NASTT NORTHEAST REGIONAL CHAPTER

NORTHEAST JOURNAL
OF TRENCHLESS TECHNOLOGY PRACTICES

World Record 36-inch CIPL Gas Main Renewal

NASTT-NE Northeast Trenchless Conference 2017

2018 SPRING EDITION

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MESSAGE FROM NASTT-NE CHAIR

Ian W. Mead, P.E., BCEE, NASTT-NE Chair

Welcome to the spring 2018 edition of the NASTT Northeast Regional Chapter's *Northeast Journal of Trenchless Technology Practices*. Our chapter is very fortunate to be represented by a wide variety of trenchless professionals working on great projects, and many of them are represented in this edition. We encourage you to review the status of research at UMass Lowell, including the efforts of our active and engaged student chapter. We introduce our newly elected Board of Directors and the executive committee; we encourage you all to engage any of the Board members with questions, comments, and suggestions. We are also very excited to announce that our 2018 conference will be held in Mystic, CT, at the Mystic Marriott on Tuesday November 13. There will be a Welcome Reception the evening of Monday November 12 (location TBD).

"WE HAVE FOUND OUR GROOVE."

In this edition we showcase the world record setting achievement by NASTT-NE chapter members Public Service Electric & Gas and Progressive Pipeline Management in successfully lining a 2,000 foot stretch of 36-inch cast iron gas main, the largest diameter gas main renewal ever done using trenchless applications. Congratulations! Other articles in the magazine include an examination of barrier island formation as it relates to trenchless project design, a look at the fundamental importance of project team communication in trenchless construction, and details of a challenging jack and bore project under the Spaulding Turnpike in Rochester NH.

"PLEASE GET INVOLVED."

In addition to these contributions, we are grateful for the generous support of our sponsors and vendors who make this publication possible. When you see them, please take a moment to thank them for their support and learn about their solutions. Most of all, we hope the time you spend reviewing the articles and information in this spring edition will encourage you to get involved in the chapter. In a very short time, we have found our groove, but the continued success of our chapter depends on the commitment of our dedicated volunteers.

Many thanks to our past Chair Dennis Doherty for setting lofty goals from the onset for our chapter, and not letting up as they were achieved. In his new role as past Chair, Dennis will also be engaging the members of our precursor organization, the Northeast Trenchless Association, to ensure that our chapter continues to benefit from the knowledge and expertise of those professionals. Thanks also to our former and current Board of Directors, and to the executive board for all your support. Finally, and most importantly, thanks to all of you, our chapter members, for participating and supporting these initiatives. Please get involved!

Ian W. Mead

Ian W. Mead, P.E., BCEE
Chair, NASTT-NE

NASTT-NE SITE

NASTT NORTHEAST REGIONAL CHAPTER
TM

MESSAGE FROM NASTT CHAIR

Frank Firsching, NASTT Chair

Greetings Northeast Chapter Members!

NASTT's Regional Chapters are the foundation of our Society and our volunteers are the reason for our growth and success. Thank you for being a part of our organization and dedicating your careers to the trenchless industry.

I'd like to start off by congratulating you on a fantastic event held in Cooperstown, NY this past November. By all accounts your regional event was a huge success and the venue was superb. The Northeast Chapter is filled with truly dedicated volunteers that go above and beyond to make your chapter such a stand out group!

2018 is off to a great start and we're ready to hit the show floor at NASTT's 2018 No-Dig Show in Palm Springs, California at the end of the month. This winter has been a cold one in the Northeast region and we're hoping you'll be joining us in sunny and warm Palm Springs for a week of networking, learning and fun!

NASTT exists because of the dedication and support of our volunteers and our 11 regional chapters. There are many Northeast Chapter Members that serve on our No-Dig Show Program Committee and volunteered this past summer to peer-review the 2018 abstracts. These committee members ensure that the technical presentations are up to the standards we are known for: Dennis Doherty, Brian Dorwart, Johnathan Kunay, Gerry Lundquist and Babs Marquis. The Northeast Chapter is also home to some of our Session Leaders. Session Leaders are Program Committee members that have the added responsibility of managing a session of the technical program and working with the authors and presenters to facilitate excellent presentations. I would like to extent a special thank you to the Northeast Chapter Members that also served as Session Leaders: Brian Dorwart, Johnathan Kunay and Babs Marquis.

NASTT is so pleased to have another leader of the Northeast Chapter join the national Board of Directors this year. Babs Marquis of McMillen Jacobs Associates was elected to the NASTT Board of Directors for a six-year term. We are also pleased that Tony Hranicka of Tony Hranicka LLC and Gerry Lundquist of National Grid will continue serving their terms on the board. These fine fellows will help direct the affairs of the Society along with the rest of our board. Welcome, Babs and welcome back, Tony and Gerry! We're looking forward to your insight and leadership and appreciate your volunteer spirits.

The North American Society for Trenchless Technology is a society for trenchless professionals. Our goal is to represent our industry and provide valuable initiatives. To do that, we need the involvement and feedback from our professional peers. If you are interested in more information, please visit our website at nastt.org/membership/volunteer. There you can view our committees and learn more about the many ways to stay involved with the trenchless community and to have your voice heard. Please consider becoming a volunteer – we would love to tap into your knowledge and skills.

NASTT continues to grow because of our Regional Chapter involvement and volunteers. Thank you again for your support of our society and the trenchless technology industry.

Frank Firsching

NASTT Chair

MEMBERSHIP IN NASTT

Molly Margosian, NASTT Membership Coordinator

All in the Family: NASTT is pleased to present new opportunities to join the NASTT Family!

Attention Students! *Available now:* Student Non-Affiliated Membership

NASTT proudly engages 18 official Student Chapters, and now we are branching out to all students throughout North America! The NASTT Student Non-Affiliated Membership ($50 USD per year) is available to any student actively enrolled full-time in a North American university that doesn't currently have an official Student Chapter on campus.

Overseas Opportunities! *Available now:* International Individual Membership

The NASTT International Individual Membership ($250 USD per year) is available to any individual residing outside of North America.

Stay Engaged! *Available now:* Retiree Membership

The NASTT Retiree Membership ($40 USD per year) is open to NASTT members after they retire from the industry.

Now that you're officially in the family, are you getting the most out of your NASTT membership? Taking advantage of all NASTT has to offer? As your membership manager, I'm happy to guide you to resources so that you can fill your trenchless toolbox with up to date industry information, webinars, events, and so much more!

Did you know NASTT has the world's largest online trenchless library, filled with technical papers focusing on a wide variety of trenchless topics? All papers are all available for download to our members compliments of NASTT. We sell industry books too!

Does your organization exhibit at NASTT's No-Dig Show? Members can enjoy discounts on training and registration at our annual No-Dig Show.

Are you hiring or searching for a new position? Being a society member allows you to view and post career opportunities on the job board on nastt.org. This complimentary membership tool houses industry specific jobs and gives members the opportunity to search for potential jobs or post positions that are needing to be filled.

Are you interested in getting to know the next generation of trenchless champions? NASTT also offers membership to students! We are proud of our 18 NASTT Student Chapters and these student members are given the opportunity to attend the No-Dig show and learn about the trenchless world while networking with potential employers. Student chapters fulfill critical roles as not only volunteers at NASTT's No-Dig Show, but are the next generation of trenchless professionals.

Does your NASTT membership also make you a member of your Regional Chapter? Yes! Take the opportunity to work your local network and get involved with your Regional Chapter. Regional Chapters offer trainings and meetings, providing you the chance to expand your regional network. NASTT Regional Chapters encourage community outreach, and are a great tool to expand your knowledgebase and meet other individuals within your industry too!

But wait, there's so much more! NASTT offers a weekly eNewsletter, blog, archived webinars on trenchless topics, and committee and volunteer opportunities for you. Now that you know a little more about the NASTT family, join us! Visit nastt.org and get your membership started today!

Sincerely,

Molly Margosian

NASTT Membership Coordinator

2018 NASTT-NE BOARD

IAN MEAD – CHAIR

Ian Mead, P.E., BCEE is a Senior Project Manager with Tighe & Bond in Worcester MA, and has over 20 years of experience working as design engineer, project manager and construction coordinator. His varied experience includes work on drinking water, wastewater, pipeline, site and civil, energy and other municipal infrastructure projects. His more recent focus is on development and delivery of projects for municipal clients across New England. Born and raised in the construction industry, Ian has spent his entire lifetime on and around heavy equipment on various construction sites. While working for a private engineering company doing survey and site design work, Ian studied civil engineering at the University of Massachusetts Amherst. His first job after graduation was doing site inspection work on pipeline projects throughout MA and RI. He was quickly introduced to trenchless technology as many municipal clients were then expanding sanitary sewer collection systems, and some of this work involved trenchless applications such as HDD, bursting, and CIPP. More recently his experience has also included comprehensive pressure pipe condition assessment and rehabilitation, and the incorporation of this information into enterprise asset management programs. Ian thinks that increasing owner acceptance, and convincing local decision makers that trenchless methods should be part of any utility's asset management plan, are important keys to future growth of the industry. Education and information provided to municipalities and utilities will help spread the word that trenchless is a viable and proven option. Ian feels there is a great opportunity to generate more interest in trenchless technology with mid to smaller sized utilities across the Northeast. Another major goal he has is building general awareness of the NASTT-NE Chapter, and coordinating its resources and activities, such as website, publications and conferences, with the parent NASTT organization and other regional chapters across North America.

BABS MARQUIS – VICE CHAIR

Babs Marquis is presently Construction Manager with the Burlington, Mass., office of McMillen Jacobs Associates. He previously worked for Jacobs Engineering Group for 10 years and Stone & Webster for 11 years. During his extensive career in the trenchless industry, Babs has been involved in major tunneling and trenchless projects in the Northeast for clients such as the Massachusetts Water Resources Authority, Boston Water & Sewer Commission, the Metropolitan District Commission (Hartford, CT), Narragansett Bay Commission (Providence, RI) NYC Dept. of Design & Construction and NYC Dept. of Environmental Protection. For the past 19 years, he has focused on underground construction management for tunnels and conveyance including water and wastewater pipeline design and construction projects, with emphasis on trenchless construction methods. He has worked on various pipeline projects utilizing microtunneling, pipe jacking, horizontal auger bore, pipe bursting and pipelines renewal methods. From 2009-2011 Babs was resident engineer on the pivotal Microtunneling, & Pipe Bursting components of the East Boston Branch Sewer Relief Project. His commitment to the trenchless practice includes co-author for revision and update of the ASCE Manual of Practice (MOP 106) for Horizontal Auger Boring Projects and is the chair leading the effort for review and update of ASCE MOP 112 for Pipe Bursting Projects. Babs was instrumental in the development of the Auger Boring School at the Louisiana Technical University where he continues to assist with the annual planning and teaching at the auger boring school. Babs views the NASTT-NE Regional Chapter as an important vehicle to promoting greater awareness and understanding of trenchless applications at the local level. He sees the level of interest and confidence in trenchless technology growing among owner groups based on the successful completion of many high profile projects across the Northeast. Drawn to the varied unique and innovative aspects of trenchless technology, Babs believes access to ongoing education is key to even greater owner acceptance and NASTT-NE Chapter is a key component towards achieving this acceptance by making information available at the grassroots level as well as attracting a robust local participation in the Chapter activities throughout the region.

ERIC SCHULER – TREASURER

Eric Schuler is a Project Engineer at Liverpool, NY-based consulting firm Barton & Loguidice who has over 7 years of experience as a consulting engineer. He earned his Bachelor of Science in Civil Engineering degree from Clarkson University in Potsdam, NY and has primarily been involved in wastewater, drinking water, civil-site, and stormwater sectors. Eric is a licensed Professional Engineer in New York whose design, project management, and construction-related experiences have helped successfully execute many "trenchless"-focused projects. Early in his engineering career he gained exposure to various trenchless technologies through utility evaluations and development of utility project design alternatives. He immediately started to envision great opportunities for communities plagued by utility

EXECUTIVE COMMITTEE

deficiencies and construction constraints to utilize CIPP, HDD, among other trenchless technologies; and for them to be able to benefit from both social and economic perspectives. Eric has also stressed the importance for municipalities to incorporate asset management into utility system evaluations and system rehabilitation designs in order to aid development of capital projects and to determine the most suitable trenchless applications for implementation. In addition to NASTT-NE, Eric is also an active member of the American Water Works Association (AWWA), and is pushing for continued growth of trenchless rehabilitation in the drinking water sector throughout the Northeast. Eric has previously presented on the use of hydraulic modeling methods for proper development of utility rehabilitation project design. He is an advocate for educating (designers & installers) of trenchless applications through proper training and increased accessibility of industry standards/ guidelines to ensure successful project design and execution. The successful use and increased awareness of modern-day trenchless technologies that incorporate innovative equipment and materials are what Eric believes will continue to shape and drive the direction of the utility industry for the coming decades.

MARSHALL GASTON – SECRETARY

With more than 40 years of experience in the construction industry, Marshall Gaston's diverse background and experience bring a unique perspective to trenchless project development. Marshall has always maintained a foot in both the academic and practical fields. Earning a Bachelor's Degree in Construction Technologies from Purdue, he was heavily influenced by his father's job as a contactor. This duality of education and hands-on experience has been evidenced throughout his career. After graduation, Marshall went back to work for his father, literally learning from the ground up. His career then shifted to work in smaller consulting firms, where he was first introduced to trenchless technology. Marshall currently serves as a Senior Project Manager in the Water Environment and Natural Resources Department at Fuss & O'Neill. Marshall's current focus is design and construction of major sewer extension and roadway projects. He sees trenchless technology as a useful component to his work, as there is increased demand for less invasive technology. He believes that trenchless technology is fast becoming mainstream as the demand for less intrusive construction techniques will drive both improvement in technology and costs downward. As Secretary, Marshall looks forward to a deeper understanding of the industry and translating that knowledge to his clients. A problem solver by nature, amplified by a lifelong interest in construction, Marshall's devotion to his clients is evidenced by the numerous facility planning, gravity and low pressure wastewater collection systems, pump station design and commissioning, and on-site decentralized renovation systems changing the landscape of New England.

DENNIS DOHERTY – PAST CHAIR

With over 30 years of experience in the trenchless technology industry, Dennis Doherty has developed a unique understanding of the full scope of trenchless techniques and risk management as it relates to trenchless design. He earned his BSCE in Civil Engineering from the University of Massachusetts at Lowell, and M.S in Management of Projects and Programs from Brandeis University. Dennis began his career in in trenchless in 1989 at Bryant Associates, moving to Metcalf & Eddy in 1996, and later for Jacobs Engineering in 2000, where he spent 10 years. Since 2010, his focus as a Senior Consultant and the National Practice Leader, Trenchless Technologies, at Haley & Aldrich has been applying a total trenchless approach, from feasibility through construction, utilizing microtunneling and HDD on projects primarily for private sector energy clients. Throughout his career Dennis has worked on a variety of innovative trenchless projects around the greater Boston area, including the New St. James Avenue Interceptor Project for the Boston Water & Sewer Commission - the first and only project to win the Trenchless Technology Magazine's Project of the Year award in both New Installation and Rehabilitation categories.

Dennis has been a long-time proponent of the benefits and value of trenchless technology. He believes regional education and outreach activity is the foremost priority for the new NASTT-NE Chapter. In his view, another positive step forwards is the formation of the new U. of Massachusetts at Lowell Student Chapter which will help draw more young engineering professionals into trenchless practice. Dennis currently serves on the NASTT No-Dig Show Program Committee and teaches the NASTT HDD Good Practices course. He is involved in ASCE Standard Design and Construction Guidelines, and Pilot Tube and Other Guided Boring methods Manual of Practice. His passion for all things trenchless is exemplified by his Twitter handle: "@TrenchlessGuru".

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ANNOUNCEMENT

2018 NASTT-NE NORTHEAST TRENCHLESS CONFERENCE

The NASTT-NE Chapter is holding the 3rd Annual Northeast Trenchless Conference
Tuesday November 13, 2018 at the Mystic Marriott in Mystic Connecticut

Following on the success of the first two Conferences at UMass Lowell MA (2016) and Cooperstown NY (2017) the NASTT-NE Chapter announces the 3rd Annual **2018 NASTT-NE Northeast Trenchless Conference** held Tuesday November 13 at the Mystic Marriott in Mystic Connecticut. There will be a Welcome Reception the evening of Monday November 12 (location TBD).

Join us for a full day of trenchless presentations and networking along with breakfast, lunch and refreshment breaks! Registration includes a useful and informative technical seminar program and mini trade-show product exhibit area. The **2018 NASTT-NE Northeast Trenchless Conference** offers all the benefits of a national conference at the local level.

The NASTT-NE Chapter provides opportunities to advance the science and practice of Trenchless Technology by promoting and conducting training and education through seminars, short courses and field demonstrations.

The **2018 NASTT-NE Northeast Trenchless Conference** is a valuable educational networking opportunity for those involved in underground infrastructure work including public works officials, utility company personnel, engineers, underground contractors, industry suppliers and students.

Mark the date on your calendar and check the NASTT-NE website for information on the 3rd Annual 2018 NASTT-NE Northeast Trenchless Conference.

For updates regarding the Conference location, Hotel accommodations and Registration, visit: www.nastt-ne.org/seminars.html

NASTT NORTHEAST REGIONAL CHAPTER

Section of 36-inch abandoned cast iron pipe

OVERCOMING CHALLENGES KEY TO WORLD RECORD 36-INCH CIPL GAS MAIN RENEWAL

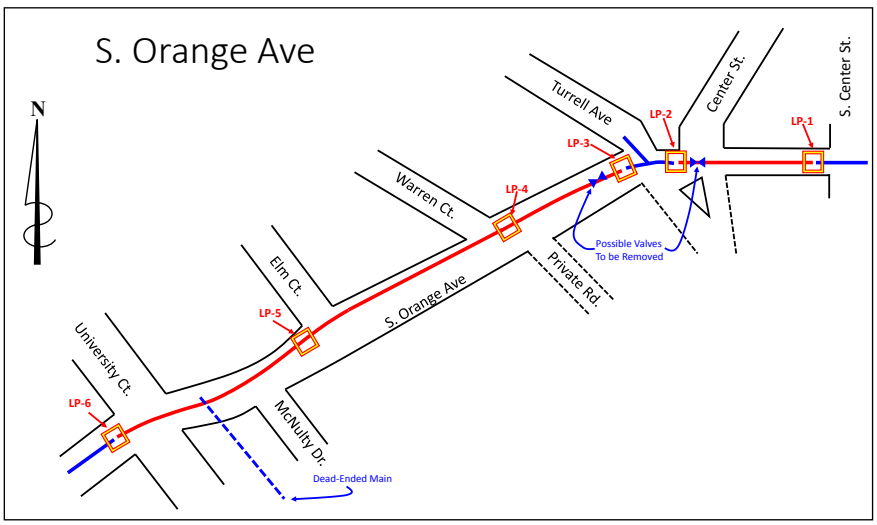
World Record Diameter Gas Main Relined in South Orange, NJ

By: George Ragula, Public Service Electric & Gas

South Orange Avenue is a major urban thoroughfare running through the Seton Hall University campus and into a nearby popular park. I was there on a late November day last year. The sun glistened on orange and yellow leaves and there was a chill in the air. I watched as pedestrians descended again on the crosswalks hustling to class and meetings. Traffic was again back to normal. It was an unlikely setting for the World Record 36-inch Gas Main Reline we had achieved only a week before. I breathed a sigh of relief and thought back on the design process and the challenges we faced during construction which led ultimately to our World Record achievement.

This large diameter feeder main reline was one of the most demanding projects of my 40-year career. Running under this section of South Orange Ave. was a 2,000 LF stretch of 36-inch cast iron gas main pipe originally installed in the fifties. With increasing deterioration over the years a lot of short term sporadic emergency work had been done on this section of cast iron pipe, however a long term permanent solution for this critical feeder main had not yet been formulated. There were now a total of 15 known joint leaks pinpointed along this section so it was critical immediate action be taken to implement a comprehensive long term solution.

Ultimately, the best and most effective long term solution we found required a Cured-In-Place-Liner (CIPL) renewal of this 2,000 LF section of 36-inch cast iron gas main – a new world record as the largest diameter CIPL project ever done on a gas main! This challenging undertaking required innovation, calculated risks and occasional round the clock shifts to complete. It was made possible by the exceptional work and expertise provided by the dedicated teams at Public Service Electric & Gas (PSE&G), Progressive Pipeline Management (PPM) and Karl Weiss Technologies GmbH. The outcome of our teamwork was a successful permanent renewal of the feeder main using trenchless technology and a new world record set for the largest diameter gas main renewed with CIPL!



South Orange Avenue 36-inch feeder main alignment

WITH SUCH AN UNPRECEDENTED SIZE DIAMETER OF PIPE TO BE LINED, A DETAILED GAME PLAN WAS CRITICAL, AND CONSIDERABLE TIME WAS INVESTED INTO PLANNING AND COORDINATING OUR APPROACH.

DECISION TO LINE: JUNE/2017 – SEPTEMBER/2017

Buried at an average depth of 4 feet under the fresh pavement surface of South Orange Ave., the 36-inch high pressure main was embedded amongst a congestion of subsurface utilities including telephone, water, multiple sewer lines, storm drains, cable, and electric. There was also a 12-inch low pressure gas main running parallel under the same street. Finding a clear alignment to relocate the main through this complex subsurface environment was therefore impossible, so replacement of the cast iron pipe was out of the question.

We considered our options. Often the easiest and most cost effective solution is to insert a much smaller diameter higher pressure plastic pipe within the host pipe. However, this was not a viable option as the 36-inch cast iron pipe was already running at 15 psig and we didn't have any 60 psig systems nearby to use as a source to maintain current volume through the smaller diameter plastic.

Another option was to excavate and encapsulate all the leaking joints over a period of time. There were already 15 known joints that leaked and it was only a matter of time before all of the cast iron pipe joints would need to be repaired. Spaced at eighteen foot intervals encapsulating all the joints along the busy South Orange Ave. corridor, was deemed impractical, cost prohibitive, with the likelihood of major negative impacts on traffic flow and the surrounding community. We concluded that the only viable and cost effective approach which guaranteed minimal disruption was trenchless renewal of the pipe using CIPL. Because it was the summertime, it was feasible to use the adjacent low pressure main as a relay to maintain service to customers as construction proceeded.

In June 2017 the decision was finalized to renew the 2000 LF section of the 36-inch cast iron main with Starline® Cured in Place Lining. For expertise in lining gas mains, all roads lead to the team of highly skilled infrastructure specialists at Progressive Pipeline Management (PPM). Since 2002, PPM have been the sole contractors in North America, exclusively licensed to install Starline® CIPL for natural gas main renewal applications. The Starline® product was originally developed by Karl Weiss Technologies GmbH, a German company with extensive experience in natural gas liner applications. The Starline® liner has undergone ten years and $14M worth of testing with PHMSA, Cornell University, and NYSEARCH. This independent testing of the liner in live pressurized pipe has determined a 100+ year's lifespan for the product. There are no other liners available for use in the gas industry that are backed with the same pedigree and extensive testing protocol.

With such an unprecedented size diameter of pipe to be lined, a detailed game plan was critical, and considerable time was invested into planning and coordinating our approach. There was significant lead time needed for the liner, materials, pipe, valves and related equipment to be manufactured and shipped. We calculated the length of liner required and determined there would be six access pits requiring excavation to install four separate liner segments varying in length from 260LF to 650LF. A specially designed custom inversion drum also needed to be manufactured and shipped from Germany.

Since this was the first installation of CIPL for such a large diameter of gas main, we felt it was important to have onsite technical support from the liner manufacturer in Germany. Karl Weiss Technologies GmbH sent Holger Turloff, a technician deeply experienced

Custom pig fabricated to remove stranded grit

Project Team: Public Service Electric & Gas, Progressive Pipeline Management and Karl Weiss Technologies GmbH

in lining large diameter gas mains. His help was invaluable in directing and training the crews through their first time working with the equipment necessary for installing this record-setting large diameter liner.

Based upon approximately a week for installation of each of the four liner segments, it was going to be a major challenge to meet a gas-in date of November 1/2017 so that this critical 36-inch feed main was back online before the cold weather hit. There were additional complications, delays and challenges which arose during the pre-construction and construction phases.

PRE-INSTALLATION: SEPTEMBER/2017 – OCTOBER/2017

From prior experience renewing cast iron gas mains, we knew there would be challenges, some known, and many unknown. We solved one of them in the planning phase, averting a potential failure of the liner material, by designing a reinforced four-ply polymer carbon fiber patch to bridge a four inch tap hole in the pipe. This patch concept was adapted from the circumferential structural reinforcement sleeve made of carbon fiber or steel that we occasionally use to bridge gaps in pressure pipe before lining (see NASTT-NE Journal Fall/2017 pp38-40).

The onsite preparations began with abandoning the 2000 LF section of main to be lined. There were two dead ended lateral mains that needed to have back feed relays installed first, before we could take the 36-inch cast iron pipe out of service. Excavations were done in locations on the 36-inch main where lateral feeds were disconnected, services were transferred and valves were replaced. These became our lining excavations. On the whole project overall, 5 old deteriorated valves were replaced with four new ones. Provisions for temporary relay feeds were put into place in the locations where the valves were being replaced.

Once excavation of the pits was underway, we knew there would be required adjustments and unforeseen circumstances related to equipment or the site. Lining four segments demanded we juggle multiple priorities with sites and equipment at the same time. Before cleaning of the pipe section commenced, a pre-clean CCTV inspection was run on each of the four segments to confirm the pipeline geometries, check for anomalies and protrusions, and assess overall internal conditions of the host pipe.

CHALLENGE: STRANDED GRIT IN SEGMENT TWO

To prepare the pipe for lining, sandblasted grit was used to clean the interior pipe wall down to white metal to ensure a tight bond between liner and host pipe. Based upon our previous experience doing sandblast cleaning and vacuum removal in large diameter mains, we thought the suction generated by an equivalent of five vacuum units would be more than sufficient to remove the debris and residual grit material from each of the four segments post-cleaning.

Due to the sequencing of access pit excavations, Segment Two was cleaned

Liner wet out involves mixing two-part chemicals

Starline® Cured in Place Liner coming off the drum guided as it enters the host pipe

first. However post-cleaning inspection revealed there was still roughly a 150 foot length of stranded grit material remaining in the pipe after the vacuum removal process was complete. Two more vacuum sources were added the next day to bring the total to seven vacuum units, along with a special fitting to increase suction. Even after an entire extra day was spent using seven vac sources, there were still piles of grit left behind in the pipe. A conventional pig didn't work to push the grit out either.

Time to innovate. We fabricated a custom pig with rollers and a tethered hold back. The rollers centered the pig into the pipe reducing the area into a small annular space. This drastically increased the suction velocity in the areas between the pipe's interior surface and pig. With vacuum source at one end we would slowly pull the pig back towards the other end against the airflow, moving it over the areas where grit had accumulated. We used CCTV to monitor the pig's position and confirm grit removal. It took us another day using this innovative process to successfully remove all the stranded grit.

The seven vac sources were effective by themselves at removing the residual grit from pipe Segments One, Three and Four. Finally, post cleaning CCTV confirmed each segment was clean and ready for the liner installation phase. We retired the custom pig.

LINER INSTALLATION: OCTOBER/2017 – NOVEMBER/2017

Segments of CIPL 36" Cast Iron Pipe	Feet	Days to Complete
One	650	7 days
Two	565	26 days
Three	450	6 days
Four	260	3 days

Lining began October 9th and was completed November 19th. Note the length of time required to complete Segment Two.

For each of the four segments, the host pipe ends were prepared at the entry and exit pits. This involved placing a crib

Liner entering host pipe after going through inversion cone

under the host pipe entry point with a T bar to help center the liner into the pipe. On the receiving end an end catch fitting was used to stop the liner. After we prepared the host pipe ends for each segment, the pipe was ready for liner installation.

The liner wet-out was done by mixing two-part epoxy resin in predetermined quantities based on diameter and length of each segment to be lined. The mixed resin was poured into the open end of the liner. Securing the liner tail properly was a critical step that prevented resin from leaking out once the liner was loaded up with epoxy. For this large diameter we prepared the tail for each segment with special adhesive tape before attaching the liner with 4 bolts to the retention belt that pulls the liner into the pressure drum. While being loaded into the pressure drum the liner was pulled through pre-set rollers gapped to wet-out or spread the epoxy inside the entire length needed for the planned inversion.

Connection of the tail to the retention belt was critical for control of the liner once it was pressurized and while inverting under air pressure. A twenty to thirty foot section of tail remained un-inverted inside of the liner while it cured with positive pressure maintained for two to three days. Once cured and deflated, the catch on the receiving end was removed and the tail pulled out. On the inversion end the cured liner was cut and separated from the pressure drum and on both ends the liner was cut flush to the end of the host pipe. Each segment was then ready for the post-lining CCTV inspection.

CHALLENGE: DELAMINATION AT ENTRY

On smaller diameter lining projects, the inversion cone is placed in the entry pit, next to the host pipe. With a large diameter liner like this, the inversion cone is placed on the pressure drum above ground, about 20 to 30 feet away from the host pipe. Doing this keeps the entry pits to a reasonably sized excavation, saving money and reducing the carbon footprint.

However, when the inversion cone is above ground, it is difficult to optimize the liner entry angle into the host pipe, the pit entry angle, and the position of the liner at the inversion cone and still have the liner be perfectly centered into the host pipe. For each segment, the T-bar and cribbing helped guide the liner into the host pipe, but the liner entry angles caused a minimal liner liftoff or local delamination at the immediate entry point.

After the liner was cured and the ends cut flush, we found that there was a very slight crescent-shaped piece at the entry end that was dis-bonded for a couple of inches at the end point where the liner entered the host pipe. We successfully repaired this minor issue on each of the four segments using epoxy and a mechanical retention band. The band held the liner in place while the local epoxy repair cured.

CHALLENGE: LINER CHAFE

These same liner entry angles also increased chafing from the retention belt which caused minor leaks on the exposed portion of the liner outside of the host pipe. The retention belt secures the tail thereby controlling installation speed and providing the capability to retract the liner. When we completed the inversion on Segment One, we used an eight-inch wide retention belt. At a few points along the liner there was too much friction between the belt and liner causing chafing and minor leaks. To prevent this liner chafe issue for Segments Two, Three and Four, we switched to a four-inch belt and doubled the lubrication.

THE BIG CHALLENGE: SEGMENT TWO

As the chart above shows, Segment Two took much more time than the other three segments taking a total of 26 days to complete. First, as noted above, delays were caused as we grappled with removing the piles of stranded grit in this segment that were left behind after cleaning. While the grit issue was being resolved, we were able to maintain schedule by moving ahead with lining Segments Three and Four. By then, we had already learned how to effectively handle the minor delamination and retention belt chafing issues notes above.

On Wednesday October 25 we were still on schedule to meet the November 1st gas-in date. That day, during the final liner installation on Segment Two, we were only 15 feet away from the catch end when one of the tail bolts failed and tore a hole in the liner due to the considerable forces at this large diameter. This meant we could no longer maintain positive pressure and complete the liner installation on Segment Two. Fortunately the retention belt was still attached to the tail with the 3 remaining bolts. We worked around the

clock to retract the liner and remove it from the pipe.

It being late October, with outdoor temperatures rapidly dropping, there was substantial pressure on us to get the 36-inch feeder main back into service as soon as possible. Now, with the liner failure in Segment Two, meeting the scheduled November 1 gas-in date was impossible.

We had to make a quick decision, and ensure it was the correct one. Would it be better to simply gas-in the entire 2000LF section and allow the leaks to continue in Segment Two? Or would it be more optimal to relay Segment Two, and look at attempting to line the segment again in Spring/2018? Neither of these options were desirable or cost effective.

Instead, we were elated when Karl Weiss Technologies GmbH agreed to manufacture an emergency replacement liner. They had it delivered to us and through Customs in record time. The new liner order was placed on Friday, October 27 and was received by us on Monday, November 13 – an incredible turnaround time of two-and-a-half weeks!

Working round the clock, the replacement liner was successfully installed into Segment Two on Tuesday, November 14 – a mere 24 hours after it had been delivered! This time round, we modified the tail bolt design to six bolts to be extra cautious, and there were no further problems. After four days of ambient curing, the final CCTV inspection was on Sunday, November 19. The results were excellent. A 25 psig pressure test confirmed the integrity of the line. We gassed-in on Monday, November 20, in time for the cold Northeastern winter fast approaching. Thirty-six inch diameter – a new World Record for the largest gas main ever relined.

With a permanent solution in place, and a new World Record under our belts, we won't have issues out there with the feeder main under South Orange Avenue for years to come. Most importantly, we gassed-in in time for the winter months, so our valued customers were not adversely affected. Successfully, achieving our world record for the largest diameter CIPL ever completed on a gas main required teamwork, true grit and a lot of preparation to persevere through the inevitable challenges.

ABOUT THE AUTHOR:

George Ragula *is the Distribution Technology Manager at Public Service Electric & Gas (PSE&G) with over 40 years of experience in gas industry engineering, operations, construction, research/development/deployment and management.*

George is a noted authority on trenchless applications for the gas industry having spent 31 years specifically focused on trenchless. He received his B.S. in Mechanical Engineering from Polytechnic Institute of Brooklyn in New York. George is a past Chair of NASTT and serves on the NASTT No-Dig Show Program Committee. He also teaches several NASTT courses on various trenchless technology topics, including CIPL for the Gas Industry.

SECOND ANNUAL NASTT-NE NORTHEAST TRENCHLESS CONFERENCE 2017

Another Great Success!

By: Marshall Gaston, Fuss O'Neill, (NASTT-NE Board Secretary)

More than 120 delegates gathered for a full day of trenchless technology education and networking

More than 120 trenchless professionals, municipal attendees, industry exhibitors and students gathered in Cooperstown, New York on November 16 for the second annual North American Society for Trenchless Technology Northeast Chapter (NASTT-NE) Northeast Trenchless Conference & Municipal Outreach Forum.

Over the lunch Dennis Doherty, outgoing Chair of the NASTT-NE Chapter, moderated presentations by the UMass Lowell Student Chapter and George Ragula, past Chair of NASTT. George, a long time gas industry professional who works for Public Service Electric and Gas in New Jersey, gave the audience a historical perspective on how the industry

A highlight was the mid-afternoon presentation by Irene McSweeney, Director of Construction, BWSC, on the West Side Interceptor

NASTT Executive Director Mike Willmets delivers closing remarks. Looking forward to the future

Mike App, Precision Trenchless LLC, discusses Large Diameter UV CIPP Planning, Design and Installation

has changed and grown to construct larger and more difficult projects.

One of the highlights of the one day event was a mid-afternoon presentation by Irene McSweeney, Director of Construction, Boston Water & Sewer Commission, which provided an overview of the West Side Interceptor Rehabilitation Project in Boston Massachusetts. The presentation highlighted the success of the project in managing construction efforts through the use of different trenchless rehabilitation techniques in two distinct sections of variably sized sewers.

Sixteen papers presented in 2 tracks covered a wide range of topics showcasing trenchless rehabilitation techniques, investigative methods, equipment innovations and good housekeeping practices. The NASTT-NE chapter is publically sharing these presentations and they are available for download from our website: www.nastt-ne.org.

In keeping with our chapter's training and educational goals, Student Advisor Raj Kumar Gondle, faculty member in the Department of Civil and

UMass Lowell Student Chapter members capably handled delegate registration

George Ragula, PSE&G, gives a presentation on applications of FRP in gas pressure pipe

Environmental Engineering at UMass Lowell, and a number of the UMass Lowell Student Chapter members met industry professionals at their exhibit booths, participated in the conference as presenters, and also provided support activities to the conference, such as staffing the registration table (please see article following).

The seminar took place at the luxurious grand hotel in Cooperstown, the Otesaga Inn, where participants had easy access to 30 industry exhibitors available to converse with attendees. Additional networking opportunities were found by those who chose to visit the nearby Baseball Hall of Fame for a walk through history on one of America's favorite pastimes.

The NASTT-NE Chapter Board of Directors thanks everyone for their participation in a highly successful second annual NASTT-NE Northeast Trenchless Conference. We wish to extend our appreciation to all our presenters, moderators, and attendees for their participation, time and effort. A special thanks also goes out to our Premium Sponsors & Exhibitors.

Building on these past year's success the NASTT-NE Chapter is taking the yearly

NASTT-NE Vice Chair Babs Marquis, McMillen Jacobs Associates, reviews the East Boston Branch Sewer Relief Project

Delegates had close personal access to 30 trenchless technology exhibits and numerous industry experts

Seminars covered a wide range of trenchless subjects and were intensely followed by conference delegates

Baseball Hall of Fame, Cooperstown, New York

Conference was at the luxurious Otesaga Inn on the shores of beautiful Lake Otsego

seminar event on the road and plans to host seminars throughout New York and New England in the coming years. The 2018 NASTT-NE Conference will be held at the Mystic Marriott in Mystic Connecticut on Tuesday November 13. There will be a Welcome Reception the evening of Monday November 12 (location TBD). For further details and updates please visit: www.nastt-ne.org

We look forward to seeing everyone again next year!

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UMASS LOWELL NASTT STUDENT CHAPTER:

My first footsteps into the world of trenchless technologies

Live pipe-bursting demonstration

By: Liam Henderson (Engineering Student)
Dr. Raj Kumar Gondle (Faculty Advisor)

A mere brush of luck brought me to my first Engineering Conference. I was turning in a misprinted homework assignment to my professor late one evening, when he mentioned my earlier remarks of having a curiosity for the geotechnical branch of civil engineering (my current major). I explained that it had been an interest of mine, and no sooner had I expressed this, he promptly invited me to attend the NASTT-NE Trenchless Technology Conference in Cooperstown, NY. Not knowing full well what I was in for, or even what "NASTT" stood for, I agreed to tag along with the student chapter to get an idea of some of the applications possible for my major. After all the sign-ups, approvals, and travel arrangements had been finalized, we were prepared to head off. About half of the student chapter was able to leave around noon to attend a social with several participants and members of the NASTT-NE Chapter. The second half of our group left later in the evening and arrived around 11 pm at our hotel. This was the first time I had ever seen a room reservation with my name on it!

Bright and early the next morning we headed off to The Otesaga, a marvelous grand hotel, with an amazing view of the Otsego Lake. Here we set up the welcome table, and organized nametags for guests and presenters. By around 8:30 in the morning, most of the presenters had set up tables, and we headed into the dining hall for a brief social breakfast. I took my seat at a vacant table and was soon joined by a man who introduced himself as Dennis. We began talking, and through

Dylan Shaffer presenting about the UMass Lowell Student Chapter activities

IT WAS COMPLETELY NEW FOR ME! ANY QUESTIONS I HAD WERE ANSWERED. MY INTEREST WAS SPARKED IMMENSELY!

UMass Lowell students welcoming attendees to 2017 NASTT-NE Conference

the conversation I learned how expansive the applications of trenchless technologies really could be. As we talked, several others joined us at the table and chimed in here and there with friendly and informative conversation. Unbeknownst to me, I was surrounded by the NASTT-NE Board Executive Committee, including the Past Chair, Dennis Doherty. Any questions I had were answered, and my interest was sparked immensely; before this, I had no idea that such a congregation of people with my interests existed. As breakfast wrapped up, I was eager to go around and see what else was in store as I examined all the presentations.

Exhibitors addressing pipe-bursting, pipe-lining, pipe-ramming, microtunneling, coating, damage detection, and rehabilitation, together with geotechnical aspects, were centered in a presentation hall on the first floor of this grand hotel. There was not an unfriendly conversation to be had, and hardly a full sentence was uttered without something new to be learned. My professor advised us to go around and talk to as many exhibitors and speakers as possible, in order to learn more about trenchless technologies and their applications. Gladly we went from table to table getting a full-on presentation of all the products at hand, some that had been around for a while, and some that were brand new. Machines that were pulled through pipes while they sprayed on a seal, sleeves of material that could be drawn through broken pipes, and monitoring equipment that could scan the utilities that had gone astray were just some of the many available products and technologies presented.

Afterwards, we were able to attend several talks, where some of these

Exhibitors sharing their knowledge with Student Chapter members Liam Henderson and Aleksandr Chongris

technologies were explained in even greater detail. Pictures of previous projects were shown, and it was really interesting to hear first-hand how several of these techniques were developed and refined. We even had the privilege of witnessing a live pipe-bursting demonstration outside in the parking lot, which I had never experienced and I never thought such technologies were available beforehand. It was completely new for me.

As the day wound down, and we began packing and cleaning up, several other students and I were approached by Marshall Gaston, Secretary of the NASTT-NE Board Executive Committee. He thanked us for our attendance and invited us to attend the 2018 NASTT No-Dig Show in Palm Springs California. Since then, I kept my eyes glued to my email for weeks, until the official sign-ups came in. In March, five other members of the UMass Lowell NASTT Student Chapter, and myself will be attending that conference, and I can't wait to see what it has in store.

ABOUT THE AUTHORS:

***Liam Hendrik Henderson** is a freshman majoring in Civil and Environmental Engineering at the University of Massachusetts Lowell, and a member of the UMass Lowell NASTT Student Chapter.*

***Dr. Raj Kumar Gondle**, Lecturer in the CEE Department, serves as faculty advisor to the UMass Lowell NASTT Student Chapter, providing oversight direction and assistance. Prior to joining the faculty, Raj worked as a research engineer at West Virginia University Research Corporation on several projects and taught civil engineering courses at West Virginia University. He received Outstanding Classroom Teaching Awards for his excellence in teaching. Also, he has been selected as a 2017 ExCEEd (Excellence in Civil Engineering Education) Teaching Fellow by the American Society of Civil Engineers (ASCE).*

UMass Lowell Student Chapter Members:

Front row (left to right) David Salinas, Steven Fallon, Brian Herwing, Pedro Lopez, Dylan Shaffer, Christopher Sarno
Second Row (left to right): Susom Dutta, Liam Henderson, Alex Horn, Ryan Fisk, Aleksandr Chongris

ONE IF BY LAND – TWO IF BY BOAT

Adventures CMP Culvert Lining in the Northeast

By: Mike App, Precision Trenchless

UV truck off the highway behind Jersey barrier. Minimal impact on traffic

CALL FROM A CLIENT...

So you get a call from a good client and they say they have a couple culverts that need to be lined right away. No problem, we'll be right there.

"Any issues" you ask, "something out of the ordinary?" "No," they say, "Just regular CMP culverts - an 18-inch and a 48-inch. "

"Where are these culverts?" you ask. "Under an interstate", they say, "Real shallow, good access, you'll see".

So you agree to go take a look at the site and you find an 18-inch CMP that, yes, is in the road. But it ends in a river, oh, and also its 10 feet off the river. And that 48-inch culvert looks like you will need some climbing gear to get down to it, or a half mile hike around through the woods hauling gear to get there…

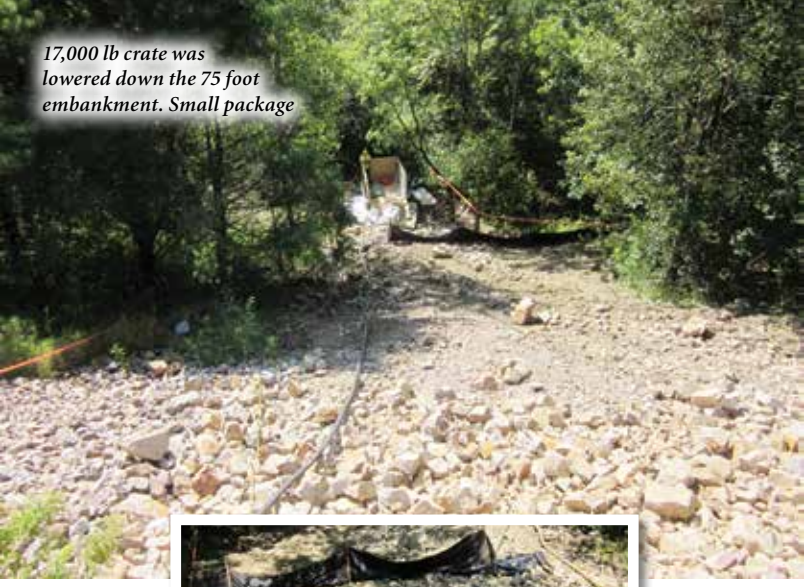
The good news is that at Precision Trenchless LLC we have been there and literally done that before in all kinds of situations. So with a little help from our GC's both situations are taken care of quickly and efficiently and both installs happen without fail. One if by land, two if by boat? Where and how can you rehab culverts in nontraditional locations? UV Fiberglass CIPP can get it done in the toughest spots.

...WOULDN'T IT BE FUNNY IF THE LINE ENDED IN THE RIVER???

42-Inch Culvert looking up hill

ONE IF BY LAND...

The One if by Land, was a 48-inch CMP culvert in Burlington, VT. This culvert was running under one of the main roadways and thoroughfares for access to the University of Vermont and the west side of Burlington. Due to storms that hit



17,000 lb crate was lowered down the 75 foot embankment. Small package

GC built a small pad to support UV truck

Liner installation took about 18 hours to complete

UV cure under way

the region back in 2012, the culvert had become compromised and was failing. The culvert was 50 feet deep below the road surface, and it was simply too busy and important to dig the road up. We could not block or alter the traffic flow in any way.

Vermont DOT placed a call to us to ask if we could do the work in conjunction with a GC doing road work in the area, Dirt Tec of Burlington, VT. We said, yes, absolutely and the 48-inch CMP liner project was in process.

The GC built us a small pad on the shoulder to allow our UV truck to sit off the road inside of the Jersey barrier to do the work more safely. Dirt Tech used their equipment to lower the crate with the liner, all 17,000 pounds of it, down the 75 foot embankment and position it in front of the culvert pipe. We then made a trail on the other side 300 LF off road through the woods with a skid steer to bring all the equipment in and winch the liner into place.

The culvert was approximately 225 LF and the entire liner installation took about 18 hours to complete. Because the culvert conveyed a seasonal stream we were required to do pre- and post-lining water testing to show no impact to water, solids, fish or animals. All in all another good couple of days spent solving a problem for a valued local client.

AS MUCH AS WE ASK FOR, AND WANT, JUST THE REGULAR AND ORDINARY JOBS, WE ARE NOT ALWAYS ABLE TO FIND THAT TYPE OF WORK.

TWO IF BY BOAT...

The Two if by Boat was rather funny, in a sinister way. The plans didn't show the line running down into the river, they showed it running the other way under

UV control room

Safety discussion

View of lined culvert under bridge

Get a boat. Build a platform

I87 South. So imagine our surprise when the CCTV operator told us the line runs the other direction down the median! We double check and verify we are in the right place and on the right line. Then, we call the Engineer in Charge (EIC) and everyone agrees we are in the right place.

As we begin the CCTV the question is where does this line end? Is there another catch basin about 200 feet away? As we look, we then see the bridge. The bridge is also about 200 feet away. SO the question was asked in one of those funny "A-ha" moments - wouldn't it be funny if the line ended in the river??? There's the old adage of be careful what you ask for, as it might come true. Well it did. The pipe dropped straight into the river, with no gantry or access. It was in the middle of the bridge and 10 feet off the water.

The EIC and GC look at us and ask can we do it? Answer, yes get us a barge or platform and we can make it work, no problem. We built a platform and used a boat to access the end. The GC and EIC then get it approved and before you know it another 18-inch UV CIPP gets successfully installed.

MAKE THE CHALLENGING LOOK REGULAR...

One if by land, two if by boat. These two projects are not at all unique. As much as we ask for, and want, just the regular and ordinary jobs, we are not always

Another successful UV CIPP install

WHERE AND HOW CAN YOU REHAB CULVERTS IN NONTRADITIONAL LOCATIONS? UV FIBERGLASS CIPP CAN GET IT DONE IN THE TOUGHEST SPOTS.

able to find that type of work. Across the Northeast we have culverts beginning and ending in all sorts of places, uphill, downhill, off cliffs, bridges, tunnels, you name, it. No one thinks about how to fix them when they are being designed.

At Precision Trenchless LLC, we can go off road, on a barge, on a boat, off mountainsides, in 30 degrees below zero, whatever it takes, you name it. What we specialize in is the ability to make the challenging look regular. The skill and talent of the Project Managers, Supervisors and Field Technicians is what allows PTLLC to do these without question and concern to our clients. Have a project that no one else will look at? Call us at Precision Trenchless, and we'll get it done for you!

ABOUT THE AUTHOR:

Mike App *is the Senior Project Manager for Precision Trenchless LLC. Mike began work for PTLLC in 2012 and has overseen the growth of the company since its inception. In addition to his current responsibilities, Mike also is managing the new West Coast Operation. When Mike is not at work he enjoys spending time with his wife Michelle and 3 children Mackenzie, Ryan and Meghan.*

UNDERSTANDING GEOLOGICAL HISTORY FOR TRENCHLESS INSTALLATIONS:

Part 1: Effects of the Coastal Plain Barrier Islands on Long HDDs

By: Dennis J Doherty, P.E., F. ASCE, Haley & Aldrich / Bradford A Miller, P.G., Haley & Aldrich

INTRODUCTION

On many large, engineered trenchless installations, it is imperative for the engineer to understand the geological history of the area, and determine the possible consequences and controlling effects the geology has on the proposed crossing. Deciphering the underlying geologic history (and local anomalies) drives selection of the best and most appropriate trenchless method.

Part 1 of this series looks closely at the complications associated with conducting long HDD crossings between and along the Coastal Plain Barrier Islands of the Southeastern US. An 18,000 LF installation of a 115-kV cable under Hamlin Sound SC will be reviewed in detail as a case example of the unique geological considerations associated with barrier island systems.

SELECTION OF TRENCHLESS METHODS

When undertaking new trenchless installation work, it is crucial that engineers and contractors understand how the ground may behave in response to a given trenchless method. Much of

FOR EXPENSIVE AND LARGE-DOLLAR TRENCHLESS PROJECTS, EXTENSIVE GROUND CHARACTERIZATION IS TYPICALLY PERFORMED, BUT FOR SMALL-DOLLAR TRENCHLESS PROJECTS, ADEQUATE GROUND CHARACTERIZATION IS OFTEN OVERLOOKED.

the expected behavior is based on real-world experience and a fundamental understanding of ground behavior when a specific soil matrix is removed from the ground, or whether the ground has sufficient strength to support equipment and/or provide a good stable borehole to prevent inadvertent returns. Terms from the Tunnel-Man's Ground Classification Guide like "raveling" (slow and fast), "squeezing," and "running" (or similar terms) are used to describe the anticipated unstable ground and emphasize a potential area of concern.

For trenchless projects that are much closer to the surface, the major concerns are: weak overburden soils, weight-of-hammer (WOH) material (based on typical Standard Penetration Test (SPT) test boring data), nested cobbles, gravel with little fines, running ground, and squeezing or swelling ground that suggest unfavorable ground conditions. For expensive and large-dollar trenchless projects, extensive ground characterization is typically performed, but for small-dollar trenchless projects, adequate ground characterization is often overlooked, either due to lack of budget, a perception of low value for the upfront project cost, or from unfamiliarity and limited experience with trenchless installations and possible risks.

To many owners, a new trenchless installation project is just a line on a piece of paper. But there is much more to it. It is understanding construction risk and how to manage that risk and how the ground will behave based on a specific trenchless method. Thus, understanding regional geology and how the underlying geologic conditions were formed provides clues that inform the designer of anticipated ground behavior. For some projects, the ground changes can be hidden or unexpected, as often occurs with HDD projects drilling between the Coastal Plain barrier Islands off of the southeastern coast of the United States.

EFFECTS OF BARRIER ISLANDS ON LONG HDD

Barrier islands are long, narrow, offshore deposits of sand or other sediment that typically parallel the coast line and are built by longshore drift and onshore currents (see Figure 1). The islands are characteristically separated from the mainland by a shallow sound, bay or lagoons, (Figure 2). These shallow, ecologically-rich sounds may be one-half to several miles wide, although there are a few exceptions (such as the North Carolina Outer Banks). Coastal sand movement forms barrier island complexes when three conditions are met:

- There is a supply of sand sufficient to form islands;
- sea level is rising or generally stable; and
- there are winds and waves with sufficient energy to move the sand from offshore to onshore.

Figure 1 - Former continuous barrier island split in half due to hurricane washover and breaching action, near Ocean City, MD (from TeachOceanScience.net)

Wind-blown sand on these barrier islands form the well-known sand dunes on the lee side of the beach ridge. These sand dunes also are submerged in the shallow sounds between the islands and the mainland, and can migrate landward on top of lagoon deposits, especially in storm conditions. If not interdicted by man-made features, the barrier islands move and migrate over time, due to wave and wind action. A good example of this is Ocean City, MD. A hurricane in the 1920s broke the island in half due to storm surge and overflow of the island. The sands from the overflow are now within the sound behind the barrier island complex and can be seen moving over time as water depths change. For trenchless HDD crossings, this loose, saturated sand makes for difficult borehole stability issues.

The barrier islands can also move seaward leaving submerged former sand dunes or barrier island complexes in the sounds. Successive, coast parallel barrier beaches such as those found at Hamlin Sound north of Charleston, SC are formed as the water moves offshore during periods when sea levels are dropping. Each beach ridge reflects a temporary halt in the overall retreat of the sea level, and are related to global sea level changes, rather than rising land masses.

The shallow sounds, bays, and lagoons behind the barrier island become filled with soft mud, peat, silts and sand deposits where ecologically-sensitive marshland is formed. Figure 2 below depicts the formation of this marshland ecological system. In the shallow bays and lagoons, marshlands are not only wildlife sanctuaries but also productive fishing grounds for oysters and crabs. Just inland of many of the barrier islands in the southeastern US, in the physiographic region termed the Coastal Plain, is the Intracoastal Waterway, an important maritime shipping corridor.

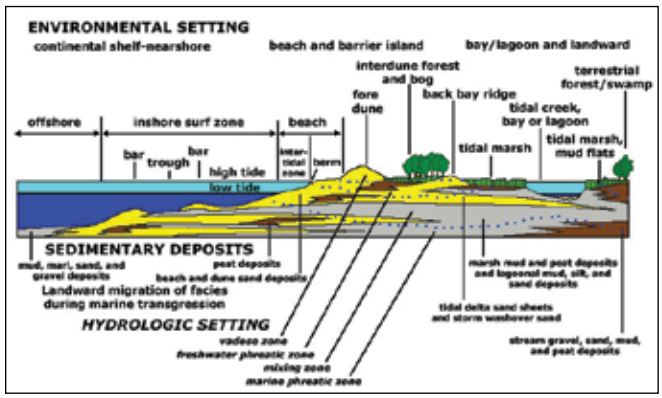


Figure 2 - The formation of Barrier Islands and inland sounds or lagoons yields complex, interfingering sedimentary relationships (from GeologyCafe.com)

Beneath the surface and within the sands there is typically a mix of fresh water near the surface; however, at deeper depths the groundwater is brackish because sea water is mixed in. Brackish water causes problems with HDD drill mud.

Barriers island systems are found all along the east coast from the New Hampshire coastline to the Texas coastline. They have increasing economic value as tourist attractions and as desirable locations to live. As a result of this increased population and the corresponding increase in electrical power demand, many energy suppliers are installing redundant underground cables between mainland sources and the barrier islands in order to maintain reliable power supply. This is done to mitigate and counter the disruptions caused when hurricanes damage and take out overhead power transmission lines. To economically and safely cross these ecologically- sensitive shallow sounds, bays, and lagoons, energy suppliers are increasingly turning to horizontal directional drilling.

CASE EXAMPLE: HAMLIN SOUND, SC:

Several years ago, South Carolina Electric & Gas (SCE&G) decided to install a 115-kV cable under Hamlin Sound between the mainland and the Isle of Palms. Although Hamlin Sound is only 12,000 feet wide at the crossing location, the actual borehole alignment required a 18,000 LF diagonal crossing. This was due to the substation location and the available workspace where barges with equipment could be placed within the environmentally-sensitive sound.

A key issue was that no drill length could exceed 7,400 LF due to the maximum length of spooled cable that could be transported to the site on a reel. This required strategically placing and building work zone platforms within the 7,400 foot maximum separation distance at locations within the shallow waters that could be accessed by barge and support boats. One of these temporary work platform is shown in Figure 3:

Figure 3 - HDD and cable splicing work platform within Hamlin Sound, SC situated in the marshland. The pipes carrying high voltage cables installed by HDD are being overboarded and buried below subsurface (Photograph courtesy of Pridmore and Varner/TD World.com)

A major area of concern requiring careful management was prevention of inadvertent drill fluid returns into the oyster beds and ecologically-sensitive marshland of the sound. Drills of this length require high downhole drill mud pressure to remove cuttings from the borehole. Geotechnical borings indicated a high potential for inadvertent returns due to the weight-of-hammer (WOH) material and loose sands, as shown on the subsurface profile in Figure 4.

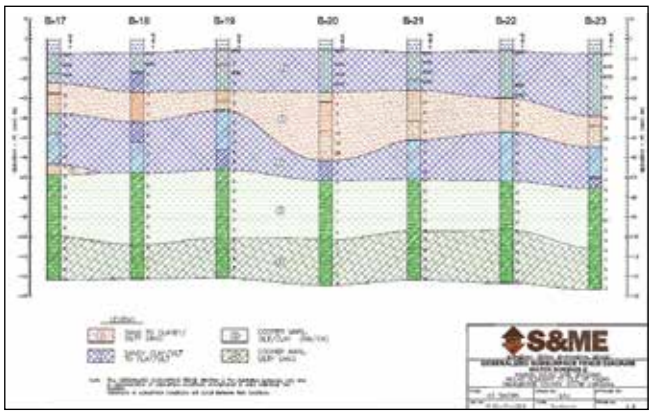


Figure 4 - Geotechnical data depicted on subsurface profile along HDD alignment below Hamlin Sound, SC (Courtesy S&ME)

As shown, the geotechnical borings indicated a geology of intermixed layers of clays, silts, peats and sand overlying a more competent deeper material known regionally as the Cooper Marl Formation. This weak overburden included 15 to 30 feet of very soft weight-of-hammer material overlying 15 to 30 feet of very loose to medium dense sands and clayey/silty sands before encountering deeper, stiff clays. The horizontal drill alignment was opportunistically designed to be in the more competent Cooper Marl formation. However, the weaker overburden led to challenges with alignment control, because the drill path had to

TO ECONOMICALLY AND SAFELY CROSS THESE ECOLOGICALLY-SENSITIVE SHALLOW SOUNDS, BAYS, AND LAGOONS, ENERGY SUPPLIERS ARE INCREASINGLY TURNING TO HORIZONTAL DIRECTIONAL DRILLING.

exit to the surface in the middle of the sound where the geology was less able to confine the drill fluid pressures. As a mitigation measure, long steel conductor sleeves were driven from ground surface into competent ground and used in combination with the "drill-intersect" method. There were no inadvertent returns reported using these methods.

CONCLUSIONS

New trenchless installation work is not without risk. Small, low-dollar value projects combined with low exposure risk on some new installations may not necessarily warrant a detailed understanding of ground conditions, especially in areas of homogenous ground conditions not impacted by glaciers and coastal climatic actions.

However, for high-dollar-value projects, and high-risk projects, more than just a few geotechnical borings are required. Having a sound understanding of how the land mass and local geology evolved and formed provides a valuable understanding of how the ground may behave when pipe jacking, microtunneling, or selecting between a small-bore HDD versus large bore HDD. The ground can be very complex. It is not just a line on a piece of paper; understanding the geology and ground behavior when selecting a trenchless method typically leads to lower risk with an associated decrease in cost of that risk.

ABOUT THE AUTHORS:

Dennis J Doherty *is a Senior Consultant and the National Practice Leader for Trenchless Technologies at Haley & Aldrich, applying a total trenchless approach on microtunneling, HDD and other trenchless method projects for private sector energy clients. An ardent proponent of the benefits and value of trenchless methods, Dennis has a unique understanding of risk management as it relates to trenchless design, having worked on a number of innovative projects across the US. He serves on the NASTT No-Dig Show Program Committee and is an instructor for NASTT's HDD Good Practices Course. Dennis is proud to be Past-Chair of the NASTT-NE Chapter.*

Bradford A Miller *is Senior Geologist at Haley & Aldrich, whose expertise is the geologic interpretation of complex soil, rock and groundwater conditions as they influence a broad variety of geotechnical projects, including trenchless utility construction, pipelines, linear energy corridors, highway rock slopes and foundation construction. He has served as President of the New England Chapter of the Association of Engineering and Environmental Geologists (AEG).*

GERMANTOWN ROAD CULVERT RELINE: GAITHERSBURG, MARYLAND

Tunnel Liner Plate Solution Most Viable Option

By: Hugh B. Mickel, P.E., Contech Engineered Solutions LLC

Host pipe stabilized with box beam frames to temporarily address structural concerns

Tunnel Liner Plate provided a safe working environment as workers progressed through the length of the structure

In 2015, Montgomery County, Maryland identified a culvert under Germantown Road that was severely deteriorated and in need of repair or replacement. The existing 96-inch culvert was located under 26 feet of cover and included a major modular block retaining wall situated over the upstream end. The depth of cover and the retaining wall, combined with the fact that the road above was heavily trafficked and difficult to detour made a replacement solution highly problematic. There were also several utilities passing through the fill above the culvert. Notwithstanding the excessive capital expense required, a normal replacement approach would have been highly disruptive to local residents and commuters.

Once a reline solution was determined to be the most viable option, the initial challenge was to determine if the culvert truly could be relined. The total lineal footage was 470 feet with a 3-degree vertical elbow located 102 feet from the outlet end. It was also critical that the hydraulics checked, including the appropriate passage of the design flows, while a manageable level of outlet velocities was attained. The county decided the best solution was to engage an outside engineer to design and detail a full reline solution. The county also determined a competitive bid approach would provide the most economical construction cost after learning that relining techniques for culverts of this size had become widely known to area contractors.

Ultimately, the consulting engineer, The Wilson T. Ballard Company, decided the best design approach would be a

> **"WE ARE VERY PLEASED WITH THE OUTCOME OF THIS PROJECT. THE FINAL SOLUTION WAS HIGHLY EFFECTIVE."**
>
> **– Brian E. Copley, P.E., Montgomery County DOT**

relining solution that incorporated an 84-inch diameter, 12 gage, aluminized type 2 (ALT2) spiral rib corrugated metal pipe (CMP). This solution would provide the desired Manning's "n" of 0.012 while also extending the service life of the existing host pipe by an estimated 100 years. Aluminum coated steel for CMP was introduced in the mid-1980s and has proven to provide an extensive service life improvement compared to galvanized steel for CMP. This improvement is commonly a factor of three times longer when in the appropriate environment.

During the project scoping and evaluation process, representatives from Contech Engineered Solutions visited the site to help assess the existing culvert conditions. Timber supports were aged and appeared to have been installed during the original construction. This caused some concern as they suspected that the soil prism above the pipe could be variable from a soil arching standpoint. The corroded invert also showed full corrosion failure resulting in inward, rotational movement of the side wall which meant that an applied coating was out of the question and that movement or shifting of the host pipe was possible. Either way, a fully structural rehabilitation method was needed.

The low bidder for the project, Concrete General Inc., Gaithersburg, MD, mobilized its crew and began the preliminary work to prepare the host pipe for relining. During this initial site preparation, a 20 foot long section of the existing culvert shifted downward. Workers were inside that section at the time and the soil arch sheared. As a result of this unfortunate movement in the culvert, the safety of the workers inside of the structure became a much higher risk, and the selected 84-inch pipe would no longer cleanly fit into the host pipe.

At this point, the County needed to reconsider the viable options at their disposal. Given the previously mentioned design considerations, open cut was still out of the question. Instead, they decided to stabilize the pipe with invert paving and box beam frames to temporarily address

Individual sections were assembled inside the host pipe; 5 plates for each pipe ring

Blocking between Tunnel Liner Plate and host pipe ensured worker safety and provided uplift resistance during grouting

the structural concerns, allowing them time to determine another reline option.

After some consideration, they selected Aluminum Tunnel Liner Plate manufactured by Contech Engineered Solutions as the best option. Tunnel Liner Plate offered several advantages over other options. The individual sections can be assembled inside the host pipe and would allow for tunneling through the host pipe if needed. It also provided a safe working environment for the workers as they progressed through the length of the structure. The structural design of the new Tunnel Liner Plate pipe adhered to the AASHTO LRFD design methodology for tunnel liners. The aluminum alloy material is extremely durable. It features a marine grade, 5052 aluminum alloy that has been used in tough culvert environments since the mid-1960s. The heaviest plate weighed only 19 pounds which allowed for easy handling and assembly and quick hand tunneling within the culvert. Each section of Tunnel Liner Plate is 18 inches width, along the centerline of the new pipe. The new pipe rings were made up by five individual plates that feature high efficiency longitudinal seams with offsets in the plate ends. The staggered bolt pattern in the longitudinal seams provided an efficient transfer of bending loads around the ring.

As part of this revised construction plan, exploratory holes were drilled into the host pipe to allow for assessment of supporting backfill which aided in determining when the timber box strutting could be removed. If voids were found, a "U" shaped cut allowed for the host wall to be opened up at the time of the liner plate assembly. These openings were located at the top of the voids and allowed the grout to fill the voids during the liner grouting process.

During the assembly of the Aluminum Tunnel Liner Plate, staging was conducted in a solid area of the host pipe where supports could be removed well ahead of the assembly at this location. Placement of blocking between the Tunnel Liner Plate and the host pipe allowed for immediate transfer of loads to keep the workers safe. The blocking provided uplift resistance during grouting as well. Grout was pumped through the new pipe wall through 2-inch diameter ports utilizing a three-lift grouting plan with a highly viscous, standard grout mix consisting of cement, water, sand and a plasticizer. It had a fluid unit weight of 125 pounds per cubic foot.

Even with the change to a different design, the County was extremely pleased with the outcome in what otherwise would have been a very costly and time-consuming replacement project. Brian E. Copley, P.E. of the Montgomery County DOT, stated, "We are very pleased with the outcome of this project. The unfortunate movement of the host pipe during construction caused a shift in our approach, but the final solution was highly effective."

ABOUT THE AUTHOR:

Hugh B. Mickel, P.E *is the Director of Reline Technologies for Contech Engineered Solutions. He has been with Contech for over 30 years and has 23 years of direct experience relining drainage and sewer pipes, culverts and small bridges. Much of this reline experience was gained while living in Massachusetts and serving as Region Engineer covering New York, Pennsylvania, New Jersey and New England. Hugh holds a B.S. in Civil Engineering from Purdue University and has been a registered Professional Engineer since 1990.*

COLONIAL PINES SEWER - SPAULDING TURNPIKE CROSSING, ROCHESTER NH

Deep Gravity Sewer Crossing of the Spaulding Turnpike (Route 16)

By: Marty Scanlan, P.E., Underground Solutions

The city of Rochester is located in the southeastern part of New Hampshire. Rochester is one of the largest cities in New Hampshire and incorporates over 44 square miles, just a short distance from New Hampshire's famous Lakes Region, White Mountains, and seacoast.

Rochester is engaged in continuous community improvement projects, and one recent project involved the Colonial Pines neighborhood. The neighborhood collected and treated domestic wastewater with septic systems and the City evaluated expansion of public sewer into the neighborhood to replace them. After looking at either a full gravity flow system, or a pumped system, they chose a gravity sewer system to avoid long-term maintenance associated with the pumped system. The primary concern in expanding public sewer to the Colonial Pines residents was their location on the east side of the Spaulding Turnpike, or New Hampshire State Route 16, while the Rochester wastewater treatment plant was located on the west side. A critical first phase to any project required crossing the turnpike.

The City budgeted $2.2M for this first phase of expansion. S.U.R. Construction was the low bidder on the project, but the overall cost was significantly higher than budgeted. Rather than throw out all bids, go into redesign and delay the entire project, the City decided to team with S.U.R. as the low bidder to develop cost saving measures and get the project completed within the allotted budget and schedule.

City of Rochester, NH logo

Steel Casing Installation by ECI using American Augers Boring Machine

TerraBrute® CR PVC Pipe and Rings Before Assembly

Termination of the Gravity Sewer Crossing into a Junction manhole

S.U.R has a history of successful projects in the Rochester area. Jason deWildt, a licensed professional engineer who has been with S.U.R. for the last 10 years, previously worked for the City's Department of Public Works-Engineering Division, first as an intern during college and then for three years after graduating with his Civil Engineering degree from the University of New Hampshire. John Storer, Director of Public Works and Mike Bezanson, City Engineer, were both instrumental in working with deWildt and S.U.R. to develop the scope and design changes needed to bring the project within budget. Per deWildt "We have worked closely with Rochester on many infrastructure projects and we greatly appreciated their confidence to team with us to meet their allotted budget for this critical, time sensitive project." In addition to reducing costs on the project, S.U.R. worked hand in hand with the City of Rochester's Department of Public Works to secure the necessary Encroachment Permit and Use and Occupancy Agreement from NHDOT required to move forward with the project.

The original design called for 12-inch Class 52 ductile iron pipe to be inserted into a steel casing under the turnpike. Due to the necessary grades of the gravity sewer, the steel casing was to be installed 25 feet under the roadway using jack & bore methods. This segment of the sewer would then be connected to PVC gravity sewer pipe on either side of the crossing. After consulting with Don Proulx of EJ Prescott, deWildt proposed a substitution of the ductile iron pipe with a restrained joint PVC pipe inside the casing. The restrained-joint PVC product chosen was 12-inch TerraBrute® CR PVC pipe, a mechanically restrained PVC pipe. It contains no metallic components to corrode, could be easily cartridge

assembled in the jack & bore excavation next to the steel casing, and Rochester had successfully used TerraBrute® CR PVC pipe to cross under a number of on-ramps for the Turnpike.

TerraBrute®CR is made to the AWWA C900 pressure PVC pipe standard and is assembled using a bell and spigot type connection with a full profile gasket. Additionally, it has an extended lip on the bell end, which contains holes, and these holes accept pultruded fiberglass pins that are inserted through the extended bell and engage a groove that has been cut into the spigot end of the adjoining pipe length. The result, after the pins have been engaged, is a fully restrained joint that is capable of being pushed or pulled into the steel casing. The pipe comes in standard, 20-foot lengths, similar to unrestrained bell and spigot PVC pressure pipe and can be assembled as it is inserted into the casing, eliminating the need for extensive assembly or layout areas.

S.U.R. subcontracted with Engineers Construction (ECI) to perform the challenging 428-foot jack & bore of the steel casing under the Turnpike. The 25-foot depth required extensive dewatering for both the jacking and receiving pits on either side of the highway. S.U.R. and ECI have teamed together on numerous projects and complement each other's skill sets.

The project was successfully completed in the fall of 2017, with the new gravity line installed and ready for the next phase of construction. Per Mike Bezanson "We greatly appreciated the efforts of S.U.R. to work closely with us on this critical first phase to provide city services for the Colonial Pines residents".

With the first phase of their gravity sewer expansion completed, Rochester can now focus on extending sewer service to the 200+ homes in the Colonial Pines neighborhood. It is anticipated that additional funds will be appropriated and construction will be phased in over the next few years.

Underground Solutions®
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ABOUT THE AUTHOR:

Marty Scanlan *is VP of Sales for Underground Solutions and manages RSM and RSE sales activity in the Eastern and Central time zones. Marty is an experienced engineer in the municipal field with a strong sales and applications engineering background with 12 years of experience at Underground Solutions. He holds a BS in Chemical Engineering and is a registered Professional Engineer in the state of California. He formerly worked as Technical Sales Manager for Siemens - RJ Environmental and has over 25 years of experience in the municipal field designing, marketing and selling capital equipment and pipe systems.*

COMMUNICATION IN TRENCHLESS PROJECT EXECUTION

By: Babs Marquis, McMillen Jacobs Associates

INTRODUCTION

This article discusses the importance of communication in the construction of trenchless projects. In the process of managing trenchless projects during its life cycle, the project team structure must incorporate leadership, personalities and trust developed amongst the team members. Often, different leadership styles and individual personalities continue to influence and dictate how decisions, concessions and conflicts are resolved during the advancement trenchless projects. As trenchless construction methods continue to evolve, leadership, management styles and methods we use to communicate project concepts through design to construction phase equally needs to transform between the Owner, the Engineer, and the Contractor.

Trenchless construction projects involve installation or rehabilitation of pipelines below grade by methods that do not require extensive open cut trenching. Trenchless construction methods are used to install new pipelines, replace existing pipelines, rehabilitate a failing pipeline or upsize an inadequate pipeline system. The various methods of trenchless installation of pipelines include microtunneling, pipe-jacking, horizontal directional drilling, pipe bursting, slip-lining, cured-in-place pipe and other variations of the above mentioned methods. This article provides an observational account of a project team's working relationships during design and construction; with more emphasis on the construction phase.

THE PROJECT TEAM

Designed to address an owner's existing infrastructure challenges or to expand the reach of an existing system due to growth, health and environmental needs, trenchless construction projects can range from a hundred foot roadway or river crossing to several thousand feet of utility pipeline installation. Whatever the reason is to compel a project's requirements, it requires pipeline installation, rehabilitation or replacement of pipelines below grade often in an urban setting, where, due to social, economic and environmental impacts, open cut trenching installation is not practical. Based on the Project Owner's objectives, pipeline alignment, size, depth, subsurface conditions, permitting requirements and the ability to fund the project, the Project Owner assembles a project team to formulate the project and develops a series of alternative concepts in which the project design and construction scope evolves.

As these project team relationships develop, the ideas and concepts that emerge translate into a series of instructions and communications to the prospective bidders in the following forms of documents: General conditions, subsurface investigations and baseline reports, Specifications and drawings. These documents outline the project design scope, contractual and technical terms for constructing the project in exchange for a bid price from the most responsive bidder.

In defining the roles for communication and cohesion required

ALTHOUGH TRENCHLESS CONSTRUCTION PROJECTS ARE UNIQUE DUE TO EVOLVING CONSTRUCTION METHODOLOGIES, THE ADMINISTRATION IS NO DIFFERENT WHEN COMPARED TO OTHER CONSTRUCTION PROJECTS.

for the execution of trenchless construction projects, the author defines the project team as:

"Contractually bound collection of individuals (owners, engineers and contractors) with diverse backgrounds, skills, and personalities working together to achieve a common project objective within a specified time frame (schedule) and budget."

Initiated by the Project Owner, the project team evolves through three major periods in the project life cycle - namely:

- Conceptual and planning phase
- Engineering and design phase
- Execution/Construction phase

The working relationship within each of these phases along with a description of the project team structure, the protocol for information dissemination and correspondence management are discussed in the sections that follow.

UNDERSTANDING CHANGES IN PROJECT TEAM BUILDING

Level I: Team Building Relationship – Conceptual and planning stage

Without getting into the details of how to assemble this early

THE OPERATIVE TERM AT THE ROUND TABLE SHOULD START WITH "WE"...

project team, it is safe to assume the rapport developed during this early stage of the project is non-adversarial, generally collaborative, rational and practical. Individuals representing the Project Owner and consultants (engineers, scientists, planners etc.) work together over an extended period to develop a workable design concept that can be permitted and funded. The structure and mode of communication at this first stage is generally based on a mutual trust and understanding that the project team is working towards a common objective. The results from this collaborative planning effort allows the owner to define the scope for the next stage of project development and project team building in the form of Request for Proposal / Qualification (RFP/Q) for engineering services.

Level II: Team Building Relationship – Engineering and Design Stage

The project owner and consultants continue to develop the project through a working team relationship to get the project advanced through engineering design stage to "Bid ready" Contract Documents. Depending on the magnitude and complexity of the project, Levels I and II project team stages typically extend from one to several years.

Many of the issues that can add to the complexities of the project during design includes subsurface utility conflicts, the required level of permitting and the extent of subsurface studies required.

Subsurface exploration (study of the ground) often is the most significant undertaking and likely the most contentious aspect of the design development. Frequently subsurface exploration activity continues through to construction execution stage. Knowledge and understanding of subsurface conditions determines the appropriate trenchless method for the project, the appropriate excavation equipment and tooling and the necessary ground support at the entry and exit sites. Similar to the Level I project team structure and working relationship, in Level II, the owner and consultants interact and communicate with a greater level of trust and understanding while working towards a common project objectives.

At the completion of the Level II project team stage, the resulting product includes:

- Specifications
- Contract Drawings
- Soils reports including geotechnical data reports, a Geotechnical Baseline Report and other documentation that may or may not become part of the contract documents

These documents are expected to provide clear and concise sets of instructions and guidelines for the successful bidder to execute and construct the project as designed, on budget and on schedule. For the most part, these sets of documents also dictate and

provide the process and procedure for resolving challenges and unanticipated issues that may arise during construction.

Level III Team Building Relationship – Execution / Construction Stage:

At this point, the final relationship develops through what the industry refers to as "competitive bidding environment". With the introduction of a new team member (the Contractor), the dynamics of the team in Level III stage of the project tend to differ significantly from the non-adversarial relationship presented for Levels I and II. The level of trust amongst the team tends to diminish soon after issuing the Notice to Proceed (NTP). Quite predictably, the Owner and the Engineer, who have developed a longer working relationship and consensus on issues while the Contractor who joins the team with the benefit of a responsive low bid appears as an outsider that must earn its place with the team. The newly inducted member to the Project must earn its place and build confidence with the already settled team of Owner and Engineers that have developed a long working relationship at this point of the Project.

It is noteworthy to identify some of the key players that play a critical role in construction communication - the Resident Engineer(s) and Resident Inspector(s) (RE/RI). These individuals are the owner's on-site representatives; they administer the contract on the owner's behalf when the project enters into the construction phase. The RE's function as the contract administrator who is the interface between the contractor, the engineer and the owner. The RE is responsible for managing the flow of information and project records (technical and contractual) in accordance with the contract documents. In addition, the RE's role can extend into arbitration when the Contractor's understanding of a contract requirement differs from that of the engineer. The personalities, communication and negotiation skills for these individuals all come into play in the team's ability to resolve issues in a timely and amicable fashion.

CONCLUSION

Although trenchless construction projects are unique due to evolving construction methodologies, the administration is no different when compared to other construction projects. When the project team works together with the understanding that they all share a common project objective, the challenges that arise are best resolved with the tools and provisions within the contract document along with skillful leadership, communication and negotiation skills. While the author recognizes that owners and engineers are meticulous in the design of trenchless projects and that majority of the trenchless specialty contractors make their best effort to deliver projects as designed, within budget and on schedule, the human aspect (temperament) of the working relationship during construction is just as crucial as the use of the contract document. The human aspect of team cohesion and working relationships on trenchless construction projects requires ongoing attention and continuous development. The use of a large conference room and a round table for pre-construction kick off meeting takes away the opposite side appearance of "them and us". The operative term at the round table should start with "We" encouraging the team to adopt a positive working experience during construction.

ABOUT THE AUTHOR:

Babs Marquis *is Construction Manager with McMillen Jacobs Associates in Burlington, MA. He provides microtunneling oversight CM services in the Northeast. For the past 19 years, he has focused on underground construction management for tunnels and conveyance including water and wastewater pipeline design and construction projects, with emphasis on trenchless construction methods. Babs is Vice Chair of the NASTT-NE Chapter, and current member of the NASTT Board of Directors.*

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