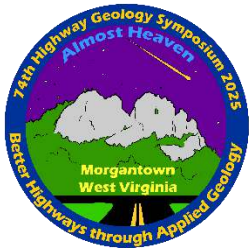
2025

HGS PROCEEDINGS

74TH HIGHWAY GEOLOGY SYMPOSIUM

AUGUST 11-14, 2025
MORGANTOWN, WV



74th Highway Geology Symposium

August 11-14, 2025
Mariott Morgantown Waterfront Place
Morgantown, WV

Grateful Acknowledgments

A huge "Thank You" to the folks who made this Symposium possible:

74th HGS Local Committee:

Wayne Perkins
Dr. Elizabeth Rhenberg
Madison Urse
Emerson Loisel
Chris Ruppen
Kyle Halverson
John Pilipchuk
Ken Ashton

Thanks also to:

Jessica Moore, WVGES Director and State Geologist
John Lasko, Michael Baker International, Inc.
Jeremiah Knavenshue, Michael Baker International, Inc.
Brandon Raines, WVDOT
Phil Dinterman, WVGES Deputy Director
Hannah Sphar, WVGES
Barnes Nugent, WVGES
Randy Toth, WVGES
John Tudek, WVGES
HGS National Steering Committee
Delaney Meeting and Event Management
West Virginia Department of Transportation
The West Virginia Geological and Economic Survey Staff

WVGES
West Virginia Geological and Economic Survey

Geology Underlies it all

74th Highway Geology Symposium

August 11-14, 2025
Mariott Morgantown Waterfront Place
Morgantown, WV

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The Proceedings of the 74th Highway Geology Symposium are dedicated to

Dr. Terry R. West

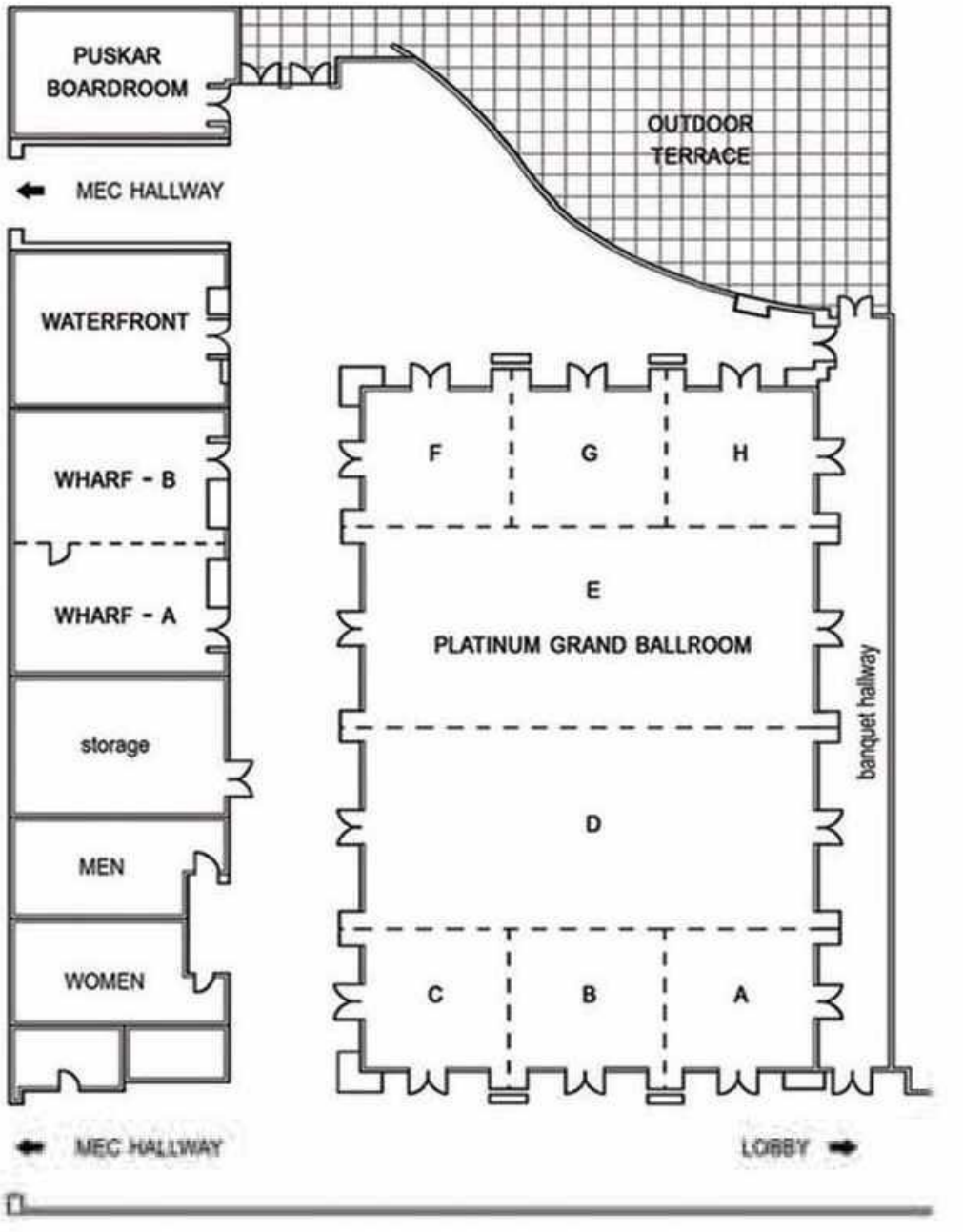
Dr. Terry Ronald West passed away March 4, 2025 at the age of 88. He was born in Saint Louis, MO August 15, 1936. Terry received two undergraduate degrees and a Master's degree from Washington University and another Master's and a PhD from Perdue University. He went on to become a full-time instructor and professor at Perdue, where he taught for 61 years. He was a Perdue multi-sport season ticket holder and enjoyed everything about his beloved Boilermakers.

Dr. West was a long-time member of Association of Environmental and Engineering Geologists and is listed on their web page as "one of the legendary professionals" in the field of engineering geology. Terry authored a widely used textbook, Geology Applied to Engineering, in 2010 and released an updated second edition in 2018.

Terry had a very long history with the Highway Geology Symposium. He was 28 years old when he presented his first paper at the 15th HGS in Rolla, Missouri in 1964. Since then, Terry has authored and presented 28 papers. In 1967, he served as a co-chairman of the local committee for the 18th HGS in Lafayette, IN, and became a member of the HGS National Steering Committee. He remained an active member of the Steering Committee for 59 years, serving on numerous committees. Terry's contributions and longstanding participation with the National Steering Committee and the Symposium will be greatly missed.

74th Highway Geology Symposium
August 11 – 14, 2025
Morgantown, West Virginia

Mariott Morgantown Waterfront Place
Main Floor



74th Highway Geology Symposium

Schedule at a Glance

	Monday, August 11, 2025	Location
9:00 AM - 6:00 PM	Registration Open	Platinum Grand Ballroom Foyer
1:00 PM - 5:00 PM	Multi-Agency Special Session	Platinum Grand Ballroom - Salon ABC
5:00 PM - 6:30 PM	HGS National Steering Committee Meeting	Wharf AB
6:00 PM - 8:00 PM	Icebreaker Reception *Sponsored by GeoStabilization International*	Platinum Grand Ballroom Foyer & Terrace

	Tuesday, August 12, 2025	
7:00 AM - 8:00 AM	Breakfast	Platinum Brand Ballroom Foyer & Salon EFGH
7:00 AM - 5:00 PM	Registration Open	Platinum Grand Ballroom Foyer
7:00 AM - 5:00 PM	Exhibits Open	Platinum Grand Ballroom Foyer
8:00 AM - 9:00 AM	Welcome to West Virginia!	Platinum Grand Ballroom Salon ABCD
9:00 AM - 3:00 PM	Guest Tour & Activity	Offsite - Depart from Hotel Lobby
9:00 AM - 10:00 AM	Technical Session 1: Young Authors	Platinum Grand Ballroom Salon ABCD
10:00 AM - 10:30 AM	Morning Break *Sponsored by Central Mine Equipment Co.*	Platinum Brand Ballroom Foyer & Salon EFGH
10:30 AM - 11:50 AM	Technical Session 2: Young Authors	Platinum Grand Ballroom Salon ABCD
11:50 AM - 1:00	Lunch	Platinum Brand Ballroom Foyer & Salon EFGH
1:00 - 2:40 PM	Technical Session 3	Platinum Grand Ballroom Salon ABCD
2:40 PM - 3:10 PM	Afternoon Break *Sponsored by Hager-Richter Geoscience, Inc.*	Platinum Brand Ballroom Foyer & Salon EFGH
3:10 PM - 5:00 PM	Technical Session 4: Improving Availability of Information on Landslide Loss and Effects	Platinum Grand Ballroom Salon ABCD

	Wednesday, August 13, 2025	
7:00 AM - 8:00 AM	Breakfast	Platinum Brand Ballroom Foyer & Salon EFGH
7:00 AM - 5:00 PM	Registration	Platinum Grand Ballroom Foyer
7:00 AM - 3:00 PM	Exhibits open	Platinum Grand Ballroom Foyer
8:00 AM - 10:00 AM	Technical Session 5	Platinum Grand Ballroom Salon ABCD
10:00 AM - 10:30 AM	Morning Break	Platinum Brand Ballroom Foyer & Salon EFGH
10:30 AM - 11:50 AM	Technical Session 6	Platinum Grand Ballroom Salon ABCD
11:50 AM - 1:10 PM	Lunch	Platinum Brand Ballroom Foyer & Salon EFGH
1:10 PM - 2:30 PM	Technical Session 7	Platinum Grand Ballroom Salon ABCD
2:30 PM - 3:00 PM	Afternoon break	Platinum Brand Ballroom Foyer & Salon EFGH
3:00 PM - 4:00 PM	Technical Session 8	Platinum Grand Ballroom Salon ABCD
4:00 PM - 4:20 PM	Field Trip preview	Platinum Grand Ballroom Salon ABCD
6:00 PM - 7:00 PM	Banquet social	Platinum Grand Ballroom Foyer
7:00 PM - 10:00 PM	HGS Banquet & Awards *Entertainment by Eric Lewis & 80s Enough*	Platinum Brand Ballroom Foyer & Salon EFGH

	Thursday, August 14, 2025	
6:30 AM - 7:00 AM	Grab & Go breakfast *Sponsored by Fragmentation Efficiency Services, Inc. and KESCO, Inc.*	Platinum Brand Ballroom Foyer & Salon EFGH
7:00 AM	Field Trip Departs Breakfast provided by FES, Inc., KESCO, Inc. Transportation sponsored by Maccaferri, Inc. Snacks/soft drinks sponsored by Ameritech Slope Constructors Beer sponsored by Scarptec Snow cones (Kona Ice) sponsored by GSI/Access Limited	Hotel Lobby
12:30 PM	Lunch *Sponsored by Geobrugg*	Blackwater Falls State Park
6:00 PM	Approximate Return to Morgantown	Hotel Lobby

	Friday, August 15, 2025	
8:30 AM - 4:00 PM	Whitewater Rafting Trip - Geology of the Cheat River Narrows *Pre-Registration required*	Offsite - Depart from Hotel Lobby

Highway Geology Symposium
History, Organization, and Function

Inaugural Meeting and Beginnings

Established to foster a better understanding and closer cooperation between geologists and civil engineers in the highway industry, the Highway Geology Symposium (HGS) was organized and held its first meeting on March 14, 1950, in Richmond Virginia. Attending the inaugural meeting were representatives from state highway departments (as referred to at that time) from Georgia, South Carolina, North Carolina, Virginia, Kentucky, West Virginia, Maryland, and Pennsylvania. In addition, a number of federal agencies and universities were represented. A total of nine technical papers were presented. W.T. Parrott, an engineering geologist with the Virginia Department of Highways, chaired the first meeting. It was Mr. Parrott who originated the Highway Geology Symposium. It was at the 1956 meeting that future HGS leader, A.C. Dodson, began his active role in participating in the Symposium. Mr. Dodson was the Chief Geologist for the North Carolina State Highway and Public Works Commission, which sponsored the 7th HGS meeting.

Organization

Unlike most groups and organizations that meet on a regular basis, the Highway Geology Symposium has no central headquarters, no annual dues and no formal membership requirements. The governing body of the Symposium is the National Steering Committee composed of approximately 20 – 25 geologist and geotechnical engineers from state and federal agencies, colleges and universities, as well as private service companies and consulting firms throughout the country. Steering committee members are elected for three-year terms, with their elections and re-elections being determined principally by their interests and participation in and contribution to the Symposium. The officers include a chairman, vice chairman, secretary, and treasurer. all of whom are elected for a two-year term. Officers, except for the treasurer, may only succeed themselves for one additional term. A number of three-member standing committees conduct the affairs of the organization. The lack of rigid requirements, routing and relatively relaxed overall functioning of the organization is what attracts many participants. The symposia are generally run for 3 days, with 2 days for technical papers and a full day field trip. The Symposium is often preceded with a special session or workshop and an opens with an evening Ice-Breaker. Occasionally, an optional workshop or field trip may follow the Symposium

Symposium Locations

Since the initial meeting, 73 annual (2 years missed for COVID) Symposiums have been held in 36 different states. Between 1950 and 1962, the meetings were east of the Mississippi River, with Virginia, West Virginia, Ohio, Maryland, North Carolina, Pennsylvania, Georgia, Florida, and Tennessee serving as host state. In 1962, the symposium moved west for the first time to Phoenix, Arizona where the 13th annual HGS meeting was held. Since then it has alternated, for the most part, back and forth from the east to the west.

1st	1950	Richmond, VA
2nd	1951	Richmond, VA
3rd	1952	Lexington, KY
4th	1953	Charleston, WV
5th	1954	Columbus, OH
6th	1955	Baltimore, MD
7th	1956	Raleigh, NC
8th	1957	State College, PA
9th	1958	Charlottesville, VA
10th	1959	Atlanta, GA
11th	1960	Tallahassee, FL
12th	1961	Knoxville, TN
13th	1962	Phoenix, AX
14th	1963	College Station, TX
15th	1964	Rolla, MO
16th	1965	Lexington, KY
17th	1966	Ames, IA
18th	1967	Lafayette, IN
19th	1968	Morgantown, WV
20th	1969	Urbana, IL
21st	1970	Lawrence, KS
22nd	1971	Norman, OK
23rd	1972	Old Point Comfort, VA
24th	1973	Sheridan, Wy
25th	1974	Raleigh, NC
26th	1975	Coeur d'Alene, ID
27th	1976	Orlando, FL
28th	1977	Rapid City, SD
29th	1978	Annapolis, MD
30th	1979	Portland, OR
31st	1980	Austin, TX
32nd	1981	Gatlinburg, TN
33rd	1982	Vail, Co
34th	1983	Stone Mountain, GA
35th	1984	San Jose, CA
36th	1985	Clarksville, TN
37th	1986	Helena, MT

38th	1987	Pittsburgh, PA
39th	1988	Park City, UT
40th	1989	Birmingham, AL
41st	1990	Albuquerque, NM
42nd	1991	Albany, NY
43rd	1992	Fayetteville, AR
44th	1993	Tampa, FL
45th	1994	Portland, OR
46th	1995	Charleston, WV
47th	1996	Cody, WY
48th	1997	Knoxville, TN
49th	1998	Prescott, AZ
50th	1999	Roanoke, VA
51st	2000	Seattle, WA
52nd	2001	Cumberland, MD
53rd	2002	San Luis Obispo, CA
54th	2003	Burlington, VT
55th	2004	Kansas City, MO
56th	2005	Wilmington, DE
57th	2006	Breckinridge, CO
58th	2007	Pocono Manor, PA
59th	2008	Santa Fe, NM
60th	2009	Buffalo, NY
61st	2010	Oklahoma City, OK
62nd	2011	Lexington, KY
63rd	2012	Redding, CA
64th	2013	North Conway, NH
65th	2014	Laramie, WY
66th	2015	Sturbridge, MA
67th	2016	Colorado Springs, CO
68th	2017	Marietta, GA
69th	2018	Portland, ME
70th	2019	Portland, OR
71st	2022	Asheville, NC
72nd	2023	Tacoma, WA
73rd	2024	Lawrence, KS
74th	2025	Morgantown, WV

Symposium Format

The symposia are scheduled for three days, with two days of technical papers and a full day for the field trip. The Symposium is often preceeded with a special session and/or workshops and opens with evening Ice-Breaker, followed by two days of technical presentations and a full day field trip.

Highway Geology Symposium Field Trip

The field trip is the focus of the meeting. In most cases, the trips cover approximately 150 to 200 miles, with stops visiting geological, geotechnical, and cultural points of interests in the host state or nearby.

Some highlights of past Symposium field trips: In Wyoming (1973), the group viewed landslides in the Big Horn Mountains; Florida's trip (1976) included a tour of Cape Canaveral and the NASA space installation; the Idaho and South Dakota trips dealt principally with mining activities; North Carolina provided stops at a quarry site, a dam construction site, and a nuclear generation site; in Maryland (1978), the group visited the Chesapeake Bay hydraulic model and the Goddard Space Center. The Oregon trip included visits to the Columbia River Gorge and Mount Hood; the Central mine region was visited in Texas.

The Tennessee meeting in 1981 provided stops at several repaired landslide in Appalachia regions of East Tennessee. In Utah (1988) the field trip visited sites in Provo Canyon and stopped at the famous Thistle Landslide.
In New Mexico (1990), the emphasis was on rockfall treatments in the Rio Grande River canyon and included a stop at the Brugg Wire Rope headquarters in Santa Fe. Mount St, Helens was visited by the field trip in 1994 when the meeting was in Portland, Oregon.

1995 the West Virginia meeting took us to the New River Gorge Bridge that has a deck elevation of 876 feet above the water, and at the time, was the longest single arch span in the world. In Cody Wyoming, the 1996 field trip visited the Chief Joseph Scenic Highway and the Beartooth Uplift in northwest Wyoming. In 1997 the meeting in Tennessee visited the newly constructed future I-26 highway in the Blue Ridge of East Tennessee. The Arizona meeting in 1998 visited the Oak Creek Canyon near Sedona and a mining ghost town at Jerome, Arizona. The Virginia meeting in 1999 visited the "Smart Road"

New River Gorge Bridge

Sidling Hill Syncline

Project that was under construction. This was a joint research project of the Virginia Department of Transportation and Virginia Tech University. The Seattle Washington meeting in 2000 visited an ancient lahar in the Mount Rainier area. A highlight of the Maryland symposium in 2001 was visiting the Sideling Hill road cut for I-68, which beautifully exposes a tightly folded syncline, common in the Valley and Ridge physiographic province of the Appalachians. The California field trip in 2002 provided a field demonstration of the effectiveness of rock netting against rock falls along the Pacific Coast Highway. The Kansas City meeting in 2004 visited the Hunt Subtropolis which is said to be the "world's largest underground business complex". It was created through the mining of limestone by way of the room and pillar method. The Rocky Point Quarry provided an opportunity to search for fossils at the North Carolina meeting in 2005. The group also visited the US-17 Wilmington Bypass Bridge which was under construction. Among the stops at the Pennsylvania meeting were the Hickory Run Boulder Field, the No.9 Mine and Wash Shanty Museum, and the Lehigh Tunnel. The New Mexico field trip in 2008 included stops at a soil nailed wall along US-285/84 north of Santa Fe and a road cut through the Bandelier Tuff on highway 502 near Los Alamos where rockfall mesh was used to protect against rockfalls. The New York field trip in 2009 included the Niagara Falls Gorge and the Devil's Hole Trail.

In Oklahoma (2010) the trip saw the complex geology of the Arbuckle Mountains in the southern part of the state along with stops at Tucker's Tower and Turner Falls. In the bluegrass state of Kentucky (2011) the trip included stops at Camp Nelson, the site of the oldest exposed rocks in Kentucky, near the Lexington and Kentucky River Fault Zones. Additional stops at the Darby Dan Farm and the Woodford Reserve Distillery illustrated how the local geology has played such a large part in the success of breeding prized thoroughbred horses and made Kentucky the "Birthplace of Bourbon". In Redding, California, the 2012 field trip included stops at the Whiskeytown Lake, which is one in a series of lakes that provide water and power to northern California. Additional stops included Rocky Point, a roadway construction site containing Naturally Occurring Asbestos (NOA), and Oregon Mountain where the geology and high rainfall amounts have caused Hwy 299 to experience local and global instabilities since first constructed in 1920.

The 2013 field trip in New Hampshire highlighted the topography and geologic remnants left by the Pleistocene glaciation that fully retreated approximately 12,000 years ago. The field trip included stops at various overlooks of glacially carved valleys and ranges; the Old

Man of the Mountain Memorial Plaza, which is a tribute to the famous cantilevered rock mass in the Franconia Notch that collapsed on May 3, 2003; the lacustrine deposits and features of the Glacial Lake Ammonoosuc; views of the Presidential Range; bridges damaged during Tropical Storm Irene in August 2011; and the Willey Slide, located in the Crawford Notch where all members of the Willey family were buried by a landslide in 1826. The 2014 (Wyoming) field trip presented a breathtaking tour of the geology and history of southeast Wyoming, ascending from the high plains surrounding Laramie at 7000 feet to the Medicine Bow Mountains along the Snowy Range Scenic Byway. Visible along the way were a Precambrian shear zone, and glacial deposits and features. From the glacially carved Mirror Lake and the Snowy Range Ski Area, the path wound east to the Laramie Mountains and the Vedauwoo Recreational Area, a popular rock climbing and hiking area. The 2015 field trip in Sturbridge, Massachusetts, focused on the Connecticut Valley, a Mesozoic rift basin that signaled the breakup of Pangea, and the Berkshires, which represents the collision and amalgamation of an island arc system with the North American Laurentian margin.

Garden of the Gods

The field trip in Colorado (2016) was an urban setting along the western edge of Colorado Springs and around Manitou Springs. Stops included the Pikeview Quarry, Garden of the Gods Visitor Center, and several other locations where rockfall and debris flow mitigation, post-flooding highway embankment repair, and a nonconformity in the rock records that spans 1.3 billion years were observed.

The Georgia (2017) field trip provided an opportunity to view the geology of northern Georgia. Stops included the Bellwood Quarry, which, at one time was run by the City of Atlanta and served as a prison labor camp. Upon completion of a tunnel to connect the quarry to two water treatment plants and three pump stations, It will serve as a 2.4 billion-gallon water storage facility for the City of Atlanta. Additional stops included the Buzzi Unicem Cement Plant to get a close up view of the Clairmont Melange, The Cooper Furnace near the Allatoona Dam, and the New Riverside Ochre-Emerson Barite mine.

Penobscot Narrows Bridge

The 2018 field trip of the Portland, Maine Symposium presented a good overview of the geology of coastal Maine. Field trip stops included the Sherman Salt Marsh near Newcastle which was recently restored to its natural state after the dam that carried US Highway 1 washed out during a 2005 storm, the site of the 1996 landslide near Rockland Harbor that consumed several homes, and the rock slope remediation project at the

Penobscot Narrows Bridge near Prospect Maine. A lobster lunch along the shore of Penobscot Bay was one of several highlights of the field trip.

The 2019 field trip in Portland, Oregon travelled the Columbia River Gorge west. Starting at the Crown Point Vista House and Portland Women's Forum State Scenic Viewpoint above the gorge to learn about the river highway. Descending into the gorge, we stopped at scenic Multnomah Falls and Benson Bridge, and saw flexible rockfall fence installed to protect the lodge and historic Columbia River Highway. Other stops included lunch at Cascade Locks, Bonneville Landslide and rockfall areas along the highway

The 2022 field trip in the Ashville, North Carolina area took us through Ordovician (500 my) to Precambrian (1.2 by) migmatized ortho and paragneisses, metamorphosed intrusives, thrust faults and contacts representing three orogenies and complex sequences of basement and terranes. We crossed the Brevard Fault zone several times, which is a structure that has been studied and interpreted for 100 years. Various attempts to define the structure have been made, especially in the pre-plate tectonic era. It has been theorized that these structures were as high, or higher than the Rockies at formation. 200 million years of rifted erosion leave us with an exposed look at deep orogenic roots of multiple thrust events. Precipitation in the areas is between 60-100" per year. There are deep ancient colluvial deposits, complex mineralization and weathering profiles, and non-linear/planar discontinuities. We traveled over I-26 and the Blue Ridge Escarpment where the highway is being widened. Stops included the I-26 Old Howard Gap Slide Area, the US 74 Gerton Slide, a shallow landslide barrier on I-40 W, and the Buckner Gap Cut.

The 2023 Field trip in Tacoma, Washington traveled to Mt Rainer where HGS goers were able to take various hikes around the park. Additional highlights included driving down into the Ohop Valley outwash channel, a drive by of Alder Lake, a drive along Copper Creek Forest Road 59, a view of Nisqually Glacier from Nisqually River and a final stop at Ricksecker Point.

The Lawrence Kansas (2024) symposium field trip took us to the Tallgrass Prairie National Preserve, lunch on the Dakota Formation sandstone bluff at Coronado Heights, and saw the unique differential weathering of the Dakota Formation at Mushroom Rock State Park.

Mushroom Rock State Park

HGS National Steering Committee

Officers

Bill Webster, Chairman CalTrans 5900 Folsom Blvd. Sacremento, CA 95819 916-662-1183 Bill_webster@dot.ca.gov	**Kyle Halverson, Vice-Chairman** Kansas DOT Bureau of Structures and Geotechnical Svc. 700 SW Harrison Street Topeka, KS 66603 785-291-3860 Kyle.halverson@ks.gov
Mark Fish, Secretary WSDOT Geotechnical Office 1655 S. 2nd Ave. Tumwater, WA 98512 360-709-5898 fishm@wsdot.wa.gov	**John Pilipchuk, Treasurer** NCDOT Geotech Engineering Unit (Retired) 1512 US Highway 70 East Hillsborough, NC 27278 919-622-3381 johnpilipchuk@yahoo.com

HGS National Steering Committee Members

Ken Ashton West Virginia Geological Survey 1 Mont Chateau Road Morgantown, WV 26508 304-594-2331 ashton@wvgs.wvnet.edu	**Vanessa Bateman** Geotechnical, Geology, & Materials CoP Leader Eng. & Construction HQ U.S. Army Corp of Engineers 202-761-7423 Vanessa.c.bateman@usace.army.mil	**Simon Boone** Geostabilazation International 10225 Westmoor Drive Westminster, CO 80021 540 420-2678 simon@alcinc.com
James Dahill Wyoming DOT 5300 Bishop Boulevard Cheyenne, WY 82009 307-777-4205 james.dahill@wyo.gov	**Bob Henthorne** PEC 400 S. Kansas Ave. Topeka, KS 66603 785-233-8300 Bob.henthorne@pec1.om	**Jody Kuhne** NCDOT (Retired) 778 Flint Street Asheville, NC 28801 828-779-9482 jodykuhne@gmail.com

HGS National Steering Committee Members (continued)

Sarah McInnes PA DOT Engineering District 6-0 7000 Geerdes Blvd. King of Prussia, PA 19406 610-205-6544 smcinnes@pa.gov	**Krystle Pelham** New Hampshire DOT Bureau of Materials and Research P. O. Box 483 5 Hazen Drive Concord, NH 03302-0483 603-271-1657 Krystle.j.pelham@dot.state.nh.us	**Victoria Porto** PA DOT (Retired) 10 Oine Lake Drive Carlisle, PA 17015 717-805-5941 vamporto@aol.com
Eric Rorem Ameritech Slope Constructors 21 Overland Industrial Blvd. Asheville, NC 28806 505 690-7144 erorem@ameritech.pro	**Christopher Ruppen** Geostabilization International 3808 Sunflower Road New Brighton, PA 15066 727-272-7532 Christopher.ruppen@gsi.us	**Tim Shevlin** Geobrugg North America LLC Salem, OR 97302 503-423-7258 Tim.shevlin.@geobrugg.com
Jay Smerekanicz Scarptec, Inc. P. O. Box 326 Monument Beach, MA 02553 603-493-6274 jay@scarptec.com	**Deana Sneyd** Petrologic Solutions, Inc. 3997 Oak Hill Road Douglasville, GA 30135 678-313-4147 dsneyd@gmail.com	**John Szturo** HNTB Corporation 715 Kirk Drive Kansas City, MO 64105 816-525-2275 jszturo@hntb.com
Cheryl Youngblood NC Dept. of Transportation 1020 Birch Ridge Drive Raleigh, NC 27610 919-707-6873 cyoungblood@ncdot.gov		

Past Present and Future Symposium Contact List

2017	Georgia	Deana Sneyd	678-313-4147	dsneyd@gmail.com
2018	Maine	Krystle Pelham	603-271-1657	krystle.j.pelham@dot.state.nh.us
2019	Oregon	Tim Shevlin	503-423-7258	tim.shevlin@geobrugg.com
2022	North Carolina	John Pilipchuk	919-622-3381	johnpilipchuk@yahoo.com
		Jody Kuhne	828-779-9482	jodykuhne@gmail.com
2023	Washington	Marc Fish	360-709-5898	fishm@wsdot.wa.gov
2024	Kansas	Kyle Halverson	785-600-8165	Kyle.halverson@ks.dot
2025	West Virginia	Ken Ashton	304-594-2331	ashton@wvgs.wvnet.edu
2026	Nevada	Gary Norris	775-331-5582	norris@unr.edu

EMERITUS STEERING COMMITEE MEMBERS

Steering Committee members who have provided outstanding service to the organization but have resigned from the Steering Committee are eligible to become an Emeritus Member. Candidates are nominated and status is granted with a majority vote from the Steering Committee.

R. F. Baker
David Bingham
Virgil E. Burgat
Hugh Chase
Dick Cross
A. C. Dodson
Tom Eliassen
John “Brandy” Gilmore
Robert Goddard
Mike Hager
Pete Ingraham
Richard Lane
Bill Lovell
Willard MaCasland
David Mitchell
W. T. Parrot
Paul H. Price
Bill Sherman
Mitchell Smith
Steve Sweeney
Berke Thompson
Burrell Whitlow

John Baldwin
Vernon Bump
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John Lemish
George S. Meadors, Jr.
Henry Mathis
Harry Moore
Nicholas Priznar
David L. Royster
Willard L Sitz
Jim Stroud
Sam Thornton
Mike Vierling
W. A. “Bill” Wisner

Medallion Award

The Medallion Award was instituted in 1969 to recognize individuals who have made significant contributions to the Highway Geology Symposium over many years. The award is a 3.5" medallion mounted on a walnut shield and appropriately inscribed. The Medallion Award is presented during the banquet at the annual symposium.

Medallion Award recipient	Year		Medallion Award recipient	Year
Hugh Chase	1970		Harry Ludowise	2000
Tom Parrott	1970		Bob Henthorne	2004
Paul Price	1970		Michael Hagar	2005
K. B. Woods	1970		Joseph A. Fischer	2007
R. J. Edmonson	1972		Ken Ashton	2008
C. S. Mullin	1974		David Martin	2008
A. C. Dodson	1975		Richard Cross	2009
Burrell Whitlow	1978		Mike Vierling	2009
Bill Sherman	1980		John Szturo	2009
Virgil Burgat	1981		Jeff Dean	2012
Henry Mathis	1982		Chris Ruppen	2012
David Royster	1982		Eric Rorem	2014
Terry West	1983		John Pilipchuk	2015
Dave Bingham	1984		Pete Ingraham	2016
Vernon Bump	1986		Richard Lane	2017
C. W. "Bill" Lovell	1989		Steve Sweeney	2018
Joseph A. Gutierrez	1990		John Duffy	2018
Willard McCasland	1990		Krystle Pelham	2018
W. A. "Bill" Wisner	1991		Vanessa Bateman	2019
David Mitchell	1993		Marc Fish	2023
Harry Moore	1996			
Earl Wright	1997			
Russell Glass	1998			

Young Author Award

The Highway Geology Symposium has always encouraged participation of young professionals knowing that they are the future of the organization. To recognize and promote participation of young professionals, an annual National Young Author Competition was established in 2014. To qualify, participants may be up to 35 years old or younger, must be the principal author, and the sole presenter of the paper at the Symposium. Papers are reviewed and judged based on technical presentation of the paper (including geology), Originality of the Work, Applicability of the Work to Others and Paper Layout. One recipient is selected each year to receive the coveted Young Author Award, consisting of a plaque and cash prize to be presented at the annual Symposium banquet.

Young Author Award winners:

2014 - **Simon Boone**, "Performance of Flexible Debris Flow Barriers in a Narrow Canyon"

2015 - **Cory Rinehart**, "High Quality H20: Utilizing Horizontal Drains for Landslide Stabilization"

2016 - **Todd Hansen**, "Geologic Exploration for Ground Classification: Widening of the I-70 Veterans Memorial Tunnels"

2017 - **James Arthurs**, "Construction of Transportation Infrastructure in Weathered Volcanic Ash Soils"

2018 - **Brian Felber**, "Geotechnical Challenges for Bridge Foundations & Roadway Embankment Design in Peats and Deep Glacial Lake Deposits"

2019 - **Anya Brose**, "The Assessment and Remediation of Wabasha St. Rock Fall"

2022 - **Christopher Mayer** "Using Geophysics to Evaluate the Results of a Grouting Program in Karstic Geology

2023 - **Cody Chaussee**, "Bolt Creek Fire: Post-Wildfire Debris Flow Risk Assessment and Barrier Design on US 2, Near Grotto, WA

2024 - **Katelyn Card**, "Post Wildfire Effects on Geotechnical Assets".

74th Highway Geology Symposium
Multi Agency Special Session
Monday August 10, 2025
1:00 – 5:00 p.m.

Challenges and Solutions for Hiring, Training and Retention of Subsurface Exploration Professionals

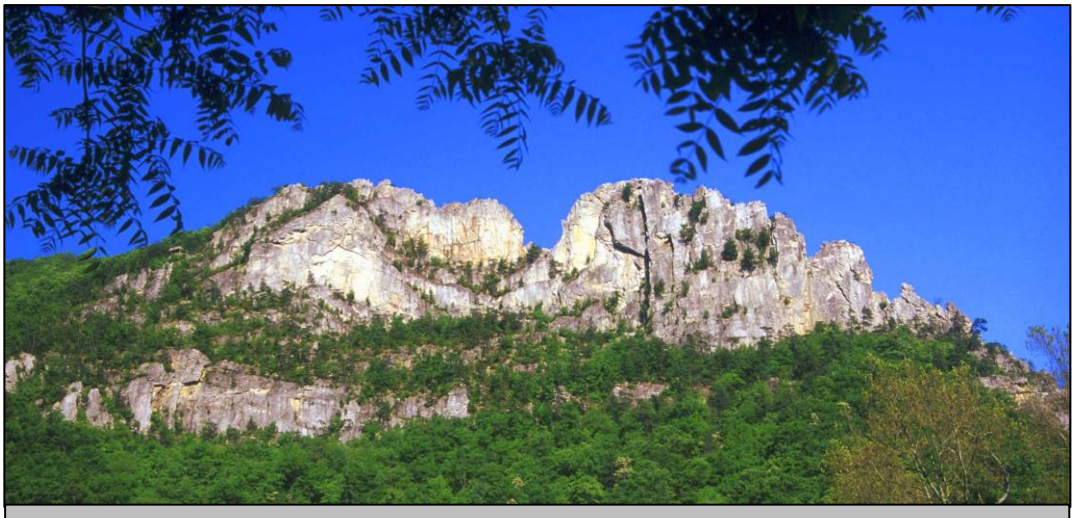
A high-quality subsurface exploration program is the basis for every successful geotechnical construction project and maintaining a reliable and skilled workforce of subsurface exploration professionals is key to gathering the data needed to accomplish this goal. However, consultants and owners in the public and private sectors are facing increasing challenges with hiring and keeping experienced staff for subsurface exploration operations. This panel discussion will address these challenges, with panelists discussing industry trends, pain points, and creative solutions to sustaining this critical workforce. The panel will discuss exploration drilling as well as alternatives like CPT and geophysics and MWD.

Time	Topic	Discussion Lead/presenter
1:00-1:05	Welcome and housekeeping	Krystle Pelham - NHDOT
1:05-1:10	Panel participant introductions	Krystle Pelham - NHDOT
Presentations		
1:10-1:25	*State DOT (discuss structure, drill crews, experience level and requirements for classification by staff geologist and drillers, status of implement new technology, retention and upward mobility, challenges/advantages of maintaining in-house drill crew versus using consultants)*	Kyle Halverson, KDOT
1:25-1:40		Chelsey Brummer, MnDOT
1:40-2:10	*Federal agency (structure, drill crews, experience level and requirements for classification and drillers, implement new technology, retention and upward mobility)*	Jason Wagner or Marty Goff, USACE
2:10-2:30	*Geotechnical drilling contractor (how they train, retain, incentives, provide opportunity for growth)*	Terracon - Tim Cleary
2:30-2:50	*CPT contractor (how they train, retain, incentives, provide opportunity for growth)*	Conetec – Ethan Cargill
2:50-3:10	*Engineering consultant (Procurement of drillers and challenges with quality deliverables)*	HNTB - John Szturo
3:10 - 3:30	***Break***	
3:30-3:45	*Survey Results – Summary of State DOT Practices*	Krystle Pelham - NHDOT
3:40 – 4:50	*Open Discussion/ Research Needs Discussion opportunities*	Matt Riegel
4:50-5:00	*Closing remarks (summary of information)*	Krystle Pelham - NHDOT

74th Highway Geology Symposium
Special Session - U. S. Geological Survey
Tuesday, August 12, 3:10 – 5:00pm

Improving Availability of Information on Landslide Loss and Effects

Landslides are a damaging, disruptive, and sometimes deadly geologic hazard that greatly affect transportation networks in our country. All 225 named roads in the US Interstate highway system are exposed to some level of landslide susceptibility. Sixty-four percent of the total length of these highways are in areas susceptible to landslides. In accordance with the National Strategy for Landslide Loss Reduction, the USGS has created a nationwide compilation of existing, publicly available landslide inventories and is preparing a preliminary data compilation of landslide damage and loss reports in the United States. These preliminary damage and loss data from landslides are heavily biased towards federal data, however much of the costs are borne at the state and local levels. By working together across levels and sectors of government, we can improve our understanding of how much landslides are costing the nation and better prioritize mitigation and preparedness activities. The session will include presentations on the current state of landslide damage accounting and facilitated discussion of how to improve availability and consistency of these data at the national, state, and county levels.

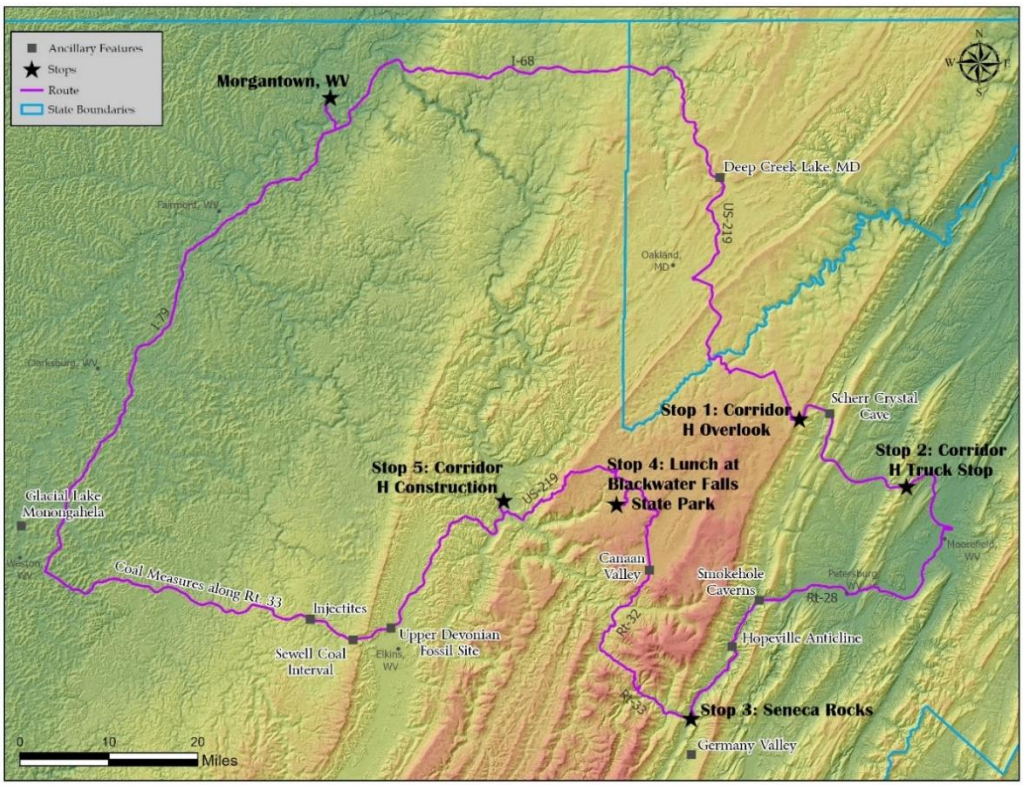


Seneca Rocks – Tuscarora Sandstone

74th Highway Geology Symposium

Field Trip Schedule

Thursday August 14, 2025



Depart	Morgantown Marriott Hotel	7:00 AM	
Stop 1	US 48 Overlook	arrive 8:45 AM	depart 9:15 AM
Stop 2	US 48 Truck stop	arrive 9:35 AM	depart 10:15 AM
Stop 3	Seneca Rocks	arrive 11:15 AM	depart 11:30 AM
Stop 4	Lunch, Blackwater Falls	arrive 12:30 PM	depart 2:00 PM
Stop 5.1	US 48 Cheat Bridge overlook	arrive 2:40 PM	depart 3:10 PM
Stop 5.2	US 48 Cut 29	arrive 3:40 PM	depart 4:40 PM
Arrive	Morgantown Mariott Hotel	6:30 PM	

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Field Trip Lunch

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Field Trip Snacks & Beverage

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Tuesday Morning Break

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Tuesday Afternoon Break

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Field Trip Beer

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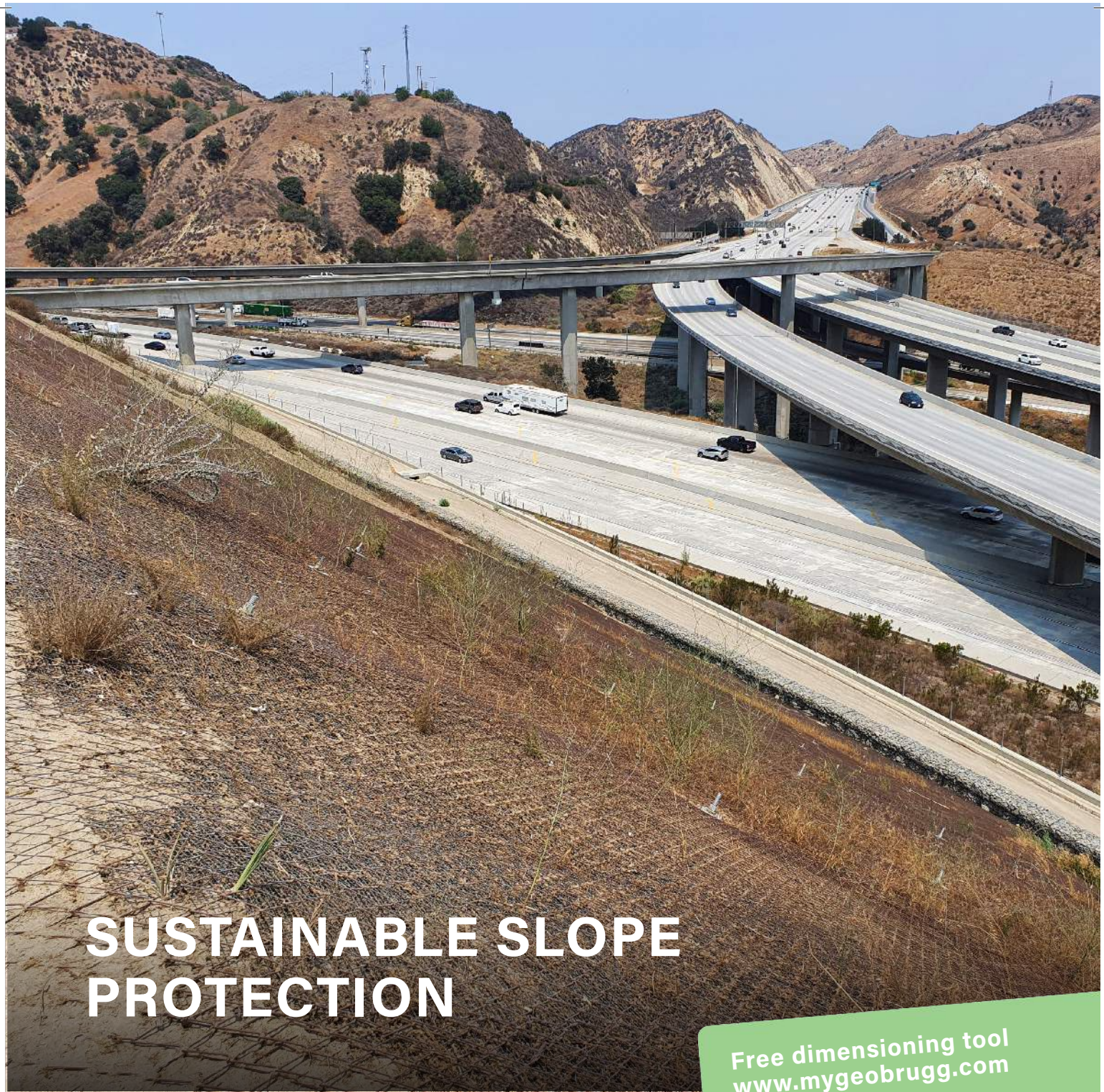

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Exhibitors

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74th Highway Geology Symposium

August 11 – 14, 2025
Morgantown, West Virginia

TECHNICAL SESSION SCHEDULE
Tuesday, August 12

8:00 AM -8:20 AM	Welcome and Opening Remarks	Ken Ashton Jessica Moore, State Geologist	WVGES
8:20 AM - 9:00 AM	Geology of West Virginia	Phil Dinterman, Deputy Director	WVGES
Technical Session 1 - Young Authors			
9:00 AM - 9:20 AM Young Author	The Rockslides of Riggins, ID: A Review of the Road Blocking Events, Rockfall Hazards, and Slope Mitigations Along a 22-Mile Stretch of US-95 between 2020 and 2025	Ethan Guzek & James Struthers	Delve Underground
9:20 AM-9:40 AM Young Author	Geology of the Big Fill Landslide, Teton County, Wyoming	Lief Swanbom	Wyoming Dept. of Transportation, Geology Department
9:40 AM-10:00 AM Young Author	Evaluating the Role of Geology, Hydrology, and Construction Practices in West Virginia Flood-Induced Landslides	Cole Schmidt	GSI
10:00 AM-10:30 AM	**BREAK**		
Technical Session 2			
10:30 AM-10:50 AM Young Author	Monitoring and Mitigation Strategies for Unstable Slopes, a Tennessee Case Study	Sebastion W. Dirringer, Darren Beckstrand, Robert Jowers	Cornforth Consultants, Inc, Landslide Technologies, TDOT
10:50 AM-11:10 AM Young Author	Measuring from a Distance, Teton Pass Remote Sensing Technology	Hunter Hinckley	Wyoming Department of Transportation, Geology Department
11:10 AM-11:30 AM Young Author	Prospective Geohazard Management: The NMDOT District 2 Rockfall Study	Begum Kurtoglu, et al.	WSP USA Inc.
11:30 AM-11:50 AM Young Author	Use of Artificial Intelligence for Identification of Embankment Failures on a Network Level	Aliena Debelak, et al.	WSP
11:50 AM-1:00 PM	**LUNCH**		

74th Highway Geology Symposium
August 11 – 14, 2025
Morgantown, West Virginia

TECHNICAL SESSION SCHEDULE
Tuesday, August 12

Technical Session 3			
1:00-1:20 Young Author	Rockfall Mitigation and Slope Stability Solutions for Interstate 78 in Bethlehem, New Jersey	Christina Comuso, Brian Felber	New Jersey DOT, HNTB Corporation
1:20-1:40	On The Geotechnical Design Considerations and Solutions of the I-80 North Fork Bridges Project	Edward H Barefield & John D. Lasko	Michael Baker International
1:40-2:00	Engineering Judgement, Managing Risk, and the Use of Software	Roch S. V. Player	Braun Intertec Corporation
2:00-2:20	Design Considerations for Consolidation Grouting of the Eisenhower Tunnel	Adam Bedel, et al.	Stantec Consulting, Colorado Department of Transportation
2:20-2:40	River Road in Wilmington, NC - A Study of Small Failures	Nick Moore & Alexandria Jones	North Carolina DOT
2:40-3:10	**BREAK**		
Technical Session 4 – Special Session Improving Availability of Information on Landslide Loss and Effects			
3:10-3:50	Landslide Loss Reporting at the National and State Scale	Aleeza Wilkins, Sarah Hall	U S Geological Survey
3:50-4:10	Discussion 1 – Current landslide loss documentation efforts		
4:10- 4:30	Discussion 2- Future opportunities for landslide loss documentation efforts		
4:30 - 5:00	Group discussion and final wrap-up activity		

74th Highway Geology Symposium
August 11 – 14, 2025
Morgantown, West Virginia

TECHNICAL SESSION SCHEDULE
Wednesday, August 13

Technical Session 5			
8:00-8:20	New Baltimore Landslide Remediation - Lessons Learned	Ala Hajdarwish and Suresh Gutta	A.G.E.S., Inc.
8:20-8:40	Proactive Slope Design: Mechanical Stabilization of Cut Slopes to Reduce Impacts of Landslides and Excavation Footprints	Bryan Radabaugh	Geostabilization International
8:40-9:00	Engineering Geology and Field Fit Solutions for Emergency Landslide Response to SH-64, Kamiah, ID	Shaun Cordes and Jim Struthers	Delve Underground
9:00-9:20	Performance of Micropiles Socketed into Schist Saprolite	Sarah McInnes, et al.	Pennsylvania Department of Transportation
9:20-9:40	The Influence of Particle Shape and Surface Roughness on the Friction Angle of Quartz Sands	Gary Norris	University of Nevada Reno
9:40-10:00	Blasting Design that Ensures Back Slope Stability	Daniel B Conn	Fragmentation Efficiency Services, Inc.
10:00 - 10:30	**BREAK**		
Technical Session 6			
10:30-10:50	Paw Paw Slope Stabilization-Chesapeake & Ohio Canal National Historical Park	Nicholas Strater, et al.	Brierly Associates
10:50-11:10	ATTERRO: A New Design Tool for Rockfall Attenuator Performance	Tim Shevlin and Remo Dudler	Geobrugg
11:10-11:30	Optical and Acoustic Televiewer Logging in Competent and Unstable Rock	Jorgen Bergstrom	Collier Geophysics
11:30-11:50	Integrated Approaches to Landslide Monitoring and Interpretation: Remote Sensing, Field Investigations, and Geomorphic Terrain Analysis in Yellowstone National Park, Montana and Wyoming	Kris Hornsby, et al.	BGC Engineering & Western Federal Lands Highway Division
11:50 - 1:10	**LUNCH**		

74th Highway Geology Symposium
August 11 – 14, 2025
Morgantown, West Virginia

TECHNICAL SESSION SCHEDULE

Wednesday, August 13

Technical Session 7			
1:10-1:30	Engineering Assessment of Field Data from A Unique Drive Point Method	Paritosh Chataut, et al.	Department of Civil and Architectural Engineering, University of Wyoming
1:30-1:50	Enhancing Risk Management in Transportation Geotechnics Through Standardized Data Collection	Declan Vanderhor	Tablogs
1:50-2:10	Subsidence and Sinkhole Geohazard Investigations using Geophysical Methods	Stan Smith	Collier Geophysics
2:10-2:30	Slip Stick: A Low Cost Solution for Shallow Landslide Monitoring in Remote and Difficult-to-Access Terrain	Brett Dougan and Michael Hogue	Pillar Innovations
2:30-3:00	**BREAK**		
Technical Session 8			
3:00-3:20	Geohazard Decision Support: Leveraging AI and Satellite Data for Infrastructure Resilience	Randy Post and Winston Wade	WSP USA Inc.
3:20-3:40	Open Roads, Open Bridge, Open...Frog? Imagining the 3D World of Geological Design with Bentley's latest 3D Subsurface Modeling Tool	D. Crotsley and W.Brandenberger	HDR Engineering
3:40-4:00	Highway Geology and Paleontology and Their Importance to Understanding Earth's History	E. Ray Garton	WVGES Museum
4:00-4:20	Field Trip Preview	Wayne Perkins	WV Geological Survey

THE ROCKSLIDES OF RIGGINS, ID: A REVIEW OF THE ROAD-BLOCKING EVENTS, ROCKFALL HAZARDS, AND SLOPE MITIGATIONS ALONG A 22-MILE STRETCH OF US-95 BETWEEN 2020 AND 2025

Authors: Ethan Guzek, LEG; James Struthers, LEG

Delve Underground, 1011 Western Ave, Suite 706, Seattle, WA 98104
guzek@delveunderground.com, struthers@delveunderground.com

ABSTRACT

US-95 is the sole north-south route in Idaho, serving as a major economic connector for the state. Located at the center of this route is the highway town of Riggins, ID, a hub for outdoor tourism and home to an impressive concentration of rockfall and rockslide problems. The canyons bounding US-95 in this region are some of the steepest in the state. Steep roadcuts, complex accreted geology, weak persistent geologic structure, and narrow roadway geometry set the stage for the rockslides that have blocked the route over the past five years within a particularly hazardous 22-mile stretch of US-95. Between 2020 and 2025, Delve Underground has been retained by ITD to provide services inclusive of reconnaissance and scoping, design, slope monitoring, exploration, blasting consultation, and slope construction management across five major slopes in this 22-mile stretch. This paper explores how variations in geology and the activity of rockfall and slope movement have dictated mitigation timelines and different mitigation strategies for the subject slopes located between US-95 Mileposts 188 and 210. This paper also explores how rope-access techniques, remote sensing, and field engineering have allowed our team to be successful in the design, planning, and construction phases of work, despite the challenges related to complex localized geology and difficult access terrain at these sites. Highlighted projects include the MP 188 Emergency Rockslide Response, MP 189 Slope Monitoring, and the recent MP 196 Slope Stabilization Construction. Also discussed are the MP 191 Mousetrap Slope Reconnaissance and MP 210 Landslide Study projects.

2

GEOLOGY OF THE BIG FILL LANDSLIDE, TETON COUNTY, WYOMING

Lief Swanbom, PG

Wyoming Department of Transportation, Geology Department, PO BOX 20486, Cheyenne, WY 82003
lief.swanbom@wyo.gov

ABSTRACT

The Big Fill Landslide, a “classic” highway embankment failure, occurred on June 8, 2024 at MP 12.8 along Wyoming Highway 22 on the western flank of Teton Pass in Teton County, Wyoming. The failure occurred in a roughly 70 foot tall embankment section of the highway built in the mid-to-late 1960’s. The failure is hypothesized as having occurred due to two primary factors; groundwater and aging infrastructure. A relatively fast winter snowmelt occurred in Spring 2024 allowing for a quicker-than-normal release of snowpack precipitation driven by average daily temperatures remaining above freezing for an extended period of time. This excessive, warm runoff period allowed for above-average groundwater levels to enable the aging, clayey embankment to lose its cohesive strength.

Wyoming Highway 22 roughly follows the boundary between two North American tectonic provinces. Mountains of Laramide age intersect with the Sevier foreland basin Overthrust Belt province. As a result, faults of various age are located along Wyoming Highway 22. The failed highway embankment traverses an isolated block of mapped, steeply dipping Cretaceous sandstone, siltstone and shale created by the southward thrusting Cache Creek Thrust Fault and the northward thrusting Jackson Thrust Fault. The Cretaceous strata are surrounded by various older Mesozoic and Paleozoic formations consisting of sandstone, limestone and shale. Boreholes drilled for the slide investigation and remediation design confirmed the geologic mapping. This report and presentation examines the complex geology and other factors that contributed to the catastrophic failure.

3

EVALUATING THE ROLE OF GEOLOGY, HYDROLOGY, AND CONSTRUCTION PRACTICES IN WEST VIRGINIA FLOOD-INDUCED LANDSLIDES

Cole Schmidt

GSI, 102 Smith Street, Columbia, KY 42728
cole.schmidt@gsi.us

ABSTRACT

In early April 2024, the Ohio River Valley of Northern West Virginia experienced two significant flood events, prompting state and federal emergency declarations. The counties including Brooke, Doddridge, Preston, Hancock, Marshall, Ohio, Tyler, and Wetzel counties, sustained widespread damage from flooding and landsliding. Each rainfall event was recorded between three (3) to four (4) inches of precipitation, approximately 10% of the region's average annual rainfall. The severity of the flooding combined with the geologic conditions, and topographic characteristics of the Appalachian Plateau, triggered hundreds of landslides and caused millions of dollars in damage to roadways and local infrastructure. Initially, the state of WV contracted teams to conduct field assessments developing designs for over two hundred individual landslides that occurred during the April 2024 flood events. Following the preliminary assessment, a detailed evaluation of anticipated soil/rock types and depths, local rainfall and flooding extents, slope geometry, historic roadway construction practices, on-site drainage considerations, and other contributing factors were considered in implementing final repair mitigation. Field observations indicated that many landslides occurred along low-trafficked rural roadways constructed using "cut-and-cast" methods. The predominant soil types within the landslide areas consisted of fine-grained loamy soils with shallow weathered sequences of mudstones and sandstones. The topographic relief across the affected sites varied, encompassing a variety of failure mechanisms including circular, block, translational, and erosional among others. This paper will further detail and emphasize the critical role of geologic, hydrologic, and original construction factors in the manifestation of slope failures following extreme precipitation events.

4

MONITORING AND MITIGATION STRATEGIES FOR UNSTABLE SLOPES, A TENNESSEE CASE STUDY

Sebastian Dirringer, CEG[1]; Darren Beckstrand, CEG[1]; Robert Jowers, PE[2]

[1]Cornforth Consultants Inc. - Landslide Technology, 9000 SW Gemini Drive, Beaverton, Oregon 97008
Sebastian.Dirringer@ccilt.com, Darren.Beckstrand@ccilt.com
[2]Tennessee Department of Transportation, Materials & Tests Division-Geotechnical Engineering Section, Building A, 1st Floor, 6601 Centennial Blvd., Nashville, TN 37243
Robert.Jowers@tn.gov

ABSTRACT

The Tennessee Department of Transportation (TDOT) sought to develop an unstable slope monitoring plan for a geotechnically problematic two-lane corridor west of Chattanooga. The subject corridor, SR-2 between Lane Mile (LM) 23 and LM 34 is the designated emergency detour route when the primary Interstate 24 evacuation route is impassable. The corridor is exposed to unstable colluvial slopes of the Pennington Formation and has experienced repeated closures and ongoing distress due to unstable slopes and landslides. The formation is a known problematic unit with low residual strength soils and high groundwater.

The project was subdivided into several phases; background data review, site reconnaissance, conceptual monitoring and early warning system, and conceptual resiliency improvement measures. The Pennington Formation is a thick accumulation of shale and siltstone overlain by thin, unstable colluvial soils. Geotechnical explorations have been carried out at several of the more problematic locations. Groundwater was observed near the top of weathered rock and inclinometers often detected movement at the top of weathered rock.

This paper describes a geologically challenging transportation corridor and evaluates different slope monitoring and mitigation strategies that can be employed anywhere. This paper also presents a framework for developing conceptual monitoring approaches, which include instrumented geotechnical borings and debris flow monitoring stations. Mitigation elements such as geosynthetic-reinforced subgrades and horizontal drains were considered at numerous locations while considering hydrogeologic conditions.

5

MEASURING FROM A DISTANCE, TETON PASS REMOTE SENSING TECHNOLOGY

Hunter Hinckley, PG

Wyoming Department of Transportation, Geology Department, 5300 Bishop BLVD, Cheyenne, WY 82009
hunter.hinckley@wyo.gov

ABSTRACT

On June 8, 2024, weather conditions created a "perfect storm" triggering a catastrophic failure on a hairpin curve, located along highway WY-22 of the Teton Pass corridor. The collapse severed a critical scenic and economic route between Victor, Idaho and Jackson Hole, Wyoming, an important lifeline for tourists and commuters. Consequently, WYDOT faced a hyper-compressed timeline with significant reconstruction challenges to open a temporary detour, while simultaneously redesigning and constructing a permanent repair. WYDOT Geology deployed a number of remote sensing instruments, safely and efficiently aiding a heavily accelerated reconstruction process.

As reconstruction efforts began, following a detour designed and built in three weeks, remote sensing methods became a vital data collection tool, greatly assisting the monitoring of site conditions post failure. Instrumentation included monitoring equipment: InSAR satellite and ground-based side-scanning radar, shape array telemetry inclinometers, and telemetry piezometers. Remote technology provided instant round-the-clock access to data, enhancing safety while limiting site visits. Due to extensive travel distances, the suite of remote detection tools were maintained throughout the failure to achieve an accurate assessment of ground conditions. These tools tracked surface heaving and subsidence movement using satellite InSAR and ground-based radar scanning, subsurface shifts using in-ground inclinometers, and water levels using telemetry piezometers. Communications transpired from the greatest subsurface depths to the highest mechanical, digital, and personnel levels, providing clear understanding and leading to ultimate success. This assessment details the steps taken to install, monitor, and analyze a combination of remote sensing instruments, and lessons learned throughout the process.

6

PROACTIVE GEOHAZARD MANAGEMENT: THE NMDOT DISTRICT 2 ROCKFALL STUDY

Begum Kurtoglu, EIT, GIT[1]; Randy Post, PE[2]; Roger Pihl, PG[1]

[1]WSP USA Inc., 7245 W Alaska Drive, Suite 200, Lakewood, CO, 80226
begum.kurtoglu@wsp.com, roger.pihl@wsp.com
[2]WSP USA Inc., 177 N Church Ave., Suite 1105, Tucson, AZ 85701
randy.post@wsp.com

ABSTRACT

The New Mexico Department of Transportation (NMDOT) District 2 Rockfall Mitigation Study is a project aimed at proactively managing geologic hazards along several critical transportation corridors. This case study focuses on the innovative approaches and methodologies employed to assess and mitigate rockfall and embankment distress hazards in Otero and Lincoln counties on portions of US 380, US 82, and NM 532. The project involved a detailed inventory of geohazard sites, drone-based photogrammetry, expert-based qualitative assessment, and the development of a custom geohazard database. Conceptual mitigation options and cost estimates were developed for 75 sites to assist NMDOT with long-term planning and project programming. The study's proactive approach emphasized the importance of early identification and prioritization of high-risk sites, leveraging advanced technologies and interdisciplinary collaboration to enhance safety, mobility, and maintenance efficiency. The findings and recommendations from this study provide a framework for future geohazard management efforts, demonstrating the value of a systematic and data-driven approach to reducing the risks associated with geological hazards. This paper highlights the project's scope, methodologies, and outcomes, offering valuable insights for transportation agencies and geotechnical professionals engaged in similar endeavors.

7

USE OF ARTIFICIAL INTELLIGENCE FOR IDENTIFICATION OF EMBANKMENT FAILURES ON A NETWORK LEVEL

Aliena Debelak[1]; Nicole Oester Mapes[2]; Sedrick Bouknight[3]; Roger Pihl[1]

[1]WSP, 8745 W Alaska Drive, Suite 200, Lakewood, CO 80216
aliena.debelak@wsp.com, Roger.pihl@wsp.com
[2]Colorado Department of Transportation, 4670 Holly St. Unit A, Denver CO 80216
nicole.oester@state.co.us
[3]WSP, 999 18th St suite 1825n, Denver, CO 80202
sedrick.bouknight@wsp.cpm

ABSTRACT

Highways in sloping terrain are constructed through cut-fill methods where material removed on the uphill side of the highway is used to construct embankments on the downhill side. Despite improved construction techniques such as benching fill into the existing slope, controlling and testing for moisture content and soil density, and limiting lift heights, embankments experience settlement or sliding, posing risks to transportation systems. Risks vary with the severity of the failure and can include safety impacts, maintenance costs, and in instances of larger failures, user mobility impacts from lane closures. The Colorado Department of Transportation (CDOT) has over 13,000 embankments identified throughout the state, many with indication of failure. Typically, practitioners rely on aerial imagery or detailed corridor-level site assessments to identify these failures. This standard practice is time intensive and only allows for embankment failure identification in localized areas.

The authors of this paper leveraged Artificial Intelligence (AI) and Machine Learning (ML) capabilities to identify the location and severity of embankment failures on a state-wide level. The system integrates a specialized LLM-based expert AI, a reasoning agent, and an autonomous framework that interfaces with tools like ArcGIS and custom ML models. Subject matter expert feedback to fine-tunes the models while CDOT data serves as both a training corpus and a key resource. By efficiently identifying embankment failures throughout the state, owners can better quantify risk exposure due to deteriorating embankments and prioritize funds to manage the risk.

8

ROCKFALL MITIGATION AND SLOPE STABILITY SOLUTIONS FOR INTERSTATE 78 IN BETHLEHEM, NEW JERSEY

Christina M. Comuso[1]; Brian T. Felber, PE[2]

[1]New Jersey Department of Transportation, PO Box 600, Trenton, NJ 08625
christina.comuso@dot.nj.gov
[2]HNTB Corporation, 9 Entin Rd., Ste. 202, Parsippany, NJ 0704
bfelber@hntb.com

ABSTRACT

This paper will discuss the design and implementation of rockfall mitigation measures along Interstate 78 in Bethlehem, New Jersey, focusing on the creation of engineered catchment ditches through presplit controlled blasting of two existing rock cut slopes. These slopes, approximately 1,500 feet long with gradients of 0.25H:1V, posed significant challenges due to their proximity to high-traffic areas and environmental restrictions related to snow and local endangered wildlife. The project incorporated the installation of rock dowels, shotcrete, and rock drains to enhance stability and safety, with slope heights ranging from 90 to 140 feet and minimal catchment widths, averaging 4 feet, adjacent to the pavement.

The comprehensive site investigation process will be discussed, including subsurface exploration, geophysical surveys, and geologic mapping, which aided with the rock slope stability analysis. Stereographic analysis was utilized to assess kinematic feasibility of failure mechanisms such as planar sliding, wedge, and toppling, while limit equilibrium analysis using RocScience SWedge provided insights into wedge sliding stability.

Key challenges included managing blasting operations adjacent to a major interstate with an anticipated 2-Way Average Annual Daily Traffic (AADT) of 87,952 vehicles per day in 2018. The paper discusses strategic approaches to minimize disruptions and ensure public safety during and post construction. An assessment of alternative mitigation strategies is also presented, highlighting the decision-making process and lessons learned.

9

ON THE GEOTECHNICAL DESIGN CONSIDERATIONS AND SOLUTIONS OF THE I-80 NORTH FORK BRIDGES PROJECT

Edward H. Barefield, PG, PE; John D. Lasko, PG

Michael Baker International, 100 Airside Drive, Moon Township, PA 15108
ebarefield@mbakerintl.com, john.lasko@mbakerintl.com

ABSTRACT

The I-80 North Fork Bridges project involves the reconstruction of approximately 2¼ miles of S.R. 0080 in northwestern Pennsylvania. Realignment of the eastbound corridor and corresponding relocation of the eastbound S.R. 0080 bridge over the gorge of North Fork Redbank Creek results in significant cut and fill earthwork necessary to establish the realigned portion of S.R. 0080 eastbound and for construction of the eastbound and westbound bridges. Coupled with the significant earthwork component of the project, site investigations revealed geohazards and site constraints related to the presence of multiple horizons of acid producing rock stratigraphy and coal measures within the roadway template and challenging foundation conditions at the locations of the proposed bridge pier foundations adjacent to North Fork Redbank Creek, e.g. weak sedimentary stratigraphy, non-uniform sloping top of rock surface, boulder conditions along the valley sidewalls, and proximity of an existing in-service municipal water supply dam.

This discussion explores the various transportation geotechnical design challenges offered by the geologic framework, steep terrain, and site constraints within the project limits as well as considerations and solutions for resolution of the challenges. Specific attention will be allocated to design considerations for integrating acid producing encapsulation zones within the proposed embankments along with select borrow material zones needed to satisfy long-term slope stability requirements, cut slope face treatment measures employed for mitigating exposed acid producing rock material, and considerations for design of drilled shaft foundations within the gorge of North Fork Redbank Creek.

10

Engineering Judgment, Managing Risk, and the Use of Software

Roch S. V. Player, PE, BC.GE, PMP

Braun Intertec Corporation, 1901 16th Ave SW, Suite2, Cedar Rapids, IA 52404
RPlayer@braunintertec.com

ABSTRACT

The power and scope of geotechnical engineering software have accelerated. The geoprofessional's ability to perform complex calculations rapidly, and the commercialization and accessibility of artificial intelligence (AI), have created unprecedented opportunities to evaluate engineering problems and develop solutions. However, the ease of use of these tools increases the risk of decoupling the analytical modeling from the inherent variability and complexity of the natural world. Therefore, rather than replacing the engineer, human engineering judgment is more vital than ever to manage risk and create solutions!

This paper will discuss putting analytical modeling into the context of the natural world by discussing the goals of modeling and prerequisites for effective modeling. The Conceptual Site Model will be presented as a tool for improved analytical modeling. Case studies will be presented showing the risks of insufficient site understanding and knowledge of soil and rock behavior, and the resulting numerically correct analytical results providing incorrect engineering answers or solutions for transportation and other projects, as well as successful use of analytical tools to understand and predict site behavior to create effective repair solutions. The purpose of this paper is to prompt better understanding of effective modeling and methods for truing-up analytical results with observed site behavior, leading to better outcomes and improved risk management.

11

DESIGN CONSIDERATIONS FOR CONSOLIDATION GROUTING OF THE EISENHOWER TUNNEL

Adam Bedell, PG[1]; Nick Cioffredi[2]; Jeff Hampton[3]

[1]Stantec Consulting, 167 Selu Creek Road, Cleveland, Georgia 30528
Adam.bedell@stantec.com
[2]Stantec Consulting, 410 17th Street, Suite 1400, Denver, Colorado 80202
Nick.cioffredi@stantec.com
[3]Colorado Department of Transportation, 425B Corporate Circle, Golden, Colorado 80401
Jeffery.hampton@state.co.us

ABSTRACT

The Eisenhower Tunnel was completed over 50 years ago and continues to be a testament to tunnel design and construction professionals demonstrating how the underground industry rises to overcome the challenges during construction. During design of the Eisenhower Tunnel, potential high rates of groundwater infiltration into the excavation during construction was expected based off construction records of two tunnels completed earlier—The Moffat Tunnel and the Roberts Tunnel which produced 1,800 gpm and 200 gpm, respectively.

Since traffic started flowing through the completed bore in 1973, groundwater continues to flow into the Eisenhower Tunnel. Water that makes it to the roadway is collected and transmitted to water treatment facility located in the basement of the east ventilation building. Water that intercepts the horizontal collectors, seep drains, and vertical wall drains bypasses water treatment facility. Once discharged from the water treatment facility, the water combines with groundwater from the mountain and together flow into Clear Creek and down the mountains; it's use governed by Colorado Water Rights legislation.

Over the past 52 years, continued groundwater infiltration into the Eisenhower Tunnel not controlled by the installed plumbing system have caused numerous challenges from an operational and maintenance perspective. In efforts to protect and ensure continued use of Colorado Department of Transportation's "Crown Jewel" and most valuable asset, a consolidation grouting program was designed as part of a pilot program to mitigate groundwater infiltration into the Eisenhower supply air plenum. The purpose of this paper is to present design considerations for the consolidation grouting program currently in construction.

12

RIVER ROAD IN WILMINGTON, NC – A STUDY OF SMALL FAILURES

Nick Moore, LG[1]; Alexandria Jones, LG[2]

[1]North Carolina Department of Transportation, 3301 Jones Sausage Road, Suite 100, Garner, NC 27529
nomoore1@ncdot.gov
[2]North Carolina Department of Transportation, 1020 Birch Ridge Drive, Raleigh, NC 27610
anjones4@ncdot.gov

ABSTRACT

New Hanover County Bridge No. 19 is a 3-span bridge on River Road over Lords Creek in Wilmington, NC built in 2018. The project carries a high-volume, two-lane roadway over a 600 foot-wide tidal creek with inundation from diurnal tides. The original subsurface investigation was completed in 2014 and noted saturated, loose sand with moderate organic content to about 18 feet below the ground surface. No recommendations were made addressing embankment settlement due to the suitable quality of sand that was reported. However, embankment settlement and longitudinal pavement cracking began north of the bridge soon after completion of the project, requiring regular maintenance. NCDOT maintenance department contacted the Geotechnical Engineering Unit to investigate the failures and recommend a long-term solution.

Our investigation consisted of 5 mud-rotary borings approximately 80 feet in depth through the failing embankments with SPT samples at 2.5 feet intervals. We sampled for grain size analysis, Atterberg limits, moisture, and organic content, and collected 5 Shelby Tubes for confined-undrained triaxial shear and consolidation testing. We discovered a 15 to 18 foot-thick layer of saturated, very soft, highly plastic, highly organic, alluvial clay. This clay layer was identified as the source of the failure by consolidation due to the addition of the new embankment loads.

The oversight of this alluvial clay layer from the original investigation was costly to NCDOT and highlights the importance of a sound field investigation by locating and identifying potential pitfalls for construction or long-term maintenance. Failure to recognize potential geotechnical liabilities can result in construction delays, cost overruns, negative public relations and unsafe infrastructure.

13

NEW BALTIMORE LANDSLIDE REMEDIATION – LESSONS LEARNED

Ala Hajdarwish, PhD, PG; Suresh Gutta, PhD, PE

A.G.E.S., Inc., 4 Grandview Circle, Suite 100, Canonsburg, PA 015317
ahajdarwish@agesinc.com, SGutta@agesinc.com

ABSTRACT

In 1940, the Pennsylvania Turnpike was constructed mostly along the path of the original alignment of the old South Penn Railroad and as a result, passed through the Borough of New Baltimore, PA, and the Allegheny Mountains. The original construction reactivated an ancient landslide, referred to as the "New Baltimore Slide" that had occurred in the geologic past due to undercutting of the mountain slope by the Raystown Branch of the Juniata River, which lies in the valley beneath the Turnpike. This slide zone eventually extended to 800 feet wide, 1,500 feet upslope of the roadway, with an average of 60 feet thick overburden sliding along a weathered clayey siltstone bedrock defined as the failure plane for over 70 years.

Historical records indicate that this slide moved 13 feet in 1940. These large movements had caused major scarps as much as 80 feet wide on the mountainside. Over the past 20 years, active movements are closer to 10 inches/year, with peak movements of 2 inches/month in the spring season. The proposed widening and the reconstruction of the Turnpike required the removal of the toe of this active landslide. The design involved characterizing the failure mechanism, instrumentation, treatment, development of sequence of construction, and development of safety systems for the protection of traU̇ic during construction. Construction for the remediation of the slide was successfully completed in September 2016.

The presentation will provide an overview of the history of the slide, geological setting, geotechnical investigation, instrumentation, monitoring results, and design challenges.

14

PROACTIVE SLOPE DESIGN: MECHANICAL STABILIZATION OF CUT SLOPES TO REDUCE IMPACTS OF LANDSLIDES AND EXCAVATION FOOTPRINTS

Bryan Radabaugh

Geostabilization International, 2 White Oak Drive, Ripley, WV 25271
Bryan.radabaugh@gsi.us

Due to West Virginia's physiographic, geomorphologic, and geologic setting, infrastructure development and expansion projects often face technical challenges which can impact the viability and cost of the project. As roadway and infrastructure expansions are initiated in Appalachia, and specifically in West Virginia, cut slopes frequently encroach into landslide-prone slopes. Slopes consisting of thick colluvium, thick residuum, and highly weathered soils are consistently encountered. Encroachment into landslide prone slopes can result in several negative consequences including:

- safety impacts to the contractor and the public as these landslide areas are exposed.
- expanded right of way as cut slopes are flattened and extended upwards.
- potential impacts to adjacent property.
- larger and/or additional waste areas for excess materials generated.
- potential impacts to adjacent infrastructure.
- additional right of way acquisition.
- environmental and permitting impacts due to expanded cuts and fills.
- extended construction schedules and project budgets.

To mitigate these potential negative impacts, non-traditional construction practices can be utilized. Recent highway expansion along US 52 in Mingo County, WV, and new school construction in Lincoln County, WV, both resulted in extensive mass excavation within landslide prone slopes. To reduce the extent of the cut slopes and reduce the risk of slope failures during and after construction, final designs for both projects include pinned and draped high-tension mesh systems, complementing conventional earthwork.

Our paper and presentation will provide two case histories, focusing on the geologic setting, right-of-way considerations, mass excavation placement, and slope stability concerns addressed by the project teams through proactive design and construction phases.

15

ENGINEERING GEOLOGY AND FIELD FIT SOLUTIONS FOR EMERGENCY LANDSLIDE RESPONSE TO SH-64, KAMIAH, ID

Shaun Cordes, CEG[1]; Jim Struthers, CEG[2]

[1]2000 SW 1st Ave, Suite 410, Portland, Oregon 97201
cordes@delveunderground.com
[2]1011 Western Avenue, Suite 706, Seattle, WA 98104
struthers@delveunderground.com

ABSTRACT

During the week of April 14, 2024, a concentrated, slow moving, and high intensity storm event dropped an estimated 2- to 2.-5 inches of rain over the duration of two hours near the town of Kamiah, Idaho. The event severely impacted SH-64 between milepost 25.1 and 26.6 resulting in scour and erosion of the road prism, undermining existing retaining walls, plugging and damage to existing culverts, landslides, and generation of debris flows within ravines.

At the request of the Idaho Transportation Department (ITD), Delve Underground mobilized two engineering geologists to perform a site reconnaissance of the damaged roadway. The ultimate goal of ITD was to develop plans for emergency mitigation, advertise and award the work in the summer of 2024, and finish construction of the repairs during the 2024 construction season. We identified and prioritized 12 key areas of damage along the alignment with ITD staff. We then collected information including the failure mode, geotechnical materials present, and failure geometry to be used in final emergency mitigation design. Site characterization was followed by rapid design and contract development with advertisement soliciting bids within three months of the storm event.

During construction of the 12 damaged areas, ITD personnel and Delve worked in close collaboration with the contractor to coordinate the phasing of work and provide adjustments and field fitting to the final design based on expected variations of subsurface conditions. This case study provides an example of rapid development, contracting, and construction of landslide mitigation work within a constrained corridor.

16

PERFORMANCE OF MICROPILES SOCKETED INTO SCHIST SAPROLITE

Sarah McInnes, PE[1]; Shimeles Badane, PE[1]; Robert Crawford, PE[2]; Lei Gu, PE[3]; Matthew Lunemann, PE[4]

[1]Pennsylvania Department of Transportation, Engineering District 6-0, 7000 Geerdes Boulevard, King of Prussia, PA 19406
smcinnes@pa.gov, sbadane@pa.gov
[2]James J. Anderson Construction Company, Inc., 6958 Torresdale Ave, Suite 200, Philadelphia, PA 19135
bobc@jjaconstruction.com
[3]Michael Baker International, Inc., 300 American Metro Boulevard, Hamilton, NJ 08619
lei.gu@mbakerintl.com
[4]STV, Inc., 1818 Market Street, Suite 2300, Philadelphia, PA 19103
matthew.lunemann@stvinc.com

ABSTRACT

Although micropiles are increasingly utilized as a reliable solution in challenging ground conditions for bridge foundations, rock socket design in weathered saprolite/IGM layers remains a great design and construction challenge. The saprolite layers of the Wissahickon Schist Formation/Wissahickon Group vary significantly with depth and have varying degrees of weathering and geotechnical properties, which can result in structural instability if not properly accounted for during design and construction. This paper explores a case study of micropiles socketed into very dense saprolite in the City of Philadelphia focusing on key considerations for successful implementation. Highlighted is the importance of thorough site investigation to characterize the saprolite's heterogeneity, including its strength and degree of weathering. The paper further discusses the design aspects of micropiles in saprolite, encompassing load transfer mechanisms, grout techniques, and the influence of groundwater conditions. Both sacrificial verification and production proof load tests were conducted on the micropiles to confirm performance. Mobilized bond stresses (43 to 54 psi) between the micropile and saprolite during load testing are compared with the design value (40 psi) as well as published values for similar geomaterials. Finally, the paper summarizes the benefits of micropiles in saprolite, which makes them a valuable solution for infrastructure development in weathered rock and provides recommendations for future projects with similar design challenges.

17

THE INFLUENCE OF PARTICLE SHAPE AND SURFACE ROUGHNESS ON THE FRICTION ANGLE OF QUARTZ SANDS

Gary Norris

University of Nevada Reno, 1664 N. Virginia St, MS258, Reno, NV 89557
norris@unr.edu

ABSTRACT

The shape of sand particles is typically characterized by the parameter, roundness, using one of the available comparison charts provided by sedimentary petrologists. Particle shape is attributable to features seen when viewing the particle as a whole. Surface roughness, on the other hand, refers to the features that exist at a level smaller than those contributing to particle shape. Shape features are the result of their original form on particles as released from the parent rock and the cumulative history of abrasion the particles undergo through the different environments through which the particles pass. Surface roughness is a function of the mechanical/chemical action of the last environment in which the particles reside. While the interaction of the particles' shape features contributes to volumetric dilatancy during shearing, surface roughness features contribute to a non-volumetric component of dilatancy as the surface of the particles' shape features slide over that of opposing particles. The objective of this paper is to establish separate components of the peak drained triaxial test friction angle attributable to particle shape versus that attributable to surface roughness. For that purpose, triaxial tests were performed on up to four uniform size fractions of quartz particles from seven different natural sands: two beach sands (high versus low wave action), two eolian sands (desert versus coastal dune sand), two river sands (poorly versus well graded sand) and a diagenetic sand. Drained tests were performed at three levels of confining pressure over a range in relative density, 144 tests in total.

18

BLASTING DESIGN THAT ENSURES BACK-SLOPE STABILITY

Daniel B Conn

Fragmentation Efficiency Services, Inc., 215 South Main St., Zelienople, PA 16063
dconn@kesco-fes.com

ABSTRACT

Traditional blasting practices will damage the final slopes for new cut and widening infrastructure projects. The downstream costs and increased liability are appreciable and can be avoided.

Fragmentation Efficiency Services, Inc. (FES) and KESCO have been engaged in every aspect of explosive manufacturing, use, and consulting for close to 70 years and may be in a unique position to frame and change how Owners and highway geologists understand and manage this problem. In one project, a 2003 United States Army Corps project in Grundy, Virginia, the initial blasting subcontractor was dismissed, and KESCO was contracted to execute two forms of precision presplitting. The net result was stable, and undamaged, final slopes in both a very weak shale and in the massive high compressive strength sandstone. These formations will be on display when we take our field trip through West Virginia. As our evolution as both a contractor and consultant evolved, FES was contracted more often to provide consulting for the specifications draft and oversight. One example was for the Vermont Agency of Transportation's Route 9 slope construction project.

This presentation has two distinct focuses:

First, we will show why there is a clear disconnect between what blasters are trained and contracted to do and what owners want and need.

Then, we will also outline design and oversight practices that must be included in project specifications and a request for pricing.

19

Paw Paw Slope Stabilization – Chesapeake & Ohio Canal National Historical Park

Nick Strater[1]; Bob Stier; Joeseph Reid

[1]Brierley Associates, 167 S. River Road, Unit 8, Bedford, NH 03110
nstrater@brierleyassociates.com

ABSTRACT

The Paw Paw Slope Stabilization Project is located in one of the most remote portions of the Chesapeake & Ohio Canal National Historical Park (CHOH), immediately adjacent to the historic Paw Paw Tunnel. The steep rock slopes on both sides of the canal have long plagued the Park with instability, including a significant rockslide in 2016, which closed the CHOH Towpath Trail, and destroyed a popular pedestrian boardwalk.

Utilizing a design-build contracting approach, the National Park Service teamed with Drill Tech and Brierley Associates to design and complete stabilization of 1,000 linear feet of rock slopes located on both sides of the canal, removal of the May 2016 rockslide debris field, and construction of a new boardwalk. The goal of the project was to improve park safety and access, while preserving the natural appearance of the site, and protecting sensitive historic features. During site mobilization it was discovered that a second, previously undetected large rockslide was imminent, requiring immediate removal and adding additional challenges to the project from the standpoint of access and safety. Innovative slope stabilization methods included top-down excavation and rope-access scaling, site-specific spot and pattern rock anchors, use of pinned steel mesh, and placement of sculpted steel reinforced concrete buttresses.

Following completion, the project won the Outstanding Project Award in ACEC/MD's 2025 Engineering Excellence Awards and the 2024 Association of Environmental & Engineering Geologists (AEG) Outstanding Environmental and Engineering Geologic (OEEG) Project Award.

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ATTERRO: A NEW DESIGN TOOL FOR ROCKFALL ATTENUATOR PERFORMANCE

Tim Shevlin, PG[1]; Remo Dudler[2]

[1]Geobrugg North America, LLC Salem, OR 97302
tim.shevlin@geobrugg.com
[2]Geobrugg AG, Aachstrasse 11, 8590 Romanshorn, Switzerland
remo.dudler@geobrugg.com

ABSTRACT

Rockfall attenuators are passive rockfall protection solutions that have been utilized for decades and often are described by other names. Previously, the instrument of the experienced geohazard practitioner, the use of Rockfall Attenuators, has become more popular among the general licensed practitioner. To date, there are no formal solutions to attenuator design. There are no guidelines for testing and validating the attenuator performance, as there are for traditional rockfall barriers. Nor is there an accepted guideline like there is for classic draped mesh performance.

Attenuators present a very complex design challenge wherein they are not stopping the rockfall but rather changing the trajectory and moderating the velocity. These two design parameters are highly difficult to predict due to site and rockfall variability combined with the complex interaction of the rock and attenuator net, the attenuator net and the ground, and the rock and the ground as the rock moves under the net. This leaves the practitioner to guess at the complex performance of attenuator systems.

Geobrugg presents a new design tool called ATTERO that is based on kinetics to estimate the performance of rockfall attenuator systems. The kinetic model considers the interaction between the rock and a hanging attenuator net; the model performance is validated from the results of a 3-year full-scale testing program. This paper summarizes the testing of Geobrugg's ATT systems, presents the ATTERO model, and shows examples of the output and how it can be used by the designer for various Attenuator geometries.

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OPTICAL AND ACOUSTIC TELEVIEWER LOGGING IN COMPETENT AND UNSTABLE ROCK

Jorgen Bergstrom

Collier Geophysics, 889 Franklin Gateway SE, Suite 104, Marietta, Georgia 30067
jbergstrom@colliergeophysics.com

ABSTRACT

Optical and acoustic televiewer geophysical logging is common in transportation projects to gather valuable information about subsurface conditions. Using these tools, engineers can assess the integrity and quality of rock masses, including discontinuities, such as fractures, faults, voids, and other features that may affect the stability and performance of transportation structures. These tools generate oriented images and can, therefore, provide the strike and dip of planar discontinuities, such as fractures, bedding planes, foliation, cleavage, etc. This paper will include case studies using acoustic and optical televiewers to assess discontinuities at proposed rock cuts and bridge abutments. Televiewer logging in unstable rock using a drilling/grouting/re-drilling technique will also be reviewed.

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INTEGRATED APPROACHES TO LANDSLIDE MONITORING AND INTERPRETATION: REMOTE SENSING, FIELD INVESTIGATIONS, AND GEOMORPHIC TERRAIN ANALYSIS IN YELLOWSTONE NATIONAL PARK, MONTANA AND WYOMING

Kristofer Hornsby, CEG, PG[1]; Brian Collins, PE[1]; Eric Lim, PE, GE[2]

[1]BGC Engineering, Suite 300 – 600 12th Street, Golden, CO 80401
khornsby@bgcengineering.ca, bcollins@bgcengineering.ca
[2]Western Federal Lands Highway Division, 610 East Fifth Street, Vancouver, WA, 98660
eric.lim@dot.gov

ABSTRACT

In June 2022, a significant rain-on-snow event in the high elevations of northern Yellowstone National Park led to flooding and bank erosion severely damaging the North Entrance Road along the Gardner River. In the immediate aftermath, the National Park Service (NPS) and Western Federal Lands Highway Division (WFLHD) rehabilitated the previously unpaved Old Gardiner Road between Gardiner, Montana and Mammoth, Wyoming as an emergency and temporary roadway replacement for the North Entrance Road. NPS and WFLHD are working on the design of a permanent alignment. The Old Gardiner Road crosses multiple large, deep-seated landslide complexes. WFLHD and Jacobs/BGC Engineering have completed site investigations, including geomorphic terrain mapping, deep geotechnical boreholes with instrumentation (Shape Accel Arrays and vibrating wire piezometers) and telemetry, radiocarbon geochronology, geologic interpretation, and remote sensing (lidar change detection and interferometric synthetic aperture radar analysis). This paper summarizes the results of these data sets, explains how integrating these data enhances the interpretation of landslide movement, and describes how these findings can inform decisions on alignment and grade selection for roadway design.

23

ENGINEERING ASSESSMENT OF FIELD DATA FROM A UNIQUE DRIVE POINT METHOD

Paritosh Chataut[1]; Keely Wolf [2]; Kam Ng, PE, PhD, M. ASCE[1]; Shaun S. Wulff, PhD[2]; Taylor Ree, PG[3]

[1]Department of Civil and Architectural Engineering, University of Wyoming, 1000 E. University Ave, Laramie, WY 82071-2000
pchataut@uwyo.edu, kng1@uwyo.edu
[2]Department of Mathematics and Statistics, University of Wyoming, 1000 E. University Ave, Laramie, WY 82071-2000
kwolf6@uwyo.edu, wulff@uwyo.edu
[3]Principal Geologist, Wyoming Department of Transportation, 5300 Bishop Blvd., Cheyenne, WY 82009-3340
taylor.ree@wyo.gov

ABSTRACT

Site investigation (*SI*) is an important part of the engineering design and construction of highway infrastructure. The Drive Point (*DP*) method, as a unique *SI* technique, has been utilized by the Wyoming Department of Transportation in most highway projects since the 1960s. This *DP* method involves driving a 1¾-inch hollow steel rod with a 2-inch solid conical tip into the ground and recording the number of blows required for each foot of penetration. The *DP* blow counts provide a "continuous" profile of the relative denseness of the subsurface. This paper presents an engineering assessment of the amassed *SI* data and a proposed method for correcting *DP* blow counts. *DP*, Standard Penetration Test (*SPT*), geotechnical and pile driving data from 86 bridge projects, including dynamic load test data of 68 test piles has been compiled. This study shows that the measured *DP* blow count is influenced by the corresponding overburden stress. Adopting the methodology developed for *SPT* N-values, a more advanced method considering both statistical and engineering criteria is proposed to correct *DP* values for the overburden effect in term of the effective vertical stress. Geomaterials were categorized based on the Unified Soil Classification System and denseness, and a reference effective vertical stress of 2 kips per square foot (ksf) was selected to improve *DP* correction. The methodology for *DP* correction is demonstrated for silty sand SM with medium density. A mathematical expression for a *DP* correction factor (C_{DP}) in terms of effective vertical stress was proposed. The proposed method was validated by evaluating the consistency of the corrected *DP* values.

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ENHANCING RISK MANAGEMENT IN TRANSPORTATION GEOTECHNICS THROUGH STANDARDIZED DATA COLLECTION

Declan Vanderhor

TabLogs Inc. 1615 Platte St, Denver, CO 80202 (Level 2, The Circa Building)
declan@tablogs.com

ABSTRACT

Risk management in transportation geotechnics relies heavily on the quality and consistency of subsurface data. Traditional borehole logging methods, often paper-based or manually transcribed, introduce variability that can lead to inconsistent interpretations, data silos, and increased project uncertainty. As infrastructure projects become more complex, ensuring standardized, reliable geotechnical data collection is essential for effective risk assessment and decision-making.

This paper explores how structured digital workflows and standardized data collection methods improve geotechnical risk management in transportation projects. By implementing consistent logging procedures, engineers can reduce variability in soil and rock classification, enhance predictive modeling for slope stability, and improve integration with geotechnical risk assessment frameworks. The ability to standardize logging practices across teams also supports regulatory compliance and long-term geotechnical asset monitoring.

Using case studies from recent transportation projects, this presentation will demonstrate how standardized borehole data collection has led to more accurate risk assessments, improved hazard identification, and better-informed mitigation strategies. The discussion will also address challenges such as data validation, training field staff, and integrating standardized logs into GIS and geotechnical modeling tools.

By adopting structured data collection methods, transportation geotechnical engineers can significantly reduce uncertainty, improve collaboration, and enhance the reliability of risk assessments, ultimately leading to safer and more resilient infrastructure.

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SUBSIDENCE AND SINKHOLE GEOHAZARD INVESTIGATIONS USING GEOPHYSICAL METHODS

Stan Smith

Collier Geophysics, 7711 W 6th Ave. Suite G&H, Lakewood, CO 80214
ssmith@colliergeophysics.com

ABSTRACT

Subsidence and sinkhole features are geohazards of concern due to their potential detrimental effect on highway projects. They can appear throughout the nation's highway system and are surface expressions of loss of subsurface support. The occurrence of sinkholes can be attributed to both geological processes and anthropogenic activity. Some examples are washouts from failing wet utilities, heavy rain, or flooding; evaporite and carbonate formations susceptible to dissolution; and mine working experiencing roof failures.

Geophysics can provide insight into their existing location and potential continued risk to surface conditions. Subsurface imaging using geophysical methods such as electrical resistivity tomography (ERT), multichannel analysis of surface waves (MASW), ground penetrating radar (GPR) and micro gravity can be useful in mapping these features to address highway engineering and construction related concerns. With differing conditions contributing to the highway distress, it is important to consider which geophysical technique(s) to use to investigate the area of concern. Case studies will be presented to illustrate effective application of the appropriate techniques.

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SLIP STICK: A LOW-COST SOLUTION FOR SHALLOW LANDSLIDE MONITORING IN REMOTE AND DIFFICULT-TO-ACCESS TERRAIN

Brett Dugan; Michael Hogue

Pillar Innovations, 104 Corporate Drive, Morgantown, WV 26501
brettdugan@pillarinnovations.com

ABSTRACT

Slip Stick is a low-cost, shallow landslide monitoring device designed for backpack-based installations, making it particularly suited for remote locations with difficult access. Originally developed for pipeline monitoring, this emerging technology leverages manual dynamic cone penetrometer methods to provide real-time data on the depth, direction, and magnitude of sliding soil masses. This information allows infrastructure operators to assess whether critical assets, such as pipelines or roadways, are impacted by subsurface landslide movement.

This paper explores the application of Slip Stick technology in highway monitoring, including a case study detailing its installation in a roadway setting. Monitoring data will be presented alongside a financial cost comparison of various monitoring strategies. The benefits, limitations, and risks of Slip Stick technology relative to conventional landslide monitoring methods will be discussed, highlighting its potential as an accessible and cost-effective alternative for transportation infrastructure.

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GEOHAZARD DECISION SUPPORT: LEVERAGING AI AND SATELLITE DATA FOR INFRASTRUCTURE RESILIENCE

Randy Post, PE[1]; Winston Wade, PE[2]

[1]WSP USA Inc., 177 N Church Ave., Suite 1105, Tucson, AZ 85701
randy.post@wsp.com
[2]WSP Canada Inc., 840 Howe St, Vancouver, BC V6Z 2L2, Canada
winston.wade@wsp.com

ABSTRACT

The integration of artificial intelligence (AI) and machine learning (ML) in geohazard management presents an emerging opportunity to enhance the prediction and mitigation of landslides and debris flows along linear infrastructure corridors. However, geotechnical engineering remains fundamentally grounded in field assessment and empirical study. Traditional landslide susceptibility mapping, which relies on static predisposing factors, has limitations in capturing the dynamic nature of geohazards, particularly with respect to precipitation and other climate variables. While AI-driven models and high-resolution satellite-derived soil moisture and precipitation data can improve situational awareness, these tools are designed to complement—rather than replace—the expertise of trained geotechnical engineers and are most useful by integration into a decision support system (DSS). By leveraging advanced ML models, such as convolutional neural networks (CNNs) and hydrological simulations, we integrate diverse datasets, including high-resolution imagery from Planet Labs and open-source satellite missions like Sentinel and Landsat. Ground-based monitoring is practical for discrete locations, but satellite data provide an additional layer of probabilistic insight over larger or remote areas, helping prioritize areas of concern for additional study. Fundamentally this workflow does not replace field validation but rather directs engineers to locations of maximum imminent hazard potential, enabling targeted assessments. Beyond improving hazard forecasting, this approach also fosters experiential learning, ensuring that the next generation of geotechnical engineers and scientists continue to refine and validate predictive methodologies through field practice. Ultimately, the goal is not just to advance predictive capability but to integrate these insights into the engineering decision-making process, balancing scientific innovation with real-world application to enable more resilient infrastructure.

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OPENROADS, OPENBRIDGE, OPEN…FROG? IMAGINING THE 3D WORLD OF GEOLOGICAL DESIGN WITH BENTLEY'S LATEST 3D SUBSURFACE MODELING TOOL.

Crotsley, D., PG; Brandenberger, W., PG, PE

HDR Engineering, Inc., 1670 Broadway, Suite 3400, Denver, CO 80202
david.crotsley@hdrinc.com, will.brandenberger@hdrinc.com

ABSTRACT

The integration of advanced 3D geologic modeling software, such as Leapfrog, with transportation engineering tools like OpenRoads or OpenBridge, represents a significant advancement in the field of infrastructure design and analysis. Leapfrog's capabilities in rapidly generating and refining geological models from large datasets allow for a detailed and accurate representation of subsurface conditions. This integration facilitates a comprehensive understanding of geological complexities which is crucial for the planning and execution of transportation projects. By incorporating LeapFrog into OpenRoads, engineers can seamlessly integrate geotechnical data with road design elements, enhancing the accuracy and efficiency of project workflows. This synergy enables the identification of potential geologic hazards early in the design process, allowing for proactive mitigation strategies and optimized design solutions. The integration between LeapFrog and 3D limit equilibrium or rockfall programs pushes the boundary of traditional design beyond the two-dimensional space. Case studies from I-70 Floyd Hill and the Coalfields Expressway provide insight into the technical strength of the 3D design space.

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HIGHWAY GEOLOGY AND PALEONTOLOGY AND THEIR IMPORTANCE TO UNDERSTANDING EARTH'S HISTORY

E. Ray Garton

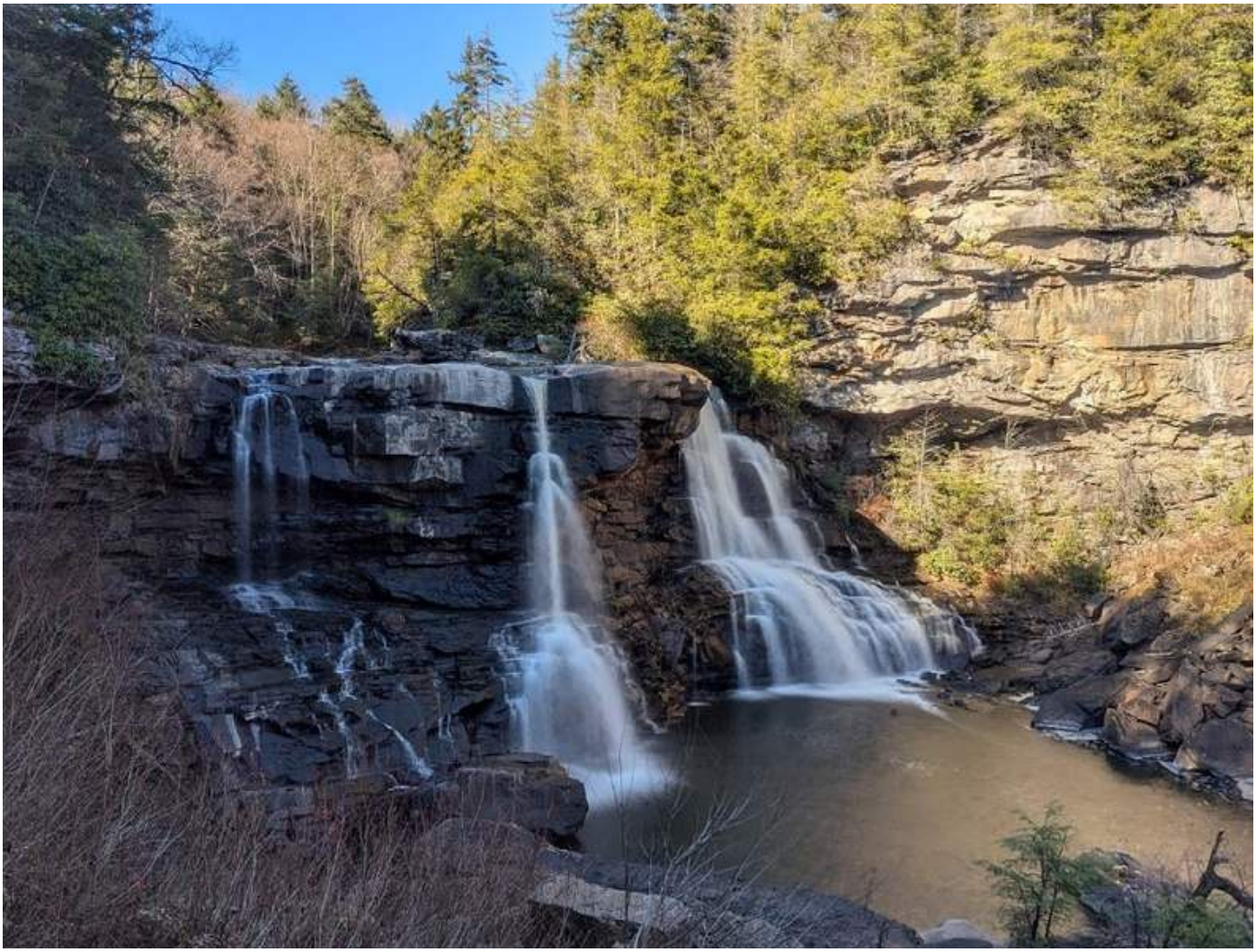
West Virginia Geological and Economic Survey Museum, 1 Mont Chateau Rd, Morgantown, WV 26508
eraygarton@gmail.com

ABSTRACT

Highway construction has almost always involved exposing bedrock, creating the opportunity for interesting, even incredible, discoveries to be made. Highway cuts have uncovered breathtaking geologic exposures and vistas. More importantly, many highway cuts have uncovered unknown fossils and prehistoric life treasures providing a wealth of information about the history of life on this planet spanning at least 500 million years. Thousands of sites have uncovered significant finds and paleontologists and museums have benefited greatly from the discoveries made possible by the geologists and engineers designing and building our transportation systems. This presentation will explore just a few of those discoveries.

Thank you for attending the 74th Highway Geology Symposium!

See you next year in Reno, Nevada.



Blackwater Falls State Park, WV

SUNSET OVER BACKBONE MOUNTAIN, TUCKER CO., WV