NASTT ROCKY MOUNTAIN CHAPTER

Trenchless Elevated Journal

2023

Trenchless Elevated 2023
13th Annual Regional Conference

Wednesday, October 11

Mount Vernon Canyon Club, Golden, CO

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MESSAGE FROM THE RMNASTT CHAIR

Stephanie Nix-Thomas, RMNASTT Chair

Pioneering a Trenchless Future in the Rocky Mountain Region

It is with immense pride and enthusiasm that I can share the return of this new and improved journal with you. Welcome to the ***Trenchless Elevated Journal***! As the Chair of the Rocky Mountain Chapter of NASTT, representing a region renowned for its breathtaking landscapes and forward-thinking spirit, I am honored to share our vision, goals, and strategies for advancing the trenchless technology industry in our remarkable corner of the world.

The Rocky Mountain Region, with its unique geological challenges and environmental sensitivities, has long been a proving ground for innovative solutions. Our region spans diverse terrains, from the towering peaks of the Rockies to the sprawling urban areas, presenting both opportunities and challenges in the field of trenchless technology.

Trenchless methods have become indispensable in addressing the infrastructure needs of our communities while preserving the natural beauty of our landscapes. This region's embrace of trenchless technology has showcased its adaptability and sustainability. As we stand at the threshold of a new era, the potential for trenchless technology to revolutionize our infrastructure landscape is greater than ever. At Rocky Mountain NASTT we try to align our goals and strategies not just with the industry but with our National Association as well.

Goals and Strategies

Promoting Awareness and Education by collaborating with educational institutions, government bodies, and industry partners to develop programs and initiatives that foster knowledge exchange and promote best practices. This year we have held 3 site visits in Omaha Nebraska, Fraser Colorado and Salt Lake City Utah. We also brought back this journal.

Research and Development, understanding that investing in research and development is key to staying at the forefront of trenchless innovation, requires partnerships with research institutions and encouraging our members to contribute to cutting-edge projects that address regional challenges.

Recognizing the power of **Networking and Collaboration**, our Regional association serves as a hub for industry professionals. We host events and conferences to facilitate networking opportunities, allowing our members to learn from each other's experiences and collectively drive the industry forward. In 2023, we have hosted 3 socials and 2 clay shoot events in Colorado and Utah as well as the Trenchless Elevated conference held in Golden, Colorado.

A skilled workforce is the backbone of any thriving industry. We are striving to work closely with educational institutions and industry partners to support **Workforce Development** programs that ensure a highly skilled trenchless workforce for our region.

In this pivotal moment, we invite each present and future member of our association, and industry stakeholder to be proactive advocates for trenchless technology. We need your expertise, passion, and dedication to continue driving innovation and sustainability in the Rocky Mountain Region. By joining forces, we can overcome challenges, seize opportunities, and create a legacy of excellence for generations to come.

> "Trenchless methods have become indispensable.

I want to thank the members of our regional board for their dedication and countless volunteer hours, ensuring that our beloved region remains a shining example of progress, environmental stewardship, and resilience.

I look forward to working with each of you as we harness the incredible potential of trenchless methods to redefine the future of infrastructure in the Rocky Mountain Region and beyond.

Sincerely,

Stephanie Nix-Thomas

North American Society
of Trenchless Technology
Rocky Mountain Region

MESSAGE FROM THE NASTT CHAIR

Matthew Wallin, PE, NASTT Chair

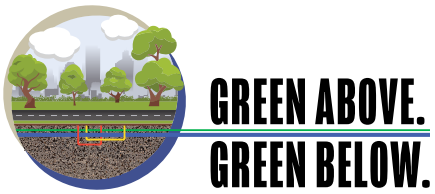
Trenchless Elevated 2023 Heads to Golden, CO!

Hello Rocky Mountain Chapter Members and Associates! Earlier this year we held the NASTT 2023 No-Dig Show in Portland, Oregon, which was a great success and a wonderful opportunity to see our industry friends and colleagues while we celebrated all things trenchless. And now we are excited to switch gears and look forward to the many upcoming Regional Chapter conferences this fall, including the annual Rocky Mountain Trenchless Elevated Conference! Trenchless Elevated will be held on October 11 at the Mount Vernon Canyon Club in Golden, CO. The event will include presentations by industry experts discussing trenchless installation and rehabilitation methodologies as well as networking with breakfast, lunch, and refreshment breaks. Public Sector scholarships and limited sponsorships are available. Visit **http://www.rmnastt.org/trenchless-elevated** for more information.

In the coming months we have many additional events planned to bring the underground infrastructure community together. Our ever-popular NASTT Good Practices Courses are being held both virtually and in-person throughout the year. Visit **www.nastt.org/training/events** to find a course that fits your schedule.

We are also already planning for the 2024 No-Dig Show which meets in Providence, Rhode Island next April.

> "Our industry is a steward of our precious natural resources.



Providence is a great central location within the heavily populated northeast corridor, just a short drive from Boston, and within reasonable drive from Philadelphia, New York City, Hartford, and many other cities in between. Our Show motto is ***Green Above, Green Below*** and it is important that our industry is a steward of our precious natural resources, so we welcome the opportunity to provide a forum for learning about the latest in innovative trenchless products and services that help us all accomplish that lofty goal. Learn more about all the No-Dig Show has to offer at **www.nodigshow.com**.

If you have attended an NASTT event (national or regional) you probably left feeling excited and eager to get more involved. I ask that you consider getting engaged in one of the many NASTT committees that focus on a wide variety of topics. Some of our committees that are always looking for fresh ideas and new members are the Training and Publications Committee, the individual topic Good Practices Course Sub-Committees, the Educational Fund Auction Committee, the No-Dig Show and No-Dig North Planning Committees and Technical Program Committees. There are many opportunities for you to consider where your professional expertise can be put to use through networking with other motivated volunteers. With education as our goal and a strong drive to provide valuable, accessible learning tools to our community, we are proud of our continued growth as both an organization and as an industry. Our volunteers and committee members are what keep us moving in the right direction.

For more information on our organization, committees, and member benefits, visit our website at nastt.org and please feel free to contact us at **info@nastt.org**.

We look forward to seeing you at a regional or national conference or training event soon! And we hope you are planning to join us in Golden for Trenchless Elevated 2023, October 11.

Matthew Wallin, PE

NASTT Chair

2023-2024 RMNASTT EXECUTIVE COMMITTEE

Stephanie Nix-Thomas, P.E. - *Chair*

Stephanie Nix-Thomas joined the family business in January of 2000. In 2002, she and her brother, Jon Nix purchased the business from their parents and two years later, they completed the first pilot tube microtunneling project in the State of Utah.

In 2005, they made the decision to focus their general contracting company on trenchless methods of construction. In the same year, they won recognition from NASTT for pioneering pilot tube pipe ramming on the commuter rail project in Utah. Over the years they have gained expertise in not only pilot tube microtunneling, but also tunnel bore, auger bore, pipe ramming, pipe bursting and any combination of methods. They have made choosing the 'right horse for the course' a resource for construction projects and for assisting engineers with trenchless designs.

At the inception of the Rocky Mountain Chapter of NASTT, Nix Construction established Utah's first group of participants. Stephanie was involved from the beginning and organized two one-day 'Training Days' in 2015 and 2016. In the fall of 2016, she led the organization of the first regional chapter conference on the west side of the Rockies and has led or helped with conferences in Utah and Colorado since. Currently, Stephanie is the Regional Chair of the Rocky Mountain Chapter and a member of the national board of NASTT.

Stephanie earned her degree in civil and environmental engineering with a business minor from Utah State University in 1984. She worked as a consultant engineer in Salt Lake City for seven years before moving to the State Department of Environmental Quality where she worked in water quality as an environmental engineer. In 1992 she moved to the policy office of DEQ as a liaison with small businesses and Native American tribes.

Benny Siljenberg – *Immediate Past Chair*

Benny Siljenberg's 20 years of progressive engineering experience with tunnel, trenchless, geotechnical and construction projects has been gained by providing responsive service to owner's, contractor's, and prime engineers. This diverse teaming experience along with his business acumen allows Benny to view project risks and impacts from beginning to end and consider each individual aspect's while crafting a plan to reach the desired goals. In 2015 Benny co-founded Lithos Engineering to bring a thorough understanding of the geotechnical and construction risks for the communities he serves. Benny's welcoming and cheerful attitude adds fun to project teams that benefit from his critically objective viewpoints.

Chris Knott – *Chair Elect*

For over 30 years, Chris Knott has shaped civil utilities construction, rising from laborer to auger bore crew operator, supervisor, overseeing diverse trenchless methods, project management and estimating roles. At BT Construction, Inc. since 2005, he was pivotal in the creation of BTrenchless, Inc., the company's trenchless division. Now, the *Director of Trenchless Estimating*, Chris endorses BTrenchless as the premier tunneling contractor, excelling in Pipe Ramming, Auger Boring, Pilot Tube, TBM, Microtunnels, Hand Tunneling and Slip Lining.

Chris assists engineers and owners, advising optimal trenchless methods across varied soil conditions, sharing insights and presentations at educational institutions such as the Colorado School of Mines and the University of Colorado-Boulder.

With his 20 years coaching lacrosse, Chris carries championship-level enthusiasm to his work. He orchestrated the first Rocky Mountain NASTT No-Dig in 2010 and remains active on the local board and Director on the national level, organizing events, such as the Program and Auction Committee for the National show. Chris fuels trenchless industry growth and NASTT memberships - channeling expertise and energy, both in and out of the field.

Rebecca Brock – *Treasurer*

Becky Brock is the president and owner of Brock Geo-Consulting, which she established in 2019. Becky has over 25 years of experience specializing in geo-engineering, geo-hazards, trenchless and tunneling design, and tunnel inspections. Becky has a BS in Civil Engineering and MS in Geological Engineering and is a registered Professional Engineer in Colorado and California. Her experience includes projects located within complex geological sites affected by collapsible and expansive soils, soft ground, running ground, and mixed face conditions. For trenchless and tunnel projects she provides geological evaluation and design, development of contract drawings and specifications, construction management, assistance with differing site condition claims, and litigation support.

Additionally, Becky is an adjunct professor at the Colorado School of Mines in the Geological Engineering Department teaching senior and graduate-level courses. As a member of the RMNASTT executive board she is working to grow the Chapter's goal of promoting trenchless technology education in the Rocky Mountain region.

2023-2024 RMNASTT EXECUTIVE COMMITTEE

Kyle Friedman – *Secretary*

Kyle Friedman is an Associate Project Engineer for Brierley Associates out of the Denver, Colorado office. Kyle has been in the trenchless industry for 7 years and has had an impactful presence within the trenchless community including one award as part of the project team for best small project of the year by Engineering News Record for the Empire State Trail Box Tunnel and one award for Construction Management Team Member of the year for the Bismarck Airport. Kyle's true skills come as being a knowledgeable, hands-on field project manager working with owners and contractors.

Kyle has worked on trenchless installations around the country within a variety of ground conditions and installation methods and has witnessed over 15,000 linear feet of trenchless installations. Committed to furthering the use and teachings of trenchless technologies, Kyle has continued to be an active member of the Rocky Mountain Society for Trenchless Technology since 2019.

2023-2024 RMNASTT BOARD OF DIRECTORS

Chair – Stephanie Nix-Thomas, P.E.
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Trenchless Elevated 2023

Rocky Mountain Chapter North American Society for Trenchless Technology - RMNASTT

13th Annual Regional Conference

Wednesday, October 11, 2023 | 7:30 am – 5:00 pm | Mount Vernon Canyon Club, Golden, CO

Come to scenic Golden CO and learn about the latest in trenchless technology from experts in the field. Registration for the conference includes an informative one-day technical program and industry exhibits. All of the benefits of a national conference in a smaller environment!

Conference Information

Who should attend?

Owners, utilities, municipalities, as well as engineers, contractors, manufacturers, suppliers, and students involved in the repair and replacement of underground infrastructure.

Why should I attend?

- NETWORK with underground construction professionals in the Rocky Mountain region
- LEARN about the practical and cost-saving benefits of trenchless technology
- EXPLORE trenchless exhibits showcasing new construction and rehabilitation products/services

Technical Program & Industry Exhibits

About RMNASTT:

RMNASTT is a non-profit organization formed in 2009 to serve as a regional chapter of NASTT (North American Society for Trenchless Technology). The Rocky Mountain Chapter promotes education and implementation of trenchless technology throughout Colorado, Kansas, Montana, Nebraska, North Dakota, South Dakota, Utah and Wyoming. The Chapter's goal is to increase education and awareness of trenchless technologies for pipeline rehabilitation and new construction applications. The RMNASTT annual conference is a valuable educational and networking event for public officials, engineers, utility company personnel, designers, consultants and contractors who are involved or interested in the construction, rehabilitation, and management of underground utilities.

Trenchless Elevated

RMNASTT 13th Annual Conference
Rocky Mountain Chapter
North American Society for Trenchless Technology

Wednesday, October 11, 2023 | Mount Vernon Canyon Club, Golden, CO

Conference Events Schedule			Time
Registration and Breakfast			7:30 - 8:30 am
Introduction and Welcome		Sean Sundermann, CEG, Conference Chair	8:30 - 8:40 am
Presentations		**Speakers**	
Session 1	Moderator: Sean Sundermann		Time
1.0	Platinum Sponsor Intro	Aegion Corporation	8:40 - 8:45
1.1	Light at the End of the Tunnel	Chris Larson, C&L Water Solutions	8:45 - 9:10
1.2	Avoiding the Hazards - Trenchless Installations at Columbine Country Club and Littleton Golf and Tennis Club	Sarah Myers, Lithos Engineering Garrick Thompson, Denver Water	9:10 - 9:35
1.3	Mitigating Risks at WWTPs During CIPP Installation	Steven Meyer, Bowen Collins & Associates	9:35 - 10:00
Break 10:00 - 10:20 in Exhibit Area			
Session 2	Moderator: Josh Shackelford		Time
2.0	Platinum Sponsor Intro	Brierley Associates	10:20 - 10:25
2.1	Rapid small diameter directional tunneling using simultaneous pilot bore and pipe-in-pipe concept	Mike Mooney, Colorado School of Mines	10:25 - 10:50
2.2	Emergency replacement of an aging damaged water main using HDD	Kurt Breitenbucher, Brierley Associates	10:50 - 11:15
2.3	Linestops- a Less Disruptive Way to Isolate Water Lines	Rick Fell, Jacobs Engineering Andrea Long, Aurora Water	11:15 - 11:40
Vendor Area Visit			11:40 - 12:00
Lunch 12:00 - 1:00 in main area, Presented by Platinum Sponsor Lithos Engineering			
Panel Roundtable: Identifying Schedule Delays from Design Through Construction			1:00 - 1:45
Session 3	Moderator: Kyle Friedman		Time
3.0	Platinum Sponsor Intro	HOBAS	1:45 - 1:50
3.1	Trenchless installations and 3D as-built requirements and examples of what is provided by utility company contractors	Rob Martindale, Colorado Department of Transportation	1:50 - 2:15
3.2	Getting Hammered at 8,500 ft	Erin Evans, Btrenchless Greg Steed, Merrick & Company	2:15 - 2:40
Break 2:40 - 3:05 in Exhibit Area			
Session 4	Moderator: Becky Brock		Time
4.0	Platinum Sponsor Intro	Btrenchless	3:05 - 3:10
4.1	Lessons learned for thrust blocks on trenchless installations	Ryan O'Connell, Kilduff Underground Engineering	3:10 - 3:35
4.2	Bay Park Forcemain Project with Alternative Delivery	Carl Pitzer, Thompson Pipe Group	3:35 - 4:00
4.3	RMNASTT 2023 Projects of the year	**New Installation:** Mtn Green GBM Hammer **Rehabilitation:** Casper North Platte Sanitary Sewer Interceptor Rehabilitation	4:00 - 4:15
4.4	Owner's Project Look Ahead	Denver Water, Thornton Water Aurora Water + Others	4:15 - 4:35
RMNASTT Conference Wrap Up		Stephanie Nix (RMNASTT Chairman)	4:35 - 4:45
Social Hour in Exhibit Area and Outdoor Deck Presented by Platinum Sponsor Claude H. Nix Construction			

Navigating a 30-inch Hammer through 8-inch River Rock:

A Utah Historic Winter Case Study

By: John Beckos, P.E., BTrenchless

Project Introduction

The Mountain Green Sewer Improvement District in Mountain Green, Utah is expanding sewer service for the town and the new private ski area Wasatch Peaks Resort (WPR). This required a new 12-inch sewer line installation from WPR to town with the most direct alignment crossing underneath UDOT's interstate I-84, a pair of Union Pacific Railroad (UPRR) lines and the Weber River. BTrenchless began discussing the trenchless portion of the project with Whitaker Construction, the general contractor, mid-2022. The final design called for installation of 382-feet of 24-inch minimum diameter casing at a 0.19 percent slope crossing from North to South with a receiving pit in the to be-diverted Weber River. Upon completion of the trenchless casing installation, an additional 60-feet of casing would be installed across the Weber River and concrete encased. Following that, a 12-inch PVC sanitary sewer line would be installed through the casing on centered casing spacers.

ABOUT THE AUTHOR:

***John Beckos, P.E.**, is a Senior Project Manager and Estimator for BTrenchless. Since becoming a part of BT in 2013, he has been involved in a wide range of trenchless underground projects, encompassing various aspects of the work, including: Auger Bores, Guided Bores, Hand Tunnels, Pipe Ramming, McLaughlin Boring, Microtunneling, TBM's, Pipe Bursting, Slip Lining, and Horizontal Directional Drilling.*

Although the project site is located just 38 miles from the Salt Lake City Airport, the weather conditions onsite can be quite different at 4,915 FT above sea level near the town of Mountain Green. A typical winter in Mountain Green sees an average of 73-inches of snowfall, but when the winter in Utah was winding down in April of 2023 the snow water equivalent readings in the Weber-Ogden River Basin was at 208 percent of normal. That equates to much, much more snow than an average winter!

Progressive Pricing and Budgeting Effort

Our estimating team worked with the general contractor, Whitaker Construction, on a variety of options to establish some baseline pricing concepts throughout the summer and fall of 2022. We proposed the following options: a standard 24-inch guided auger bore, a 30-inch guided hammer bore, and some combination concepts that also included adding a 42-inch hammer underneath the UPRR tracks. The 42-inch concept would only be used should the entire bore length of 382 feet

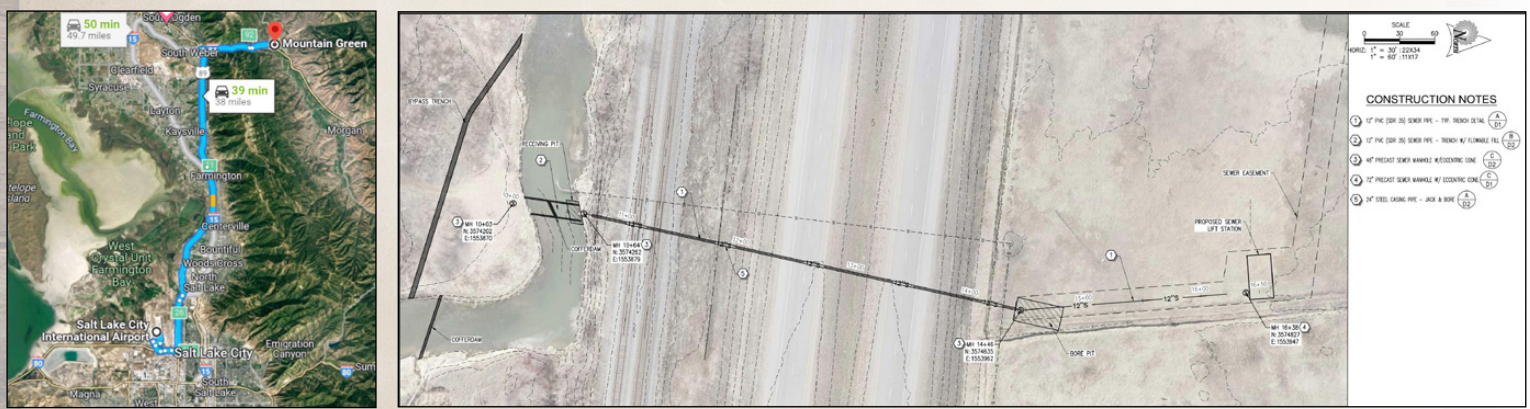

Figure 1. 30-inch GBM-Hammer location in Mountain Green, UT and eventual bore alignment

prove to be impossible. That section under the UPRR tracks could be constructed from the river back towards the 30-inch casing should advancement cease after the initial 282-foot effort past the I-84 highway. Keep in mind these initial concepts were all priced prior to soils information being provided to BTrenchless.

Soils Information and Final Proposal

Dewatering wells were installed in late November 2022 with BTrenchless staff onsite to witness the vertical auger spoils and see firsthand the non-cohesive river rock with cobbles ranging in size from 6 to 8 inches that would be encountered in the bore alignment. With ground water starting approximately 6 feet below grade, and a bore alignment 20 to 25 feet below grade at UPRR's and UDOT's critical infrastructure, a Guided Pipe Ramming method was selected as the best method for the bore.

The decision was then made to increase the casing size to 30-inch to handle the larger cobbles and to use a TriHawk V head at the front of the pilot tube to navigate the in-situ material. The 0.19 percent grade-critical slope required an initial pilot tube installation with very little room for error. Our estimating and construction teams were very concerned about the chances of completing the pilot tube so an attempt fee was negotiated and included in the final schedule of values in the contract. Should the pilot tube attempt be unsuccessful, at least the construction team would be paid for their efforts and a new plan could be developed at that point.

The site logistics on this project allowed for a pre-determined hold point at the 282-foot mark. If advancement of the pilot tube or the 30-inch casing could not be completed past that point and successfully pushed past the UPRR tracks, the option was in place to dig a rescue pit between the tracks and the I-84 interstate. In this situation, the team could have opted to setup in the rescue pit and continue 30-inch installation from there or setup on the south side and bore back to the rescue pit with 42-inch casing. Fortunately, this rescue pit was never required on the project as is shown in the markups on the final design profile with some key bore elements noted (see Figure 5).

Bid #	Bid Date	Description	Qty	UOM
1	7/15/2022	GBM/Auger Bore - 24" Casing under I-84 and UPRR Tracks	382	LF
2	7/21/2022	GBM Hammer Bore - 36" Casing under I-84 and UPRR Tracks	382	LF
3	7/29/2022	GBM/Auger Bore - 30" Steel Casing Under I-84	282	LF
		Hammer Bore - 42" Casing Under UPRR Track	100	LF
		Final Footage	***382***	***LF***
4A	11/23/2022	GBM Hammer Bore - 30" Casing Under I-84	282	LF
		GBM Hammer Bore - 30" Casing Under UPRR (24 Hour Shifts)	100	LF
		Total Footage	***382***	***LF***
4B	11/23/2022	GBM/Auger Bore - 30" Steel Casing Under I-84	282	LF
		Hammer Bore - 42" Casing Under UPRR Track (24 Hour Shifts)	100	LF
		Total Footage	***382***	***LF***

Figure 2. Pricing and Proposal Concepts provided throughout summer and fall 2022

Figure 3. Soils pulled out in the planned bore alignment indicated 6 to 8-inch smooth rock with little cohesion

Bid #	Bid Date	Description	Qty	UOM
Final	1/10/2023	GBM Hammer Bore - 30" Casing Under I-84	282	LF
		GBM Hammer Bore - 30" Casing Under UPRR (24 Hour Shifts)	100	LF
		Total Footage	***382***	***LF***
Option	1/10/2023	Pilot Rod Attempt Fee	1	LS

Figure 4. Final schedule of values for the trenchless portion of the work

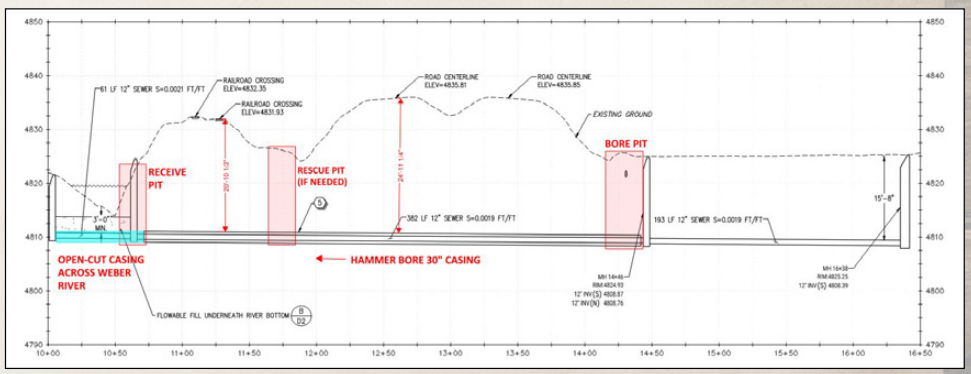

Figure 5. Bore Profile with key elements called out

Construction – Phase 1 – Site Setup and Pilot Tube Installation

Final pricing efforts and contract negotiations in late December 2022 and early January 2023 got us to the final schedule of values, which included the following items:

1. GBM Hammer Bore of 30-inch Casing Under I-84 (282LF),
2. GBM Hammer Bore of 30-inch Casing Under the UPRR (100LF) and a Pilot Rod Attempt Fee.

While these final contract negotiations were taking place, the construction team stayed busy. Whitaker Construction spent all of December and the first few days of January 2023 getting the bore and receive pits ready for the start of trenchless construction. This involved relocating the Weber River through a temporary bypass trench and initial installation of 14 dewatering wells with well points located around both bore and receive pits as well as along the alignment (between east and westbound I-84 and on both sides of the UPRR tracks).

While Utah skiers and snowboarders were enjoying the snowiest winter on record at nearby Snowbasin ski area, BTrenchless crews got to work onsite, mobilizing to the site on January 16, 2023, just 6 days after our final proposal was approved. Pilot tube installation took place from January 19 – 27. This critical first step to establish our designed grade of the bore was not without challenges. Progress on the pilot tube ceased at the 160-feet mark; approximately 42 percent across the 382-foot alignment. The rods were pulled back to the bore pit and the Trihawk bit was evaluated, seen to be worn down near smooth, and replaced.

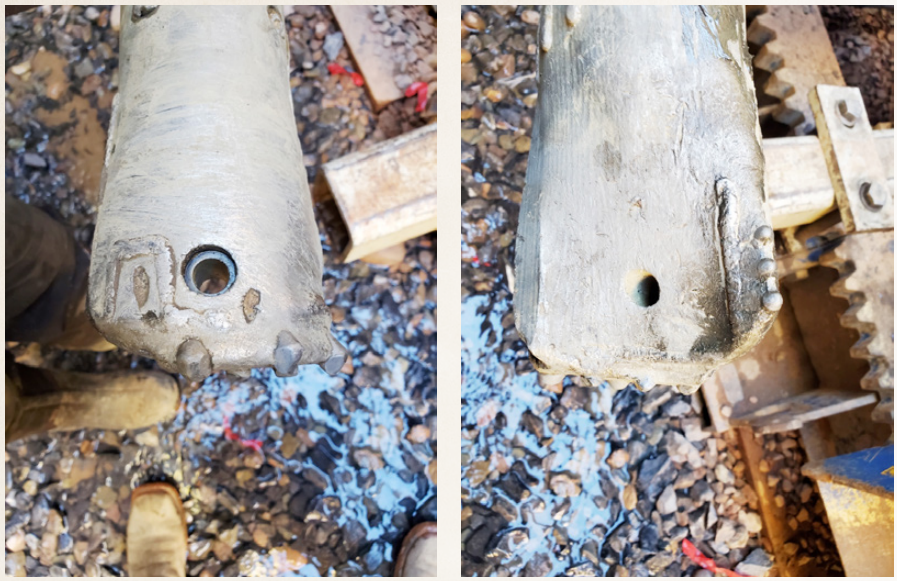

Figure 6B. The Trihawk IV bit following the first 160 feet of installation

With a new Tri-Hawk bit on the end of the pilot rods, we were able to get our pilot rod back through the initial 160LF path and push all the way across the 382LF alignment with bit number two. At this point the construction team celebrated the completion of a huge milestone, accomplishing an on-line, and on-grade 382-foot installation of the pilot tube through some of the most aggressive river rock we had seen in recent memory. At this point the hard part seemed to be over, the pilot tube was across! Little did we know that the most challenging parts of the job were still ahead. Potential foreshadowing notwithstanding, extremely cold temperatures at the end of January (-16 degrees F) would shut the project down for 2 days.

Construction – Phase 2 – Sacrificial Rod Installation

On this project BTrenchless chose to push out the threaded pilot tubes with a 4.5-inch OD extra heavy wall steel sacrificial rod. This was done for two reasons:

1. Removes the chances of a 2.5-FT pilot tube section uncoupling/unthreading itself from the next one somewhere along the 382-foot string during the pipe ramming operation.

Figure 6A. The brand new Trihawk IV bit prior to the start of the bore

2. Protects the threaded pilot tube threads from wear and tear on such a long pipe ramming effort.

This turned out to be one of the more challenging aspects of the project. A combination of the squeezing effect of the cobbles, combined with the porous nature of the cobble in the ground preventing the extensive dewatering system from ever truly drawing the water table down in the alignment, made the advancement of the sacrificial rod extremely challenging. After some trial and error, the decision to place a lubrication port at the lead sacrificial rod combined with spinning the rods with an auger bore machine turned out to be the winning solution. Work on the sacrificial rod installation took place from February 1 – 13.

Figure 7. The 4.5-inch to 30-inch step-up adapter just prior to the start of pipe ramming

Construction – Phase 3 – 30-inch Casing Pipe Ramming Install

The next step involved increasing our 4.5-inch sacrificial rod to the 30-inch diameter final casing. With our step-up adapter and lubrication system in place, pipe ramming began on February 20 with the crew working 6-day weeks through Saturday March 4. This got our 30-inch casing completed up to the 260-foot mark, in other words just one pipe joint short of the pre-determined hold point before we began crossing underneath the UPRR property. There were 3 weather days lost to mother nature during that first 68 percent of the installation. With the 30-inch casing advancement at the edge of UPRR's Zone A, it presented a great opportunity to clean-out the casing before transitioning into 24/7 operations. For readers unfamiliar with the UPRR Zone A requirements, the railroad has a permitted

Figure 8. Soil and ground water encountered during pipe ramming operations

excavation zone that begins 15 feet, 6 inches from the centerline of the nearest track and extends at a 1:2 slope away from the track. Trenchless work within this permitted zone must be performed continuously (i.e. 24 hours a day) to reduce the chances of settlement around the lead piece of casing.

With the casing cleaned out to within 50 feet of the lead piece to maintain a soil plug, pipe ramming continued from the 260 to 382-foot mark with two crews working continuous shifts from March 5 - 9. The UPRR Zone-A continuous working requirements meant that the crews could not shut down at any time during the three winter blizzards that would occur during those 24/7 shift.

On the morning of March 9, the final 10-foot piece of casing was welded on and hammered into place. Immediately following completion of the pipe ramming effort, the crew removed our equipment from the receive pit to allow Whitaker Construction to install the open-cut casing across the diverted Weber River. While the 12-inch carrier pipe was being installed through the casing, placement of the concrete encasement through the Weber River channel was taking place. A few days later, warming temperatures indicated that spring was on the horizon and the river diversion was no longer capable of holding back the start of the spring run-off.

> "The weather conditions can be quite different at 4,915 FT above sea level.

Fortunately, the casing was across the river and the concrete encasement was cured. Just in time!

The following project statistics represent the trenchless portion of the work:

- Start Date – January 16th, 2023
- Finish Date – March 17th, 2023
- Bore Details – 382LF of 30-inch diameter x 0.750-inch wall casing with 12-inch PVC carrier pipe
- Method utilized – Guided Pipe Ramming

BTrenchless wants to thank all parties involved on this project including: our talented Trenchless crews, Whitaker Construction, Sunrise Engineering, Union Pacific Railroad and RailPros, Utah Department of Transportation, and the Mountain Green Sewer Improvement District.

Figure 9. Some of the harshest winter conditions our crews have ever been asked to work through were witnessed on this project

APRIL 14-18 | PROVIDENCE, RI

NO-DIG SHOW 2024

GREEN ABOVE.
GREEN BELOW.

THE NASTT 2024 NO-DIG SHOW MUNICIPAL & PUBLIC UTILITY

Scholarship Program

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Preserving Casper's Infrastructure:

A Large Diameter Pipeline Trenchless Rehabilitation Project

By: Leanne Goodhue, Insituform Technologies, LLC

This case study delves into the successful execution of a large diameter pipeline rehabilitation project in Casper, Wyoming, a region with few large-scale projects. With a focus on overcoming challenges and adopting innovative solutions, this project preserved and enhanced the City's aging wastewater infrastructure for an additional 50+ years.

Background of the North Platte Interceptor

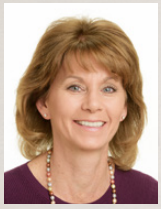
(Background provided by Mark Wade, PE, BlueWater Solutions Group)

The City of Casper owns nine miles of sanitary sewer trunk lines known as the North Platte Sanitary Sewer Interceptor (NPSSI). The interceptor was initially constructed in four phases between 1980 and 1983 as part of a wastewater regionalization effort in the Casper metropolitan service area. The pipe material for the interceptor was unlined reinforced concrete pipe (RCP). Due to slower-than-expected growth rates in the past 40 years, the NPSSI remained (and still remains) oversized for current and projected flows. Consequently, daily wastewater flow rates through the NPSSI caused lower than anticipated velocities, resulting in elevated levels of hydrogen sulfide (H2S) in both the ambient air space and below the water surface within the NPSSI. The H2S and associated sulfuric acid formation became problematic along the entire interceptor alignment, causing serious deterioration of the NPSSI.

Although various corrosion control strategies and limited rehabilitation had been performed, a significant portion of the NPSSI needed immediate rehabilitation. The team of CEPI, BlueWater, and Jacobs had a long history in the assessment and development of solutions to extend the life of the NPSSI, dating back to 2008, when the team began a series of strategic meetings to develop a two-part condition assessment of the entire NPSSI alignment. The initial assessment included detailed inspections of all 155 manholes and large portions of the interceptor at these access locations using remote top-side digital technologies and tools. Based on the initial inspection, the engineering team prioritized the interceptor segments for the more detailed end-to-end CCTV inspections. By using CCTV equipment designed specifically for large-diameter pipelines, the team selected the highest priority pipe segments (approximately 25 percent of the NPSSI), to advance the assessment to the second phase of assessment. Following this second phase of inspection and assessment which involved the measurement of wall loss and the development of a risk-based model to determine scores for both likelihood and consequence of potential and sudden failures over the next twenty years. The engineering team completed a condition assessment report in 2012.

Full scale pilot testing of corrosion control chemicals was performed in 2012 and 2013. It was cost effective at the time and it deferred renovations to critical sections for several years. It also provided time and allowed the ability to adopt a capital improvement strategy versus reactive emergency repairs approach. With this strategy in place, the Engineers continued to evaluate the highest-priority pipelines that required immediate replacement and/or rehabilitation. Next, rehabilitation methods were evaluated to determine the best-fit solutions for what would become a complex project. The project engineering team identified key project issues based on their insights from the earliest discussions, designed a project, met strategic goals, found multiple sources of funding, and released a bid package in February 2022, with Sliplining and CIPP rehabilitation pricing options to find the best contractor/technology to begin construction in Summer, 2022.

ABOUT THE AUTHOR:



***Leanne Goodhue** is the Business Development Manager for Insituform Technologies covering CO, WY, MT, NM. She has been with the company for 10 years.*

North Platte Interceptor Project Scope Overview

> The State of Wyoming does not take breaks from cold weather.

-5F Installation and -30F Cure Evening - cold snowy weather extended CIPP cure times

Project Description

Project scope consisted of (6,675 LF) 48-inch and (885 LF) 54-inch RCP interceptor pipe rehabilitation along with point repairs, (24) 72 and 84-inch doghouse manhole construction (depths of 8 to 16 feet), abandonment of (15) manholes, epoxy lining of (10) existing manholes, and rehabilitation of (2) siphon inlet and outlet structures. Proposing contractors were allowed the option to bid and construct the pipe rehabilitation project with either Cured-In-Place Pipe lining (CIPP) or sliplining methods. The project bid in March 2022, with completion scheduled for April 2023.

Insituform proposed the CIPP method, was awarded the project, and immediately assembled the project management team and subcontractors to develop the critical path scheduling that would be required for this type of scope. Upon initial conversations with the consulting engineer, Mark Wade of Blue Water Group, the largest challenges would be winter weather, the volume of debris inside the pipe and the erosion of the RCP pipe down to the rebar ribbing making man entry unsafe.

The 48-inch and 54-inch CIPP was broken into two phases for bypass

Interior Image 27-inch Dia Pipe Through 48-inch Dia Pipe Manhole Structure

pumping to create efficiencies for the participating subcontractors, and to strategically place a break in the work activities during expected colder periods of weather. It was soon discovered the State of Wyoming does not take breaks from cold weather nor windy conditions during the wintertime. Phase two in Dec 2022/ Jan 2023 had most daily temperatures near or below zero, which seriously impacted CCTV Cleaning and CIPP lining. On one CIPP installation morning the high temperature was -5F and the low that evening while the liner was steam curing was -30F.
Mark Wade did a fantastic job providing inspection services from the inside of his heated truck!

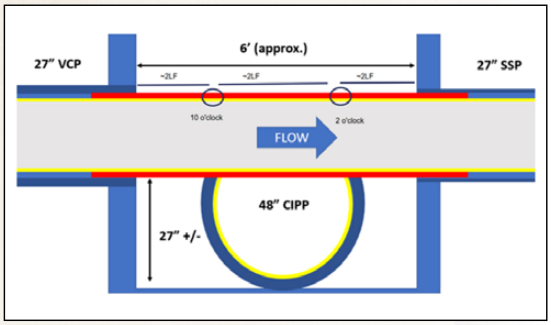
Value Engineering

Prior to the aforementioned cold weather, new manhole/vault construction and abandonment originally planned at the design stage was evaluated by the entire team. The goal was to maximize CIPP installation lengths using heavy hauler refrigerated trucks with added axles and overweight permits, cut down on bypass time, and reduce the quantity of new doghouse manhole construction. The cost savings based on this approach allowed the City to rehabilitate more sections of pipe without increasing the cost of the contract.

Also, as part of the original project analysis, the City and project team decided to eliminate the Lidar mapping assessment offering a cost savings of over $100K back to the City. Results from the third-party mapping vendor would have taken up to 60 days to get the assessment back to the team – much too long with expensive bypass pumping. Since an average of 12 to 18 inches of debris was inside the pipes, it had to be removed first before proper assessment anyway. It was already known the interior conditions of the RCP pipe was severely compromised, having lost one-half of its wall thickness with erosion down to the ribs. Insituform could design the correct CIPP thicknesses to accommodate the existing ID conditions of the host pipe and meet the fully deteriorated design requirement. The City agreed, and the team got to work performing one of the anticipated difficulties before the project started – removal of the debris. With bypass pumping running 24 hours a day, the CCTV cleaning company who under normal conditions, would be working several pipe segments ahead of CIPP, but with all the debris, CIPP lining quickly caught up to cleaning activities, so an additional cleaning crew was added, and debris removal became a 24-hour operation. Insituform's CCTV camera van and manpower was also dedicated to the cause to hasten the cleaning process. Progress finally happened and the project was back on the planned schedule.

Innovations and Unique Applications Due to Unknown Circumstances

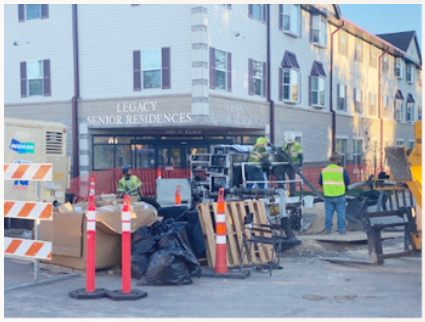
Innovation 1: CCTV cleaning and televising discovered a diameter change inside the pipe from 48 to 54 inches approximately 20 LF upstream between MH 140 and MH 150. Rather than installing a new structure where the diameter transition occurred, Insituform designed, manufactured, and installed a transitional CIPP liner to span the diameter change. The CIPP with a thickness of 22.5 mm was installed from the 48-inch diameter end. Insituform manufactured a thickness/ diameter transition and increased the CIPP liner thickness by adding 6.0mm for the last 70 LF (22.5 to 28.5mm) to manage the strength required for the 54-inch diameter.



Insituform Engineering Schematic for Utility Conflict

Innovation 2: A Utility conflict was found inside MH 25 with a 27=inch stainless steel pipe installed through the middle of the vault structure leaving only 30 inches clearance, which was not enough access to install the 48-inch diameter CIPP material. Insituform engineered a creative solution to rehabilitate both sewer lines to keep them in service. The 27-inch diameter pipe was temporarily taken out of service with bypass pumping tied into the existing bypass set up. This provided the required room to install the 48-inch diameter CIPP segment. Insituform's internal applications engineer ran a calculation for the 27-inch diameter CIPP and found no issue with spanning the 6-foot vault structure. Deadload designs were approved, as well. The 27-inch diameter pipe was tied back together after the 48-inch diameter CIPP installation using fittings and then CIPP was installed through the 27-inch pipe section. Historically, the 27-inch diameter pipe had periods of maximum capacity flows, so the Insituform engineer recommended cutting two circular openings at two locations of the spanned pipe at the 10 o'clock and 2 o'clock positions. The purpose of the four openings was to allow overflow to run from the 27-inch diameter pipe into the vault when needed and get picked up by the 48-inch diameter sewer line. The excavation contractor poured concrete into the bottom of the structure to provide additional structural integrity, the structure was spraylined and put back into full service once bypass was shut down.

> City officials were greatly impressed and an article about the project was published in the local newspaper.



Excavation & CIPP Installation at Legacy Senior Residences

Experienced crew overcame extremely cold weather completing the job

Other Challenges Encountered

1. **Legacy Senior Residences:** One intersection location required excavation and CIPP installation 10 feet from the front door of the Legacy Senior Residences. Keeping the public safe from the work activities was challenging because the residents were very curious about the work. Insituform's CIPP crew took the time to talk with a resident about the process and why it is done. The resident was so impressed she purchased Subway sandwiches to give to the crew as a way of saying thanks for their hard work. Word of the crew's efforts made its way to City officials who were greatly impressed and an article about the project was published in the local newspaper.
2. **Extremely Cold/Snowy Weather:** Extended CIPP cure times. Very hard on workers and equipment.
3. **Siphon Structure Rehabilitation:** Removal/replacement of slide gates, concrete, spraylining, and access to site.
4. **Public Safety:** Some sections of pipe were in locations of residential, commercial and parks and recreational areas. Working around closures of streets for public events was carefully planned to keep the public safe. Notifications to stakeholders occurred early in the project and throughout the duration of the project to keep everyone well informed.
5. **Change Orders:** Internal timing to approve change orders would have been costly to everyone. 19 change orders were approved and bundled into 6 formal change orders, using a combination of debit COs and credit COs to keep the total overall cost of the 6 change orders below a certain financial threshold. This allowed for faster approval to keep the project moving and keep to the overall schedule.

Conclusion

Despite weather, time involved for value engineering, and all the site challenges encountered, Insituform Technologies delivered the project to the City of Casper with only one time extension (due to winter asphalt paving conditions) The total cost of the project finished approximately $10,000 below the original contracted amount.

The Casper North Platte Interceptor Project exemplifies the successful execution of a critical infrastructure initiative. This comprehensive project demonstrates the importance of understanding the history of a system, collaboration by all stakeholders, careful planning, and executing innovative technologies, to achieve an outcome beyond expectation.

Combining Light-Cured CIPP Technologies to Complete Otherwise Infeasible Sewer Rehabilitation beneath Denver International Airport

By: Christopher Larson, C&L Water Solutions Inc.

INTRODUCTION

Denver International Airport (DEN) has maintained its distinction as one of the world's top 20 busiest airports year after year. Its layout is designed to safely and efficiently support continuous airport operations above, below and at the surface.

Its primary buildings are the Jeppesen Terminal and three midfield concourses, A, B and C (Figure 1). The concourses are spaced far apart from each other to permit safe, smooth taxiing of commercial airliners to and from the concourses 179 gates amid speeding airport maintenance vehicles and baggage tugs.

Pedestrians can take a skyway to get from the terminal to Concourse A high above the surface traffic, or they can take the underground Automated Guideway Transit System (AGTS train). Concourses B and C are accessible solely by the train. The train runs continuously between the Main Terminal and the three Concourses with five-minute stops at each, its route dissecting the layout of the concourses through the middle, dividing each into west gate and east gate wings.

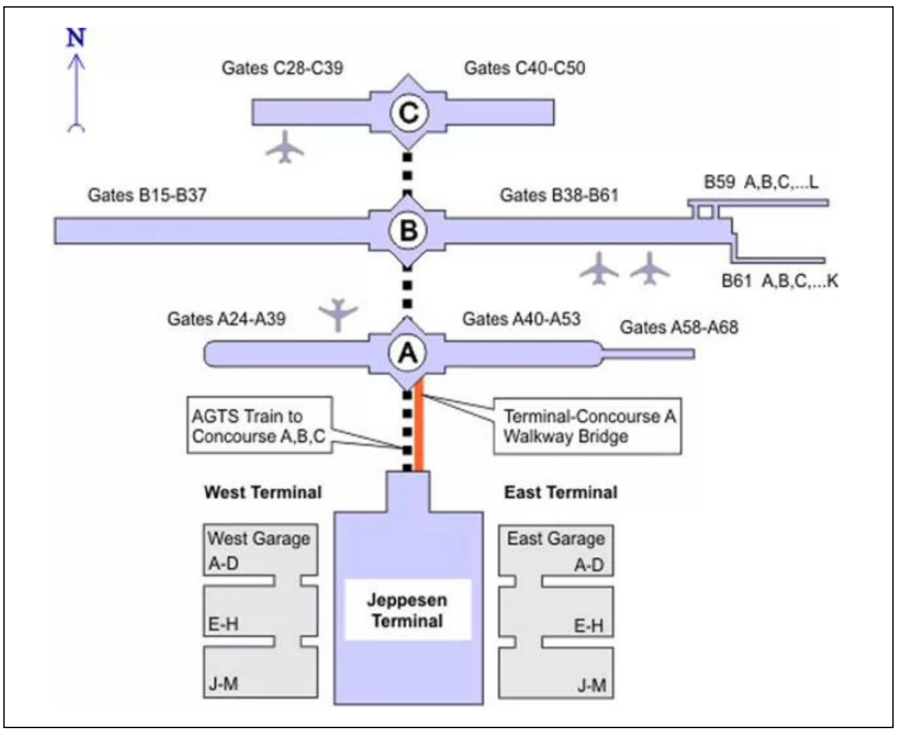


Figure 1. KDEN Terminal and Concourse Reference

> "The project appeared to be impossible until the team discovered an alternative light-cured CIPP system.

Maintenance and repair of drainage pipes beneath the DEN facilities cannot be allowed to obstruct airport activities. Cured-in-place-pipe (CIPP) renovation methods provide an ideal solution, minimizing any impact on the environment and activities beyond the small workspace required for their application.

In 2012, DEN undertook a renovation project on 400 linear feet of sewer pipe beneath the Jeppesen Terminal. C&L Water Solutions Inc. of Denver, the contractor performing the renovation, successfully demonstrated the additional advantages of using CIPP system whose styrene-free, vinyl ester resin is cured by ultraviolet light (UV-CIPP) rather than air, hot water or steam. Having no odor and no toxic fumes, and a much shorter project time that other CIPP technologies, it was ideal for use within the busy DEN environment with its crowds of travelers and airport personnel.

The contractor efficiently and effectively rehabilitated all 400 linear feet of cast iron pipe, restoring it to full use and capacity (Figure 2).

Figure 2. Installation Crew Uses Its UV-Light Cured CIPP System in the 2012 Job to Perform High-Quality CIPP Pipe Lining Installations from Excavation to Excavation in Slab-on-Grade

Ten years later, DEN contracted C&L Water Solutions to use the same technique for rehabilitating 5400 linear feet of failing cast iron drainage pipe beneath Concourses A, B and C. However, the contractor's team discovered great portions of the project were not compatible with their UV-CIPP system due to access and working space limitations. The project appeared to be impossible until the team discovered an alternative light-cured CIPP system based on a narrow band of "blue" light. Although the length of runs it can complete are shorter than the UV-CIPP system, using it in combination with the UV-CIPP technology allowed the contractor to complete an "impossible" project. The following case study of the 2022 DEN pipe renovation project presents lessons in how best the two light-cured CIPP systems might be used together.

Case Study: 2022 Rehabilitation Of Remaining Drainage Pipes

The baggage tugs with their luggage carts in tow travel to and from each airliner on the surface through three sets of underground tunnels that run beneath the concourses and the AGTS train. Airport maintenance vehicles also use these same underground driveways.

The concrete surfaces of these routes must be kept dry during rain and snow events. The drainage system that has served this purpose since the airport's construction comprises cast iron sewer pipes 6 inches and 12 inches in diameter. It is designed to return water that finds its way underground back to the surface and direct it away from all traffic and runway areas.

The cast iron sewer pipes were no longer functioning as designed and needed replacement or rehabilitation. Replacement, however, was not an option since the pipes lay beneath the concrete of the underground baggage tug driveways. The pipes had been installed before the concrete was laid over them more than 30 years ago, blocking access to the pipe for nearly its entire route. The job was therefore bid for CIPP pipe rehabilitation.

Only odorless materials safe for use in an enclosed human environment could be used since the airport ventilation system was connected to the underground space. Vehicles or machinery that required gasoline or diesel fuel were prohibited. Only hand tools and propane-powered or electrically powered equipment were allowed.

The plan initially was to cut accesses into the slab-on-grade concrete tug driveways. UV-CIPP lining operations would then be conducted from excavation to excavation without significant impact on airport activities in the underground tunnels. The project team, however, discovered that about 80 percent of the project's 5400 linear feet of pipe lay beneath prestressed concrete panels, precast slabs resting on cement caps under pressure. Cutting into prestressed panels bears the potential for sudden, violent, catastrophic failure posing a risk of injury similar to an explosion.

The only other way to access the pipes was through their cleanouts. Many of the cleanouts, however, had been destroyed due to corrosion and movement of the surrounding soil over the years.

The crew discovered a maintenance level below the tug tunnels, enabling them to access the pipe from narrow recesses along the side (Figure 3). This required manually moving equipment to the recesses, where they burrowed to the pipe, excavating soil by hand.

Fortunately, the soil, which had been disturbed during original tunnel construction, was mostly protected from compaction by the floating prestressed panels. In many places, they could shift the dirt by hand over and aside from the hanging

Figure 3. A Maintenance Level below the Tug Tunnels, Enabling Project Crews to Access the Pipe from Narrow Recesses along the Side

pipe, clearing a narrow crawlway to work from, although headspace in some places was as small as 18 inches. This gave the crew little room around the hanging pipe to move themselves and their equipment.

The UV-CIPP rehabilitation equipment could not be used in such restrictive locations, rendering nearly four-fifths of the total linear footage unlineable by the system the contractor had used so effectively in the earlier, 2012 project beneath the terminal. The contractor needed to find a more flexible CIPP system. It must have at least the same advantages of the UV-CIPP system yet be well suited for use in the highly confined work environment of this project, as well as navigate the cleanouts and previously undocumented bends in the pipe path that the crew discovered as work progressed.

Bluelight Led-Cipp System

The contractor chose the Bluelight LED-cured CIPP system by U.S.-based HammerHead Trenchless Equipment.

The LED-CIPP and UV-CIPP systems are similar in that both utilize odorless, styrene-free resins whose cure is initiated by light.

UV-CIPP resins are activated by a low-intensity light in the 100 to 400 nanometer (nm) range. This range of light is often referred to as "ultraviolet radiation" instead of light, since it is not visible to the human eye.

The curing of LED-CIPP resins is activated by a much narrower range of wavelength, 444 to 457 nm. Light in this range of the spectrum is visible to the unaided human eye and is perceived as blue, giving the system its trademarked name. Since blue light is more intense, higher energy radiation, it penetrates resins more deeply and more thoroughly, allowing faster, higher quality curing.

While UV-CIPP liners use heavier, more robust materials to resist stretching, distortion and damage while being drawn into place by a winch, the LED-CIPP liners are lighter weight and more flexible. They do not require fiberglass reinforcement or a layer of reflective foil to enhance light penetration. The blue light emitted from a 360-degree LED head penetrates wet-out liners reliably and consistently on its own.

The lighter weight, flexible liners also mean no winch is needed for pullback. Equipment is light, portable and easily maneuverable at the jobsite. In addition to a liner inversion drum and nozzle, a Bluelight installation crew needs only an LED head and cable plus a control panel with monitor for the automated pullback (Figure 4).

Figure 4. Equipment Specific to a Bluelight-CIPP Installation

Figure 5. Cleaning Pipes Progressed as Little as 1 Foot Over Several Hours with a Low-Powered Jetter

LED-CIPP liners are "blown in" using a small air compressor set to about 10-12 psi. The air pressure sends the liner gently over fixtures, past offsets, through bends and around sweeping corners, pressing the resin side of the liner uniformly against pipe walls for good fit and adherence during the brief curing time. The LED light proceeds down that pipe at an automated, controlled pace ensuring optimal curing time based on size of the pipe and type of resin used.

Despite their lighter weight, a properly installed Bluelight-CIPP liner creates a composite pipe meeting ASTM F1216 standards. In addition, the system also permits CIPP installation with a smaller crew, making it even further suited for use in confined workspaces.

For these reasons, the LED-CIPP system was an ideal solution for CIPP rehabilitation of pipe in the tight workspaces beneath the prestressed concrete panels, complementing its UV-CIPP capabilities. C&L assigned a three-person LED-CIPP crew to all cleanout installations on 6-inch-diameter pipe beneath the prestressed

Figure 6. Yet Another Challenge to Overcome: Hand Tunneling to the Cleanouts While Ensuring Ventilation and Worker Safety in the Confined Spaces

panels, averaging 100-foot runs between them. The contractor designated a five-person UV-CIPP crews to lining 12-inch pipe and longer, straighter runs of 6-inch pipe that averaged 450 to 500 feet in length, from one slab-on-grade excavation to another.

Planning The Work, Working The Plan

The cleaning and preparation of the pipe for lining operations took eight months. The pipe-cleaning subcontractor cleaned pipes as they became accessible using only a low-power jetter that met the worksite's equipment restrictions. At times, rate of progress was reduced to as little as one foot over a period of several hours (Figure 5).

The crew rigged a vacuum to a wheelbarrow to assist in removing jetted water and evacuated sediment and scale.

While the cleaning sub's team worked ahead on pipes as they could access them, the CIPP crew hand-tunneled their way to the cleanouts. They restored the cleanouts and made point repairs on damaged and collapsed sections of the pipe (Figure 6).

One electrical breaker was designated for the installation crew's use underground. The array of equipment on hand meant they needed to make their own power distribution unit (PDU) to accommodate the various needs of their tools: the 120 V LED, 220 V appliances (such as the air compressor), and 400 V outlet for their European UV-CIPP machine (Figure 7). Power cords from the power unit were safely barricaded along one side of the underground tunnel and moved from location to location as required.

Rehearsing Cleanout Inversions Prior To Onsite Shots

While UV installations were seamlessly performed from excavation to excavation without having to overlap each other, the LED-CIPP inversions would feature a positive overlap requiring a smooth seam. Determining the best approach to this was one thing, but to perform it on the job while getting it right the first and every time was another. The crew made use of HammerHead University's instructors and facilities and to select and then perfect the technique they would use.

Figure 7. C&L Needed to Make Its Own Power Distribution Unit (PDU) to Accommodate Various Tool Requirements

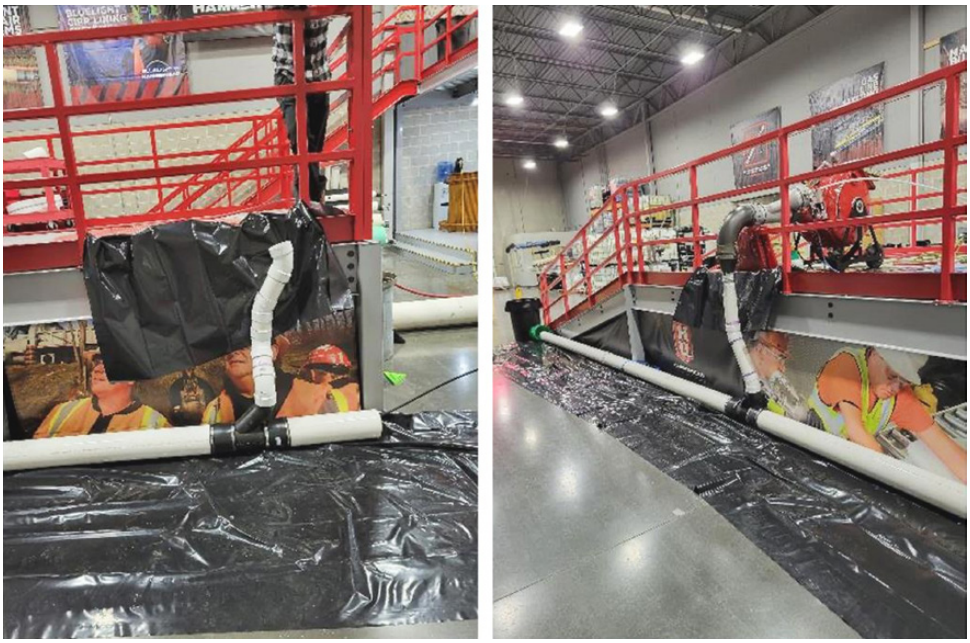


Figure 8. Rehearsing LED-CIPP Inversions in the Manufacturer's Learning Facility Ensures Success on Location

> "The system also permits CIPP installation with a smaller crew, making it even further suited for use in confined workspaces.

Classroom instruction and hands-on training were conducted in a two-story, 5,000 square-foot facility at HammerHead's Lake Mills, Wisconsin, headquarters. This provided a distraction-free, low-risk environment to rehearse the application on a mockup exactly mimicking the project's jobsite conditions and requirements using the same 6-inch iron pipe, cleanouts and fittings, with the same angles as the job at DEN (Figure 8). They determined the specific procedure for achieving the best bonding and smoothest transitions at cleanout overlaps.

A few tweaks were made to the overlapping installation process in the first two attempts. After five successful installations on the mockup, the crew returned to DEN confident in their ability using this technique.

Application Process Back In Denver

The crew chose to start the installation from the lowest point in the line, which was a discharge station on west side. Water collected from the drainage system was pumped to runway level to a gravity line that led the discharged water away from airport operations.

Each successive liner was inverted just past the end of the previously cured liner as the project progressed up the pipe. To make a seamless transition at each overlap, the crew left the last few feet of liner dry. After curing the liner, they used a Picote Miller with SmartCutter tool to cut the excess dry section of liner away, then smooth the seam, leaving each overlap free of "speed bumps."

Conclusion

The combined use of UV-CIPP and LED-CIPP systems on this job, assigning each to a portion of the job it was best suited for, enabled this installation contractor to give its customer the most desirable results on a project that initially appeared infeasible, if not impossible, to complete.

Physical work on the project took roughly 18 months to complete, beginning spring 2021 and ending October 2022. The contractor returned 5400 linear feet of failing cast iron drainage pipe to use at its full rated capacity. UV-CIPP accounted for approximately 2200 feet of the project in 6 inch and 12 inch pipe. LED-CIPP was used to rehabilitate 3200 linear feet of 6 inch pipe.

ABOUT THE AUTHOR:

Chris Larson *currently serves C&L as its Chief Operations Officer. Business development expertise is one of Christopher's strongest attributes. Since his graduation from the University of Denver in 2007, Christopher began launching the UV cured in place pipe movement in the predominately-felt driven CIPP pipelining marketplace. With determination, he enabled C&L to become one of the largest UV cured in place pipeline contractors in the United States as of 2022 with more than 1,000,000 feet installed to date. Chris has served as the chair and past chair on the Board of Directors of the North American Society for Trenchless Technology – Rocky Mountain Chapter (RMNASTT).*

New Installation in Cobbles and Boulders below Sensitive Wetland

New Trenchless Method Overcomes Project Hurdles in Record Time

By: Richard Revolinsky, Geonex Inc, (GEO)

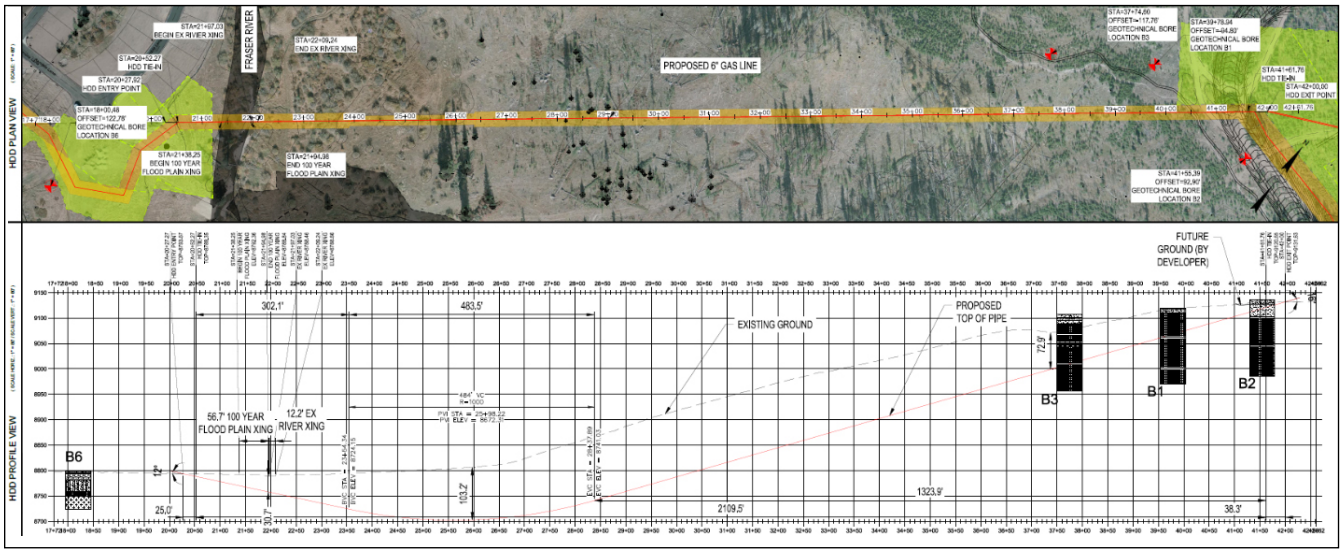
To meet the needs of rapidly growing resort communities in Colorado, two existing natural gas pipelines required interconnection with a new 1.5 mile 6-inch, high pressure line. In July 2021, Blackeagle Energy Services of Berthoud CO was contacted by their client to construct the interconnection, which needed to be complete by winter 2021. "Residential construction growth in Colorado is occurring at breakneck speed, faster that most gas companies can keep up." Said Erik Hepker, Field Services Manager for Blackeagle. "This would normally be a 2 - 3 year project for design and construction. In July 2021 design was not finalized. It would be design as you go and were up to the task." In addition to only having 4 months to complete the project, several other challenges made this new installation even more complex. Traversing hiking and biking trails, a 600-foot elevation change in the 1.5 miles, survey, clearing, material procurement, soil investigations, and coordination with Army Corps of Engineers, the installation, testing and putting the line into service by October 2021. Adding further difficulty, the proposed path included crossing the Fraser River at a Fen Wetland, a crossing which saw 9 design reiterations before being finalized.

A Fen Wetland is a peat-forming wetland that relies on groundwater input and requires thousands of years to develop. The ecological functions of fen wetlands cannot be easily restored once disturbed, thus, selecting techniques with minimal disturbance was paramount consideration when choosing the methods for crossing the fen. Installation of conductor casings is a common technique in directional drilling when encountering gravel and cobbles at the entry pit. Conductor casing provides a mechanism to mitigate inadvertent returns and maintain good flushing of the bore hole. Setting drilling operations back from the fen wetland prevented surface damage, but to prevent subsurface damage the need to protect the wetland from inadvertent returns from below also had to be considered.

Soil borings along the proposed path revealed a cobble layer about 50 feet deep before hitting bedrock. Drilling would need to go 240 feet at a 12-degree entry angle before hitting bedrock at a 12-degree entry angle. Utilizing the GEONEX™ downhole hammer boring system allowed trenchless contractor NewTech Drilling of Nebraska City NE to install the conductor casing twice as long as traditional hammer boring methods would allow. Installing 300 feet of conductor casing provided NewTech with the ability to get through the cobbles and boulders and established into bedrock. This approach provided significant benefits to the 2,200 LF HDD installation by mitigating inadvertent

> "The need to protect the wetland from inadvertent returns had to be considered.

System does not require the use of drilling fluids



Proposed 2,200 LF HDD path included crossing the Fraser River at a Fen Wetland

returns as well as being able to avoid having to steer the HDD through the cobbles and boulders. Once into the bedrock NewTech would drill another 50 feet in elevation before beginning to steer upward to hit an exit angle of 16 degrees at El. 9,131, nearly 2,200 LF away.

Blackeagle selected NewTech Drilling of Nebraska City, NE to perform the trenchless works. "We have done a lot of work for Blackeagle, in some really challenging conditions." said NewTech's president Brandon Olson, they trusted our expertise and opinion in selecting the best approach." Olson had been researching GEONEX™ for a while. "We really struggled on a project in Steamboat Springs a few years ago, and I knew there had to be a better way to deal with cobbles and boulders. I found GEONEX™ online, spoke with them and believed their technology was the answer."

Geonex allowed the contractor to install the conductor casing twice as long as traditional hammer boring methods

Down the Hole (DTH) Horizontal Hammer Boring was selected as the best method to install the 300 feet of 24-inch conductor casing

NewTech met with Blackeagle and the pipeline owner to discuss using GEONEX™. "The project schedule was too tight to wait for a new Geonex system to arrive from Finland where GEONEX™ manufactures their equipment, but they were great to work with. They (GEONEX™) helped coordinate a rental and technician with one of their clients in Minnesota." said Olson. To install the 300 feet of 24-inch conductor casing, the GEONEX down-the-hole (DTH) Horizontal Hammer Boring (HHB) solution presented the best opportunity for success.

The GEONEX™ system is an umbilical system consisting of 3 main components, a drill machine, hydraulic power pack, and air compressors. The drill machine which provides rotation for auger and the means of conveying air to the downhole hammer at the face of the steel casing is placed in the launch pit. The Hydraulic power pack sits on grade and provides power to the rotary system and other hydraulic components, air flow regulation, and the brains for wireless remote control. Air compressors to meet the air requirements of the downhole hammer were placed on site and connected via hosing to the powerpack. The GEONEX™ Down-The-Hole horizontal boring system does not require the use of drilling fluids, which further served as benefit to mitigate impacts to the fen wetland.

"While coordinating and planning for the drill, we were installing the 6-inch gas main on either side of the bore path," said Hepker, "so we were really counting on the crossing going well. There was no margin for error." The GEONEX™ HZR610 was adjusted via independent hydraulic legs to meet the desired 12 degree entry angle.

System consists of 3 main components, a drill machine, hydraulic power pack, and air compressors

Because the downhole hammer and auger string would be removed to accommodate the HDD drilling components, the lead section of casing was fitted with an integrated ring bit to prevent the ring bit from becoming an obstruction once the hammer is removed. The process of installing 300 LF of 24-inch casing through the 50-foot thick layer of cobbles and boulders and terminating in bedrock took approximately 2 days to complete.

Upon completion of installing the conductor casing and retraction of the auger and hammer, air and hydraulic hoses between the GEONEX drilling unit and the powerpack were removed and the drill machine pulled from the launch pit. Next, a 16-inch steel casing with centralizing legs was slid inside the conductor casing to aid in centering the HDD tooling. NewTech utilized their Vermeer D330x500 accompanied by a 14-inch bit with centralized mud-motor for the 2,200 LF pilot drill. "We used a wireline for steering." said Olson. "You can't get a reading until you're out of the casing because of magnetics. The 24-inch casing was within ½ degree vertically and 2 inches horizontally from target, so we

Desired 12 degree entry angle was met by adjusting independent hydraulic legs

Drilling needed to go 240 feet through cobbles before hitting bedrock

were very pleased with how the GEONEX™ system performed, and it gave us a great start to our drill."

NewTech completed their 2200 LF pilot drill in 6 days, on target and keeping the project moving at the pace it needed to achieve schedule. After pulling back the 6-inch steel gas main, Blackeagle quickly wrapped up the tie-ins, completing testing and putting the line into service before the first snow falls.

"We were really proud of the work" said Hepker referring to the project team. "We have a few more projects coming up which we plan on utilizing the GEONEX system." After the project, NewTech, purchased the first of now three GEONEX™ systems in their fleet. "I was really impressed by how the GEONEX™ system performed. We now have the capabilities to go from 5-1/2-inch casings up to 32 inches with our equipment. We have both power packs, the HZR 610, HZR400 and our HZR220 should be here soon. I don't expect to see these machines in our yard too often."

ABOUT THE AUTHOR:

***Richard Revolinsky** is the North American Operations Manager for Geonex Inc. He has served the trenchless industry for the past 10 years in various roles as Project Manager for Auger Boring and HDD projects and material sales. He is committed to furthering the Trenchless Construction industry with viable innovative solutions.*

Safeguarding Fragile Ecosystems Using HDD in Environmentally Sensitive Areas

By: Shrey Arora, P.E. & Dennis M. Walsh, P.E., Kilduff Underground Engineering

Horizontal Directional Drilling (HDD) has emerged as a viable solution for installing underground infrastructure projects in environmentally sensitive areas. With a growing focus on maintaining our infrastructure and preserving and protecting delicate ecosystems, traditional excavation methods can be impractical and pose significant environmental risks, including soil erosion, habitat destruction, and water contamination. In response to these concerns, HDD offers an innovative approach that minimizes the environmental footprint while effectively installing pipelines, cables, and other underground structures. This article explores the significance of HDD projects in environmentally sensitive areas, highlighting their benefits, potential environmental challenges, and the importance of adopting sustainable practices to ensure the preservation of these fragile ecosystems.

HDD is a trenchless technology that involves drilling a borehole from the surface horizontally underground, allowing for infrastructure installation without requiring extensive excavation. This method is particularly valuable in environmentally sensitive areas, such as wetlands, wildlife habitats, or protected landscapes, where the disturbance caused by traditional open-cut methods could have far-reaching ecological consequences. By utilizing HDD, construction activities can be conducted with minimal disruption to the surface environment, reducing the risk of soil erosion, loss of vegetation, and disturbance to wildlife populations.

One of the significant advantages of HDD in environmentally sensitive areas is its ability to minimize the impact on water bodies. Traditional methods often require crossing rivers, streams, or lakes, resulting in sedimentation, alteration of water flow patterns, and potential contamination. In contrast, HDD allows for the installation of pipelines or utility lines beneath water bodies, preserving the integrity of aquatic ecosystems and safeguarding water quality. This method significantly reduces the risk of disturbing sensitive

HDD offers an innovative approach that minimizes the environmental footprint

> HDD significantly reduces the risk of disturbing sensitive aquatic habitats.

aquatic habitats, protecting the diverse species that rely on these environments for survival.

However, despite the numerous benefits, HDD projects in environmentally sensitive areas also pose unique challenges that must be carefully addressed. One such concern is the potential for inadvertent fluid return (IFR). These fluids, usually consisting of bentonite and water, are used to lubricate and cool the drilling process and transport the drilled material to the mud pit at the drill location. They can also contain additives and chemicals that may be harmful to the environment if released. Therefore, stringent containment and management practices must be implemented during drilling operations to prevent any accidental spills or leaks. Additionally, drilling waste disposal, including cuttings and fluids, should adhere to strict guidelines to avoid the contamination of nearby ecosystems.

Adopting a comprehensive approach that encompasses effective environmental impact assessments, rigorous regulatory frameworks, and robust monitoring and mitigation measures is crucial to ensure the success and sustainability of HDD projects in environmentally sensitive areas. Engaging with environmental experts and

HDD can effectively protect delicate ecosystems while meeting societal and infrastructure needs

stakeholders throughout the planning and implementation stages can help identify potential risks and develop appropriate strategies to minimize adverse effects. Furthermore, ongoing monitoring and regular inspections during and after project completion can provide valuable data on the effectiveness of mitigation measures and inform future practices.

During the design phase, multiple factors are considered to minimize the potential for IFR. First and foremost, a thorough site investigation is carried out to understand the subsurface geology, including the presence of aquifers, faults, and other sensitive

HDD has emerged as a viable utility installation method in environmentally sensitive areas

formations. This information helps identify the "path of least resistance" or potential pathways for fluid migration and assess the risk of IFR. Based on the geotechnical information, designers perform an iterative hydrofracture analysis using the Delft Equations to arrive at an optimized HDD borepath with the least IFR risk.

Projects today require an "Inadvertent Fluid (Frac Out) Release Contingency Plan" as part of the contractual document. The plan is a comprehensive strategy designed to address and mitigate potential spills or leaks of drilling fluids or other hazardous substances during the drilling process. It outlines the necessary actions and procedures to promptly respond to and manage such incidents, minimizing their impact and ensuring a swift and effective response.

The plan is a collaborative effort between multiple design leads on a project and should encompass the following key objectives:

- The plan should provide a detailed overview of the HDD process, specifically focusing on drilling fluids' composition, management, and utilization. By understanding the characteristics and properties of the fluids involved, appropriate measures can be implemented to prevent and control inadvertent releases. A Safety Data Sheet (SDS) information for all proposed drilling fluid should be provided.
- The plan must identify a range of controls to be implemented during construction to minimize the potential for IFR. These controls may include the use of appropriate drilling techniques, regular equipment maintenance and inspections, proper training for personnel involved in the drilling process, and adherence to industry best practices and regulatory requirements.
- To facilitate early detection of inadvertent fluid releases, the plan should outline planned means of monitoring. This may involve the use of real-time monitoring systems, visual inspections, pressure monitoring, and other appropriate techniques to identify and respond to any potential releases promptly. Monitoring the mud flow/circulation and the drilling head pressure will also minimize the possibility of IFR.
- Contingency plans should address the step-by-step procedure in the event of an IFR. On past jobs with our staff, we had to establish communication protocols with several water companies downriver so that if we did have an IFR, they would immediately take steps to minimize the impact on its operations. This was an essential requirement of the permit issued by the Army Corp of Engineering and the state's Department of Environmental Protection.
- Bore abandonment may be considered necessary when exhaustive measures to control IR within the current directional bore have been unsuccessful. The plan will encompass specific criteria used to assess the requirement for drill hole abandonment, along with a comprehensive strategy for sealing the drill hole if the decision to abandon is made.
- The plan must identify ways to protect environmentally sensitive areas, such as rivers, wetlands, biological resources, and cultural sites. This may involve implementing buffer zones, utilizing containment measures, employing sediment control practices, and adhering to specific guidelines for working in proximity to these sensitive areas.
- Prior to, during, and following drilling and pipe installation activities, site-specific environmental protection measures are established to minimize and control erosion and sediment releases into adjoining wetlands or watercourses. This may include implementing soil erosion sediment control measures, sedimentation ponds, and the proper disposal of excavated material.
- At the start of construction, all field crews establish and understand site-specific preplanned general response programs. These programs ensure that personnel can take immediate action in the event of an inadvertent release of drilling fluid. Clear protocols and communication channels are established to enable an efficient and coordinated response. All required training by the government agencies and the client should be completed. Some companies will require daily checklists to be completed, ensuring all safety steps are taken, the equipment is maintained, and all staff on site are trained.
- As previously stated, establishing a Chain of Command for Reporting and Notifying is critical. Pre-job drills should be run to ensure all staff are prepared in the unlikely event of an incident affecting the environment. Daily safety tailgates should reinforce those safety and environmental protection requirements. In the event of an IFR, the plan must establish a transparent chain of command for reporting and notifying the construction management team, Certificate Holders, and relevant authorities promptly. This ensures that all necessary parties are promptly informed and that the preplanned actions can be implemented swiftly and effectively.

In closing, HDD projects offer a promising solution for developing infrastructure in environmentally sensitive areas. By minimizing surface disturbance, reducing the impact on water bodies, and employing responsible drilling practices, HDD can effectively protect

Careful design and construction measures can help alleviate Inadvertent Fluid Return concerns

> HDD is particularly valuable in environmentally sensitive areas.

delicate ecosystems while meeting our societal and infrastructure needs. However, it is essential to recognize and address the unique challenges associated with such projects, including the proper containment and disposal of drilling fluids and waste. Through careful planning, stringent regulations, and continuous monitoring, we can strike a balance between development and environmental preservation, ensuring the sustainable coexistence of infrastructure and sensitive ecosystems. Finally, regardless of the design and other efforts, one can expect an HDD project in an environmentally sensitive area to take years of effort and will be met by environmental resistance. Enlisting the capabilities of a good design firm with a strong permitting staff and a professional trenchless contractor will provide the best opportunity to overcome the resistance and yield a successful outcome.

ABOUT THE AUTHORS:

***Shrey Arora, P.E.**, has been with Kilduff Underground Engineering since 2017, supporting their underground tunneling and trenchless projects with a multitude of design services. He received his undergraduate degree from India and a master's in Underground Construction and Tunneling from Colorado School of Mines.*

***Dennis M. Walsh, P.E.**, has been in the utility industry for over 40 years and involved in trenchless technology since 1990. Dennis is a 1972 graduate of the University of Dayton, Ohio with a B.S. in Civil Engineering and a 2002 graduate of the Polytechnic University of New York with a M.S. in Technology. He retired from KeySpan Energy Company in 2005 after a 28-year career in the gas utility field with a background in engineering, operations, construction, Quality Assurance, and HVAC.*

Impacts of HDD Design Modifications after Municipal Bid Award

By: Matthew Olson and Lance Heyer, Lithos Engineering

Introduction

There is an increased importance for the engineer to design an HDD project in a well thought out and constructible way when using DBB project deliveries in comparison to alternatively delivered projects. When there are constructability concerns with a design put out under the design, bid, build (DBB) project delivery method, significant negative consequences related to schedule, cost, quality, or third-party impacts often result. One strategy to combat this is utilizing design services from engineers who specifically focus on trenchless or HDD designs.

Another strategy adopted by some engineers is to require the contractor's HDD engineer to review the HDD design and sign off on the feasibility of constructing the design with the contractor's planned means and methods. Benefits of this approach include:

1. The contractor thinks through challenging aspects of the project, develops risk mitigation strategies, and clearly articulates their means and methods.
2. The contractor's HDD engineer performs design calculations based on the contractor's preferred means and methods.
3. It encourages collaboration between the contractor and the contractor's HDD engineer regarding risk and mitigation strategies.
4. It allows for the contractor to understand the means and methods assumptions used by the design engineer during the design process.
5. It serves as an additional check on constructability of the original design.

Although this strategy presents some benefit to the project, it should not be used as a substitute for engaging qualified engineering personnel to complete a proper HDD design, nor to shift risk to the contractor. Sufficient resources should be deployed in the design phase of a DBB project to ensure a constructible design and allow for a clear understanding of the contract requirements, a competitive bidding environment, and limited complications during construction. Although contractors can identify constructability issues associated with designs after the project has been advertised, there often is not sufficient time for a contractor to completely review the engineering of advertised projects prior to completing and submitting their bid. Furthermore, many contractors must bring in an HDD engineer as a subcontractor to satisfy submittal requirements or to modify an HDD design. It is the authors' opinion that it is unreasonable to ask the contractor to review the project documents, consider constructability and their anticipated means and methods, estimate the cost of the project, and fully review the engineering design between advertisement and the bid due date.

In a DBB project it is the job of the trenchless engineer to fully understand the project goals and risks, work the problems, find solutions, and draft contract documents that clearly describe the work. Alternative delivery models are better project approaches if the contractor is to supply the solution to design challenges. Hiring a contractor as a consultant during the design phase of a DBB is also not an effective way to gain contractor input to development of solutions as the contractor is often conflicted out from being able to bid the project. However, soliciting unpaid advice from contractors during the design phase is common and can provide benefit to the project.

> "The Owner's Engineer has a duty to produce a design that is constructible, economical, and does not pose undue risk to the public or third parties.

Changes may be proposed for an HDD project either as a value add or based out of necessity due to constructability concerns. Changes to an HDD alignment/profile may be proposed prior to or after bid award. There are often disincentives to proposing changes prior to bid award since disclosing means and methods efficiencies or other contractor strategies might diminish a contractor's advantage over competition. Further, although contractor involvement during design does provide benefits to an HDD project, a contractor's hesitancy to release trade secrets and discuss construction efficiencies can limit the benefit of contractor involvement during the design phase of DBB projects. What happens when changes are proposed to HDD designs post bid award?

Lithos interviewed 12 trenchless professionals (contractors, municipalities, engineers, and academia), reviewed relevant industry papers, and called on our own experience to answer this question. The following paragraphs provide case history examples and specific interview questions providing insight to the effect of changes to HDD designs post award of DBB contracts.

Case History Number One

The first case history included a value engineering (VE) change. The goal of this project was to install an 8-inch diameter raw waterline along an approximately 5,000-foot-long alignment with an elevation differential of 200 feet. The alignment traversed through a 20- to 40-foot easement with significant old tree growth that was encroached upon by several of the adjacent homeowners. The Owner was interested in a construction solution that would be economical, have an acceptable risk profile, and minimize impact to third parties. Lithos believed HDD would be a reasonable solution to achieve the Owner's goals. The Owner hired Lithos to investigate the subsurface conditions, prepare a geotechnical investigation report, perform an HDD design, and provide bidding and construction phase services. The HDD design included alignment selection, drawings, specifications, and calculations of estimated pull forces, short-term and long-term pipe loading and stresses, and inadvertent drilling fluid return (IR) factors of safety.

The alignment was divided into two individual HDD segments to minimize risk of IR, maintain lower installation pipe stresses, reduce difficulties with mud management, and increase the likelihood that the lowest bidder could successfully complete the work. One segment was approximately 2,600 feet and the other segment approximately 1,100 feet. The rest of the alignment would be completed with open cut, direct bury construction. After award of the construction contract, the Contractor provided a VE proposal to combine the two HDDs into one longer HDD, approximately 4,100 feet, with some open cut, direct bury pipe sections on either side of the HDD alignment. To accommodate the increased installation loading of a longer, deeper alignment, the proposal included increasing the pipe thickness from an 8-inch DR 11 to a special order 10-inch DR 7.3. The Contractor's proposal was accompanied with revised drawings, pull force and pipe stress calculations, IFR calculations, and other work plan and equipment related submittals. VE engineering was completed by the Contractor's selected Engineer subcontractor.

The Owner evaluated the proposed change with guidance from Lithos. Based on the Contractor's plan to control risk, engineering calculations for IR factor of safety, pull force and pipe stress based on the proposed HDD means and methods, collective HDD experience, and history of being a fair and equitable contractor, Lithos recommended accepting the Contractor's proposed VE change. The Owner accepted the proposal and construction proceeded according to the VE proposal. The pilot bore began on February 6, 2020, and pipe installation was completed on March 13, 2020 (Figure 1).

This VE change post contract award did not result in a significant change to the contract price. Although there was extra money paid due to the increased

Figure 1. Completion of 10-inch HDPE DR 7.3 pipe installation

HDD footage, credits were given back to the Owner for reduced time and materials associated with the open cut connection work that was avoided. Installing a single HDD also streamlined the HDD construction schedule, primarily by eliminating the need to move the HDD equipment spread to a second location. In speaking with the Owner after the project had been completed, the Owner was satisfied with the way the project turned out and was glad the contractor proposed the VE modification. The Owner was able to meet their project goals with a reasonable cost and construction duration. Often, it is good to investigate proposed changes to construction documents post-bid, as long as the proposed changes are carefully reviewed and vetted by a design expert. Considering VE proposals within reason can help ensure good Contractors stay engaged and bid future work for a given municipality or Owner. Although Lithos was pleased the Contractor was able to VE and properly execute the project, Lithos also stands by their decision to put out a design consisting of two lower risk HDD alignments that would achieve project goals such that the design would be more approachable for a greater number of potential bidders.

One difficulty the Owner expressed was that there was not a lot of time available to review the Contractor's VE proposal. Although Lithos performed an in-depth review of the proposal and provided a recommendation for acceptance, the Owner is still left with an important decision that can impact not only themselves, but other project stakeholders. To enable more time for review of proposed changes, Owners and Engineers may want to consider allocating additional time to the project schedule for contractor submittal preparation and Owner and Engineer review. Construction submittals often require modification after the first submittal round. Adding more time for the submittal process can relieve this schedule constriction and may promote quality VE proposals because it will allow the contractor more time to properly vet and document potential VE options.

Case History Number Two

The second case history required design changes due to constructability concerns on a DBB project. The project included installation of a 36-inch HDPE pipe with HDD for transmitting raw water. The contract documents attempted to shift risk to the Contractor regarding the design of the HDD, as well as the risk of encountering unexpected conditions by including various risk shedding disclaimers in the HDD specification. Further, the submittals section of the specification required significant HDD engineering services be provided by the Contractor. In summary, the specification required that the Contractor be responsible for performing a complete design of the proposed HDD and under no circumstances would there be extra payment for adverse conditions. Elsewhere in the contract, measurement and payment language prohibited additional payment in the event of a lengthened HDD alignment.

Lithos was hired as the Contractor's HDD Engineer and upon review of the contract documents significant constructability

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concerns were identified. The Contractor submitted the following changes to HDD alignment as a necessary step to mitigate risk and provide the best possible chance for a successful HDD installation:

1. Lengthen the HDD alignment by 280 feet for a total length of 820 lineal feet.
2. Deepen the bottom tangent six feet to gain additional clearance from existing utilities.
3. Increase the vertical and horizontal bending radii to 1,700 feet such that the HDD alignment transitions are more gradual and the horizontal curve does not start and end as the profile breaks plane with the ground surface. This increased the minimum radius of the compound curve from 666 feet to 1,202 feet.

Due to the risk placed on the Contractor, and in turn Lithos as the Contractor's HDD Engineer, the quoted price for the HDD engineering work not only included cost for the requested design in the submittals but also for acceptance of risk and increased communication between stakeholders. Although costs of engineering submittals are generally low in comparison to scope of an HDD project, Lithos understands the quoted price was not fully accounted for in the Contractor's bid for this project.

The design Lithos produced was ultimately accepted by the Owner/Owner's Engineer with reasonable communication effort and alignment changes. During the reaming phase, the reamer was thought to encounter a stronger formation than originally anticipated, requiring a drill rig with more torque to finish the reaming phase. This resulted in schedule and cost increases. Once the borehole was properly conditioned the pipe was pulled in without complications. Extra payment to accommodate the increase in schedule due to the harder formation encountered and the additional 280 lineal feet of HDD installed pipeline was not provided to the Contractor.

This case history is an example of how the low bid Contractor did not bid the work including costs to re-design the HDD alignment, install an additional length of pipe, obtain additional geotechnical information, and cover the magnitude of construction, and design risks as specified in this contract.

Conclusion

The study presented in this article evaluated the effect of changes to an HDD design post award for DBB contract delivery methods. Changes post-award can be due to constructability issues with the original design, or simply value add changes proposed by the Contractor. Depending on the change, the original design, and project goals and constraints, the effect of the proposed change has on schedule and cost can vary widely. Ensuring the original design is well thought out, constructible, and contains key elements of quality design is especially important for HDD DBB projects where contractor involvement is minimized prior to release of the design and the Owner must award to the lowest responsible bid. The Owner's Engineer has a duty to produce a design that is constructible, economical, and does not pose undue risk to the public or third parties. Including an HDD design specialist as part of the design team can greatly improve constructibilityy of HDD designs.

The Contractor has a duty to fully understand the design prior to bidding. Often, there is a contractual requirement that bid award is contingent on the

Figure 2. Product pipe ready to go as a larger rig is mobilized to the site

Contractor presenting any concerns with the design prior to award. As such, it is recommended that Contractors do their due diligence when reviewing potential work and voice their concerns during the bidding process. Should those concerns fall on deaf ears, the Contractor should include cost to mitigate those concerns if possible or refrain from bidding the project if the concerns pose significant risk to project success, public and crew safety, or third-party impacts. Owners and Owner's Engineers must understand the implications of fair and equitable risk sharing and develop DBB HDD projects with conservatism in mind and a willingness to work with the Contractor, within reason, to achieve project success. If a Contractor is not successful in installing the pipe then the project will not be successful either. The ability of Owners and Owner's Engineers to remain flexible to reasonable Contractor input post-bid is often beneficial to all parties.

Early Contractor involvement is important when a project is complex or has a high-risk profile. If an HDD project has a lot of risk, it may warrant bringing in a specialized HDD designer and/or using an alternative contract delivery method. Although Contractor involvement in design of a DBB HDD contract is beneficial, alternative project delivery mechanisms can allow the Contractor to provide increased input they might otherwise be hesitant to provide if the design were to be be advertised for public low bid.

As the HDD industry continues to evolve so must project delivery methods and risk identification, elimination, mitigation, and appropriation. Knowledgeable HDD professionals exist in the Owner, Engineer, Contractor, and Academic categories. One key to maximizing success on difficult or risky HDD projects is to tap the expertise of each of these professional categories and facilitate communication between all parties to come up with solutions to today's infrastructure challenges.

Matthew Olson *is a professional engineer with experience in a myriad of trenchless technologies. He has valuable experience working from a consultant and contractor's perspective regarding installation techniques that maximize workflow efficiencies and minimize project risk for trenchless operations. Mr. Olson serves on the board of RMNASTT and the student chapter and program committees for NASTT.*

Lance Heyer *has 13 years of experience as a geotechnical and structural engineer, and was one of the four founding members of Lithos Engineering. During his career, he has compiled a diverse skill set that includes expertise primarily related to the geological, geotechnical and geostructural components of heavy-civil projects. Lance takes pride in being a valued member of the project team and bringing expertise to complicated underground projects."*

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