WM-T2-03

Water Agency in North Suburban Chicago Adds Six Communities to System Using Mix of Open Trench and Trenchless Construction

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1. ABSTRACT

The Central Lake County Joint Action Water Agency (CLCJAWA) was formed in 1986 to provide a reliable source of drinking water to a dozen communities in Lake County, IL. With decreased water demand due to increases in water usage efficiencies over the last 20-30 years, CLCJAWA was able to share their excess treatment capacity to provide treated Lake Michigan water to additional communities in the region. Six new communities were recently added to the CLCJAWA transmission system as a result of the design and construction of approximately 23 miles of new transmission mains that now serve more than 260,000 people.

In designing a project of this length and magnitude, the route of the new transmission mains traveled through varying landscapes requiring a mix of open trench and trenchless construction. The trenchless construction included both horizontal directional drill (HDD) and jack-and-bore installations in order to cross roads, avoid wetlands, save existing landscaping, and minimize disruptions to the residents. Overall, the project included over 9,000 feet of HDD in pipe sizes ranging from 10-inch to 24-inch diameter.

This paper will focus on the thorough evaluation, design, and construction execution process that CLCJAWA and their engineering team conducted for the HDD sections of the project. It will discuss the specific applications chosen for using HDD installations and walk through the design considerations that were required. Finally, the paper will review the construction of the HDD sections and discuss hurdles the contractors faced during construction.

2. INTRODUCTION

Prior to forming CLCJAWA, the communities within the agency relied primarily on groundwater wells. The initial CLCJAWA communities were all north suburban communities of the greater Chicago metropolitan area, located in Lake County, Illinois within an approximately 15-mile radius of Lake Michigan. These communities did not have direct and independent access to treated lake water, so they were not able to fully control water supply costs and availability for their residents. Relying on groundwater wells was the alternative to Lake Michigan water, but many of the wells within these communities had high levels of radium or could not produce enough water to meet the demands of their residents. As a result, CLCJAWA was formed in 1986, to explore options for providing its 12 communities with an independent source of Lake Michigan water.

The CLCJAWA consortium decided to design and construct their own Lake Michigan water supply system, which included a 50 million gallon per day (MGD) treatment plant in Lake Bluff and over 32 miles of water transmission
piping to serve their member communities. After years of planning, design, and construction, the CLCJAWA water treatment and supply system became operational in March of 1992. Since then, CLCJAWA has continued to make improvements to their system by increasing its quality, reliability, and capacity. As of 2005, this system provided water to 210,000 residents of CLCJAWA member communities.

During the nearly 30 years since the CLCJAWA system was constructed, technological improvements in water usage efficiencies decreased the projected water demand from the initial member communities. Consequently, the CLCJAWA water treatment facility had excess capacity to provide treated Lake Michigan water to additional communities in the region with the benefit of spreading fixed costs over a larger user base. Many communities within Lake County expressed interest to become members of CLCJAWA when the opportunity became available.

In total, six new communities were added to the transmission system. The communities of Lindenhurst, Lake Villa, Fox Lake Hills, and Grandwood Park formed what became known to the project as the North Group members after reaching an agreement with CLCJAWA in 2013. Similarly, the Villages of Wauconda and Volo joined together to form the West Group members in 2014. With the addition of these new six communities, the system service area increased to more than 260,000 residents and required constructing 23 miles of new transmission mains, a 72% increase over the existing system, to connect to these new areas.

The proposed transmission main was comprised of 10-inch, 16-inch, 20-inch, and 24-inch pipelines that crossed through varying urban and rural landscapes. Open trench construction was used for the majority of the transmission main construction, but a number of sections along the various transmission main routes also employed HDD methods to install the piping. HDD construction was considered and used for wetland crossings, driveway crossings, minimizing disturbance to commercial areas, and limiting disturbance to the existing landscape.

3. DESIGN EVALUATION

CLCJAWA hired CDM Smith as the lead engineering firm for the design and construction management of the new water transmission main expansion project, and they worked together to design and manage the project. The initial design of the project began with planning workshops and group sessions with officials from the member communities to gain input from them on the proposed transmission mains. These sessions combined with field studies led to the creation of route study reports and ultimately the selection of routes for each of the new transmission mains.

After analyzing the potential options for extending the CLCJAWA infrastructure, it was determined that two separate transmission mains would be required for serving the North Group communities of Lake Villa and Lindenhurst. Below are maps showing the selected transmission main routes for serving Lake Villa and Lindenhurst.
Figure 1-1. North Group Transmission Main Route to Lake Villa

Figure 1-2. North Group Transmission Main Route to Lindenhurst
Connecting the West Group communities of Wauconda and Volo only required the construction of one singular transmission main. Below is a map showing the route that was chosen for the West Group transmission main.

Figure 2. West Group Transmission Main Route to Wauconda and Volo

After determining routes for the proposed transmission main, the design team was able to begin evaluating areas that might require construction with trenchless technologies. Areas that required construction through wetlands were the most prominent candidates for HDD. Aside from wetland crossings, HDD was also used to preserve existing landscaping, cross roadways and driveways, and limit disturbance to commercial business parking lots.

CDM Smith and their sub-consultants, Applied Technologies, Inc., weighed the potential costs and benefits of open trench versus HDD versus jack-and-bore installation technologies in all of the areas where limiting construction impacts was important. In areas where restoration and permitting costs were minimal, open trench construction proved to be the most cost-effective option. Jacking and boring with a steel casing was also used in a number of areas on the project and especially made sense for short road crossings and areas where set-up room was too limited for HDD operations. HDD worked well on longer sections of the water main alignment that could not be disturbed.

Table 1 below provides a listing of the numerous HDD that were spread throughout the various phases of the project. The table also provides a description of why HDD was used for each particular section.

<table>
<thead>
<tr>
<th>Bid Package</th>
<th>HDD</th>
<th>Start Sta.</th>
<th>Ending Sta.</th>
<th>Length (ft)</th>
<th>Pipe Size (in)</th>
<th>DR</th>
<th>Reason for HDD</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Group BP 1</td>
<td>No. 1</td>
<td>153+68</td>
<td>161+16</td>
<td>748</td>
<td>24</td>
<td>18</td>
<td>Wetland crossing</td>
</tr>
<tr>
<td>West Group BP 2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>West Group BP 3</td>
<td>No. 1</td>
<td>100+23</td>
<td>111+92</td>
<td>1,169</td>
<td>20</td>
<td>18</td>
<td>Preserve existing road and landscaping</td>
</tr>
<tr>
<td>West Group BP 4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
After forming a list of potential HDD sections for the transmission mains, the design team developed a set of general parameters to follow from an HDD design standpoint.

4. HDD DESIGN

Geotechnical Considerations

Geotechnical investigations were completed in advance of the project by Wang Engineering. The geotechnical investigation and engineering reports concluded that the soils along the proposed transmission main routes for both the North Group and West Group projects were mostly clays. The relatively cobbled free clays were favorable for HDD and maintaining a stable borehole for installation of the new piping. One of the major concerns on the project was minimizing the potential for a frac-out during the HDD installations. The HDD contractors typically like to keep the pipe deep to prevent frac-outs, but the end user needs to keep the pipe at a depth that is manageable from an access standpoint. Most of the HDD sections were designed at depths between 14-20 feet in order to protect against frac-outs and that was an acceptable depth from the owner’s standpoint.

Pipe Materials
CLCJAWA’s existing system is composed primarily of pre-stressed concrete cylinder pipe and to a much lesser extent, double cement lined ductile iron pipe and polyvinyl chloride pipe. For this expansion, the design team evaluated several different potential material options for the HDD sections. Primarily, they considered restrained joint ductile iron piping, HDPE piping, and fusible polyvinylchloride piping (FPVCP) as candidates for the HDD sections. All of these materials have been successfully used for potable water applications in the HDD industry, and all of these materials are currently in use by CLCJAWA’s member communities. Ultimately, the design team decided to go with FPVCP for the HDD sections due to familiarity with the material, fittings and repair methods. The FPVCP also had the benefit of gasket free joints, no allowable leakage, normal interior diameter, no concerns in high ground water conditions and is not susceptible to corrosion, so it eliminated the need for cathodic protection on the HDD sections. Additionally, polyvinylchloride pipe had proven reliable in the existing CLCJAWA system as resistant to oxidation from chlorine drinking water disinfectants, which was important to CLCJAWA for the long-term reliability of the water main. The sizes of piping used for the HDD sections included 10-, 16-, 20-, and 24-inch diameters, which are also detailed in Table 1 above.

**HDD Profile**

With the wide range of pipe sizes and HDD lengths shown previously in Table 1, there was not necessarily one class of drilling rig that fit the project perfectly. Contractors could potentially use either mini, midi, or maxi drilling rigs depending on what HDD they were constructing. All of the HDD sections on the project were designed with 10-degree insertion and exit angles, which are well within the capabilities of any sized drilling rig that might have been used on the project. Additionally, the 10-degree insertion and exit angles allowed the general contractor to reconnect either end of the HDD with a standard 11.25-degree ductile iron fitting.

Most of the existing ground above the HDD sections was relatively flat, so CDM Smith was able to design a traditional bore profile for each section. Each profile transitioned from the insertion angle into a vertical curve, followed by a straight tangent section along the bottom of the drill before a vertical curve transition to exit the borehole. Below is an example of a 20-inch HDD profile from one of the phases of the project.

![Figure 3. 20-inch HDD Profile](image)

The shaded portions on either end of the drill profile show the room that CDM Smith designated for reconnections and pipe insertion pits. It was important to clearly designate the pipe insertion pit locations in order to ensure that the
contractors would provide enough room for the fusible polyvinylchloride pipe to flex from its above ground layout and into the borehole. The pipe insertion pits were sized with assistance from the pipe manufacturer and an example pit diagram is shown below in Figure 4.

Figure 4. Pipe Insertion Pit Diagram for 20-inch Fusible Polyvinylchloride Pipe

**Pipe Layout**

Because the pipe chosen for the HDD sections was a fused pipe, it was important to identify layout areas for the prefused pipe in the design phase of the project (Figure 5). When pipe layout is really limited, it is possible to fuse two or more pipe strings together with an intermediate joint during pull back. However, fusing intermediate joints is avoided when possible because it requires the driller to halt their pull-back process, which increases the risk of a borehole collapse and getting the pipe stuck while waiting for the intermediate joints to be fused. Fortunately, CDM Smith spent time on the design phase of this project to ensure that there was sufficient pipe layout room for each HDD and they were able to eliminate the need to fuse any intermediate joints during the pipe pull back.
5. CONSTRUCTION

The project was broken into four separate phases for the North Group transmission mains and another four separate phases of the project for the West Group transmission main. With needing to construct 23 miles of new transmission mains, CLC JAWA and their design teams felt that it would be appropriate to divide the overall project into smaller phases to make things more manageable for the local bidding contractors.

Construction on the transmission mains started in late 2016 and will be finishing up in 2019. In total, there was over two miles of pipe installed via HDD, which was spread over approximately 19 separate drills. The installation of the trenchless sections of the project proceeded largely as designed.

Two different Contactors have been subcontracted to complete the drills, and both generally followed the procedures laid out in the specifications. A number of challenges were encountered, including tight work areas, poor soils, minor frac-outs, and allowable work hours, but all drills have now been successfully completed, except for the 1,169-ft drill of 20-inch pipe on the West Group BP3 phase of the project. The size of HDD rigs used for the pipe installations varied based on the length of the pulls, but included a Vermeer 36 x 50 (Figure 6), a Ditch Witch JT100, and a Prime Drilling 80-ton rig.

One item of note is the requirements put on the contractor for record data from the drills. For this important pipe, it was essential that the client have exact data on the location of the pipe, even when installed via HDD. To get this data, a few different methods were used by the Contractor that yielded exact, to the inch, data points on the location of the pipe throughout the drill. These methods required by the HDD specifications allowed the Owner to have accurate record drawings, protect their pipe from other encroaching utilities, and know where the pipe is if a repair is ever needed.
6. CONCLUSION

The installation of the new 23-mile transmission main has been a success thus far. The use of a combination of open trench, HDD, and jack-and-bore methods allowed for seamless installations that minimized project cost and disturbance to the surface features. The success of the overall project was a result of robust planning, engineering, and execution by the parties involved.

HDD proved to be a good trenchless application for this project to allow for timely permits, minimize disturbance, and minimize restoration. The favorable soil characteristics, ample staging area, and flat ground surface contributed to the successful outcome of the HDD installation. Pipe material selection was also vital for the HDD installation method. The use of FPVCP eliminated the need of corrosion protection on the wetland crossings and provided a pipe that would be easily compatible with the ductile piping used on the sections of the project that were installed with open trench construction.

Ultimately, CLCJAWA is satisfied by the project result. The installed transmission main now connects and conveys Lake Michigan water to four new member communities (and expansion of an existing member). With the continuous advancement in water usage efficiencies, CLCJAWA may have the ability to add more communities in the future. The success of this project will serve as a stepping stone toward potential future projects.

7. REFERENCES

CDM Smith (2014) – North Group Route Study Report
