ABSTRACT

The York County Eastern Water System is located in the northeast corner of York County, SC north of the Catawba River. The water system is supplied through two sources: a connection to Charlotte Mecklenburg Utility Department (CMUD) to the north and the Rock Hill Water Treatment Plant (WTP) to the south. Prior to the completion of this project, finished water was conveyed to York County from Rock Hill through the Fort Mill water distribution system via a 24-inch pipe on a utility bridge spanning the Catawba River. During periods of peak demand, this supply feed was inefficient, and York County relied heavily upon the connection to CMUD.

The goal of this project was to construct a direct feed from the Rock Hill WTP to the Eastern Water System across the Catawba River with the capacity to meet the current and future demands of the system while remaining independent of the connections to CMUD and Fort Mill. The new water main would also provide redundancy to the water systems north of the Catawba River.

The design and construction of the project included approximately 33,600 lineal feet of 30-inch and 24-inch water main with a 12,000-gpm booster station. The water main was installed under the Catawba River by Horizontal Directional Drill (HDD) using approximately 1,000 lineal feet of 36-inch high-density polyethylene (HDPE). As a result of this project, York County will have the capacity to serve the projected demands of the Eastern Water System to the year 2030.

This paper outlines the background of the project and the problems faced by the Eastern Water System, present the determined solution, and provide a synopsis of the design and construction of the water main. Particular emphasis is placed upon the HDD crossing of the Catawba River, including choosing the location and method of the crossing, geotechnical conditions, general design, performed installation by the contractor, and lessons learned.

KEYWORDS

Water Distribution, Horizontal Directional Drilling, Catawba River Water Main, York County, Hydraulic Modeling
INTRODUCTION

The York County Eastern Water System is located in the northeastern corner of York County, an area that has seen significant growth over the past decade. The municipalities in this region include the Town of Fort Mill and the City of Tega Cay. The Eastern Water System serves mainly the commercial and residential developments located outside of the incorporated city limits and is a part of an interconnected web of distribution systems, owned and operated by York County, Tega Cay and Fort Mill (Figure 1).

The Eastern Water System water is supplied primarily through the City of Rock Hill Water Treatment Plant (WTP) to the south and a secondary connection to Charlotte Mecklenburg Utility Department (CMUD) to the north. The supply feed from Rock Hill consists of a single 20"/24" pipe that extends from the WTP to HWY 160 by way of US HWY 21 and spans the Catawba River on a utility bridge. The utility bridge is owned and maintained by the Town of Fort Mill and is currently the only supply line from the WTP to the areas north of the Catawba River. Finished water is conveyed to the Eastern Water System through the Fort Mill distribution system. During periods of peak demand, the supply was inadequate to meet the demands of Fort Mill, Tega Cay, and York County and does not provide the needed pressure gradient to operate the system and fill the elevated tanks. As a result, York County relied upon the connection to CMUD to meet demands which led to increased costs associated with CMUD’s higher unit price of water.

The purpose of the Catawba River Water Main project was to provide an alternative means of supply to the Eastern Water System. The new water main will give York County a direct, large-diameter connection to the Rock Hill WTP and allow the County to eliminate the need for connections to Fort Mill and CMU for uses other than emergency. The direct connection will provide financial stability and an adequate supply for future growth, as well as redundancy for the water systems north of the Catawba River.

The greatest challenge to the design and construction of the new water main was the installation of the pipe under the Catawba River which spans approximately 500 feet just downstream from the Lake Wylie Dam. The installation was performed through the use of Horizontal Directional Drill (HDD) technology over a seven week period. Prior to the design and construction of the
water main, a hydraulic evaluation of the Eastern Water System was performed to determine the size and parameters of the water main and other infrastructure required to meet the objective of eliminating dependency on CMUD and Fort Mill. A routing study was also completed to ascertain the best alignment of the water main with respect to cost, constructability, operation, and viable options for the river crossing.

**METHODOLOGY**

**Hydraulic Evaluation**

York County currently maintains approximately 128 miles of water main in the Eastern Water System ranging in size from 2” to 24” in diameter. As explained previously, water is conveyed from the Rock Hill WTP to the Eastern Water System through the Town of Fort Mill and a 20” water main spanning the Catawba River by way of a utility bridge. Water enters the system at two locations near the intersection of HWY 160 and HWY 21. In addition to this feed, York County receives water from CMUD at two connections located in the vicinity of Carowinds Boulevard. The County also provides wholesale water service to the communities of Tega Cay. The service area is shown in Figure 1.

Within the Eastern Water System, York County operates and maintains five elevated storage tanks and a booster pumping station located on HWY 160. The booster pump station operates at constant speed delivering approximately 1100 gpm and is controlled by the Stockbridge Elevated Tank levels. The Fort Mill connection provides 90 psi at a hydraulic grade of 823 feet and the CMU connection provides 100 psi at a hydraulic grade of 865 feet. A schematic of the system is shown in Figure 2.

![Figure 2](image)

**Figure 2**

*Schematic of the Eastern Water System*
As seen by Figure 2, the distribution systems of Fort Mill, Tega Cay and York County operate as a single system with little hydraulic separation. The distribution system north of the Catawba River is supplied by the 20" water main from Rock Hill. On days of peak demand this arrangement has proven insufficient due to the restricted capacity of the 20" pipe. The problem is further exacerbated within the Eastern Water System due to the presence of Interstate 77. The presence of I-77 and the absence of a large diameter, east-to-west aligned water main have resulted in a notable division of performance between the eastern and western portions of the distribution system. Water is currently conveyed from the 20"/24" pipe on HWY 21 to the main elevated tank at Stockbridge through the 12" pipe located on HWY 160. The 12" pipe expands to a 16" in the Baxter area and eventually to a 20" pipe at the intersection of Gardendale Road. The 12" pipe on HWY 160 creates a bottleneck that reduces the hydraulic energy, thereby restricting the flow of water through the system which requires the operation of the HWY 160 booster station to provide the needed energy to fill the Stockbridge Tank. The operation of the booster station in turn lowers the hydraulic grade of the Fort Mill system reducing their ability to fill the Dolby Bridge Tank (Fort Mill).

Service area demand projections were provided by York County. The projections were based upon parcels identified for development over a 20 year period and a chronological progression of construction was assigned for each projected development. Demands were calculated for each parcel based on the parcel area, type of development (residential or commercial), development density, known number of units to be developed, and capacity letters. Commercial parcel demands were calculated on a per acre basis. Residential parcel demands were based upon the known or projected number of units to be developed. The projected demands can be found in Table 1.

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<th>Year</th>
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* Demands provided by York County.

Table 1
Summary of Demands for Eastern Water System

In order to evaluate the effect of the proposed water main on the existing water system, a hydraulic model and mode of operation for the Eastern Water System was developed. The City of Rock Hill owned a 30" ductile iron raw water main that extended from the WTP to Lake Wylie. The raw water main was not being used due to a new 54" raw water main that had been constructed to serve the Plant. At the time of the hydraulic evaluation, plans were in process to convert the water main for potable use. It was determined that the proposed water main would connect with the converted water main and be extended across the Catawba River to serve as the suction line for a proposed Booster Pump Station (BPS). The BPS would be operated to provide a constant flow rate over the course of a 24 hour period. This proposed mode of operation would float the elevated storage based upon diurnal demands. The station pump sequencing and speed control would be programmed to provide the average daily flow rate as estimated by the operators or by an estimating algorithm.

Through discussion with York County personnel, two hydraulic scenarios were considered for the connection of the Rock Hill WTP to the York County Eastern Water System with the proposed water main: 1) connection to the 16" water main located on HWY 160; or 2) connection to the 24" water main located on HWY 24. The drawback to the connection with the 24" would be the additional cost to extend the water main to the location across I-77.
It was determined that the connection to the 16" water main at the intersection of Sutton Road and HWY 160 could provide some relief to the system at current demands by bypassing the 12" bottleneck across the interstate and the HWY 160 booster station; however, the Eastern Water System would still rely upon the connection to CMUD and Fort Mill to provide present and projected demands due to the limited connectivity between the eastern and western portions of the system. In order to eliminate the dependency on the CMUD and Fort Mill connections for the forecasted period, York County was required to connect the proposed water main to the 24" water main located at US HWY 21. This provided a large diameter backbone through the system that conveyed water across both the Catawba River and I-77, improving not only the supply feed north of the river, but the east-west connectivity of the system. Using the previous schematic, Figure 3 shows the required connection of the proposed water main.

Initial evaluations of the system were modeled using a 30" and 24" water main. Although a 24" water main would be sufficient at present demands, future projections warrant the construction of a 30" water main to the 16" located on HWY 160. The evaluation also concluded that an additional 1.5 MG of elevated storage would be required to serve the projected demands and be located in the northeastern portion of the system.

Figure 3
Proposed Water Main Schematic

Routing Analysis

A routing analysis was performed in order to determine the best alignment of the water main from the connection to the City of Rock Hill’s converted raw water main to the ultimate connection to the 24" water main located on HWY 24. The analysis considered cost, environmental and archeological impacts, constructability, and operation with particular emphasis on the feasibility of crossing the Catawba River.
Factors for choosing the Catawba River crossing location included access, environmental buffer regulations, HDD operation constraints, topography profile, and easement requirements. The recommended site for the river crossing was between two large parcels, an undeveloped tract of land owned by Crescent Resources and Westminster Park (Figure 4). Westminster Park is a recreational facility owned and operated by Westminster Presbyterian Church in Rock Hill, SC that includes sports fields, family pavilions, and nature trails.

![Recommended Location for Catawba River Crossing](image)

The advantages of installing the water main across the Catawba River at this location included the following:

- Both parcels offered access options to the river front. Westminster Park has a main access road to the sports fields and a secondary road to the river which was improved by the County in turn for temporary easement access. The Crescent Resources parcel has logging roads which were available for use by the Contractor as well as a force main easement maintained by the City of Tega Cay.

- The area by the river front at Westminster Park was ideally suited for HDD operation. The area was generally flat and had a cleared field suitable for locating the drill rig, control building, hydraulic pumps, hydraulic fluid recycler, fluid containment, and the drill shafts, drill bit and reamers. In general, the land surrounding the Catawba River is forested. Additionally, the cleared force main easement on the Crescent Resources property provided the necessary length to string out the pipe and fuse prior to the pull back.

- There is a 100 feet environmental disturbance buffer on the Catawba River. The entry and exit locations of the pipe were able to be located outside of this buffer.

- The topography profile from the entry to the exit points was such that the HDD pipe profile could be designed with the proper geometry without the need to extend the length of the drill to achieve standard parameters such as entry and exit angles, depth under the river bed, and drill radius.
The Westminster Park and Crescent Resources parcels are both large tracts of land which limited the need to obtain easements from multiple owners and simplified the acquisition process.

**Horizontal Directional Drill Design**

The technical feasibility of HDD installation at a given location can be determined by three parameters: drilled length, pipe diameter, and subsurface conditions. With the anticipated length of the drill being approximately 1,000 feet, the length and diameter was found to be well within current HDD technology. With respect to subsurface conditions, large grain content in the soils such as gravel and boulders and excessive rock strength and hardness can hamper successful HDD installations. Additionally, poor rock quality and voids in the bedrock may impact the feasibility of a drilling operation. A geotechnical investigation was performed through the use of soil bores and rock cores at the anticipated entry and exit location of the drill to determine the parameters of the existing soil and rock conditions.

The site was explored by drilling four test borings (two on either side of the river) and analyzing the material obtained from the borings. The borings extended to depths ranging from 21.5 feet to 30 feet below the existing grade using hollow-stem, continuous flight auger drilling techniques. Rock coring techniques were performed for two of the borings to an approximate depth of 90 feet to determine the character and continuity of the rock encountered.

The general subsurface stratigraphy at the bore sites comprised of residual soils consisting of sand and silt to as deep as 25 feet. Blow counts of the residual soils ranged from 4 to 29 blows-per-foot. Partially weathered rock was encountered underlying the residual soils from the approximate depths of 15 to 25 feet. Rock was sampled from depth ranging from 26 feet to 90 feet. In general, the cored rock consisted of igneous metamorphic rock with a Rock Quality Designation (RQD) value ranging from 90 percent to 100 percent. RQD values of 90 percent and higher are characterized as “excellent” rock quality and favorable for tunneling conditions. Unconfined Compressive Strength (UCS) tests were performed and values ranged from 11,000 psi to 22,000 psi.

High Density Polyethylene (HDPE) pipe with a DR 11 pressure rating and PE 4710 resin was chosen for HDD installation. In order to achieve an approximate 30 inch inside diameter for a DR 11 HDPE pipe, a 36 inch outside diameter pipe was required due to wall thickness. A 36-inch OD HDPE can be designed at roughly 900 feet using HDD industry standards. 30 inch welded steel has the disadvantage of requiring approximately 1,350 feet and would have extended the length of the design and was ruled out for use.

The design of the HDD crossing contained a horizontal length of 904 feet, entry and exit angles of 12 degrees, and a single 24 degree sag bend at a radius of 1,500 feet. The design provided a minimum depth of cover of 30 feet from top of bank to top of bank using an assumed depth of the river bed.

**RESULTS**

The HDD operation was performed in seven weeks from the start of the pilot hole to the pull-back of the pipe. The HDD contractor worked a schedule of 10 hours per day seven days a week for the first three weeks and then shifted to a 24 hour schedule. The contractor operated a horizontal drilling rig with a pull-back capacity of 500,000 lbs, a torque capacity of 48,000 ft-lbs, and a foot print of 100’ x 50’.

The pilot hole was successful and stayed within the required design tolerances. The pilot hole was performed with a 12-inch drill bit and exited three feet short and two feet to the left of the
designed exit point. Reaming passes were made with 24-inch, 28-inch, 32-inch, 40-inch, and 48-inch reamers. The pull-back of the pipe was made in approximately eight hours with no issues.

**DISCUSSION**

The project went exceptionally well and few problems were encountered during the HDD operation. However, some lessons were learned that can be applied to future operations.

The hydraulic fluid pumping and recycling was assumed to take place only at the drilling entry location and temporary construction easement was only provided at the drilling site to accommodate fluid containment and recycling. Since the exit site was remote and pumping the fluid back over the river was not allowed, the contractor contained and recycled fluid at the exit site in addition to the entry site and used hydraulic pumps to spin the reamer from both the exit and entry locations. The temporary construction easement located at the exit site was inadequate for hydraulic fluid operations.

The access road to the exit location was inadequate for pipe delivery and the HDPE was delivered to an area just prior to the start of the road. This caused several problems for pipe delivery and handling. The HDPE pipe was manufactured in 50 foot segments and weighed approximately 7,000 lbs per segment. In order to move the pipe to the job site for fusing and installation, the contractor chained one end of the pipe to a track excavator and drug the pipe down the access road. The method of moving the pipe caused damage to the ends and side walls significant enough to require the areas to be cut out and fused back. The repairs caused delays before the pipe was able to be pulled.

**REFERENCES**

JD Hair and Associates. "Assessment of Proposed Water Main Crossing beneath the Catawba River". May 7, 2009