NASTT PACIFIC NORTHWEST CHAPTER

Pacific Northwest Trenchless Review

Forward With Trenchless Technology

2026

Pacific Northwest Trenchless Symposium 2026

Seattle Airport Marriott

October 14 - 15, 2026 Seattle WA

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NASTT PACIFIC NORTHWEST CHAPTER

Chair – Rylee Archuleta PE
rylee.archuleta@leewayengineeringsolutions.com

Past Chair – Glen Wheeler
glenw@jwfowler.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

Rylee Archuleta, PNW NASTT Chair

Dear Pacific Northwest NASTT Members and Colleagues:

As we we move into 2026, I'd like to recognize the accomplishments our chapter has made in 2025 while also looking forward to the exciting trenchless technology opportunities in the Pacific Northwest (PNW) for the upcoming year.

One of the most rewarding moments from the past year was our 2025 PNW Trenchless Symposium held in Portland, Oregon. We have been working on building engagement in our chapter and saw increased attendance from the previous year's symposium. In addition to a full day of technical presentations highlighting trenchless technology in the PNW, the event included a site visit to the Clackamas Water Environment Services' Tri-City Water Resource Recovery Facility Outfall. This project involved construction of a large diameter outfall from the Tri-City treatment plant to the Willamette River, with a portion of that outfall being 90-inches in diameter and installed trenchlessly. The symposium also allowed for face-to-face connections with other chapter members, bringing new energy into our community.

Other highlights include the addition of three new board members, the continued growth of our Oregon State University student chapter, and increased meeting frequency between our board members – allowing us to make greater connections and create more opportunities for the PNW trenchless chapter.

This year's Pacific Northwest Trenchless Symposium will be held October 15th in Seattle, Washington, and will include a full day of technical presentations as well as a happy hour with food and beverages the evening prior. We are looking forward to an engaging lineup with a variety of speakers and subjects to provide their insights into the trenchless industry, as well as networking opportunities to connect with our peers. We also hope to host a trenchless construction site visit in 2026 as part of our commitment to sharing construction experiences and elevating trenchless technology innovations.

> *"Thank you for your continued support in the PNW trenchless community."*

Thank you for your continued support in the PNW trenchless community. As chair of the PNW chapter, I am proud of the growth our chapter has made in 2025 and look forward to the opportunities that 2026 will continue to bring. I hope to see and meet many of you at the upcoming 2026 No Dig in Palm Springs later this March!

Best regards,

Rylee Archuleta

Rylee Archuleta, PE
PNW NASTT Chapter Chair

HDPE PE4710 PIPE

The Best Choice For Water Systems

	TOP 10 Features and Benefits	HDPE	D. Iron
1	**Applications:** Potable Water (Lead Free), Raw Water, Reclaimed Water, and Wastewater	✓	✓
	References: AWWA C901, C906, C151, & NSF 61 + Health Effects of HDPE Pipes and Fittings for Potable Water Applications, NSF 2024		
2	Open Cut Construction: Design and install per AWWA Standards and Manuals eliminating thrust blocks	✓	✓
	Ref: AWWA M55, M41 + MAB-3, MAB-6		
3	Trenchless Construction: Material of choice for HDD, Pipe Bursting, Sliplining, and Compression Fit	✓	X
	Ref: ASTM F585, F1962, F3508 + MAB-5, MAB-7, MAB-11		
4	**Fully Restrained Joint-Free System:** Minimize need for fittings to facilitate horizontal and vertical deflections	✓	X
	Ref: AWWA M55, M41		
5	**Longevity & Corrosion:** Pipes, Fittings, and Joints have the least potential for corrosion or tuberculation	✓	X
	References: Durability and Reliability of Large Diameter HDPE Pipe for Water Main Applications, EPA/WRF/WERF 2025 + Critical Need for Corrosion Management in the Water Treatment Sector, NACE 2019 + PPIPACE.com + Long-Term Aging of Polyethylene Pipes, UKWIR 2020		
6	**Flow Capacity:** New pipes have similar flow capacity per AWWA Standards and Manuals	✓	✓
	References: AWWA M55, M41 and PPIPACE.com		
7	**Water & Energy Conservation:** Fused Joints have zero allowable water leakage and zero infiltration	✓	X
	Refrences: AWWA M55, M41 + ASTM F2620, F3190, F3565 and MAB-1, MAB-2, MAB-8		
8	**Cost Effective:** Has the lowest initial cost, lowest life cycle cost, and lowest restoration cost for trenchless installations	✓	X
	References: Life Cycle Analysis of Water Networks, CSIRO 2008 + Annual Drinking Water Quality Report for 2014, Kittery Water District, 5/31/15		
9	**Resilient:** Ability to resist water hammer and ground movements due to droughts, freeze/thaw, earthquakes and hurricanes with the ability for flow control and squeeze off	✓	X
	References: Recent Earthquakes: Implications for U.S. Water Utilities, WRF 2012 + Polyethylene Pipeline Performance Against Earthquake, Kubota 2018 and MAB-9, MAB-10		
10	**Permeation/BTEX:** Pipes and elastomeric joints need to be properly engineered for contaminated conditions	X	X
	References: AWWA C901/C906 and C111/C151, Sec. 4		

MUNICIPAL ADVISORY BOARD

Additional information including MAB-3 Model Spec Guide can be found at www.plasticpipe.org/mabpubs

MESSAGE FROM THE NASTT CHAIR

Greg Tippett, P.Eng., NASTT Chair

Dear Pacific Northwest Regional Chapter Members & Supporters

On behalf of the NASTT Board of Directors, I would like to extend my sincere appreciation to the members and volunteers of the Pacific Northwest Chapter for your continued dedication to advancing trenchless technology throughout the region. The strength of NASTT has always come from the energy, expertise, and commitment of its chapters, and the Pacific Northwest Chapter is an example of how local leadership can make a meaningful impact on our industry.

Your chapter has built a strong reputation for bringing together engineers, contractors, owners and manufacturers who are passionate about improving underground infrastructure through trenchless methods. From organizing educational events and seminars to fostering collaboration across disciplines, the work you do helps ensure that trenchless technology remains at the forefront of sustainable infrastructure solutions. These efforts would not be possible without the time and dedication of your volunteers. Whether you are serving on the chapter board, helping organize events, supporting student engagement, or simply showing up to share your expertise with peers, your contributions are deeply valued.

> *"Your chapter has built a strong reputation!"*

> *"Thank you to the Pacific Northwest Chapter for your leadership!"*

I am happy to welcome all of you to join us this spring at the **2026 NASTT No-Dig Show in Palm Springs, California**. The No-Dig Show remains the premier trenchless technology conference in North America and offers an unparalleled opportunity to learn, network, and experience the latest advancements shaping our industry. Attendees can take part in comprehensive technical sessions, explore the exhibition hall featuring leading manufacturers and service providers, and connect with colleagues from across the continent. The event also features NASTT's highly regarded Good Practices Courses, providing valuable training based on the latest trenchless standards and guidelines.

Beyond the educational opportunities, the No-Dig Show is also an important place for our community to reconnect. It is where new partnerships begin, innovative ideas are shared, and the collaborative spirit that defines trenchless technology truly comes to life. I hope to see many Pacific Northwest Chapter members in Palm Springs as we continue building momentum for the future of our industry.

Looking ahead, I also encourage you to **save the date for the 2026 No-Dig North conference**, which will take place this fall in **Calgary, Alberta, November 2–4, 2026**. No-Dig North continues to grow as an important event for trenchless professionals across Canada and the northern United States. The conference will feature technical sessions highlighting innovative projects, an engaging exhibition hall, and valuable networking opportunities that bring together professionals from across the trenchless community.

Events like the No-Dig Show and No-Dig North are made stronger by the involvement of our chapters and their members. Your participation helps ensure these gatherings remain vibrant, informative, and representative of the many perspectives that drive trenchless innovation.

Once again, thank you to the Pacific Northwest Chapter for your leadership, your enthusiasm, and your commitment to advancing trenchless technology. Your work strengthens not only your local community but the entire NASTT organization.

I look forward to connecting with many of you in Palm Springs and again later this year in Calgary.

Sincerely,

Greg Tippett

Greg Tippett, P.Eng.
Chair, NASTT Board of Directors

PACIFIC NORTHWEST REGIONAL CHAPTER BOARD OF DIRECTORS & OFFICERS 2026-2027

ELECTED OFFICERS:

RYLEE ARCHULETA PE – CHAIR
Leeway Engineering Solutions

rylee.archuleta@
leewayengineeringsolutions.com

Rylee has 11 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 enjoys building client relationships and utilizing trenchless technology to find creative solutions to complex problems. Her role as NASTT Pacific Northwest Chapter Chair allows her to expand her technical knowledge and create meaningful connections in the industry. Rylee obtained a B.S. in Civil Engineering from the University of Portland and is licensed as a Professional Engineer in both Oregon and Washington.

DIANA WORTHEN – VICE CHAIR
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.

JASON HSU – SECRETARY
Staheli Trenchless Consultants

jason@stahelitrenchless.com

As a project engineer with three years of experience in the trenchless industry and eight years as a civil engineer, Jason brings a broad background in trenchless design, inspection, and construction management across a wide range of methods – including HDD, auger boring, pipe ramming, open shield pipe jacking, pilot tube guided boring, CIPP, and spiral wound lining.

Jason has had the privilege of working on complex infrastructure projects at Staheli Trenchless Consultants, primarily in Washington and Oregon, delivering trenchless solutions for municipal clients such as King County, the City of Bellevue, the City of Bellingham, and the Port of Portland. His roles have included both field inspections and design support, where he has led efforts in feasibility studies, alignment selections, geotechnical investigations, and field-driven changes.

His recent work at PDX involved full-time HDD inspection for a major geothermal heat pump installation transferring water underground to injection wells, while in Bellingham he oversaw installation of steel casing using Open Shield Pipe Jacking and Guided Auger Boring methods.

Jason is driven by a commitment to advancing trenchless technologies across the industry. Inspired by leaders such as Dr. Kim Staheli and NASTT Director Matthew Izzard at No-Dig 2025, he has begun volunteering within the organization and looks forward to contributing through future paper development, panel participation, and event support.

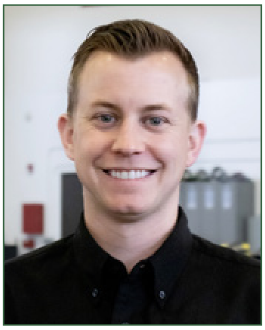
BOARD OF DIRECTORS & OFFICERS 2026-2027

ELECTED OFFICERS:

HEIDI HOWARD – TREASURER
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.



GLEN WHEELER
PAST 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.

BOARD MEMBERS AT LARGE:

BRIAN GASTROCK PE – Coffman Engineers, Inc.

brian.gastrock@coffman.com

Brian Gastrock, PE has been a member of NASTT since 2007 and brings more than 23 years of civil engineering experience working on condition assessment, design, and construction management projects. Brian has more than 795,000 feet of stormwater, sewer, water, and conduit piping experience on hundreds of projects. Brian provides condition assessments, trenchless evaluations, recommendations, and design of existing and new buried utilities. He has extensive experience implementing trenchless solutions, helping clients realize the cost and construction impacts of trenchless alternatives, where applicable, versus traditional open cut installation methods.

BRENDAN O'SULLIVAN - 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 20 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.

BOARD MEMBERS AT LARGE:

RUSSELL PORTER
Stephl Engineering
rporter@stephleng.com

Russ Porter is the managing member of Stephl Engineering. Stephl Engineering LLC is an Anchorage Alaska based civil engineering firm that specializes in trenchless technology and its application to projects in Alaska. They design a wide range of projects from CIPP (water and sewer), sliplining, pipe bursting, auger boring, pipe ramming, and HDD type trenchless applications. In addition, we also perform infiltration and inflow studies and condition assessments on water and sewer systems across Alaska. Russel has worked in the trenchless engineering field in Alaska for the past 17 years and is responsible for a wide range of projects including the ones listed above.

RYAN WARD
J. D. Hair & Associates
rward@jdhair.com

Ryan Ward earned a Bachelor of Science in Civil Engineering from Gonzaga University in Spokane, Washington. Shortly after graduation, he joined Michels Trenchless, Inc. (then Michels Corporation) as a field engineer. In this role, Ryan gained hands-on experience in the field working on Direct Steerable Pipe Thrusting, Microtunneling, and Auger Boring projects across Texas, Minnesota, Pennsylvania, Illinois, and North Dakota. His time in the field provided a deep understanding of the New Install Trenchless construction methods across both the heavy civil and oil and gas industries. The work demanded a strong ethic of creative problem-solving in a fast-paced environment, characteristic of the trenchless industry.

Ryan then transitioned to J.D. Hair & Associates, Inc. after it became part of the Michels Family of Companies. As a Project Engineer and later Project Manager, he supported Michels' Design-Build projects through the design phase and provided trenchless crossing designs for JDH&A's third-party clients. His Design-Build work included Microtunneling, Horizontal Directional Drilling, Sliplining, and Auger Boring projects in Oregon, Washington, and Missouri, serving the Heavy Civil and Power industries. In the conventional consulting role, he primarily focused on designing Horizontal Directional Drilling crossings for the oil and gas sector.

Pacific Northwest Trenchless Symposium 2026

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

Wednesday, October 14 - Thursday, October 15
Seattle Airport Marriott - 3201 South 176th Street, SEATTLE WA

206-504-1397

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 afternoon/evening happy hour networking event at the venue followed by a full-day technical program featuring presentations on leading edge trenchless technologies.

Conference Information

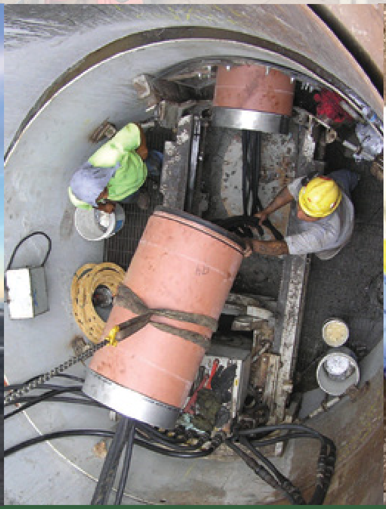
Earn valuable Continuing Education Units (CEU's)!

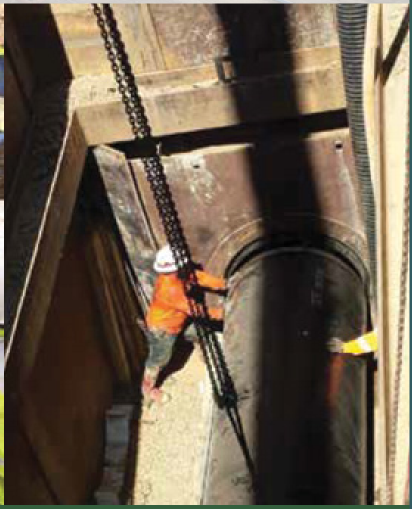
PNW-NASTT
PNW-NASTT (www.pnwnastt.org) is the Pacific Northwest regional chapter of the North American Society for Trenchless Technology (NASTT) (www.nastt.org), promoting education and development of Trenchless Technology for public benefit. PNW-NASTT is a non-profit organization established in 2009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

Trenchless Networking Event - Wednesday, October 14
Join us for a happy hour trenchless networking event with food and beverages in the Seattle Airport Marriott lounge.

Pacific Northwest Trenchless Symposium Format – Thursday, October 15
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 and breaks.

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.





Building a Path for Salmon:

Trenchless Construction of the Cle Elum Juvenile Fish Passage Tunnel

By: Glen Wheeler, James W Fowler Company
Jeremy Lorberau, United States Bureau of Reclamation

In 1979, Congress directed the United States Bureau of Reclamation to undertake a feasibility study for what became the Yakima River Basin Water Enhancement Project (YRBWEP), now known as the Yakima River Basin Integrated Water Resource Management Plan. The objective was to develop a comprehensive approach to water management and habitat enhancement within the Yakima River Basin, restoring ecological function while ensuring reliable water supplies for agricultural, municipal, and domestic users.

Early in the study process, fish passage deficiencies were identified as a priority concern. In 1984, Congress authorized YRBWEP Phase I, which focused primarily on rebuilding fish ladders and constructing fish screens on river diversions. Over time, the scope of basin restoration expanded. In 2006, Reclamation and the Confederated Tribes and Bands of the Yakama Nation entered into a Settlement Agreement to resolve litigation and committed to collaborate on technical planning for fish passage at Cle Elum and Bumping Lake Dams. The agreement also required interim downstream fish passage at Cle Elum Dam until a permanent solution could be implemented or determined infeasible.

Several legislative authorities underpin the project, including the Act of December 28, 1979 (Public Law 96-162), the Hoover Power Plant Act of 1984 authorizing fish passage facilities at Reclamation dams, and Title XII of Public Law 103–434 (1994), which advanced non-storage components of basin enhancement.

When Cle Elum Dam was completed in 1933, native salmon runs, particularly sockeye, were effectively eliminated from upstream habitat. As part of the broader Yakima River Basin Integrated Water Resource Management Plan, the Cle Elum Fish Passage Project aimed to restore both upstream and downstream migration, reestablishing access to historic spawning and rearing habitat. The overall effort

> *"Fish passage deficiencies were identified as a priority concern."*

included facilities for both adult and juvenile fish passage.

Prior to construction of the permanent system, interim downstream passage was provided by a plywood flume constructed along the existing spillway, equipped with PIT-tag detectors to monitor fish movement. While functional, this temporary measure underscored the need for a permanent, hydraulically controlled solution.

The construction phase focused on establishing a permanent hydraulic connection between the upstream juvenile collection facility and the Cle

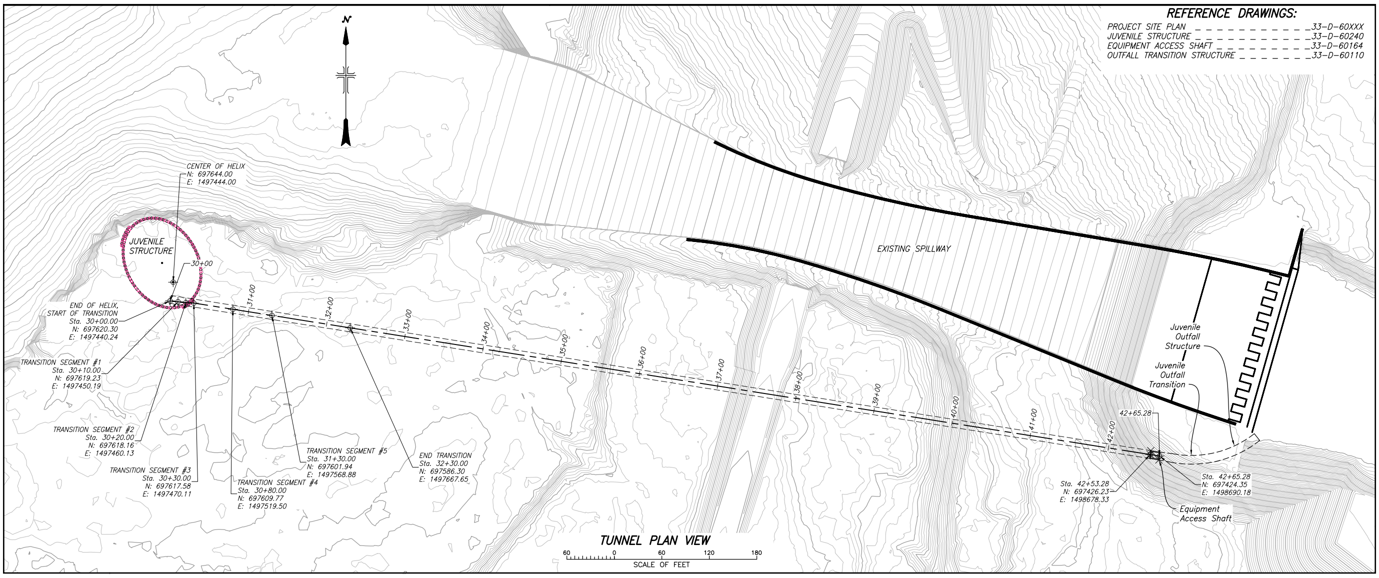


Figure 1: Tunnel Alignment

Figure 2: Encountered Ground Conditions

Figure 3: Shield TBM Launch

Elum River downstream of the dam. The 1,233-foot-long tunnel conveys flows and out-migrating juvenile salmonids safely from the reservoir to the river through a wide range of reservoir stages. Project objectives extended beyond hydraulic conveyance and included maintaining dam safety and reservoir operations, minimizing environmental and operational disruptions, and delivering a constructible solution within challenging glacial outwash and glacial till conditions.

GEOLOGIC CONDITIONS

The project site lies within the glacially influenced Upper Yakima Basin, characterized by heterogeneous deposits of glacial outwash and glacial

Figure 4 – Initial Tunnel Support

Figure 5 – Shield TBM Reception

till. Subsurface investigations identified dense sands and gravels with varying fines content, interspersed with rounded cobbles and occasional boulders up to 36 inches in diameter. These materials were generally dense to very dense, with limited cohesion and variable gradation.

The coarse granular matrix presented several challenges. Face stability in dense, cohesionless soils required careful control of excavation advancement and immediate support installation. The presence of large cobbles and boulders introduced the potential for obstruction, tooling wear, and localized loading on tunnel support systems. Abrasion was a constant consideration in equipment selection and maintenance planning.

Groundwater conditions were influenced by proximity to Cle Elum Reservoir, the Cle Elum River downstream, and seasonal/operational reservoir fluctuations. Although full hydrostatic pressures were not encountered, the potential for seepage and localized inflows required a system capable of controlled excavation and rapid stabilization to mitigate.

Given these conditions and the proximity of the active dam embankment and spillway structure, an adaptable, accessible tunneling method was essential.

SHIELD TBM EXCAVATION AND INITIAL SUPPORT

The tunnel was constructed using a 114-inch outside diameter open-faced shield tunnel boring machine (TBM) equipped with a hydraulic jacking can (thrust can) system. The decision to use an open-face configuration was driven by the granular nature of the glacial outwash and the anticipated presence of oversized cobbles and boulders. Direct access to the face allowed operators to remove obstructions manually and adjust excavation methods as conditions changed.

The hydraulic thrust can reacted against an initial steel structure outside the tunnel portal and then continued tunnel advancement thrusting off installed liner plate rings, transferring jacking forces through the completed portion of tunnel. This configuration allowed the shield to advance in controlled increments while maintaining line and grade. Each advance was intentionally limited to maintain face stability in the dense granular formation.

Excavation proceeded in short strokes. Once the shield advanced, crews installed a bolted steel liner plate ring immediately behind the tail shield. Structural steel ribs were incorporated within the liner system to increase ring stiffness and resist concentrated loads from cobbles and boulders bearing against the lining. The ribs enhanced structural performance during both jacking operations and long-term loading.

The liner plate system served dual purposes. It functioned as the initial ground support system in the granular soils and ultimately became the permanent structural substrate for the cast-in-place concrete lining. This two-pass lining approach allowed tunneling to proceed efficiently while preserving final fish-critical hydraulic and structural performance requirements.

The combination of controlled shield advance, immediate liner installation, structural rib reinforcement, and systematic annular grouting proved effective in managing mixed glacial conditions while protecting nearby dam infrastructure.

BREAKTHROUGH AND RECEPTION AT THE SECANT SHAFT

The upstream terminus of the tunnel was an elliptical secant pile shaft constructed adjacent to the existing embankment and spillway structure. The shaft had been completed in advance to serve as the interface between the juvenile collection facility and the tunnel.

Approach to the shaft required careful monitoring of line, grade, and advance

Figure 6 – Invert Pour

Figure 7 – Closure Pour

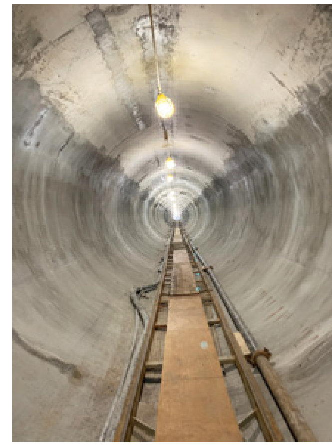


Figure 8 – Finished Tunnel

pressures. As the shield neared the secant pile wall, excavation increments were reduced and ground conditions and tunnel position were closely monitored. Controlled penetration of the shaft wall via perimeter core drilling was executed to prevent ground loss or disturbance within the shaft excavation.

Upon breakthrough, the shield was received within the existing secant shaft. The controlled reception sequence ensured structural integrity of the shaft and maintained dam safety requirements. Once excavation was complete, the shield components were removed through the shaft, allowing final lining activities to commence.

CAST-IN-PLACE CONCRETE LINING

Following completion of the full 1,233-foot excavation and installation of the liner plate system, a cast-in-place reinforced concrete liner was constructed as the second-pass lining.

Concrete placement was performed in approximately 30-foot increments to balance constructability, formwork handling, and curing control. Each segment was completed in two stages. First, the invert was formed and poured. The invert placement established a stable working surface, ensured proper geometry, and provided structural continuity at the base of the tunnel. Reinforcement was placed to integrate with the liner plate substrate and resist long-term hydraulic and structural loads.

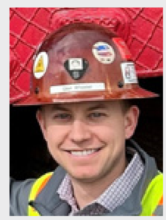
Once the invert reached sufficient strength, crown forms were erected and the upper portion of the lining was poured to complete the full circular section. This two-stage approach minimized form pressures, allowed controlled consolidation, and ensured high-quality surface finishes.

The finished concrete lining provided several critical functions: structural capacity to resist external ground loads and long-term service conditions; hydraulic efficiency, delivering a smooth, durable surface capable of accommodating high design velocities; and smooth surface finishes and joints to pass juvenile fish through the length of the tunnel.

Hydraulic criteria required the tunnel to convey flows at velocities ranging from approximately 11 to 44 feet per second near the upstream end, reducing to approximately 5 to 7 feet per second downstream. Surface smoothness and joint detailing were essential to prevent descaling or injury to juvenile salmon during downstream migration.

The completed tunnel represents a carefully sequenced integration of geotechnical management, shield tunneling, liner plate support, secant shaft interface, and staged concrete lining construction. Through controlled excavation in challenging glacial soils and precise coordination adjacent to critical dam infrastructure, the project successfully established permanent downstream fish passage, restoring a vital ecological connection nearly a century after it was lost.

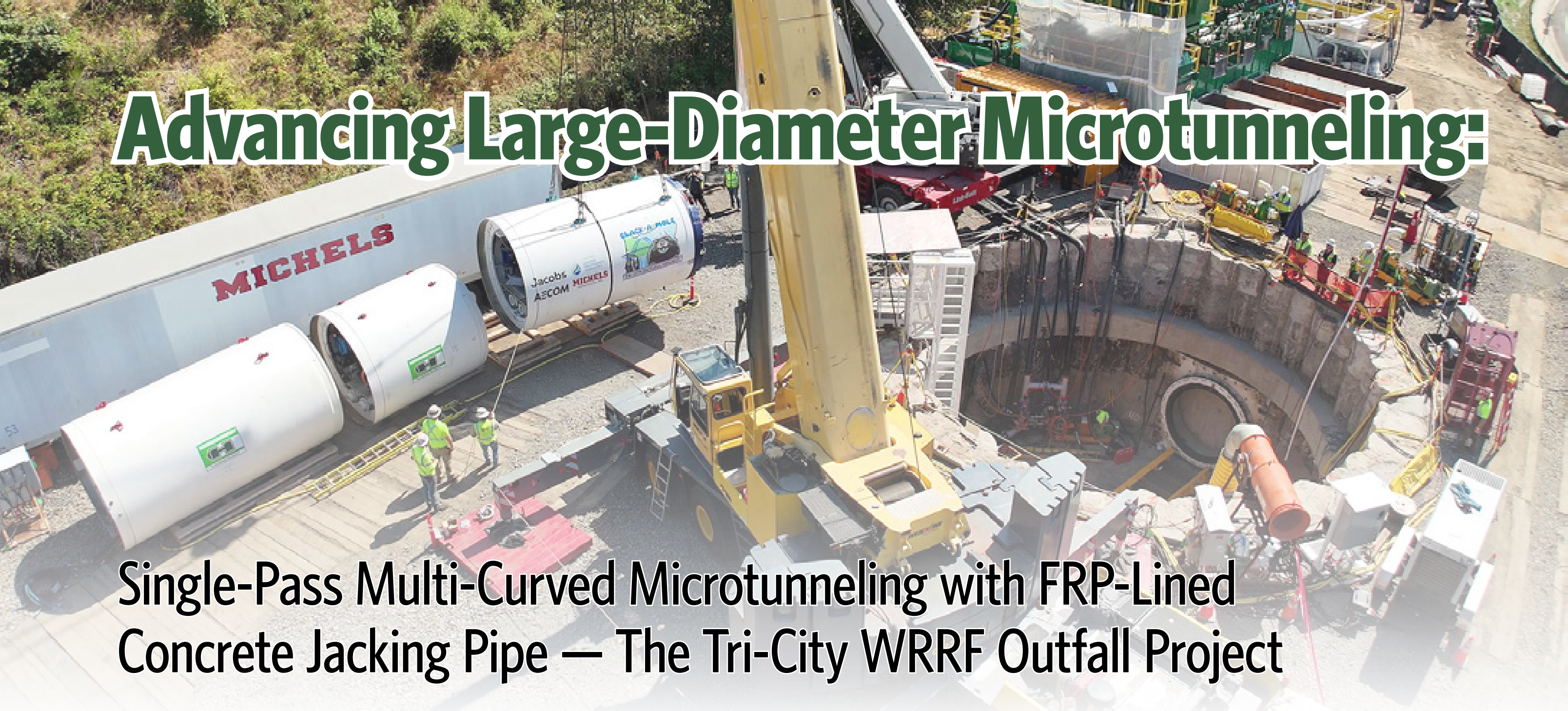
ABOUT THE AUTHOR:



***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.*

ABOUT THE AUTHOR:

***Jeremy Lorberau** is a Civil Engineer with the Water Conveyance 2 group of the Civil Engineering Services #1 Division of Reclamations' Technical Service Center (TSC) in Denver, Colorado. He has a bachelor's degree in civil engineering technology from Metropolitan State College of Denver. He is a licensed Professional Engineer in the states of Colorado and Montana. Jeremy has conducted numerous presentations to Reclamation-wide and other audiences on topics including tunneling, canal design and construction, trenchless technology design, and precast concrete design and use.*



Advancing Large-Diameter Microtunneling:

Single-Pass Multi-Curved Microtunneling with FRP-Lined Concrete Jacking Pipe — The Tri-City WRRF Outfall Project

By: Carl Pitzer, PE, Thompson Pipe Group
Sanaz Ghalambor, PhD, Thompson Pipe Group

> *Thompson Pipe Group's FlowCrete provided an innovative solution to the Michels Team. What otherwise would have been a two-pass installation, Flow-Crete, with its independently structural fiberglass reinforced polymer mortar pipe allowed for a single curved trenchless installation to be executed via microtunneling.*
>
> – Tucker Toelke, EIT, Director of Alternative Delivery at Michels Corporation

INTRODUCTION

Municipal agencies are increasingly required to expand capacity while minimizing environmental disturbance, community disruption, and long-term maintenance risk. Large-diameter outfalls present particular challenges when alignments pass beneath highways, bridges, residential areas, and waterways. The Tri-City Water Resource Recovery Facility (WRRF) Outfall Project in Oregon City, Oregon, represents a milestone in U.S. trenchless construction through the successful execution of a single-pass, multi-curved microtunnel utilizing FRP-lined reinforced concrete jacking pipe (Flow-Crete). This article summarizes the project drivers, design evolution, alignment constraints, construction innovations, and lessons learned, highlighting how integrated composite pipe systems and advanced installation and monitoring technologies enabled a technically demanding installation with reduced surface impact and enhanced long-term performance.

PROJECT BACKGROUND AND DRIVERS

The Tri-City WRRF serves a rapidly growing service area in the Portland metropolitan region and processes more than 10 million gallons per day of wastewater. The original outfall infrastructure, constructed decades earlier, was approaching its hydraulic capacity and experienced infiltration and inflow during wet-weather events. Clackamas Water Environment Services (WES), the owner and operator, initiated a capital improvement effort to increase discharge reliability, improve effluent dilution in the Willamette River, and ensure compliance with evolving environmental standards.

The project corridor traversed Interstate 205, the OR-99E interchange, residential neighborhoods, and public parkland before reaching the river. These conditions significantly restricted the feasibility of conventional open-cut excavation, driving the design team, led by Jacobs with AECOM and Michels delivering the project through a progressive design-build approach, to pursue a hybrid trenchless strategy combining open-cut FRP pipe installation and long-drive microtunneling.

The preliminary 10-percent design proposed a traditional two-pass microtunneling system consisting of a primary casing tunnel for ground support, installation of an internal carrier pipe, and grouting of the annular space.

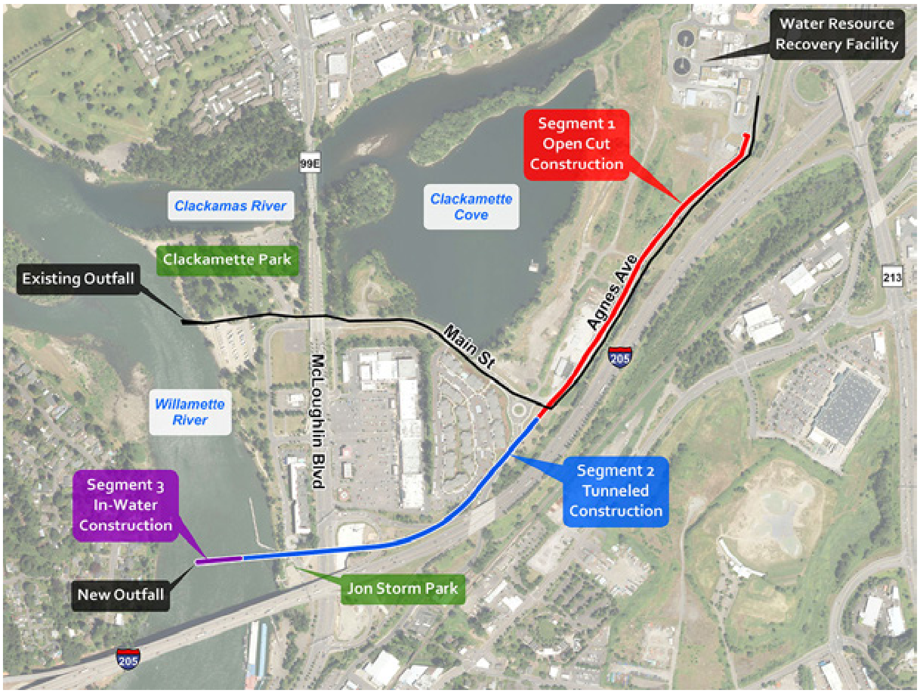


Figure 1: Project Location and Alignment Map

Although technically viable, this approach required multiple launch and reception shafts, conflicted with staging areas of a concurrent bridge-widening project, and introduced schedule and cost risks. During the progressive design-build phase, coordination challenges between the tunneling contractor and bridge contractor prompted evaluation of alternatives.

The project team ultimately adopted a single-pass microtunneling solution using FRP-lined reinforced concrete jacking pipe (Flow-Crete). This integrated composite system eliminated the need for casing and annular grouting, reduced the required tunnel diameter, and minimized the number of shafts, by introducing multiple curves into the alignment. The redesign also resolved site congestion issues and enabled construction to proceed without delaying the bridge works, which are ongoing and are expected to continue for several years beyond completion of the tunneling phase.

ALIGNMENT GEOMETRY AND CONSTRUCTION CONFIGURATION

The final microtunnel alignment comprised approximately 2,370 linear feet executed in one continuous drive from a single launch shaft. The alignment included four curves within a single push, one horizontal and three vertical, with radii on the order of 1,000 to 1,100 feet. Five Intermediate Jacking Stations (IJS) were incorporated to maintain permissible jacking forces along the pipe string.

Figure 2: Kiewit's I-205 Abernethy Bridge Expansion Project

Figure 4: Flow-Crete Jacking Pipe in Microtunneling Launch Shaft

A Herrenknecht microtunnel boring machine (MTBM) was utilized, culminating in a wet retrieval at the Willamette River. The combination of horizontal and vertical curvature within one drive is uncommon in U.S. large-diameter microtunneling and represented a significant technical achievement for the project team.

PIPE TECHNOLOGIES AND STRUCTURAL PERFORMANCE

Open-Cut FRP Carrier Segments:

In accessible areas, Thompson Pipe Group's 90-inch FRP pipe was installed using open-cut methods. FRP was selected for its corrosion resistance, hydraulic smoothness, and favorable strength-to-weight ratio, which simplified handling near existing utilities and constrained trench conditions.

FRP-Lined Reinforced Concrete Jacking Pipe (Flow-Crete):

For the microtunneled segment, Flow-Crete pipe, manufactured by Thompson Pipe Group, combined the rigidity and axial load capacity of reinforced concrete with the corrosion resistance and hydraulic efficiency of a factory-installed FRP liner. The liner functions independently of the structural shell, ensuring long-term chemical resistance without reliance on field-applied coatings or adhesive bonding.

The reinforced concrete shell accommodates high axial jacking forces and localized point loads, while the pipe joints maintain watertight performance throughout tunneling operations. The integrated FRP liner provides sustained pressure resistance, corrosion protection, and a smooth hydraulic interior for the duration of the service life. Jacking forces remained within the permitted jacking force limits, and no pipe distress, joint failure, or alignment deviations were observed.

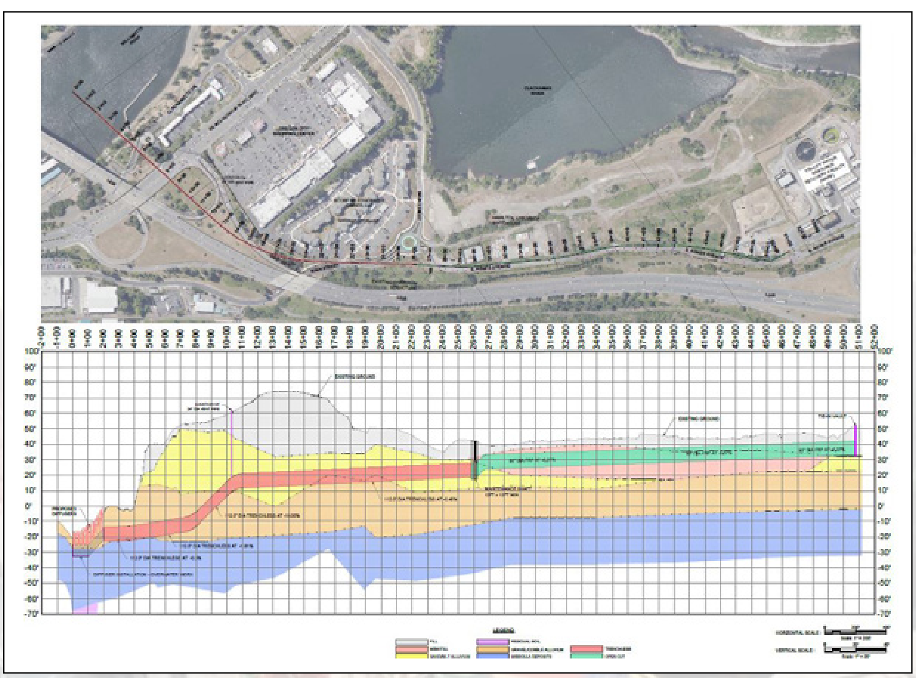


Figure 3: Plan and Longitudinal Geotechnical Section of the Tri-City Outfall Alignment

INNOVATION IN JOINT LOAD TRANSFER AND MONITORING

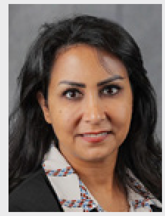
A distinguishing technical feature of the project was the adoption of hydraulic hose joint packers in lieu of conventional timber packers. Traditional wooden packers perform adequately in straight drives but can produce uneven contact and stress concentrations at articulated joints in curved alignments, reducing allowable jacking loads and increasing the risk of pipe damage.

Hydraulic hose packers provided continuous circumferential contact between pipe segments, enabling higher transferable jacking forces, accommodation of tighter curvature, use of longer pipe segments with fewer joints, and real-time pressure monitoring at each joint.

ABOUT THE AUTHOR:

***Carl Pitzer, PE**, directs Thompson Pipe Group's trenchless division. A graduate of Oregon State University, he began his career with Kiewit Construction building bridges before transitioning to underground infrastructure in 2015. A licensed Washington Civil Engineer, Carl actively presents and contributes to industry organizations, advancing trenchless technology education nationwide.*

ABOUT THE AUTHOR:



***Sanaz Ghalambor, PhD,** is a Technical Resource Engineer at Thompson Pipe Group with over 20 years of experience in pipeline solutions, with a strong emphasis on polymer-based pipeline protection, corrosion control, and rehabilitation. She actively contributes to ASTM, AWWA, and ASCE committees, advancing standards and best practices in pipe design, trenchless technologies, and infrastructure renewal.*

Figure 5: FRP-Lined Reinforced Concrete Jacking Pipe (Flow-Crete)

Sensors attached to the hydraulic system relayed real-time pressure data to the operator through a color-coded interface, enabling immediate localized corrective action. This system significantly improved operational control and safety, particularly during long or multi-curved drives.

CONCLUSION

The Tri-City WRRF Outfall Project demonstrates that large-diameter FRP-lined reinforced concrete jacking pipe can successfully enable single-pass, multi-curved microtunneling in highly constrained urban environments while maintaining structural integrity, watertight performance, and operational safety. The integration of composite pipe technology, real-time force monitoring, and collaborative design-build delivery reduced surface impacts and construction risk, providing a strong precedent for future long-drive trenchless wastewater infrastructure projects.

Over 130,000 Feet of Fusible PVC® Conduit for the Willamette River Crossing and Onshore Duct Banks

A Critical Component for the Portland Harbor Superfund Site in Downtown Portland, OR

By: Patrick Laidlaw PE – Underground Solutions

> *Complex and variable subsurface conditions made conventional horizontal directional drilling extremely difficult.*

Polychlorinated biphenyls (PCBs), once widely used in products like paints and transformers, were banned in 1978 but persist in sediment along waterways. In 2017, the EPA recommended dredging or capping PCB-contaminated sediments near Willamette River Mile 11 East (RM11E), which required relocating Pacific Power's underwater electric cables. Seizing the opportunity, Pacific Power also decided to upgrade the aging cables to meet Portland's growing energy demands, installing new ones at least 200 feet below the riverbed. However, complex and variable subsurface conditions made conventional horizontal directional drilling extremely difficult, as shown by previous contractors' failed attempts. After evaluating several design-build teams, Pacific Power selected Michels and AECOM to complete the river crossing.

Figure 1. Ten Fusible PVC® Conduit strings are fused in parallel, stick-by-stick, in preparation for bundling in spacer rings (shown in Figure 4) and pulled into the steel casing

TRENCHLESS CHALLENGE

To protect the new 11.7 kV power transmission cables, Michels elected to install two parallel 24-inch steel casings, each 3,000 feet long and reaching depths to well over 300 feet below the HDD entry points. Challenging geotechnical conditions, including flood-deposited cobbles and boulders near the surface and the denser Troutdale Formation at depth, required innovative construction methods. Michels used 60-inch diameter steel conductor casings driven through the flood deposits by pipe ramming, followed by the Direct Pipe method to install 48-inch casings into the Troutdale Formation. From there, a conventional horizontal directional drill (HDD) intersect connected the two sides. The final 24-inch pipe casings were successfully pulled through the conductor casings in late 2024 and early 2025.

Figure 2. Fusible PVC® Conduit fusion operation – five Fusion Techs provided by Underground Solutions, Inc. using ten McElroy fusion machines

Pacific Power, Michels and AECOM chose Fusible PVC® (FPVC®) over HDPE, installing over 60,000 feet in two 3,200-foot bundles of ten conduits each. Each bundle included:

- Six 5-inch DR17 FPVC® conduits - rated to 228 psi long term critical buckling pressure (critical for grouting at 300 feet + depth)
- One 4-inch DR17 FPVC® conduit – also rated to withstand 228 psi grout pressure
- Three 3-inch Schedule 40 FPVC® tremies rated to 260 psi, maximum working pressure, which did not span the full crossing length

REASONS FOR FUSIBLE PVC CONDUIT SELECTION

- **Smaller Outer Diameter:** FPVC's thinner walls allowed all conduits to fit within a 24-inch steel casing. Comparable HDPE (DR7.3) would have required larger diameters, necessitating 30-inch casings, raising both cost and installation risk.
- **Better Thermal Resistivity Performance:** The Thermal Resistivity of FPVC has a Rho value of 565-degrees C-cm/W compared to approx 350-degrees C-cm/W for HDPE. However, since FPVC has twice the tensile strength of HDPE, the required conduit wall is less than half as thick, giving FPVC a thermal performance benefit.

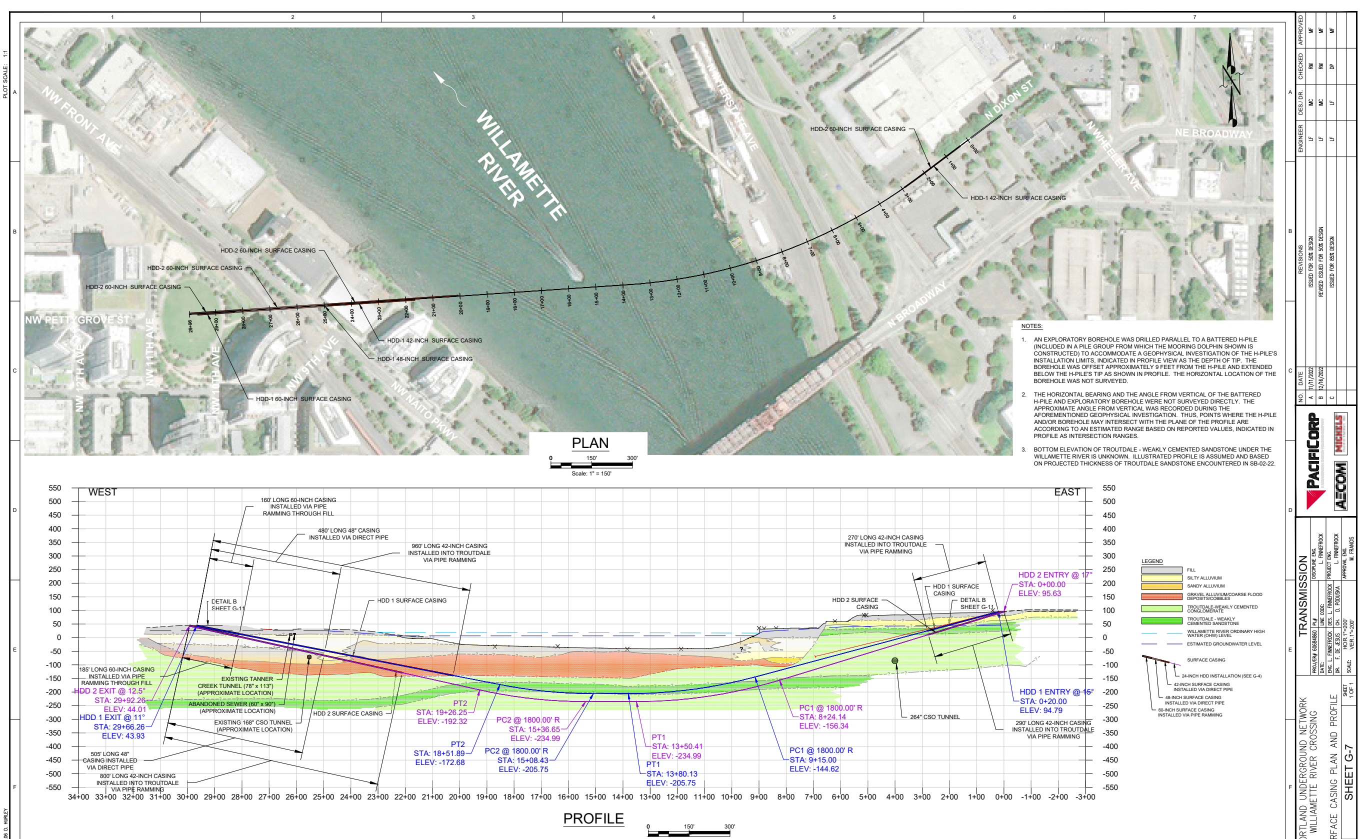


Figure 3. HDD Plan and Profile Alignment (Courtesy of Michels). A dual, 3,000 LF crossing under the Willamette River requiring a 60-inch steel conductor pipe, a 48-inch steel casing installed via Direct Pipe, and a 24-inch steel casing installed via HDD intersect before insertion of a ten-conduit, Fusible PVC® bundle

- **Pressure Rating:** Given the total grouting head of over 300 LF, HDPE presented challenges in meeting the required pressure specifications, making the grout tubes (tremies) made from Fusible PVC® a more suitable choice.
- **Greater Tensile Strength and Stiffness:** Fusible PVC® Conduit offers twice the tensile strength (7,000 vs. 3,500 psi) and three times the modulus of elasticity (400,000 vs. 130,000 psi) of HDPE, minimizing stretching and ovaling…making it more reliable for these long and deep directional drills.
- **Heat Resistance:** Fusible PVC® Conduit maintains its structural integrity at cable temperatures up to 105°C at the conductor, exceeding the NEC's 90-degree C standard, under certain conditions, for standard bell & spigot PVC…making FPVC® more suited for expected thermal loads.

Figure 5. After exiting the fusion tents, the ten FPVC® conduits are strung out along NW. Pettygrove St and under a pedestrian walkway

Figure 6. Casing Spacer (by Underground Devices) are used to contain the ten Conduit FPVC® bundle. The individual conduits were organized into the spacer using forming templates during each 45-foot fuse-and-pull operation

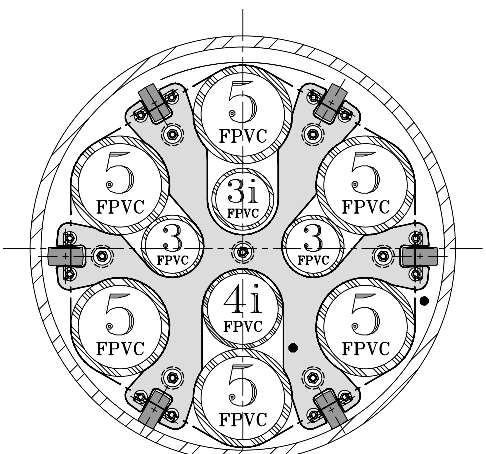


Figure 4. Fusible PVC® Conduit bundle within a spacer ring (provided by Underground Devices) comprised of six 5-inch DR 17 FPVC® conduits, three 3-inch SCH 40 FPVC® conduit tremies, and one 4-inch DR 17 FPVC® conduit for fiber optic cable. The bundle was slip-lined into each of the 24-inch steel casings

FUSIBLE PVC® CONDUIT FUSION AND DEBEADING OPERATION

The project's urban location in Portland's Pearl District posed unique challenges due to the surrounding businesses. To minimize disruption, Pacific Power and Michels actively engaged with the public and worked to reduce noise, enclosing much of the operation within a fenced, sound-walled structure in Fields Park. However, critical components like the two 3,000-foot strings of 24-inch steel casing and the ten bundled FPVC conduits required street-level access during pull-in.

Michels coordinated closely with the City of Portland and transportation departments to limit road closures, maintaining pedestrian and vehicle access where possible-including the installation of a temporary pedestrian bridge over the pipe. Underground Solutions collaborated with Michels in advance to plan around the tight footprint, layout, staging, and noise constraints.

Due to space limitations, it wasn't feasible to string out all 3,000+ feet of conduit in advance. Instead, ten electric McElroy fusion machines were operated simultaneously by five Underground Solution Fusion Technicians, each managing two machines to maximize efficiency.

Figure 7. The FPVC® bundle is laid out just before the entry pit – Note, there is a bundle already installed on the right side

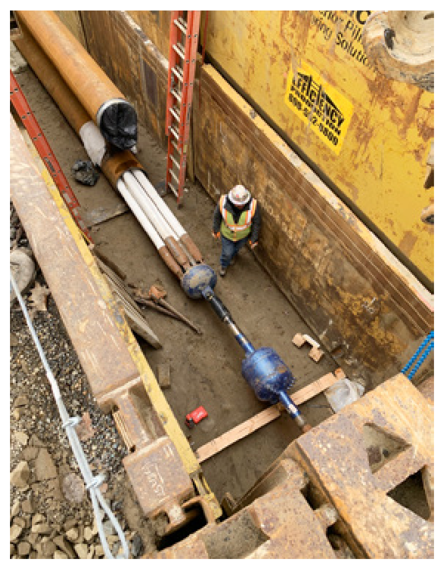


Figure 8. FPVC® bundle exiting on the other side of the Willamette River. Each conduit was fitted with a pull-head and swivel, with a single pull-shield in front. Note how close the parallel steel casing is located just above

Challenging geotechnical conditions required innovative construction methods.

After each fusion, internal beads were removed to allow smooth cable pull-through, with video confirmation for quality assurance.

The process followed a precise sequence:

1. Load one, 45-foot stick of FPVC conduit onto each fusion machine
2. Fuse and data-log the joints
3. Remove internal beads and verify via video
4. Pull the 10-stick conduit bundle 45 feet into the casing from the other side of the river
5. Organize the ten newly fused conduits into the casing spacers
6. Repeat sequence

This fusion, debeading, and pull-in process was repeated for over 60,000 feet of conduit and completed in just 19 days.

Figure 10. Belled FPVC® Conduit bundle exits after being pushed through jack & bore operation

ONSHORE INSTALLATION OPEN-CUT AND JACK & BORE

Over 67,000 linear feet of Underground Solutions segmented Fusible PVC® Conduit were installed onshore in downtown Portland, primarily using conventional direct-bury methods within duct banks. Several street crossings required jack & bore installation. The same FPVC® formulation used for the river crossings was selected but manufactured in 10-foot bell-end segments. This pipe was chosen over standard PVC conduit for several key reasons:

- **Ease of Installation:** Underground Solutions provided customized sizes; Michels selected 10-foot lengths of 6-inch SCH 40 FPVC® Conduit, each weighing under 40 pounds for easy single person handling. The shorter length also allowed easier navigation around dense underground utilities in downtown Portland.
- **Superior Thermal and Mechanical Properties:** Fusible PVC® Conduit's proprietary formulation delivers enhanced thermal and mechanical performance compared to standard PVC bell-and-spigot conduit – a key benefit for the onshore duct bank application.

The project's urban location in Portland's Pearl District posed unique challenges.

Figure 9. Onshore FPVC® Conduits arriving in 10-foot lengths with belled ends

ABOUT THE AUTHOR:

***Patrick Laidlaw PE** has been in the water and engineering industry for over 20 years. He is a registered Professional Engineer in the State of Utah and holds a Master of Science from Penn State in Environmental Engineering and an MBA from the University of Utah. Since 2006, he has been a Regional Sales Manager for Underground Solutions covering eight western states. He has been involved in nearly 1,000 trenchless pipe installations projects from Seattle to Fargo.*

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- Curtain grouting
- Soil treatment and stabilization
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- Below-grade parking decks
- Retaining walls

Advantages

- The variable set time range is long– from minutes to more than an hour– and is adjustable in the field.
- High chemical resistance
- Extremely flexible
- Great adhesion even below the water table
- Non-corrosive in both liquid and cured forms

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Primary Applications:

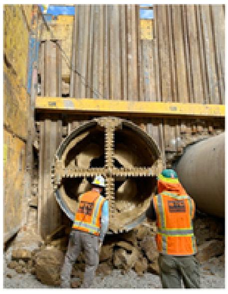
- Curtain grouting
- Soil treatment and stabilization
- Tunnels (subway, water, utility, etc.)
- Storm sewers and box culverts
- Below-grade parking decks
- Retaining walls

Advantages:

- Variable set time range is long– from minutes to an hour – and is adjustable in the field.
- High chemical resistance
- Extremely flexible
- Great adhesion even in damp environments
- Non-corrosive in both liquid and cured forms
- NSF-61 compliant for contact with potable water
- Minimal project footprint
- Made in the USA
- Maximum permeation - variable levels of viscosity

Example projects:

Jackson Street Storm Sewer
Contractor: Nicholson Construction Company



Horizontal directional drilling. Chemical grouting prior to tunneling activities for the installation of storm drain pipes.

Los Angeles Metro Purple Line Extension 2
Contractor: Tutor Perini-O&G Industries- JV

Stabilizing loose, poorly compacted soils encountered while crews excavated the cross passages between the twin tunnels comprising the extension.

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TURNING GROUNDBREAKING FIELD VALIDATION INTO FULL-SCALE EXECUTION

Proving SoiLok in Saturated, Below-Sea-Level Soils

By: Robert Epp, infraStruct Municipal Services

BREAKING NEW GROUND BELOW SEA LEVEL

Across North America, infrastructure is expanding into ground that does not want to cooperate.

Transit corridors are pushing below water tables. Utilities are crossing tidal zones. Urban redevelopment is forcing excavation beside aging foundations. In many of these environments, groundwater is not an occasional inconvenience, it is a constant condition.

The traditional responses are familiar. Sheet piling. Aggressive dewatering. Heavy equipment and larger footprints. Sometimes those methods are appropriate. Sometimes they are necessary. But increasingly, we are encountering sites where vibration is restricted, discharge is regulated, adjacent utilities are vulnerable, and surface disruption is more challenging or even unacceptable.

Excavation footprint was subject to hourly tidal influence

On a recent project in Richmond, British Columbia, built on unconsolidated deltaic soils from glacial deposition and influenced by a tidally affected groundwater table, excavation had stalled under precisely those constraints. The work zone sat below sea level. Groundwater was present approximately one metre below grade. Dewatering posed unacceptable risk to adjacent infrastructure, including a live gas main. Sheet piling was not permitted due to vibration and proximity concerns.

The question we faced was not which product to use. The question was whether the ground itself could be conditioned rather than fought.

At infraStruct, our decisions are guided by what we call the D.A.T. Methodology: Diagnose, Advise, Treat. It is not a marketing phrase. It is a structured way of thinking in complex subsurface environments.

> ***"When sheet piling conflicts with existing utilities the advantage goes to teams who diagnose correctly and apply the right solution with discipline."***
> ***– Robert Epp***
> ***VP Business Development, infraStruct***

The first step is always diagnosis. Before selecting a system, we assess soil conditions, groundwater behavior, site constraints, regulatory limitations, and constructability risks. In Richmond, the diagnosis was clear. We were working in saturated, below-sea-level soils with tidal influence. Conventional dewatering would not only be expensive but could induce settlement or impact adjacent services. Driven shoring introduced vibration risk and regulatory barriers. The soil profile included silty sands with elevated fines content, limiting the effectiveness of more viscous grouts.

Once the diagnosis was completely understood, the advisory phase began. This is where many projects either accelerate toward a default solution or pause long enough to consider alternatives. We worked collaboratively with our friends at Prime Resins to evaluate whether SoiLok® polyacrylamide permeation grout could achieve two objectives simultaneously: stabilize the soil matrix and isolate groundwater within a defined treatment zone.

SoiLok's ultra-low viscosity, near water consistency, allows it to permeate soils containing higher fines while maintaining controllable gel times for us. That technical capability made it viable in theory. But theory alone does not solve excavation problems. The advisory stage demanded more than reviewing a technical data sheet. It required field validation.

Early phases of the work were structured as controlled trials conducted under live roadway conditions adjacent to the work zone where it would be removed for mainline excavation activities later on. We refined vertical perimeter injections to establish confinement. We calibrated gel times to accommodate groundwater temperature and tidal variability. We adjusted probe spacing to achieve treatment continuity without excessive material consumption. Horizontal passes were tested below invert to determine whether a base cutoff could be reliably formed.

These were not sales demonstrations. They were constructability experiments.

What we confirmed was that a continuous treated soil matrix could be created below the water table without soil displacement. In a location where excavation beyond four feet had historically been unstable, we achieved dry, stable excavation during test phases. The ground did not collapse. Groundwater did not migrate through the treated zone. For the first time on that site, the subsurface environment became predictable.

Only then did we proceed to treatment.

The final application involved conditioning a critical roadway intersection where pipe installation had previously stalled. Vertical injections were installed from surface to below target invert, forming a perimeter cutoff wall. The

No active dewatering system was needed

Vertical injections were installed from surface

excavation footprint itself sat roughly half a metre below sea level, subject to hourly tidal fluctuation. Horizontal injections were then completed within the confined area to create a treated base layer extending approximately one metre below invert.

Together, the vertical and horizontal treatments formed a fully encapsulated zone, what we describe internally as a "bathtub." The objective was not to remove groundwater from the site. The objective was to isolate it outside the excavation boundary. If there was only a small amount of water to be managed, this would be reasonable.

With treatment complete, excavation proceeded using conventional shoring from the surface. Material was removed to approximately 4.5 metres depth, directly into the water table.

- No sheet piling was required.
- No active dewatering system was needed.
- No groundwater intrusion occurred.
- No soil sloughing was observed.

The excavation behaved predictably as though it were in dry ground.

That outcome was not the result of chemistry alone. It was the result of disciplined sequencing and adherence

> ***"We didn't remove the groundwater, we isolated it and cut it off." when you know the process works."***
> ***– Glenn Votkin, President, infraStruct***

to the D.A.T. framework. The diagnosis informed the advisory process. The advisory process defined the treatment geometry. The treatment geometry dictated injection sequencing and quality control.

An additional development during execution was improved material efficiency. Through refined probe spacing and calibrated gel times, resin consumption decreased compared to initial validation phases without compromising performance. That evolution illustrates an important reality about permeation grouting: predictability increases with disciplined methodology. In ground improvement, diagnosis never truly ends, it informs every adjustment. Field feedback refines design assumptions. Execution improves.

While this project occurred in Canada, the conditions are not uniquely Canadian. Across the United States, End Users, Designers and Contractors encounter coastal corridors influenced by tidal fluctuation, river basins with shallow groundwater, floodplains where drawdown is restricted, and urban environments where vibration is tightly controlled. In these settings, large-scale dewatering or driven shoring may introduce more risk than benefit.

Permeation grouting is not a universal replacement for conventional systems. It is a tool. But when integrated within a structured diagnostic framework, it becomes more than a material choice. It becomes a strategic alternative.

For infraStruct, the lesson from Richmond was not that a specific grout solved a problem. The lesson was that conditioning the ground can expand excavation limits when guided by disciplined evaluation. Instead of forcing the project to adapt to unstable soils, we adapted the soil to support the project.

As infrastructure investment accelerates across North America, subsurface challenges will only grow more complex. Aging utilities intersect with new transit alignments. Environmental regulations tighten around groundwater discharge. Urban density limits surface access and

New way forward for groundwater control and soil stabilization in these environments

tolerance for vibration. The industry's response cannot rely solely on default methods.

The future of ground improvement lies in structured decision-making. Diagnose the conditions honestly. Advise collaboratively with our technical partners. Treat with defined geometry, calibrated controls, and field accountability.

That philosophy is not exclusive to one region. It is transferable. It scales from roadway crossings to shafts, cross-passages, underpinning operations, and groundwater cutoff systems in saturated soils.

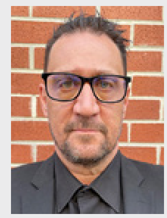
In Richmond, an excavation that had stalled became a controlled operation. Groundwater remained in place, but outside the work zone. Construction progressed safely. Risk was reduced without introducing new impacts.

The takeaway is straightforward. Groundwater does not always need to be removed. Sometimes it needs to be isolated. Soil does not always need to be replaced. Sometimes it needs to be conditioned.

When method guides material selection, not the other way around, previously impossible conditions can become quite manageable.

And in complex geotechnical conditions, that difference matters to all stakeholders.

ABOUT THE AUTHOR:



Robert Epp *is VP of Business Development for infraStruct and currently serves as Chair of NASTT-BC, advocating for greater use of trenchless technology methods across BC and the Pacific Northwest. Robert takes pride in utilizing trenchless technology applications, problem solving underground infrastructure challenges and water infiltration mitigation in even the most challenging situations.*

March of the Frogs:

Trenchless Solution to a Migration Challenge

By: Brendan O'Sullivan, PE, Consor
Brandon Falk, PE, Consor

> *"Traffic had to remain operational throughout construction."*

INTRODUCTION

Each winter and early spring, northern red-legged frogs make the same journey they have followed for generations. They leave the cool forest floor of the Tualatin Mountains and move downslope toward their breeding grounds in the wetlands along the Columbia River within the J. R. Palensky Wildlife Area. The two habitats are close together but are decidedly separated by restless highway US-30.

On migration nights, hundreds of frogs traversed the busy highway, leading to many fatal interactions with traffic. Local volunteers assembled "bucket brigades" to ferry frogs across during peak movement, bringing awareness to the issue but providing only temporary intervention. Without a safe passage under the highway, the species could not easily access the breeding habitat in the J. R. Palensky Wildlife Area that agencies had previously invested in restoring.

A permanent connection via an underpass beneath US-30 was identified to allow frogs to migrate safely and independently between the wetland and upland habitats. Delivering that crossing within a constrained corridor with rail infrastructure, buried utilities, overhead utilities, and active highway traffic became the central engineering challenge of the project.

CORRIDOR CONSTRAINTS AND SUBSURFACE CONDITIONS

US-30 is a four-lane, 80-foot-wide highway that passes between the Tualatin Mountains and the Columbia River lowlands. The proposed underpass alignment extended beneath the highway, with an active railroad immediately east at an elevation approximately 15 feet lower than the roadway surface. Storm, water, and fiber optic communications utilities crossed above the proposed profile, limiting available vertical clearance. Full open cut construction across US-30 would not be feasible: traffic had to remain operational throughout construction as the highway is a critical freight route.

The geotechnical conditions along the planned alignment consisted of roadway embankment fill over quaternary fan deposits, producing mixed-face conditions at the crossing elevation. Two exploratory borings indicated low cohesion to cohesionless soils, soft to very stiff silt and silt with sand, and medium dense gravel that could contain large cobbles. Although borings did not encounter boulders, ODOT embankments in this corridor are known to contain subsurface boulders up to 2 to 3 feet in diameter, and boulders were observed at the surface of both road embankments. These conditions required careful selection of a trenchless method.

Figure 1: Pipe Ram Launch Shaft Location

TRENCHLESS METHOD EVALUATION

A feasibility study evaluated four trenchless methods for the underpass: auger boring, pipe ramming, pipe jacking with hand mining, and microtunneling. Each method was assessed for constructability within the constrained corridor and performance in mixed-face conditions.

Auger boring had the technical capability for the short drive length but presented a stall risk where large cobbles or boulders were present and offered only limited face support, which increased the possibility of over-excavation and surface settlement. Pipe jacking with hand mining allowed deliberate excavation at the face, yet it provided little face support in mixed soils and carried similar obstruction risks. Microtunneling offered guidance and positive face stabilization; however, for a relatively short installation, it introduced cost and mobilization complexity disproportionate to the drive length.

Pipe ramming, though it is non steerable and has the potential for localized consolidation of loose soils, presented lower risk of over-excavation at shallow depth. The method could also engulf cobbles and isolated boulders at the open face. Given the absence of nearby residents and businesses, anticipated noise and vibration impacts were acceptable. With the combined constraints of mixed-face ground conditions, limited cover, and required traffic maintenance, pipe ramming provided the most balanced risk profile for the project.

Figure 2: Channelizing/Retaining Walls East of US-30

SPECIES-DRIVEN DESIGN PARAMETERS

The trenchless method had to be compatible with the design, which needed to support relatively small, moisture-dependent frogs with an approximately 36-inch vertical jump. The installed casing diameter would be 54 inches, with a total length of 132 feet.

To intercept and funnel migrating frogs towards the underpass, custom channelizing/retaining walls were designed to be compatible with criteria established by project biologists at Oregon Department of Fish and Wildlife. The walls were designed to a height of 3 feet, measured from finished grade at the front face to top of wall, with an additional 2-foot flare added above to further prevent frogs jumping over. To prevent wildlife entrapment, finished grading at the back face was constructed flush with the top of wall.

Table 1. Trenchless Method Risk Factors

Trenchless Method	Identified Risk Factors
Auger Boring (Guided and Unguided)	Large cobbles/boulders Limited face support Woody debris impeding auger
Pipe Ramming	Non-steerable Localized consolidation of sands/loose soils
Pipe Jacking (Hand Mining)	Large cobbles/boulders Limited steering Limited face support
Microtunneling	Large cobbles/boulders

Figure 3: Illumination Light Boxes in US-30

Figure 4: Substrate Within the Casing

> *"Frogs are using it and frog mortality is down!"*

Interior conditions were designed to be wildlife- and frog-friendly, providing adequate light, moisture, and substrate continuity. Eight illumination light boxes – three within US-30 outside of the travel lanes and five located in the road embankments – were installed along the alignment. The boxes were comprised of a standard ODOT storm inlet grate and frame installed flush with the existing surface. Embedded steel riser pipes extended downwards from a concrete collar, poured beneath the frame, to the casing. The riser pipe interiors, starting three feet below the existing surface, and interior of the underpass were coated with a white elastomeric paint to increase light refraction.

Furthermore, the casing interior was designed to encourage frogs to use it. To create a reliably flat passageway, 8 inches of concrete was poured into the invert of the casing pipe. The finished surfacing was 4 inches of natural substrate consisting of organic soil and leaf litter salvaged from the site to simulate the surrounding habitat.

PHASED INSTALLATION AND FIELD ADJUSTMENT

Construction, which began in summer 2024, was shaped by tight staging limits and the need to maintain both highway and rail operations. The project site spanned US-30, with a significant footprint on either side of the highway. On the east side, construction was constrained to a narrow strip between the roadway and the railroad, where clearance and railroad flagging requirements controlled staging and movement.

It was determined during design that the easternmost 92 feet would be installed by pipe ramming, while the remaining length on the west side would be installed by open cut. The pipe ramming section extended from the steep east road embankment to the westernmost fog line of US-30. The reasoning for the phased installation approach was twofold, as the open cut section allowed for existing utility protection to be properly managed as well as the mitigation of risks inherent to pipe ramming.

Because of insufficient clearance between the 54-inch casing and an existing storm utility crossing above, the storm pipe had to be cut back and reinstalled at a lesser grade in the open cut section. It was also best practice to expose and protect a critical adjacent fiber optic line rather than pipe ram beneath with minimal clearance.

The phased approach also provided a controlled means managing the non-steerability of pipe ramming and potential localized consolidation of sands and loose soils in the roadway embankment. Constructing the western section by open cut provided the opportunity to rectify any line or grade deviations arising from the pipe ramming installation.

The design grade for the casing was 5.1 percent; however, the installed grade in the pipe ramming section was approximately 4.0 percent. This was likely caused by substantial voids in the large-diameter fill material used to construct US-30, with sands/loose soils moving into the available void spaces. This consolidation resulted in surface settlement in the east shoulder of US-30, with asphalt concrete pavement settlement approaching 6 inches in the highway shoulder. The affected pavement surface areas were removed and replaced.

To maintain the invert elevation at the west end, a vertical bend at the transition

Figure 5: Settlement in East Shoulder of US-30

from pipe ramming to open cut was introduced. Despite the field adjustment, approximately 54 percent of the interior vertical clearance still remained visible end to end. The installed line differed from design by roughly 2.5 feet, likely resulting from an inaccurate initial penetration or deflection at an unknown buried obstruction.

During removal of soil from the pipe ramming installation, a boulder was encountered that was able to be engulfed inside the casing. Because the western section was constructed by open cut, the final wall penetrations and approach geometry were adjusted to suit the as-built casing without compromising function.

PERFORMANCE OUTCOMES AND TRANSFERABLE LESSONS

The underpass restores a direct connection between wetland and upland habitat within a constrained transportation corridor. The project required coordination across agencies and consulting teams to deliver a crossing that met ecological objectives while maintaining highway and rail operations.

The outcome was collaborative by design. Biologists defined what the crossing needed to do. Engineers fit those requirements into a crowded above-grade and subsurface utility corridor with limited available workspace. Inspectors and the design team pivoted when settlement appeared and implemented contingency plans developed during design to finish construction of the structure to meet project goals. The result is a functional crossing delivered by people who shared a clear purpose.

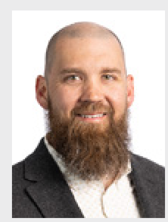
Field performance and construction experience yielded several repeatable lessons for agencies considering wildlife crossings in similarly constrained transportation corridors:

1. Define the ecological objective at project outset and carry it through method selection and design decisions.
2. Map corridor constraints early, including utilities, adjacent infrastructure, and staging limitations.
3. Leverage past projects in project area for subsurface and utilities information.
4. Treat geotechnical borings as a snapshot of conditions and understand risks when installing in road embankment fill.
5. Build in the ability to address line and grade issues that can arise for non-steerable technologies.
6. Establish biological performance criteria at start so that wildlife-specific needs are incorporated into all facets of design.

> *"Conditions required careful selection of a trenchless method."*

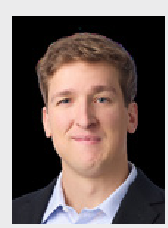
Teamwork made this possible, but the true measure of success is: Are frogs using the underpass? An entire first season of data indicates that yes, frogs are using it and frog mortality is down. In fact, cameras have captured nearly 1,800 amphibians, reptiles, and small mammals as big as opossums using the underpass, including more than 300 observations of northern red-legged frogs. Continued post-construction monitoring will guide small adjustments that keep the crossing a low-resistance path in all seasons.

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 21 years of experience in the consulting industry serving municipal clients throughout the United States. He is Member-at-Large on the PNW-NASTT Board of Directors.*

ABOUT THE AUTHOR:



***Brandon Falk** is a Portland, Oregon professional engineer with water, wastewater, and transportation project experience across the PNW. As on this project with Brendan O'Sullivan, Brandon's trenchless work experience includes condition assessment, rehabilitation, and new installation projects.*

From Push-Cameras & Man-Entry to AI-Driven Analysis:

How CCTV Inspection Transformed Underground Infrastructure Inspections

By: Brian Gastrock, PE, Coffman Engineers, Inc.

Since the first underground pipes were installed, understanding what was happening inside sewer and stormwater pipes required a combination of guesswork, indirect testing, and even sending people underground. Today, closed-circuit television (CCTV) inspection has become the backbone of how agencies assess buried infrastructure, turning once-invisible assets into measurable, manageable systems.

The evolution of CCTV inspection has come about two-fold. First, is the ever-evolving technology of cameras and equipment. Second, is based on the need for greater safety, standardization, and data-driven decision-making. What began as a way to keep people out of dangerous environments has grown into a sophisticated practice that now incorporates artificial intelligence and advanced analytics.

> *"CCTV inspection has become the backbone of how agencies assess buried infrastructure."*

OVERVIEW OF CCTV: SEEING UNDERGROUND WITHOUT DIGGING

CCTV inspection is a non-invasive method that uses robotic crawlers or push cameras to capture video footage from inside pipelines. By visually assessing pipe interiors, inspectors can identify structural defects, operational issues, and construction features without excavation. For gravity sewers, CCTV has become the primary inspection method supporting rehabilitation planning, regulatory compliance, and long-term asset management. In stormwater systems and roadway culverts, it plays a growing role alongside transportation-focused inspection programs.

While traditional CCTV relies on visual inspection, advanced inspection programs can integrate laser scanning, sonar, and multi sensor platforms to supplement video data. Laser profiling can capture pipe geometry and deformation, sonar is used to assess submerged conditions and sediment buildup, and scanners provide quantitative measurements that cameras alone cannot fully document. These tools are especially valuable in large diameter pipes, partially submerged assets, and systems where understanding shape, volume loss, or obstruction is critical to decision making.

Together, these technologies expand CCTV inspection beyond what can be seen on screen, allowing agencies to move from purely visual observations to measurable, repeatable datasets.

The value proposition is simple: better information at lower cost and risk. But getting there took decades.

THE DEVELOPMENT OF SEWER AND STORM PIPE INSPECTION

Pre CCTV and Manual Inspections: Risky and Inconsistent Inspections

Prior to CCTV technology, sewer inspections were often performed manually, with workers entering large-diameter pipes or relying on indirect methods like dye testing and smoke testing. These approaches were slow, subjective, and more hazardous. Confined spaces, toxic gases, and flood risks made manual inspection dangerous, while documentation varied widely from one inspector to another.

As underground infrastructure has expanded and is continually aging, the trenchless industry has helped guide safer and more repeatable inspection methods.

The Rise of CCTV Inspection

The first practical sewer CCTV systems appeared in the early 1960s, pioneered by companies developing remotely operated camera systems capable of traveling through pipes while transmitting live video to operators at the surface. By the 1970s and 1980s, improvements in camera durability, lighting, and self-propelled crawlers made CCTV inspection viable for widespread municipal use.

Several CCTV equipment manufacturers have developed 360-degrees inspection cameras. These cameras take multiple images per second, and stitch the images together. The

Man-entry Inspection of 48-inch Storm Drain Pipe

Cross Bore Defect in Storm Drain Using AASHTO Culvert Inspection Manual

software then allows the inspector to pan, tilt, and zoom within the software to observe the defects. This method decreases the risk of the CCTV operator passing a defect, requiring a re-inspection.

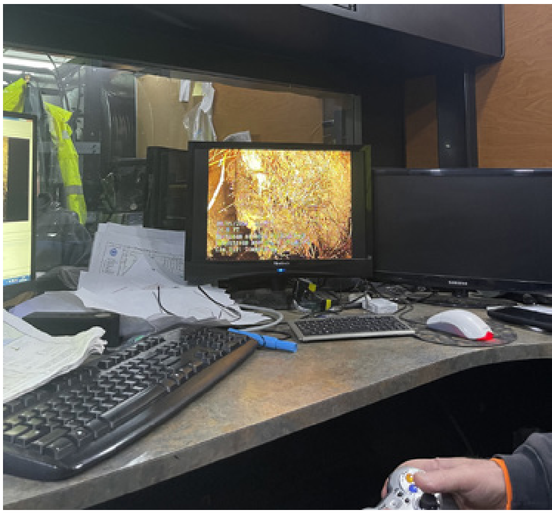
Additionally, this allows for faster camera operations, reducing traffic control and field time. The drawback is increased back-office inspection time to review the CCTV inspections.

These systems eliminated the need for manned entry and fundamentally changed how agencies understood their buried assets. Instead of relying on written descriptions or memory, decision-makers could see conditions for themselves.

Digital Video and the Need for Standards

As inspection technology advanced through the 1990s and early 2000s, digital

Manhole Defects in Storm Drain System



Root Ball Defect Observed in Sewer Using PACP

video dramatically improved image quality, storage, and reporting. Pan-and-tilt cameras with color, distance encoders, and inspection software allowed video to be synchronized with defect logs and spatial data.

However, it was becoming apparent to consultants in the industry that one of the new challenges was the interpretation of information. Different inspectors could watch the same video and reach different conclusions. Without standardized defect definitions and coding rules, inspection data was difficult to compare, analyze, or use consistently across projects and agencies.

STANDARDIZED CODING SYSTEMS IN CCTV INSPECTIONS

PACP and AASHTO

To address the gap in interpretation, standardized coding systems were developed. In the utility world, the National Association of Sewer Service Companies (NASSCO) introduced the Pipeline Assessment Certification Program (PACP) in 2002. PACP created a common language for describing defects, defined coding rules, and introduced severity grading and condition scoring. Subsidiary inspection coding programs under NASSCO have been created to account for subsections of sewers; laterals (LACP), manholes (MACP), and Building Sewer and Drain Inspection (BSDI). The NASSCO inspection format remains the foundation of most municipal sewer asset management programs in North America.

Transportation agencies, meanwhile, faced different priorities. The American Association of State Highway and Transportation Officials (AASHTO) Culvert and Storm Drain System Inspection Guide, first published in 2020, focuses on evaluating entire systems and components rather than individual defects. Its component-based rating approach supports roadway safety, hydraulic performance, and federal reporting requirements.

While PACP excels at detailed rehabilitation planning, AASHTO's framework is optimized for risk prioritization and transportation asset management. Many agencies now use both, depending on asset ownership and purpose.

NASSCO PACP/LACP/MACP/BSDI focuses on rehabilitation planning and lifecycle analysis, while AASHTO is optimized for transportation safety, hydraulic performance, and regulatory reporting. Many sewer agencies use NASSCO, but many transportation departments use both frameworks due to the training required for NASSCO certification and asset ownership and function.

Comparison: NASSCO PACP vs. AASHTO Coding

Aspect	NASSCO PACP	AASHTO Culvert & Storm Drain Guide
Primary Use	Sewer & storm pipelines	Transportation culverts & storm drains
Focus	Defect-level detail	System and component condition
Coding Style	Defect-based, granular	Component-based, holistic
Output	Condition grades, rehab planning	Condition ratings, risk prioritization
Typical Users	Utilities, consultants, contractors	DOTs, transportation agencies

Enter Artificial Intelligence

Even with standardized coding, traditional CCTV inspections remain labor-intensive. Trained coders spend hours reviewing footage, and staffing shortages have made it difficult for agencies to keep pace with growing inspection backlogs.

This is where artificial intelligence is beginning to change the equation.

Modern AI platforms use computer vision and machine learning to identify defects directly from video footage and apply standardized codes; most commonly PACP compliant codes. When paired with human quality control, these systems can

CCTV Camera with Crawler for Sewer PACP Inspections

significantly reduce review time while improving consistency across inspections.

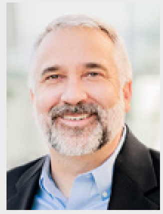
Rather than replacing inspectors, AI is increasingly viewed as an augmentation tool. Certified professionals remain responsible for validation and engineering judgment, but automation allows them to focus on higher-value analysis and decision-making.

What Comes Next

As inspection data becomes faster to collect and more consistent, agencies are moving away from reactive maintenance toward proactive, risk-based asset management, enabling better forecasting of failure risk and investment needs.

The future of CCTV inspection is not just about better cameras or faster coding, rather it's about turning visual data into insight and making informed, data-driven decisions for successful outcomes. Agencies that successfully combine CCTV inspection, standardized coding, and AI-driven analytics will be better positioned to manage aging sewer and stormwater systems in a defensible, cost-effective way.

ABOUT THE AUTHOR:



Brian Gastrock, PE *has been a member of NASTT since 2007 and brings more than 25 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 an Associate at Coffman Engineers and a Member-at-Large of the PNW-NASTT Chapter Board of Directors.*

Technical Nuances to Applying Spiral Wound Lining to Sewers with Complex Diversions

By: Jake Andresen, PE, Staheli Trenchless Consultants

1.0 INTRODUCTION

Maintenance, repair, and upgrading of existing sewer systems is an ongoing task for any sewer service provider across the United States. Application of a variety of renewal techniques, collectively known as "pipeline rehabilitation" is a common choice for service providers to use when the lifespan of existing sewer pipelines are reached and the sewers need to be replaced. By proactively renewing the sewers, the municipality can avoid the public disturbance, duration, and cost associated with installing an entirely sewer pipeline. There are several rehabilitation techniques available, suitable for a project based upon the installation criteria such as sewer diameter, condition, distance between maintenance holes, number of lateral connections, and ability to divert existing flow.

Spiral wound lining is a pipeline rehabilitation technique used to renew existing pipelines by installing a new flow surface that extends the length of the pipeline. The subject of this technical paper is the style of spiral wound liner produced by Sekisui, specifically the SPR TF/RO product. Spiral wound lining feeds a long strip or "profile" of liner material the pipe by placing profile flush with the host pipe and against the strip of the previously installed liner. Sekisui has a patented PVC profile which incorporates a mechanical lock that is distinct from other spiral wound lining techniques. A winding machine is setup in the host pipe, the profile is fed into the machine, and the machine is advanced the length of the pipe. Once the machine reaches the ending maintenance hole, the liner has been installed on the entire circumference and length of the host pipe, pulling from experience lining 54-inch and 48-inch concrete sewers in 2023.

This technical paper highlights key technical nuances required to implement the Sekisui product in mid- to large trunk sewers that require significant bypass of 15 to 20 million gallons per day (MGD).

2.0 TECHNICAL CONSIDERATIONS

The following technical considerations are based upon experience with a public capital works project wherein a bid advertisement is issued by the pipeline operator/owner and a winning contractor proceeds with the construction (design-bid-build contract).

2.1 Application of High Flow Diversions

Flow diversions are commonly incorporated into sewer rehabilitation projects, temporarily removing the liquid from the pipeline section being worked on to allow cleaning and lining while maintaining conveyance. The diversion for this project was performance based in terms of the piping and pumping system, requiring a capacity on the order of 16 MGD, with two allowable piping materials – Ductile Iron and high-density polyethylene (HDPE) as options, with HDPE eventually being used. The contract requirements included two Quality Control checks, a) hydrostatic pressure test and b) full scale demonstration.

The Sekisui methodology has an option for lining in live flow with no diversion. Based upon the experience with this project, lining in live flow would be extremely difficult given the number of personnel and extent of time required within pipelines of this size. Planning for lining within live flow should be reserved for those projects which have favorable conditions (short run lengths, small height of flow compared to pipe size, pipe size large enough for personnel stand up in and no bends at maintenance holes).

Diversion Piping

The pipe used was re-used from past projects/diversions and contained many existing butt fusion welds. This represented a risk of pipe failure that difficult to quantify. It is recommended that where HDPE piping is used for a diversion, new piping be required, or at minimum that all untested fusion welds be cut out and replaced with a documented fusion process. In the process of constructing the diversion on this project, an old/untested fusion weld broke when the piping was lifted/shifted, highlighting the concern over untested connections within the system for a critical component.

Hydrostatic Test Pressure

A specific sequence and criteria for the hydrostatic test of the diversion was not included in the contract requirements on the referenced 2023 project because it was a temporary feature. Because the requirements were vague in the contract, it was not tracked by submittal control and related documents. This created a reliance on field personnel to flag the need for a methodology, which led to last minute resolutions as opposed to a planned-out procedure. It is recommended that any pressure test have a clear reference base standard of criteria such as ASTM F2164 (HDPE pipe). Further, the parameters of pressure, length of time held at that pressure, and allowable drop should be established for all phases of the test. The available standards were found to be vague on these details, which led to disagreements in the field as to what constituted a suitable test.

It is notable that the pressure test failed on one occasion at an old/untested butt-fusion weld. The piping had previously held the test pressure for one hour but with excessive pressure drop. The leak occurred on the second attempt once the pipe had been in the expansion phase for several hours. If the test had been only 1 hour at the required pressure, this defect would not have been discovered by the test. All phases of the hydrostatic pressure test are considered crucial to demonstrating that the piping will not leak.

Full Scale Demonstration

The flows to be diverted came primarily from an upstream pump station with approximately 2MGD contributed from local collectors between the PS and the trunk. Therefore, any diversion had to be closely coordinated with the main pump station control staff. The extent of that coordination and procedural requirements such as notifications, allowable test days, and roles/responsibilities between Contractor and the owner was not clearly outlined in the contract documents. Two items stood out a) control strategy and b) procedure for performing the demonstration at the highest rated flows.

Control Strategy – A control strategy is considered the detailed breakdown of how various pumps will work individually or in sequence to effectively divert the distribution of flows. This strategy was required to be tested, but the definition of that test, nor of what the control strategy entailed was not clear. This led to confusion wherein the contractor did not have all the expectations outlined beforehand and multiple rounds of submittal review slowed the process significantly.

The test requirements should speak to both what a control strategy entails and how its effectiveness will be demonstrated.

Demonstration of highest flows – For this project, the only way to generate flows of 16+ MGD to allow the full demonstration was for the upstream pump station to hold flows in the wet well for ~1 day to have suitable volume to then pump for the requisite flow rate and duration. In this case, the pump station had two pumps, each theoretically capable of approximately 7.5 MGD flow rate. During the initial test, the flows were called for, quickly ramping up to 2 pumps running on full. The diversion system was not able to keep up with the flows and MH surcharged up to and over the rim within the contained work zone. There were three issues with this process.

1. The abrupt change in flow volume was not representative of what would happen in real life. The flow is 80 percent controlled by this pump station, therefore there is no scenario that the pumps would need to deal with the full flow abruptly increasing in that manner.
2. This did not allow vetting of individual pumps and pump sequences. In the later, successful demonstration – the test was completed at intervals such that each pump demonstrated its ability to operate and to operate in sequence and move through the flow control sequences that would be seen during the project.
3. Based upon flow rates measured at the diversion maintenance hole, each pump was capable of pumping more than the estimated 7.5 MGD. These large pumps did not have a specific measurement on the flow rate being generated, therefore, the received flow was higher than needed for the full-scale demonstration.

From this experience, it is important to avoid the situation of simply requiring the diversion to carry a certain high flow in all circumstances. The characteristics of the upstream system should be incorporated into the understanding of how the sewer operator can control flows to avoid unrealistic expectations and conservative requirements such that a reasonably sized system is not able to achieve performance in that theoretical maximum flow event.

2.2 Manufacturer Engagement

Spiral wound lining with the Sekisui product was not a widely established commodity installation such as cured-in-place pipe (CIPP) or sliplining at the time of this project (2022-2023). Therefore, the manufacturer is likely to have the greatest levels of expertise in the installation and application of the product compared to construction personnel or engineers regularly engaged in the industry. Assessments, technical comparisons of technologies, understanding of comparative risks, overall projects costs, and other design elements associated with preparing a project for bid may require preparation by licensed professionals. However, this should be supplemented by coordination with the manufacturer to understand quantities for a given installation and application as well as materials lead times, qualified contractors capable of bidding, and related information that is useful in the planning and delivery of a project.

The Contractor often uses the manufacturer to demonstrate requisite experience, provide training to crew members, and otherwise promote a successful installation as an on-site advisor. For projects in areas with limited experience with the product, it is recommended to build a manufacture representative on site into the contract scope. This ensures that the requisite experience is on site and is particularly important for projects which will draw from construction crews with limited or no previous experience with the methodology.

2.3 Construction Metrics and Learning Curve

The crew that worked on the referenced project were comprised of crew members which had not specifically worked with the Sekisui product before. The crews completed two distinct sections: 4,000 linear feet of 54-inch concrete in 31 shifts and 3,100 linear feet of 48-inch concrete in 17 shifts. The crew demonstrated improvement over this time. The key items identified to impact the learning curve are:

1. Operating winding machine at a consistent speed – there was a noticeable production increase when operators were shifted. The most productive was a moderate speed, with emphasis on keeping the advance rate as constant as possible. This made it much easier for the crew members within the pipe to anticipate the movements of the profile and prevent kinks.
2. Coordination of workers within the pipe – the contractor staged workers within the pipe to feed the profile smoothly from the reel to the winding machine, with more workers needed as the length from reel to machine increased. This is a crucial task as kinking of the profile was a major factor in slowing production. Having a team that communicates effectively and generally functions together vs. acting as individuals is crucial.
3. Eliminating kinking – kinking of the profile has two primary impacts a) severe slowdown in production while the crew cuts the profile to remove the kink and reset the profile into the machine and b) a gap in the liner which must be patched. Kinking also contributes to a higher waste factor.

2.4 Application of Patches

The spiral wound lining will not be fully continuous across the entire length of any given rehabilitation segment. The liner profile will have an approximate 1-inch gap anytime that the profile must be fed into the lining machine. This happens at the end of each liner spool, and whenever the liner is kinked or otherwise needs to be reset during the installation. On the referenced project, contractual requirements did not address this nuance of the spiral wound lining leaving interpretation as to a suitable patch. Contracts should at a minimum address this aspect of the technology with guidance as to the requirements. It is recommended that the gaps be filled with a product with a lifespan and corrosion resistance equal to the PVC profile, such as an epoxy.

2.5 Machine Access and Navigating Maintenance Holes

The spiral lining machine must be inserted and set up within the pipe. This is not possible within the standard maintenance hole lids for the 54-inch and 48-inch sewers, and the cone removal and associated disturbance should be anticipated to allow access. This requires a much larger footprint, timeline, and restoration cost compared to access solely through established maintenance holes.

The machine was able to navigate maintenance holes easily when the channel was inline and of the same size as the sewer invert. The winding machine can simply advance through the maintenance hole barrel, with the profile cut as needed at the channel spring line.

If the sewer turns at the maintenance hole or the channel is otherwise smaller than the sewer pipe, the process may take significantly longer. The winding arms are not able to fit and need to be rebuilt at the opposite side of the maintenance hole. This is possible from within the maintenance hole to a limited extent. If the chamber is smaller than ~6 feet diameter, the cone of the maintenance hole needs to be removed so that the machine can be brought to the surface and configured for the next run.

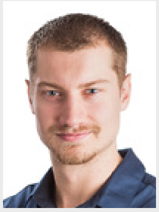
If the lining machine must be reconfigured, there is potential the geometry of the maintenance hole will not allow the lining machine to advance the lining to the full length. This occurred in several instances, with 1 to 4 feet being left unlined in select instances.

The transition to the maintenance holes should be considered in the contract. If the geometry is of the maintenance holes channel is not consistent with the sewer size, the cost and materials to apply an epoxy or equivalent sealant to extend the liner to the maintenance hole should be anticipated.

2.6 Quality Control Measures

A standard convention within the pipeline lining industry is that the payment for a given stretch of sewer, maintenance hole to maintenance hole (or equivalent termination) is not made until CCTV footage demonstrating satisfactory performance has been completed and submitted. For the referenced project, this provision was not included in the measurement and payment and caused confusion as to the required sequence. The sequence governing CCTV prior to payment is a key quality control measure for lining processes and should be used for spiral wound lining projects to ensure that the work is fully complete prior to issuing payment.

ABOUT THE AUTHOR:



***Jake Andresen PE**, is a geotechnical engineer who serves as a senior engineer/PM at Staheli Trenchless, holding a M.S. degree in geotechnical engineering and a B.S.E in civil engineering from Arizona State University. He serves as the construction inspections manager/supervisor and as a senior designer, engineer of record for complex trenchless design challenges. Jake has extensive experience with the trenchless techniques of microtunneling, horizontal directional drilling, pipe ramming pipe bursting, auger boring, direct steerable pipe thrusting, and various pipe lining and rehabilitation techniques. Jake enjoys backcountry skiing in the winter and spring - you'll often find him on one of the Cascade volcanoes or other high points around Washington State.*

Open-Face Trenchless Construction in Challenging Ground Conditions – Case Study

By: Natascha Lambing, EIT, Farid Sariosseiri, PhD, PE, Luke Erickson, PE,
& Mark D. Havekost, PE, Delve Underground

1.0 PROJECT DESCRIPTION

The Willamette Water Supply Program (WWSP) is a drinking water infrastructure program implemented by Tualatin Valley Water District, the City of Beaverton, and the City of Hillsboro in Oregon to provide a seismically resilient water supply for the service area. The WWSP was divided into multiple design packages and proceeded with a phased approach. Pipeline Section PLM_1.0 consists of approximately 3.3 miles of 66-inch inside-diameter (ID) welded steel pipe located in Clackamas and Washington Counties. Delve Underground was retained by HDR to provide geotechnical engineering and trenchless design services for the PLM_1.0 alignment.

The section of the PLM_1.3 alignment along SW Ridder Road in Clackamas County was initially designed to be constructed with open-cut trenching methods; however, during construction it was determined that two existing concrete culverts (54-inch- and 48-inch-diameter) that convey Tapman Creek from north to south under SW Ridder Road were deteriorating and vulnerable to damage during open-cut construction. Replacement or upgrading the culverts to the current code would have required significant coordination and permitting effort that would have caused delays in the overall project schedule; thus the design team identified trenchless construction methods as the preferred alternative. The crossing was approximately 180 feet long and groundwater was approximately 10 feet below ground surface.

The trenchless alignment was extended through the Missoula Flood Deposits Gravel Facies (MFD-GF) through the first half of the alignment and then transitioned to the Missoula Flood Deposits Fine-Grained Facies (MFD-FF) as seen in the idealized Geologic Profile in Figure 1. The MFD-GF encountered in the explorations near the trenchless crossing generally consisted of predominantly very loose to dense, clayey gravel with various amounts of sand and cobbles up to 6 inches in diameter.

Trench excavations in vicinity of the project encountered 4-foot-diameter boulders while trench excavation for the PLM_1.2 alignment less than 0.25 mile west of the Ridder Road crossing encountered boulders up to 9 feet in diameter. MFD-FF generally consists of sequence of clay, silt, and fine-grained clayey sand (CL, ML, SC) with gravel.

2.0 CONSTRUCTION METHODS EVALUATION

2.1 Anticipated Ground Behavior

A key consideration in selecting a trenchless method was the anticipated ground conditions and how the ground was expected to behave during excavation. The selected construction method needed to maintain ground stability at the excavation face to prevent ground loss and subsequent ground deformations, surface settlement, and damage to the existing culverts.

The casing was launched in the MFD-GF and transitioning to the MFD-FF. Below the groundwater table, both units were expected to exhibit fast-raveling to flowing ground

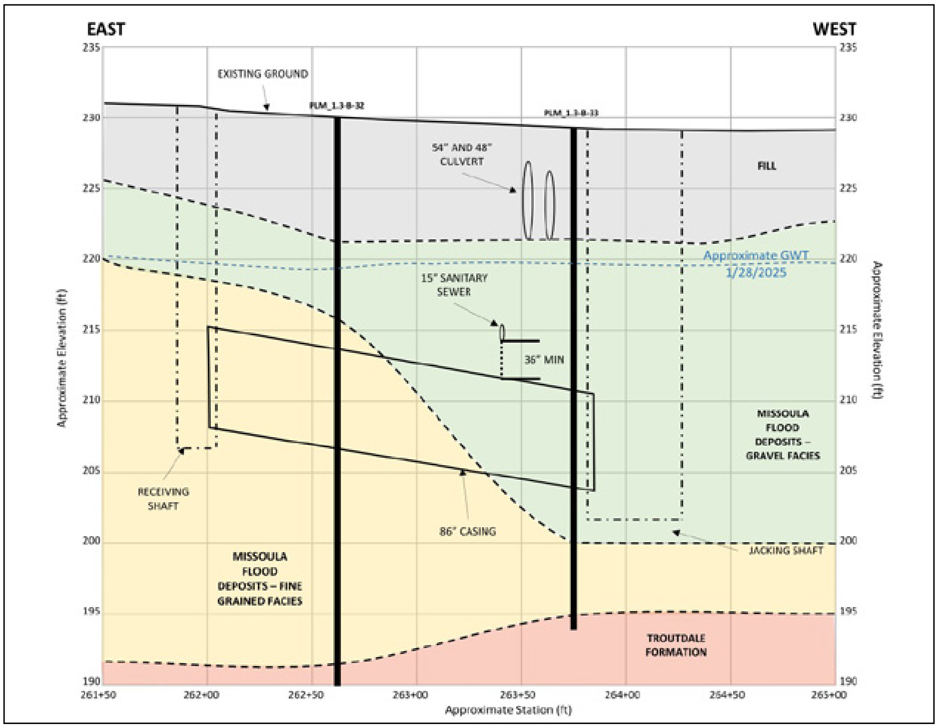


Figure 1. Geologic Cross Section

conditions. A fast-raveling condition is defined as a ground behavior at which material breaks up into chunks or angular fragments within a few minutes. Flowing ground is a material that advances like a viscous fluid into a tunnel heading. Because of risks associated with flowing ground below the groundwater table, including settlement, ground loss, and groundwater inflows, the crossing was expected to be fully dewatered during construction.

2.2 Feasible Construction Methods

Trenchless construction methods were evaluated against three critical performance objectives: minimizing ground loss–induced settlement, maintaining line and grade accuracy near existing utilities, and ensuring suitability with respect to drive length and ground conditions. While several methods could meet these objectives and final selection was left to the tunneling contractor, access to the excavation face was considered critical for potential boulder removal. Pipe jacking and auger boring were identified as suitable methods, with pipe jacking offering the most efficient face access while boulder removal with auger boring could slow advancement due to the need to remove the augers to gain face access. Pipe ramming, while technically feasible, was not recommended due to noise and vibration impacts, lower installation accuracy, and potential risks to nearby utilities and the Tapman Creek culverts. Microtunneling was not considered due to high equipment mobilization and operating costs relative to the other methods over the relatively short drive length.

2.3 Settlement Considerations

Settlement is typically induced by over excavation and/or ground loss at the tunnel face and is largely governed by the contractor's means, methods, and quality of workmanship. When settlement occurs, the maximum vertical displacement generally manifests at the ground surface directly above the tunnel centerline and diminishes laterally with distance, forming a characteristic trough shaped settlement profile.

Predicted settlements are highly sensitive to assumed volume loss, which varies with trenchless method, ground conditions, and contractor workmanship; therefore, actual settlements may be lower or higher than calculated. The analyses considered annular overcut volume losses of 25–75 percent per ASCE 36 15 using the Wallin et al. (2008) method (with a 1.0 inch radial overcut), and total excavation volume losses of 1–3 percent using the Mair et al. (1996) method, representing conditions ranging from excellent to poor workmanship and ground control. The maximum surface settlement along the trenchless alignment was estimated to be between 0.4 and 1.3 inches, depending on ground behavior and workmanship.

3.0 DESIGN SUMMARY

The WWSP Pipeline Design Guide required a minimum vertical clearance of one pipe diameter beneath existing utilities; however, given the dense utility distribution, an exception was allowed for the deepest mapped utility; a 15-inch sanitary sewer bisecting the crossing, designed with 3 feet of vertical clearance from the crown of the crossing casing. An 86-inch-diameter, 5/8-inch-thick steel casing was advanced from west to east, approximately 180 feet in length, ranging from 15 to 19 feet of ground cover at the crown, driven upward at a 3 percent slope as approximated in Figure 1. The jacking shaft was approximately 27 feet in depth with a receiving shaft at 24 feet in depth.

4.0 CONSTRUCTION

The casing was advanced by pipe jacking techniques with an open-face tunnel shield by Gonzales Boring and Tunneling Inc. Gonzales had previously performed multiple other trenchless crossings along the PLM_1.0 alignment and was familiar with the anticipated ground conditions and potential for encountering boulders. The open-face tunnel shield utilized a mechanical digger arm mounted inside the shield while the spoils were removed within a smaller casing at the invert of the pipe string with continuous flighted augers.

The construction was planned to be completed during the dry season where groundwater was expected to be adequately lowered to below the bottom of casing with sump pumps in the shafts and intermediate dewatering wells along the alignment. However, the jacking shaft construction for the trenchless crossing began in early October 2025, which commonly marks the approximate end of the dry season in the region.

The contractor installed eight, 40-foot-deep dewatering wells at approximately 35-foot spacing near the shafts and along the alignment but continued to observe the groundwater level at about 20 feet below ground surface throughout construction, corresponding to the depth of the top of the steel casing at the launching shaft. Despite the observed depth of groundwater and the exposed face of the tunnel being below the groundwater level, tunneling proceeded as planned.

Upon launch of the open-face tunnel shield, the spoils observed consisted of very wet, silty, sandy and clayey gravel and cobbles (Photo 1) and groundwater was reported flowing into the casing along the bottom of the exposed tunnel face. However, the tunneling contractor reported adequate stand-up of the exposed tunnel face. (Photo 2)

Photo 1. Pipe jacking at approximitaly 23 feet of progress

Photo 2. Exposed tunnel face Oct. 20, 2025 (Courtesy Gonzales)

Photo 3. Stormwater pond to north of jacking shaft

Photo 4. Jacking shaft Nov. 1, 2025 with ponded groundwater

Photo 5. Groundwater flow from casing invert

During trenchless construction, multiple heavy rain events up to 1.75 inches of rain in a 48-hour period overwhelmed the dewatering system and caused difficulties managing groundwater. Furthermore, as a result of poor storm drain conditions in the vicinity of the site, stormwater basins adjacent to the culverts remained full throughout the trenchless drive (Photo 3), causing additional inflow in the jacking shaft and through the casing (Photo 4).

During two heavy rain events, the tunneling contractor elected to shut down tunneling activities until the storm subsided due to increased inflow of groundwater at the tunnel face. At one point, the primary jacking equipment was even removed from the shaft as a precautionary measure due to the risk of groundwater inflow. Groundwater flow of approximately 5 gallons per minute was observed flowing from the pipe casing invert flowing back into the shaft from the exposed tunnel face, similar to what is seen in Photo 5.

The tunneling contractor continued to report excess groundwater at the tunnel heading, but that the stability of the face could be maintained. A grout mix of primarily bentonite with minimal cement was pumped intermittently into grout ports in the steel casing throughout construction in effort to reduce the risk of settlement from washout of fines from the soil matrix surrounding the casing.

Throughout the trenchless drive, the contractor documented any boulders over 24 inches in diameter. Boulders of this size were too large to be transmitted along the auger flights for removal and had to be broken up by jack hammering methods. Throughout the trenchless alignment the tunneling contractor documented a total of eleven boulders ranging from 24 to 38 inches in diameter in the first 152 feet of the tunnel.

Breakout of the tunnel shield into the receiving shaft occurred on the seventeenth day of tunnel construction. The excess groundwater conditions continued throughout the trenchless drive with groundwater seepage visible in both the jacking and receiving shafts. The spoils excavated continued as very wet, silty, sandy, and clayey gravel and cobbles. After completion of tunnel breakout and advancement of the casing pipe, the tunneling contractor performed a grouting program consisting of pumping a cement and bentonite slurry into the grout ports with the lowest workable water ratio. Review of the contact grouting data indicated a grout volume of approximately 2.6 times the theoretical volume of the tunneling equipment overcut was used.

5.0 SETTLEMENT MONITORING

The settlement monitoring program included eight roadway monitoring locations and three critical utility monitoring points (Figure 2). The settlement monitoring data indicated some settlement occurred before trenchless construction began, likely due to dewatering.

Most of the settlement observed in instruments 1367, 1368, and 1369 occurred during trenchless construction in the vicinity of the existing stormwater culverts as shown in Figure 3. The settlement during construction was attributed to ground loss from boulder removal, localized raveling of coarse-grained soil, and migration of fines due to excess groundwater flow. Remedial actions were implemented by the contractor, including pumping bentonite grout to fill in voids as trenchless construction progressed.

Settlement observed at the roadway monitoring points near the shafts was likely due to disturbance during the shaft excavation and ground loss during tunnel break-out and break-in. Only two of the eight roadway points observed notable settlement but with

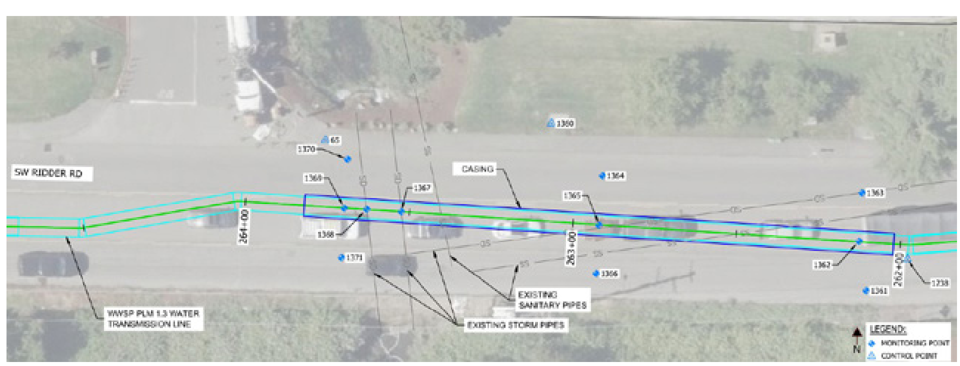


Figure 2. Settlement monitoring points (courtesy Longhorn Geomatics)

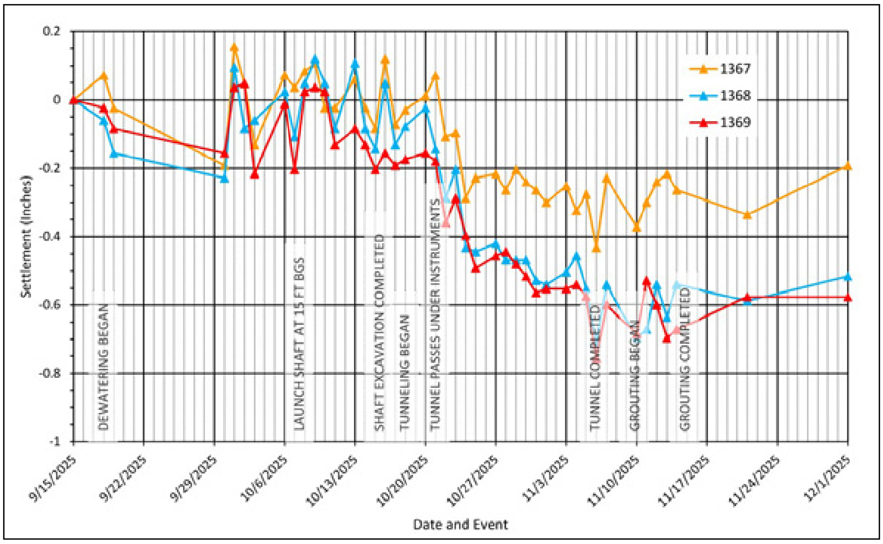


Figure 3. Settlement Plot

careful observation and remedial actions performed by the contractor, these were limited and thus the associated data not included in the presented data (Figure 3).

As a result of the remedial actions taken to stabilize the ground, no significant additional settlement was measured after tunneling beneath these instruments was completed. Following the completion of casing installation, the contractor performed contact grouting as required in the project specifications. Based on the remedial actions implemented by the tunneling contractor and review of the construction records, voids created during tunneling were likely effectively filled with grout, and the potential for additional long-term settlement affecting the two culverts is not anticipated.

In general, settlement measured along the trenchless alignment was within the anticipated range of settlement for trenchless construction through gravelly soil. In comparison to a nearby trenchless crossing of similar scale and construction type through MFD-GF, the recorded settlement at the SW Ridder Road crossing was greater. However, it is likely that adverse groundwater conditions led to washout of fines from the soil matrix causing localized raveling and increased settlement.

6.0 SUMMARY AND CONCLUSION

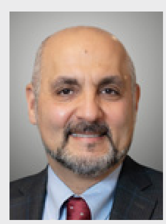
Trenchless construction methods were selected for this segment of the pipeline to minimize construction impacts to the culverts and avoid delays to the PLM_1.3 project. Given the anticipated presence of boulders, pipe jacking with an open-face tunnel shield was used to allow direct access to the face for boulder removal. Construction was originally planned for the dry season; however, it ultimately occurred during the wet season, during which several heavy storm events overwhelmed the dewatering system and resulted in particularly challenging tunneling conditions. In response to these conditions and the sensitivity of the culverts to settlement, the tunneling contractor implemented appropriate measures to control settlement. Despite these challenges, measured settlements ultimately remained within the anticipated range.

Through selection of appropriate tunneling methods, careful advancement of the tunnel shield, monitoring groundwater conditions, implementing a grouting program, and close communication with the tunneling contractor, the trenchless crossing was completed successfully.

ABOUT THE AUTHOR:

***Natascha Lambing, EIT**, is a Senior Staff Engineer with Delve Underground in Portland, Oregon. She provides geotechnical engineering and trenchless design for water and wastewater pipeline projects throughout the Pacific Northwest and beyond.*

ABOUT THE AUTHOR:

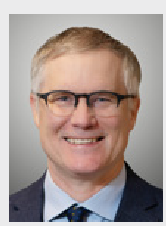


***Farid Sariosseiri, PhD, PE**, is a Senior Associate geotechnical engineer with Delve Underground in Portland, Oregon. He specializes in ground characterization, seismic design and evaluation of pipelines, and trenchless construction. He has been involved in the Willamette Water Supply Program projects since 2017, serving as the project manager and geotechnical engineer of record for several segments of the program.*

ABOUT THE AUTHOR:

***Luke Erickson, PE,** is a Principal for Delve Underground in Columbus, Ohio, and is one of Delve Underground's Trenchless Practice Group Leads. Luke has more than 19 years of geotechnical and underground engineering experience with a focus on trenchless projects in the water, wastewater, and energy markets. He currently serves on the North American Society for Trenchless Technologies (NASTT) Midwest Chapter Board of Directors.*

ABOUT THE AUTHOR:



***Mark Havekost, PE,** is a Principal Engineer with Delve Underground based out of Portland, Oregon with over 30 years of experience. Mark has been involved in a number of industry firsts using trenchless construction methods to address unique pipeline design challenges related to access subsurface conditions, hydraulic performance, and seismic resiliency.*

Streamlining a Two-Mile Industrial Water Main Installation:

Certa-Lok® PVC Pipe Proves Beneficial For Kamloops, BC

By: Morgan Howard, P.Eng., Westlake Pipe & Fittings

In the Southwest Sector of Kamloops, the city needed to expand its water infrastructure to accommodate future industrial development, but the project required coordinating multiple permits, managing supply chain risks for large-diameter fittings, and handling site-specific issues like a highway crossing and water tie-ins without interrupting services to businesses, residents, and a correctional facility.

CHALLENGE

The City of Kamloops, British Columbia, planned to install 2 miles (3.3km) of large-diameter water main in its Southwest Sector to supplement an existing system and support industrial expansion. The effort involved complying with multiple permits from various stakeholders, which required aligning schedules with permit holders to prevent delays. Large-diameter fittings were not off-the- shelf items, raising concerns over potential cost increases during tariff negotiations and supply chain disruptions. Long-lead items influenced the overall timeline, necessitating advance planning to avoid project stalls. The busy trans-Canada highway crossing called for a boring machine, introducing technical complexity. Testing and flushing the water main required discharging approximately 830,000 L of water - and with no immediate discharge points available - demanded solutions that met environmental and regulatory standards. Multiple water tie-ins added risks of disruptions to businesses, residents, and a correctional facility, emphasizing the need for coordinated communication and minimal downtime.

> *"The project stayed within the $11 million budget, with the system providing improved flow and reliability."*

Soil conditions varied along the route, including saturated soft silty areas that involved geotechnical engineering review and well-graded gravels suitable for trench backfill. The project took place on an urban road on the town's outskirts,

The highway crossing involved a guided auger bore inserting the PVC pipe through the steel casing using cartridge-style assembly

Multiple tie-ins emphasized the need for coordinated communication and minimal downtime

> *Communication with permit holders ensured regulatory compliance and coordinated timelines.*

providing accessible laydown areas and straightforward traffic control, but the setting still required a product that could address these constraints more efficiently than alternatives like ductile iron (DI), which involves higher weight and labor, or high-density polyethylene (HDPE), which offers lower stiffness for grade maintenance.

APPLICATION

This $11 million project focused on installing 2 miles of PVC water main to create a looped connection with the existing system, improving capacity and reliability for the Southwest Sector industrial area. The scope included 8,700 feet (2,650m) of 26-inch diameter PVC C900 DR 18 water main and 2,030 feet (620m) of 16-inch diameter PVC C900 DR 18 water main, along with a guided auger bore Trans-Canada highway crossing using 312 feet (95m) of 18-inch diameter Certa-Lok® Restrained Joint Integral Bell (RJIB) DR 18 PVC pipe inserted through a steel casing.

SOLUTION

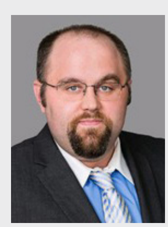
The project began in April 2025 with early procurement of the large-diameter PVC water main before contract award, addressing supply chain uncertainties and tariff concerns, to keep costs stable. This preparation allowed scheduling to align with long-lead items, supporting steady progress.

From the start, communication with permit holders ensured regulatory compliance and coordinated timelines. Most of the work used open cut trenching, adapting to the site's soil variations leveraging the geotechnical input. The highway crossing involved a guided auger bore, after which 312 feet (95m) of 18-inch Certa-Lok PVC pipe was inserted through the steel casing in just hours, using cartridge-style assembly and a field-proven spline lock design delivering a strong, secure, service-ready joint without the need for welding or fusion. Flushing and disinfection were planned with the client, directing 830,000L of water into existing drainage channels to meet standards. Tie-ins were managed with advance notices to affected parties, including temporary water supplies for the correctional facility to limit interruptions.

Completed by September 2025 after five months, the project stayed within the $11 million budget, with the system providing improved flow and reliability.

"Westlake pipe delivered exceptional service, when it came to procuring, delivering, communications with deliveries, and providing alternate products that meet specifications that help production and costs," said Brandy Unger, project manager, Extreme Excavating LTD.

ABOUT THE AUTHOR:



Morgan Howard, P.Eng *is a Specification Engineer for Western Canada at Westlake Pipe & Fittings. Registered in the four western provinces, he brings over 15 years of municipal waterworks expertise, with a focus on trenchless technologies. He partners with municipalities, engineers, owners, distributors, and contractors to deliver corrosion-resistant PVC solutions that extend service life and reduce lifecycle costs.*

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