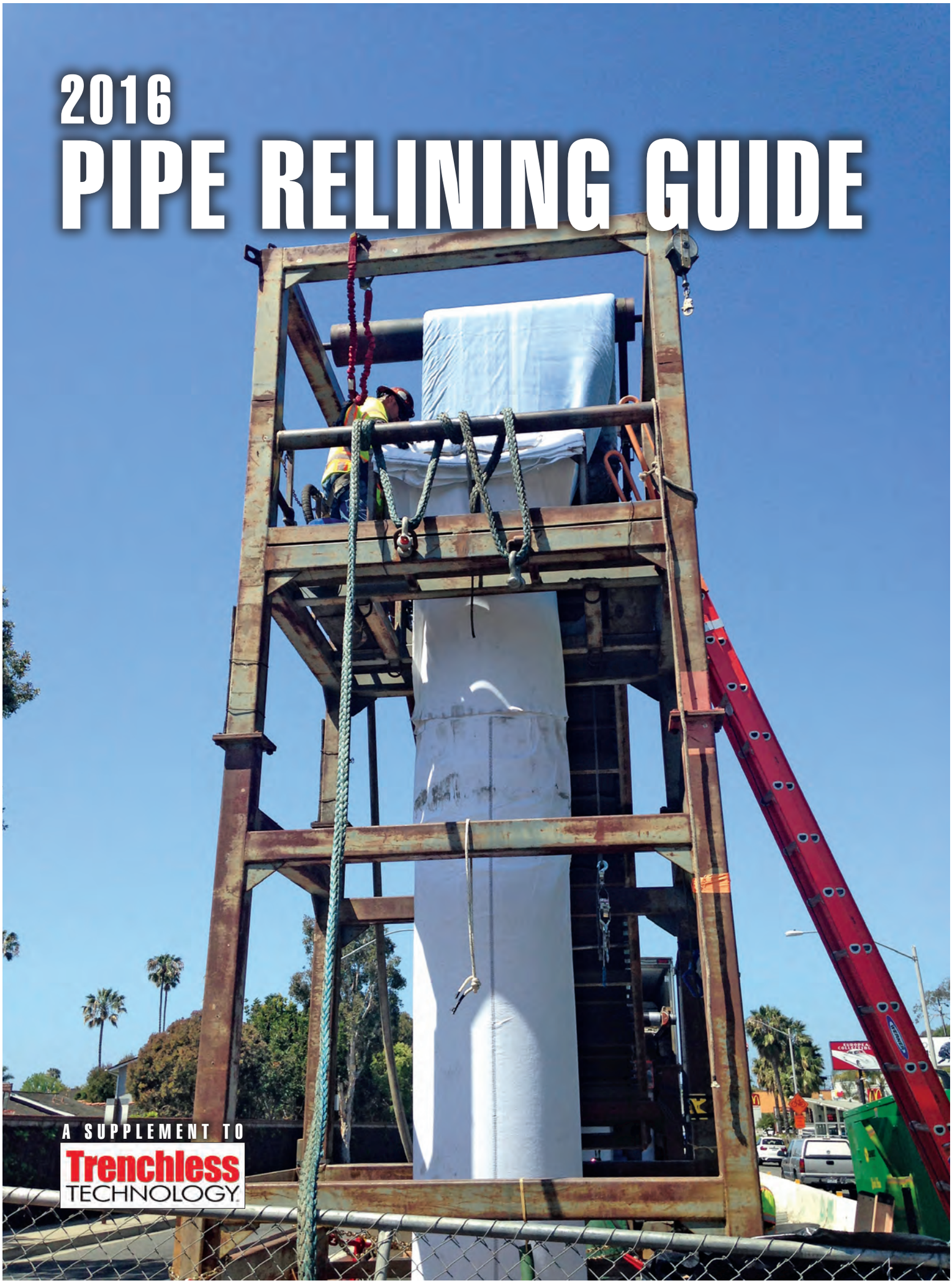
2016
PIPE RELINING GUIDE



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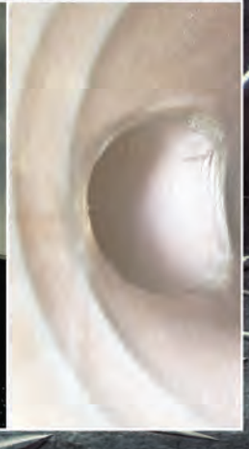

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THE *2016 PIPE RELINING GUIDE*: HERE WE ARE AGAIN!

The *2016 Pipe Relining Guide*, a special supplement to *Trenchless Technology*, is in the books. Once again, we have presented readers with an interesting lineup of pipe relining case studies and topical articles that we believe you will find interesting and generate discussion. Lots of good stuff on these pages.

In looking over the articles we have assembled for you, one thing is clear: This is certainly an exciting time to be involved in the pipe relining market. I wish we could put every story idea we have in the *Pipe Relining Guide* because that is how endless the list is. The pipe relining market has continued to grow leaps and bounds each year, as more and more municipalities and owners turn to trenchless technology to address their underground infrastructure needs.

Once thought of as the new kid on the block when it came to infrastructure needs, today, pipe relining is the go-to option for many municipalities and owners as its success, minimal social disruption and light footprint, resonates and are accepted. The relining methods available today whether it be cured-in-place pipe (CIPP) or sliplining, make cost-effective and long-lasting, minimally invasive solutions at the ready.

A couple stories you should definitely check out. One is by associate editor Andrew Farr, who examines the impact of the Flint, Mich., water crisis on the trenchless relining market. The Flint story is the water story of the year and has put a very large and needed spotlight on the plight of our aging infrastructure, specifically the risks of lead service lines that delivery potable water to homes. How has this crisis affected the trenchless market? This is a very good and important read for you.

Another story I want to tell you about comes from associate editor Mike Kezdi, concerning the issue of quality assurance (QA) and quality control (QC). He spoke with NASSCO, NASTT and the Trenchless Technology Center to share their perspectives on how quality assurance and quality control impact a trenchless project and the trenchless market as a whole. Good stuff from the leading trenchless organizations. QA/QC doesn't grab the big headlines like a cool project story but it is an important component to the overall success of any project and a reflection on the industry itself.

The work that people are doing in the pipe relining market is outstanding and the technologies available to users continue to push the industry forward and make it stronger. I never tire of reading about the fascinating applications and circumstances under which trenchless methods are being used. The growth and impact of the trenchless industry is mind-blowing, with increasing emphasis on pressure pipe and stormwater applications. Ultra violet CIPP also remains a growing market segment.

It's no surprise that pipe relining is the most-talked about topic in every issue of *Trenchless Technology*. Not a week goes by that we aren't contacted about a project taking place in this part of country or that part. Can we do a story on it, we are asked. You bet. The *Pipe Relining Guide* allows us to expand our coverage that much more, yet there still isn't enough space to tell all the great stories out there — but we do our best. Keep letting us know about the great work you are doing so we can share it with the rest of the trenchless community!

Until next year's *Pipe Relining Guide*!

Managing Editor,
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LEADING OFF

Examining the Trenchless Relining Market in the Wake of Flint's Water Crisis

BY ANDREW FARR

If one word encapsulates the biggest story of the year when it comes to anything related to water or pipelines, it very well could be "Flint."

The very mention of the Michigan city evokes thoughts beyond a low-income, poverty-stricken community and reminds us of the city's water crisis that originated in 2014 and received national news coverage by early 2016. The aftermath of the entire catastrophe has called into question the credibility and accountability of public utility systems and has given the public doubt about the ability of local and state governments to deliver safe drinking water to the taps of ratepayers.

Perhaps most obvious, the water crisis in Flint has pushed the discussion around aging infrastructure into the national spotlight and has raised questions about the risks of lead service lines that deliver potable water to homes.

It didn't take long for the industry and politicians to reinforce their stance on lead. The American Water Works Association (AWWA) has announced its support for the complete removal of all lead service lines in the United States, and in March, published an analysis, estimating that 6.1 million lead service lines remain in U.S. communities. AWWA said that number suggests progress in lead service line removal over the past two decades but also indicates an estimated $30 billion challenge remains (when the Lead and Copper Rule was instituted in 1991, the U.S. EPA estimated there were 10.2 million lead service lines nationwide).

"Communities have taken positive steps for more than two decades to reduce lead exposure from water and other sources," said AWWA CEO David LaFrance upon release of the AWWA analysis. "But there is clearly much more to be done. The Flint crisis lays bare a simple fact — as long as there are lead pipes in the ground or lead plumbing in homes, some risk remains. As a society, we should seize this moment of increased awareness about lead risks to develop solutions for getting the lead out."

The Serline system from Aquam Corp. is a pressurized pipe rehabilitation solution specifically for small diameter lead service lines.

The campaigns of presidential nominees Hillary Clinton and Donald Trump have also addressed the need for water infrastructure improvements. However, the two parties have taken different approaches, with Republicans criticizing the EPA in its Party Platform over excessive regulations, while Democrats have addressed Flint more directly with many calling for the resignation of Michigan Gov. Rick Snyder, a Republican, over the crisis.

We now know Flint's water crisis stems from the city's decision in 2014 to switch from Lake Huron water, supplied by the City of Detroit, to water from the Flint River treated at Flint's city treatment plant. The decision was made in an effort to save the City $5 million over the course of about two years. Officials from Michigan's Department of Environmental Quality (DEQ) have since acknowledged they made a mistake when they failed to require the needed corrosion control chemicals to be added to the water. As a result, lead leached from pipes and fixtures into the drinking water. To date, three DEQ employees and three state health department employees in Michigan have been charged with felonies in connection with the water crisis.

"The experience of Flint underscores the importance of public communications about lead risks," added LaFrance. "Water

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utility customers should know how to determine if they have lead service lines, the benefits of removing lead service lines, and the steps to protect themselves and their families from lead exposure."

ADDRESSING LEAD SERVICE LINES

In December 2015, the National Drinking Water Advisory Council, which advises EPA on matters related to drinking water, made the following key recommendations for water utilities:

1. Locate and replace all lead service lines completely, sharing responsibility for that replacement with customers;
2. Conduct additional monitoring and analysis of water quality parameters in order to better manage corrosion control;
3. Expand on current educational outreach to alert customers, particularly customers with lead service lines, to the risks posed by lead and steps they can take to reduce those risks, and
4. Analyze customer samples for lead upon request.

But even for large utilities, complete removal of service lines is a challenge, and for some, perhaps an unrealistic goal at least in the short term. DC Water had challenges with lead in its drinking water system in the early 2000s. The Lead and Copper Rule required DC Water to replace 7 percent of its lead service lines. DC Water CEO and general manager George Hawkins says that, at the time, the utility was replacing about 10 percent with the goal of replacing all, but ran into legal challenges that prohibited the utility to use public funds to replace service lines on private property or mandate it.

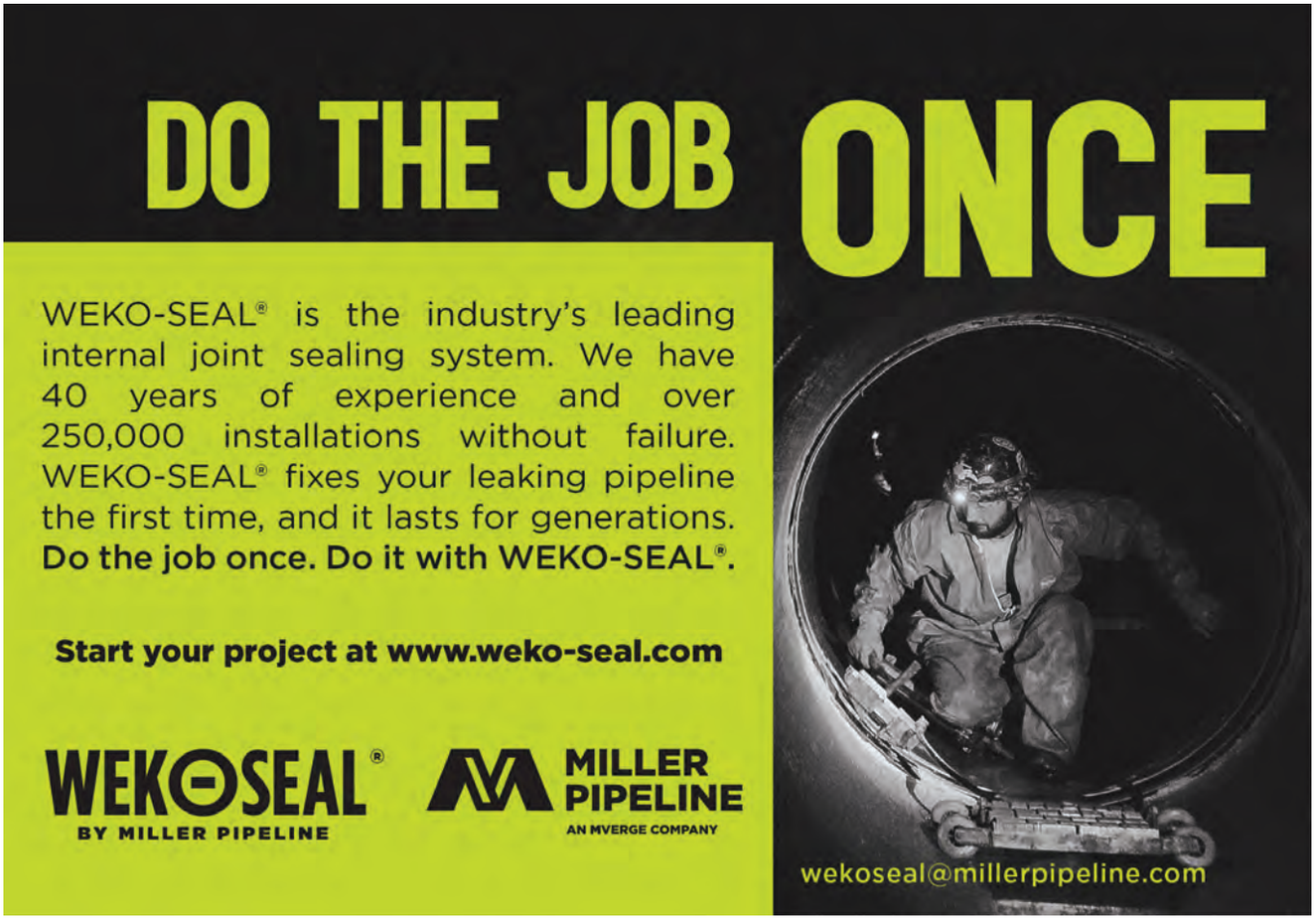
Since then, DC Water has been proactive about continuing to address the issue, particularly from a public awareness standpoint. Earlier this year, the utility launched an interactive "lead map" that provides customers in its service area the ability to access information about lead pipe materials in the ground in their communities.

"My premise on almost any issue is that visibility, transparency and information is the first step toward making good decisions," says Hawkins.

The lead map is a collaboration between DC Water and ESRI that displays collected pipe material data for service lines based on permit records, water main tap records, meter records and maintenance, repair and replacement work. If available, DC Water has recorded the type of pipe material by the sections of the service line in public space and the portion from the property line to the building.

DC Water does not currently have a partial lead service line replacement program. Instead, it uses an on-demand replacement program in which residents can request DC Water to do the project on the public and private side, and the customer is later billed for the private side. The other way the utility is replacing lead service lines is if they need to be replaced during water main replacement projects. In these cases, DC Water will also replace the private side at the owner's discretion and cost. Hawkins says these programs have expanded due to attention directed from Flint and because of the information available on the lead map.

"All we're releasing is what we have in our records," Hawkins says. "What we've gotten feedback on in a number of cases already is that our information is not up to date, particularly on the private side. And that's a good



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thing. We encourage [the public] to help us [update it]. The only kind of action we think this will trigger is good action."

TRENCHLESS RELINING OF LEAD LINES

Although replacing lead service lines is the only way to fully eliminate the threat of lead leaching into a drinking water system, it may not always be the most cost-effective or efficient. Trenchless relining of service lines has become common practice with sewer laterals, but potable lines can be more complex.

"Lead is really a problem everywhere and now you're hearing all kinds of stories about lead service lines all across the U.S. and Canada," says Cameron Manners, CEO of Aquam Corp., whose Serline system is a pressurized pipe rehabilitation solution specifically for small diameter lead service lines. The Serline system has been employed for the past 15 years in the United Kingdom.

The application process involves drying the pipes with heated and filtered air through the use of air hoses which are connected directly to the piping system. The dried pipes are cleaned using a glass-free abrasive that smooths and cleanses the inside surface of the pipes. This process is used in conjunction with the application of the polyurethane coating.

The application of the polyurethane coating is the final stage of the process. The coating provides protection against pipe corrosion and future contamination. Aquam's Serline system uses 3M's Scotchkote 166L, a liner specifically designed for an in-situ application to the internal surface of small diameter service pipes for potable water. The Serline system can reline pipes as small as a ½-in. to 1 in. The entire process takes about 45 minutes to one hour to complete and Manners says Aquam recently signed a contract with Affinity Water in the U.K. to reline the lead service lines for 29,000 homes using 3M's Scotchkote 166L.

Manners says another attribute of Serline is that it is essentially an automated system that is also Drinking Water Inspectorate (DWI)-certified in the U.K. for quality assurance of equipment and materials for drinking water.

"With the Serline system, the entire application is totally controlled by computer," says Manners. "So basically, actuators and sensors throughout the system are telling us exactly what our temperatures and air flows are and it gives us real time data reporting. A big part of this is that the data comes with validation."

The Serline system is controlled by computer and sensors throughout the system relay temperature, air flow and other information to field crews to give real time data reporting.

MARKET OUTLOOK FOR SERVICE LINES

Lead service lines have clearly drawn the attention of both the industry and the public, and going forward, it will be interesting to see what kind of expansion takes place in the United States with rehabilitation and/or replacement programs.

"Lead can be eradicated," says Manners. "I think one of the issues that people are running into is the magnitude of what the problem is. I think that now people need to understand that there is a solution and that it can actually be tackled now in a reasonable amount of time."

Hawkins agrees and says he suspects there will be more programs to replace or rehabilitate service lines in the near future, but the difficult part will be funding it.

"My suspicion is that there will be more programs about replacement of service lines, but every city is going to face the same issue that we do," he says. "The challenge of where you find the funds exists, and this is on top of the tremendous existing need for infrastructure improvement throughout the rest of the system. So either it's going to have to take away from existing funds for other projects or it's going to need to be new money. Those are tough questions not just for water or lead, but for any issue."

"I think most utilities will want to do it in a systematic fashion and plan it out," Hawkins continues. "It will take a period of time. These are millions of service lines. But on the other hand, we certainly learned the lesson that leaving it there is just a problem waiting to happen. We take great pride in the quality of what we deliver, but these enormous logistical and financial challenges are not easy to overcome.

"But I think you will see more action on it. There's no good reason to have a Flint situation happen. But given that it did happen, it has definitely elevated the issue on the consciousness of the public and the utilities that serve the public."

Andrew Farr is an associate editor of *Trenchless Technology*.

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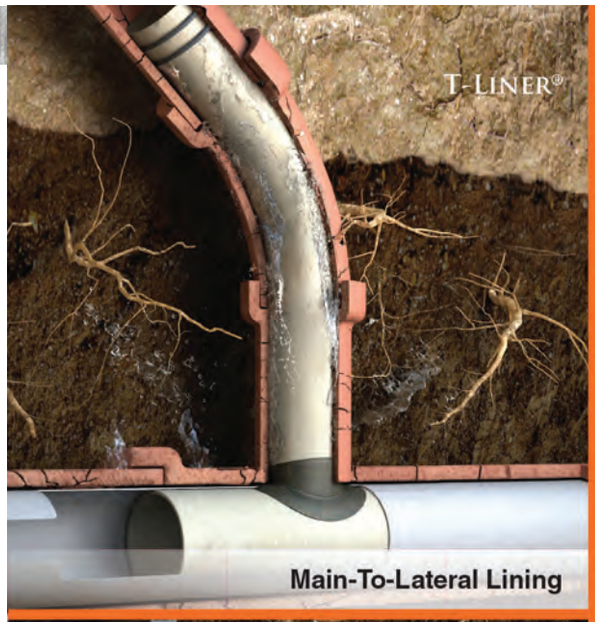

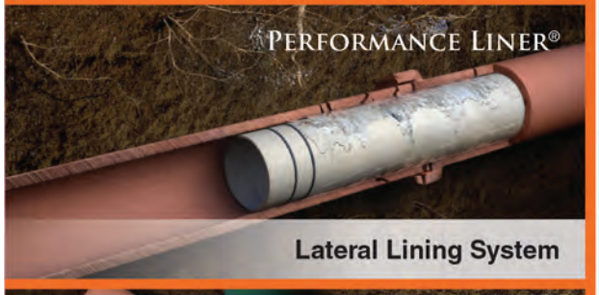

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HAND-IN-HAND

QA/QC Protocols Integral to Successful Projects

BY MIKE KEZDI

The overall success of a construction project — no matter how big or small — often depends on the levels of quality assurance and quality control that all parties involved in the project adhere. This is even truer when working in the trenchless world, as much of the work is done underground and out of sight.

It is important to note that while many people use quality assurance (QA) and quality control (QC) interchangeably, they are not the same. The American Society for Quality (ASQ) defines QA as, the planned and systematic activities implemented in a quality system so that quality requirements for a product or service will be fulfilled and QC are the observation techniques and activities used to fulfill requirements for quality.

Looking at this in terms of a trenchless relining project, QA comes on the front end of the project in the condition assessment and design phase. The owner agency is assured that the project it is putting out to tender is the one that will address the desired outcome. Quality control deals with the contractors and materials used and ensuring the installation and finished product are as prescribed.

"You can have a job without any quality control standards and it can be a good job. That happens, but when you look at the overall picture, projects that have a good quality system have a much greater chance of being a successful project," says Lynn Osborn, technical director, NASSCO. "Pipelines fail for a lot of reasons, but two reasons are that low quality materials are installed or the installation is poor. Both can be included in a quality program making certain the right materials are selected and the correct installation procedures are used. That goes a long way toward determining the success, as far as quality is concerned, of the project."

Osborn sees QA/QC as a three-legged stool. To have a quality product that will meet the owner's requirements requires good engineering design, qualified installers and trained inspectors. When the first relining projects took place, contractors would bid on a job and, if they won the bid, they would go ahead and tackle the project. Once complete, the extent of sampling or review might be a grainy CCTV video that the owner would review and nothing more. If the project failed, the owner likely wouldn't revisit trenchless in fear of being burned again.

Mike Willmets, NASTT executive director, recalls one of the early potable water relining projects he worked on as the project manager for the Region of Ottawa-Carleton, Ontario. This was in the early days of potable water pipe relining and the contractor took what they knew about gravity pipe lining and applied it to pressure pipe. Unfortunately, there was always the risk of the exterior liner resins clogging the service connections.

"Some of the first contracts we did had problems, not problems that could not be fixed, but problems that cost additional funds," Willmets says. "As you move forward, you realize there might be a better way to complete these projects in more timely and economic fashion."

The fix for the clogged service connections was as simple as adding a temporary plug to the connections to avoid the resin migration. In the end, the plugging perfected the process ensuring the savings that are typical of a trenchless solution — cheaper, faster and greener!

"There are generally few cast in stone regulations for this practices and that is where organizations like NASTT comes in and where the value of networking can play a major role. When I worked for the municipal government, I'd engage other city employees at engineering events and other functions where we would chew the industry fat," Willmets says. "This brought a net benefit to everybody because sometimes they would have issues we never

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thought of and the dialogue helped us all in the long run. I always shared our specs with others because they were public documents and we worked very hard on developing early specs. Sharing knowledge with others helped them get a start in alternative solutions with innovative products and I believe helped grow the trenchless industry."

It is through this trial- and-error effort across the industry and via associations like NASSCO, NASTT, ASTM and ASCE that standards started and continue to evolve.

"When we talk about lining, QA and QC applies to everyone," says Dr. Tom Iseley, director of the Trenchless Technology Center (TTC) at Louisiana Tech University. "There is a tendency to think that QA and QC only come in to play during the construction phase and through inspections. It must be built in to every aspect of the project."

This starts at the condition assessment phase and using a variety of tools to determine the problem and the proper repair(s) for the conditions. With a quality assessment complete, the owner and design engineer work in tandem to determine the best specification for repair taking into consideration pipe type, pipe condition and desired outcome. The owner can put the best possible project out and the right contractors will submit the best bids.

For example, Iseley cites a city having an inflow and infiltration (I/I) problem and the city has an excellent QA/QC process for relining pipes. However, when the city and its design engineer put the project together it only addresses the pipe and not the service connections and manholes. The project scope needs to address all three in order for the city to receive the I/I benefits it originally hoped.

"So many times we see where QA and QC is placed solely on the backs of contractors and there are poor and inadequate contract documents produced," Iseley says. "They [the owners] expect the contractor to do magic and have a perfect project. Contractors can only do so much."

Putting the best possible project out with the correct specifications is paramount in a day and age of increased scrutiny from regulators, environmental agencies and the public alike. Willmets notes that the increased scrutiny means a project has to be "pretty much bullet proof," before it gets off the ground.

"For every dime you spend, you better make sure that you are doing it exactly as you should in the most efficient way that you should," Willmets says.

On the quality control side, an owner must perform due diligence to make sure the approved contractor is qualified to meet the project specifications. In recent years, owners have increasingly required contractor pre-qualification before bidding. Once the project is under way and through completion, a qualified inspector should monitor the project for the owner. Quality control measures must be clearly defined in the project specifications and include material sampling, CCTV inspections and data logging.

As the trenchless industry matures, asset owners are becoming more cognizant of the importance of a full quality assurance and quality control program when working on a project.

"As the industry matures, we will see standards developed and the ones that are out there will be revised." Iseley says. "We need to see more focus on training, not just for the overall construction process, but training that goes into designing and planning projects as well."

Not unlike other sectors of the construction industry, the key to a quality project are qualified and trained designers, contractors and inspectors. These trained individuals are the front line in making sure QA/QC measures are met, and this is an area where NASTT, NASSCO and TTC, among others, shine. Willmets points to the NASTT website, where course offerings are listed as well as technical papers from 1991 to present, many of which cover QA/QC. And NASSCO is known for its Pipeline Assessment & Certification Program (PACP,) Manhole Assessment & Certification Program (MACP) and Lateral Assessment & Certification Program (LACP), as well as its Inspector Training and Certification Program (ITCP).

Mike Kezdi is associate editor of *Trenchless Technology*.

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THE NEW TRADITION

Montreal Rehabilitates Aging Water Mains Using CIPP

BY DIDIER GIRARD, ING. AND MICHAEL DAVISON, ING.

In 2015, the most populated and influential city in the Province of Quebec, the City of Montreal, continued its quest to lead the way in performing trenchless work on aging sewer and water main networks.

As a part of Montreal's multi-year plan, city leaders announced that there would be a $257 million investment to update and maintain the City's aging water infrastructure. An important part of the budget would be allocated to projects using trenchless technologies.

The CIPP Solution

Montreal materialized its projections in Spring 2015 by tendering approximately 28 km of water main rehabilitation using cured-in-place pipe (CIPP) lining. The project consisted of the rehabilitation of pipe diameters ranging from 6- to 12-in., the replacement of 163 fire hydrants as well as 157 valve chambers throughout the 17 boroughs of the city.

Sanexen Environmental Services Inc. proudly won the bid and, using its patented Aqua-Pipe product, accepted the challenge to complete the project before year's end.

This water main rehabilitation project, on the secondary distribution system, was seen as a great challenge for multiple reasons. The 28 km of water mains were spread over 120 streets each with its subtle challenges and was matched with the replacement of just under 800 lead service connections that needed to be replaced simultaneously.

This undertaking had an impact on scheduling but Sanexen was confident in their planning and their technology to complete this part of the project accordingly. Throughout the last few years working with the City of Montreal, Sanexen successfully completed similar projects with the integration of lead service replacements in the job timeframe by using pulling and pipe ramming technologies, severely reducing the impact on the neighborhoods and surrounding businesses and making for a true trenchless project. Many of the job sites were in very sensitive areas such as the busy downtown core where traffic is quite heavy and historic old Montreal where tourism is essential to the city's economy.

The most difficult jobsite was on Bridge Street, at the mouth of one the most travelled bridges connecting the

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downtown area to the residential south shore: Victoria Bridge. The 445 m (10-in.) section of water main is located at the center of the street and there needed to be replacements of many accessories such as hydrants and valve chambers. It was not possible to close the street at any time of the day so scheduling was essential from securing the site to enable the excavation crews to dig access pits to the positioning of lining equipment over top. The water main temporary bypass was installed with very few obstructions as traffic was passing by.

The rest of the Aqua-Pipe operations, such as cleaning, plugging and reinstatement of service connections were completed by working around the clock and by constant modifications to signage in order to accommodate changing traffic flow. The Aqua-Pipe team lined the water main in only two insertions, each more than 200 m in length. A very tight schedule was the key to this worksite as every team was closely followed by the next to assure no downtime. The whole worksite lasted 22 days from bypass installation to restoration and was a complete success in the eyes of the city of Montreal.

Aqua-Pipe Shines

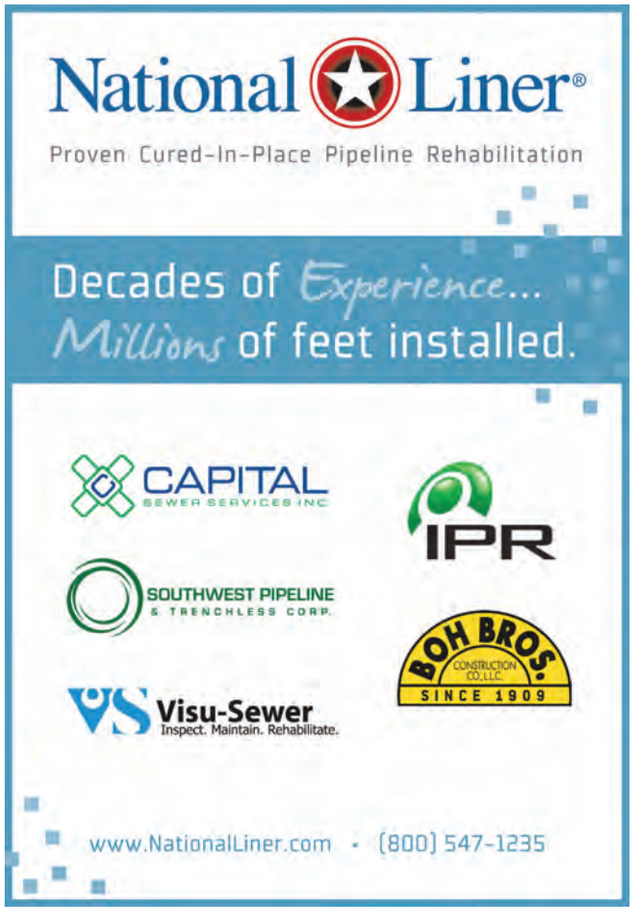
Throughout a project of this magnitude, Aqua-Pipe had the opportunity to show on many occasions its adaptability to various situations.

Some of the pipes that were lined were installed in the early 1900s and the plans given by the city were not always accurate. It is when you face situations like unmarked bends and services, abandoned valves and variations in the pipe diameter that a good versatile product like Aqua-Pipe shows its value. Many non-protruding service connections were found in residential areas of the eastern part of the city, with redesigned plugs and great team of operators, they were drilled with an excellent rate of success. Furthermore, the entire crew demonstrated poise and creativity, when facing unknowns, quickly finding solutions that were cost effective for the city and in line with the schedule.

This water main rehabilitation project executed in Montreal was a success from different standpoints: cost and time efficiency. The amount of water saved from the now lined 28 km, over the past eight months of work is quite impressive. The City of Montreal is convinced that it found, through rehabilitation, the way to upgrade and durably sustain its water main network. As confirmation, the City recently confirmed its plans to continue to invest equivalent amounts of capital over the next three years in their water and sewer infrastructure.

Due to the complexities of managing such a large territory, the City of Montreal continues to prioritize the use of rehabilitation and trenchless technologies before considering traditional infrastructure dig and replace. The often priceless or intangible cost benefit to the residents and businesses is important to the City is shown through its choice of technologies. The new tradition has become rehabilitation.

Didier Girard, ing., is a project manager for Sanexen Environmental Services Inc., Aqua-Pipe division and Michael Davison, ing., is Aqua-Pipe product director.



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UV-CIPP Rehabbed a Major Interceptor in Maine

BY PETER GOODWIN

The Greater Augusta Utility District (GAUD) in Maine was originally formed in 1903 as the Augusta Water District. In 1960, the Augusta Sanitary District was formed by the state legislature and by 1963, 48 miles of sewers and a wastewater treatment facility were completed and in operation to protect the Kennebec River.

In 2007, the state Legislature voted to merge the water and wastewater districts. Currently, GAUD provides drinking water, wastewater collection/treatment, and stormwater services to the state capital of Augusta and the portions of the neighboring communities of Hallowell, Monmouth, Winthrop and Manchester. With more than 5,700 residential, commercial and industrial customers, GAUD operates and maintains hundreds of miles of water distribution, wastewater collection and storm water conveyance pipelines that are aging and in need of replacement or rehabilitation.

Like many systems of this era, the wastewater collection system was originally designed as a combined system with wastewater and storm water collected and transported to the treatment facility in the same pipe. The treatment facility was designed to handle wet weather flows of 2.5 times the average daily wastewater flows. During wet weather conditions, however, system flows could reach 10 to 15 times treatment facility capacity and combined sewer overflow (CSOs) would divert flow directly to the river. Starting in 1987, the Maine Department of Environmental Protection under the Clean Water Act initiated a statewide program to reduce and eliminate CSO discharges to the waters of

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Reline America's Alphaliner UV-CIPP liner was installed and cured in one day and the pipe was put back into service. The entire rehabilitation project was completed within one week.

the state. Since then GAUD has invested more than $44 million to separate and/or provide storage to eliminate CSO events.

In addition to separating the wastewater and stormwater systems, some areas in the system were reaching their useful life, with sewers more than 40 years old. One critical interceptor was an aging 24-in. reinforced concrete pipe (RCP) that conveyed flows under the Maine Turnpike (I-95) in a low lying wet area. This 450-lf pipeline not only crossed under four lanes of interstate highway, but was under the Old Winthrop Road overpass further complicating rehabilitation alternatives. I-95 is the major highway that typically sees more than 20,000 daily vehicle trips and is heavily utilized for commerce.

GAUD staff had identified the interceptor for evaluation because the pumping station was experiencing significant wet weather flows and gravel had begun to be found following wet weather events. During wet weather periods, GAUD staff would continuously monitor the station and at times utilize septic haulers to alleviate surcharging. This was a critical section of infrastructure, therefore, GAUD performed a closed circuit television (CCTV) inspection condition assessment. Significant root intrusion and infiltration was found with deteriorating pipe conditions. Immediate rehabilitation was required.

GAUD quickly determined that an open-cut replacement was not an option due to wetland/stream crossings, depths in excess of 12 ft in some areas, groundwater, and most importantly I-95 and Old Winthrop Road Overpass.

GAUD staff collaborated with the Ted Berry Co. Inc. (TBCI), Livermore, Maine, which specializes in infrastructure condition assessment and trenchless pipeline rehabilitation or replacement. Initially, sliplining the 24-in. RCP was considered, however, the reduction in hydraulic capacity was not desirable with the potential for additional sewer system expansion to the west of the interstate highway.

The GAUD and TBCI teams then evaluated the cured-in-place pipe (CIPP) technology, which would only slightly reduce the pipe diameter. TBCI had been installing the next generation CIPP liners from Reline America, Saltville, Va., for over a year. This CIPP liner is cured with ultraviolet (UV) light, which reduces the environmental issues associated with conventional CIPP technology using steam or hot water. The UV-CIPP liner also is

Once the Alphaliner UV-CIPP was installed, the Ted Berry Co. Inc. blower truck utilized low pressure/high volume air to inflate the liner up against the host pipe.

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significantly stronger with a smaller wall thickness due to the liner manufacturing process, which uses glass reinforced Fiberglass and a patented spirally wound manufacturing process that provides superior strength characteristics.

Budgetary cost estimates were prepared for both sliplining and UV-CIPP; costs were comparable. GAUD staff prepared the final design contract documents and the project was publicly bid in fall 2015. TBCI was the low bidder at $60,000 and was awarded the contract. Based on the collection system configuration, TBCI engineers and operators developed a comprehensive work plan to handle the wastewater flows during the anticipated two- to three-day installation process. Since the interceptor condition was severely deteriorated and based on its criticality and location, GAUD desired the rehabilitation to be complete in advance of the spring 2016 wet weather conditions.

Site work began in late December 2015, with the temporary bypass system installed to provide isolation of the 450-lf section. Temperatures ranged from single digits at night to the mid-teens during the day. A series of bypass pumps was utilized and a 6-in. HDPE bypass force main was temporarily sliplined through a nearby box culvert. This allowed flow to be diverted around the interceptor from west of I-95 to a downstream manhole East of the Interstate.

Once isolated, the TBCI team began installation of the UV-CIPP liner by installing a "slip sheet," which protects the liner as it is pulled into place with a constant tension variable speed winch. Reline America Alphaliner UV-CIPP liners are designed for each application based on a fully deteriorated host pipe condition and design parameters including soil, groundwater, depth, and traffic loadings. The liners range from 6 to 54 in. in all conventional pipe shapes at lengths of up to 1,000 lf.

Once the Alphaliner UV-CIPP was installed, the TBCI blower truck used low pressure/high volume air to inflate the liner up against the host pipe. The UV light train, which has an integral CCTV camera, was then inserted and a pre-inspection of the entire length was performed to insure that the liner was in place properly. Once the pre-cure CCTV inspection was complete, the Reline America Quality Tracker System activated the nine 1,000 watt bulbs and the UV curing process was initiated. Curing speed is controlled by the Quality Tracker System and is based on the liner design with during speeds in the 2 to 4 lf per minute range.

The UV-CIPP liner was installed and cured in one day; the pipe was put back into service. The entire rehabilitation project was completed within one week. During spring 2016, GAUD staff immediately identified that the rehabilitation was an immediate success with wet weather flows no longer transporting gravel to the pump station and peak flows were significantly reduced to the point where staff no longer had to monitor the station during rain events.

Peter Goodwin, P.E., is client services manager at The Ted Berry Co. Inc.

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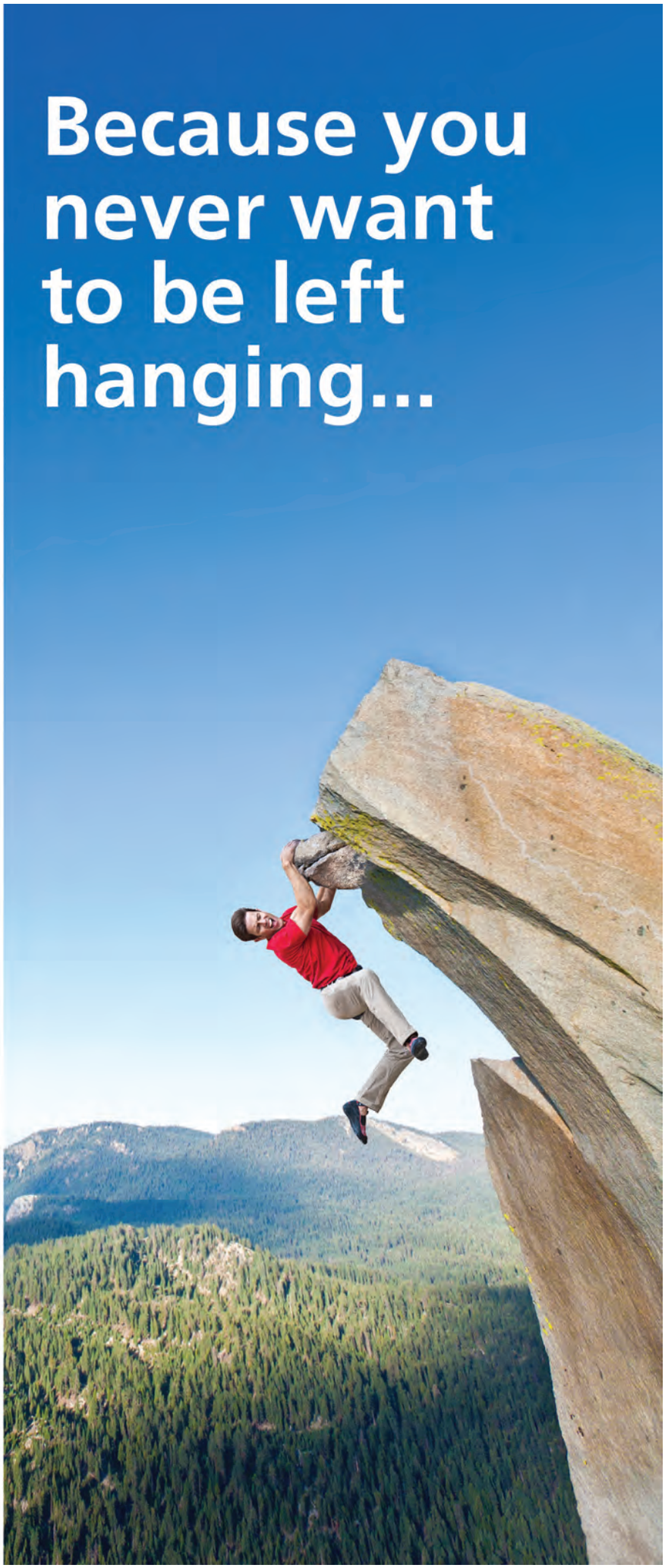

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Overview of Lateral and Main/Lateral Connection Lining and Sealing Technologies

BY THE NASSCO LATERAL COMMITTEE

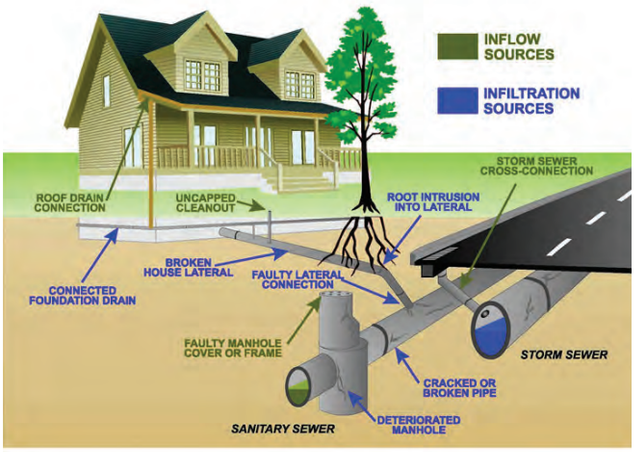
NASSCO is dedicated to informing the public and industry on advancements and utilization of trenchless technologies for the purpose of renewing and sealing laterals and lateral service connections. In many cases, plumbing codes do not specify the use of trenchless technologies, including lining, sealing, grouting or bursting as viable alternatives to excavation. Their use and advantage are still undiscovered by many, and yet these technologies have existed for years, confirming their viability as a proven resource for renewing infrastructure.

The NASSCO Lateral Committee has developed an overview technical document as an educational resource for advancing the acceptance of trenchless lateral rehabilitation. The Committee works with local system owners, state health departments and plumbing boards in an effort to educate owners on the advantages these technologies provide and enable acceptance into relative codes.

Several studies have confirmed that many of the lateral pipes in typical collection systems have reached their life expectancy and are either failing and/or contributing large amounts of infiltration and/or inflow (I/I) to the main sewer pipeline. In response, technology providers have developed a number of products and technologies to line and seal lateral pipes and their connection to the mainline sewer. Lateral pipes often have multiple bends, diameter changes, offset joints, cracks, deposits and roots, which create considerable challenges when lining or sealing. The lateral pipe connection to the sewer main also poses problems due to leaks, cracks and poor alignment often created by improper connection procedures. Trenchless rehabilitation can address these issues while minimizing the impact to property owners and sewer providers. These technologies also provide an effective service life through proven, tested materials and refined installation procedures to meet owner expectations.

There are seven main approaches to consider when evaluating how to renew a lateral pipe:

- **Sectional Pipe Lining** - Repair by lining a portion of the lateral pipe.
- **Lateral Pipe Lining** - Repair by lining the entire lateral pipe.
- **Main/Lateral Connection Lining** - Repair by lining the lateral/mainline connection.
- **Lateral and Main/Lateral Connection Lining** - Repair by lining a portion of the lateral pipe or the entire lateral pipe and lining the lateral/main connection.
- **Main/Lateral Connection Sealing** - Repair by sealing the main/lateral connection by resin injection.



Several studies have confirmed that many of the lateral pipes in typical collection systems have reached their life expectancy and are either failing and/or contributing large amounts of I/I to the main sewer pipeline.

- **Lateral and Main/Lateral Connection Grouting** - Repair by sealing the main/lateral connection and the entire lateral pipe (or a portion of the lateral Pipe) by chemical grout injection.
- **Lateral Pipe Bursting** - Replacement of either part of or the entire lateral pipe by pipe bursting.

The NASSCO overview document presents the advantages to assist with selection; however, system owners are encouraged to utilize the technical document as a guide in collaboration with their local consultants and contractors.

CIPP for laterals closely follows the principles outlined in ASTM F 1216 and F 1743 and is capable of accommodating small diameters (4 in.) while maintaining a fully structural wall, navigating bends and enabling blind terminations, which allows installation from one point of direct access to the lateral (in most cases being an excavated installation pit or clean out). There are lining technologies that can be installed from the mainline, eliminating excavation altogether, and often will incorporate a seal for the lateral's connection to the mainline. One hundred percent solids epoxy is a popular component enabling adhesion at the liner's blind terminated opening, provided proper surface preparation of the host pipe has been employed. Typically, lateral lining with and without the lateral seal incorporates the use of a resin-impregnated tube installed by either water or air pressure and cured inside the host pipe by heat (water or steam), ambient temperature or UV light. Sectional CIPP systems can also accommodate laterals wheth-

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er pulled-in-place or inverted into place when rehabilitation of a specific location is desired.

Lateral seals can stand apart from lateral lining when only the point of connection with the mainline sewer requires attention, whether due to ownership level or physical condition. Lateral seals are typically installed from the mainline and can travel up the lateral variable distances, depending on the technology type, but can range from 4 in. to several feet and, in some cases, continuing up the lateral to include lateral lining with the seal. The seal can incorporate either a brim style or complete wrap configuration at the point of connection with the mainline sewer, and the latest technologies enable watertight seals through gasket materials in addition to the resin systems.

Grouting presents an advantage by pumping reactive chemical grouts to reach behind broken sections of piping filling voids while effectively eliminating infiltration. Grout systems can accommodate both points of connection and locations within the lateral (or main). Grout packers are designed for either insertion from the mainline or from an existing cleanout.

Pipe bursting is a proven option for fracturing the existing lateral and installing a new, factory-manufactured pipe. This technology is popular when the pipe's internal condition prohibits the installation of a liner due to collapses, severe offset joints or other physical constraints. Pipe bursting may also be the most cost-effective alternative when the sum of contributing factors such as cost, availability, host pipe configuration and so on justify bursting over other rehabilitation methods.

These technologies are designed to be trenchless, but do not necessarily eliminate excavation altogether. In various cases, the repair system may warrant an access pit to gain access to a portion of the host pipeline. Other key elements when considering trenchless rehabilitation include CCTV inspection and host pipe cleaning, inclusive of such technologies designed to launch up the service lateral from the main line. Condition assessment and planning can make a substantial difference on projects where it is necessary to prioritize a large number of laterals. Technological improvements and new inventions continue to support and inspire this growing industry to meet the demand of aging infrastructure.

The NASSCO Lateral Committee is comprised of industry professionals including manufacturers, contractors, consultants and wastewater agencies throughout North America who provide a pool of knowledge capital and unite their experience and knowledge in an effort to reach out to the industry and promote educational resources and best practices for developing technical guidelines and specifications. The Lateral Committee meets quarterly to continuously refine and add technical content, research and present case studies to promote the further development of trenchless lateral rehabilitation. The Lateral Committee encourages and welcomes participation. The "Overview" technical document can be found on NASSCO's website, *nassco.org,* under the Industry News & Trends section.

This article was prepared by NASSCO's Lateral Committee.

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BIG JOB IN THE BIG EASY

Swagelining Delivers Value to New Orleans Water Main Replacement Program

BY TODD GRAFENAUER

Replacing failing water pipelines across North America is not an attractive option on any level, not just economically. With the environmental and technical aspects, plus the complexity associated with excavating, removing and replacing existing pipelines will create havoc on our daily lives.

Globally, the rise of trenchless technologies has been at the heart of efforts to maintain and refurbish existing buried systems. Essentially, the concept is to reduce excavation to the absolute minimum and launch the renewal technology from the surface. In relation to water pipelines, one of the most effective trenchless methods has been the introduction of technology that retrofits HDPE pipe into existing pipelines in order to renew them back to fully operational status — and give it an extended lease of life for another century.

Swagelining, also referred to as compressed fit HDPE lining, dates back to the 1970s, when U.K.-based British Gas began the research, development and implementation of many of the trenchless technologies that are in use today. They did so out of necessity to replace and rehabilitate their ageing pipeline systems with the aim of cutting costs and increasing efficiency.

The method of Swagelining specifies an HDPE pipe with an outside diameter larger in size than the inside of the host pipe to be renewed. After the HDPE is butt fused to correspond to the pull distance, the pipe is pulled through a reduction die immediately before entering the host pipe. This reduces the HDPE pipe temporarily below the ID of the host pipe allowing it to be inserted. While the towing load keeps the HDPE under tension during the pull, the pipe remains in its reduced size. The HDPE remains fully elastic throughout the reduction and installation process. After installation, the pulling load is removed. The HDPE pipe naturally expands until it is halted by the inside diameter of the host pipe resulting in a tight compressive fit. The tight fit maximizes the final ID compared to slip lining with a smaller size pipe.

The Big Easy

New Orleans was settled by the French in 1718 on the high ground adjacent to the Mississippi River, only 14 ft above sea

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Trenchless Technology: Planning, Equipment, and Methods

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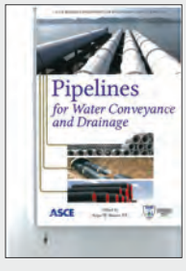

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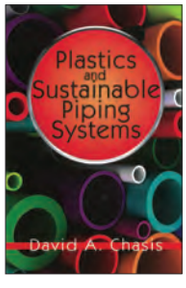

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This compendium of over 40 articles is certain to be an eye-opening educational tool for the experienced and novice designing or specifying engineer, installer, end-user, and students. Plastic is the preferred material in countless applications -- municipal water and sewer lines, drain/waste/vent lines, and chemical waste drainage because they are durable, easy and safe to install, environmentally sound, and cost-effective.

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level. Many sections of the city are as much as 6 ft below sea level. As a result of its unusual topography, the City was subject to periodic flooding from the Mississippi River and Lake Pontchartrain, as well as frequent inundation from the high intensity rainfall.

Water for drinking or general use was either collected in large cypress cisterns that stored rain water from the roof tops or taken from the river and allowed to settle in large earthenware jars. At this time, there were no purification or sterilization procedures.

The Sewerage and Water Board of New Orleans (S&WB) has been serving citizens and protecting the environment since 1899. Originally formed to combat disease by providing safe drinking water and eliminating the health hazards of open sewer ditches, today the S&WB continues its mission using 21st century technology.

Once formally organized, the S&WB set out to fulfill its goals of providing the city with adequate drainage, sewerage collection, and drinking water. Between 1879 and 1915, $27.5 million was spent on the construction of water, sewerage, and drainage facilities. Such extensive construction was a bold step for a city at that time. The Louisiana Engineering Society, in honor of its 75th anniversary in 1973, selected the water, drainage, and sewerage systems of New Orleans as among the ten most outstanding engineering achievements in the state.

Reducing Customer Impact

With a large replacement program in the works and seeking a solution geared toward reducing customer impact, minimizing capital spending, and reducing operational costs; S&WB selected the Swagelining technology to install new HDPE pipe to replace existing cast iron water transmission mains. Each project has been located in a sensitive urban environment requiring a fast construction completion.

Wallace C. Drennan, a third generation construction company founded in Louisiana in 1953 and Murphy Pipelines, which specializes with the Swagelining technology, were awarded the projects. To date, work has progressed replacing 3,100 ft of 16-in. and 1,800 ft of 30-in. water main.

The 16-in. water main was located on Calhoun Street, adjacent to both Tulane University and Loyola University New Orleans. With a history of water main breaks and some occurring in late summer, S&WB made the decision in early August to replace the 3,100 ft of water main before both Universities started school in September.

"We looked into traditional open cut, directional drill, CIPP, and ultimately Swagelining. After putting all the options on the table and comparing costs, schedule, and the impact to the neighborhood — residents, two universities, and an elementary school all within the project site, we opted to go with Swagelining. Traditional open-cut would have taken several months and cost S&WB a significant amount of more money. This technology allowed the S&WB to replace a deteriorating main quickly and with substantially less inconvenience to the general public — not to mention, saving several hundred thousands of dollars." Carmelo Gutierrez, P.E., project manager, Wallace C. Drennan

With only a few weeks allotted for the project before the fall semester began, crews mobilized onsite, developed the Swagelining installation plan and using McElroy equipment fused three sections of HDPE pipe for the pull lengths of 1,300, 1,000 and 800 ft. While insertion/receive pits were being excavated, the HDPE lengths were pre-chlorinated. After the pits were shored, Swagelining operations began. Each pull was installed in less than four hours on subsequent days. In addition to replacing the 16-in. main, cross connections, valves and end connections were made. Within a few weeks the project was complete, in time before fall semester began.

The 30-in. water main was located in the Central City District, and one of the main transmission lines that supplies water to the Superdome, Smoothie King Center, downtown New Orleans, and the French Quarter. The 1,800 ft of 30-inch ran down the middle of Magnolia Street through a congested urban residential and business setting, crossing many busy roads. It was imperative to get the line back in service quickly.

"Swagelining, when compared to traditional open-cut replacement, presents a unique opportunity to rehabilitate a large amount of water or sewer main in a very short amount of time. Traditional open-cut excavation would have taken approximately two months to complete this 30-in. project." says Bart Peak, vice president of operations with Wallace C. Drennan.

The plan was to pull in the entire section of HDPE in one continuous pull to minimize excavations and reduce impact to the residents, business and traffic flow. While installing the HDPE in one continuous pull would optimize the economics and timing of the project, the one challenge was fusing this length of pipe without blocking major roadways. Martin Luther King Jr. Blvd, located four blocks from the Superdome could not be closed to string out the long section of HDPE. To counter this problem, Wallace C. Drennan and Murphy Pipeline crews fused two 900-ft sections of HDPE.

During Swagelining installation, the majority of the first 900 ft was pulled through the swage die and into the existing 30-in. host pipe. As the end of the first HDPE pipe string was nearing the insertion pit, the pull was stopped and the next 900-ft HDPE pipe string was fused on. During this process, the first section of HDPE that already entered the host pipe remained in its reduced state as constant tension pull equipment from TT Technologies was used. Set up and fusion of the second string of HDPE to the first took around two hours. Once the HDPE fusion joint was made, Swagelining operations resumed until the entire length of HDPE pipe was installed. While the Swagelining installation was completed in one day, from mobilization to project completion took 10 working days.

"Reducing customer impact is a top priority for our water and sewer construction projects. Replacing utilities in congested neighborhoods and business districts, coupled with heavy pedestrian and vehicle traffic is challenging. We also have another element with our restaurants, universities, major events, festivals and parades. Each Swagelining project was completed in a few weeks compared to a few months with open cut, which tremendously reduced our customer impact." Mark Bear Child, S&WB project manager.

Todd Grafenauer is vice president and educational director for Murphy Pipeline Contractors, a national leading contractor in static pipe bursting and Swagelining technologies.

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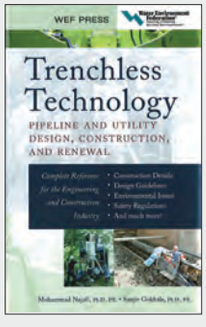

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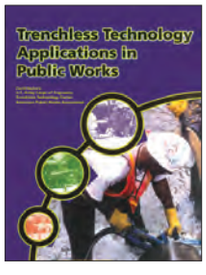

Trenchless Technology Applications in Public Works

This must-have reference assists engineers and contractors in the design, specification and construction of trenchless projects in the public works sector. These guidelines cover the effect of pipe bursting on nearby utilities, pavement and structures. The information in this manual is presented in a format patterned after Corps of Engineers Guide Specifications, but with more detailed information. The guidelines in this book focus on three major aspects of trenchless technology.

Topics Covered Include:

- Rehabilitation of existing pipelines using cured-in-place pipe (CIPP); fold-and Formed pipe (FFP); and Deformed-Reformed Pipe (DRP) methods
- Installation of pipelines using mini-horizontal directional drilling (mini-HDD) and microtunneling
- Replacement of pipelines using pipe bursting and similar techniques

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Sliplining Twin Arch Pipes in Greece… New York

BY HUGH B. MICKEL, P.E.

The Monroe County Department of Transportation bridge engineering and operations division's responsibilities include an extensive planning, engineering, inspection and maintenance program for 175 bridges and nearly 275 major culverts in Monroe County, New York.

One of the bridges is a twin 117-in. x 79-in. galvanized corrugated steel pipe arch that has been in service since the 1980s. It carries Larkin Creek underneath North Greece Road, just north of West Ridge Road, in the town of Greece, New York, just west of Rochester.

The county had been watching this structure via its countywide inspection program. When significant corrosion reached the point of perforating the corrugated wall, the county decided to begin the process of replacement or repair (*see Figure 1)*. It was soon realized that there were various utilities including a gas main that crossed over this structure. The culvert is near a very busy intersection with lots of daily traffic. In addition, overhead power lines could make construction activities, especially full replacement, quite tedious and expensive.

The county's engineering staff has been aware of relining and sliplining technologies for quite some time. The Rochester office of Hunt Engineers Architects Surveyors, P. C. (Hunt EAS) was engaged to consider and evaluate rehabilitation and sliplining options. Hunt EAS was also asked to handle hydraulic design, the creation of plans and specifications to publicly bid the project, and to provide construction oversight.

The structure accepts 3.73 sq miles of drainage area, which generates a design flood flow rate of 542 cu ft per second for the 50-year storm recurrence interval and a 100-year rate of 629 cu ft per second. It was desired that the high water elevation at the point of maximum backwater would not increase from the original elevation of 406.5 ft for the 100-year event.

Hunt EAS soon realized the great challenge of this project: finding a liner material

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FIGURE 1.
Original Twin Galvanized CSP Arch

that would provide the desired hydraulic capacity and still fit within the structures. After consulting with SnapTite and Contech Engineered Solutions in the spring of 2014, it was determined that specially sized ULTRA FLO aluminized steel type 2 (ALT2) corrugated metal pipe arch could be made that would fit inside the host structures and provide the necessary waterway area.

It should be noted that Contech and SnapTite have partnered on a number of reline projects in the Northeast and Mid-Atlantic states. The collective expertise of both companies provide a valuable resource to the municipal, county, state agency and consultant community when it comes to relining a culvert, storm sewer or small bridge. Contech's broad manufacturing capability and engineering knowledge, along with SnapTite's local relationships and field reline know-how make it a highly valuable partnership.

Hunt EAS decided to specify spiral rib CMP in the material specifications for the project after learning the material would provide a Mannings 'n' of 0.012 per the FHWA. Additionally, it could be designed structurally using AASHTO LRFD published methods to carry the entire soil overburden load and the HL-93 live load without any load shedding or composite action from the host pipe. Hunt also appreciated the fact that this pipe material would provide a 100-year service life, as defined by various state DOT standards, and has an exceptional track record in the area.

The plans and specifications detailed all relevant construction requirements.. A note in the plans included this, "It should be noted that the existing pipes have deformed from their original shape which may make sliplining with a standard shaped liner pipe difficult. It is the contractor's responsibility to clean out the existing pipes and profile them prior to procuring the liner pipe so that an appropriate pipe is supply the cost for cleaning and profiling the pipe shall be included in the unit price bit item (for the new pipe)." Also included was, "Note that jacking or cutting of sections of the host pipes may be required to facilitate slip lining or specially shaped pipes may be required. It is the contractor's responsibility to ensure that the liner pipes procured will function as required. If a specially shaped pipe is used the contractor shall provide calculations stamped by a P.E. registered to perform work in New York State, showing that the pipe is capable of carrying highway loading as called out in the general notes."

Inclusion of these notes likely caused some angst amongst even the seasoned segmental sliplining contractors in the

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area, but the low bidder, Villager Construction of Fairport, New York saw it as a chance to demonstrate its expertise.

Upon award of the contract, they issued a purchase order to SnapTite, and the shop drawing submittal process began. They also initiated cross sectional profiling. Meanwhile, Contech developed a method to arch what is termed a half-size pipe and arch it as much as possible such that its geometry matched the host pipe's geometry as closely as possible.

At the time of this writing, a test piece of 110-in. x 73-in. pipe arch was successfully pulled through both lines, and the remainder of the pipe arch segments were released for fabrication. The segments will be placed on half-inch thick wood runners that were attached to the invert of each pipe. Then the segments will be pulled through using a pulling mechanism that attaches to the leading ends. Internal expanding bands and flat neoprene gaskets will be placed over the joints to keep the grout out of the joints. Cellular grout will be used to fill the annular space and any voids behind the host structure. The grout will provide a structural backfill that is self-compacted and self-leveling. The bands are removed after the grouting process.

Based on the success of the test piece placement, it is expected that this challenging sliplining project will be built and completed without issue, and the Monroe County DOT will have saved a substantial amount of money to go with the avoidance of various headaches for themselves and the traveling public.

Construction Sequence*

The construction sequence included the following steps:

1. Place necessary maintenance and protection of traffic signage and delineation devices.
2. Install temporary waterway diversion and erosion control measures.
3. Remove debris and clean out existing culvert pipes.
4. Profile existing pipes to determine available openings.
5. Fix and bulges that may interfere with sliplining operations.
6. Excavate and pour footing for upstream headwall.
7. Pull template through existing pipes to ensure available space.
8. Slipline the existing culverts and grout the annular space between the existing and new pipes.
9. Pour remainder of upstream headwall.
10. Backfill and place rip-rap protection on both the upstream and downstream ends, new rip rap to match existing at the outlet in size and texture.
11. Remove roots and vegetation from grouted rip-rap on the downstream end. Replace any missing or loose stones and re-grout as necessary.
12. Restore the remainder of the site.
13. Remove the temporary waterway diversion and erosion control measures.
14. Remove maintenance and protection of traffic measures.

*Courtesy of Hunt EAS

Acknowledgement:

The author would like to thank Don LeBlanc, P.E., regional sales manager for ISCO - SnapTite Culvert Division, who has been instrumental in the success of this project.

Hugh B. Mickel, P.E., is the vice president of Reline Technologies for Contech Engineered Solutions.

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Asset Management of Force Main Infrastructure

EDITOR'S NOTE: The following is excerpted from the recently released report "Asset Management of Force Main Infrastructure" Synthesis Report published by the Water Environment & Reuse Foundation (WERF) and IWA Publishing and written by Sunil K. Sinha, Bhaskar Dasari and Berk Uslu of Virginia Tech. For more information or to access the full report, visit werf.org.

According to a 2004 WERF survey, 7.5 percent of wastewater collection system assets are force mains. Traditionally, most utilities have relied on a reactive approach to managing their force main assets. The primary reason for this approach is the difficulties associated with force main condition assessment, which requires the force main to be taken out of service for inspection — a major limitation. Moreover, providing bypass pumping during inspection is typically very expensive. The limited proven technologies available to determine pipe wall thickness and defects are part of the critical gaps associated with force mains inspection.

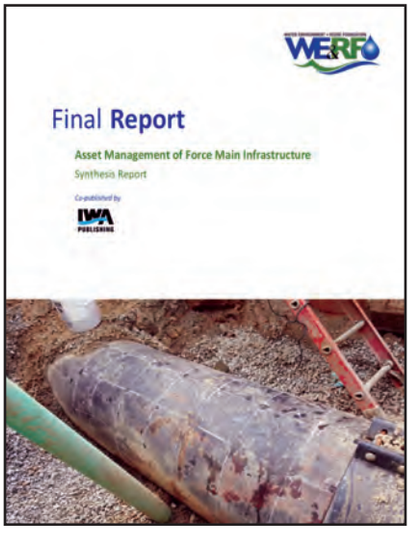
With advancements in inspection technologies, utilities are beginning to take a proactive approach to managing their force main assets. The foundation of risk management of pipeline infrastructure is based on estimating the likelihood and consequence of failure for the assets in the network. This will allow the development of a strategy to prioritize renewal of the force main assets through risk analysis.

Force Mains

When the gravity sewers are incapable of transferring sewage due to insufficient gradients for gravity flow, pumping stations and force mains are necessary. The pumps supply the pressure required to pump the wastewater to the higher elevation. The major components of force mains include pipes, valves, surge control devices and cleaning systems. Even though the majority of collection systems consist of gravity sewers, force mains are necessary in circumstances that require pumping. Lack of a redundant or parallel bypass line is a challenge to take the force mains out of service for inspection and renewal. Additionally, the high consequence of failure, and susceptibility to corrosion, are major concerns associated with force mains.

The key elements that significantly influence the need to address the inspection, condition assessment, and renewal strategies of force mains are:

- **Lack of sufficient redundancy.**
- **High consequence of failure.**
- **Accessibility of force main.**



Materials and Failure Characteristics

Force mains are made of different materials and have various design and installation standards. The pipe materials that are found in force main networks are steel, ductile iron (DI), cast iron (CI), pre-stressed concrete cylinder pipe (PCCP), reinforced concrete cylinder pipe (RCCP), reinforced concrete non-cylinder pipe, concrete bar-wrapped cylinder pipe, polyvinyl chloride (PVC), polyethylene (PE), fiberglass, asbestos cement (AC) and clay. Ferrous pipes (steel, DI and CI) constitute about 60 percent of the force main network. Force mains with diameters less than 36 in. are predominantly ferrous pipes and the pipes

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with diameter greater than 36 in. are largely non-ferrous.

The failure mode associated with force mains varies depending on the pipe material. The physical failure of the pipes is manifested through lining damages, loss of wall thickness, coating damage, joint leaks, circumferential cracks, etc. Other ways pipes fail are through capacity or level of service and economic failure. Capacity or level of service failure is when the pipe cannot perform as it was originally intended. It could be undersized or oversized. Physically, it can be in good condition and functional. Economic failure is when the pipe (asset) is no longer the lowest cost alternative.

Inspection Practices and Technologies

The failures associated with various pipe materials can be quantified by investigating the condition of the pipes through use of inspection technologies to identify the types of defects found in the system. The technologies can be selected based on the required condition assessment information. The current inspection practices and technologies employed by the utilities capture some parameters that are crucial in prioritizing force mains for renewal. Inspection techniques can be categorized into: visual inspection, structural condition assessment, leak detection, and multi-sensor platforms.

Visual Inspection

Visual inspection techniques include CCTV inspection, digital scanning, and laser profiling.

- A permanent video record of the defects of pipe segments is captured through CCTV inspections.
- Digital scanning is a subset of the camera inspection technology where multiple high resolution cameras are transported through the force main using self-propelled crawlers.
- The practical applications of CCTV inspection and digital scanning include detection of defects at the downstream sections of the force mains near the discharge point where the pipeline may flow as a gravity line.
- The changes in pipe shape due to deflections and deformations can be detected through laser-based pipe inspection.

Structural Condition Assessment

The structural integrity of the pipes cannot be determined through visual inspection techniques. The structural condition of the pipes can be assessed through ultrasonic wall thickness measurement and electromagnetic corrosion detection techniques.

Ultrasonic Wall Thickness

The pipe wall thickness, corrosion intensity and the presence of cracks in ferrous pipeline can be detected through in-line inspection and guided wave ultrasonic testing.

- The external remote detection of pipe structural condition is carried out through Guided Wave Ultrasonic Testing. The guided-wave method is used primarily as a screening tool that indicates an existing wall anomaly along the pipeline but does not return actual wall thickness data.
- The wall thickness and corrosion of the pipelines can be measured by an in-line inspection technique, which uses a piezo-electric transducer to generate an ultrasonic pulse.
- The ultrasonic wave is stopped by the joints in DI and CI pipes and therefore is suitable only for one pipe length.

Electromagnetic Corrosion Detection

The defects in ferrous pipes are detected using electrical/electromagnetic current. The defects in the pipe wall and the wall thickness are quantified using three major techniques: Magnetic Flux Leakage (MFL), Remote Field Eddy Current (RFEC), and Broadband Electro-Magnetic (BEM).

Magnetic Flux Leakage: The pipe wall surface is magnetized and the leakages produced because of defects or metal loss in the pipe wall is measured by the MFL technique.

- The disadvantages of the MFL technique include the large amount of data that need to be analyzed to quantify the defects.
- The magnets and the Hall Effect sensors should be placed very close to the pipe wall in the MFL technique, which makes it impractical for the DI and CI pipes due to wall variations and joints. This adds significantly to the cost of inspection.

Remote Field Eddy Current: The corrosion intensity and location can be evaluated by the RFEC inspection technique. Pipes with internal linings can be scanned using the RFEC tool.

Broadband Electro-Magnetic: The wall thickness of ferrous pipe is measured through the BEM non-destructive testing technique. The advantage of employing the BEM technology is its ability to scan through coatings and linings without requiring contact with the pipe wall. The disadvantage when scanning pipelines internally, compared to intelligent pigs, is that the process is not continuous and therefore it takes more time to survey a pipeline.

Leak Detection

The leaks in force mains are detected by analyzing the vibrations or sound generated through leak detectors. The various types of leak detectors are hand-held listening devices, leak noise correlators and in-line devices. The major acoustic leak detection monitoring techniques are free swimming leak detection and tethered leak detection.

Free Swimming Leak Detection

SmartBall is a free swimming leak detection product that continuously measures the acoustic signal and detects an increase in the signal when it encounters a leak. Gas pockets can also be detected through this technique.

Tethered Leak Detection

The Sahara system is a tethered leak detection product that can detect acoustic signals indicating leaks, gas pockets or areas of turbulence within the pipeline. An advantage of the Sahara system is that it can be used to track the location of the pipeline from the ground surface.

Correlators

Correlators are sensors, installed at intervals along the pipeline leak points to identify the location of leaks. Currently available products include LeakFinder and Permalog .

Multi-Sensor Inspection

Various types of defects in the wastewater collection system can be detected by employing multiple technologies. The extensively used camera based technologies can be supplemented with other

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leak detection, ultrasonic testing and electromagnetic technologies to offset the drawbacks of visual inspection technologies. Multi-sensor inspection robots are available that incorporate CCTV, laser profiling etc., to identify the defects in the system. Hydromax USA, Redzone Robotics and Hibbard Inshore provide multi-sensor platforms.

Condition Assessment and Risk Management

The data obtained from the inspection of the force mains should be analyzed to understand the trends in the system. The raw data obtained can be used to mitigate the risk associated with the assets. Therefore, the data need to be analyzed further to estimate the likelihood and consequence of failure. The current condition of the asset can be measured through the collection of data from the inventories, records, observations, and inspections. The force main inspection data can be analyzed to quantify the defects and determine the level of service. The defects detected through structural inspection techniques can be coded according to Water Research Centre (WRc)'s system or NASSCO's PACP and MACP programs. A defect index similar to the PACP defect coding for force mains was developed to assist with re-inspection, repair, rehabilitation, or replacement decisions (*Derr and Gabriel, 2014*). This defect system uses a grading scale which is similar to the PACP grading scale (1 to 5) and is based on the failure modes for various pipe materials. In addition, hydraulic analysis is used to assess the condition of the force mains by determining the friction loss in force mains.

Utilities provide efficient service to the customers by defining the service goals. Establishment of Level of Service (LOS) provides the basis for monitoring the performance of the assets against the defined goals. The social, environmental, and economic objectives of the community can be met by establishing key performance indicators (KPIs). The KPIs that can be used to develop the target service levels are:

- Sewer overflow rate.
- Collection system integrity.
- Wastewater treatment effectiveness rate.
- Operations and maintenance cost ratio.
- Planned maintenance ratio.
- Customer service complaints and technical quality complaints.
- System renewal/replacement rate.

Renewal Practices and Technologies

The risk associated with deteriorated force mains can be mitigated through renewal engineering. Renewal engineering can be categorized into repair, rehabilitation and replacement.

The renewal technology can be selected based on the operating condition of the force mains, site specific attributes, and business case evaluation of the alternatives which includes the life-cycle cost ad the benefit/cost analysies of the renewal techniques. Additionally, cathodic protection and polyethylene encasement can be employed as a corrosion mitigation technique.

The extent of deterioration of the force main dictates the renewal method that can be cemployed.

- Repair technologies can be classified into open cut repair and spot repair. The spot repairs can be addressed through clamps and pothole excavations. Installation of repair clamps entails open-cut excavation.
- Rehabilitation technologies that are applicable to force mains are spray-on linings, close-fit linings, CIPP, CFRP and woven hose liners.
- Replacement technologies that are applicable to force mains are sliplining, pipe bursting, pipe splitting, horizontal directional drilling, pipe jacking, auger boring and pipe ramming. Open-cut construction is also used for pipe replacement.

The key parameters that should be considered for a renewal strategy are: bypass requirements, public disruptions, capacity requirements and structural requirements. The critical renewal techniques are addressed below.

- Sliplining is a cost-effective method that can be installed under live flow conditions with minimum service disruption. A limitation associated with sliplining is the reduction of pipeline hydraulic capacity due to reduction in interior pipe diameter.
- Close-fit lining operates similar to sliplining and offers a better hydraulic capacity compared to sliplining. High strength structural rehabilitation can be provided by close-fit and sliplining.
- CIPP offers minimal reduction in hydraulic capacity, but requires bypass pumping. The service disruptions can be minimized through a rapid installation process.
- UV Cured CIPP method which employs a rapid UV curing process can be used to minimize public disruptions.

The most widely employed strategy by utilities to renew force mains is pipe replacement due to limited available experience with force mains renewal strategies. Open cut and trenchless methods are the available renewal technologies.

Capital Improvement Program (CIP) investment strategies can be developed for high-risk assets based on the renewal method. The renewal costs associated with high-risk assets should be determined prior to employing a renewal option. The unit costs of the feasible renewal option for the force main segments of different diameters and materials need to be estimated to establish a CIP investment strategy. The unit costs should include all renewal costs not limited to equipment cost, installation cost, labor cost, clean up and disposal cost, bypass cost, etc. A comprehensive asset management program should include a long-term funding strategy to support asset improvements. An effective funding strategy includes the funding sources, estimated renewal cash requirements, and the renewal schedule. A sustainable funding strategy can be ensured through continuous monitoring and adjustment of utility rates and investigating private, federal, and state financing. The key outcomes of financial planning are safety, reliability, timeliness, minimized annual rate impacts, cost minimization, and optimum use of resources.

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Guidelines for Asset Management of Force Main Infrastructure

The asset management of force main infrastructure can be broadly categorized into a three-step process: inspection, condition assessment and renewal engineering. A structured approach can be followed to execute a comprehensive asset management program that includes:

Step 1: Develop force main asset registry and understanding

Step 2: Analyze the technologies for condition assessment

Step 3: Assessing condition and performance of force main

Step 4: Determine performance deterioration of force main

Step 5: Develop and set target Levels of Service (LOS)

Step 6: Develop risk assessment and prioritization for decision making

Step 7: Analyze the technologies for renewal engineering

Step 8: Determine the funding strategy and optimize capital investment

Step 9: Evaluate force main asset management plan for improvement

Step 10: Build database to support advanced asset management

Conclusions and Recommendations

Force mains are installed at critical points in the wastewater collection system. The key elements that significantly influence the need to address the inspection, condition assessment, and renewal strategies of force mains are:

- Lack of sufficient redundancy.
- High consequence of failure.
- Accessibility of force main.

These limitations for the management of the force mains need to be addressed through the selection of suitable inspection technologies. Due to wide ranging defects observed in different force main materials, no single technology is able to provide effective useful data. Therefore, to identify the defects cost effectively, appropriate technology can be selected based on the consequence of failure of the force mains in the network. A force main investigation program can be developed to estimate the likelihood of failure, consequence of failure and the remaining service life through condition assessment programs.

The gaps and limitations in the force main infrastructure asset management can be partially addressed by standardizing utility asset management practices. A standardized defect index and grading scale should be established by the utilities. A good point of departure would be the defect index developed by WERF. The performance index and prediction models can be combined with consequence of failure indices to establish the business risk exposure associated with assets for prioritization and renewal decisions. Consequence of failure models in practice from Baltimore County, Fairfax County, City of Houston, or Hampton Roads Sanitation District can be a starting point for these consequences of failure indices.

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Intracoastal Waterway Force Main Renewal

BY JAYNE SHEPHERD

The Town of Palm Beach, Fla., continued its Accelerated Capital Improvements program in 2014 to rehabilitate almost 4,700 lf of ductile iron force main.

Mock Roos & Associates worked with Insituform Technologies LLC after the Town had experienced some previous sanitary sewer overflows to design and rehabilitate the force main in order to prevent future issues.

Success of the project was extremely important due to environmental issues and the jobsite's proximity to multi-million dollar beachfront property. In fact, this high-profile neighborhood includes the homes of radio personality Howard Stern, singer Jimmy Buffet and a current presidential candidate. Additionally, the easement for the jobsite consisted mainly of an 8-ft wide bike path located right between the manicured yards of the rich and famous and a seawall to the Intracoastal Waterway. The small jobsite footprint made for extremely tight access.

As the project was located right next to a natural waterway, Insituform worked closely with the City to make sure all necessary environmental considerations were taken during installation. The project crews worked diligently to prevent sanitary sewer discharge. It was imperative that any dumping was avoided.

Choosing a Solution

The engineer on the project had to find a solution to address not only the tiny jobsite footprint but also the pressure requirements of a 12-in. diameter force main. This led Mock Roos & Associates to partner with Insituform Technologies. Together, they designed the project using Insituform's InsituMain system, a fiber-reinforced structural cured-in-place pipe (CIPP) that would meet the structural and pressure requirements of the pipe while causing the least amount of disruption to the surrounding community.

The InsituMain system is comprised of an epoxy composite layer reinforced with glass fiber material. With its AWWA Class IV rating and engineered design that stands up to both internal pressure and external loading, the InsituMain system provides a fully structural solution for pressurized pipelines.

Project Challenges

There were numerous project challenges throughout the Town of Palm Beach force main project, but the main challenge by far was accessibility. With a total easement of roughly 10 to 12 ft, tight access resulted in custom equipment packages being built to fit the jobsite footprint. In fact, the project led to the innovation of specialized equipment packages, including trailer-mounted boilers and modified torpedo launchers for the installation.

These pieces were constructed specifically for this job, had not been previously used and were then disassembled upon project completion. This specialized equipment allowed the contractor to not only fit the small jobsite footprint, but also to transport the equipment along the tight bike path where the equipment had to be confined. The boiler and torpedo launcher installation machine were able to be towed along the bike path using just a small tractor.

Additionally, while traditional CIPP is 100 percent trenchless, pressure pipe rehabilitation requires excavation in order to access the pipe needing rehabilitation.

In order to access these pipelines, crews had to chisel through the concrete bike path. In order to keep disruption as low as possible, the size of the excavation pits was kept to an absolute minimum.

Since the jobsite was directly next to the seawall of the Intracoastal Waterway,

As part of Aegion's Infrastructure Solutions platform, Insituform was able to further engineer the project to not only rehabilitate the existing pipeline, but also ensure an extended lifespan.

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another issue was the elevated water table. In fact, crews hit the water table after only digging approximately two feet down, requiring constant dewatering.

Scheduling, a challenge faced on many pipeline projects, was exacerbated by the water issue. In addition to the elevated water table, the tidal schedule made it possible to work at only certain times of the day. Additionally, inaccurate as-builts contributed to scheduling issues as project plans had to be changed to work around unforeseen utilities. Crews engaged in some night work in order to comply with the project's strict 8-week timeline.

The inaccurate as-builts presented more surprises than simply utilities. One particular pipe connection had to be reworked in order to compensate for not only a 90-degree horizontal bend, but also a 90-degree vertical bend. This required the installation of additional couplings to tie the segments together.

Proximity to multi-million dollar homes also presented several challenges not encountered on typical projects. Crews had to be mindful and take special precautions around extremely expensive landscaping. Exhaust had to be monitored in order not to burn shrubs, bushes and other high-end sodding as any damaged landscape would need to be replaced.

Environmental Considerations

As the project was located right next to a natural waterway, Insituform worked closely with the City to make sure all necessary environmental considerations were taken during installation. The project crews worked diligently to prevent sanitary sewer discharge. It was imperative that any dumping was avoided.

Leveraging Aegion Resources

As part of Aegion's Infrastructure Solutions platform, Insituform was able to further engineer the project to not only rehabilitate the existing pipeline, but also ensure an extended lifespan. For instance on this project, 57 Corrpro magnesium anodes, offered by Aegion's Corrosion Protection platform, were added to specialized Hymax fittings in order to prevent degradation and corrosion on the fittings connecting each pipe segment.

The success of marrying products on this project has led to utilizing other Aegion product offerings as solutions on pressure pipeline projects as well. These include the Tyfo Fibrwrap fiber-reinforced polymer system, Fusible PVC and the Tite Liner thermoplastic lining system.

Project Outcome

The project was completed in seven shots over an eight-week period, ranging in length from almost 400 to more than 900 lf. Once the project was finished, the pipe was successfully pressure tested according to ASTM F1216-09. Since the successful completion of the project, Insituform has completed additional pressure pipeline work for the Town of Palm Beach, including roughly 7,500 lf of 16-in. and 20-in. pre-stressed concrete cylinder pipe using the same fiber-reinforced product. The company is also currently working in nearby West Palm Beach doing large-diameter pressure pipe rehabilitation along with cathodic protection.

Jayne Shepherd is senior marketing communications specialist at Aegion Corp.

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Large Diameter Slipline in Houston

BY ERIN BOUDREAUX

The City of Houston operates and maintains approximately 6,000 miles of gravity sewers with diameters ranging from 6 to 144 in. in diameter. The average daily wastewater flow through the system is estimated at 277 million gallons per day (MGD). With some depths reaching 80 ft, the City's extensive urban population makes access to these sewers for inspection and repair difficult.

Constructed in the mid-1980s, the Northside Sewer Relief Tunnel (NSRT) was the largest of Houston's deep sewer tunnels. In 1988, the NSRT was completed and put into service. It was lined with a mechanically attached liner of high density polyethylene (HDPE) and in the early 1990s, sections of the liner began to fail leading to overflows and the removal of the liner. In 1994, an inspection found that more than half of the tunnel showed signs of corrosion.

In early 2000, multiple engineering firms began designing the rehabilitation of roughly eight miles of the reinforced concrete pipe (RCP) tunnel. This was known as the Northside Sewer Rehabilitation Program. Due to funding constraints these projects were put on hold until around 2007-08 and beginning with the largest diameter sections first, NSRT was bid in phases.

Innovative Installation Techniques

NSRT-Area 5, Phase One was put out to bid in September 2011. It was decided in the design process to slipline the RCP with Fiberglass Reinforced Thermosetting Plastic (FRP) pipe. Boyer Inc. of Houston was awarded this phase. They installed 2,200 ft of 120-in. centrifugally cast, fiberglass reinforced, polymer mortar (CCFRPM) pipe. The flush reline CCFRPM pipe was manufactured by Hobas Pipe USA of Houston. The existing tunnel was approximately 132 in. in diameter and the 120-in. CCFRPM pipe has an outside diameter (O.D.) of 126 in. "This size pipe had never been installed before inside a 132-in. tunnel and Boyer was ready to take on the challenge. In fact, Hobas had never manufactured this size pipe before," stated Datta Shirodkar, P.E., project manager, Boyer Inc.

NSRT- Area 5, Phase One was designed by the engineer as a sliplining project to be installed in live flow. "We knew from the beginning that it was not possible to install such a large pipe in minimum live flow and decided to carry the pipe in place one joint at a time," explained Shirodkar. "Bill Ofiel, one of our senior project managers, designed a custom pipe carrier to transport the 120-in. pipe inside the 132-in. tunnel and a custom pipe pusher to push one joint of pipe into another (Bell & Spigot connection). Boyer Inc. also developed an innovative way of making miters onsite by cutting two pieces of pipe at an angle and then joining the pieces together using a FWC coupling. This method of making miters using FWC couplings had been used on smaller size pipe but never on a pipe with 126-in. OD. The size and weight of the pipe along with the constraint of installing it inside a 132-in. ID tunnel forced us to think outside the box and come up with new and innovative methods. There were a lot of stressful moments and passionate discussions within our team during the course of this project, but the successful installation of the pipe without any re-work made it all worth the effort."

Restoring Structural Integrity

NSRT-Area 4 bid in April 2012 and consisted of about 4,900 ft of the same 120-in. flush reline pipe. Oscar Renda Contracting of Roanoke, Texas, was the low bidder on NSRT-Area 4. NSRT-Area 5, Phase Two was awarded to Oscar Renda in March 2014 and they installed 3,000 ft of 120-in. pipe in early 2016. Before Oscar Renda could begin the installation, crews had to prepare the existing tunnel. "Most of the joints had deteriorated and were leaking ground water," explained Bart Adams, Houston-area project manager, Oscar Renda Contracting. "The former corrosion protection system was in disrepair and had to be removed. Finally, many areas of the tunnel contained up to 3 ft of debris that had settled into the existing system. The cleaning process required us to remove the debris, as well as sheets, battens and anchors from the protection system."

In addition, Oscar Renda prepped the tunnel by essentially pressure washing the tunnel to remove any loose debris and inject the joints to stop the groundwater infiltration.

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The flush reline pipe was manufactured with a flush bell-spigot. The flush bell-spigot joint consists of an integral straight bell fixed to one pipe end that seals to the spigot end of another pipe by compressing an elastomeric gasket contained in a groove on the spigot. An important characteristic of this joint in relation to this project is that the joint has approximately the same outside diameter as the pipe, so when assembled, the joint is essentially flush with the pipe outside surface. "This allowed a clearance of only 3 in. around the pipe and a very tight fit," explained Adams. "The existing tunnel was 50 to 60 ft below grade and only a limited number of access shafts were installed."

Overcoming Challenges

A project of this scope has its challenges. During the bid phase, there was no confirmed method of by-passing the flows in the Northside Sewer system. The exact flows going through the NSRT 4 portion of the system were not known at the time of the bid. The bid documents explained that the contractor was responsible for bypassing, blocking, and/or diverting 33 MGD of average daily flows. After the system was installed, adjustments had to be made due to the average daily flows being much higher than anticipated.

"The biggest issue for the NSRT 4 project was how to bypass the flows in the system," stated Adams. "The City of Houston Wastewater Operations was a big help in working with us to figure out the best route to divert the flows within the system to maintain operations and be able to install the pipe. Over several months, many coordination meetings were conducted, and several iterations of the by-pass system were developed before Oscar Renda and the City of Houston was able to agree on a path forward. An additional complexity to the NSRT 4 project was that both projects were dependent on the same by-pass system. An additional by-pass system was setup on the NSRT 5 project to by-pass additional lines coming into that system. All flows were being diverted to the 69th Street Wastewater Treatment Plant."

The traditional segmental slipline installation method of a liner pipe being pushed or pulled into an existing pipe usually during episodes of live flow was not utilized on this project. The existing RCP tunnel was made of mitered sections that would not allow the traditional sliplining method. Instead a combined method of sliplining and tunneling was used to install the new 120-in. pipe. The pipe sections were carried into place and assembled inside the tunnel, much like a two-pass operation with the host pipe serving as the primary tunnel. There are a number of curves throughout both phases; this along with the condition of the existing RCP made traditional segmental sliplining difficult.

"Sliplining could not be used because the relining pipe could not be pushed through the mitered sections of the existing tunnel using a true sliplining method," stated Adams. "Pipe carriers had to be used in order to take individual pipe pieces through the tunnel to the point of installation. Extensive surveying and modeling was used to map the miters in the existing tunnel. This information was used to develop the layout for the reline pipe segments. During the installation, once the straight run of pipe reached a mitered section, dimensions were confirmed and a system was developed in the field to miter each section of pipe as required. This method allowed us to make adjustments in the field in order to minimize delays to the installations."

Hobas manufactured the pipe in varying lengths to assist with this process.

"The Hobas FWC gasket-sealed, push-on coupling seals directly to the unmodified exterior pipe surface," explained Randy Whiddon, field service manager, Hobas Pipe USA. "Since the O.D. is constant along the entire pipe section, field length changes may be accomplished by simply cutting the pipe at the desired location, chamfering the cut end and joining with the FWC coupling. This is true for pressure applications as well as non-pressure service."

Successful Installation

To summarize, approximately 10,000 ft of 120-in. CCFRPM pipe was installed deep beneath Houston. Creative installation techniques allowed for a successful project. The remaining phases of the NSRT are currently under design.

Erin Boudreaux is marketing manager at Hobas Pipe USA.

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United Initiators SPI Inc.
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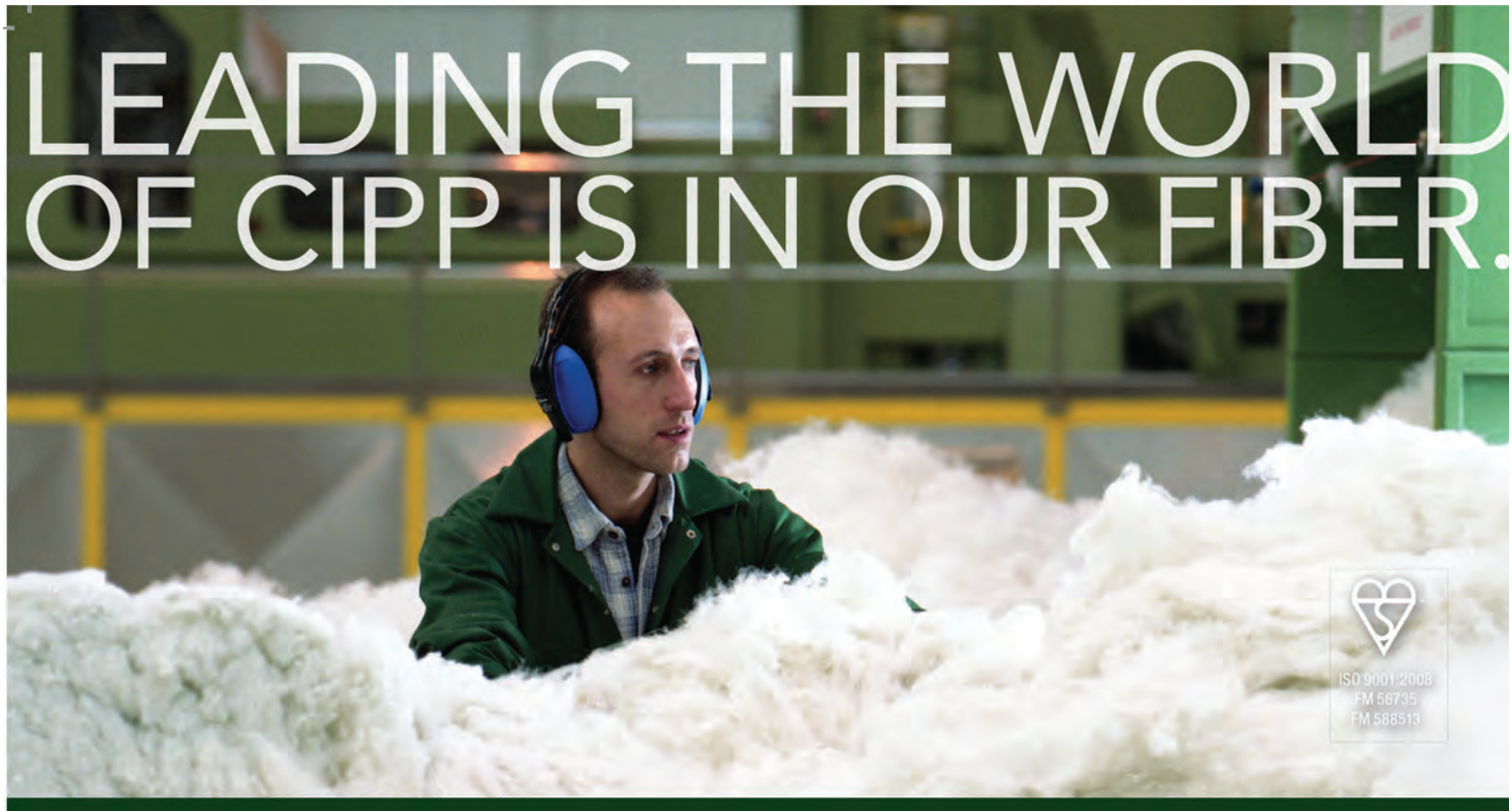

Everything we do at Applied Felts — from maintaining full control of our raw materials to helping ensure every felt liner we make is successfully installed — makes us the global leader in supplying the world's finest CIPP liners. It's who we are because Applied Felts was there from the beginning, helping take the first innovative steps to invent the CIPP process over 40 years ago. Now we are taking the next big leap by introducing our latest innovation, AquaCure PS®. This breakthrough liner provides the most innovative CIPP custom solutions for your pressure pipe applications. Our exclusive technology fully integrates and blends state-of-the-art strength with millions of feet of proven results to provide the highest quality liners for pressure sewer and non-potable water applications. AquaCure PS is just one more reason customers from Singapore to San Francisco depend on us year after year. They know what we're made of.

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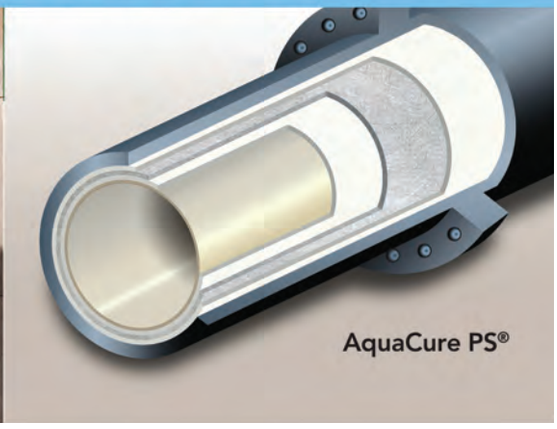

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