construction of this would require underwater blasting to remove the rock forcing frequent lock closures. After award of the contract, the contractor submitted a Value Engineering Change Proposal to eliminate blasting by setting the cofferdam boxes on the top of rock, after mechanically excavating the weathered rock. The weathered rock was excavated by means of a drum cutter mounted on the arm of a track hoe, with the cuttings removed by an airlift. The foundation was inspected by divers to ensure that the weathered rock was removed. Precast concrete shells were placed with a custom-built, floating gantry crane. Once a shell was set-down, the sides were sealed, and concrete was placed inside the shell. The quality of the concrete in-fill and the concrete-to-rock bond was verified by core drilling inside the shell and by having samples shear tested at the laboratory.

Geotechnical Hole Logging. How We Do It, and Why It Matters

Elson, Mark, U.S. Army Corps of Engineers, mark.s.elson@usace.army.mil (TS #19)

A drill log is one of the most important pieces of information used for site characterization. It is also a potentially expensive method of data acquisition. A drill log is the official record of a boring and should contain all of the information observed and measured during drilling. As such, it is important to gather as much information from the hole, as reasonably possible. Unfortunately, the information recorded on drill logs is too often sloppy and sparse. Accurate records of soil, rock, and sample collection is critical to site characterization and can mean the difference between a successful and unsuccessful project. Therefore, it is vital that the field geologist takes care to collect accurate data and understands why this data is important. This presentation discusses core logging, boxing, and photographic records, as well as the importance of ensuring its accuracy, and is targeted towards younger, field geologists.

Natural Occurrence of Actinolite in Lynchburg, Virginia – Those Who Do Not Learn History Are Doomed to Repeat It

Ennis, Jonathan, RTI International, jte@rti.org (TS #7)

Michael E. Beard and Todd Ennis went on a field trip to Lynchburg, Virginia, on July 10, 2007, after being notified that actinolite asbestos had been encountered at a construction site of a Badcock Furniture Store in Lynchburg, VA. When they arrived, they found that they were about two weeks late for the actual discovery but were able to talk to site managers and workers that had been involved in the initial findings and follow-up ambient air monitoring. We were informed that removal

of thousands of tons of asbestos-laden red clay fill dirt had been dug out and trucked to another location across the county without anyone's knowledge during the preparation of the site for the new building's foundation slab. This presentation will provide a snapshot of what RTI learned and gained from the experience as they sampled directly from the site where water cannons were keeping the yet-to-be-removed contaminated soil soaked to prevent further contamination of an active construction site. Mike and Todd brought home a bounty of over 100 pounds of green fibrous mineral in massive form to our facility in Research Triangle Park, NC to our asbestos repository for material characterization and potentially for our use in proficiency testing. The most interesting thing they learned that day was that this occurrence of actinolite was not the first time this discovery had been made; the Walmart next door had concrete encapsulation of this same rock body. Unfortunately for all the workers on that Badcock Furniture jobsite, those in charge had not benefited from information that the Virginia State Geologist could have provided and thus doomed themselves to a significant inhalation exposure.

Legacy Landfills and Rising Sea Level in Southern Patagonia and Tierra Del Fuego

Ercolano, Bettina, Universidad Nacional de la Patagonia Austral (UNPA), bercolano@yahoo.com.ar; Jorge Rabassa, jrabassa@gmail.com; Christopher Stohr, cstohr@geo-imaging.com (Presented By Patricia Bryan) (TS #12)

Open dumping remains to be the most common method for disposal of solid wastes in parts of the world including Tierra Del Fuego and Southern Patagonia, Argentina. Wastes discarded in littoral zones of in Santa Cruz province in the Rio Gallegos estuary suffer an additional problem of being subject to erosion from tides. Patagonia exhibits hyper tidal conditions i.e., greater than 6m (20 ft). Rio Gallegos has tides of 9.6 m (31.5 ft) during spring and 5.8 m (19 ft) during neap, with an extremely value of 14 m (46 ft) among the highest in the world [5th]. The low, intertidal areas were historically used to dump wastes. Gradually rising sea level and tidal processes in the estuary have caused erosion and sorting of the discarded wastes at the "old" dump to create a new, coastal landform at least since the 1970s. Sorting of wastes in the littoral zone has created a 3-m-wide, 100-m-long coastal spit composed mostly of broken glass. The nominally 5- to 10-cm (1- to 2-in) glass pieces are imbricated i.e., overlapping to form a terraced surface. Three or five micro-terraces are formed in the linear spit, which is observable during low tide. Plastic bags are ubiquitous in the exposed wastes. Creation of a landform composed entirely of wastes by natural processes is a notable if not sobering commentary on several issues of global concern: the adverse effects of legacy dumps and landfills on surface and ground water, contribution of wastes from eroded coastal dumps to oceanic pollution, exacerbation of coastal erosion by rising sea levels, and the growing problem of waste generation and disposal worldwide. The speaker will describe geologic features of Tierra del Fuego and Southern Patagonia region. Dr. Jorge Rabassa invites AEG to visit landforms and geomorphological features of Patagonia.

The Soos Creek Hatchery Emergency Landslide Repair

Evans, Stephen, PanGEO, Inc., sevans@pangeoinc.com (TS #13)

In 2012, due to recurring flooding and other issues, Washington State decided to replace the existing Soos Creek hatchery with a new facility. On the opposite side of the stream was a former construction yard with adequate room for hatchery facilities and at a higher elevation. PanGEO, Inc. was part of the winning team for the design and construction of the new facility. One of the challenges was that

construction would impinge on the steep valley slopes mantled with mass wasting deposits, and on the BNSF railway mainline above the planned hatchery site. PanGEO's field investigations confirmed the presence of disturbed material on the hillslope. Construction began in 2017 and included sheet pile walls to stabilize the slope in some areas but not in the area of the heavy settling pond. On January 18 of 2018, movement began above the pond excavation opening up a 3-ft headscarp located about 10 to 15 feet below the BNSF tracks. This was deemed to be an uncomfortable situation, and planning began immediately on remediation. The plan selected was to place a rock buttress along the lower slope. Construction began on the buttress on February 6, 2018, with the excavation of loose slide material above the pond wall. The resulting trench was backfilled with quarry spall material using the wall for additional stabilization. Next, surficial material was removed from the slope base, and the rock buttress material was placed against the clean slope. For the final portion of the buttress, the slide plane was clearly visible and the plan was modified to a bench cut below the slide mass on which the buttress was constructed. Remediation was completed on February 9, 2018. Ongoing surveys of the slope suggest that some minor movement continues as the soils readjust to the disturbance.

Terrain Strength Characterization Using Remote Sensing

Ewing, Jordan, Michigan Technological University, jjewing@mtu.edu; Thomas Oommen; Jayakumar Paramsothy; Russel Alger (TS #17)

Determining the terrain strength characteristics is critical for achieving accurate mobility performance prediction as well as reliable operational planning using the NATO Reference Mobility Model (NRMM). Some of the essential terrain data inputs for NRMM include the USCS soil type classification and soil strength data within the 0–6" and 6–12" from the surface. The current methods to derive the inputs for the NRMM rely heavily on in-situ soil strength measurements, which is difficult to obtain from unknown territories and combat zones. Therefore, having the ability to remotely sense the terrain strength properties of the areas that lack in-situ soil measurement and to utilize this remotely sensed data for NRMM model is imperative for the mobility of forces in unknown territory. In recent years, there has been a proliferation of research on the application of remote sensing for earth observation. However, studies on the use of remote sensing to derive engineering properties of earth material are limited, mainly because, mostly the signature derived from remote sensing is from the earth surface and lack easily derivable information on the material properties controlled by factors that extend beyond the surface. In this study, we demonstrate the application of thermal and hyperspectral remote sensing to characterize the terrain strength. Experiments were carried out in a controlled environment in the lab. The variable of interest from thermal remote sensing is the apparent thermal inertia. Apparent thermal inertia is sensitive to the volume composition, surface density, and porosity of the near surface, up to a depth influenced by diurnal heating. The results demonstrate that the apparent thermal inertia is correlated with the stiffness of the soil measured using a geogauge. The hyperspectral imaging shows promise in identifying the soil types. Preliminary results indicate that thermal and hyperspectral imaging information together can be valuable for terrain strength characterization using remote sensing. DISTRIBUTION STATEMENT: Approved for public release; distribution unlimited. OPSEC #2101

Developing Landslide Modeling Capabilities within LandLab to Evaluate Landscape Response and Recovery to Mega-Landslides

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Mega-landslides reside on the surface and in the subsurface throughout the Basin and Range province of the western U.S. These basins are bounded on one or both sides by Miocene to recent normal and/or strike-slip faults. Basins within the province are filled with several km of poorly consolidated to unconsolidated clastic material making seismic imaging in this region very difficult and expensive. Therefore, the purpose of this study is to identify persistent clues in range front morphology to help locate buried mega-landslide deposits. We used the LandLab software to develop numerical landscape models of a developing horst range affected by mega-landslides. Idealized modeling exercises were run to evaluate the scope of potential range front morphologies resulting from mega-landslide processes. The baseline modeling exercise used a deep-seated dip-slope landslide process to simulate the evolution of a range during regional extension. From these baseline results, landslides were imposed according to a size-frequency distribution and conditioned for the range of local lithologies and structures within the Basin and Range. Model stratigraphy was tracked to evaluate how different distributions of landslide sizes impact the alluvial architecture with a range of fault slip rates and climatic parameters. This idealized landscape modeling has provided information on (i) the general evolution of range front stratigraphy as it relates to landsliding and landslide deposits; (ii) estimating the time scale for relaxation of landslide source areas following an event, and what lingering impacts on the fluvial network may remain to be extracted from the topography; and (iii) disruptions to the pattern of alluviation on the fans and other basin fill by emplacement of a mega-landslide. These results will be compared to exposed mega-landslides throughout the province. Key geomorphic features from these models will be used to guide analysis of range fronts for potential buried mega-landslide reservoirs in the Basin and Range.

Use of Rendered Animal Co-Products as Electron Donors in Environmental Remediation

Finneran, Kevin T., Clemson University, ktf@clemson.edu (TS #16)

Chlorinated solvents account for approximately three quarters of all bioremediation sites. The vast majority of these remediation applications are predicated on a simple strategy: amend a high molecular mass electron donor into the subsurface so the necessary microorganisms are stimulated, and the activity is promoted over the long term. To date, all long-term electron donors have been derivatives of soybean oil, which is problematic because of: a) limitations in the microbial populations that actually utilize strictly lipid electron donors, and b) competition with foodstuffs in U.S. production. We have developed electron donors from rendered animal co-products, which are combinations of lipid, protein, and minimal carbohydrate. Thus far, 21 co-products have been tested, and all stimulate complete dechlorination to a rate and extent, which is better than any current soybean oil-based electron donor. In addition, these materials are fractions of the cost of soybean-based commodity products, on the order of pennies per ton. Batch incubations were used to screen 21 animal co-products. Batches were constructed using TCE-contaminated aquifer material, and each electron donor (rendered co-product) was added as the sole electron donor. Each animal co-product was compared to five controls containing common electron donors (lactate, acetate + hydrogen, and one soybean oil-based electron donor) and a sterile and unamended controls. TCE and its degradation products were quantified over time. The data demonstrate that of the five

controls, lactate was able to completely dechlorinate TCE in approximately 45 days and EVO in 81 days. Lactate was the fastest of the five controls and as a result each animal co-product was compared to it. Of the 30 animal co-products, 20 completely dechlorinated the TCE to ethene at rates faster than lactate or EVO, and four generated ethene at the exact same rate as lactate. In general, the more proteinaceous animal co-products were able to promote dechlorination at a faster rate than the animal coproducts with a higher fat content. All materials reduced TCE to ethene (at a 1:1 stoichiometry) faster than the commercially available soybean-based electron donor (e.g. emulsified vegetable oil). This strategy introduces a new electron donor for TCE bioremediation, which thus far is faster and more cost-effective than any electron donor reported to date. In addition, it provides a novel application for rendered co-products, including the lesser-valued materials. Given the exceptionally low cost of these raw materials (\$100 to \$500 per ton), it is likely that this could disrupt the current marketplace for long-term electron donors, and introduce a much more effective and lower cost technology to the in situ remediation sector.

Asbestos Content in Operational and Historic Aggregate Quarries in Virginia, Maryland, and Pennsylvania

Fitzgerald, Sean, Scientific Analytical Institute, sfitz927@hotmail.com (TS #7)

Quarries for aggregate rock (e.g., gravel for roads, fill, riprap, etc.) throughout the mid-Atlantic region have repeatedly been found to contain asbestos, including serpentine and amphibole varieties. In fact, some of the largest and most extensively quarried locations are in serpentinite bodies, some of which have been operational since the colonial period and are still open to this very day. In the 1980s and 90s, the EPA took an interest in the potential asbestos exposure from such quarries, and found that many produced high levels of airborne fiber concentrations. The geology, mineralogy, and environmental testing including results from the EPA studies will be discussed in this presentation.

Case Examples of NOA in North Carolina: Anthophyllite in the Blue Ridge Belt and Tremolite in the Murphy Belt

Fitzgerald, Sean, Scientific Analytical Institute, sfitz927@hotmail.com (TS #11)

For many years, the olivine mine near the little town of Frank in Avery County, North Carolina, has been a stop for introductory mineralogy classes from Appalachian State University, 30 miles south of ASU off the Blue Ridge Parkway. The professors would caution students that there “might be asbestos,” but that encouraged rather than discouraged sample collection by students in the ‘80s and ‘90s—a select few who would later become analysts in our asbestos laboratory. One such student donated an extraordinary specimen of asbestiform anthophyllite to the Natural Science Museum in Greensboro, while another former ASU student provided it to our laboratory for full characterization by PLM, TEM, SEM, and XRD analysis. The samples are being considered for development of a new anthophyllite asbestos standard through ISO. The site and the asbestos characterization will be described. An informal excursion to the Frank mine will hopefully occur the day after this presentation.

Sacramento Region Levee Rehab – 2017 Event

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California received record precipitation during the winter of 2016–17. Many area levees suffered varying types and degrees of damage as a result of extended periods of high river levels and heavy precipitation. In addition to flood fighting during an event, Public Law 84-99 gives the Corps of Engineers the authority to repair damage to federally authorized flood control levees, returning them to their pre-event conditions, often at 100% federal cost. Qualifying damages are often related to waterside erosion, landslide distress (slumping or sinkholes), seepage and piping, and sometimes even levee breaches. While the goal of the program is to have all damages repaired prior to the next flood season, it is recognized that more complex repairs may take longer to implement. After the 2016–17 event, local sponsors submitted requests to the Corps of Engineers for rehabilitation assistance. The portfolio of sites approved for repair was evaluated using risk-informed decision making to establish priority for repair. Several sites will be presented as case-studies, highlighting our original assessment of the damage right after the event, justification for repairs, investigations performed, analyses and design efforts, and in some cases, results of construction activities. Finally, lessons learned will be presented.

Investigation and Risk Assessment of NOA in Sapphire Valley, North Carolina

Frederick, Tim, U.S. EPA, frederick.tim@epa.gov (TS #11)

In 2005, the USGS published a map of reported historic asbestos mines, historic asbestos prospects, and natural asbestos occurrences in the Eastern United States (Van Gosen, 2006). As a follow up to this report, the State of North Carolina and EPA Region 4 reviewed the locations of potential sites of interest that may require further evaluation for potential human health risk. EPA will present on the work performed to investigate a former asbestos/sapphire mine located in a popular mountain resort area. Methods included soil sampling, activity-based sampling, and evaluating unique site-specific exposure scenarios.

Know Before You Go: Geologic Mapping in the Digital Age

Gagnon, Hawkins, Schnabel Engineering, jgagnon@schnabel-eng.com; Fred Snider; Robert Indri; Susan Buchanan; Benjamin Bradley (TS #19)

Historically, geologic mapping has been performed in the field by trained geologists taking measurements of discontinuities on rock outcrops that could be identified. With modern lidar and laser scanning datasets, and analyzation tools, highly detailed true-earth point clouds and surfaces can be created and analyzed from a desktop. This means that before a geologist steps into the field to begin mapping, they can already have an informed working geological conceptual model that includes observations and measurements of important structural features, many of which would not have been seen or have been accessible otherwise. The result is a new workflow in which mapping occurs in the office and is field confirmed. By mapping in programs like Maptek’s I-Site Studio, we can measure large discontinuities over space to provide more accurate measurements of geologic structures, we can measure features that we otherwise couldn’t reach, and we can weight discontinuities based upon their importance to the overall structure, an important distinction when performing stereonet analyses. Overall, we can get better data and interpretations often times at lower costs. A few examples of recent projects that we’ve performed digital mapping to inform our field mapping are: Conklingville Dam, Corinth, New York, et al.

Effects of Climate Change and Extreme Weather on Geohazards in Colorado

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The Colorado Department of Transportation and the Federal Highway Administration are interested in what effects a changing climate would have on highway infrastructure through changes to historical trends in geohazard occurrence and how transportation agencies will need to adapt to these changes. These organizations recognize that climate change could affect the frequency and severity of both snow and rain precipitation events and the number of freeze thaw cycles, at a minimum. There has been considerable modeling of change associated with different greenhouse gas concentration scenarios through the end of the 21st Century, but this isn't generally focused on areas as small as a state, or eco-regions within a state like Colorado. This paper summarizes some of the work done in this regard and explores where multiple models are in agreement, and where there is considerable discrepancy. Given the range of uncertainty with these predictions, how changes to precipitation and temperature would influence the frequency and severity of geohazards is considered for geohazards in Colorado. Colorado formally identifies hazards such as rockfall, landslides, sinkholes, debris flows and avalanches in addition to deteriorating embankments, cut slopes, and subgrades as geohazard sites and makes long range funding decisions based on historical event data. This work will allow CDOT to consider which highways, regions and geohazards will increase risk on their system in the future and how to appropriately plan for the future impacts of climate-related geohazards through processes such as planning studies, asset management and resiliency programs.

A Remote Sensing Approach to Map Water Tracks Identified Using Soil Hydraulic and Geophysical Properties

Gates, Jonathan, University of Alaska Fairbanks, jdgates@alaska.edu; Kate Clancy, kmclancy2@alaska.edu; Debasmita Misra, dmsira@alaska.edu (Poster)

During the 2017 Annual Meeting of the Association of Environmental and Engineering Geologists in Colorado Springs, we presented mapping of water tracks at Goldstream Road, Fairbanks using temperature, hydraulic and geophysical data collected from a study site. As introduced then, subsurface slope interflow channelizes into features known as "water tracks" when constrained by bottom boundaries such as permafrost, clay, and bedrock. Water tracks indicate an immature hydrological network and are widely found in the Arctic and Boreal regions, due to the thawing of permafrost. Despite their abundance, there is a lack of understanding of the interplay between water tracks and its environment as well as its impact on the landscape that it channels through. A common impact is increased subsidence with progress of the water track. Mendbayar et al. (2016) observed water tracks intersecting roads near Fairbanks, which may intensify road damages. Goldstream Road near Fairbanks is known to have permafrost issues, some of which are likely amplified by water tracks. No method, except ones developed by us, currently exists to map narrow water tracks in densely vegetated areas. The question we asked ourselves is whether it was possible to detect known water tracks remotely using multi- or hyperspectral images? Hence, the objective of this project was to develop a method to identify and map water tracks using remotely sensed data so that future damage to intercepting infrastructures could be prevented. We procured GEOEYE-1 multispectral data of 2m spatial resolution that included our study site and was procured on

May 18, 2015. We pan sharpened the image to a 0.5m resolution and used several indices to assess the viability of identifying water tracks. We will present our results on some success we had using this approach and methods that proved to be unsuccessful in identifying those water tracks.

Emergency Response and Mitigation for a Rockslide on Snowshed #4, BNSF Stampede Subdivision, Washington

Gates, William, McMillen Jacobs Associates, gates@mcmjac.com; Dale Moore, DMoore@mcmjac.com (TS #1)

One of BNSF's primary freight lines crosses the Cascade Range in Washington State at Stampede Pass. On November 27, 2015, a large rockslide occurred above the east portal of Tunnel #4, at MP49.4 within the Stampede Subdivision. Approximately 50 cubic yards of rock debris hit and penetrated the snowshed roof, breaking some of the timber set members, and fouled the track. Rock debris was spotted by the BNSF track inspector and traffic was stopped, averting a derailment. BNSF requested that McMillen Jacobs Associates mobilize to the site to evaluate the damaged snowshed and rockslope conditions. We inspected the structural integrity of the snowshed and worked closely with BNSF maintenance-of-way personnel to safely remove a large boulder lodged in the roof over the tracks. We oversaw rock scaling above the snowshed to establish safe working conditions for BNSF staff and rail traffic. After completion of the initial rock scaling, BNSF constructed a temporary roof cover over the open holes. Rail traffic was restored within 72 hours of the incident. When conditions improved in 2016, the author directed additional rock scaling during live track windows. Once scaling was completed, we characterized the existing rockslope conditions using rope access techniques to evaluate geologic kinematic stability and rockfall characteristics. Based on the results, we produced conceptual designs for mitigation measures, including rock anchors and wire mesh, and then provided construction management during final repair of the snowshed. In the summer of 2017, we oversaw additional rock scaling and installed over 30 rock anchors at key blocks. During scaling, a controlled rockfall event missed the protective standoff and punched a large new hole through the roof of the snowshed, but did not foul the track with debris. BNSF is presently reviewing repair options for the snowshed.

Our Hills Are Moving, and They Are Not Doing it Peacefully: How to Communicate Complex Geologic Issues to Real People

Gath, Eldon, Earth Consultants International, gath@earthconsultants.com (TS #10)

Geologic advocacy can take many categories: legislative, regulatory, licensure, and educational, but it can also include just simply increasing geologic awareness to the people around us. There comes a time, and it comes more often than we take advantage of, that you get the opportunity to convey important geologic issues to non-geologists: bars, parties, Rotary, or even Orange County Historical Society's monthly meeting. Listening to their list of Centenary Year speakers it was concerning that to those in the room, OC's history started with the AD-1769 Gaspar de Portolá trek from San Diego to Monterey. To his credit/luck, their July 29th coincided with the strongest earthquake since experienced in the OC, but warranted merely a footnote in his diary. Hence my OCHS talk, *The Full History of Orange County: 1 Million Years Before Portolá and on to Tomorrow*. My approach is to tell a story (the history), populating it with characters (geography) and villains (faults), and using the clues geology provides us (stratigraphy, geomorphology) to guide the tale, leaving behind an enthralled audience better prepared to face the reality that the villains still live amongst us, as the story must go on and on, like Game of Thrones.

About one million years ago, Orange County was the Pacific Ocean, and our beach was east, into today's Inland Empire. Things have changed for the better if you own property in Orange County, but this change is not without hazard to those properties. Although Orange County has not experienced its own large earthquake since 1769, the earthquake hazard is very real, and it has been the repeated occurrence of such large earthquakes that crafted the landscape of the Orange County we see today. This is the story of that landscape we live upon and what we can expect in our future.

Implementation of In-Situ Remedial Injection – Communicating with Contractors to Improve Results

Giannetti, Anthony, Cascade Environmental, agiannetti@cascade-env.com (TS #16)

Drilling and injection subcontractors are experienced professionals with valuable knowledge that can be tapped to improve outcomes of remedial actions for consultants and their clients. Communication is key, especially for complex sites and heterogeneous formations. During the bidding phase, providing a conceptual site model and detailed project background will assist the contractor in selecting the approach, equipment, and personnel, ensuring more accurate cost estimates and laying the foundation for success. Basic site conditions such as access limitations, water source, security, and utility concerns are also essential considerations. Pilot tests can be very beneficial for both consultants and contractors: consultants can confirm or modify design parameters and provide proof-of-concept to clients, and contractors gain familiarity with a site and use lessons-learned to improve productivity and results on the full-scale implementation. Pre-mobilization coordination aligns all parties in support of project goals, improves relationships with a facility/owner/client, and provides motivation for the contractor to meet expectations. Incomplete site details result in delays, inefficiencies, and poor results. Case studies of failures and successes in field preparation and execution will be used to emphasize the importance of communication.

3D Geological Modeling as a Tool for Evaluating Foundations: A Case Study for Lower Baker Dam, Washington State, USA

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3D geological modeling allows for detailed extrapolation of geological features into areas of the subsurface where limited information is otherwise available, resulting in an increased understanding of bedrock conditions which can be used to inform geotechnical assessments. A case study is provided for the Lower Baker Dam, Skagit County, Washington, USA where Leapfrog Geo was utilized to construct a geological model of the dam foundation in order to identify potential abutment instability and karst-related leakage pathways. The 3D model effectively outlines a series of discrete fracture planes along which leakage is occurring, as well as kinematic interactions that have the potential to create instability within the abutments. The increased knowledge of the precise location, extent and geometry of these discontinuities provides for a more efficient and cost-effective evaluation process among the various disciplines working to mitigate these issues and stabilize the dam.

Observations of Instrumented Packer Performance during Grouting

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The standard of practice for dam foundation grouting in the United States has experienced rapid evolution in the last two decades through the widespread use of stable grout mixes, real time computer monitoring during injection, and the use of data management systems incorporating data from injections, geotechnical instrumentation responses, and other environmental conditions. The latest tool, which is beginning to be widely used to advance the practice, is the instrumented packer. Leading contractors have developed instrumented packers, which are able to reliably and directly measure actual pressures at the point of injection during water pressure testing and grouting. This presentation will draw on experience from contemporary grouting projects and the Boone Dam Seepage Remediation to describe those observations which have become possible from the ability to measure injection pressures directly at the point of injection, as well as improvements in geologists' and engineers' understanding of grouting conditions which arise from use of these devices.

GenX Litigation in North Carolina

Gisler, Geoffrey R., Southern Environmental Law Center, ggisler@selcnc.org (TS #3B) (Presented By Kelly Moser)

The discovery of GenX in the Cape Fear River and treated drinking water in southeastern North Carolina has resulted in litigation filed by the Department of Environmental Quality, public utilities, local governments, property owners, and public interest organizations. This presentation will provide an up-to-date summary of litigation related to GenX.

Using Lichenometry to Evaluate Rockfall Rates and Talus Fan Development, Glenwood Canyon, Colorado

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Lichenometry, a Quaternary dating technique that uses lichen sizes to estimate surface exposure age, is used to evaluate rockfall rates in Glenwood Canyon. Glenwood Canyon hosts a stretch of Interstate-70 that has a history of severe rockfall problems. Previous rockfall incidents in Glenwood Canyon have resulted in injuries, fatalities, and lengthy road closures for repairs. Lichenometry has the potential to aid in quantifying rockfall frequency over the past couple of centuries, allowing mitigation to be targeted to the most active slopes. This research seeks to estimate rockfall rates for individual talus fans, to evaluate talus accretionary behavior, and to compare talus development across multiple fans in the same region. Calibration curves were locally prepared for two lichen species, *Lecidea atrobrunnea* and *Lecanora novomexicana*. In total, 654 *L. atrobrunnea* and 595 *L. novomexicana* lichens were measured on boulders larger than 0.5m on the long axis from six talus fans: three in Glenwood Canyon and three in a connected canyon along Grizzly Creek. Only largest lichens were measured, and GPS coordinates, boulder size, and lithology were also recorded for each boulder. Cumulative density functions of lichen ages were used to estimate rockfall rates for each fan. Lichen ages were also plotted spatially to observe accretionary trends. Estimated rockfall rates are approximately 30 to 80 blocks/year and match, within error ranges, between the two species. At these talus fans, rockfall appears to be dominated by scattered, small-volume rockfalls occurring at a relatively constant rate through time, rather than larger rock slides that cover portions of the fan. Lichenometry presents some challenges for use in rockfall studies due to potential

delays in lichen colonization, climatic variables, and limited numbers of lichens available for growth rate calibration. Potential solutions to these problems are suggested.

Unexpected Ground Movements at Ryerson Station Dam

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In the summer of 2005, leakage began to increase at Ryerson Dam in southwestern Pennsylvania. In July, leakage from the east side of the dam reached 80 gallons per minute. Dam Safety officials drained the reservoir. Breaching the dam was, subsequently, ordered. The Pennsylvania Department of Environmental Protection (DEP) had issued a permit for longwall mining under high hills north of the dam. The closest mining was approximately 900 feet from the east end of the dam. This interval was significantly greater than previously observed, damaging movements from coal mining. The conventional understanding of coal mine subsidence on which most current subsidence prediction techniques are based includes the concept of angle of draw which effectively limits the lateral extent of subsidence. Experience from Australia over the last two or three decades has identified what is referred to as non-conventional surface subsidence behavior. This is found to occur in areas of irregular surface topography or variable terrain and is characterized by movements, which can occur beyond the conventional angle of draw limits. These ground movements, although small, may occur over 1.2 miles from the longwall mine panel and well outside the angle of draw. Significant structural movement of the Ryerson Station Dam, evident just following observation of the July 2005 leakage, included two inches of westward movement of the east side of the dam and uplift of the east side by several inches. Detailed studies were conducted to determine the cause of the leakage. All of the possible causes of leakage were found to not be credible except for longwall mining. Observations confirmed that both Valley Closure and Far Field movements were occurring well outside the confines of the conventional subsidence angle of draw and, therefore, offered a plausible explanation for the damage to the dam in 2005.

Communicating Science with the Media – A Workshop

Green, Deborah J., deb@geologistwriter.com; Jennifer B. Bauer, jennifer@appalachianlandslide.com (TS #6)

Reporters work on short deadlines and with limited time and space for their stories. Communicating science under those constraints is not taught to students and is not intuitive to professionals, but it is a skill geoscientists should learn. In this workshop, local reporters from a variety of media outlets will give us tips on how to explain our work to them—on and off the record, in planned interviews, and during on-scene emergency situations. Come with a story you'd like to tell to a wider audience, and learn how.

Introduction to Speaking Their Language – Communicating Science with Non-Scientists: Who, Why, and How

Green, Deborah, www.geologistwriter.com, deb@geologistwriter.com (TS #6)

There's been a disturbing shift in recent years in how scientific information is received outside of the scientific community. The greatest concern with that troubling shift is the public's point of view, and the negative consequences with respect to public policy. As scientists, we must assume some responsibility for this problem. We haven't mastered clear communication about why and how geologic principles are applied to solve societal problems—like mitigating geologic hazards,

remediating environmental contamination, or properly siting and permitting critical facilities. To convey the importance of the work we do, geoscientists need to “speak their language”. In this symposium, presenters will discuss many issues related to science communication, including with whom we need to communicate, why we need to engage those audiences, and how to do so. As the 2018–19 Richard H. Jahns Lecturer, I've had the opportunity to talk with students and professionals throughout the U.S. about geoscience communication. This opening to the “Speaking Their Language” symposium will outline lessons learned from those conversations and introduce topics to be covered, such as: condensing months of geologic work into a concise presentation for a public hearing; instruction in and examples of speaking with State and Federal legislators; a mini-workshop by reporters about how to provide the information needed for them to report science accurately and effectively; the importance of and how to communicate about climate change science; and advice on why and how geoscientists should run for public office. Advocating effectively for our work will make it possible to do more of the science we so value, and for society to realize that value. Advocating does not happen without communicating, so please join us in learning to speak their language.

Mineralogy and Structural Control of Jamaican Bauxites Ores

Hagni, Richard D., Missouri University of Science and Technology, rhagni@mst.edu; Ann M. Hagni, ahagni@gmail.com (TS #21)
(Presented By Ann Hagni)

Jamaican bauxite deposits have ranked as world-class producers for several decades and they currently are the largest suppliers of bauxite ore to the United States. The bauxite ores formed by deep lateritic weathering and leaching of aluminum from Quaternary air-fall volcanic ash derived from volcanoes in the Lesser Antilles, together with additions of Sub-Saharan dust blown from Africa, and probably sediments from a more local alluvial source, all deposited on Tertiary high-purity limestones. The limestones are highly karstified and karst features provide the major structural controls for the locations of the bauxite ore deposits. Jamaican bauxites contain the world's highest phosphate, reaching 32% P₂O₅, and it is a deleterious constituent that must be eliminated during metallurgical treatment of the ores. We have employed petrography, ore microscopy, SEM-EDS, XRD, and cathodoluminescence (CL) microscopy to examine the mineralogy of the phosphorus-bearing grains. SEM-EDS analyses indicate that the small amounts of phosphorus in low-phosphorus Jamaican bauxite occurs as rare earth (Ce, Nd, and Dy) phosphates. In high-phosphorus bauxites, 200-500 μm crandallite [CaAl₃(PO₄)₂(OH)₅·H₂O] fecal pellets are the dominant phosphorus mineral. The crandallite fecal pellets are interpreted to have been deposited by invertebrate organisms rummaging through the organic-rich materials beneath rookeries of sea birds such as cormorants.

Multi-Faceted Investigation to Locate a High-Capacity Production/Remediation Well in Karst

Hall, Mike, Ramboll, michael.hall@obg.com; Joe Perry, joseph.perry@obg.com; Nicholas Panzera, nicholas.panzera@obg.com (TS #8A)

A multi-faceted investigation was used to locate a high-capacity (400–1,000 gpm) groundwater production well at a chemical-manufacturing facility. The production well was intended to provide water for manufacturing operations, and also facilitate containment of an extensive groundwater contaminant plume in a karst. Numerical modeling with Modflow[®] identified areas that produced effective containment when pumped at the targeted rate. This area included a linear, laterally

extensive area of high hydraulic conductivity that was possibly a fracture or fracture zone. Because modeling was based on limited data, a field investigation was needed to verify the presence and nature of the high conductivity feature. Field outcrop and lineation mapping and review of regional geologic studies were used to define broad structure. Lineations, as well as other structural and karst features were further delineated with a combined seismic/micro-gravity survey. Test wells provided cores and borehole geophysical logs to characterize lithology and karst features, and define vertical geometry. Testing with FLUTE[®]/FACT[®] defined contamination vertically and slug testing was used to estimate hydraulic conductivity. Combined data were used to refine the conceptual site model, select a location, and develop a design for a new groundwater production well to be installed in 2020.

Field Screening of Low Concentration Chlorinated Compounds in Groundwater

Hall, Mike, Ramboll, michael.hall@obg.com; Nicholas Panzera, nicholas.panzera@obg.com (TS #16)

Remedial Investigation of a former Navy Blimp Base in Eastern North Carolina (NC) identified the presence of trichloroethene (TCE), and dichlorobenzene in groundwater at concentrations above NC Action Levels, but below concentrations detectable by most common, real-time screening technologies. Screening values for total chlorinated VOCs ranged as high as 576 ug/L, although most were in the range of 0–100 ug/L. With the objective of performing real-time delineation of the extent of the groundwater plume, the project team developed a field screening approach that made use of a colorimetric, head-space screening technology (AQR Color-Tec[®] Instrument) to provide fast and accurate quantification of total chlorinated volatile organic compounds in groundwater. The approach was effective, enabling the team to rapidly and accurately delineate a diffuse plume that encompassed approximately 25 acres. Split samples analyzed with standard laboratory methods demonstrated that the screening results were remarkably accurate.

Estimation of Long-Term Rock Slide Creep Movement from Tree Trunk Deformation

Hamel, James, Hamel Geotechnical Consultants, jvhamel3918@gmail.com (TS #13)

Marginally stable Pleistocene age rock slides were reactivated by slope excavation for Interstate Route 79 near Pittsburgh, Pennsylvania, in 1968–69. I studied these slides as part of my PhD research at that time, then left the area from 1969–72. Portions of these slides were excavated in 1969–70 to stabilize the slopes. Unexcavated slide remnants have continued to creep downslope; because of a large buffer zone, they pose no threat to the highway. I have visited the slide area intermittently as time permitted since 1972 for visual monitoring of slide behavior, with annual visits, typically each spring, since 2014. One of the major areas I studied in 1968–69 is 1,000 feet long between Stations 900 and 910. This area has partially excavated slide remnants still creeping. In April 2019, on the fiftieth anniversary of my original research, I measured tree root-trunk offsets in the most active part of this major slide area. This part extending from Station 906 to 909 had horizontal movement of approximately 60 feet from 1969–70. This movement created a graben approximately 240 feet long and 30 feet deep on its downslope side with a 50-ft-high near-vertical sandstone face on its upslope side. Nine trees (six maple; one each elm, oak, hickory) with trunk diameters of 0.6 to 4.0 feet, located in the graben and along its downslope side, had root-trunk offsets of 1.2 to 4.0 feet, typically about 2 feet. Because of tree sizes and locations, these deformations are considered to reflect mainly geotropism, with only minor, if any, phototropism influence. These offsets imply average

creep rates of 0.024 to 0.08 feet per year (about 0.3 to 1.0 inch per year), with a typical rate of about 0.04 feet per year (0.5 inch per year), over the past half-century.

Naturally Occurring Asbestos in the Virginia Appalachians – Impacts to Worker Health and Safety, Regulatory Compliance, and Economic Impacts

Hargrove, Glenn, Froehling and Roberetson, ghargrove@fandr.com (TS #7)

Naturally occurring asbestos (NOA) occurs throughout the Piedmont and Blue Ridge Provinces of the Appalachian Mountains from southwest to northeast Virginia. NOA is largely confined to metamorphosed ultramafic rocks such as soapstone and serpentine although it can also be detected in associated soils and saprolites. NOA is not currently regulated by Virginia state agencies. However, the presence or potential presence of NOA has an impact on a variety of enterprises in the state. The goal of this presentation is to discuss where NOA occurs, methods of detection, and appropriate analytical techniques to confirm the presence of asbestos. The subsequent impacts of the presence of NOA are also discussed with an emphasis on projects that involve personal involvement.

Applicability of Analytical Methods, Reference Materials and Proficiency Testing for NOA

Harper, Martin, University of Florida, mharper@zefon.com (TS #11)

In any analysis it is critical to first define the sample. It is rare that an entire material can be interrogated regarding its composition; it is nearly always that only a small sample is available, and the major question to be asked about any sample is whether it is sufficient to characterize the whole. In the analysis of asbestos and related mineral particles, the sample can be an air filter (or more often a portion of filter), soil, lung tissue, building material, bulk mineral, a consumer product, or a reference material. The representativeness of the sample to the whole is a matter of considerable concern and has not always been addressed properly. A second question relating to any analysis is the nature of the analytical technique. Many are available, and their range of application is not always overlapping. The magnification at which an examination proceeds is important, for example: eyeball to hand-lens; low-power stereo-microscope; polarized light and phase-contrast microscopes; scanning electron or transmission electron microscope. Examination at each level is for different purposes, and quality assurance also varies by level. The final question relating to the analysis is the nature of the variation encountered between different tests in the same, or different, laboratories, and whether these variances might lead to different decisions. Analytical calibration, along with reference materials and proficiency testing schemes are all aids to resolving these differences.

Hydrogeology of Two Reservoir Sites in the Indian River Lagoon – South Watershed, Florida

Hayes, Kevin, U.S. Army Corps of Engineers, kevinhayespg@gmail.com (TS #8A)

The results of hydrogeologic and geotechnical investigations of two surface-water reservoir projects, the C-44 Reservoir in Martin County and the C-23/24 North and South Reservoir site in St. Lucie County, are presented along with the design and construction implications for each structure. The C-44 Reservoir project, currently under construction, has included multiple phases of investigation, field and operations testing, laboratory analyses, and groundwater level monitoring since the early 2000s. The C-23/24 project, located approximately 30 miles to the

north-northwest of the C-44 project, is currently in the investigation phase. Both projects are located within the Eastern Valley Geomorphic feature and are underlain by the Tertiary-Quaternary Shelly Sediments unit (TQsu; Shelly Sediments of Plio-Pleistocene age), as mapped by the Florida Geological Survey. The Surficial Aquifer System (SAS) is approximately 110 to 130 feet thick in the area and consists primarily of the sandy, shelly sediments and sandy limestones of the TQsu. The water table typically ranges from approximately 3 to 8 feet below ground surface at both project sites. Aquifer testing conducted at the C-44 Reservoir site yielded horizontal hydraulic conductivity values for the SAS of approximately 20 to 28 feet per day. An approximately 20- to 30-ft-thick interval of relatively high permeability, fine to coarse grained, quartz sand and sand to gravel-size shell is encountered beneath the clayey sands of the C-44 embankment foundation and reservoir footprint. The sand and shell interval is hydraulically connected to the chimney/blanket/toe trench drain and the embankment seepage canal in order to control seepage pressures within the structure. The initial drilling work conducted at the C-23/24 site indicates similar soil lithologies and hydrogeologic conditions are also present beneath the St. Lucie County project site. Well construction and aquifer testing activities are planned for summer 2019 at the C-23/24 site.

Managing NOA at a Large Construction Project: Lessons Learned from the Calaveras Dam Replacement Project

*Hernandez, Dan, Riscicare, riscicaredan@gmail.com (TS #11)
(Presented By Mark Bailey)*

The speaker will share experiences related to the construction of a large dam in rocks of the California Franciscan Assemblage found to contain fibrous blueschist amphiboles. Thousands of exposure and ambient air samples were collected to evaluate NOA risks and offsite migration.

Geologic Support for Foundation Preparation and Inspection at Oroville Dam Spillways Recovery

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The replacement of the Oroville Dam Flood Control Outlet (FCO) chute and Emergency Spillway roller compacted concrete apron were completed under a very short schedule. Capacity for both spillways were completed over two construction seasons in 2017 and 2018 from about late March to late October. The limited construction windows required 24-hour operations to remove the original chute, prepare the foundation, and construct the new spillways. California Department of Water Resources (DWR) Project Geology group was responsible for documenting the foundation rock conditions prior to concrete placement. This included geologically mapping the prepared foundation surface. The geology team also verified that the rock quality fully met specification requirements for the rock foundation. The geology team identified areas that required additional excavation, including areas with weathered amphibolite and shear zones. Foundation specifications for the Emergency Spillway repair, although not as stringent as the FCO chute, also required the same level of documentation and inspection prior to concrete placement. With over 1.2 million cubic yards of concrete placed on both spillways, inspections were made routinely to ensure the foundation conditions were met prior to concrete placement and to keep the contractor on schedule.

Climate Change Communication that Works

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In 1982, Pennsylvania Republican Congressman Robert Walker (one of the more conservative members of Congress) said this after a Congressional hearing on global warming: "Today I have a sense of déjà vu ... we have been told and told and told that there is a problem with the increasing carbon dioxide in the atmosphere. We all accept that fact, and we realize that the potential consequences are certainly major in their impact on mankind. Now is the time. The research is clear. It is up to us now to summon the political will." That was 37 years ago, and our nation has yet to summon the political will to take bold steps to reduce greenhouse gas pollution and work collectively towards stabilizing the climate. In fact, in many instances, rather than summoning collective political will, laypeople, business leaders, and politicians have sown seeds of discord, creating a taboo subject at many dinner tables and on Capitol Hill. Meanwhile, greenhouse gas levels in the atmosphere continue to rise. However, there is solid evidence—such as that from the Yale Program on Climate Change Communication—that public opinion is now heading in a positive direction in terms of the acknowledgement of the science of climate change and its human-caused origins from greenhouse gas pollution. For the first time in a decade, bipartisan legislation to address greenhouse gas pollution has been introduced in both the U.S. House and Senate, legislation facilitated, in large part, through the grassroots lobbying done by volunteers with the nonpartisan Citizens' Climate Lobby (CCL). Attendees of this presentation will learn about effective communication methods championed by CCL and many others working towards bipartisan, long-lasting climate change policies, including aspects of Motivational Interviewing; use of simple, clear messaging; utilizing trusted messengers; and storytelling.

"Third Time's the Charm?" History of Landslide Risk Reduction and the Current Path Forward at the Pine Flat Dam, California

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Construction of Pine Flat Dam in 1954 (operated by the U.S. Army Corps of Engineers (the Corps) in Fresno County, California) required removal of the toe of a relic landslide on the downstream right abutment of the dam. After a season of heavy rainfall in 1996, movement near the upper portion of the slide sparked early attempts at mitigation by the Kings River Conservation District (KRCD), which operates the powerplant downslope of the landslide. In 2011, debris shedding caused a blockage of the lower right dam abutment, which initiated a series of attempts by the Corps to investigate, monitor and mitigate the landslide risk. The first attempt at mitigation involved installation of sub-horizontal drainage and construction of a diversion wall to protect the abutment. This construction was discontinued prior to completion due to reactivation of the landslide during percussion drilling. Following additional investigation and instrumentation installation, a second and more robust design was completed involving tieback anchors, walers, retaining walls, drainage and instrumentation (2016). Due to budget constraints, the implementation of this design was determined to be unfeasible. In the absence of viable risk reduction options, landslide monitoring continued from 2014 to 2017 with discrete (manual) piezometer and inclinometer readings and very little reliable, continuous (automated) data. Additional movement of the landslide in 2016 and 2017 prompted the need to develop a new plan to better understand and reduce the risk associated with this landslide. The questions remained: how can we efficiently and cost effectively manage the risk associated with continued movement of

the landslide? And how can we improve landslide monitoring to get continuous instrumentation data that is compatible with the Corps' current data importing systems? Our current design aims to address these concerns with a series of debris and rockfall barriers paired with a fully automated instrumentation system.

Susceptibility of Risks based on Urban Geology from the City of La Paz, B.C.S., Mexico (Southeast Portion)

Hirales-Rochin, Joel, Technological Institute of La Paz, joelhirales@itlp.edu.mx (Poster)

Geology, when used to identify areas of geological risk, is a useful tool to determine the close relationship between the geological space and the urban development of a city. Based on this interaction, we can respond to the growing demand for environmental and urban solutions. The first is formed by geology, biology, soil science and the second is anthropic, represented by cities, infrastructure, public works, populations, etc. Both environments interact constantly and, in the case of the study area, a planned and sustainable relationship that allows a harmonious relationship between the two has not yet been established. The present study shows a characterization of the geological, hydrogeological and geomechanical conditions of the state capital at the level of the main suburbs of the urban and suburban zone (southeastern part) that reflects the current problems related to geological hazards. In susceptible areas to debris flows, fallen rocks and landslides. Through the generation of thematic maps and using the Analytic Hierarchy Process (AHP) methodology, a risk susceptibility map is obtained. This research reveals the observation and recording of both natural indicators, and those produced by anthropic action, which are being integrated into a Geographic Information System (ArcGIS), to update the information corresponding to the natural hazards involved in this studio. These results will be used to analyze the urbanized areas, and the future urban development, which will allow the capital of the State a sustainable growth of the population of the city, the improvement of the current construction standards and the corresponding zoning to anticipate its development orderly manner.

Investigations of Karst Controlled Seepage at Jim Woodruff Lock and Dam, Sneads, Florida

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Jim Woodruff Lock and Dam has a history of seepage since its construction in the 1940s and 1950s. Located on the Apalachicola River along the Florida-Georgia border, it impounds Lake Seminole. During construction, more than 250 solution features, including large caverns, were cleaned and grouted. Progressive enlargement of solution features and sediment-filled voids creates a maintenance nuisance and increases risk of damaging infrastructure or reservoir loss. There is continued interest in acquiring new information to evaluate seepage pathways and determine if there are features developing that could threaten the dam. The U.S. Army Corps of Engineers collaborated with the U.S. Geological Survey in March 2018 to conduct a multi-method geophysical investigation along the foundation of the fixed-crest weir and right abutment using direct-current (DC) resistivity, self-potential (SP), frequency-domain electromagnetics (FDEM), and ground-penetrating radar (GPR). The resistivity data indicate apparent fractures extending to the Floridan Aquifer located ~70 feet below ground surface that are co-located with large amplitude, positive SP anomalies. The largest SP amplitude anomaly is situated above the former

channel of the Apalachicola River where erosion largely cut through the Tampa Limestone and indicates upward flow from the unconfined aquifer below the dam. The variation in SP amplitudes correspond strongly with potentiometric data measured along the weir adit shaft. Along the right abutment, coincident, linear anomalies observed in the DC resistivity, SP, and FDEM data are interpreted as northwest-southeast trending fractures. Ground-penetrating radar was deployed in the northern right abutment area. Although borehole data indicate thick clay-rich layers in the near surface, several potential karst-related anomalies as well as anthropogenic features were observed in the upper 15 feet. These results have been briefed to the operations team at the dam and are being used to inform future remediation efforts.

Identification and Adverse Impacts of Carbonate Reef Structures for Tunnel Projects

Isaacson, J. Ike, Brierley Associates, isaacson@brierleyassociates.com (TS #8B)

Subtle differences between the hydrogeologic and geomechanical behaviors of carbonate reef deposits and the surrounding carbonate strata can result in adverse impacts to tunnel excavation and construction if not identified and anticipated prior to exposure during construction. In-situ packer test results do not appear to accurately distinguish the true, order-of-magnitude differences in hydraulic conductivity between the two facies types. Specific laboratory tests have been found to accurately allow engineering geologists to distinguish these problematic lithofacies along tunnel alignments and to segregate strength and characteristics data within both the Geotechnical Data and Baseline Reports for tunnel projects.

Soil Monolith Preparation and Associated Physico-Chemical Properties Analysis from the Gray Fossil Site, Tennessee

Jarvis, William, ESTU, jarvisw@mail.etsu.edu; Sarah Harris; Gabriel Johns; Joshua Welty; Rachel Whiteman; Patrick Brown; Garrett Strawn; Eric Briegel; Erika Goforth; Zachary Murphree; Charles Neyman; Arpita Nandi (Poster)

Site investigation is a critical part of engineering and environmental geology, where collection and analysis of soil core samples are vital. The objective of the study is to acquire, preserve, and analyze a deep vertical soil core in the form of a monolith from the Gray Fossil Site (GFS), TN. The GFS is a late Miocene/early Pliocene aged (about 7 million-4.5 million years) sinkhole pond site consisting of black clay-rich soil, which preserved a variety of vertebrate and plant fossil assemblages. The black clay layer is interpreted as lacustrine sediments, originating from a karst landscape. To display the natural soil horizons and subsurface structure, a monolith was created by first excavating a small hill slope using shovels and hand tools and extracting a 40" × 8" × 6" (101cm × 20cm × 15cm) core extending into the black clay rich layer. The core was then trimmed and sealed to preserve the soils appearance. Excess soil was trimmed and set aside for physical and chemical tests. Physical tests included free-swell, bulk density, and soil texture and chemical tests included pH, percent organic, cation exchange rate (CEC), calcium content, nitrogen content, and phosphorus content. The sample location had been excavated in the early 2000s and is missing roughly 30ft (9.1m) of upper soil layers. The monolith displays three regions within the soil profile, a thin top layer formed since the excavation in the early 2000s, and a tan clay-rich layer followed by a black clay-rich layer. The difference in color is due to the anoxic conditions, as the water table was above the darker region before the year 2000. The black clay region also displays silt rich lenses produced from ancient flooding event. Now preserved, the monolith can be used as a visual aid for education of the site.

A Study on the Weathered Granite Soils for the Prevention of Residual Subsidence of the Motorway

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When encountering weathered granitic soils at a construction site, it may be necessary to change the design and construction plans for geotechnical structures. Most weathering is due to exposure to the air and the weathering progresses rapidly, which can have serious effects on the earthwork structure. It is difficult to control the compaction of these soils due to water-sensitive conditions of the weathered granite soils. It is important to study and report on local characteristics of these weathered soils as they often vary locally. In this study, two sites were selected for study; Site A contains a large amount of clay minerals due to the weathering of biotite and amphibole, while Site B contains granitic gneiss in many fault lines and soft shear zones. Also, at two locations of granitic gneiss in the Gansung area of Gangwon-do, geological studies were performed at 22 and 8 sites, respectively. At each site, test samples were collected for analysis by XRD and to measure particle size, consistency, and compaction. To evaluate the suitability of the material for road subgrade, we examined the interrelationship between CBR value and the uniformity coefficient, the 200 sieve passing ratio, and the aggregate (≥ 2 mm) content. We found that for the weathered granitic soil, aggregate sized > 2 mm, has a significant effect on the CBR value. In addition, the mixing of aggregate sized > 2 mm with sub-quality soil improves the soil condition.

Vapor Intrusion: Assessment and Mitigation Options for Sites with Known or Suspected Chlorinated Solvent Contamination

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Chlorinated solvent contamination, whether known or suspected, impacts public health and public perceptions. Each year more tools and resources are developed and revised to assist with assessment and mitigation of sites with vapor intrusion issues. This presentation will provide a general overview of vapor intrusion assessment and mitigation options, discuss new developments, and review case studies of NC Brownfields sites to illustrate common approaches employed in assessment and mitigation.

EPA's Action Plan for PFAS

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This presentation will briefly introduce basic PFAS nomenclature, chemical properties, and also address their historical and current uses in consumer products and industrial settings. This talk will further address previous actions taken by EPA to date, and give an update on the status of several of the agency's ongoing multimedia efforts to address PFAS via EPA's PFAS Action Plan.

A (Literally) Hot Topic:

The Critical Nature of Nuclear Communication

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Communication about complex technical issues is challenging, particularly in areas of science and technology where strongly-held views among stakeholders vary widely. One of the most societally controversial scientific topics is civilian use of nuclear power, siting and use of nuclear-related facilities, and management of radioactive waste. Nuclear projects present unique difficulties for communication not only

because of the highly technical nature of the topic, but because of the fear-factor embedded in our society. This fear is due in part to media hype, misinformation, and the entertainment industry, but is also in part rooted in real concerns that the accidents at the Chernobyl and Fukushima nuclear power plants could be repeated. Thus, to ensure effective dialogue and information sharing about nuclear-related projects, the timing and content of communications is critical. Over the last decade, staff of the Center for Nuclear Waste Regulatory Analyses (CNWRA®) at Southwest Research Institute® (SwRI®) provided comprehensive support to the U.S. Nuclear Regulatory Commission (NRC) for public outreach efforts across a wide variety of nuclear activities. Many of these projects included public involvement and consultation activities for compliance with the National Environmental Policy Act (NEPA), including scoping, public meetings, responding to public comments on draft documents, and holding small meetings with affected local, state, and tribal governments. For these projects, communication to a broad audience of non-scientific stakeholders—ranging from members of the public to advocacy groups to governing officials—is necessary. In this presentation, the author addresses the challenges of communicating about risk-sensitive scientific issues, benefits of strategic communication, and best practices and lessons learned from real-life experience. This abstract is an independent product of the CNWRA and does not necessarily reflect the view or regulatory position of the NRC.

Asbestos Dust Mitigation Plans: What to Consider when Preparing for Ground Disturbing Activities at an NOA-Containing Construction Site

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So you've confirmed naturally occurring asbestos on a project site through mapping and analysis of soil or rock samples, what to do next? Depending on your location, some states and localities have requirements to prepare a written plan and perform perimeter air monitoring, which are triggered by the size of the soil disturbance, weight percent of asbestos, and occupancy of the surrounding area. An asbestos dust mitigation plan may include procedures for air monitoring (consisting of daily samples and laboratory analysis), dust control measures, vehicle speed limits, off-haul procedures to minimize generation of asbestos-containing dust, and personal monitoring to ensure workers are protected in accordance with nationwide OSHA regulations. What to do when your project has been completed? We'll discuss pros and cons of various post-construction capping methods and recommendations for monitoring these mitigations. This presentation will also summarize the regulatory petition that was written by geologists and CIHs in an effort to adapt existing OSHA standards to the challenges presented by outdoor work.

Suggested Refinements for the Enhanced Geologic Model Complexity Rating System

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The Geologic Model Complexity Rating System (System) was fashioned after the Oregon rockfall hazard rating system and enhanced to reduce the number of components and give them weights. The enhanced System still used exponential scoring of components, which emphasize the most hazardous slopes on highways so they would receive priority for mitigation. Our enhancement grouped components into 1) regional geologic complexity, 2) site factors, and 3) field factors, and weighted them for landslide hazard studies with a pairwise comparison using a multi-factor decision analysis procedure called

Analytic Hierarchy Process (AHP). The 1–9 scheme used for AHP scoring, 1 indicating the pair had equal importance, 9 and 1/9 indicating that one had extremely more importance than its paired component, appeared to be useful for objective comparisons. The enhancements to the system better aligned it with the Oregon system, which included facility features (i.e., what is at risk) for which its single hazard was being rated. Regional geologic complexity was considered to be a single four-element component that depended not only on the basic geology of the site area, but also on the purpose of the geologic evaluation. Our suggested refinements to the system propose a scoring scheme that emphasizes good qualities and combine the information quality component, which was considered to be a site factor, with the level-of-effort field component, reducing site factors from three components to two. The refined system uses regional geologic complexity as high-level information that is represented in the site geologic complexity component, thus further simplifying the system to two site components and two field components. The scoring scheme used for the Geological Strength Index (GSI) combines two factors, which lends itself well to the refined site components (geologic complexity and terrain) and field components (geologist competency and level-of-effort), and recognizes the gradational nature of component boundaries.

Revisiting “Insurance, Climate Change, and Landslide Damage Mitigation: Thinking Outside the Shear Box” 12 Years Later

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A dozen years ago, the authors discussed reasons why landslide damage should be insurable and commented on continuing urban and residential development in hazard areas, increasing losses from insured catastrophic events of all types, rising facility values, and natural processes occurring more frequently at damaging intensities. Climate change, responsible for more frequent natural processes at potentially damaging intensities, can initiate landslides or intensify their immediate or future damage potential. The contribution of climate change to landslide damage and evolution of insurance as an alternative mitigation response deserved to be considered by landslide geologists and engineers. Damage statistics, typically disregarded by geo-specialists, are vitally important in these considerations. The unknown degree to which humans might be responsible for contemporary climate change was mentioned in the context of documented prehistoric rapid advance and retreat of an ice sheet near Seattle and rise and fall of a pluvial lake in Utah that may have influenced geologists' dismissal of giant, apparently stable, landslides as relicts of the Ice Age. The City of Laguna Beach, CA, was discussed in terms of its response to two relatively small landslides that occurred following heavy rainstorms 28 years apart by managing funds from a voter-approved special tax, even though the actual damage potential had not been quantified. Over the past 12 years the authors have described a landslide analogy to the successful earthquake hazard reduction program, proposed a simple model for zoning landslide hazard areas, and inspired the USGS to create a prototype landslide hazard map of the United States by focusing on areas of low landslide hazard, instead of inventories of past landslides in obviously high-hazard areas. Landslides remain a major challenge for quantifying hazard in terms that relate to damage and loss because they are secondary to primary triggering events and damage statistics are not being collected.

Innovative Seismic Refraction Survey Reveals the San Andreas Fault Zone from inside the Elizabeth Tunnel

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The San Andreas fault was a recognized hazard when the Los Angeles Aqueduct was being designed in 1906. Los Angeles Department of Water and Power's current seismic enhancement project includes two 24-in-diameter HDPE pipes inside the unreinforced concrete-lined horseshoe-shaped Elizabeth Tunnel across the 480-ft-wide fault zone. The fault zone was located with comprehensive geologic evaluations, including inclined borings with downhole seismic velocity measurements, near the midpoint of the five-mile-long tunnel. Sketchy construction geology notes document some bad ground areas, but no strong shaking has occurred to reveal potential collapse zones. The steeply dipping San Andreas fault exhibits right-separation greater than 100 miles brought Paleozoic(?) gneiss against Cretaceous granodiorite, and near-vertical geologic structures should exist along the tunnel. Ground conditions above the tunnel were impractical to measure with borings; seismic refraction could be performed, but challenging inside this wet tunnel. Constraints included a semicircle invert shape, flowing water, ventilation fan vibrations, and a brief aqueduct-shutdown period. A 48-channel system with 10-Hz hydrophones spaced at 10-ft intervals was advanced in 400-ft increments with 70-ft overlaps. A cart-mounted propelled energy generator configured to operate on the curved tunnel invert stacked 10 shots at five points per spread. P-wave velocity structure was represented by first-arrival-time differences at adjacent hydrophones after discounting the concrete lining; velocities were calculated with the slope of the cumulative travel time over user-defined intervals. The lowest P-wave velocity along the tunnel coincided with the San Andreas fault location. Some low velocities coincided with mapped faults projected to tunnel depth or with notes of bad ground, many others were without notes. Sixty-foot-average P-wave velocities in the San Andreas fault reach were $10,390 \pm 1,380$ fps ($n = 375$; minimum 7,643 fps), velocities in the granodiorite northeast of the fault were $13,571 \pm 1753$ fps ($n = 973$), and velocities in the gneiss southwest of the fault were $15,539 \pm 1,846$ fps ($n = 1248$).

Project-Level Execution of Risk-Informed Decision-Making during the Boone Dam Remediation

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The occurrence of a sinkhole in near proximity to the downstream toe of Boone Dam and subsequent observations of turbid discharge into the nearby tailrace motivated the Tennessee Valley Authority (TVA) to immediately implement several interim risk reduction measures, including a significant lowering of the reservoir's pool elevation. The selection of an interim operating pool constituted the first operational decision made within TVA's newly adopted procedures for Risk-Informed Decision Making (RIDM) in its dam safety program. The TVA further advanced its practice within RIDM by completing semi-quantitative risk analyses to evaluate the efficacy of various candidate techniques during its selection of a remediation strategy. In its assessment of potential risks which may be imposed by implementation of each of the various candidate remediations, TVA further identified a means by which dam safety risks and project execution risks for a given construction approach could be simultaneously evaluated prior to construction. This technique constitutes an advancement of the state of risk assessments for dam safety projects within federal agencies, and the results of the assessments can be formally tied to the agency's

management strategy for corporate risk, as imposed by the ongoing operation of all its facilities. A discussion of all risk assessments conducted for the project is provided for context and is followed by a detailed exposition of the specific means by which dam safety risk and project execution risk are simultaneously evaluated by semi-quantitative means to aid the TVA in managing corporate risk during major dam modification projects.

Karst, Geologic Mapping and Geotechnical Engineering in the State of Qatar

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The State of Qatar in the Middle East, a country underlain by carbonate and evaporite rocks and having abundant karst features, has recognized the significance of reliable and accurate geological and geotechnical information and has undertaken a project to collect and compile country-wide geotechnical data to support preparation of geologic and thematic digital maps. The geologic maps being used in Qatar require updating due to rapid economic growth, ongoing infrastructure development and increased natural resource demands. The two most referenced geologic maps were prepared in the 1970s and 1980s with limited fieldwork, lower resolution imagery than is available today, and older stratigraphic nomenclature that contains conflicting stratigraphy and imprecise age information. Detailed geologic maps founded on new highly accurate base maps along with modern, high resolution remote sensing data, comprehensive fieldwork, laboratory analyses, and detailed cross sections are critical to support planning, design, and decision-making processes related to urban infrastructure development in the rapidly growing state. This is especially important in karst terrains that are prone to sinkhole hazards and groundwater quantity and quality issues. The Qatar Ministry of Municipality and Environment partnered with Gannett Fleming, Inc. and the U.S. Geological Survey to design a geologic mapping project that will merge geological and geotechnical information to develop a framework to model the geology, karst, and resources important to support growth in the State. The Qatar Geologic Mapping Project has a mission to integrate sound geoscience data for the State of Qatar to address societal, environmental and educational needs that include water and mineral resources management and natural hazards reduction.

Assessing Structural Uncertainty in 3D Geologic Models of Mountain Tunnels

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In engineering, uncertainty is traditionally treated in an objective sense where a given model's uncertainty is evaluated based on the uncertainty of the observations from which it is made. When considering a 3D geologic model, observations are typically sparse (e.g., surface mapping and drillholes) and prior geologic knowledge must be used to interpret how the geology is expected to vary in the subsurface. This prior knowledge, and the interpretations made from it, contributes its own, subjective uncertainty to the resulting model. For tunnels built in hard rock settings, faults are typically of primary concern to construction as they introduce zones of weakness into the surrounding rockmass. In the subsurface, these deformational structures create a fault network with complex 3D geometry describing both the individual structures and their interactions with each other. 3D geologic models present a powerful medium for predicting and visualizing the geometry of the fault network intersecting a tunnel alignment. Assessing the impact of uncertain data and interpretations on the 3D geologic model

is imperative for informing subsequent tunnel design. Structural traces and orientations observed at the surface provide the basis for a 3D structural geologic model. Interactions and terminations of faults in the subsurface are interpreted during modeling based on prior geologic knowledge. Probability distributions are parameterized for each modeling input (orientation, trace, thickness and terminations) to allow for the simulation of perturbed inputs and generation of model realizations. Model discrepancy is applied to generate a 3D likelihood describing the possible locations and geometries of faults along a tunnel alignment. The approach can be applied to a wide range of 3D geologic models in structurally controlled hard rock settings to establish a probabilistic understanding of the subsurface geology. Here, the approach is demonstrated on the Eisenhower-Johnson Memorial Tunnels in Colorado.

A 6,000 Year-Old Earth and the Continued Devaluation of Professional Licensure – Ongoing “Lessons” from Missouri

Kreuger, Duane, Geotechnology, Inc., dkreuger@geotechnology.com (TS #6)

Since 2013, the Missouri Geologists' Consortium (MGC) has observed new and continued threats to not only licensure for geologists, but seemingly each of the regulated professions in the State. The anti-licensure movement is one spoke in the wheel that is gaining momentum to strip the various levels of government of the ability to collect fees, support boards and committees and enforce regulations. A bill that surfaced in 2019, and thankfully has not advanced, was titled “Occupational Licensing and Consumer Choice Act.” The intent was to allow an unlicensed person to provide service for which state law requires occupational license, as long as the person discloses that they are not licensed. The MGC is a grassroots alliance of geoprosessionals and scientists that have united to affirm the sound practice of geology in the best interest of Missouri's citizens. Some examples of our efforts will be discussed including organized meetings with legislators at the State Capital, scheduled meetings with the Director of the Missouri Department of Natural Resources, and establishing mutually beneficial relationships with affiliated societies. Our main lesson to share is that although the lobbying efforts and the corresponding number of anti-licensure bills continue to increase, many of the threats can be addressed with effective pro-science and pro-licensure communication and education effort.

Exploring the Need for Improved Precipitation Measurements for Rainfall-Induced Landslide Hazard Characterization

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Precipitation is a key triggering factor for landslides. However, often landslide hazard characterization at regional or statewide scales use sparse rain gauge measurements or assume constant rain measurements. In this study, we explore the need for improved precipitation measurements for landslide hazard characterization. Identifying spatial and temporal precipitation patterns allows for improved understanding of precipitation patterns and their influence on geohazards, like landslides. Rain gauges measure precipitation in situ to gather point data, and satellites measure precipitation remotely to gather areal data at a coarse spatial resolution. Integration of point rain gauge measurements with downscaled areal precipitation data improves the overall spatial resolution of precipitation maps. The areal precipitation product being downscaled is the monthly Integrated Multi-satellitE Retrievals for Global Precipitation Measurement data (IMERG) for Colorado for

several months in 2018. This project also investigates the relationship between precipitation with vegetation and terrain variables, specifically elevation and aspect. Correlation coefficients for April 2018 between Colorado's areal precipitation with Normalized Difference Vegetation Index (NDVI), elevation, and aspect are 0.95, 0.41, and 0.11, respectively. Correlation coefficient results indicate vegetation and areal precipitation are highly correlated, but terrain variables are poorly correlated with precipitation. Spatial resolution of the product is improved tenfold from 0.1° x 0.1° to 0.01° x 0.01°. Areal precipitation maps are downscaled using two methods: (1) area-to-point kriging (ATPK), using areal variogram deconvolution, and (2) machine learning regression algorithms relying on NDVI as the explanatory variable. The rain gauge station measurements for monthly accumulated precipitation are interpolated with the downscaled satellite precipitation products using simple cokriging, with full cokriging and two Markov models being considered for comparison (i.e., three kriging models compared). Finally, landslide locations, taken from a publicly available Colorado landslide inventory, are correlated to areas experiencing high precipitation throughout the year.

Landslide Vigilance – A Bird's-Eye View: I-68 at Haystack Mountain, Cumberland, Maryland

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In late September 2018, heavy rains triggered a sizeable debris flow along the east flank of Haystack Mountain just above Interstate I-68 westbound near Cumberland, Maryland. Following this event, the Maryland Department of Transportation (MDOT) State Highway Administration (SHA) Engineering Geology Division (EGD) deployed an unmanned aerial vehicle (drone) to capture aerial imagery and lidar point data of the site. The aerial imagery data revealed various tension cracks and other indications of potential ongoing movements along the length of the hillside above I-68. Follow-up field reconnaissance visits and subsequent movement monitoring indicated that several portions of the mountain along I-68 were potentially at risk of failure. As a result, SHA-EGD engaged Gannett Fleming to evaluate the nature of the observed landslide features and develop a conceptual stabilization design. Due to the size and magnitude of the areas exhibiting signs of ongoing movement, SHA EGD deployed the drone and collected aerial imagery of the site on a routine basis. Over a monitoring period of four months, the aerial imagery had revealed a significant slow-moving debris flow, and three separate landslide features that were in various stages of failure. The aerial imagery data combined with detailed field reconnaissance observations and geological measurements allowed the project engineering geologists to model the geologic conditions and perform detailed stability analyses. Based on the results of the stability analyses and visual evidence of ongoing movement at the site, the MDOT initiated an emergency procurement project to construct a soil nail stabilized slope and catchment area. This project illustrated MDOT's ability to proactively respond to threatening slope failure conditions by utilizing innovative investigation methods and teaming with consultants and contractors to provide a safe and efficient design and expedited construction.

Landslide Mitigation at MM 7.5, Interstate 40, Haywood County, North Carolina

Kuhne, Jody, North Carolina Dept. of Transportation, jkuhne@ncdot.gov (TS #1)

2018 produced a record rainfall year in Western North Carolina. Since the region is contained within the Blue Ridge Province this necessarily resulted in many landslides, rockfalls and other mass earth movements and particularly wreaked havoc on engineered and constructed slopes. For the NC Department of Transportation, the I-40 corridor from Tennessee to MM 20 represents the longest stretch of nearly continuous steep rock slopes in the state transportation system. The complex bedding, tectonic and post-tectonic structures represent virtually every failure mode common to rock and colluvial slopes. Any precipitation event of measure can be expected to produce rockfall, and eventually a slide of some volume resulting in road closure. An economic study has shown that this results in nearly 1 million dollars in damages per day in effects to the regional and southeastern economy. The precipitation of 2018 lingered into February 2019 when it produced a perched weathered rock failure at MM 7.5. This presentation will review the investigation, risk assessment, mitigation approach and construction effort to successfully repair the site. Included in the discussion will be aspects of asset management, slope rating, and decision analysis.

Buffalo Creek Road Landslide, Rutherford County, North Carolina, January 2019

Kuhne, Jody, NC Department of Transportation, jkuhne@ncdot.gov; Justin Wilson; Matt Moler (TS #17)

After a year of record rainfall in 2018 this location exhibited large scarps affecting nearly three acres and 200' of roadway above and below the road. The roadway section previously failed in May 2018 and was repaired with underdrains and embankment reconstruction. Continued precipitation and movement revealed a much larger mass with a likely toe scarp obscured in the lakebed of Bald Mountain Lake. Top scarps are readily visible above the road but the sense of movement in this Big Slow Moving (BSM) slide was not apparent enough to proceed with mitigation plans. Further study using slope inclinometers and a NCDOT Aviation grant for aerial drone surveys was conducted to get a better sense of long-term movement and volume of the slide mass. This presentation will examine that process, results, and discuss the mitigation options for re-establishing connectivity of Buffalo Creek Road.

Lithological Mapping in Hutti-Maski Gold Mineralization Area India Using AVIRIS-NG Hyperspectral Data and Machine Learning Algorithms

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Lithological mapping is an essential task in geological exploration. The present study exploited a recently developed Airborne Visible Infrared Imaging Spectroradiometer - Next Generation (AVIRIS-NG) data and matured Machine Learning Algorithms (MLA) such as Linear Discriminant Analysis (LDA), Artificial Neural Network (ANN), Random Forest (RF), and Support Vector Machine (SVM) to map the lithological units in Hutti-Maski area. The lithological units found in the area are acidic intrusive, migmatite, granites and metavolcanics, and well known for gold mineralization in India. MLA has been evaluated by considering various parameters such as the number of input spectral bands, and size and quality of training samples. The number of input

bands has been categorized into four datasets: (1) visible-near infrared, (2) shortwave infrared, (3) all spectral bands, and (4) optimum spectral bands derived from Normalized Joint Mutual Information Maximization (NJMIM). These datasets have been used in MLA for training, optimization, and testing. The SVM outperformed compared with other methods and achieved an Overall Accuracy (OA) and k-statistics (k) of 83.90% and 0.78 using NJMIM bands. The ANN and LDA also show good accuracy, but RF yields the least accuracy and fails to map the lithological units in the area. The study also illustrates that SVM and LDA are less sensitive to the number of samples given in model training. The models decrease their OA by less than 5–10% when there is a 45% reduction in total training datasets. Furthermore, SVM and ANN appeared to be less sensitive to mislabeling as compared with RF and LDA. The SVM and ANN decrease in accuracy by 25% when there is 45% of mislabeling in entire datasets while LDA and RF completely failed in discriminating the lithological units. Therefore, the “SVM,” which is less sensitive to the number of samples and mislabeling, has been recommended for successful lithological mapping.

Effects of Anthropogenically-Forced Global Warming on the Risks of Extreme Rainfall and Flooding

Kunkel, Kenneth E., North Carolina State University, ken.kunkel@noaa.gov (TS #2)

Analysis of climate observations extending back to the early 20th - Century indicate that extreme rainfall events in the U.S. have increased substantially in frequency and intensity. There is regional variability in these increases with larger increases in the eastern U.S. Globally, most areas have seen increases as well. Anthropogenic activity, most importantly the burning of fossil fuels, has caused increases in atmospheric greenhouse gas concentrations and this has led to increases in global temperature. If greenhouse gas concentrations continue to increase, global temperature will also increase. What are the implications for extreme rainfall? There is a high level of scientific confidence that rising global temperatures will increase the future intensity and frequency of extreme precipitation events, even in regions where overall precipitation may decrease. This arises principally from the well-known relationship between saturation water vapor pressure and temperature. Saturation water vapor pressure increases by 6–7 % per °C. As oceans warm in response to the radiative energy imbalance of the atmosphere, water vapor content over the oceans, the source region of water vapor for major precipitation-producing weather systems, will increase. This will increase the potential, or capacity, of the atmosphere to produce heavy rain. The implications for flooding are more complex. While extreme precipitation is a necessary factor in producing floods, actual runoff can be modulated by other factors, e.g. soil moisture status, land use changes, seasonal timing, the spatial distribution of precipitation, and (in colder climates) snow on the ground. Nevertheless, the risks of future increases in flooding are real.

North Fork Dam – A Major 65-Year Makeover

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The North Fork Spillway and Embankment Improvements Project is being implemented by the City of Asheville to increase the hydraulic capacity and improve the stability of the dam, specifically during a seismic event. North Fork Dam is a high hazard structure located approximately two miles northwest of the Town of Black Mountain, North Carolina. The impounded reservoir is the primary water source

for the City of Asheville and surrounding communities. Since construction of the 133-ft-high dam was completed in the early 1950s, dam safety regulations have been significantly revised. Given that the dam and ancillary facility are critical infrastructure, the City is proactively moving forward with upgrades to bring the project into general compliance with current engineering guidelines for dam safety. The proposed improvements to the North Fork Dam will allow for the controlled discharge of flows associated with a Probable Maximum Precipitation (PMP) event and increase the global stability of the Main Dam and Saddle Dam (specifically during a 5,000-yr return period seismic event). Items we intend to cover in this presentation include seismic stability upgrades, selection of the foundation location for the new spillway system, foundation grouting, and soil nail and tieback wall. We will also present an overview of the structural features of the improvements to include:

- New Auxiliary Spillway with 8 Fuse gates and bridge
 - Parapet along the upstream edge of the crest of the Main Dam
 - Addition of blanket and trench drain systems for the Main and Saddle Dams
 - Principal Spillway chute concrete overlay
 - Principal Spillway control section modifications and new bridge
 - Waterproofing of Raw Water Intake Tower
 - Mechanically stabilized earth wall on the Main Dam embankment
- Construction is underway and anticipated to be complete in spring 2020. A field trip to the North Fork Dam will be conducted as part of the 2019 AEG Annual Meeting.

The Breakdown of Indiana's Excess Liability Trust Fund (ELTF) System – What Went Right and What Went Wrong

Lenz, Richard J., Creek Run LLC Environmental Engineering, jlenz@creekrun.com (TS #12)

Indiana, prior to 2017, had established itself as a leader in environmental due diligence. Following regulatory guidelines implemented in 1986, Indiana created a state regulatory agency led by environmental professionals. Two years later, in 1988, the Underground Storage Tank (UST) division within the state agency established the Excess Liability Trust Fund (ELTF), a fund for financial to aid UST owners with abatement and remediation activities after the removal of UST's. The fund was subsidized via a statewide tax placed upon the retail sale of fuel. The intended purpose of the program was widely underutilized for many years following its creation allowing for a large surplus. However, once access to the fund by environmental consultants became a marketing tool, environmental due diligence escalated, and hundreds of properties were successful at obtaining closure and no further action (NFA) for historic releases. Success led in some cases to greed, and by 2017 Indiana led the nation in the cost for an environmental cleanup of a release from a UST. It has become evident that over the last decade, fraud, waste, and abuse of the fund is and was all too common, and the regulatory agency was not equipped to take fiduciary responsibility in properly managing the fund. Now the state ELTF has dwindling resources and access is being limited as new regulatory leadership attempts to react to the situation and seek out help from the state legislature.

Assessing Drainage Tile Efficacy Using Geophysical Techniques

Leverett, Kelsi, *Missouri University of Science and Technology*, ktln7d@mst.edu; Katherine Grote, grotekr@mst.edu (Poster)

It is estimated that 121 million acres of land in the Midwest (Illinois, Indiana, Iowa, Ohio, Minnesota, Michigan, Missouri, and Wisconsin) are used for agriculture, with approximately 39 million acres of that benefitting from the use of subsurface drainage systems (Sugg, 2007). Subsurface drainage systems are utilized to remove excess water from agricultural soils to enhance growing conditions, increase crop yields, reduce yearly yield variability, and improve soil quality. Drainage systems that are constructed with control structures can also be used for sub-irrigation. Designing these drainage systems requires an understanding of how drainage tile type, lateral depth, and spacing impact the extent of surface drainage for different soil textures. Current design standards are based on hydraulic conductivity, soil texture, site gradient, and land use-land cover parameters with some consideration for climatic trends. Drainage system design is typically done using drainage charts and calculators that assume uniform parameters across a field. However, most field sites have significant variations in soil properties across the field, so assuming uniform soil textures may result in inefficient drainage system design. In this work, we measured the efficacy of different drainage tile designs (different tile configurations, depths, and drainage control structures) for different crop types using high-resolution water content estimates obtained with ground penetrating radar to determine the degree to which drainage tile design affects the residual water content in varying soil textures. These results can be used to guide drainage tile design for heterogeneous field sites.

Modifying Landslide Susceptibility Mapping Methods to Better Represent the Geology in Mesa County, Colorado

Lindsey, Kassandra, *Colorado Geological Survey*, kolindsey@mines.edu; Jonathan White, jwhite@mines.edu (Poster)

The CGS aims to provide geologic hazard susceptibility maps to state and local governments for use in planning processes and mitigation plans. The Landslide Susceptibility Map of Mesa County is part of a statewide effort to develop inventory and susceptibility maps for landslide-prone areas in Colorado. Mesa County is located on the western boarder of Colorado with Utah where a several-thousand foot thick package of weak, clay-rich rocks overlay the Ancestral Uncompahgre Uplift. Slopes below Grand Mesa, Battlement Mesa, and the Book Cliffs are susceptible to landslides. Grand Junction lies within the county and is a nexus of major transportation corridors including I-70, Highway 50, and the Colorado Railroad, that frequently experience damage due to landsliding. This study seeks to evaluate and map known and previously unmapped landslide deposits with the aid of new high-resolution lidar data, define boundaries for previously unknown landslides, and identify landslide susceptible zones based on slope derived from a 10-m digital elevation model (DEM) and geology from geologic maps at various scales. Methods for mapping susceptibility in the county were modified from Wills and others (2011), Ponti and others (2008), and Wilson and Keefer (1985) because rockfalls, debris flows, and very slow-moving slumps and soil creep were not mapped as a part of this study. Modifications include using alternative slope groups, and changing landslide susceptibility classifications to better represent the area. Similar modifications were made to maps for Jefferson County and Douglas County, Colorado (Lindsey, 2018a; Lindsey, 2018b).

Shallow Landslide Characteristics and Solutions

Lyne, Bob, *Geobrugg North America*, bob.lyne@geobrugg.com (TS #19)

Record rainfall in parts of the Southeast U.S. has caused shallow landslides and debris flows in areas of the Appalachians. This presentation will address the types and characteristics of hydro related slides and show examples of recent events as well as implemented mitigation options. Geobrugg has developed, tested and implemented shallow landslide and debris flow barriers. I will discuss the different types of barriers, site conditions and flow characteristics to be considered when choosing a mitigation option. Emphasis will be on shallow landslides and mitigation options.

Full-Scale Implementation: Arsenic Sequestration in Biogenic Iron Sulfides in Groundwater of Northwest Florida

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Arsenic sequestration in sulfide minerals is an emerging technology for arsenic-contaminated groundwater. At a 0.3-acre site in northwest Florida with elevated concentrations of arsenic, studies by others have shown that site conditions are conducive for iron sulfides to form naturally and sequester up to one percent arsenic. The data suggest a viable cost-effective remedial alternative by optimizing site conditions to enhance naturally occurring sulfate-reducing bacteria (SRB) to form hydrogen sulfide, which then reacts with ferrous iron to form iron sulfide precipitates. As the iron sulfide minerals precipitate, arsenic is incorporated into their crystal structure (coprecipitation) and adsorbed to their surfaces, thus reducing dissolved arsenic concentrations by rendering the metal immobile in a solid crystalline state. After a successful pilot test, a full-scale site remediation was implemented in June 2018 involving injections of aquifer amendment designed to enhance SRB growth and iron sulfide formation. The amendment was composed of ferrous sulfate (iron and sulfate), molasses (organic carbon), fertilizer (nutrients), and chlorine-free water. Approximately 6,625 gallons of the solution were injected via gravity into eight injection wells screened across the 20-ft surficial aquifer consisting predominantly of fine to medium quartz sand. The injection wells are spaced approximately 25 feet apart to encompass a radius of influence of 15 feet observed in the pilot test. The data collected to date indicate that sulfate-reducing conditions have been enhanced in most Site wells and that iron sulfides are precipitating and removing arsenic from groundwater at several locations. Through December 2018, 17 of 24 wells were below their pre-injection arsenic concentration, and 12 of those were below the Site arsenic standard. Trend testing of the arsenic data also shows statistically significant or mildly decreasing trends in arsenic in nine wells. Long-term stability analysis is currently being conducted to evaluate the permanence of the arsenic sequestration.

Former Mine Site Remedial Efforts in the Tri-State District – Progress of Efforts by Private Industry

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The area known as the Tri-State Mining District (corner of Missouri, Kansas and Oklahoma) was a major source of lead and zinc in the early 1900s and the mine residuals still remain. The residuals of ore processing waste (chat), resembles a lunar landscape, that is a mining waste high in lead, zinc and cadmium. The USEPA has directed former mining firms to perform remedial efforts to clean up chat areas to meet surface cleanup criteria so exposure is eliminated. Institutional

controls have eliminated the groundwater pathway uses in these areas. USEPA's Superfund (CERCLA) program provides oversight of the cleanup process with many layers of submittals: work plans for investigation, remedial design for corrective action. During the investigations all mine shafts and mine vents that extended to the underground mines required mapping for subsequent backfilling. An estimate of the amount of mine residuals was needed to prepare a repository design. The impacted soil area and outlying chat is typically consolidated to reduce the affected geographic areas and size and then capped with adequate soil. Field sampling and testing was done using an XRF for confirmation that the contractor's excavation efforts were meeting the cleanup levels. Periodic inspections are required to confirm the clean soil caps are maintained. A multi-year monitoring period of cap integrity of typically five years is required. For some sites the material has been excavated and removed to an adjacent approved EPA repository. The benefit of the remedial efforts is the ability for the mining firms to reduce their liability, mitigate exposure and return the land to future pastoral uses. Deed restrictions on capped land will remain to prevent repeated exposure. This paper will illustrate how a mining client has successfully completed over 170 acres of land reutilization of former mines and excavated over 200,000 cubic yards of mine waste residuals.

Professional Ethics vs. Political/Social Correctness

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The Business Directory (businessdirectory.com) defines ethics as "the basic concepts and fundamental principles of decent human conduct. It includes study of universal values such as the essential equality of all men and women, human or natural rights, obedience to the law of land, concern for health and safety and, increasingly, also for the natural environment." The AEG web page defines AEG's values as "based on the belief that its members have a responsibility to assume stewardship over their fields of expertise" but does not include any political or social values. Any code of ethics has to maintain continuity with changes in human, social, political and cultural attitudes as well as following changes in laws and regulations that directly impact the specific profession. Today we are seeing a national conflict between what was considered to be "being friendly and pleasant." A daily greeting "Good Morning Beautiful" caused one Administrative Assistant to become upset and to comment to that it was NOT acceptable. A shock, there was no intent to insult her, but it was a great awakening! The greeter realized that what is not "Politically/Socially Correct" was more accurately a sample of "Poor Ethical Actions." When you consider the number of famous people (men and women) who are now being criticized and punished for their "friendly and pleasant" actions that are no longer considered to be appropriate, we must recognize that the climate has changed and we must also change. AEG and other professional organizations and licensure boards need to adopt a portion from the Business Directory to enforce the "equality of all men and women, and human or natural rights."

Using Communication Science to Communicate about Science: A Case Study for Aftershock Forecasts

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The U.S. Geological Survey was faced with a challenge: how to communicate aftershock forecasts quickly and effectively with people who maybe had not experienced an aftershock sequence. Aftershock forecasts are based on operational earthquake forecasting models.

Forecasts are produced after an earthquake of significance, either a large main shock (M6.0 +) or an earthquake of note, e.g. located in relatively novel areas. The models used to develop the forecasts are probabilistic, using statistics, history, and physics to inform the outputs. The communication challenges are numerous, with probabilities and uncertainty being notoriously difficult topics to communicate to non-technical publics. To meet the challenge of communicating the forecasts, the USGS incorporated communication research to inform its first response template. The M7.1 Anchorage, Alaska earthquake in November 2018 was the first major earthquake when the template deployed on the USGS's earthquake website, within the first hour of a main shock. Using hierarchy of information, the template starts with simple messages and grows in technical complexity to help traumatized publics living in the area grapple with their new reality, and then the messaging grows in complexities to focus on the needs of first responders, emergency managers, and vested publics. Further research includes a monitoring and evaluation plan to further iterate the template. As a state agency, delivering objective, and understandable messages outside of partisan politics and the regulatory environment is essential to be considered a trusted source of information. Recognize when you need help in communicating science to non-scientists, as would be the case when making landslide hazard maps readily available and understandable to the public. Organizations like the UNC-Asheville's National Environmental Modeling and Analysis Center facilitate interactions between the producers of applied science and users, and specialize in science communication and decision support tools. Communicating messages in ways that tell the human sides of stories within a historical context can help bridge the gap between science and public awareness.

Analytical Problems of Analyzing Erionite through the Paradigm of Asbestos Analysis

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Erionite is a zeolite group mineral that can occur in vugs in basaltic rocks and diagenetically altered volcanic tufts. Erionite has an Al-Si framework with an R value (Si/(Si+Al+Be)) ranging from 0.68-0.79 and has the capability undergoing cation exchange in the extra-framework cations, generally they are either K, Na, or Ca (Bish and Ming, 2001). Zeolite nomenclature is thus based on the crystal structure of the Al-Si framework and of secondary importance is the dominant extra-framework cation. If samples are exposed to environments conducive to cation exchange, the observed composition may not be representative of the pre-exchanged material. Thus, any use of composition alone is unreliable to determine the zeolite phase(s) present. Erionite belongs to the hexagonal crystal system and space group P63/mmc (a = 13.26, c = 15.12). Diffraction data must be collected to confirm this in order to reliably identify erionite. Consequently, identification of erionite without diffraction evidence is unreliable. Studies have shown there is a link between mesothelioma and erionite exposure, but the mechanism of the disease formation is still not clear (Wagner et al., 1985; Baris et al., 1987; Carbone et al., 2011). Many researchers in academia, government, and industry have used or have proposed the established asbestos testing methods and counting rules to characterize erionite in samples, but these methods lack the robust crystal structure evaluation needed to properly distinguish erionite from other zeolite group minerals. Furthermore, the general test methods used for asbestos analysis were not designed to deal with zeolite group minerals. This talk will explore why the established asbestos methods are not adequate for the characterization of erionite and show examples of

why a much more robust mineralogical characterization is necessary. We will discuss the usefulness of each analytical technique employed and some of the challenges that we encountered.

Use of Passive Soil Gas Samplers to Scope Remedial Investigation and Accelerated Vapor-Intrusion Evaluation

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The Lea and West Second Street Groundwater Plume Site, an EPA National Priorities Listed site in Roswell, New Mexico, consists of four sources of tetrachloroethene (PCE) to shallow groundwater: three former dry cleaners and one unknown. Remedial Investigation (RI) began in mid-2017. Shallow groundwater contamination is extensive and commingled in commercial and residential areas creating a potentially complete vapor intrusion (VI) pathway. Plume lengths range from 1,100 to over 4,400 feet, and several private wells are contaminated. Data gaps include source area and plume delineation and evaluation of VI. Passive soil gas (PSG) surveys were used to swiftly scope the RI, being placed throughout solute plumes, along sanitary sewers, and in source areas. The PSG data were used to place soil borings and monitoring wells along plume centerlines and upgradient and cross-gradient of source areas to collect definitive data. PSG suggested minimal soil impacts as verified by soil samples. PSG substantially delineated groundwater impacts, allowing three of the groundwater plumes (total length: 8,700 feet) to be delineated with only 32 additional monitoring wells. Within one year, all sites were assessed for VI, three sites with PSG, and soil and groundwater assessed at the two highest priority sites. Site priority was based on existing contaminant data from existing wells, sensitive receptors, and impacted water supply wells. Use of PSG and vapor samples accelerated evaluation of VI pathways and provided useful data regarding plume trajectory, centerline, and width. A long-term groundwater monitoring network was substantially designed prior to installation of monitoring wells. Access for VI sampling was obtained by canvassing potentially affected neighborhoods. VI investigations began shortly thereafter, resulting in rapid assessment of thirteen residences, one pre-school, and three multiple tenant commercial properties with three to five samples points per property. Sewer gas samples were collected at three sites. VI pathway was found complete at one commercial property.

“CSI Vapor Intrusion” – Investigating a Source of TCE in a Residential Home over a Large TCE Groundwater Plume

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TCE migrated from the source area through bedrock into the underlying aquifer present at 70 feet below ground surface. This release resulted in a groundwater plume that is more than a mile long by a mile wide that has affected numerous private water wells and two municipal wells. Vapor intrusion (VI) evaluations were completed in 2011 and again in 2018. The VI evaluations conducted in 2011 indicated that the VI pathway was not complete. In 2018, several residences were reassessed. One reassessed residence had exceedances of TCE above the EPA residential screening levels (SLs) for indoor air. Multiple sampling events occurred at the residence consisting of indoor air, sub-slab soil gas, and tap water from March through July 2018 to determine if the contamination was site-related and to identify the source of contamination. Sampling indicated that there was a probable indoor air source for the TCE, since the sub-slab soil gas results were below the EPA residential SLs. Tap samples collected from multiple faucets in the

residence identified the water from an auxiliary kitchen tap and an outside tap were connected to a separate water line supplied by contaminated well water. The water line from the well was located and disconnected from the home. Indoor air grab samples were recollected to determine if the disconnection of well water reduced the indoor air concentrations. The sample results showed the concentrations of TCE remained above exceedance levels. A portable gas chromatograph/mass spectrometer referred to as a HAPSITE® was used to locate the indoor air contamination source. The HAPSITE® readings in the master bedroom indicated the highest concentrations of TCE were coming from a dresser and nightstand of similar design from the same manufacturer. It was determined the source of TCE was varnish and glue used in the manufacture of the furniture.

Development of National Database Evaluating Distribution of Natural Occurrences of Group One Human Carcinogen Minerals

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This study evaluates the distribution of amphiboles, serpentine, zeolites, and quartz within soils, rock outcrops, mines, and other documented natural occurrences across the United States using a compilation of various mineralogic databases. The International Agency for Research on Cancer (IARC) has deemed the following mineral groups as group 1 human carcinogens (i.e., known to cause cancer in humans: 1) asbestos (chrysotile, crocidolite, amosite, asbestiform anthophyllite, asbestiform tremolite, and asbestiform actinolite), 2) erionite (a rare zeolite), and 3) crystalline silica (quartz and cristobalite) dust. Concerns surrounding the health impacts of exposure to these minerals (asbestos in particular) have extended from occupational settings to their presence in soils and rock deposits. Furthermore, certain non-asbestos varieties of amphiboles and serpentine are currently regulated as asbestos and quartz is a carcinogen, but not regulated as in the same manner as asbestos. The distribution of these minerals is ubiquitous and this study highlights defining these minerals is complex, but key in regards to regulations. The “U.S. Geological Survey mineral databases; MRDS and MAS/MILS” by McFaul et al. (2000), “Asbestos mines, prospects, and occurrences in the continental U.S.” by Van Gosen (2005, 2006, 2007, 2008, 2010, 2011), and “Geologic occurrences of erionite in the United States: an emerging national public health concern for respiratory disease” by Van Gosen et al. (2013) list localities that contain known occurrences of these minerals, compiled from literature and historical records. The USDA-NRCS National Cooperative Soil Survey database (<http://ncsslslabdatamart.sc.egov.usda.gov/>) and the “Geochemical and mineralogical data for soils of the conterminous United States” by Smith et al. (2013) reports mineral content of the soils, but do not focus on the morphology of the particles or their specific composition. Thus, sites that contain $\geq 1\%$ (regulatory limit) amphiboles, serpentine-group minerals, zeolites, and/or quartz are included in the results as potential localities.

Boone Dam Internal Erosion Remediation Project: Integrated 3D Modeling of Subsurface Conditions

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The Boone Dam Internal Erosion Remediation Project has produced a large and diverse subsurface data set consisting of: historical information from the design and construction of, and improvements to the dam; subsurface investigations, geophysics, hydrogeologic, and instrumentation data associated with the initial responses to sinkhole events in 2012 and 2014; geology, permeability, geophysics, and grouting data observed during the preparatory grouting programs executed

between 2016 to 2019; and targeted geotechnical investigations undertaken by the design team. An important aspect of the project has been to integrate the growing volume and density of information into a three-dimensional model which accurately represents the subsurface conditions at the site. Initial development of the model required compiling and tabulating existing analog data, and importing of existing digital data into the 3D database. Subsurface information acquired during the grouting phase of the project was uploaded to the database in near-real-time using tablet or phone-based apps that were configured to allow field personnel to view current grout curtain plans and profiles (design and geologic models) and to digitally record (log) borehole information. Hand-drawn interpretive geologic profiles from the original dam construction, as well as new versions based on recently acquired subsurface data, were imported to the model as image layers. In addition, automated instrumentation, grouting, dam operations, and climate data have been imported directly to the database. Finally, components of the remediation design have been imported to the model to allow the team to view the spatial relationships between proposed construction elements and subsurface conditions. The resulting 3D model is a “living” data repository that can be used to visualize subsurface site conditions and can be updated as new information is acquired.

Using a Hybrid Flow Model for Evaluating Rock Erodibility and Mitigating Leakage in Fracture Flow Pathways around Lower Baker Dam, Washington

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A 3D numerical groundwater flow model has been developed in order to provide a tool to help design and implement a leakage mitigation effort and address related potential failure modes (PFMs) at the Lower Baker Dam in Skagit County WA. Significant leakage has been occurring through the fractured rock mass since the reservoir was filled and past grouting has resulted in only temporary leakage reductions. Outputs from the FEFLOW™ model are being used to identify the magnitudes and distribution of heads and velocities throughout the rock mass, and estimate and rank erodibility along the flow paths. Through the use of discrete features, the model simulates flow along fourteen fracture flow pathways embedded within a low permeability matrix. The fracture pathways were delineated by correlating structural surfaces extracted from a 3D geologic model to 50 separate leakage vectors defined by dye-tracing. Discrete 2D features were assigned along model slices designed to follow the strike and dip of the fracture network connecting source and discharge locations. The model was calibrated to 30 piezometric heads measurements, 27 tracer-defined travel-times, and total measured leakage. Simulated velocities range from 10 + 5 feet/day in the fractures to 10-9 feet/day in the surrounding rock mass. Applied stream power available along the simulated fracture flow pathways was calculated using fracture thicknesses in conjunction with simulated heads and velocities. Erosion potential was determined by comparing the model-derived values to critical threshold values calculated for the fractured rock mass from cores using the Erodibility Index Method. 3D exports of hydraulic heads, groundwater velocities, and applied stream power are providing the basis for engineering decisions regarding leakage mitigation and PFMs. Flow model scenarios depicting the probable consequences of mitigation designs on heads, flows, and erodibility are providing a means to optimize effort and cost relative to desired outcomes.

A Multi-Phase Fault Rupture Hazard Study in Century City, Los Angeles, California

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Determining the locations of the active branches of the Santa Monica fault in the Century City area of Los Angeles has been the subject of significant investigation and contention among several consultants and stakeholders. Starting in 2011, investigations were commissioned by The Los Angeles County Metropolitan Transportation Authority for the siting of the Purple Line subway station in the Century City area, with an objective to avoid siting the station near or on an active branch of the fault zone. Subsequently, numerous other agencies commissioned separate studies conducted by other consultants, which often disputed the findings made by Metro consultants regarding the postulated locations of the active branches of the fault zone. In 2018, Applied Earth Sciences was retained by a private landowner to conduct a site-specific fault rupture hazard study for a single parcel in the Century City area, south of Santa Monica Boulevard, which incidentally was situated directly along strike from where previous investigators had found faults in the area using CPT and core boring methods. Our investigation involved multiple phases of exploration, including continuous-core borings and cone-penetrometer soundings, large-diameter borings, and a trench across where prior phases of exploration had confirmed the location of several faults. The trench excavation allowed direct observation of the faults that had previously been mapped by AES and other workers. This project, therefore, presented a rare and fortunate opportunity to directly observe faults in the Santa Monica fault zone in-situ using the trench exploration method. Fortunately for the client, the faults crossing through the subject property were found to be capped by unruptured Pleistocene soil horizons, confirming that the active strand of this fault zone is located north of the subject study area, likely under Santa Monica Boulevard based on other CPT and core data.

“Where to Focus” Using the PFMA/SQRA Process to Manage Risk at a Single Dam or an Entire Portfolio

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Where best to use limited resources is a key decision for dam owners and regulators, whether focused on a single facility or an entire portfolio. Risk informed decision-making (RIDM) was developed by large Federal agencies such as the Bureau of Reclamation and Army Corp of Engineers to address this problem. However, use of RIDM by smaller agencies and dam owners has been less common; perhaps because of a perception that a large commitment of resources is required. The Dam Safety Section of the Colorado Office of the State Engineer has developed a Comprehensive Dam Safety Evaluations (CDSE) process to effectively implement a potential failure modes analysis (PFMA) and Semi-Quantitative Risk Analysis (SQRA) of high hazard dams under their jurisdiction. A SQRA is much less resource intensive than a traditional Quantitative Risk Assessment, yet provides an economical and beneficial process for RIDM. RJH Consultants and Denver Water has successfully used the CDSE process at several dams to economically identify risk-driving potential failure modes (PFMs) and recommend mitigations and investigation activities to address the risk-driving PFMs. Geo-professionals are an important part

of the PFMA and SQRA process because many PFMs are based on impacts from geologic materials and because we are practiced in the big picture thinking that is critical to identifying PFMs, evaluating how PFMs impact a dam and its foundation, and quantifying the likelihood of PFMs resulting in dam failure. This presentation will present our experiences with the SQRA process and case histories highlighting how the SQRA process effectively prioritized PFMs.

Community Effort to Develop an Interactive National-Scale Map of Landslide Occurrence across the United States

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Detailed information about landslide occurrence is needed to develop effective tools for landslide risk reduction and to advance process understanding. The recent revolution in digital elevation data and remote sensing technologies has rapidly advanced landslide identification, yet there is no national-scale map of landslide inventories across the United States. To address this deficiency, we developed a compilation of geodatabases of landslide occurrence across the U.S. We present these data in the form of a searchable online map, with common attributes and centralized access to the original data sources. This map of landslide inventories represents a broad community effort with contributions from numerous local, state, and federal agencies. It highlights the regions where high-confidence mapping has occurred and where additional resources could further improve landslide characterization. Overall, the mapped spatial pattern and density of landslides is consistent with prior qualitative understanding of landslide hazards at the national scale. However, this new compilation is preliminary because it is known to be incomplete across many regions of the country. For example, contributed inventories tend to be biased towards landslides that have been identified because they caused damage to transportation and infrastructure. Absence or sparseness of mapped landslides in areas of moderate to high relief identifies likely areas of insufficient landslide characterization where further mapping is warranted. Planned periodic updates of the database as new or improved landslide data becomes available will maintain and increase its usefulness in coming years. The database provides a starting point for centralized access to information about landslide occurrence for the public, land managers, emergency planners, and researchers. Please contact gs-haz_landslides_inventory@usgs.gov for more information on how to contribute additional inventories to this community effort.

NIOSH Elongate Mineral Particle Research

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During the mining and processing of some mineral commodities and other rock types there is the potential to produce respirable dust containing naturally occurring elongate mineral particles (EMPs), including both asbestos and/or non-asbestos fibers. The National Institute for Occupational Safety and Health (NIOSH) estimated that 44,000 mine workers may be exposed to EMPs. EMPs have been documented to cause lung cancer and mesothelioma in humans in addition to fibrotic lung disease (asbestosis), with some estimating up to 76,700 EMP-caused lung cancer deaths between the years of 1980 and 2009.

Unfortunately, there is little information available relating the geologies of the materials being mined to the potential for EMP exposure to mine workers. There is a strong need for research on fundamental mineralogical properties of EMPs-relevant to toxicology, epidemiology, and exposure assessment-and their geographic distribution, which industry can use as a basis for exposure monitoring and miner protection. This presentation will outline the NIOSH research addressing these concerns including: 1) assessment of miners' potential exposure to asbestos and other EMPs by analyzing bulk material samples previously collected from copper, granite, gold, iron, limestone, sand and gravel, coal, and other types of mines across the country, 2) further elucidation of the toxicology of EMPs by creating new separation methods to allow both in vitro and in vivo toxicity tests on EMPs of specific lengths, widths and other characteristics of concern, 3) establishment of an application of qualitative and quantitative analysis of regulated asbestos and other EMPs for end-of-shift measurement using newly developed and novel techniques for EMP analysis, and 4) making new reference materials (anthophyllite asbestos and actinolite-tremolite asbestos) available to laboratories analyzing the elongate mineral particle fraction of bulk rocks and airborne dusts, and for toxicity testing.

Boone Dam: A Comprehensive Workflow and Data Management System during Project Execution

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The design and implementation of a major dam safety modification project at Boone Dam has generated a huge amount of data, which needs to be quickly compiled, synthesized, visualized, summarized, and analyzed by a diverse team of geologists, engineers, and construction professionals. The Boone Dam Information Management System (IMS) has been created to meet this challenge. The IMS consists of a centralized enterprise database (EDB), a comprehensive Geographical Information System (GIS), a secure File Transfer Protocol (FTP) site, and an interactive website that allows project personnel to upload data to, and interact with the data in these tools. All of these tools are driven by automated workflows, which receive data in multiple formats, validate the data, import it into the EDB, and serve it to reports and GIS tools. From inception of the tool in the early phases of site investigation to its present uses during construction, data within the IMS has served the project team during site characterization, remedial concept design, risk assessments, quality control efforts, workflow routing during construction, and documentation of configuration changes. The structure and content of the IMS is detailed, along with several descriptions of its applications in project activities to date.

Karst in the Southern Highlands of Papua, New Guinea

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The Southern Highlands are formed by a fold and thrust belt that is predominantly capped by Miocene Darai Limestone that has extensive mature to complex karst. The fold and thrust deformation occurred principally during the Quaternary. It is a result of the Australian-Pacific plate subduction north of the island of New Guinea and is still active as evidenced by the February 2018 Mw 7.5 earthquake. The Southern Highlands are a densely vegetated tropical jungle; thus, while published topographic (1:100k) and geologic (1:250k) maps indicate numerous karst features, these maps and traditional aerial photography have limited value in assessing the true nature of the karst. Synthetic aperture radar (SAR) and lidar-based imagery provide the ability to see through the trees and reveal the impressive array of sinkholes and other karst features on the limestone carapace of the

elongate, doubly plunging anticlinal ridges. These features include major river channels abandoned and diverted by the growing anticlines, faults and fractures enhanced by dissolution, and surface textures that resemble an egg carton and alligator skin. Remotely sensed images and oblique aerial photographs will be presented to illustrate these and some current interesting hydrologic features.

3D Groundwater Model of the District of Columbia and Its Use to Assess the Effects and Environmental Impact of Construction Dewatering

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The District of Columbia developed a 3D groundwater model, the objective of which is to quantify the flow, distribution, recharge, and discharge to surface water, and to evaluate the water quality of groundwater resources within the District of Columbia. The intent was to provide detailed and quantitative knowledge of the groundwater resources in the District to understand the contribution of groundwater to the base flow and to address the seepage of non-point source pollution in the District. This poster will illustrate with one example how this groundwater model has been very useful to support the review of applications of dewatering wells for depressurization of the main aquifer of DC, and how the model helps to assess the environmental impact and effects caused by the dewatering or depressurization.

Changing Times: The Evolving Role of Engineering Geology for Considering Resilience in Dam Safety Risk

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In modern dam safety practice, Risk = f (loading, response, consequences). Typical engineering geology input for Risk is for: (1) loading – seismic/geologic hazard; and (2) response – site characterization. By contrast, in considering Resilience, we commonly think of: (1) hydrologic loading, changing over time; and (2) consequences, changing over time. At first glance, engineering geology for Risk does not appear to overlap with Resilience topics, i.e., the “changing” parts are hydrology and consequences, versus the relatively static geology conditions. However...we often think of Resilience as ability of the structure to “withstand” loading; but this is only one facet of Resilience. Resilience also involves ability to “respond” and “recover.” “Respond” is ability to take action during a loading event to compensate for the structure not “withstanding” loading. “Respond” includes actions to achieve the structure’s intended function (i.e., intervention) and actions to lessen consequences (e.g., evacuation). Engineering geology informs evaluation of intervention. Engineering geology also may inform consideration of measures that impede breach, to allow more evacuation and lessen consequences. “Recover” is our ability to take action after the loading event to restore the damaged facility and impacted consequence area. Engineering geology informs post-event conditions and resources required to restore the damaged facility. Engineering geology also informs post-event conditions in the consequence area (denuded banks, destabilized slopes, etc.) and resources required to restore those areas. Usually we focus on the “withstand” part of Resilience. With “Risk” methodologies sweeping the industry, and owners with limited resources, we experience increasing pressure to shift from “withstand”-based solutions to “respond” and “recover”-based solutions. Engineering geologists will have a key role in appropriately characterizing the true ability to “respond” and true cost of “recover,” so we don’t inadvertently delude ourselves into over-relying upon “respond” and “recover” instead of “withstand” as we consider Resilience while grappling with Risk.

Environmental Forensic Analysis of Data for Evaluation of a Statically Significant Increase (SSI) in Ground Water Monitoring Data at an Environmental Remediation Site

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Evaluation of a Statically Significant Increase or Statically Significant Decrease (SSI/SSD) is typically required when an out-of-control statistical condition is observed for a well-compound pair and the SSI/SSD is confirmed via a verification resampling procedure. The purpose of the subject project was to identify potential construction related impacts to groundwater quality in the event that the subject construction activities had an adverse effect on the integrity of a Barrier Wall and Groundwater Collection/Treatment System present at an adjacent environmental remediation site. SSI Evaluation Reports were conducted utilizing available data to determine if the SSI was attributed to construction related activities or other natural or anthropogenic activities. The SSI evaluation included analysis of other forms of site performance monitoring data including: groundwater level data measured in monitoring wells, inclinometer data collected to detect ground movement in vertical boreholes, vibration monitoring data from seismograph vibration monitors, and deformation monitoring data from prisms installed to detect transversal, longitudinal and vertical displacement. During the course of the project, multiple SSI evaluations were conducted utilizing available data to identify lines of evidence which indicated which of the potential natural conditions or anthropogenic activities was the likely cause of the observed SSI.

The Oroville Dam Spillways – Wrapping up Construction and Moving Forward

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On February 7, 2017, a hole formed in the concrete-lined spillway chute at Oroville Dam. The events that unfolded over the next few months led to damage to both the spillway chute and the unlined emergency spillway. The spillway recovery design and construction effort had the short-term goal of repairing the damage in time for the 2017–18 winter season, and the two-year goal of restoring capacity to both the spillways. During the span of about two years, the geology team completed a massive amount of geologic exploration to support the recovery design and construction: over 170 rock core borings, 20 seismic refraction lines, over 2 million square feet of geologic mapping, installation of over 40 piezometers and 10 inclinometers, and many other design, construction, and dam safety-related tasks. As the construction effort has tapered off, the DWR has initiated a comprehensive review of the Oroville Dam facilities as part of the Oroville Dam-Safety Comprehensive Needs Assessment. This dam safety program uniquely applies qualitative risk analyses to identify opportunities to improve the reliability, redundancy, and resiliency of the Oroville Dam facilities. This risk assessment will be incorporated into DWR’s State Water Project asset management program to help identify areas statewide that need the most improvement. The geological information collected and analyzed during the spillways recovery design and construction efforts will provide a sound basis for evaluating the geology-related potential dam safety risks associated with the Oroville Dam spillways.

16 % and 2 %, respectively. Overall, the hydrogeochemistry of the groundwater was classified into three zones from North to South based on the major aquifer subunits. Precipitation and rock-water interaction were identified to dominantly influence the groundwater chemistry in the region. The surface water chemistry, on the other hand, was influenced more by precipitation with minor contribution from the proximal aquifer system. Principal component analysis (PCA) revealed that four components explained ~70% of the variance seen between the geochemical parameters, with two out of the three groundwater zones exhibiting significant clustering. Chloride was an important factor affecting the surface waters of RBR, whereas the groundwater had a complex array of parameters influencing its chemistry owing to diverse aquifer properties. Few groundwater samples showed higher than normal values for certain cations of concern, including arsenic and mercury. The characterization of the groundwater and surface water obtained through this study will help in better managing the quality of the water resources and serve as a baseline for future studies in the UPRW region.

Case Study on Atmospheric Deposition of GenX Part I and Part II

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Measurements of a per- and polyfluoroalkyl substance (PFAS), C3 Dimer Acid or GenX, were made in the Cape Fear River in North Carolina. The source of the GenX was a Chemours chemical facility in Bladen County, North Carolina. Industrial discharges to the Cape Fear River contributed to the compound's measurement in the river and water system intake sites along the river to Wilmington North Carolina. Residential drinking wells nearfield to the facility were sampled and the results also indicated the GenX compound in the groundwater. Further investigation into the air emissions from the facility, including a requirement for first of its kind source testing, assisted in understanding the facility's air emissions contribution of GenX to the groundwater. Air dispersion and deposition modeling was coupled with well sampling to evaluate the field of contamination. Although ambient air measurement of GenX was deemed to be difficult, measurement of GenX in water was possible. Ultimately rainwater sampling was performed by Division of Air Quality staff near the facility during several rain events in early 2018. The results indicated atmospheric deposition of GenX. Further investigations measured GenX deposition through rainwater measurements at high concentrations five and seven miles from the facility. GenX was measured in rainwater as far as 21 miles from the facility. Measurements from the sampling in early 2018 helped to develop a baseline for deposition. Fixed rainwater collection sites were established in April 2018 and weekly samples have been analyzed. The rainwater deposition data is being evaluated with the introduction of carbon adsorption interim control devices and process data from the facility. Rainwater collection will continue into the future as the facility adds additional controls for their air emissions.

Comparing Use of Semi-Analytical and Dual-Domain Method as Matrix Diffusion Modeling Tools

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A recently adapted semi-analytical method was utilized as a diffusion modeling tool in a series of fractured media experiments. In the parallel fractured system, all modeling parameters of the semi-analytical method can be computed directly using the fracture spacing and aperture. For the dual-domain method, the mass transfer coefficient can only be estimated using an empirical formula. Results indicate that as fracture spacing increased, the normalized root mean square errors (NRMSEs) between the concentrations simulated by the dual-domain models and the analytical solutions increased (up to 18% at the largest fracture spacing). Meanwhile, the NRMSEs between the concentrations simulated by the semi-analytical method and the analytical solutions remained largely constant at less than 4% and were attained without calibration. Results are similar when the sorption or the decay rates were varied along with the fracture spacing. Coarse grid dual-domain and semi-analytical models were created to simulate contaminant transport in 3D fine-grid heterogeneous models but at a fraction of the computational costs. Mass rates from coarse grid models were compared against mass rates from the fine-grid 3D models. Coarse grid models require calibration of either the mass transfer coefficient when the dual-domain method is used, or the diffusion length when the semi-analytical method is used. Prior to calibration, in a highly diffusive system, the semi-analytical method produced mass rates matching those of the fine grid models at a NRMSE of 5%, whereas the dual-domain model produced a larger NRMSE of 16%. In a less diffusive system, the semi-analytical method achieved a NRMSE of 1% while the NRMSE of the dual-domain method was 8%. The NRMSEs can be lowered for both models with calibrations.

Geologic Assessment of Bridal Veil Falls near Highlands, North Carolina

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The U.S. Forest Service requested Anchor QEA to perform a geologic assessment of Bridal Veil Falls, located in Franklin, North Carolina. The goal of the assessment was to determine the potential for rock fall, to understand potential risk to the visiting public, and to develop appropriate mitigation strategies. The location is known for the novelty of being able to drive under the falls, which was the result of excavating into the cliff-face to create the roadbed. Many years ago, the road was re-routed to pass in front of the falls. Now the former roadbed is a roadside attraction allowing the visiting public to walk behind the falls. The location has been subject to several rock fall episodes throughout its history. As part of the geologic assessment, work was performed to understand the structural character of the area. Structural measurements of discontinuities were made along a scanline at the base of the cliff and above the cliff with rope assist. Measurements on the cliff face were more difficult to obtain without using more advanced rope methods or renting a manlift. Instead, data collection on the cliff face was made using lidar, safely from the road surface, and resulted in a unique dataset collected in a single day. The resultant data set is stored as a 3-dimensional data cloud of geo-referenced x, y and z data points. The resulting 3D scan was used to identify discontinuities and determine their orientations on the cliff face in out-of-reach locations. The data were then compared to field measurements made with a Brunton compass. Potential rock fall locations were identified and ranked based on potential risk to visitors of the roadside attraction.

Effects on Pre-Excavation Grouting Posed by Limestone Interbeds in Shale Bedrock

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Soft shales overlying karstic limestone is a common occurrence in the Midwest. There have been major CSO tunnel projects constructed in karstic limestone. Quite often this requires excavation through the overlying shale for shafts and near-surface structures. These interbeds of limestone in the shale can influence the overall rock mass behavior in ways that are not often anticipated with respect to pre-excavation grouting.

Characterization and Analysis of the Cedar Pass Landslide Complex, Badlands National Park, South Dakota

Radach, Kyle, Colorado School of Mines, Department of Geology and Geological Engineering, kradach@mymail.mines.edu; Paul Santi, psanti@mines.edu (TS #19)

The purpose of the research discussed in the presentation is to characterize and analyze the Cedar Pass Landslide Complex located in Badlands National Park, South Dakota. Over the last three decades, the Park Service has had to regularly maintain the approximately 1.25-mile section of Badlands Loop Road (South Dakota Hwy-240), which travels through the landslide complex. Road surface distress caused by slope movement and other natural processes in the Cedar Pass area have created a financial burden for the park, as the Park Service is responsible for maintenance of the highway. While there has been successful mitigation work completed to stabilize portions of the road, stability and erosion problems have persisted. Maintenance and mitigation work completed to this date include the construction of two large earth buttresses, roadway resurfacing, regular crack sealing and asphalt patching or grinding to smooth surface offsets, and the installation of a new stormwater collection and conveyance system. Various geotechnical investigations have been conducted to analyze parts of the complex, but detailed field mapping of landslide features and slope stability modeling of several untreated landslides has not been completed. This project aims to produce detailed maps of the multiple landslides in the complex, focusing on specific landslide-induced geomorphic features to identify the lateral extent of earth movement. In addition to mapping, laboratory testing to calculate material strength and slope stability modeling was completed. The modeling outcomes were used as a basis to test the effectiveness of a variety of remedial measures the park may implement to increase the overall stability of the landslides and to reduce the required maintenance of the roadway. The results of mapping and modeling will be shared with Park Service staff to help them make future management decisions regarding the highway.

Communicating Volcano Hazards and Risk: Before, during, and after a Crisis

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The mission of the U.S. Geological Survey (USGS) Volcano Hazards Program (VHP) is to enhance public safety and minimize social and economic disruption from eruptions. VHP accomplishes this through delivery of forecasts, warnings, and information of volcano hazards that are based on scientific understanding of volcanic processes. Mission success depends upon effective communication of potential volcanic hazards and risks to emergency-management professionals and the public before, during, and after a volcanic crisis. VHP hazards and risk communication occurs in many different ways. (1) Collaboration with emergency management partners before a volcanic crisis

helps prepare populations at risk from potential volcanic hazards. VHP participates in volcano working groups with local, state, and Federal partners to prepare interagency coordination plans and deliver consistent messaging to populations that can be impacted by volcanic events. This collaboration helps strengthen necessary relationships between VHP and partners. (2) During times of crisis, these established lines of communication facilitate the delivery of timely warnings of potential volcanic hazards and risks to emergency-response decision makers. VHP scientists serve as liaisons in emergency operations centers during times of crisis, ensuring that the latest volcano monitoring data and activity forecasts are available to serve as the analytical foundation upon which emergency managers can integrate their information, assets, abilities, and priorities to make science-based decisions. VHP coordinates public communications with partners using notices of volcanic activity, websites, and social media. (3) Following a crisis, VHP and partners evaluate the effectiveness of communications to target audiences and develop strategies and products to improve preparation for the next volcanic eruption.

Identifying and Mapping the locations of Landslides after the 2018 Floods in Kerala, India, Using Remotely Sensed Satellite Imagery

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The Monsoon of 2018 turned out to be devastating for India's southernmost state of Kerala with more than usual rainfall, which led to severe flooding. Termed as the worst flood in the century, more than a million people were evacuated, 483 people died, and U.S. \$5.6 billion worth of property was damaged. These rains also triggered thousands of landslides in the mountainous regions. This study aimed to identify landslides that occurred in Idukki District in Kerala using high spatial resolution optical satellite images from the planet. Landslide analysis was done using several image processing tools like change detection using image differencing, Normalized Difference Vegetation Index (NDVI) change, and unsupervised classification of the post-event image. A thresholding technique was also applied to identify the change and no-change categories in the images produced by image differencing. Output files from the image processing were used to map the landslide location, shape, and size. Validation of the results was done by field survey at selected locations. Although confidence in our landslide map is reasonable, we identified several factors that could contribute false alarms, like the uncertainties in the images due to the swelling of Muthirappuzhayar River, giving us landslide-like results that need to be rectified.

Staten Island Serpentinite

Ray, Robyn, EMSL Analytical, Inc., rroy@emsl.com (TS #7)

Naturally Occurring Asbestos (NOA) is found in the contiguous USA. Here on the East Coast the asbestos mostly follows the axis of the Appalachian Mountains. In a USGS map published in 2005, Brad Van Gosen listed 60 former asbestos mines, 66 former asbestos prospects and 205 asbestos occurrences on the Eastern United States, from Maine to Alabama. This presentation will discuss a historically important site on Staten Island. On Staten Island and Manhattan, a serpentinite lens can be found in north central Staten Island. The serpentinite here is of a low-grade metamorphism of peridotite. Research conducted in 1994 has suggested that average sample of the Staten Island serpentinite contains 66% lizardite and 27% chrysotile. Minor talc, anthophyllite, olivine, chromite, and magnetite makes up the remaining 7%. H.W. Johns began mining this low quality chrysotile for

local manufacture of fire-resistant shingles and this would later become Johns Manville. We collected samples of soil and rock from the highway road cut that crosses Staten Island. We will present the results of our study at the conference.

Site Characterization for Risk Assessment of Cougar Dam, McKenzie River, Oregon

Richards, Kevin; U.S. Army Corps of Engineers Risk Management Center, kevin.s.richards@usace.army.mil (TS #9)

Cougar Dam is a 519-ft-high, zoned, rockfill dam on the South Fork of the McKenzie River, Oregon. The project stores up to 219,000 acre-feet of water, providing flood risk, recreation, and hydropower economic benefits in addition to being a source of irrigation water and maintenance of low flows during dry periods. Designed in the late 1950s and constructed in the early 1960s, the dam was first filled on June 19, 1964. The dam is operated with high pools in the summer recreation months with fall drawdowns of 150-ft for the winter wet season. The dam has experienced 1% total settlement that is not considered unusual for rockfill dams. However, it has a history of continuous settlement punctuated by short periods of accelerated differential settlement. The differential settlement is characterized by an echelon displacements in the crest along prominent longitudinal cracks. The majority of settlement is in the upstream segments, which is an ongoing concern. The original 1950s embankment design did not consider seismic loads. During the period from 2009 to 2016 there were several advances in the understanding of seismic hazards from Cascadia Subduction Zone seismic events. The USACE is conducting a quantitative risk assessment for Cougar Dam, which required an update of the project site characterization. This paper will discuss the project background, details of the site investigation plan and goals and latest site geological engineering characterization in the context of the risk assessment.

Preliminary Results – Risk Assessment of Cougar Dam, McKenzie River, Oregon

Richards, Kevin, U.S. Army Corps of Engineers, kevin.s.richards@usace.army.mil (TS #9)

Cougar Dam is a 519-ft-high zoned, rockfill dam on the South Fork of the McKenzie River, Oregon. The project stores up to 219,000 acre-feet of water, providing flood risk, recreation, and hydropower economic benefits in addition to being a source of irrigation water and maintenance of low flows during dry periods. Designed in the late 1950s and constructed in the early 1960s, the dam was first filled on June 19, 1964. The dam is operated with high pools in the summer recreation months with fall drawdowns of 150-ft for the winter wet season. The dam has experienced 1% total settlement that is not considered unusual for rockfill dams. However, it has a history of continuous settlement punctuated by short periods of accelerated differential settlement. The differential settlement is characterized by an echelon displacements in the crest along prominent longitudinal cracks. The majority of settlement is in the upstream segments, which is an ongoing concern. The original 1950s embankment design did not consider seismic loads. During the period from 2009 to 2016 there were several advances in the understanding of seismic hazards from Cascadia Subduction Zone seismic events. The USACE is conducting a quantitative risk assessment for Cougar Dam, which required an update of the project site characterization. This paper will discuss the project background, details of the site investigation plan and goals and latest site geological engineering characterization in the context of the risk assessment.

The Dissolution Front: A Qualitative Geospatial Model Developed to Assist in Dam Safety Assessment at Mosul Dam, Iraq

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In 2017–18, an exploratory program was undertaken at Mosul Dam, which provided the first new data in 30 years about the condition of the sulfate-bearing stratigraphic layers of the foundation. From this data, GIS surfaces were generated which reflected the condition of the strata according to a conceptual model known as the “dissolution front.” The dissolution front describes the zone of active dissolution where fresh sulfate rocks are being degraded to some point along the weathering continuum between intact anhydrite/gypsum to stable collapse breccia. The front is characterized by rapidly changing subsurface conditions which can be observed in drill core and OPTV images, and further indicated by grout takes, piezometer behavior and surface displacement. Several datasets were compiled in the geospatial analysis including: piezometer contours, original top of ground contours, faults, sinkholes, bathymetry and daylighting geologic contacts. The final geospatial model of dissolution presented a clearer picture of the foundation condition and seepage, and was able to identify and confirm areas of dam safety interest, which may impact future grouting and other interventions.

A Geospatial Model of Dissolution in Gypsum Karst to Facilitate Dam Safety Assessment and Remediation at Mosul Dam, Iraq

Robison, Laurel, United States Army Corps of Engineers Nashville District, laurel.e.robison@usace.army.mil (TS #14A)

From 2017–19 an exploratory program was undertaken at Mosul Dam which provided the first new data in 30 years about the condition of the sulfate-bearing stratigraphic layers of the foundation. From this data, stratigraphic intervals of interest were assigned a qualitative value at each boring, and surfaces of these units were generated by automated interpolation in GIS using kriging. The resulting surfaces reflected the condition of the strata according to a conceptual model known as the “dissolution front.” The dissolution front describes the zone of active dissolution where fresh sulfate rocks are degrading to some point along the weathering continuum between intact anhydrite/gypsum to stable, low-permeability collapse breccia. The front is characterized by rapidly changing subsurface conditions which can be observed in drill core and OPTV images, and further indicated by grout takes, piezometer behavior and surface displacement. Several datasets were compiled with the dissolution surfaces in a dam safety analysis including: piezometric contours, water pressure tests, original top of ground contours, InSAR imagery, faults, sinkholes, bathymetry and geologic contacts expressed at the surface. The final geospatial model of dissolution presented a clearer picture of modern foundation condition, character and seepage, and confirmed areas of dam safety interest, which may inform future grouting efforts and other interventions.

Geotechnical Investigation of a Landslide at the Howard Cemetery, Loyall, Kentucky – The Integration Dynamics of Regional and Stress-Relief Fracture Systems

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A rockslide occurred in February, 2016 that endangered historic graves within the Wix Howard Cemetery located adjacent to the USACE Cumberland River flood control channel near Loyall, Kentucky. The slide first appeared as settlement cracks with one foot of vertical movement and quickly progressed in the following weeks to 5 feet of horizontal and 15 feet of vertical movement. The slide was near the grave of a Revolutionary War Veteran, Samuel Howard, causing the focus of both congressional and regional media attention. The USACE Nashville District performed two rounds of geotechnical investigation, utilizing an optical-acoustical televiewer to define and orient the subsurface fracture systems of the slide bedrock. Lidar high-resolution imagery was used to map the surface, outline the fracture surfaces, determine movement, and define areas endangered by the slide. The televiewer logging and field exploration revealed the basal failure plane of the slide to be a clay shale seam approximately 1 inch thick, which exhibited slickenside surfaces. The regional vertical fracture responsible for the initial phase of failure was found to be oriented parallel to several strike-slip faults in the area that are associated with the Pine Mountain Thrust Fault. The integration of the vertical and stress-relief fracture systems was determined to be the secondary phase of the slide, allowing increased infiltration of water. This infiltration allowed the basal clay shale seam to become hydrated, experiencing subsequent failure due to the reduced angle of friction and increased hydrostatic pressure. These two failure factors resulted from the enhanced infiltration produced by the integration of the regional and stress-relief fracture systems within the slide area.

Investigating Sources of Heavy Metal Contamination in the Tri-State Mining District

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Heavy metal release from historic mines and abandoned mine waste has caused major water quality issues in Missouri. However, these contaminants can also occur naturally in bedrock layers, and it is not always clear whether high levels of these contaminants in the groundwater are the result of historic mining or dissolution through undisturbed strata. This project will investigate whether heavy metal contamination observed in the historic tri-state mining district is derived primarily from anthropogenic or geogenic causes. To determine this, groundwater monitoring wells will be installed near streams that are impaired by heavy metals. Some wells will be placed down-gradient of historic mining areas, while others will be placed in unmined areas. Water samples will be collected from all wells, and elemental concentrations and ratios will be determined using an ICP-MS. The water quality data will be analyzed using groundwater mixing models and other statistical techniques to determine the source of the contaminant. This project is expected to advance the use of elemental isotopes to determine contaminant sources and aid in groundwater remediation efforts.

Risk-Based Approach and 3D Modelling Clarify Artesian Pressure Risk – An Example from a FERC RIDM Pilot Project

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Alcona Dam is one of the first projects to implement Risk Informed Decision Making under a pilot program for FERC regulated projects. One of the Potential Failure Modes (PFMs) at Alcona Dam was related to high artesian pressures at the site. A comprehensive review of historic and modern records at this 100 year old dam resulted in a much more complete understanding of risks posed by high artesian pressures at the site. Review of original construction photographs and development of a 3D model revealed that risks associated with artesian pressures were significant during construction. Hundreds of borings and numerous subsurface cross sections were compiled into the 3D model along with the powerhouse, spillway and dam features. The 3D model allowed for a comparison of the location of the confining clay layer overlying the artesian aquifer before and after initial construction that included driving of wood piles and steel sheetpiles through the clay confining bed. A key historical cross section and the 3D model revealed that the confining clay layer had broken and dropped in elevation due to the pile driving activities during initial construction. Use of the 3D model, along with artesian pressure and flow monitoring records, were instrumental in the development of potential failure modes and evaluation of artesian related risks, resulting in the understanding that the risks posed by the artesian pressures are significantly less for the constructed structure than they were during construction.

A Proactive Approach to Addressing Potential Acid-Producing Rock-Potters Mills Gap Transportation Project

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In 2002, during construction of Highway I-99 at Skytop on Bald Eagle Ridge in Centre County, Pennsylvania, the inadvertent excavation and use in embankments of acid-producing rock (APR) resulted in acid-rock drainage that contaminated Buffalo Run and local water wells. The incident suspended construction of the I-99 project for several years, and the subsequent remediation cost more than \$79 million. PennDOT has applied the lessons learned from the Skytop experience to subsequent highway construction projects as exemplified by the Potters Mills Gap Transportation Project (PMGTP), which is currently under construction in Centre County, Pennsylvania. The PMGTP includes deep cuts through the same Ordovician-age clastic rocks that contained vein sulfide deposits at Skytop, so during design of the PMGTP, core samples from all drilled borings were collected and laboratory-tested for the presence of potential APR. The chemical testing indicated no significant sulfide deposits in the Bald Eagle and Juniata Formations; however, elevated sulfur concentrations were measured in a portion of the underlying Reedsville Shale. Within the zone of elevated sulfur concentrations in the Reedsville Shale, the construction drawings and specifications require encapsulating and treating the potential APR with lime and covering potential APR rock cut slopes with a geomembrane and geocells containing limestone gravel. An anomalous elevated sulfur concentration in one core sample in the Bald Eagle Formation prompted the drilling of inclined borings intended to intercept near vertical dip joints in the Bald Eagle Formation, which were considered most likely to contain

vein sulfide deposits introduced during the Alleghenian orogeny. During construction, a geologist routinely visited the rock excavations to examine blast hole cuttings, excavated rock, and rock cut slopes for indications of potential APR and to measure the pH of seeps and springs. This paper illustrates Penn's proactive approach to addressing potential APR on the PMGTP.

Characterizing the Geology and Geotechnical Conditions of Soft Soils Surrounding Aged Water Tunnels in Detroit Using an Integrated Multi-Faceted Investigation Campaign

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The City of Detroit's principal raw water tunnel system pumps up to 350 MGD of raw water from the Belle Isle intake on the Detroit River to three Water Treatment Plants: Water Works, Springwells, and North-east. The raw water tunnels were hand mined from the 1920s to the 1940s using compressed air and various liner construction methods, ranging in diameter from 10 to 14 feet. Over the last decade, diver inspections have identified localized damaged sections up to several hundred linear feet. In order to maximize the future service life of the tunnels, sections of the tunnels are going to be rehabilitated. To evaluate best repair methods, a series of geological, geotechnical and survey studies were performed over the damaged sections. The studies included background geologic review to evaluate the geologic origin and inherent variability of the glacially-derived soil formations surrounding the tunnels, a series of geotechnical studies to evaluate soil properties and loading on the tunnels, and ROV/diver surveys of the water filled tunnels to assess characteristics such as ovality and crack patterns. The geologic studies indicated that some of the damaged tunnel sections included zones completely encapsulated by soft lean clays described as Late-Wisconsin era glacial materials. Other damaged sections had tunnel crowns excavated in soft soils but the inverts rested in older, much denser glacially derived cohesive to granular soils with occasional boulders, locally termed Hardpan. Geotechnical studies performed included conventional soil sample borings to collect samples for laboratory testing, Cone Penetration Tests, insitu vane shear tests, pressuremeter and dilatometer tests, and installation of standpipe and vibrating wire piezometers to monitor groundwater levels and fluctuations. A comprehensive Geotechnical Data Report (GDR) summarizes this dataset, and an interpretive review of insitu soil conditions compared to mapped tunnel damage will be conducted in the next phase of the study.

Abandonment-In-Place of USTs at Complicated Sites

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Removal of Underground Storage Tanks (USTs) is a common industry practice to address USTs that are out of service, damaged, or leaking. Due to a variety of complicating issues with structures, utilities, poor subsurface conditions, and disruption to site activities, in-place closures may be the preferred option to keep operations going while being less expensive than trying to remove the UST. This presentation will provide an overview of the in-place closure process, common regulatory items to keep in mind, and information needed to generally assess if in-place closure of USTs is a good option for your site. Multiple case studies will be provided as examples.

Reliability Analysis in Engineering Geology

Santi, Paul, Colorado School of Mines, psanti@mines.edu (TS #14A)

One form of risk assessment that is seldom used in engineering geology is reliability analysis. In traditional engineering design, it often measures failure of mechanical or electrical components. However, these well-developed tools can be used in engineering geology for a variety of applications, including instrumentation, mitigation, and hazard analysis. Examples of series, parallel, or hybrid networks are given for measuring piezometric levels in landslides, debris-flow hazard prediction, debris-flow mitigation, and bridge-scour reduction. Fault tree analysis is another powerful tool to estimate failure rate, but it requires special attention to performance of individual components and it must be accompanied by a sensitivity analysis. Case studies of the Taum Sauk dam failure and the Oroville dam near-miss illustrate the benefits of fault tree application. The concept of bathtub curves, which specifies useful life periods of constructed features, with failure rates highest both early and late in the life cycle, also applies to many engineering geology problems. Designing for maintainability is also important, and examples are given of accessibility, modularization, standardization, and interchangeability in engineering geology projects. Finally, rules of thumb to optimize reliability include converting series to parallel systems, converting "or" gates to "and" gates during planning, and quantifying error estimates for each design component.

Securities and Exchange Commission S-K 1300 Rules – Understanding the Changes and Complexities

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In October 2018, the Securities and Exchange Commission's (SEC) adopted amendments to modernize the property disclosure requirements for mining registrants, and related guidance, under the Securities Act of 1933 and the Securities Exchange Act of 1934 and Industry Guide 7. The amendments, designated as Regulation 1300, are to be provided to investors to provide a better understanding of U.S. registrants mining properties. These disclosures will align the SEC's disclosure requirements with the international practice and standard. SEC's Industry Guide 7, which only allowed Reserve reporting is rescinded and new disclosure rules will be reported in subpart 1300 in Regulation S-K, effective January 1, 2021. This reporting will align and be largely consistent with the Committee for Reserves International Reporting Standards (CRIRSCO) under NI43-101. All U.S. registrants that show Materiality shall report all aspects relating to the Exploration Information, Mineral Resources, or Mineral Reserves on which the audience of a Public Report and include a balanced discussion on uncertainties and risk for the Resource and Reserves. The reporting will be by a Qualified Person (QP) defined as suitably qualified and experienced mining industry professional(s) who are either Registered Members of SME or eligible members of another Recognized Professional Organization (RPO) subject to an enforceable professional code of ethics and rules of conduct.

Engineering Geology Investigations for the Cedar Cliff Auxiliary Spillway Upgrade Project, Southwest North Carolina

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Engineering geology investigations were performed to support the Cedar Cliff Spillway Upgrade Project (SUP). The SUP includes deepening and widening the existing Auxiliary Spillway Channel and replacing the two existing erodible fuseplugs with an engineered, concrete Fusegate system. The existing spillway will be widened from 95 feet to 145 feet and the channel bottom will be lowered by 15 feet on average. The rock cut height along the eastern side of the channel wall will increase from a current average height of 127 feet (160 feet maximum) to an average height of 162 feet (220 feet maximum). Twenty-five-foot-wide intermediate benches are included to divide the steep slopes into 60- to 90-foot-high sections. The field investigations included: field reconnaissance to describe rock lithologies and measure structural features (contacts, foliation, joints, and other discontinuities); drilling of 26 boreholes and geophysical logging consisting of optical and acoustic televiwer and synthetic caliper logs calculated from the acoustic televiwer travel time data; measurements of the Joint Roughness Coefficient of rock mass discontinuities (foliation and joints) for estimating rock mass discontinuity shear strength; and selection of rock samples for geotechnical laboratory testing, including unit weight of bedrock, unconfined compressive strength of bedrock, and splitting tensile strength of bedrock. The field and laboratory data were used to determine the primary orientation and continuity of the rock mass discontinuities used in the kinematic analysis of potential rock slope failure modes of the proposed cuts, to estimate the rock mass strength parameters for the Fusegate structure foundation, to determine the shear strength of the rock mass discontinuities for analysis of rock slope stability and the design of rock cut stabilization methods, and to determine the shear strength of the concrete/rock interface for analysis of potential sliding of the Fusegate foundation sill.

PFAS in North Carolina – State Regulatory Climate and Developments Part I and Part II

Scott, Michael, NC Department of Environmental Quality, michael.scott@ncdenr.gov (TS #3B)

Michael Scott, Division of Waste Management Director within the Department of Environmental Quality, will present on the Division's ongoing investigations of PFAS compounds in the environment, how that has led to multiple media being tested across the state for PFAS and the importance of stakeholder engagement.

A Catchment Based Microzonation of Landslide Zone – A Case Study of Sirobagarh Landslide Zone, Uttrakhand, Garhwal Himalayas, India

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The Sirobagarh landslide zone falls at the major pilgrimage transportation route NH-58 to Kedarnath and Badrinath in the Garhwal Himalayas, India. This region is a nightmare for the people living nearby and commuters. An attempt has been made to do microzonation of this landslide zone with a view to demarcate the most vulnerable slopes to failure. Geological structure of the area and consequent development of hydrostatic pressure due to heavy precipitation appears to be the major reason of multiple failures in this zone. Slopes in the region consist of highly jointed quartzites, along

with weathered, loose, crushed, and pulverized rock mass made of quartzites and shales. There are a number of small streamlets traversing the landslide area that meet at high angles with the Alaknanda River flowing parallel to landslide zone. Catchment based microzonation of this region is carried out using LHEF ratings, where each catchment represents a facet and defines the land area where surface water can be accumulated. The various landslide causative factors, which are found significant in the present study are lithology, slope morphometry, hydrogeological conditions, relative relief, and flow accumulation. Geological and geotechnical data of these catchments are collected and further utilized for the determination of facet wise Slope Mass Rating and Continuous Slope Mass Rating. The LHEF results are been compared with evaluated values of SMR and CSMR and are found to be in good agreement with each other. Catchment facets that belong to present failure processes and that are near failure are clearly demarcated in this study. Catchment-based micro-zonation of hilly terrains can be very useful for adopting suitable measures for stabilizing the hill slopes. This study also reveals the usefulness of GIS in large-scale microzonation of landslide areas.

Communicating Climate Science with Professional Practitioners in Multiple Sectors

Shea, Eileen, CASE Consultants International, shea@caseconsultantsinternational.com; Marjorie McGuirk mcguirk@caseconsultantsinternational.com; Scott Shuford, shuford@caseconsultantsinternational.com (TS #6)

Beginning with the formation of the U.S. Global Climate Change Research Program in the 1980s, great efforts have been expended to communicate climate science in meaningful ways. To build resilience to a changing climate, use-driven science knowledge must be imparted to those who act on it, while at the same time, climate service professionals must listen to the needs of those actors in order to prepare the most usable products, summaries, and services that apply to the various sectors. Eileen Shea will present a broad sweep of history of climate services and the evolution of use-driven communication, ending with efforts by CASE Consultants International to mainstream climate science into the practices of professionals in climate-sensitive sectors, such as architecture, public health, transportation infrastructure, brownfields, polity and security.

Surface Water Quality in Missouri

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The natural variance in water quality in low-order streams can make interpretation of water quality data difficult. Misinterpretations can easily occur when attempting to understand these variances when data are collected irregularly or at long temporal intervals. The research presented here seeks to better understand water quality variability as a function of season and land use/land cover. Data were acquired in low order streams in the Mid-Missouri area. Five of the sampled watersheds are primarily forested, five are primarily urban, and four are rural residential/agricultural. Water quality parameters that were evaluated include pH, turbidity, electrical conductivity, temperature, nitrate concentrations, bacteria count, and biotic index. Data with higher temporal resolution were also acquired at the rural residential/agricultural to better understand temporal variations in water quality in these streams.

Planning for Changing Land Use Practices in Climate-Changed-Precipitation: A CASE Example of Climate and Geo Sciences Expertise

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Communities are reeling from the continual flooding brought on by unprecedented heavy precipitation. Both riverine flooding and inland coastal flooding have washed away the steady-state planning in urban and rural areas. How to bring professional planners and geologists together with climate scientists to assess the need for new flood plain practices is the topic of this talk. Scott Shuford, an AICP professional planner, has led climate resilience work with the American Planning Association over the past decades. He describes case studies of his efforts in land planning and working with geologists to advance the resilience of neighborhoods and counties.

DRONES! Geologic Discontinuity Mapping Using UAS (Unmanned Aerial System) Technology and Photogrammetric Methods for Rock Fall Mitigation

Simpson, Bryan K., Bureau of Reclamation, BKSimpson@usbr.gov (TS #17)

This presentation provides an illustration of recent UAS technology and photogrammetry methods used in support of geologic mapping to evaluate ongoing rock fall analysis of the Hoover Dam area, located near Boulder City, Nevada. Photogrammetry data collected by a UAS was used successfully in conjunction with field geologic mapping, which included collection of topographic data and measurement of joint orientations to develop a comprehensive three-dimensional model of exposed rock faces. Digital photographs were taken of the exposed rock faces in the rock fall project area. This work was performed using off-the-shelf UAS, cameras and autonomous flight planning which allowed for rapid and repeatable data collection (20-minute flight times). "Boots on the ground" dip and dip direction measurements were also taken of select rock faces for ground truthing. DTMs (Digital Terrain Models) were constructed of the project area using on the order of 400 digital photographs per flight. Processing included face recognition of exposed rock faces, statistical/kinematic analysis of potentially incipient sliding, topple and wedge rock fall failures as defined by joint sets, and presentation of stereonet pole plots. Lessons learned regarding the processing challenges included using different camera settings for specific field conditions, overcoming lighting variations, and optimizing survey and ground control requirements. With the use of photogrammetric methods via UAS data collection, very accurate data can be easily obtained, which has many advantages over traditional surveys. Kinematic analysis performed for specific areas that indicate incipient rock may occur. Considerations provided regarding implementation of mitigative rockfall measures. Additional UAS data collection flights are planned in the future to allow for comparison and difference modeling of rock face photogrammetric models over time to determine rock fall that has occurred, detect incipient rock fall, and provide kinematic data in support of rock fall mitigation.

Studying the Relationship between Transit Systems and Economic Segregation in Three Major MSAs

Singh, Vani, UNC Charlotte, vsingh12@uncc.edu; Todd Doane, tdoane@uncc.edu; Luis Martinez, lmarti98@uncc.edu (Poster)

This project examines geographic patterns of income segregation in relation to the opening of transit systems. We analyzed the spatial distribution of income classes across the Metropolitan Statistical Areas of Washington DC, Minneapolis, and St. Louis, using decennial median household income data at the census tract level and coordinate data for transit stations opened between 1970 to 2010. We conducted hot-spot (Getis-Ord G_i^*) analysis of each MSA for each decennial census year and compared them with opening dates of each station. Through the hotspot analysis, we are able to visualize and quantify the changes in income segregation through time. Our results demonstrate similar patterns of economic segregation in each MSAs. In general, patterns did not change much. However, after the opening of stations, some neighborhoods saw higher-income residents moving away from station neighborhoods, creating areas lower-income. Therefore, the new stations seem to be a factor in the change. However, it is important to note that spatial correlation does not necessarily imply causation, and that other factors may be playing a role in causing the change.

Vapor Phase Source Area Loading at a Dry Cleaner Site

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Source area groundwater concentrations of perchloroethene (PCE) at a dry cleaner in New Mexico indicated DNAPL source. Initial concentration at a loading dock monitor well where the spill occurred had initial PCE concentration of 170,000 $\mu\text{g/L}$, roughly 10 percent the solubility indicating DNAPL. Nonetheless, nested monitoring wells several hundred feet downgradient were clean in deep intervals, providing countervailing indication of DNAPL. A soil vapor extraction (SVE) system was installed to initiate source removal. Four SVE wells spanned the areas of spills. Initial influent PCE vapor concentrations upon SVE startup were 6,900 mg/m^3 . At 7 days of operation, PCE vapor concentration was reduced to 2,100 mg/m^3 , and at 60 days, to 490 mg/m^3 . Within 120 days, PCE vapor concentrations were less than 50 mg/m^3 and at one year, 10 mg/m^3 . Over the first year of SVE, 642 pounds of PCE were recovered, accounting for over 80 percent of the total 763 pounds of PCE recovered. It is thought the operation of the SVE system eliminated contaminant loading to groundwater based on groundwater monitoring trends at the loading dock. Over the same period, groundwater concentrations in the loading dock well decreased from 170,000 $\mu\text{g/L}$ to 1,300 $\mu\text{g/L}$ after three weeks of SVE, and to 750 $\mu\text{g/L}$ after 7 months. One year after SVE startup, the PCE in this well had dropped to 17 $\mu\text{g/L}$. The rapid reduction in source area groundwater concentrations is attributed to vapor phase transport and partitioning at the water table versus DNAPL migration to below the water table. It is congruent with down-gradient vertical delineation being clean. Reversing the vapor concentration over the impacted groundwater allowed PCE to partition from groundwater to vapor phase to be removed by SVE. This accounts for the rapid decline in groundwater concentrations not attributable to attenuation processes in the aquifer.

Biosparging in a Confined Aquifer

Snyder, Jay, EA Engineering, Science, and Technology, Inc. PBC, jsnyder@eaest.com; Vener Mustafin, vmustafin@eaest.com; Tyler Curley, tcurley@eaest.com (TS #16)

A confined aquifer biosparging system was installed at a former gas station on Laguna Pueblo, New Mexico. Site characterization revealed two contaminated zones: (1) a shallow water table zone, and (2) a confined zone beneath a clay aquitard with residual NAPL. The NAPL migrated to this position during historically lower groundwater levels that resulted from local municipal pumping and previous diversion of surface water upstream for irrigation, which cut off stream recharge. The full-scale Sparge-Vent system includes deep-zone sparge points installed 20 feet below the confining layer, deep-zone vent wells screened immediately below the confining layer, shallow-zone water table sparge wells, and vadose zone vent wells. The deep vent wells are open just below the aquiclude and allow the sparge air that accumulates under the confining layer to discharge to the surface where it is conveyed through the soil vapor extraction (SVE) system. The Vent-Sparge system includes 49 deep and 34 shallow sparge wells, 20 deep vent wells, and 14 vadose zone SVE wells. Full-scale system operation began in early 2016, and the system has operated full-time. Currently, the shallow sparge circuit pressure is 27 psig at flowrate of 50 scfm, the deep sparge circuit runs at 34 psig and a flowrate of 32 scfm, and the SVE flowrate is 79 scfm at 5.9 in Hg. Deep zone dissolved oxygen (DO) averages 0.5 mg/L indicating oxygen utilization in balance with "biosparging" mineralization. DO in the shallow zone averages around 1.7 mg/L. Since startup, the shallow groundwater impacted area has decreased by 77% with a total BTEX decrease of 82%. Deep zone impact has decreased by 82 percent in area and 90 percent in total BTEX concentration. A total of 92,000 pounds of gasoline (15,000 gallons equivalent) have been remediated via physical stripping and in situ aerobic biodegradation.

The Use of Powdered Activated Carbon in Excavation Backfill to Sequester Residual Contamination and Enhance Bioremediation

Snyder, Jay, EA Engineering, Science, and Technology, Inc. PBC, jsnyder@eaest.com; Vener Mustafin, vmustafin@eaest.com (Poster)

Excavation of grossly contaminated soil was specified at a former new car dealership that included numerous maintenance garages. Fuel hydrocarbons from several leaking underground storage tanks and waste oil from maintenance had grossly contaminated the site. Because of the clay nature of the vadose zone, excavation was specified. The permeability of the aquifer was determined to be low enough that dewatering was not required to remove soil below the water table short-term. Excavation of all contaminated soil was not possible due to buildings and a U.S. Highway, which parallels the site. A concern arose that contamination from these areas could seep into the clean backfill and re-contaminate the backfill to above groundwater standards. To mitigate this problem, powdered activated carbon (PAC) was batch mixed in a slurry with water and sprayed in and on the backfill as it was placed prior to compaction. The spraying was performed to disperse the slurry in the backfill; however, it was further mixed with the hydraulic excavator. Once mixed, it was compacted. PAC was placed to (1) increase foc in aquifer matrix to sorb contaminants, and (2) provide attachment substrate for microbial growth and enhance in situ bioremediation. A total of 15,015 pounds of PAC was added to approximately 8,500 cubic yards of backfill to yield approximately 0.001 fractional foc. After the job was completed, two years passed before performance assessment monitoring was initiated. A total of eight replacement monitoring wells were installed, with several proximal to buildings and the highway. Three quarters of groundwater

samples have been collected. The first quarter yielded all concentrations below standards; however, there were detections of BTEX. The subsequent two quarters of monitoring have yielded even cleaner results, indicating the permanence of the remedy.

Construction of Multi-Level Monitoring Wells in Karst Environment

Snyder, Jay, EA Engineering, Science, and Technology, Inc. PBC, jsnyder@eaest.com; Ryan Guth, P., rguth@eaest.com; Ted Telisak, ttelisak@eaest.com (Poster)

Multi-level monitoring wells were installed in Karst terrain at a Superfund site in Texas. Monitoring wells constructed in Karst are often completed open-hole below the cemented surface casing. This construction typically provides a well with multiple producing karst features that commingle groundwater and as such, provides no discrete vertical contaminant profile. To avoid this problem, and to establish a vertical profile at each well, multi-level monitoring wells were employed. However, design and construction of these multi-level wells in a karst environment presented unique obstacles to overcome. Solinst Continuous Multichannel Tubing™ (CMT) was selected for multi-level monitoring. CMT is typically installed in rota-sonic boreholes in soil allowing detailed logging, description and selection of open intervals. Wells are constructed inside the sonic casing, allowing precise placement of annular materials. In hard limestone at the site, use of air-rotary and down-hole air hammer drilling was necessary. Construction of CMT wells in karst required (1) temporary surface casing across soil horizons with air rotary drive casing keyed into top of limestone; (2) drilling open-hole through hard limestone; (3) containerizing a substantial amount of produced groundwater while drilling, and (4) using a steel tremie pipe to contain the assembled CMT well and guide it to completion depths across voids in the karst. Since the drilling returns were rock cuttings, the driller was instructed to keep a log of every noticeable "bit drop" to identify karst intervals for open channels. The completed boreholes were then video and caliper logged to assist with well design. Characteristics of cuttings and drilling rates were useful in discerning massive limestone versus karst zones. When completing the wells in large karst features, 3/8th-inch pea gravel was used versus bagged silica sand to allow voids to be filled rapidly. Bentonite seals consisted of 3/4-inch bentonite chips to rapidly plug off zones.

Why is USGS Doing That!? – Establishing a Biological Identity in the Geological Survey

Soileau, Suzanna, USGS, ssoileau@usgs.gov (TS #6)

Our biological world-ecosystems and the wild things that live in them is a natural resource that humans value and depend on for their livelihoods and wellbeing. In the U.S. Geological Survey (USGS), the Ecosystems Mission Area (EMA) is the biological research arm of the U.S. Department of the Interior, providing science that better enables society to understand how and why ecosystems change. As a non-regulatory, non-policy making government agency it is this objective science that supports the conservation and management of the Nation's fish and wildlife, and the landscapes they inhabit. But, it can be hard to stand out within the legacy and branding of the nation's oldest science agency, established in 1879 to classify public lands and examine the geological structure, mineral resources, and products of the nation's lands. The biology discipline was brought into USGS in 1996, making EMA one of the youngest of the agency's Mission Areas. For over 20 years EMA has worked to build its identity within USGS and stand apart, yet beside sister agencies such as U.S. Fish and Wildlife Service and the National Park Service. While partners and cooperators are keenly aware of EMA's science priorities, it is most often those non-science audiences that ask the question, "Why is USGS doing that!?" Today, EMA has placed emphasis on outreach and communicating its priority science to

Congress, the public and others who benefit from the research that supports some of the Nation's most valued natural resources. Through an expanded outreach portfolio of internal and external communications, EMA has embraced social media, revamped its web presence, developed a podcast series, and expanded local outreach through 16 ecological science centers across the U.S. These tools are enabling EMA to reach a broader audience and change the question to a statement, "That's why USGS does that."

Geoscience Information and Decision Making Support from the National Geologic Map Database

Soller, David, U.S. Geological Survey, drsoller@usgs.gov; Nancy R. Stamm (Poster)

From its mandate in the Geologic Mapping Act of 1992, the U.S. Geological Survey (USGS) and the Association of American State Geologists (representing the State geological surveys) have worked together to build the National Geologic Map Database (NGMDB, <http://ngmdb.usgs.gov/>). The NGMDB is a standardized, "national archive" of geoscience information (maps and reports, both published and unpublished), made available to the public to support decision-making, research, and other needs. The website for this resource launched in 1996. Each month, it serves 90,000+ users, who visit the site roughly a quarter-million times. To support the engineering and environmental geology community, online resources provided by or linked from the NGMDB include: 1) the Geoscience Map Catalog, which contains citations and Web links to >104,000 maps, stratigraphic charts, and reports by >630 publishers, many containing GIS data, and map images in GeoTIFF, jpg, and pdf formats; 2) mapView, an interactive viewer that provides a visual front-end to selected bedrock and surficial geologic maps in the Catalog; 3) topoView, a popular interface that enables users to quickly search, browse, and download USGS topographic maps, in several file formats including GeoTIFF; 4) the U.S. Geologic Names Lexicon (Geolex), the standard reference for the Nation's stratigraphic nomenclature; and 5) standards and techniques that are essential to compilation and production of geologic maps and databases (including the FGDC geologic map symbolization standard, the GeMS database schema, and reports and presentations from the twenty-three annual Digital Mapping Techniques workshops). We anticipate extending the GeMS map database schema to include certain engineering properties and land-use classifications, and we seek input from the engineering and environmental geology community.

Earthquake Hazards Outreach to Those Who Need to Know about Earthquake Risks: Finding and Reaching Key Decision-Makers

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Geologists work with earthquake hazards, the physical processes that affect the earth during and after an earthquake. Earthquake hazards include ground shaking, liquefaction, landslides, lateral spreading, uplift or down-drop, and surface rupture. We map, measure, estimate, document, and test many physical aspects of earthquake phenomena. We discuss among ourselves the minutia of this technical work. But in our society, key decision-makers are actually more interested in earthquake risks, which are quite different. Earthquake risks affect the economic world: somebody pays for it when it happens. Earthquake risks include disruption to public and private infrastructure, such as transmission and transportation corridors, housing, factories, commercial facilities, utilities, and engineered works. Earthquake risks adversely impact public and private economic properties, such as equity portfolios, market share, just-in-time inventory, production capacity, revenue, profitability, tax base, and insurance reserves. Finding key decision-makers who recognize these business risks to

their operations and who can authorize risk mitigation to manage those risks is unfamiliar to many of us. One way is to identify key "watering holes" of key decision-makers in business, industry, government, and infrastructure by enlisting their professional associations. Key decision-makers include treasury officers; business continuity managers; property-casualty insurers; risk managers; actuaries; portfolio officers for insurers, lenders, and investors; and many others. Each of these facets of the economic world has dozens of professional organizations that are similar to AEG: their editors are looking for relevant articles to publish and their meeting planners are looking for speakers—an "in" for proactive geologists who are ready to leverage their understanding of earthquake hazards into the practice of those who will mitigate earthquake risks.

The Pros and Cons of Operating Drones In-House or Subcontracting

Steckel, Richard J., UAViation, LLC; rjsteckel@charter.net (TS #17)

While drones appear to be a simple and inexpensive technology for organizations to operate, certain aspects of drone operations can be time consuming and expensive. Dr. Steckel will discuss factors that could help an organization decide if it wants to maintain full or partial in-house drone capabilities, or subcontract to a dedicated drone-services provider for a finished product. Factors to be discussed include pilot certification and recurrency, insurance, frequency of use, processing raw data and availability of the equipment.

Highlights from the Fourth National Climate Assessment Volume II: Impacts, Risks, and Adaptation in the United States

Stevens, Laura, North Carolina State University, laura_stevens@ncsu.edu (TS #2)

Volume II of the Fourth National Climate Assessment (NCA4): Impacts, Risks, and Adaptation in the United States, released in November 2018, is the Nation's most authoritative assessment of climate impacts to date. Developed by more than 300 authors from across the country, the report focuses on the ecological, societal, and economic aspects of climate change for ten regions and seventeen national topics across the U.S. Key findings from the report will be presented, focusing on climate-related impacts to natural hazards such as flooding, landslides, and coastal erosion. These impacts are projected to intensify—the magnitude of which will depend on actions taken to reduce global greenhouse gas emissions and to adapt to the risks from climate change now and in the coming decades.

Communicating about Resolution of a Site Characterization Issue for a Nuclear Plant in a Mandatory Hearing at the NRC

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The Atomic Energy Act of 1954, as amended, requires the U.S. Nuclear Regulatory Commission (NRC) to conduct public hearings prior to granting an applicant a license to construct and operate a nuclear power facility. NRC's siting factors in 10 CFR Part 100.23(d)(2) indicate an applicant must determine the potential for surface deformation at a new facility. Consequently, geologic features that might cause surface deformation must be addressed by NRC staff during the hearings. The example presented is the William States Lee III nuclear power plant site in South Carolina, located in crystalline rock at the original site of the Cherokee Nuclear Station (CNS) that was licensed for construction in early 1970 but never completed. The site characterization issue arose because location of Lee Unit 1 matched that for CNS Unit 1, the foundation rocks of which were covered by

CNS concrete, making it impossible for the applicant to implement the NRC's Geologic Mapping License Condition (GMLC). The GMLC requires a licensee to map lithologies and geologic features in excavations for safety-related engineered structures to ensure no significant potential exists for surface deformation. Because concrete cover precluded direct examination of foundation rocks at Lee Unit 1, during the Lee hearing the NRC Chairman asked how foundation materials were evaluated to confirm the applicant's conclusion that negligible potential existed for tectonic surface deformation at Lee Unit 1. The author provided expert testimony explaining that the NRC's evaluation involved confirming the similarities between crystalline lithologies, faults, and shear zones shown in the original CNS Unit 1 geologic maps and lithologies and tectonic features observed in adjacent Lee Unit 2 and the surrounding area; comparing archived CNS Unit 1 core samples with core from Lee Units 1 and 2; and examining radiometric dates documenting an age for faulting of more than 145 million years.

Proposed Concrete Aggregate Classification

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IUGS and ASTM C294-C295 rock classification schemes are inadequate for concrete aggregate. A better method would classify rock according to its potential reactivity for any reason during the service life conditions of normal concrete. The service life is often less than 25 years for minor structures, 50 years for pavement, 100 years for buildings, and 300–500 years for major structures. Aggregate may contain components with variable abundance and reactivity (ASR, ACR, oxidation, or a reaction with water). Reactivity is often increased in some varieties of polymorphic minerals, in amorphous crystal structures, by a fine grain size (generally indicated as $<50\mu$ or $<62\mu$), by high crystallographic strain (undulatory extinction $>25\%$ in quartz), and by intracrystalline permeability.

Reactivity Classification of Concrete Aggregate:

Natural Rocks

Extremely Reactive: rocks containing natural glass (such as obsidian, pumice, some basalt), opal (opaline shale and opaline chert, vug fills, veins, opal fossils, siliceous fossils such as sponge spicules), cristobalite, coesite, tridymite, marcasite, framboidal pyrite, chalcocopyrite, smectite clays, expansive mixed-layer clays, anhydrite, laumontite and other zeolites

Considerably Reactive: fine-grained chert, micro-crystalline quartz (such as some intergranular cements, chalcedony), micro-granular quartz, highly strained quartz, clay/dolomite mixtures, pyrrhotite, pentlandite

Moderately Reactive: rocks containing strained quartz, porous fine-grained pure dolomite, vermiculite, gypsum

Rarely Reactive: rocks containing lignite, bitumen, large pyrite, potassium feldspar

Contributory Reactive: feldspathoids, feldspars

Non-Reactive: Calcite marbles, medium to coarse grain-size dolomite, amphiboles, pyroxene-group minerals, wollastonite, talc, aragonite or calcite shell, coral, sphalerite, galena, magnetite, hematite

Man-Made Aggregate Components

Extremely Reactive: glass, MgO, glassy bottom ash, agglomerated silica fume, bentonite pellets, glazed brick and ceramics, aluminum, refractory mortar

Considerably Reactive: mineral and rock wool, fiberglass, water-chilled BFS (WCBFS)

Moderately Reactive: Sintered fly ash

Rarely Reactive: Terracotta, interior brick, exterior brick, paving brick, HMA, alkali-resistant glass

Non-Reactive: ACBFS, steel, iron, brass, bronze, tin

Geology of NOA Minerals in Southern Appalachian Mountains

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Ultramafic rocks in the southern Appalachian Orogen host several varieties of naturally occurring asbestos (NOA). The ultramafic rocks occur in a western, Blue Ridge belt, and eastern, Piedmont belt. The western belt contains 100's of small bodies of ultramafic rocks while the Piedmont belt contains far fewer bodies. The rocks consist of meta-peridotites and metapyroxenites. Mineralogy of the metaultramafic rocks is related to the bulk composition of the protolith, the metamorphic grade and the history of fluid interaction with the metaultramafic rocks. Generally, olivine-bearing rocks of the western belt are less hydrated and of higher metamorphic grade than the amphibole chlorite rocks of the Piedmont. However, the mineralogy is extremely sensitive to recrystallization in the presence of fluids at lower temperatures. For example, small bodies in the western belt often contains rocks ranging from olivine-enstatite-chromite rocks to olivine-amphibole rocks, to amphibole chlorite schists to talc amphibole schists to serpentinite. The NOA minerals in the southern Appalachian Orogen include the amphiboles magnesiocummingtonite and anthophyllite and, less commonly, chrysotile. In olivine-rich bodies, the NOA minerals occur along veins or cover fractures reflecting former fluid pathways. A metasomatic reaction zone between the ultramafic rocks and other rocks often contain anthophyllite. Olivine-poor bodies are composed mainly of amphibole, reflecting more extensive hydration. Mineral textures document a history of replacement and recrystallization. For the NOA phases, magnesiocummingtonite forms at the highest temperatures. Acicular anthophyllite replaces magnesiocummingtonite at lower temperatures. Talc replaces anthophyllite. Intergrowths of talc and anthophyllite are common. Chrysotile forms at the lowest temperatures. Metaultramafic rock bodies in the southern Appalachian Orogen (mainly in the western belt) were mined for a variety of minerals for over 100 years. Olivine, chromite, vermiculite and anthophyllite were mined at various times in various places. Reclamation of the mine sites is variable.

Coordinated Emergency Responses to Sinkholes and Mine Collapses by the North Carolina Geological Survey with Local Emergency Managers

Taylor, Kenneth, *North Carolina Geological Survey*,
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In 2008, the N.C. Geological Survey (NCGS) was dispatched to respond to Onslow County Emergency Management for technical assistance on a sinkhole impacting a residence. Local government was briefed on sinkhole hazard prior to visiting the impacted neighborhood. Other agencies assisted, including NC DOT, county health department, emergency management, building department, as well as a planner from the regional Council of Governments (COG). The impacted residence had been split in half several days before dispatch. As more local governments heard about our response capability, the number of service requests increased to between three to five per quarter. We noted a direct correlation between the ending a multi-year drought period and an increased impact from sinkholes. This included impacts to interstate highways. The NCGS added mine collapse when the number of reported "sinkholes" in non-carbonate regions increased. Last year in Charlotte, a three-foot wide shaft opened under a residence, with one of the steel support columns in the basement falling 30 feet in a vertical shaft. The Survey's historical collection of mine maps were used to identify the abandoned mine under that neighborhood. Mecklenburg County (Charlotte) had been provided with detailed maps of two abandoned mines in the downtown. State Emergency Management even used those maps to demonstrate the potential for extensive collapse and the impact of such an event on freeways, potable water and sewer, and emergency response.

Geologic Input for Dam and Levee Risk Assessments

Terry, Thomas, USACE, thomas.terry@usace.army.mil (TS #9)

The level of geologic input as well as other inputs for various levels of risk assessments can and should be scaled to the level of effort for the decisions to be made. The scaling of geologic detail necessary to support risk assessments is similar to the level of detail being used from site investigations for various levels of studies. The geologist level of knowledge of the site will need to increase to lead and assist the team in understanding the geologic related PFMs as the level of risk assessment and level of decisions being made change. For a qualitative risk assessment to support a planning level study where only preliminary sketch plans are available, a basic understanding of the regional and local geology may be adequate. For a semi quantitative risk assessment (SQRA) of an existing structure, a good understanding of the regional/local and site-specific geology is a must. For a quantitative risk assessment (QRA), the geologist must have a thorough understanding of the geology similar to an SQRA, and be able to determine geologic gaps in the existing data that would lower risk uncertainty for geology-based risk driving failure modes. Additionally, the lead geologist for a QRA must be able to help the other members of the risk assessment team understand the geology related to the specific risk driving PFMS. As the level of the risk assessment increases, the level of geologic information and understanding needs to increase to support the risk assessment and decision-making process, which usually requires increased level of communication of the geology and its impacts on the risk. This presentation is based on lessons learned by participating as a geologist in over 40 dam and levee risk assessments in the past 8 years, from planning level to modification.

Assessing Climate Change and Coastal Hazard Vulnerability in National Parks: Working towards Adaptation

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The Program for the Study of Developed Shorelines, in partnership with the National Park Service (NPS), has developed a new approach for assessing the natural hazard and climate change vulnerability of NPS infrastructure. This vulnerability assessment protocol standardizes the methodologies and data used, allowing managers to compare the vulnerability of assets across local, regional, and national levels. Asset-specific vulnerability assessment results can also be used by managers in developing short- and long-term adaptation strategies. Standard practice for vulnerability assessments includes three metrics: exposure (degree to which a system will experience a stressor), sensitivity (how a system fares when exposed), and adaptive capacity (ability of a system to sustain itself by adapting). While this formula has been successfully applied to natural systems, certain aspects are less appropriate for application in the built environment. The new protocol for infrastructure includes only exposure and sensitivity in the vulnerability score for each asset; adaptive capacity is evaluated separately. The rationale is that infrastructure does not have intrinsic adaptive capacity, like that of a natural system. Adaptive capacity for infrastructure depends on external influences, including cost, use, politics, and historic significance. In fact, with an infrastructure vulnerability assessment, the adaptive capacity evaluation process helps managers identify potential actions for reducing the exposure or sensitivity of an asset and, in turn, its vulnerability. The protocol has been successfully applied for coastal hazards (sea-level rise, flooding, storm surge, tsunami, coastal erosion, and cliff retreat) at 19 national parks, 11 of which are in the southeastern United States. Furthermore, the

vulnerability assessment protocol has now been adapted to assess other natural hazards (river flooding/migration, wildfires, earthquakes, landslides, and geothermal) as well as municipal infrastructure. Pilot studies are currently underway at Yellowstone National Park, and the coastal community of Duck, North Carolina.

Innovative Plume Stability Evaluation and Groundwater Monitoring Program Optimization

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At most large sites, monitoring wells tend to be added sequentially during site characterization in a process that can take years. The result can be a site with hundreds of wells that are required to be monitored on a regular (often quarterly) basis. These monitoring networks may have prolific redundancies in spatial coverage. Depending on the overall stability of the plumes being monitored, there can be tremendous opportunities to streamline both the monitoring network as well as the frequency of monitoring. A new groundwater monitoring program optimization method has been developed to evaluate the monitoring well networks and sampling frequency for groundwater monitoring programs using Earth Volumetric Studio (EVS) in combination with Python algorithms to implement advanced workflows following logical statistics. As part of this process, a method providing a visual and mass-distribution based analysis of plume stability for all COCs using EVS was also developed. The first project to use this method was a large refinery site in the Los Angeles Basin. The site has a large array of monitoring wells (860) dating back to the 1980s, intended to characterize plume conditions in seven aquifer units. The existing program included quarterly sampling of ~450 wells, and an average of ~1,400 samples per year. The newly approved program samples 57 wells semiannually, 158 wells annually, and 99 wells biennially, for an average of 322 samples per year. The new program will save the client 65% of their annual monitoring and reporting costs, and an estimated \$18M over the next 30 years. The customization of criteria and the automation of the decision algorithms allow for application of this method at a variety of monitoring sites, providing tremendous value.

Distribution and Geology of Natural Occurrences of Asbestos in the Eastern United States

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A systematic State-by-State search of the geologic literature found 331 reported natural occurrences of asbestos in the Eastern United States. Examples of asbestos mineralization are reported in 13 eastern states, from Alabama to Maine, ranging from small veins to large ore bodies once mined for commercial and industrial uses. At least 60 asbestos mines operated in the Eastern U.S. during the 20th century; they varied widely in size. The first large-scale production in the Eastern U.S. was in 1894 near Sall Mountain, Georgia (anthophyllite asbestos). Anthophyllite asbestos was mined from small operations in Georgia, North Carolina, Virginia, Maryland, Pennsylvania, Connecticut, and Massachusetts. Over time, asbestos mining shifted to large chrysotile deposits such as Belvidere Mountain, north-central Vermont, the last Eastern U.S. mine, closing operations in 1993. The most common asbestos mineral observed in the Eastern U.S. is anthophyllite, especially in Alabama, Georgia, and North Carolina. From northern Virginia to New Jersey and southeast New York, chrysotile is common, along with tremolite-actinolite asbestos. Instances of crocidolite occur in New Jersey, Pennsylvania, and Rhode Island. Only a few asbestos deposits occur in Connecticut and Massachusetts. Chrysotile deposits occur along a north-south-trending belt of ultra-

mafic rocks in Vermont, and similar rocks in western Maine. Most Eastern U.S. asbestos occurrences are in serpentinites formed from metasomatism of ultramafic rocks, mainly serpentinization of olivine-rich intrusions (peridotite and dunite), amphibolites, and pyroxenites. Other hosts are alteration zones in dolomitic marbles, diabase (gabbro), and metamorphosed volcanic basalt. These host lithologies are magnesium-rich rocks invaded by silica-rich fluids under conditions of moderate temperatures and pressure (greenschist facies); these geologic conditions can also form chrysotile and asbestiform amphiboles. These associations explain the asbestos mineralization occasionally found in magnesium-rich industrial minerals, such as some deposits of talc, dunite, dolomitic marble, and diabase and ultramafic rock (used as aggregate and building stone).

Geology and Construction of Tibble Fork Dam Rehabilitation, Utah County, Utah

Vargo, Ana, USDA NRCS, ana.vargo@co.usda.gov; Michael N. Hansen, mhansen@rbgengineering.com (Poster)

Tibble Fork Dam rehabilitation design included a 15-foot raise in the dam height, cutoff wall, grout curtain, new dam alignment, new downstream berm, additional construction material required for dam raise, and new spillway location on the left abutment. Review of existing data indicated that the site is located in a geologically complex area, which included the potential for liquefiable soils. During the rehabilitation process (2010–16), 28 boreholes were drilled, and 86 test pits were dug. Eight cross sections were generated to demonstrate the complexity of the geology below the dam and berm and help determine the excavation and replacement of liquefiable foundation soils. The stream has cut into a conglomerate, tuff, and Tertiary deposits creating a complex relationship. Youngest alluvium from the current stream was deposited on the tuff, additionally, in a few boreholes, unconsolidated alluvium occurs below the tuff. This alluvium was deposited prior to the volcanic action, which formed the tuff. Previously mapped Tertiary volcanics (tuff) deposited in a graben are actually part of the Tibble Formation; therefore, the left abutment fault does not exist as shown on existing maps. However, the possibility of pre-Quaternary age faulting or interfingering of the Tertiary Volcanic rocks of the East Traverse Mountains is possible. The tuff is known to cause landslides. The tuff has characteristics of lean clay (CL), clayey sand (SC), clayey gravel (GC), fat clay (CH), and elastic silt (MH). Much of the dam embankment is founded on relatively pervious alluvium and colluvium requiring a cutoff wall to inhibit seepage beneath the dam. Additionally, the Wasatch Fault occurs about 5.2 miles (8.4 km) west requiring the new downstream berm to enhance embankment stability. The construction of the dam was completed in 2017.

Integration of Non-Invasive Geophysical Methods with Invasive Geotechnical Sampling for Optimized Karst Characterization

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The karst environment can be challenging to characterize, and often resolves a moderate to high degree of variability within the subsurface. Karst hazards encountered during site exploration can result in increased costs for removing undiscovered rock pinnacles, or sinkhole mitigation. Invasive geotechnical sampling is beneficial for retrieving a physical sample representing subsurface conditions at a precise location but can be costly when increasing the density of sampling locations. Additionally, site constraints such as steep slopes, waterbody crossings, impact to sensitive areas, and confined or unusual spaces can limit site accessibility for invasive sampling. Non-invasive geophysical methods can access places where drilling equipment cannot,

allowing for versatile testing coverage. As a result, the combined use of non-invasive geophysical methods with invasive geotechnical sampling has become prominent in exploring the karst environment. Specifically, the use of electrical resistivity imaging combined with invasive drilling results in a comprehensive understanding of subsurface conditions. Electrical resistivity imaging can rapidly acquire data related to the distribution of physical properties within the subsurface, such as the soil-bedrock interface in karst environments. Electrical resistivity imaging acquires data as cross-sectional profiles, with adjustable depths of data acquisition. When several profiles are obtained across a site, the data can be combined into a three-dimensional data set of which interpreted bedrock elevations can be extracted and rendered into georeferenced surfaces for calibration and integration with geotechnical drilling data. Combining electrical resistivity imaging and drilling data with high precision Global Positioning Systems (GPS) precisely identifies the locations of structures or anomalous conditions. The data can be incorporated into industry standard programs such as AutoCAD, ArcGIS, and Google Earth. The combined analysis of non-invasive geophysical methods with invasive geotechnical sampling is an effective and powerful tool for characterizing karst environments. Case studies exploring the advancements of this combined analysis illustrate the benefits.

Public Outreach Experiences during a Major Dam Modification Project

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The reservoir at Boone Dam provides multiple benefits to the surrounding communities which include flood control, recreation, water supply, downstream water quality and support for aquatic ecology, and hydroelectric power generation. In response to observations of conditions at the site indicative of a threat to the integrity of the dam, the Tennessee Valley Authority (TVA) immediately lowered the reservoir approximately 30 feet and committed to maintaining the lower pool elevation until a satisfactory remediation was implemented. In July 2015, the TVA announced it would undertake a seven-year project to mitigate the seepage and return the reservoir to normal operations. A major dam modification of the type underway at Boone Dam is a highly technical endeavor for which geologists, engineers, and scientists are accustomed to thinking and communicating in technical terms. A unique set of challenges is imposed upon the project by the need to relate the technical motivations and plans to remediate the dam to a wide variety of stakeholders, including the general public. These efforts are an exercise in transparency involving the oft-competing interests of multiple audiences, many of which are strongly vested in a set of highly specific impacts which may differ significantly among stakeholder groups, especially with decreasing proximity to the project. This adventure into the “soft skills” of project management has to be focused but flexible. This presentation will summarize the challenges, lessons learned, and surprises of public outreach during the Boone Dam Remediation project.

Honoring the Final Repose of America’s Veterans: Karst Mitigation at Jefferson Barracks National Cemetery

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Jefferson Barracks National Cemetery has been serving as the final resting place of soldiers, sailors, air men and women, and veterans since the United States Civil War ended. It was established as a National Cemetery in 1866. The location also served as a military barracks and supply center beginning in 1826 with an excellent view from atop the bluffs of the Mississippi River. Underneath many graves and

structures lie a plethora of karst geomorphology. Sinkholes pockmark the landscape with solutioned fractures conveying water into the sub-surface or providing a path to rise from below. As the Nation's veteran population ages, cemetery space is at a premium and is projected to fill by 2023. The Veterans Administration sought to maximize space by constructing columbaria and crypts. These structures will be a home for the dead for years to come and must keep the remains safe. To do so, the karst bedrock, with its solutioned cavities and sinks, must be treated to prevent, manage, or modify the flow of groundwater and prevent collapse or settlement through shrink/swell of the clay residuum and fill soil profile. Geophysics and strategically-placed conventional borings and cone penetrometer test (CPT) soundings were used to identify possible karst features and aid designers in creating a resting place within minimal geologic impacts. These features were found, exposed, and treated during construction. This presentation will discuss the geology of the site, the investigation methods used to locate the karst features, the remedies designers planned to mitigate hazards, and the treatment of the bedrock during construction to help protect the final repose of honored veterans.

An Overview of the Tennessee Valley Authority and Geologic Challenges at TVA Projects

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The Tennessee River watershed covers parts of seven states, six physiographic provinces, and is home to the nation's fifth-largest river system. On May 18, 1933, the Tennessee Valley Authority (TVA) was created by congressional charter and tasked with a mission that includes flood control, generating electricity, and improving navigation on the Tennessee River and its tributaries. To this end, TVA has constructed 24 hydroelectric projects and one pumped storage facility; acquired six previously constructed hydroelectric projects (one of which was subsequently removed), and constructed 19 non-power dams. During World War II, electricity from TVA facilities was used to produce aluminum and power for the Manhattan Project. Nine main river dams and one tributary river dam include navigation locks that cumulatively provide \$500 million in annual savings compared to other transportation methods, and TVA's reservoir system has averted more than \$8.6 billion in flood damage since 1936 (including \$1.6 billion in 2019 alone). Geologic issues across the TVA system include: karst-susceptible bedrock; saprolite; rockslides associated with adversely bedded metamorphic rocks; artesian groundwater; earthquake hazards from the East Tennessee and New Madrid Seismic Zones; and concrete growth due to alkali-aggregate reactions. This presentation will discuss how TVA has addressed many of these geologic challenges, and also provide some fun facts about how the United States Navy, NASA, the Olympic Games, Appalachian Trail through-hikers, Bassmaster Classic anglers, and farmers worldwide have or continue to benefit from TVA's dams and reservoirs.

Justifying Science to Non-Science Faculty and to the General Public in the Age of "Big Bang" TV

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Evidence of society devaluing science for more than a decade is everywhere. It is visible in choices made by citizens every day, in profit-driven big business practices, and in divisive political debate. Examples include denial of basic facts like impacts of climate change and importance of vaccines. In my academic world, a disturbing trend is the growing consensus among non-science faculty that General Education, the foundation on which students build knowledge across broad disciplines, fostering productive and well-informed citizens,

should provide students a way to totally "escape science." Science is seen by them as unnecessary, bothersome, and a threat to their ways of thinking. To me, this is unconscionable. Tracing the origins of such views is difficult, but correlations exist that we can address. Trust disappears when people encounter conflicts they are not equipped to evaluate critically. Without a foundational understanding of scientific reasoning, many rely on "gut feelings" regarding what they want to be true. Others blindly follow political or religious leaders. Critical thinking is difficult for many. I have watched the decline through many years, as a Congressional Science Fellow, a Jahns Distinguished Lecturer covering public policy, and by seeing academic programs wane over 35+ years. Trust ebbs when facts are molded to fit special interest agendas; when faulty logic is championed; when truth feels inconvenient; and, whenever scientists see themselves as too superior to care about public perception. "Big Bang Theory," a television program portraying the lives of quirky scientists, is the highest-rated sitcom since "Friends." By contrast, science documentaries do not rate nearly so high. Considering such amazing public exposure, we examine both positive and negative messages from television. Let us strive to convince others that not everyone needs to be a scientist; but, for the good of all, everyone needs to appreciate science.

Tales from the Muck: Airborne Asbestos Concentrations since the Late 1800s

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Paleolimnology, analytical transmission electron microscopy, particle-separation techniques, and empirical aerosol-sediment modeling were combined to provide the first measurements of airborne asbestos concentrations prior to the 1970s. Airborne concentrations of chrysotile, the most common type of asbestos, reconstructed from control lake sediments followed chrysotile's 20th-century usage, with highest concentrations mid-century (~0.1 fibers/cm³), and decreasing in the last quarter century. Anthophyllite asbestos recovered in study lake sediments were consistent with contamination in talc ores from mines located ~8 km upwind of that lake. Calculated airborne concentrations of anthophyllite asbestos increased from <0.004 to 0.022 fibers/cm³ from 1847 to 1995. These airborne anthophyllite asbestos concentrations during the ~100-year period of talc mining correlated well ($r^2 = 0.80$, $p < 0.001$) with annual production of local talc and were much higher ($p = 0.004$) than concurrent concentrations from a control lake located upwind of the mines and mills. All chrysotile and more than 70% of the anthophyllite asbestos fibers were too narrow to be detected by phase-contrast light microscopy (PCM), the method used to measure airborne fiber concentrations before ~1980.

Tracking Design Pore Water Pressure against Design and Design Factor of Safety

Weigel, Jim, Rio Tinto Kennecott, Jim.Weigel@riotinto.com (TS #19)

Pore water pressure has long been known as a driver in the geotechnical design and performance of open pit mine walls and slopes. It is the one parameter used in the design that may change over time, being influenced by precipitation, the design of the pit wall and active depressurization systems. Design pore pressure distribution adopted in the pit design phase generally remains in that phase with actual pore pressures observed during pit development seldom tracked against the underpinning pore pressure used in the geotechnical design. The methodology outlined sets up a framework for providing continuous feedback through the design and pit development phases.

The framework provides the foundation for relating observed pore water pressure back to design acceptance criteria such as Factor of Safety (FoS) and Strain Reduction Factor (SRF). The framework relies on a series of pore water pressures sensitivities that are run through the geotechnical models for each stage or year of a specific open pit mine design. There are multiple methods to create these pore water pressures and approaches that we have adopted include:

- Design pore water pressures as hydrostatic conditions by incrementing pore pressures across pit stage/year
- Maintaining the original pore water pressure gradients at stage/year and increment a range of pore water pressures.

Once these staged/yearly datasets have been created, the geotechnical models are re-run and a FoS and SRF sensitivity range centered on the design or target pore pressure distribution is generated for each stage or year. As mining progresses in accordance with design, the observed piezometer data is used to track pit wall FoS through time and assess the implications of pore pressures deviating from the target values assumed in the pit design. A downward trend in FoS, as an example, provides early warning of a potential slope stability issue.

Local Contractor Shows Lack of Knowledge about Cold Weather Deterioration of Exterior Concrete

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Sound exterior concrete can be placed that resists freeze-thaw attack and de-icing salts. Concrete of adequate strength (3500 psi or 25 MPa), proper water-cement ratio ($w/c = 0.5$) and air entrained (6 % air) is resistant to deterioration in cold climates. This information has been known since the mid 1950s due to findings by the Portland Cement Association. However, in the author's experience a number of local concrete contractors are unaware of these requirements. Some years ago, a study of concrete at a gasoline station indicated concrete that contained only a small amount of entrapped air voids and showed extensive deterioration. In another case, concrete that was placed in too wet a state showed deterioration where cars were parked and salt water had dripped on to the pavement. In a recent example several driveways in a new subdivision showed extensive scaling of the surface area of the concrete. The problem was limited to driveways placed by a specific contractor. Comparing three houses built in a row at approximately the same time, the two driveways placed by the contractor of concern showed massive scaling. The third house built by a different contractor showed no sign of deterioration on its driveway. A neighbor reported that for the two problem driveways, the surface had a wet, soupy appearance on completion. It is not likely that the concrete supplier would not have delivered air entrained concrete, so the acute scaling was due to adding extra water when placing the concrete. Concrete finishers know that concrete is more workable when it contains more water and a smooth finish is easy to obtain at a higher water-cement ratio. This approach must be resisted because the addition of extra water greatly reduces the quality of the concrete. Less water is required than that provided by a water-cement ratio of 0.5 but less water makes it difficult to finish concrete.

Rock Mechanics and its Effects on Spillway Modification Design

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Success Lake is a U.S. Army Corps of Engineers dam and reservoir located about 6 miles upstream of the city of Porterville, CA on the Tule River and provides flood damage risk reduction, agricultural water supply, and recreation. Project studies have shown that the main risk drivers are extreme loading events and that raising the spillway 10 feet and widening it from 200 to 365 feet would provide additional flood risk reduction and irrigation water supply. General site geology consists of moderately fractured diorite, with large bodies of quartzite and metavolcanics with known areas of block failure and sliding. The existing spillway is unlined with a 3-ft-wide \times 200-ft-long reinforced concrete sill that is embedded into rock. Modifications will include widening the spillway to the right by blasting and excavating, reassessing the side slope rock stability, and investigating a landslide that occurred in the left abutment during original construction. New structural features include a 10-ft-high reinforced concrete ogee weir, a 100-foot-long concrete apron with a downstream concrete headcut cutoff wall, reinforced concrete sidewalls anchored into rock, and relocation of a public access road. Additional geologic site investigations include: geologic mapping, seismic refraction survey, structural geologic data gathering, subsurface drilling, downhole televiewer, and lab testing. This data was processed to analyze all potential cut slopes and to design stable slopes based on block stability analyses for sliding, wedge failure, and toppling. Hydraulic erosion potential along the invert and side slopes was also analyzed for input into the stability analyses and design. The extensive geologic investigations and kinematic analyses have decreased design and construction risk by reducing the number of onsite unknowns and allowing the design team to proceed forward with increased confidence in slope geometries and less risk of significant differing site conditions during construction.

Advanced Continuous Surface Wave Testing (ACSW): Geologic and Geotechnical Site Characterization for the 21st Century

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Continuous Surface Wave (CSW) testing has been the "next big thing" in ground characterization for the last 25 years. The technique uses surface geophones to measure the speed at which Rayleigh waves (generated by a vibratory source) travel through the ground over a range of frequencies. The velocity at which surface waves travel through the ground is directly related to ground stiffness; the velocity of shorter wavelengths is influenced by the stiffness of shallower soil layers, while the velocity of longer wavelengths is influenced by the stiffness of deeper layers. Measuring the surface wave velocity over a range of frequencies, therefore, allows a stiffness/depth profile to be produced. Using the small-strain stiffness data measured by the CSW technique greatly improves the accuracy of simple limit state analyses; the data are also of sufficient quality for use in Finite Element modelling. Nonetheless, the technique has suffered from a perception of high cost, low productivity and poor repeatability. An improved Advanced Continuous Surface Wave (ACSW) testing system, developed by Ground Stiffness Surveys in the United Kingdom, has been deployed in the UK commercially for several years and is now available in the United States. ACSW uses an automated electronic control system that generates vibrations (from a purpose-designed and manufactured "shaker") at different frequencies, measured across a 10-ft array of geophones, linked to a robust data acquisition and analysis software

package. The range of applications in geologic and geotechnical site characterization includes rapid preliminary non-intrusive site assessments (utilizing published soil correlations), stiffness profiling to detect discrete layers (such as a variation in rockhead), rock quality and rippability assessments, and full 3D modeling of data. Other geotechnical applications include average stiffness profiling for earthwork or ground improvement control testing, vs. profiling for seismic design and liquefaction assessment, and void detection.

When Worlds Collide

Winn, Russell, R.E. Janes Gravel Company, rusty.winn@rejanescos.com (TS #21)

A modern-day account of miners, cowboys, and roughnecks on the Southern High Plains of Texas. What happens when industries encroach on each other? Can surface mining coexist with ranching and the oil industry? Stewardship of the land and maintaining multi-industry regulations are small pieces of the puzzle. Communication and a willingness to coordinate projects are key. This is an examination of an aggregate mine working in conjunction with landowners (ranchers) and energy producers to best meet everyone's needs. Lessons learned and possibilities for future inter-industry related goals.

Landslide Geometry: Modeling Landslide Depths

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Obtaining landslide depths can be one of the biggest challenges in quantifying accurate erosion rates. The aerial extent of a slide can easily and efficiently be determined through remote sensing, however, landslide depths can only be determined on the ground or by using a model. Understandably, time and budget constraints affect both public and private projects, typically rendering the depth dimension unattainable for larger watershed scale projects. Models for landslide depths are necessary but are typically imported from outside the region and rarely validated with local data. This can be problematic as landslide depths can have a significant impact on volume calculations in general and especially when developing a sediment budget or calculating erosion rates. After completing a rather large project focused on the assessment of shallow landslides in Northern California, we have developed a model for determining landslide depth based on the area of a landslide. Our model uses a database of over 3,400 landslides of which we were able to determine landslide depth based on field-developed cross sections for each landslide. These data provided a unique opportunity to evaluate depth versus landslide geometry of shallow landslides. Landslide area is relatively easy to evaluate using aerial imagery and now this model can help landowners and policy makers estimate landslide volumes and evaluate erosion rates more accurately throughout Northern California.

Communicating with Stakeholders About Landslide Hazards: Go It Alone at Your Own Risk, and the Only Failure Is to Stop Trying

Wooten, Richard M., North Carolina Geological Survey, rick.wooten@ncdenr.gov (TS #10)

Building support for a proactive, loss reduction effort like landslide hazard mapping requires a long-term effort over many fronts. Understanding and communicating landslide hazards is an inter-disciplinary endeavor, involving geologists, hydrologists, engineers, soil scientists, meteorologists, and forest ecologists among others. Building relationships and partnerships with the scientific and professional communities is important in the ongoing need for public engagement and education about landslide hazards. Building relationships with stakeholders outside

of the scientific community can be challenging, but equally important. In mountain communities, emergency managers, local governments, non-governmental organizations, realtors' and homebuilders' associations, the media and others have vested interests in landslide hazards, and landslide hazard mapping. It is important to engage stakeholders at the beginning of a project, not just when you are done, and trying to explain what you did, why it is important to them, and why they should be interested. By establishing relationships with stakeholders some of them may become advocates for your work.

A Metrological Look at NOA

Wylie, Ann, Department of Geology, University of Maryland, awylie@umd.edu (TS #11)

Natural occurrences of asbestiform amphibole (NOA) are widely occurring in certain geologic settings and are abundant in mineralogy collections. The metrological properties of aerosol-sized particles from NOA may differ from asbestos occurrences associated with asbestos-related diseases. This paper discusses the distributions of frequencies of length, width, and length-width sets from a wide variety of NOA and compares them to asbestos that has caused mesothelioma, lung cancer and asbestosis.

Impacts of Design Characterization and Geological Characteristics on Remedial Strategy Optimization

Young, David, Wood Environment & Infrastructure Solutions, Inc., david.young2@woodplc.com; Sheri Knox, sheri.knox@woodplc.com (Poster)

An undisclosed facility located in the mid-Atlantic region was previously used to manufacture printed circuit boards. In 1986, chlorinated volatile organic compounds (CVOCs) were identified in soil, however, the impacts were not adequately assessed at the time. In 1991, the U.S. Environmental Protection Agency (EPA) required the installation and operation of a groundwater treatment system (GWTS) to contain a large groundwater contaminant plume. The GWTS initiated operation in 1995 and includes 18 extraction wells that historically has pumped approximately 1.5 million gallons per month and the site was developed into a shopping mall in 2006. The objective of our work is to identify and update remedial strategies by assessing the fate and transport of CVOCs. In support, the GWTS was temporarily "shut down" during 2016 to evaluate groundwater flow dynamics under non-pumping conditions and assess plume stability. Recently, design characterization of the site soils was performed to facilitate remedial optimization. During this work, historically reported areas of vadose zone contamination were assessed and delineated to identify areas of impacted vadose zone soil contributing to the mass of groundwater contaminants. Additionally, continued aggressive and strategic sampling has been performed to evaluate abiotic/biotic attenuation pathways. Site-specific geological characteristics were found to influence the fate and transport of CVOCs, exposure pathways and associated risk, in-situ biogeochemical processes, and attenuation pathways. As a result of the design characterization performed recently and better knowledge of site-specific geological influences, the current optimized approach includes operation of the GWTS with two extraction wells located near preferential pathways influenced by underground utility corridors, as opposed to 18 extraction wells. In the interim, long-term risk is being evaluated for receptors. This current approach and the planned future optimization will result in millions in savings over the course of a lifetime.

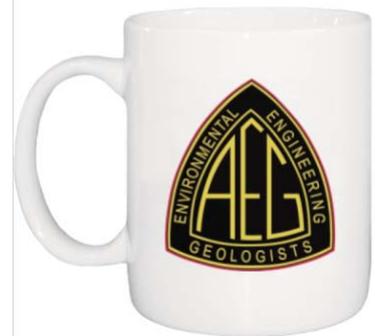
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Bailey, Mark R.	Investigation, Sampling and Identification for the Presence of Naturally Occurring Asbestos
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Bauer, Jennifer	They're Still Moving: Debris Flows and Debris Slides of the North Pacolet River Valley, Polk County, North Carolina in 2018 and 2019
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Bergstrom, Jorgen	Geophysical Borehole Logging in Fractured Rock for Hydrogeological Applications
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Cameron, Cortney	Spatiotemporal Patterns of Rainfall in West-Central Florida, 1940–2016
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Carpenter, Alexis	Laboratory Development and Evaluation of Technologies for Groundwater Remediation (Presented By Jared Haselow)
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Das, Raja	Application of GIS-Based Kinematic Analysis to Evaluate Debris-Slide Initiation Zones
De Bacco, Gianluca	Case Study: Comparative Analyses of No-Purge and Low-Flow Groundwater Sampling Methods
Dean, Jennifer	An Engineering Geologist's Contribution to Concrete Gravity Structure Stability Analyses at Oroville Dam
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Fontaine, April	Sacramento Region Levee Rehab – 2017 Event
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Gates, Jonathan	A Remote Sensing Approach to Map Water Tracks Identified Using Soil Hydraulic and Geophysical Properties
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Kumar, Chandan	Lithological Mapping in Hutti-Maski Gold Mineralization Area of India Using AVIRIS-NG Hyperspectral Data and Machine Learning Algorithms
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Meier, Dan B.	Boone Dam Internal Erosion Remediation Project: Integrated 3-D Modeling of Subsurface Conditions
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Mininger, Kevin	"Where to Focus" - Using the PFMAAA/SQRA Process to Manage Risk at a Single Dam or and Entire Portfolio
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Mischler, Steven	NIOSH Elongate Mineral Particle Research
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Shea, Eileen	Communicating Climate Science with Professional Practioners in Multiple Sectors
Shields, Sierra	Surface Water Quality in Missouri
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Stevens, Laura	Highlights from the Fourth National Climate Assessments Volume II: Impacts, Risks, and Adaptation in the United States
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Torres, Eryn	Innovative Plume Stability Evaluation and Groundwater Monitoring Program Optimizations
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Vargo, Ana	Geology and Construction of Tibble Fork Dam Rehabilitation, Utah County, Utah
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Vinson, Samuel	Public Outreach Experiences During a Major Dam Modification Project
Voss, Stefanie	Honoring the Final Repose of America's Veterans: Karst Mitigation at Jefferson Barracks National Cemetery
Waddington, Betsy	See Carter, Richard
Walker, Graham	See McNamee, Brittani
Walker, Scott	An Overview of the Tennessee Valley Authority and Geologic Challenges at TVA Projects
Wanhatalo, Matthew	See Eisold, Eric

Name	Title
Ward, Dylan J.	See Ferry, Nicholas
Watts, Skip	Justifying Science to Non-Science Faculty and to the General Public in the Age of "Big Bang" TV
Webb, Matt	See Eisold, Eric
Webber, James	Tales from the Muck: Airborne Asbestos Concentrations since the Late 1800's
Weigel, Jim	Tracking Design Pore Water Pressure against Design and Design Factor of Safety
Wely, Joshua	See Jarvis, William
Werth, David	See McMillan, Teresa (2)
West, Terry	Local Contractor Shows Lack of Knowledge About Cold Weather Deterioration of Exterior Concrete
White, Jonathan	See Lindsey, Cassandra
Whiteman, Rachel	See Jarvis, William
Wilhite, Coralie	Rock Mechanics and Its Effects on Spillway Modification Design
Wilhite, Coralie	See Hilmar, Jerilynn
Wiles, Sarah	See Arles, Michael
Wilshaw, David	Advanced Continuous Surface Wave Testing (ACSW): Geologic and Geotechnical Site Characterization for the 21st Century
Wilson, Justin	See Kuhne, Jody (2)
Winn, Russell	When Worlds Collide
Woodward, Jason	Landslide Geometry: Modeling Landslide Depths
Wooten, Richard	Communicating with Stakeholders About Landslide Hazards: Go It Alone at Your Own Risk, and the Only Failure Is to Stop Trying
Wooten, Rick	See Bauer, Jennifer
Wylie, Ann	A Metrological Look at NOA
Young, David	Impacts of Design Characterization and Geological Characteristics on Remedial Strategy Optimization
Young, Robert S.	See Tormey, Blair
Zamora, Carolina	See Bailey, Jim
Zhou, Wendy	See Krajnovich, Ashton

Help AEG's Foundation Stay Strong!

Please stop by our **AEG FOUNDATION SILENT AUCTION BOOTH** in the Exhibitors' Hall.

Bid on one of our many items: vintage and classic geology books and other interesting books, rocks and minerals, geodes, and much, much more.

We can arrange shipping for those of you with limited luggage space.

To donate to the AEG Foundation, please visit www.aegfoundation.org.

"A Night in the Mountains"

Wednesday, September 18

Special Event Fee: \$100 per person

Taylor Ranch is a fifth-generation, privately owned, 500-acre, working quarter horse and Texas longhorn cattle ranch. Scenic mountain views, gently rolling hills, a 7-acre lake stocked with brim and bass, and a beautiful lakeside post and beam pavilion make Taylor Ranch the perfect place for our special event. Casual attire suitable for strolling a ranch is recommended.



Tentative Timeline

6:00 pm Buses depart from Hotel Lobby

6:30 pm Arrival at Taylor Ranch. Try your hand at sport fishing, horseshoes, corn hole, and other varieties of lawn games, or sit by our lake, relax and enjoy the views and view the wildlife that calls Taylor Ranch home. All recreational equipment provided. Fishing poles and artificial bait are provided with good fishing assured as the ranch allows sport fishing with a catch-and-release policy.

6:30 pm – Watch in awe as a member of the Taylor Ranch staff calls and feeds the herd of registered Texas Longhorn cattle. There will be a great photo opportunity with one of their prize steers.

6:30–10:00 pm – Enjoy bottomless non-alcoholic beverages to include: a large assortment of soft drinks, freshly brewed iced tea and coffee, lemonade, and a variety of infused waters. A *literal* cash bar will be available (they DO NOT accept credit cards); one drink ticket is included. They feature several of the local breweries in Asheville, aka Beer City USA!



6:30–10:00 pm – Enjoy true Appalachian culture with the sounds of a professional bluegrass band. Listen as local musicians play their favorites and take your requests. A member of the band will call and instruct audience participation at square dancing and mountain broom dances.

6:30 pm–Dark – Go back in time as you travel across the ranch for a tour in one of their authentic horse-drawn covered wagons.

7:00 pm – Dinner is served! The dinner bell rings as the aromas from the grill call all to dinner.

8:30 pm – Sit by the campfire and have a s'mores roast, or sip on your cold local brew and listen to the tales of true Appalachia as told by the ranch's professional story teller. Guests of all ages will be mesmerized as they take you back to the era of the Cherokee Indian, the homesteaders, the moonshiners, and many more.

10:00 pm – Guests depart Taylor Ranch with memories made that will last a lifetime.



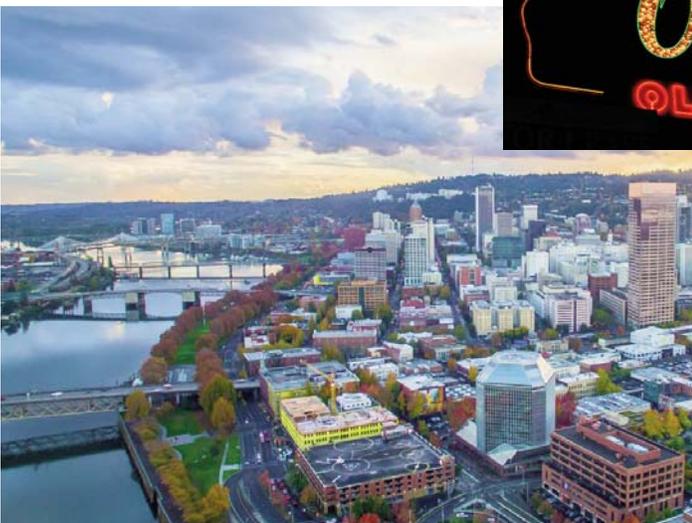
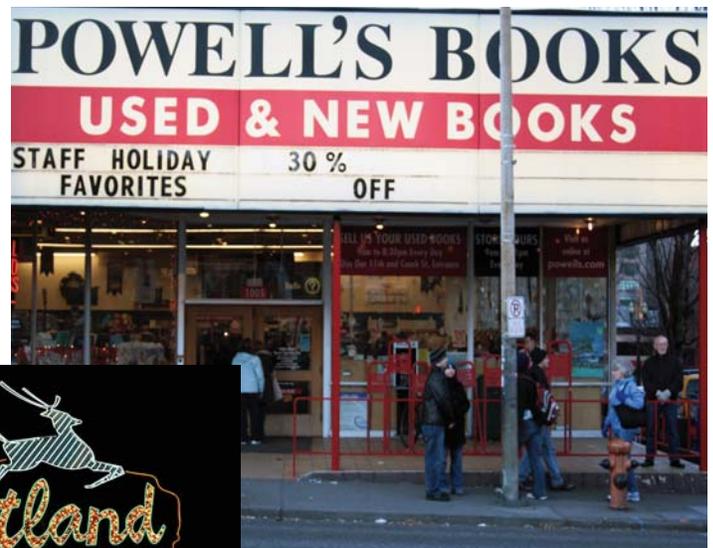
You don't want to miss what promises to be a truly Special Event!

Be sure to check the box and include the event fee for you and your guest on the Registration Form.

Thinking ahead... to Portland 2020



Portland, Oregon's largest city, sits on the Columbia and Willamette rivers, in the shadow of snow-capped Mount Hood. It's known for its parks, bridges and bicycle paths, as well as for its eco-friendliness and its microbreweries and coffeehouses. Iconic Washington Park encompasses sites from the formal Japanese Garden to Oregon Zoo and its railway. The city hosts thriving art, theater and music scenes.



**SAVE
—
THE
—
DATE**



**AEG 2020
PORTLAND OREGON**

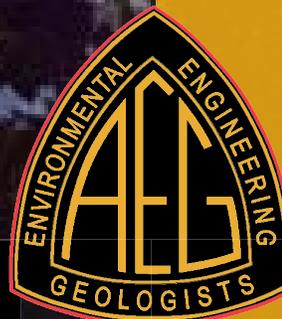
HAZARDS IN HINDSIGHT
LESSONS FOR THE FUTURE

**AEG 63RD ANNUAL
MEETING**

SEPTEMBER 15-19, 2020

**MARRIOTT PORTLAND
DOWNTOWN WATERFRONT**

**DETAILS COMING
IN SEPTEMBER**



AEGannualmeeting.org