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Packet A

QUALIFICATIONS FOR

Engineering Geology & Rock/Rockfall Geotechnical Project Delivery

December 1, 2023

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CRITERIA 1 QUALIFICATIONS AND EXPERTISE

Founded in 1954, Delve Underground is a heavy civil engineering firm with 25 offices and 350 team members throughout the United States, Canada, Australia, and New Zealand. The firm has a long and successful legacy and has earned a reputation for providing top-notch engineering consulting services to clients globally.

Delve Underground has always recognized the importance of providing high-quality geologic engineering and engineering geology services for highway and civil clients. To further expand its services, the firm introduced a dedicated rock slope and landslide mitigation group in 2011.

This specialized practice group has grown significantly since then and continues to expand its services. This team consistently provides expert geological engineering solutions for the most challenging geohazards.

DELVE *(verb):*
1: to dig or labor with or as if with a spade
2a: to make a careful or detailed search for information.
2b: to examine a subject in detail.

A. Introduction

Delve Underground maintains a strong team of engineering geologists and geological engineers that specialize in geohazard mitigation work including rock engineering and rockfall. This team draws from decades of experience in the design of rock slope geohazard mitigation and design solutions in the transportation and heavy civil areas of practice, to provide responsive, and cost-effective solutions. Delve Underground's hands-on, full-service approach to design ensures that our solutions are developed with a keen eye toward constructability.

Expertise

Specific services Delve Underground offers include:

- **Rockslide and Rockfall Mitigation**: adept at hazard evaluation, rockslide characterization, and mitigation design.
- **Roped Access Work**: our team maintains unmatched capabilities for rockfall emergency response, hazard evaluation, design, and construction.
- **Emergency Response**: deep experience in responding to rock slope failures, collecting reliable, complete data, and providing timely recommendations for mitigation and asset protection.
- **Contract Development**: we support our designs with full-service contract implementation, bringing considerable expertise specific to development of and costing of rock slope contracts.
- **Construction Support**: we are experts at handling difficult slope mitigation challenges during construction.

Team Expertise and Structure

The WSDOT State Geotechnical Office (SGO), and specifically the Engineering Geology Section, has a significant responsibility in delivering high-quality geotechnical services in support of WSDOT's mission to provide and maintain safe, reliable, and cost-effective transportation for the citizens of Washington State. These services include emergency response to rockfall events impacting the highway, rock slope mitigation design as part of standard project delivery, as well as delivery of geotechnical recommendations for the development of various transportation projects.

To assist the SGO in its mission, Delve Underground has assembled a team of select individuals with specific expertise in rockslide emergency response, characterization, mitigation design, and rock-cut design. Our team is strategically located throughout the Pacific Northwest and can effectively assist state-wide in the SGO's emergency response efforts. Our team will work collaboratively to provide timely technical support in emergency response situations and in the execution of projects under accelerated timelines. This team will be led by Delve Underground and closely integrate our specialized partner firms, Wallace Technical Blasting, Inc., SubTerra, Inc., Emerio Design, and Ciani & Hatch Engineering. Each firm brings unique capabilities, primarily in blasting design, geotechnical instrumentation, and engineering support. Our team can readily apply unique solutions to complicated slope problems. The following is a summary of each team member, which includes their ability to support SGO's technical and project development-related needs.

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For more than 65 years, Delve Underground has focused on providing full-service engineering geology and geotechnical engineering design and construction services. It has maintained a dedicated rock slope service group since 2011. We deliver a wide range of services, from early phase alternatives analyses and routing studies, investigations, and geologic assessments to detailed design. Our expertise includes the development of complete construction bid packages for various civil structures and geohazard mitigation projects.

Our technical staff have extensive hands-on construction field experience, meaning that design solutions are based on a direct understanding of the realities of geotechnical construction. Recent Delve Underground projects delivered for the Idaho Transportation Department have received two Association of General Contractors awards for excellence in partnering.

For this contract, Delve Underground has selected a team of senior-level engineering geologists and geological engineers, many of whom have decades of experience in the engineering geology design of rock cuts, rock slope stabilization, rockfall mitigation, and unstable slope management.

This team is tightly integrated and excels at complex, difficult emergency rockfall response work and rock slope mitigation designs for highways and other transportation facilities. All key team members are trained in roped access work specific to unstable rock slopes.

One of the critical lessons learned and imparted to our staff is that engineering geologists must have a sizeable experiential toolbox of mitigation schemes in their back pocket, especially when access and equipment are limited. This allows the engineering geologist to make real-time decisions and adapt the design or construction process as the project evolves. We are proponents of thorough, knowledgeable field support during the construction of rock slope mitigation projects, and we maintain solid working relationships with rock slope contractors throughout the region.

Similarly, our team focuses on bringing seasoned technical staff to emergency response projects so problems can be addressed efficiently, and solutions can be proposed promptly. We consistently provide senior-level engineering geology expertise for DOTs and other agencies throughout the Pacific Northwest and the western United States. Delve Underground recently co-authored the Idaho Transportation Department's latest revision to their rock bolt, rock dowel, horizontal drain, and blasting specifications.

As rock slope mitigation and construction often involve specialized blasting services, we have engaged Jerry Wallace of Wallace Technical Blasting to provide blasting and blasting consultation support for this proposal. We have worked with Jerry on numerous rock slope remediation, construction, and emergency response projects, including ITD Riggins Rockslide on US-95 and a rockslide on the SH-55 Smiths Ferry Widening project. Delve has trained his staff in roped access techniques, as discussed further under Criteria 2.

Since 1992, Wallace Technical Blasting (WTB), has provided technical blasting, consulting, training, and communication services. As the premier technical blasting company of the Pacific Northwest, WTB has led over 150 successful projects. WTB focuses on complex, unique, and challenging projects, including rock slope remediation, underwater blasting, hydro-dam rehabilitation, soil densification, environmental mitigation, seismic research, and rescuing projects in jeopardy. WTB applies over two decades of blasting excellence to address unique project needs. They specialize in solving technical problems, designing innovative blasting solutions, and providing safe, efficient, and effective results.

For this contract, we envision utilizing WTB for the following services: blasting feasibility consultation, blasting plan review, and blast design for mitigation work. Jerry can also train WSDOT with blasting techniques, technology, and blasting review to augment WSDOT's capabilities in this area.

SubTerra Engineering was founded in 1991 as a consultant firm specializing in geotechnical, rock mechanics, mining, and civil engineering design. They have direct experience providing blasting-related and geotechnical instrumentation and telemetry services to WSDOT.

SubTerra was selected for this team because of its proven track record in rock mechanics-related instrumentation. They bring considerable ability in designing, deploying, and maintaining the remote monitoring equipment often required for rock slope mitigation and emergency response projects. For WSDOT's I-90 Snoqualmie Pass project, SubTerra provided a range of instrumentation to monitor rock slope strain and performance during and following construction.

Ciani & Hatch Engineering PLLC (CHE) is a woman-owned, woman-led geotechnical engineering firm. CHE was founded in May 2023 to create a space where women and minorities can thrive while expanding the definition of success within the A/E industry. The founders, Whitney Ciani and Mikayla Hatch, have over 17 years of experience working with various state agencies and local municipalities on roadway improvement, bridge replacement, multi-use pathways, local transit improvement, and utility projects.

As part of this scope of services, WSDOT has requested support from a general geotechnical subject matter expert to assist with, among other items, the administration of geotechnical elements of design-build projects and preparing contract documents for alternative delivery. As the company principals have significant experience delivering geotechnical services for WSDOT design-build projects, Ciani & Hatch are well qualified to provide this support.

In 2005, Neil Fernando started Emerio Design with a vision of doing business differently. In addition to civil engineering, Emerio Design provides land survey and construction management services. The firm also has a dedicated public works team to serve federal, state, and local agencies. Delve is currently partnered with Emerio on the Arizona Inn Landslide Mitigation for ODOT. For public works projects, they specialize in providing topographic and base mapping services in both AutoCAD/Civil 3D and Microstation/ InRoads.

As part of this contract, Emerio joins our team to provide valuable survey and civil engineering services. Emerio Design's survey services will lend spatial control to Delve Underground's UAV work, or such work performed using their in-house drone survey crew. Emerio Design will also provide the team with terrestrial LiDAR scanning of unstable slopes and support in developing civil design drawings.

Team Qualifications and Services

Our engineering geologists and geological engineers have many years of experience in rock slope engineering, design, and remediation. The resultant knowledge contributes directly to developing cost-effective and constructible designs. Our local team has successfully worked on geotechnical projects for multiple transportation agencies, giving us a unique perspective and knowledge of slope failures and how they impact critical transportation infrastructure. Key considerations that make Delve Underground uniquely qualified include:

Rockfall Mitigation and Design: Delve Underground brings decades of comprehensive rockfall mitigation expertise ranging from initial hazard identification to detailed rockfall modeling, limit equilibrium analysis, and mitigation design for numerous transportation agencies.

Unstable Slopes Program Management: The Delve Underground team includes two former DOT engineering geology leads who administered and managed state unstable slope programs, and additional senior staff who consulted with WSDOT for 12 years on their Unstable Slopes Management Program. We have performed a multitude of conceptual designs in support of these programs. We remain active in this area and are currently assisting ODOT's Region 1 team in optimizing their rock slope inventory to better position them for future funding.

Roped Access Team: Our roped access team is the strongest in the industry and uniquely qualified to access slopes and collect the correct information to carry a project through design. Criteria 2 provides additional detail on our program and capabilities.

Emergency Response: Our team excels at responding to and effectively delivering solutions for emergency response projects. We pride ourselves on providing unparalleled support to transportation agencies, as detailed in Criteria 3.

Essential to Success
Peer Development

Like WSDOT, Delve Underground considers the development of project staff an essential element of internal program success. We look forward to collaborating to provide additional quality training opportunities.

Blasting Services: Delve Underground has supplemented our already considerable background in blasting with Wallace Technical Blasting, with whom we have previously teamed successfully. This combination will allow WSDOT to address virtually any blasting issue and create multiple training opportunities for WSDOT personnel.

Contract Development: Delve Underground provides comprehensive rockfall mitigation designs for our clients. We are well-versed in developing special provisions to match project conditions, structure the bids, and save the owner money. Our design work is based on practical solutions that are less likely to encounter issues during construction. We recently successfully completed the development of ITD's special provisions for rock anchorage, horizontal drains, and blasting.

Emergency Response Locations

The Delve Underground engineering geology team specializes in rapid response to rock-slope-related emergencies. Team members maintain packed go bags, complete with personal roped access gear, and are often called upon to mobilize to various remote locations throughout the western US.

Because of our team's experience and the geographic spread of our team members, we can provide rapid response to emergency slope failures state-wide. Although all can respond throughout the state, the location of team members in the northern portions of the state will speed up response in the Northwest and North Central Regions, and our locations in the south and east will speed up responses to emergencies in the Southwest, South Central, and Eastern Regions.

As discussed in greater detail in Criteria 3, members of Delve Underground's strong and diverse local team, at WSDOT's request, will be dispatched by our project manager, Jim Struthers, and team resources will be placed in a ready status to support their efforts with data collection and design resources. Although our local team provides a significant level of geotechnical and geological expertise, Delve Underground can supplement this expertise with resources from our nationwide network of offices. It is not uncommon for us to supplement our geotechnical effort, as necessary, with full-service, in-house structural engineering, civil design, and contract development services.

Professional Licenses/Accreditations

Delve Underground team comprises core technical staff with decades of regular experience in complex slope stabilization projects, further supported by blasting, instrumentation, and geotechnical experts.

Key Team Member/Role	Years of Experience	Office	Registrations/Certifications
James Struthers, LEG, CEG, PG. Project Manager, SLG	28	Olympia	LEG: WA #275 (2002) LG: ID #PGL 1718 (2020)
William C.B. Gates, PhD, PE, D.GE, LEG, CEG Principal Consultant Technical Review & Blasting	55	Auburn	PE (Civil): WA #30391 (1993) LG, LHG & LEG: WA #613 (2002)
Jamie Schick, LEG Principal Engineering Geologist	28	Bend	LEG & LHG: WA, #2365 (2003)
Bryan J. Duevel, PE, GE Principal Geological Engineer	23	Portland	PE: WA #40157 (2003) RGE: OR #59847PE (2009)
Ethan Guzek, LEG, P.G. Engineering Geologist	5	Monroe	LEG: WA # 22034446 (2023)
Shaun Cordes, LEG Lead Engineering Geologist	11	Portland	CEG: OR #E570 (2017) LEG: WA #3286 (2017)
Mark Pinske, PE Lead Geotechnical Engineer	11	Seattle	PE: WA #53460 (2016), CA #81973 (2013)
Luke Fergusson, PE Geotechnical Engineer	8	Bend	CA #87945 (2017)
Thomas Pallua, PG Geologist	22	Seattle	PG: WA #3187 (2015)
Malcolm Perkins, PE Geotechnical Engineer	7	Seattle	PE: WA # 20123337 (2020)
Jerry Wallace Blasting Consultant	50	Woodland	Explosives: #EXPU 00018690, #EXU 00018690
Chris D. Breeds, PhD, PE Instrumentation	45	North Bend	PE: WA #30182 (1993)
Whitney Ciani, PE Geotechnical Engineer	17	Boise	PE: WA #48245 (2011)
Dan Adsit, PLS, CWRE Survey Project Manager	44	Beaverton	Professional Land Surveyor: OR #75495

● Delve Underground ● Wallace Tech. Blasting ● SubTerra Engineering ● Ciani & Hatch ● Emerio Design

Consultant Agreement Manager

James Struthers, LEG, CEG, PG.

James (Jim) Struthers is a principal engineering geologist with 28 years of experience in geotechnical design and construction. This experience includes a broad range of projects of varying sizes in primarily the transportation and heavy civil sectors. Jim has significant experience in the characterization of unstable rock slopes and landslides and the design and construction of mitigation measures and was previously the Chief Engineering Geologist at WSDOT. He managed the State's engineering geology section in this position. His duties included reviewing and overseeing all geotechnical designs and work products generated by the engineering geology section. He is an expert in rockfall and landslide mitigation, rock slope and grading design, geotechnical seismic design, geologic subsurface characterization, debris flow mitigation, and rock blasting.

28 years of experience

Washington licensed engineering geologist

Seattle home office

Available on an on-call basis

2 Days per week in State Office

Jim will be the Senior Level Engineering Geologist (SLG) and project manager for this contract. He is uniquely qualified based on his experience on WSDOT projects, his continuing engagement in slope mitigation and rock cut design for other transportation agencies, and his proximity to the WSDOT Geotechnical Office in Tumwater. Jim has worked both as the Assistant Chief Foundation Engineer and as the Chief Engineering Geologist at WSDOT. As such, he brings considerable knowledge of WSDOT standards and operating procedures, including administration of rockslide emergency response work. Jim will work as an extension of the SGO staff and serve as the liaison between SGO staff and other State offices. We have also identified several other highly qualified senior level engineering geologists and geotechnical engineers throughout the region to support Jim in managing workload and to help provide the best expertise for the scope, schedule, and budget of each task.

Jim's Areas of Expertise

- Rockfall, rockslope, and landslide design
- Debris flow mitigation
- Geotechnical seismic design
- Geological subsurface characterization
- Emergency rockfall and landslide mitigation

Jim's SLG Responsibilities Include:

- Geotechnical schedules, deliverables, scopes of work and budget negotiations.
- The development, negotiation, and management of task orders.
- Confirmation that project designs and construction meet WSDOT's standards, practices, and policies.
- Reviewing and preparation of geotechnical memorandums and reports.
- Mentoring and training SGO staff and State team members on specialized Geotechnical expertise.
- Submitting monthly invoice to the SGO for all work completed per task order.

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William C.B. Gates, PhD, PE, PG, D.GE, LEG, CEG | Principal Consultant Technical Review/ Blasting SME

Registrations/Certifications: LG, LHG & LEG: WA #613, 2002 | PE (Civil): WA #30391, 1993 | PEng (Geology): BC #141723, 2006 |PG: CA #5556, 1992; ID #747, 1992; WY #2541, 1997 | CEG: OR #E1471, 1993 | PE (GEOEG), ID#21547, 2022

Bill has over 55 years of experience in engineering geology, geological engineering, blasting, and hydrogeology. He has gained valuable exposure to diverse geological, engineering, and regulatory problems worldwide, which has made him a sought-after technical expert in his field. Bill is very familiar with WSDOT's Geotechnical Design Manual (GDM) and will bring this understanding into the project review. Bill consulted with WSDOT for over 12 years on their Unstable Slopes Management Program and assessed and provided conceptual designs for over 500 unstable slopes (rock slopes, landslides, and debris flows). He co-authored with Steve Lowell and other WSDOT personnel to present a paper titled "Conceptual Designs and Cost Estimates: A Critical Step in Managing Unstable Slopes along Washington State Highways" at the 56th Highway Geology Symposium in Wilmington, NC. Bill is the firm's senior technical advisor on the ITD's geotechnical engineering and blasting term agreement. Bill was the principal-in-charge for the rock slope emergency response at US-95 near Riggins, Idaho. He provided follow-on rock slope designs and blasting consultation and was the Engineer of Record (EOR) on SH-55 near Smiths Ferry as part of an ITD. Bill started the roped access program for Delve Underground in 2011.

Jamie Schick, LEG | Principal Engineering Geologist

Registrations/Certifications: LEG: WA, #2365, 2003 | CEG: OR, #E1860, 2000 | PG: UT, #11841658-2250, 2020 | FHWA Certified Tunnel Inspector | Level I SPRAT Certified, Society of Roped Access Technicians, 2020

Jamie is an engineering geologist with 28 years of experience applying geological sciences to large- and small-scale rock engineering projects. Jamie has extensive experience with unstable rock and soil slope investigations and previously worked for the Oregon DOT on their unstable slopes program and later became the state rock slope geologist. While working on ODOT's unstable slopes program, Jamie evaluated over 1,000 unstable slopes (landslides, rockfall, debris flow) and developed over 300 conceptual designs for a wide variety of slope failures. As the state rock slope geologist, he was responsible for developing and maintaining design standards for the state, as well as providing technical support to regional staff associated with landslide and rockfall hazards. Jamie has completed numerous rockfall and rock slope projects, including being the lead designer for the Mountain Tunnel rock slope mitigation program and the Yellowtail Dam rockfall attenuator. Jamie also administers Delve Underground's roped access program.

Bryan J. Duevel, PE, GE | Principal Geological Engineer

Registrations/Certifications: PE: WA #40157, 2003; OR #59847PE, 2002; AK #CE12479, 2009, ID #18322, 2019; DC #PE40000648, 2022, RGE: OR #59847PE, 2009

Bryan has 23 years of geotechnical and construction engineering experience on many projects, including highways, tunnels, dams, pipelines and water resources, and hydroelectric infrastructure. He has extensive experience in developing designs for large, multidisciplinary projects through all phases, including the initial development of field investigation programs, detailed design, and support during construction. He has extensive experience in site characterization and designing complex rock slope stabilization programs and was the Engineer of Record (EOR) for the IDT Rockslide on US-95, MP 188. Bryan will support WSDOT with design development and provide technical review of design reports, construction specifications, and final design drawings.

Ethan Guzek, LEG, PG | Engineering Geologist

Registrations/Certifications: LEG, PG: WA #22034446, 2022, 2023

Ethan is an engineering geologist with five years of experience who routinely provides design, field engineering, and construction management services on rock engineering projects. Ethan is regularly involved in rock engineering projects that require site reconnaissance, data collection, design, stability, construction monitoring, project management, and reporting. With a background in engineering geology, roped access techniques, and UAV-based photogrammetry, he is proficient in rock slope mapping and stability assessment in difficult-access areas. His routine comprehensive participation in projects from desk reconnaissance to project close-out provides him the skills to generate effective designs and operate efficiently in the field. Ethan was a key engineering geologist on ITD's US-95, MP 188 Rockslide, Smiths Ferry Rockfall, and Bull's Eye Rockfall mitigation projects.

Shaun Cordes, LEG, PG | Lead Engineering Geologist

Registrations/Certifications: LEG, PG: WA #3286, 2018

Shaun is an engineering geologist with 11 years of experience in geotechnical engineering and engineering geology and more than a decade of experience utilizing GIS technology with geology. His experience includes geohazard assessments, slope assessments, geotechnical subsurface characterization, geologic mapping, GIS analysis, fish passage culvert replacements, and pavement rehab. Shaun has managed/ completed projects throughout southwest Washington, including geotechnical and geologic evaluations of large-scale industrial facilities, roadway improvement projects, rock slope evaluation and mitigation, emergency landslide response, and slope evaluations. Shaun recently completed design of a rockfall mitigation project at the Big Muddy Ranch in eastern Oregon involving dowel reinforcement, attenuator design and rockfall protection mesh.

Mark Pinske, PE | Lead Geotechnical Engineer

Registrations/Certifications: PE: WA #53460, 2016; CA #81973, 2013; ID #21241, 2022

Mark is a senior project engineer with 11 years of experience covering design, construction management, design services during construction, and engineering support for a variety of geotechnical, civil, and underground projects. Mark's design experience includes retaining structures, excavation support, shallow and deep foundations, slope stability analyses, and seismic design analyses. His field experience includes geotechnical investigations, soldier pile lagging and tieback walls, drilled shafts, secant piles, soil nail walls, slurry walls, rock bolts, and grouting for rock dam abutments. Mark was the project manager and engineer of record for the Hetch Hetchy Roadways project, which included response to rockfall hazards. Mark also provided technical support to the IDT Rockslide on US-95, MP 188 and SH55, Smiths Ferry Cut 8 rockfall mitigation.

Luke Ferguson, PE | Geotechnical Engineer

Registrations/Certifications: PE: CA #87945, 2017

Luke is a project engineer with eight years of experience in geotechnical and geological engineering and construction. Luke has been involved in surface and subsurface field explorations and investigations, quality control and construction inspections, geotechnical design, recommendations, and report creation. Luke is a core member of the Delve Underground roped access team and was integral to the delivery of the IDT Rockslide on US-95, MP 188, SH-55 Smiths Ferry Rock Slopes Project, and rockfall mitigation on US-12 in Idaho. Luke has experience in design and construction in rock slope stabilization, ranging from rockfall analysis and mitigation to rock dowel design and pattern dowel layout.

Malcolm Perkins, PE | Geotechnical Engineer

Registrations/Certifications: PE: WA, #20123337, 2021

Malcolm is a project geotechnical engineer with over seven years with Delve Underground. Malcolm's expertise includes analyzing and designing geotechnical structures, developing and monitoring geotechnical exploration programs, interpreting subsurface conditions, and overseeing rock excavation projects. Malcolm has also used roped access techniques to conduct rock slope and structural inspections. Malcolm is one of the lead rock mapping and rock anchor inspectors for the large underground rock excavation LBNF project in Lead, South Dakota.

Thomas Pallua, PG | Geologist

Registrations/Certifications: PG: WA #3187, 2015

Thomas has over 22 years of experience providing geologic/geotechnical site characterization, geologic modeling services and rock slope mitigation design development. His exploration experience ranges from organizing, directing, and conducting geological and geotechnical field investigations to executing geologic mapping efforts to collect lithological and structural data. Thomas has been a core member of the roped access team and has accessed numerous slopes using his skills. He also has over ten years of experience reviewing and designing blasting programs for various private and public entities. Thomas was the senior engineering geologist on the New Jersey Transit Roseville Rock Engineering Project. He also worked with Jerry Wallace on the blast design for the IDT Rockslide on US-95, MP 188.

Alexis Judy, GIT | Engineering Geology Staff

Registrations/Certifications: Geologist in Training, OSBOG State of Oregon, #T2686

Alexis has over four years of experience in rock slope and related geotechnical work. Alexis is a member of our core roped access team and has experience collecting rock mass and discontinuity data for reinforcement and the kinematic design of new rock cuts. She was key in developing kinematic design for a mile of rock cuts for the SH-55 Smiths Ferry to Round Valley Widening and mitigation design for the ITD Bullseye Rock Slope Mitigation. She was responsible for trim blast loading and quality assurance for the ITD MP 188 Emergency Rockfall Response.

Jim Siemens, GIT | Engineering Geology Staff

Registrations/Certifications: Geologist in Training: OR, 2019

Jim has three years of geological, geotechnical, and construction engineering experience and is a core roped access team member. Jim has provided design and construction support for multiple rock slope mitigation projects, including the SH-55 Smiths Ferry, New Jersey Transit Roseville Rock Engineering Project, and the Yellowtail Dam Rockfall Attenuator Design.

Jerry Wallace | Blasting Consultant

(Wallace Technical Blasting)

Registrations/Certifications: WA Blaster (Unlimited) #18690

Jerry is a highly technical blaster with over 50 years of experience in the blasting field. He provides a full range of technical blasting services to the construction industry as well as consulting services to government agencies. Jerry specializes in critical, close-order, and unique blasting situations. Services include blast feasibility & estimating, specifications, blast plan review, blast-site services, blast remediation, explosives training & safety education, and expert testimony. Jerry instructs periodic blasting courses at the University of Washington as a faculty member and has instructed ODOT, the Oregon Department of Forestry, and the US Bureau of Reclamation. He is a former president of the International Society of Explosives Engineers.

Chris D. Breeds, PhD, PE | Geotechnical Instrumentation

(SubTerra)

Registrations/Certifications: PE: WA, #30182

Chris has been providing instrumentation services for the geotechnical, civil, tunnelling, and underground mining industry for over 30 years. He has been involved in multiple complex instrumentation efforts involving remote data acquisition, including the rock slope instrumentation for WSDOT's widening of I-90 through Snoqualmie Pass. For this contract, he can assist in remote instrumentation efforts required to monitor rock mass strain, individual blocks, or installed rock reinforcement.

Whitney Ciani, PE | Geotechnical Engineer *(Ciani & Hatch)*

Registrations/Certifications:

PE: WA #48245, 2011

Whitney has 17 years of progressive experience leading the design and quality assurance, bid support, and project plans and specifications for a variety of projects. Whitney has extensive onsite experience providing construction oversight and geotechnical inspection, affording her valuable perspective on constructability. Whitney's design expertise includes laboratory test data analysis, soil property determination, shallow and deep foundation design, soft ground engineering, ground improvement alternatives analysis, slope stability analysis, temporary and permanent shoring design, and retaining wall design.

Mikayla Hatch, PE | Geotechnical Engineer *(Ciani & Hatch)*

Registrations/Certifications:

PE: WA #48245, 2021

For the past six years, Mikayla has provided project management, design staff management, design documentation, and construction phase services to clients in the public and private sectors. She has successfully delivered technical memoranda, geotechnical engineering reports, and calculation packages for the Washington State Department of Transportation.

Dan Adsit, PLS, CWRE | Survey Project Manager *(Emerio Design)*

Registrations/Certifications:

Professional Land Surveyor: OR #75495

Dan has 43 years of experience in land surveying, providing expertise in transportation and utility surveys. His extensive field and office survey capabilities include rights-of-entry, topographic survey and base mapping, 3D LiDAR data, 3D laser scanning and GIS mapping, establishing control networks, monumentation and control surveying, determining right-of-way and writing legal descriptions, and construction support services, including bidding, contract communications, and contract management. Dan has successfully managed over 80 survey projects with deliverables on time and budget since starting at Emerio in 2017, including all of Emerio's current on-call survey contracts.

Delve Underground's Capabilities Toolbox

Our experience allows us to bring an unparalleled toolbox of capabilities to WSDOT.

	Rockfall hazard assessment and mitigation	Rock slope design	Roped access expertise	Corridor studies	Unstable slopes asset management	Emergency response	Blasting Consulting	Development of contract plans and specifications	Construction support
Jim Struthers, LEG, PG. Project Manager / SLG	●	●	●	●	●	●	●	●	●
Bill Gates, PhD, PE, LEG Principal Consultant Tech. Review	●	●	●	●	●	●	●	●	●
Jamie Schick, LEG, P.G. Principal Engineering Geologist	●	●	●	●	●	●	●	●	●
Bryan Duevel, PE, G.E. Principal Geological Engineer	●	●		●		●	●	●	●
Ethan Guzek, LEG, P.G. Engineering Geologist	●	●	●	●	●	●	●	●	●
Shaun Cordes, LEG, PG. Lead Engineering Geologist	●	●	●	●	●	●		●	●
Mark Pinske, PE Geotechnical Engineer	●	●	●	●		●		●	●
Luke Ferguson, PE Geotechnical Engineer	●	●	●			●		●	●
Thomas Pallua, PG Geologist	●	●	●	●		●	●	●	●
Malcolm Perkins, PE Geotechnical Engineer	●	●	●			●	●	●	●
Alexis Judy, GIT Engineering Geology Staff	●	●	●			●			●
Jim Siemens, GIT Engineering Geology Staff	●	●	●				●		●

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B. Emergency Rockslide Response and Long-Term Mitigation; US-95, MP 188

Riggins, ID (2020)

The US-95, MP 188 emergency response and mitigation project made extensive use of drone imagery, highly technical blasting, instrumentation, and relied heavily on roped-access for design and construction support.

2021
Association of General Contractors Top Gold Medal for Excellence in Construction Partnering

US-95 is the sole north-south route in the Idaho panhandle. The route passes through the steep-sided Salmon River canyon and cuts large rock slopes that have been historically prone to rockslides due to the presence of adverse, persistent geologic structures. In early July 2020, two large, sequential rockslides occurred, blocking this critical highway and leaving a large unstable block stranded 200 feet above the highway.

Delve Underground was notified of the failure by the Idaho Transportation Department (ITD) on July 4th and mobilized to the site the following day. Initial response work included geologic and geomechanical assessment of the slope using roped access techniques, provision of emergency scaling recommendations, installation of monitoring equipment, and development of conceptual mitigation options for the slope. Monitoring of the rock mass included around-the-clock observation for rockfall, UAV-based visual assessment of PVC extensometers installed across major tension fractures, installation, and survey of key targets on the rock mass, installation and remote monitoring of over 20 crack gauges, tilt meters, and prisms.

The application of remote monitoring methods during the response was critical to the safe completion of this project. Equally important to the collection of data was the development of specific criteria such that results could formally be used to support decisions related to highway reopening and construction operations.

Because of the need to reopen the route, plans and specifications for the project were developed on an expedited timeline, and ITD advertised the project 21 days after the failure. During this period, ITD contracted with Wallace Technical Blasting and Delve Underground to jointly develop a trim blasting plan to remove the approximately 14,000 cubic yard remnant unstable block.

Blasting design was heavily reliant on constraint of the geologic structure and block geometry. Delve Underground engineering geologists used 3D point clouds produced by Delve engineering geologists using UAV-based photogrammetry techniques to constrain essential elements of the blast design. These elements included pre-split line location, inclination, and orientation of each pre-split hole to capture the controlling wedge structure at depth, hole depths, burden, inclination, and location of “looker” production holes for the overhung portion of the block.

The UAV modeling was subsequently used to assemble drilling plan sheets for the contractor and to plan the detailed drilling and loading for each hole.

Drilling for the blast holes started within 48 hours of contractor selection and was completed in seven days. Delve Underground staff were present throughout drilling to support any geologically driven changes and relayed any adjustments of hole geometry, along with drill logs, to the blaster-in-charge to support ongoing blast modeling of delays and charge design. A total of 122 blast holes were loaded with about 6,000 pounds of explosives and detonated on August 28th, removing the remnant block in one shot. This program required the placement of equipment and personnel on the unstable rock mass. The layered monitoring program and associated communication protocols developed for this unique situation facilitated the team's ability to complete this work safely. Delve Underground served a critical role in monitoring block movement during this process and assisted in the design and execution of the large trim blast from conceptual inception to completion. Following the blast, Delve Underground organized and led efforts to provide long-term rockfall mitigation for the blasted area and adjacent slopes. Characterization of the post-blast surface and final development of long-term solutions required extensive use of roped-access techniques.

Mitigation solutions included the design and implementation of rock anchor reinforcement, on-slope rockfall mesh, brow stabilization via grading, and design of rockfall catchment systems. The Delve Underground team oversaw rock scaling, additional trim blast shots, and designed and oversaw the installation of over 5000 feet of rock dowels, 300 feet of drains, 60,000 square feet of wire drape, 2000 square feet of Tecco Mesh, and a T-35 rockfall fence and the base of the slope.

Delve worked with the contractor superintendent daily to communicate design objectives, track construction progress, and continuously assess opportunities to increase constructability, efficiency, and effectiveness of design solutions. This close coordination resulted in significant project cost savings. Mitigation of the rock slope was completed on November 14th. ITD and the Delve Underground Contractor team were awarded the Association of General Contractors Top Gold Medal for Excellence in Construction Partnering.

Key Personnel:
William Gates (Principal Geological Engineer & Project Manager), James Struthers (Principal Engineering Geologist), Jamie Schick (Principal Engineering Geologist), Luke Ferguson (Engineering Geologist), Ethan Guzek (Engineering Geologist & drone operator), Alexis Judy (Geologist) and Bryan Duevel (EOR).

Essential to Success
Strategic Solutions

Mountain Tunnel Improvements Project
SFPUC | Moccasin, CA

The Mountain Tunnel Improvements project included significant upgrades to three roadways to provide reliable access to the Mountain Tunnel, an 18-mile tunnel providing water to San Francisco. Rockfall hazards were addressed through a combination of approaches ranging from draped double-twisted wire mesh and cable net systems to attenuator systems and pattern rock bolting. Significant reaches of these roads required scaling and rock doweling to reduce rockfall hazards along the corridor. Over 30 rockfall mitigations were developed for the roadways.

DELVE
underground

C. Blasting Consulting, Emergency Response, Geotechnical Design and Mitigation, SH-55

Smiths Ferry | ID (2020-2023)

For the SH-55 widening project, Delve Underground provided blasting consultation, emergency response services, and full re-design of cut slopes for the 1-mile corridor, including construction support, design of stabilization, and rockfall mitigation.

2023
Association of General Contractors Top Gold Medal for Excellence in Construction Partnering

This project was overseen by Idaho Department of Transportation (ITD), District 3 and involved the widening of SH-55 between Smith's Ferry and Round Valley, where the highway follows a deep incised canyon formed by the Payette River. The rock mass within the project limits ranges from very strong to completely decomposed granodiorite with adversely dipping structural control and extreme local joint persistence. This one-mile-long widening project included rock cuts ranging from 30 to 150 feet in height and was designed prior to Delve Underground's involvement. For project construction, ITD originally retained Delve Underground as the blasting consultant. Delve Underground is an ITD-approved Blasting Consultant and has demonstrated expertise in highway blasting techniques. Following a series of slope failures in early 2021, Delve Underground's role on the project was expanded to include:

- Emergency mitigation of the failed rock slopes
- Kinematic analysis and redesign of all rock cuts on the project
- Engineering support for the rock slope construction, including inspection of newly formed benches, design of post-blast reinforcement, design of rockfall mitigation measures for the new cuts.

As the blasting consultant, Delve Underground reviewed the general blast plan for the project, over 80 blast plans and post-blast reports, and conducted multiple site visits to observe blasting quality and progress. Blast plan review consisted of a stepwise logical process focused on the following items:

- Appropriateness of blast type with respect to production and pre-split blasting
- Appropriateness of blast hole design and layout, including evaluation of number, depth, diameter, burden, spacing, stemming depth, sub-drill depth, and input parameter used in the blast plan.
- Selection of explosive type, primers, and powder factor for each planned shot
- Evaluation of the maximum number of delays and pounds of explosives per delay
- Evaluation of anticipated vibrations per delay and the potential of the shot to generate fly rock. Fly rock into the Payette River was a significant project concern and was controlled by proper blast design, rock berms, and Conex container barriers.

For each shot, Delve Underground was responsible for reviewing, approving, and communicating our recommendations to the ITD Project Manager before the shot proceeded. Following blasting, each post-blast report was reviewed to verify the performance of the blasting operations.

In March 2021, Rock Cut 9 failed catastrophically, damaging several pieces of heavy equipment and closing the road. After the rockslide, a large 1,500 cubic yard overhung rock mass remained on the slope, creating a hazard to the highway. ITD retained Delve Underground to provide emergency response services to remove the mass and stabilize the slope. Delve Underground employed roped access techniques to characterize the structure bounding the mass and worked with Jerry Wallace to develop a trim blast that would safely bring the unstable mass to the ground. Because of the difficult access, an excavator, blasting drill rig, and explosives were sling-loaded to the top of the rock slope with a Chinook Helicopter. The mass was successfully removed within ten days of the initial failure, and the route was reopened to traffic.

The subsequent rock cut failures led to a lack of faith in the existing original rock cut designs across the project, resulting in ITD retaining Delve to assume the role of engineer of record for the project and complete an expedited full redesign of slopes throughout the 1-mile-long corridor. The methodical approach taken by Delve Underground consisted of:

- Redesign of cut inclinations rooted in kinematic analysis for each cut to reduce the occurrence of viable block failures
- Lift-by-lift bench inspection, onsite block reinforcement design, and construction sequencing coordination
- Assessment of degraded rock masses and design of pinned mesh in focused areas
- Rockfall hazard assessment and design of draped mesh in areas with limited ditch catchment width

Insight and experience relevant to cut-slope construction resulted in complimentary blasting and reinforcement designs. Relatively minor adjustments to pre-split inclinations resulted in a significant reduction of slope hazards and improved construction safety.

In some instances, controlling geologic structure was characterized and incorporated directly into the blasting approach through a team effort between Delve Underground and the blaster. We provided blasting support for objectives with complex geometries using UAV-derived 3D models. For example, controlling structure at depth was projected up-slope and laterally to help establish pre-split-line drilling locations. Related, isopach maps, essentially bathymetry of structure at depth, were also generated to help constrain vertical production hole depth across irregular ground surfaces.

Close coordination with ITD and positive working relationships with the blaster and contractor team led to the production and facilitation of designs that efficiently mitigated slope hazards across highly variable ground throughout the project corridor. Despite overhauling the geotechnical design, the project was completed within the original project timeline. In 2023, this project was awarded the Association of General Contractors Award for excellence in construction partnering.

Key personnel:

Bill Gates (Principal Geological Engineer, PM and EOR), James Struthers (Principal Engineering Geologist). James Schick (Principal Engineering Geologist), Mark Pinske (Geotechnical Engineer), Luke Ferguson (Engineering Geologist), Ethan Guzek (Engineering Geologist and Drone pilot), Alexis Judy (Geologist).

Check out the Project Blast Footage

D. DBE Inclusion Plan

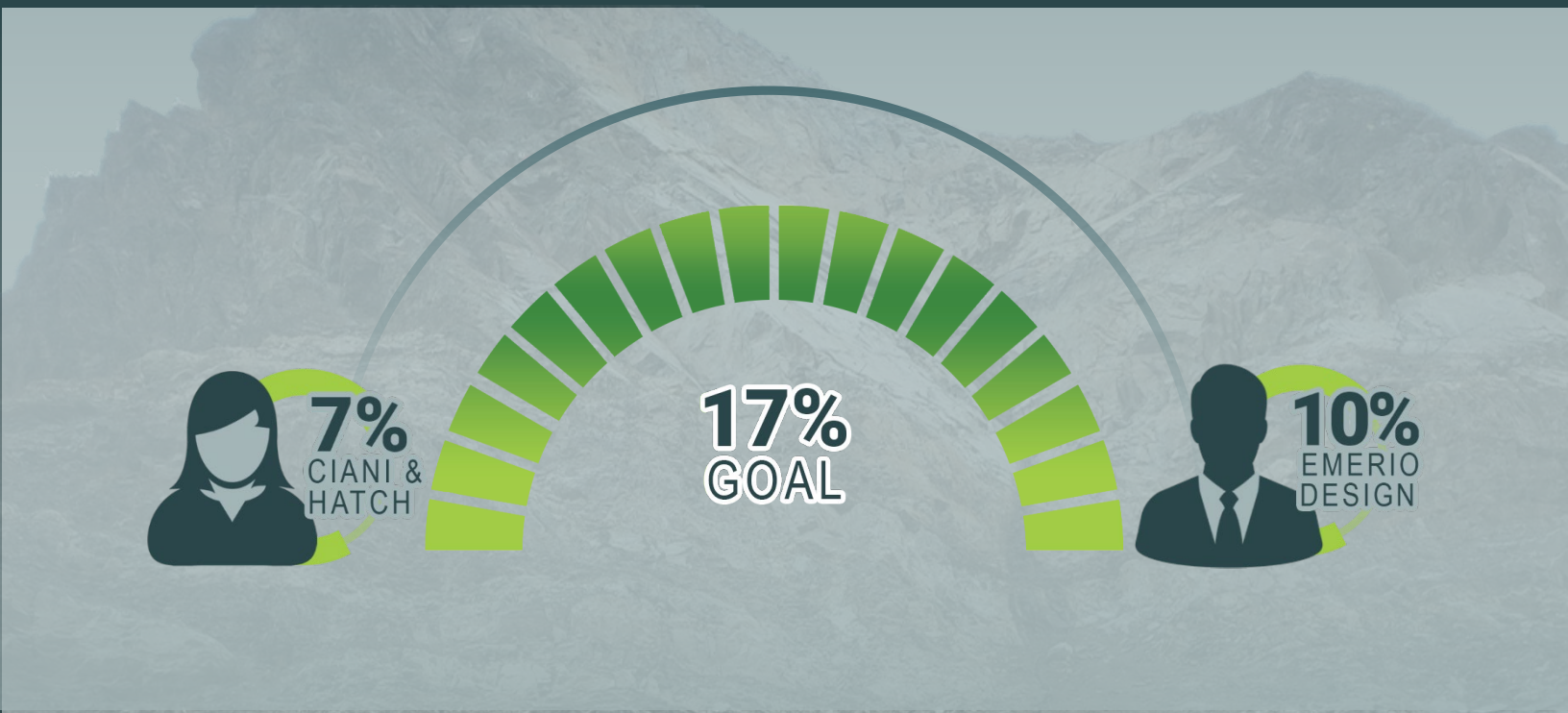
At Delve Underground, we prioritize meeting diversity participation goals and fostering high-performance, collaborative design teams.

Our unwavering dedication to creating an environment that promotes diversity and inclusion for all project delivery partners sets us apart. We are thrilled to have certified DBEs Ciani & Hatch (WBE) and Emerio Design (MBE) on our team. Their specialized expertise and relevant project experience with Delve Underground are essential to the overall success of this contract. By partnering with these certified DBEs, we're not only fostering diversity and inclusion, but we're also able to tap into their wealth of knowledge and experience, ensuring that we deliver the best possible results.

Delve Underground is currently teamed with Emerio Design on the ODOT Arizona Inn Landslide on the Oregon Coast. Emerio Design is providing civil support for a 200 ft vertical drainage shaft in the landslide, geotechnical engineering services, and licensed surveying. For this WSDOT contract, Delve Underground will utilize Emerio's survey expertise, civil design capabilities, and drone survey team to augment our capabilities.

Emerio's in-house LiDAR survey services will be utilized to provide accurate delineation of rock slope features as well as the ability to monitor differential slope movement. Furthermore, they will provide support in the development of CADD and other civil design products required for project delivery. Emerio's drone capabilities are robust and will be used for projects where imagery with tight spatial control is needed.

Ciani & Hatch's specialized team further augments our capability through their extensive knowledge of WSDOT geotechnical design standards, particularly as applied to alternative methods of contract delivery. Whitney Ciani's impressive background with WSDOT design-build projects makes her an excellent engineer for supporting alternate delivery contracts while providing robust geotechnical resources to the team. Whitney can support WSDOT during all phases of project development and act as a geotechnical subject matter during the development and administration of design-build contracts.



CRITERIA 2 EXPERTISE/EXPERIENCE FOR WORK ON STEEP SLOPES UTILIZING ROPED ACCESS TECHNIQUES AND DRONES/UAV

Delve Underground has developed a highly trained and experienced roped access team. We have approximately fifteen team members led by Jamie Schick. As outlined below, we maintain a rigorous training and safety program to ensure our team is prepared to respond to any emergency and safely access steep slopes. Our program has received annual recognition from the Association of Geohazard Professionals (AGHP) since 2018. We also provide roped access training for other consultants, contractors, and agency staff, including WSDOT and FHWA Western Federal Lands. Our team's extensive experience in roped access methods, paired with in-house UAV capabilities, will provide WSDOT with rapid response times to emergency response events, improve coverage for detailed on-slope observation, and maintain slope presence throughout construction. Roped access is critical to routine engineering geology tasks throughout the design and construction. Proficiency in roped access methods directly supports properly constraining a slope hazard and providing the construction support required to keep mitigation efforts on target and schedule.

A. Selecting a Method for Slope Assessment

Delve Underground uses roped access techniques and unmanned aerial vehicles (UAVs) to perform slope reconnaissance and technical design to mitigate slope hazards in steep environments. Project success for this type of work relies heavily on the observations that allow our engineering geologists to constrain slope stability problems properly. Delve Underground prioritizes a combination of methods to enable detailed surface data collection in the spatial context of critical slope features. Delve Underground routinely implements a full-coverage approach in developing mitigation solutions supported by rigorous bi-annual training in roped-access techniques and UAV-based methods that can be readily utilized for steep slopes. This approach allows us to reduce the assumptions required for the execution of design, which directly influences project cost and timeline. Implementing regimented safety protocols and ownership of relevant skills within our engineering geology team have facilitated safe operations and routine success in our professional practice.

The core components of Delve Underground's approach to slope hazards include ground-based observation from a safe distance, UAV-based imagery collection, onsite team collaboration, establishing a slope access safety plan, and execution of focused roped access work.

The division of labor between UAV-based reconnaissance and roped access work is adjusted based on the project site condition, design objectives, and project timeline. Under limited circumstances, the application of a particular method may be reduced for safety or legal reasons.

Typically, our engineering geologists complete initial ground-based reconnaissance and UAV-based imagery collection within 1-3 hours of arriving onsite. Efficient UAV operations are supported by employing engineering geologists who are licensed FAA Part 107 remote pilots. Delve Underground trains pilots in free-flight operation, specific to steep slope reconnaissance, such that we do not rely on pre-programmed flights for capture of photo sets that support conceptual understanding of the project objectives and provide quality data for 3D point cloud generation. Skill in free-flight operation accelerates the flight process and provides better coverage of slope features.

Because the user is participating in an active form of slope observation, primary slope objectives can often be targeted immediately upon completion of the flight. Further, safe flight operations are supported by procedural forms and checklists developed by Delve Underground, to support compliance with FAA regulations and maintain public safety.

The development of UAV procedural forms was inspired by the slope access safety and equipment form (SASE) developed by Delve Underground and WSDOT staff. The SASE supplements the general site-specific safety plan and standard roped-access safety procedures. The SASE form is integral in formulating the subsequent slope access planning and safe execution of roped access work. The SASE provides a simple, consistent framework for an engineering geologist to evaluate, characterize, and identify geologic hazards and safety issues concerning slope work. To promote slope readiness, all Delve Underground engineering geologists maintain a go-bag that contains a complete personalized rope kit, two-way radios, and first-aid kits. Each kit includes a variety of gear, allowing our personnel to access slopes safely and efficiently under a variety of conditions or circumstances. We also maintain team gear that contains less commonly used, specialized equipment that usually travels to the site with one of the staff.

Our engineering geologists are trained in vertical and horizontal aid climbing and installing mechanical anchors to support slope access. This allows us to be self-reliant in establishing roped access on a slope, which reduces costs and the project timeline. Our engineering geologists also carry scaling bars during initial slope reconnaissance. They can perform limited scaling activities to support access to primary objectives during the early stages of a project. This type of activity is typically accompanied by additional slope operation procedures to protect personnel, public assets, or civilians potentially occupying the roadway below the active work area. In the past, this has involved the use of an extra spotter at the base of the slope or the involvement of a traffic control contractor.

In difficult-access or hostile environments, additional steps may be taken to maintain the ability to execute on-slope roped access work safely or more efficiently. This might include increased gear, increased personnel, and increased communication.

In combination, UAV technology and roped access techniques allow detailed observations to be made in the big-picture context. Experience in the year-round application of these methods allows us to understand limitations associated with reducing one method and how to best compensate for information gaps by exercising additional flight or roped activities as needed. Rigorous training and development of field methods specific to steep slope reconnaissance allow our engineering geology team to obtain critical project data and observations effectively. Implementing our general process is supported by controlled safety procedures such that project goals can be achieved quickly and safely in various adverse conditions and hostile environments.

B. Steep Slope Roped Access Safety Training Program

Our roped access program was initiated by Bill Gates in 2011 and is rooted in decades of experience in rock engineering, mountaineering, and military special forces experience. The program is unique because it blends traditional mountaineering and industrial roped access methods, providing our engineering geologists with diverse skills appropriate for work on steep, unstable slopes. In all the years Delve Underground has practiced roped access work, there has never been a significant safety incident. This can be attributed to program organization, annual to bi-annual training, and regular participation practice in roped access work throughout the year. Our program is nationally recognized and has received safety awards annually from the Association of Geohazard Professionals (AGHP) since the association's inception in 2018. Delve Underground's roped access program consists of approximately 15 members and is led by Jamie Schick and Bill Gates.

Our training is motivated by the irreplaceable insight and quality data collection afforded by getting on the slope. Delve Underground has commonly been involved in slope work where ground-based and UAV-based observation can build a partial picture of the situation. Still, upon accessing the slope with rope techniques, critical on-slope observations guide the mitigation design and best course of action.

Delve Underground's in-house roped access safety program requires our staff to participate in a rigorous 3-day roped access training at least once a year. In addition to this, core staff meet by region at least one other time per year to gain additional practice. Emphasis is placed on basic skills such as knots, anchorage, gear safety, up-down travel on rope, passing knots, and simple rescue of a victim on descending gear. During training, we also practice high-level maneuvers, complicated rescue scenarios, and introduce unique challenges each year that force employees to use their existing skills and knowledge to solve problems they have not been exposed to before. In addition to internal training, Delve Underground usually sends several employees to SPRAT training every three years to maintain certifications for structure work. Following these trainings, employees bring back knowledge of varying techniques and gear. This expands our employees' toolboxes and encourages program growth to include more diverse skills and strategies for complex situations.

Within our internal program, we have three designated skill levels. Skill levels are based on knowledge of roped access, ability to perform aerial maneuvers and rescues, total experience, yearly experience, ability to set up access for a slope, ability to construct or install anchors, and experience and training in assessing a hazardous slope for team access and safe execution of work. Emphasis is placed on the final point mentioned, as prioritization of safety and developing a roped access work plan by an experienced team member, are the two most important aspects for a successful roped access reconnaissance.

To support this, team members practice completion of slope access safety and equipment safety (SASE) forms and procedures during training.

Delve Underground staff also provide external roped access training to a variety of teams, including WSDOT and Western Federal Land's engineering geology and geotechnical teams, every two years. The content of these trainings is similar to our in-house training.

Essential to Success
Slope Access

Delve Underground's roped access capabilities allow us to fully investigate slopes and integrate critical observations into design.

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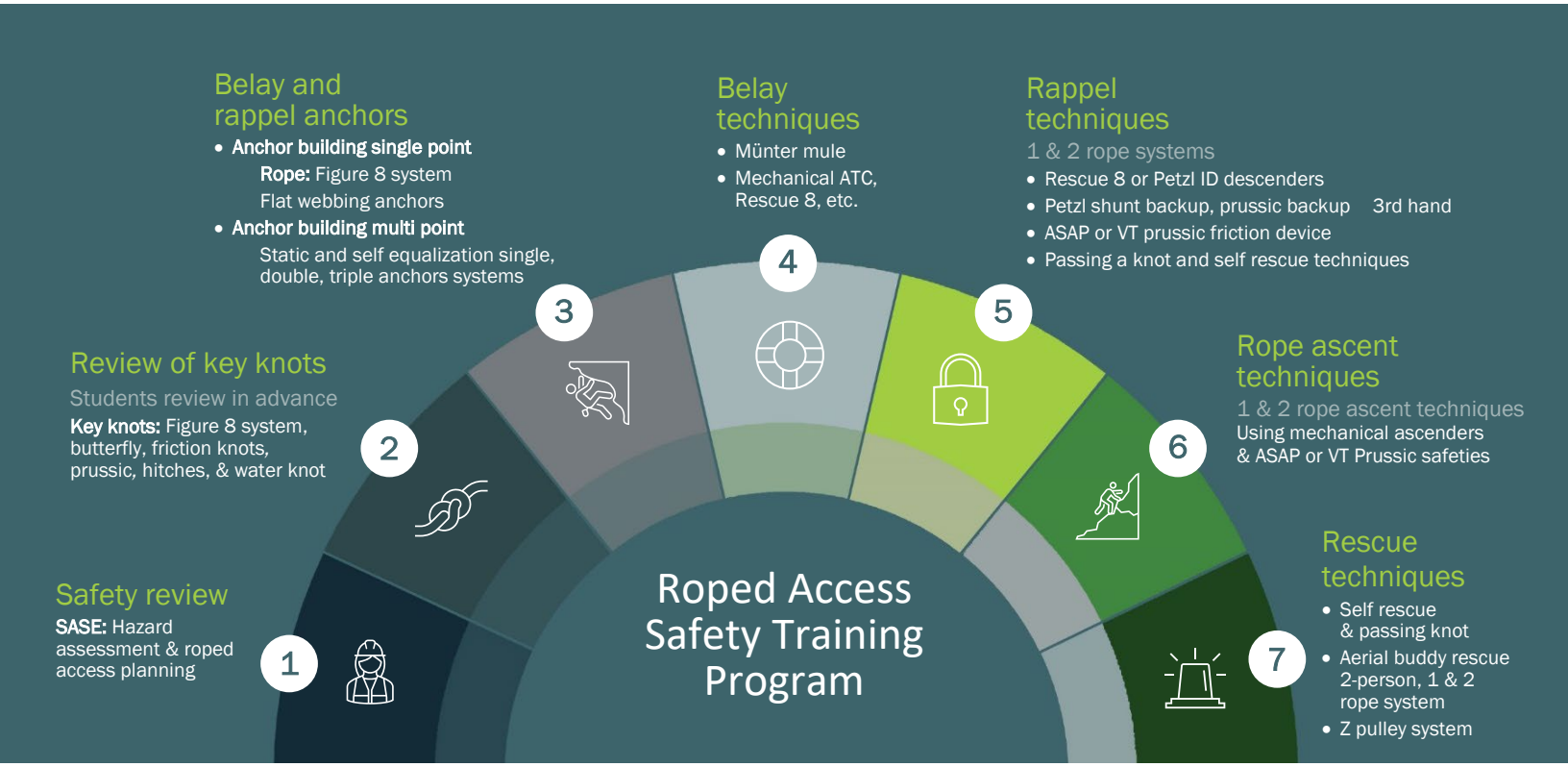


C. Types of Data and Samples Collected on Slope

On-slope reconnaissance accomplished two things: 1) conceptual understanding of the slope stability problem and 2) collection of detailed technical information supporting mitigation solutions design.

Most of our data collection objectives focus on rock mass characterization and discontinuity descriptions, as these data support block stability analyses and characterization of rockfall source areas. To stabilize existing slopes, rock data is collected at specific locations identified during initial reconnaissance or prior roped access activities. Common objective locations consist of tension cracks, blocks showing potential for planar or wedge sliding, or locations where disaggregation or significant weathering of a rock mass exists. The primary data types targeted during our investigations include intact rock strength, approximate block dimensions, joint orientations, and joint conditions for any controlling structure. Standard tools used to collect and document this data include geologic rock hammers, CLAR geo-stratigraphic compasses, tape measures, and cameras.

Observation of the controlling discontinuities is made as it relates to the engineering geology properties pertinent to the design of resisting forces in limit-equilibrium analysis. This includes parameters such as attitude, persistence, weathering, roughness, shape, infilling, and joint roughness coefficients (JRC).

General block sizes can be documented, the depth of a disaggregated or weathered mass measured, or limited live rockfall tests conducted. These types of observations and activities will facilitate the extent and type of mesh system (draped or pinned) recommended to mitigate rockfall hazards in a disturbed area. Collectively, the above-mentioned data types may also inform the extent and effort required for rock scaling activities or even provide critical data for specialized remedial blasting to remove large hazardous rock masses.

When performing reconnaissance work in support of cut-slope construction, data collection is targeted slightly differently than it would be for the design of an existing slope. Emphasis is applied to general joint orientation, persistence, and joint condition information. Data collection for this type of work relies on a series of vertical scan lines spaced across the slope accompanied by horizontal scan lines that traverse the base of the slope or any ledge systems that may exist.

Unique or potentially problematic areas, such as weathered masses along brows or structural contacts, may also receive focused window mapping. By performing kinematic analyses using collected orientation data, the common types of block failures for a proposed cut-slope inclination and slope orientation can be anticipated. With associated joint persistence and rock quality information, the size of failure and general level of effort related to slope reinforcement may be predicted. This method is effective in designing the inclination of the slope such that the majority of kinematically viable block failures can be eliminated. In cases where degraded or low-quality rock masses are encountered, this general approach may assist in anticipating the amount or type of mesh that may be required to increase surficial stability or contain rockfall.

Delve Underground also applies our proficiency in roped access to assist in other, less common, project components that might otherwise be contracted out. For example, during the US-95 MP 188 rockslide project, Delve Underground installed telemetered, highly sensitive slope extensometers and tilt-meter instruments across a 14,000 cubic yard wedge-shaped mass that formed a large overhang at its base. This was accomplished using a team of two, with backup roped access personnel on standby. This endeavor successfully allowed the team to monitor the mass for movement during remedial blasting operations.

D. Use of Drones/UAV Imagery and Spatial Data

Delve Underground has an in-house UAV program organized and maintained by our engineering geology group. Using photogrammetry techniques, we train in free-flight imagery collection specific to steep slopes and subsequent imagery processing into 3D point clouds. This program operates in compliance with FAA Part 107 Rules as it relates to remote pilot licensure and aircraft registration. Our UAV deployment is instrumental in initial reconnaissance, roped access planning, and detailed final design. Imagery datasets are typically compiled, and 3D products are generated at the end of day one during a project response.

Having these products available for meetings following initial project reconnaissance is critical for communicating with our clients and developing a clear path forward. Communication may include conceptual designs for final solutions or emergency mitigation concepts that need to go into effect immediately. This may include project plans with location and identify designations of reinforcement, blasting objectives, or mesh types and extents. The availability of high-resolution 3D data also lends itself to making accurate measurements for design work and estimating construction material quantities.

The key objectives during UAV work include the collection of high-level imagery that captures the site and surrounding area, overview imagery of critical slope features, and execution of gridded flights that capture high-overlap photo sets for 3D point cloud generation using photogrammetry techniques. Photo sets are successfully delivered quickly and include critical imagery of features that require imagery to be captured from specific altitudes in combination with specific camera angles. This method of imagery collection effectively eliminates gaps in coverage around complex slope geometries, such as overhangs or rockfall chutes, that otherwise often result from poorly targeted pre-programmed flights. The provision of 3D data collection and analysis by Delve Underground engineering geologists significantly increases project cost-efficiency and timeline of delivery (hours rather than days or weeks).

Using the 3D point cloud, any linear, surficial, or volumetric dimension can be measured. Delve Underground has experience in multiple 3D editing/analysis software, further supporting complex 3D data analysis. We use Pix4DMapper to process and produce photogrammetry products such as point clouds, mesh surfaces, photo orthomosaics, and digital surface model raster files. Alternatively, more complex interaction in 3D space can be achieved using Rhino and AutoCAD, and Microstation software products.

We import raster datasets into GIS software such as ArcPro and Global Mapper for general mapping purposes and cross-section generation. Typical applications for simple analytical spatial measurements include block dimensions, slope heights, overall slope angle, slope orientation, ditch width, joint persistence, joint surface dip and dip direction, and tension crack aperture for large separations on the order of several inches to feet. These types of data may be used to conduct block stability analyses, provide cross-sectional surfaces for large-scale limit-equilibrium analyses, perform rockfall modeling, or provide surface area estimates for potential mesh application quantities.

Raster datasets are transferred to GIS applications to cut cross-sections and produce overview maps of the project site or objective area. These maps may be used to project a proposed re-alignment across existing terrain to understand possible cut dimensioning. Orthomosaics and digital surface models produced by Delve Underground are also compared to publicly available LiDAR DEMs of the area to “ground-truth” our data. In cases where the land mass has changed as a result of an event or high degrees of vegetation cover is present, public data and data collected by Delve Underground may be used in combination for slope differencing analysis. In some cases, more complex 3D analysis may be required than simple rock slope solutions. Applications may include creating bathymetry maps of persistent inclined rock structure at depth to support complex blasting designs. In a slightly different application, 3D objects such as projected joint surfaces and linear representations of rock reinforcement may be created and projected at depth to assess element embedment lengths for complex block stabilization geometries. Delve Underground’s skill and ability to manipulate and create 3D data allow us to develop solutions for unique site-specific problems during projects. It also allows us to be efficient in our designs regarding construction material costs and scheduling.

Lastly, we understand the limitations of 3D methods. We do not use digital methods to replace fieldwork but rather support it. By continuing to engage in difficult access fieldwork, combined with UAV-based 3D data, we have routinely produced well-constrained designs. Maintaining these capabilities in-house within our project team is critical to the timely application of the method and related execution of the overall process.

Essential to Success
Strategic Solutions

Yellowtail Dam Attenuator Project
USBOR, Billings MT

The Yellowtail Dam is 525 feet high concrete arch dam with a tunnel spillway that exits downstream beneath a near vertical cut and natural slope that is over 500 feet high. Rockfall impacts from adjacent slopes were impacting the spillway and existing gates. Delve Underground completed the design of a rockfall attenuator fence above the near vertical spillway cut intended to arrest up to a 3-foot diameter block with bounce heights in excess of 12 feet. The final design was constructed in the fall of 2022.

The following examples illustrate a typical application for which Delve Underground utilizes drone imagery and UAV data.

1

Blast Design: For the US 95 MP 188 Emergency Rockfall Mitigation Project near Riggins Idaho, Delve Underground used drone imagery and point cloud modelling to develop and refine blast design for several trim blasts required as part of this work. This information was used to determine the location, length, orientation, and burden for both angled cushion holes along the cut line and production holes in the main rock mass.

2

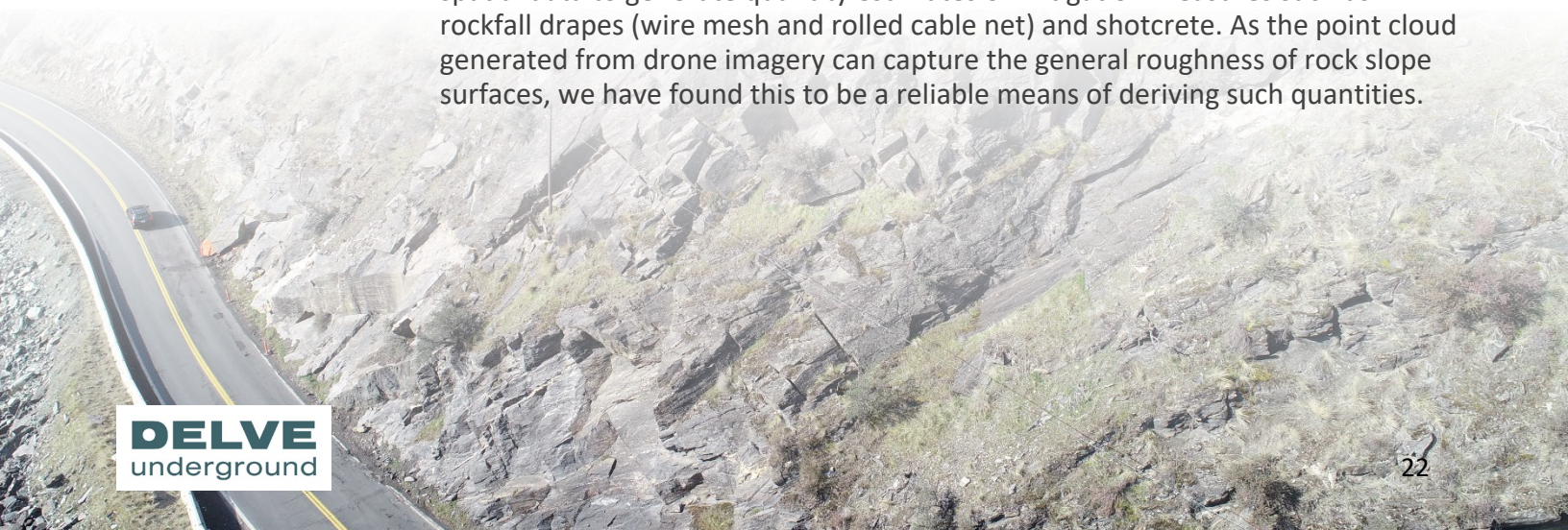
Rock Anchor Design: Estimating wedge and planar block failure geometry relative to rock anchorage from field conditions can introduce a source of uncertainty in rock slope mitigation projects. Delve Underground uses UAV spatial data to provide input to limit equilibrium models to evaluate both required rock anchorage forces and reinforcement length. For example, SH-55 Smiths Ferry to Round Valley emergency response we utilized UAV spatial data to develop topographic sections for limit equilibrium analysis of rock dowels.

3

Rockfall Modeling: As topographic profiles can be directly extracted from the UAV point cloud information, Delve Underground utilizes this information to aid in rockfall modeling using the software Rockfall by Rocscience, Inc.

4

Mitigation Measure Quantification: Delve Underground utilizes UAV spatial data to generate quantity estimates of mitigation measures such as rockfall drapes (wire mesh and rolled cable net) and shotcrete. As the point cloud generated from drone imagery can capture the general roughness of rock slope surfaces, we have found this to be a reliable means of deriving such quantities.



DELVE underground

CRITERIA 3 EXPERIENCE IN EMERGENCY RESPONSE SITUATIONS

Emergency Response

Delve Underground maintains a team of engineering geologists and geotechnical engineers specializing in emergency response to slope and other geotechnical failures. This team includes Jim Struthers' years of experience coordinating emergency response for WSDOT, Jamie Schick's work at ODOT, and their combined experience with ITD. Similarly, Jerry Wallace with Wallace Technical Blasting and Chris Breeds with SubTerra bring decades of experience in instrumentation and blasting work for transportation agencies to the project team. **The keys to a successful emergency response include:**

- Careful assessment of site conditions
- Communication that keep the team informed
- Stakeholders are aware of decision points at every step

The timeline below summarizes our team's proposed approach to emergency response work for this proposal, illustrated by a recent example of an emergency response to a rockslide failure that we performed for the BNSF Railway. The project example was a significant rock slope failure that destroyed a snowshed over an active BNSF railway line at Stampede Pass, WA, requiring an emergency response and mitigation effort. The rockslide significantly damaged the rock shed and jeopardized the rail line.
Our emergency response included an initial assessment, mobilization of a rock contractor, rock scaling, emergency design and installation of rock anchors, and shotcrete buttress to stabilize the rock slope.

Initial Contact and Mobilization 1

Delve Underground's Proposed Response Approach

We will respond immediately to requests for emergency response by WSDOT. Jim Struthers will be the primary point of contact for this initial outreach. Backup staff will be identified if he is unavailable due to unforeseen circumstances. The point of contact will also continuously monitor progress for any active response and be available to provide updates as necessary. Initial contact will focus on obtaining pertinent information regarding the emergency.

This baseline information will identify key staff who will complete the initial response. Personnel selection will be based on experience, geographic proximity, and availability. Our geographic breadth makes our team uniquely capable of rapid site response. If support staff are needed for safety or roped access, this will be coordinated by the responding staff, Jim, and WSDOT. Our team can respond to any location in the state within 12 hours of notice.

The initial response is a critical first step toward addressing any emergency response. A rapid but thorough assessment of site conditions is necessary to restore mobility at the site as soon as possible. The WSDOT onsite contact will be engaged to obtain updates on current conditions and establish a meeting time and location. Concurrent with this effort, our team will conduct initial research to develop baseline information regarding the site. This could include geotechnical files for areas, imagery, and basic geology/topography. The responding team member will conduct this research but may be allocated to other team members if onsite presence is the priority.

Initial Contact and Mobilization Project Example:
Stampede Pass

On July 11, 2019, BNSF crews were repairing roof timbers for a snowshed along a rail transportation route that crosses Stampede Pass near Easton, WA. During maintenance, roof timbers that were unknowingly buttressing slope were removed, and a mass of rock, soil, and trees translated down the slope, buckling the structure and exposing the rail to rockfall. In response to this event, BNSF exercised a 10-mph speed restriction for the area and phoned Bill Gates of Delve Underground. Bill reviewed existing conditions with onsite BNSF personnel, developed a plan to access the site, and completed an initial evaluation.

Initial Site Assessment 2

Delve Underground's Proposed Response Approach

Initial site assessment objectives include defining the limits of the site hazard(s) and developing an understanding of the failure mechanics at the site. Work performed will vary depending on the type of failure. For instance, primary considerations following a rockslide event include the potential for additional displacement and the risk that this rockslide poses to existing facilities. Developing a field cross-section and defining the deformation limits will be critical in an initial assessment. Our team understands different emergency response priorities and is prepared to address them. This assessment will also focus on public safety and operation considerations, critical for any agency action. We will engage WSDOT with an immediate verbal summation of observations and recommend the next steps within the same day the site reconnaissance is completed. This information will be verbally communicated to the onsite WSDOT technical teams and summarized in a detailed email.

Initial Site Assessment Project Example:
Stampede Pass

Upon completion of the initial site assessment, Delve Underground called BNSF from the site to inform them of their findings and the level of effort likely required to stabilize the slide. In agreement on the general action required, Delve Underground contacted several rockfall contractors and got an available rock contractor onsite within four days. In the meantime, Delve Underground worked with BNSF crews to remove debris, further characterize the rockslide, and prepare the area for scaling access and slope repairs. On July 14, 2019, Delve Underground delivered a presentation to BNSF officials to discuss the project understanding, observed hazards and recommended actions to achieve BNSF's desired outcome. Thoughtful presentation of the information accompanied by focused background info and precise site figures effectively put the client personnel onsite. It allowed them to understand the complexities of the project despite the subject matter being outside their usual scope.

Delve Underground's Proposed Response Approach

Regardless of the delivery method or schedule, the Delve Underground staff will continue moving the design of remedial measures forward. This may be as simple as refining debris removal quantities and extending and/or expanding into significantly more complex remedial measures. Time frames for project delivery are highly dependent upon the severity of the failure and could range from a day to weeks if additional site data and analysis are required. We will continue to provide technical support with preparing PS&E plans for bids and assistance with unit costs, quantities, and any required plan sheets/ documentation. We aim to quickly bring remedial solutions to the site and have a strong track record in rapidly delivering mitigation design. During construction, we will be on-call and onsite as necessary to ensure the intended solution is achieved. Given the aggressive time frames and sometimes limited data, an observational approach is often essential to implement mitigation measures during construction.

Mitigation Development & Implementation Project Example: Stampede Pass

The initial remedial effort included rock scaling, rock anchor installation, and buttress construction, completed between July 15 and July 25, 2019, as part of the emergency repair construction effort. Ethan Guzek, engineering geologist, was on site throughout construction to observe the contractor as design and construction proceeded simultaneously. Delve Underground communicated ongoing slope observations during scaling, design decisions, and construction progress via daily field reports submitted to the client each evening by email. Delve Underground submitted a comprehensive report documenting the emergency response action. Due mainly to our communication during the emergency, Delve Underground received limited comment on the documentation. Following this emergency response effort, Delve Underground designed and delivered additional long-term repairs to minimize the potential for future issues. These included shotcretes facing and drainage improvements.

Delve Underground has experienced repeated success driving emergency transportation projects forward to the owner's satisfaction, whether railway clients or other transportation departments such as WSDOT. Our accomplishments in the emergency response environment can largely be attributed to the continuity between the Delve Underground and owner teams. This continuity is achieved by establishing a clear path forward and using a balance of simple updates and organized discussions to maintain congruent project understanding at critical junctures throughout the emergency response effort.

CRITERIA 4 WSDOT KNOWLEDGE

Design, Contracting, Construction, and Operating Procedures

A team working as an extension of the WSDOT Geotechnical Office, and the Engineering Geology Section in particular, must have a clear understanding of not only the design procedure and standards contained in the WSDOT Geotechnical Design Manual but also the internal operating procedures at the Project Office, Maintenance, and Programming levels. Our knowledge and experience in this area are discussed in more detail below.

Operating Procedures

Jim Struthers worked at the WSDOT Geotechnical Office for 19 years. During this time, he served in the Engineering Geology and the Foundation Engineering Sections, working at the project level for each section and holding the positions of Chief Engineering Geologist and Assistant Chief Foundation Engineer. Working in these senior-level positions allowed him to develop a detailed working knowledge of operating procedures of the Geotechnical Office, Region Project Offices, and Region Maintenance. This knowledge provides him with an excellent understanding of the more significant role of the Geotechnical Office within WSDOT as well as workflow within the Office. Jim will act as the team's primary point of contact and guide our team's efforts to mesh efficiently with day-to-day operations. Specific subjects with which Jim is intimately familiar include:

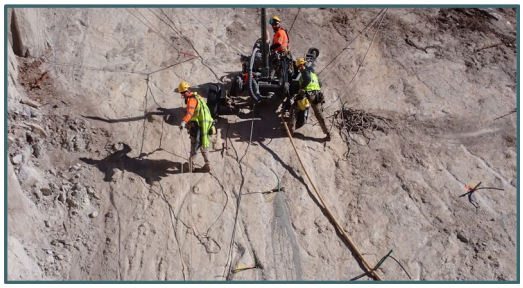
- Procedures for developing scope for work and cost estimates for regional clients
- Appropriate communication with project office and maintenance clients on both standard design and emergency response projects
- Procedures for requesting both field drilling and laboratory support services
- Review requirements for deliverables, including scope of work documents, exploration requests, interim design recommendations, final design documentation, and construction field and office documentation
- Division of labor between the Foundation Engineering and Engineering Geology Section and the Region Materials Engineers
- Understanding of the internal resources of the Geotechnical Office and how external Consultant Services are acquired
- Expectations for client billing and budgeting

As the previous Chief Engineering Geologist, Jim is very familiar with the operational structure of Region Maintenance throughout the state as well as their difference in culture, organization, and preferences from region to region. He is familiar with their chain of command and the roles that each level plays in maintenance operations.

He is also familiar with and comfortable in interacting with Program Management personnel at the Regions and Headquarters levels. Such interaction is important in the emergency response workflow as mitigation recommendations must often be explained in terms of fiscal impact.

Essential to Success
WSDOT Familiarity

Delve Underground thoroughly understands the WSDOT special provisions used for rockfall contracting and recently utilized them to author contract provisions for the Idaho Transportation Department for horizontal drains, rock reinforcement, rockfall attenuators, and rockfall barriers.



Jim's broad experience as a designer and manager gives him significant insight into how projects are developed in different regions. This experience is vital in understanding the junctures and timing at which geotechnical input is needed to facilitate project development (e.g., environmental, ROW, preliminary design, final design, contract documents). He has considerable experience as a subject matter expert in CEVP, value engineering, and constructability exercises.

The addition of Ciani & Hatch to this team augments our understanding of WSDOT procedures, particularly in administering Design Build Projects. They will fill an important role in providing SME services in this area, whether acting as WSDOT's representative on active design-build projects or acting as a subject matter expert during contract development. Jerry Wallace and SubTerra bring years of experience working on WSDOT projects related to blasting requirements and instrumentation of critical structures.

Geotechnical/Engineering Geology Practices & Design Procedures

WSDOT has a historically strong Engineering Geology Section that has, over the years, made significant contributions to the state of practice at the regional and national levels. It is fair to say that WSDOT Engineering Geology Section has played a significant role in promulgating standard drawings, specifications, research, and design guidance that represent the standard of care for this work in much of the industry. Accordingly, the Delve Underground team utilizes standards and guidelines developed by or with the participation of WSDOT in our own practice. Examples include:

- WSDOT special provisions for horizontal drains and reinforced soil slopes
- WSDOT Geotechnical Design Manual
- WSDOT Unstable Slopes Management Program

Jim and the rest of the team are familiar with applying these standards to the design of both standard geotechnical work and the design of landslide and debris flow mitigation projects. He was employed at the WSDOT Geotechnical during the initial and ongoing development of the Geotechnical Design Manual and provided review and input to its ongoing development. Additional, specific design procedures utilized by the Engineering Geology Section include:

- Use of the Rocscience software suite for analysis of geotechnical problems. The Delve Underground team also uses this software in our work and is adept at the use of Slide, RocFall, Dips, RocPlane, SWedge, and RSData
- Methods typically used to establish rock strength parameters.
- Standards are typically applied for retention of rockfall and design of rockfall barriers

Design development at WSDOT is also backed up by a robust QA process. As a former designer and senior reviewer at WSDOT, Jim clearly understands the expectations of design calculation packages and the review process to which they are subjected.

Essential to Success
WSDOT Familiarity

Delve Underground's senior personnel have deep familiarity with the WSDOT Unstable Slope Management system, having assisted in development of hundreds of conceptual designs for rock slopes. Our team was part of the effort to transition WSDOT to a Geotechnical Asset Management System that included constructed rock slope mitigation assets.

Contracting & Geotechnical Office Construction Support Procedures

WSDOT issues contracts for projects under both the design-build and the design-bid-build models. The Geotechnical Office plays a critical role in both delivery methods, which includes the following services:

- Providing special provisions & information required for general special provisions
- Providing estimates of quantities and unit pricing required for the contract
- Providing documents for the contract, such as reference geotechnical report and summary of geotechnical conditions
- Review of final PS&E packages
- Attendance at prebid meetings
- Responding to questions by contractors during bidding process
- Construction support

The Geotechnical Office provides construction support for both DBB and DB contracts during construction.

Work includes:

- Attendance at precon meetings
- Review of contractor submittals, particularly with contractor-designed items
- Construction observation and verification of geotechnical design
- Support in contract disputes

The Delve Underground team brings a deep understanding of project delivery of WSDOT projects through work on both design-bid-build and design-build projects. This includes working for contractors, which provides a unique perspective on the bid development and contract execution process. For example, the Delve Underground team, including Ciani & Hatch, Wallace Technical Blasting, SubTerra, and Emerio Design have worked on multiple design-build projects for which WSDOT standards were used and will bring their learned experience to the WSDOT team to assist in the development and delivery of future alternative delivery projects.

Essential to Success
Compressed Delivery

Bullseye Rock Slope Mitigation

In Spring of 2022, Delve Underground responded to a request by the Idaho Transportation Department to identify, scope, and develop a PS&E bid package for a yet unidentified rock slope mitigation project. Delve assisted ITD in selection of an appropriate site near Riggins, Idaho.

The selected 250-foot-tall slope was the site of chronic rockfall associated with steeply dipping planes and located immediately north of the city limits. Delve Underground performed all field work, design of rock reinforcement,

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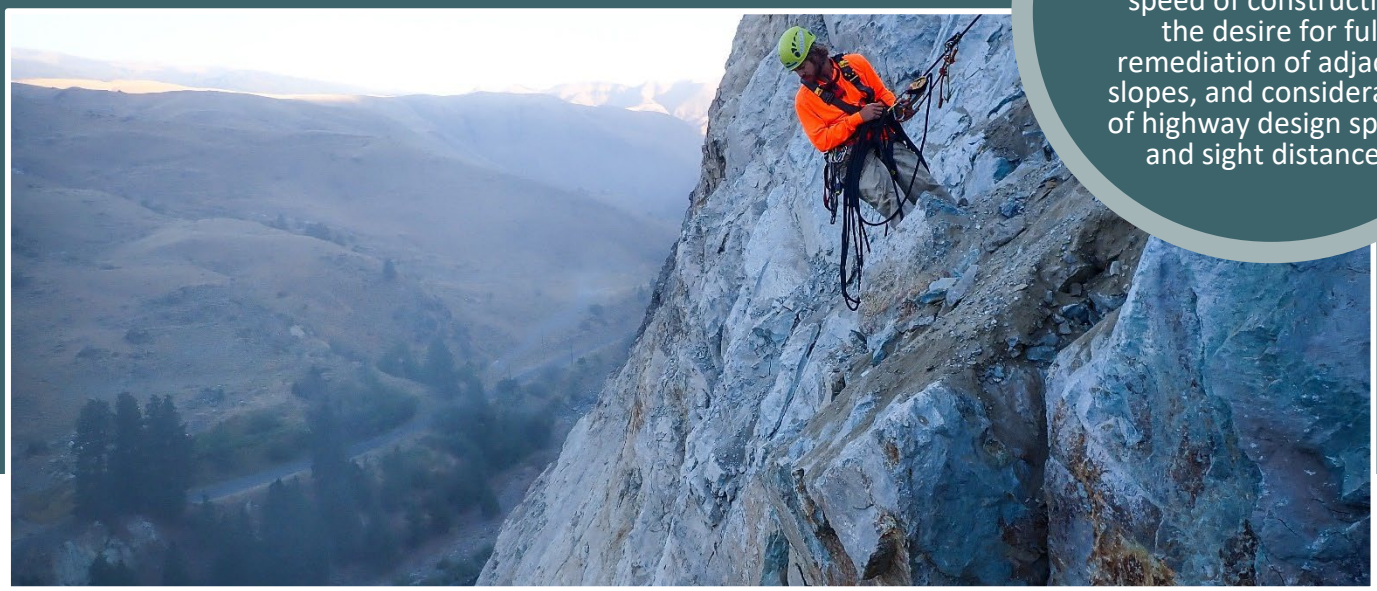
CRITERIA 5 ABILITY TO RESPOND TO CLIENT NEEDS

A. Emergency Rockslide Response and Long-Term Mitigation; US-95, MP 188, ITD | Riggins, ID (2020)

This emergency response design met the needs of our client with respect to mobility, speed of construction, the desire for full remediation of adjacent slopes, and consideration of highway design speeds and sight distances.



The July 2020 rockslide at MP 188, along US-95, closed the only north-south route for Idaho's northern panhandle. As there was no viable long-term detour, ITD needed to open the route immediately and maintain traffic flow throughout the remainder of the long-term slope improvement construction. Thus, project workflow focused on minimizing impacts on mobility. The primary objective of the hazard mitigation effort was to mitigate a 14,000 cubic foot hanging block formed by a wedge structure at the top of the slope. Because of the rock quality and size of the mass, removal by blasting was the only viable mitigation option. The blast was designed to be executed in a single shot to limit impacts on roadway operations.

Simultaneously with the blasting design process, Delve Underground established a telemetered, multi-component, slope monitoring system consisting of extensometers, tilt meters, and total-station prism targets. Constraint of ongoing rotational and translational block movement allowed the project team to keep the route open during initial design and drilling operations related to blasting. This was supported by movement criteria and response protocols developed by Delve Underground and ITD.

During this process, Delve Underground also assisted ITD in rapidly generating contract bid documents for construction related to the execution of the blast and implementation of long-term hazard mitigation solutions. Contract documents were organized to include speed incentives for discrete phased work, including drilling for blasting and clearing of blast debris to reopen the route.

In addition to emergency response work related to the main failure, Delve Underground was also charged by ITD to provide mitigation solutions for the adjacent slope area to the south. Delve Underground performed the rapid design of block stabilization and rockfall containment systems to include this work in the bid package. These solutions were recommended as the most economical options to minimize rockfall hazards. The geometry of the rockfall barrier system across the north half of the site was designed in cooperation with the ITD Roadway Design team to meet their sight distance and travel speed requirements for the route. Throughout the project, Delve served as an extension of the ITD design and inspection team, delivering all design and construction in a 5-month period.

B. Blasting Consulting, Emergency Response, Geotechnical Design and Mitigation for 10 Rock Slopes, SH-55, ITD | Smiths Ferry, ID (2023)

Delve Underground worked tirelessly to meet ITD's needs on this project by providing a redesign of all rock slopes and coordinating directly with the Contractor to deliver the project within the original contract timeframe.

During the Smiths Ferry to Round Valley SH-55 widening, Delve Underground acted as Idaho Transportation Department's (ITD) in-house blasting experts to ensure blasting operations proceeded safely and complied with relevant regulations. This consultation helped ITD achieve their goals of reducing impacts to the corridor and the Payette River. Although blasting operations were successful, six months into the project, it became apparent that the geotechnical design of the cut slopes was deficient, and the project team lacked a clear path forward.

In need of a functional design and related engineering support to get the project back on timeline and projected budget, ITD requested Delve complete an expedited redesign of the ten slopes along the one-mile-long project corridor. At this time, ITD made it clear that the extension of the project timeline was unacceptable and that maintaining roadway operations during construction was of the utmost importance. Delve Underground answered this request by performing an emergency response to mitigate ongoing failures at Cut 9 and completed a kinematic redesign of all cut inclinations.

The project team immediately initiated full-time presence on site and effectively directed construction sequencing and live application of mitigation methods onsite to keep construction progressing during the ongoing redesign process. This included constructing temporary buttresses at locations where the slope had been kinematically undermined. Upon Delve Underground receiving control of the geotechnical design, some of the cuts were partially complete such that re-initiation of the cut was not possible. At these locations, extensive reinforcement operations were pursued, as recutting the slope was not practical due to concerns over ROW and construction staging. Where possible, the kinematically redesigned cut inclinations were chosen to improve safety, long term performance and increase project efficiency in terms of time and materials. Delve Underground served ITD during this process by providing live slope reinforcement design during blasting and excavation activities for each bench at each cut location. Pinned and draped mesh systems were allocated as needed where rock quality was low, or ditch widths were insufficient to capture potential rockfall. Delve Underground continued to provide design services and direct construction, until the project was successfully completed by the original deadline.

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