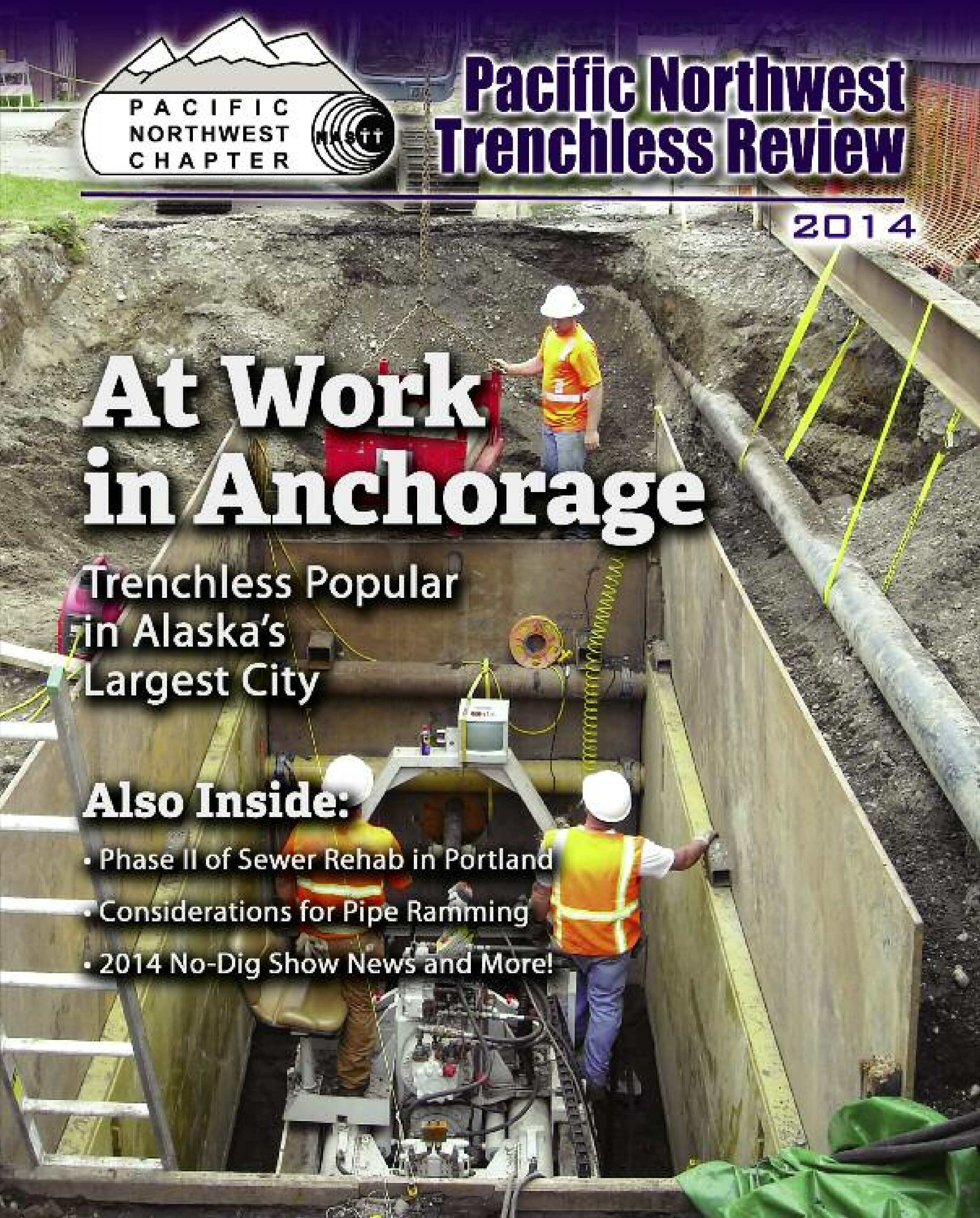
Pacific Northwest Trenchless Review

PACIFIC NORTHWEST CHAPTER NASTT

2014



At Work in Anchorage

Trenchless Popular in Alaska's Largest City

Also Inside:

- Phase II of Sewer Rehab in Portland
- Considerations for Pipe Ramming
- 2014 No-Dig Show News and More!

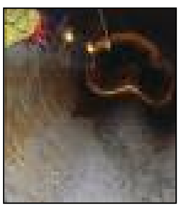

TOUGH. TRUSTED.
TRENCHLESS.
STATIC PIPE BURSTING
FROM 30 TO 175 TON MACHINES
PNEUMATIC PIPE BURSTING
SYSTEMS FOR BURSTING PIPE UP TO 36"
PIPE RAMMING/HDD ASSIST
INSTALL STEEL CASINGS, RESCUE STUCK HDD BORES AND MORE!
LATERAL PIPE BURSTING
REPLACE 4 & 6" LATERALS
HYDROGUIDE® WINCHES
FOR BURSTING AND LINING APPLICATIONS
HAMMERHEAD
HammerHead, a leader in unique answers for underground utility installation and replacement since 1989. Genuine HammerHead Trenchless equipment is available only at your authorized dealer.
FIND YOUR LOCAL DEALER AT HAMMERHEADTRENCHLESS.COM OR CALL +1 262.567.8833.
MOLING | RAMMING | BURSTING | HDD ASSIST | WINCHES | LINING

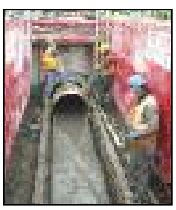
Pacific Northwest Trenchless Review

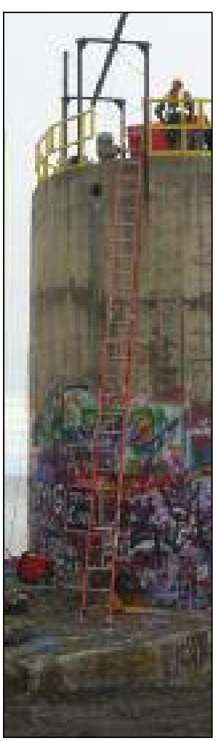
PACIFIC NORTHWEST CHAPTER NASTT

WINTER 2014

Featured...







Also...

COVER PHOTO: Stephl Engineering LLC

Published by:

PTR COMMUNICATIONS INC.

Unit 1 – 73 Fontaine Crescent
Winnipeg, Manitoba
Canada R2J 2H7

President
Elaine Chouinard
204.255.6524
elaine.ptrcom@mts.net

Editor
Mike Stimpson
204.231.4707
ptrcommike@gmail.com

Advertising Sales
Andrew Pattison
204.275.6946
ptrcom@shaw.ca

Arlene Nowicki
204.505.0040
nowickia@shaw.ca

Bert Eastman
204.997.6371
ptrcom@outlook.com

Layout & Design
Lunch Pail Productions
204.237.6611
lunchpailproductions@shaw.ca

PTR Communications Inc.
Unit 1 - 73 Fontaine Cres.,
Winnipeg, Manitoba
Canada R2J 2H7

Printed in Canada 12/13

An Exciting Year Ahead

Christopher Price

It was quite a busy 2013 for trenchless construction in the Pacific Northwest. The year began auspiciously with our two-day biennial Pacific Northwest Trenchless Symposium in late January. The Cedarbrook Lodge played host to a record crowd with 40 students of the NASTT New Installations Short Course followed by a full day of presentations and exhibits with over 70 people in attendance.

Leaders of every facet of our industry were represented, and the feedback afterward was extremely positive. I would like to take this opportunity to express my sincere thanks to the exhibitors that helped fund the event, and a very special thanks to the speakers who agreed to invest their time and energy into making our symposium a success. The presentations and thought-provoking discussions were well received and promoted an atmosphere of shared experience and education that is invaluable.

While the next symposium will not be held until 2015, the PNW Chapter of NASTT will hold a trenchless luncheon in 2014 to continue our efforts to expand membership and promote trenchless technology throughout the region.

The 2013 No-Dig Show in March was a resounding success. Innovations in trenchless equipment, methods, and projects were highlighted with Sacramento serving as an exciting backdrop. Most of you reading this have attended past No-Dig Shows and know their value; however, if you have never had the opportunity to attend, I cannot overstate the intensive educational experience that No-Dig has become. The 2013 edition saw the first-ever implementation of a Municipal and Public Utility Scholarship in which applicants from municipalities, government agencies and utility owners with limited or no travel funds were selected and awarded full conference registrations including overnight accommodations. Aided by a donation from the PNW Chapter, our region saw more than a dozen individual scholarships awarded to attend the 2013 No-Dig Show. The scholarship proved so successful that it is being continued for the 2014 No-Dig Show in Orlando, Florida, April 13-17.

As 2013 winds down and 2014 gets into full swing, I look forward to the challenging projects on the horizon. The trenchless industry continues to provide ever-innovative solutions to meet increasingly complex project demands. New technologies, refined installation methods, increased engineering capability, and clearer risk comprehension promise to advance our industry forward as we face an evolving need for trenchless technology. In this issue of the Pacific Northwest Trenchless Review, several projects demonstrate the varying capabilities and application of trenchless methods in our region. I encourage you to contact the authors with questions and to get involved with our local Chapter of NASTT to learn about the myriad trenchless solutions that are available.

Without a doubt, 2014 will prove to be another banner year for the Pacific Northwest Chapter. We are excited to welcome new members to join us. For more information and to stay informed of current and upcoming events, please visit our website at www.pnwnastt.org. I look forward to seeing you at the 2014 No-Dig Show in sunny Orlando. Please feel free to contact me for more information at chris@stahelitrenchless.com or (425) 205-4930.

A special thanks to Laura Wetter for her continued efforts as editor-in-chief of the Pacific Northwest Trenchless Review. Without her commitment, this publication would not be successful.

Regards,
Christopher Price
Chair, NASTT PNW Chapter

Volunteers Make it Happen

Derek Potvin - NASTT Chair

Our Regional Chapters are vital to the success of the society and the industry. The Pacific Northwest chapter is home to many of our important volunteers that make us what we are, and I appreciate you giving me this opportunity to recognize and thank some of those dedicated industry leaders.

NASTT members have been hard at work this summer and fall planning for the future of the society. In August we launched a membership-wide survey gathering feedback on the current state of NASTT and how we can enhance our service to the trenchless industry. We hope you were able to participate in this online survey and give us your feedback on our efforts and initiatives.

Once the surveys were completed and the data was gathered, a committee of your peer members met to discuss the findings and outline a Strategic Plan for our future. Your fellow Pacific Northwest chapter member, Kimberlie Staheli, is a valuable member of this volunteer committee. Thank you for helping us with this important endeavor, Kim!

NASTT is all about education, and it is our fine volunteers that help make this happen. We were fortunate to have many Pacific Northwest representatives on the Program Committee and the Auction committee at NASTT's 2013 No-Dig Show held in Sacramento, California in March. In addition, industry expert Kimberlie Staheli volunteered to be one of the instructors for the New Installation Methods Best Practices Post Show Course. We appreciate the instructors and committee members coming in early or staying after the conference to make these special educational seminars available to the trenchless industry.

Many members also volunteered as session leaders during NASTT's No-Dig Show. We appreciate the following Pacific Northwest chapter members for their dedication: Jack Burnam II, Steven Donovan, Rick Hanford, Kimberlie Staheli and Laura Wetter.

NASTT has successfully partnered with other organizations including the American Gas Association (AGA), Benjamin Media and the American Public Works Association (APWA) to bring our Best Practices courses around the country. NASTT's New Installations Short Course was offered at APWA's annual conference in Chicago this past August. The course was presented by Pacific Northwest instructor Kimberlie Staheli along with Don Del Nero.

The Pacific Northwest chapter will also be represented at NASTT's biggest fundraising social event of the year, the 13th Annual Educational Fund Auction and Reception. Pacific Northwest member, Anna Porter, is a volunteer for the Educational Fund Auction Committee. Since its inception, the auction has raised over $600,000 for NASTT's educational initiatives. The 2014 auction is expected to be another huge success!

Thank you so much to all the Pacific Northwest chapter volunteers. We appreciate your dedication to NASTT and to the growth of the trenchless industry. If you would like to join these industry volunteers on a committee, please let us know!

Sincerely,
Derek Potvin
NASTT Chair & International Representative

NASTT Pacific Northwest Chapter
Board of Directors

Director
Yuxin (Wolfe) Lang
Shannon & Wilson, Inc.
Lake Oswego, Oregon
(503) 210-4772
ywl@shanwil.com

Chair
Christopher Price
Staheli Trenchless Consultants
Bothell, Washington
(425) 205-4930
chris@stahelitrenchless.com

Secretary
Matthew Pease
Staheli Trenchless Consultants
Bothell, Washington
(425) 205-4930
matt@stahelitrenchless.com

Director
Brandon Simonds
Trenchless Construction Services
Arlington, Washington
(360) 474-0123
bs@trenchlessconstruction.com

Vice Chair
Chris Sivesind
Akkerman
Brownsdale, Minnesota
(507) 567-2261
csivesind@akkerman.com

Treasurer
Richard Hanford
Hanford Geotechnical Services
Ridgefield, Washington
(360) 487-9393
hanford.richard@gmail.com

Immediate Past Chair
Erik Waligorski
Stantec Consulting
Bellevue, Washington
(425) 869-9448
erik.waligorski@stantec.com

'Spreading the Word'

Chair Says Chapters Are Heart of NASTT

PTR Communications

If you've been to the NASTT No-Dig Shows in the last 15 years, you've probably met Derek Potvin. NASTT's new Chair has been a regular at No-Digs, including the 2013 edition in Sacramento, California.

Potvin, previously Vice-Chair of NASTT, has been an active member for more than 15 years. He's President of Ottawa-based Robinson Consultants Inc. and also Treasurer of NASTT's Great Lakes, St. Lawrence and Atlantic (GLSLA) Chapter. No-Dig Show veterans may recall one or more of the many papers he has authored for the annual event, including one that won an award for Outstanding Paper.

He has seen trenchless technology progress considerably since attending his first No-Dig Show in 1995. "Initially, trenchless was seen as revolutionary and unique," he recently told Trenchless International magazine. "However, it is now viewed as a responsible and progressive approach to infrastructure construction and renewal. In my area, almost all clients are now using trenchless technology in their everyday work programs."

We spoke with him briefly in Sacramento and later exchanged emails to get the new Chair's views on NASTT, its Chapters and the future of trenchless.

First up: What motivates Derek Potvin to stay active within the NASTT organization and the GLSLA Chapter? The first source of motivation he mentioned is "the belief that trenchless technologies benefit society by minimizing disruption to residents and businesses, limiting impact to the natural environment, offering potential cost savings and reducing greenhouse gas emissions." He also mentioned the "overall dedication and volunteer spirit of the organization," and said it is "exciting to be part of an organization that is supporting something we are truly passionate about. The spirit of the organization makes it easy to volunteer time."

Derek Potvin is Chair of the North American Society for Trenchless Technology

"We are pushing forward in educating people about trenchless technology," he added. "Seeing the success and advances over the years is very rewarding and motivating. Now that I am Chair, I am privileged to have the chance to guide something I have been a part of for so long. This too, is very rewarding. "

Asked about his objectives as NASTT Chair, he pointed out that assistance from Regional Chapters is vitally important. Among his key objectives is advancement of NASTT's "exceptional educational lineup," including the Webinar series, Good Practices seminars and Trenchless Technology Short Courses. He wants to see NASTT expand the Trenchless Bookstore and pledges NASTT's support of Chapters by offering local training.

Potvin wants to see awareness of trenchless technology increased by developing relationships with other industries. "We are already committed to providing training to the American Public Works Association, the American Gas Association, the Alberta Water and Wastewater Operators Association, the Atlantic Canada Water and Wastewater Association and the Association of Equipment Manufacturers, and we are currently discussing training opportunities with other associations," he noted.

He also mentioned a desire to further

the success of the Municipal and Utility Scholarships and said NASTT encourages its members in Regional Chapters to talk to non-member colleagues about the benefits of joining. Having more members will improve NASTT's ability "to reach out to even more municipal and utility owners and an even broader audience," he said.

"NASTT's Carbon Calculator is nearing completion of Phase II, which will offer a web-based user-friendly version of the software," he remarked. "This is a standalone NASTT initiative, and a Phase III training module is being contemplated."

Asked to describe the relationship between NASTT and its Chapters, he emphasized that "Chapters are the driving vehicles of NASTT's mission to provide trenchless technology education and training." The Chapters and NASTT – the organization as a whole – must work together for the key objective of increasing awareness of trenchless technology. Potvin said the Chapters have shown dedication to that objective with their successful work in education and training.

"Chapters' assistance at the grassroots level is vitally important, and it is their enthusiasm and dedication which really makes NASTT a successful organization," Potvin declared. "Chapters encourage peers, colleagues, members and non-members to participate in NASTT, whether it is at Regional Chapter events, with the student chapters, or via a subcommittee."

The Chapters' work is mainly about "spreading the word," he said, and they're "already doing a tremendous job promoting trenchless technology. Many Chapters have a great lineup of seminars and workshops available. Our Chapter functions reach out at the grassroots level to our members and potential members. The future of our industry involves each of us doing our part in educating people about the benefits and capabilities of trenchless technology."

It's important that trenchless technology education and training be accessible, and Chapters help with accessibility by holding local and regional events that people can get to. In a similar vein, Potvin said "NASTT has found that our complimentary webinars are a great success because the participants have no travelling cost. It allows more members and prospective members to participate in our education initiatives."

NASTT and its chapters are in a partnership to advance understanding and awareness of trenchless technology.

NASTT is always looking to grow the benefits of membership, which in turn enhances benefits for all members. "NASTT is continually updating and improving existing courses, developing new courses, preparing new publications and offering courses in new formats such as webinars," Potvin said. "These education initiatives greatly benefit the joint NASTT and Regional Chapter mission to educate and promote the benefits of trenchless technologies. New initiatives such as the Municipal and Public Utility Scholarship program will allow more Chapter members to attend the annual NASTT No-Dig Show."

NASTT Executive Director Mike Willmets, Communications and Training Manager Michelle Hill and Board members will attend Chapter functions and events to support education initiatives or to discuss what NASTT has to offer its membership, he said.

Potvin said Regional Chapter magazines such as this one are "a place to show new technology and share the successes of trenchless technology. They also promote local and national education seminars, webinars, conferences, etc. They are a great outlet of education and information for the trenchless community and even those interested in learning about trenchless technology. They also allow for the showcasing of regional trenchless projects and local industry champions."

The Chapters those magazines serve are hubs where people "share ideas, network with colleagues and find solutions to trenchless questions," he said. "The great thing about the Chapters is that everyone is so passionate about trenchless technology and is very willing to share their knowledge and inform others about the benefits of the technologies. NASTT really profits from all of the Chapters' contributions."

He underscored the importance of Regional Chapters when he was asked for concluding thoughts in our conversation: "We must thank our Chapters as NASTT's strength evolves from a Chapter-based level, and it is that volunteer spirit that really makes it a successful organization."

Massive Sewer Rehabilitation Program in Portland, Oregon

Steven Burger, P.E.
Ayda Forouzan, P.E.
Scott Gibson, P.E.
Colleen Harold
John Houle, P.E.
Jill Hutchinson, P.E.

Bureau of Environmental Services, City of Portland

In trying budget times, the City of Portland's Bureau of Environmental Services (BES) requested a major reinvestment in sewer infrastructure via the Phase II Sewer Rehabilitation Program. The request was granted, and now it is imperative that BES deliver. The signs of successful delivery include the reduction and prevention of sewage releases to the environment and citizens' basements, and the reduction and prevention of sinkholes (which represent a risk to the traveling public and result in major repair projects). Inherent in the authorization for Phase II spending is the belief that the program will ultimately save ratepayers money. A smaller-scale Phase I program, recently completed, was instrumental in this Phase II program.

PLANNING & DEVELOPMENT

BES has two goals for its risk and cost-benefit analysis process. First, given $7.4 billion in pipe assets, identify the pipes likely to fail. Despite the current $123-million Phase II budget, selectivity is paramount. Using likelihood-of-failure and consequence-of-failure ranking, BES identifies which pipes should be replaced prior to failure and which should be run to failure.

Second, BES needs to determine whether pipes should be spot-repaired, fully replaced or rehabilitated, or added to a "watch list." Assets in the current Phase II plan include $14 million in spot repairs, $138 million in whole-pipe replacement/rehabilitation, and $174 million in "watch list" pipes.

Allocating a probable course of action to each eligible pipe helps leverage repair dollars. For example: analysis indicates the $14 million in spot repairs defers $307 million in whole-pipe replacement for the foreseeable future.

The likelihood-of-failure and consequence-of-failure ranking system mentioned above generates maps depicting pipes that are color-coded according to their cost-benefit ratio (CBR) (see Figure 1). A city-wide map was used to create the Phase II Program, which is the umbrella plan for 16 priority-based construction projects (approximately $70 million contract value) (see Figure 2). The projects are prioritized based on average CBR of the identified whole-pipe replacements. In practice, it is necessary to balance rehab need and timely project delivery. For example, the prioritizations of some projects have been reduced while supplemental CCTV inspection data is acquired.

Initially, geographic boundaries were intended to serve as project boundaries for Phase II projects. However, program planners soon discovered the art of project "packaging": collecting asset management planning-level information and forming manageable, biddable and buildable capital improvement projects. The goals of the project-packaging strategy are twofold: first, to match the capacity of the local and regional contracting community and capture efficiencies-of-scale in contract prices and administrative costs (contractors tend to bid lower on larger projects, and a large pool of bidders tends to yield lower bids). BES attempts to advertise packages that consider these two factors equally. The second goal is to best manage impacts to the community (i.e., the location, duration, frequency and level of construction disturbance/disruption).

Example project-packaging guidelines:

- $3-5 million contract value (cap eventually increased to $10 million).
- Similar rehabilitation/replacement methods and construction constraints. (For example: If a project is 12,000 feet of small-diameter open-cut construction, avoid including 200 feet of 48-inch auger bore.)
- Reasonably tight geographical boundaries.

Figure 1 – Closeup View of Map Color-Code According to Cost-Benefit Ratio

DESIGN CONSIDERATIONS

BES has experience with a wide range of trenchless technologies including cured-in-place pipe (CIPP), sliplining, pipe bursting, pilot tube microtunneling (PTMT), bore and jack, and horizontal directional drilling (HDD). Trenchless technologies are the best solution when businesses and homeowners are greatly concerned about the impacts of traditional, more invasive techniques. They are also the most appropriate method for environmentally sensitive areas. BES staff consider a host of variables when designing Phase II projects and seek to design the most efficient, economic, and constructible projects.

The type of soil in a project area is one of the most important factors when considering open-cut versus trenchless methods. BES's Materials Testing Lab performs geotechnical services – including boring logs, lab test data, and recommendations from geotechnical engineers – to help designers characterize subsurface conditions and choose the most appropriate construction method.

Trenchless technologies are proven to be safer in caving grounds and areas with a high water table. High water tables also increase the risk of sloughing and trench widening, and are associated with elevated dewatering and trench support system costs for both sewer and nearby utility trenches. Given the above underground conditions, BES has found trenchless technologies to often be the less disruptive and more economical choice.

As mentioned above, when properly applied, trenchless methods can eliminate the risk of damage to nearby utilities and save money and time on surface restoration. Minimizing trench resurfacing and reducing damage by excavation equipment extends the life of existing pavement, another of the City's important assets. Trenchless methods have been applied to several Phase II projects where the geotechnical investigations show a high risk of trench cave-in leading to failure of adjacent utilities and pavement failure.

During construction, bypass pumping for laterals can become complicated when lengthy sewer shutdowns are required for trenchless methods. In one recent CIPP project, the City reminded the contractor that bypass pumping was part of the contract; the contractor installed Vac-a-Tees on each and every service lateral to achieve bypass in areas where longer cure times were required (due to large pipe size) and sewer shutdowns could not be coordinated with homeowners.

In this same project, two 36-inch pipes (each approximately 250 feet long) were lined and cured concurrently; the contractor steam-cured one main and water-cured the other and indicated both pipes would require 12 hours to cure. Equipment malfunctioned due to the pressure required to cure the thick liner, and it ended up taking approximately 48 hours for the first main and 18 hours for the second. After construction, the contractor claimed the City was responsible because of asking for such a thick liner. In this particular case, sewer shutdown was required, so the City provided per diem stipends for each resident whose home was directly connected to the pipe so they could leave their homes for up to three days. The stipends accounted for accommodation (i.e., hotel room) and food, and the residents were given the dates for which they needed to vacate their homes.

Figure 2 – City-Wide Cost-Benefit Ratio Map

SUSTAINABLE PRACTICES

The City of Portland is recognized as a community leader in the implementation of sustainable practices and programs. BES supports these city-wide practices, and the Project Delivery Team ensures that the Phase II Rehab Program contributes to these efforts by evaluating all aspects of project delivery for the consistent application of sustainability principles.

The Healthy Purchasing Initiative is mandated by the City's 2006 Toxic Reduction Strategy, and the Overlook Sewer Replacement Project is the first Phase II project to incorporate the Initiative's "Health Product Declaration" questionnaire into its project documents. Pipe manufacturers are required to complete the questionnaire per project contract documents; it provides information about the base components of the pipe, as well as their known associated health hazards. Information collected through the questionnaire will enable the City to make better-informed decisions about materials or manufactured products used on this and other City projects.

The Phase II program fund was also used to fund a technical literature review by a local consulting firm. The report, titled "Environmentally Preferable Product Review of Sewer Pipes," researched and compiled existing information regarding the environmental, human health, and social/labor impacts of three pipe types over their respective life cycles, from the production of raw materials and the manufacture of the pipe itself, to the end use of the pipe, and through to the end of its life.

CONCLUSION

Phase II is challenging the City of Portland's Bureau of Environmental Services to deliver its largest-ever sewer rehabilitation program. BES is seizing this opportunity to improve asset management processes for today and the future, which has led to program goals that may be a useful model for other municipalities. This work has influenced and impacted every aspect of the way BES approaches rehabilitation and replacement of sewers. The increased scope and scale of the projects in Phase II it have forced us to be more efficient and innovative out of sheer necessity, and to be willing to change while remaining consistent. From BES Process Standardization, to plans, specifications and even sustainability, this Phase II work has allowed us many meetings with healthy discussions, and finally resolution and clear direction to staff and stakeholders as to how to successfully proceed on all levels of delivery.

Examining Pipe Ramming Design:
A Forensic Analysis of a High-Risk Project

Christopher Price
Staheli Trenchless Consultants
Kimberlie Staheli, PhD, P.E.
Staheli Trenchless Consultants

There is little design guidance available to engineers utilizing pipe ramming as a project solution. In general this gap has been effectively bridged with conservative designs based on rules-of-thumb and previous experience. However, as projects become more complex it is incumbent on designers to develop a comprehensive and economical design solution. To this end, key elements of pipe-ramming design are illustrated using two case histories. Both pipe rams were contractor-designed and exhibited identical modes of failure.

Two road crossings were bid as a trenchless crossing with performance specification, allowing the contractor to design the trenchless project. Both crossings were approximately 300 feet long; however, the capacity requirement dictated one 120-inch casing and one 144-inch casing. The soil conditions for the crossings were nearly identical, consisting of fill placed over the native glacial till soil deposits. This created a soil profile of relatively loose fill material consisting of sand, silt, wood and other fill debris overlying a dense to very dense glacial till.

The 144-inch casing installation advanced 135 feet before progress slowed in the last foot of installation and eventu-

Figure 1. Deformation of Pipe

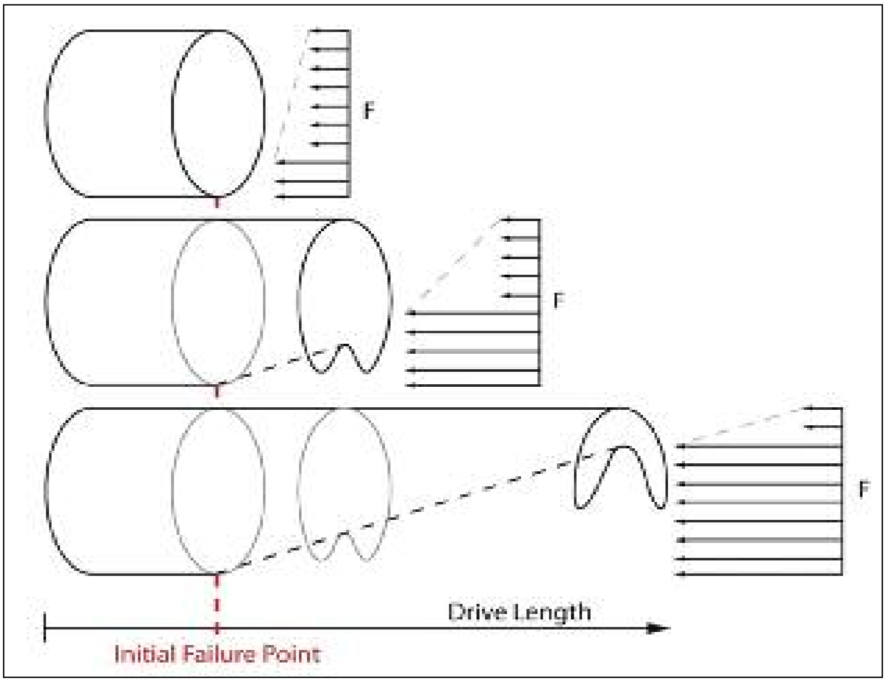


Figure 2. Illustration of Differential Stress

ally resulted in refusal of forward movement. After removing the hammer and excavating the material inside the casing, deformation was observed for the leading 70 feet of the casing. The deformation of the pipe began at the bottom center of the pipe and continued to increase vertically until the bottom of the pipe met the crown (see Figure 1). Based on the 70-foot length of damaged pipe, the pipe started to deform when it was approximately 65 feet past the insertion ring.

When ramming the second crossing, although there was no indication of damage, ramming was stopped after approximately 105 feet of advance to excavate within the casing and verify that the pipe was not being damaged. Unfortunately, the excavation operation exposed a damaged pipe. Approximately 35 feet of pipe was deformed at the invert. The deformation began at the bottom center of the pipe and continued to increase vertically until the invert met the crown, as in Figure 1. Based on the 35-foot length of damaged pipe, the pipe started to deform at approximately 70 feet past the insertion ring. Though the pipe failure manifested in the same fashion as on the previous crossing, there was no obvious evidence for the cause of failure for either crossing.

Investigation at the initial points of failure consisted of cutting out sections of the deformed inverts to expose and excavate the immediately surrounding material. This investigation revealed that there were no drag marks or voids created by displaced objects being pushed in advance of or being dragged along by either pipe, that the exterior material was dense glacial till consistent with that described in the contract documents, and that no evidence of wood or rock fragments was found in the glacial soils. In both crossings, the leading cutting shoe failure had occurred and simply progressed to a point of total collapse.

The modes of failure for both pipe crossings are identical, as are the initiating circumstances. At both crossings, the pipes were rammed through a dense glacial till layer at the pipe invert with loose to medium dense fill soils at the crown. This created an unbalanced load distribution on the pipe with a stress concentration at the invert, illustrated in Figure 2. To ram the pipe successfully, it was necessary to design a leading pipe segment that was sufficiently stiff to withstand the

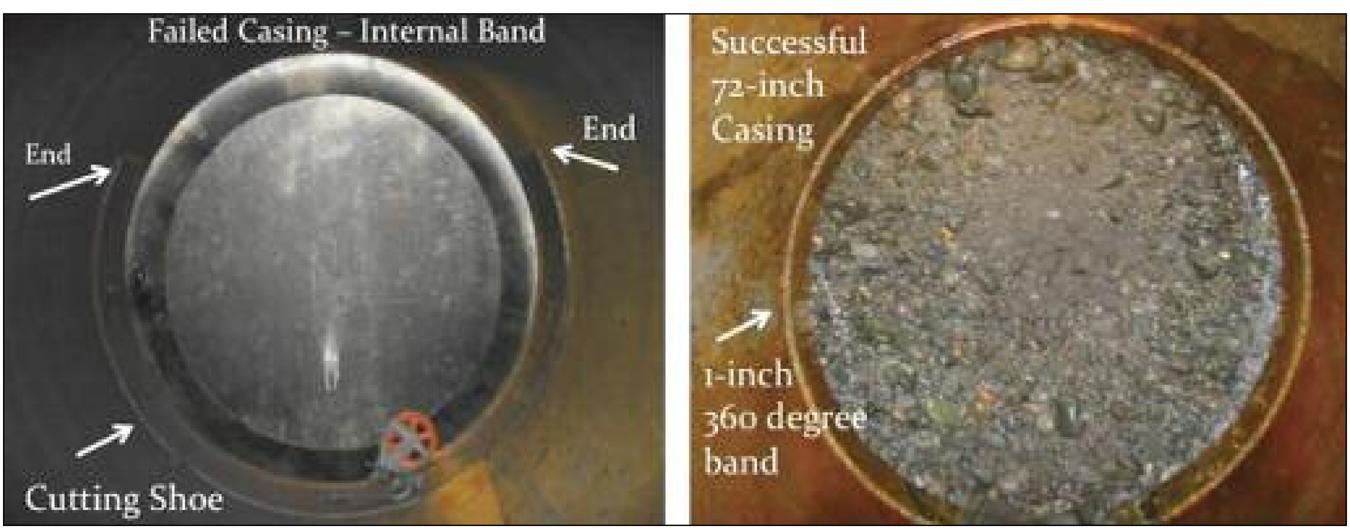


Figure 3. Partial Internal Banding (left); Full Internal Banding (right)

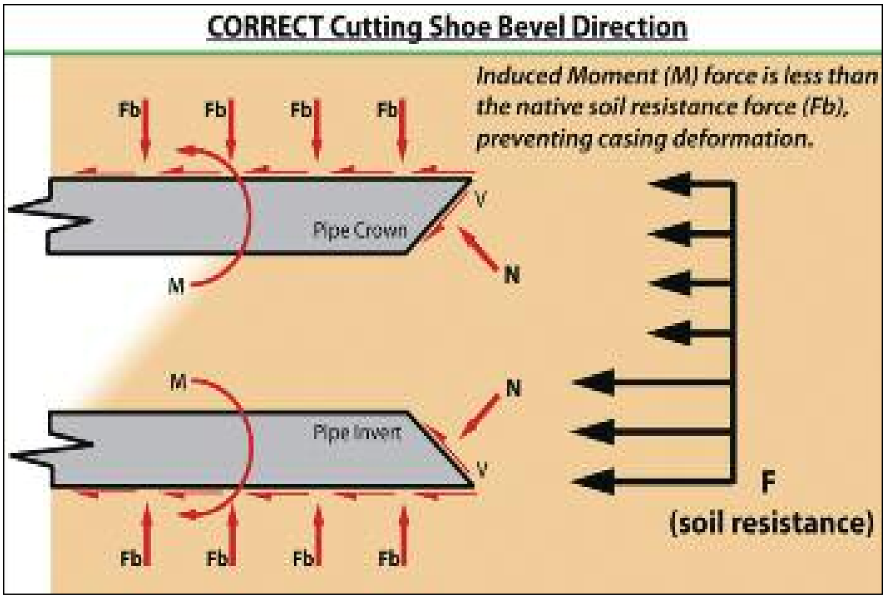


Figure 4. Force Diagram of Properly Designed Cutting Shoe

unbalanced loads. A few other conditions that led to the pipe failure are described in detail below.

Interior Banding

For larger-diameter pipe rams (48 inches and greater), it is common practice to fit the first section of pipe with an interior reinforcing band. This band serves to increase the stiffness of the leading pipe section, which allows penetration into dense to very dense soils without deformation. Full 360-degree interior banding is common practice in pipe-ramming applications in dense soil formations and is critical to the success of a pipe ramming in these conditions.

Figure 3 (left photo) shows the 0.5-inch thick interior band that was used on both the 120- and 144-inch casings. The interior banding did not provide 360-degree coverage, but instead covered only 270 degrees of the casing, giving up crucial hoop strength. Full banding of the leading pipe segment provides significantly more stiffness than partial banding.

Figure 3 (right photo) shows the interior of a 72-inch pipe ram that was successfully completed in Oregon. On this project the soil was identified in the boring logs to be very dense glacial soil with cobbles and boulders. Due to the very dense soil formation, the contractor designed a one-inch-thick full circumferential inner band to increase the flexural stiffness of the leading edge of the casing. This casing was driven successfully without deformation.

Cutting Shoe Bevel

The bevel angle and direction of the cutting shoe is very important and serves to direct the soil into the casing. Forces that act on the leading edge of the casing cause a localized moment force. If the bevel is angled in the proper direction, the moment force pushes the casing outward – toward the soil, which acts to hold the casing in a cylindrical shape.

Figure 4 shows the proper configuration of the cutting shoe and the forces and moments associated with a proper cutting shoe design.If the bevel is cut in the wrong direction – forcing the soil to the outside of the pipe – the moment force acts to deform the casing inward and can cause the casing to collapse. This force distribution is illustrated in Figure 5 and is especially significant in dense soil conditions where the concentrated forces on the leading edge of the cutting shoe are significant.

Due to the incorrect bevel direction, concentrated high stresses deformed the casing invert. As ramming progressed the deformed leading edge of the casing continued to fail until the invert of the pipe met the crown, resulting in total refusal of casing advance.

Casing Wall Thickness

TT Technologies publishes a list of recommended pipe wall thickness for pipe

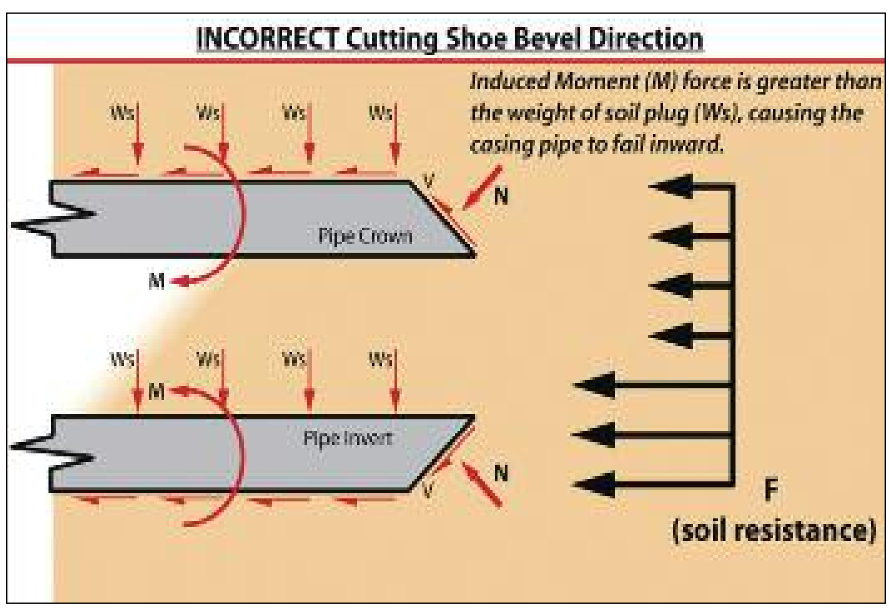


Figure 5. Force Diagram of Improperly Designed Cutting Shoe

ramming projects based on pipe diameter and the length of the pipe ram. The minimum recommended thickness for a 300-foot, 120-inch pipe ram is 1.5 inches. A pipe wall of only 1.125 inches was used for both creek crossings. It is important to note that a wall thickness of 1.125 inches is sufficient for crossing lengths of up to 65 feet and that the casing began to deform at 70 feet.

Similarly, an extrapolation of the data results in a "recommended" wall thickness for a 144-inch pipe of 1.75 inches. Increasing the stiffness of the pipe with a thicker casing and proper cutting shoe would have provided a greater ability to penetrate the dense glacial material without deformation. Clearly, the inadequate stiffness was the cause of failure of the steel casings.

Both crossings were eventually completed by removing the deformed portions of casing and reinforcing the internal circumference, which prevented the leading edge from further deformation.

Summary

The ultimate cause of the casing failure was an improper design of the lead casing pipe that was not stiff enough to prevent deformation. The primary inadequacy was the design of the cutting shoe, which was beveled incorrectly, applied at the wrong location, and not of sufficient stiffness; it was insufficient to withstand the concentration of stresses at the pipe invert that led to deformation and ultimate failure.

Pipe ramming is a viable and attractive method of installation in many cases, but careful planning and design is essential until clear guidelines and standards are developed. As further research is performed and the failure modes of pipe ramming are investigated, one point remains clear: More guidance is needed for designing pipe ram installations. Detailed design is most critical for larger diameters and longer pipe ramming installations where data is limited and rules-of-thumb may not adequately address particular conditions.

REFERENCES

Stein, D., "Unmanned, Non-Steerable Techniques," in Trenchless Technology for Installation of Cables and Pipelines, 1st ed., D. Stein, Ed. Germany: Stein & Partner, 2005, pp.198-206.

Sterling, R.L., and J. Simicevic, "Guidelines for Pipe Ramming – TTC Technical Report No. 2001.04," for US Army Corps of Engineers, Engineering Research and Development Center. Vicksburg, MS, December 2001.

Stuedlein, A.W., and T. Meskele, "Preliminary Design and Engineering of Pipe Ramming Installations," Journal of Pipeline Systems Engineering and Practice, ASCE, Vol. 3 (4), pp. 125-134, November 2012.

German Association for Water Wastewater and Waste, "ATV Working Sheet A 125E: Pipe Driving," General Technical Specifications for Building Works, Germany, Tech. Std., September 1990.

German Association for Water Wastewater and Waste, "ATV Standard A 161E: Structural Calculation of Driven Pipes," General Technical Specifications for Building Works, Germany, Tech. Std., January 1990.

Popular in Anchorage

AWWU Applying Trenchless Technology More Than Ever Before

Brian Gastrock, P.E.
Stephl Engineering LLC
Matt Stephl, P.E
Stephl Engineering LLC
Stephen Nuss, P.E.
Anchorage Water and Wastewater Utility

Trenchless technology is becoming increasingly popular in Alaska, and it is being used by the Anchorage Water and Wastewater Utility (AWWU) now more than ever before. The trend is partly because conventional pipe repair work is becoming more expensive in Anchorage while trenchless technology is becoming more competitive. A deep burial depth (eight to 10 feet) coupled with the short construction season (May to October) is contributing to higher excavation costs.

Traditional cut-and-cover construction can cost between $500 and $1,000 per foot. Increased repair costs, combined with other operating cost increases, have forced AWWU to cut its capital budgets. Accordingly, AWWU has had to rethink its strategy for R&R (replacement and rehabilitation) of mains; as a result, AWWU has actively sought technologies that reduce project costs.

Currently many of AWWU's pipe R&R projects have at least one form of trenchless technology in use. A combination of factors contribute to this expansion of trenchless technology within AWWU: buried utilities are getting older; AWWU is willing to try new techniques; local contractors are investing in the equipment; and trenchless technology is becoming more cost-effective in Alaska.

The System is Aging

Approximately 60 percent of AWWU's pipe system was installed prior to 1985 and is 30 to 60 years old. AWWU's water system consists of an 834-mile pipe network, 672 miles of which are constructed from either ductile iron (DI) or cast iron (CI) pipe. Many of the mains are buried in corrosive soils and were constructed prior to cathodic protection becoming standard. AWWU has seen a moderate increase in external-corrosion-related failure of its DI and CI water pipes.

The sewer system contains over 746 miles of DI, asbestos cement (AC), vitrified clay (VC), corrugated metal and concrete pipe. Some sewers were installed in weak soils and break apart when they settle or lose sidewall support. The 1964 Great Alaska Earthquake produced significant ground movement that affected the older AC, VC and concrete pipes.

Growth of Trenchless

AWWU's exposure to trenchless technologies began cautiously in the 1990s, with a few cured-in-place pipe (CIPP) lining, pipe-bursting and sliplining projects that had mixed success. The local industry matured over time, and in 2000 AWWU began utilizing more trenchless technologies, including water main CIPP, sewer main CIPP, pipe bursting, sliplining, trenchless point repairs, horizontal directional drilling (HDD), pilot tube microtunneling (PTMT), pipe jacking, and auger boring. Additionally, their pipe condition assessment program has grown significantly in the last 13 years.

AWWU completed their first water main CIPP project in 2009,

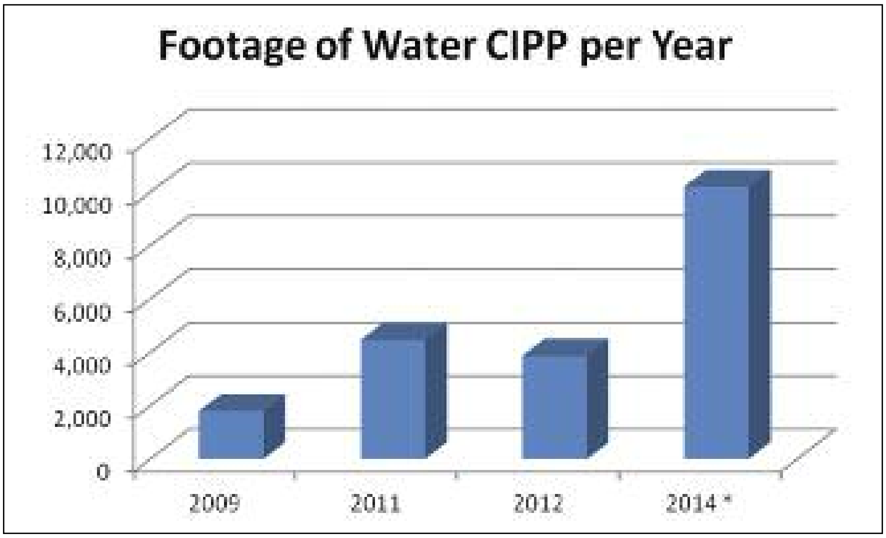


Figure 1. Annual Linear Footage of Water CIPP

and by the fall of 2013 they had finished 11 projects with 10,200 feet of lined pipe for a total construction cost of $6.1 million. Three more CIPP lining projects are planned for construction in 2014 with a combined length of approximately 10,000 feet. By the end of 2014, AWWU will be one of just a handful of public utilities in the United States that have completed such a large volume of water main CIPP lining work. (Water CIPP in Canada significantly exceeds the volume installed in the U.S. at this time.)

Besides CIPP lining, trenchless rehabilitation of existing water mains has been limited to the use of pipe bursting. Pipe bursting has been used on half a dozen AWWU projects, with four of them occurring in the past six years.

Sewer main CIPP projects have grown significantly. Approximately 100,000 feet of CIPP have been installed in sanitary and storm sewers across Alaska. AWWU has installed more than 32,000 feet of CIPP liner in their sewers since 1994. Approximately 80 percent, or 26,000 feet, of the CIPP was installed since 2007. All of the CIPP projects have been built by local contractors. The first ultraviolet (UV) cured liner was installed in an AWWU sewer pipe in 2008. The UV process helped to lengthen the CIPP construction season. It was feasible to install the UV liner in colder weather in comparison to the proven water cure system, which was challenging to use when temperatures got below freezing.

For new installations AWWU has used HDD, PTMT, auger boring, and pipe ramming. Auger boring has remained relatively consistent over the past several years, generally being completed under private development projects. Pipe ramming equipment is available in Alaska but has been used only on rare occasions in Anchorage. Guided pilot tube microtunneling was successfully used on an AWWU project in 2008 to install a new water main in an area congested with other utilities. Larger cobbles found in the local glacial tills and the cost of mobilizing equipment from the Lower 48 have significantly limited the use of PTMT in Anchorage.

After a failed attempt by AWWU in the 1990s to drill through rocky soils under a river, HDD was first used successfully in 2006 to install a new water main. This project, and a dozen subsequent AWWU installations, have been smaller than 24-inch diameter and less than 1,000 feet in length. HDD has generally been used in AWWU's system at creek crossings, highway crossings, airport locations and areas with limited access for digging.

AWWU has been using closed circuit television (CCTV) inspection equipment since the 1990s to inspect sewer pipes. In the beginning, the CCTV inspections were limited to sewer pipes with existing problems. Now AWWU has an ongoing annual program to inspect their sewer system to confirm its condition.

AWWU now has five in-house CCTV

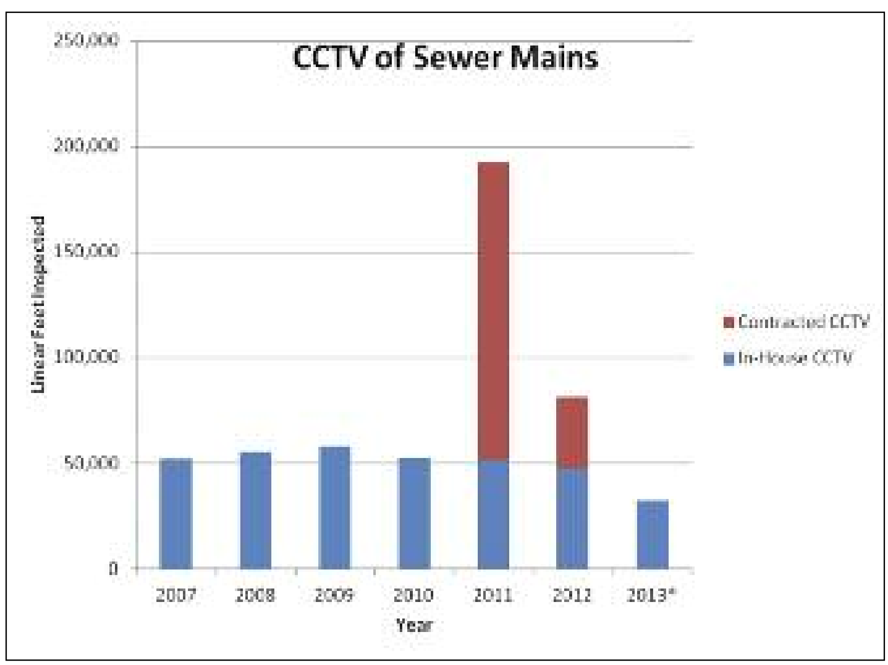


Figure 2 – CCTV Inspection of Sewer Mains

cameras (four sewer and one water) and a sewer lateral launch camera. The equipment is supported with two modern CCTV trucks. In 2013, AWWU converted their pipe inspection data system to the NASSCO Pipeline Assessment Certification Program (PACP) format for all their in-house and subcontracted CCTV work.

Trying Technologies

AWWU developed an Asset Management Program to prioritize its maintenance and capital work. Implementation of this program helped AWWU confirm that it lacked accurate information about the condition of much of its existing buried infrastructure. As a result, AWWU has invested heavily in condition assessment work and equipment in the last five years. AWWU has used various newer technologies to evaluate the state of their pipes. Within their water system the utility has used proprietary technologies from PICA, Echologics, and Pure. The results have helped to prioritize water R&R projects.

The utility has recently used RedZone robotics on their sewer system to obtain more than 100,000 feet of CCTV inspection of its small-diameter sewers at a fraction of the cost of traditional CCTV inspections. This data has helped to identify point repairs, and also pipes requiring additional cleaning and CCTV inspection with larger equipment. The use of less costly CCTV inspections to gather larger volumes of assessments has allowed the utility to focus the increasingly limited funds to areas in its system that require immediate attention.

AWWU has been willing to try different technologies for the installation of new and rehabilitation of old water and sewer mains. Partnering with both local and lower 48 consultants and contractors, and sending its staff to conferences such as No-Dig, AWWU has been able to successfully execute installations using pneumatic and static pipe bursting, HDD in glacial till, down-the-hole hammer (DTH) auger boring, and modified PTMT.

Contractor Investments

When designing and building trenchless projects in Alaska, considering local contractor equipment and expertise is important. Mobilizing equipment and labor to Anchorage is cost-prohibitive. Sometimes the best technical trenchless solution for a project is not employed because the equipment is not available locally. In these cases an alternate, less desirable trenchless method may be used, or the project is completed using open-cut excavation. Local contractors recognize that a successful trenchless project continues to promote the growth of the technology in Alaska.

As the utility bids more projects with trenchless technology installation methods, local contractors are investing in the equipment and training to complete the work. Both UV cure and traditional hot water (felt) cure sewer main lining systems are now available in Anchorage, and in the last few years the number of privately owned modern sewer main CCTV cameras has increased from one to five.

AWWU has seen the benefit of other utility companies moving to more trenchless installations. Local electric and gas utilities are performing more HDD for their larger-diameter facilities. This has resulted in an increase in the number of contractors available to perform HDD of water and sewer pipes.

More Cost-Effective

In the Anchorage urban areas, a water CIPP lining project will have a construction cost that is approximately 70 percent of an equivalent open-cut project to replace the water main. Similarly, a sewer CIPP lining project will have a cost that is approximately 50 percent of an equivalent open-cut project.

Water CIPP costs remain higher than sewer CIPP costs due to the requirement to have temporary water systems constructed, large-diameter services that cannot be reinstated robotically, and the requirements for pressure testing and disinfection.

The use of trenchless continues to grow in Anchorage, and in Alaska in general. The increasing use allows AWWU and other utilities to achieve more with less. For AWWU, trenchless technology supports the utility's vision of "excellence through Innovation."

Trenchless construction in Anchorage has grown since the 1990s

HORIZONTA
CORRECTIO
DRI

L

ONAL

LLING.

LIKE ALL GOOD REVOLUTIONS, THIS ONE STARTS UNDERGROUND.

The pressures of a job can go beyond mere drilling fluids, but with the revolutionary new F5® Fluid Pressure Transmitter, there's a new industry standard in how to control them.

Real-time monitoring of downhole drilling fluid pressures helps significantly reduce the risk of frac-outs or damage and provides additional data for monitoring your pilot bore's progress.

Immediate feedback and documentation of fluid pressure data provide reporting and analysis for operators, contractors and project owners previously unavailable in any other walkover system.

Post-bore documentation and real-time data lead to higher-quality installations and increased confidence in job planning and performance.

Backed by world-class customer service 24/7.

For more information contact your DCI distributor or visit **www.digitrak.com**.

The F5® Fluid Pressure Transmitter from DCI. Ready to take HDD in a whole new direction.

DCI

Digital Control Inc.

Industry leaders. Passionate visionaries. And genuinely nice guys.

Wastewater Collection Conveyance Condition Assessment in the Far North

Mark A. Corsentino, P.E.
Project Manager, Anchorage Water and Wastewater Utility
Jack Burnam, P.E.
Project Manager, CH2M HILL
Daniel Buonadonna, P.E.
Project Engineer, CH2M HILL

The Anchorage Water and Wastewater Utility (AWWU) owns, operates, and maintains a sewer pipe network with over 750 miles of pipe ranging from three-inch lateral pipe to 96-inch interceptors consisting of 15 different pipe materials, which were installed periodically since 1917. Like many utilities, AWWU is trying to become more proactive and less reactive in its maintenance of these critical assets. To do this, AWWU realized it needed first-hand data on the condition of its sewer conveyance system and disposal system.

Through its asset management program, AWWU used the limited data available on the existing interceptors to organize them into risk categories based on the probability and consequence of their failure. AWWU then retained a team led by CH2M HILL, with subconsultant services provided by Red Zone Technologies and BC Excavating LCC, to complete a condition assessment of major-risk interceptors and the treatment facility effluent outfall system between August and November 2011.

Work included inspection of 132,969 LF of large-diameter, high-risk interceptors and high-risk force mains, 75,000 LF of high- and moderate-risk laterals, and the 6,717-LF effluent outfall system. The selection of inspection technologies was driven by the goals of not only assessing the condition of the pipes, but also collecting the relevant information that could be used to evaluate and design trenchless rehabilitation and/or replacement methods. The final data was used to schedule future repair/rehabilitation/replacement efforts in coordination with their Capital Improvement Program (CIP).

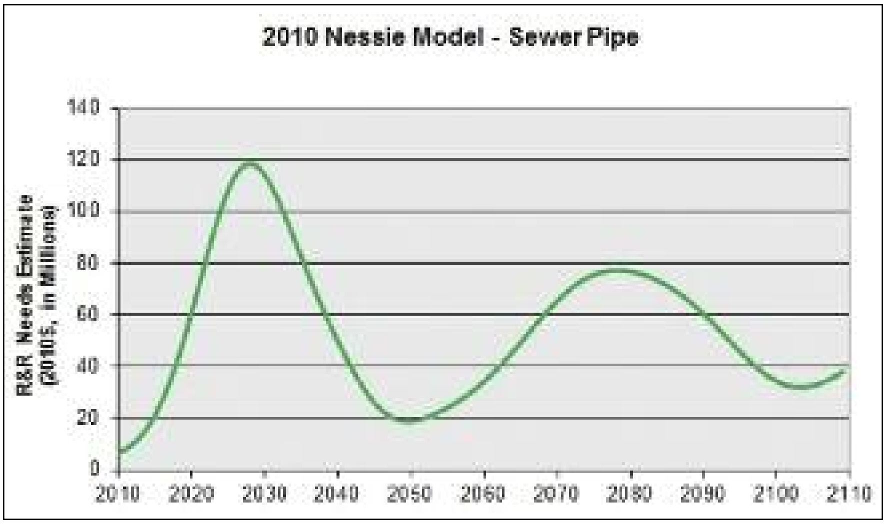


Figure 1. Estimated Repair & Rehabilitation Needs to 2110

Asset Management Planning

In June 2011, AWWU Strategic Asset Services (SASS) completed a sewer asset management plan, to be used as a tool to manage the risk associated with an aging sewer pipe system. As part of the plan, SASS used an asset management model (Nessie) to predict future R&R needs for AWWU's sewer pipes.

AWWU's Nessie Curve (Figure 1) for sewer pipes shows dramatically increasing capital replacement needs based on current R&R and maintenance practices, particularly in the near term. The current level of funding authorization for capital R&R in the Long Range Financial Plan (LRFP) does not meet this need. As such, it was determined that a change in practices relating to asset management was needed to maintain the highest possible level of service as the assets age and increasingly fail.

This information was used in developing the project to inspect the remaining high-risk interceptors. The relative location of the high-risk interceptors to each other within Anchorage is shown on Figure 2.

The first order of work was to find all of the 279 manholes that were identified on the AWWU geographic information system (GIS) map to determine their existing condition and evaluate their use as either a launching or receiving access. Once crews embarked on this identification process it was discovered that of the 279 MHs identified in the AWWU GIS system:

1. 38 MHs were underground "tees" 79 MHs were located in backyard easements, some buried up to 6-inches. 1 MH was buried 5-feet deep during a park landscaping project.
2. Some of the backyard MHs were located in areas that flood each winter and then freeze over.
3. Many of the GIS coordinates were off the existing MHs by 20 to 40 feet. A few of the MHs were located in the center of a creek. Several MHs were located within a railroad right of way and required special access permits to open. Working with the AWWU O&M crews allowed the use of their permit to access and maintain the MH for the purposes of this project.

O&M Coordination

It was the ability to coordinate with AWWU's O&M crews that made the project work, and inspection shifts operated on a 24-hour basis (12 hours for the day shift and 12 hours for the night shift). For example, of the 79 MHs located on or across private property, several were located in marsh areas that made equipment access virtually impossible during the early months of the work (August, September, October). Permitting to disturb these marshes is a rigorous and time consuming process that has been known to take up to a year to complete. However, once the winter freeze has set in (along with the low land snows that accompany it), most agency requirements for permits are suspended because the frozen condition of the soil and marsh prevents the damage that driving over it would normally cause. Working with AWWU O&M and using their six-wheeled all-terrain vehicle (ATV) pulling a sled allowed crews to transport the CCTV, laser, and sonar equipment and complete the inspection work required.

In addition to the condition assessment of the interceptors, the project also included inspection of the 6,700 foot Asplund

Figure 2. Project Location/Critical Issues Map

Wastewater Treatment Facility (WWTF) effluent and outfall system. The unique location and construction characteristics of the effluent and outfall system raised multiple challenges for field crews.

- The WWTF effluent and outfall system lies directly in the final approach path for the Anchorage International Airport, is within the Anchorage Coastal Wildlife Refuge, and is near a fault line (adjacent to Earthquake Park).
- The only access to the final 800 feet of the outfall is via a 40-foot-tall beach tower that exists in the active tidal zone.
- To accommodate the condition assessment of the effluent and outfall system, the schedule and procedure for the field work needed to operate within the constraints of the treatment plant, airport authority, wildlife refuge, potential summer storms, and high ocean tides.
- Cook's Inlet exhibits the widest tidal range in the US and fourth widest in the world, averaging 36 feet in 7-8 hours and swift tidal bores.
- All inspection work initiated from the beach tower needed to be completed within the narrow low tide window to avoid trapping personnel on top of the tower.

Access to final 800 feet of outfall via a beach tower

The inspection was conducted using portable CCTV equipment, and deployed with the assistance of the local Anchorage contractor, BC Excavating LLC. Flow charts of contingency plans were developed beforehand in order to streamline field decisions regarding encounters with marine life, obstructions, tidal impacts, and other potential complications.

Lessons Learned

The following lessons were learned during the completion of this work.

Location-related lessons:

- Having backup CCTV equipment parts pre-shipped and ready to be installed can significantly reduce down-time. Of significant concern is the extra time it takes to obtain replacement parts in Alaska versus the lower 48 states.
- Warm weather storage location for cleaning, drying, and charging equipment after daily inspections is necessary to keep sensitive electronics from freezing or failing after a cold night.
- Wheeled/tractor mounted cameras may not be able to navigate in heavily sedimented interceptors, and vice versa float mounted cameras may not be able to navigate those same heavily sedimented interceptors without adequate flow depth.
- Interceptor MHs are often not accessed, and they may appear to be abandoned. As a result, they get overgrown and/or buried.
- Heavy equipment for snow removal was critical for project success in several ways.
- Having off-road vehicles was also necessary for success. Having access to a

AWWU's sewer asset management plan is one tool in managing the risk associated with an aging sewer pipe system.

jetting truck to provide tether lines for dual control over robots and sonar equipment was necessary.

- Old easement agreements often did not provide adequate access, so private landowner coordination was critical for success.
- All sources of information on the location and access to the MHs needs to be used in the development of a work plan.

Integration Into the CIP

A risk-based rating system was used to prioritize the recommended improvements for the system. Inspection data was used to determine the condition or "likelihood of failure" for pipe and manhole assets, and a determination of the criticality or "consequence of failure" was based on pipe failure's potential impact to public safety, the environment, and facility operations. The combination of likelihood and consequence was used to develop a risk matrix to identify the pipe and manhole assets that represented the highest risk, and prioritize recommendations for improvement accordingly.

Currently, AWWU and CH2M HILL are in the process of integrating the recommendations into the CIP by evaluating multiple rehabilitation/replacement methods, including trenchless technologies to determine the most cost-effective alternative. In evaluating the trenchless alternatives, the data collected from the condition assessment is being used to estimate the design parameters for the different technologies, and therefore the associated cost. For example, laser scanning data is being used to estimate the required liner thicknesses for cured-in-place technologies, annular space grouting requirements for spiral-wound technologies, and bend-radius calculations for sliplining technologies.

Final results will include a set of alternative rehabilitation projects for each interceptor in which the non-cost benefits are quantified and, when combined with the cost estimate, could be used to determine the best alternative with the lowest cost-benefit ratio. Final recommendations for the specific trenchless rehabilitation projects will be incorporated into the Utility's CIP by order of their priority as identified during the original condition assessment program. The use of quantifiable cost-benefit analysis and openness to recent advances in trenchless technologies were examples of AWWU's ongoing commitment to proactive system maintenance and optimized asset management.

The Challenge of Selecting the Right Sewer Replacement Method

Erik Waligorski, P.E.
Stantec

The Pacific Northwest has a wealth of cities with deep and storied pasts – a fact cherished by historians, but often a challenge for engineers tasked with maintaining their infrastructure. One Washington town with more than 100 years of history was faced with replacing large portions of its sewer system, with looming concerns about technology, costs and impacts on roadways. In the end, they found a cost-effective solution to address their concerns while paving the way for the next chapter in the city's history.

Shelton is a historic community located 35 miles northwest of Olympia on the shores of Oakland Bay at the southernmost tip of Puget Sound. Shelton now encompasses roughly six square miles and has approximately 9,800 residents. Like many small towns in the Pacific Northwest, Shelton's commerce consisted of logging, farming, and ranching. With Shelton's proximity to Oakland Bay, the cultivation of oysters is also a large part of its commerce and culture.

A common problem facing aging communities in the region is the increased inflow and infiltration (I/I) during wet weather events, and Shelton is no different. The majority of Shelton's sewer system is very old and well past its intended design life. Most of the existing pipes in the downtown core were installed in the 1910s while many of the pipes in the southern part of town were built in the 1940s and '50s.

In 1998, the City of Shelton was issued an administrative order by the state Department of Ecology (DOE) to come into compliance with the National Pollutant Discharge Elimination System (NPDES) permit that allows discharge into Oakland Bay from the City's primary wastewater treatment plant.

The City found that during wet weather events, one of the permit requirements that becomes difficult to comply with is the 85 percent removal of suspended material due to high I/I inundating the wastewater treatment plant. In 1997, municipal leaders completed the "City of Shelton I/I Facility Plan Update" in which I/I reduction projects were listed and prioritized. As part of the Administrative Order, DOE approved the plan and agreed to the completion of the identified projects over a period of time so that

Shelton could come into compliance with its NPDES permit.

One of the projects identified in the I/I Facility Plan Update was the Basin 5 Rehabilitation Project. The project initially consisted of the replacement or rehabilitation of approximately 38,480 linear feet of six-, eight- and 12-inch-diameter sewers in the Hillcrest and Angleside neighborhoods in the southern part of the city. The existing neighborhoods consist mostly of residential properties built in the 1940s and '50s with varying levels of existing road conditions and infrastructure.

As can be imagined, taking on a large-scale sewer replacement project was a significant capital investment. Several funding sources were required to complete the project without overly burdening residents. It was equally important that design of the Basin 5 project consider the overall project cost, as proposed construction methods were determined.

New Ideas

The City of Shelton, having already completed the first basin rehabilitation project required by DOE, was open to alternative construction methods, including the use of trenchless technology, to complete the Basin 5 project. The challenge facing the design team was to determine which factors would affect using trenchless technologies while working with the City to develop cost-effective solutions for any issues they encountered.

Based on preliminary meetings, three methods of construction were analyzed for the Basin 5 project: standard open-cut construction, pipe bursting, and rehabilitation using cured-in-place pipe (CIPP).

To determine what construction method was most cost-effective, the design team completed a preliminary engineering study that analyzed the construction methods for each sewer pipe against several factors which included existing pipe condition, hydraulic capacity, depth of the existing sewer, and existing road conditions. In many cases, a combination of these factors was used to determine the most cost-effective construction method. In total, the design team analyzed 42,300 linear feet of existing sewer pipes, which included the addition of approximately 3,800 linear feet of sewer over the initial project scope.

The first step in determining the construction method was identifying if the existing sewer had enough capacity to convey the flow from residences to the treatment plant. The design team knew that over half of the analyzed sewers consisted of six-inch-diameter pipe. The City of Shelton design standards required that all six-inch-diameter sewers be upsized to eight-inch-diameter pipe, thus eliminating the possibility of using CIPP technology to rehabilitate the existing pipes.

The City had no accurate hydraulic model for the analysis of the remaining eight-inch and 12-inch pipes. Fortunately, the existing density of the neighborhoods, limited visible surcharging, and forecasted I/I reduction allowed the City to specify that the majority of the remaining pipes be replaced or rehabilitated without increasing diameter.

The next phase of the preliminary engineering analysis consisted of reviewing available CCTV inspections of the existing pipes to determine the feasibility of rehabilitating the sewer using CIPP technology. The analysis identified existing defects such as root intrusion, offset joints, sags, and cavities which may or may not preclude the use of CIPP rehabilitation. If the defect was minor or could be mitigated during construction, the pipe was earmarked for CIPP rehabilitation. If the defect was major – such as a pipe collapse or a significant offset joint – the pipe was identified as needing replacement using open-cut or pipe-bursting construction methods. Based on the engineering analysis conducted, approximately 16,600 feet of existing sewer was identified as potential candidates for rehabilitation using CIPP technology.

Once a pipe segment was identified for replacement, the analysis shifted to determining if the pipe segment should be replaced using open-cut construction methods or pipe-bursting technologies. There were two main factors considered in making this decision. The first was the depth of the existing sewer. Due to the age and construction approach of the sewers within the neighborhoods, a large portion of the sewers were installed extremely shallow compared to today's standards. Noting the increase in pipe diameter from six-inch to eight-inch, using pipe bursting technology was either challenging or impossible at most locations without heaving the ground surface.

The second factor considered in determining the method of pipe replacement was the condition of the existing road. Only a small portion of the area had recently paved roads that needed to be preserved. Most of the project area had poorly maintained asphalt pavement or chip seal roads that were cracking and failing due to poor subgrade material. Some existing sewers were installed in alleyways between the main residential streets. These alleyways were typically gravel surfaces with substantial potholing and rutting.For the majority of the pipe segments that required replacement, the design team used a combination of the depth of the existing pipe and the existing road condition to determine whether the pipe should be replaced using open-cut construction or pipe bursting. If the pipe met the depth requirements for bursting without heaving the ground surface, but the road was in such poor condition that it needed to be reconstructed anyway, the cost benefit of pipe bursting was negated and the pipe was earmarked for open-cut replacement.Likewise, if the pipe was a candidate for pipe bursting and located in an alley with a substantially lower restoration cost, the cost of the restoration did not surpass the additional cost for bursting the line and that pipe segment was also replaced using open-cut construction. At the completion of the engineering analysis, the design team identified approximately 11,500 feet of pipes for replacement via pipe bursting and 14,200 feet of pipe to be replaced using standard open-cut construction.

Success

In summary, the design team went through an exhaustive analysis of approximately 42,300 feet of existing sewer within the project area. We looked at the capacity of the existing pipe, what condition it was in, how deep it was, and what condition the road was in. This information was then used to determine what method of construction would be proposed for the replacement or rehabilitation of the existing pipes. The analysis identified 16,600 feet of pipe to be rehabilitated using CIPP, 11,500 feet of pipe to be replaced using pipe-bursting technology, and 14,200 feet to be replaced with standard open-cut construction.

So, what actually happened? During the design phase of the project, the City acquired additional funding for the project through grants and low-interest loans and was able to be more inclusive with the roads that would get full restoration. This substantially reduced the number of pipes replaced using pipe-bursting technology by removing concerns about road surface preservation. In the end, the design called for 23,375 feet of open-cut replacement, 1,590 feet of replacement using pipe-bursting technology, and 15,836 feet of rehabilitation by CIPP; approximately 1,500 feet of pipe analyzed did not require rehabilitation and was removed from the project.

An Owner's Guide to Managing Trenchless Risks

John Parnass
Zak Tomlinson
Pacifica Law Group, LLP

Trenchless projects in the Pacific Northwest present a uniquely challenging set of risks. At best, these risks lead to an increase in the rate and size of project claims. At worst, these risks lead to outright project failure, and the inevitable litigation that saps the increasingly stressed financial and human resources of public owners.

There are straightforward and proven ways that a public owner can and should address these risks in the trenchless procurement process. This article highlights three effective contracting practices that we – as construction lawyers who have litigated numerous claims arising out of Pacific Northwest trenchless projects – have found proactively manage trenchless risk: **establish bidder qualifications; provide clear contractual baselines; specify the equipment to be used.**

None of these recommendations are novel or radical. We continue to find, however, that they remain practices most often observed in the breach. And so we reiterate: Where appropriate, these practices provide effective contractual means to mitigate owner risks in trenchless construction, and deserve careful consideration at the start of the procurement process.

Bidder Qualifications

The first key to ensuring a successful project is to ensure that the trenchless contractors bidding on the projects are qualified to do so (and conversely, to ensure that unqualified contractors do not bid on the project). The laws permitting this vary from state to state: In Washington, public owners may do so pursuant to RCW 39.04.350, which allows an owner to identify "supplemental bidder criteria" in the bid documents as an essential element of bidder responsibility.

The use of supplemental bid criteria on trenchless projects is nothing new. Many trenchless bid documents require the low bidder to identify key qualified personnel and demonstrable success in tunneling minimum distances through similar ground conditions. While some have critiqued overly specific supplemental criteria, these filters have been – and continue to be – useful: Relevant trenchless experience is critical in ensuring a successful project.

We suggest an additional step and require that the bidders demonstrate, as an element of bidder responsibility, that they possess or plan to acquire the trenchless equipment specified in the contract documents. Think of this as a pre-award submittal review. The early vetting of this crucial issue up front has obvious advantages. It prevents the awkward (and costly) situation of awarding the contract to a low bidder on faith that they will eventually mobilize the specified equipment, only to discover months into the job that they have no intent to bring the specified TBM. This is not a hypothetical concern, as we have seen numerous projects where the low bidder does not possess and refuses to mobilize the equipment specified in the contract.

Contractual Baselines

We strongly suggest that all public owners consider the inclusion of express contractual baselines in the procurement documents. Such provisions, if thoughtfully and properly drafted and tailored to the specific project at hand, can provide owners (and courts) a clear and enforceable framework in which to assess and evaluate differing site condition (DSC) claims.

Public owners traditionally presented geotechnical baseline information by way of boring logs or the occasional Geotechnical Data Report. This approach led to ambiguous and often conflicting contract "indications" and is still (unfortunately) a widespread procurement practice to this day. At best, the traditional approach is ineffective in properly allocating risk. More often, it is profoundly counterproductive. In claims and litigation, owners pay exorbitant settlements and ultimately lose lawsuits because they have ineffectively and ambiguously conveyed baseline contract indications in the project documents.

Owners have gradually begun writing true baselines into project specifications or have adopted the use of a separate Geotechnical Baseline Report (GBR), both generally positive developments.

Regardless, we have found that truly-enforceable baselines share the following characteristics:

- **Clarity.** Contractual baselines (whether in a GBR or other contract documents) must be clear and easily understood. The parties (and ultimately a court) must be able to interpret those baselines consistent with the intended contractual risk allocation. Clarity is not easy to accomplish: It runs counter to the instinct of most geotechnical engineers to avoid specifically identifying inherently unpredictable geotechnical conditions. But a resort to descriptive wishy-washiness defeats the entire point of the GBR exercise, and reminds us to heed Randall Essex's mantra: A baseline condition is not a warranty of conditions as they actually are, but a contractual mechanism that allows the parties to allocate risk and ultimately determine whether a DSC exists. (**Tip:** In general use definitive words such as "shall" and "will," and avoid "may" and "might.")

War Story: A recent trenchless case we handled for a municipal water and wastewater district in King County, Washington, underscored the importance of clearly drafted and enforceable contract baselines. Among other things, the project specifications in the case instructed the contractor to assume the presence of cobbles in the tunneling alignment, and to provide a TBM "capable of ingesting any and all cobbles encountered." The court (which interpreted the baseline indications as a matter of law) dismissed the contractor's cobble-based DSC claim, finding that the DSC claim was barred because the contract clearly and unambiguously indicated cobbles.

- **Precedence.** Whether the owner chooses to specify baseline conditions in a formal GBR or in the contractual specifications itself, the contract should plainly establish that those baseline indications have precedence over the underlying data or summaries of data. For instance, while the data in a GDR is often helpful to the project participants, it should never take the place of a thoughtfully-considered contractual baseline indication.
- **A View to Administration.** An effective baseline is one that can be administered in light of the project and the chosen trenchless methodology. For instance, "cobble counting" baselines are often flatly inconsistent with the actual technology to be used on the project. MTBMs larger than 36 inches are capable of and (if the specification is written correctly) required to crush and ingest a high quantity of cobbles. Once the cobbles are crushed into small particles, it is impossible to "count" the number of in situ cobbles truly encountered by the machine from analyzing the spoils or the drive records, leading to inevitable disputes.
- **Legal Input.** It is imperative that a public owner enlist the assistance of both technical experts (i.e. the geotechnical consultant) and construction counsel in the drafting of the baseline documents. The baselines have profound legal implications: An owner embarks on a significant trenchless project without legal review at its own risk.

Machine Specification

We increasingly recommend that Pacific Northwest owners and their geotechnical consultants (particularly in MTBM projects) affirmatively specify the minimum type of TBM that is best suited to the geotechnical conditions on the project. While this strays from the traditional "let the Contractor pick its means and methods" school of thought, we have become convinced that owner direction in this area can address the unique risks associated with trenchless jobs.

This direction can take two forms, both project-specific. First, when the trenchless design consultant has concluded that certain types of TBMs, cutterheads and associated equipment are necessary for success, the specification should establish mandatory minimum machine requirements.

Second, when the trenchless design consultant establishes that certain equipment will likely fail in the anticipated ground conditions, the specification should be written to prohibit the use of specific machines—expressly. For instance, the specification should prohibit the use of an underpowered soft-ground head on an MTBM when the trenchless design consultant is aware of the presence of gravel, cobbles and boulders in the formation through which the tunnel will progress.

Finally, a word of caution: Every trenchless project is unique. There is no such thing as a canned set of contracts, specifications or language appropriate to all projects, and we advise as always to consult your legal counsel before embarking on any trenchless procurement.

Repair of Culverts with StifPipe™

Mo Ehsani, PhD, PE, SE
President, PipeMedic, LLC

Corrugated metal pipe (CMP) culverts have been used for decades in highway construction. Many of these structures have deteriorated over the years and are in need of repair. In most cases, the culverts support traffic loads, so any repair or replacement must restore the structural integrity of the original culvert.

The newly developed StifPipe™ takes advantage of developments in the aerospace field to build a lightweight but very strong pipe. Unlike conventional pipes, the wall of this pipe is not solid. It consists of a lightweight honeycomb that is covered with glass or carbon fiber reinforced polymer (FRP) as skin reinforcement. Similar to an I-beam, the honeycomb acts as the web portion, while the strong FRP layers represent the flanges in an I-beam.

The construction of the pipe begins by building a mandrel of the desired size and shape. The mandrel is covered with a non-bonding release material. Depending on the design requirements for internal pressure rating of the pipe, one or more layers of carbon fabric saturated with resin is wrapped around the mandrel. These fabrics typically have a thickness of less than 0.05 inches per layer. For gravity-flow pipes, lower-cost glass fabrics can be used in lieu of carbon.

Next, a honeycomb sheet is coated with epoxy and wrapped around the carbon fabric; the thickness of the honeycomb typically varies between a half-inch and 1 1/2 inches, and is determined based on the overall stiffness and strength requirements for the pipe.

Additional layers of carbon or glass fabric saturated with epoxy are wrapped on the outside of the honeycomb. The pipe section is cured in ambient condition before it is removed from the mandrel. If necessary, the curing process can be accelerated by heating the assembly to a moderate temperature (e.g., 180 degrees Fahrenheit).

The relatively simple construction technique allows pipes to be made to virtually any size or shape (Fig. 1); this is particularly helpful for repair of non-circular culverts or sewer pipes. The pipe weighs only 10-15 percent of what conventional pipes weigh, which lowers transportation and installation costs. The non-metallic pipe does not corrode.

FIELD INSTALLATION

The first installation of StifPipe was recently completed at the Arc Terminal in Mobile, Alabama, to repair a 60-foot-long 24-inch CMP that was corroded. Due to access limitation, the client required pipe

Figure 1. StifPipe can be made to virtually any shape

Figure 2. StifPipe is made and connected on site

sections that were only eight feet long. The construction of the pipe consisted of two layers of glass fabric on each face of a half-inch-thick honeycomb. This resulted in a nominal wall thickness of 0.7 inches. In order to maximize the flow through the pipe, the internal diameter of the pipe was selected as 20 inches. Figure 2(a) shows the manufacturing of the pipe.

To connect the pipe segments, a slightly larger-diameter StifPipe of the same construction was built. As shown in Fig. 2(b), the pipe segments can be connected using the sleeves. The completed eight-foot-long pieces of the pipe weighing about 50 pounds each can also be seen in the photo. The pipe segments were shipped to the job site.

The corroded culvert is shown in Fig. 3. The lightweight StifPipe segments were easily lifted by hand and assembled together. The finished segments were manually pushed into the pipe. The annular space around the liner was filled with grout, and the completed installation is shown in Fig. 4.

Figure 3. Highly corroded culvert at Arc Terminal

Figure 4. StifPipe at Arc Terminal – completed installation

ADVANTAGES

The main advantage of the new StifPipe for gravity-flow applications is the fact that the pipe can be manufactured to virtually any size and shape. This will minimize flow loss and grouting requirements during installation. Depending on the size of the project, a temporary manufacturing facility can be set up at or close to the job site. The constituent materials are shipped in a compact container that will reduce transportation charges compared to shipping completed pipe sections. The lightweight pipe reduces labor costs and minimizes the need for heavy equipment during installation. A mobile manufacturing unit is currently being designed that will further facilitate on-site construction of the pipe.

The method of manufacturing StifPipe and repair of pipes described above are subject to pending U.S. and international patents by the author.

An Alternative Option

Small-Diameter Boring Machines Add Up to Big Savings in Wyoming

The Robbins Company

A 54 inch (1.4 m) diameter Robbins Motorized Small Boring Unit (SBU-M) was used on two mixed ground bores in Wyoming, USA

Robbins Field Service personnel were onsite to assist the contractor, Claude H. Nix Construction, in launching the Small Boring Unit

A phosphate plant in Wyoming may not seem the most likely place for a trenchless construction success story, but Utah-based contractor Claude H. Nix Construction/JASCO Inc. was up for the challenge.

The plant, owned by The Simplot Company of Rock Springs, Wyoming, needed water cooling lines installed for phosphate production. The trajectory of the lines, meant to cool byproducts of the plant's production, required crossing under State Highway 430. The contract did not specify the method, so C.H. Nix acted as a surveyor on the project to determine the best way forward.

"The original alignment was supposed to be for five 36-inch (900-mm) casings below the highway," said John Nix, Vice President & COO of Claude H. Nix Construction. "When we dug a test hole, we hit a solid sandstone layer below clay, about 11 feet down."

The contractor already owned a Robbins Auger Boring Machine (ABM) and, given the rocky conditions, contacted

Robbins Small Boring Unit (SBU) Product Manager Kenny Clever to discuss the possibilities.

"Kenny suggested a 54-inch Motorized SBU (SBU-M) and did some CAD drawings to see how many 24-inch water pipes could fit in the larger casing. We reduced the scope to two crossings, which cut down on pit construction costs and project duration from about 180 days to 60-80 days," said Nix.

The contractor proposed it to project owner Simplot and it was approved, resulting in $250,000 in savings.

Robbins Field Service assisted the crew in launching the mixed ground SBU-M, which was specially designed for mixed face conditions consisting of rock and clay. The mixed ground cutterhead was mounted with both carbide bits and disc cutters, while large muck openings allowed muck to flow into an invert auger running through the casing to the ABM.

The machine was launched in a 45 feet (14 m) wide by 50 feet (15 m) long bore pit at 20 feet (6 m) deep and welded to a 20-foot (6-m) length of casing. The custom casing, specified by Simplot, included a special epoxy coating on the inside.

During excavation, spoils were removed via an invert auger attached to the ABM, transferring spoils out a door in the ABM's master pusher. Line and grade were monitored using a laser targeting system, and adjustments were made using hydraulic articulation cylinders. The crew made slight steering changes from the operator's console inside the machine's rear shield.

The first 300-foot-long crossing below the highway was completed in about six weeks, despite difficult ground including sticky clay that required a water injection system to be installed behind the machine. The water line added enough liquid to make the clay the consistency of a slurry, easing transport through the invert auger. Hole through was within line and grade requirements – since the crossings were just 5 feet (1.5 m) apart, line was the more important of the two.

Robbins Field Service members were a big part of proper training that led to the success, said Nix. "They were instrumental—we have a lot of experience with Akkerman TBMs, but running an SBU is different from a soft ground TBM. They helped us out immensely."

The second crossing, done without a learning curve, was completed in just three weeks, with no cutter changes required during either drive. Nix stated that he would definitely use the machine again given the right ground conditions: "This was an awesome piece of equipment. I was very impressed with the construction quality of this machine."

The contractor additionally felt that the machine gave his company a competitive advantage: "The technology is certainly there. Given the right ground conditions, such as a rock job or harder ground, it's the go-to weapon."

Come to Orlando for Trenchless Magic

Kevin Nagle
No-Dig Show Program Chair

Richard (Bo) Botteicher
No-Dig Show Program Vice Chair

Dear Trenchless Colleagues,

We officially invite you to join us at NASTT's 23rd annual No-Dig Show, April 13-17 at the spectacular Gaylord Palms Resort and Convention Center.

In 2014 we are bringing "The Magic of Trenchless" to Orlando, Florida. The NASTT No-Dig Show will return to Orlando for the third time, and to the Gaylord Palms for a second time – which is a testament to the state of Florida's support of the trenchless industry. The No-Dig Show is the only conference in North America that focuses solely on trenchless technology, providing a single event where attendees, sponsors, students and exhibitors can gather to promote and learn about all things trenchless.

The 2014 No-Dig Show Program Committee has put together an industry-leading program. The cornerstone of the NASTT No-Dig Show is the caliber of its educational program. Our technical program begins on Monday featuring 160 high-quality non-commercial papers in a six-track schedule. In addition, our pre- and post-conference courses present a wide array of trenchless applications in detail, including CIPP, HDD, laterals and more.

A successful conference incorporates opportunities for quality educational classroom learning and hands-on exhibit-floor product knowledge with just enough of a relaxing social networking nightlife. At the No-Dig Show, leaders of the industry provide this combination with the opportunity to exchange the ideas that move our industry forward.

Monday is a day that bookends with two terrific networking events. The day gets under way with our "Kickoff Breakfast" and finishes with NASTT's Annual Educational Auction and Reception. Since 2002, NASTT has raised more than $600,000 for the Educational Fund which supports NASTT educational initiatives. Make sure you pack your pirate gear, as this year features a wild costume contest allowing you to exhibit your inner swashbuckler!

The Program Committee has assembled an outstanding edition of NASTT's No-Dig Show

Tuesday evening's event is the annual Gala Dinner, which brings everyone together for a night of great food, live entertainment and recognition for our industry's best and brightest. During this evening, NASTT formally presents the Chair's Award for Outstanding Lifetime Service, the Trent Ralston Award for Young Trenchless Achievement, and the winners of the Joseph L. Abbott Jr. Innovative Product Awards. The highlight of the evening will be the induction of the third class to NASTT's Hall of Fame; stay tuned for more details on this event.

NASTT's 2014 No-Dig Show comes to an end on Wednesday with our annual Closing Luncheon — where we will draw the winning ticket for our third annual vacation raffle! We hope you purchase your tickets for a chance to win a trip to the Caribbean! All proceeds benefit NASTT's Educational Fund. This popular raffle is made possible through a generous $5,000 donation from Vermeer Corp.

Ask any child and they will tell you that Orlando can be a very "magical" place. Come share in the excitement as North America's premier trenchless event brings the "Magic of Trenchless" to Florida. The Gaylord Palms Resort and Convention Center is located just minutes from the main gates of EPCOT, MGM and Disney World. This is the perfect Spring Break location for you and your family, so make sure you come early and stay late to enjoy all that Orlando has to offer. We'll see you in Orlando!

NASTT Calendar of Events

NASTT's Sewer Laterals Good Practices Course

Wednesday, January 29, 2014
George R. Brown Convention Center,
Houston, TX
Info: www.nastt.org

NASTT's HDD Good Practices Course

Wednesday, February 12, 2014
PSE&G Edison Training & Development Center,
Edison, NJ
Info: george.ragula@pseg.com

NASTT's Trenchless Technology Short Course – New Installation

Sunday, April 13, 2014
Gaylord Palms Hotel & Convention Center,
Orlando, FL
Info: www.nastt.org

NASTT's Trenchless Technology Short Course – Rehabilitation

Sunday, April 13, 2014
Gaylord Palms Hotel & Convention Center,
Orlando, FL
Info: www.nastt.org

NASTT's HDD Good Practices Course

Wednesday, April 16, 2014
Thursday, April 17, 2014
Gaylord Palms Hotel & Convention Center,
Orlando, FL
Info: www.nastt.org

NASTT's Sewer Laterals Good Practices Course

Wednesday, April 16, 2014
Thursday, April 17, 2014
Gaylord Palms Hotel & Convention Center,
Orlando, FL
Info: www.nastt.org

NASTT's Pipe Bursting Good Practices Course

Wednesday, April 16, 2014
Thursday, April 17, 2014
Gaylord Palms Hotel & Convention Center,
Orlando, FL
Info: www.nastt.org

NASTT's Cured-In-Place Pipe Good Practices Course

Wednesday, April 16, 2014
Thursday, April 17, 2014
Gaylord Palms Hotel & Convention Center,
Orlando, FL
Info: www.nastt.org

NASTT's New Installation Methods Good Practices Course

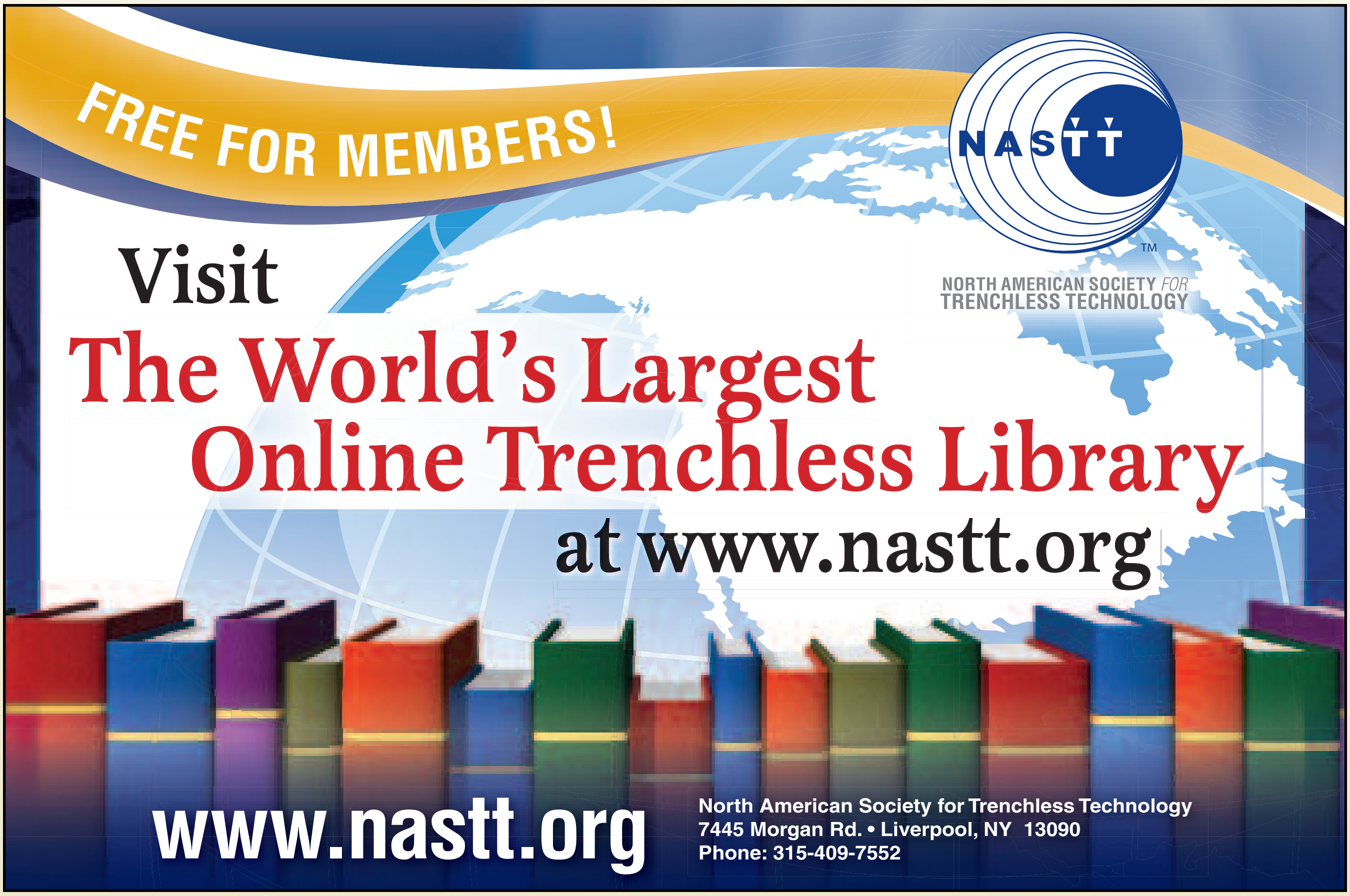
Wednesday, April 16, 2014
Thursday, April 17, 2014
Gaylord Palms Hotel & Convention Center,
Orlando, FL
Info: www.nastt.org

NASTT's 2014 No-Dig Show

April 13-17, 2014
Gaylord Palms Hotel & Convention Center,
Orlando, FL
Info: info@benjaminmedia.com,
www.nodigshow.com

Index to Advertisers

PLEASE SUPPORT THE ADVERTISERS WHO HAVE MADE THIS PUBLICATION POSSIBLE



An essential part of your SMART lighting

The SceptaCon™ Solution

SceptaCon™ is one of the first PVC systems designed for the rigors of trenchless applications. Made of durable Schedule 40 PVC, SceptaCon links seamlessly to existing PVC conduit infrastructure and allows utilities to standardize on PVC throughout their entire electrical system.

Sceptacon is the ideal solution to short drilling projects where heavy local traffic can't be interrupted.

Now available in a 2" diameter, SceptaCon is ideally suited for street lighting and traffic signal applications where installation requires a smaller diameter pipe than your typical electrical raceway. As the only approved, boreable PVC electrical raceway available in a 2" size, SceptaCon allows contractors to install RW cables instead of the more expensive TECK cables.

No Fusion or Cementing Required

With SceptaCon's slide-in locking system, a watertight joint can be made in seconds, without fusion or cementing

Pressure Rating & Flexibility

SceptaCon is pressure rated to 80 psi and approved for a 65 ft bend radius

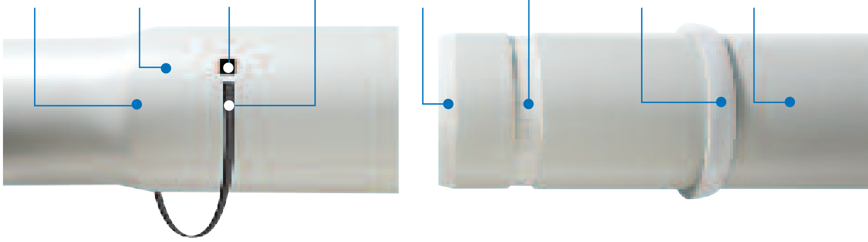
Easier to Handle & No Reel to Return

Installed one length at a time, SceptaCon doesn't require the use of a reel…no reel deposit, no reel truck, and no need to return the reel after use

For more information visit www.kraloyfittings.com

The SceptaCon™ Joint

Featuring slide-in spline locking system.



KRALOY®
The Fitting Choice

Toll Free: 1-800-265-1815
Phone: 519-681-2140
www.kraloyfittings.com