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United Water Pennsylvania and the Susquehanna River

Pipeline Rehabilitation and Sliplining Solution

Figure 1: This small geyser appeared in the Susquehanna River in the Summer of 2005. A leak in a 16-inch cast iron line produced the geyser. It was under high pressure to help locate the leak.

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A 16-inch cast iron water line installed in a hand-carved rock trench at the bottom of the Susquehanna River near the capital city of Pennsylvania. That's what the Pennsylvania Railroad Company engineers and workers accomplished in the early 1900s north of Harrisburg, PA. It is also the site of the famous 100-year-old Rockville Railroad Bridge, which is the longest stone masonry arch railroad bridge in the world. And both are still in operation today.

During the time when the bridge was built, the railroad engineers also designed and installed a 3,500+ foot, 16-inch cast iron water pipe that ran along the bottom of the Susquehanna River. This original water pipe was extremely well engineered and very well constructed considering the lack of heavy equipment and sophisticated instrumentation. In some places, workers hand carved a trench through the rock at the bottom of the river. This trench provided very good protection for the pipe, but as United Water Pennsylvania - the local water utility- discovered, the trench made it nearly impossible to perform repairs on the pipe in some places.

INTRODUCTION

United Water Pennsylvania provides water to nearly 100,000 residents of the suburban Harrisburg area, located one hundred miles west of Philadelphia, PA, and is situated along both the east and west banks of the Susquehanna River. With an average daily flow of 22 billion gallons of water, the Susquehanna is the largest contributor of freshwater to the Chesapeake Bay. The River's 27,500-square-mile watershed covers parts of New York, Pennsylvania, and Maryland. As the 16th largest river in the U.S., it is also the largest river lying entirely within the United States that drains into the Atlantic Ocean.

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Figure 2: Two fusion machines were used to increase production.

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The Harrisburg area is a major hub for business, industry, and government in Pennsylvania. Current conditions of pipelines crossing underneath the river are of critical importance for maintaining the large flow of potable water to about 10% of United Water's nearly 100,000 consumers. When a leak in the 16-inch cast iron pipe was discovered during the summer of 2005, United Water sought immediate action to repair the pipeline. The length of the pipeline crossing was measured to be approximately 3,515 linear feet (LF). Ultimately, repair was ruled out and United Water sought a full rehabilitation solution.

THE PROBLEM

When United Water became aware that it was losing a significant amount of water somewhere along the 16-inch cast iron line, locating the problem became a top priority. For months they attempted to locate the problem and noticed during the summer of 2005 that the losses had increased. Through a comprehensive series of tests, they located the main site of the leak, and with the water under high pressure, a small geyser in the middle of the river showed the exact location of the hole where the water loss was occurring. (See Figure 1.) A primary concern was that after its long service, there could be many other weakened areas along the length of the pipe that was on the floor of the river. This raised many questions. How many other smaller holes were there along the line? How long would it be until other weakened areas would become holes and add to the loss of water? It was determined that as a result of the leak hundreds of gallons of water per minute were being lost from the system.

Inspection determined that the hole in the pipe was due to abrasion and erosion of the pipe's exterior from sand, dirt, rocks, ice and the swiftly flowing water. Consequently, fixing this particular hole in the pipe would not solve United Water's problem. It was recognized that the combined effects that

Uni-Bell is the non-profit association of the PVC pipe industry, providing engineering and other technical support services to the public. Uni-Bell's mission is to help people gain access to safe, sustainable water and wastewater sanitation through the responsible and resource-efficient use of PVC pipes and fittings. As a result of the efforts of cities and counties to attain sustainable pipe infrastructures, non-corrodible PVC pipe has become the number one pipe product.

Founded in 1971, Uni-Bell is supported by manufacturers committed to providing quality products and service to the PVC pipe industry. They all share in a philosophy that top quality pipe, service, and technology go hand-in-hand. Through their membership in Uni-Bell they serve the piping industry and their customers with quality products, professional personnel, and Uni-Bell technical expertise.

In this issue, we are pleased to feature Underground Solutions Solutions.

Underground Solutions (UGSI) was founded in western Pennsylvania during the late 1990s as a small start-up technology company. In early 2000, UGSI obtained the US and international rights to the patented Duraliner™ pipeline rehabilitation system that was developed in Canada. Duraliner™ is a patented, close-fit pipeline renewal system creating a stand-alone structural liner. After acquiring the Duraliner™ technology, UGSI continued the development, engineering, and marketing of the technology to municipalities and contractors throughout the US.

In 2003, after extensive research and development, UGSI introduced the latest and most popular product line – Fusible C-900™, Fusible C-905™, and Fusible PVC™. UGSI's Fusible C-900™, Fusible C-905™, and Fusible PVC™ products contain a proprietary PVC formulation that, when combined with UGSI's patented fusion process, results in a monolithic, fully restrained, leak-free piping system.

caused the primary leak would also eventually cause additional holes in the original pipe. United Water needed a complete and long lasting pipeline rehabilitation.

TH OPTIONS

In addressing the leak issue, United Water evaluated many different alternatives for pipeline repair, replacement, and rehabilitation. Different dive companies from around the country were contacted in an effort to access and repair the leak. A number of divers attempted to reach the site of the leak, but only one diver was actually able to put a hand on the hole in the pipe. It was determined that any conventional external pipe repair would be impossible because of the river and pipe conditions. Rapidly moving water at high flow and velocity precluded the divers from being able to reach the leak safely for a thorough assessment, let alone to make repairs.

Proposals were solicited from other local contractors, but many of those proposed solutions would result in reduced flow capacity or require major work for access sites at various points along the river. Replacement options were determined to be extremely expensive, of long duration, and possibly requiring approvals that would take many months to secure.

Figure 3: By pulling this "prover" through the host pipe, it demonstrated that both the pipe and pulling head could negotiate the entire run.

Trenchless installation was determined to be the preferred solution to restoring the pipeline. Horizontal directional drilling (HDD) was found to be an unacceptable alternative because of the cost to drill under the river and the minimal availability of access sites and access pits. Non-structural liners were evaluated as an option to fix the pipe, but it was determined that these approaches would only be effective in the short term. Many of the methods initially proposed would be viable solutions for projects " on land", but they were not feasible or suitable at the bottom of a river.

After research and evaluation, United Water determined that sliplining with thermoplas-

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Today, Underground Solutions is an infrastructure technology and pipeline rehabilitation company. UGSI has developed and continues to develop unique and proprietary technologies focused on the underground infrastructure industry. Fusible C-900™, Fusible C-905™, and Fusible PVC™ are NSF-61 certified and cover a full range of piping diameters from 3 inch to 36 inch (with larger sizes in development) and provide the only available method of installing a continuous, monolithic, gasket-free PVC pipe or conduit capable of being used in numerous trenchless or conventional "open-cut" applications including:

- Horizontal directional drilling
- Pipe bursting
- Sliplining
- Direct bury

Applications for this technology cover every aspect of piping installation including both pressure and non-pressure situations in the water, sewer, electrical, industrial and telecommunications industries. As of August 2006, more than 120,000 linear feet of Fusible C-900™ , Fusible C-905™, and Fusible PVC™ have been installed at numerous sites throughout the US and Canada.

TODAY, UNDERGROUND SOLUTIONS IS AN INFRASTRUCTURE TECHNOLOGY AND PIPELINE REHABILITATION COMPANY. UGSI HAS DEVELOPED AND CONTINUES TO DEVELOP UNIQUE AND PROPRIETARY TECHNOLOGIES FOCUSED ON THE UNDERGROUND INFRASTRUCTURE INDUSTRY.

Fusible C-900™, Fusible C-905™, and Fusible PVC™ have distinctive properties allowing full-strength, butt-fusion joints. While other thermoplastic materials have been fused routinely, the Underground Solutions PVC fusion process incorporates a unique combination of heat, pressure, and time while using industry standard fusion machines.

UGSI product lines meet:

- AWWA C900/C905 requirements
- NSF-61 certification
- Formulation requirements of Plastic Pipe Institute TR-2
- ASTM cell classification 12454

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tic pipe was the best alternative. Sliplining is a pipe rehabilitation method where a pipeline of a smaller diameter is inserted into a damaged host pipe with subsequent grouting of the annulus. Installations requiring minimal surface disruption or situations involving long runs of pipe under surfaces that prevent access to the pipeline (such as rivers or lakes) are ideal opportunities for sliplining.

MANY OF THE METHODS INITIALLY PROPOSED WOULD BE VIABLE SOLUTIONS FOR PROJECTS "ON LAND", BUT THEY WERE NOT FEASIBLE OR SUITABLE AT THE BOTTOM OF A RIVER.

The use of plastic pipe was recommended due to its inherent properties of durability and corrosion-resistance. The United Water engineers evaluated the use of HDPE and a PVC product with a proprietary formulation and a patented fusion process. (See "Uni-Bell Introduces Underground Solutions, Inc." in the inset below for details.) Vinyl was considered the best option because it allowed for a higher flow rate when compared to HDPE. It could also handle the significant pull forces that result from sliplining the entire 3,500+LF length in a single pull.

United Water needed a total solution for their pipeline rehabilitation project– not just segments of pipe for a repair. United Water worked with us to prepare a comprehensive plan that included:

- Pre-video inspection of the entire line
- Cleaning the line while simultaneously fusing a portion of the 3,500+LF of pipe during the cleaning process
- Using two machines for PVC butt fusion
- Performing a proof pull prior to the actual sliplining
- Grouting the annular space in the pipe
- Reconnecting the line on both ends of the river using standard waterworks fittings

In order to avoid any interruption in water service to its residential and business customers, United Water arranged for a bypass line to handle the flow. They temporarily re-commissioned an above ground steel water line that runs along the Rockville Railroad Bridge. The water line was not in use, but it was put into service for the duration of this project so that there was no down time as the 16-inch cast iron line under the river was repaired and restored.

The initial video inspection was completed in a few days in September 2005. Cleaning, PVC fusion, and sliplining took place over a two-week period at the end of November. Because of near flood stage conditions after the Thanksgiving weekend, reconnection was delayed for a few weeks until early December. At the end of the project, United Water had a rehabilitated, corrosion resistant, leak-free, fully restrained, gasket-free pipe system operating at the same flow rate that it had previously.

VIDEO INSPECTION

To be certain that sliplining would be a feasible solution with a high probability of success, United Water contracted to have a video inspection of the line done before the initial pipe cleaning step. Typically, the water line is cleaned first and then inspected. In this case, it was recommended that before United Water finalized their decision, they determine that sliplining would have a high likelihood of success. Performing this video inspection as a first step mitigated United Water's schedule and cost risks if sliplining was not an option. Video inspection identifies alignment issues, concerns about fittings, and other possible impediments to sliplin-

VINYL WAS CONSIDERED THE BEST OPTION BECAUSE IT ALLOWED FOR A HIGHER FLOW RATE WHEN COMPARED TO HDPE. IT COULD ALSO HANDLE THE SIGNIFICANT PULL FORCES THAT RESULT FROM SLIPLINING THE ENTIRE 3,500+LF LENGTH IN A SINGLE PULL.

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Structural and mechanical advantages for Fusible C-900 ™, Fusible C-905™, and Fusible PVC ™ include:

- Use of PVC – the most widely accepted pipe material used in water systems today
- Monolithic, fully restrained, leak-free piping system
- Maximum flow capability for given OD at a defined pressure
- Maximum cross sectional flow area (ID)
- Easy to pull – reduced wall friction
- Improved tensile strength (ASTM D 638)– up to 7,000 psi
- Greater safe pulling stress–in sliplining, HDD, and pipe-bursting applications
- Specific gravity of 1.38 – PVC does not float
- No relaxation period – relatively high coefficient of linear expansion
- Use of standard water works fittings
- Operator familiarity with PVC
- Suitability for open cut and trenchless applications

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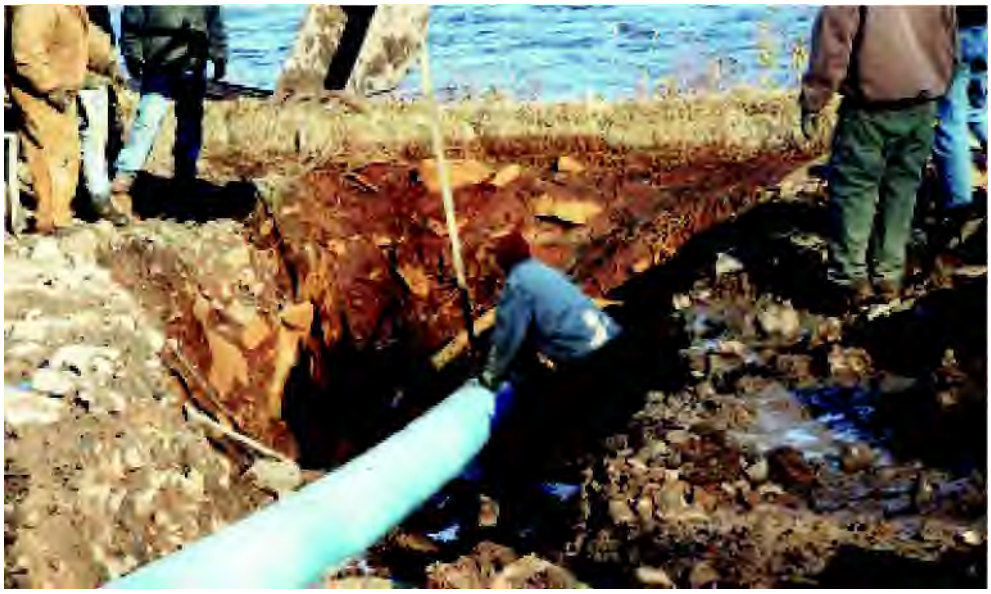

Figure 4: 12-inch product being inserted into a 16-inch iron main.

ing including abandoned valve bodies, service taps, and the like. The video inspection was performed with the line being accessed from both the east and west side of the river. A high resolution track-mounted camera with high intensity LED lighting and a 3,000-foot-Kevlar tether was used. Because the line would be full of water, camera quality and lighting were critical for viewing the line's interior surfaces. All parties were able to see a definitive view of the leak and the extent of the tuberculation. It also confirmed that there were no unusual changes in alignment or fittings – allowing the project to move forward with sliplining.

The diameter selected for the project was 12-inches, and the Pressure Class was 150 psi. The sliplining was to begin at the west bank of the river and end at the east bank. This was the longest single pull of PVC in the world to date.

FUSION

Butt-fused PVC pipe was made possible through two key developments: a proprietary PVC formulation used in all of our products and a patented fusion procedure. This allows long lengths of PVC pipe to be fused into gasketless runs and pulled into the ground in single pulls. The product is designed for use in potable water systems and is NSF-61 certified. The PVC fusion procedure uses standard fusion machines that are readily available in the industry and modified for PVC fusion. A unique set of temperatures, pressures, and times for each step during the fusion process is used to butt fuse each joint. The duration of fusion per joint compared to that of other thermoplastic butt fusion is approximately the same.

THIS [3,588 LF] WAS THE LONGEST SINGLE PULL OF PVC IN THE WORLD TO DATE.

Our company's trained fusion technicians butt fused the joints using two McElroy TracStar 500 machines. Data loggers were used with each machine to record the real-time pressure, duration, and initial temperature of each joint. Due to difficult pipe handling and site conditions along the bank of the river, each joint took approximately 45 minutes to fuse and about a half hour to set-up. (See Figure 2.)

Two twenty-ton-truck-mounted Ramsey Winches were arranged on the eastern bank of the Susquehanna. A series of snatch blocks were utilized with the winch system in order to increase the pulling power of the cables if it became necessary.

ARRANGEMENT OF PIPE PULLS

A prover (See Figure 3.) was sent through the host pipe after cleaning. This" proved" that the pipe and pulling head could pass through the newly cleaned host pipe interior and accommodate any alignment changes. The prover passed through the 3,515 LF of cast iron host pipe and emerged from the pipe outlet on the eastern bank of the river without difficulty.

The new pipeline to be inserted into the host was divided into fifteen segments, one 156' segment, two 312' segments, and twelve 234' segments. Once the individual 39 foot lengths were fused into these fifteen segments, each individual segment was pulled in until another segment could be fused to the end of the inserted segment and so on until all 3,588 LF of pipe was fused together into one continuous length. (See Figure 4.) The actual length finally fused and pulled into the host pipe was 3,515 LF and about 73 LF remained fused as extra pipe but un-inserted on the west bank. The pull-in was done with both the 16-inch cast iron line and the new 12-inch line filled with water. The pulling head was modified to allow the water to flow through the head. This took maximum advantage of PVC's density because the butt-fused PVC pipe was able to slide on the bottom of the host pipe without fighting a buoyant force against the top of the pipe. The sub-contractor, Heitkamp, owned and operated the two twenty-ton winches under our company's direction as part of the installation. They were very pleased with the ease of insertion and to see that only a fraction (1/4) of their forty-ton winch strength was needed, even towards the end of the pull-in when all 3,588 LF were being pulled together.

CONCLUSION

Using butt-fused PVC pipe facilitated the rehabilitation of a 4-inch hole in the 16-inch cast iron pipeline running underneath the Susquehanna River in Harrisburg Pennsylvania. Due to the circumstances that the river presented, the installation of new pipe via open cut, HDD, or the use of non-structural liner methods was impractical. Sliplining allowed a structural stand-alone system to be inserted in one long single length totaling 3,515 LF. Because the pipeline serviced the suburbs of Harrisburg, maintenance of flow capacity was of utmost importance. The butt-fused PVC was pulled in effortlessly and reconnected without difficulty. Overall the installation was a huge success for United Water, and all involved expect that many years will pass before this pipeline at the bottom of the Susquehanna River needs attention again.