Water Line + Wetlands = HDD Installation of 30" Pipe

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Abstract

The West Harris County Regional Water Authority (WHCRWA) was established in 2001 to reduce groundwater consumption through surface water conversion. WHCRWA has constructed over 57 miles of new water transmission lines to deliver millions of gallons of surface water per day to a population of approximately 460,000 in various utility districts. The boundaries of WHCRWA are generally US290 on the north/northeast, Houston city limits on the east, and Forth Bend County line on the west. Contract 34 is part of the water transmission system being developed to prepare the far western Houston area for mandated conversion from groundwater to surface water.

Contract 34 includes approximately 18,700 linear feet of 30-inch and 24-inch potable water lines to Harris County MUD 371/374 Water Plant. Methods of construction included primarily open cut with some trenchless installations. Approximately 2,160 LF was installed across Cypress Creek by horizontal directional drilling (HDD) to avoid a protected wetland area. The selected pipe material for the HDD crossing was DR 21 Fusible PVC® (FPVC®). A bore geometry including curve radii and entry and exit angles was developed along with connection details and technical specifications for the bid package. Drill pad areas were delineated and additional easements were obtained to accommodate drilling and slurry equipment. Pipe ballasting during pullback was required due to the anticipated installation stresses. Special details were developed for the transition from FPVC® to standard pipe materials which included steel, ductile iron, prestressed concrete cylinder pipe, and bar-wrapped steel cylinder pipe. The pipe material selected by Meiners, the General Contractor, for the remainder of the project was bar-wrapped steel cylinder pipe.

The 30-inch water line HDD was successfully completed by TCH drillers, the drilling subcontractor to Meiners, on March 3, 2016. This paper will present the challenges during the design and installation of the 2,160 ft. HDD crossing, believed to be one of the longest large diameter pressure pipe trenchless installations in the state.

Cypress Creek Protected Wetlands

A Wetland Determination study was performed and identified Cypress Creek as within a PFO palustrine forested area (PFO) comprised of tree and sapling/shrub layer dominated by Chinese tallowtree and an herbaceous later dominated by small spike-rush and Cherokee sedge. A vine layer of Alabama supplejack was also observed. The proposed water line would cross within the identified wetland area for approximately 2,100 linear feet. The US Army Corps of Engineers (USACE) regulates the placement of structures

and or/work performed in/or affecting navigable waters of the US under Section 10 of the Rivers and Harbors Act of 1899. USACE also regulates the discharge of dredged and/or fill material into waters of the US, including navigable waters, under Section 404 of the Clean Water Act. A trenchless installation across the identified wetlands would ensure compliance with federal requirements.

However, the size of the identified wetlands area exceeded the typical length for conventional trenchless installation methods such as augering and microtunneling, which would have required multiple intermediate pits within a crossing of this length. It became evident that HDD was the ideal method for installation, as the crossing could be achieved without disturbing the protected wetlands area.

Fusible PVC®

Standard pipe materials allowed for 30-inch diameter included steel, prestressed concrete cylinder, bar-wrapped steel cylinder, and ductile iron. For the HDD crossing, based on the diameter, length, depth, and bending radius requirements, FPVC® was recommended. The highest DR available for 30-inch FPVC® is DR 21 which provides a 200 psi pressure rating according to AWWA C905. Pipe OD would be 32 inches, wall thickness 1.52 inches, and average ID 28.77 inches. As a comparison, a 30-inch HDPE PE4710 with DR 11.0 (200 psi) would have a 32-inch OD, 2.909 inch thick wall, and a 25.833 inch ID.

To determine if FPVC® would be feasible for the proposed crossing, the following had to be evaluated:

1.) General check on constructability – including alignment (bend radius), angles, fusion and layout, project site, etc.
2.) Estimated required pull force compared to pipe capability.
3.) Estimated critical collapse requirement compared to pipe capability.
4.) Estimated long term vertical loading compared to pipe capability.

Underground Solutions, manufacturer of FPVC®, provided the pipe stress analysis. The minimum allowable bending radius for FPVC® is 667 feet and the safe pulling force is 408,500 lbs. Based on the bore geometry of 10-degree entry angle, 5-degree exit angle, and 40-foot maximum depth, calculations were performed for HDD pulling force and long-term vertical loading analysis (post-installation). The HDD pulling force was performed for both pipe empty and pipe filled. The pull force for pipe filled was 112,000 lbs, and for pipe empty, 323,000 lbs, nearly 3 times greater. Furthermore, the external pressure on the ballasted pipe was 19.1 psi vs. 37.2 psi for unballasted pipe, reducing factor of safety by more than half relative to critical buckling pressure for unballasted pipe. As such, requirements were added to Bid Documents for Contractor to fill pipe with water as it enters the bore to maintain neutral buoyancy during pullback, with no exceptions.

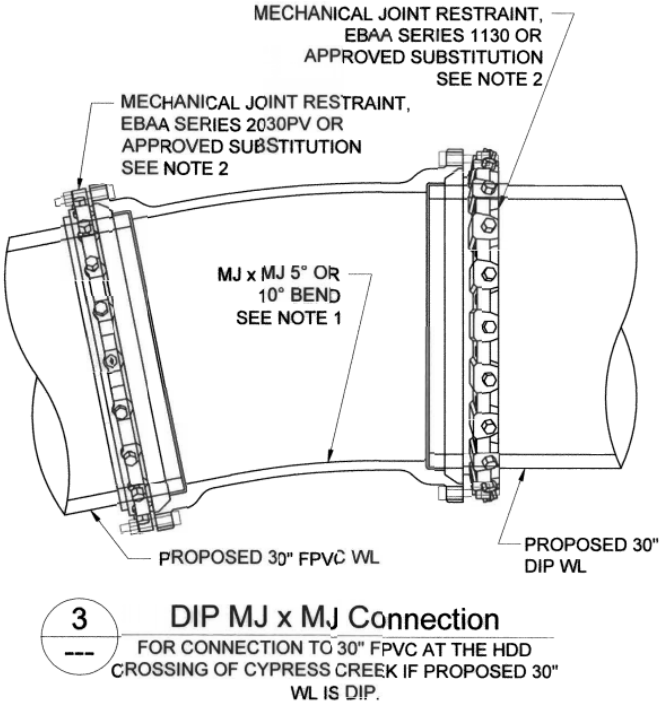
Underground Solutions provided a long-term vertical loading analysis based on the maximum depth of 40 feet below grade, assuming poor soil conditions of saturated silty sand, to confirm the maximum deflection would not exceed 5% allowable.

Specifications

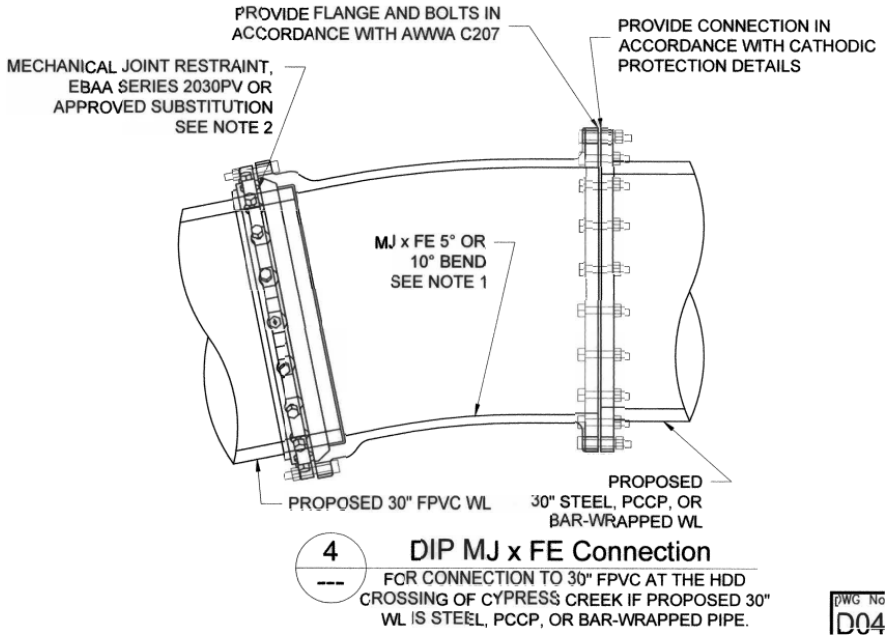
A custom specification was provided for the project which included requirements for FPVC® and the HDD. Basic material requirements for FPVC® included compliance with AWWA C905, DR21, NSF 61 certification, 40-ft lengths, and the pipe should be homogeneous throughout and free of visible cracks, holes, foreign material, blisters, or other visible deleterious faults. Fusible FPVC® joints shall be assembled in the field with butt-fused joints by a qualified fusion technician. An HDD work plan was required including a contingency plan for inadvertent drilling fluid returns and buoyancy modification procedure for pullback of pipeline. Connections to other pipe materials would be mechanical joint ductile iron fittings conforming to AWWA C153 and high strength, low alloy steel bolts conforming to AWWA C111.

Special Connection Details

The upstream and downstream portions of the 30-in water line would be standard allowable pipe materials including steel, prestressed concrete cylinder (PCCP), bar-wrapped steel cylinder (B303), and ductile iron pipe. To connect the FPVC® on each side, a special connection detail was developed. Various alternatives were considered including ductile iron and steel adapters. Two details were provided, one for connection to a ductile iron pipe, the other for connection to steel, PCCP, or B303 pipe. Detail 3 (below) shows an EBAA Series 2030PV MJ x MJ connection to ductile iron with mechanical joint restraint.



Detail 4 (below) shows the same EBAA Series 2030PV with an MJ x flanged end connection to steel, PCCP or B303. An insulating kit was required for the flange connection.



The Contractor for this project selected bar-wrapped steel cylinder pipe (B303) for the remaining portions of 30-in water line, with connection to FPVC® achieved per Detail 4.

Temporary Construction Easements

The majority of the proposed 30-in water line was to be placed within a 20-ft wide easement, with a 15-ft adjacent temporary construction easement. For the HDD, a much larger area would be needed for the drill rig, mud system, vacuum truck, track hoe, and 18-wheeler carrying drill stem. A minimum 80 ft by 100 ft area was needed. To accomplish this, an additional temporary construction easement of 70' x 150' was acquired for the drill pad, with the 20' easement and 15' temporary construction easements also being utilized. On the exit side of the crossing, the pipe could be fused in one long string with no obstructions to intersections or driveways.

Drilling Operations

Drilling operations started around February 10, 2016. TCH Drillers was the drilling contractor. American Augers 440T was the drilling rig. The Power Flow mud control system mixed the drilling fluids, and separated and clean the solids from the mud so it could be recycled back into the process. A vector magnetics steering tool for guidance (Para-Trak guidance system) was used to track the pilot bore.

Once the rig and equipment was set up at the entry location where the drill enters the ground, they drilled the pilot bore along a predetermined path with a 9-10 inch bit. When they reached the 40-ft elevation, they continued across. The pilot hole was completed on Feburary 14, 2106. A gradual hole enlargement process was used to keep the solids manageable. The next pass was a 24-inch diameter cut with trailing stem. The drillers add more stem behind the reamer in the event of a hole collapse, they could regain the path. The geotechnical conditions were multiple layers of changing faces including sand and lean clays. At the bottom elevation of 40 feet, which continued for approximately 1,500 feet, the layer was sandy.

After the 24-inch pass was complete, they cut the hole to 36-inch, then 48-inch. At all times, the drilled hole is filled with drilling fluid and cuttings. At the exit end of the crossing, the drilling fluids had to be trucked back to the entry side where the mud could be processed and re-used. In rainy, wet conditions, it was difficult for trucks to drive within the easement without getting stuck. Also, there was no direct route between the entry and exit locations, requiring drivers to weave through different roads and adding time to the process.

While the hole was being reamed, the 2,160 ft pipe string was being fused and strung out on rollers. The fusion equipment was housed in a tent and a heat plate was placed between the butt joints and heated to over 300 deg F to melt the joints just before they are pressed together. A log sheet records all details including ambient temperature, heating plate temperature, and fusion pressure.

After the 48-inch hole was complete, a swab pass was done with a barrel-type reamer that spins through the hole and pumps drilling fluid through it to help flush the hole. This ensures that the path is clear for the pipe. From exit point to the rig, they connect to the pull head which is attached to 2,160 feet of pipe. The drill stem and reamer rotate as pipe is pulled in so there is no torsional stress of pipe. As required in the documents, the Contractor filled the line with water as it was being pulled in for buoyancy control, to achieve neutral buoyancy, significantly reducing stress and extrenal forces on the pipe, and significantly reducing the pulling force required by the drill rig. The pullback was successfully completed on March 3, 2016.