1. ABSTRACT

Ray is a small town in northwest North Dakota, located in an area commonly referred to as the “Bakken.” Prior to the discovery of advanced oil extraction methods in the Bakken rock formation, Ray had been a quiet, quaint town with a population of 534 in the year 2000. With the influx in oil activity, came the realization of an increasingly already deteriorating infrastructure. Since the oil boom, Ray has doubled in population and their city limits increased by 76% in 2012.

The project, constructed in 2012-13, consisted of upsizing and replacing approximately 16,000 feet of 6 and 8-inch cast iron watermains, fire hydrants, valves and service reconnections and total replacements. In terms of cost, this project consisted of about 25% of the total infrastructure improvements needed to sustain Ray in the short term (5 years) and was designed for 3.5 times the current population (1,050) for year 2023.

Due to heightened construction costs associated with the oil boom, every effort was made to stretch a tight budget. Interstate Engineering provided a pipe replacement bidding alternate via open-cut or trenchless to save on paved street restoration costs. Nine bids were received: five open-cut and four pipe bursting (static). A trenchless contract awarded to Lakeshore Toltest Corporation (LTC), provided a 24% cost savings to Ray. LTC selected DR18 Fusible C-900® pipe for the bursting material. Trenchless equipment and expertise was provided by Hammerhead®.

The final project ($2.3 million), consisted of upsizing and replacing approximately 18,750 feet of 6 and 8-inch watermain, 119 gate valves, 27 fire hydrants, and reconnecting or replacing 177 existing services.

2. INTRODUCTION

Ray, a small town in northwestern North Dakota, was a self-sustaining community experiencing very little growth and requiring minimal outside assistance. That was until advanced oil drilling and recovery methods were introduced in the Bakken, a rock formation stretching over 200,000 square miles in northeastern Montana, northwestern North Dakota, southern Saskatchewan and southwestern Manitoba (Figure 1). The Bakken, to some, was once considered a marginal resource due to its unique geologic characteristics that trap oil and gas within the formation. Now, horizontal drilling and hydraulic fracturing have made the Bakken an economic natural resource, one that has sought attention on a national level and resulted in an “oil boom.”
Ray, located along US Highway 2 in Williams County, North Dakota, had a population of 534 in the year 2000. The town was generating just enough funds to get by with their day-to-day operations and maintenance responsibilities. Traffic was scarce and public water, sewer and garbage demand was manageable with what some would call a skeleton crew. As years went by, the infrastructure aged. Prior to the oil boom, the water distribution system was marginally adequate for Ray’s current constituents. The system needed upgrading but it was serving the needs of Ray.

Currently the town is estimated to have a population in excess of 1,000, doubling between the Censuses conducted in 2000 and 2010. In addition, Ray’s city limits were increased by 76% in 2012. People have been pouring into the region from near and far, whether they’re in search of new oil-related jobs, expanding their business, or just trying something new. The oil industry is volatile but long term it appears the demands on public service will continue to increase and public infrastructure is taking the brunt of the impact as a result. With a population of 1,050, many of the watermains and the water storage tank were operating well above capacity.

With a rise in oil activity came the realization of an increasingly already deteriorating infrastructure. Ray’s roads, water distribution system, sanitary sewer collection and treatment system were long outdated but weren’t necessarily on the radar for improvements due to a diminishing population and affordability of the long term. Ray, with the help of Interstate Engineering, enacted a short-term plan to provide a solution to their immediate infrastructure needs while valuing the health and safety of their residents and constituents. The plan placed importance on a reliable, potable water supply as historically Ray has been plagued with regular breaks in their distribution system. Each break requires hiring an outside contractor to provide emergency assistance as the town’s budget does not allow for the manpower or equipment on standby for such situations.

A vast majority of Ray’s water distribution system was made of cast iron (CI) and installed between the 1930’s and 1950’s. In 2011, the North Dakota Department of Health put the City on notice regarding low disinfectant residuals. Encrustation occurs due to precipitation of minerals transported in the water delivery system (i.e., iron, calcium and magnesium carbonates), resulting in a biofilm deposit within the interior surface. The presence of such deposits is directly related to the presence of bacterial populations, creating a serious threat to the health and safety of Ray’s water users (Figure 2). Ray’s delivery flows for firefighting are also directly related to the encrustation due to reduced pipe capacity leaving nearby residents and businesses with inadequate fire flows. Additionally, the water system was documenting unaccounted water usage levels for the years 2004-2009 ranging from 34% to 46%. The high amount of unaccounted water use was resulting in wasted energy costs for pumping, wasted chemicals for treatment, and unnecessary wear and tear on equipment throughout the water system.
Ray’s immediate goal was to upsize and replace approximately 16,000 lineal feet of existing watermain suffering from the effects of encrustation, wear and tear and install 500 lineal feet of new watermain for future transmission lines and/or increasing fire flows. Like most municipalities, Ray’s existing water distribution system is located within City rights-of-way and the majority of infrastructure is located under streets consisting of at least 3 inches of hot bituminous pavement. Traditionally, water piping projects have been performed using an open-cut method; however, with the heightened construction costs associated with the Bakken, other methods were explored to help stretch the town’s overburdened dollar.

3. DESIGN

Prior to 1982, Ray’s water distribution system was served by municipal wells located throughout the community. In 1982, R&T Water Supply successfully connected to and began supplying the town’s distribution system with a 6-inch transmission line. Ray currently receives all of its water supply through the R&T water plant coupled with the Western Area Water Supply Association (WAWSA) as of August 2013.

In April of 2011, the City of Ray approved moving forward with an approximately 2.5 million dollar watermain improvement project. The funds were secured through the North Dakota Department of Health Drinking Water State Revolving Loan Fund (DWSRF). In terms of dollars, this project made up approximately 25% of the total infrastructure improvements needed to sustain Ray in the short term (5 years).

With a limited budget, watermains, hydrants, fittings and valves were ranked and the facilities with the highest ratings were selected for replacement. Priority was given to areas that would help increase distribution and flows, reduce unnecessary repairs and provide functioning valves to properly operate the system. Replacing and upsizing old CI mains around the perimeter of the City and the 8-inch CI main that feeds the existing water tower were rated as the highest priority items due to the health and safety risk to the public. The second highest priority was given to areas where excessive repairs and maintenance to the existing watermains have occurred. With areas of concern established, the project moved from preliminary to design phase.

Design for the selected improvements to Ray’s water distribution system began with a topographic survey. Above-ground features were located using Trimble GPS equipment, downloaded into MicroStation and analyzed using KY Pipe’s software. The 50,000 gallon water tank level was modeled at ¾ full when the hydraulic analysis was performed. During existing conditions, 23 out of the 44 hydrants had fire flows below the International Fire Code requirement of 1,000 gallons per minute (gpm).

Ray is anticipated to continually experience growth due to the increased oil activity. In 2012, the City limits increased by 76%. Projecting ahead, a population of approximately 3.5 times the 2011 population (1,050) for the year 2023 was used in designing Ray’s water improvements. The best way to plan for growth was to ensure the town...
had an adequate water supply and room for expansion. KY Pipe was again used to analyze the hydraulic capacity of Ray’s water distribution system with the proposed improvements. Replacing and upsizing old CI mains around the perimeter of the city and the 8-inch CI main that feeds the existing water tower decreased the amount of hydrants falling below fire flow recommendations from 23 to only 2 out of 44 hydrants.

Two alternatives for the project’s base bid were evaluated during the design process: watermain replacement using traditional open-cut methods and watermain replacement using trenchless technology methods. The open-cut method alternate would replace the existing CI watermains, valves, and hydrants using traditional methods. The watermains selected for replacement were based on creating a rehabilitated loop around the City and focusing on areas that have experienced numerous breaks and continued maintenance issues. Using traditional open-cut methods of construction typically requires extensive surface repair. Generally, one third of the cost for improvements is attributed to surface restoration of paved streets. Public disruption is anticipated to be longer as long open trenches prevent limited access at times during the project and an extended duration of the public on a temporary water supply. The trenchless technology method alternate would replace the same items as the previous alternate but would reduce the amount of surface restoration and public disruption.

The project has provided immediate benefits to the city and its constituents. The City was able to provide essential utility services that helped resolve low chlorine residuals, improved system pressure throughout the community and helped resolve low distribution and fire flow rates. In addition to the immediate effects, the City of Ray will also experience long term benefits to the community. With the expected growth resulting from the oil industry, rehabilitating portions of the water system was a necessary step in reaching the City of Ray’s goal of replacing all of its outdated and unreliable components of their water system.

4. CONTRACTING

Construction costs have been steadily increasing in the Bakken since the oil boom. Splitting up the entire project into four parts (base bid, additive alternate 1, additive alternate 2, and additive alternate 3) allowed the city to award work to a level within the predetermined budget. In addition to the project’s four parts, the water improvements were broken down into two Schedules, “A” & “B”. Schedule “A” was intended for contractors to utilize open-cut methods while Schedule “B” gave contractors the option to use trenchless technology methods (pipe bursting).

Plans and specifications for “Water Main Improvements for the City of Ray, ND” were advertised for bids in March 2012 and the bid opening was held at the Ray City Hall on April 12, 2012. Nine bids were received to complete the project; five for Schedule “A”, open-cut and four for Schedule “B”, trenchless technology. See Table 1, below and on the following page, for a summary of the bid results.

Table 1. Water Main Improvements for the City of Ray, ND - Bid Tabs

<table>
<thead>
<tr>
<th>Contractor Name</th>
<th>Base Bid</th>
<th>Additive Alternate 1</th>
<th>Additive Alternate 2</th>
<th>Additive Alternate 3</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wagner Construction</td>
<td>1,781,334.00</td>
<td>$272,771.00</td>
<td>$190,233.00</td>
<td>$42,089.00</td>
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<td>Quam Construction</td>
<td>1,864,777.25</td>
<td>$272,086.00</td>
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<td>$2,387,055.50</td>
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<tr>
<td>Lakeshore TolTest</td>
<td>1,872,163.00</td>
<td>$255,974.00</td>
<td>$171,600.00</td>
<td>$34,315.00</td>
<td>$2,334,052.00</td>
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<td>Duinnick, Inc.</td>
<td>2,137,815.80</td>
<td>$344,787.20</td>
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<td>$68,114.55</td>
<td>$2,790,910.35</td>
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<tr>
<td>Knife River</td>
<td>2,361,700.90</td>
<td>$367,379.60</td>
<td>$245,293.20</td>
<td>$53,420.20</td>
<td>$3,027,793.90</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Schedule “B” – Trenchless Technology Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lakeshore TolTest</td>
</tr>
</tbody>
</table>
A trenchless contract was awarded to Lakeshore Toltest Corporation (LTC), a Detroit-based company for the amount of $1,770,656.00 for Schedule “B” base bid, additive alternate 1, 2 and 3. Utilizing trenchless technology methods over the traditional open-cut methods provided a 24% cost savings to Ray and, more importantly, came well within their budget. The town, which was once in danger of not having all necessary improvements completed within DWSRF monies, now had the opportunity of pursuing change orders using LTC’s contract prices during the construction phase of the project to provide additional rehabilitation to their existing water distribution system.

5. CONSTRUCTION

The climate in Ray is typical of the northern plains and can be very unpredictable at times. Erratic temperature changes and conditions pose a challenge when Contractor’s plan their schedule for the construction window allotted. Typically, summers tend to experience warm days and cool nights while winters are naturally cold with snow cover. A windy day on the northern plains is inevitable. Precipitation averages approximately 14.5 inches of moisture a year.

Notice to commence work in accordance with the Contract Agreement was issued on June 11, 2012 with final payment by November 1, 2012. LTC began mobilizing to Ray, North Dakota right away. Housing is a premium in the area as there is neither vacant housing to rent/buy nor trailer hookups available. Fortunately for LTC, the City of Ray owned a vacant lot without utility services. The City Commission voted to allow LTC the use of the vacant lot to house employees during their construction window and in return, LTC was to bring water/sewer services and dry utilities to service the property.

Lakeshore TolTest selected DR-18 Fusible C-900® PVC as their bursting medium while trenchless equipment and expertise was provided by Hammerhead®. As pipe began to arrive on site, LTC’s project schedule started with installing new watermain using push-on joints while Fargo Water, LTC’s supplier, began fusing the DR-18 Fusible C-900®. Fargo Water completed their fusion services after multiple trips to Ray from their North Dakota-based office. Fusible PVC was staged in residential, industrial and rural parts of the town (Figure 3) until bursting operations commenced.

<table>
<thead>
<tr>
<th>Contractor</th>
<th>Base Bid</th>
<th>Alternate 1</th>
<th>Alternate 2</th>
<th>Alternate 3</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kemper Construction</td>
<td>$1,608,970.00</td>
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<td>$2,381,544.00</td>
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<td>SAK Construction</td>
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<td>$427,577.50</td>
<td>$214,365.00</td>
<td>$65,400.00</td>
<td>$2,456,192.50</td>
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<tr>
<td>Robert Gibb &amp; Sons, Inc.</td>
<td>$2,051,380.00</td>
<td>$513,814.00</td>
<td>$260,036.00</td>
<td>$67,362.00</td>
<td>$2,892,592.00</td>
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</tbody>
</table>

Figure 3 – Fusible Pipe Staging In Residential, Industrial and Rural Parts of Town
Creating a bursting plan was beneficial for LTC’s schedule. The plan allowed for LTC to minimize resident’s time on a temporary water supply during the installation, reconnection and testing of the new watermains. Moving from block to block, LTC began replacing and upsizing the aged CI watermains with new Fusible C-900® PVC. The new PVC watermains were reconnected to the existing mains using standard ductile-iron fittings (Figure 4). Hydrants and valves were replaced while private service lines were analyzed on a case-by-case basis. If the City of Ray was able to operate a private service’s curb stop, LTC would install a new saddle, corporation stop, service line and connect to the existing service line (typically under 3’ in length). If the City could not operate a private service’s curb stop but their service line was acceptable to their standards, LTC would install a new curb stop in addition to a new saddle, corporation stop and connect to the existing service line. If an individual service provided water to multiple residences (piggy-backing), LTC would install a new saddle, corporation stop, service line and curb stop at each individual resident’s property line. The resident(s) responsible for piggy-backing would be accountable for contracting out the construction of a new service line from their new curb stop to their residence. Any service lines that were found to be in poor shape or constructed of lead piping, were also replaced in their entirety from the main to the property line.

Figure 4 – Reconnection To Existing Main Using Standard Fittings

During the course of construction, the City of Ray was notified of the North Dakota Department of Transportation’s plan to begin a reconstruct on US Highway 2 through the extents of the City’s limits in the summer of 2013. US Highway 2 was proposed to be reconstructed with a 13.5-inch thick, non-reinforced concrete pavement section. Sitting below US Highway 2 laid an aging 8-inch CI watermain serving multiple commercial businesses outside of the original contract to be replaced.

Utilizing the cost savings attributed to rehabilitation via trenchless technology allowed the City of Ray their first opportunity to issue a Contract Change Order to LTC. Design engineering for approximately 1,400LF (4 blocks) of watermain replacement ensued and was presented to the City Commission for approval. Once again, trenchless technology assisted in competitive pricing for the additional rehabilitation work. Change Order 1 was executed in September 2012 for less than $200,000.00. LTC planned to commence work within US Highway 2 rights-of-way in the spring of 2013 and finished just prior to the US Highway 2 reconstruct project’s commencement.

LTC ran into their biggest challenge when petroleum-contaminated soils were encountered near US Highway 2 rights-of-way while wrapping up the 2012 construction season. The soils were easily recognizable to the contractor and resident observer when exposed. Interstate Engineering (IEI) promptly reached out to the North Dakota Department of Health (NDDoH) for assistance. The contamination resulted from abandoned leaking underground storage tanks from nearby properties. Efforts were made by the Department to visit Ray and test the level of hydrocarbons in the soil. Coordination between IEI, LTC, NDDoH and the City of Ray was vital in developing a feasible, cost-effective and timely solution.
The new watermain was to be Ductile Iron Pipe Restrained Joint Class 51, new services were to be Cooper type K, and all gaskets used in connections to valves, hydrants and fittings were to be petroleum resistant where contaminated soils were present. All contaminated soils were to be disposed at the Ray Inert Landfill in accordance with NDDoH’s requirements for future remediation by the City. Fortunately for the City, the contaminated soils were encountered during the 2012 project and the aging cast-iron mains were replaced before any serious harm was done to the City’s water supply.

In order to fully realize the breadth of the contaminated area, exploratory excavation ensued during the winter months of 2012. Contamination stretched west (beneath US Highway 2) and east under a parking lot not currently under LTC’s contract for watermain improvements. Due to the nature of the situation, the City spent money out of their reserves, while again utilizing cost savings associated with trenchless technology, to increase the lineal footage of watermain to be replaced in contaminated soils with Ductile Iron Pipe. Change Orders were executed in December 2012 and March 2013 for LTC to perform the additional work. Watermain improvements beneath US Highway 2 were completed before June 2013. Figure 5, below, shows Fusible PVC connecting with Ductile Iron Pipe where soil contamination was first encountered.

![Figure 5 - Ductile Iron Pipe to Fusible PVC Connection](image)

LTC was able to continue on their original contracted work with the City once the high priority of US Highway 2 work was complete. LTC’s original contract was scheduled for final payment by November 1, 2012; however, throughout the course of the project, LTC experienced many watermain breaks, unfavorable and winter weather conditions, and completed additional work that warranted time extensions executed by the City Commission via Change Orders. During the course of the project, the City of Ray experienced more than 10 breaks in their aging CI watermains that required immediate attention. The City’s Public Works Department’s budget does not allow for the manpower or equipment on hand for such emergency situations. Fortunately for the City, LTC was willing to assist. Additionally, more than 2,000 LF of additional watermain replacement by trenchless technology was added to LTC’s original contract during construction. The lion’s share of all originally contracted and additional watermain improvements concluded in September 2013.

### 6. CONCLUSION

Ray a small, rural town situated in northwestern North Dakota in an area known for its abundance of oil and gas as the Bakken is becoming victim to the nation’s fast moving oil industry. The City’s residents, coupled with the influx of new people, have been placing a heavy burden on Ray’s increasing and already deteriorating water distribution system. With heightened construction costs accompanying the oil boom, every effort was made to stretch a tight budget. Trenchless technology provided a 24% cost savings over traditional open cut methods to Ray, limited surface repairs and decreased public disruption throughout construction.
The 2012-13 project consisted of upsizing and replacing 18,750 feet of 6 and 8-inch cast iron watermains, 119 gate valves, 27 fire hydrants, and 177 existing services and the majority of the work was completed by September 2013 for $2.3 million. This sizable investment only helped sustain Ray’s short term infrastructure needs (about 25% in terms of cost). The City expects to bid a new 750,000 gallon elevated storage tank in 2015. However, the City is still seeking assistance to help protect their constituent’s health and safety by maintaining and rehabilitating the remaining water distribution system in addition to their sanitary sewer collection system. Trenchless technology proved beneficial in 2012 and may aid in the solution to Ray’s long-term infrastructure troubles.
7. REFERENCES


