PACIFIC NORTHWEST CHAPTER

Pacific Northwest Trenchless Review

Forward With Trenchless Technology

2024/2025

Pacific Northwest Trenchless Symposium 2025
Bull Run Filtration Facility Microtunneling Site Tour
February 11 - 12, 2025 Portland OR

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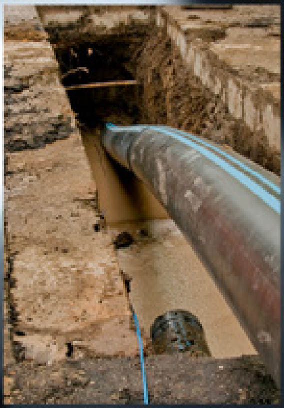

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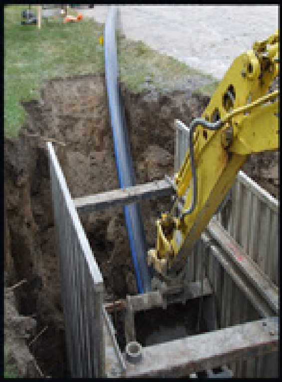

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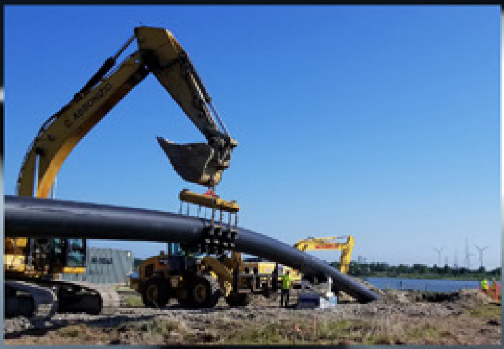

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Departments:

NASTT PACIFIC NORTHWEST CHAPTER

Chair – Glen Wheeler
glenw@jwfowler.com

VICE-CHAIR – Rylee Archuleta PE
rylee.archuleta@
leewayengineeringsolutions.com

PUBLISHER

A to B PUBLISHING INC.
662 Dudley Avenue
Winnipeg, MB Canada
R3M 1R8

EDITORIAL
Andrew Pattison
204.275.6946
marcomap@shaw.ca

ADVERTISING SALES
Bert Eastman
204.997.6371
bert@atobpublishing.com

Wayne Jury
204.803.1300
waynej@atobpublishing.com

PRODUCTION TEAM

harper media
your social media strategy & web marketing partner
700 - 200 Main Street
Winnipeg, MB
R3C 1A8

DIRECTOR
Aaron Harper
204.318.1121 xt. 101
aharper@harpermedia.ca

LAYOUT ART & DESIGN
Joel Gunter
204.318.1121 xt. 108
joel@harpermedia.ca

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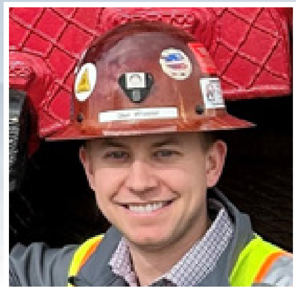


MESSAGE FROM THE PACIFIC NORTHWEST NASTT CHAIR

Glen Wheeler, PNW NASTT Chair

Dear Pacific Northwest NASTT Members and Colleagues:

As we commence 2025, I want to take a moment to reflect on the significant strides we made in 2024 while looking ahead to the exciting opportunities that await us this year in trenchless technologies within the Pacific Northwest.

One of the most rewarding developments of 2024 was the continued growth of our Oregon State University student chapter. The influx of students and their enthusiastic involvement has injected fresh energy into our Chapter, fostering innovation and commitment to the trenchless industry. It's inspiring to see emerging leaders eager to engage and contribute, and I encourage all members to support and mentor these future professionals.

This year's Pacific Northwest Trenchless Symposium will be held February 11 - 12 in Portland, Oregon, and I want to highlight the anticipation surrounding this event. We are looking forward to an engaging program with a variety of speakers to provide their insights into the trenchless industry and networking opportunities to connect with peers. Additionally, the symposium will feature a site visit to the Bull Run Conveyance S03 project, showcasing the innovative use of microtunneling technology, a perfect blend of learning and real-world application.

As we move further into 2025, we have many initiatives on the horizon. The No-Dig Show in Denver March 30 – April 3 is another exciting event we will be participating in this year, offering excellent opportunities for professional growth and connection with industry leaders.

Moreover, our chapter elections are coming up soon, and this will be an important occasion for members to step into leadership roles and help guide our chapter toward its future endeavors. Your engagement is crucial as we seek to represent the interests and aspirations of our members.

This year, we are also committed to sharing construction experiences and promoting collaborative delivery construction opportunities within the trenchless industry. Embracing new technologies and sharing innovative applications with municipalities, engineers, suppliers, and students will be a central focus. By doing so, we can collectively enhance our processes, drive efficiency, and cultivate a deeper understanding of trenchless technologies across various stakeholders.

> *"The influx of students has injected fresh energy into our Chapter."*

Additionally, we will emphasize increasing in-person site visits to trenchless projects throughout the Pacific Northwest. These hands-on experiences will not only enhance our technical expertise but also strengthen camaraderie among our members and collaborators in the industry.

Thank you for your continued support and commitment throughout 2024. Together, let's embrace the opportunities that 2025 will bring and continue to elevate trenchless technologies in the Pacific Northwest.

Best regards,

Glen Wheeler

Glen Wheeler
PNW NASTT Chapter Chair

Call for Abstracts

SUBMISSION DEADLINE: MARCH 18

The North American Society for Trenchless Technology (NASTT) is now accepting abstracts for its 2025 No-Dig North conference in Vancouver, BC at the Vancouver Convention Centre, October 27-29, 2025. Prospective authors are invited to submit a 250-word abstract outlining the scope of their paper and the principal points of benefit to the trenchless industry.

The abstracts must be submitted by March 18 online:

nastt.org/no-dig-north

NASTT 35 YEARS

Connecting Trenchless Partners

No-Dig North is owned by the North American Society for Trenchless Technology (NASTT), a not-for-profit educational and technical society established in 1990 to promote trenchless technology for the public benefit. For more information about NASTT, visit our website at nastt.org.

MESSAGE FROM THE NASTT CHAIR

Matthew Wallin, P.E., Chair, NASTT

Hello Pacific Northwest Regional Chapter Members!

As we welcome the new year, I want to share some key updates and upcoming opportunities that are of importance to your chapter and our organization and industry.

We are currently in the thick of 2025 planning and we hope you will mark your calendars for March 30-April 4 in Denver, CO for the NASTT 2025 No-Dig Show as well as October 27-29 in Vancouver, BC for the 2025 No-Dig North conference. Your engagement and contributions make these events so successful. The presentations are insightful, and the networking opportunities are invaluable. Make plans to join us! If you have any feedback or suggestions for future events, please do not hesitate to reach out to us at **info@nastt.org**.

We are excited for the upcoming Pacific Northwest Trenchless Technology Symposium being held in Portland February 11 - 12. The Symposium includes a site visit to a large-diameter microtunneling project at the new Bull Run water filtration facility. Learn more about the Symposuim on the following pages. Don't miss this opportunity to stay at the forefront of trenchless technology. Join industry experts, network with peers, and gain invaluable insights that will propel your work forward.

"Together, we are driving the future of trenchless technology forward."

Recently the fifth edition of the Horizontal Directional Drilling (HDD) Good Practices Guidelines book was released. And by popular demand, the book is now available in a digital format you can access online from any device, as well as a print-on-demand version! The fifth edition includes updated content reflecting the latest advancements and techniques in HDD. Alongside the book, we have also updated our HDD training course to align with the new edition. These courses are designed to provide both new and experienced professionals with the knowledge and skills needed to excel in their roles. Please check our website for more details on how to purchase the book and enroll in the courses.

Thank you for your continued support and dedication to your Chapter. Together, we are driving the future of trenchless technology forward. If you have any questions or need further information on any of the topics mentioned, please do not hesitate to contact me.

Matthew Wallin

Matthew Wallin, P.E.
NASTT Board Chair

PACIFIC NORTHWEST REGIONAL CHAPTER BOARD OF DIRECTORS & OFFICERS 2024-2025

ELECTED OFFICERS:

GLEN WHEELER
CHAIR
J. W. Fowler Co.

glenw@jwfowler.com

Glen Wheeler joined J.W. Fowler Co. (JWF) as their first college intern over 10 years ago, serving as a Field Engineer Intern for a King County, Washington Earth Pressure Balance Tunnel Boring Machine crossing under the ship canal in downtown Seattle. After graduating from the Colorado School of Mines with a B.S. in Mining Engineering, Glen joined JWF full time as a field engineer in the tunneling and trenchless division. Throughout his career, he has continually assumed more responsibilities, leading to his current role of Chief Tunnel Engineer overseeing a staff of intern, field, and tunnel engineers.

Glen has led the technical development of some of JWF's most challenging tunnels including microtunneling, open face shield tunneling, pipe ramming, pilot tube boring, hard rock tunneling, earth pressure balance tunneling, and other underground projects across the United States.

As the author of several white papers and articles, Glen has been active in sharing his experience and expertise with the trenchless industry. He has spoken at several NASTT events, to the Wash. Dept. of Transportation, to Oregon State University engineering students, and to other industry association groups about the challenges and achievements of trenchless technology.

RYLEE ARCHULETA PE - VICE CHAIR
Leeway Engineering Solutions

rylee.archuleta@
leewayengineeringsolutions.com

Rylee has 9 years of civil engineering experience specializing in sanitary and storm sewer design and inflow and infiltration study and reduction planning. She is an employee at Leeway Engineering Solutions in Portland, Oregon where she is currently managing multiple projects related to trenchless rehabilitation design. Rylee obtained a B.S. in Civil Engineering from the University of Portland and is licensed as a Professional Engineer in Oregon and Washington. She is an active member of NASTT and currently serves as Vice Chair of the PNW chapter. In her free time, Rylee enjoys spending time outdoors, whether it's biking, skiing, or enjoying a cool drink on a sunny patio – preferably with her dog in tow.

BOARD OF DIRECTORS & OFFICERS 2024-2025

ELECTED OFFICERS:

HEIDI HOWARD – SECRETARY
Staheli Trenchless Consultants
heidi@stahelitrenchless.com

Heidi is the Operations Manager at Staheli Trenchless Consultants (STC) and the glue that keeps the company together and running smoothly. Heidi performs a wide variety of tasks including, but not limited to, managing STC's accounting and bookkeeping functions, human resources needs, marketing materials and proposals, and jumping in as support staff on project work when needed. In her spare time, Heidi can usually be found at the barn with her beloved horse, Junior, exploring the backroads in her Jeep, or relaxing with a good book.

BRIAN GASTROCK PE – BOARD MEMBER AT LARGE
Coffman Engineers, Inc.
brian.gastrock@coffman.com

Brian Gastrock, PE has been a member of NASTT since 2007 and brings more than 21 years of civil engineering experience working on condition assessment, design, and construction management projects. His experience includes sliplining, CIPP, pipe bursting, coatings, HDD, pipe ramming, auger boring, and pilot tube guided boring for water, wastewater, and storm drain projects. Brian has extensive experience implementing trenchless solutions; helping clients realize the cost and construction impacts of trenchless alternatives.

DIANA WORTHEN – TREASURER
Cascade Trenchless Consulting
diana@cascadetrenchless.com

Diana is the owner and principal engineer of Cascade Trenchless Consulting, based in Portland, Oregon. Cascade Trenchless specializes in delivering trenchless projects from concept through construction, providing trenchless feasibility and engineering expertise with a focus on collaboration, attention to detail, and risk mitigation. Diana's practice focuses on water & wastewater, transportation, environmental, and energy projects located throughout North America. Her projects have utilized a range of trenchless technologies including horizontal directional drilling, auger boring, pilot tube guided boring, microtunneling, open shield tunneling, and pipe ramming. Diana earned her Bachelor of Science and Master of Science degrees in Civil Engineering from Washington State University and is a registered professional engineer in Oregon, Washington, Idaho, Montana, California, and Texas.

BRENDAN O'SULLIVAN - BOARD MEMBER AT LARGE
Consor Engineers
brendan.osullivan@consoreng.com

Brendan O'Sullivan is a Principal Engineer and Trenchless Technologies Technical Practice Leader for Consor working out of Portland, Oregon. He has 18 years of experience in the consulting industry serving Municipal clients throughout the United States. Brendan graduated from the University of Portland with a bachelor's degree in civil engineering in 2004 and serves in a variety of roles for infrastructure projects that focus on pressure pipelines, gravity conveyance, and trenchless technologies (rehab and new installation) for water and wastewater projects. He is a licensed professional engineer in Oregon, Washington, Texas, and Tennessee.

Pacific Northwest Trenchless Symposium 2025

Pacific Northwest Chapter – North American Society for Trenchless Technology (PNW-NASTT)

Tuesday, February 11 - Wednesday, February 12
Embassy Suites by Hilton Portland Airport • 7900 NE 82nd Avenue, Portland, OR

503-460-3000

All of the benefits of a national conference in a smaller forum with a personalized touch! A great opportunity to mingle with infrastructure professionals throughout the Pacific Northwest while learning about the latest in trenchless technologies from experts in the field.

Registration for the conference includes an exciting informative site visit to a Microtunneling construction site followed by a full-day technical program featuring presentations on leading edge trenchless technologies.

Earn valuable Continuing Education Units (CEU's)!

Conference Information

PNW-NASTT

PNW-NASTT (www.pnwnastt.org) is the Pacific Northwest regional chapter of the North American Society for Trenchless Technology (NASTT) (www.nastt.org), promoting education and development of Trenchless Technology for public benefit. PNW-NASTT is a non-profit organization established in 2009 encompassing Alaska, Idaho, Oregon and Washington.

Microtunneling Project Site Visit – Tuesday, February 11

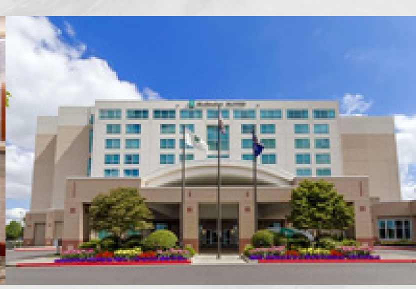
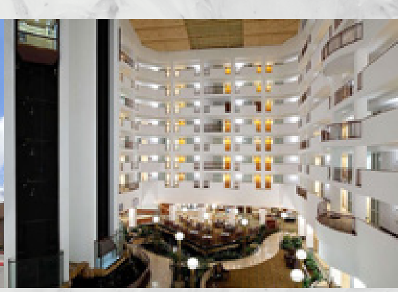
PNW-NASTT has coordinated a site visit of a large-diameter microtunneling project at the new Bull Run water filtration facility. Shuttles will be provided to the project site with pick-up and drop-off at Embassy Suites Portland Airport. The following PPE is required to attend the site visit: high-visibility safety vest, steel toed boots, hardhat, safety glasses, and gloves. The site visit will be followed by a happy hour back in Portland at the hotel.

Pacific Northwest Trenchless Symposium Format – Wednesday, February 12

The PNW-NASTT Chapter will present a full day of technical presentations from industry experts, diving deep into the latest trends, technologies, and best practices in trenchless technology. CEUs will be available to attendees who request them. Attendees will also have several informal opportunities to interact with exhibitors and industry experts during sponsored meals, breaks, and a happy hour reception the evening before.

Attendees

The conference and course are both useful to public officials, engineers, utility company personnel, designers, and contractors who are involved with constructing, rehabilitating, and managing underground utilities in the Pacific Northwest.


Pacific Northwest Trenchless Symposium 2025 Agenda

Tuesday February 11th - Wednesday February 12th

Embassy Suites • 7900 NE 82nd Avenue, Portland, OR

	Conference Event Schedule		Time
	Day 1: Tuesday, February 11th		
	Sign in	Embassy Suites Parking Lot	12:45-12:50
	Welcoming Remarks	Glen Wheeler, NASTT PNW Chapter Chair	12:50 - 1:00
	Shuttle to site visit at Bull Run filtration facility*		1:00 - 1:45
	Bull Run Filtration Facility Microtunneling Site Visit. PPE is required.**		1:45 - 2:30
	Shuttle back to Embassy Suites		2:30 - 3:15
	Break 3:15 - 4:00		
	Happy Hour	Embassy Suites	4:00 - 5:30
	Day 2: Wednesday, February 12th		
	Registration and Breakfast	Embassy Suites	7:30 - 8:30
	Introduction and Welcome	Glen Wheeler, NASTT PNW Chapter Chair	8:30 - 8:35
	Presentations	Speakers	
1	Protecting Wildlife with Pipe Ramming Technology	Brendan O'Sullivan & Brandon Falk, Consor	8:35 - 9:10
2	Sliplining for Christmas - Spokane's Corroded Interceptor Repair	Duane Studer, City of Spokane	9:10 - 9:45
3	Case Studies in Computer Vision and Cloud in Sewer Assessment and Rehab Planning	Eric Sullivan, Sewer AI	9:45 - 10:20
	Morning Break & Exhibits 10:20 - 10:35		
4	Sliplining a Failing 42-inch Wood Stave Penstock with 24-inch HDPE in Sitka, Alaska	Brian Gastrock & Spencer Osgood, Coffman Engineers	10:35 - 11:10
5	The Willamette Water Supply Tualatin River Crossing	Elliot Mecham, Brown and Caldwell; Farid Sariosserieri , Delve Underground; Jennifer Kersh, Brown and Caldwell	11:10 - 11:45
6	Innovations and Environmental Considerations in CIPP Rehabilitation	Chantal Evans & Amber Wagner, Insituform	11:45 - 12:20
	Lunch & Exhibits 12:20 - 1:20		
7	Oregon City Inflow and Infiltration Program - Challenges and Solutions	Kenny Cannady-Shultz, Oregon City	1:20 - 1:55
8	When Dumb Pigs Get Smart – An old approach coupled with innovative technology to assist with cleaning and condition assessments of sewer force mains and other pressurized pipelines.	Mike Lemmen, SFE Global	1:55 - 2:30
	Afternoon Break & Exhibits 2:30 - 2:45		
9	Utilizing HDD and Finite Element Modeling to Achieve Seismic Resilience for the Golden Ears Forcemain River Crossings, Vancouver British Columbia	Yuxin "Wolfe" Lang, Carollo	2:45 - 3:20
10	Tri City Outfall - 2,370 LF of 90-inch Flowcrete Microtunneled in a Single Drive with 4 Curves and 5 IJS	Carl Pitzer, Thompson Pipe Group	3:20 - 3:55
	Closing Remarks	Glen Wheeler, NASTT PNW Chapter Chair	3:55 - 4:00

*Attendees must take shuttle to site visit. No public parking available at site. RSVP will be sent out separately for shuttle.

**The following PPE is required to attend the site visit: high-visibility safety vest, steel toed boots, hardhat, safety glasses, and gloves.

Bull Run Filtration Facility Microtunneling Site Visit

Tuesday, February 11

PNW-NASTT Chapter has coordinated a site visit of a large-diameter microtunneling project at the new Bull Run water filtration facility, which involves the installation of a new raw water pipeline to tie the new filtration facility to the raw water coming from the Bull Run watershed, as well as a finished waterline connecting the filtration facility to the existing finished water distribution network. Shuttles will be provided to the project site with pick-up and drop-off at PDX Embassy Suites. The site visit will be followed by a happy hour back in Portland at the Embassy Suites.

*Attendees must take shuttle to site visit. No public parking available at site. RSVP will be sent out separately for shuttle.
**The following PPE is required to attend the site visit: high-visibility safety vest, steel toed boots, hardhat, safety glasses, and gloves.

Utilizing Trenchless Technology for Large Tunnels:

A Case Study of the Climate Pledge Arena Project

By: Glen Wheeler, JW Fowler

INTRODUCTION

The Climate Pledge Arena project in Seattle presented unique challenges. Its location in a densely populated urban area, coupled with the necessity to preserve the historic Bressi Building (*Figure 1*), demanded innovative solutions. The project successfully navigated these obstacles using trenchless technology and a design-build contract delivery method, showcasing the efficacy of these approaches in complex urban environments.

Figure 1: The Bressi Building, a historic structure requiring preservation during the Climate Pledge Arena construction

PROJECT OVERVIEW

The Climate Pledge Arena project wasn't merely a renovation; it involved constructing a virtually new arena while preserving its iconic roof. This necessitated extensive underground work, including the creation of a large access tunnel connecting the arena to the Bressi Parking Garage. The project's success stemmed from the innovative use of trenchless technology and the collaborative approach facilitated by the design-build contract. JWF was selected as the tunnel subcontractor, partnering with McMillen Jacobs Associates (MJA) as the subcontractor's designer.

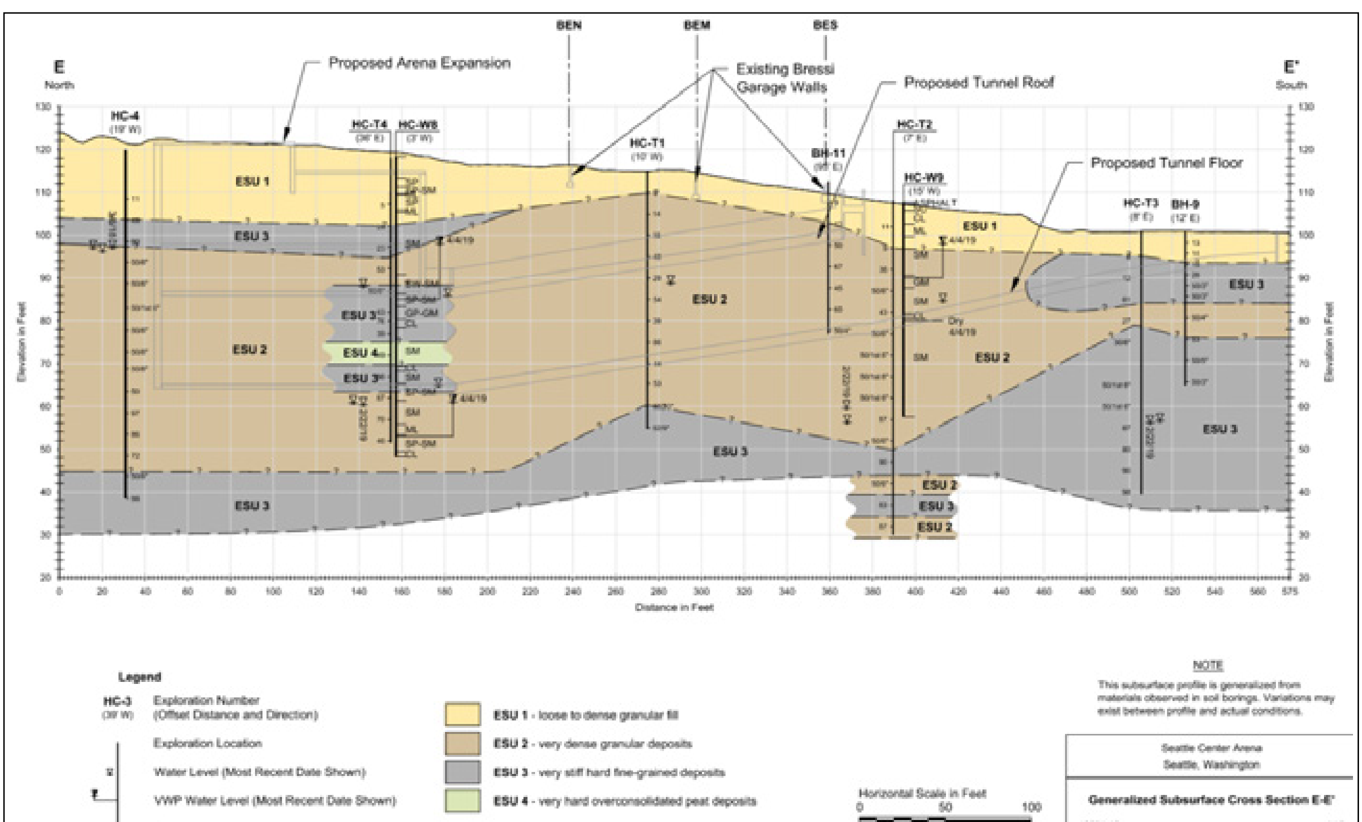


Figure 2: Geologic Profile showing subsurface soil conditions, including various soil strata and the presence of significant boulders

THE DESIGN-BUILD ADVANTAGE AND GEOTECHNICAL CONSIDERATIONS

The owner's strategic decision to use a design-build approach was instrumental. This collaborative model brought the general contractor, Mortenson, and the design-build team (JWF and MJA) into the project early. This early contractor involvement (ECI) provided several key advantages: risk mitigation, optimized design, value engineering, and improved communication. Crucially, early involvement allowed for thorough geotechnical investigations (*Figure 2*), which significantly impacted the selection of the appropriate trenchless technology.

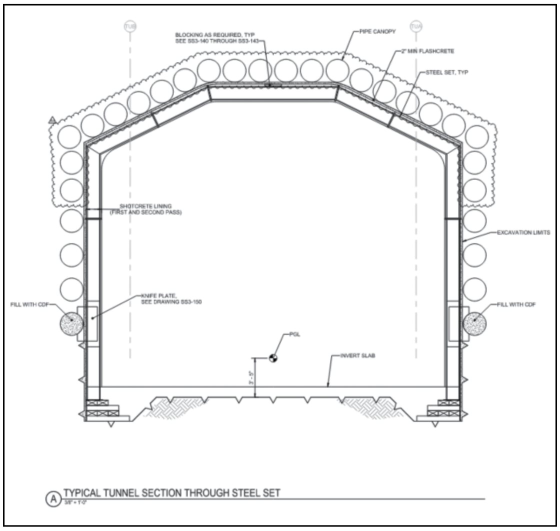


Figure 3: Auger boring method used for arch construction

Figure 4: Example of boulders encountered during excavation

> *The project's success stemmed from the innovative use of trenchless technology.*

TRENCHLESS TECHNOLOGY SELECTION AND IMPLEMENTATION

The construction of the ramp and tunnel beneath the Bressi Parking Garage required careful selection of trenchless methods. The geotechnical investigation (*Figure 2*) revealed the presence of significant subsurface boulders. This, coupled with the need to minimize ground disturbance near the historic building, led to the selection of auger boring as the most suitable approach to install the arch canopy. The auger boring process is depicted in *Figure 3*.

Encountering the boulders (*Figure 4*) presented a challenge, requiring careful planning and execution of the auger boring process. The selected method successfully navigated these obstacles.

Key features of the trenchless solution included:

- Steel Pipe Canopy: A system of 28 each, 24-inch diameter steel casings, installed using auger boring, created an arch that initially supported excavation. This temporary support system later integrated into the final tunnel structure, as detailed in *Figure 5*.
- Sequential Excavation: Excavation proceeded sequentially to maintain stability and minimize ground collapse. The steel pipe canopy provided crucial support, enhancing both safety and efficiency.
- Shotcrete Lining: A 2-inch minimum shotcrete lining, applied in two passes as detailed in *Figure 5*, provided strength and durability. The shotcrete's flexibility and strength were essential for the tunnel's long-term integrity. *Figure 6* shows the shotcrete application during construction.
- Invert Slab: The invert slab, as depicted in *Figure 5*, provided additional structural support and a stable base for the tunnel.
- Temporary Support Systems: A robust system of temporary supports (soldier piles, timber lagging, tiebacks, and soil nails) was used for the open-cut ramp section, guaranteeing worker safety and structural stability.

CHALLENGES AND SOLUTIONS

The project faced several challenges. Limited staging areas and difficult site access necessitated meticulous planning and precise staging of materials and equipment. The proximity of the historic Bressi Parking Garage presented a significant hurdle. The design team's carefully planned construction methodology, minimizing ground disturbance, successfully protected this landmark structure.

PROJECT OUTCOMES

The project's success demonstrates the effectiveness of trenchless technology and the design-build delivery method. The successful completion of the tunnel and ramp beneath the Bressi Parking Garage, without damaging the historic structure above, is a testament to the project team's expertise and collaboration. The

> *Early contractor involvement provided several key advantages.*

Figure 5: Typical Tunnel Section Through Steel Set

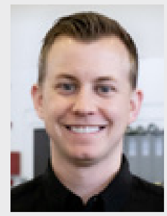
Figure 6: SEM Construction

> *A valuable model for future large-diameter tunnel projects in urban settings.*

Figure 7: Completed Climate Pledge Arena Tunnel

completed project is shown in *Figure 7.* The project met its schedule and budget goals, delivering a state-of-the-art facility that enhanced the Seattle skyline while preserving its historical heritage. The collaborative effort between JWF and MJA exemplifies the benefits of subcontractor collaboration in complex projects. *Figure 2* highlights the importance of geotechnical investigations in selecting appropriate trenchless methods. This project serves as a valuable model for future large-diameter tunnel projects in urban settings.

ABOUT THE AUTHOR:



Glen Wheeler *is the Chief Tunnel Engineer for the James W. Fowler Company, based in Dallas Oregon. He leads technical development of JWF's most challenging trenchless projects with a focus on new tunnel installations including microtunneling, hard rock tunneling, pipe ramming, earth pressure balance tunneling, and deep shafts. Glen continues to further education and training in the trenchless construction industry by authoring technical papers, presenting case studies, and participating on technical publication committees.*

Sliplining a Failing 42-inch Wood Stave Penstock with 24-inch HDPE in Sitka, Alaska

By: Brian Gastrock, PE & Spencer Osgood, PE – Coffman Engineers, Inc.

1.0 ABSTRACT

In Sitka, Alaska, the Sitka Sound Science Center (SSSC) existing 42-inch wood stave pipe reached the end of its useful life. The pipe is approximately 100-years old and has experienced multiple failures resulting in sinkholes, pipe obstructions, and loss of service to the hatchery. The need to provide a reliable water source to the hatchery prompted the rehabilitation. The slipline design was a 24-inch DR17 high-density polyethylene (HDPE) pipe sized to accommodate required hatchery flows. In coordination with the SSSC, the initial design included evaluation of cured in place pipe (CIPP) and sliplining. Unknown structural capacity of the existing 42-inch wood stave pipe, as well as contractor capabilities, mobilization costs, and owner preferences resulted in selection of sliplining for the trenchless rehabilitation method. The semi-remote location, limited soils information, and minimal existing horizontal/vertical alignment information impacted the design and implementation. The project challenges included:

- Semi-remote location restricted on-site coordination, access, and evaluation of the existing 42-inch wood stave pipe during design.
- As-builts and/or record drawings did not exist for the existing 42-inch wood stave pipe.
- Staging and laydown coordination on the State of Alaska campus.

The initial evaluation of the project weighed the outcomes of CIPP versus sliplining installation. Sliplining was selected due to the remote location of the project, repurposing the use of the existing pipe, and preferences from the owner. The project evaluated excavation sites, determining during design that one primary excavation was required with interim access excavations for downstream piping connections and annular space grouting application. The project was constructed in Spring, 2024.

2.0 INTRODUCTION & PROJECT DESCRIPTION

The project took place in Sitka, Alaska, located in the southeast region of the state.

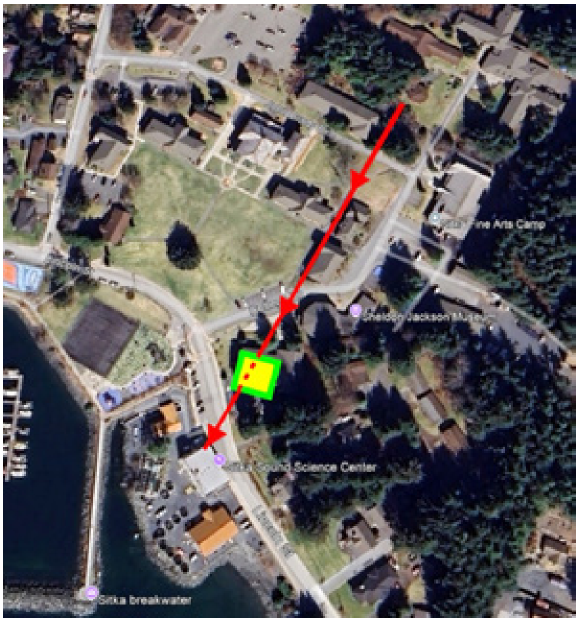


Figure 1. Project Alignment with Flow Direction, Green Box Indicates Library Footprint

Figure 2. Exposing the Damaged Penstock Pipe in 2001, Note Library Proximity in the Background

Sitka is only accessible by air and ocean, with no road access to the community. The population of Sitka is approximately 8,000 with historical records dating back to Russian colonization in 1799.

An existing 42-inch wood stave pipe, originally installed to provide water to a small hydro-electric turbine was re-purposed when the SSSC converted the building into a fish hatchery. The original wood stave penstock pipe was oversized for the hatchery's use and experienced a significant failure in 2001, signaling the penstock pipe had reached the end of its useful life. To add to the project urgency, the SSSC hatchery operations required water to continue without disruption, as there were no other readily available sources of freshwater.

As shown in Figure 1, the penstock pipe conveys freshwater from the Indian River flume to the hatchery building, approximately 800 feet from the flume. The existing penstock pipe is routed under the library, increasing the risk of damage to the building if the penstock pipe failed before rehabilitation could be completed. The SSSC contacted Coffman Engineers (Coffman) in 2022 to provide recommendations and design to rehabilitate the existing penstock.

Figure 3. Historical Penstock Repair

3.0 RECOMMENDATIONS

Once under contract, Coffman reviewed the existing information and evaluated rehabilitation alternatives with construction cost estimates. During initial discussions between SSSC and Coffman, the use of CIPP was evaluated due to the structural characteristics and equal flow capacity.

> *"Sliplining was selected due to the remote location of the project and the unknown structural condition of the host (wood stave) pipe."*

SSSC informed Coffman that the penstock pipe was oversized and could be reduced to 24-inch diameter. The discussions and information provided made sliplining a feasible alternative with both high density polyethylene (HDPE) and restrained joint C900 polyvinyl chloride (PVC) pipe. SSSC's preference was to use HDPE due to familiarity with local contractors performing the work. Coffman then

Figure 4. Slipline Access Pit Locations

developed a Draft Design to present the impacts and construction cost estimates.

3.1 EXISTING CONDITIONS

The project area was on a campus with a dorm, museum, theater and other multi-use buildings. The alignment is also located under roadways and existing mature vegetation. To further complicate construction methods, the laydown area for fused HDPE was located to the north and required mid-pull fuse to minimize impacts to campus activities. The laydown area had mature trees, fences, and various surface improvements including a gazebo and wetlands.

3.2 REHABILITATION ALTERNATIVES – SLIPLINING

With experience on multiple large-diameter slipline projects, Coffman evaluated the option of sliplining. Coffman's prior experience of large diameter sliplining provided the SSSC with a constructable design alternative. Coffman coordinated the Draft Design with SSSC to minimize excavation requirements and other anticipated disturbances associated with construction.

4.0 SLIPLINING, DESIGN AND CONSTRUCTION

The SSSC selected fused HDPE sliplining as the preferred rehabilitation alternative and contracted with a local construction contractor to complete the work. The Draft Design identified two excavations access pits required for sliplining. Coffman provided drawings and sheet specifications to SSSC to gather cost estimates from construction contractors.

Plan and profile drawings, including the location of the slipline access pit locations were included in the design. The locations were selected based on site access, surface impacts, existing easements, and minimizing the slipline lengths. The first slipline access pit was selected near the north end of the site due to the need to avoid a potentially contaminated site and reduce surface impacts. The second access pit was located near the SSSC hatchery in order to address the deflection fittings in the existing penstock pipe. Figure 4 shows the location of the access pits.

4.1 DESIGN SUMMARY

Addressing the slipline access pits and site laydown area was the primary design challenge encountered on the project. Coffman met with the SSSC to determine the proper site limitations to minimize impacts to the campus during construction, while also providing an acceptable final design after the slipline was completed.

To aid with the local Contractor's bid estimating, Coffman developed a detailed drawing showing the access pit dimensions and bend radii for the HDPE. Figure 5 shows the detail with the dimensions and construction requirements.

The design included using cellular concrete for annular space grouting – the process of filling the annular space between the wood stave penstock and the new HDPE.

4.2 CONSTRUCTION

The design was completed in 2022 and construction was completed in 2024 after grant funding was acquired to complete the project. Construction began in March of 2024, and the project was completed in April of the same year. The sliplining process of placing the new HDPE in place took less than

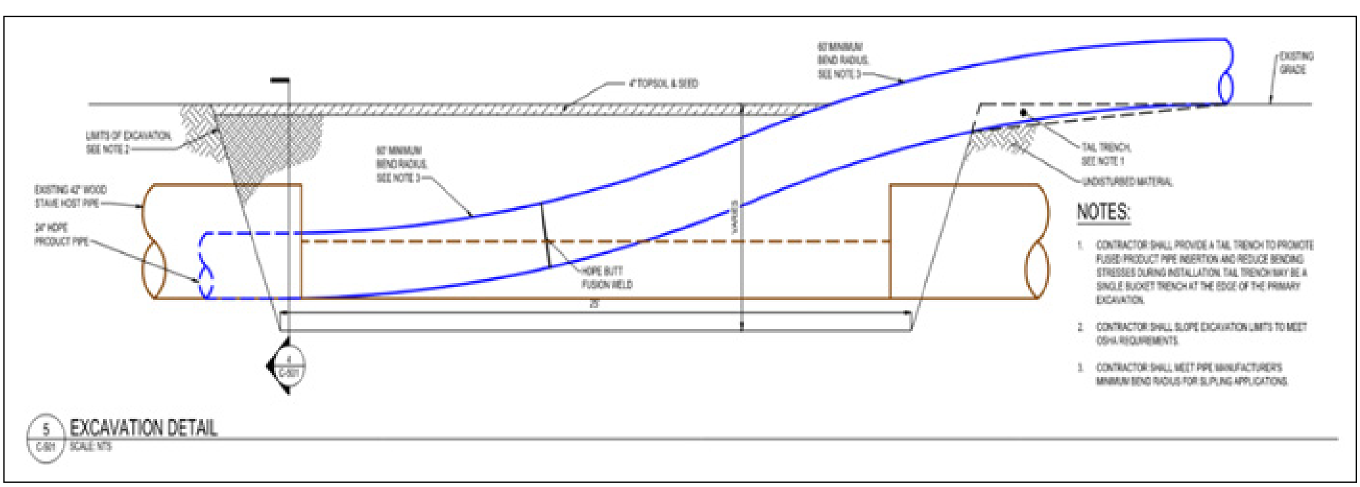


Figure 5. Slipline Access Pit Detail

Figure 6. Slipline Access Pit Near SSSC Hatchery

Figure 7. Slipline Access Pit Near Penstock InletNear Penstock Inlet air

a week. The contractor then spent a week building bulkheads for the annular space grouting.

After the bulkheads were constructed, the contractor completed the annular space grouting. During the grouting process, the volume of cellular concrete exceeded the estimated volume. The site was investigated to determine where the excess cellular concrete traveled to. After significant examination, the crawlspace of the library was observed to have several inches of the cellular concrete throughout the crawlspace. Due to the very limited use of the crawlspace and the cellular concrete properties, it was decided to leave the cellular concrete in the crawlspace.

5.0 SUMMARY & CONCLUSIONS

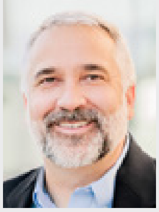
Construction in Sitka, Alaska presents unique challenges due to its remote location, harsh climate, and difficult terrain. The original project design was completed under budget and on schedule. Even with the unique challenges due to accessibility to supplies and skilled labor, coupled with high transportation costs, the contractor was able to complete the project according to the design. Only minor modifications to the access pits and annular space grouting were required. No additional claims or costs were incurred on the project from heavy rainfall or strong winds. The SSSC hatchery has been operating as desired after the slipline project was completed.

Figure 8. Bulkhead Construction

ABOUT THE AUTHOR:

Spencer Osgood, PE *is a civil engineer with more than eight years of engineering experience in the design of arctic water, stormwater, and wastewater utility systems, as well as site design, permitting, trenchless utility design, and fuel storage and containment systems. Spencer's project experience includes military and commercial projects throughout the state of Alaska and United States unincorporated territories, including remote sites such as Wake Island and Eareckson Air Station. He is also skilled in AutoCAD Civil 3D to assist in design processes.*

ABOUT THE AUTHOR:



Brian Gastrock, PE *has been a member of NASTT since 2007 and brings more than 22 years of civil engineering experience working on condition assessment, design, and construction management projects. His experience includes sliplining, CIPP, pipe bursting, coatings, HDD, pipe ramming, auger boring, and pilot tube guided boring for water, wastewater, and storm drain projects. Brian is a Member-at-Large of the PNW-NASTT Chapter Board of Directors.*

Ultra-Violet Cured-In-Place-Pipe Lining of Deer Creek Trunk, A Large Diameter Sewer with Complex Site Constraints

By: Rylee Archuleta, PE, Leeway Engineering Solutions
Ryon Kershner, PE, Roseburg Urban Sanitary Authority, Roseburg Oregon

1.0 INTRODUCTION/ PROJECT BACKGROUND

The Roseburg Urban Sanitary Authority (RUSA) provides sanitary sewer service to the City of Roseburg and the surrounding Urban Growth Boundary. As part of this system, RUSA owns and operates the Deer Creek Trunk, a sanitary sewer trunkline which runs along Deer Creek in Roseburg, Oregon. The Deer Creek Trunk contains over a mile of 18- and 24-inch diameter gravity sanitary concrete sewer pipe that was determined to be structurally deteriorating and in need of rehabilitation, along with adjacent manholes and laterals.

In 2022, the City contracted Leeway Engineering Solutions (Leeway) to design the rehabilitation of approximately 3,000 LF of the Drunk Creek Trunk, along with the adjacent 38 laterals and 29 manholes. In June 2023, Titan Utilities (Titan) was selected as the contractor for the project with construction beginning in August. Titan brought on Oxbow Construction (Oxbow) as their CIPP lining subcontractor, who was responsible for the CIPP lining of all mainlines, laterals, and associated connections.

2.0 SITE CONSTRAINTS

Due to its alignment primarily outside of right-of-way (ROW) and adjacent to Deer Creek, several site constraints exist which complicate the design and rehabilitation of the trunk. The Deer Creek corridor is an environmentally sensitive area with steep, unstable slopes, as shown in Figure 1, where digging would trigger extensive permitting and need significant reinforcement to avoid compromising the soil stability.

> *"UV-CIPP was an ideal candidate for this project."*

Another constraint preventing open cut replacement is that the Deer Creek Trunk runs beneath two separate buildings. One of these buildings sits atop a manhole located at a bend in the alignment, and the other covers a service lateral – blocking access to both. A plan view of the trunk alignment is shown in Figure 2.

Figure 1. Manhole Along Deer Creek Trunk, Adjacent to Steep Slope

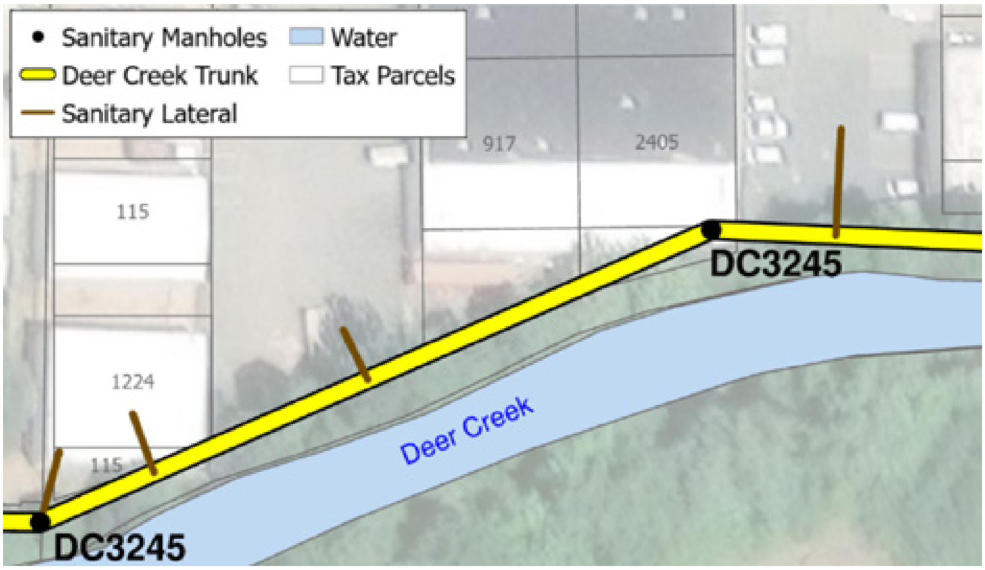


Figure 2. Manhole D3245 Location Beneath Building

In addition to the constraints mentioned above, the Deer Creek Trunk does not follow a road for most of the alignment and is located almost entirely on private property, with a mix of commercial, residential, and industrial properties. Manhole access alone for trenchless rehabilitation requires coordination with numerous private property owners.

3.0 SELECTION OF UV CIPP

Based on the trunk's location and existing condition, RUSA knew trenchless rehabilitation via cured-in-place pipe (CIPP) was likely the best option to avoid any digging or disturbance of soils so close to the creek canyon and existing building foundations.

CIPP is a trenchless method of sewer rehabilitation that involves inserting a resin saturated liner into an existing host pipe and then exposing the liner to a curing element. The cured liner can then act as a fully structural pipe, independent of the host pipe's condition.

The two main types of CIPP are thermal or ultraviolet (UV) cured. Thermal CIPP uses hot water or steam which is pushed through the inflated, uncured liner. UV-CIPP utilizes a UV light train which is pulled through the inflated liner. Figure 3 shows a diagram of the UV-CIPP curing process and Figure 4 shows a photo of a UV light train used for curing.

After evaluating the site constraints discussed above, ultraviolet light-cured CIPP (UV-CIPP) was selected as opposed to thermal-cured CIPP. UV-CIPP was an ideal candidate for this project for numerous reasons. For one, in these diameters, UV-CIPP has a smaller construction footprint and greater ease of staging compared to thermal-cured CIPP. Since UV-CIPP does not use water or steam for curing, a boiler truck is not needed at the construction site. Additionally, UV-CIPP does not run the risk of curing pre-maturely in certain temperatures and does not need to be kept in a climate-controlled truck at the project site. Because UV-CIPP has a protective exterior liner and can only be cured by UV light from the interior of the liner, the liner can be staged in open-air conditions at the insertion site, as shown below in Figure 6. These traits of UV-CIPP were strong considerations when working in tight spaces on private property.

Another benefit of not using water for curing is that there is no need to capture the thermal-curing process water (e.g., curing water, steam condensate, etc.), which causes additional risk when working adjacent to an environmentally sensitive area.

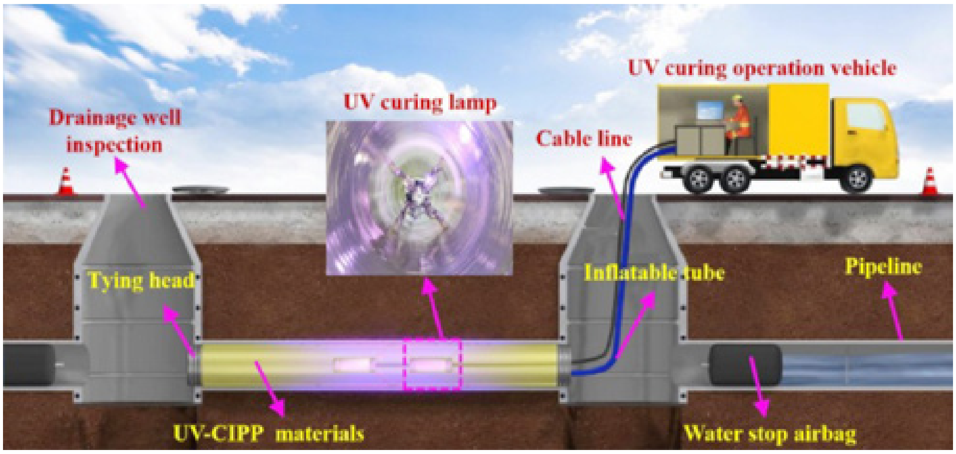


Figure 3. UV-CIPP Curing Process

Figure 4. UV Light Train

Figure 5. Staged UV-CIPP liner

> *UV-CIPP has a smaller construction footprint and greater ease of staging.*

Finally, UV-CIPP utilizes fiberglass-reinforced tubes, resulting in a thinner minimum liner thickness than for thermal-CIPP, leaving more capacity in this crucial trunkline which would be very difficult to upsize.

4.0 MANHOLE REHABILIATION

Manholes were rehabilitated via trenchless methods as well. All 29 manholes along this section of pipe were reinforced using the Mainstay ML-72 lining system, a spray-on structural cementitious liner and an epoxy coating corrosion barrier, along with a chimney seal.

Additionally, lightweight composite manhole frames and locking covers replaced the existing cast iron covers in difficult to access areas.

For this work, Underground Tech (UT) and Cradar Enterprises (Cradar) were brought on as subcontractors to Titan. UT was responsible for the rehabilitation of all manholes, while Cradar was responsible for replacing all manhole frames and covers.

5.0 LATERAL TECHNOLOGY

Laterals were also addressed as part of this project. RUSA only owns the lateral at the mainline connection, while the full lateral is owned and maintained by the property that it serves. However, because RUSA was already conducting work on the trunkline, they decided to rehabilitate and replace the adjacent laterals to the edge of the right-of-way (ROW) or easement as part of this project. In total, 27 laterals were addressed via CIPP lining and 11 via open-cut replacement, with the deciding factor based on the existing lateral condition and location.

CIPP was chosen for laterals located on private property (which made up the majority) to avoid further impact to property owners. For the CIPP laterals, bidders were given the option to select the most cost-competitive curing method that met the technical specifications for performance. Oxbow selected the Bluelight LED lateral CIPP lining system, which has a very similar setup to UV, but uses an LED light for curing. Figure 6 shows the lateral lining process through an existing cleanout.

Figure 6. LED lateral lining through existing cleanout

Figure 7. Cosmic Tophat Lateral Connection Liner

There was one lateral connection located beneath an existing building. Based on CCTV inspection data, RUSA determined the lateral was in good enough condition that only the lateral connection to the mainline required rehabilitation.

A brim-style lateral connection CIPP product was used for all rehabilitated laterals to provide a watertight connection between the newly rehabilitated mainline and laterals and prevent infiltration from entering RUSA's sanitary sewer collection system. For this lateral mainline connection liner, Oxbow selected the Cosmic Tophat Lateral Connection System, as shown in Figure 7.

Figure 7 includes a photo of the packer that was used to place and install the Cosmic Tophat liners.

Laterals and lateral connections located within the ROW were replaced using open-cut methods and were reconnected to the mainline using Inserta Tees. Work on open-cut laterals was completed by Cradar.

6.0 TEMPORARY BYPASSING

In addition to the rehabilitation design, the temporary bypassing was a complicated component of this project. The Deer Creek Trunk is one of the major

Figure 8. Lateral Mainline Application Device

Figure 9. Sanitary Sewer Bypass Piping Entering Stormwater System

pipelines in RUSA's collection system and conveys significant flow year-round, requiring a robust bypassing set up. To bypass the flows into pipes with adequate capacity, the bypass piping needed to cross NE Diamond Lake Blvd. which is Oregon Department of Transportation (ODOT) ROW and a major arterial in Roseburg.

Due to the strict traffic control requirements in ODOT ROW, the original design considered the need to dig a trench and bury the bypass piping to cross the NE Diamond Lake Blvd. As discussions advanced with RUSA and ODOT personnel, the design team determined that the bypass piping could be pulled through the existing storm sewers that cross beneath NE Diamond Lake Blvd. During dry weather, these storm sewers have plenty of capacity to contain the sanitary bypass piping without jeopardizing stormwater conveyance.

The design team provided a conceptual bypass plan in the Bid Documents which showed the latter option of routing through the storm system, with the bypass piping entering a storm manhole on the south side of NE Diamond Lake Blvd. and exiting the system via a manhole north of the road. Ultimately it was up to the

Figure 10. Location of Building Covering Deer Creek Trunk Manhole

Figure 11. CCTV Inspection Footage of Pinholes in Cured Liner

contractor to determine the means and methods of temporary bypassing, who ended up choosing this route as well.

Because the sanitary sewer piping ran through a storm system which discharges into Deer Creek, several precautions were taken to avoid raw sewage entering the creek. The storm system was plugged downstream of the bypass piping so that if a leak did occur, no sewage would reach an outfall. Additionally, a monitoring and spill response plan was submitted to the City for approval prior to construction.

Figure 9 shows the bypassing setup of the piping entering the stormwater system, south of NE Diamond Lake Blvd, where 2- to 4-inch fused HDPE bypassing pipe was pulled through 24- to 48-inch storm sewers.

7.0 UNEXPECTED CONSTRUCTION CHALLENGES

Despite the planning and coordination between the project team and local agencies, unexpected challenges inevitably occurred during construction. The first of these challenges stemmed from the inaccessible manhole located beneath an existing industrial building. As this manhole is located at a slight bend in the alignment of the trunk, the contractor was unable to line through the manhole. In addition, due to the close proximity of the manhole to the unstable slopes of the Deer Creek corridor and the permitting challenges mentioned previously, digging in this location would have created numerous additional challenges. The proximity of the building to the creek banks can be seen in Figure 10.

To rehabilitate the trunk line without digging at this location, the contractor ended up coordinating with the private property owner to gain access. The contractor paid the property owner a fee to uncover the manhole and install a permanent access point in the form of a locking, watertight manhole cover within the building that can be used by RUSA in the future. Since the manhole is inside a building, it will still require coordination with the property owner for future access, but RUSA now has the option for any needed maintenance or repairs.

The second unexpected challenge was encountered through post-construction closed-circuit-television (CCTV) inspection of the cured mainline CIPP liner. Several points were noticed throughout a handful of the pipes, where a green liquid appeared to secrete from a pinpoint in the liner, as shown in Figure 11 below.

It was discovered that the provided liner had pinpoints which did not cure properly, causing uncured resin to leak out of these points. In order to determine whether these defects structurally compromised the cured liner, the contractor was required to send a sample of the defective liner to a third-party testing company. Testing confirmed that the cured liner met the structural specifications of the Bid Documents and that the defects were non-structural in nature. In addition to these test results, an extended 3-year warranty was provided by the contractor and manufacturer in order to protect RUSA in case of deterioration of the defects.

8.0 CONCLUSION

In conclusion, the use of trenchless technology, specifically UV-CIPP, facilitated the successful rehabilitation of the Deer Creek Trunk sanitary sewer. A total of 29 manholes and 27 laterals were also rehabilitated trenchlessly via a spray-on structural lining system and LED CIPP lining, respectively. Where site constraints were not of concern, 11 laterals were repaired using standard open-cut replacement methods.

Construction commenced in August 2023, with the majority of construction completed by the end of November. Due to a supply issues, the composite manhole frame and covers were delayed and were installed in February of 2024, and final completion occurred in March.

The majority of the Deer Creek Trunk alignment came with complex site constraints, including unstable slopes, environmental permitting triggers, private property access, and difficult access points. Due to its small construction footprint and ease of staging, UV-CIPP was the ideal candidate for this job. Avoiding digging within the creek corridor eliminated the need for environmental permitting, which would have added significant time and cost to the project.

In addition, routing the temporary bypass piping through the existing storm system proved to be a creative solution to a complex bypass situation. Even with the bypass staged throughout the fall season, no issues arose during construction and the setup allowed RUSA to save cost and time by avoiding digging a trench in ODOT ROW, which would have caused extensive permitting and traffic control.

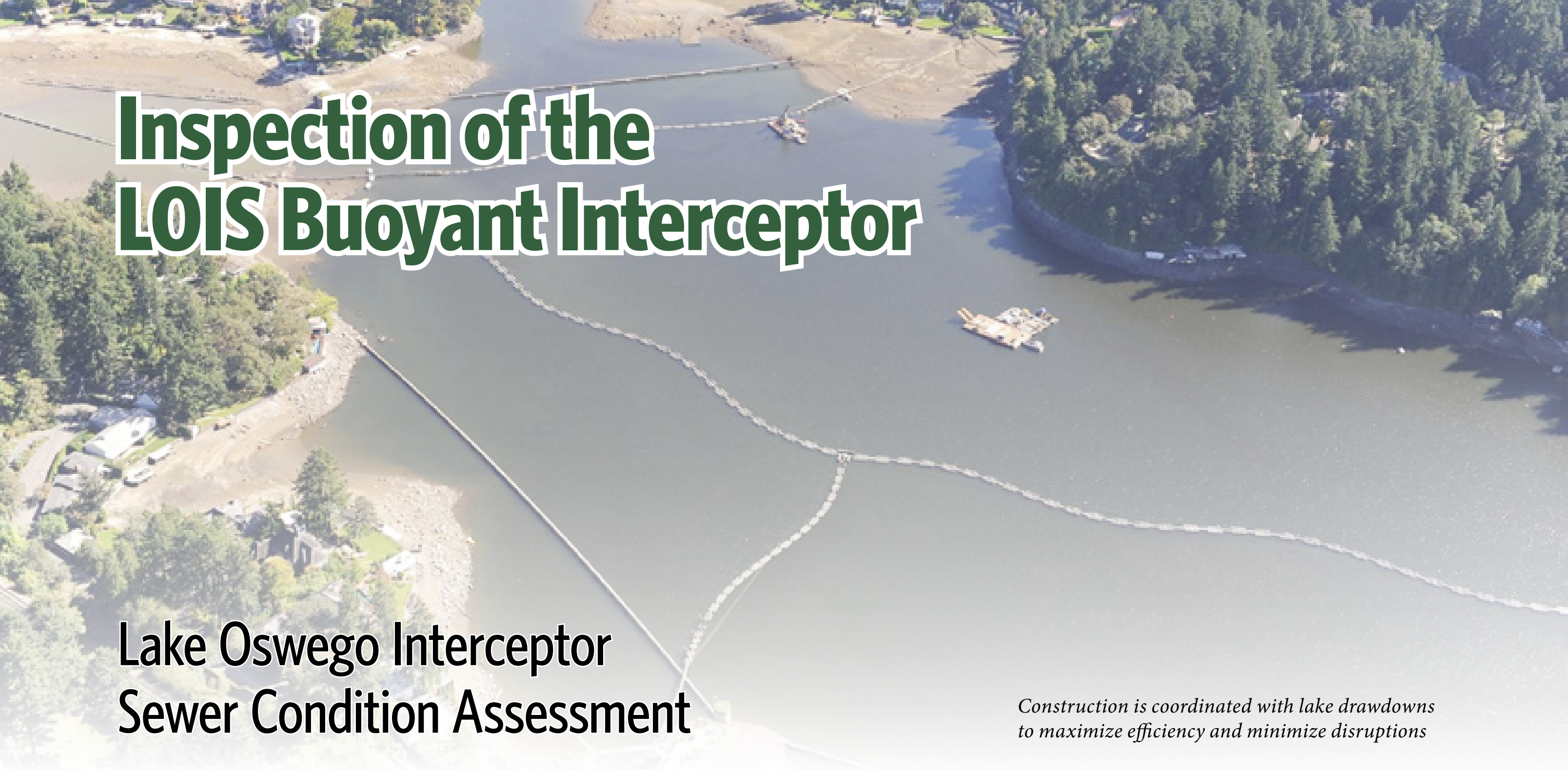
ABOUT THE AUTHOR:

Rylee Archuleta, PE *is a civil engineer with Leeway Engineering Solutions in Portland, Oregon specializing in sanitary and storm sewer design and inflow and infiltration study and reduction planning. She is currently managing multiple projects related to trenchless rehabilitation design. Rylee is licensed as a Professional Engineer in both Oregon and Washington. She is an active member of NASTT and currently serves as the Vice Chair of the PNW chapter.*

ABOUT RUSA:

ROSEBURG URBAN SANITARY AUTHORITY

Founded in 1983, the ***Roseburg Urban Sanitary Authority (RUSA)*** *has an internationally recognized Natural Treatment System. The RUSA collection system consists of pipe segments ranging in age from new to 110 years, with 61 percent of the system installed prior to 1983 and 39 percent new or rehabilitated. Due to the aging infrastructure, RUSA has established an aggressive annual collection system rehabilitation program.*



Inspection of the LOIS Buoyant Interceptor

Lake Oswego Interceptor Sewer Condition Assessment

Construction is coordinated with lake drawdowns to maximize efficiency and minimize disruptions

By: Brendan O'Sullivan, PE, Consor

In 2011 the City of Lake Oswego, Oregon finished the construction of a 42-inch diameter High Density Polyethene (HDPE) buoyant gravity sewer system. Known as LOIS (Lake Oswego Interceptor Sewer), the approximately 21,000 linear foot sewer floats 13 feet below the water surface of Oswego Lake and is designed to convey up to 4.5 MGD of raw sewage through the heart of the lake to the Tryon Creek Wastewater Treatment Plant. Ten years later in 2021, the City needed to develop an approach for, and execute, their first condition assessment of the fully submerged sewer system and its associated 25 manholes (6 buoyant and 14 nearshore).

The City turned to a team of engineers, divers, marine construction specialists, and condition assessment professionals. To perform the inspection, the team relied on boats and barges during the off-peak recreational season to facilitate access to the sewer.

On water inspections were completed in 12 weeks

PROJECT GOALS

The LOIS inspection project was guided by three primary objectives to ensure the system's efficiency and longevity. First, perform a comprehensive condition assessment to thoroughly evaluate the interior and exterior conditions of the sewer, manholes, and appurtenances to identify any structural or operational deficiencies. Second, use the findings from this assessment to inform the development of a structured Capital Improvement Plan (CIP) to address deficiencies. Third, design and coordinate improvements to align with the planned lake drawdown in 2023. The team was well prepared to take on this uniquely challenging project, which was no small task.

INSPECTION PLANNING AND EXECUTION

> *The team exceeded City expectations in completing an inspection that had never been performed before in the world.*

The inspection project required meticulous planning and the application of specialized expertise to ensure success. Our operational preparations included consulting the operations and maintenance manual developed with the original design and construction of LOIS; engaging highly skilled contractors and engineers versed in underwater and confined space operations; and deployment of watertight caissons, barges, and boats to perform the internal and external inspection work while maintaining the highest safety standards.

Planning and preparation efforts for getting on to the lake took approximately 2 months and the on-water work to perform the inspection was executed in under 12 weeks. The inspection team employed a variety of advanced inspection techniques:

- Boat mounted multi-beam sonar (3D imaging) and diver-based visual inspections of the sewer exterior and its appurtenances (tethers, anchors, and internodal cables),
- CCTV crawlers and multi-sensor platforms (including laser profiling) assessed interior conditions both above and below the flow line,
- Manhole assessments utilized advanced 360-degree panoramic scanning technology, offering comprehensive insights into the interiors of these critical structures,
- Corrosion analysis was conducted on the cathodic protection systems, which included five impressed current systems and one galvanic anode system.

The execution of interior inspections of LOIS required the use of tandem barges, Alpha and Bravo, to install stainless steel caissons on adjacent submerged manholes to facilitate access into the sewer. Working from west to east across the lake, caissons were installed and dewatered, providing the inspection team access into the sewer for the deployment of crawlers and/or multi-sensor platforms (depending on the flow levels) to collect video/imaging data of the pipe interior.

To avoid multiple caisson installations at the same structure, the engineering team reviewed all inspection data the day of collection to verify quality and completeness of the data before leap frogging the operation to the next manhole. If the collected data didn't

Barge Alpha – the team relied on two barges for inspection

meet the stringent standards required for performing the condition assessment per NASSCO PACP and MACP standards, the inspection equipment had to be redeployed until the collected data met requirements. This approach limited the production rate of the daily inspection work but ultimately saved both time and cost — while minimizing the project's carbon footprint — by avoiding remobilization of the barges and caissons back and forth across the lake.

FINDINGS

The inspection findings highlighted both positive outcomes and areas requiring improvement across the LOIS system. The condition assessment found the trunk sewer to be in good overall condition, with no blockages or major pipe defects detected. However, the interior of the sewer had staining/FOG lines. Anchor blocks of the tether system were observed by Consor's engineer divers to be buried in sediment, along with minor corrosion on anchor hardware. The near shore manholes had extensive concrete spalling on the exterior and two infiltration points were identified, accompanied by issues with inside drop structures.

The cathodic protection systems revealed minor corrosion of mild steel and signs of weak or dying anodes. Additionally, a discontinuity in isolation kits was detected on a pile-supported manhole of LOIS where the existing connection bolts, attaching in the submerged manholes to support piles, had nearly completely disintegrated. This necessitated the immediate replacement of the bolts and isolation kits to prevent catastrophic failure and ensure system integrity. Divers for the marine contractor made/managed/completed this repair in a couple hours once appropriate materials were sourced.

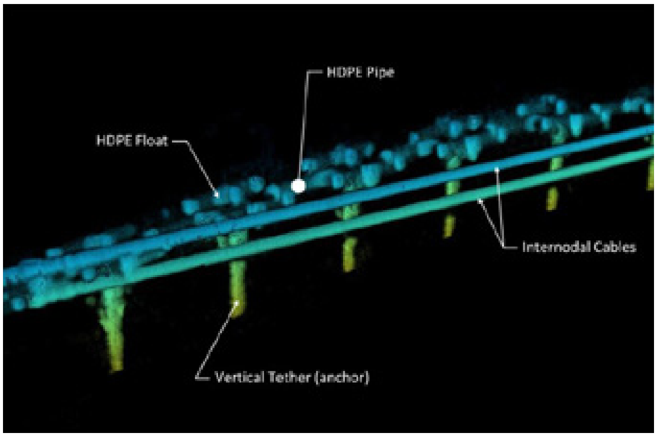
RECOMMENDATIONS

To address the issues identified during the inspection, the design team made several targeted recommendations. For manhole rehabilitation, the proposed actions included implementing solutions to mitigate infiltration and repair concrete spalling on the nearshore manhole exterior surfaces, as well as addressing structural issues with inside drop structures to enhance their functionality and durability.

For the cathodic protection systems, the team proposed increasing the rectifier voltages for four of the five impressed current cathodic protection (ICCP) systems, as well as replacing or considering the replacement of anodes for systems. Additional anodes were recommended for one system and additional testing was recommended to confirm potential discontinuity in half of the ICCP system after adjusting the rectifier voltages.

The nature of the construction techniques recommended for system improvements allowed the decoupling of repairs with the planned 2023 lake draw down, an operation that is executed by Lake Corporation on a three-year cycle. This beneficial outcome allows the City greater flexibility for planning, scheduling, and funding the repairs which was a welcomed relief of pressure for City staff.

Caissons were installed and dewatered to facilitate access to the sewer



3D imaging from boat mounted multi-beam sonar

CAPITAL IMPROVEMENT PLAN (CIP)

Based on the inspection findings, a five-project CIP was developed to guide future upgrades:

1. *CIP-1: Manhole Infiltration Rehabilitation*
   - o Address infiltration points to prevent lake water intrusion.
2. *CIP-2: Manhole Concrete Rehabilitation*
   - o Repair and reinforce external concrete spalling of near shore manholes.
3. *CIP-3: Additional Inspections and Drop Structure Improvements*
   - o Conduct further inspections to refine understanding and fix drop structure issues.
4. *CIP-4: Corroded Hardware Replacement*
   - o Replace anchor hardware showing signs of corrosion.
5. *CIP-5: Cathodic Protection Improvements*
   - o Upgrade systems to ensure optimal protection against corrosion.

NEXT STEPS

The path forward for the project involves several key actions aimed at ensuring its successful execution. First, securing funding for the recommended improvements through the adoption of the CIP budget will be crucial. Following this, procurement and design phases will begin, where contractors and designers will be engaged to carry out detailed planning and execution of the CIP projects. Construction coordination will also play a vital role, with efforts focused on aligning construction activities with the 2023 lake drawdown to maximize efficiency and minimize disruptions.

STAKEHOLDERS AND PARTNERS

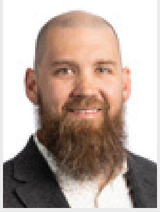
The success of the LOIS inspection project relied on collaboration among various stakeholders and partners. The City of Lake Oswego provided oversight and ensured that the project was in line with municipal goals. Consor and Advanced American Construction, Inc. contributed their specialized expertise in condition assessment, exterior condition assessment divers, and underwater construction, while Pro Pipe provided the interior inspection and Lake Corporation provided logistical and operational support for lake access.

LOIS was the first known buoyant sewer at the time of construction, a title it still holds to this day. The inspection and assessment team members were assembled for their expertise and reputation to complete an inspection that had never been performed before in the world. With constant communication, collaboration, transparency and respect the team exceeded City expectations on this career defining inspection project. One that will surely never be forgotten by those involved.

CONCLUSION

The LOIS inspection project exemplifies the importance of proactive infrastructure management. By conducting a thorough condition assessment and development of a robust CIP, the City of Lake Oswego is poised to maintain the reliability of its buoyant interceptor sewer for decades to come. This assessment gives the City the peace of mind that the large $110 million investment made in the construction of LOIS was worth the cost and the system will serve the City and their residents in its important task of managing sanitary flows in a reliable and safe manner for the betterment of the community in an ever changing world. This project not only underscores the value of regular maintenance and operation forward design but also highlights the role of innovative techniques and collaborative efforts in ensuring sustainable urban development.

ABOUT THE AUTHOR:



Brendan O'Sullivan *is a Principal Engineer and Trenchless Technologies Technical Practice Leader for Consor working out of Portland, Oregon. He has 20 years of experience in the consulting industry serving Municipal clients throughout the United States. He is a Member-at-Large on the PNW-NASTT Board of Directors*

GBRs on Trenchless Projects - Are they working?

By: Kimberlie Staheli, Ph.D, P.E. Staheli Trenchless Consultants Inc.

1.0 ABSTRACT

Geotechnical Baseline Reports (GBRs) were developed to be a risk sharing mechanism between the Owner and the Contractor and introduced to the trenchless sector over 20 years ago. Complex trenchless projects often have a GBR that is intended to define the conditions that constitute a differing site condition, allowing the Contractor to be eligible for payment under the contract's Differing Site Condition (DSC) clause. However, GBRs have often been used by Owners and Engineers as a risk-shedding document instead of a risk-sharing document. This paper details case histories where GBRs were included in the contract documents but were not effective in defining a DSC, leading to disputes over the validity of a differing site condition claims. The case histories focus on how the GBRs were executed during construction and the impacts of GBR statements on claims and disputes. It details a number of DSC claims were filed, the execution of the GBR and whether it was an effective tool when determining the existence of a DSC, and whether the GBR met the goal of sharing risk between the Owner and Contractor.

2.0 INTRODUCTION

One of the critical elements of any design for a new pipeline installed with trenchless construction is the identification of construction risks. Inherently, trenchless construction carries more risk than open-cut construction. Therefore, quantification of trenchless risk is a critical portion of the design. Most trenchless risks are geotechnical in nature and rely on the site-specific geotechnical information and experience of the Engineer and the Geotechnical Engineer of Record (EOR). A

> *"Each trenchless method offers a unique risk profile."*

trenchless risk register is used to identify and compare the risks associated with different trenchless techniques.

The trenchless EOR must be familiar with the intricacies of the trenchless method under consideration to identify a comprehensive list of risks. Significant risk elements with high impacts can be overlooked when choosing a trenchless method if the designer does not have design and construction experience. To select the most appropriate trenchless method, the EOR must understand what can go wrong during construction and what is necessary to overcome specific risk elements. Each trenchless method offers a unique risk profile that is specific to the capabilities of the technology and the challenges of the geotechnical conditions.

An example would be the selection of the appropriate trenchless method for a pipeline installation where the geotechnical conditions are known to have cobbles and boulders. If microtunneling, auger boring and pipe ramming were all considered feasible for a project, it would be necessary to evaluate all three methods with the consideration of the impacts of cobbles and boulders. In this example, the probability of encountering cobbles and boulders is the same for all three trenchless alternatives; however, if cobbles and boulders were to be encountered on the project, the impacts to the project would be significantly different:

1. Microtunneling. Encountering cobbles and boulders may result in a microtunneling machine getting stuck. There are a number of mitigation measures that can be considered including digging up the machine or a compressed air intervention, both of which are extremely expensive. In addition, there have been projects on which microtunneling machines have been abandoned because machine recovery was not possible. (Staheli, 2007)
2. Auger Boring: Encountering cobbles and boulders may result in the inability to move the auger boring machine forward. Cobbles and boulders can also lock the auger flights. The mitigation for such a risk typically involves pulling the augers from the casing and sending personnel to the face to remove the offending rock from the auger flights, both of which are relatively inexpensive.
3. Pipe Ramming: cobbles and boulders are typically considered low impact items because pipe ramming is uniquely suited to installing pipelines in boulder and cobble environments without getting stuck.(Staheli, et. al, 2018). However, even if the pipe ram were stuck, there is no equipment at the face of the tunnel that gets "lost down hole."

> *Inherently, trenchless construction carries more risk than open-cut construction.*

This comparison illustrates the importance of evaluating different trenchless methods for a pipeline installation to ensure that the method selected has a risk profile that is in concert with the Owner's risk tolerance.

3.0 MANAGING RISK

On any pipeline project that includes open cut and trenchless installations, the trenchless installations are much higher risk than the open cut portions of the project. Risk analyses are of critical importance to successful trenchless design and construction. As the industry has evolved, Owners and Engineers have used geotechnical baselines reports (GBRs) to manage trenchless risk.

Evolving forms of the GBR have been used on construction projects since the early 1990s (Essex, R. ed., 2022). GBRs were traditionally used on conventional tunneling projects to ensure that all bidders were using the same basis to prepare their bid, including the amount of risk that was included in the up-front cost of the project. This approach allows the Owner to decide if they want to pay for risk recovery in the base bid cost or whether they prefer to negotiate a change order if the risk event occurs. As the trenchless industry has evolved, GBRs have been incorporated into contract documents, largely guided by the ASCE publications that provided guidance on the development of the GBR.

The first ASCE guidance publication was entitled "Geotechnical Baseline Reports for Underground Construction – Guidelines and Practices" and was published in 1997 (Ed. Essex. R. 1997). The publication has been updated twice providing additional guidance for effective ways to prepare baseline reports. The latest version is entitled, "ASCE Manuals and Reports on Engineering Practice No. 154. Geotechnical Baseline Reports suggested Guidelines" was published in 2022 (Essex, R. ed., 2002). The 2022 is the first edition to reference trenchless technologies. No specific guidance is provided for trenchless applications; however, the document states:

> *"For the purposes of this book, tunnels include jacked pipe, microtunneling, and horizontal directional drilling applications."*

Microtunneling is the most common trenchless technique on which GBRs have been included in the contract documents. However, the GBR has proven to be a largely ineffective way to share risk on many microtunneling projects. Their ineffectiveness is largely because of the difficulty in determining whether the geotechnical conditions encountered reflect the presence of a differing site condition. The closed excavation face on a microtunneling machine does not allow observation or measurement of the material at the face, leading to man disputes over whether the baselined condition was actually encountered.

4.0 ADDRESSING TRENCHLESS RISK

The GBR is intended to be a risk sharing mechanism where the Owner decides specific risk items that they want to share with the Contractor. The Owner/Engineer identifies specific risk elements in the project to include in the GBR if they want to share the risk cost allocation with the Contractor. If the Owner has a risk tolerance that allows risk sharing, the specific risks are addressed in the GBR, and the terms of the risk sharing are identified accordingly. If the Owner is risk averse, they may elect to put all construction risk on the Contractor, negating the purpose of the GBR. Risk sharing should result in a lower bid price; however, if specific risks (constituting a differing site condition) are realized during construction the

Owner should expect to compensate the contractor in a fair manner for the costs associated with the risk event. Additional payment for recovery from the risk event is executed according to the differing site condition (DSC) clause, typically included in the general conditions of the specification.

Theoretically, this approach allows the Owner to dictate the risk costs that are carried in the Contractor's bid price. However, in a low-bid environment, if the contractor includes the cost of risks apportioned to them as detailed in the GBR, they likely won't be the low bidder. As such, many contractors do not include the risk costs that were outlined in the GBR in their bid. Instead, if a risk is realized, a claim will likely be provided to the Owner for additional project costs or schedule, regardless of any GBR statements. These claims are often focused on the interpretation of the baseline statements, and whether any condition at the site was different than the baselined parameter, regardless of whether the baselined parameter was the primary cause of the damages.

If the contractor does not price the risk in their work, a differing site condition dispute arises, whether or not the DSC relates to the GBR. If the dispute raises to the level of litigation, the contractor then argues about the interpretation of the baseline statement rather than the conditions that were encountered and how they impacted construction. The GBR must be concise with specific quantified baseline. If a histogram of parameters is included in the baseline, the baseline value must be clear. The histogram helps the Owner understand the probability of encountering the baseline condition; however, it is not a baseline as it would allow the contractor to make a reasonable interpretation of the data in the histogram. The Contractor's interpretation of the histogram could be completely different than the interpretation of the Owner. For the GBR to effectively provide risk sharing between the Owner and the Contractor, it must include a specific baseline value.

Often the GBR statements are not clearly written, making it very difficult to determine if a DSC exists. If a GBR is written such that a DSC can't be determined, either because the GBR is ambiguous or it is not possible to observe the conditions at the face of the excavation, the dispute then changes focus and is evaluated by what a reasonable contractor should have expected given the information provided in Geotechnical Data Report (GDR). When this occurs, the GBR does not fulfill the primary purpose of allowing determination of a differing site condition. In fact, the poorly-written GBR can be very disadvantageous to the Owner during dispute resolutions, especially in the courts, and the Owners attempt to risk share is negated (Parnass, 2013). Many Owners that have included a poorly-written GBR in the project document have negative experiences, even after they have invested a considerable amount to get site-specific geotechnical information and the development of the GBR, to find out it does not serve the intended purpose.

5.0 THE MISSING PIECE

The ASCE GBR guidance (Essex, R. ed., 2022) provides a section of the purpose of a GBR:

*"the principal purpose of the GBR is to set realistic, **measurable, and observable** baselines that represent the best estimate of the subsurface conditions that will be encountered during construction. In doing so, the bidders are provided with a single contractual interpretation that can be relied on in preparing their bids and in the **administration of the DSC clause in the contract**." (Essex, R., ed., 2022; highlights added).*

There are key words in the defined purpose of the GBR that need to be considered carefully by the Owner, Engineer and Geotech before deciding if a GBR is appropriate on trenchless projects:

5.1 Measurable and Observable Baselines

It is crucial that the author of the GBR considers whether the Baseline is both measurable and observable. However, on many trenchless installation techniques do not allow observation of the excavated material or a way to measure the quantity of a specific geotechnical parameter to determine if the material encountered during installation is more averse than the baseline.

For example, in horizontal directional drilling (HDD) applications the in-situ soils are not available for examination as the borehole is supported by drilling mud. Any excavated material is pulverized by the drill bit, dramatically altering them from their in-situ conditions, and making it very difficult to determine whether the conditions encountered on the project were materially different from the conditions represented in the contract, let alone determining if a baselined parameters were exceeded.

This is also true of microtunneling where the soil at the face of the microtunnel machine enter the machine by way of a rotating cutter and advance into the soil mass. The material is then crushed to a particle size of approximately one to two inches (depending on the machine manufacturer). That material enters a slurry chamber where it is mixed with slurry and transported from the machine to the ground surface using pumps. The maximum size of particle is often dictated by the size of particle that can move through the slurry pumps. In turn, the size of the slurry pump is often dictated by the size of the machine, which simply may not have sufficient space to use larger pumps.

When the slurry containing the excavated material is pumped to the ground surface, it typically passes through a slurry separation plant that separates the particles by size. Figure 1 shows a portion of a typical slurry separation plant used on microtunneling projects. This photo shows the "coarse screen" on the plant that retains the larges particles that are within the slurry.

Figure 1 Coarse Screen on Microtunneling Slurry Separation Plant

On microtunneling projects, baselines for cobbles and boulders are often included in GBRs, providing definitive sizes or numbers of each, alerting the contractor to prepare their bid according to the cobble and boulder baseline. Since neither cobble nor boulder size particles can pass through the slurry, it is not possible to determine if cobbles or boulders were encountered during normal microtunnel operations. If the Owner elected to include a baseline in the GBR that indicated two boulders of a specific size would be encountered during microtunneling, it is not possible to ***observe and measure*** the baselined parameter unless the machine is exposed after it has become stuck. However, microtunneling is commonly used to install pipelines beneath a feature such as a river, roadway, railroad, or wetland. It can be difficult to get permission from the permitting agencies to construct a rescue shaft at the location where the microtunnel is stuck, eliminating the opportunity for the material to be ***observed and measured***. In addition, microtunneling is commonly used beneath the groundwater making it difficult to observe the actual conditions at the face, even if the machine has to be removed from the ground at the location where it became stuck.


Figure 2. Launch Pit

5.2 Administration of the Contractual DSC Clause

Whether or not a GBR is used for risk sharing in a contract, the mechanism of payment should be the Contract's DSC clause. It is important that the GBR not repeat or redefine conditions of the GBR as there is a risk of negating the DSC language that is typically in the project General Conditions. As such, Courts can find that the direction within the GBR may have been intended to negate some of the provisions of the DSC clause that has historically been the contractual language that provides provisions and mechanisms that must be followed to show entitlement of additional payment by the Owner.

5.3 Dispute Resolution

The ASCE 2022 guidelines include four critical key provisions that are necessary on underground projects from the publication Avoiding and Resolving Disputes During Construction (as cited in Essex, R., ed., 2022):

1. Differing Site Conditions (DSC) clause
2. An interpretive geotechnical report, at the time called a Geotechnical Design Summary Reports (GDSR) – A GDSR was intended to reflect the designer's anticipated subsurface conditions and their impact on design and construction. The title was later changed to Geotechnical Baseline Report (GBR).
3. Escrow Bid Documents (EBDs) – submitted at the time of bidding, preserve the contractor's calculation and the information used in preparing the bid so the information can be reviewed, if required, to assist in the resolution of a dispute.
4. Disputes Review Board (DRB) – A three-person board, mutually selected and agreed on by the Owner and Contractor with knowledge and technical expertise in the type of project to be constructed. The DRB is formed following contract initiation to foster cooperation between the parties to provide for prompt and equitable resolution of disputes.

Of these provisions, the most critical element is the inclusion of the DRB. The DRB, as defined by number 4, is intended to be the body that provides a resolution to a dispute. Further, it is intended to provide a recommendation for resolution without the need to use the legal system. If a DRB is not used, and the Contractor and Owner can't agree on the existence of a DSC claim, the only remedy for the Contractor to obtain additional payment is to file a lawsuit against the Owner. The disadvantage with this approach is that the judge or jury may not have sufficient geotechnical knowledge or knowledge of the trenchless method to make an informed ruling. In addition, a Judge most commonly rules in accordance with standing legal precedent, which may resolve the dispute that is not in accordance with the conditions set by the GBR.

Although GBRs have been used on many trenchless projects, very few trenchless projects use a DRB for dispute resolution. As such, when a dispute arises on a project, claims that are unable to be resolved on the project are adjudicated through the legal system, resulting in tremendous costs to both the Owner and Contractor for legal representation and technical experts.

6.0 CASE HISTORIES AND THE APPLICATION OF GBRS ON TRENCHLESS PROJECTS

Some trenchless methods do allow observation and measurement of parameters that are baselined such as cobbles and boulders. These technologies include open shield pipe jacking, auger boring, or pipe ramming, where there is clear access to the face. These methods are feasible in conditions that are above the groundwater or the groundwater is controlled such that material does not flow into the face of the excavation. The case histories are included to illustrate how GBRs can be ineffective and effective on trenchless methods where face access, visual observations, and measurements of materials encountered are possible. This section presents two Open Shield Pipe Jacking projects on which a GBR was included and illustrates impact of the GBR on resolving disputes.

6.1 Case History #1

This project included several pipeline segments that were specified for installation with open shield pipe jacking as required by the Contract Documents. The geology of the project included glacial till and glacial outwash at the face of the excavation. The Owner elected to use a GBR to reduce the risk of litigation on an unresolved claim. However, this project did not include a DRB.

Subreach 1: STA 7+65 to STA 11+90

ESU	Percentage
RGD	55 to 65
TLD	35 to 45

Note: the RGD/TLD contact is between the crown and invert of the casing.

Figure 3 Soil Unit Baselines contained in the GBR on Case History #1

In the glacial soils, the presence of cobbles and boulders was identified as a risk to the trenchless installation. The Geotechnical Engineer of Record wrote the GBR and recommended baselines to the Owner that were ultimate included in the Contract Documents. The GBR classified the geotechnical conditions by defining Baseline Engineering Soil Units which included 8 different soil units – four of which were defined as Non-Overridden Deposits and four defined as Glacially Overridden Deposits. Baselines for each tunnel drive were defined as the volumetric percentage of the soil unit that would be encountered during the tunneling. Figure 3 shows the baselined ground conditions on two tunnel segments on the project.

There are three important things to note:

1. The baselined conditions for Subreach 1 contained two soil types: one classified as non-overridden deposits and the other as glacially overridden deposits. These baselined definitions for the two soil units were very similar except for density, with the glacially overridden soil that was the denser unit.
2. The upper end percentages add up to more than 100 percent, making the baseline ambiguous; and
3. The baseline is based on a volumetric analysis – also undefined. If the intention of the baseline was to be the total volume of the tunnel, all spoils would have to be saved and the material percentages evaluated after excavation when the in-situ density is unknown. This is very difficult if possible. However, the Contractor argued that they interpreted the volumetric analysis to be measured at the face of the machine at any one time. The actual intent of the GBR was later clarified by the author; however, this was during a DSC dispute that eventually led to a lawsuit.

In addition, the note beneath the baseline states that the contact between the two materials will occur between the crown and the invert of the casing. This baseline was odd as if the tunnel was expected to encounter two different materials, there would have to be a contact that was within the cross section of the tunnel.

Subreach 1: STA 7+65 to STA 11+90

Boulder Size (feet) *	Number
1-3	51
3-5	3
5+	1

Figure 4 Boulder baseline in the GBR for Case History #1

On this project, the Contractor filed a DSC claim. The definitions of the baselines were so vague and subject to multiple interpretations. As such, there was no clear way to evaluate the DSC by the Owner or the Contractor, making the baselines ineffective.

On the same project, the Geotechnical Engineer baselined the incident of boulders on which the contractor should expect (and include in their bid price) as shown in
Figure 4.

The project included the installation of a 72-inch casing installed by Open Shield Pipe Jacking. It is unlikely that a boulder of 3-foot diameter could be excavated by the machine and would likely require intervention. According to this baseline, the contractor was to include 51 incidents of removing 3-foot boulders from the face within the bid price. On a drive length of 425 feet, the boulder baseline would have required that the contractor plan for face intervention on a possible 55 occasions prior to exceeding the baseline, four of which would likely require excavation from the surface or extensive work from within the tunnel shield.

The Contractor did not include these costs in the bid. Clearly, the low bid contractor could not include all of the boulders baselined and develop a reasonable bid price. As such, the contractor used geotechnical borings to develop a reasonable interpretation of the numbers of boulders for which he accounted for in the bid price, which is the legal percent. Since there was no DRB on the project, a lawsuit was filed and the parties mediated three times and settled out of court. The mediator recommended settlement to the Owner because he determined that the baselines were not reasonable for the tunneling method specified and the court precedent allows the bidder to make a reasonable interpretation based on the project site-specific borings. The mediator felt that the Contractor could

> *The GBR is intended to be a risk sharing mechanism.*

have considered a design defect claim if the DSC dispute was not settled. Both the Contractor and the Owner expended over a million dollars in legal fees and experts by the time the case settled.

The GBR for Case History #1 was represented as written following the ASCE GBR Guidelines when clearly it violated the recommendations contained within the report in many ways. The GBR did not allow the determination of a DSC leading to a protracted dispute. It is unknown whether the Engineer of Record recommended a DRB for the project; however, the Owner should have been informed that a DRB was essential to settle the dispute without litigation. In addition, it was clear that the Owner did not understand that a GBR is not a risk-shedding document but a risk-sharing document. It is difficult to imagine more adverse conditions than were baselined for boulders, which theoretically should have resulted in an extremely high bid price.

6.2 Case History #2

This project included a 60-inch casing to be installed by Open Shield Pipe Jacking by specification. This project also had soil conditions where encountering boulders was a possibility along the tunnel alignment. The Owner decided to include a GBR on the project to share the risk of encountering boulders with the Contractor and ensure that all bidders were making the same assumptions when preparing their bid. This project did not include a DRB.

The GBR included baseline statements regarding the boulders that included the following language:

"For baseline purposes, the Contractor is instructed to assume that boulders up to 14 inches will be encountered along the alignment. All costs of any kind incurred in connection with ingesting and excavating boulders that measure up to 14 inches shall be included in the base bid and are not compensable under the Differing Site Condition clause or otherwise.

The Contractor is instructed to The Contractor is instructed that it is responsible for all costs associated with excavating and removing five (5) boulders measuring from larger than 14 inches to 25 inches, whether such excavation and removal is accomplished with the trenchless equipment or requires additional intervention for removal. All costs of any kind incurred with removing the five (5) boulders at any location ranging from larger than 14 inches to 25 inches (including costs for drilling rocks, breaking rocks, removing broken parts of rocks, jack-hammering, or other necessary tasks including repair to equipment) shall be included in the base bid and are not compensable under the Differing Site Conditions Clause or otherwise.

Additional compensation under the Differing Site Condition Clause will be considered when the number of boulders measuring from larger than 14 inches to 25 inches exceeds five (5) and for boulders measuring over 25 inches. To be considered for additional payment under the Differing Site Condition Clause, such boulder must exceed the quantity or dimension stated herein (more than five (5) boulders measuring larger than 14 inches to 25 inches or boulders greater than 25 inches) and stop forward progress of the open shield pipe jacking machine in spite of diligent efforts by the Contractor to overcome such boulder."

The baselines in the GBR were clear and the baselined item, in this case boulders, was observable and measurable. In addition to the baseline, the supplemental conditions of the contract stated that all additional work would be paid for on a time and materials basis.

During construction, the specialty trenchless inspector collected information on the boulders that were encountered and what means were necessary to remove the boulders and resume tunneling. During tunneling the contractor encountered eight boulders that were between 12 and 25 inches in the longest dimension (note that this is a different definition than used in the United Soil Classification System that defines boulders by the smallest dimension). During the recovery from the first 5 boulders, the inspector tracked the actual time and equipment necessary to determine the reasonable "value" of excavating the boulders. The three remaining boulders that necessitated intervention at the face were paid on a time and material basis, and the contractor submitted an RCO based on the number of boulders encountered that were above the baseline. The total contractor claim was approximately $50,000. The Owner evaluated the claim documents and paid the Contractor a total sum of $43,000 for the DSC.

Figure 5. Hole Out

In Case History #2, the GBR functioned as intended, even without a DRB; however, the contract was written such that the provisions of the baselines were clear. In addition, the construction documentation collected by the specialty trenchless inspector allowed the Owner to determine if the RCO reflected the actual costs of boulder removal as opposed to other project costs. Figure 4 shows one of the boulders that was removed from the face of the open shield machine and the measurements performed by the inspector.

Figure 6 Boulder that was recovered from machine face. Note the tape measure is for scale. The largest dimension was measured with calipers that could measure up to 36-inches

7.0 CONCLUSIONS

To date, very few GBRs that have been used on trenchless projects have met the full objective of the GBR as presented in the ASCE Guidelines (Essex, R., Ed. 2002). Writing effective, clear baselines is not a simple task and requires an Engineer with experience writing GBRs, with the construction method that is specified in the Contract, and how disputes are resolved when a GBR is a contract document. Owners should require that the author of the document have significant experience in geotechnical engineering as well as extensive experience authoring and executing GBRs. A poorly worded baseline increases the Owners risk as often the baselines result in a dispute over whether a DSC exists that can't be resolved easily and results in litigation. The effective use of the GBR on a trenchless project will only occur when the baselines are clear, and the conditions can be observed and measured. As such, the GBR is not compatible on projects such as microtunneling or HDD where the material encountered can't be observed and measured in the in-situ state. Other critical items to consider when contemplating a GBR include the following:

- The purpose of the GBR and the required contracting components must be understood by the Owner and the Engineer. All of the necessary components of the GBR need to be included in the contract, including a DSC clause, escrow bid documents, and the use of a DRB for dispute resolution.
- It is incumbent on the Engineer/ Geotechnical Engineer to explain that the GBR is not intended to shed risk and that an overly conservative baseline will end up in a very high contract price. If the Owner is risk averse and is not willing to share the geotechnical risk, the document is not appropriate for inclusion in the contract.
- In a low bid environment, the contractor with the low bid is unlikely to include the costs of the risks that were baselined in the GBR.
- A dispute resolution mechanism, other than legal avenues, must be included in the Contract as GBRs have limited legal precedent. Litigating a GBR can be challenging when legal precedent indicates that the contractor has a right to base the bid on reasonable interpretation of the geotechnical borings.
- The Owner and Geotechnical Engineer must understand that baseline parameters must be observable and measurable if the baseline is going to be an effective means for evaluating a DSC. The Engineer and Owner should discuss how the baseline will be measured and their strategy of verifying the baselined parameter before including the baseline in the GBR.
- The GBR works in concert with the DSC clause of the contract. Serious caution should be used to any GBR statements that define the conditions under which a valid DSC will be eligible for payment. The determination of entitlement and quantum should be determined in accordance with the DSC Clause included in the General Conditions of the contract.

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ABOUT THE AUTHOR:

***Kimberlie Staheli, Ph.D, P.E.**, is the President of Staheli Trenchless Consultants. As a researcher with the USACE, Dr. Staheli was the author of some of the first research studies on HDD and trenchless construction mechanisms in the United States. She is passionate about using her 30 years of field and design experience to mitigate trenchless risk.*

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