Powering the Future with Trenchless Technology

By: Kyle Friedman, Brierley Associates;
Adam Smith, Power Engineers;
Jim Williams, Brierley Associates;
Mehana Ho'opi'i, Xcel Energy

The Denver metropolitan area has experienced unprecedented growth in recent years, leading to increased demand for reliable electricity. As the demand for electricity increases, substations reach their capacity and become unable to supply enough low-voltage electricity to meet customer needs.

Xcel Energy's Lacombe to Barker Underground Transmission Project includes the installation of parallel 230-kilovolt underground electrical transmission lines underneath 20th street from Lacombe Substation west of Chestnut Place to the alley between Blake and Market Streets, and along the alley between 20th Street and the Barker Substation located in the historic district of Lower Downtown and Ballpark neighborhood.

The system in this area does not currently have the capability to reliably serve future customer electric needs. Building additional, or upgrading and interconnecting existing substations, like the Barker Substation, enables Xcel Energy to continue to provide safe reliable electric service in the future, while enhancing system resiliency.

The Lacombe to Barker Design and Construction team, comprised of Power Engineers, Brierley Associates, and Michels Corporation, completed the construction of two 2,100-foot, 14-HDPE pipe duct bundle transmission lines under 20th Street in Lower Downtown Denver by using a horizontal directional drill (HDD). A horizontal directional drill is a trenchless construction technique that allows for installation of underground utilities by drilling a curved path beneath the surface to reach a desired exit point.

> "Stakeholders played a significant role in the project.

Logistical Challenges

With the project in the heart of downtown Denver, stakeholders played a significant role in the project.

The City and County of Denver (CCD) typically does not allow closures of public Right-of-Way (ROW) including street, alley, sidewalk, and parking lane closures from Thanksgiving Day to New Year's Day in the Downtown Business Area. This area includes 20th Street between I-25 and

Site plan – located within the heart of lower Downtown

Market Street, and the alley between 20th Street and the proposed Barker Substation. This Holiday Moratorium would result in a 1.5 month stoppage of work for duct bank construction outside of Lacombe Substation. However, POWER worked with the CCD Department of Transportation and Infrastructure (DOTI) to have them better understand the construction process, which resulted in construction being allowed to continue through the Holiday Moratorium as long as the permits were in place prior to the start of the Holiday Moratorium.

Also, CCD restricts construction activities and closures of travel lanes, parking lanes, and sidewalks in the ROW on Game Day during Colorado Rockies' baseball season, which typically extends from April 1st to October 1st. The boundaries of the moratorium include 20th Street between I-25 and Market Street, and the alley between 20th Street and the proposed Barker Substation. This restriction created tight construction windows dependent upon the success of the Rockies season, which could be prolonged if the team was successful in the playoffs. Lastly, work within 20th Street between Blake Street and Market Street was also restricted on St. Patrick's Day each year due to the work areas proximity to the St. Patrick's Day parade route.

> "Trenchless technologies were going to play a large role in this project.

For an HDD option, the conduit bundle strings would be assembled at the entry point. However, due to the close proximity to I-25, the entire 2,100-foot pipe string could not be assembled, and an intermediate fusion point was required. Additionally, the pipe string layout alternative faced challenges from the need to keep Little Raven Street accessible to I-25 for residents. This required the pipe bundle to either be trenched below Little Raven Street through a temporary chase or being suspended in the air for the pull back.

Geology Encountered

The alignment for the underground transmission lines is located in an older part of downtown Denver where old building debris was utilized as fill. For this project, a total of 5 borings were drilled along the trenchless alignment along 20th street ranging in depth from 64 feet to 102 feet. All borings were drilled with a 6-inch diameter sonic rig, where drilling/coring is performed using high-frequency vibrations to obtain continuous sampling. Standard geotechnical sampling techniques were used at 5 feet on center intervals.

Urban fill was encountered in in all borings along the alignment from the below the pavement to approximately 12 feet below the ground surface. The urban fill consisted of multiple soil types with traces of bricks, asphalt, and rebar. This material was determined to be unstable. Native alluvial soils were encountered below the urban fill on the western half of the project near the South Platte River, ranging in depth from 14 feet to 24 feet

Pipe string layout required an intermediate fusion point

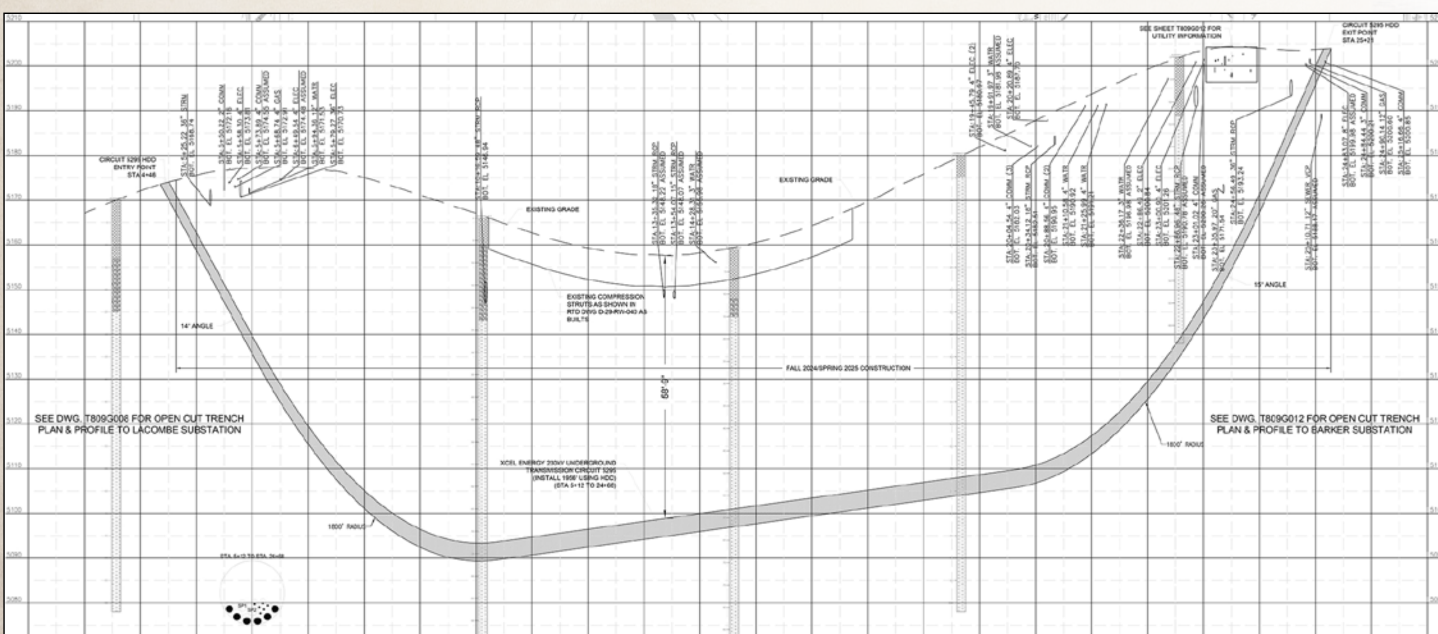
below the ground surface. The alluvial soils consisted of poorly graded sand with gravel with blow counts ranging from 16 to 34.

Further below the urban fill and the native soils was bedrock consisting of Denver Formation Claystone. The claystone ranged in blow count from 50/12 inches to 50/1 inches. Some sandstone stringers were found within the claystone at depths greater than 91 feet.

Trenchless Design

During the first phase of design, it became apparent that trenchless technologies were going to play a large role in this project. The underground transmission lines needed to be installed beneath 20th Street, a major thoroughfare into and out of the downtown area. The street has a below grade area with large retaining walls that support the RTD and Amtrak bridge to Union station. The retaining walls are supported by concrete 3 feet wide and 4 feet tall compression struts spanning 20th street just below grade, and are located approximately every 15 feet for 650 feet.

To keep 20th Street open to traffic during construction, a short trenchless crossing design was not possible to span the compression strut section below 20th street. The team worked with CCD to determine where entry and



Fill material was encountered down to 14 feet, with alluvial soils below then bedrock at 30 – 40 feet depth

> HDD was the most feasible method for installing the underground transmission lines.

exit locations would be for a trenchless crossing with minimal traffic impacts.

The teams identified two areas for the ends of the trenchless crossing, which consisted of a section of 20th street between Blake Street and Market Street, and the area of 20th street just west of the intersection with Chestnut place. This created two parallel trenchless crossings that needed to be approximately 2,100 feet in length and a diameter of 48 inches with 50 feet elevation difference between the highest point and lowest point along the alignment.

Brierley Associates worked with Power Engineers to determine feasible trenchless options for a crossing of this length and magnitude, while meeting the ampacity requirements for the cable. The duct bundle required the installation of eight (8) 8-inch ducts and six (6) 4-inch ducts for each installation creating a bundle diameter of approximately 32 inches.

First, a microtunneling concept was created. This concept would either require the crossing to be constructed as a single crossing or be split up. If it was constructed as a single crossing, a larger diameter machine would have been required to reach the lengths needed, and it would also require deep shafts that would range from 55 feet to 80 feet in depth. If the crossing was split into two drives to alleviate the grade changes along the alignment, a 1,440 foot crossing and a 500-foot crossing would be required. Again, due to the crossing length, a larger machine would have been required, and shafts would have varied from 55 feet to 65 feet in depth. Ultimately, the microtunneling option was determined to be impractical for this project due to the lengths, diameter, and depths required for this installation within a downtown street.

Brierley determined that a HDD was the most feasible method for installing the underground transmission lines. This concept would require the final ream pass for the installation to be approximately 48 inches in order to fit the 32-inch duct bundle. Determining the geometry of the HDD and balancing the stresses on the duct bundle and the HDD tooling was critical to this installation. Brierley worked with Michels to understand the installation needs, and with Power to determine the maximum depth the HDD could reach due to ampacity concerns within the electrical cables, and worked backwards from there. The radiuses for the crossings would need to be on the order of 1,800 feet minimum in order to minimize the stresses on the HDPE pipe, drill steel, and the tooling during installation.

The radiuses and bottom tangent inclination were all designed to reduce the total depth of the underground transmission lines while the entry and exit angles were increased, gaining depth as quickly as possible at both sites to reduce the length of the conductor casing required due to the urban fill that would be encountered.

The geotechnical borings encountered fill material at all borings to a maximum depth of 14 feet with alluvial soils below the fill layer. The bedrock formation in this area is the Denver Formation and is encountered at a depth of about 30 to 40 feet below ground surface. Temporary steel conductor casings were installed from grade through the fill and alluvium layers into the bedrock layer at the HDD entry points. The conductor casing was utilized to provide borehole stability within the soft soils, which also added risk mitigation against the potential inadvertent release of drilling fluid to the ground surface and the potential for settling issues under the intersections near the entry and exits. Since a pilot hole intersect is planned, casings will be installed on the exit side as well for each of the HDDs to protect the existing utilities in Blake Street.

HDD Construction

Construction for the Lacombe to Barker project has been stretched into multiple baseball off seasons due to the project's proximity to Coors Field. The installation of the HDDs occurred after the Rockies 2024 regular season ended and continued through March 2025 before the start of the 2025 regular season.

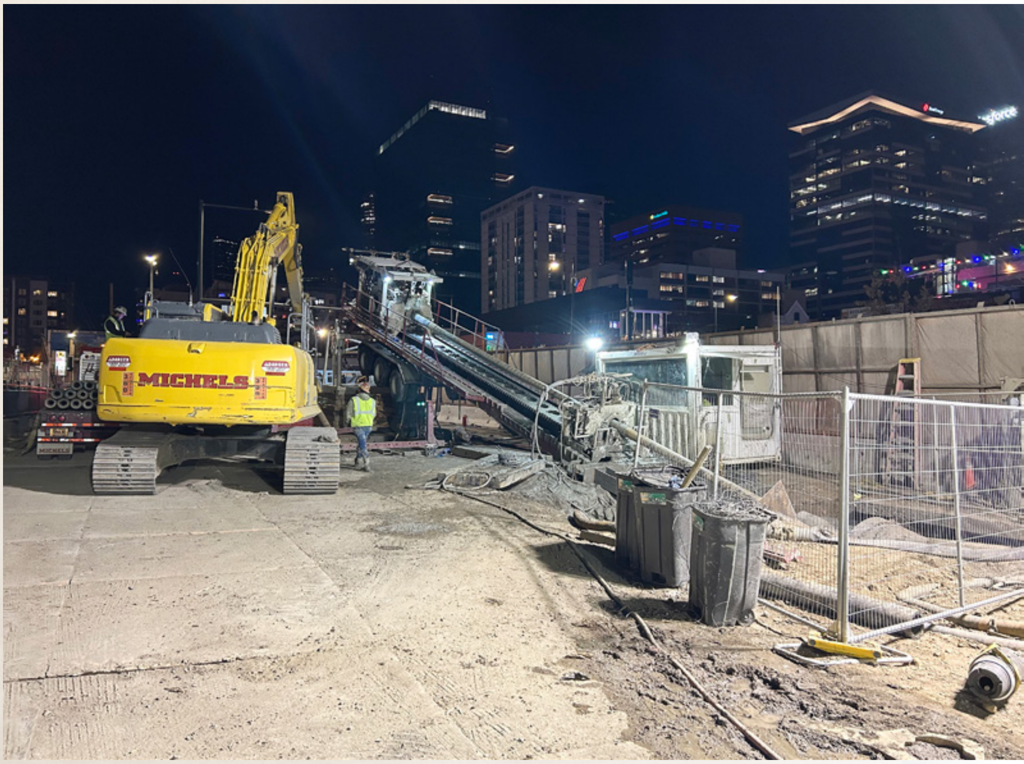
For the start of the HDD construction, Michels worked to install the conductor casing through the overburden and down to bedrock for both circuits at both sides of the crossings. The conductor casings consisted of 54-inch diameter, 1.00-inch wall steel pipe and was installed with a 24-inch TT Technologies Taurus pneumatic hammer. At the Lacombe and Barker ends, the conductor casings were installed to a length of 155 feet and 50 feet respectively.

Once the Conductor casings were installed, Michels could begin the setup for the Pilot bore operations. On the Lacombe side, all equipment had to sit within the two west bound lanes of 20th street and a sidewalk. The Lacombe side was an extremely tight work area which required almost all pieces of equipment necessary for an HDD to be touching. The Barker side is where a majority of the HDD operations occurred, using not only the west bound lanes of 20th street but also a parking lot located next to the entry location. Michels began the pilot bore operations from both the Lacome and Barker sites using their custom built Atlas 840 drill rig, with a minimum pullback of 840-thousand pounds and 180-thousand foot-pounds of torque. Michels engaged Brownline USA for steering assistance so Michels could perform an intersect drill within the claystone formation. Brownline monitored pressures during the pilot hole to prevent drill fluid migration to 20th street above and mapped the installation of the pilot bores.

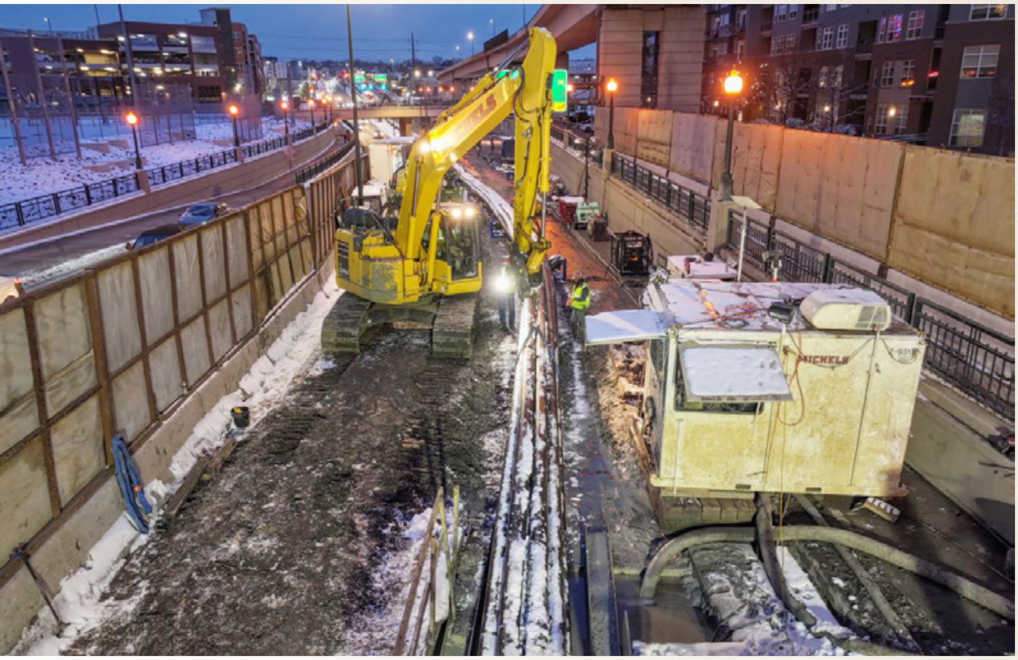
During the drilling and reaming process, Michels fused 50-foot sections of the (8) 8-inch DR9 HDPE and (6) 4-inch DR9 HDPE duct bundle along 20th street west of the Lacombe site up onto the overpass of Interstate 25. The length for the pipe layout was not long enough for the entire bundle, which required a 300-foot section to be mid-fused during pullback operations. Internal de-beading of the ducts occurred during the fusing process.

> "Radiuses for the crossings would need to be on the order of 1,800 feet minimum in order to minimize the stresses.

Extremely tight work area on the Lacombe side



More room on the Barker side where a majority of HDD operations were launched



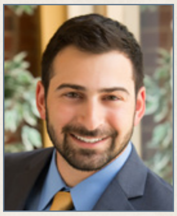
Duct bundle pullback completed during late spring snowstorms

Pullback completed in only two shifts

The duct bundle pullback for each installation was completed over the course of 2 shifts using only 120,000 pounds and 135,000 pounds of pull force for Circuit 5295 and Circuit 5297, respectively. Pullback occurred with Michels 840-thousand pound rig positioned on the Barker side of the crossing.

Battling multiple early season snow storms, the installation of each HDD crossings were successfully completed before the start of the Rockies 2025 regular season. Work will continue on the Lacombe to Barker project through 2027 to complete construction on the substations and install electrical distribution lines.

ABOUT THE AUTHORS:



Kyle Friedman *is an Associate Project Engineer for Brierley Associates out of the Denver, Colorado office. He has worked on trenchless installations around the country within a variety of ground conditions and installation methods and has witnessed over 15,000 linear feet of trenchless installations. Committed to furthering the use and teachings of trenchless technologies, Kyle has been an active member of the NASTT Rocky Mountain Chapter since 2019.*

Adam Smith, PE *is the Department Manager in the Idaho Underground Lines group for POWER Engineers. He has extensive experience with both solid-dielectric and pipe-type cable systems. He has a B.S. in Electrical Engineering from the University of Wyoming and has been with POWER engineers for ten years.*

Jim Williams *is a Senior Consultant with Brierley Associates working out of their Tampa, Florida office. He has 30 years of trenchless experience primarily in horizontal directional drilling projects. Jim received his bachelor's degree in engineering from the University of Florida and is a licensed engineer in 10 states.*

Mehana Hoʻopiʻi, PE, PMP *is a Principal Engineer in the Substation, Transmission Engineering & Design (STED) Department at Xcel Energy. She has 15 years of utility experience in transmission and distribution, having worked at both Hawaiian Electric and Xcel Energy. Mehana holds a B.S. in Biomedical and Electrical Engineering from Santa Clara University.*