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Sliplining Renews Critical 30-Inch Cast Iron Water Transmission Main

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1. ABSTRACT

Norwich Public Utilities (NPU) built a new one million gallon water storage tank which would be fed by an existing 30-inch transmission main, directly from their Deep River Reservoir Water Treatment Plant. The existing cast iron water transmission main had provided a long service life but was showing signs of deterioration. This 3,500 foot long transmission main was the single source connection for the new tank and NPU decided that the line would need to be evaluated and rehabilitated.

Since the pipeline alignment was located in environmentally sensitive wetlands, the project team leaned on trenchless methods to rehabilitate the main. In the end, slipline methodology was used to provide a new pipeline within the existing cast iron watermain that met the flow and pressure requirements of the application. Project construction included construction of a functioning bypass system in the same alignment as the sliplining work, cleaning, inspecting, and proofing the existing line, and then final installation of the sliplined pipe. The pipe was installed from a single location, minimizing the operational footprint and limiting the impact to the project area.

This paper will review the project in terms of the trenchless technologies evaluated and the decision to utilize a 'tried and true' rehabilitation method in sliplining. It will also review the inspection, cleaning and installation results for the project.

2. INTRODUCTION

The Deep River Transmission Main rehabilitation project was linked with a series of projects centered around upgrading the efficiency and operational flexibility of the Deep River Water Purification Plant located in Lebanon, Connecticut. Lebanon is a small town in New London County, which lies on the southeast corner of the state (just to the northwest of Norwich). The existing 30 inch cast iron water transmission main that served both the Lebanon and Norwich area was constructed in 1929 through an approximately 80-acre undeveloped parcel when water from the Deep River Reservoir supplied the City of Norwich. The alignment of the main followed an existing access road which runs across streams and wetlands. Since 1974 when the Charles W. Solomon Water Purification Plant was commissioned at Deep River Reservoir, the plant has continuously pumped water through the transmission main to create pressure to the system. After years and years of successful operation and serving as a reliable water source, the 30 inch cast iron transmission main was showing signs of decline and corrosion, so action had to be taken so that water service was not interrupted due to what would be an increasingly probable failure event.

In December 2008, Norwich Public Utilities (NPU) submitted eligibility applications to the Connecticut Department of Public Health (DPH) for funding to upgrade the deteriorating water system through the Drinking Water State Revolving Fund (DWSRF) program. Rehabilitating the water system would include the upgrade of the existing pumps and drives within the Solomon Plant, construction of a one million gallon storage tank in the vicinity of the plant to eliminate the need to continuously pump, and construction of a new transmission main to link the plant, storage tank, and connection to the balance of the 6.6 mile transmission main. Due to the amount of time that had elapsed since the 1929 installation of the 30 inch cast iron main, the underdeveloped 80-acre parcel had been subdivided into 18 residential properties, so an environmental assessment was a necessity prior to bidding and construction. Due to the new developments that were added on the land over the years, if the new transmission main were to be installed near the existing transmission main, the new main would lie in an easement cross country through environmentally sensitive areas and private properties. NPU's vision was to place the proposed storage tank at a location of appropriate base elevation such that the 30 inch transmission main could be abandoned and replaced with a new watermain located within public rights-of-way.

After careful consideration and several months of discussion, NPU decided on the location of the new water storage tank. On the southern tip of Lebanon, on Lynch Road, Lebanon purchased the land from the state where the tank would be located, and lease it to NPU for use of the tank. Once the purchase of the land was finalized, NPU then diverted attention to the existing 30 inch transmission main and what alternative methods could be taken to rehabilitate the failing pipeline that has served the area for decades. At this point the options were limited because the surrounding area now involved several residential properties. NPU hired Tata & Howard Engineers in early 2011 to complete a system gradient study that evaluated how to significantly improve water quality in the distribution system and adjust system pressures to reduce system leakage while maintaining an appropriate amount of system storage. NPU further authorized Tata & Howard to conduct preliminary engineering analysis that would lead to the design and construction of the new storage tank, water mains, and energy saving alternatives.

Numerous plant shut-downs were required to replace the 40+ year old pumps and drives at the Solomon Water Purification Plant. Therefore, to avoid multiple disruptions to NPU water customers, the tank and new transmission main had to be continuously functional prior to the initiation of the pumps and drive replacement project. The transmission main rehabilitation project also included construction of approximately 400 linear feet (LF) of new ductile iron pipe main from the alignment of the transmission main to the new tank location to allow for filling, leak testing, and disinfection of the new tank.

Considerable time was required to combine and ultimately secure the parcels needed for construction of the proposed one million gallon water storage tank and obtain all the necessary permits and land lease agreements. This caused a delay in construction, even though the project had already been approved for funding. The properties were closed in April 2014 but notice of award and authorization to proceed for construction of the transmission main rehabilitation project was not issued until July 2014 due to challenges to the award process.

3. PROJECT DESIGN

Tata & Howard Engineers began exploring options to rehabilitate the existing cast iron water main, performing a series of calculations and analyses to determine the best alternative. Traditional cleaning and cement mortar lining was ruled out as it would not add any structural strength or reliability to the pipeline. A fully structural liner was necessary to ensure longevity of the pipeline, and a number of factors were taken into account. Since the location of the new water storage tank had been determined by NPU, the new water main had to be designed and constructed around the tank location. The proposal for a new waterline within the public right-of-way was denied, so NPU had to redirect to plan B, which included the approved location of the new storage tank and establishing a proposed water main suitable with the new storage tank location.

Tata & Howard considered rehabilitating the existing cast iron water main via standard open trench or through trenchless application. Environmental factors were considered, since the area surrounding the project had since been developed. It was immediately determined that open trench installation would present several obstacles. The volume of soil excavation that would be involved would cause an inconvenience, due to the excessive amount of truck trips to import and export excavated material. In addition, an open trench along the project alignment would restrict access for residents in the area whose properties lie within the pipeline construction. Furthermore, the existing wetlands and environmentally sensitive areas within the project limits would offer a challenge during open trench installation because the soils may not be as compacted as expected. The project area contained several trees that would be eliminated or relocated in an event that the ground would have to be trenched.

On the other hand, sliplining a new pipe into the existing cast iron pipe minimizes disruption of the existing conditions and would be less intrusive to the environment. Sliplining would also alleviate any additional costs to the contractor as a result of an open trench installation. Due to these determining factors, it was decided that the new watermain was to be installed via sliplining (see Figure 1).

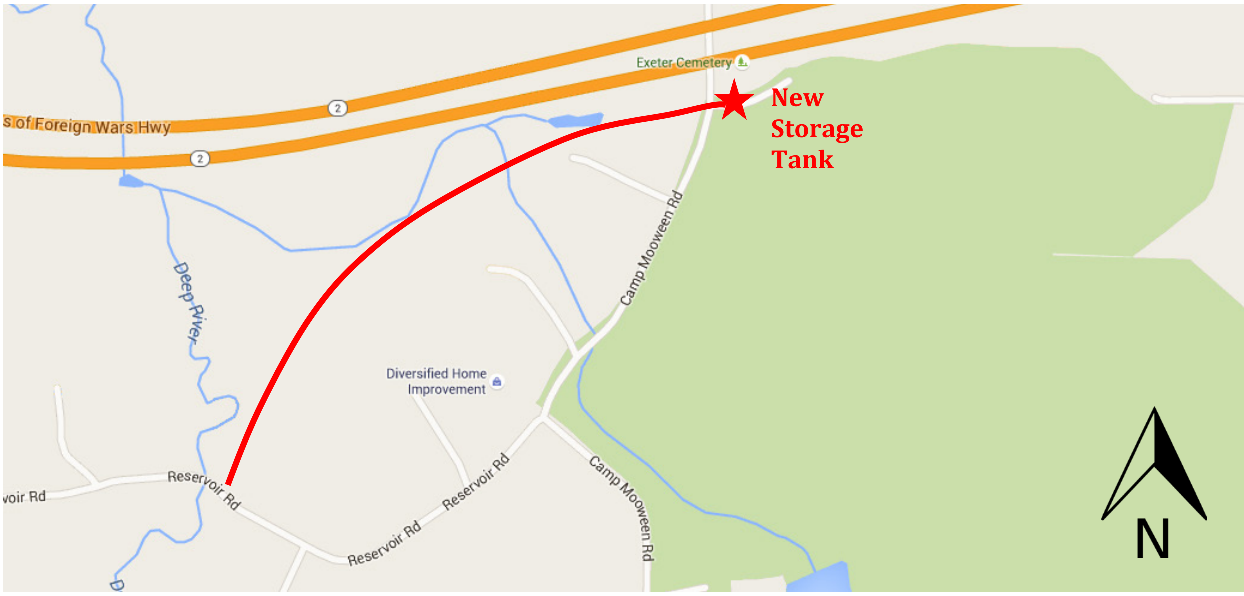

Figure 1. General Locaton of New Water Storage Tank and Proposed Water Main

Since the existing cast iron main was 30 inches, Tata & Howard knew that the pipe that was to be sliplined had to be smaller, but would still have to provide efficient flow. The maximum pipe size that would fit into existing cast iron pipe was 24 inch diameter pipe, assuming there are no major variations in the alignment of the existing pipeline. NPU expressed its interest in using plastic pipe for the new pipeline, in order to eliminate long-term corrosion concerns. Therefore only non-metallic pipe was considered, and the choices for pipe material for the new water pipe were narrowed down to polyvinyl chloride (PVC) and high-density polyethylene (HDPE) pipe. Since the project required a restrained joint product with a low profile joint, fusible polyvinylchloride pipe (FPVCP) was evaluated as the best alternative for a PVC product that would provide the smallest effective outer diameter compared to the pipe size.

4. PROJECT BIDDING AND CONSTRUCTION

Tata & Howard researched the properties of both PVC and HDPE pipe, trying to determine what material would provide the best service. The pipe sizes that were considered were 24 inch DR 25 FPVCP and 24 inch DR 11 DIPS HDPE pipe. A side by side comparison of both pipes showed that FPVCP provided a larger inside diameter (ID) for the equal size outside diameter (OD) and pressure versus the HDPE Pipe. A larger inside diameter meant a larger cross-sectional flow area. Because of this, FPVCP would provide reasonable headloss through the length of the pipeline whereas HDPE would provide a less reasonable headloss based on the smaller cross-sectional flow area. In order to meet the hydraulic requirements of the pipeline segment, Tata & Howard concluded that FPVCP was the best option for the sliplining of the new watermain inside the existing pipe.

Plans and specifications were completed, and the project was advertised to prospective bidders. The bid form specified 3,500 linear feet (LF) of 24 inch FPVCP Sliplining of 20 inch Diameter Main. The standard specifications also included grouting of the annulus between the existing pipe and the new sliplined watermain, with the contractor being responsible for the means and methods for grouting.

Once the project bid, the contractor that was selected for the job was Heitkamp, Inc., who had extensive experience with trenchless construction.

Since the cast iron pipe was the only transmission main between NPU's water main and the distribution system, Heitkamp had to assure that the water service of residents and businesses was not interrupted during construction. Before decommissioning the existing cast iron pipe, Heitkamp had to install two large 18-inch bypass water mains to compensate for the area's daily operation. Although one bypass main could carry sufficient flow under average day demand conditions, they decided that two mains were needed under peak day demand conditions. In addition, the use of two mains also reduced costs (as opposed to one large main) and provided redundancy in case one of the mains happened to fail. The bypass lines were connected to an existing 24-inch cast iron line on the west side of the project near the first slipline installation point, and then connected to an existing 30-inch cast iron water main on the east side of the project, just north of the proposed new water storage tank location, which connected to an existing storage tank. Once the bypass mains were installed aboveground and placed into operation, the contractor was ready to begin the slipline installation of the new pipeline (see Figure 2).

Figure 2. Installed bypass piping laying at grade along the existing transmission main alignment.

The new water main installation began in June of 2014. The construction of the new water storage tank also began around this time. Before the pipe installation, the contractor cleaned and inspected the existing line, making sure there was no debris or abnormal variations inside the cast iron pipe. Also, in observing best practices of sliplining pipe, the contractor pulled a 40 LF "proof" piece of FPVCP through the entire length of the existing pipe to be sliplined. Video inspection and pulling a proof piece provided assurance that the existing line had no obstructions or deflections that would prevent a successful slipline operation. The proof piece was inspected for scratches or gouging and showed only superficial scratching (see Figure 3).

Figure 3. "Proof" piece of pipe after travelling 3,500 LF through the existing cast iron pipe.

Once the video and proof were completed successfully, the pipe was shipped to the jobsite and prepared for sliplining. Heitkamp contracted with Underground Solutions, Inc. to provide 3,500 LF of FPVCP and fusion services. Project setup and pipe layout took place on the west end of the project, and the pulling machine was positioned at the opposite end of the project, ready to pull the new pipe through using steel cables that attached to the pull-head at the end of the pipe. With barely enough space in the area for all necessary vehicles and equipment, Heitkamp was not able to lay out the entire fused pipe string for each slipline prior to pull-in.

To maximize the available space, the "fuse-and-pull" installation technique was used. In extremely limited space, during a fuse-and-pull install, the fusion machine is lowered into an excavation, just behind where the pipe is to be sliplined into the existing pipe. Where more space is available, the fusion machine may be set up at grade, and the pipe is then deflected into an insertion pit and into the existing pipe, much like it would be done if the entire pipe length is pre-assembled. In either case, each delivered length of pipe is lowered into the fusion machine, and fused onto the assembled length of pipe as it is inserted into the existing alignment. As each joint is fused, the pipe is then pulled slowly into the existing pipe. This process is repeated until the entire length of pipe is installed.

A total of three separate pull-ins were completed for this project. The first pull, 870 LF, had extremely limited laydown space and required in-ditch fusion (Figure 4). The fusion machine was staged approximately 45 LF directly behind the start of the slipline. The second and third pulls were 1,530 LF and 1,025 LF, respectively, and both were fused outside of the installation pit, at grade (Figure 5). There was considerably more space for the second and third pulls and the fusion machine was staged approximately 200 LF behind the start of the slipline insertion. During installation there were no major issues encountered with the slipline portions of the project. Trees were not disturbed during construction, as Heitkamp researched the area very carefully in order to select the location of each bore pit. They made sure that there was adequate space for all equipment involved in the project. The entire 3,500 LF of 24 inch DR 25 FPVCP water main was fused and installed in only 11 days.

Figure 4. In-ditch fuse-and-pull installation.

Figure 5. Aboveground fuse-and-pull installation.

After the pipe was pulled into place, the contractor was able to begin the grouting operation. A low-density, highly air entrained, cellular grout was used for the annular fill material. Grouting the annular space is a key process in ensuring longevity of the pipe system, which was what Tata & Howard emphasized during the design phase. Not only does installing grout restrain the pipe inside the existing pipe, but it also fills the void space around the new asset and eliminates a location of nuisance water collection. Once Heitkamp completed the grouting of the entire new transmission main, a few days needed to pass in order to allow for the grout to cure and strengthen within the annular space. Once the grout was cured, the final connections were made

5. CONCLUSION

As a result of NPU's hard work in searching for a suitable location for its new water storage tank, they were able to find a setting and coordinate with the town for approval of the location. Although there was a major concern with environmental conditions surrounding the existing pipeline, the design engineer was able to consider all major factors that would negatively impact the project, and provide necessary feedback to the contractor. The engineer's research would ultimately result in a pipe installation that provided minimal disturbance to the local residents and business in the area. Installation of the bypass lines was imperative to the project because it allowed the contractor to provide uninterrupted service to the water utility customers. The contractor that was selected for the project was efficient and followed all protocol - from installing bypass lines, to the video inspection, the pull of proof pipe to the slipline of then new pipe. There were no unexpected drawbacks during construction, and the project was completed as scheduled with no issues.

6. REFERENCES

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Tata & Howard, Inc. (2014) – Contract Documents and Specifications for the Deep River Water Treatment Plant Transmission Main Rehabilitation Project, Lebanon, CT