AEG News

Program with Abstracts – 2017

PEAK OF THE PRACTICE

AEG | COLORADO SPRINGS 2017

ENVIRONMENTAL AND ENGINEERING GEOLOGY

FRIDAY SEPTEMBER 15TH, 2017
ANNUAL FORUM MEETING

FGIM Presentations and Field Trip

Presentations concerning Industrial Minerals will include topics such as local industrial minerals, processing, reserve/resources, environmental and transportation. Also, information regarding land management, reclamation and permitting of industrial minerals facilities.

FGIM inc.

Check out our new website!

FGIMinc.com

ANNUAL MEETING

Friday September 15th, 2017

Learn about issues and advances in industrial minerals Mining and Geology

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FGIM FIELD TRIP

Saturday & Sunday September 16th-17th, 2017

Industrial Minerals Mining & Geology in the Royal Gorge Region, Colorado

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Trip Leaders: David Bieber & Tom Newman

WE ARE STILL ACCEPTING ABSTRACTS!

Please contact:
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FGIM, Inc. President
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AEG News

2017 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), with the regular issues Nos. 1–3, published in April, July, and December, respectively. The Annual Report and Directory issue is published in March. The Annual Meeting Program with Abstracts is published in September. Print copies are distributed at the meeting. Association members receive the electronic copy of all five issues of the AEG News as part of their dues. Print subscriptions for Association members, which includes all five 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 (#1–3) of the *News*. The Annual Report and Directory issue is priced separately. Back issues of *AEG News* are $10 each. Inquiries should be sent to AEG Headquarters: Yolanda Natividad, Association Manager, 1100 Brandywine Blvd. Suite H, Zanesville, Ohio 43701 844-331-7867.

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In order of preference:

1. Send files via email, preferably as attachments, to both email addresses above. Optimum file format is MSWord 2011. Users of other software programs should convert their file to ASCII or text only.
2. Images should be sent as high-resolution jpeg or tiff files. **Questions?** Contact Andrea Ptak at 206-300-2067/andrealeighptak@me.com.
3. The policy of *AEG News* editorial staff is to limit the credentials of an individual to two. For example, if John Smith has a MS, a PhD and a PG plus a CEG and a CGWP, his credentials would be limited to John Smith PhD, PG, the two principal credentials. BS/BA and MS degrees will not be recognized. 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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NEXT SUBMISSION DEADLINE

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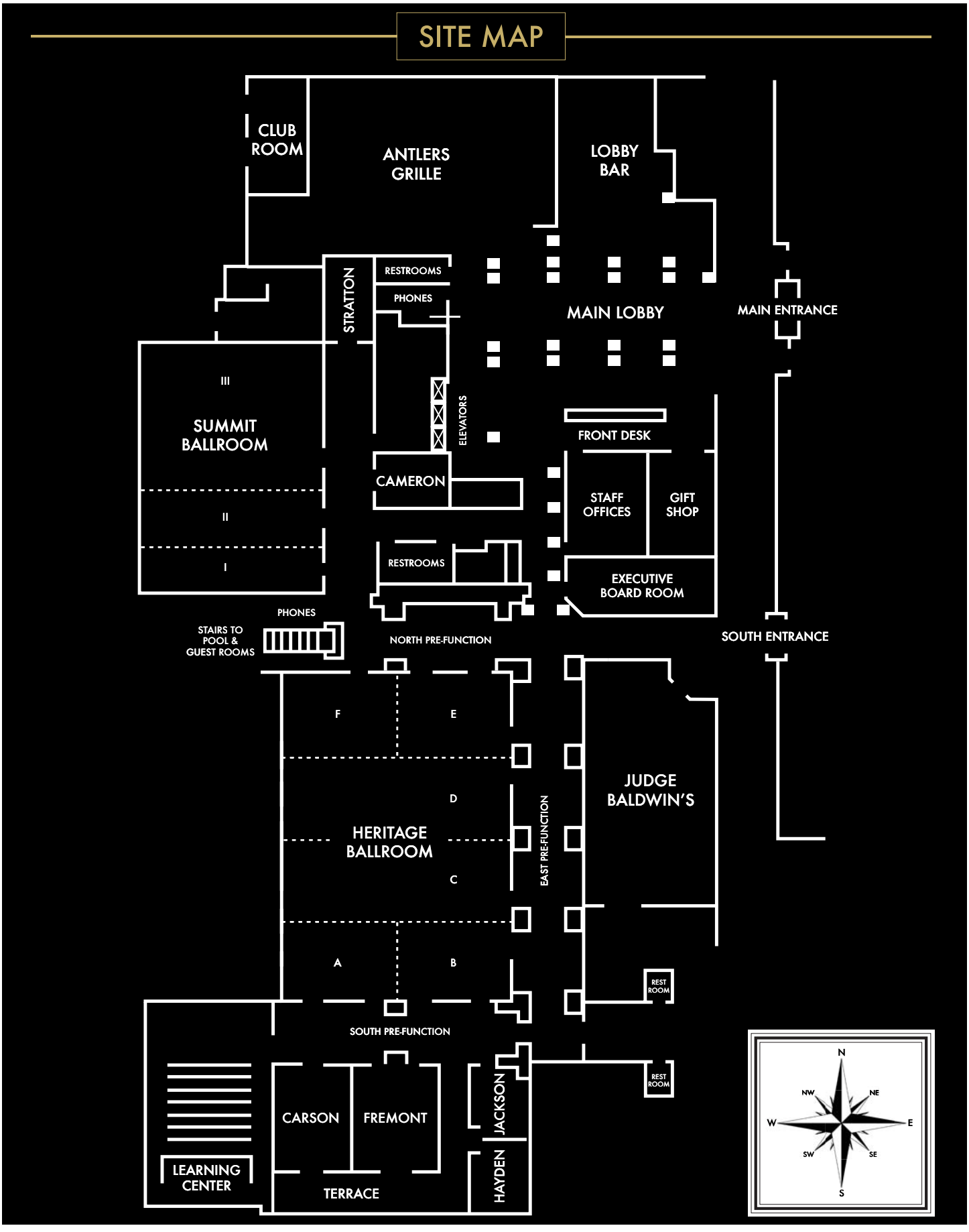
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Schedule of Events

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

EVENT	PLACE	TIME
TUESDAY, SEPTEMBER 12		
Registration Desk	Heritage Ballroom Foyer	7:00am–5:00pm
AEG Executive Council Meeting	Fremont	8:00am–5:00pm
AEG Foundation Board Meeting	Jackson	8:00am–5:00pm
Field Trip #1: Fire, Flood, and Landslide Impacts and Mitigation	Departs from Hotel Lobby	8:00am–5:00pm
Field Trip #2: Garden of the Gods Geology	Departs from Hotel Lobby	8:00am–5:00pm
Short Course #1: Debris Flow	Stratton	8:00am–5:00pm
Short Course #2: Professional Ethics for Geoscientists and Engineers	Carson	4:00pm–5:00pm
Guest Tour #1: Colorado Springs Fine Arts Center	Departs from Hotel Lobby	10:00am–2:00pm
Student/Professional Networking Reception	Summit III	5:15pm–6:15pm
Ice Breaker Reception and Exhibitor Opening	Heritage Ballroom	6:30pm–8:30pm
Young@Heart Happy Hour!	Phantom Canyon Brewery	8:00pm–11:00pm
WEDNESDAY, SEPTEMBER 13		
Registration Desk	Heritage Ballroom Foyer	7:00am–5:00pm
Committee Room	Stratton	7:00am–5:00pm
Speaker Preparation Room	Hayden	7:00am–5:00pm
Speakers'/Moderators' Breakfast	Fremont	7:00am–8:00am
Exhibitors	Heritage Ballroom	8:00am–5:00pm
Guest Tour #2: Cave of the Winds	Departs from Hotel Lobby	10:00am–1:00pm
Opening Session Welcome	Summit III	8:00am–8:10am
AEG Foundation Awards	Summit III	8:10am–8:30am
Keynote 1: Tony Waldron - Mining Regulation and Successful Reclamation	Summit III	8:30am–9:00am
Keynote 2: John Hunyadi - Colorado Dept. of Natural Resources Division of Water Resources – Dam Safety Branch	Summit III	9:00am–9:30am
Keynote 3: Ethan Greene with the Colorado Dept. of Natural Resources – Avalanche Hazards Program	Summit III	9:30am–10:00am
Mid-Morning Break	Summit III	10:00am–10:30am
OEEG Project Award: Colorado Inactive Mine Reclamation Program	Summit III	10:30am–11:15am
2016–17 Jahns Lecturer: Scott Anderson	Summit III	11:15am–11:45am
Introduction of the 2017–18 Jahns Lecturer	Summit III	11:45am–12:00pm
Exhibitors' Luncheon	Heritage Ballroom	12:00pm–1:30pm
Volunteer Recognition	Stratton	1:00pm–2:30pm
Poster Presentation Session #1	Heritage Ballroom	1:00pm–3:00pm
Technical Session #1: Resolving Complex Geologic Issues...Using Geophysics – Symposium	Carson	2:00pm–5:00pm
Technical Session #2: Subsidence and Soil Behavior Hazards	Fremont	2:00pm–3:20pm
Technical Session #3: Stream and Surface Water Management	Fremont	3:40pm–5:00pm
Technical Session #4: Landslide, Rockfall and Debris Flow Analysis and Remediation Part 1	Summit I	2:00pm–5:00pm
Technical Session #5: Environmental Characterization and Remediation	Summit II	2:00pm–5:00pm
Technical Session #6: Advocating for Geoscience: Ideas, Resources, and Examples	Learning Center	2:00pm–5:00pm
Poster Presentation Session #2	Heritage Ballroom	3:00pm–5:00pm
Mid-Afternoon Break	Heritage Ballroom	3:20pm–3:40pm
Special Event: Phantom Ranch Brewery	Departs from Hotel Lobby	6:00pm–10:00pm

EVENT	PLACE	TIME
THURSDAY, SEPTEMBER 14		
Registration Desk	Heritage Ballroom Foyer	7:00am–5:00pm
Chapter Chair Breakfast	Jackson	7:00am–8:00am
Speakers'/Moderators' Breakfast	Summit III	7:00am–8:00am
Speaker Preparation Room	Hayden	7:00am–5:00pm
Poster Presentation Session #3	Heritage Ballroom	8:30am–10:30am
Exhibitors	Heritage Ballroom	8:00am–5:00pm
Technical Session #7: The Impact of Geology on Flood Control and Water Storage Dams and Levees – Part 1	Summit II	8:00am–12:00pm
Technical Session #8: Landslide, Rockfall and Debris Flow Analysis and Remediation – Part 2	Summit I	8:00am–12:00pm
Technical Session #9: Emerging Contaminants Symposium Part 1	Carson	8:00am–12:00pm
Technical Session #10: Transportation and Infrastructure Projects	Fremont	8:00am–12:00pm
Guest Tour #3: Manitou & Pike's Peak Railway	Departs from Hotel Lobby	8:30am–3:30pm
Committee Room	Jackson	9:00am–5:00pm
Mid-Morning Break	Heritage Ballroom	10:00am–10:20am
Poster Presentation Session #4	Heritage Ballroom	10:30am–12:30pm
AEG Awards Luncheon & Corporate Business Meeting	Summit III	12:15pm–1:45pm
Poster Presentation Session #5	Heritage Ballroom	12:30pm–2:30pm
Technical Session #11: The Impact of Geology on Flood Control and Water Storage Dams and Levees – Part 2	Summit II	2:00pm–5:00pm
Technical Session #12: Materials Characterization and Ground Improvement	Learning Center	2:00pm–3:20pm
Technical Session #13: The Impact of Geology on Government Projects and Assets – Symposium	Learning Center	3:40pm–5:00pm
Technical Session #14: Sliding the Scale: Improving Communications and Public Policy for Landslide Hazards – Symposium	Summit I	2:00pm–5:00pm
Technical Session #15: Geophysics and Remote Sensing	Fremont	2:00pm–3:20pm
Technical Session #16: Hazard Characterization and Management	Fremont	3:40pm–5:00pm
Technical Session #17: Emerging Contaminants Symposium Part 2	Carson	2:00pm–5:00pm
AEG K-12 Earth Science Fair Projects on Display	Heritage Ballroom Foyer	3:00pm–5:00pm
AEG K–12 Earth Science Fair Awards Ceremony	Cameron	5:00pm–5:30pm
Mid-Afternoon Break	Heritage Ballroom	3:20pm–3:40pm
Poster Presentations Reception	Heritage Ballroom	5:30pm–7:00pm
Annual Banquet	Summit III	7:00pm–10:00pm

Women in AEG/AWG Breakfast

Friday, September 15 – 7:30-8:30am

Join Karen Berry, Director and State Geologist, Colorado Geological Survey, for what has become an AEG Tradition!

Karen Berry earned a geological engineering degree from the Colorado School of Mines and completed graduate work in geotechnical engineering and Graphic Information Systems.She has worked for the Colorado Geological Survey since 1999 where she has held positions including land use program manager, deputy Director, Director and State Geologist. Prior to her time with CGS, Berry worked as an exploration geologist in Texas, engineering geologist in Arizona, geotechnical reclamation specialist for the Colorado Mined Land Reclamation Board and county geologist for Jefferson County, Colorado. Berry is a Professional Geologist in Colorado and Wyoming; a Certified Planner by the American Institute of Certified Planners, American Planning Association. She is Vice President of the American Association of State Geologists and serves on a number of boards and commissions. Berry also served on the Wheat Ridge City Council; the Board of Directors, Denver Regional Council of Governments; and the Natural Resources Committee, National League of Cities.

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EVENT	PLACE	TIME
FRIDAY, SEPTEMBER 15		
Registration Desk	Heritage Ballroom Foyer	7:00am–5:00pm
Committee Room	Jackson	7:00am–2:00pm
Speaker Preparation Room	Hayden	7:00am–2:00pm
Speakers'/Moderators' Breakfast	Summit III	7:00am–8:00am
Women in AEG/AWG Breakfast	Cameron	7:30am–8:30am
Exhibitors	Heritage Ballroom	8:00am–11:30am
Guest Tour #4: Garden of the Gods Tour	Departs from Hotel Lobby	9:00am -2:00pm
Technical Session #18: Landslide Hazards of Colorado Springs: What the General Public Needs to Know	Carson	9:00am–12:00pm
Technical Session #19: Remote Sensing and GIS for Geohazards Assessment and Environmental Studies – Symposium	Fremont	9:00am–12:00pm
Technical Session #20: The Impact of Geology on Flood Control and Water Storage Dams and Levees – Part 3	Summit II	9:00am–12:00pm
Technical Session #21: Reclamation of Industrial Mineral Extraction Sites	Summit I	9:00am–12:00pm
Mid-Morning Break	Heritage Ballroom	10:00am–10:20am
Past Presidents' Luncheon (invitation only)	Cameron	12:00pm–1:45pm
Student Luncheon and Career Discussion	Summit III	12:00pm–1:45pm
Board of Directors' Orientation Meeting	Stratton	2:00pm–5:00pm
Technical Session #22: InSAR Applications for Geology and Geological Engineering – Symposium	Summit II	2:00pm–5:00pm
Technical Session #23: Rock Engineering and Rock Mechanics	Carson	2:00pm–5:00pm
Technical Session #24: Geology and Industrial Minerals	Summit I	2:00pm–5:00pm
Technical Session #25: Hydrogeology	Fremont	2:00pm–3:20pm
Technical Session #26: Environmental Geology	Fremont	3:40pm–5:00pm
Mid-Afternoon Break	Heritage Ballroom Foyer	3:20pm–3:40pm
SATURDAY, SEPTEMBER 16		
Field Trip #3: Cripple Creek/Victor Gold Mine	Departs from Hotel Lobby	8:00m–4:00pm
Field Trip #4: Industrial Minerals Mining and Geology in the Royal Gorge Region	Departs from Hotel Lobby	8:00am on 9/16 to 5:00pm on 9/17
Short Course #3: Characterization of Rock Core and Borehole Conditions for Engineering & Environmental Projects	Fremont	8:00am–5:30pm
Short Course #4: geoDRONEology©	Carson	8:00am–5:00pm
AEG Board of Directors' Meeting	Summit Ballroom	8:00am–5:00pm
SUNDAY, SEPTEMBER 17		
AEG Board of Directors' Meeting	Summit Ballroom	8:00am–12:00pm

Technical Session Numbers and Names

See page 34 for full Technical Session listings.

SESSION	TIME
WEDNESDAY MORNING, SEPTEMBER 13	
Opening Session Welcome (Dale Andrews, Julia Frazier and David Bieber)	8:00am–8:10am
AEG Foundation Awards (Briget Doyle)	8:10am–8:30am
Keynote Speaker: Tony Waldron: Mining Regulation and Successful Reclamation	8:30am–9:00am
Keynote Speaker: John Hunyadi, Colorado Department of Natural Resources Division of Water Resources Dam Safety Branch	9:00am–9:30am
Keynote Speaker: Ethan Greene with the Colorado Department of Natural Resources Avalanche Hazards Program	9:30am–10:00am
Break	10:00am–10:30am
Outstanding Environmental & Engineering Geologic Project Award	10:30am–11:15am
2016–17 Jahns Distinguished Lecturer in Engineering Geology Award: Scott Anderson	11:15am–11:45am
Introduction of the 2017–18 Jahns Lecturer	11:45am–12:00pm
WEDNESDAY AFTERNOON, SEPTEMBER 13	
Technical Session #1: Resolving Complex Geologic Issues... Using Geophysics – Symposium	2:00pm–5:00pm
Technical Session #2: Subsidence and Soil Behavior Hazards	2:00pm–3:20pm
Technical Session #3: Stream and Surface Water Management	3:40pm–5:00pm
Technical Session #4: Landslide, Rockfall and Debris Flow Analysis and Remediation Part 1	2:00pm–5:00pm
Technical Session #5: Environmental Characterization and Remediation	2:00pm–5:00pm
Technical Session #6: Advocating for Geoscience: Ideas, Resources, and Examples	2:00pm–5:00pm
THURSDAY MORNING, SEPTEMBER 14	
Technical Session #7: The Impact of Geology on Flood Control and Water Storage Dams and Levees Part 1 – Symposium	8:00am–12:00pm
Technical Session #8: Landslide, Rockfall and Debris Flow Analysis and Remediation Part 2	8:00am–12:00pm
Technical Session #9: Emerging Contaminants Part 1 - Symposium	8:00am–12:00pm
Technical Session #10: Transportation and Infrastructure Projects	8:00am–12:00pm
THURSDAY AFTERNOON, SEPTEMBER 14	
Technical Session #11: The Impact of Geology on Flood Control and Water Storage Dams and Levees Part 2 – Symposium	2:00pm–5:00pm
Technical Session #12: Materials Characterization and Ground Improvement	2:00pm–3:20pm
Technical Session #13: The Impact of Geology on Government Projects and Assets – Symposium	3:40pm–5:00pm
Technical Session #14: Sliding the Scale: Improving Communications and Public Policy for Landslide Hazards – Symposium	2:00pm–5:00pm
Technical Session #15: Geophysics and Remote Sensing	2:00pm–3:20pm
Technical Session #16: Hazard Characterization and Management	3:40pm–5:00pm
Technical Session #17: Emerging Contaminants Part 2 – Symposium	2:00pm–5:00pm

SESSION	TIME
FRIDAY MORNING, SEPTEMBER 15	
Technical Session #18: Landslide Hazards of Colorado Springs: What the General Public Needs to Know	9:00am–12:00pm
Technical Session #19: Remote Sensing and GIS for Geohazards Assessment and Environmental Studies – Symposium	9:00am–12:00pm
Technical Session #20: The Impact of Geology on Flood Control and Water Storage Dams and Levees Part 3 – Symposium	9:00am–12:00pm
Technical Session #21: Reclamation of Industrial Mineral Extraction Sites	9:00am–12:00pm
FRIDAY AFTERNOON, SEPTEMBER 15	
Technical Session #22: InSAR Applications for Geology and Geological Engineering – Symposium	2:00pm–5:00pm
Technical Session #23: Rock Engineering and Rock Mechanics	2:00pm–5:00pm
Technical Session #24: Geology and Industrial Minerals	2:00pm–5:00pm
Technical Session #25: Hydrogeology	2:00pm–3:20pm
Technical Session #26: Environmental Geology	3:40pm–5:00pm

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Women in AEG/AWG Breakfast

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Acknowledgements

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BC Engineering, Inc.
Cesare, Inc.
Colorado Geological Survey
Colorado School of Mines
Engineering Analytics
FHWA
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USDA-NRCS

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Karen Berry (Technical Session Moderator)
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Bryan Simpson (Short Course Instructor)
Phil Sirles (Symposium Convener)
Terry West (Technical Session Moderator)
Wendy Zhou (Symposium Convener)

COLORADO GEOLOGICAL SURVEY AT THE COLORADO SCHOOL OF MINES

An Open Welcome to AEG Conference Attendees

Welcome to Colorado Springs, Olympic City USA. The city is home to the United States Olympic Committee Headquarters, more than 50 National Sport Organizations, an Olympic Training Center and the future US Olympic Museum.

Colorado Springs is also home to world-class geology. Massive Pikes Peak, the inspiration for "America the Beautiful", makes an impressive backdrop for Colorado Springs and the Garden of the Gods. At more than 14,000 feet above sea level and the farthest east of the big peaks, it is easily seen from across the plains. It became a national symbol of the 1859 Gold Rush with the slogan, "Pikes Peak or Bust". Pikes Peak is also the most visited mountain in North America and the second most visited mountain in the world behind Mount Fuji.

Garden of the Gods Park is a National Natural Landmark. Dramatic 300 feet tall vertical sandstone formations are set against the backdrop of Pikes Peak and Colorado's intense blue skies. Every year, millions come to enjoy the beauty of the Park and learn about mountain building, plate tectonics, and dinosaurs.

If your notion of striking it rich is golden hops in a frosty mug, Colorado Springs is your dream destination. The city is home to more than 200 artisan breweries and Colorado is credited with perfecting the art of craft beer.

From landslides to mine subsidence to contaminated groundwater to heaving bedrock to post wildfire debris flows, the Colorado Springs area offers many learning opportunities for experienced and aspiring geoscience professionals. A special session, sponsored by AEG and the Colorado Geological Survey (CGS), on Colorado Springs landslides will be held Friday morning.

Nature and geology are humbling forces in Colorado and the mission of the CGS is to protect public safety and enhance the economy of Colorado. We have been helping citizens and communities build economic resiliency and resiliency to geologic hazards since 1874. Check out our website at ColoradoGeologicalSurvey.org and be sure to visit some of the geological wonders and explore the planning, engineering, and environmental challenges of Colorado Springs.

Even purple mountain majesties above the fruited plain can't compare to a great conference: the atmosphere of being immersed in a crowd of professionals with the same passions as you, the questions and answers you learn, and the old friends you get to meet and the new ones you make. You will leave Colorado energized — full of fresh ideas.

Regards,

Karen A. Berry, PG, AICP

State Geologist and Director

1801 19th Street Golden, CO ColoradoGeologicalSurvey.org

The Peak of the Practice!

The 60th Annual Meeting– Colorado Springs Colorado

It gives me great pleasure to welcome you to the Association of Environmental & Engineering Geologists' (AEG) 60th Annual Meeting being held at the beautiful Antlers Hotel in Colorado Springs, Colorado. This meeting offers an incredible array of field trips, short courses and technical sessions that are sure to peak your interests. To touch on a few highlights, topics will include induced seismicity, slope stability and debris flows, rock mechanics, drone technology, industrial minerals and mining, geophysics, groundwater, flood hazards and more. Of course, an AEG meeting is not complete without taking advantage of one or more of the wonderful field trips planned.

I would like to take this opportunity to thank those that made this meeting possible. This includes each of the volunteers of the organizing committee and AEG staff who have worked tirelessly to put on this conference. I want to thank all the companies and individuals that elected to be a meeting sponsor or exhibitor. Without your commitment to AEG, these meetings would not be possible. I also want to thank our speakers whose contributions have culminated in providing us with an astounding wealth of information. Lastly, I want to thank you, our attendees, for your participation and recognition of the high-quality meetings that AEG provides every year.

> "…our speakers, whose contributions have culminated in providing us with an astounding wealth of information."

Allow me to close by welcoming each of you to Colorado Springs, a city of spectacular beauty! Please enjoy the conference and the city. Be sure to also introduce yourselves to the members of the Forum on the Geology of Industrial Minerals who have partnered with AEG for this meeting.

I hope to personally meet and warmly welcome each and every one of you at the conference.

Sincerely,

Dale C. Andrews

AEG President, 2016–17

Welcome to Colorful Colorado!

A warm hello to familiar friends, comrades, and to the new connections we hope to make during this meeting! Colorado is an amazing place with uniquely beautiful and complex geologic and human history to stir anyone's professional or personal interests. The State of Colorado stretches from high peaks to high plains and everything in between. Colorado has a rich earth history, with rocks being formed today in hot springs, rocks dating back to the precambrian in the Rocky Mountains, and rocks between these ages throughout the state. The variability of the geology and geography across this part of the North American continent makes for an intense and adventurous place to visit, live, love, and practice the geosciences.

Our hope for this meeting is that you will have many opportunities for exploration, expansion of knowledge, and excitement as you attend talks, field trips, and social and professional networking events—and as you venture out over the beautiful Colorado landscape with upturned sandstone pillars and flatirons, mountainous terrain rich in minerals, gemstones, and breathtaking vistas, riverways of rushing meltwater, and colorful fall colors in the aspen groves that blanket the mountain slopes. Colorado is home to many geologic, geotechnical, and environmental resources and challenges, some of which include: landslides, rockfall, debris flows, floods, expansive soils and bedrock, collapsible soils, subsidence, and groundwater issues; as well as mineral, aggregate, and geothermal resources to utilize and protect; emerging contaminants; and many others.

These resources and challenges are dealt with by diverse professionals in industry, academia, and government roles, many of whom are coming together at this meeting. These professionals utilize tools and expertise in geotechnical, civil, and environmental engineering, geology, hydrology, geomorphology, geophysics and remote sensing, global information systems (GIS), and unmanned aircraft systems (drones). They collaborate to provide solutions and perform hazard assessment, remediation, resiliency program development, and effective and proactive land use planning and policy.

So many emerging, innovative and evolving technologies and methods exist at this time to give us quicker, more detailed and more comprehensive information, answers and solutions—a truly exciting time to be a geoscientist! We look forward to this opportunity to meet in this beautiful place with our fellow AEG members and others involved in the professional, academic, and governmental facets of our geoscience community. Welcome to the AEG 60th Annual Meeting!

Julia Frazier
General Co-Chair

David Bieber
General Co-Chair

AEG 2017 Awardees

Honorary Member

Jeffrey R. Keaton

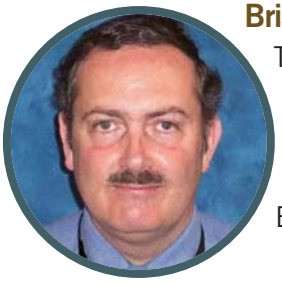
AEG confers an honor of such high esteem that the distinction is recognized as a membership class: Honorary Member. This recognition is given to those persons whose careers have exemplified the ideals of AEG.

Karl and Ruth Terzaghi Mentor Award

James H. Williams

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.

Floyd T. Johnston Service Award



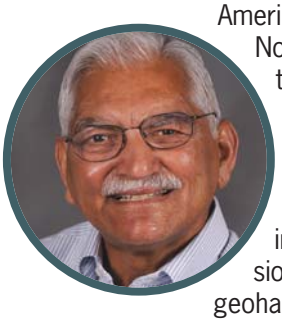
Brian H. Greene

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.

Schuster Medal

Dr. Abdul Shakoor

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.



Douglas R. Piteau Outstanding Young Member Award:

Stephanie Coffman

This award, established in 1985, is named in honor of Douglas R. Piteau is presented to a Member who is age 35 or under and has excelled in the following areas: Technical Accomplishment, Service to the Association, and Service to the Engineering Geology Profession.

Claire P. Holdredge Award

Steve D. Bowman

and

William R. Lund

The Association's highest publication award, the Claire P. Holdredge Award, is presented to an AEG Member who has produced a publication within the past five years that is adjudged to be an outstanding contribution to the Environmental and Engineering Geology Profession.

Richard H. Jahns Distinguished Lecturer in Engineering Geology

Dr. John Wakabayashi

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.

AEG Foundation 2017 Scholars

Beardsley-Kuper Field Camp Scholarship

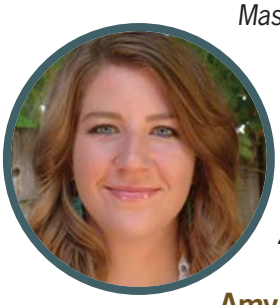
Andrew Oberhelman
University of Puget Sound

Jeffrey Weiss
NC State University

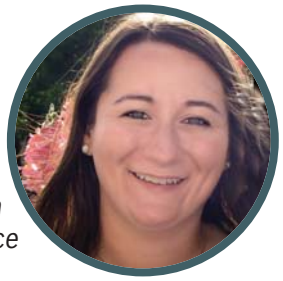
The Beardsley-Kuper Field Camp Scholarship Fund supports expenses for geology field camps with applied environmental and engineering geology components that will be useful to the students' future profession as an environmental or engineering geologist. The scholarship was established in 2009 by Cathryne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

Norman R. Tilford Field Study Scholarship

Johanna Eidmann
Colorado State University
Masters Division 1st Place



Erin Lathrop
Utah State University
Masters Division 2nd Place



Amy Plechacek
Virginia Tech University
Undergraduate Division 1st Place

Anna Stanczyk
University of Alaska, Anchorage
Undergraduate Division 2nd Place

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.

Martin L. Stout Scholarship

Tyler C. Gilkerson
Colorado State University
Graduate Division 1st Place

Cole D. Rosenbaum
Colorado School of Mines
Graduate Division 2nd Place

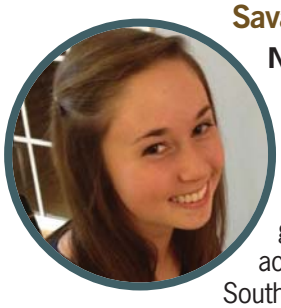
Melissa Anne Magno
East Tennessee State University
Undergraduate Division 1st Place

Tenaya Brown
University of Nevada Reno
Undergraduate Division 2nd Place

Allan W. Foster III
Colorado School of Mines
Undergraduate Division 3rd 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.

Carolinas Scholarship



Savannah Bryant
NC 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.

Christopher C. Mathewson Scholarship

Joshua Peterson
University of Texas at El Paso
Graduate Division

Alyssa Kirkendall
University of Texas at San Antonio
Undercraduate Division

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.

Marliave Scholarship

Robert Huber
South Dakota School of Mines

The Marliave Scholarship Fund was established by AEG in 1968 and transferred to the AEG Foundation in 1992. The Fund honors the late Chester E. Marliave, Burton H. Marliave, and Elmer C. Marliave, outstanding engineering geologists and supporters of AEG. The scholarship support academic activity and reward outstanding scholarships in Engineering Geology and Geological Engineering.

Shlemon Quaternary Engineering Geology Scholarship

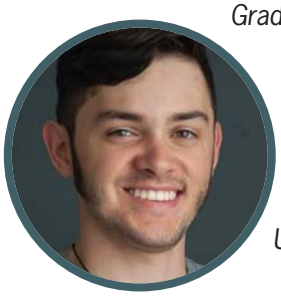
Omid Arabnia
Colorado School of Mines
PhD Division

James McNeil
California State University Northridge
Masters Division

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.

West-Gray Scholarship

Kelly Hickcox
University of Missouri
Graduate Division



Luke Weidner
Michigan Technological University
Undergraduate Division

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.

Keep AEG's Foundation Going Strong!

Please stop by our AEG FOUNDATION SILENT AUCTION BOOTH in the Exhibitors' Hall.

Bid on one of our more than 125 items, from vintage and classic geology books (one is from 1913) and other interesting books, an espresso maker specifically designed for high end camping, rocks and minerals, art photographs, a silver tray, decorative Bali mask, leather gloves, geode and glass napkin rings (really!), and much, much more.
We can arrange shipping for those of you with limited luggage space. THANK YOU!

To donate to the AEG Foundation, please visit www.aegfoundation.org.

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, AEG would not be able to offer the special touches that make our 2017 Annual Meeting a "step above the rest."

Be sure to:

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

Exhibit Hours:

Tuesday	**September 12**	**6:30pm–8:30pm**
Wednesday	**September 13**	**8:00am–5:00pm**
Thursday	**September 14**	**8:00am–5:00pm**
Friday	**September 15**	**8:00am–11:30am**

Associated Environmental Industries – Booth #40

PO Box 5300, Norman, OK 73070
405-360-1434
www.aei-corp.com
Contact: Joseph Datin, joseph@aei-corp.com

Associated Environmental Industries is a proven environmental services company with over 25 years' experience. We specialize in vertical drilling, horizontal drilling and excavation in the environmental market. Our rigs are capable of sonic, water rotary, air rotary, hollow stem auger, coring, direct push, and horizontal drilling with the flexibility and experience to successfully complete the most difficult projects. Our experiences span a wide array of industries including oil & gas, municipal, industrial, federal, and mining.

AEG – Registration Area

1100-H Brandywine Blvd., Zanesville, OH 43701
844-331-7867 x3229, Fax 740-452-2552
www.aegweb.org
Contact: aeg@aegweb.org

AEG welcomes you to Colorado Springs! 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 2018 Annual Meeting – Booth #39

Contact: Sarah Kalika, sarah@georx.net
Mark your calendar to join us for the 61st AEG Annual Meeting/13th IAEG Congress in San Francisco, CA, on September 17–21, 2018. AEG is partnering with the International Association of Engineering Geologists and the Environment (IAEG) to host the first ever Congress in the United States in IAEG's 54-year history. The 2018 meeting will have a five-day format featuring prominent national and international keynote speakers, four days of technical sessions and symposia, and an all-day Wednesday tour of local geology for full meeting registrants. Stop by our booth to get all of the details.

AEG Foundation Silent Auction and Booth – Booths #14 & 15

4123 Broadway #817, Oakland, CA 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.

Authentic Drilling, Inc. – Booth #33

201 W Perry Park Avenue, Unit 105, Larkspur, CO 80118
303-465-1450
https://authenticdrilling.com
Contact: Sherri Meiklejohn, sherri@authenticdrilling.com

Authentic Drilling is a geotechnical, environmental, water well and exploration certified woman small business drilling company located in the Denver metro area. Our fleet consists of truck, track and buggy rigs. Our specialty is difficult access sites with odex, coring, casing advancer, air/mud rotary and auger drilling methods.

BETA Analytic Inc. – Booth #31

4985 SW 74th Court, Miami, FL 33155
305-667-5167
http://www.radiocarbon.com
Contact: Florencia Goren, advertising@betalabservices.com

ISO 17025-accredited Beta Analytic is a dedicated radiocarbon dating laboratory with standard turnaround time of 14 business days for its AMS Dating service. Expedited services are available (2–6 business days). All analyses are performed in-house. Respected worldwide for accuracy, quality, and customer care. Results are accessible 24/7 via web access.

ConeTec, Inc – Booth #13

3750 West 500 South, Salt Lake City, UT
801-973-3801
www.conetec.com
Contact: Shawn Steiner, ssteiner@conetec.com

ConeTec is a full service geotechnical and environmental site investigation contractor. We safely solve problems by generating high quality subsurface information used in geotechnical, environmental, and mining geotechnique. Our team of experts is dedicated to safe, quality, and efficient site investigations using the best possible equipment.

Enviroprobe Services, Inc. – Booth #35

81 Marter Ave., Mt Laurel, NJ 08054
484-833-3003
www.enviroprobe.com
Contact: Matthew J. McMillen, mattm@enviroprobe.com

Enviroprobe Service, Inc. provides a variety of engineering, environmental, and archeological geophysical services across the US and overseas. These services include borehole logging, electromagnetics (EM), ground penetrating radar (GPR), magnetics, gravity, electrical resistivity, and seismic surveys. Our expert field staff of five geophysicists/geophysical technicians has nearly 95 combined years of experience. We also provide fast, efficient, and cost effective environmental and geotechnical drilling, geoprobe operations, and subsurface investigations.

Exploration Instruments LLC – Booth #38

2808 Longhorn Blvd., Suite 304, Austin, TX 78758
512-346-4042
Contact: Dennis Mills, dmills@expins.com

Exploration Instruments is the best-known geophysical equipment rental firm in North America specializing in near-surface applications. We maintain a diverse inventory of 85 different systems including seismic, radar, EM, gravity, magnetics, resistivity, radiometrics, hydrologic, marine and non-destructive testing tools. Offices in Austin, Texas and Harrisburg, PA are ideally situated to service projects world-wide.

Gannett Fleming, Inc. – Booth #25

270 Senate Ave., Camp Hill, PA 17011
717-763-7211, Fax 717-761-7059
www.gannettfleming.com
Contact: Brian Greene, bgreene@gfnet.com

Gannett Fleming provides a full range of geotechnical and geological services, ranging from foundations, dams, and levees, to earth retaining structures, tunnels and mining operations. These services include geotechnical analysis, digital photogrammetry, drilling and geophysics, site characterization, instrumentation, ground modification, design of earth structures, and groundwater studies. We are among a select number of Engineering News-Record Top 100 Design Firms that are ISO 9001:2008 certified.

Gehrig, Inc. – Booth #32

PO Box 46, 212 E. Main St., Muenster, TX 76252
817-915-6174
www.gehriginc.com
Contact: James Branch, rbranch@rustybranch.com

Gehrig, Inc. provides surface and borehole geophysics services for exploration, engineering, and environmental projects throughout the United States. Our toolbox includes seismic, electrical resistivity, electromagnetic, microgravity, ground penetrating radar, and a full suite of borehole tools. Recent projects involved dams, levees, landfills, karst and voids, faults, USTs, and general site characterization.

Geo-Instruments – Booth #30

24 B Celestial Drive, Narragansett, RI 02882
425-999-5517
www.geo-instruments.com
Contact: Rick Monroe, rick.monroe@geo-instruments.com

GEO-Instruments provides geotechnical and structural monitoring services. We supply, install, and integrate geotechnical sensors and geomatic systems, and we automate the collection, processing, and delivery of data.

Geobrugg North America, LLC – Booth #3

312 S Larkspur Dr., Castle Rock, CO 80104
303-598-7896
www.geobrugg.com
Contact: Kevin McNeill, kevin.mcneill@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 wit 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.

Geokon, Inc. – Booth #12

48 Spencer Street, Lebanon, NH 03766
603-448-1562
www.geokon.com
Contact: John Flynn, jflynn@geokon.com

Geokon Incorporated, The World Leader in Vibrating Wire Technology (TM), manufactures a complete line of high-quality geotechnical instrumentation suitable for monitoring the safety and stability of dams, tunnels, foundations, ground water and the like. Our complete selection of Instrumentation includes extensometers, piezmeters, strain gages, crackmeters, load cells, settlement sensors, pressure cells, inclinometers, and dataloggers.

Geological Society of America – Booth #4

3300 Penrose Place, PO Box 9140, Boulder, CO 80301
303-357-1004
www.geosociety.org
Contact: Rebecca Freeman, rfreeman@geosociety.org

The Geological Society of America, founded in 1888, is a scientific society with more that 25,000 members from academia, government, and industry in more the 100 countries. Through its meetings, publications, and programs GSA enhances the professional growth of its members and promotes the geosciences in the service of humankind.

Geostuff – Booth #20

12996 Somerset Drive, Grass Valley, CA 95945
530-274-4445
www.geostuff.com
Contact: Doug Crice, dcrice@geostuff.com

Geostuff manufactures innovative seismic systems and accessories. The AnySeis operates without seismic cables, simplifying logistics, minimizing field time and maximizing flexibility at the job site. We are also the leading manufacturer of wall-lock borehole geophones for borehole shear wave surveys and land streamers for fast, easy seismic surveys, especially MASW.

GEOVision, Inc. – Booth #19

1124 Olympic Dr., Corona, CA 92881-3390
603-448-1562, Fax: 603-448-3216
www.geovision.com
Contact: John Diehl, jdiehl@geovision.com

Specializing in an understanding of subsurface geologic and hydrologic conditions, subsurface infrastructure, engineering properties of soil and rock, and earthquake hazards.

Hayward Baker – Booth #37

5775 Eudora St., Commerce City, CO 80022
713-591-5396
www.haywardbaker.com
Contact: Phillip Gallet, pagallet@haywardbaker.com

Hayward Baker is North America's leader in geotechnical solutions, continually evolving and expanding to meet the increasingly complex needs of the construction community. Hayward Baker is a contractor specializing in all ground improvement, structural connections, and earth retention techniques.

Hi-Tech Rockfall – Booth #29

PO Box 674, Forest Grove, OR 97116
503-357-6508, Fax 503-357-7323
www.hitechrockfall.com
Contact: Dane Wagner, dane@hitechrockfall.com

HI-TECH is a General Contractor who specializes in rockfall mitigation and installs rockfall protection systems throughout the United States. HI-TECH constructs a vast array of rockfall mitigation systems in a variety of locations such as highways, railroads, dams, quarries, mines, construction sites, commercial, and residential properties. Protection systems and services include, but are not limited to: wire mesh drapery, cable net drapery, rockfall catchment barriers, rock scaling, debris flow systems, rock dowels, and rock bolts.

International Geophysical Services, LLC - Booth #9

9302 West Kentucky Place, Lakewood, CO 80226
303-462-1466
www.igsdenver.com
Contact: Ronald Bell, rbell@igsdenver.com

IGS is a Geophysical Consulting and Services Company specializing in geophysical imaging of the subsurface and drone photogrammetry for geologic mapping and asset management. Our mission is to provide you with the up-to-date geoscientific data and information to enhance your decision-making process while simultaneously improving your workflow all the while keeping firmly focused on increasing the cost effectiveness of your project.

Kane GeoTech, Inc. – Booth #26

7400 Shoreline Dr., Ste. 6, Stockton, CA 95219
209-472-1822
www.kanegeotech.com
Contact: William Kane, wkane@kanegeotech.com

KANE GeoTech, Inc. is a civil engineering firm specializing in difficult geotechnical problems such as landslide, debris flow, rockfall mitigation, and instrumentation. As a relatively small, innovative company we can work closely with clients to develop the best solutions for their needs. As a result we have maintained long term relationships with many clients.

Maccaferri, Inc. – Booth #6

10303 Governor Lane Blvd., Williamsport, MD 21795
301-223-6910, Fax 301-223-4590
www.maccaferri-usa.com
Contact: Mike Koutsourais, mkoutsourais@maccaferri-usa.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 of experience, providing local solutions for complex projects around the world.

Midwest GeoSciences Group – Booth #27

1950 Greyhound Pass, Suite 18, Carmel, IN 46033
763-607-0092
www.midwestgeo.com
Contact: Dan Kelleher, dan@midwestgeo.com

We are motivated by serving others toward professional success, global stewardship, and personal growth. We strive to create meaningful educational experiences through workshops, webinars and short courses. It's a privilege to collaborate with experts who create field tools that become valuable and popular. Despite our pride in our on-demand webinar programs, we are humbled to help people in the special way. We are grateful for the opportunity to serve AEG and it's mission, members and vision.

National Association of State Boards of Geology (ASBOG) – Booth #18

1800 NW Brickyard Rd, Topeka, KS 66618
785-640-2477
www.asbog.org

Contact: Robert Henthrone,
bhenthorne@midstatesmaterials.com

ASBOG serves as a connective link among the individual state geologic registration licensing boards, with the principal service of developing standardized written examinations for determining qualifications of applicants seeking licensure as professional geologists.

NHAZCA– Booth #11

via Vittorio Bachelet, 12, Rome, Italy 00185
+39 06 9506 5820
www.nhazca.com
Contact: Paolo Mazzanti, paolo.mazzanti@nhazca.com

NHAZCA is a spin-off company of "Sapienza" University of Rome (Italy) providing services and consultancy based on innovative remote sensing technologies for the management, control and monitoring of natural and man-induced hazards. Thanks to tailored solutions, NHAZCA supports companies and authorities working in the fields of large infrastructures, hydroelectric, oil & gas, mining and land management.

NORCAL Geophysical Consultants Inc. – Booth #36

321 Blodgett Street, Cotati, CA 94931
707-796-7170
www.norcalgeophysical.com
Contact: Kenneth Blom, kblom@norcalgeophysical.com

NORCAL has been providing innovative borehole and surface geophysical services for over 30 years.

Olson Engineering, Inc. – Booth #21

12401 W 49th Ave., Wheat Ridge, CO 80033-1927
303-423-1212
www.olsonengineering.com

Contact: Nicole Pendrigh,
nicole.pendrigh@olsonengineering.com

Olson Engineering is a specialized firm that reduces risk by solving complex problems for engineers regarding structural and infrastructure condition assessment, and geoscientists regarding geological and geotechnical problems for site characterization. Olson routinely applies advanced NDE and geophysical methods to provide superior structural assessment and subsurface imaging for our customers.

Pyramid Geophysical Services – Booth #28

503 Industrial Ave., Greensboro, NC 27406-4601
336-335-3174
http://www.pyramidgeophysics.com
Contact: Eric Cross, eric@pyramidenvironmental.com

Pyramid Geophysical Services offers a full line of geophysical capabilities to North Carolina and the entire east coast of the U.S. We have experience in a wide variety of geographical areas and projects, including hazardous waste sites, underground storage tanks, landfills, groundwater studies, and geotechnical investigations. We design geophysical surveys that meet the client's needs in the most efficient and cost effective manner possible.

Sandia National Labs – Booth #10

PO Box 5800, Mailstop 0735, Albuquerque, NM 87185
505-845-8438
Contact: Michelle Williams, mwilli9@sandia.gov

Sandia National Laboratories is operated and managed by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc. National Technology and Engineering Solutions of Sandia operates Sandia National Laboratories as a contractor for the U.S. Department of Energy's National Nuclear Security Administration (NNSA) and supports numerous federal, state, and local government agencies, companies, and organizations.

sensemetrics, inc. – Booth #34

406 Ninth Ave Ste 209, San Diego, CA 80246-1104
619-485-0575
http://www.sensemetrics.com
Contact: Todd Roberts, todd@sensemetrics.com

sensemetrics offers a turnkey wireless monitoring solution by providing THREAD integration devices that collects sensor data with minimal effort. All data is visualized using our in-house developed software program, offered to both CLOUD and ENTERPRISE platforms. sensemetrics' autonomous monitoring plateform is the one source solution you have been waiting for.

Terramar Instruments – Booth #16

7930 327th Avenue NE, Carnation, WA 98014
425-306-0174
www.terramar.xyz
Contact: Matthew Benson, matt@terramar.xyz

Terramar Instruments specializes in sales and rentals of geophysical and GIS survey equipment. We integrate sensors, software, and training to remove the barriers customers face when entering new business markets. Terramar is an authorized distributor of Teledyne OPTECH and Routescene LiDAR sensors, LaserData lidar information systems software, GuidelineGEO brands Mala Geosciences and ABEM, LEICA GIS, as well as Hemisphere GNSS GPS and IRIS Instruments.

University of Pennsylvania – Booth #17

269 Hayden Hall, Philadelphia, PA 19104
215-573-9145
https://www.sas.upenn.edu/lps/graduate/msag
Contact: Yvette Bordeaux, cardy@sas.upenn.edu

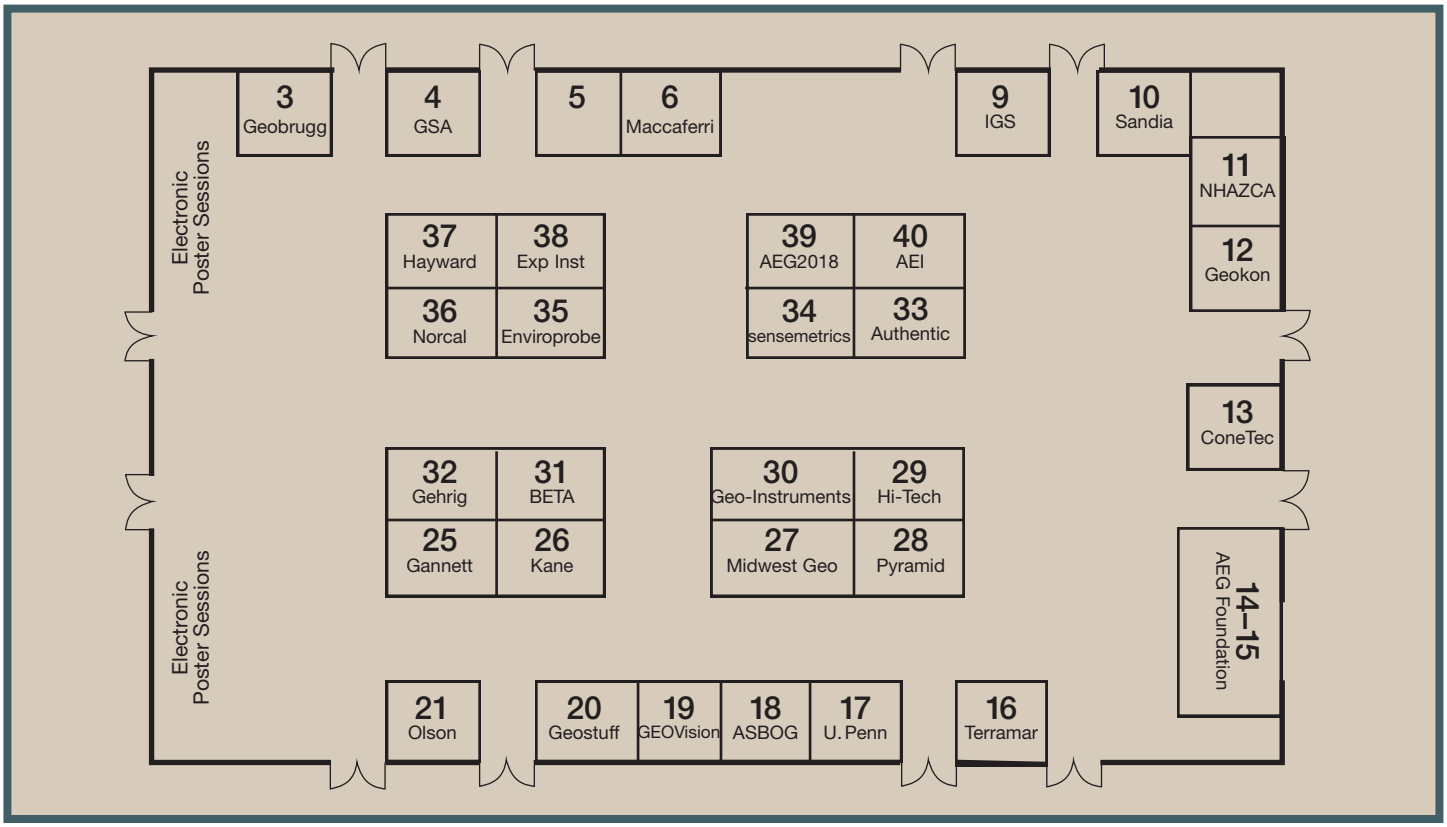
Master of Science in Applied Geosciences – The Master of Science in Applied Geosciences (MSAG) degree offers students a specialized degree that combines knowledge in theoretical areas of geology with technical expertise in geochemistry, geophysics, hydrogeology, and engineering geology with a focus on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

The Exhibitor Hosted Luncheon

Free for All Full Meeting Registrants!

Wednesday, September 13 – Exhibit Hall, Noon–1:30 pm

Exhibit Hall – Heritage Ballroom



The Association of Environmental & Engineering Geologists (AEG), as part of its Annual Meeting, provides an exhibit area with special events. The sole purpose of this exhibition is to provide the attendees of the meeting with an opportunity to view current and relevant products and services that may be of interest to working engineering geologists, environmental geologists, and hydrogeologists. AEG makes no claims or representations with respect to the quality, performance, or fitness for any purpose, of any given product or service that an exhibitor(s) may offer at the conference. AEG makes no endorsement of any product or service. AEG makes no warranty either expressed or implied with respect to any product or service offered at the conference. The quality, performance and/or warranty of any product or service offered at the conference is the exclusive, sole and complete responsibility of the exhibitor(s). AEG shall assume no responsibility for or liability resulting from the representations made by any exhibitor(s) for any product or service offered at the conference.

Sponsors

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.

At Press Time:

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Geobrugg North America, LLC

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303-598-7896
www.geobrugg.com
Contact: Kevin McNeill, kevin.mcneill@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 wit 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.

OPENING SESSION

Gannett Fleming, Inc.

PO Box 67100, Harrisburg, PA 17106-7100
717-763-7212 x2222
www.gannettfleming.com
Contact: Marty Hoff, mhoff@gfnet.com

Gannett Fleming provides a one-stop shop for geotechnical and geological services, ranging from foundations, dams, and levees, to earth retaining structures, tunnels and mining operations. These services include geotechnical analysis, digital photogrammetry, drilling and geophysics, site characterization, instruments, ground modification, design of earth structures, and groundwater studies. One of only 27 ENR Top 100 Firms to be ISO 9001:2008 certified, Gannett Fleming has more than 60 offices worldwide.

PAST PRESIDENT'S LUNCHEON

Department of Geology, San Jose State University

San Jose, CA, 95192-0102
408-924-5011
www.sjsugeology.org
Contact: John W. Williams, Professor of Geology, Williams@geosun.sjsu.edu

This academic program in Geology leads to a Master's Degree with an emphasis in engineering geology.

ANNUAL BANQUET

sensemetrics, inc.

406 Ninth Ave Ste. 209, San Diego, CA 80246-1104
619-485-0575
http://www.sensemetrics.com
Contact: Todd Roberts, todd@sensemetrics.com

sensemetrics offers a turnkey wireless monitoring solution by providing THREAD integration devices that collects sensor data with minimal effort. All data is visualized using our in-house developed software program, offered to both CLOUD and ENTERPRISE platforms. Sensemetrics' autonomous monitoring platform is the one-source solution you have been waiting for.

AWARDS LUNCHEON & CORPORATE BUSINESS MEETING

Associated Environmental Industries

PO Box 5300, Norman, OK 73070
405-360-1434
www.aei-corp.com
Contact: Joseph Datin, joseph@aei-corp.com

Associated Environmental Industries is a proven environmental services company with over 25 years of experience. We specialize in vertical drilling, horizontal drilling and excavation in the environmental market. Our rigs are capable of sonic, water rotary, air rotary, hollow-stem auger, coring, direct push, and horizontal drilling with the flexibility and experience to successfully complete the most difficult projects. Our experiences span a wide array of industries including oil & gas, municipal, industrial, federal, and mining.

SPECIAL EVENT: PHANTOM RANCH BREWERY

Gehrig, Inc.

PO Box 46, 212 E. Main St., Muenster, TX 76252
817-915-6174
www.gehriginc.com
Contact: James Branch, rbranch@rustybranch.com

Gehrig, Inc. provides surface and borehole geophysics services for exploration, engineering, and environmental projects throughout the United States. Our toolbox includes seismic, electrical resistivity, electromagnetic, microgravity, ground penetrating radar, and a full suite of borehole tools. Recent projects involved dams, levees, landfills, karst and voids, faults, USTs, and general site characterization.

WOMEN IN AEG/AWG BREAKFAST

Steele and Associates

2390 Forest St, Denver, CO 80207
303-333-6071
Contact: Susan Steele Weir and Bob Weir, steeleweir@aol.com

ALL DAY COFFEE STATIONS

Wednesday–Friday

Creek Run, LLC

PO Box 114, Montpelier, IN 47359-0114
765-728-8051
www.creekrun.com
Contact: Jason Lenz, jlenz@creekrun.com

Creek Run is a full-service regional environmental engineering company with offices in Indiana.

FIELD TRIP 1:

Fire, Flood, and Landslide Impacts and Mitigation

DirectAMS

11822 North Creek Parkway North, Suite #107, Bothell, WA 98011
425-481-8122
www.directams.com
Contact: Janet C. Niessner, janet@directams.net

REGISTRATION GIVEAWAY:

Headlamps

Northwest Geophysics

18392 Redmond Way, Redmond, WA 98052
425-497-9015
www.northwestgeophysics.com
Contact: Matt Benson, mbenson@northwestgeophysics.com
Northwest Geophysics an equipment lease company specializing in land, marine, borehole logging and NDE geophysical instruments for the engineering and environmental communities.

SHORT COURSE 3:

Characterization of Rock Core and Borehole Conditions for Engineering & Environmental Projects

Schnabel Engineering

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

SHORT COURSE 4:

geoDRONEology©

Midwest GeoSciences Group

1950 Greyhound Pass, Suite 18, Carmel, IN 46033
763-607-0092
www.midwestgeo.com
Contact: Dan Kelleher, dan@midwestgeo.com

We are motivated by serving others toward professional success, global stewardship, and personal growth. We strive to create meaningful educational experiences through workshops, webinars and short courses. It's a privilege to collaborate with experts who create field tools that become valuable and popular. Despite our pride in our on-demand webinar programs, we are humbled to help people in the special way. We are grateful for the opportunity to serve AEG and it's mission, members and vision.

and

International Geophysical Services, LLC

303-462-1466
www.igsdenver.com
Contact: Ronald S. Bell, rbell@igsdenver.com

IGS is a Geophysical Consulting and Services Company specializing in geophysical imaging of the subsurface and drone photogrammetry for geologic mapping and asset management. Our mission is to provide you with the up-to-date geoscientific data and information to enhance your decision-making process while simultaneously improving your workflow all the while keeping firmly focused on increasing the cost effectiveness of your project.

TECHNICAL SESSIONS

The Impact of Geology on Flood Control and Water Storage Dams and Levees, Part 1

RJH Consultants, Inc.

9800 Mt. Pyramid Court, Suite 330, Englewood, CO 80112
303-225-4611
www.rjh-consultants.com
Contact: Edwin Friend, efriend@rjh-consultants.com

RJH Consultants, Inc. 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. Our projects range from small geotechnical explorations to large embankment dam design and construction. We manage projects with overall costs ranging from several thousand dollars to in excess of $200 million.

The Impact of Geology on Flood Control and Water Storage Dams and Levees, Part 2

AEG Texas Chapter

http://www.aegweb.org/group/TX
Contact: Benson Chow, benson.chow@nacoal.com

Sliding the Scale: Improving Communications and Public Policy for Landslide Hazards – Symposium

Hi-Tech Rockfall

PO Box 674, Forest Grove, OR 97116
503-357-6508
www.hitechrockfall.com
Contact: Dane Wagner, dane@hitechrockfall.com

HI-TECH is a General Contractor who specializes in rockfall mitigation and installs rockfall protection systems throughout the United States. HI-TECH constructs a vast array of rockfall mitigation systems in a variety of locations such as highways, railroads, dams, quarries, mines, construction sites, commercial, and residential properties. Protection Systems and Services include, but are not limited to: Wire Mesh Drapery, Cable Net Drapery, Rockfall Catchment Barriers, Rock Scaling, Debris Flow Systems, Rock Dowels, and Rock Bolts.

Transportation and Infrastructure Projects

Shannon & Wilson, Inc.

1321 Bannock St
Denver, CO 80204-2718
303-825-3800
www@shanwil.com
Contact: Kami Deputy, kdd@shanwil.com

Shannon & Wilson is a nationally-recognized consulting firm dedicated to providing quality services in the fields of geotechnical engineering and the applied earth sciences. Founded in 1954, we are an employee-owned company serving governmental agencies and private clients through the United States and internationally.

Landslide, Rockfall and Debris Flow Analysis and Remediation Part 1 & 2 and Landslide Hazards of Colorado Springs: What the General Public Needs to Know

Maccaferri, Inc.

9210 Corporate Blvd Ste. 220, Rickville, MD 20850
301-223-6910
/www.maccaferri.com/us
Contact: Mike Koutsourais, mkoutsourais@maccaferri-usa.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.

Advocating for Geoscience: Ideas, Resources, and Examples

AEG Carolinas Chapter

www.aegcarolinas.org
Contact: Madeline German, madeline@smithgardnerinc.com

TECHNICAL SESSION BREAKS

Wednesday Morning

AEG Mile High Chapter

Contact: Jill Carlson, carlson@mines.edu

Wednesday Afternoon

Authentic Drilling, Inc.

201 W Perry Park Avenue, Unit 105, Larkspur, CO 80118
303-465-1450
https://authenticdrilling.com
Contact: Sherri Meiklejohn, sherri@authenticdrilling.com

Authentic Drilling is a geotechnical, environmental, water well and exploration certified woman small business drilling company located in the Denver metro area. Our fleet consists of truck, track and buggy rigs. Our specialty is difficult access sites with odex, coring, casing advancer, air/mud rotary and auger drilling methods.

Thursday

GEOVision, Inc.

1124 Olympic Dr., Corona, CA 92881-3390
603-448-1562, Fax: 603-448-3216
www.geovision.com
Contact: John Diehl, jdiehl@geovision.com
GEOVision, Inc. specializes in an understanding of subsurface geologic and hydrologic conditions, subsurface infrastructure, engineering properties of soil and rock, and earthquake hazards.

Friday Morning

AEG San Francisco Bay Area Chapter

Contact: Elizabeth Beckman, mbeckman@kleinfelder.com
AEG's San Francisco Bay Area Chapter is proud to sponsor this year's poster session. Our thriving chapter holds monthly meetings in Oakland/Berkeley. Find out more at www.aegsf.org!

FRIDAY BEER BREAK

Maccaferri, Inc.

9210 Corporate Blvd Ste 220, Rickville, MD 20850
301-223-6910
www.maccaferri.com/us
Contact: Mike Koutsourais, mkoutsourais@maccaferri-usa.com

Maccaferri's extensive engineering capabilities and range of products help clients overcome challenges associated with geo-hazards, 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.

STUDENT LUNCHEON:

"Get a Job & Make It Your Own"

Jeffrey and Julie Keaton

Contact: aegjuliek@aol.com

and

Gary and Leigh Luce

Contact: lucegc@charter.net

and

Gill Editing Online

Contact: Jane Gill Shaler, janehgillshaler@gmail.com

STUDENT/PROFESSIONAL NETWORKING RECEPTION

Geological Society of America

3300 Penrose Place, PO Box 9140, Boulder, CO 80301
303-357-1004
www.geosociety.org
Contact: Rebecca Freeman, rfreeman@geosociety.org

The Geological Society of America, founded in 1888, is a scientific society with more that 25,000 members from academia, government, and industry in more the 100 countries. Through its meetings, publications, and programs GSA enhances the professional growth of its members and promotes the geosciences in the service of humankind.

STUDENT TRAVEL GRANT

PanGEO, Inc.

1061 NE 102nd St., Seattle, WA 98125-7519
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www.pangeoinc.com
Contact: Stephen Evans, sevans@pangeoinc.com

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

REGISTRATION GIVEAWAY

Headlamp

Northwest Geophysics

18392 Redmond Way, Redmond, WA 98052
425-497-9015
www.northwestgeophysics.com
Contact: Matt Benson, mbenson@northwestgeophysics.com

Northwest Geophysics an equipment lease company specializing in land, marine, borehole logging and NDE geophysical instruments for the engineering and environmental communities.

2017 Technical Program

The 2017 Technical Program will focus on a variety of topics including three sessions on the impact of geology on flood control and water storage dams and levees; two sessions on landslide, rockfall and debris flow analysis and remediation; and two sessions in partnership with the Forum on the Geology of Industrial Minerals on geology and reclamation as they relate to industrial mineral sites. There will also be a two session symposia on emerging contaminants that will feature many of the regions foremost experts in the field. Other symposia and technical sessions include Resolving Complex Geologic Issues ... Using Geophysics, Subsidence and Soil Behavior Hazards, Stream and Surface Water Management, Environmental Characterization and Remediation, Advocating for Geoscience: Ideas, Resources, and Examples, Transportation and Infrastructure Projects, Materials Characterization and Ground Improvement, The Impact of Geology on Government Projects and Assets, Sliding the Scale: Improving Communications and Public Policy for Landslide Hazards, Geophysics and Remote Sensing, Hazard Characterization and Management, Landslide Hazards of Colorado Springs: What the General Public Needs to Know, Remote Sensing and GIS for Geohazards Assessment and Environmental Studies, InSAR Applications for Geology and Geological Engineering, Rock Engineering and Rock Mechanics, Hydrogeology, and Environmental Geology. Field Trip 1: Fire, Flood, And Landslide Impacts and Mitigation; Field Trip 4: Industrial Minerals Mining and Geology in the Royal Gorge Region; Short Course 1 on debris flows; and Short Course 4: geoDRONEology© - Applying Drones to Geoscientific Mapping tie directly into the technical program.

The 2017 Annual Meeting Planning Committee has put together a technical program and selection of short courses that are sure to provide an outstanding educational experience for attendees. PDHs will be available for all technical sessions and short courses. The main meeting activities will begin at 8:00 am on Wednesday, September 13, with the Opening Session Welcome. It will feature three keynote speakers from the Colorado Department of Natural Resources: Tony Waldron of the Colorado Division of Reclamation, Mining, and Safety; John Hunyadi of the Colorado Department of Natural Resources Division of Water Resources Dam Safety Branch; and Ethan Greene with the Avalanche Hazards Program. In addition, the session will feature the current and upcoming Jahns Lecturers and presentation of the AEG Foundation Awards and Outstanding Environmental & Engineering Geologic Project Award. A Speaker's Preparation Room will be open from September 13 to 15, from 7:00am to 5:00pm, Wednesday and Thursday, and 7:00am to 2:00pm on Friday. A computer 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 expressed by speakers do not necessarily represent the views or policies of AEG.

TECHNICAL PROGRAM SPONSORS

Opening Session - Gannet Fleming

Landslide, Rockfall and Debris Flow Analysis and Remediation - Macaferri

Sliding the Scale: Improving Communications and Public Policy for Landslide Hazards – Symposium - Hi TECH Rockfall

The Impact of Geology on Flood Control and Water Storage Dams and Levees Part I - RJH Consultants, Inc.

The Impact of Geology on Flood Control and Water Storage Dams and Levees Part II - AEG Texas Chapter

Advocating for Geoscience: Ideas, Resources, and Examples - AEG Carolinas Chapter

Transportation and Infrastructure Projects - Shannon & Wilson

Landslide Hazards of Colorado Springs: What the General Public Needs to Know - Maccaferri

OPENING SESSION

Keynote Speaker – Tony Waldron

Tony Waldron is the Supervisor of the Minerals Program for the Colorado Division of Reclamation, Mining and Safety (DRMS). He provides leadership and direction for the Minerals Program, which has a staff of 18 and oversees 1,600 mining and prospecting sites across Colorado. He is responsible for implementation of DRMS' mission which is to balance the need for mineral extraction with protection of public health, the environment and Colorado's other natural resources while ensuring that mined lands are reclaimed to a beneficial use. Waldron has a degree in Agronomy-Soil Science with a minor in Chemistry from Colorado State University ('86). He has worked for DRMS since 1988 in both the Coal and Minerals Programs and solely in the Minerals Program since 1998. He became supervisor of the program in 2011 and is actively involved with the industry's trade associations, working to address their concerns while advancing the Division's mission. Waldron was first exposed to and gained an appreciation for mining while working in a large underground molybdenum mine from 1978–81. While his first passion is agriculture, he understands the need for the responsible extraction of resources and is pleased to apply his efforts towards successful reclamation of mine sites.

Abstract

The talk will address the history of mining regulations from the discovery of gold in Colorado to current regulatory structure. This will include how Federal, State and Local governments interact with respect to proposed mining projects and existing permitted sites, including areas of overlap such as water and land use. The discussion will also include several examples of successful reclamation—which is the primary goal of present day regulations.

Keynote Speaker – John Hunyadi, PE

The State of Colorado has over 2,700 registered jurisdictional dams. Colorado Dam Safety is responsible for the safe administration of these dams to protect the citizens living below these structures while maximizing the available safe storage capacity. In his role as Dam Safety Engineer, Hunyadi is responsible for inspections, engineering analyses to set the safe storage level behind these structures, design review for new dams and modifications to repair existing structures, and emergency planning and response. He is the Colorado Dam Safety Risk Committee Chair and has led developmental and incorporation of specific failure mode evaluation and consequence assessment into regulation of these dams. Hunyadi was selected as Colorado Emergency Manager of the Year in 2015 for his response and handling of multiple dam safety incidents during a heavy snowpack and runoff year. He received his engineering degree from the Colorado School of Mines and has spent his career in private and public sectors focusing on rock stabilization and dam safety improvement projects.

Abstract

The presentation will focus on recent incorporation of risk analysis into the Colorado Dam Safety regulatory process. This will focus specifically on development of failure modes associated with contact erosion through contact of the earthen embankment with underlying geologic conditions. Three recent Colorado High Hazard dam scenarios will be presented where implementation of risk analysis has driven emergency response, safe storage level determination, project design, and construction planning, all associated with contact erosion due to seepage flow through fractures in underlying volcanic, sedimentary rock, and a dam constructed on a historic landslide.

Keynote Speaker – Ethan Greene

Ethan has directed the CAIC since 2005. He has approached snow and avalanches from both a practical and theoretical perspective. He grew up in Boulder skiing Colorado's Front Range. After a few winters in the San Juan Mountains, he worked at Big Sky Ski Resort in Montana as a ski patroller and at the Forest Service Utah Avalanche Center in Salt Lake City as an avalanche forecaster. Ethan also studied meteorology at the University of Utah (BS) and snowdrift formation at Colorado State University (MS). He has spent a lot of time looking at the microstructure of snow and its metamorphism in very large freezers in Colorado and Switzerland (PhD). Ethan has published a variety of articles on snow, weather and avalanches and been a member of national and international working groups on snow and avalanche projects. Ethan lives in Leadville.

Abstract

This presentation will describe the Colorado Avalanche Information Center's efforts to reduce the impact of snow avalanches on people that live, work, and travel in the mountains of Colorado. It will place avalanches in context with other natural hazards in Colorado, cover basics of snow avalanche formation and release, and current efforts to safeguard infrastructure and communicate the risk of avalanches to the general public.

AEG K–12 Earth Sciences Fair

Thursday, September 14
3:00pm–5:00pm
Heritage Ballroom Foyer

K-12 students have been invited to participate and compete in the AEG Earth Science Fair. Students will have the opportunity to demonstrate and discuss their earth science projects with earth scientists who are attending a professional conference.

The 2016–17 GSA/AEG Richard H. Jahns Distinguished Lecturer in Engineering Geology

Scott Anderson, PhD, PE

Scott Anderson was the Geotechnical Engineering Technical Services Team Manager for the Federal Highway Administration (FHWA) last fall, when he began his lecture tour. In that role, he led a national team of geotechnical engineers that assist state and local transportation agencies through technical assistance, training and deployment of new technologies. Scott also worked several years with the FHWA Federal Lands Highway Program, mostly in the west, and feels very fortunate to have had these opportunities with an agency that has done so much for the engineering geology and geotechnical engineering practice.

Prior to joining FHWA in 2002, Scott worked in positions from Staff Geologist to Senior Consulting Engineer and Landslide Technology Leader for a major A/E design firm and spent four years as an Assistant Professor of Civil Engineering at the University of Hawaii. The return to Hawaii for the AEG Annual Meeting and to receive the Jahns award must have put change back in Scott's mind, because he retired from FHWA and now is a Principal Geotechnical Engineer for BGC Engineering Inc., in Golden Colorado.

Scott earned his bachelor's and master's degrees in engineering geology from the University of Colorado at Boulder (1978) and Colorado State University, and master's and doctorate degrees in civil engineering from the University of California at Berkeley (1992), and likes to say that college was the best 14 years of his life. More than 30 years of experience in the university, in consulting, and for the federal government has led to lots to share, and Scott has done so through approximately, 100 publications and many speaking engagements, across the country and internationally.

The Jahns lecture tour was his biggest commitment yet and has led to talks from Charleston, South Carolina to Seattle, Washington, and from Los Angeles, California, to Boston Massachusetts, with nearly 35 other stops in between. Three of his talks were most requested:

- Natural hazards, risk, and the resilience of transportation infrastructure
- Solid as a Rock: How engineering geology relates to transportation asset management
- Technical observations from the 2014 Oso (SR 530) Landslide reconnaissance

Late in the year, interest in Scott's talk on the use of remote sensing and even social media grew, and he worked those subjects into his presentation. It is interesting to note that while on a summer break from his Jahns tour, it was a social media post—a video of a tsunami in northern Greenland—that got Scott on a 500-mile helicopter trip to capture his first oblique aerial photography data and, using structure from motion processing, his first personally acquired remote sensing model of a 70 million cubic yard landslide. This landslide created a tsunami, and ties back to many concepts presented in his other talks.

Scott gave a few more lectures this fall before his lecture delivered at the GSA Annual Meeting in Seattle. He will miss the great opportunity to visit with so many, old and young, when the tour is over. He is very honored to have had the opportunity to represent the AEG and GSA in this way, and encouraged about our future together.

INTRODUCING THE 2017–18 JAHNS DISTINGUISHED LECTURER

John Wakabayashi, PhD

John Wakabayashi is a San Francisco Bay Area native who moved to Fresno in 2005 to begin his academic career as a geology professor at California State University, Fresno. He received his B.A. in Geology in 1980 from UC Berkeley, and his PhD in Geology in 1989 from UC Davis. He is a Professional Geologist (California) and a Fellow of the Geological Society of America.

After graduating from Davis he worked as an engineering and environmental geologist for 16 years (1989–2005), the last 13 years as an independent consultant based in Hayward, California, before becoming an academic. He worked on a variety of different types of projects, including seismic hazard evaluation/paleoseismology, slope stability, engineering and

forensic petrography, naturally occurring asbestos, and two Superfund projects on which his primary specialty was evaluation of ambient concentrations of metals of environmental concern in soils and rock. He was a member of the Working Group on California Earthquake Probabilities.

When not doing project work, he conducted independent research, some of which derived from his project work, but most of which dealt with more esoteric research issues such as subduction initiation processes, metamorphic P-T paths and metamorphic contrasts as tectonic indicators, emplacement of ophiolites, subduction interface processes and development of subduction complexes, evolution of orogenic belts, development of strike-slip fault systems, and long time and length scale geomorphology. He incorporated academic research of his own and others into all of his project work, trying to bridge the academic-applied geology gap from the standpoint of a practitioner. After becoming an academic he has continued his efforts to bridge this gap, with realization that the vast majority of geology professors have never been employed in the engineering and environmental geology profession that most geology graduates will work in.

He incorporates both his professional and research experience into his teaching so as to better prepare students for professional careers, as well as providing a foundation for students who wish to undertake graduate study.

His research has resulted in 82 published papers, over 100 abstracts tied to presentations at major geoscience meetings. The breadth of his research has broadened rather than narrowed over time. In spite of the wide range of research interests, the geology of that beguiling train wreck of rocks known as the Franciscan Complex of coastal California remains his chief interest and the many aspects of mélanges have become his main focus since 2009. At Fresno State he teaches non-major introductory geology, geology major undergraduate courses in petrology, geomorphology, and structural geology, graduate courses on active tectonics/seismic hazard analysis and orogenic belt tectonics, and his bread-and-butter undergraduate course in advanced geologic field mapping (he makes his students map Franciscan along with landslides, flights of stream terraces and some potentially active faults). He has supervised or is supervising a large number of graduate and undergraduate student researchers, and this includes a number of students from outside of Fresno State.

The 2017–18 Jahns Lectures Include:

Insight into Geologic Mapping of Mélanges from Structural Geologic Research: Implications for Engineering Geologic Analysis and Illustration of the Value of Field Geologic Training

With the continued decline in the amount and intensity of field training for geology students, researchers and young professionals are less well equipped to deal with the geologic complexity of mélanges as they were 10 to 20 years ago when they were already vexed. The sad truth is mélanges are even more complex from a mapping standpoint than we had imagined a decade ago and this places a premium on geologic mapping skills and the training that builds such skills.

A Field-Based Alternative to Subduction Channel Models: Insight from Mélange Studies

This is the more purely academic focused look at mélanges. Mélanges are viewed by most in the research community as "subduction channels" that accommodate subduction interface slip across a very broad (kilometers of thickness) shear zone.

Attempting to Bridge the Growing Gap between Academic and Applied Geology: A Personal Odyssey

Here I will tell a few stories from my days as an engineering and environmental geologist as well as some other stories from the academic world.

Evolution of Step-overs and Bends along Strike-Slip Faults: Implications for Seismic Hazard Assessment

Step-overs along strike-slip faults have been traditionally considered to grow in size and cumulative slip accommodation as more slip accrues on the parent strike-slip fault. In such a model with greater slip, a pull-apart basin grows larger and deeper and a restraining step-over generates more uplift and exhumation.

Geomorphic Evolution and Cenozoic Tectonics of the Sierra Nevada, California, and Alternatives Interpretations of Paleoaltimetry Data

Although stable isotope paleoaltimetry data has been interpreted to show that late Cenozoic uplift of the Sierra Nevada did not take place, stratigraphic-geomorphic relationships indicate otherwise.

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/JahnsLecturer2017

AEG's Outstanding Environmental and Engineering Geology Award – 2017

Colorado Inactive Mine Reclamation Program

Introduction

The Colorado Division of Reclamation, Mining and Safety's Inactive Mine Reclamation Program was established in 1980 to address the hazards and environmental problems that arise from abandoned mines across Colorado. Legacy mining has resulted in over 23,000 hazardous mine features and impacts to 1,300 miles of streams. There is no other state program to address these hazards.

The major program activity is to identify the hazards and environmental problems arising from abandoned mines, design appropriate closure methods and reclamation techniques for project sites, reclaim or safeguard abandoned mine hazards, and address environmental problems. Project activities include field investigations, project development, project design, realty work, construction contract bidding and management, site construction and reclamation, construction inspection, site monitoring and maintenance of prior project work. To date, the program has been responsible for safeguarding over 10,000 hazardous features, reclaiming over 4,000 acres of mining disturbed lands, improving water quality at more than 220 sites, and investigating and managing 33 underground coal mine fires throughout the State of Colorado.

IMRP has numerous partners participating in closure projects and also works to alert the public of hazards of exploring abandoned and inactive mines. Partners include the US Forest Service, US Bureau of Land Management, Colorado Division of Parks and Wildlife, local county and city governments, mining associations, and private citizens.

The program is funded through the Department of the Interior Office of Surface Mining by reclamation fees paid by active coal mining operations. Additional funding has been provided through partnerships with the US Forest Service, US Bureau of Land Management, Colorado Department of Public Health and Environment, the US Environmental Protection Agency, US Department of Energy, various counties, mining companies, and state severance taxes.

Nomination Documentation

National Significance

With the passage of the Colorado Surface Mining and Reclamation Act in July of 1979, the Colorado Inactive Mine Reclamation Program (IMRP) was formed and given the mission of undertaking a statewide reclamation effort aimed at reducing the hazardous situations associated with past mining activities. Since that time, the CIMRP has been nationally recognized as one of the premier Abandoned Mine Land (AML) programs throughout the country and has received numerous national awards from the National Association of Abandoned Mine Land Programs (NAAMLP) and the Office of Surface Mining, Reclamation and Enforcement (OSMRE), both for leadership in the field of AML work and various projects demonstrating outstanding reclamation. The awards not only represent the high caliber of work the program has accomplished in its 35+-year history, but speak to the national significance and prominence that AML issues possess.

The myriad of problems associated with past mining practices in Colorado that the IMRP is responsible for addressing consist of open coal and hardrock shafts, adits and stopes, coal mine subsidence in residential neighborhoods, coal mine fires, acid mine drainage from hardrock adits, waste rock and tailings piles. Colorado's innovative and tireless approach to addressing these issues through the design and implementation

of hazard abatement projects and the use of Best Management Practices (BMPs) to address environmental issues related to past mining activities is a national model of government at its most effective.

Project Description

The CIMRP was established to address the hazards and environmental problems arising from past mining activity. The initial physical inventory of abandoned mine lands within the state focused on known mining districts and sites near populated regions, identifying approximately 8,000 mine hazards, eventually resulting in an estimated inventory of over 23,000 hazards. Additionally, more than 400 abandoned mine sites were identified as impacting more than 1,300 miles of streams in many of the State's pristine headwater watersheds.

Over the course of the CIMRP's existence funding to address the immense scope of this has come from multiple sources including the Office of Surface Mining, Reclamation and Enforcement, US Forest Service, US Bureau of Land Management, Colorado Department of Public Health and Environment, US Environmental Protection Agency, along with local counties and municipalities and generous donations by various industry partners. These funding partners enable the program to engage in activities including project feasibility, development, construction, monitoring and maintenance activities to identify the hazards and environmental problems arising from abandoned mines, design of appropriate closure methods and reclamation techniques for project sites, and reclaiming or safeguarding abandoned mine hazards and environmental problems. Project activities include: field investigations, project development, project design, realty work, construction contract biddings and management, site construction and reclamation, construction inspection, site monitoring and maintenance of prior project work.

The CIMRP has and currently engages in mine fire characterization and mitigation, subsidence drilling and grouting, subsidence investigations, groundwater and surface water investigations, historical preservation, safety closures, geomorphic reclamation and landscape stability analysis, water quality improvement, acid mine drainage treatment, hydrologic source control, along with education and outreach related to AML issues throughout Colorado.

History of Project Need and Problem Definition

The history associated with the need for this project and program truly begins in 1858 with the discovery of placer gold along Cherry Creek in what is now downtown Denver, and the subsequent "rushes" to various locations in Colorado to extract the valuable resources placed there geologically. During the majority of mining history in Colorado there were no environmental regulations of any kind requiring operators to return mined land to any beneficial use resulting in the gargantuan inventory of AML problems we see today.

The existence of so many past mining-related problems that pose health and safety risks to the public in addition to impacts on the environment defines the need for the CIMRP.

Independence headframe adjacent to footing

Problems Solved

To solve the broad myriad of problems associated with hazards and environmental problems from past mining practices, the program uses a general bid specifications "cookbook" designed in-house for safety closure selection, and implements innovative site specific reclamation designs that address water quality impacts and provide long term, low maintenance solutions for those projects. A necessity for AML work is the development of unique reclamation projects and strategies that provide the best "bang for the buck," often accomplished through trial and error.

Mine Hazard Abatement (Safety Closure Projects)

One of the main missions of the CIMRP is to protect the public from the hazards associated with past mining practices. A majority of funding for the program has been focused on developing and implementing safety closure projects that attempt to reduce the estimated 23,000 hazardous features in Colorado. To date the CIMRP has completed safety closures at over 10,000 sites and continues to safeguard features at a rate of nearly 300 per year.

These mining hazards consist of dangerous horizontal and vertical mining features (adits, shafts and stopes), hazardous structures, highwalls, underground mine fires, and coal mine subsidence. Early on in the development of the CIMRP it was obvious that individually engineering over 500 safety closures a year would become cost prohibitive, in addition to a significant increase in the amount of time required to take projects from initial proposal to completion. To that end, the program recognized that many of the safety closure methods could be distilled and standardized for application over a broad base of hazard types. For instance, a grated shaft closure could be standardized to account for various shapes and dimensions through upscaling of support beams to provide for minimum spans, thereby reducing the need to individually engineer each grated shaft closure. Instead, a project manager or contractor could look through the general bid specs for a grated shaft clo-

sure and apply the same set of already approved engineering designs at a 4 ft by 8 ft rectangular shaft or a 12 ft by 12 ft square shaft.

This process of standardizing safety closure methodology eventually resulted in a general bid specifications document describing seventeen various closure methods from backfill to grating to polyurethane foam to concrete, applicable in both vertical and horizontal mine features. The general bid specifications has allowed the program to complete an average of 300 safety closures per year with a limited budget and staff.

One example of implementation of this approach occurred on the Box Canyon Project. The Box Canyon Project was located along the Arkansas River in steep terrain just east of the town of Salida. The mine site consisted of six mine openings created during mining of limestone near the top of a ridge, and was visible from highway 50 resulting in significant public visitation. The mine features posed a significant public hazard, but biological evaluations at the site determined that the mine closures must be constructed with access for bats due to evidence of extensive bat use. The other challenge associated with the features was their enormous size, with one of the horizontal openings measuring 20-ft-tall by 50-ft-wide. The project manager and contractor were able to adapt the existing grated bat closure specification to fit the site conditions without the need for additional engineering services and costs. One of the horizontal grated closures became affectionately known within the Program as the "mother of all bat grates."

Project Prioritization through Thorough Site Characterization

Many of the environmental problems associated with past mining practices have at their core the interaction of water, oxygen, sulfide and the production of acidic metal influenced water resulting from reactions between those constituents. Developing projects to remediate these effects requires adequate yet extensive characterization of sites from a watershed perspective allowing stakeholders to utilize resources in a responsible way to achieve the most improvements for the money available. CIMRP has conducted many watershed wide loading analyses to assist in delineating impacts associated with acid mine drainage including one of the first watershed wide reports for the Animas River Watershed in Silverton, Colorado, that has been extensively relied upon by multiple agencies for prioritizing cleanup work under the newly listed Bonita Peaks Superfund site.

Additionally, CIMRP has performed underground investigations at mine sites including the Red and Bonita Mine, Pennsylvania Mine, Mary Murphy Mine, Dinero Mine, and Standard Mine, in addition to numerous other mines throughout the State, to understand the movement of groundwater within these mine environments and what remedies might exist for addressing the discharges. Adequately understanding the underground hydrology at mine sites has opened the door to implementing more innovative source control technologies than just relying on typical pH adjustment treatment plants.

Thorough site characterization applies not only to mining environmental sites, but also many of Colorado's AML mine fire issues. CIMRP has conducted extensive characterization of the 33 active coal mine fires across the State, enabling a better understanding of where and how funding should be directed. Currently, the program is in the process of updating a coal fire status report completed every five years, which will incorporate field visits and observations of all coal mine fires across the State.

Development of Innovative BMPs to Reduce Environmental Impacts

Utilizing thorough site characterizations to inform decisions about design at environmental AML sites along with coal mine fire sites has resulted in the development of very unique and innovative approaches to address the problems. CIMRP has long advocated for source control alternatives at hardrock AML sites to reduce the long term costs and liabilities that typically accompany reclamation projects. Source control remedies can consist of reducing infiltration into waste piles and mine workings, moving mine waste and tailing into high/dry repositories, altering surface flow pathways to reduce the amount of contact that water has with waste rock and tailings, segregating clean and dirty flow paths in underground mines, and plugging drainage tunnels to return groundwater tables to "pre-mining" conditions. These practices can provide lower cost long-term solutions to address the environmental impacts associated with past mining activities. CIMRP has also deployed paste backfill to address historic tailings impoundments, amended soil with lime, cement and other ingredients to reduce metal mobility following rainfall and snowmelt.

Environmental and Engineering Geologic Principles Applied

The implementation of projects to safeguard mining hazards and address environmental problems required significant ingenuity and adaptability due to the often-challenging location of many of Colorado's AML sites along with highly variable geologic conditions. The following are examples of some specific projects that CIMRP completed where various environmental and engineering geologic principles were applied.

Independence Headframe Stabilization

The Independence Headframe is a historic headframe listed on the National Historic Registry owning to its unique place in Colorado's mining history. The headframe represents one of the best remaining examples of a 4-post, wooden gallows headframe and sits at the location of Bob Womack's Cripple Creek gold discovery.

The headframe experienced settlement and collapsing around the shaft collar that began affecting the adjacent headframe supports. Initially, guywire cables were placed at the top of the +100-ft-tall headframe to reduce the impact of wind loading and help stabilize tilting in the upper headframe pieces. Additional destabilization of the foundation posts due to subsidence began causing additional rotation in the headframe structure that could not be addressed through the stabilizing guywires, so two large bridge beams (W30x148) were slid into

place spanning the collapsing shaft collar. Footing pads were created outside the area of subsidence for the beams to rest on, and then the beams were attached to the main support posts of the headframe with sandwich plates.

This system of beams provided sufficient support for the overlying headframe until additional collapse around the shaft collar resulted in encroachment on the beam footing pads. At this point, CIMRP began discussing with the landowner and local officials about the possibility of dismantling the headframe and reconstructing it at an alternate location. Due to the historic significance of the location, and the potential cost to dismantle and reconstruct the headframe it was decided that some other method of in-place stabilization needed to occur.

CIMRP contracted with a local geotechnical driller to conduct exploratory drilling around the perimeter of the headframe to determine the extent of undermining and the location of bedrock for potential foundation systems. Angle drilling around the shaft collar provided a clearer picture of the extent of collapse, and determined that bedrock was relatively shallow and extremely competent. Based on these discoveries, it was determined that a micropile and cap system could be installed under the existing load transfer beams to provide long term stability of the headframe structure. Construction of the micropiles and caps will begin during summer of 2017.

Skull Creek Mine Fire

The Skull Creek mine fire is located near Rangely Colorado in the northwestern part of the State near the Utah border. The mine fire was an extremely active fire with the potential to express at surface due to significant subsidence fracturing occurring due to burnout of the underlying coal seam. This fire was a high priority fire due to the amount of combustion activity and potential for wildfire initiation resulting from surface expression of the fire.

The fire site was previously investigated by drilling and installation of thermocouples to monitor the fire progress and determine the active fire front. Additionally, geophysical techniques were employed to assist in refining the active fire front along with the presence of burned and unburned coal locations. These investigations led CIMRP to develop a project involving complete excavation of the coal fire, quenching, and replacement due to the shallow nature of the fire zone.

CIMRP contracted with Bower Brothers Construction to begin excavation and quenching of the fire in 2015. Construction at the fire occurred over an area of approximately 5 acres, and resulted in the excavation and quenching of approximately 168,000 cubic yards of material. Initially, the construction method involved excavation of the burning coal, dispersal of the hot material into a thin lift, addition of water and firefighting foam to cool the coal below 100ºF, and, finally, replacement and compaction of the cooled material into the excavation. During this process it was discovered that addition of water and foam acted to insulate the hot coal instead of quenching, increasing the amount of time required for cooling. A new method of mixing the hot coal with cool overburden material was determined to provide the fastest cooling, allowing placement of the material back into the excavation more quickly.

Utilizing this mixing method, the Skull Creek fire was completely excavated and cooled in approximately 7 months. Following replacement of the cooled material the site was recontoured to natural slopes and revegetated.

Protection and Enhancement of the Environment

Many of the projects that CIMRP has completed over the years are intended to reduce the environmental impacts associated with past mining practices. The following are specific examples of some of those projects.

Pride of the West Stope Closure

The Pride of the West stope is located in the upper reaches of the Animas Watershed just to the east of Silverton, Colorado. Discharge from the Pride of the West mine was determined to be a significant source of metals to the Animas River, with a majority of that discharge being fed from direct inflow of rain and snowmelt water into the stopes and out the portal. CIMRP working in conjunction with the Animas River Stakeholders Group (ARSG) developed a plan to cover the stopes with structural steel paneling to reduce, if not eliminate infiltration of rain and snow into the stope.

The stope is a linear surficial opening extending approximately 300 ft across an extremely steep mountain slope with a width of up to 50 ft and depths exceeding 100 ft. With the stope lying approximately 800 ft from the valley floor, access to the site required a 1.5-mile hike. CIMRP contracted with Frontier Environmental Services Inc. (FESI) to construct the structural steel cap over the stope.

Dinero Bulkhead
ABOVE LEFT (top to bottom): under construction, placement on concrete, and after construction
ABOVE RIGHT: One year after construction

All materials and equipment for the closure required a helicopter lift to the site, which was accomplished with Heliquest Aviation's Kaman K-max. Due to the steep slopes (~40º) along with most work occurring adjacent to the deep stope, worker safety was paramount. All workers were required to wear full body harnesses, and remained tied off during all work around the stope.

Construction of the closure required placement of 49 W12x65 steel beams by helicopter across the stope into beam pockets prepared by hand using air chipping hammers. Following placement of the steel beams, approximately 7,500-sq ft of ¼-inch steel plate was lifted to the stope by helicopter and welded to the beams to provide a watertight seal across the open stope. Final construction of the closure included application of a spray-on polyurethane coating to protect the exposed steel from corrosion. Completion of the stope cover/closure resulted in a significant load reduction to the Animas River.

Dinero Tunnel Bulkhead

The Dinero Tunnel is a draining mine located in Sugarloaf Gulch approximately 5 miles west of Leadville, Colorado. Discharge from the mine workings was determined to be the largest single source of heavy metals to the Lake Fork of the Arkansas River, resulting in impairment of water quality and lack of water quality standards attainment.

The CIMRP began investigations at the mine site in 2004 to explore potential remedial options not involving water treatment. Due to the collapsed and flooded nature of the mine workings, it was difficult to investigate potential source control alternatives, so in 2005 CIMRP contracted with Mining and Environmental Services (MES) to conduct rehabilitation of approximately 1,800 ft of historic mine workings. Rehab involved installation of steel sets, timber sets, and split set bolts and mesh for structural support, along with spiling to remove collapsed stope debris.

Following rehab of the mine workings, the tunnel was investigated for possible installation of a hydraulic seal bulkhead. Investigations determined that the tunnel conditions were optimal for construction of a bulkhead at 1,250 ft from the portal. During 2009, CIMRP contracted with MES to construct a

15-ft-thick concrete bulkhead capable of impounding water to a height of 600 ft. The contractor completed cleanout of the tunnel to bedrock at the bulkhead location along with construction of the inner and outer form works. Following form construction a 4,000 psi, self-compacting concrete (SCC) was pumped from the portal 1,250 ft back to the bulkhead location filling the forms. Following a 28-day concrete cure period, contact grouting was conducted to ensure a watertight seal of the bulkhead with the surrounding rock.

After completion of the bulkhead and final grouting, the valve was closed resulting in a flow reduction of approximately 90% from the portal. The remaining 10% of the flow was occurring through various fractures along the length of the tunnel. Following valve closure, the pressure behind the bulkhead stabilized at nearly 160 psi (368 ft of water head). It is anticipated that the overall zinc loading to the Lake Fork of the Arkansas will be reduced by 77% resulting in near attainment of water quality standards.

Benefit to the Public

Safety

CIMRP records indicate that since 1955 abandoned mine hazards in Colorado have claimed more than 20 lives. The safety closure projects that the program has completed since 1980 are specifically designed to protect the health and safety of the public from the dangers associated with past mining activities. Of the 23,000 estimated mine hazards in Colorado, the program has completed over 10,000 safety closures, and continues to safeguard nearly 300 hazardous features each year in areas where the general public is exposed.

Improved Water Quality

CIMRP has completed reclamation on over 4,000 acres of mining disturbed lands, and completed environmental reclamation projects at over 220 mine sites. These projects are intended to reduce downstream water quality impacts from heavy metal loading and sediment laden runoff from unreclaimed mine sites.

Advancement of the Public's Understanding of Environmental and Engineering Geology

The CIMRP actively participates in numerous organizations including the National Association of Abandoned Mine Land Programs (NAAMLP), Association of State Mine Reclamationists (ASMR) to help promote innovative technological approaches to reclamation of active and historic mine sites. The program participates in local watershed groups throughout the State to provide technical assistance to non-profit organizations looking to improve water quality within their local watersheds. Many federal agencies including BLM, USFS, EPA, and DOE have initiated cooperative agreements with CIMRP to provide technical assistance on mining related reclamation projects. CIMRP also works closely with other State and local agencies to provide technical expertise on reclamation projects and the issues associated with AML problems in those areas. Program personnel are frequent speakers at various forums and conferences, presenting information on completed reclamation projects and innovative techniques used to address many of legacy problems associated with past mining.

CIMRP also actively engages in a "Stay out, Stay alive" campaign aimed at educating the public on the hazards of abandoned mines. Pamphlets describing the campaign that detail the hazards of abandoned mines are provide to local chambers of commerce and are available at tourist rest stops upon entry into the State. Additionally, the program promotes visiting permitted tourist mines throughout the State as an alternative to exploring abandoned mines

Enhancement of Local Cultural and Historical Understanding

The CIMRP is actively engaged in promoting the historical understanding of Colorado's rich mining history. The program has completed a number of projects that not only address physical safety, but are designed to maintain and enhance in many cases the historical character of the sites being reclaimed. As described above, the Independence headframe stabilization project is not only intended to protect the health and safety of the public from the subsiding shaft and leaning headframe, but is intended to preserve the historically significant headframe structure for future generations to enjoy.

As part of any project that expends federal dollars, the program is responsible for complying with the National Environmental Policy Act (NEPA). As part of compliance with NEPA, cultural resource specialist document each of the sites for compliance with Section 106. All of the site documentation is turned over to the State Historical Preservation Office (SHPO) to gain concurrence for site reclamation activities. Without CIMRP efforts to safeguard or reclaim these sites documentation of the rich cultural heritage would often never take place and likely would never be preserved. CIMRP activities have resulted in the historical documentation of thousands of mining sites throughout Colorado preserving that history for generations to come.

Project Honorees

DRMS-CIMRP

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The Outstanding Environmental and Engineering Geologic Project Award was established in 1993. For information on award conditions and selection procedure, with AEG's webpage at http://www.aegweb.org/?page=OEEGProjectAward

Technical Program Schedule

(Final Schedule will be listed in the onsite Program With Abstracts)

Wednesday, September 13 – Afternoon

Technical Session #1
Resolving Complex Geologic Issues... Using Geophysics - Symposium

"We've all encountered them… tough-to-resolve geologic issues, often confounding other intrusive investigation aspects of a project. The purpose of this symposium is to provide a suite of geophysical case histories that exemplify the value of interjecting various geophysical methods, to create an integrated answer to complex geologic conditions. Presentation topics include: imaging between borings in karst for design of a vertical shaft to create tunnel access where water infiltration is the enemy; evaluating the geologic implications of selecting a major transportation route, including a possible tunnel, through a mountain range; reducing impacts of blasting to structures, geologic features and natural resources; detailed characterization of soils beneath a levee for underseepage design; and more. Through this symposia the value geophysics plays to aid site investigations, as well as design, will be displayed."

Room: Carson **Conveners: Doug Lambert and Phil Sirles**

Time	Speaker	Title
2:00–2:20	Greg Hempen	Minimizing Impacts to Structures, Geologic Features and Natural Resources from Blasting
2:20–2:40	Doug Lambert	Integrating Cross Hole Seismic Tomography and Wireline Geophysical Logging to Characterize Karstic Bedrock for Vertical Shaft Excavation Design
2:40–3:00	Julie Kelley	Empirical Study of the Development of Sand Boils near Ware, IL, Middle Mississippi River
3:00–3:20	Reed Brown	Site Characterization with Geophysics for Levee Underseepage Design
3:40–4:20	John Diehl	Aren't Mountains Challenging Enough?
4:20–4:40	Jeremy Strohmeyer	Using the 2D MASW Method to Estimate Depth to Bedrock and Soil Variations to Facilitate Environmental Remediation (Presented by Doug Lambert)
4:40–5:00		Discussion

Technical Session #2
Subsidence and Soil Behavior Hazards

Room: Fremont **Moderator: Ken Fergason**

Time	Speaker	Title
2:00–2:20	Robert Duran	Evaluation of a Known Sinkhole Area Using Geophysical and Conventional Subsurface Exploration Methods
2:20–2:40	Ken Fergason	Land Subsidence and the California High-Speed Rail Project
2:40–3:00	Ken Fergason	Earth Fissures and Infrastructure: A Case History at the Siphon Draw Detention Basin, Apache Junction, Arizona
3:00–3:20	Robert Kirkham	Do Faults Caused by Evaporite Dissolution and "Unfolding" of Colorado's Grand Hogback Monocline Pose a Seismic Hazard?

Technical Session #3
Stream and Surface Water Management

Room: Fremont **Moderator: Stephen Evans**

Time	Speaker	Title
3:40–4:00	Stephen Evans	Canyon Creek Intake Structure and Fishway
4:00–4:20	Steven Ladavat	Horizontal Directional Drill Pipeline Crossing Design in Buried Glacial Valleys; A Multi-Faceted Approach
4:20–4:40	William Flanigan	Water Management and Planning at Mine Sites
4:40–5:00	Christoph Goss	An Overview of Underground Mine Bulkheads in a Fractured Mountain Setting

Technical Session #4
Landslide, Rockfall and Debris Flow Analysis and Remediation Part 1

Sponsored by Maccaferri

Room: Summit I **Moderator: Paul Santi**

Time	Speaker	Title
2:00–2:20	Paul Santi	Landslide Analysis with Incomplete Data
2:20–2:40	Yonathan Admassu	Terrestrial LiDAR-Based Quantitative Geologic Rockfall Hazard Rating System (QG-RHRS)
2:40–3:00	Sevin Bilir	Mapping of Potential Landslide Hazards along the River Corridors of King County, Washington
3:00–3:20	Robert Huber	Evaluation of Rock Slope Stability and Crack Monitoring at Dinosaur National Monument
3:40–4:00	William Kane	Investigation, Design, and Construction of Flexible Debris Flow Barriers
4:00–4:20	Matthew Morris	Slope Stabilization of State Route 120, Clinton County, Pennsylvania
4:20–4:40	Scott Anderson	Reconnaissance Observations of the 17 June 2017 Karrat Fjord Landslide and Tsunami, Greenland
4:40–5:00		Discussion

Technical Session #5:
Environmental Characterization and Remediation

Room: Summit II **Moderator: Sarah Kalika**

Time	Speaker	Title
2:00–2:20	Jeff Binder	Using HPT-GWS Direct Push Tooling to Delineate Uranium Impacts in Groundwater at a Former Fuel Processing Facility
2:20–2:40	Kami Deputy	Breckenridge Second Water Plant – Geologic and Environmental Hazards in the Colorado Mountains
2:40–3:00	Allen Hatheway	Massachusetts as a Basis for Perspective on Coal-Tar Cleanup — Our Forthcoming (2018) Case History Volume
3:00–3:20	Sarah Kalika	Using Sanborn Maps as a Historical Resource
3:40–4:00	Todd Knause	Subsurface Mapping Using Direct Push Technology in Site Characterization Studies
4:00–4:20	Richard Lenz	Leaking Underground Storage Tanks – Forty Years Later, What Has Been Accomplished?
4:20–4:40	Bharat Patel	Chlorinated VOC Contaminant Plume Assessment in Tidally Influenced Aquifer at a New Jersey Industrial Site
4:40–5:00	Madeline German	Managing Your Portfolio: Tips for Surviving Environmental Site Assessments

Technical Session #6:
Advocating for Geoscience: Ideas, Resources, and Examples

Sponsored By: AEG Carolinas Chapter

Room: Learning Center **Moderator: Briget Doyle**

The AEG Advocacy Committee works to raise awareness and understanding of the value of geoscience. This effort is for our profession and for our science before decision-makers, stake-holders, the general public, and society at large. This session includes examples, ideas, and a discussion forum to explore ways to further this goal.

Time	Speaker	Title
2:00–2:20	Paul Weaver	Advocating for Geoscience, The Roles of AEG and AEG Members
2:20–2:40	Madeline German	Reaching Out! Advocate by Educating the General Public
2:40–3:00	Briget Doyle	Using the Media to Advocate for the Geosciences
3:00–3:20	Eldon Gath	AEG's Learning from Disasters Program: A Proposal to Advance Engineering Geologic Relevancy and Advocate for Geology
3:40–5:00	Daniel Schneider	GBA Case Histories - Subsurface Construction in Urban Settings – Where Geotechnical Meets Environmental
	Feist, Ryan	Don't Learn Safety by Accident

Thursday, September 14 – Morning

Technical Session #7
The Impact of Geology on Flood Control and Water Storage Dams and Levees Part 1 - Symposium

Sponsored by: RJH Consultants, Inc.

The Dams Technical Working Group of AEG is pleased to host the 12th Dams Symposium at the Colorado Springs AEG Annual Meeting in September 2017. The theme of this year's symposium is The Impact of Geology on Flood Control and Water Storage Dams and Levees. Topics of keen interest include the ongoing work activities at Mosul Dam as well as the recent dam safety event at Oroville Dam in California. The speakers will come from a range of backgrounds including Federal and State agencies, academia and private companies. The focus of the symposium will be on dams and work being accomplished on the nations' aging inventory of these important water resource structures. In addition, this year, a significant focus will be placed on levees to include investigations, levee risk assessment and a new USACE engineering geology guidance document dealing with drilling in embankment dams and levees. Finally, a number of notable case histories of dams and levees will be presented with important lessons learned.

Room: Summit II **Conveners: Edwin Friend and Kevin Mininger**

Time	Speaker	Title
8:00–8:20	Tatia Taylor	Foundation Geology at Mosul Dam, Iraq
8:20–8:40	Tatia Taylor	Mosul Dam – Interim Results of Remedial Grouting Program
8:40–9:00	J. David Rogers	Design Evolution of the Oroville Dam
9:00–9:40	Holly Nichols	The Oroville Spillways – Geology and Why it Matters
9:40–10:00	Kerry Cato	Assessment Of Rock Erosion Initiation In Unlined Emergency Spillways
10:20–10:40	Reid Fisher	Geologic Control of Spillway Erosion Features, Sierra Nevada Foothills, California
10:40–11:00	Cari Beenenga	Utilizing Geophysics in Auxiliary Spillway Evaluation New Creek Site 14 Dam, Grant County, WV
11:00–11:20	Derek Morley	Why So Many Borings? A Framework for the Dam-Site Exploration Plan
11:20–11:40	Coralie Wilhite	How Do I Know What I Don't Know!?
11:40–12:00		Discussion

Technical Session #8
Landslide, Rockfall and Debris Flow Analysis and Remediation Part 2

Sponsored by Maccaferri

Room: Summit I **Moderator: Alex Strouth**

Time	Speaker	Title
8:00–8:20	Daniel Martt	A Geological Investigation of the Cherry Valley Road Landslide, Stroundsburg, Pennsylvania
8:20–8:40	Caroline Scheevel	Considering Area as a Proxy for Volume in H/L Correlations
8:40–9:00	Mark Squire	Using Hydrated Lime and Wick Drains for Urgent Remediation of a 2015 Landslide in Colorado Springs
9:00–9:20	Mark Squire	An Old Landslide Never Dies – Data Collection & Initial Engineering Analyses of the Gros Ventre Landslide
9:20–9:40	Alex Strouth	Debris-Flow Risk Management: Recent Activity in Western Canada
9:40–10:00	Scott Burns	As Urban Infrastructure Ages, we see an Increase in Landslides and Sinkholes - a Case History from Portland, OR, USA
10:20–10:40	John deLaChapelle	A Whirlwind Tour: The Value of Helicopters in Landslide Assessments, with Project Examples from Across North America
10:40–11:00	Michael George	Rockfall Monitoring and Prediction: A Bayesian Approach to Forecasting Time to Failure
11:00–11:20	Ghislain Brunet	Design Built Semi-Rigid Rock Fall Fence on SR 11 in Perry County Pennsylvania
11:20–11:40	Luke Weidner	Comparison of Two Physically-Based Regional Landslide Susceptibility Models in Kerala, India
11:40–12:00	Yonas Zemuy	Large Landslide Remediation by Slot-Cut Construction Technic at a Southern California Landfill

Technical Session #9
Emerging Contaminants Part 1 - Symposium

Room: Carson **Conveners: Patty Bryan and Loren Lasky**

AEG's Symposium on "Emerging Contaminants" will include presentations by a nationally recognized experts on the sources, toxicity and remediation of Pharmaceuticals, 1,4-Dioxane, Per- and Polyfluorinated Substances (PFAS), Coal Tar and other pervasive anthropogenic organic compounds. Panel discussions will include local scientists explaining how Colorado Springs is addressing the perfluorocarbon impact to its drinking water. See the ad on page 38.

Time	Speaker	Title
8:00–8:10	Patty Bryan, Loren Lasky	Introduction
8:10–8:40	Edward Furlong	An Introduction to Emerging Contaminants
8:40–9:00	Christopher Higgins	The Importance of Per- and Polyfluorinated Substances as Drinking Water Contaminants – Part I: Background and National Relevance
9:00–9:20	Christopher Higgins	The Importance of Per- and Polyfluorinated Substances as Drinking Water Contaminants – Part II: Why Organic Chemistry Should Matter to Geologists
9:20–9:40	Edward Furlong	Landfill Leachate and Urban Stormwater as Environmental Source Inputs
9:40–10:00	David Blye	Analytical Methods and Challenges Associated with Polyfluoroalkyl Substances
10:20–10:40	Michael Burke	An Introduction to Emerging Contaminants: 1,4-Dioxane and Per and Polyfluorinated Alkyl Substances
10:40–11:00	Ryan Andersen	Case Study: An Emerging Contaminant Impacted Public Water Supply Well Field
11:00–11:20	James Occhialini	1, 4- Dioxane – A Review and Evaluation of the Available Analytical Methodologies Used in Support of the Latest State and Federal Standards
11:20–11:40	Stewart Abrams	Remedial Technologies For The Treatment Of 1,4-Dioxane And PFAS
11:40–12:00		Panel Discussion

Technical Session #10
Transportation and Infrastructure Projects

Sponsored By: Shannon & Wilson

Room: Fremont **Moderator: James Arthurs**

Time	Speaker	Title
8:00–8:20	James Arthurs	Construction of Transportation Infrastructure in Weathered Volcanic Ash Soils
8:20–8:40	Brierley, Gary S.,	Good Engineering Geologists – Worth Their Weight in Gold
8:40–9:00	Jason Andrews	Stabilization of a Relic Landslide in Colorado
9:00–9:20	Michael Arles	Utilizing Controlled Blasting Techniques for Phased Rock Excavation for New Kentucky Lock Adjacent to Existing Lock
9:20–9:40	Robert Auber	Gas Tries to Give a Vertical Boring Machine the Shaft
9:40–10:00	Deniz Karadeniz	Design of Piles for the Stabilization of Bridge Abutments
10:20–10:40	J. David Rogers	William Jackson Palmer, Civil Engineer, Rail Magnate, and Founder of Colorado Springs
10:40–11:00	David Kwietnewski	Challenges of Inspecting Unlined Rock Tunnels Based on the New National Tunnel Inspection Standards
11:00–11:20	Thomas Waldron	Linear Construction Projects – Transco Natural Gas Pipelines
11:20–11:40	Derek Irving	Panama Canal Third Set of Locks: Key Findings Concerning Seismic Hazard in Central Panama
11:40–12:00	Dan Markowski	US-85 Through the North Dakota Badlands – Development of a Stratigraphic Column and Correlation to Landslides

Announcing AEG's 1st Annual Environmental Geology Symposium:

Emerging Contaminants

Thurs., Sept. 14, 2017 — 8:00 AM–5:00 PM

AEG Annual Meeting–Colorado Springs, CO

What are emerging contaminants and why should we care?

EMERGING CONTAMINANTS:

- are a new specialized subfield of Environmental Geology at the intersection of Chemistry, Toxicology and Hydrogeology!
- are impacting our nation's Drinking Water supply and Food chain, in subtle and pervasive ways!
- present new and difficult remedial challenges for today's Environmental and Engineering Geologists!

SYMPOSIUM KEYNOTE SPEAKERS:

MORNING SESSION

Christopher P. Higgins, PhD

An Associate Professor of Civil and Environmental Engineering at the Colorado School of Mines, Chris is a Harvard and Stanford trained Environmental Chemist who examines the fate and transport of contaminants in natural and engineered systems. He is involved in the investigation of the AFFF (Aqueous Fire Fighting Foam)-impacted drinking water south of Colorado Springs and is often quoted in the press.

AFTERNOON SESSION

Kristy Richardson, PhD

An Environmental Toxicologist with the Colorado Department of Public Health and Environment (CDPHE), Kristy leads the Colorado fish consumption advisory program and served as point of contact for the multi-agency water quality data on the perfluorinated chemicals discovered south of Colorado Springs.

SYMPOSIUM FEATURED SPEAKERS:

Edward T. Furlong, PhD

Ed is an Environmental Analytical Chemist, USGS Denver and well-known author of over 85 journal articles and 25 USGS reports (Thomson Reuters Highly Cited Researcher) was one of the first to document in 2002 the wide variety of hormones, pharmaceuticals, and personal care products present in surface waters throughout the U.S.

Barbara Mahler, PhD, PG

A Research Hydrologist, Geochemist with the USGS in Austin, TX, Barbara looks at widespread contaminant sources such as parking lots, roof runoff and house dust. Dr. Mahler's research has been instrumental in proving the importance of coal-tar-based parking lot sealcoat as a source of PAHs on a national scale.

William Battaglin

A USGS Research Hydrologist in Lakewood, CO, Bill is a School of Mines and UC Boulder- trained Geological Engineer who investigates contaminants of emerging concern in the National Parks as well as the effects of pesticides and oil and gas development on amphibian populations.

Chad A. Kinney, PhD

A Professor of Analytical and Environmental Chemistry and Chairman of the Chemistry Department at Colorado State University-Pueblo, Chad researches the presence, fate, behavior, and effects of anthropogenic organic contaminants in environmental matrices.

Stewart Abrams, PE, Principal, Corporate Director of Remediation Technology at Langan Engineering and Environmental Services, Lawrenceville, NJ

Ryan Andersen, CHMM, Project Engineer at Langan Engineering and Environmental Services, Philadelphia PA

David Blye, CEAC, Principal Chemist at Environmental Standards, Inc., Valley Forge, PA

Michael Burke, CHMM, Principal, Langan Engineering and Environmental Services, NYC, NY

James Occhialini, VP, Alpha Analytical, Westborough, MA

CEUs Available!

Cost to Attend JUST the Symposium: $195

Questions? Contact heather@aegweb.org ***Register at:*** aegannualmeeting.org/registration. Use Discount Code "ES2017"

Thursday, September 14 – Afternoon

Technical Session #11
The Impact of Geology on Flood Control and Water Storage Dams and Levees Part 2 - Symposium

Sponsored by: AEG Texas Chapter

Room: Summit II **Convener: Brian Greene**

Time	Speaker	Title
2:00–2:20	J. David Rogers	Overview of the 1921 Pueblo Flood; One of the Deadliest in American History
2:20–2:40	J. David Rogers	Aftermath of the 1921 Pueblo Flood
2:40–3:00	Thomas Terry	USACE Levee Risk Assessment Process – Lessons Learned
3:00–3:20	Cassandra Wagner	Using Multidisciplinary Field Investigation to Improve the Assessment of Internal Erosion
3:40–4:00	Donald Riley	History and Results of the Calaveras Replacement Dam Foundation Grouting Program
4:00–4:20	Michael Nield	Stability Analysis for the Right Abutment Spillway - Isabella Dam, CA
4:20–4:40	Suzanne Hess-Brittelle	Assessment of Historic Piezometer Data, Abiquiu Dam and Reservoir, Rio Chama, New Mexico
4:40–5:00		Discussion

Technical Session #12
Materials Characterization and Ground Improvement

Room: Learning Center **Moderator: Phillip Gallet**

Time	Speaker	Title
2:00–2:20	Phillip Gallet	Methods for Improving Collapsible Soils
2:20–2:40	Evan Saint-Pierre	Engineering Rock Mass Classification for Las Vegas Valley Caliche (Presented by Robert Watters)
2:40–3:00	Charlie Wildman	Characterization of Recycled Crushed Glass Cullet as an Aggregate for Coastal Nourishment and Restoration Applications
3:00–3:20	Charlie Wildman	Applications of Modern Limit-Equilibrium Computer Applications to Assess Deep-Mixed Shear Panels in Accordance with USACE Design Specifications

Technical Session #13
The Impact of Geology on Government Projects and Assets - Symposium

Room: Learning Center **Conveners: Paul Santi and Alex Strouth**

Time	Speaker	Title
3:40–4:00	Todd Loar	USACE Dam Safety Risk Assessment Program Overview and How Engineering Geology Contributes to the Level of Confidence and Results
4:00–4:20	Eric Bilderback	Managing Unstable Slopes in the National Parks
4:20–4:40	James Wright	The “New” Project Data Books and How They Impact Risk Assessments
4:40–5:00	Ty Ortiz	Geohazard Mitigation Using a Risk-Based Asset Management Plan

Technical Session #14
Sliding the Scale: Improving Communications and Public Policy for Landslide Hazards - Symposium

Sponsored by: HI-TECH Rockfall

Room: Summit I **Convener: Kevin McCoy**

Time	Speaker	Title
2:00–2:20	Jerome De Graff	Be an Advocate for Landslide Hazard Reduction within Your Organization
2:20–2:40	Jennifer Bauer	The Importance of Connecting with your Audience to Communicate Landslide Hazards
2:40–3:00	Scott Burns	A Major Role for Engineering Geologists Internationally - Help Produce Resiliency Plans for Major Hazards with an Example from Oregon
3:00–3:20	Don Knight	Responding to the Challenge of Planning for Landslide Hazards—The Colorado Springs Experience
3:40–4:00	Jonathan Godt	Transforming USGS Science to Support Landslide Loss Reduction
4:00–4:20	Jeffrey Keaton	Analytic Hierarchy Process: A Possible Semi-Quantitative Alternative to “on the Other Hand…” for Geologic Complexity
4:20–4:40	Jeffrey Keaton	Mapping Landslides for the Insurance Industry – Lessons from Earthquakes
4:40–5:00	David LaPorte	Evaluating Landslide Risk Management in Guatemala City through a Study of Risk Perception and Behavior Changes

Technical Session #15
Geophysics and Remote Sensing

Room: Fremont **Moderators: Doug Lambert and Phil Sirles**

Time	Speaker	Title
2:00–2:20	Ronald Bell	A Quiet Revolution: Using Drones for Geophysical Mapping
2:20–2:40	Eric Cross	Electromagnetic (EM) Ground Conductivity Mapping: Using Secondary Geophysical Methods and Invasive Testing to Ground-Truth EM Results
2:40–3:00	Sarah VanderMeer	Subsurface Exploration of Glacial Landforms using Ground Penetrating Radar in Pictured Rocks National Lakeshore, Michigan
3:00–3:20	Christopher Stohr	Assessing the Potential for Groundwater Contamination From Illinois’ Landfills Using Remote Sensing and GIS Technology

Technical Session #16
Hazard Characterization and Management

Room: Fremont **Moderator: Darrel Schmitz**

Time	Speaker	Title
3:40–4:00	Reid Fisher	Cumulative Slope Stability Effects of Daily Reservoir Oscillations, Southern Peruvian Andes
4:00–4:20	Jamie Goldsberry	Tunnel Design -Categorizing Glacial Soil Types by Depositional Environment for a Better Understanding of the Project and the Hazards Associated
4:20–4:40	Darrel Schmitz	Completing a Mentor’s Surficial Geologic Maps in Coastal Plain Sediments
4:40–5:00	Hassan Elhifnawy	Automated Unsupervised Change Detection Technique from RGB Color Images
5:00–5:20	Issa El-Hussain	Ground Motion Modification by Topographic Irregularities: A Case Study in Al Jabal Al Akhdar, Sultanate of Oman

Technical Session #17
Emerging Contaminants Symposium Part 2

Room: Carson **Conveners: Patty Bryan and Loren Lasky**

Time	Speaker	Title
2:00–2:20	Kristy Richardson	Perfluorinated Compounds in the Widefield Aquifer, Colorado Springs - Part I: Impact to Water Supply
2:20–2:40	Kristy Richardson	Perfluorinated Compounds in the Widefield Aquifer, Colorado Springs- Part II: Alternative Options for Drinking Water
2:40–3:00	William Battaglin	Pharmaceuticals and Other Contaminants are "Flushed" to Streams by Storms, Floods, and Us
3:00–3:20	Chad Kinney	Transfer of Pharmaceuticals and Personal Care Products in Terrestrial Systems
3:40–4:00	William Battaglin	How Do Anthropogenic Bioactive Chemicals in the Illinois Waterway Impact the Big-headed Carp Population Migration Front
4:00–4:20	Barbara Mahler	Coal-Tar-Based Sealcoat—a Potent Source of PAHs with Emerging Concerns - Part I: A Potent Source of PAH
4:20–4:40	Barbara Mahler	Coal-Tar-Based Sealcoat—a Potent Source of PAHs with Emerging Concerns - Part II: Implications for Aquatic Health
4:40–5:00		Panel Discussion

Friday, September 15 – Morning

Technical Session #18
Landslide Hazards of Colorado Springs: What the General Public Needs to Know

Sponsored by Maccaferri

Room: Carson **Convener: Karen Berry**

Colorado Springs lies at the boundary between the Great Plains and the Front Range of the Southern Rocky Mountains. Western sections of the city are underlain by weak claystones and shales that are prone to landslides. Several developed areas have experienced various degrees of damage from landslide movements during the 1990s and over the last several years. These landslides were widely reported in the press; however, it is apparent that significant segments of the general public are not aware that they reside in areas with landslide hazards. This purpose of this symposium is to help educate the public about the inherent risks, liabilities, and responsibilities of living and developing in such terrain. Speakers and topics include: Opening Remarks, John Suthers, Mayor, City of Colorado Springs; Don Knight and Tom Strand, Councilmembers, City of Colorado Springs, Process to Develop a Geologic Hazard Ordinance; Jon White, Colorado Geological Survey, Past Landslide Damages and Overview of Landslide Susceptibility; Marcia Waters, Division Director, Colorado Department of Regulatory Agencies Real Estate Division, Real Estate Disclosure Roles and Responsibilities; Robert Moore, Risk Management Engineer, 2-10 Home Buyers Warranty, Risk Management Requirements for Colorado Springs Landslide Susceptibility Zone; Peter Wysocki (or other staff), Colorado Springs Planning Director, New Requirements for Developing in the Landslide Susceptibility Zone; Geotechnical or Engineering Geologist Not Yet Confirmed, Buying or Repairing Homes in Landslide Susceptibility Zone, What You Need to Know; Karen Berry, Colorado Geological Survey, Special Districts, Geologic Hazard Abatement Districts —Non-traditional Ways to Address Landslide Risks; Local Homeowner's Association, Landslides from a Homeowner's Perspective; and Panel Discussion.

Time	Title
9:00–12:00	Presentations and Panel Discussion

Technical Session #19
Remote Sensing and GIS for Geohazards Assessment and Environmental Studies - Symposium

Room: Fremont **Conveners: Wendy Zhou and Thomas Oommen**

Time	Speaker	Title
9:00–9:40	Kevin McCoy	From Outcrop to Web: CGS Integrates Digital Data and GIS Technologies to Map Geology, Hazards, and Groundwater Resources
9:40–10:00	Erin Bessette-Kirton	An Analysis of Landslide Volume and Structures from Satellite Imagery of the 2016 Lamplugh Rock Avalanche, Alaska
10:20–10:40	Priscilla Addison	Burn Severity Estimation Using Radar Remote Sensing
10:40–11:00	Ashton Krajnovich	A Framework for Dynamic Risk Assessment in Subsurface Excavation Projects
11:00–11:20	Cole Rosenbaum	Rio Chama Landslide Mapping and Analysis and Evaluation of Regional Landslide Susceptibility, Archuleta County, Colorado (Presented by Wendy Zhou)
11:20–11:40	Stephen Semmens	Evaluation of Environmental Predictors for Sand Boil Formation
11:40 -12:00	Lauren Southerland	Probability Statistics in GIS: Mapping Landslide Susceptibility, A Case Study in Colorado Springs, El Paso County, Colorado

Technical Session #20
The Impact of Geology on Flood Control and Water Storage Dams and Levees Part 3 - Symposium

Room: Summit II **Convener: Kerry Cato**

Time	Speaker	Title
9:00–9:20	Matthew Strasser	Search for the Dog Valley Fault — Cause of the M 6 Truckee Earthquake Near the Stampede, Boca, and Prosser Creek Dams
9:20–9:40	Morley Beckman	Chabot Dam Seismic Upgrade – When Cement Deep Soil Mixing Meets Franciscan Melange Bedrock
9:40–10:00	Visty Dalal	Lake Needwood Dam Incident - A Geological Twist!
10:20–10:40	Muhammad Ahmed	Impact of Prehistoric Landslide Dams on the Formation of Knickpoints along the Gilgit River of Northern Pakistan (Presented by J David Rogers)
10:40–11:00	Erica Anderson	Slope Stability Analysis in the Vicinity of the Enguri Hydroelectric Dam, Republic of Georgia
11:00–11:20	April Fontaine	Sacramento Region Flood Fight 2017 – Through the Eyes of a Geologist
11:20–11:40	Thomas Terry	Taking the Mystery Out Of USACE's ER 1110–1-1807 Drilling in Earth Embankment Dams and Levees
11:40 -12:00		Discussion

Technical Session #21
Reclamation of Industrial Mineral Extraction Sites

Room: Summit I **Moderator: Tom Newman**

Time	Speaker	Title
9:00–9:20	Oliver Barker	Competition for Land Within the Witwaterstrand "Mining Belt"
9:20–9:40	Michelle Lee	Permian Sand Dune Mining: "What's All the Frac About?"
9:40–12:00		Forum on Geology of Industrial Minerals Speakers and times will be announced on the Annual Meeting Mobile App. *See page 5 for the QR code to access the app.*

Friday, September 15 – Afternoon

Technical Session #22
InSAR Applications for Geology and Geological Engineering - Symposium

Room: Summit II **Conveners: El Hachemi Bouali, Wendy Zhou, Thomas Oommen**

The goal of this symposium is to illustrate the application of Interferometric Synthetic Aperture Radar (InSAR) for geology and geological engineering purposes. Topics of interest include the monitoring or prediction of natural hazards, such as landslides, ground subsidence, seismology, tectonics, and volcanology; glaciology; hydrology and hydrogeology; infrastructure monitoring; asset management programs using InSAR; structural/deformation analyses; long-term displacement-time series analyses. This symposium will provide state-of-the-art information on InSAR applications to professionals, researchers, and students working in the field of engineering geology.

Time	Speaker	Title
2:00–2:40	Paolo Mazzanti	Advanced InSAR and Photomonitoring: the Contribution of Satellite Imagery for the Investigation and Monitoring of Landslides
2:40–3:00	Wendy Zhou	The Benefit and Limitation of InSAR Technique for Geohazard Assessment
3:00–3:20	Francisco Gomez	Applicability of a Portable Ground-Based Radar Interferometer (GBIR) for Monitoring Rock Faces and Earth Slopes
3:40–4:00	Alvaro Puente	Assessment of the Progression of Coal Mine Subsidence in Colorado, Using InSAR
4:00–4:20	El Hachemi Bouali	Monitoring the Casitas Dam in Ventura County, California with Satellite InSAR
4:20–4:40	Kelly Hickcox	Analysis of the Debeque Canyon Landslide using Ground-Based Radar and Aerial Photogrammetry, Mesa County, Colorado
4:40–5:00	Kendall Wnuk	Using InSAR Time Series Analysis to Characterize Tunnel Induced Surface Deformation

Technical Session #23
Rock Engineering and Rock Mechanics

Room: Carson **Moderator: Evan Lindenbach**

Time	Speaker	Title
2:00–2:20	Rachael Delaney	Slope Stability Analysis Using Discontinuity Data Collected Via An Unmanned Aerial Vehicle (UAV)
2:20–2:40	Danny Sims	Use of Borehole Data in Defining Structure Sets for Rock Slope Kinematic Analysis
2:40–3:00	William Swanger	Evaluating the use of Google Earth and Google Street View for Rockfall Hazard Rating (Presented by Yonathan Admassu)
3:00–3:20	Sam Bartlett	Engineering Geology Challenges on a Micro-Scale for the Morrison-Golden (CO.) Fossil Areas, National Natural Landmark
3:40–4:00	Forrest Whitney Smith	Influence of Secondary Structure on Toppling Failure of an Overhanging Limestone Cliff, Lake Whitney, Texas
4:00–4:20	Gerry Stirewalt	Locating a Nuclear Power Plant at a Previous Plant Site in Crystalline Rock – A Unique Situation for NRC Geologists
4:20–4:40	Evan Lindenbach	In-Situ Rock Testing Equipment: A Review of Current Practice
4:40–5:00		Discussion

Technical Session #24
Geology and Industrial Minerals

Room: Summit I **Moderator: Tom Newman**

Time	Speaker	Title
2:00–2:20	David Abbott Jr.	The SEC's Mining Disclosure Guides Past, Present, and Future; with Notes for Industrial Minerals
2:20–2:40	Rahul Verma	Qualitative Analysis of Sand Resources in Texas for Hydraulic Fracturing
2:40–3:00	Terry West	Evaluation of Freeze-Thaw Durability of Concrete Containing Carbonate Aggregates: A Comparison of Test Methods
3:00–3:20	David Bieber	Mining; the Birthplace of Engineering Geology
3:40–4:00	Jeffrey Binder	The Use of Flyash in Mine Stabilization
4:00–4:20	John Cowley	Getting a Grip
4:20–4:40	Andrew Rupke	Great Salt Lake: A Dynamic Industrial Mineral Resource
4:40–5:00	Curt Campbell	Digging in the Water: An Overview of Mining in and Around Water

Technical Session #25
Hydrogeology

Room: Fremont **Moderator: Rosanna Saindon**

Time	Speaker	Title
2:00–2:40	Matthew Sares	Nontributary Groundwater in Colorado: Its Definition, Administration, and Case Studies
2:40–3:00	John Jansen	Seismic Attribute Processing to Find Deep Aquifers
3:00–3:20	Christopher Mathewson	Physical Properties of Monitor Well Grouts: Application to Geologic Settings

Technical Session #26
Environmental Geology

Room: Fremont **Moderator: Rosanna Saindon**

Time	Speaker	Title
3:40–4:00	Wayne Isphording	Property Owners Call It "Trespass"; Lawyers Call It "Heaven!"
4:00–4:20	Karl Schuler	Non Scope Risk Assessment Needs for Redeveloping Industrial/Commercial Property to Residential Use
4:20–4:40	Rosanna Saindon	Environmental Hazards and Risk Overview and Helpful Hints for Explaining to Your Clients
4:40–5:00	Melissa Magno	Physicochemical Characteristics and Spatial Distribution of Heavy Metals in Soils Near an Abandoned Mine-Complex in Bumpus Cove, TN

Poster Sessions

Wednesday, September 13 – Thursday, September 14

NEW this year, AEG is going electronic for the first time for the poster presentations. The posters will be separated into three sessions, Wednesday afternoon, Thursday morning and Thursday afternoon. We will have five concurrent electronic monitors for the presentations. In addition, we will have 3 iPad stations for attendees to view all of the posters on their own. We will conclude the poster presentations on Thursday evening with a Poster Reception. All presenters will be given 10 minutes to present their poster at the reception. We will have snack mix and a cash bar at the reception.

PDF's of the posters will be available prior to the Annual Meeting on the website for attendees to plan their poster presentation viewing schedule in advance.

Wednesday, September 13: 1:00–3:00pm and 3:00–5:00pm

Thursday, September 14: 8:30am–10:30am, 10:30am–12:00pm, 12:30–2:30pm

Poster Presentation Reception – Thursday: 5:30pm–7:00pm

Vote for Your Favorite Poster!

We will once again be holding a student poster competition. AEG is offering three cash prizes ($250, $175, $75) for the top three vote recipients. Voting will be conducted exclusively through the Guidebook app, so bring your mobile device to vote for your favorite. Winners will be announced and prizes awarded at the Poster Reception on Thursday evening from 5:30–7:00pm.

Location: Heritage Ballroom

Wednesday: 1:00-3:00pm

Presenter	Title
Erica Anderson	Utilizing a Simplified Hydrology Model to Map Fire-Induced Debris Flow Travel Paths (Presented By Thomas Oommen)
Kenneth Bansah	Sinkhole Investigations Using Electrical Resistivity Tomography and Multichannel Analysis of Surface Waves
Clay Johnson	Reducing Fault Location and Slip Uncertainty for Gas Pipeline Crossings at the San Andreas and Hayward Faults in California
James Bialas	Importance of Segmentation Scale Parameter in Detection of Earthquake Damage in Remotely Sensed Imagery Using Machine Learning

Wednesday: 3:00–5:00pm

Presenter	Title
Pratop Bohara	Geophysical Characterization of a Confederate Cemetery
Clarke DeLisle	Using low-Altitude Drone Photogrammetry to Identify and Quantify Subtle Quaternary Surface Faulting in the Northern Wind River Basin, Wyoming (Presented by Francisco Gomez)
Sheila M. Arias-Román	Scour Level II Assessment of U.S. Army Installation Bridges
Zhen Guo	Seismic Site Effect Parameters by HVSR Method Considering the Variation of Source Energy (Presented by Adnan Aydin)

Thursday: 8:30–10:30am

Presenter	Title
Jonathan Gates	Development of an Accurate Method to Map Water Tracks Using Remote Sensing and Soil Hydraulic and Geophysical Properties
Kate Clancy	Study of the Interaction of Water Tracks with Soil Piping to Prevent Subsidence in Alaskan Soils
Ryan McCoy	From Cradle to Lobe: Catchment Characteristics Supporting Frozen Debris Lobe Formation, Brooks Range, Alaska

Thursday: 10:30am–12:30pm

Presenter	Title
Shishay Kidanu	GIS-Based Spatial Analysis for Determining Sinkhole Influencing Factors in Greene County, Missouri
Gerry L. Stirewalt	Integrating Geologic and Geotechnical Data to Assess Suitability of a Nuclear Power Site in Carbonate Rock at the NRC
Charles Miles	Comparison of Ground Based Interferometric Radar and Lidar for Detecting Rockfall Hazards
Rebecca Rhodes	Geophysical Characterization of a Short Segment of a River Levee

Thursday: 12:30–2:30pm

Presenter	Title
Matthew L. Morgan	Change Detection of the West Salt Creek Landslide, Colorado Using Multi-Temporal Lidar and UAVSAR Datasets
Grant Elliott	Ground Based Radar Interferometry Measurements of the Slumgullion Earth Flow (San Juan Mountains, Colorado)
Hyeong-Dong Park	Selection of Sites for the Installation of Solar Panel with a Consideration of Surface Flow in Some Active Mining Areas in Korean Peninsula

Thursday Poster Reception Presentation Schedule

#	Time	Abstract Title/Author
1	5:30	Utilizing a Simplified Hydrology Model to Map Fire-Induced Debris Flow Travel Paths/Erica Anderson (Presented By Thomas Oommen)
1	5:40	Sinkhole Investigations Using Electrical Resistivity Tomography and Multichannel Analysis of Surface Waves/Kenneth Bansah
1	5:50	Importance of Segmentation Scale Parameter in Detection of Earthquake Damage in Remotely Sensed Imagery Using Machine Learning/James Bialas
1	6:00	Geophysical Characterization of a Confederate Cemetery/Pratop Bohara
2	5:30	Using low-altitude drone photogrammetry to identify and quantify subtle Quaternary surface faulting in the northern Wind River Basin, Wyoming/ Clarke DeLisle (Presented by Pack Gomez)
2	5:40	Ground Based Radar Interferometry Measurements of the Slumgullion Earth Flow (San Juan Mountains, Colorado)/Grant Elliott
2	5:50	Development of an Accurate Method to Map Water Tracks Using Remote Sensing and Soil Hydraulic and Geophysical Properties/Jonathan Gates
2	6:00	Reducing Fault Location and Slip Uncertainty for Gas Pipeline Crossings at the San Andreas and Hayward Faults in California/Clay Johnson
3	5:30	Study of the Interaction of Water Tracks with Soil Piping to Prevent Subsidence in Alaskan Soils/Kate Clancy
3	5:40	GIS-Based spatial statistical analysis of sinkhole influencing factors in Greene County, Missouri/Shirley Kidanu
3	5:50	Integrating Geologic and Geotechnical Data to Assess Suitability of a Nuclear Power Site in Carbonate Rock at the NRC/Gerry L. Stirewalt
3	6:00	From Cradle to Lobe: Catchment Characteristics Supporting Frozen Debris Lobe Formation, Brooks Range, Alaska/Ryan McCoy
3	6:10	Comparison of Ground Based Interferometric Radar and Lidar for Detecting Rockfall Hazards/Charles Miles
4	5:30	Seismic Site Effect Parameters by HVSR Method Considering the Variation of Source Energy (Presented by Adnan Aydin/Zhen Guo
4	5:40	Selection of Sites for the Installation of Solar Panel with a Consideration of Surface Flow in Some Active Mining Areas in Korean Peninsula/ Hyeong-Dong Park
4	5:50	Geophysical Characterization of a Short Segment of a River Levee/Rebecca Rhodes
4	6:00	Scour Level II Assessment of U.S. Army Installation Bridges/Sheila M. Arias-Román

"Get a Job & Make It Your Own" Student Luncheon

A Presentation by AEG Past President and Former Jahns Lecturer Greg Hempen Leading to Students' Comments and Discussion

Friday, September 15, 2017 – 12:00–1:30pm

(Complimentary for Students - Must register)

The talk and free lunch for students seeks to gain students' involvement and discussion via a PowerPoint presentation. Interrupting the presentation to comment or ask a question is encouraged. Three areas are developed to touch on many concepts, chiefly to gain the comments, inquiries and discussions of individual 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.

A Focus on Tunneling…

News from AEG's Tunneling Committee

After nearly ten years as the Tunneling Committee chairmen, Alan Howard and Richard Escandon will be transitioning leadership to a new group of volunteers; Paul Headland, Jon "Ike" Isaacson, and Michael Piepenburg. Many thanks are due to Alan and Richard and the other members of the AEG Tunneling Committee for their service to the underground community. We look forward to their continued input, guidance and camaraderie in the future. Like Alan and Richard, we remain committed to the idea that engineering and environmental geologists are a key component to the success of well-designed and well-constructed underground projects. For the 2018 AEG Annual Meeting in San Francisco, we will renew the tradition of featuring a either a half-day or full-day Tunneling/Underground Construction Symposia. We encourage AEG members to start thinking now about possible topics of interest to present at that symposium.

Here in Colorado Springs, several presentations related to underground construction will be made and meeting attendees are encouraged to listen to the following talks:

- **Horizontal Directional Drill Pipeline Crossing Design in Buried Glacial Valleys: A Multi-Faceted Approach** (Ladavat) – Technical Session #2
- **Gas Tries to Give a Vertical Boring Machine the Shaft** (Auber, Piepenburg, Sullivan) – Technical Session #10
- **Challenges of Inspecting Unlined Rock Tunnels Based on the New National Tunnel Inspection Standards** (Kwietnewski) – Technical Session #10
- **Tunnel Design – Categorizing Glacial Soil Types by Depositional Environment for a Better Understanding of the Project and the Hazards Associated** (Goldsberry, Headland) – Technical Session #16
- **Downhole Techniques to Assess Mine Subsidence and Mitigation Effectiveness** (Knott) – Technical Session #23

Additional announcements in *AEG News* and at the 2017 Annual Meeting will serve to remind readers of the 2018 Tunnel Symposia abstract and presentation deadlines. We will continue to use the newsletter to keep AEG members informed about underground news and events as well as training sessions relevant to our profession and specialty. We look forward to working with our colleagues and can be contacted as follows:

- **Paul Headland**, PE, PG: Vice President – Geological Services, Aldea Services LLC. 5301 Buckeystown Pike, Frederick MD 21704, (O) 301-979-7484, (C) 301-910-0847, (F) 301-355-9705 (E-mail) PHeadland@AldeaServices.com
- **Jon "Ike" Isaacson**, PE, PG, GE, CEG: Senior Engineer, Brierley Associates. 921 W. Van Buren Street, Chicago IL 60607, (O) 414-395-3180, (C) 414-630-4161, (E-mail) iisaacson@brierley associates.com
- **Michael Piepenburg**, PG, CEG, CCM: Principal Project Geologist, Associate, Mott MacDonald. 18013 Cleveland Parkway Drive, Suite 200, Cleveland OH 44135 (O) 216-536-3640, (C) 216-385-9121 (E-mail) Michael.Piepenburg@mottmac.com

Abstracts

The SEC's Mining Disclosure Guides Past, Present, and Future; with Notes for Industrial Minerals

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The SEC's Industry Guide 7 (IG7) provides the current disclosure guidance for mining entities wishing to sell securities in the United States. IG7 was developed from concepts included in H.C. Hoover's Principles of Mining (1909). The present text of IG7 was based on previous guidance that was revised in 1981 and incorporated with no changes in wording into IG7 in 1992. IG7, like most internationally accepted mining classification systems is biased towards the precious and base metals. The current international standard is the CRIRSCO template and the U.S. industry-supported standard is the SME's Guide for Reporting Exploration Information, Mineral Resources and Mineral Reserves. In June 2016, the SEC issued its proposed "Modernization of Property Disclosures for Mining Registrants" that purported to follow the CRIRSCO definitions. The SEC's proposal reflected a change in how disclosure guidance is developed. More than 73 mining firms and professional organizations commented on the SEC's proposal generally deploring the numerous and substantial deviations from both the CRIRSCO definitions and the SME Guide. The Trump administration has or will appoint three of the SEC's five Commissioners and has generally expressed interest in eliminating complex regulation. The SME and NMA are proposing a revised version of IG7 that follows the CRIRSCO template and refers to an updated SME Guide for further guidance. The current status of this effort will be reviewed.

Remedial Technologies for the Treatment of 1,4-Dioxane and PFAS

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This presentation will provide an overview of remedial technologies for the Emerging Contaminants (ECs) 1,4-dioxane and PFAS. These compounds present significant challenges when assessing potential remedial and treatment options due to their unique chemistry and our evolving scientific understanding. This presentation will provide an overview of treatment technologies commercially available or under development to address these key emerging contaminants. We will discuss the capabilities, limitations and current industry acceptance of these technologies, as applied or under consideration, for treatment of 1,4-dioxane and PFAS.

Burn Severity Estimation Using Radar Remote Sensing

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The increasing ability to utilize satellite imagery in monitoring wildfires has significantly decreased the risks associated with fighting these fires as well as their post-hazards. Currently, the most widespread approach to determining the burn severities of wildfires is through the use of the differenced normalized burn ratio (dNBR) index, obtained by using data from optical sensors. However, progress of this existing protocol is mostly hampered by the presence of clouds and smoke during data acquisition since optical sensors cannot penetrate either. An alternative approach is the use of synthetic aperture radar (SAR), by harnessing the unique ability of radar sensors to penetrate clouds and smoke. This will be especially useful in emergency situations where immediate burn severity information is needed to assess the vulnerability of fire-affected areas to post-fire hazards such as floods and debris flows. Any delay to obtaining the burn severity data increases the risk of life-threatening post-fire hazards and the degree of property damage. Limited literature on the SAR approach investigated relationships between SAR backscatter coefficients and ground truth data and has shown limited success (maximum R2 = 0.41). In our current study, we evaluate the ground based composite burn index (CBI) data on 37 fire sites in western United States as ground truths and backscatter coefficients of the X-, C-, and L- SAR bands as predictors. Ten different machine-learning algorithms were then explored using a 10-fold cross validation resampling. The resulting best model, Multivariate Adaptive Regression Splines, gave an R2 of 0.8, a two-fold increase on the linear approach. Having this improved alternative model will furnish emergency responders with an increased ability to better assess the associated risks of wildfires and the post-effects.

Terrestrial Lidar-Based Quantitative Geologic Rockfall Hazard Rating System (QG-RHRS)

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Rockfalls are one of the most common types of slope failures that affect cut slopes along roadways in mountainous regions. The Rockfall hazard rating system (RHRS) is used to rate cut slopes with respect to their likelihood of releasing rockfalls. Existing rating systems use semi quantitative approaches to rate geological and non-geological factors that control the release of rockfalls and their impact on roadways. The main geologic factors are the favorability/unfavorability of orientation of discontinuities with respect to the orientation of slope faces and the likelihood of differential weathering leading to undercutting of strong rock units. lidarfrom terrestrial platforms has been used to remotely measure discontinuity orientations. This research introduces an expanded application of terrestrial lidar(TLS) for quantitative RHRS mainly quantifying geologic factors and hence referred to as the quantitative geologic rockfall hazard rating system (QG-RHRS). Five TLS based parameters, A, B, C, D and E have been identified to evaluate geologic factors. The five parameters A, B, C, D, and E quantify the likelihood of discontinuity orientation-controlled failures, the degree of undercutting, past rockfall activity based on rockfall release surfaces, rockfall sizes from rockfall release surfaces/discontinuity spacing, and slope surface roughness, respectively. This rating system, although not inclusive of other non-geological factors appears to be more reliable and produces reproducible results. Two cut slope sites in Virginia are used to demonstrate the proposed QG-RHRS.

Impact of Prehistoric Landslide Dams on the Formation of Knickpoints along the Gilgit River of Northern Pakistan

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Landslides, rockfalls, and rock avalanches are the predominant mass wasting events that influence slope morphology in the Gilgit River watershed of northern Pakistan. The Gilgit River is one of the major tributaries of the Indus River in northern Pakistan. The watershed is located within a tectonically active zone, where the uplift rates approach 10mm/year. A number of prehistoric landslides along the river exhibit unique surface expressions influenced by their respective

slope movement, depth, and scale. The longitudinal profile of the Gilgit River appears to be impacted by number of geomorphic features, including prehistoric landslides. Satellite imagery and Digital Elevation Models (DEMs) of varying resolution are globally available to use as base maps to perform regional geomorphic analyses of the ongoing processes of mass wasting. The current study utilizes the ASTER DEM 30m resolution data that was obtained from (http://www.jspacesystems.or.jp/ersdac/GDEM/E/index.html). The longitudinal profile of the Gilgit River along with geomorphic parameters, such as the normalized steepness Index (ksn), were extracted from processed DEM data in the Matlab environment by employing Stream Profile Coding. Individual knickpoints were identified by examining the longitudinal profile and exporting these to ArcGIS software. The user-identified knickpoints were then compared with the location of mapped prehistoric landslides along the river channel. Numerous knickpoints were noted where remnants of documented landslide debris dams had occurred along the thalweg profile of the Gilgit River. The user-identified knickpoints adjacent to historic landslide dams revealed fairly high normalized steepness indexes (Ksn in the range of 600 to 2000m) as compared to the rest of the channel profile. This study highlights the likely role of landslide dams in the formation of knickpoints along the Gilgit River channel. Similar studies could help to understand the complex relationship between the river morphology and mass wasting processes in this region.

Case Study: An Emerging Contaminant Impacted Public Water Supply Well Field

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A case study on the Emerging Contaminant, 1-4-Dioxane, will be presented to illustrate the technical, regulatory and ethical challenges faced by environmental professionals, regulators and members of the regulated community as a result of inconsistent promulgation of groundwater remediation and drinking water standards for 1,4-dioxane under various federal and state programs. While the USEPA's Unregulated Contaminant Monitoring Rule (UCMR) has identified potential concerns with the presence of ECs in the public water supply, state and federal policy makers have been unable to agree on how (or even whether) to regulate these contaminants. The tangle of inconsistent regulations/guidance that has emerged from this morass has reinvigorated debate on the question of "how clean is clean?" and confused the regulated community and the general public about true risks and legal obligations associated with this Emerging Contaminant.

Slope Stability Analysis in the Vicinity of the Enguri Hydroelectric Dam, Republic of Georgia

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Enguri is the largest hydroelectric facility in the Republic of Georgia and plays an integral role in the geopolitics of the region. Completed in 1980, the dam is the second highest arch dam in the world at 271.5 meters and holds back approximately 1.1 billion cubic meters of water in a 15-kilometer reservoir. The aim of this study is to investigate the slope stability in the vicinity of the Enguri hydroelectric dam through the use of multiple software packages to define, analyze, and quantify the vulnerability of the dam that could undermine the social and geopolitical stability of the Transcaucasian area between Georgia and the separatist region of Abkhazia. Field data were collected at the site to characterize the strength of the geological bodies. Landslide analyses were performed using several slope stability models: Slide 6.0, Scoops3D, and Pisa-m. Output files from the software were integrated with GIS to create end-user information and assess slope stability in the region. The models predicted low factors of safety for the Khoko landslide area and showed that seismic activity significantly impacts the stability of the slopes in the region. Although confidence in the models is reasonable, uncertainties regarding the depth to the water table and thickness of the clay need to be better quantified. It is possible that the mining activity is related to instability of the slopes near Khoko Landslide due to the weakening effects of weathered gypsum within the clay layer.

Utilizing a Simplified Hydrology Model to Map Fire-Induced Debris Flow Travel Paths

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An increase in post-wildfire debris flow events has warranted the need for the development of a simplistic yet robust model that can effectively predict these hazards and their impact on critical infrastructure. To date, researchers have developed probabilistic models to predict potential locations and associated volumes of erodible material generated from the wildfire affected areas. This research works to supplement these previous efforts by identifying the potential travel path of debris flows, utilizing the Hydrology toolset within ArcMap 10.4. The study evaluates twenty-eight post-wildfire debris flow events with varying terrain conditions within three testing, eight calibration, and four validation sites. The basic assumption of this study is that debris flow has a similar travel path to surface runoff, and thus by creating a flow accumulation feature from Digital Elevation Models (DEMs), travel paths can be predicted. The simplicity of this model lies in the minimal inputs and understanding of Geographic Information System (GIS) required to produce results. Training and calibration debris flow paths were mapped based on pre and post Google Earth historical imagery of known wildfires. Testing and calibration results showed that a threshold break value of 50 gave the greatest precision; 81% compared to a 69% and 63% precision score for threshold break values of 25 and 100, respectively. The validation results on a threshold break value of 50 indicated consistency in accurately capturing the post-wildfire debris flow paths. The model was least accurate in mapping debris flow paths in relatively flat terrains that had average slopes below 20º. Due to the simplistic nature of this model, it is recommended that it be used in congruence with other information and analysis on the interested locations in order to better isolate the pertinent basins most susceptible to post-wildfire debris flow hazards before any mitigation or preventative measures are taken.

Reconnaissance Observations of the 17 June 2017 Karrat Fjord Landslide and Tsunami, Greenland

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A large landslide from the northern side of the Karrat Fjord in northwest Greenland caused a tsunami that propagated up and down the fjord and into relatively open waters, inundating the village of Nuugaatsiaq, more than 20 km away, and causing coastal flooding at the village of Illorsuit, more than 50 km away. The damage in Nuugaatsiaq was severe, as many buildings were destroyed and four people lost their lives. The villages of Nuugaatsiaq and Illorsuit remain evacuated and a large unstable slope adjacent to the landslide still provides a visible threat. On July 8, the authors conducted reconnaissance of part

of the west coast of Greenland, the Karrat fjord, some nearby alluvial fans, and the impacted villages to record wave run-up characteristics and characterize the landslide and slope. The reconnaissance involved approximately 800 km of helicopter flight, and landings in several key locations. Signs of run-up include changes in vegetation and damage to roots, deposits and scour of soil and rock, and stranded icebergs, as well as damage to homes and infrastructure. The observations are still being interpreted, but wave run-up heights exceeded 50 m, and may well have exceeded 100 m, in the vicinity of the slide. Observations and the basis for these interpretations will be presented.

Stabilization of a Relic Landslide in Colorado

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Development in the mountain towns of Colorado has often necessitated that engineers and geologists address problematic soils and potential slope instability. For the last 3 years, Engineering Analytics has been addressing slope stability for a 240 unit development being constructed in the mountains of Colorado that will reside on a relic landslide complex. Design for the site required the investigation and stabilization of the relic landslide complex. The design process involved reviewing the mapped relic landslide features and site reconnaissance by a number of geologists and engineers. Over 50 geotechnical borings were drilled and 10 test pits were excavated at the site to investigate the landslide features and collect soil samples. Inclinometers and piezometers were installed starting more than 10 years prior to development of the site to monitor slope movement and groundwater fluctuation. Inclinometer and piezometer data was used to guide additional geotechnical investigations and the design of stabilization measures. The design of stabilization features for the infrastructure included the installation of 4,500 feet of horizontal drains, 13,000 feet of underdrains, and 45,000 square feet of soil nail, ground anchor, and Hilfiker wall systems. The piezometers and inclinometers will continue to be monitored after construction.

Scour Level II Assessment of U.S. Army Installation Bridges

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Most common cause of bridge failures is due to flood scouring of the streambed material from around the structure foundations. Several researchers suggested that the leading causes of bridge collapses are scour. This is the engineering term used to describe the natural process that involves the removal of sediment from around the bridge's structure such as abutment walls and pier columns and from the bottom and sides of the streambed due to the flow of water. The aim of this project is to develop analytical calculations using acquire data to determine scour depth for 100-yr. and 500-yr. event or over-topping flood. The current method implemented by the United States Army Corps of Engineers (USACE) to predict the scour depth is based on the general guidelines within the Hydraulic Engineering Circular (HEC) No.18 and No.20 recommended by Federal Highway Administration (FHWA). Bridge scour is a combination of natural process that involves hydrology, river hydraulics, geomorphology, and the geometry of the structures. Hence, in order to implement the current procedure was necessary to perform reviews of historical field channel profiles, hydrologic analysis based on rainfall events at the bridge location, hydraulics assessment based on the flood flow, and laboratory testing of soil properties. Water surface profiles and the components of scour depths such as total scour, contraction scour, pier and abutment scour were determined for the bridge.

Utilizing Controlled Blasting Techniques for Phased Rock Excavation for New Kentucky Lock Adjacent to Existing Lock

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Kentucky Lock, owned by Tennessee Valley Authority (TVA) and operated by U.S. Army Corps of Engineers (USACE), currently has a new lock addition under construction in Gilbertsville, KY. The new 110-ft by 1,200-ft lock chamber being constructed by USACE Nashville District and is located landward of the existing 110-ft by 600-ft lock. The new lock is founded below the existing lock's foundation in Ft Payne Limestone. The project is being built in phases and the upstream monoliths (15% of total monoliths), miter gates, and right embankment are completed. Due to lessons learned on the failure of the TVA Wheeler main lock during construction of an adjacent lock in 1961, additional design and construction techniques were utilized for Kentucky Lock. These techniques included phased post-tensioning of lock walls, an extensive automated and manual instrumentation monitoring program, and phased overburden and rock excavation. The phased excavation included strict perimeter control and controlled blasting techniques, such as precision presplitting and "checkerboard" phased excavation adjacent to the operating lock. The material excavated consists of Mississippian age limestone of generally thick to massive horizontal beds with large silica content and karst features. The checkerboard concept incorporated phased excavation so that pre-designed stabilizing masses of rock blocks of Ft. Payne Limestone were left adjacent to the existing lock wall during the initial construction phase. The blocks provided additional protection against sliding of the adjacent existing lock monoliths. The checkerboard blocks were later excavated by means of mechanical excavation techniques and expansive grout in order to protect the recently placed, adjacent concrete. Excavation work and focused precision presplitting, line drilling and controlled blasting operations occurred while river traffic passed through the existing lock, often adjacent to the blasting area. These measures required significant investments in instrumentation and monitoring of the construction site to ensure worker safety and structure stability.

Construction of Transportation Infrastructure in Weathered Volcanic Ash Soils

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Roadway construction in volcanic terrain is subject to numerous geologic hazards. Examples include lava tube collapse and thick, unstable deposits of volcanic ash. In saturated conditions, weathered volcanic ash moisture contents commonly reach 250 percent. Saturated, thick weathered volcanic ash layers are frequently unconsolidated and prone to excessive settlement and strength loss when subjected to traffic loading. It is frequently highly plastic and cannot support construction traffic without improvement. Dry volcanic ash is nearly impossible to hydrate to meet AASHTO compaction requirements. It also highly mobile, causing dust plumes and hazardous conditions during construction. The Central Federal Lands Division of FHWA recently completed construction of Saddle Road, located between Mauna Kea and Mauna Loa on the Island of Hawaii. The road was constructed through several phases and largely traverses new alignment through rugged volcanic terrain. The project encountered challenging conditions related to both fresh and weathered volcanic ash soils. Thickness of the ash soils present in the alignment subgrade was highly variable from none (basalt at surface) to greater than 25 feet. On the west side of Hawaii, the climate is relatively dry; ash encountered was generally

unweathered with moisture contents near 25%. During construction, dry ash was scarified and mixed with crushed rock to improve compaction and reduce mobility. On the east side, frequent rainfall increased the degree of weathering volcanic ash, making it soft and wet, with moisture contents typically measured between 150% and 300%. Construction and long term performance of the roadway prism was a major concern during design. To reduce potential settlements, the wet, soft ash below the roadway embankments was removed and replaced with geogrid reinforced crushed rock. This paper presents lessons learned, effective construction practices, and remedial actions performed during construction of several miles of roadway on both weathered and unweathered volcanic ash soils.

Gas Tries to Give a Vertical Boring Machine the Shaft

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The Chagrin Shale is a flat-lying and thinly bedded shale with harder interbeds of siltstone, widely spaced joints, with medium to medium-high slake durability and a tendency for localized slaking and swelling. The shale is classified as potentially gassy as can be attested by over 110 years of tunneling and shaft excavation experience across northeast Ohio. Gas inflows into Cleveland-area tunnels are well documented and have traditionally been addressed by ventilation. More recently, gas inflow control in these tunnels has been expanded to include higher fresh-air volume exchange, the use of remote monitoring of gas sensor data, the establishment of stand-by time and payment rates in the contract documents, and the use of gasketed precast segmental tunnel linings. Until recently, the focus on gas control has been on tunnel construction. Previously, shafts were seen to be open and accessible enough to be readily ventilated with a combination of natural and OSHA-established mechanical ventilation means and flow rates. The 19-foot-diameter, 220-foot-deep, DST-7 Baffle Drop Structure shaft located along the Dugway Storage Tunnel (DST) project alignment in northeast Cleveland, Ohio, was recently completed using a vertical boring machine (VBM). Recorded gas inflows into the shaft exceeded the volume that could be controlled with ventilation as positioned on the VBM relative to the inflow source, and the VBM could not be manually accessed so that it could be advanced or easily extracted. As a result, nearly thirty working days of delay occurred before the atmospheric gas levels returned to safe levels that permitted manned entry and completion of the shaft excavation. A case history from the DST-7 Baffle Drop Structure shaft is presented along with observations and recommendations that may help reduce the impact of gas on future VBM advanced shafts.

Sinkhole Investigations Using Electrical Resistivity Tomography and Multichannel Analysis of Surface Waves

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This study explores the utility of using two geophysical techniques - electrical resistivity tomography (ERT) and multichannel analysis of surface waves (MASW)—to more cost-effectively investigate sinkholes. A multi-electrode resistivity system and a multi-channel engineering seismograph were used to acquire ERT and MASW data, respectively. The ERT and MASW data were further verified and constrained with borehole control. The two geophysical techniques provide less expensive, rapid, and reliable data on variations in lithology and engineering properties of soil/rock in karst terrain. In author's view, the two geophysical techniques are valuable techniques for sinkhole investigations.

Engineering Geology Challenges on a Micro-Scale for the Morrison-Golden (CO.) Fossil Areas, National Natural Landmark

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When the road to Red Rocks Park was completed over the hogback in the 1930's, several dinosaur fossil footprints were uncovered. Since that time further dinosaur footprints and bone fossils have been discovered making Dinosaur Ridge a world renowned fossil preserve in the Denver metro-area. With renown comes ever increasing visitor-ship and the need to protect both visitors and fossils from the ravages of the geologic processes released through building a cut and fill roadway in steeply dipping, alternating shale and sandstone beds. In addition to the normal rockfall, rockslide, dangerous overhangs, freeze-thaw and rain events exacerbating the downslope movement of soil and rock, we are required to preserve the fossils on these same downslope moving beds while maintaining the visual appeal of the sites. To accomplish these objectives of protecting the public and the fossils and still making the fossils accessible to the general public, we have accomplished many unique and unprecedented small-scale stabilization projects. For instance, we have stabilized single sandstone beds overlying a saturated shale beds on a 45 degree slope without damaging the delicate fossils within the sandstone bed. In other instances, we have constructed large protective structures directly upon the impervious membrane covering a somewhat dubious landfill. In still another project, we have stabilized a large, overhanging rock-block while preserving a rare and delicate fossil footprint on the underside of the overhang. All of this work is accomplished in a most cost effective manner by a non-profit (The Friends of Dinosaur Ridge) with limited funds.

Competition for Land Within the Witwatersrand "Mining Belt"

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Williams (1992) noted that there are two inescapable truths about our earth on which we live. The first is that the useable land surface for human activities is finite. The second is that the number of people vying for land is growing rapidly. Both of these scenarios apply in South Africa and in particular to the gold mining area of Gauteng and which is home to over 22% of the South African population. Even though access to "mining land" was opened up through new legislation and regulations in 1991 and 2002, the mining land was avoided by developers. One of the main reasons for this is that the current undermining safety zoning for property set by the Department of Mineral Resources is stringent but based largely on depth from surface criteria and predicated on no remedial work to improve the rock mass stability. To meet this demand for land for a variety of uses, particularly for housing, new developers are now looking at undermined ground, which remains derelict and often polluted. Recent growth in demand for gold and the development of new mining methods of low grade deposits or residual pockets in the old mines the growth in the demand for land for urban development is now increasingly being challenged by new mining applications. This paper looks at this growing tension and competition for land with reference to mining restrictions that derive from Section 17 mining regulations. It will reflect on work conducted by Barker, Stacey and others over a period of 25 years since 1992, which takes scientific approach to land use zoning for development. This work evolved from a hazard mapping and settlement risk assessment conducted in 1994.

Pharmaceuticals and Other Contaminants Are "Flushed" to Streams by Storms, Floods, and Us

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The occurrence of pharmaceuticals and other contaminants of emerging concern (CECs) in streams in remote locations such as National Parks is poorly understood, as is the transport and fate of CEC in streams during storms and floods. We assessed the occurrence and fate of CECs prior to and just after heavy rainfall that caused flooding in Rocky Mountain National Park (ROMO) and environs extending downstream to the main stem of the South Platte River. We collected water samples from 20 sites in ROMO, seven sites on tributaries to the South Platte River, and six sites on the South Platte. Samples were analyzed for approximately 110 pharmaceuticals of which 49 were detected at least once and 29 were detected within ROMO. Human waste is the most likely source of pharmaceuticals within the Park. Samples were also analyzed for approximately 70 wastewater indicators chemicals and 20 hormonally active chemicals. Concentrations and numbers of CECs detected in floodwaters increased markedly in the downstream direction and some were not diluted despite the large flow increases in the affected rivers.

How do Anthropogenic Bioactive Chemicals in the Illinois Waterway Impact the Bigheaded Carp Population Migration Front

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Two nonnative bigheaded carp species have invaded the Illinois River system and are a potential threat to the Great Lakes ecosystem. Poor water quality in the upper Illinois Waterway, a result of discharges from industry, wastewater treatment plants, and urban and agricultural runoff, may be a factor contributing to the stalling of the upstream movement of the bigheaded carp population migration front near Illinois Waterway mile 278. In 2015, the U.S. Geological Survey collected four sets of water samples under a range of seasonal and hydrologic conditions from three locations upstream and four locations downstream from river mile 278 using a Lagrangian-style sampling strategy. Water samples were analyzed for 635 constituents, of which 280 were detected at least once, including many anthropogenic bioactive chemicals (ABC) such as pesticides, pharmaceuticals, hormones, and volatile organic compounds (VOCs). Many anthropogenic bioactive chemicals were detected upstream of river mile 278, and some persisted or were introduced downstream. For example, in May 2015, at river mile 286 we detected 54 of 105 pharmaceuticals; 50 of 250 pesticides; 12 of 55 wastewater indicator chemicals; 11 of 116 VOCs; and 3 of 31 disinfection by products (DBPs). By the time that water moved downstream to river mile 243, we detected 20 pharmaceuticals; 58 pesticides; 9 wastewater indicator chemicals one VOC and 2 DBPs. Differences between the two sites are a function of dilution, downstream inputs (i.e. pesticides), degradation, sorption, uptake, and other geochemical processes.

The Importance of Connecting with your Audience to Communicate Landslide Hazards

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Many geoscientists communicate their findings and work to others in similar technical fields quite frequently. These talks contain data, facts, graphs, maps, photos, and technical terms to explain the information the author is trying to convey. Within a technical community, these presentation styles are quite appropriate. However, when communicating with the public or a non-technical audience, these technical methods will often lose the audience's interest and the important information will not be conveyed as effectively as it could have been. When communicating with a non-technical audience, it is important to first connect with them. When crafting these presentations, think of the point of view of an audience member and what they would like to come away with. Begin by engaging the audience and relating the information that you are about to present to their daily lives or something with which they can empathize. One of the most effective ways to capture the audience's attention, and leave them with a visual image of the importance of understating the hazard you are trying to communicate is through storytelling. As humans, we remember things better if we can relate to them, and feel as if we are a part of the story being told. By using stories, we have a mechanism for emphasizing the hazard we are communicating. Throughout your presentation, relate the facts and data to the audience by giving examples of how it applies to their lives. This presentation will discuss methods for engaging the audience and give examples of these methods in practice when communicating landslide hazards to the public.

Chabot Dam Seismic Upgrade – When Cement Deep Soil Mixing Meets Franciscan Melange Bedrock

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Chabot Dam is one of five terminal storage reservoirs operated by the East Bay Municipal Utility District (EBMUD) in the San Francisco Bay Area. The compacted earth and sluice fill dam was originally constructed in 1875 and subsequently upgraded in 1892, 1967 and 1980. In 2016, EBMUD embarked on the Chabot Dam Seismic Upgrade by constructing a cement deep soil mixing (CDSM) buttress and seepage collection trench across the downstream toe of the dam to alleviate seismic concerns from the adjacent Hayward fault zone. Underlying alluvial deposits and variable Franciscan Melange bedrock posed unique engineering geology challenges during the CDSM portion of this project. Decomposed serpentinite bedrock and other stiff soils led to a two-phase CDSM installation method, in which CDSM elements were pre-drilled with water prior to grout drilling. Ultimately several different drilling index criteria were developed during CDSM production, allowing for a range of embedment scenarios depending on the nature and hardness of the underlying bedrock. This presentation will discuss the CDSM design, adaptations to design parameters considered during construction of four test sections and subsequent CDSM production, and the design implications of installing CDSM at a site with a highly variable subsurface profile.

Utilizing Geophysics in Auxiliary Spillway Evaluation New Creek Site 14 Dam, Grant County, WV

Beenenga, Cari, P.E., Gannett Fleming, Inc. cbeenenga@gfnet.com; Andy Deichert; Richard Lee (TS#7)

New Creek Site 14 Dam is a zoned earth embankment located south of Keyser, WV. The 100-foot high dam was constructed in 1963. Gannett Fleming is the designer working with NRCS on the rehabilitation of this dam to meet current design standards. Geophysical surveys, as well as geotechnical drilled borings and test pits, were performed at New Creek Site 14 Dam in the summer of 2009. As part of the rehabilitation efforts, evaluation of the grass lined auxiliary spillway integrity was performed and the geophysical and geotechnical information was gathered to assist in performing this evaluation. A headcut erodibility analysis of the spillway using the SITES computer

program was completed by Gannett Fleming as part of the design. The existing auxiliary spillway is 200 feet wide at the control section and was constructed as a side hill cut in the left abutment. The spillway is approximately 1150 feet long and tapers to 100 feet wide as it extends downstream. The spillway bends approximately 90 degrees to travel nearly parallel to the toe of the dam. Project site geology consists primarily of shale, sandstone, siltstone and minor amounts of limestone. Seismic refraction survey lines were completed across the project site to determine the bedrock depth along the existing auxiliary spillway. The survey included a total of 8 seismic refraction lines running parallel and perpendicular to the auxiliary spillway. Seismic refraction surveys are conducted from the ground surface and use seismic waves to determine the seismic velocity of the underlying material. Seismic waves were generated using a 12 pound sledge hammer and an aluminum plate every 40 feet along the survey lines. The seismic refraction data was processed using the generalized reciprocal method (GRM) which determined lateral changes in seismic velocity of the subsurface strata. GRM provides better velocity definition, and therefore more precise depth calculations, than other data processing methods. The SITES computer program utilizes geologic parameters in the evaluation of the erodibility of the auxiliary spillway. The Headcut Erodibility Index (Kh) is the most sensitive parameter in the SITES program when evaluating erodibility of the auxiliary spillway. The Kh values at New Creek Dam were determined by correlations from the seismic velocities, information from the borings and test pits, and data from laboratory testing. Preliminary Kh values determined from the seismic refraction survey results indicated that the material in the auxiliary spillway was not as dense as anticipated and was highly susceptible to erosion during a flooding event. Further refinements of the Kh values, as more information was made available, did not change this conclusion. Performing a seismic refraction survey at New Creek Site 14 Dam provided a large quantity of information concerning the soil and rock seismic velocities. This information was collected in less than a week prior to the start of geotechnical borings and test pitting. Preliminary results of the geophysical work were used to verify and modify test boring and test pit locations. In several instances, test pits were strategically located to verify and confirm conclusions drawn from the geophysical data. Based on the speed in which a seismic refraction survey can be performed, the large area it can cover, and the results it provides, seismic refraction surveys are an economical and reliable tool to use to perform a preliminary SITES analysis of auxiliary spillways.

A Quiet Revolution: Using Drones for Geophysical Mapping

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The use of small unmanned aircraft systems (sUAS) has grown by leaps and bounds since the Federal Aviation Administration (FAA) implemented the 14 CFR Part 107, the regulations governing the civil use of drones, on August 29, 2016. In large part, the flurry of activity has been driven by the desire to obtain a bird's eye view coupled with the availability of affordable, robust drone technology. What does this really mean to geologists and engineers tasked with characterizing a site or managing the risks and costs of a design–build project or engaging in the exploration for extractable resources or the detecting of buried objects and infrastructure or simply mapping the variation in rock type under cover? High definition photogrammetric and infrared mapping via sUAS are arguably becoming fundamental method to the development of the knowledge base needed to make informed decisions. But these techniques only observe and measure what is on the surface of the earth. Is it possible to use drones to detect and measure what is below the surface? During the past several years, numerous industry practitioners as well as academic and government researchers have been striving to cost effectively apply drones to acquisition of geophysical data. While some have simply adapted existing technology others have developed a new generation of low power light weight geophysical sensors, and examined the manner in which geophysical data are acquired. The net result has been nothing less than a quiet revolution in geophysical mapping that will no doubt result in huge benefits to the workflows of environmental geologists and geotechnical engineers.

Landslide Hazards of Colorado Springs: What the General Public Needs to Know

Berry, Karen, Colorado Geological Survey, kaberry@mines.edu (TS#18)

Colorado Springs lies at the boundary between the Great Plains and the Front Range of the Southern Rocky Mountains. Western sections of the city are underlain by weak claystones and shales that are prone to landslides. Several developed areas have experienced various degrees of damage from landslide movements during the 1990s and over the last several years. These landslides were widely reported in the press; however, it is apparent that significant segments of the general public are not aware that they reside in areas with landslide hazards. This purpose of this symposium is to help educate the public about the inherent risks, liabilities, and responsibilities of living and developing in such terrain. Speakers and topics include: Opening Remarks, John Suthers, Mayor, City of Colorado Springs; Don Knight and Tom Strand, Councilmembers, City of Colorado Springs, Process to Develop a Geologic Hazard Ordinance; Jon White, Colorado Geological Survey, Past Landslide Damages and Overview of Landslide Susceptibility; Marcia Waters, Division Director, Colorado Department of Regulatory Agencies Real Estate Division, Real Estate Disclosure Roles and Responsibilities; Robert Moore, Risk Management Engineer, 2-10 Home Buyers Warranty, Risk Management Requirements for Colorado Springs Landslide Susceptibility Zone; Peter Wysocki (or other staff), Colorado Springs Planning Director, New Requirements for Developing in the Landslide Susceptibility Zone; Geotechnical or Engineering Geologist Not Yet Confirmed, Buying or Repairing Homes in Landslide Susceptibility Zone, What You Need to Know; Karen Berry, Colorado Geological Survey, Special Districts, Geologic Hazard Abatement Districts—Nontraditional Ways to Address Landslide Risks; Local Homeowner's Association, Landslides from a Homeowner's Perspective; and Panel Discussion.

An Analysis of Landslide Volume and Structures from Satellite Imagery of the 2016 Lamplugh Rock Avalanche, Alaska

Bessette-Kirton, Erin, Colorado School of Mines, U.S. Geological Survey, ebessettekirton@gmail.com; Jeffrey A. Coe, jcoe@usgs.gov; Wendy Zhou, wzhou@mines.edu (TS#19)

Slope instabilities are common in mountainous terrain and increasing development in these areas necessitates hazard analyses. During the past five years, occurrences of large rock avalanches over glaciated terrain in Glacier Bay National Park and Preserve (GBNP), Alaska have drawn attention to the complex, highly variable, yet poorly understood dynamics of these events. The objective of this research is to study the emplacement processes of the Lamplugh rock avalanche through an analysis of the volume and distribution of material in conjunction with small-scale structures and surficial features within the deposit. This research demonstrates the ability to use high-resolution remotely sensed data to study rock avalanches in glaciated terrain and provides an improved framework with which to estimate many of the uncertainties affecting volume measurements in glacial environments. The

Lamplugh rock avalanche occurred on June 28, 2016 and is the largest rock avalanche on record in GBNP. WorldView satellite stereo imagery was used to derive pre- and post-event, high-resolution (2m) Digital Elevation Models (DEMs). Differenced DEMs were used to calculate both source and deposit volumes and examine variations in deposit thickness. DEMs were also used in conjunction with high-resolution (~0.5m) optical imagery to map landslide structures and surficial features. The characterization of landslide structures and the evaluation of volume and thickness were used to make interpretations about emplacement processes. An improved understanding of rock avalanche processes is critical to future hazard assessments of rock avalanches traveling on ice within GBNP and in other glaciated regions.

Importance of Segmentation Scale Parameter in Detection of Earthquake Damage in Remotely Sensed Imagery Using Machine Learning

Bialas, James, Michigan Technological University, jpbialas@mtu.edu, Thomas Oommen, toommen@mtu.edu; Umaa Rebbapragada, umaa.D.Rebbapragada@jpl.nasa.gov; Timothy C. Havens, thavens@mtu.edu (Poster)

Geographic Object Based Image Analysis (GEOBIA) has proven to be a useful tool in detecting earthquake damage in remotely sensed imagery. A key parameter in the performance capabilities of this tool is the segmentation scale parameter- a variable that controls the number of pixels grouped together in an image object and thus influences its geospatial extent. Extensive work has been done in finding the best single segmentation scale parameter for many different image classification problems. However, considering the problem of earthquake damage detection in high resolution aerial imagery, we find that a range of scale parameters prove acceptable when using a large number of features and a classification algorithm capable of robust feature selection. Our work considers various measures of segmentation goodness and classifier performance as indicators of the upper bounds of useful segmentation scales. We also consider the impact user labeling approaches on classifier performance relative to scale parameter and these measures of segmentation goodness.

Mining: the Birthplace of Engineering Geology

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The roots of modern engineering geology are firmly planted in mining and mining engineering. Many of the earliest applications of soil mechanics, rock mechanics, and geohazards recognition focused on creating and maintaining mining excavations. In fact, it can reasonably be argued that one of the earliest known engineering geology text is Georg Bauer's De re metallica, published in 1556. Even today, many of the types of investigations performed and the tools used by mining geologists and engineers are virtually identical to those performed by engineering geologists. Investigations related to slope stability, hydrogeology, rock and soil strength, and subsidence are among the many areas common in the mining and engineering geology realms. The significance of these commonalities is that in this era of predicted scarcity of mining professionals, the engineering geology profession represents a pool of people who can be readily brought in to the mining profession. Conversely, the mining industry provides additional opportunities for employment for engineering geology graduates and practitioners.

Managing Unstable Slopes in the National Parks

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Rockfall and landslides are hazards that can potentially affect National Park visitors, facilities, and employees. Often unstable slope hazards are managed after-the-fact under incident command or other emergency scenarios. While there is broad recognition that this is neither cost effective or an acceptable risk reduction strategy, more proactive strategies must be minimally complex and clearly communicated as management resources are spread thin. To accomplish this the National Park Service is actively working with the Federal Highways Administration and other federal land management agencies to develop an Unstable Slope Management System to inventory and proactively manage rockfall and landslide issues in Parks through a set of online and mobile database tools. In addition, recently deployed quantitative risk estimation methods place risk to individuals and visitor populations into a societal context. Quantitative risk estimation provides risk comparisons that are accessible to managers who may not be trained in physical sciences and provide a method that is scalable, depending on the amount of information available about the hazard. These efforts attempt to bring together a National Park Servicewide approach to landslide and rockfall risk management.

Mapping of Potential Landslide Hazards along the River Corridors of King County, Washington

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The 2014 SR-530 landslide in Snohomish County, WA, focused attention on landslide hazards in the Pacific Northwest. King County, located immediately south of Snohomish County, is similar in topography, geology, and climate; and is subject to similar landslide hazards. In order to better understand the character and extent of the landslides in the County, a project to map landslide hazards was initiated in 2014 by King County. Study limits for this project were along the river corridors of Cedar, Green, Sammamish, South Fork Skykomish, Snoqualmie, and White Rivers and Issaquah Creek. The following landslide types were mapped using landscape-scale methods; deep-seated landslides, debris slides, depositional fans, rock fall, and rock avalanches. A different approach to mapping was required for each of these types of landslides. Mapping methods were selected based on consultation with technical experts and current literature research. Evidence of long runout events was identified at multiple locations. Although, it was determined that there is no feasible method for delineating runout areas on a landscape scale, characteristics that might predispose a large landslide to have a long runout event were identified. A webtool was prepared and is intended to be used as an information source on the mapped locations and types of potential landslide hazards identified by this mapping project.

Using HPT-GWS Direct Push Tooling to Delineate Uranium Impacts in Groundwater at a Former Fuel Processing Facility

Binder, Jeff, Burns & McDonnell Engineering, jbinder@burnsmcd.com (TS#5)

Groundwater was impacted with uranium above the Nuclear Regulatory Commission (NRC) unrestricted release criteria for site decommissioning and in excess of the Maximum Contaminant Level (MCL) for drinking water. Two areas of concern (Western Alluvial Area and in Burial Area #1) had plumes that could potentially impact an offsite receptor, the Cimarron River, but previous delineation had not determined the extent of the uranium plumes interfacing with the river.

Usage of the hydraulic profiling tool-groundwater sampler (HPT-GWS) proved to be key in moving the investigation forward for a groundwater remediation system design at a former uranium reactor fuel production facility near Crescent, OK. In both of these areas, uranium in groundwater (as well as other contaminants) extends hundreds of feet downgradient from the source of the contamination. If the distribution of chemicals of concern (COCs) in groundwater were confined to a single zone, targeting that zone may accelerate the rate at which groundwater is remediated and allow for optimization of pumping regimes. The Decommissioning Plan proposed the installation of groundwater extraction wells that fully penetrate the saturated alluvial zone in both areas. The HPT-GWS was used to vertically delineate the extent of uranium impacts in above the MCL. The data provided a higher resolution delineation of impacts and physical characteristics in reference to the receptor and the remedial design. Groundwater samples were also collected from discrete intervals from existing monitor wells. Analysis of the samples for uranium provided information needed to evaluate the vertical distribution of contaminants in groundwater, and to determine if the design of extraction wells should address uneven distribution of COCs in groundwater.

The Use of Flyash in Mine Stabilization

Binder, Jeffrey, Burns & McDonnell Engineering, jbinder@burnsmcd.com (TS#24)

Coal flyash and bottom ash from electric generating plants is being used to backfill an underground limestone mine in Kansas City, Missouri as part of a stabilization plan to allow real estate development above the mine. The flyash is mixed with water at the ground surface to form a slurry, and then placed into the mine through a borehole drilled from the ground surface. The bottom ash is mechanically placed and compacted in locations accessible to equipment. The mine area is considered stabilized when the combination of bottom ash material and cementitious flyash slurry material has backfilled the void. Room-and-pillar mining was carried out in the Bethany Falls Limestone at this site from 1952 to 1969, via a sloping adit at the base of the Missouri River bluffs. By 1991, when the mine room and pillar dimensions were surveyed, a number of domeouts had formed, where slabs of roof rock had fallen in some localized areas. Routine inspections performed at this mine over a number of years indicated that some of the domeouts continued to spread, leapfrogging to adjacent, previously unaffected rooms of the mine. These routine inspections have also documented the formation of several new domeouts as well, remote from any existing domeouts. The principal challenges faced in mine remediation efforts in Bethany Falls Limestone mines in Kansas City are to prevent single-room domeouts from spreading or coalescing to form multiple room domeouts (because multiple room domeouts can progress to the ground surface), and to then prevent multiple room domeouts from collapsing (because of their potential to cause subsidence at the ground surface). Backfilling of the open mine area prevents degradation of the mine roof and the formation of domeouts. Backfilling of the domeouts prevents further degradation of the materials exposed in the roof, and stops the coalescing of domeouts. When backfilling is completed, the open mine area and the domeouts are remediated and stabilized to allow for surface develop that may occur with no risk of mine collapse impacting surface infrastructure.

Analytical Methods and Challenges Associated with Polyfluoroalkyl Substances

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Polyfluoroalkyl Substances (PFASs) are emerging contaminants that have risen to the forefront of concern as environmental contaminants in the last 24 months. PFASs have been used in a wide array of consumer and industrial products and are widely distributed in the environment. The liquid chromatography –tandem mass spectrometry (LC-MS/MS) analytical techniques used to measure PFASs are complex and largely new to the commercial environmental laboratory marketplace. Additionally, the only U.S. EPA-approved analytical procedure to measure PFASs is for drinking water. Comparability of data amongst laboratories for groundwater, surface water, soil, sediment and air matrices is problematic because of the lack of standardized procedures. This presentation, which will be given at the Emerging Contaminants Symposium, will review basic PFAS environmental chemistry and focus on the challenges with the lack of standardized analytical techniques. Further, assessment of PFAS data quality will be presented.

Geophysical Characterization of a Confederate Cemetery

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There are many confederate cemeteries scattered throughout Mississippi and neighboring states. In most of these cemeteries, the numbers of burials are unknown. This study is an attempt to demonstrate the effectiveness of combined use of geophysical methods in characterizing these historical sites and shed some light on the numbers and arrangements of the burial chambers. The pilot study site is a confederate cemetery located within the Mississippi University main campus. The site is roughly 65 m x 55 m wide situated on a relatively flat, small hilltop and is surrounded by a rectangular brick wall. Three different geophysical methods were employed: seismic refraction, ground penetrating radar (GPR) and vertical electrical sounding (VES). The surveys were conducted at two different scales targeting different features. Long traverses along the inner perimeter of the wall were to determine the general geological setting as well as to guide the high resolution and 3D surveys. The study shows that combining geophysical images obtained by different tools offsets the limitations of individual methods and helps improve the characterization of both natural and anthropogenic features of the near surface.

Monitoring the Casitas Dam in Ventura County, California with Satellite InSAR

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The Casitas Dam is an earthfill dam built in 1959 and operated by the Bureau of Reclamation in Ventura County, California. The dam is 2,000 feet long, 334 feet tall, and impounds Coyote Creek to form Lake Casitas, a reservoir with a volume of 254,000 acre-feet. An environmental report was released in 1998 labeling the dam at risk of rupture if a magnitude-7 earthquake occurs on the proximal Red Mountain Fault. A rupture would release a 300-foot wall of water down Coyote Creek, possibly killing 400 people and causing about $430 million in property damage. This report prompted an effort to strengthen the

dam, which began in May 1999 and concluded in December 2000, by replacing liquefaction-prone soils with firm earth and building a buttress behind the dam. Interferometric Synthetic Aperture Radar (InSAR) can be utilized for the measurement of structural displacement across the Casitas Dam. This allows for long-term monitoring of dam movements and quantification of the effectiveness of stabilization efforts in 2000. For example, 24 ENVISAT images (acquired between 2005 and 2010) were processed with the Persistent Scatterer Interferometry (PSI) algorithm and revealed that portions of the Casitas Dam underwent approximately five centimeters of displacement and the buttress experienced nine centimeters of displacement, both in the downward direction. Aerial images correlate some areas of dam displacement with surficial erosion. However, there are regions of centimeter-scale displacements with no evidence of erosion, possibly indicating internal deformation of the earthfill dam and buttress. The authors use PSI results, displacement-time series, and interpolation maps to demonstrate InSAR capabilities of monitoring the Casitas Dam.

Good Engineering Geologists – Worth Their Weight in Gold

Brierley, Gary S., Doctor Mole Incorporated; gbrierley@drmoleinc.com (TS#10)

Competent engineering geologists are a key component to the success of well-designed and constructed infrastructure and underground projects. Effective subsurface investigation program development and implementation, preparation of well-written and thoughtful Geotechnical Data and Baseline Reports, and good in-field documentation during construction all require sound engineering geology skills to help underground construction projects reach a successful completion. Several case histories from major projects over the past forty years will be presented to demonstrate why and remind us that what we do—as engineering geologists—is important.

Site Characterization with Geophysics for Levee Underseepage Design

Brown, Phillip, U.S. Army Corps of Engineers, reed.brown@usace.army.mil (TS #1)

The U.S. Army Corps of Engineers, Kansas City District utilized both geophysical and traditional subsurface investigation methods to characterize the subsurface conditions along portions of the East Bottoms Levee Unit in Kansas City, Missouri, for design of underseepage control measures. Numerous physical site constraints complicated the subsurface investigations, including the site's proximity to a major chemical processing plant, overhead power lines and security fencing. In many locations, traditional subsurface explorations were impractical, or even impossible, because of the site constraints. Geophysical investigation methods proved vital to overcoming these constraints to get the necessary subsurface information and maintain the project's design schedule. Geophysical methods used in the project included both cone penetrometer testing (CPT) and multi-electrode resistivity (MER). The results of these investigations were combined with information gained from traditional sampling to define the depth and extent of the fine-grained impervious blanket overlying the aquifer, which is a key variable in assessing levee underseepage. The presentation will focus on how geophysical methods were used to save time, reduce costs and decrease uncertainty in the subsurface characterization with regards to underseepage analysis. Additionally, the presentation will discuss interpretation methods, advantages, and disadvantages associated with the utilized geophysical methods compared to each other and to traditional investigation methods. Lastly, lessons learned for scoping investigations and selecting the right geophysical tools for the application will be discussed.

Design Built Semi-Rigid Rock Fall Fence on SR 11 in Perry County Pennsylvania

Brunet, Ghislain, Maccaferri, Inc, gbrunet@camvax.com; William K. Petersen, wpetersen@schnabel-eng.com; Lucas Maben, lmaben@jdeckmaninc.com; Giorgio Giacchetti, giorgio.giacchetti@maccaferri.com (Presented by Sage Evans) (TS#8)

A series of rock cut slopes along State Route 11 near Marysville, Pennsylvania has presented a chronic rockfall hazard, and the stabilization of these slopes became a high priority for the Pennsylvania Department of Transportation (PennDOT) Engineering District 8-0. The cuts expose steeply inclined clastic sedimentary rocks of Devonian and Silurian age, having variable resistance to weathering. The primary challenge to developing rockfall mitigation measures was the very limited lateral space between the high rock slope to the west of the road and railroad tracks to the east, which are situated along the western shore of the Susquehanna River at a lower elevation than the roadway. With slope heights of up to about 230 feet, very large impact loads (2000 kJ) had to be resisted without deflecting beyond the roadway edge. Standard tested flexible rockfall fence as per the European Norm ETAGE 027 could not be used because the elongation would have far exceeded the allowable value for the specified impact energies, which were developed by CRSP simulations performed by the District's preliminary design team. As such, the fences for this project had to be custom designed to perform as semi-rigid structures at impact. The design approach for modeling the behavior of the semi-rigid barrier was developed by Cantarelli and Al in "Modeling Rockfall Protection Fences." The design theory refers to the elastic deformation of the net under impact in relation with the area of contact surface for a tested barrier. To optimize the material cost versus the ease of installation, a limited number of impact energy level and fence height combinations were selected. The unique fence designs for each segment were performed interactively by the contractor's design engineer and fence material supplier, with the latter providing reactions to allow for design of the steel posts, wire rope anchors, and post base supports.

An Introduction to Emerging Contaminants: 1,4-Dioxane and Per and Polyfluorinated Alkyl Substances

Burke, Michael, Langan Engineering and Environmental Services, mburke@langan.com (TS#9)

Emerging contaminants (ECs), notably 1,4-dioxane and per- and polyfluorinated alkyl substances (PFAS), have been receiving increased attention from state and federal regulators and the media. This presentation will provide basic information on how ECs are defined, background on how they are identified by regulators as needing investigation, and insight on how they are different from currently regulated contaminants. The presentation will also discuss the prevalence of 1,4-dioxane and PFAS in the environment, including relevant aspects of evolving science such as toxicology, laboratory analysis, environmental fate and transport, sampling considerations, regulatory and legal challenges, noteworthy cases, and risk management principles.

As Urban Infrastructure Ages, We See an Increase in Landslides and Sinkholes – A Case History from Portland, OR, USA

Burns, Scott, Portland State University, burnss@pdx.edu (TS#8)

Infrastructure is aging all over the world. When they were built, many of the walls, bridges, roads, and pipelines were properly designed, and major climatic events were handled by them properly without failure. With time, infrastructure begins to fail and not properly transmit water. Lack of proper funds to upgrade the infrastructure is common around the world as governments and homeowners are strapped for funds.

Weep holes in walls get clogged, and pore water pressure builds up in back of them causing walls to fail and landslides to occur. Landslides are not covered by homeowner's insurance and as a result, these failures cause great losses for homeowners. In the streets, pipes (clean water, storm water and sewer pipes) break and water escapes from them, creating subsurface cavities that eventually collapse into sinkholes in the streets. In the future, we will see more of these in the urban environment as infrastructure ages and is not maintained. Examples from Portland, Oregon, USA will be used to show this trend.

A Major Role for Engineering Geologists Internationally – Help Produce Resiliency Plans for Major Hazards with an Example from Oregon

Burns, Scott, Portland State University, burnss@pdx.edu (TS#14)

Major geological hazards are found around the world and affect populations each year. Major hazards are earthquakes, floods, landslides, volcanic eruptions, tsunamis, and hurricanes (flooding). We, as engineering geologists and civil engineers, must work to reduce the effects of these hazards on the lives of humans and the infrastructure we live in. Each area of the world has its own set of hazards that dominate that environment. We must first study these hazards and understand their processes and the factors that affect them. Then, we must put together a resilience plan for the community working with emergency managers and local politicians. Such a plan defines the local hazards, the severity of the types of hazards, the vulnerability to those hazards, and then concludes with ways of how to reduce vulnerability and therefore loss of property and loss of life. I have been involved in preparing the resilience plan for my state of Oregon in the United States mainly for our biggest hazard, a subduction zone earthquake (also called a megathrust). These are the biggest earthquakes in the world with magnitudes over 9.0. We live on the Cascadia Subduction Zone. I will explain how we put together the study and then how we put it into action with the population of Oregon through talks and outreach and changes to laws.

Digging in the Water: An Overview of Mining in and Around Water

Campbell, Curt G., Westward, ccampbell@westwardenv.com (TS#24)

Westward's Engineering Services has been assisting clients with their permitting and regulatory compliance with regard to mining in and around water for many years. Strategies for permitting mining operations near water include coordination between a multitude of regulations and agencies including EPA, FEMA, State, and Local. This presentation will focus on discussing the various regulatory strategies and expectations related to multiple siting conditions adjacent to and within Waters of the U.S. and State.

Rock Erosion Initiation In Unlined Emergency Spillways

Cato, Kerry, California State University San Bernardino, kerry.cato@csusb.edu (TS#7)

Thirty-five years ago emergency spillway erosion was recognized as a problem in USACE and NRCS dams; since then, understanding the erosion process and development of erosion prediction methods have advanced. However, ongoing spillway erosion suggests gaps exist in the ability to predict which spillways are susceptible to erosion. Assessment of erosion initiation in unlined spillway channels can be facilitated through the use of qualitative recognition criteria that include: assessment of rock material quality, rock mass characteristics, and spillway channel geometry. Assessing regolith thickness and its variability establishes a depth where changes in erosion resistance may increase. However severe damage may continue along discontinuities with shears often being the most continuous features that should be investigated. Mapping the depth and extent of rock weathering along discontinuities across the site allows prediction of localized erosion. The spillway channel geometry may contribute to erosion initiation. While flow in spillway floors downstream of control weirs assumes sheet flow, the tendency for channel widths to narrow downstream, as the flow gradients steepen, increases the tendency to incise. The presence of knickpoints in the vertical gradient may initiate scour holes that produce headward migration of a knickpoint. Rock type changes that create a gradient change, the presence of a road embankment across the flow, or a road running parallel to the flow are features that have been shown to focus erosion initiation. All these macroscopic criteria can be used to focus more detailed studies such as a block detachment analyses.

Study of the Interaction of Water Tracks with Soil Piping to Prevent Subsidence in Alaskan Soils

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Soil piping is a major cause of soil subsidence. In Alaska, soil piping could be induced due to geology, slope, soil texture, hydraulic and thermal properties and frost. Another process that is evolving in the sub-Arctic is the subsurface slope interflow that channelizes into features known as "water tracks" when constrained by bottom boundaries such as permafrost, clay, and bedrock. The interaction of water tracks with soil pipes have caused significant subsidence in Martins' property near Fairbanks. These subsidence patterns have progressed steadily and rapidly to threaten the foundation of their house. Hence, the objective of our study was to assess and characterize the interplay between soil pipes and water tracks to assess the factors that are responsible for soil subsidence. We have collected soil temperature, moisture and intrinsic permeability data along and across a major water track and a few soil pipes in Martins' property. We have used thermal infrared images over a period of time to study the changes in thermal regime of the water track and the soil pipes. Additionally, we have collected water pressure data at selected times to study the advancement of soil pipes. We have collected soil samples from water track and soil pipes for texture analysis. We have mapped the geology of the area using well logs to assess the role of geology and slope. We have used high-resolution satellite imagery to segregate and map soil pipes in the site. We have conducted repetitive surveys to document changes in topography to assess the progress of subsidence. We will present our analysis and results on factors that influence the development and progression of soil piping and how interception of water tracks factors into soil subsidence.

Getting A Grip

Cowley, John, Mineral & Resource Planning Ltd, jcmarpa@aol.com (TS#24)

Uncertainty as to what exactly might be the impacts (or not) of climate change (anthropogenic or not), confuse our response to the issue. Will this mean more cloudy wet weather; milder winters; wetter summers; more intense rainfall; more fog; wider extremes around an average? But the future for highway safety may be different for a host of other reasons. Driverless vehicles may for example increase vehicle use because they enable those currently excluded from driving (for age and/or physical reasons [poor eyesight]) to start/continue driving. Indeed, as technological change always leads to more demand/-availability of goods or services, not less, the challenge for the future will be managing the interface of these trends. More vehicles on the

roads may mean more accidents, deaths and injuries, unless we reduce the potential for collisions. Ultimately, the extent to which vehicle stopping distances can be reduced is one of the main factors, which can reduce collisions. Whatever the technology within a vehicle or the abilities of drivers, improving the skid resistance of road surfaces is a simple, low-tech, passive, reliable action to reduce skidding impacts. In the UK, with our variable climate and frequent rainfall, high Polished Stone Value (PSV) road surfacing aggregates have been of considerable effectiveness in that context. To deal with this the values required in the UK are much higher than adopted in many other countries, but with postulated climatic variability elsewhere and increase in traffic demand for higher PSV aggregate may grow elsewhere as a simple response to reduce collisions. However, resources of such material are relatively restricted. This paper will consider the above issues, the available resources and a potential new supply.

Electromagnetic (EM) Ground Conductivity Mapping: Using Secondary Geophysical Methods and Invasive Testing to Ground-Truth EM Result

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The use of electromagnetic (EM) geophysical methods to evaluate ground conductivity variations is an effective tool to resolve environmental issues. However, the EM profiling instruments commonly used for such applications provide depth-averaged conductivity values at point locations. Additionally, a variety of factors can contribute to conductivity variance, including soil type, moisture content, and the thickness of stratigraphic units. For many projects, it may be necessary to resolve the depth or thickness of such soil units, and to verify the dominant factor that is causing the observed conductivity changes. This presentation examines two case studies where an EM31 MK-1 ground conductivity meter was used to evaluate conductivity changes across project sites. The first site was known to contain isolated zones of shallow clayey soils and organic deposits. An EM survey was conducted to identify the locations of these deposits based on conductivity variance. Subsequent to the EM survey, electrical resistivity tomography (ERT) was performed across specific locations to further constrain the zones of high conductivity identified by the EM, and to examine the depths of the high conductivity soils. Additionally, shallow hand auger borings were performed to provide physical samples to correlate to the geophysical data. The second project site was thought to contain a significant volume of buried coal fly ash. The EM survey was performed to delineate the extent of the buried ash deposit. A clear zone of high conductivity was observed in the EM results. Shallow soil borings were performed to ground-truth the EM data, allowing for a well-constrained ash/soil boundary to be established. The benefit of the geophysics was that soil data were only needed across one transition location. The sampling information was used to extrapolate the correct boundary around the entire site based on the geophysics.

Lake Needwood Dam Incident – A Geological Twist!

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The Lake Needwood Dam was designed by the U.S. Department of Agriculture, Soil Conservation Service (now Natural Resources Conservation Service) and constructed in 1964–65. The dam is a 65-feet-high earthen embankment flood control structure that captures flood waters of a 12.8 square mile watershed within the upper Rock Creek in Montgomery County, Maryland. On June 26, 2006, heavy rains in the upper Rock Creek watershed led to a 23-feet rise of the water level in Lake Needwood. Soon after the rise in the pool elevation, uncontrolled seepage started at the junction of the downstream slope and the left abutment, as well as a rise in the water levels in the piezometers on the downstream slope. Soil particles were observed in the seepage flow. These unusual events led to the evacuation of the downstream residents for couple of days. The current owner of the dam, Maryland-National Capital Park and Planning Commission, hired a private engineering company (URS, now AECOM), to conduct a geological and geotechnical investigation to evaluate the cause of the seepage at the dam. The geologic evaluation of the rocks around the lake and dam revealed abundance of schistose and gneissic rocks that were heavily foliated and showed rock cleavage. The foliations in the metamorphic rocks formed the joint sets that would have provided the preferred seepage paths through the bedrock. Review of historic boring logs indicates that the bedrock below the dam also had open joints and fractures. Packer test results indicated that the bedrock exhibits hydraulic conductivity values that ranged from 18 to 322 lugeons, which is indicative of relatively open flow paths in the bedrock. Different alternatives for remediation of the dam were considered by all stakeholders. Curtain grouting of the bedrock together with a new downstream drainage/filter blanket on the downstream slope of the dam was selected as the preferred means of remediating the dam.

Be an Advocate for Landslide Hazard Reduction within Your Organization

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Landslide hazard reduction is only achieved when scientific information is successfully translated into positive actions influencing landscape-altering human activities. Engineering geologists are responsible for producing the scientific information, i.e., landslide hazard, susceptibility and/or risk maps. Less obvious is their responsibility to play an active role in integrating that information into policy, regulations, and operating processes so actual risk reduction is achieved. Often, geologists will be a minority among the professionals involved with the primary function of an organization or entity whose activities may trigger landslides or suffer losses due to them. Therefore, successful advocacy for landslide hazard reduction requires the geologist to find ways for this information to support the organization's primary functions. My experience as a U.S. Forest Service geologist, on national forests where timber management was a significant function, illustrate how this advocacy can work. Clearly, timber management requires maintaining soil productivity and transportation access to timbered slopes. Landslides adversely affect both requirements. Landslide information was used to achieve effective, sustainable timber management activities through designation of suitable lands, identification of feasible timber sale areas, and employment of appropriate design prescriptions. As an advocate, the geologist develops the landslide hazard information and participates in translating it into all actions needed for landslide hazard reduction. The geologist also is responsible for keeping this integration current with technological advances and our understanding and representation of landslide hazard. Because human activities change in response to societal, political, and economic factors, advocacy for landslide hazard reduction is an ongoing process.

A Whirlwind Tour: The Value of Helicopters in Landslide Assessments, with Project Examples from Across North America

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Landslides often occur in steep, rugged, difficult to access terrain. This difficult access is compounded for system-wide assessments that involve multiple landslides located along linear projects; i.e., pipelines and proposed road alignments that cross large swaths of remote and rugged terrain. A comprehensive landslide assessment relies on a variety of information sources including existing geologic maps and databases, and remote sensing information (historic aerial imagery and Lidar). However, these data sources are often not current and may not be available for the entire project area. The use of helicopters as a supplement to a landslide assessment program is beneficial in two ways, 1) helicopters allow for real-time, geomorphic reconnaissance of the project alignment, and 2) helicopters provide physical access to sites that would otherwise be difficult to access from the ground. Real-time helicopter-supported aerial reconnaissance along project alignments allows scientists to geomorphically identify and characterize landslides. In some cases getting a good aerial view of landslides that were identified during a desktop review may eliminate the need for a ground-based assessment. Helicopters have a reputation for being expensive and potentially dangerous. However, in many cases a ground-based landslide mapping program that is helicopter-supported can be a safer alternative because it eliminates the need for field teams to hike through potentially hazardous terrain in order to reach landslides. Likewise, a helicopter-supported field program can also be a less expensive alternative because it reduces the overall labor costs associated with long drives and long hikes into remote study sites. This presentation will cover the basic logistical, safety and technical considerations regarding the use of helicopters on a project, and will provide examples of how helicopter use has successfully supported landslide assessments for multiple project sites in North America.

Slope Stability Analysis Using Discontinuity Data Collected Via an Unmanned Aerial Vehicle (UAV)

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Current methods of discontinuity data collection for slope stability analysis include Brunton compass and ground-based LiDAR. This study compares discontinuity data acquisition via an unmanned aerial vehicle (UAV) to these established methods in order to determine if UAV technology can be used reliably to collect structural data. Unmanned aerial vehicles have the benefit of eliminating "shadow zones" (a prevalent weakness of LiDAR) and easily accessing portions of an outcrop that may be otherwise physically impossible to access. Two field sites in Virginia were scanned for this study, a shale pit in Cove Mountain and a cut slope in Deerfield along highway 629. Approximately 300 Brunton compass measurements of orthogonal joint sets and other discontinuities were taken at each site in order to provide a "control group" for orientation data. In addition, ground-based lidarscans and UAV photogrammetric data were collected at each location. Scans from the lidarunit and the UAV were converted into point clouds for use in stability analysis using such programs as Cyclone and Pix4DMapper Pro. These point clouds were then imported into Split FX for analysis of discontinuity patches and to export data to DIPS for determining principal joint sets and kinematic analysis. Samples of rock were taken at each site for use in laboratory testing of important engineering characteristics including slake durability index, friction angle, and unconfined compressive strength. Preliminary results indicate that discontinuity data collection by UAV method closely matches the data collected using lidaror Brunton compass.

Using Low-Altitude Drone Photogrammetry to Identify and Quantify Subtle Quaternary Surface Faulting in the Northern Wind River Basin, Wyoming

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The Stagner Creek Fault, near the southern margin of the Owl Creek Mountains is one of a several of WNW-ESE striking faults in central Wyoming that demonstrate Quaternary activity. Owing to low slip rates, surface expressions, such as fault scarps, can have subtle landscape expressions. This study constructs a high-resolution surface model using low-altitude photogrammetry for the Birdseye Creek section of the Stagner Creek fault, near Boysen Reservoir. Alluvial surfaces spanning the late Pleistocene and Holocene potentially contain fault scarps. More than 1700 aerial photographs were collected using small unmanned aerial vehicles (sUAVs) along a ~2 km swath along the fault. High-precision (centimetric) ground control was provided by ground targets located using real-time kinematic (RTK) GPS. The resulting point cloud has a density of ~400 points per square meter. False sun-shading of a 10 cm digital elevation model allows reliable mapping of the fault scarp despite its low relief of 30 cm. A notable result is identification of fault scarp within the Holocene surface—a previously undocumented result that changes the estimate of timing for the last surface-rupturing event. The point cloud is also useful for analysis of fault scarp profiles, including modeling of age, throw, and degradation. The minimum fault scarp height of 30 cm is interpreted to correspond with the last, single event of magnitude 6.4–6.7. Greater relief is observed across fault scarps in older surfaces suggesting a slow, average uplift rate of 0.03–0.04 mm/yr. This study also applies shallow seismic reflection profiling that suggests the controlling fault is a north-dipping reverse fault—possibly a reactivated Laramide-age structure. The study demonstrates that applying new techniques to previously documented, intraplate faults can provide useful insight that improves the understanding of the earthquake hazard.

Breckenridge Second Water Plant – Geologic and Environmental Hazards in the Colorado Mountains

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In 1859, gold was discovered along the Blue River in Colorado. A mining camp was setup and the Town of Breckenridge (Town) was in its initial beginnings. During the Pike's Peak Gold Rush days, one of the many forms of mining performed in the Breckenridge area included dredge mining. More than 150 years later, as the Town expands its resources to support the growing population, the dredge tailings have affected the foundation stability of new construction. The Town is planning to construct a new water treatment plant (WTP), an intake structure and raw water pump station (RWPS) that diverts and transports water from the Blue River, a raw water pipeline from the RWPS to the WTP, and a treated water pipeline to transport water from the WTP to an existing storage tank. This project provides supply demand as well as an alternative to the aging existing water treatment facility. Multiple hazards and challenges were identified during the geotechnical exploration: Dredge tailings underlying the WTP site are saturated, loose granular soils with depths up to 50 feet before bedrock is encountered; while seismicity is not generally an issue in Colorado, the valley has the potential for a seismic event that may cause liquefaction of the dredge tailings; to combat loose soils at the WTP site, foundation

improvements using vibro-compaction and vibro-replacement columns have been recommended; the dredge tailings are considered an environmental concern by the Colorado Department of Public Health & Environment; existing buildings at the WTP site require asbestos abatement prior to demolition of the buildings; granular soils and high groundwater will be challenges during construction; and, additional concerns include a potential debris flow cute near the RWPS, corrosive soils, considerable frost depth, and multiple agency interaction.

Aren't Mountains Challenging Enough?

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Planning for a major transportation tunnel from the Central Valley into Los Angeles necessitated evaluating multiple routes, including a possible tunnel through a mountain range, under a National Forrest. The challenges were numerous, including working at heritage sites within the rules and regulations of the USFS, difficult 4x4 roads, helicopter access locations, inclined borings through a fault zone, and depths to over 3,000 feet. Geophysical methods included caliper, fluid temperature and conductivity, induction, natural gamma, optical and acoustic televiewer, and downhole seismic velocity logging. The authors will present the challenges, the methodologies and the results in two contiguous talks; one focusing on the geophysics, and the other on the geologic interpretation and project application.

Using the Media to Advocate for the Geosciences

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Advocating for the geosciences can happen at many levels, from personal interactions to legislative lobbying to public speaking. Most geologists are comfortable discussing their work with individuals and even small groups, but are often unsure of how to implement both proactive and reactive communication with the media. Whether it is quickly responding to requests for background on a natural disaster or toxic spill, or sharing expert knowledge of long-term issues such as climate change or development in areas of geohazards, geoscientists can efficiently and effectively communicate important information to the public through the media. The print and broadcast media will allow geoscientists to reach a broader segment of the public and make the public aware of the importance of the geosciences in their everyday life. Cultivating relationships with local news outlets as well as presenting feature story ideas to national media can help to bring the geosciences into the public eye. This paper will present resources for effective communication with both print and broadcast media, including tips on writing press releases and op-eds, communicating ideas for feature stories or responding to breaking news, and giving interviews to both print and broadcast media.

Evaluation of a Known Sinkhole Area Using Geophysical and Conventional Subsurface Exploration Methods

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The Cordillera Valley Club is a gated community in Eagle County located on Beard Creek Trail on the north side of Interstate-70 just east of Wilmore Lake. A recreation facility and park are proposed to be built on the west end of the Cordillera Valley Club development on a known sinkhole area that has been backfilled and graded. The proposed park and recreation facilities include an all-weather soccer field, a gazebo, restrooms, and playground equipment, as well as automobile parking. The sinkhole area is in the Eagle Valley Formation and underlain by the Eagle Valley Evaporite. The Eagle Valley Formation is folded and steeply dipping to the west at this location on the eastern limb of the Ute Creek Syncline. The Eagle Valley Evaporite is an evaporite consisting of gypsum, anhydrite, halite, and gypsiferous silts, shales, and sandstones that is prone to dissolution. Dissolution of the Evaporite can lead to subsurface voids and sinkholes. Sinkholes are more common in the Eagle Valley Evaporite but can also occur in the more clastic Eagle Valley Formation. A Multi-Channel Analysis of Surface Waves (MASW) survey was conducted to acquire seven two-dimensional shear wave velocity profiles in order to evaluate possible infilled voids, as well as bedrock depth and conditions. Two deep exploratory borings into the evaporite bedrock were drilled to assess subsurface conditions and provide correlation for the geophysical survey. Six exploratory pits were excavated to evaluate the depth and quality of the existing fill in the sinkhole area. The combination of geophysical surveying and pit excavations/borings provided valuable information that was essential to the evaluation of the sinkhole hazard for planning and to forming preliminary recommendations for the design of the park and recreation facilities.

Ground Motion Modification by Topographic Irregularities: a Case Study in Al Jabal Al Akhdar, Sultanate of Oman

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The recent growth of infrastructure in Al Jabal Al Akhdar region, which is characterized by high and irregular topography, requires seismic hazard assessment taking into account the local site effects. A specific site located at the hilltop (1883 m above sea level) is selected to construct a three-story building. The PSHA is provided in terms of the unified hazard curve at the bedrock conditions for 475, 975 and 2,475-year return periods. To evaluate the site effects, microtremors measurements were carried out utilizing a single station at four sites (one on-site at the top of the hill and three distributed in the surrounding valley) for four days continuous recordings, simultaneously. In addition, 2D MASW and shallow seismic refraction tomography profiles were performed on-site, at the hill top. The results of MASW and refraction tomography reflect high P-wave and S-wave velocities were VS30 = 1300 m/sec near the surface. This confirms the rocky nature of the site, with B class according to NEHRP standard. Despite the flat HVSR curves at the four microtremor sites, the topographic effect at the hill top is calculated with respect to the surrounding foothill sites using a spectral ratio technique (from the microtremor records and two earthquakes recorded during recording times). The ground motion at the hilltop was found to show an amplification factor of 2.2 at corresponding frequency of 1.3 Hz. The modified hazard results at the hilltop is used to calculate the short period and 1.0 Sec elastic design spectral accelerations SSD and S1D facilitating the construction of the design response spectrum. The SSD and S1D are found to be 331 and 75 cm/sec2, respectively.

Automated Unsupervised Change Detection Technique from RGB Color Images

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Change detection is an important process for many applications as monitoring the effects of environmental hazards, landslides, rockfall and city development projects. RGB images are commonly used as commercial sources of data for monitoring changes visually because they have powerful descriptive information for different features. Automation of detected changes from two RGB images is a challenge because the two images are usually captured in different environments, as temperature, sun angle, clouds, capturing time, etc. The objective of this research is to introduce an automated technique for detecting changes from RGB image based on color channels. The image pixel is represented as a set of its color channels' values, R, G and B, which is called color signature of image pixel. A real data is used to fulfill the research objective without pre-knowledge about the changes. The correlation coefficients are calculated between color signatures of each two associated pixels from two different registered high-resolution satellite images for the same area of study. The detected pixels of changes are identified based on specific correlation value that is identified based on degree of change sensitivity. The degree of sensitivity is based on the importance of detection procedure that is considered as a main part of decision making for risk and crisis management system. The results of the proposed technique are assessed versus change detection outputs using one of commercial techniques through ERDAS IMAGINE software. The proposed technique is unsupervised and fully automated. It can be applied through a real time process based on the processing capabilities and size and resolution of input images. This technique is easy to use and gives accurate results with neglecting the effects of atmospheric effects.

Ground Based Radar Interferometry Measurements of the Slumgullion Earth Flow (San Juan Mountains, Colorado)

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The Slumgullion earthflow is a ~4 km mass movement in the San Juan Mountains of Colorado, moving at up to ~2 cm per day, and is often regarded as a "natural laboratory" for mass wasting. This study aims to document spatial and temporal variations in movement of the Slumgullion earthflow over a short time scale (time periods of hours to days) using ground-based interferometric radar (GBIR). Prior studies of the Slumgullion flow have documented temporal variations in the flow velocity, including possible correlation with tidal periods. GBIR has significant potential utility for landslide studies owing to spatial completeness and sensitivity to small (sub mm) displacements. Prior applications of GBIR to the Slumgullion earth flow have been limited by radar range and/or limited line of site. This study uses a Gamma Remote Sensing GPRI2 system (a Ku-band GBIR) with demonstrated range greater than 12 km. In our survey, radar images are acquired with 10 minute sampling intervals throughout a ~72 hour period of observation. Data processing utilizes a multi-interferogram (zero-baseline) approach involving more than 2400 interferometric combinations that span up to 4 hours. Interferograms are corrected for atmospheric refractivity using meteorological data. Redundant interferograms permit calculating a displacement time series for points throughout the earth flow with standard errors better than 0.5 mm. Movement varies with periods of hours or more, and the mass appears to move in pulses of accelerated flow. We also assess possible correlation with other periodic phenomena such as atmospheric tides. GBIR measurements are compared with high precision GPS "ground truth" collected during the study, as well as Sentinel-1 satellite InSAR results spanning the field survey. GBIR captures behavior of the Slumgullion earth flow that may help improve the understanding of basic earth flow mechanisms and the links to other forcings.

Canyon Creek Intake Structure and Fishway

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The 1903 Dungeness Fish Hatchery near Sequim, Washington obtains its preferred water supply from a tributary of the Dungeness River, Canyon Creek. However, the water intake structure and diversion dam, located in a water gap the creek had cut through a ridge of Crescent Basalt, was in poor condition and created a barrier that prevented access to the creek by fish for spawning or rearing. The existing diversion structure required remediation, as it leaked in many areas, and some of the concrete apron areas had been eroded. In 2012, the State of Washington decided to replace the intake structure, rehabilitate the dam and construct a fishway to allow fish access to the upper portion of Canyon Creek. Harbor Engineers was selected to design the new intake, with PanGEO as part of the team. Design challenges included designing a vertical slot fish ladder and intake structure that provided water but protected fish. Construction issues included excavation of the hard Crescent Basalt rock while protecting the county road bridge above and diverting the creek waters during construction. Design was complete in 2015 and construction began in June. Sequencing the rock excavation using hydraulic breakers proved difficult and time consuming, but the new facilities were completed and in service by late 2015.

Don't Learn Safety by Accident

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Intentional Safety Engagement. Sure we all want to create a safe work environment. But how safe do we want to be? Any conversation about risk versus reward can be confusing if neither risk nor reward can be quantified. This presentation will help us consider the "Safety ROI." We will follow the journey of a national geotechnical firm as they resolved to create a safety culture, the journey that ensued. Participants will gain a stronger understanding of key parameters used to judge safety in the workplace. They will understand means to help build a culture of safety in their office, and they may just be able to keep at least one employee from getting injured by gaining this renewed safety awareness. That employee wants you to attend and participate vibrantly!

Land Subsidence and the California High-Speed Rail Project

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The over-drafting of groundwater in many deep alluvial basin aquifers in the Western U.S is causing land subsidence, especially in the San Joaquin Valley of Central California where recent rates of land subsidence in excess of 1 foot per year have been observed. Land subsidence can impact infrastructure and alter existing floodplain designations by changing the ground elevation and slope (gradient), and through the development of ground cracks known as earth fissures that can erode into large gullies. Due to the alteration of topography, surface water flow patterns and ground cracking, subsidence has the potential to pose a hazard to linear infrastructure such as the California high-speed rail project. This presentation will discuss preliminary investigations into the potential impact of land subsidence

on the high-speed rail project. In general, it is believed that vertical curvatures induced by land subsidence can be managed by monitoring and maintenance. The potential for horizontal curvatures or the development of earth fissures or compaction faults to impact the high-speed rail project appears to be small. Potential changes to flooding patterns in the vicinity of the historic Tulare Lake could be significant, but it is anticipated that this hazard could be addressed by coordinated flood control measures. Included in the presentation is a reinterpretation of geologic conditions near the Pixley Earth Fissure, first observed in the late 1960s several miles east of the planned high-speed rail alignment. Additional discussions will include land subsidence and geological conditions in the Corcoran area, including potential implications to the Tulare Lake bed, and discussion of the Pond-Poso Fault to the south.

Earth Fissures and Infrastructure: A Case History at the Siphon Draw Detention Basin, Apache Junction, Arizona

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Land subsidence can severely impact infrastructure and alter existing floodplain designations by changing the ground elevation, ground slope (grade), and sometimes through the development of ground cracks known as earth fissures that can erode into large gullies. Due to the alteration of surface water flow, ground elevation, and ground cracking that can undermine foundations, subsidence poses a particularly high risk to water conveyance, flood control, and other linear infrastructure. The Siphon Draw Detention Basin (SDDB) in Apache Junction, Arizona provides a unique opportunity to observe the impact of an actively propagating earth fissure. Earth fissures were first identified in the area in the 1990s. In the mid-2000s, plans were developed to construct a basin to provide flood control along Siphon Draw. A series of land subsidence and earth fissure investigations were performed as part of the design process for the SDDB. During investigations, the Southeastern Earth Fissure (SEF) extended over 200 feet overnight following a rain event. Later during the investigation a trench located at the termination of the fissure extension was flooded by another rain event. The SEF extension terminated just upstream of the boundary of the basin. It was determined that the consequence of failure of the basin due to the earth fissure was low enough that avoidance was not necessary. However, it was decided to implement some mitigation. Mitigation strategies included constructing two slurry, cutoff walls along the fissure extension, placing an embankment over the fissure extension, and placing geotextile liner in part of the basin. SDDB construction was completed in 2010. An annual monitoring program has been implemented that includes evaluation of satellite-based interferometric synthetic-aperture radar (InSAR), real-time kinematic GPS survey, high-resolution aerial imagery, and annual ground inspection.

Cumulative Slope Stability Effects of Daily Reservoir Oscillations, Southern Peruvian Andes

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We found that persistent landsliding next to an Andean mine reservoir stemmed from small daily oscillations in reservoir level resulting from daily thunderstorms, each leading to small rapid-drawdown failures. Cumulatively, these failures fashion a globally unstable slope that episodically sheds larger landslides, resetting the slope face "clock." Our drilling and mapping first focused on possible reactivation of regional-scale landslides involving the Miocene-age (Huaylillas) fragmental and flow volcanics. Back-analysis found that these large-scale landslides formed under a significantly wetter climate. We were also able to eliminate simple wetting of the toe-of-slope, and structural control by bedding and fractures as important factors in modern slope failures. Patchy hydrothermal alteration has significantly weakened parts of the slope. Under the modern arid natural conditions the strength reduction is not particularly notable. However, laboratory testing showed that the argillized rhyolite failed readily after longer exposure to wetting, being especially vulnerable to recurrent undrained conditions (rapid-drawdown cycles). The natural slopes have been metastable for thousands of years, with the arid climate generating only ephemeral runoff, and no standing water. With reservoir construction, however, came new conditions attacking these rocks: standing water, and daily water level oscillations. The daily thunderstorms of the rainy season subject reservoir shores to hundreds of small rapid-drawdown cycles each year and resultant mass wasting. We suspect that this phenomenon is widespread next to Andean reservoirs, significantly increasing the sediment influx into reservoirs. The cumulative volume of sediment from repeated small (and resultant episodic larger) failures potentially threatens intake structures, and shortens the useable life of reservoirs.

Geologic Control of Spillway Erosion Features, Sierra Nevada Foothills, California

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Mitigation of potential spillway erosion has become the new watchword for California dams following the erosional damage at the Oroville Dam spillways in February 2017. In anticipation of runoff from a historic snow pack, regulators urged dam owners to immediately evaluate, and mitigate as necessary, spillways potentially susceptible to erosion. New Exchequer Dam (NED) is located in the Sierra Nevada Foothills, on the Merced River. Like Oroville, the dam and gated spillway were built in the 1960s. The spillway structure consists of an ogee weir with radial gates, and a relatively short concrete-lined apron. During its 50-year history, the NED spillway has experienced flow only once, with attendant erosion, after which limited armoring was emplaced. NED offered a unique opportunity to evaluate geologic aspects of erodibility because of: spillway location outside of a natural channel; single episode of flow of known discharge and duration; simple initial geometry of the apron and channel; and a channel axis that crosses rock type belts and structural grain at a high angle. We found that while rock type alone does correlate with erodibility, erosion is most strongly associated with narrow brittle shear zones cutting the native volcaniclastic schist, slate, and agglomerate rocks. MID and its consultant team evaluated the hydrologic regime of the spillway, and developed a mitigation approach consisting of concrete armoring encompassing open-stacked riprap (D50 on the order of 3 feet), with about 25 to 33% of the exposed riprap boulders extending above the concrete surface to provide surface roughness. The bedrock surface was prepared by aggressive excavation of weaker rock and unconsolidated colluvium, followed by high-pressure water jet and vacuum cleaning, and hand detailing using shop vacuums and hand harvesting of individual clasts. With an accelerated regulatory review and construction schedule, mitigation was completed prior to runoff reaching the spillway gates.

Water Management and Planning at Mine Sites

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The continuously increasing pressure on natural resources requires that all critical components of the extractive process be carefully evaluated. Understanding and management of the cycle of water at a mine site has always been critical from an operational perspective; however, increasing pressure on water quality and quantity have elevated the importance of sustainability and public perception for both permitting

and operational purposes. The interaction of groundwater, surface water, recycled water and waste water coupled with the concept of water rights, water use and consumptive use can have a significant impact on local, state and federal permitting. The perception and understanding of real risk to stakeholders is critical to the successful permitting and operation of a mine site. This paper will illustrate the interaction of a variety of concerns and the planning and management of a water conservation and management plan for a construction materials site.

Sacramento Region Flood Fight 2017 – Through the Eyes of a Geologist

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California received record precipitation during the winter of 2016/2017. Distress at Oroville Dam was the kickoff to flood fight and provided constant uncertainty regarding how much water would be in the system and how the levees would respond to rapidly changing water levels. Uncertainty in river levels drove the local levee owners and maintainers to take action (fill in ditches, construction seepage berms, etc.) on their own in some cases. Significant distress was seen on area levees, with one breach occurring. In general, the U.S. Army Corps of Engineers Sacramento District supports the State of California through technical and direct assistance missions only at their request, as we do not own or operate any levees in the region. Sacramento District provided technical support to the State of California 13 February 2017 through May 2017, with more than 75 site visits performed to provide technical advice and recommendations. Sacramento District provided direct assistance at four sites through construction of three seepage berms and one erosion fix, to include in-house design and construction through a contractor. We utilized a new contracting vehicle for these efforts under emergency authorities. Since Sacramento District personnel had not flood fought in approximately 20 years, there were many lessons learned and experience gained.

An Introduction to Contaminants of Emerging Concern

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For the past 15 years, growing news and scientific reports about contaminants of emerging concern (CECs), have reflected the substantial interest from the public and the scientific community. These CECs, which include pharmaceuticals, personal-care products, surfactants, perfluorinated compounds, pesticides, and many other chemical classes, are a heterogeneous array of chemicals that have diverse anthropogenic sources, are present at sub-ppb environmental concentrations, and can exhibit chronic effects upon aquatic and terrestrial biota. The first part of this presentation provides an overview of the current understanding of the range of CECs present in water resources, their typical mixture compositions and concentrations, and potential chronic toxicological effects on biota that have been documented under field and laboratory conditions.

Landfill Leachate and Urban Stormwater as Environmental Source Inputs

Furlong, Edward T., U.S. Geological Survey/National Water Quality Laboratory, efurlong@usgs.gov; Jason R. Masoner, jmasoner@usgs.gov; William R. Selbig, wrselbig@usgs.gov; Aniela Burant, aniela.burant@gmail.com; Dana W. Kolpin, dwkolpin@usgs.gov (TS#9)

In the second half of this presentation, the compositions and concentrations of CEC mixtures in final landfill leachate and storm water runoff are assessed in national- and local-scale studies. Landfill leachate CEC compositions were complex; 101 different CECs were detected in leachate samples, including 43 prescription pharmaceuticals, 22 industrial chemicals, 15 household chemicals, 12 nonprescription pharmaceuticals, 5 steroid hormones, and 4 animal/plant sterols. The most frequently detected CECs were lidocaine (91%), cotinine (86%), carisoprodol (82%), bisphenol A (77%), carbamazepine (77%), and N,N-diethyltoluamide (DEET; 68%). Concentrations of CECs spanned 7 orders of magnitude, ranging from 2.0 ng/L (estrone) to 17,200,000 ng/L (bisphenol A). As part of a national network, urban stormwater samples were collected from a residential and a commercial site, with differing population densities and fractions of impervious surface in Madison, Wisconsin. Initial observations demonstrate temporal heterogeneity of stormwater CEC composition, particularly for corn/soybean herbicides that may be atmospherically derived. Class-specific differences in contaminant concentrations between residential and commercial sites also were observed. These and other observations demonstrate the potential for substantial, compositionally heterogeneous inputs from both landfill leachate and stormwater to water resources.

Methods for Improving Collapsible Soils

Gallet, Phillip, Hayward Baker Inc, pagallet@haywardbaker.com (TS#12)

Shallow Collapsible Soil deposits can be difficult and expensive to mitigate for construction. This presentation will present multiple successful case histories where Hayward Baker has successfully used water injection in combination with aggregate piers to create a suitable subgrade for construction. This combination has proven to be a cost effective alternative to remove and replace methods.

Development of an Accurate Method to Map Water Tracks Using Remote Sensing and Soil Hydraulic and Geophysical Properties

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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 due to the thawing of permafrost. Despite their abundance, there is a lack of understanding of the interplay between water tracks and its bio-geophysical 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) have observed water tracks intercepting 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. Geophysical data along the Goldstream Road have been procured in 2011 and 2016 by state agencies. However, no method is existent in mapping such narrow water tracks in densely vegetated areas. Our goal was to develop a method to map existing water tracks on Goldstream Road using temperature, hydraulic and geophysical data collected from a

study site. Additionally, we used a DEM from a high resolution aerial photograph and correlated that with geophysical and hydraulic data procured from our study site. We utilized high-resolution satellite imagery to identify water tracks that influenced moisture availability to plants along and beside the water track. We also procured infrared images to identify thermal differences influenced by availability of moisture in the soil along and across the water track. We surveyed the site, over a period of time, using a MapTec Lidar equipment to study the changes in topography. We will present our analysis and results on the developed method to accurately map water tracks so that future damage to intercepting infrastructures is prevented.

AEG's Learning from Disasters Program: A Proposal to Advance Engineering Geologic Relevancy and Advocate for Geology

Gath, Eldon, Earth Consultants International, gath@earthconsultants.com (TS#6)

Disasters occur every hour of every day, somewhere in the US, and around the world. Geology is often the cause, although frequently bad or no engineering has helped in the disaster's facilitation. In every disaster there is a lesson that can be learned. This is a proposal to AEG/IAEG to help our members stop the insanity of repeating the errors of the past by forming a Learning from Disasters committee/commission to respond to natural disaster events, document them, and communicate this knowledge to our membership in a timely and succinct manner. As the U.S. National Group for IAEG, the AEG has thousands of members scattered across the United States, plus over 200 International Members around the world. IAEG has thousands of additional members across the entire globe. This membership is the principal resource that this program will tap, putting ourselves at the forefront of advancing the state of knowledge through rapid response, rapid assessment, and rapid communication. Purpose: To collect time-sensitive data from disasters, to compile what went wrong and what went right, and to communicate these findings to the professional engineering geology community, locally and internationally. It is not the intent to make these reports full technical reports (although some may eventually morph into that), but rather brief summaries and photos of a disaster event, focusing on the geologic aspects that contributed to the event. The summaries will be posted to the AEG/IAEG Learning from Disasters website blog, where other members can access them, learn from them, and comment upon them. This is intended to be an active discussion site, hopefully one that will be almost daily visited by our members, and potentially by the news media as well [ex. the USGS earthquake page]. There they will see the relevancy of geology, and our response, in real world events.

Rockfall Monitoring and Prediction: A Bayesian Approach to Forecasting Time to Failure

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Rockfall and rockslides pose a significant hazard for civil and mining projects (highways, railways, reservoirs, pit slopes, etc.) due to the potential for personal injury and high capital costs associated with remediation and infrastructure closures. Existing rockfall hazard rating systems serve to identify key slopes most prone to rockfall but do not provide any information regarding specific rocks that may fall or the timing of rockfall events. High-resolution remote sensing technologies (such as LiDAR, photogrammetry, and GB-InSAR), however, have permitted detailed identification and monitoring of problematic blocks/slides and their associated displacements leading up to failure. Such information has facilitated an ability to forecast the time to failure of specific rocks through repeated measurements at localized sites. Probabilistic forecasts for block time to failure are estimated using the inverse velocity method along with Bayesian regression to assess parameter uncertainty arising from the inherent variability of the rockfall / rock slide process and due to measurement noise. As new observations of block displacement are gathered, model parameters and forecast predictions are updated to reflect the current state of knowledge in the system. Additionally, triggering effects (such as rainfall events or freeze-thaw cycles) can be incorporated into the Bayesian approach to provide updated time to failure predictions given their respective forecasts. Time to failure estimates provided with a certain degree of statistical confidence allow decision makers to plan appropriate actions should failure be imminent (e.g., shutting down a section of a transportation corridor precursory to a rockfall event). This work is being conducted within a broader rockfall framework to incorporate remote sensing technology for effective and efficient characterization and prioritization of numerous sites on a network scale spanning several hundreds of miles.

Reaching Out! Advocate by Educating the General Public

German, Madeline, Smith Gardner, Inc., madeline@smithgardnerinc.com (TS#6)

The skill set for many excellent geologists is not the same skill set used to advocate and bring awareness to the geosciences. Most scientists love data and research and working on their projects not grandstanding and vying for political attention. However, years of inactivity have unfortunately made geoscience an easy target. Advocacy is supporting our profession by sharing information. This presentation will discuss methods to reach out to the general public. The objective is to provide AEG Members with tips and ideas to implement personally and in their local chapters. These resources are available to provide any AEG member, retired, working, or student with options, activities and avenues to speak with people and help them understand the importance of the geosciences.

Managing Your Portfolio: Tips for Surviving Environmental Site Assessments

German, Madeline, Smith Gardner, Inc., madeline@smithgardnerinc.com (TS#5)

Environmental Site Assessments are a staple in the Environmental realm. They are performed by every company from the one-man shop to the massive global corporation. We have all read very good and very poor quality reports, however, we probably learn more about what to include when writing these reports from reading the bad ones. In this talk I will use two recent: "portfolios" of Phase 1 and Phase II Environmental Site Assessments to demonstrate tips to improve the overall quality of your Phase I and II ESAs. The first portfolio included 12 sites in 3 states, and the second included 5 sites in 4 states. Using these projects as examples I will provide key points to help you more effectively manage these monster projects, keep yourself organized, maximize staff utilization and not get the sites confused. These tools will be provided for the field reconnaissance, research and writing.

Transforming USGS Science to Support Landslide Loss Reduction

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Improved scientific understanding of landslide processes and the geologic, hydrologic, and anthropogenic factors controlling their initiation and motion is insufficient to reduce losses. Landslide risk reduction requires changes in perception, policy, and behavior to encourage avoidance or mitigation of landslide hazards. Fundamentally, those

changes are predicated on the values of individuals, communities, and policymakers related to risk tolerance, private property rights, public safety, and economic security. The role of the U.S. Geological Survey (USGS) is to provide defensible and actionable science to inform choices and decisions made by individuals, communities, and organizations at all levels. Effective delivery and usability of landslide science are rooted in understanding community and individual vulnerability to landslide hazards, as well as information needs to address these vulnerabilities. Societal vulnerability is characterized not only by the physical interaction of people and the built environment and landslides, but also by a complex mix of social, economic, and demographic factors that set the stage for these vulnerabilities. The USGS has contributed significantly to the development and application of risk and vulnerability studies; however, work on landslide issues lags efforts for other hazards, such as earthquakes and tsunamis. The USGS has developed a new plan to increase the development and use of scientific research, tools for hazard assessment and early warning, and accessible products to support risk-management decision-making. Using recent landslide events, we discuss how existing landslide science can be used to advance disaster risk reduction and highlight the partnerships needed to reduce landslide losses.

Tunnel Design -Categorizing Glacial Soil Types by Depositional Environment for a Better Understanding of the Project and the Hazards Associated

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The study of project depositional environments should be incorporated into the field investigation for tunnel design especially in glacial environments, in order to identify potential geological hazards (e.g. boulder fields) that may be encountered during construction. Some Geotechnical Baseline Report (GBR) geotechnical investigations categorize soils by granular distribution only and do not inter-relate the depositional environment for which they were found. Other geotechnical investigations discuss depositional environments in the regional geology section of the GBR but not take the next step to baseline/classify soil types by depositional environment. The baseline soil types should incorporate depositional environments and grain size distribution as well as the stratigraphy for the best understanding of the project geology. Categorizing soil types by the granular distribution and the depositional environment during design of a tunnel or subsurface structure will provide a more in depth understanding of the project geology as a whole and will identify locations along the alignment where high-risk conditions can be expected during tunneling.

Applicability of a Portable Ground-Based Radar Interferometer (GBIR) for Monitoring Rock Faces and Earth Slopes

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Ground-based interferometric radar (GBIR) is an imaging-based technology with potential for early detection of unstable rock faces and earth slopes, owing to its capability to measure small (sub-millimeter) displacements. Displacements are measured as the difference in radar phase between two radar images. Fixed GBIR systems are used for long-term, continuous monitoring in mines and similar settings. On the other hand, infrequent surveys using a portable GBIR facilitates monitoring in cases where a fixed system is not feasible. Compared with fixed GBIR systems, the infrequent, repeated GBIR surveys face more significant challenges owing to significant atmospheric variations, and temporal decorrelation of interferometric phase. There is also a need for stable monumentation. Furthermore, the capability of GBIR to detect likely displacements depends upon the magnitude of movement, as well as the size of the moving area. Herein, we present strategies developed to reduce these sources of uncertainty and improve the detection threshold for GBIR when used in infrequent, repeat surveys. Atmospheric effects are modeled using meteorological data collected during each survey. Interferometric coherence is improved through image stacking and, for larger mass movements, spatial filtering. Data redundancy can enable other statistical approaches, such as time-series analyses, when a sufficient number of measurement epochs are available. Two examples illustrate these approaches. In the first example, a slow moving landslide near Granby, CO, is studied with multiple, independent surveys. The slide moves fast enough (mm/day) to be observed in a single session spanning several hours, and the GBIR provides reliable assessment of efforts to mitigate the slide. In the second example, semi-annual surveys identify previously undetected rock face instability near Moab, UT. In both cases, the displacement magnitudes are less than detection limits of other imaging technologies and demonstrate the unique capability of portable GBIR systems for geohazard studies.

An Overview of Underground Mine Bulkheads in a Fractured Mountain Setting

Goss, Christoph, Deere & Ault Consultants Inc., christoph.goss@deereault.com (TS #3)

Underground hard rock mining tends to take place in fractured mountain settings for the simple reason that this is where the mineralization has occurred. While early stages of tectonic activity formed mountains, later stages emplace minerals in the fractures through hot fluids or gas. The fractures that accumulate enough minerals of commercial interest become ore veins that are discovered and mined out. Historically, the mines are abandoned after the ore is mined out. Water then seeps into the fractures, mined out veins, and other mine workings where it combines with oxidized minerals to form sulfuric acid which then brings heavy metals into solution which then flows out as acid mine drainage (AMD). The AMD impacts the surrounding streams by providing a steady influx of acidic metal rich water. Over time, partial mine collapses and sludge buildup can create underground dams that cause AMD to back up and form pools. The underground dams eventually fail and send a large surge of AMD and sludge out the mine portal. Such surges and sometimes all flows can be controlled by installing concrete plugs (bulkheads) in strategic locations. When designing a bulkhead, one has to consider both the specific bulkhead and the area it will impact. The bulkhead itself must be designed for the highest anticipated pressure without jacking the surrounding rock, shearing along the adit interface, structurally failing, dissolving, or letting excessive seepage past. This requires a detailed study and mapping of rock conditions, joints, and shears in the vicinity of the bulkhead. It also requires a comprehensive understanding of the mine workings, other nearby mines, veins, faults, and other fractures. Only after the effectiveness and regional impact of a bulkhead has been evaluated should it be installed.

Seismic Site Effect Parameters by HVSR Method Considering the Variation of Energy Sources

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This study presents the results of 13 continuous single-point long-term ambient noise recordings (LTRs) at five inland and two coastal locations selected in Mississippi and Louisiana states and 234 single-point short-term ambient noise recordings (STRs) in northern Mississippi where the unconsolidated sediment thickness (UST) varies from zero to 1400 m. Applying the horizontal-to-vertical spectral ratio (HVSR)

method, the predominant frequencies (f0) were estimated to be between 0.15 and 0.5 Hz in the area where UST is larger than 200 m in northern Mississippi and a reasonably good correlation was found between f0 and UST. Estimates of amplification factor, taken as HVSR values at f0 (HVSR@f0), display a strong time-dependency, potentially caused by variations of location and energy level of double frequency microseism, which is the energy within 0.085-0.5 Hz caused by ocean activities. Validity of this observation is examined by calculating transfer functions between HVSR@f0 and ocean data (ocean wave height, ocean wind speed and atmospheric pressure above ocean). Additionally, 3D microtremor spectra of each LTR and those of all STRs within each 100 m-UST group are converted into spatial spectral vectors and projected on stereographic nets. Patterns of the clusters formed by these projections show that theHVSR@f0 values are related to both UST and vibration source location and energy level. Finally, a modified HVSR method based on stereographic projection is proposed to determine the average spectral vector of each cluster, which enables a more accurate estimation of amplification factor.

Massachusetts as a Basis for Perspective on Coal-Tar Cleanup – Our Forthcoming (2017) Case History Volume

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We are in press (Taylor & Francis) with the first detailed statewide study of the historic manufactured gas industry, and its modern environmental legacy. We chose Massachusetts (1823-1971) and applied Chapter content of Hatheway's 2012 book, to gather, test and define this impact. Our book serves as an overarching technical and historical guide for assessment and remediation of gasworks, waste dumps, and other coal-tar sites that threaten public health. There has been no "middle ground" in the professional literature on this topic between individual site assessment reports and macroscopic historical reviews such as USEPA's 1985 "Radian Report." Using contemporary primary sources, we documented the manufactured gas industry's historical footprint in Massachusetts, then queried MassDEP's database of oil or hazardous releases to identify relevant sites and their regulatory status. We identified a "core population" of over 190 confirmed locations, 130 of which have been reported to MassDEP since inception (1984) of the remediation statute: 95 derelict town gasworks; 17 "producer" fuel gas plants; 35 district holder stations, 22 off-site "gasworks dumps" one massive by-product coke plant, 11 acetylene plants; and seven by-product plants utilizing coal tar feedstocks. Large numbers of off-site dumps and former private gasworks likely exist but have not yet been identified. Utilities retain the largest liability, with RP or PRP status for 77 of 114 listed sites. Private entities are RP/PRPs for 29 sites, and municipalities have RP/PRP status at eight sites. Response actions are generally conducted under MassDEP regulations, USEPA having generally nationally abdicated its historic role in addressing derelict gasworks. The authors offer general observations and suggestions backed by our research and author Hatheway's twenty-eight years of experience; including identification of areas meriting assessment, alternatives for compensating for lack of access to utility archival information, evaluation of potential remedial approaches, and modern-era cost-recovery litigation.

Minimizing Impacts to Structures, Geologic Features and Natural Resources from Blasting

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Blasting can achieve its desired purpose and, when cautiously conducted, will have assurance of avoiding significant impacts or damage. Adverse impacts may not only affect structures, but may need to be minimized for the public's response, geologic hazards (sinkhole collapse, slope instability…) and natural-resource (flora and fauna) concerns. Many applications of blasting will require an assessment of geophysical properties of the site and potentially impacted concerns to properly minimize an adverse impact. Blasting is considered an extremely dangerous art by the public. Blasting is very effective in moving low-tensile materials (rock & concrete) that cannot be easily excavated mechanically. Blasting is effective, because the chemical release of energy from the blasting agent results in shock energy and in great gas-volume production in a very short time. The three primary and many secondary impacts can be controlled by the blasting parameters used, and for some projects by additional mitigating measures. Achieving the required goal of blasting project may require reduced blasting efficiency to minimize the potential secondary impacts. The application of mitigating actions for unusual blasting cases usually requires geophysical assessment of the site. A few case histories are briefly developed to note the proper approach to mitigating human, natural resource, geologic-hazard and structural impacts without diminishing the capacity to effectively perform the blasting. The important issues are to: anticipate varied adverse impacts, research past similar projects, geophysically characterize the environs, resolve a means to measure impacts (if warranted), anticipate important blasting parameters, and develop the blasting contract's specifications for the intended purpose. Many projects require some education of the owner (client), engineer-in-charge, blasting firm, those that could be harmed by blasting, and/or the general public. Blasting can be conducted to achieve the project's goals without causing adverse impacts to surrounding areas.

Assessment of Historic Piezometer Data, Abiquiu Dam and Reservoir, Rio Chama, New Mexico

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Abiquiu Dam and Reservoir is located on the Rio Chama, approximately 35 miles northwest of Española, New Mexico. This facility consists of a rolled earth fill dam with a low permeable core, controlled outlet works and an uncontrolled rock-cut spillway. The dam was authorized for flood control and sediment retention and was designed as a dry dam, intended to hold flood pools for relatively short durations. The dam is founded on fractured sedimentary mudstone, sandstone and conglomerate of Permian and Triassic age. Construction was completed in 1963 and the first pool was impounded in 1964. Due to water resource issues in the desert southwest, the dam has been repurposed to store water year round. Seepage along both the right and left abutments has been a concern historically. Efforts to alleviate and mitigate these concerns have included re-grouting within the original foundation grout curtains footprint, extending these grout curtains into both abutments, drilling horizontal drains, and excavation of two seepage control adits. In 2014, the U.S. Army Corps of Engineers initiated a risk assessment for Abiquiu Dam, which included a comprehensive evaluation of historic instrumentation data, including piezometers. Results of the evaluation of piezometer data and how it relates to performance of the grout curtain(s), seepage control adits, and overall performance of the dam will be presented.

Analysis of the Debeque Canyon Landslide using Ground-Based Radar and Aerial Photogrammetry, Mesa County, Colorado

Hickcox, Kelly, University of Missouri, kbhy96@mail.missouri.edu; Dr. Francisco (TS#22)

Debeque Canyon Landslide is an active landslide impacting I-70 in Western Colorado that is the result of displacement along the southern wall of an approximately 150 m deep canyon incised into the Mesa Verde Group by the Colorado River. Since the late 1800s, three catastrophic failures have damaged infrastructure within the canyon along what is now the I-70 corridor. The slide continues to gradually creep toward the canyon floor, endangering I-70, and Union Pacific rail lines. The Debeque Canyon Landslide is an active monitoring site of the Colorado Department of Transportation. The site is heavily instrumented, including tiltmeters, extensometers, inclinometers, rainfall gauges, piezometers, and GPS monuments. This data provides insight for monitoring the slide, but has a significant limitation; accessibility precludes instrumentation on much of the rubble zone. In an effort to address the limitations of current landslide monitoring efforts, my research team began conducting periodic remote monitoring of the Debeque Canyon Landslide. We have employed ground-based interferometric radar, aerial photogrammetry, and satellite based synthetic-aperture radar to study movement of the entire slide, including areas where accessibility has precluded extensive monitoring. Ground-based radar sites are chosen to provide multiple lines-of-site, allowing for the calculation of true 3-dimensional vector displacements. To date, five research missions have been conducted to collect field data. Preliminary results show movement of 2–3 centimeters per year, primarily along the upper portion of the slide. The Debeque Canyon Landslide provides a rare opportunity to study surficial evolution as it occurs. Ground-based radar interferometric landslide analysis is an emerging technique, but the size, orientation, and displacement velocity of the slide make this an ideal site. By combining this analysis with 3-dimensional models derived from aerial photogrammetry, we can not only monitor displacements, but also model the impact of failures on infrastructure within the canyon.

The Importance of Per- and Polyfluorinated Substances as Drinking Water Contaminants
Part I: Background and National Relevance
Part II: Why Organic Chemistry Should Matter to Geologists

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This talk will present an introduction as to why poly- and perfluoroalkyl substances (PFASs) have become important drinking water contaminants of concern in the U.S. In particular, this presentation will discuss how the broad uses of these chemicals, particularly as part of aqueous fire fighting foams (AFFFs), has likely led to contaminated groundwater throughout the U.S. In this context, our rapidly emerging picture of the broad suite of polyfluorinated PFASs, which can serve as chemical precursors to the more problematic perfluorinated species, will be presented.

Evaluation of Rock Slope Stability and Crack Monitoring at Dinosaur National Monument

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The Carnegie Quarry at Dinosaur National Monument is an in-situ fossil display that preserves a portion of a prolific fossil bearing zone within the Morrison Formation in northeastern Utah. This exhibit is unique because it displays ~1,500 in-situ fossilized dinosaur bones which are contained within a sequence of rock units that are steeply dipping between 60 and 70 degrees. Recently, the condition of this exhibit has come into question and is being evaluated by an interdisciplinary team of scientists and engineers. One of the concerns regarding the condition of the quarry is the stability and durability of the rock units comprising the display. Although the fossils themselves are contained within what appears to be competent rock, fractures are common throughout the rock face and have propagated through fossils in numerous locations, which has caused extensive damage to the exhibit, including destructive loss of fossils. These fractures have also raised concerns of potential instability of portions of the rock face that could pose a significant threat to the health and safety of visitors and/or employees of the park. To address these concerns, an investigation is underway to assess both the magnitude of any ongoing motions within the quarry as well as the potential for future instability of the materials comprising the exhibit. Vibrating wire crackmeters and analog crack monitors will provide insight into ongoing ground motions at the site and will be used to correlate any slope movement with external forces that could trigger slope movement. Intact rock and joint shear strengths estimated from samples collected in the field will be used to investigate the gravitational stability of the quarry face. The presented material will be a progress report of the work completed and data that have been collected and interpreted thus far.

Panama Canal Third Set of Locks: Key Findings Concerning Seismic Hazard in Central Panama

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Holocene deformation in central Panama tectonic province has been investigated since 1988 using Seismicity, Satellite Imagery, Trenching, CASA GPS network and geophysics, all contributing with valuable information for assessing the earthquake hazard in Central Panama. More recently, new light has been brought to the discussion with the results of geologic mapping, trenching and age dating performed for the final design of civil structures and along the major excavations required for the Panama Canal Third Set of Locks. Key findings of this work show that no significant displacement occurs in early Holocene and late Pleistocene alluvium overlying the Pedro Miguel Fault, which is a major tectonic feature in Central Panama. This suggests that repeated Holocene displacements and high slip rates along the fault as proposed by some previous studies are very unlikely. These new findings are consistent with results of previous field studies through Gatun Fault along river outcrops, seismicity studies in central Panama and geophysics studies through Limón Bay Faults. Deformation studies using CASA GPS network results also suggest that the virtually aseismic central Panama is behaving at present as a rigid block. This paper will illustrate Panama Canal - Third Set of Locks geologic investigations key findings and discuss its correlation with previous works associated with the seismic hazard in Central Panama.

Property Owners Call It "Trespass"; Lawyers Call It "Heaven!"

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An attendant consequence of industrial, commercial, and residential development of properties is the oft present occurrence of anthropogenic contaminants. These result from waste debris arising from inefficient "baghouse" collection of particulates during manufacturing processes adjacent to residential areas or the down slope movement of eroded sediment when land developers fail to insure that "best management practices" have been carried out. While debris generated from industrial processes (steel mills, power plants, paper

manufacturing, cement plants, etc.) can invariably be identified by distinctive chemistry and/or characteristic particulate morphology, proving trespass of sediment from distant upslope sources is often more difficult. A case involving the latter was strenuously contested by attorneys representing a large mall when landowners living adjacent to a stream down slope argued that sediment derived from the mall site during construction had heavily in-filled the stream. The infilling of the stream with eroded sediment prevented property owners from using watercraft in the stream and accessing adjacent Mobile Bay and the Gulf of Mexico. Cores taken throughout the entire length of the stream clearly disclosed the presence of an "event boundary" that occurred when the inflow of large quantities of non-indigenous sediments impacted the stream. This was seen by not only abrupt changes in sediment particle sizes in the cores, but also by a distinctive change in the trace minerals present in the heavy mineral fraction of the sediments. Though occurring in quantities of less than 1 percent in samples, the ratio of Zircon+Tourmaline÷Rutile (the ZTR index) clearly allowed identification of the impact boundary, even where particle sizes of adjacent "pre" and "post" impact sediments were similar.

Seismic Attribute Processing to Find Deep Aquifers

Jansen, John, Leggette, Brashears and Graham, john.jansen@lbgmn.com (TS#25)

The scarcity of water in arid and semi-arid regions has increased interest in sources of water much deeper than traditionally considered economic. Many projects have targeted fresh to brackish water sources at depths of 2,000 to over 5,000 feet. In many formations the potential yield of a well varies based on stratigraphic changes making it difficult to predict the potential yield of a given location without more information. The cost of drilling to such depths limits the availability of data and makes developing these resources risky and expensive. Seismic reflection surveys collect data on the propagation of seismic waves to depths of several thousand feet. Developed by the oil and gas industry, seismic data can be used to map structural features in fine detail. Modern processing and interpretation techniques can map aquifer units, faults, and other structural features that can control well yield. With a little more processing, the shape of the waveforms can identify changes in the stratigraphy, porosity, and pore fluid characteristics in a unit. Seismic attribute processing can be used to identify permeable features such as narrow channel sand deposits at depths of thousands of feet to target permeable zones. The cost to acquire reflection data is relatively high, which has limited the application of the method for water supply applications. Fortunately many areas have libraries of existing reflection data from previous oil and gas exploration activities. This data can often be purchased for a few thousand dollars per mile and used to map units that can potentially serve as aquifers. Several case histories will be presented to demonstrate how modern interpretation methods can be used on 2D or 3D seismic reflection data to map features such as sand channels, faults, and pinch outs in aquifer units and direct drilling programs toward higher yielding sites.

Reducing Fault Location and Slip Uncertainty for Gas Pipeline Crossings at the San Andreas and Hayward Faults, California

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Pacific Gas and Electric Company (PG&E) has developed, and maintains, an Earthquake Fault Crossings Program (Program) for their gas transmission pipeline system in California where they cross known active faults. The goal of the Program is to quantify potential surface fault displacement at individual pipeline fault crossings, to quantify the pipe strains from the fault displacement, and to develop hazard mitigation options. By the end of 2016, PG&E has evaluated more than 150 fault crossings, including nine at the San Andreas Fault (SAF) and seven at the Hayward Fault (HF). In 2015/16, Golder conducted geologic studies to assess fault location and slip amounts and uncertainties at three pipeline crossings of the SAF and four at the HF. Fault crossing evaluations incorporated remote sensing data (e.g. lidar, bathymetry, and historic aerial and ground imagery), detailed historical literature review (geologic mapping, engineering reports and consultant studies), and field-based analyses to quantify geologic conditions at each fault crossing. Data reviewed during the assessments ranged from poor to good quality, and in some cases included significant disagreement between datasets. At the SAF crossings, uncertainty of fault location ranges from ±15 m to ±335 m, principally because of the variable width of cosesimic deformation measured at the crossing locations following the 1906 earthquake and right-lateral fault rupture that ranges from 2.68 m to 5.2 m. Fault location and width along the HF is generally well constrained because ongoing fault creep offsets anthropogenic features. Single-event fault slip, however, is poorly constrained because of the limited number of observations from the 1868 earthquake and surface fault rupture, and the lack of paleoseismic data. The results of the Program are used to manage PG&E's Gas Transmission Pipeline System, including risk analysis, mitigation planning, and emergency preparedness.

Using Sanborn Maps as a Historical Resource

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Sanborn Maps were published from the mid 1800s to the 1970s in 12,000 major cities for the purpose of assessing structural risks and providing this information to fire insurance underwriters. The information contained within a Sanborn Map is often very detailed and helpful to uncover the history of a developed area, particularly if researching potential sources for subsurface soil or groundwater contaminants. Sanborn Maps, when available, are a fascinating resource when performing historical research in preparation of a Phase I Environmental Site Assessment. This presentation will explain some of the map symbols used on Sanborn Maps and show several case studies where the Sanborn Map provided information that was unable to be obtained using other historical research sources.

Investigation, Design, and Construction of Flexible Debris Flow Barriers

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Post-wildfire debris flow events are common in the southwestern United States. Typically, thousands of acres of forested land are burned of their vegetative cover during the dry season. Subsequently, monsoonal rains or intense winter storms rapidly erode the burned areas. Large debris flows follow carrying boulders, trees, and other materials resulting in significant destruction to habitat and communities. In the past, rigid barriers or large detention basins were constructed. In recent years, flexible rockfall barrier technology has been modified to develop mitigation that can be rapidly constructed with little environmental impact in rugged terrain. The barriers are the result of extensive modeling and testing. They have been proven to be a reliable, relatively inexpensive, and rapid response to debris flow mitigation. The availability of computerized design tools allows for efficient

site investigation, rapid design, and quick construction with readily available materials. This paper illustrates the process of investigation, design, and construction of these barriers with case studies in Colorado Springs, Colorado; Santa Clara and Nambé Pueblos, New Mexico; and Camarillo Springs, California.

Design of Piles for the Stabilization of Bridge Abutments

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Bridge approach embankments and abutments walls can be reinforced by stabilization elements such as driven piles and/or drilled shafts when global/slope stability does not meet a minimum factor of safety. In some cases, when the embankment loads are high and cause global stability problems, other associated issues may emerge as well including excessive settlement, downdrag load on the abutment piles, lateral squeeze, and bearing capacity. The structural piles may be designed to go deeper, closer spaced, or increased in size, or longer construction waiting time may be required, and the construction may become more expensive as a result of these considerations. As part of the widening of the Interstate 64 Segment I corridor between Williamsburg and Newport News, Virginia, USA, three new bridges were constructed. At one bridge location in particular, the abutment was proposed to be supported on deep foundation elements and the approach embankment by a Mechanically Stabilized Earth (MSE) wall reaching heights of up to 25 ft. As a result, multiple short-term and long-term global stability, settlement, lateral squeeze, and downdrag issues emerged. To resolve these issues efficiently and timely, we used the structural piles supporting the abutment within open ended pipe piles. This alternative was accepted and was constructed with a substantial lesser cost. These pipe piles served two purposes: first they were used as an additional reinforcing element for slope stabilization; and second they were used to eliminate the downdrag forces on the structural piles. There were no definitive and universally accepted approaches on how to analyze the piles influencing the stability of the slopes. Therefore, we considered various methods to analyze a pile supporting a "failing soil mass" including widely used displacement methods and pressure distribution methods. Design methodologies for slope stabilization using driven piles will be discussed.

Analytic Hierarchy Process: A Possible Semi-Quantitative Alternative to "on the Other Hand…" for Geologic Complexity

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Geologists working on engineering projects tend to give qualified answers because only partial geologic information can be observed, which leads to multiple working hypotheses and requests for more data to improve confidence. A recent attempt to quantify geologic variability and uncertainty with a nine-factor Geologic Model Complexity Rating System followed the Oregon rockfall hazard rating system with four possible power-function scores for each factor (3, 9, 27, & 81); each of the nine factors has equal weight. A thought experiment considered these nine Complexity parameters as they might be applied to a landslide hazard study using a pair-wise comparison method of multi-factor decision analysis called the Analytic Hierarchy Process (AHP). Each pair of factors is denoted with a 1–9 rating for relative importance: 1 indicates both factors contribute equally and 9 indicates that one factor contributes extremely more than the other, with 3 indicating moderately greater, 5 strongly greater, and 7 very strongly greater contribution. The factor with lesser importance in a pair is rated with the inverse contribution (e.g., 1/7). The analysis is performed with a matrix of factors, summing the rows, and then dividing each row sum by the total sum of all rows to give the equivalent of a weight for each factor. A possible AHP matrix suggests that Geologist Competence has the highest weight (20%), followed by Genetic Complexity and Deformation Complexity (18% each), followed by Site-Scale Complexity and the Allotted Time (11% each). The remaining factors (Terrain Features, Alteration Complexity, Weathering Complexity, and Information Quality) ranked between 8% and 3%. AHP appears to be an approach that allows geologic factors contributing to complexity and uncertainty to be compared objectively; the factor ratings in the AHP matrix should be a consensus of stakeholder opinions to allow each stakeholder to have some ownership of the results.

Mapping Landslides for the Insurance Industry – Lessons from Earthquakes

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Earthquake insurers currently can quickly identify 'risk' for a building street address by using probabilistic models based on 1) proximity to earthquake sources, 2) likelihood of earthquake occurrence, 3) attenuation of shaking with distance, and 4) amplification effects caused by site conditions. Loss estimates are based on building type, age, and use. Earthquake insurance coverage price is based on risk of loss and value of property. Landslides currently are uninsured because risk of loss is not quantified; therefore, insurance coverage price cannot be set. The insurance industry needs probabilistic models of landslide processes that quantify the likelihood that they will occur and the extent of damage that will result. The earthquake example should provide geoscientists and engineers with valuable lessons of probabilistic models of landslide initiation and movement. Loss estimates will depend in part on the nature of buildings sitting on the landslide and in part on the amount and duration of ground movement. Earthquakes tend to be catastrophic with a single event resulting in widespread damage that ranges from slight to severe over a period of a few tens of seconds. Landslides tend to be localized with a single event resulting in damage to relatively few buildings, but may occur over a period of days to years. Landslide triggers can be regional, but landslide damage remains localized. Local governments effectively tend to become insurers by providing funds for response, recovery, and reconstruction following landslide events. The same type of geoscience regarding landslide risk management is needed for the private insurance industry as for local governments. A systematic approach is needed to apply earthquake lessons to quantifying landslide occurrence and severity, as well as the nature and amount of damage incurred by buildings and infrastructure.

Empirical Study of the Development of Sand Boils near Ware, IL, Middle Mississippi River

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During the Middle Mississippi River Flood of 2013 and 2016, numerous large sand boils developed along the toe of the Mainline Mississippi River Levee between St. Louis and Cape Girardeau, MO. Flooding involved moderate and large scale events, but both floods were below the design event the levees were built to withstand. Several large sand boils were discovered near the town of Ware, IL, in

2013 in the Preston Drainage and Levee District, and are the focus of a case history study. Geotechnical data were collected from the Ware site using cone penetrometer tests (CPT), soil borings, laboratory soil testing, piezometer data, and multiple geophysical surveys. Important parameters contributing to sand boil formation were identified and involve top stratum thickness, soil type, site stratigraphy, depositional environment, and associated engineering, and hydraulic properties. Additionally, flow pathways in the foundation were successfully imaged using Electrical Resistivity Tomography (ERT). It was assumed that sand boils discovered in 2013 were formed during this flood event. However, sand boils are typically associated with chronic seepage activity along the levee right away that tend to progress with time in terms of their severity at smaller magnitude floods. A model of sand boil development was developed from continuously recorded piezometer data during the 2016 Flood and the geologic and geotechnical data collected. Factors responsible involved a blocked exit condition, due to levee orientation with the underlying site geology, abrupt changes in hydraulic conductivity in the flow path, and concentrated underseepage at this site, including sand boil activity.

GIS-Based Spatial Analysis for Determining Sinkhole Influencing Factors in Greene County, Missouri

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Sinkholes are inherent features of the karst terrain of Greene County, Missouri, which present hazards and engineering challenges to development. Analysis of relationships between the spatial distribution of sinkholes and possible influencing factors can help in understanding controls on the geographic distribution of sinkholes and thereby aid assessments of the susceptibility to future sinkhole problems. In this research GIS-Based, Ordinary Least Squares Regression (OLS) and Geographically Weighted Regression (GWR) methods were used to determine and evaluate the principal factors appearing to influence the formation and distribution of karst sinkholes. From the OLS result, six out of twelve possible influencing factors were found to exert significant influence on sinkhole formation processes in the study area. These factors are overburden thickness, depth-to-groundwater, slope of the ground surface, distance to the nearest surface drainage line, distance to the nearest geological structure, and distance to nearest spring. These factors were used as independent variables in the GWR model. The GWR model examined the spatial non-stationarity among the various factors, and showed better performance than OLS. GWR model coefficient estimates for each variable were mapped and these maps provide spatial insights into the influence of the variables on sinkhole densities throughout the study area. GWR spatial analysis appears to be an effective approach to understand sinkhole influencing factors, and the results may be useful to provide an objective means of parameter weighting in models of sinkhole susceptibility or hazard mapping, as well as other decision-making tools to mitigate risks associated with sinkhole formation and reactivation.

Transfer of Pharmaceuticals and Personal Care Products in Terrestrial Systems

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Pharmaceuticals and personal care products (PPCPs) are among a wide range of anthropogenic organic contaminants that enter the municipal waste stream, some fraction of which survive the wastewater treatment process. PPCPs are widely reported components of wastewater end products, treated wastewater effluent, and sewage sludge. As a result, PPCPs can be released into the aquatic environment through discharge of wastewater effluent, or released into the terrestrial environment through use of treated wastewater as an irrigation source or land application of biosolids (treated sewage sludge). This presentation will focus on two studies designed to investigate the movement of select PPCPs within terrestrial systems. The first study discusses the occurrence of the disinfectants triclocarban (TCC) and triclosan (TCS) in various trophic levels in a control (biosolids free) and a biosolids amended agro-ecosystem. Samples included in this study were earthworms (Lumbricus), deer mice (Peromyscus maniculatus), and eggs of European starlings (Sturnus vulgarus) and American kestrels (Falco sparverius). Concentrations of both antimicrobials were higher on the biosolids amended site than on the control site in soils, earthworms, mice (liver), and European starling eggs, but not American kestrel eggs. Inter-species comparisons on the biosolids amended site indicated significantly higher TCC concentrations in mice (12.6– 33.3 ng/g) and in starling eggs (15.4–31.4 ng/g) than in kestrel eggs (3.6 ng/g). A second greenhouse scale study was conducted to monitor transfer of the pharmaceutical carbamazepine (CBZ), previously accumulated in tomato plants, via herbivory on the plants by hornworms (Manduca sexta), and subsequent conservation of CBZ from hornworms through metamorphosis to adult hawkmoths. Carbamazepine was detected in the samples from the CBZ fortified system: tomato leaves (184.77 ng/g dw), hornworm tissue (27.48 ng/g dw) and hawkmoth tissue (3.76 ng/g dw).

Do Faults Caused by Evaporite Dissolution and "Unfolding" of Colorado's Grand Hogback Monocline Pose a Seismic Hazard?

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Interstratal dissolution and flow of Pennsylvanian evaporite during the late Cenozoic created the Carbondale Collapse Center, a prominent structural and topographic depression that extends across ~1200 sq km in west-central Colorado. Miocene basalt flows (~10 Ma) that originally were subhorizontal are now downdropped as much as 1,200 m into the collapse area. All collapse is post-basalt, but it may have accelerated after 3 Ma. The steeply west-dipping, late Laramide, Grand Hogback Monocline forms the western margin of the collapse area. As halite and gypsum dissolves and/or flows out from beneath the monocline, the monocline relaxes or unfolds eastward. This effect is accompanied by differential slip along bedding planes within the monocline. These flexural-slip faults offset unconformably overlying basalt flows and Quaternary piedmont deposits, creating conspicuous half-graben depressions that are bounded by uphill-facing fault scarps and that follow bedding planes in monoclinally folded bedrock. A paleoseismological study involving two trenches dug across scarps in the two stratigraphic markers (basalt and piedmont deposits) was undertaken to better characterize recent slip on the faults. Scarps heights are as much as ~90 m in the basalts, ~30 m in late Tertiary-early Pleistocene(?) pediments, and ~3 m in late Pleistocene-Holocene pediments. Although we expected to find evidence of fault creep, the trenches surprisingly revealed multiple late Quaternary ruptures, each with ≥1 m of displacement. The trench on the piedmont contained evidence suggesting three faulting events at <32 ka, 32-28 ka, and 5.6-1.5 ka. Four events were inferred from exposures in the trench on the faulted and tilted basalt cap—all older than ~20 ka. Although the largest recorded earthquake in the vicinity of the monocline was only ML 3.2, the paleoseismological study raises several questions regarding the seismic hazard posed by the flexural-slip faults.

Subsurface Mapping Using Direct Push Technology in Site Characterization Studies

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Real-time data is critical to subsurface site characterization studies. The direct-push Hydraulic Profiling Tool (HPT) is one such technology that provides rapid and accurate data collection in unconsolidated materials. The HPT provides continuous lithologic profiles of both fine- and coarse-grained sediments. As the probe is advanced, it measures the hydraulic properties of the formation, which allows for the determination of the lithology and its relative permeability. This data can be used to develop detailed geologic cross-sections in which grain-size and bedding characteristics can be determined, water-bearing zones distinguished from aquitards, and highly transmissive preferential pathways for groundwater migration can be mapped. Equipped with an electrical conductivity dipole, the probe can also be used evaluate depositional environments and to detect the presence of saline solutions in the subsurface. The pressure, flow, and electrical conductivity data is recorded on a series of logs providing real-time high resolution site characterization data without generating any soil cuttings.

Responding to the Challenge of Planning for Landslide Hazards—The Colorado Springs Experience

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Landslides in Colorado Springs have destroyed or damaged dozens of homes, utilities and other infrastructure. To help protect the community from geologic hazards, Colorado Springs adopted an ordinance in 1996 that governed development in areas with geologic hazards and required site-specific geologic hazard investigation prior to development. However, in 2015, heavy rains triggered additional landslides and damages. The Mayor and City Council sought to strengthen the city's geologic hazard ordinance to better protect public safety and public and private investment. City Councilman Don Knight and Tom Strand lead a diverse task force to revise the existing ordinance. They will discuss the challenges of the process and the diverse, and sometimes competing, policy tools/issues that were discussed and ultimately chosen for addressing landslide hazards at the local level.

A Framework for Dynamic Risk Assessment in Subsurface Excavation Projects

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Unexpected ground conditions force the designers of underground construction projects to take on unnecessary levels of risk and expense when excavating. Rigid contractual agreements exacerbate this issue by impeding the sensible modification of design plans in response to newly collected geotechnical data. Together, inflexible contractual obligations and the lack of real-time risk assessment in excavation projects result in an inability to effectively adapt design plans to unexpected ground conditions. Here we propose a framework for dynamic risk assessment in excavation projects, utilizing dynamic geological modeling techniques to automatically update subsurface models following the collection of new data. Lithographic modeling techniques provide a straightforward method to extrapolate information from preliminary borehole measurements to construct an initial 3-D geological model, while geostatistical modeling techniques allow for relatively easy updating of the predicted models following the addition of a wide variety of newly collected data (e.g. geophysical, remote sensing, in-situ observations). An additional benefit of using geostatistical techniques is the ability to quantify uncertainty in our model; subsurface model uncertainty plays a large role in quantifying risk, just as potentially adverse ground conditions do. Combining these two modeling techniques, a dynamic geological model is obtained which complies with initial lithographic interpretations while accounting for changes in ground conditions illuminated by newly collected data. This model also highlights where, according to collected data, we are uncertain about predicted ground conditions, allowing for a more realistic risk assessment. Additional features of the dynamic risk assessment framework will include a GIS-based data aggregation system to incorporate data into the geological model in real-time, as well as modifications to the contractual system to allow for adaptation of initial design plans to dynamically unfolding ground conditions.

Challenges of Inspecting Unlined Rock Tunnels Based on the New National Tunnel Inspection Standards

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In 2015, Congress mandated the inspection of all vehicular tunnels in the country on a regular basis. The FHWA developed the National Tunnel Inspection Standards (NTIS) to comply with the mandate and all tunnel inspection information shall be reported to FHWA. The tunnel inspection program is based on a very similar program for bridge inspections that has been in place for many years. Detailed condition assessments are collected during tunnel inspections to populate a database used to forecast Department of Transportation maintenance and rehabilitation funding and efforts. The NTIS uses two manuals; Specifications for the National Tunnel Inventory (SNTI) and Tunnel Operation Maintenance Inspection and Evaluation (TOMIE). The data produced from these program inspections will be maintained in the National Tunnel Inventory (NTI). The NTI database provides information for a data driven, risk based approach to asset management that can be used for information investment decisions. This national program is geared towards concrete lined tunnels with multifaceted systems, where the integrity of the tunnel is comprised primarily of manmade materials. In Colorado, a handful of vehicular tunnels are unlined tunnels and/or approach embankments comprised of bare bedrock. This presentation describes the new NTIS for tunnels and focuses on the inspection of unlined rock tunnels and rock embankments per the manuals.

Horizontal Directional Drill Pipeline Crossing Design in Buried Glacial Valleys; A Multi-Faceted Approach

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Buried glacial valleys can present unpredictable subsurface conditions. Bedrock surfaces can drop off steeply over the course of a few horizontal feet. Great risk can be incurred by engineering consultants when using "geological judgement" to connect the dots between stratification boundaries on a profile using geotechnical borings as sole data sources, therefore, a multi-faceted approach utilizing geophysical exploration and thorough desktop research should be taken. Lateral extent of both bedrock depth and soil strata are two particularly defining factors when designing a horizontal directional drill (HDD) pipeline crossing. The following project consists of a natural gas pipeline replacement located within the limits of a high value waterway in Orange County, New York. HDD was preferred as the least environmentally invasive construction method to replace the pipeline, given that an accurate picture of the subsurface conditions could be provided for design. A combination of literature research, field reconnaissance, geotechnical borings, and shallow surface geophysical exploration methods were used by the

geotechnical team to characterize the site. The design team consisted of the lead geologist, civil permitting engineers, pipeline engineers, and contractors working together to determine an optimal and constructible alignment within the variable subsurface conditions. The stream's high quality designation limited geotechnical drilling to the land surface, which created a ~400 foot gap in soil and rock sampling data. The geophysical study concluded the bedrock surface drops at a high angle to form a "wall" beneath the east side of the stream crossing, which was corroborated by historical reports. Bedrock depth in the valley bottom was determined to be variable as well, resulting in design challenges for the HDD geometry. The final design was a 30° skewed centerline relative to the stream and an installation depth of 60 to 100 feet below the stream.

Integrating Cross Hole Seismic Tomography and Wireline Geophysical Logging to Characterize Bedrock for Vertical Shaft Excavation Design

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A 90-foot-diameter, 150-foot-deep drop shaft for access to a horizontal tunnel is to be excavated in an area of known karst. A grouting program must be designed to account for voids, fracture zones, and solution cavities that may serve as groundwater flow pathways. Cross-hole seismic tomography and wireline geophysical logging were performed to investigate possible karstic conditions surrounding the proposed shaft. Sixteen air hammer borings were advanced along the perimeter of a 140-foot-diameter cylinder around the proposed shaft. The depths of the borings ranged between 120 and 140 feet below ground surface to a uniform bottom of hole elevation. In each boring wireline geophysical logging consisted of acoustic televiewer (ATV), natural gamma, spontaneous potential (SP), and electrical resistivity. Crosshole seismic data were collected between adjacent borings in cylindrical fashion around the proposed drop shaft. A Geotomographie 5 KV compressional wave borehole sparker was energized at 0.5- to 1-meter spacings within each source boring. A string of 24 borehole hydrophones (Model AQ2000) were deployed at 0.5-meter intervals within each receiver boring. A Geometrics Geode seismograph was used to record the data. First breaks were picked and tomography profiles were processed using XW TOMO Version 7.3 by Geogiga Technology Corp. The resulting three-dimensional cylinder comprised of 16 adjacent, two-dimensional, tomographic profiles was tied to the geologic and geophysical logs and interpreted for the presence of groundwater flow pathways. In general, the geophysical data exhibited distinct geo-mechanical and geo-electrical signatures between the relatively horizontal limestone, dolomite (due to greater porosity) and clay. A highly incised weathered zone or solution-widened vertical joint was observed at two different locations along the cylinder which suggested an orientation of N70E. Other potential groundwater flow pathways were observed including high angle, low velocity zones (clay or water-filled solution-widened joints).

Evaluating Landslide Risk Management in Guatemala City through a Study of Risk Perception and Behavior Changes

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In October of 2015, a devastating landslide killed an estimated 350 people in the community of El Cambray II, located in a Guatemala City ravine, highlighting the need to manage landslide risk in precarious urban settlements in the area. The goal of this project is to evaluate and improve landslide risk management in the Guatemala City metropolitan area, and to encourage at-risk community members to change behaviors to reduce landslide risk. To evaluate specific risk management initiatives, the authors are tracking changes in community members' risk perception and behaviors by surveying communities before and after the implementation of initiatives. Using these factors as metrics, we demonstrate the degree to which these factors will change when a community-based risk management initiative is implemented in a precarious settlement. To characterize landslide risk perceptions, perception of landslide risk is compared to perception of other societal risks to which community members are exposed, and a rubric of relative knowledge of landslide risk is developed. A preliminary F-N (frequency of events vs. number of fatalities) plot quantifies societal acceptance of landslide risk. Landslide risk faced by settlement residents is estimated with a preliminary landslide event database, for comparison to a quantified perception of risk to understand if communities perceive risk accurately, and to identify the level of intervention that would encourage behavioral change. The results of this study are being shared with risk managers to improve their selection of initiatives, and to empower at-risk communities by incorporating their knowledge and perception of risk into risk management strategies.

Permian Sand Dune Mining: "What's All the Frac About?"

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In 2017 Westward Geological Services (Westward) crews spent over six months in West Texas assessing the regional dune sands for suitability as use as proppant, or frac sand. Westward designed and supervised the exploration program that comprised of drilling 678 borings across 87,000+ acres in Winkler & Ward Counties on 11 separate tracts. As of last count, that totaled a little more than 56,000 ft. core drilled of which over 50,000 ft. of sample was bagged in five-foot intervals and transported to laboratories in Illinois and Texas for frac sand testing. Total depths drilled ranged from 18 ft. to 168 ft. and were drilled in 80 ft. tall dunes as well as on level ground. Although the overall thickness of the deposit varied widely across the region, physical characteristics of the sand did not. This was the first phase of several large projects where Westward was involved with construction and permitting phases of multiple frac sand plants in the region. This presentation will focus on the methodology used and results obtained from the exploration effort in the areas of Kermit & Monahans, Texas.

Leaking Underground Storage Tanks – Forty Years Later, What Has Been Accomplished?

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Prior to the passage of the 1976 Resource Conservation and Recovery (RCRA) under President Gerald Ford, 1.6 million bare steel Underground Storage Tanks (UST) were in use for the retail sale of petroleum in the United States. More 100,000 of them reportedly were in Indiana. Many of them were leaking and creating soil and groundwater environmental problems. With the passage of the Superfund Re-Authorization Act (SARA) in 1986, the Indiana Department of Environmental Management (IDEM) was created. All UST in Indiana were now required to be registered if they would remain in use. This paper discusses the registration and upgrade process from an economic, and political perspective including funding the environmental impacts and environmental clean-ups, specifically in the state of Indiana.

Correlations of Soil Index Properties Obtained from Different Locations in Manyana, Botswana

Letlole, Portia Tshepiso, Botswana Geoscience Institute, pushie50@gmail.com (Poster)

There is substantial cost allied with soil testing, both in situ and lab. In preliminary phases where there is limited available funds for soil exploration, empirical correlations become useful. Index properties for eighteen samples from different locations in Manyana, Botswana were determined by laboratorial testing in accordance to ASTM standards. The laboratorial results showed that these soils exhibited wide range of 0.12 to 20.67% clay, 9.05 to 36.51% silt and 13.34 to 90.35% sand. The Atterberg limit results showed liquid limit of 20 to 77.5%, plastic limit of 6.37 to 45.33% and plastic index of 5.95 to 35.13%. It was observed that with low clay fraction there is no correlation with Atterberg limits as indicated by values of correlation of coefficient, R2 based on regression analysis being less than 0.03. The soil plasticity decreased with sand content, while liquid limit increased with increase in plastic index. A good empirical relationship of plastic index as a function of liquid limit has been established in the form of linear, exponential and logarithm equations. The values of correlation of coefficient, R2 is within the range of 0.6955 to 0.7943. The equations are valid for liquid limit values within range of 20 to 80%.

In-Situ Rock Testing Equipment: A Review of Current Practice

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Accurate understanding of rock engineering properties is critical for design, however determinations of rock mass strength or deformation characteristics are complicated by scale effects. Simply put, testing volumes of rock in the lab or field, which fully represent the volume of rock loaded by a large structure or tunnel is impossible. Laboratory testing only characterizes small portions of the rock mass and engineering judgment is required to extrapolate from the lab to the field scale. Field scale testing of in-situ properties can be used to overcome some of the scale effects by performing tests on larger volumes of rock that have experienced less disturbance than laboratory samples. This presentation details in-situ methods for determining deformation modulus (rock mass modulus), the in-situ state of stress, and shear strength. In-situ field testing can often be costly due to time, preparation, and equipment, therefore this presentation also provides a literature-based opinion as to which devices provide the best cost/benefit for determining rock engineering parameters at the current state-of-the-practice. The presentation will detail what devices can work well for differing rock conditions, i.e. BIM rock, soft versus hard rock etc. Additionally, the uses or potential uses of equipment for assessing aging concrete infrastructure is discussed.

USACE Dam Safety Risk Assessment Program Overview and How Engineering Geology Contributes to the Level of Confidence and Results

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The U.S. Army Corps of Engineers implemented a comprehensive risk analysis approach in 2006 to evaluate and prioritize its portfolio of over 700 dams as part of the Dam Safety management program. This process has since evolved and now includes approximately 1,200 miles of USACE-owned, and 13,000 miles of federally authorized levee systems. This risk analysis program involves a series of assessments each with increasing levels (as necessary) of complexity. A risk assessment involves potential failure mode analysis, engineering analysis, risk evaluations, comparison of assessed risk relative to the Tolerable Risk Guidelines, and to support risk-informed decision-making. This process allows the USACE to prioritize the inventory prior to performing additional dam/levee safety studies, additional field investigations, or implementing risk reduction actions. The contribution of engineering geology to data evaluation and compilation; site characterization; and field investigations can be critical to the quality of the risk assessment, level of confidence in the results, and ultimately influences the decisions made at each sequential level of study. This presentation attempts to familiarize those outside the USACE with the risk assessment process and how engineering geology contributes to the results.

Physicochemical Characteristics and Spatial Distribution of Heavy Metals in Soils Near an Abandoned Mine-Complex in Bumpus Cove, TN

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Generally, mining activities increase heavy metal concentrations in soils by producing waste rock, tailings and slag. Un-reclaimed abandoned mine sites may accumulate heavy metals in soil and threaten environmental and public health. Determination of soil physicochemical properties' role in the spatial distribution of metals in soil is essential to monitor environmental pollution. Bumpus Cove, once a rich mineralized district of eastern TN, comprises ~47 abandoned, un-reclaimed mines permanently closed in the 1950s. Mineral deposits include primary sulfide deposits, and secondary oxidized deposits within the residual clay. The 0.67 km2 study area encompasses 7 known abandoned Pb, Zn, and Mn mines. This study evaluated the relationships between soil physical (texture, moisture content, bulk density), chemical (cation exchange capacity [TEC], percent base saturation, pH, total carbon content [TOC]), and heavy metal (Cu, Fe, Mn, and Zn) concentrations in 53 soil samples. Heavy metal concentration ranges as follows: 0.34-2.25 mg/kg Cu, 32-727 mg/kg Fe, 2-750 mg/kg Mn, and 1.31-879.1 mg/kg Zn. Of the measured heavy metals, only Zn concentrations exceeded permissible limits, possibly due to the presence of mining sludge or tailings and slag. Spatially weighted multivariate regression models developed for all heavy metals using soil physicochemical properties produced improved results over OLS regression models. For Fe, the spatial error model retained bulk density only (R2=0.57), for Mn the spatial lag model retained moisture content and TEC (R2=0.60), for Cu, the spatial error model retained moisture content, bulk density, TEC, and percent silt (R2=0.51), and for Zn, the spatial lag model retained pH and TEC (R2=0.67). In general, strong positive correlation is expected between the metals and TOC and clay fractions. This was not evident in the present study. This analysis of soil properties will help define heavy metal concentration and transport in Bumpass Cove, TN.

Coal-Tar-Based Sealcoat—a Potent Source of PAHs with Emerging Concerns – Part I: A Potent Source of PAHs

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Pavement sealants are applied to the asphalt pavement of many parking lots, driveways, and even playgrounds in North America. Sealant products used commercially in the central, eastern, and northern United States typically are coal-tar-based, whereas those used in the western United States typically are asphalt-based. Coal tar and coal-tar pitch are known human carcinogens, and coal-tar-based pavement sealants contain, on average, about 70,000 mg/kg polycyclic aromatic hydrocarbons (PAHs), which is about 1,000 times higher than the concentration of PAHs in asphalt-based sealants. PAH

concentrations in stormwater runoff from coal-tar-sealed pavement are highest in the months following sealant application and decrease with time, but even years after application PAH concentrations remain much higher than those in runoff from unsealed pavement. Additionally, pavement sealant is worn by vehicle tires into a fine powder that collects on pavement surfaces and at curbs and is readily transported by runoff down storm sewers. PAH-contaminated sediment that is not trapped by stormwater ponds can be transported to streams and lakes. The contribution of coal-tar-based sealant to PAHs in lake sediment has been evaluated by a variety of approaches, including environmental forensics, microscopic identification of particles, and land-use analysis. Independent research by scientists and engineers from academic institutions and government agencies demonstrates that coal-tar-based sealant is a potent source of PAHs to water, and to stream and lake sediment.

Coal-Tar-Based Sealcoat—a Potent Source of PAHs with Emerging Concerns – Part II: Implications for Aquatic Health

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Coal-tar-based sealcoat is marketed as a product that will protect and beautify asphalt pavement; it is used on driveways and parking lots primarily in the central, southern, and northeastern U.S. and in Canada. Acute 2-d toxicity of runoff from coal-tar-sealcoated pavement to stream biota, demonstrated for a cladoceran (Ceriodaphnia dubia) and fathead minnows (Pimephales promelas), continues in water-runoff samples collected as long as weeks or months following sealcoat application. Water-runoff samples collected as much as 36 days following coal-tar-sealcoat application caused DNA damage and impaired DNA repair capacity in the fish-liver cell line RTL-W1. These results demonstrate that water runoff from coal-tar-sealcoated pavement is a potential hazard to aquatic ecosystems for at least several weeks after sealant application, and that exposure to sunlight can enhance toxicity and genetic damage. Recent research has provided direct evidence that restricting use of CT sealcoat in a watershed can lead to a substantial reduction in PAH concentrations in the waters and sediments of receiving water bodies.

US-85 through the North Dakota Badlands – Development of a Stratigraphic Column and Correlation to Landslides

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U.S. Highway 85 is a primary north-south transportation artery in western North Dakota that accesses the heart of the Bakken Oil Field. With the increase of oil and gas production, the area is booming and with that comes the need to improve infrastructure. The North Dakota Department of Transportation plans to widen U.S. Highway 85 between Interstate 94 and the Watford City Bypass. The project also includes improving or replacing the existing Long X Bridge over the Little Missouri River, improving or replacing several smaller bridges, and constructing several wildlife crossings and culverts. The primary focus of our evaluation is from Reference Point (RP) 121 to RP 130 along the highway. This section of the alignment traverses badlands topography of the Sentinel Butte Formation that is prone to landslides. The Tertiary Sentinel Butte Formation consists predominately of gray claystone interbedded with siltstone, sandstone, and coal (lignite) seams. Data was collected to characterize the surface and subsurface through several phases of field reconnaissance, mapping, drilling geotechnical borings, laboratory testing, and installing and monitoring of geotechnical instruments. Using this data, Shannon & Wilson developed a stratigraphic column summarizing our interpretation of geologic conditions along the alignment between Elevations 2,580 to 1,805 feet. Twelve coal seams identified during our field investigations were used as primary marker beds throughout the alignment. We also plotted index and geotechnical engineering property laboratory tests results, such as Atterberg Limits and clay mineralogy, to highlight weaker layers or layers of low long-term rock strength within the stratigraphic column. The results of our work are being used to identify those stratigraphic zones contributing to landslide activity in the area and to develop appropriate mitigation recommendations to support highway improvements and reconstruction activities.

A Geological Investigation of the Cherry Valley Road Landslide, Stroudsburg, Pennsylvania

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A landslide south of Stroudsburg, Pennsylvania, occurred on Cherry Valley Road after the heavy rains from Hurricane Lee in 2011. The area is mapped as a glacial kame. Investigations indicated the material located between the stream and the roadway consists of a saturated layer of very soft to hard clay and silt with gravel near the surface. Underlying the upper materials was a layer of very dense silty sand, gravel, cobbles and boulders. Inclinometers and piezometers were installed to measure slope movement and water levels. Readings from the inclinometer confirmed failures surfaces extending from the roadway to the saturated wetlands above Cherry Creek. Due to site constraints based on legal slope easements upslope of the roadway and high quality wetlands downslope of the roadway, slope reconstruction and repair options were limited. The goal of the remediation was stabilization of the roadway while avoiding impacts to the upslope hillside. The materials encountered along with the groundwater conditions impacted the selected remediation for the slope. Reconstruction of the roadway embankment with borrow rock was considered, but the presence of high groundwater levels would complicate excavations and require temporary excavation support during construction. Due to variability of the soils encountered during the geological investigation, drilling during construction for either soil nails or drilled caissons would require considerations for maintaining an open hole due to the potential for granular material. The presence of cobbles and boulders was considered for constructibility due to the need for the contractor to select the appropriate advancement methods for drilling operations. The presentation will also discuss the local geology and its influence on groundwater flow, which may have been disrupted by local conditions such as increased stream flow and surface runoff.

Physical Properties of Monitor Well Grouts: Application to Geologic Settings

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Pumpable bentonite grouts have shear strengths of 0.1 psi or lower; chips approximately 0.7 psi and pellets around 2 psi when placed dry and 0.8 psi when placed through water. Cement-based grouts had undisplaced shear strengths of 4.7 psi or greater; but once displaced, shear strength significantly declines. Cement grouts develop cracks during curing causing a conduit for downward movement of water. Bentonite/cement grouts have been accepted in environmental and other near surface applications, because of a misconception that the addition of bentonite to cement reduces the amount of cement shrinkage during curing and the lowered curing temperature is necessary to prevent collapse of PVC and other plastic well casing; however, bentonite/cement grouts have lower strength, higher porosity,

increased fracturing and are often improperly mixed in the field. Microscopic analyses of cement-bentonite grouts show a reaction fringe along all cracks. Three minerals identified with X-ray diffraction in all cement-bentonite grouts and the neat cement-grout were calcite, vaterite, and portlandite. One unidentified peak in grouts that contained sodium montmorillonite was determined to be calcium silicate hydrate, a common secondary mineral formed from the dissolution of montmorillonite. It is concluded that the fracturing within bentonite/cement grouts is the result of the dissolution of montmorillonite and formation of the secondary minerals. Pumpable grouts are best suited for pressurized (artesian) well conditions or in conditions where subsidence is anticipated. Semi-rigid bentonite seals (chips and pellets) are best suited for wet hole conditions or in environments where vertical movement may occur. Cement grouts are best suited for dry fractured, strong-rock environments where fracturing of the cement does not create a unique vertical conduit for water. Cement/bentonite grouts should only be used in fractured hard rocks.

Advanced InSAR and Photomonitoring: the Contribution of Satellite Imagery for the Investigation and Monitoring of Landslides

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Over the past decades, remote sensing has demonstrated to be a fundamental tool for geotechnical asset management purposes. At this regard, remote sensing techniques based on Synthetic Aperture Radar (SAR) represent a great opportunity for the Earth Observation and landslides investigation & monitoring. Advanced Differential SAR Interferometry (A-DInSAR) allows the identification and measurement of deformational trends for structures and infrastructures, by analyzing very large areas (up to thousands of sq. kms) with a temporal frequency on the order of few days. Moreover, thanks to satellite SAR images archived by several Space Agencies starting from 1992, A-DInSAR allows for detection and measurement of ground displacements occurred in the past with millimeter accuracy. Beside to SAR interferometry, new approaches (like Photomonitoring) have been recently developed to detect and measure higher and faster deformations (meters order), sometimes not well-observed by using common InSAR methodologies. In this work, several case histories will be described to show the potentiality of such techniques for the investigation of landslides processes occurred in the past with millimeter accuracy. More in details, the combination of InSAR and Photomonitoring allowed to combine different scales of investigation and results, such as for the analysis of a huge landslide recently occurred in Italy: the Montescaglioso landslide. In another case, the use of high resolution SAR data (COSMO-SkyMed satellites) allowed to assess the state of activity of more than 25 landslides in the Alpine region (Northern Italy), by observing the evolution of such processes in more than four years from 2010 to 2014. Finally, thanks to new satellite SAR missions with very low revisit time, the capability to predict the time of failure has become a key-topic for such techniques. In this work, such issue will be also described thanks to specifically designed models.

From Outcrop to Web: CGS Integrates Digital Data and GIS Technologies to Map Geology, Hazards, and Groundwater Resources

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The Colorado Geological Survey (CGS) employs an array of digital data and GIS technologies for mapping geology, natural hazards, and groundwater resources, and disseminating the resulting data to the public. Key technologies include iPads with GIS software for data collection and field verification of GIS models, a growing lidardata set for the state, digital aerial stereo imagery, GIS-based models for natural hazard analysis, GIS tools for mapping and analyzing groundwater resources, and web-based platforms for disseminating digital maps and data to the public. This talk will provide an overview of these technologies, a summary of current lidardata acquisition and statewide goals, and a summary of goals for integrating newly-emerging technologies in future projects. Two detailed case studies illustrating use of the technologies will be provided. In the County-Wide Debris-Flow Susceptibility Mapping Program, CGS is mapping areas susceptible to debris flows and/or mudflows on a countywide basis for 43 counties in 13 Priority Areas comprising the mountainous portions of the state. Maps are prepared using GIS-based debris-flow source area and runout models, visual interpretation of high-resolution digital terrain data, and digitized geologic and soil survey data. In the County Geology and Groundwater Resources Program, geologists create three-dimensional layered models of geologic formations on a countywide basis in a GIS environment. This process integrates data from multiple sources starting with surface geologic maps and incorporating other datasets such as subsurface depth information, well distribution data, and water quality data. The compilation is presented in a format that allows users to visualize the spatial distribution of groundwater resources.

From Cradle to Lobe: Catchment Characteristics Supporting Frozen Debris Lobe Formation, Brooks Range, Alaska

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Frozen debris lobes (FDLs) are permafrost features composed of soil, organic material, ice, and liquid water that act as slow-moving landslides transporting soil and debris downslope en masse. Estimated to be a few thousands of years old, we have identified 43 FDLs within the Dalton Highway corridor and nearly 160 located throughout the south-central Brooks Range of Alaska. FDLs have received more attention in recent years as their movement rates increase and as they approach the only transportation corridor connecting Alaska's resource-rich North Slope to Interior Alaska. FDLs flow from cirque-like catchments; however, not all of the catchments within our area of interest (AOI) support FDLs. This research involves studying FDL catchment characteristics and contrasting them with catchments associated with alluvial fans. We present the preliminary analysis of eight catchments within our AOI, four with FDLs and four with alluvial fans. Analysis of slope, curvature, and area indicate that smaller catchment areas with gentle slopes facilitate accumulation of debris, potentially leading to FDL formation. Future analysis will include 1) analysis of precipitation and runoff; 2) an examination of the character and availability of sediments within the catchments; and 3) how bedrock geology and erosion contribute to the type of feature formed by the catchment.

Comparison of Ground Based Interferometric Radar and Lidar for Detecting Rockfall Hazards

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Early detection of imminent slope failures using remote sensing techniques may augment preventative measures that protect both infrastructure and human lives. This study investigates ground based interferometric radar (GBIR) and terrestrial lidar applications for rockfall detection and measurement. A block fall simulation was performed using air bags to dislodge a 2-meter-wide by 1.5-meter-tall boulder, gradually inflating the airbags until the rock was released and fell downslope. The push was not constant- performed over a period of ~40 minutes, including one brief pause where pushing was stopped to readjust airbags. In total 280 radar and 161 lidar images of the push were captured. The radar interferometric processing was performed using software from GAMMA Remote Sensing. Although the pixels corresponding to the studied rock were known a priori (e.g. lidar), we also assess the reliability of persistent scatter identification methods against these known points. The result is a displacement time series with 1-s uncertainties less than 0.4 mm that capture the time dependent motion prior to release. lidar images were segmented to separate the rock face out from the background terrain. Meshes were created from the subset point clouds of the rock and co-registered to the first image. Incremental displacements were calculated using an iterative closest point approach to calculate a transformation matrix to align the rock at each point in time. Line of site displacements were then calculated from these transformations for comparison with the GBIR measurements. The calculated interferograms show finer sensitivity to small-scale displacements than the lidar point clouds, however the lidar data provide unique utility for modeling the rigid body movement of rocks prior to release. Ideally, they would be deployed in tandem to detect and model real rockfall scenarios in near real time.

Change Detection of the West Salt Creek Landslide, Colorado using Multi-Temporal Lidar and UAVSAR Datasets

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The West Salt Creek landslide (WSCL) occurred on May 25, 2014 about 60 km west of Grand Junction, Colorado. Three local men perished in the event. The landslide extended down the West Salt Creek valley for 4.5 km with a peak velocity exceeding 37 m/s and mobilized over 30 X 10^6 m3 of rock and debris. The event resulted in a ~45 Mm3 disturbed bedrock block to back rotate and form a large depression at the base of the headscarp. Surface water began to immediately fill the large depression, reducing the stability of the deformed, partially disaggregated landslide block. Rising pond levels caused local emergency officials and scientists to begin monitoring water levels and the stability of the block using field-based instruments. Due to the large extent of the slide (~2.5 km2) remotely-sensed data were acquired to help assist emergency responders and monitor future slide movements. An initial lidar dataset was collected on June 1-3, 2014 with subsequent flights on November 1, 2015 and July 13-16, 2016. Multiple UAVSAR datasets were collected at several return intervals between April 2015 and 2017. Differential analysis of the lidar between June 2014 and November 2015 indicates minor retrograde migration of the headscarp and occurrence of a small debris flow on the northwest face of the block. Similar analysis of the November 2015 to July 2016 lidar, captured the May 27, 2016 breach of the pond embankment, subsequent channel downcutting (near 20 vertical m in places) through the disturbed block material, deposition of debris, and other small landslides. Additional, smaller-scale movements that are undetectable by lidar, are expressed on interferograms of UAVSAR data. These findings underscore the importance of collecting multi-temporal baseline datasets that can be used to remotely monitor landslide activity and provide valuable information to emergency officials and researchers.

Why So Many Borings? A Framework for the Dam-Site Exploration Plan

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When we explore a dam site to characterize site conditions, we each tend to perceive different needs for exploration, dependent on our individual background and focus of interest. Sometimes different disciplines don't agree where to do explorations. Even more often there is consternation from those responsible for funding the exploration about how many explorations are planned. Sometimes our rationale is too a-specific to be convincing (e.g., "exploration is an investment that will pay off later by reducing uncertainty"). Instead we may gravitate toward the philosophy of "each exploration should be answering a specific question"; then we get mired in a sea of questions, and may even find ourselves creating questions to justify explorations that we innately know we need. It may help to develop our plans under a Dam Exploration Framework, to provide context to the planning process, facilitating development and communication of rationale for the variety of explorations needed. The Dam Exploration Framework recognizes five principle categories of exploration need: 1) Understanding site geology – its domains, features, trends, and anomalies; 2) Answering design questions – characterizing engineering geology constraints and parameters with respect to design analyses and decisions; 3) Informing potential failure modes (PFM) analysis – identifying geologic characteristics, morphology, variability, and uncertainty with respect to PFMs; 4) Evaluating constructability – characterizing engineering geology constraints and parameters with respect to construction activities and temporary configurations; and, 5) Supporting construction management – geologic characteristics and variability (parametric and spatial) with respect to solicitation/bidding risk, construction management risk, and construction claims management (in particular, differing site conditions claims). This presentation will provide an example of how to use this framework as a lens to view a dam site and develop a comprehensive geologic exploration plan.

Slope Stabilization of State Route 120, Clinton County, Pennsylvania

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As part of a project to mitigate slope stability issues along a 1.35 mile section of State Route 120 in Clinton County, PA, The Pennsylvania Department of Transportation (PennDOT) incorporated a Design Build component to rehabilitate five existing concrete and stone retaining walls and 13 areas of slope instability below the roadway. In many areas the slope had failed away from the edge of the travel lane, removing all support from the guiderail, creating a safety hazard. GeoBuild, LLC, was subcontracted by Francis J. Palo, Inc., to design and construct a slope stabilization system to support the roadway in these areas. GeoBuild worked with Gannett Fleming to design the stabilization system, consisting of soil nails along with a structural facing of shotcrete or GeoBrugg Tecco® high tensile strength wire mesh facing with turf reinforcement underlayment. The structural facing uti-

lized was dependent on the subsurface conditions, future erosion probability and slope geometry. Project constraints required that a single lane of traffic be maintained on S.R. 120 for the duration of construction, with limited shutdowns allowed for equipment mobilization. In addition to the roadway constraints there was an active railroad at the toe of the slope below the roadway and overhead utilities running above the slope for the entire length of the project. GeoBuild completed the construction of the soil nails and facing from the existing roadway surface, utilizing a single 11'-wide lane as the work area, without relocating any of the overhead utilities. The soil nails, mesh and shotcrete were installed using excavator mounted drills, manlifts, and rope access. In total, 1,020 soil nails, 25,000 square feet of Tecco Mesh and 12,000 square feet of shotcrete were installed in the 18 areas of slope instability over the course of five months.

The Oroville Spillways – Geology and Why it Matters – Part 1 and Part 2

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The Oroville Dam is located in northern California just outside the town of Oroville. The dam and appurtenant structures were constructed in the mid-1960s. There are two spillways: a gated, concrete-lined chute and a concrete monolith weir with an unlined spill area. The dam site is located in the foothills of the western Sierra Nevada within the Smartville Complex, which has a roughly north-south regional structural trend. The Oroville Dam and spillways were constructed in an unnamed unit of the Smartville Complex, composed of Jurassic meta-volcanic rocks consisting primarily of amphibolite. The amphibolite has a strong structural fabric in roughly the north-south direction and is crosscut by shears oriented about N50E (roughly parallel with the gated spillway) and lower angle shears dipping towards and away from the reservoir. On February 7, 2017, a hole formed in a portion of the concrete-lined spillway at Oroville Dam. Continued operation of the gated spillway caused additional erosion and damage to the concrete structure. The areas of deepest erosion occurred in portions of the spillway that were mapped during original construction as strongly weathered to decomposed amphibolite rock. On February 12, 2017, during operation of the emergency spillway, rapid, deep headward erosion was observed in the northern portion of the unlined emergency spillway. This presentation will discuss the geologic conditions that were understood at the site prior to construction, the geologic conditions that were documented during construction, and what we have learned about the geologic conditions since the spillway failure.

Stability Analysis for the Right Abutment Spillway - Isabella Dam, CA

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Isabella Dam, CA, is located within the southern Sierra Nevada mountain range, approximately 40 miles northeast of Bakersfield. Isabella is a multi-use embankment dam that was constructed in 1953 for the primary purpose of flood control. However, Isabella Dam is susceptible to hydrologic and seismic dam safety concerns. A Dam Safety Modification Project is currently under construction to address these concerns. The modification will include construction of a 440-foot long concrete spillway structure, located along the Dam's right abutment. This additional spillway is designed to facilitate continued usage of State Route 155 and, during extreme flood events, will safely divert flow downstream, bypassing the main dam, to prevent erosion of the embankment and subsequent potential dam failure. The presentation will cover the geologic design and construction concerns pertaining to the foundation of the spillway structure, and will include discussion on challenges in determining suitable founding elevations due to the varying degrees of weathering of the highly jointed Alta Sierra granitic unit. The presentation will describe planar and wedge analyses used to support the sliding stability analysis of the concrete spillway structure, and will also demonstrate the kinematic stability analysis and design of the proposed rock cut slopes above the structure.

1, 4- Dioxane – A Review and Evaluation of the Available Analytical Methodologies Used in Support of the Latest State and Federal Standards

Occhialini, James, Alpha Analytical, jocchialini@alphalab.com (TS#9)

A widely used chemical compound, 1,4-dioxane has a multitude of industrial uses and may be present in a variety of commercial products. Historically, 1,4-dioxane has not been included on most laboratory or regulatory target compound lists and it is now considered as an emerging contaminant. When it was included on VOC target lists, many of the physical and chemical properties that make it such a useful industrial chemical also made it very difficult to determine using conventional analytical methods. Due to the relatively recent classification of 1,4-dioxane as "likely to be carcinogenic to humans," many regulatory standards and guidelines have been lowered. This presentation will review the three most commonly used analytical methods for low-level 1,4-dioxane analysis—Method 8260 SIM, Method 8270 SIM and Method 522. Each method will be evaluated and the data generated in a method comparison study will be presented.

Geohazard Mitigation Using a Risk-Based Asset Management Plan

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The Colorado Department of Transportation (CDOT) is developing a method to manage geohazards using a risk based asset management framework. Through a Geohazards Management Plan (GMP) information from rockfalls, rockslides, landslides, debris flows, embankment failures, and other geohazards is collected and used to measure the risk these events present to the transportation system. The risk is measured as a dollar cost to safety, mobility, and maintenance. In addition, an effort to incorporate slope imaging data on a corridor scale into the GMP to better resource allocation is underway. By comparing slope images over time and combining image data with information collected from Geohazards events, CDOT hopes to direct mitigation efforts to areas of a corridor most susceptible slope failure. This effort in conjunction with the GMP will direct efforts to areas, which will have the most impact to the highway if failure were to occur.

Selection of Sites for the Installation of Solar Panels with a Consideration of Surface Flow in Some Active Mining Areas in Korean Peninsula

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Some part of the Korean Peninsula is lack of electricity on which mining operation severely rely. One possible solution is the installation of solar panels on the available area around the mining site. The suitable site for

solar panel installation should satisfy the following conditions: (i) surface slope in a southern direction to get the maximum sunshine, (ii) enough area for the generation of ample electricity, (iii) low potential of landslide due to rainfall, and (iv) high ground with no risk of flooding. The Musan mine and Gumdeok mine were selected for the study. A series of GIS analyses using digital elevation data was performed to identify possible surface water flow direction and zones of potential flooding. Calculation of the possible electricity generation was conducted for the proposed area using the solar radiation data. The results showed that GIS is a good tool for planning the scenarios for the selection of sites for the installation of solar panels.

Chlorinated VOC Contaminant Plume Assessment in Tidally Influenced Aquifer at a New Jersey Industrial Site

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Historic chlorinated solvents releases from a parts degreaser at a former New Jersey industrial complex resulted in a ground-water contaminant plume migrating beneath residences and toward a tidally influenced creek. Contaminant distribution was characterized using temporary well points and conventional, cluster and multi-port monitoring wells. The tides and periodic storm surges affected plume geometry, and the movement of contaminants into creek-base sediments and toward prospective ecological receptors, and are influencing remedial selection. Ground-water investigations traced the CVOC contaminant plume to within ten or so feet of the creek. Based on the ground-water flow conditions in the aquifer, it is projected that the deeper plume portion extends for some distance beneath the creek, while the upper aquifer contaminant plume discharges into the creek bed. Overall, plume migration is limited and its potential impact diminished by the oscillating tidal effects. This presentation illustrates that the CVOCs distribution is attributed to the diurnal tidal fluctuations within the intermediate zone. The highest CVOCs concentrations at the in-plume wells downgradient of the source area were detected at top of the black silt layer while the highest CVOCs concentrations at near-creek wells were detected much shallower. The CVOC concentrations detected in the near-creek uppermost zone of the upper aquifer are lower than those in the in-plume intermediate zone. The contaminant distribution appears to result from the continuously alternating, tidally-influenced flow directions. The upward ground-water flow component caused by infiltrating surface water during high tides, and ground-water mounding caused by slow dispersion during low tides appears to control and limit ground-water and contaminant flow toward and into the Creek. The contaminants discharging to the creek are insignificant, as demonstrated by pore water and sediment sampling results.

Assessment of the Progression of Coal Mine Subsidence in Colorado, Using InSAR

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Coalmine subsidence is the deformation of the Earth's surface caused by the collapse of rock and unconsolidated deposits into underground mine voids, induced by the extraction of coal. The deformation can cause damage to roads, buildings, utility lines, or pipelines. This project evaluates the applicability of Interferometric Synthetic Aperture Radar (InSAR) for quantifying and delineating the progression of subsidence from active coalmines in Colorado. The data used for this analysis is limited to SAR images collected by the Advanced Land Observation Satellite (ALOS), the Environmental Satellite (ENVISAT) and the European Remote Sensing (ERS) satellites I and II. Three study areas were selected to assess the method's applicability under different conditions (density of vegetation, topography, activity status, and mining method). The study areas are the Deserado Mine, the King Coal II Mine, and the historical mining complex in Colorado Springs. SAR images were processed with Generic Mapping Tools SAR (GMT5SAR) and the Generic InSAR Analysis Toolbox (GIAnT) to produce a time series of quantified deformation. Clear subsidence signatures were found over the Deserado Mine and the King Coal II mine. Deformation above the longwall mine (Deserado) was detected with all the utilized data sets, proving that InSAR can be used to delineate the extent of subsidence over such type of mines. Deformation above the active room and pillar mine (King Coal II) was only detected using ALOS data. No clear signs of deformation were found within the historical mining complex in Colorado Springs. The low density of coherent pixels limits the use of InSAR for delineating troughs above active and historical room and pillar settings.

Geophysical Characterization of a Short Segment of a River Levee

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There are numerous levees in the Mississippi Embayment area that protect adjacent land from frequent and pervasive flooding. Failure of levees causes severe economic and environmental damage, and must be closely monitored and periodically maintained. Failure potential within a short levee segment can be quantified if internal variations and their causes can be identified and incorporated into the geomechanical models. However, lengths of these linear structures make this mission impossible using conventional site investigation methods. This study aims to present a case study demonstrating how a combination of geophysical methods can be used to make the levee characterization as viable objective. For the purposes of this study, a short segment of the Coldwater River levee near Crenshaw, MS was selected as the application site. The geophysical methods utilized in the study include ground penetrating radar (GPR), seismic refraction and vertical electrical sounding (VES). These methods were employed to define the key internal features and flaws of the levee segment studied. The ground model constructed from these surveys was used as the basis for geomechanical modeling to determine the conditions under which the levee segment may experience failure, including seismic shaking and high groundwater levels.

Perfluorinated Compounds in the Widefield Aquifer, Colorado Springs
Part I: Impact to Water Supply and Perfluorinated Compounds in the Widefield Aquifer, Colorado Springs
Part II: Alternative Options for Drinking Water

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Perfluorinated compounds (PFCs) are a family of organofluorine chemicals that have been used for several decades in various products including firefighting foams, coating additives, and surface protection products for carpets and clothing because of their ability to resist heat, oil, stains, grease and water. EPA's third unregulated contaminant monitoring rule, published in 2012, required public drinking water systems to test for 6 PFCs (but did not regulate these chemicals). PFCs were detected in the Widefield Aquifer region, located south of Colorado Springs, in water and other environmental samples.

Levels throughout the aquifer exceed the drinking water health advisory level designed to provide a margin of safety from the potential toxic effects of these chemicals. The three large water supply systems in the region have had to alter their use of groundwater to reduce PFC levels in drinking water, and many smaller private wells and small water systems turned to alternate sources of drinking water. Treatment systems are being installed, so the use of the Widefield Aquifer as a drinking water source may again increase. CDPHE has also issued recommendations to allow a level of protection from PFCs for residents growing and eating food in the region. As there is no natural degradation process of PFCs, these chemicals will leave a lasting impact on the region.

History and Results of the Calaveras Replacement Dam Foundation Grouting Program

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The San Francisco Public Utilities Commission (SFPUC) is currently constructing a replacement dam at Calaveras Reservoir in response to seismic safety concerns. The Calaveras Reservoir provides approximately 40 percent of the SFPUC's water storage capacity in the Bay Area. The dam is located on the Calaveras Creek in the Diablo Mountain Range in Alameda County, California. The new earth/rockfill dam will be 1,210 feet long, 220 feet high and approximately 1,180 feet wide at the base. The foundation grouting program for the replacement dam began in September, 2012 and was completed in December, 2016. Foundation bedrock across the valley bottom and right abutment is composed of Franciscan mélange. The Cretaceous-age mélange is a folded and sheared block-in-matrix formation composed of a shale matrix with variably metamorphosed inclusions of greywacke, serpentinite, greenstone, siliceous schist and blueschist. The left abutment is mostly composed of Miocene-age Temblor Sandstone that lies unconformably over the erosional surface of the Franciscan mélange. A double row 100-foot deep grout curtain has been installed using the split-spacing method. Curtain holes were inclined at 70 degrees in opposing directions along the dam axis. Down stage grouting was performed in the Franciscan mélange; while up-stage grouting was utilized for the Temblor Sandstone. Due to construction schedule constraints, a program of grouting through the overburden was performed prior to final foundation excavation and curtain grouting along the Valley Reach. Approximately 67,500 feet of drilling and 42,350 feet of redrilling were performed during the grouting program. The presentation will review the foundation geology, grouting methodologies used and illustrate the results accomplished during the fifty-two month duration of the CDRP Foundation Grouting Program.

William Jackson Palmer, Civil Engineer, Rail Magnate, and Founder of Colorado Springs

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During the American Civil War William Jackson Palmer (1836-1909) rose up through the ranks to command the 15th Pennsylvania Cavalry and Medal of Honor recipient, who had the distinction of capturing Jefferson Davis before he escaped into Mexico at war's end. Breveted as a brigadier general, after the war, he served as Vice President and Chief Engineer of the Eastern Division of the Union Pacific Railroad, directing construction of the Kansas Pacific Railway between Kansas City and Denver. In 1867-68 Palmer directed the most thorough railroad reconnaissance ever attempted until that time, surveying more than 2,700 miles with a party of 116 surveyors, working in five separate parties, heading south over Raton Pass and then west along both the 32nd and 35th Parallel routes using transits and chains (not just barometers) to the California coast, then up to San Francisco and back across the plains to Missouri. This was the largest and longest railroad survey in American history. For this massive undertaking Palmer chose John Leconte as his geologist and C. C. Parry as his botanist/naturalist/geologist. Palmer and William Abraham bell co-founded the Denver & Rio Grande Railroad, and operated the largest network of narrow gage rail lines in North America, which included the Rio Grande Western Railway, and the Central Mexican Railway. Palmer was "Mr. Colorado," and founded the town of Colorado Springs, as well as Colorado College, and the Colorado Coal & Iron Company in Pueblo. He also made significant financial contributions to funds seeking to educate freed slaves after the Civil War. Palmer fought many battles with the Santa Fe Railway; winning one round in the Royal Gorge of the Arkansas River of his home state, but losing the transcontinental path he had blazed over Raton Pass, which made Santa Fe one of the largest transcontinental carriers.

Overview of the 1921 Pueblo Flood; One of the Deadliest in American History

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The first hint of an impending flood on the Arkansas River in Pueblo, Colorado came at 6:30 PM on June 3, 1921, when an unknown person called and reported that the river was flooding upstream because of a sudden cloudburst ten miles west of town. The flood worsened when Fountain Creek also began to flood from down pours 30 miles north. The flows of the two swollen rivers combined and peaked a little after midnight, while a Denver & Rio Grande Western Railroad train was parked in the City Station, filled with sleeping passengers. At the time Pueblo was the major commercial center of Colorado, with a population of 43,000 people. Approximately 18,000 men worked for one of the four railroads, two foundries, and casket, broom, mattress, macaroni, or coffee roasting factories. At the time one in every five Colorado jobs were in Pueblo and 55 percent of all products manufactured in Colorado came from the city. The flood was very short lived, reaching a peak flow of 108,000 cfs around midnight, which only held for about 6 minutes. The total volume of water during the storms of June 2–5 was about 90,000 acre-feet in Pueblo. The water depth was over 15 feet deep in some portions of the downtown area, drowning almost everyone aboard the trains. All of the bridges over Fountain Creek were destroyed; however, the bridges over the Arkansas River remained. 510 dwellings were washed away, 98 buildings wrecked, and 61 buildings washed off their foundations. It was the deadliest natural flood in American history, with more than 1,500 people losing their lives and $20 million dollars in damages to Pueblo.

Aftermath of the 1921 Pueblo Flood

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Soon after the floodwaters of June 3, 1921 subsided, Pueblo leaders realized the city needed more protection from the Arkansas River. Pueblo hired Arthur Morgan to perform similar studies to those he had overseen for Dayton, Ohio after the flood of 1913. In April 1922, the Colorado Legislature passed an act authorizing formation of the Pueblo Conservancy District to construct flood controls on the Arkansas and Dry Creek, and the district issued $4.5 million in bonds to pay for the construction (1922–29). The central feature of the new system was a rubble masonry dam termed the "Barrier at Rock

Canyon." The half-mile wide structure was constructed of cyclopean masonry up to 40 feet high, and capable of storing about 20,000 acre-feet of water during a flood event (the reservoir pool was normally dry). It was constructed with three vertical notches, through which the Arkansas River and the railroads passed. The river channel through Pueblo was enlarged by constructing 15,000 lineal feet of concrete-faced embankments 32 feet high, which required one million cubic yards of earth and relocation of railroad tracks and four new bridges. The new levees had 45 degree side slopes with a maximum flow capacity of 110,000 cfs, and the improvements were completed by June 1925. A half century later, the Bureau of Reclamation considered replacing the 1925 rock barrier dam with a massive multiple arch concrete dam at the same site, as part of their Fryingpan-Arkansas Project. They ended up settling on a zoned wing embankments with a central concrete buttress spillway structure constructed in 1974–77 and christened Pueblo Dam. In 2014 the Pueblo Conservancy District lowered the Arkansas River Levee by 12 feet as part of a $15 million project to improve flood protection for downtown Pueblo, using the flood storage afforded by Pueblo

Design Evolution of Oroville Dam

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At 770 feet high and 5,600 feet long, Oroville Dam was the highest dam in the world when it was constructed in 1961–68. After voters approved the California Water Project in 1956, The California Department of Water Resources (DWR) appointed a Board of Engineering Consultants (1956-60), an Earthquake Analysis Board (1962-77), and an Earth Dams Consulting Board (1962-74). Research contracts were also let to the University of California-Berkeley to perform traixial tests on 1-meter diameter samples of rock cobbles for the dam's supporting shells, and model tests of the submerged service spillway by the Bureau of Reclamation. The final design employed a concrete pad of 200,000 yds3 supporting the toe of a 400-ft-high cofferdam, which was incorporated into the main embankment in 1965–67. The enormous cofferdam prevented the 100-yr flood of December 1964 from overwhelming downstream levees that had been breached a decade previous, much to everyone's relief. The composite embankment included 80 million yds3 of soil and rock. It was the most heavily instrumented earthen dam up to that time. Oroville's design is rather unique as compared to other American dams and it was the largest non-federal dam ever built in the United States. On August 1, 1975 an M 5.9 earthquake occurred on the Cleveland Hills fault a few miles south of the dam, ushering a new cognizance of seismicity in the Sierra Foothills. CA DWR responded by appointing a Special Consulting Board for the Oroville Earthquake, which convened for four years (1975–79). This board evaluated the information collected in the wake of the quake and gradually expanded to include a series of independent analyses of DWR's existing hydraulic structures in vicinity of Oroville. The board advised DWR on how these could be evaluated for dynamic loading and retrofitted to better resist earthquake-induced damage.

Rio Chama Landslide Mapping, Analysis and Evaluation of Regional Landslide Susceptibility, Archuleta County, Colorado

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Recent catastrophic landslides, such as the West Salt Creek landslide in Colorado and the Oso landslide in Washington, have reemphasized the need for more extensive landslide evaluations in order to prevent disasters. The goal of this research is to map and characterize the Rio Chama landslide, evaluate conditions at failure, predict future behavior, and apply these findings to create a regional susceptibility model for similar failures. The Rio Chama landslide is located near the headwaters of the Rio Chama River in south-central Colorado. It is an active multiple rotational slide and debris flow complex based on the classification scheme proposed by Cruden and Varnes (1996), with observed activity since 1952. Site reconnaissance was conducted in October 2015 and August 2016 and coupled with laboratory testing of samples and limit equilibrium stability analysis in order to evaluate landslide causative factors and physical-mechanical properties of the earth materials. After causative factors were evaluated, a hierarchical heuristic model was applied to evaluate the susceptibility in the surrounding region to failures similar to that of the Rio Chama landslide. Weights were assigned to causative factors based on their influence on landslide susceptibility using pairwise comparison matrices, and weighted parameters were then combined to produce a regional susceptibility map. Validity of the susceptibility map was evaluated by manual interpretation and a consistency ratio. The regional model aims to identify areas susceptible to similar failures, supporting better decisions on appropriate preventative actions to be taken.

Great Salt Lake: A Dynamic Industrial Mineral Resource

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One of Utah's most productive and valuable industrial mineral resources is Great Salt Lake. Several mineral commodities, including salt, potash, magnesium metal, and magnesium chloride, are produced from the lake. In fact, Great Salt Lake is the only domestic source of potassium sulfate (a high-value form of potash) and magnesium metal. At least one operator has considered lithium as a byproduct. Unlike most industrial mineral deposits, the resource at Great Salt Lake is dynamic due to changing salinity caused by lake level fluctuations and modifications to manmade causeways and dikes that divide the lake system. Generally, salinity has an inverse correlation with lake levels, as lake level drops, salinity increases. In 1959, the main body of the lake was divided by a rock-fill railroad causeway, and, as a result, different salinity regimes have developed in the north and south arms because of the imposed flow restriction. Since construction of the causeway, salinity levels in the north arm are often at or near saturation with respect to sodium chloride (ranging from 18 to 28%) due to a net flow of salt to the north. As a result, a salt crust has precipitated within this part of the lake. Salinity in the south arm is significantly lower, ranging from about 5 to 22%, because the vast majority of the lake's freshwater input flows into the south arm. At times, a dense, more saline layer (deep brine layer) forms at the bottom of the south arm as high-salinity brine moves from north to south through the causeway. Recently, modifications to the causeway have affected these dynamics. Three of the lake's major mineral operations are located in the south arm and one is located in the north arm.

Environmental Hazards and Risk Overview and Helpful Hints for Explaining to Your Clients

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Environmental hazards and risks are varied and often unknown prior to beginning a construction project. Identifying and explaining these hazards and risks to non-technical personnel are additional challenges. This presentation will provide an overview of the common environmental hazards that are encountered, how to identify them, how they

can affect your project, and pointers for educating the client about their risk. We will also cover some environmental activities that provide legal environmental protections to the client. Some topics that will be included are: Phase I Environmental Site Assessments, Phase II Environmental Site Assessments, Asbestos, Lead, Mold, Wetlands and Waters of the U.S., Endangered species, Floodplains, Underground storage tanks (heating oil vs. other), Groundwater impacts, Vapor intrusion, How clean is "Clean Fill." This presentation is intended to be useful for non-environmental professional personnel, environmental personnel who specialize in one or two topics, students, and non-technical personnel.

Engineering Rock Mass Classification for Las Vegas Valley Caliche

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Assessing the true performance of deep foundations in the Las Vegas Valley is challenging due to the existence of calcium carbonate cementation of valley sediments. These sediments are fine through coarse grained in size producing a rock-like material, caliche (analogous to concrete), which is formed when the grains are strongly cemented. The strength of this material is a function of the degree of cementation, which can rapidly vary both vertically and laterally. The delineation of caliche thickness, lateral extent, degree of cementation, and strength is challenging. Sample collection is problematic for all but moderately-strongly cemented material owing to the fact that diamond core drilling produces a water based slurry termed "ice cream" by the local drillers. Consequently the engineering strength of weak caliche is often regarded as a soil, potentially producing "conservative" strength design values. To overcome drilling limitations in sample collection, large blocks of caliche (100–400 pounds), representing strong, intermediate and weak materials, have been recovered from excavations within the Las Vegas Basin using excavators. Samples were produced from the various caliche blocks using different methods. Careful core drilling was used for the strong material; hand-carving technique was used for the intermediate material; and re-molding was used for the weak material. The samples enabled the determination of unconfined compressive strength (UCS), P and S seismic velocities, density and porosity for material with low through high cementation. Logging of open trenches from which the large samples were obtained combined with seismic traverses prior to excavation have enabled comparisons to be made between the laboratory and seismic field values, and the seismic values to UCS and degree of cementation permitting global assessment.

Landslide Analysis with Incomplete Data

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Although there is no substitute for careful investigation for slope stability analysis, in reality we are often missing important parameters and still must proceed with the study. This may be because the site is unsafe for drilling and mapping, public safety requires a rapid response, collected samples are not ideal for testing, or topography or groundwater are not accurately known. Several tools allow us to reduce error and estimate both current and future stability. First, analysis of several cross-sections permits iteration as parameters are modified to meet an expected factor of safety of unity at initial failure for all sections. Likewise, unknown parameters can be analyzed within reasonable bounds, based on literature or limited laboratory testing, and these bounds tightened during the iterations. Programs that allow Monte Carlo analysis are ideal for this procedure. Next, a thoughtful incorporation of sensitivity analysis can help focus testing on vital parameters, reduce error and improve confidence in the results. Sensitivity analysis unique to the site is preferred, but general studies show that cohesion is equally important as friction angle for deeper failures, but is about twice as important for shallow failures. Ground-water levels are about half as important as strength parameters. Depth to failure plane becomes more important for shallower slides. Analysis is sensitive to soil unit weight, but this parameter is tightly constrained and does not tend to dominate the error. Finally, for larger slides, there are often smaller failures off the toe that can be used as another calibration point to constrain input parameters. Overall, use of these procedures is good practice for all analyses as it reminds us that even our "known" values, like strength and depth to failure plane or groundwater, always have more variability than we can accurately measure, but that we should account for nonetheless.

Nontributary Groundwater in Colorado: Its Definition, Administration, and Case Studies

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Colorado allocates water based on the doctrine of prior appropriation, which distributes available water based on the date of first beneficial use. Those who put water to beneficial use (water rights holders) earlier have priority over later water users. This allocation started as surface water allocation. Later, when groundwater use increased through mechanization of well drilling and water pumps, it became clear that groundwater pumping could affect surface-water flow rates. In 1969, knowing that groundwater is tributary to surface water, the Colorado legislature integrated groundwater administration with surface water under the doctrine of prior appropriation. The legislature later recognized that some groundwater has a very limited connection to surface water, to the extent that it is essentially unconnected to the surface water system. This type of groundwater is termed nontributary groundwater and is administered separately from the prior appropriation system. To obtain a nontributary groundwater determination evidence must show that an aquifer 1) is hydraulically disconnected or 2) has a limited connection to the surface water system. Case studies of these types of nontributary groundwater are presented.

Considering Area as a Proxy for Volume in H/L Correlations

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Landslide runout is often characterized using the ratio of H/L, where H is the fall height of the landslide and L is the length between its geometric extremes. Previous studies identified a correlation between landslide volume and H/L. However, landslide volume is difficult to estimate accurately, typically requiring high quality before- and after- DEMs or physical excavation of the deposited material. Since these methods are unavailable or impractical at most field sites, volume estimates are often reported only to the order of magnitude. Planimetric area, in contrast, can be estimated easily from surface mapping or satellite imagery. This research explores whether landslide area can act as a proxy for volume in the H/L relationship. Planimetric area is not as fundamental as volume to sliding mechanics and may be greatly affected by restricting topography. Therefore, area vs. H/L correlation curves are likely to be valid only when considering slope failures in similar geologic and topographic settings. This investigation examines the correlation between area and H/L using two types of data sets: 1) subaerial volcanic landslides published in existing landslide inventories, and 2) sets of subaerial landslides clustered in small geographic

areas. Results indicate that area and H/L measurements of local landslides are significantly impacted by young landslides that crosscut and obscure the margins of older landslides; consequently, the area vs. H/L curves do not show a strong correlation. The correlation curves built from published landslide inventories show a much stronger relationship. These landslides were often investigated shortly after failure, when accurate planimetric area and H/L measurements could be recorded. The promising results from the published landslide inventories indicate that area vs. H/L curves, if built from appropriate data, may help create accurate preliminary runout estimates and improve our ability to characterize landslide hazards, thereby protecting people and infrastructure at risk.

Completing a Mentor's Surficial Geologic Maps in Coastal Plain Sediments

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The National Park Service's prioritization in the delineation of geologic resources along the Natchez Trace Parkway and National Scenic Trail (NATR) resulted in the need to finalize the compilation of geologic maps that had been initiated by a mentor and colleague. The quadrangles are in the coastal plain sediments in northeast Mississippi through which the NATR runs. The author had been asked to participate in the development of the Tupelo, Mississippi 7.5 minute quadrangle by the mentor. In that process field excursions were conducted in surrounding areas in the Cretaceous outcrop area. After the mentor's death his family gave the author field maps, field books, field stratigraphic sections, and photographs – some of which the author had participated in developing. A Surficial geologic map was compiled for the Tupelo, MS quadrangles. In addition to the field data, USDA Natural Resources Conservation Service Soil Survey data and Mississippi Department of Environmental Quality, Office of Geology geophysical logs were utilized to complete both quadrangles. In addition Mississippi Department of Transportation borings and lidar were utilized in completing the Tupelo quad. Small-scale geologic maps were also utilized but were of limited use due to their scale and age. The resulting geologic map has been digitized. Surficial units mapped on both quads were Cretaceous sediments with Quaternary alluvium and terrace deposits. Of significant note, the use of lidar was challenging in the gently dipping sedimentary beds and the even gentler sloping floodplains and associated alluvial terraces. However it was determined that using the most possible topographic elevation classifications, but shifting the classes to closely adjacent elevations provided the best way of using the lidar in this case.

Subsurface Construction in Urban Settings – Where Geotechnical Meets Environmental

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We have all heard the adage "Location, location, location!" In a booming real estate market, the most desirable development locations are often in areas that are either within inner cities or areas immediately adjacent to them. These properties often have substantial land use history and have been impacted by previous generations of waste management operations and practices. When these properties are selected due their prime locations, environmental issues often impact redevelopment. Geotechnical issues such as excavatability, groundwater control, foundation support and ground improvement can be significantly affected by contamination and regulatory requirements. This presentation will discuss "real world" geotechnical and environmental construction concerns within the current regulatory environment in the State of Colorado.

Non Scope Risk Assessment Needs for Redeveloping Industrial/Commercial Property to Residential Use

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The urban development of Chattanooga, Tennessee and many other small sized cities has recently experienced former industrial/commercial properties being redeveloped for residential and mixed-use purposes. The increased repurposing of industrial property to residential use always presents site-specific challenges for environmental assessments. Environmental issues that surface when redeveloping an industrial property for residential use include typical issues identified within the scope of ASTM E1527-13 "Standard Practice for Environmental Site Assessment: Phase I Environmental Site Assessment Process" (Phase I). Although the Phase I investigates many potential issues in connection with a property, several environmental issues outside the scope of the Phase I also need to be addressed. When investigating a former industrial/commercial property, potential issues beyond the scope of the Phase I typically include: asbestos, lead in soil, lead paint, mold, wetlands, threatened & endangered species, indoor air quality, cultural & historical reviews and many more. Due to limited available space in urban areas of Chattanooga, developers have increased the footprint of their developments by expanding projects to include adjacent residential property. In addition to addressing environmental issues at older industrial/commercial property, many environmental issues beyond the scope of the Phase I can potentially exist at residential properties in older neighborhoods. Typical issues addressed at older residential properties include: heating oil tanks, asbestos, lead paint, mold, and many more. During an environmental risk assessment of a former industrial/commercial property the use of both the Phase I standard and non scope environmental data is an integral part of risk assessment. Identifying both the scope and non-scope environmental issues during initial site investigation allows clients to best anticipate critical development needs for future intended use of a property.

Evaluation of Environmental Predictors for Sand Boil Formation

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Subsurface erosion poses a significant threat to the maintenance and stability of artificial levees. Sand boils and other features indicative of subsurface erosion typically form only during high water events when our ability to address the hazard is most limited. The purpose of this study is to improve our ability to forecast where sand boils will form by evaluating a variety of environmental factors. The first study area is a 140 mi (225 km) section of levees adjacent the Lower Mississippi River (USA). The second study area is composed of two levee segments: 33 mi (53 km) section along the Ijssel River and a 30 mi (48 km) segment along the Waal River (Netherlands). Utilizing geographic information systems (GIS) the levees are divided into small segments and assigned a series of environmental factors. These factors include normalized difference vegetation index (NDVI), orientation of channel fill deposits, soil physical properties, and more. The information is then fed through a binary logistic regression to evaluate correlation between environmental factors and recorded locations of sand boils. The regression also provides a predictive model for forecasting the locations of future sand boils. Initial results indicate correlation between the formation of sand boils and four factors: NDVI, channel fill orientation, saturated hydraulic conductivity, and AASHTO soil classification. It was also observed that sweetgum, nuttal oak, and willow oak correlate with a decrease in sand boil formation in the Lower Mississippi study area. Plots of

sycamore, pecan, American elm trees, and regions covered by water bodies correlate with an elevated rate of sand boil formation. Despite significant correlation with some environmental factors, sand boils formation could not be reliably forecast using the predictive equations derived from the logistic regression.

Use of Borehole Data in Defining Structure Sets for Rock Slope Kinematic Analysis

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Kinematic analysis for rock slopes requires measured structure orientations. Poles to planes are plotted on a Schmidt net and pole clusters define geologic sets. For a given geologic set, strike and dip values follow normal distributions. Because of waviness of structures, localized stress, sample size, and limitations of measurement techniques, the variability in measured strike and dip values decreases with increasing structure length. Also, variation in the length of structures follows a Weibull distribution, with the shortest structures being most abundant, so the short structures with the greatest orientation variability are the ones that are most sampled. Because of these characteristics, it is important to use structures of various lengths appropriately. For rock slope design, surface exposures provide necessary data for structure length, spacing, roughness, and other characteristics. Conversely, boreholes provide limited data from small samples. The purpose of borehole data is largely to confirm that the structural domain at depth is the same as that at the surface, by comparing structure orientations. For the comparative analysis, the directional blind zone for the borehole should be placed on the Schmidt net for surface data. Poles within the blind zone are removed. Comparison of Schmidt nets for the modified surface data and for borehole data provides evidence of whether the structure domain is the same at depth. Comparison of contoured plots of modified surface data verses the entire surface data set often provides striking evidence of how the borehole blind zone can affect geologic set definition. This method eliminates potential introduction of error related to the common practice of using Terzaghi corrections on borehole data to remove directional bias. The borehole data should be used to define structure sets for kinematic analysis only if there are insufficient surface data.

Influence of Secondary Structure on Toppling Failure of an Overhanging Limestone Cliff, Lake Whitney, Texas

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In February 2014, a tension crack was discovered beneath a 5,800-square-foot home situated above a 90-foot-high overhanging cliff on the east shore of Lake Whitney, Texas. The tension crack enlarged until the south portion of the cliff collapsed in June 2014, destroying the home. The north portion of the cliff collapsed during a severe storm in May 2015. The cliff formed by differential erosion between the Edwards limestone caprock and the more erodible argillaceous limestones and shales of the underlying Comanche Peak. The cliff was undercut approximately 65 feet prior to collapse, and is unique to this portion of the shoreline. The severity of the undercut may be associated with the cliff's position adjacent to a sharp meander bend in the Brazos River, forming largely before impoundment of Lake Whitney in 1951. The collapse exposed a set of steeply dipping joints oriented subparallel to the failed cliff face. Where the failure surface diverged from the strike of the joints, they were separated by intact rock "bridges" of thickness roughly equivalent to the joint spacing. Joints of similar orientation were mapped in other nearby outcrops. An undercut shale bed at the bottom of the cliff formed the base of the failure. The joints combined with the shale bedding acted as planes of weakness, which controlled the geometry of the failure. The center of mass of the cliff under study was located five feet beyond the toe, rendering it kinematically unstable with respect to toppling. Shale undercutting rates estimated from slake durability indices suggest that the cliff had been in an unstable configuration for decades. Considering negligible tensile strength along the joints and shale seams, the delay in failure is attributed largely to the strength provided by the rock bridges between joints and, in some cases, bedding.

Probability Statistics in GIS: Mapping Landslide Susceptibility, a Case Study in Colorado Springs, El Paso County, Colorado

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With its western portions located on the foothills of the Rocky Mountains, Colorado Springs, Colorado has proven to be highly susceptible to landslides, which cause ongoing destruction of numerous hillside and mesa top developments. In 2003 the Colorado Geological Survey (CGS) published Map Series 42: "Potential Areas of Landslide Susceptibility in Colorado Springs, El Paso County, Colorado." These maps are based on site conditions that are similar to areas where landslides have previously occurred and are intended to show areas that have geologic, topographic, and geomorphic characteristics that indicate potential landslide susceptibility. Developing a methodology that can help provide information based on geotechnical data could assist in endeavors prior to any fieldwork or additional subsurface investigation design. The goal of this study is to provide two workflows appropriate for mapping landslide susceptibility using a 1) Indicator Kriging method and a 2) Logistic Regression method, different than that of CGS Map Series 42. Both produces probability of occurrence of an event based on the geologic, topographic, and groundwater conditions and are compared for effectiveness in both workflow and results. The study area includes a southwestern portion of Colorado Springs, a specific area that exhibits landslide susceptibility. These workflows are part of an effort to produce a useable product that could potentially be used by the industry given the necessary parameters to map landslide susceptibility.

Using Hydrated Lime and Wick Drains for Urgent Remediation of a 2015 Landslide in Colorado Springs

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In the spring of 1999, and 2015, Colorado Springs, Colorado, received rainfall that significantly exceeded historical averages. In 1999, various residential areas situated on sloping terrain on the west side of Colorado Springs experienced landslides. In 1999, impacted homes were subsequently eligible for a Federal Emergency Management Agency buyout program. In 2015, several residential areas in southwest Colorado Springs, unaffected in 1999, experienced landslides. In 2015, one residential property in the vicinity of the upper part of an ancient landslide and older debris flow was adversely affected. While the residential structure was safe, a large part of the home's property experienced a landslide. Complicating the situation were two separate waterline easements with pipes traversing the landslide perpendicular to the direction of ground movement. One pipeline was abandoned in 1966, and the second one, owned by a local utility, was active at the time of the landslide in early May 2015. The landslide crown area was owned by two different owners with the local utility's active water line and easement along the property line shared by the two owners. The cost estimate

for a permanent fix to ground movement for the owner with the undamaged structure exceeded $10 million. This greatly exceeded the value of the property and the home. Funding to address the situation was a very small fraction of the $10 million. The site had very limited access and there were other constraints, which eliminated most remediation options. This paper explains how the landslide crown was addressed using hydrated lime and wick drains to slow down the progressive failure of the landslide. In time these solutions may evolve to be the longterm solution.

An Old Landslide Never Dies – Data Collection and Initial Engineering Analyses of the Gros Ventre Landslide

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The Gros Ventre Landslide (GVLS) is in Teton County, approximately 15 miles northeast of Jackson, Wyoming. The GVLS occurred on June 23, 1925, creating a landslide dam in the Gros Ventre River Valley that was subsequently breached on May 18, 1927. The landslide consisted of over 50 million cubic yards of rock, soil, trees, debris and other materials. The dam breach resulted in the loss of human lives, cattle and property. Today, the GVLS remains an active and complex landslide with multiple hazards and dynamic processes at work. Notable features within the GVLS footprint provide evidence that must be considered in any analysis. This presentation summarizes information that has been collected and highlights processes, features and other site specific information pertinent to site hazards and understanding the conditions at the time of the 1925 landslide and the landslide dam breach in 1927. A possible sequence of failure for the 1925 landslide is shown as a preliminary hypothesis. This paper is an interim report and future work includes additional data collection and civil engineering analysis.

Locating a Proposed Nuclear Power Plant at a Previous Plant Site in Crystalline Rock – A Novel Issue for NRC Geologists

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The foundation unit at the proposed William States Lee III nuclear power plant site in South Carolina comprises deformed Charlotte Terrane rocks, specifically a metagranodiorite older than 300 Ma and metadiorite dikes. The proposed plant is located at the original site of the Cherokee Nuclear Station (CNS), which was previously licensed but never constructed. Original CNS Unit 1 corresponds to Lee Unit 1 and lies under foundation concrete, creating a novel issue for implementation of the NRC's Geologic Mapping License Condition (GMLC) that requires a licensee to map lithologies and tectonic and non-tectonic features in excavations for safety-related structures to ensure a negligible potential exists for surface deformation at a new plant site. Because concrete cover precluded direct examination of foundation rocks at Lee Unit 1, staff evaluated the applicant's rationale for concluding that no significant potential exists for tectonic deformation at Unit 1 by conducting the following activities: (1) Examining the original CNS foundation geologic maps; (2) Comparing lithologies, faults, fractures, and shear zones captured on the original CNS maps with rock types and tectonic features observed at adjacent Lee Unit 2 and in the surrounding area; (3) Examining outcrops at the southeastern edge of CNS concrete that expose a prominent northwest-striking shear zone mapped at CNS Unit 1; (4) Comparing foundation rocks in archived CNS Unit 1 core with archived and new core samples from Lee Units 1 and 2; and (5) Reviewing radiometric age dates acquired for CNS and examining relationships between exposed tectonic features at Lee Unit 2 and in the surrounding area to confirm that shearing occurred more than 145 Ma ago. NRC will require the licensee to implement the GMLC for Lee Unit 2, once excavations are completed, to ensure no tectonic features exist that might produce surface deformation at Unit 2.

Integrating Geologic and Geotechnical Data to Assess Suitability of a Nuclear Power Site in Carbonate Rock at the NRC

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The foundation unit at a proposed nuclear power plant site in Levy County, Florida, is made up of the Avon Park Formation, a partially dolomitized limestone that is older than 38 My and contains some weathered horizons. Site geology necessitated an integrated approach to NRC's independent assessment of the potential for non-tectonic surface deformation at the site resulting from karst development, specifically potential subsidence or collapse associated with subsurface dissolution in the Avon Park that could affect site suitability. NRC staff reviewed information provided by the applicant related to geologic controls on karst development (site stratigraphy, fracture spacing and density, secondary porosity, dissolution rates), karst characteristics (location and dimensions of subsurface dissolution voids, void coalescence, distribution and thickness of void infillings), geomorphology and lineaments as surficial indicators of karst, and potential effects on geotechnical site parameters. Staff confirmed the applicant's characterization of the Avon Park and subsurface dissolution voids therein through direct examination of sparse rock outcrops, borehole lithologic and geophysical logs, rock core, and grout uptake test data during field audits. During a July 2016 mandatory public hearing convened by the NRC for the Levy County site, staff provided testimony to confirm that, even considering influence of secondary fracture porosity on groundwater movement in the Avon Park, no significant potential exists for non-tectonic surface deformation at the site due to subsurface dissolution. Staff also confirmed that a proposed 75-foot-thick grouted zone beneath the safety-related structures, designed to keep excavations dry during construction, is not required to ensure stability of the foundation unit. A Geologic Mapping License Condition, which the NRC will impose once excavations for safety-related structures are completed, requires detailed mapping of the newly exposed Avon Park to document geologic and geotechnical characteristics of foundation materials at grade level as an important final assessment of site suitability.

Assessing the Potential for Groundwater Contamination From Illinois' Landfills Using Remote Sensing and GIS Technology

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Prior to implementation of the 1993 Subtitle C and D regulation of disposal, solid wastes were incinerated, "dumped," and buried in unlined sanitary landfills sited without consideration for local geology, hydrogeology, and natural hazards. These 3,430 legacy landfills were covered and closed with thin, compacted-earthen caps and rooting layer. Seasonal weathering, waste decomposition, and erosion have reduced the effectiveness of the caps to reduce infiltration of precipitation into the landfill to make unwanted leachate. Post-closure assessment by GIS analysis using regional geologic, land cover and aquifer maps can improve identification of landfills having a higher probability to contaminate the groundwater. Landfill inspections when performed, are conducted by field 'walkover' reconnaissance that can overlook defects hidden by vegetation, inaccessibility, or lack of time for a thorough examination. Inspection reports are key to landfill cover maintenance, which is critical to prevention of groundwater con-

tamination. The combination of reduced oversight, inadequate or no groundwater monitoring, coupled with increased need for water resources warrants stringent management of the poorly located structures. Since the only accessible part of the landfill is the cap through which as much as one-half of annual precipitation infiltrates, maintenance of the earthen cover is critical. Unfortunately customary 'walkover' field inspections are insufficient to find defects obscured by dense or tall vegetation; steep, inaccessible slopes or other obstacles. Publicly available remotely sensed imagery, aerial lidar and photography, can improve field inspections by providing detailed image maps from which defects and features of interest can be identified prior to 'walkover' inspections. The GIS-based photo interpretations can form the basis of a landfill inspection.

Search for the Dog Valley Fault – Cause of the M 6 Truckee Earthquake Near the Stampede, Boca, and Prosser Creek Dams

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The M 6.0 Truckee earthquake of 12 September 1966 has a reported location of 39.438°N 120.160°W at ~10 km depth (Ryall et al., 1968). The epicenter was just ~5 km southwest of the location of Stampede Dam—an earth-fill structure built in 1970 to impound as much as 280,200 acre-feet of water in Stampede Reservoir. USBR estimates 148,000 people living downstream along the Truckee River and in Reno would be affected should the Stampede Dam fail and cause failure of the Boca Dam just downstream. The Truckee earthquake was attributed to a previously unrecognized fault called the Dog Valley Fault (DVF). The surface trace of the DVF has remained elusive. We have used the Seismo-Lineament Analysis Method, focal mechanisms and location data for earthquakes and aftershocks originating nearby since 1966, geomorphic analysis based on newly acquired lidar data, and geological fieldwork to search for the DVF. The fault plane solution of the Truckee earthquake has a strike of 44° and dip angle of 80° toward 134° with a horizontal slip vector indicating left-lateral strike slip (Tsai and Aki, 1970). The trend of aftershock epicenters located with a local network in 1966 was ~32°. We found small faults on the drought-exposed shoreface of the reservoir within ~50 m of the upstream side of the dam, on both the north and south sides. These faults had cores measuring ~10 cm wide filled with clay gouge between slip surfaces displaying near-horizontal shear striae. Other small faults had previously been mapped on the roadcut above the north side of the dam. Continuing work on the search for the DVF is motivated by concern for the safety of the Stampede Dam and its reservoir, and the potential hazards they pose to people and property downstream should the DVF produce another substantial earthquake.

Using the 2D MASW Method to Estimate Depth to Bedrock and Soil Variations to Facilitate Environmental Remediation

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Operations before 1965 at a 17,000+-acre Superfund site created large plumes of trichloroethene (TCE) and explosive compounds. Current remediation of soil and groundwater consists of four groundwater treatment plants and several groundwater extraction wells. Some extraction wells exhibit greatly reduced flow rates compared to other nearby extraction wells. Previous work at the site indicated that discontinuous zones of higher shear wave velocity in the unconsolidated materials were located in the vicinity of extraction wells with low flow rates. A 2D MASW survey was devised to determine the variation in the depth to bedrock and variations in lithology of the unconsolidated deposits that could affect pumping rates in order to facilitate the optimal placement of a new groundwater extraction well. 2D MASW data were collected along six lines ranging from about 1,100 to 1,800 feet long, for a total of 8,600 feet. Four lines were collected in a northeast-southwest orientation and two lines were collected in a northwest-southeast orientation over the area where the new extraction well was needed. The data were processed using SurfSeis software produced by the Kansas Geological Survey. The data were interpreted to indicate the estimated top of bedrock. This estimated top of bedrock elevation was contoured in a pseudo-3D fashion to better indicate lower elevation areas of bedrock where TCE and other dense non-aqueous phase liquids would likely settle. The data also revealed a discontinuous higher shear wave velocity layer in the overlying soil, which could indicate more dense material that could impact the extraction rate of a well because of lower permeability. The optimum location for the new extraction well could then be determined by the absence of the higher shear wave velocity layer in an area of lower bedrock elevation.

Debris-Flow Risk Management: Recent Activity in Western Canada

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A variety of debris-flow and debris-flood risk management projects have been undertaken in British Columbia and Alberta, Canada during the past five years, following a series of damaging events. This presentation will provide an overview of these projects, focusing on new tools and techniques that have been developed and lessons learned. Risk assessment methods are commonly applied as a decision-making tool, both at a regional level to prioritize hazard sites, and at a site-specific level to aid in the selection of mitigation measures and design events. Regional-scale assessments have relied heavily on digital and desktop analysis of topography and aerial photographs to efficiently identify the most important, highest risk sites through simple characterization of debris flow hazard and potential consequence. Site-specific debris-flow risk management projects have relied on quantitative risk assessment methods to estimate loss of life risk and economic impacts of damaging events. Life loss risk has then been compared to quantitative risk thresholds to assess risk acceptance, and to demonstrate that proposed debris-flow mitigation measures reduce risk to a tolerable level. Design of debris flow mitigation measures, both at conceptual and detailed levels, has been completed at a variety of hazard sites, protecting facilities ranging from individual houses, to neighborhoods, highways, and buried pipelines. Lessons learned at each project include the importance of a sequential design process, risk transfer considerations, and new methods for estimation of debris-flow protection design parameters. These lessons have been incorporated into a debris-flow protection design tool, created to guide practitioners from mitigation option identification through option selection and detailed design. The design tool draws heavily from European and Japanese literature and design examples, where centuries of experience in debris-flow risk management have produced substantial practical design knowledge.

Evaluating the use of Google Earth and Google Street View for Rockfall Hazard Rating

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Rockfall hazards from cut slopes along highways are primarily caused by unfavorable orientations of discontinuities or undercutting of strong rocks by weaker rocks. A rockfall hazard rating system (RHRS) was first introduced in Oregon in 1987 to rate a cut slope's potential for releasing rockfalls (Pierson 1993). RHRS is a numerical score-based rating of parameters that promote rockfalls and amplify their impact. The parameters include slope geometry (height, angle, roughness, orientation), driver's line of sight, climate, and geologic data (discontinuity characterization, undercutting susceptibility). Geologic information such as discontinuity orientation data is traditionally collected using the line survey method at the site. The method is time consuming, expensive and can be dangerous. The purpose of this study is to test the use of Google Earth and Google Street View tools to remotely collect data for RHRS purposes for selected parameters. The selected parameters, categorized under are slope profile, geologic characteristics, and impact factor parameters are quantitatively and qualitatively measurable using Google Street View and Google Earth. A section of U.S. 33 with a high density of road cuts and two more sites along interstate 64, all located in Virginia were selected for the study. Sites were evaluated by using a combination of measurement tools available in Google Earth and a visual inspection of the rock units in Google Street View. The overall rating results showed rating scores ranging from 147 to 411, where the maximum possible score is 891. These results were also compared with on site evaluations.

Foundation Geology at Mosul Dam, Iraq (1 of 2)

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Mosul Dam is a 3.4-km-long zoned embankment dam completed in 1984 to impound the Tigris River about 50 km north of the city of Mosul Iraq. The dam was built on a karst foundation common to this region of northern Iraq. The geology in this area includes layered sequences of evaporitic units including anhydrite and gypsum interbedded with limestone and alternating clay units known as marls. This stratigraphy extends several hundred meters at depth and has been complexly folded and faulted within the foreland fold belts of the Zagros Mountains to the northeast. Solubility rates for gypsum and anhydrite are several times that of limestone and other karstic rocks more commonly seen in the US. When anhydrite becomes hydrated to become gypsum, it undergoes up to 60 percent dilation in situ, causing intense fracturing to adjacent rock units. As the resulting gypsum goes into solution, voids and collapse features form, which are filled with broken clasts of limestone and clay marl from overlying units forming massive gypsum breccias. The processes of dilation, solution, collapse and brecciation leave rocks in core and outcrop with a shattered appearance and significant permeability. The effects of these chemical and geologic subsurface processes are critical to the evaluation and monitoring of the Dam. The U.S. Army Corps of Engineers (USACE) have performed an extensive evaluation of the dam that has categorized the dam at extremely high risk. The Mosul Dam Task Force is a multinational effort led by the USACE to perform emergency foundation grouting beneath Mosul Dam. Objectives are to reduce immediate risk of failure by intensive grouting of the foundation from the 2.2 km long grouting gallery constructed on centerline of the dam. The focus of the emergency grouting program is to identify critically affected foundation areas and remediate by grouting.

Mosul Dam – Interim Results of Remedial Grouting Program (2 of 2)

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The consequences from failure of Mosul Dam would be catastrophic for the country of Iraq. The U.S. Army Corps of Engineers (USACE) has been involved with the project since 2003 and currently is providing technical assistance to the Government of Iraq (GoI) for remediation of the dam. Construction of the dam began in 1981 with closure in June 1984. First filling of the reservoir was initiated in the spring of 1985. Seepage was immediately observed due to the high permeability of the karstic foundation units and solutioning of interbedded gypsum and anhydrite layers within the foundation. The Ministry of Water Resources (MoWR) has been grouting the foundation during different periods since 1985. The GoI has awarded a contract to the Trevi Group for foundation grouting and repair of the Bottom Outlet (low level outlet). The GoI has designated the USACE to be their Engineer and provide oversight of the contract. A detailed Risk Analysis (RA) has been completed by USACE to advise on further dam safety actions. The USACE is working closely with the MoWR and Trevi to plan and execute the work. The existing instrumentation system is also being evaluated and upgraded to provide for assessment of the performance of the dam. The presentation will summarize the results of the ongoing remedial grouting program and potential additional risk reduction measures that may be implemented.

USACE Levee Risk Assessment Process – Lessons Learned

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Risk assessment methodology has been developed and applied to dams to increase the overall safety of individual dams and groups of dams. When applied to individual dams the process is used to identify potential failure modes for the dam and assess the level of risk for each failure mode, as well as the total probability of failure for all loading conditions. The results of many dam risk assessments have been used to assess the relative risks from a portfolio of dams to aid in priority ranking for funding of improvements to reduce the risk related to the portfolio of dams. The risk assessment process that has been developed for dams is being applied in a modified form to levees by USACE. The focus of this presentation is to discuss the differences in the risk assessment process between dams and levees. Based on the completion of several USACE levee risk assessments, the biggest differences are related to the location and variable foundation conditions of levees, and levee operational issues that are not common with dams. The technical portion of a risk assessment is essentially the same for levees and dams. Additional differences in risk assessments also stem from multiple entities involved in funding the operation, maintenance, and ownership of levees that create differences in the way the results of a risk assessment are applied to the implementation of remedial measures.

Taking the Mystery Out of USACE's ER 1110-1-1807 Drilling in Earth Embankment Dams and Levees

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Engineering Regulation for Drilling In Earth Embankment Dams and Levees (ER 1110-1-1807) was adopted in December 2015. This regulation applies to all USACE dams and levees where there is a government interest either through ownership and O&M, federally authorized and turned over to local sponsor for O&M, or through P.L. 84-99. Under P.L. 84-99 (33 USC 701n), USACE will assist in repairing levee

systems and other flood risk management projects after a flood event if the projects meet the required eligibility criteria through the voluntary Rehabilitation Program. This ER contains numerous requirements for the drilling plans, for the personnel preparing the plans and those implementing the plans in the field with the primary purpose of minimizing the risks to the structures from these intrusive actives. If these activities are being done for any outside agency or owner, the work also needs to undergo the 408 process. Section 14 of the Rivers and Harbors Act of 1899, as amended, and codified in 33 USC 408 (Section 408) provides that the Secretary of the Army may, upon the recommendation of the Chief of Engineers, grant permission to other entities for the permanent or temporary alteration or use of any USACE Civil Works project (raises, alignment changes, penetrations through, under or over the structure, utilities, drainage features, etc.). This presentation will cover the general requirements of this ER, along with the submittal and review processes.

Subsurface Exploration of Glacial Landforms using Ground Penetrating Radar in Pictured Rocks National Lakeshore, Michigan

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Pictured Rocks National Lakeshore features sandstone cliffs and a high-relief landscape along the southern shore of Lake Superior in the Upper Peninsula of Michigan. Landforms in this region show geomorphic evidence of a complex glacial history, yet until recently, interpretations of landscape development at Pictured Rocks have been fairly vague. While detailed surficial geology maps can be interpreted to understand the most recent glacial influence, subsurface data can show internal structures of various landforms to allow a more comprehensive understanding of landscape origin and development. Ground Penetrating Radar (GPR) was selected as an ideal non-invasive method to rapidly acquire subsurface data to view meter-scale depositional structures in glacial landforms around Pictured Rocks. Over 42 km of GPR data were collected in three days along unpaved roads using 100 MHz bistatic antennas. The extremely sandy sediment in the region yielded excellent GPR reflections to an approximate depth of 20 m. Minimal post-processing was necessary to interpret the data, requiring only horizontal stacking (3-5 scans), a 60 MHz high-pass (low-cut) filter, a gain multiplier function, and topographic correction. Results show a clear distinction between reflection patterns of sandy outwash and sandy till. Reflections in some areas indicate several buried outwash events that show increasing deformation with depth. Additionally, we determine that the crest of a prominent upland that parallels the southern Pictured Rocks border is constructed of several interchanging sections of outwash and sandy till. These findings suggest that at least two glacial advances with different hydrological conditions influenced the surficial geology of this region. This study highlights the importance of interdisciplinary research to understand the complex glacial and geomorphic history of Pictured Rocks.

Qualitative Analysis of Sand Resources in Texas for Hydraulic Fracturing

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Proppant cost is becoming an increasingly significant component of hydraulically fractured wells in Texas. A typical well in the Delaware and Midland basins consumed 2.5 million lbs. and 5.5 million lbs., respectively, in 2010, but the quantity has since risen to more than 5.5 million lbs. in the Delaware basin and 9.5 million lbs. in the Midland basin. The total proppant cost, $0.8 - $1.8 million per well, forms 6-25% of the total well cost in these basins. Therefore, a reduction in proppant will favorably affect well economics. Natural sand, which forms over 80% of the proppant market by volume, has two major cost components: (1) mining and (2) transportation. The Great Lakes region in the Northern US, the country's largest source of high quality "Northern white sand," results in a high transportation cost when hauled over 1,200 miles to the Permian basin in West Texas. Hence, the locally mined "Texas brown sand" provides a competitive advantage in transportation cost but has lower compressibility strength as compared to the Northern White Sand. Several sand mining companies in the region have targeted markets requiring up to 6,000–8,000 psi compressibility strength. A previous study has shown that Texas has over 5 billion metric tons of undeveloped frac sand resource, but the quality of this sand is largely unknown. This paper analyzes samples from the several regions in Texas, as per the industry's testing standard: ISO 13503-2. The findings are then used to identify regions within the Permian basin that are suitable for Texas sand.

Using Multidisciplinary Field Investigation to Improve the Assessment of Internal Erosion

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El Vado Dam was originally designed and built by the Middle Rio Grande Conservancy District during the early 1930s. Ownership of the dam was later transferred to the Bureau of Reclamation in 1954. El Vado Dam is distinctive in design and construction, as the dam was constructed with a ¼ inch steel plate on the upstream face that serves as the sole water barrier for the random earth-fill structure. In conjunction with the unique seepage protection of the embankment, the left abutment of the dam foundation is comprised of a highly fractured landslide within the Tres Hermanos Sandstone Member of the Mancos Shale Formation. These factors, along with historical observations of seepage and distress, demonstrated the need for further assessment of the potential for internal erosion. A field investigation was developed to include a multidisciplinary approach for assessing internal erosion conditions in the embankment and foundation of the dam. Investigations included drilling and strength testing, specialized laboratory testing, geophysical applications, hydrogeological testing, and assessments of instrumentation, aerial photography, and field mapping. These investigative approaches were used to thoroughly characterize the embankment and foundation materials, and to detect and characterize the locations of flaws in the foundation which could represent geologic vulnerabilities to the embankment structure. As no single investigative method would inform all of the potential factors related to internal erosion, the results from all investigations were integrated in a visual and conceptual format to improve judgment and reduce uncertainty. As such, the integrated results were used to identify discontinuities in the rock foundation and at the contact with the embankment, provide evidence for or against the migration of embankment material into the foundation, characterize the flow characteristics of the discontinuity network, and assess the continuity of any erodible features within the foundation.

Linear Construction Projects – Transco Natural Gas Pipelines

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Natural gas-fired generators account for over 33% of all electrical generating capacity in the United States, surpassing coal in 2016. With the increased utilization of natural gas, additional pipeline construction is needed to supply the power plants. Contaminated sites

and wastes generated during construction can be a major environmental concern effecting both cost and schedule of a project. Several Transcontinental Gas Pipe Line Company, LLC (Transco) pipeline projects in New Jersey, including the pipeline delivery laterals associated with the Woodbridge Energy Center and the Newark Energy Center, are presented to illustrate some of the preconstruction investigation and construction activities needed to address contamination encountered during construction. Transco's Woodbridge Delivery Lateral (WDL) is a 2.4-mile pipeline that was constructed through a congested urban environment of mixed residential, commercial and industrial area in eastern central New Jersey to service a new power plant generating electricity for more than 700,000 homes. Three sections of horizontal directional drills were completed under rows of aboveground solar panels, the New Jersey Turnpike and interstate exchange ramps. The route also crossed a remediated site containing a former landfill that was surrounded by a hydraulic barrier wall, which needed to be temporarily breached during the installation of the pipeline. The 1,400-foot-long Transco's Newark Energy Center (NEC) lateral traversed three separate properties, including a bulk petroleum storage facility, a railroad, and a vacant contaminated site. The management and handling of excess contaminated materials and dewatering effluent encountered throughout both project corridors were major environmental concerns.

Advocating for Geoscience, The Roles of AEG and AEG Member

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Increasingly, the geoscience profession is being harmed by poor decisions and shortsighted laws enacted by legislative bodies without input from those with the knowledge and expertise to know the potential ramifications of those decisions and laws. In addition, basic science education has been compromised either from budget cuts or from unreasonable dictates of what can and cannot be taught. Basic geoscience research funding has also faced significant cuts and appears to be facing even more drastic cuts in the near future, and multiple attempts have been, and are being, made to de-license or eliminate professional registration for geoscience professionals. Development in high geohazard areas has been allowed to continue without consideration of the associated life and monetary risks associated with such development. We in the geosciences are in debt to the future of geoscience because of our past inaction in responding to the threats to our profession and to the science we represent. This paper will present ways in which we can advocate for geosciences such as through proactive outreach to the public, the press, and to legislative bodies, and by providing sound geoscience reactions though the media to events that could use the input of those knowledgeable in the scientific principles associated with such events.

Comparison of Two Physically-Based Regional Landslide Susceptibility Models in Kerala, India

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Physically based deterministic and probabilistic slope stability models are promising candidates for quantifying the effect of climate and land-use change on landslide susceptibility. In contrast with statistical models, physical models directly incorporate environmental variables such as root cohesion and pore water pressure into stability calculations, but their application towards regional and global scale factors has been limited, particularly in Asia. I compared two infinite slope models, PISA-m and TRIGRS, over the state of Kerala, India to determine their suitability for application to large data-poor regions. Several remote sensing data products, global models of soil properties, and rainfall statistics were together employed to parameterize the two models in the absence of local data sources. Both programs succeeded in developing reasonable outputs with the available data, however, PISA-m consistently predicted much more failure area compared to TRIGRS, which was thought to be caused by differences in the data sources used for some properties, such as soil thickness. The efficient stochastic computation of PISA-m and the flexibility of inputs of TRIGRS were identified as individual strengths of the two programs. However, it is concluded that a comprehensive model would include both elements to create the most realistic approximations of parameters in data-poor situations. This demonstrates the applicability of physical models to a growing field of analysis and lays the groundwork for future studies in the continent of Asia.

Evaluation of Freeze-Thaw Durability of Concrete Containing Carbonate Aggregates: A Comparison of Test Methods

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Concrete durability subject to freeze thaw attack is a major concern for pavements in many regions of the United States including Indiana. Deterioration due to D-cracking has been a major, long-term problem for concrete composed of carbonate coarse aggregate. Beam freeze thaw testing (ASTM 666) is a proven method for predicting concrete durability, but the method involves 350 cycles of testing and a 3.5 month time span. Testing of the unconfined aggregates is less time consuming but typically yields less reliable results. The author has been involved with this concern for a considerable period of time and has contributed to a series of studies that included laboratory testing and petrographic evaluation, the most recent one being Desta, et al., (Proc. Highway Geology Symposium, 2015). A comparison of testing of unconfined aggregates is made in the current presentation, including 1. Bulk specific gravity and absorption, 2. Acid insoluble residue, 3. Brine freeze thaw testing, 4. Sulfate soundness testing, and two new techniques, 5. Hydraulic fracture testing, and 6. Coupled Plasma Optical Emission Spectroscopy testing. These last two were developed by Desta. The author in the past has relied on acid insoluble residue, sulfate soundness and petrography to evaluate carbonate aggregates for use in concrete. Results from the above techniques are compared to those of the beam freeze thaw test based on a study of 18 sources of carbonate aggregates in Indiana (from Desta, et al., 2015.)

Characterization of Recycled Crushed Glass Cullet as an Aggregate for Coastal Nourishment and Restoration Applications

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Coastal southeastern Louisiana, formed over the last few thousand years by the natural delta switching process of the Mississippi River, is lacking sufficient sediment supply to continue to grow the delta of the Mississippi, as dams and water impoundments upstream of the mouth of the river, within the Mississippi River watershed entrap sediments upstream that would otherwise be entrained in river flow and deposited in the Mississippi River Delta. On a seemingly separate note, a 2016 study reported that Louisiana recycles the lowest percentage of municipal solid waste of any state in the nation. How are these two statements related? What if improving the recycling rate in Louisiana provided a previously unaccounted sediment source? Glass is amorphous silica dioxide. Sand is silica dioxide. Glass crushed to sand-size (cullet), when tested in geotechnical engineering laboratories has per-

formed equally well or superiorly to natural sand of similar composition. Previous studies have characterized glass cullet properties for use as highway subgrade, filter media, and embankment backfill, as well as material used for beach nourishment. This paper builds on previous research and presents new laboratory results that suggest recycled crushed glass cullet, when used as an aggregate mixed with dredged material for marsh creation projects, will substantially decrease marsh edge elevation loss over the life of the project while simultaneously decrease the amount of glass in the waste stream, decrease municipal waste disposal costs, and create a new market for glass recycling within the state that recycles the least.

Applications of Modern Limit-Equilibrium Computer Applications to Assess Deep-Mixed Shear Panels in Accordance with USACE Design Specifications

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Deep soil mixing (DSM) as a means of ground improvement was pioneered by Asian and Scandinavian countries in the mid-20th century. Although first employed in the United States in 1986, DSM was not widely practiced until recently, specifically in the aftermath of levee destruction in south Louisiana resultant of Hurricane Katrina. Deep-mixed shear panels - overlapping, circular DSM columns constructed to create a subsurface shear wall perpendicular to centerline of the levee, can provide many construction benefits including reduction of lateral footprint of the levee by allowing construction of steeper slopes and reducing the time of construction by eliminating the time required for consolidation settlement. Considering these and additional benefits, the Corps of Engineers funded the preparation of Design Guide for Levee and Floodwall Stability Using Deep-Mixed Shear Walls. The guide presents closed-form recommendations to analyze the deep mixed zone for internal, external, and global stability as well as analyzing potential for soil extrusion between panels. Despite the commendable engineering acumen showcased in the design guide, the guide is functionally outdated as, despite being published in 2011, it uses a less than user friendly MS-DOS based computer program to define driving and resisting forces acting on the deep mixed zone. This paper uses the force equilibrium equations presented in the design guide and modern limit-equilibrium and standard spreadsheet computer software to evaluate examples presented in the design guide to ultimately compare results of each method and make recommendations for the use of modern computer software in conjunction with the design guide when designing deep-mixed shear walls.

How Do I Know What I Don't Know!?

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We have all had that "aha!" moment when you notice an error. The error gets resolved and all is right in the world, right? Then, months later you have another "aha!" moment, when you learn something new on a different project that relates to the previous project. You go back and make the change before the contract goes out and all is good, right? Hopefully, but if I had two "aha" moments, how many didn't I have? How do I notice something, if I haven't learned about it yet? Some projects go to completion without ever knowing there were unrealized "aha" moments, but many "aha" moments occur during or after construction. If we are lucky, no cost is associated with these late realizations. More often though, the costs build up through project modifications and sometimes, horribly, through the loss of life. So, how do I know what I don't know? Industry has come up with ways to safeguard against this: well-rounded teams (yeah, show me the money), factors of safety (but, what about that estimated input parameter?), engineering during construction (hey, why was the student intern the only one performing QA?), independent reviews (why was the soils engineer reviewing rock slope stabilization plans?), … you know what I'm getting at! We can also suffer from our own knowledge gain. The more I learn, the more confident I become and the less likely I may be to question my own work. And if I tell the engineer that the levee is founded on a 15-foot-thick layer of well sorted sand and he interprets that as well graded sand we are still good to go right? RIGHT? WRONG! The point of all this? Well, I'll see you in Colorado Springs!

Using InSAR Time Series Analysis to Characterize Tunnel Induced Surface Deformation

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As transportation corridors reach capacity, tunneling has become an increasingly necessary means of providing infrastructure to densely populated urban areas. Tunnels are often constructed close to the surface, increasing the likelihood of excavation induced ground subsidence and the potential impact on overlying established core infrastructure such as buildings, bridges, and utility lines. It is therefore necessary to quantify surface deformation induced by tunneling processes in order to better understand the factors that contribute to surface subsidence. Interferometric Synthetic Aperture Radar (InSAR) is an ideal tool for measuring surface deformation related to tunnel construction because of its ability to make measurements with sub-centimeter accuracy over large areas, as well as the availability of historical data needed to identify any pre-construction deformation. Theoretical analysis of tunneling in homogeneous media indicates that surface settlement profiles are transversely Gaussian in shape, with maximum displacement observed directly above the center of an individual tunnel. However, surface settlement geometry is dependent upon a variety of factors including geology, water table depth, and excavation method. Here we apply Persistent Scatterer (PS) and Small Baselines Subset (SBAS) InSAR time-series techniques incorporating ascending and descending Sentinel-1 data acquired during recently completed and ongoing tunneling projects in the United States. Surface deformation measured before, during, and after tunnel excavation allows us to make inferences about subsurface conditions and better characterize the impact of tunnel excavation on overlying ground and structural deformation.

The "New" Project Data Books and How They Impact Risk Assessments

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The purpose of the Project Data Book (PDB) is to provide U.S. Army Corps of Engineers (USACE) personnel with a single source document that contains all readily available and relevant data that is technical in nature for use in subsequent analyses, evaluations, and risk assessments. This information is critical to the success of the risk evaluation process and must be available in a summarized and well-organized format given the very large amounts of data. The geologist, geotechnical engineer, and instrumentation specialist should work together to prepare and properly assemble the PDBs. Risk assessment is an integral part of the USACE dam safety program. The need to gather and assimilate historic design memorandums, site investigation data, construction documentation with photos, and performance data over the life of the project is essential to making sound risk informed decisions. The PDBs are also a critical resource in evaluating if data gaps exist,

and in the subsequent development of additional field investigations. Every risk assessment should begin with gathering, organizing, and scanning data for easy access but this data has not always been kept close at hand. Locating and identifying relevant project data may involve site visits to project offices, USACE District offices and the National Archives and Record Administration. The PDB is created with the participation of subject matter experts who understand what should be included. New data, either discovered or collected after the preparation of this data book, should be reviewed for inclusion into subsequent revisions and information not found or is inaccessible should also be documented.

Large Landslide Remediation by Slot-Cut Construction Technique at a Southern California Landfill

Zemuy, Yonas, Geosyntec Consultants, yzemuy@geosyntec.com; Zahra Amini, zamini@geosyntec.com; Alex Stern; Saverio Siciliano (TS#8)

Construction in existing landslide debris can be very challenging. The complexity of such construction becomes unique when livelihood of the project is tied to constructing steep slopes. Landfills are great examples of such projects where maximizing the air space capacity coupled with maintaining the stability of existing landslides demand advanced design, analysis, construction technics and sequencing. Segmental (also known as slot-cut) excavations have been widely used to maintain stable slopes during excavations adjacent to structures or at the toe of steep and potentially unstable slopes. It is well known that the improvement of slope performance in slot-cut excavations over what would be expected based on two-dimensional evaluations is due to the contribution of out-of-plane resistance or the three-dimensional (3D) effect on slope stability. The evaluation of slot-cut stability in practice, however, is often based on a highly simplified single-block wedge analysis valid only for simple slope geometry and homogeneous soil conditions. We recently proposed a remedial design for a large landslide (over 75 acres) in formation materials at a major landfill in Southern California, incorporating the slot-cut excavation approach. The design calls for a staged development with segmental excavation and engineered buttress construction along the toe of an existing creeping landslide. Using 3D software, the critical slots at several locations along the toe of the landslide were analyzed to provide input into the project specifications. The landslide was evaluated from several different orientations and appropriate recommendations were made. This presentation will discuss the overall approach to remediation of the landslide, origins of the slot cut approach for this project, and the proposed implementation of the approach including monitoring with geotechnical instrumentation.

The Benefit and Limitation of InSAR Technique for Geohazard Assessment

Zhou, Wendy, Colorado School of Mines, wzhou@mines.edu (TS#22)

Interferometric Synthetic Aperture Radar (InSAR of IfSAR) is an active radar remote sensing technique used in geodetic imaging. Two or more Synthetic Aperture Radar (SAR) images can be used to generate digital elevation model (DEM) and maps of surface deformation by taking advantage of the phase shift between images. The SAR sensors can be carried by satellite, aircraft, or any ground-based sensor holders. InSAR technique has broad implications in geohazard assessment. These implications include, but are not limited to, volcanoes monitoring, earthquake risk estimating, measuring landslides displacement rate, ground subsidence mapping, measuring flood extents, and determining climate related changes in glacier outflow. InSAR's all-weather day-and-night large-area imaging capability makes it particularly useful for analyzing ground surface deformation and identifying deformation patterns. There are many successful examples of InSAR application for geohazard assessment in the literature. The limitations of InSAR technique, however, were discussed to a much less extent in the literature. The technique has potential to detect millimeter-scale ground deformation over a time span of a few days, months to years. It cannot, however, detects ground deformation at anywhere and anytime. There are many factors that prevent the production of desired deformation signals, including atmospheric noise, heavy vegetation, steep terrains, fast deformation rate, small study area, and bad incident angle. Additionally, InSAR results are often algorithm, software or operator dependent. This presentation will present the benefit and limitation of InSAR techniques through data processing examples from a few research projects.

Foundation Spotlight:

The West-Gray Scholarship Fund

July 11, 2017

Dear Chapter Chair

The West-Gray Scholarship Fund was initiated in 2014 by Dick Gray and myself to fund scholarships in the eastern portion of the United States. Since that time, we have granted scholarships for three years. Currently we are able to award two scholarships per year, $500 to an undergraduate and $1000 for a graduate student. Since it's a newly established fund, the corpus is so small that it is unable to generate much income. To date, annual contributions have been used to pay for the awards. We would like to build up the endowment to the point that it generates a significant amount of annual interest to provide a meaningful scholarship award.

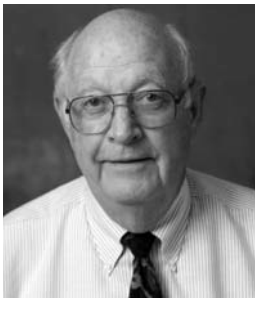
This scholarship is the only AEG Foundation fund that is targeted specifically to the eastern U.S. Therefore, for us in the eastern U.S., it is our scholarship that is eligible to only candidates in our part of the United States. To accomplish the goal of building the endowment to a significant level, I am asking for your support to bring this about.

For those areas west of the eastern U.S., I am asking you to support the West-Gray scholarship as well. Students located outside the eastern U.S. are eligible to win the scholarship if their research area is situated within the eastern U.S. In addition, some of your members may have ties to the eastern U.S. and would be inclined to support a scholarship dedicated to that region. Lastly, I am certain that some of your members would like to participate in a worthy AEG cause and participate in establishing this new scholarship.

There are several ways to support the scholarship:

- At your chapter meeting, ask the attendees to contribute by passing around a basket for donations. If one or more of your members is motivated to do so, propose a challenge by matching the contributions made by those present. I have done this on two occasions at the Chicago Chapter meeting with good success.
- Conduct a fund raising event to raise money for the scholarship. The Texas Chapter gives short courses to generate money for the Mathewson Scholarship for students studying in Texas. Funds accumulated by conducting a field trip is another possible source.
- By making a contribution directly to the West-Gray Scholarship through the AEG Foundation. Send contributions to Alex Vazquez, Operations Manager, AEG Foundation, 4123 Broadway # 817, Oakland, CA, 94611.

This is certainly a worthy cause and a meaningful way to generate interest in AEG from our current geology students. Please contact me for further information and to report progress made on generating funds for the West-Gray Scholarships.



Very truly yours,

Terry R. West.
Professor of Earth Science
Purdue University
AEG Past President

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