Guided Auger Boring Project Under UPRR Tracks in Sacramento CA

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INTRODUCTION

The City of Sacramento initiated a city-wide water meter installation program in 2005 to comply with California State Law Assembly Bill 2572 which requires urban water suppliers to install water meters on all unmetered municipal water service connections on or before January 1, 2025. In response to drought conditions, the City Council approved a resolution in 2015 to accelerate the water meter installation program. Approval of the resolution to accelerate the installation of water meters enhanced the City's ongoing water conservation measures and better enabled the City to promote conservation through consumption-based billing. Carollo Engineers, Inc. was selected to provide program management and engineering services for the new Accelerated Water Meter Program (AWMP). The AWMP is designed to enable the City to complete water meter installation by June 2021, three and a half years ahead of the State of California's deadline.

The AWMP is comprised of thirty projects throughout the City to meter approximately 40,000 residential, commercial, and irrigation water services. Given the large-scale construction effort, the City elected to leverage design and construction efficiencies by replacing aged and deteriorated water distribution mains concurrent with meter installations, thereby minimizing public disruption and reducing long-term rehabilitation and replacement costs. Of the more than 1,500 miles of water mains in the City, approximately 60 miles of 6 to 12-inch water mains were designated for replacement.

The River Park neighborhood was developed in the 1950s and is bounded by the American River to the north and Union Pacific Railroad tracks to the south with limited ingress and egress. The AWMP water main assessment indicated that nearly 90 percent of the neighborhood's 12 miles of water mains were in need of replacement, including a primary supply main crossing beneath the UPRR tracks.

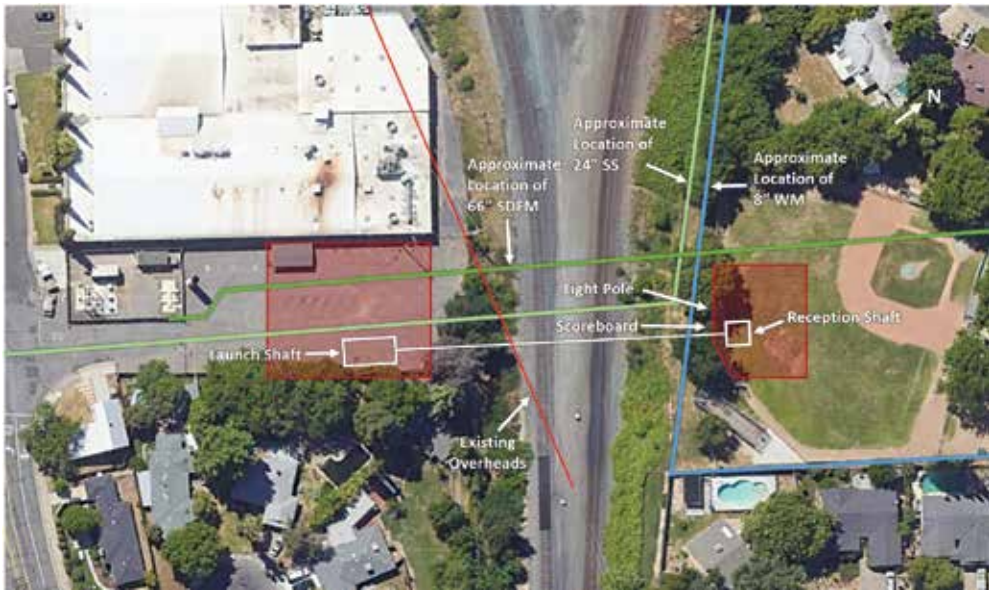

Figure 1. Aerial view of guided boring crossing of the two sets UPRR tracks showing key project constraints. Work areas are shown shaded in red.

To maintain adequate water supply and system pressure, a new trenchless crossing of the UPRR tracks was required as there were no available corridors for open-cut main installation. Carollo partnered with Bennett Trenchless Engineers to assist with trenchless construction evaluation and design of the UPRR crossing.

PROJECT REQUIREMENTS

To meet the requirements of both the City and UPRR, a casing was required for the 12-inch cement-mortar lined and coated steel (AWWA C200) carrier pipe. The 0.75-inch thick wall, 20-inch diameter steel casing required passive magnesium anode cathodic protection for long-term corrosion control. UPRR required that launch and reception shafts be located a minimum 50 feet from their right-of-way and ground settlement be monitored to verify that track settlement was limited to less than 0.25 inches.

The only feasible launching and receiving locations for trenchless installation of the new pipeline were an industrial laundry parking lot on the south side of the UPRR tracks (launching shaft) and a community baseball field on the north side (receiving shaft). A City storm drain pump station with a 66-inch diameter force main represented an additional alignment constraint in the industrial parking lot. Due to limited space and the presence of several existing

utilities between the UPRR right-of-way and outfield fence, the smaller receiving shaft was located in the ballpark's centerfield. Work areas were identified on both sides of the crossing to limit impacts to operations of the industrial laundry and to minimize necessary restoration in the baseball field. The launching and receiving shafts and their work areas for the 250-foot trenchless crossing are shown in Figure 1 with key project constraints.

Due to the high public visibility of AWMP construction, careful coordination with groups that would be potentially impacted by the trenchless work was required. The primary schedule driver was the local baseball league, which required use of the field by September 1, 2020. To ensure that construction would not impact operations at the baseball field, the contract documents included a requirement that all trenchless construction, including restoration of the outfield grass, be completed by August 31. Because of the strict schedule requirements, close coordination with UPRR was required to avoid delays to the contractor's construction sequencing.

TRENCHLESS DESIGN

Two geotechnical borings were drilled on either side of the UPRR embankment to evaluate the anticipated ground conditions for the trenchless crossing. Both borings encountered mixtures of sand, silt, and clay with generally medium stiff and medium dense consistencies. Groundwater was encountered approximately 20 feet below the ground surface, approximately 10 feet below the pipe invert, indicating that watertight construction methods were not necessary.

Several trenchless construction alternatives were identified as potential candidates for completing the trenchless crossing including auger boring, guided boring, pipe ramming, and microtunneling. All four alternatives were deemed technically feasible for the anticipated geotechnical conditions and approximately 250-foot crossing length. Two of these methods, however, were considered less desirable for this project due to logistical constraints. Pipe

Figure 2. Launch shaft constructed using soldier piles with steel plate lagging due to low groundwater and stable ground conditions.

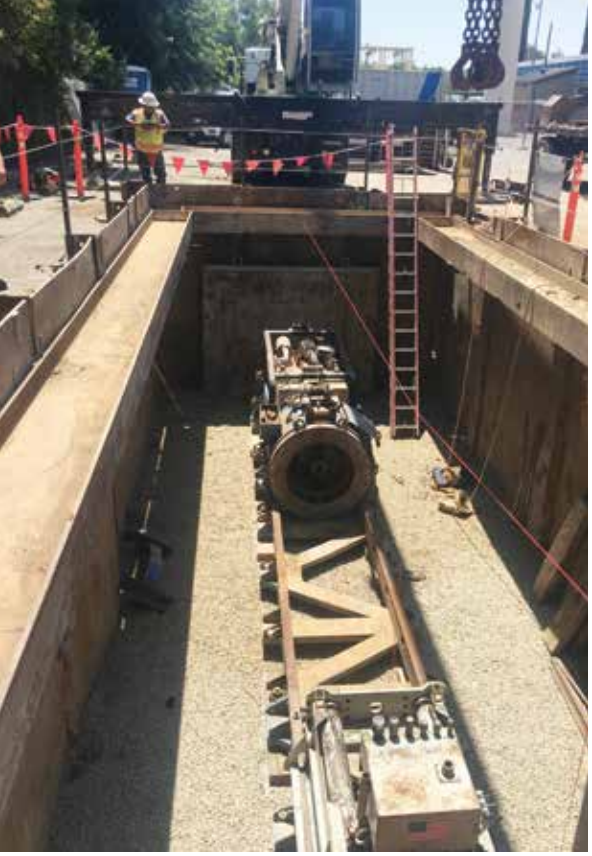

Figure 3. Auger boring rig set in the launch shaft with pilot tube guided boring equipment in foreground. Installation of 250 feet of guided pilot tubes took two hours.

Figure 4. Reception shaft located in community baseball park's centerfield. Careful coordination with local baseball league was required and construction schedule was restricted to minimize construction impacts on community.

ramming, although generally well-suited to crossing railroad embankments, was eliminated from consideration for this project due to noise concerns for the nearby residential neighborhoods and its lack of steering capabilities. Microtunneling was eliminated from further consideration due to its relatively high cost and relatively long construction schedule compared to the other feasible methods.

Although auger boring and guided boring were both viable and cost-effective trenchless installation alternatives, guided boring was selected as the preferred construction method. This decision was made due to the limited steering capability of auger boring and relatively minimal cost impact of adding the pilot tube guidance step to the process. Limited steering was not a concern from the perspective of the pressurized water line installation, where line and grade were not as critical as they would have been for a gravity pipe. However, steering limitations were a concern due to the risk of striking or damaging the site features on the northern side of the crossing which included trees, existing utilities, and baseball field infrastructure (scoreboard, lights, etc.). The design team felt that the additional cost of specifying the pilot tube guidance step was offset by reducing the risk of schedule impacts and/or claims due to damaging or striking an existing site feature.

Figure 5. Pilot tubes entering reception shaft and being removed as 20-inch casing is advanced. Pilot tubes entered reception shaft precisely on line and grade.

Figure 6. Auger boring installation of 20-inch casing beneath two sets of UPRR tracks.

CONSTRUCTION

The general contractor for the trenchless crossing was Navajo Pipelines (Sacramento, CA) with Pacific Boring (Caruthers, CA) as the trenchless subcontractor and Blue Iron Foundation and Shoring (West Sacramento, CA) as the shaft subcontractor. Blue Iron mobilized for shaft construction on July 8, 2020. Both the launch and reception shafts were constructed with soldier piles and steel plate lagging due to the low groundwater and stable ground conditions. The 10-foot deep launch shaft, including placement of the crushed rock shaft floor, was completed on July 13 (4 days) and the 11-foot deep reception shaft was completed on July 16, 2020 (3 days).

Pacific Boring mobilized to the launch shaft on July 20, 2020 and launched guided boring operations the following day. A UPRR representative was on site throughout guided boring operations to ensure that the approved work plan was followed. Pacific Boring began installation of the pilot tubes at 10:30 in the morning and by 12:30 had successfully installed the tubes to the back of the shoring in the reception shaft. The pilot tubes were pushed into the reception shaft and survey confirmed that they had been precisely installed on design line and grade. With plenty of work hours remaining in the day, Pacific Boring then proceeded to remove the pilot tube equipment from the pit and completed installation of the first section of 20-inch casing. Installation of the remaining 240 feet of 20-inch casing took place over the following two days. Installation of the 12-inch cement-mortar lined and coated product pipe inside the steel casing was completed in three days, completing the trenchless components of the project.

Site restoration included removing

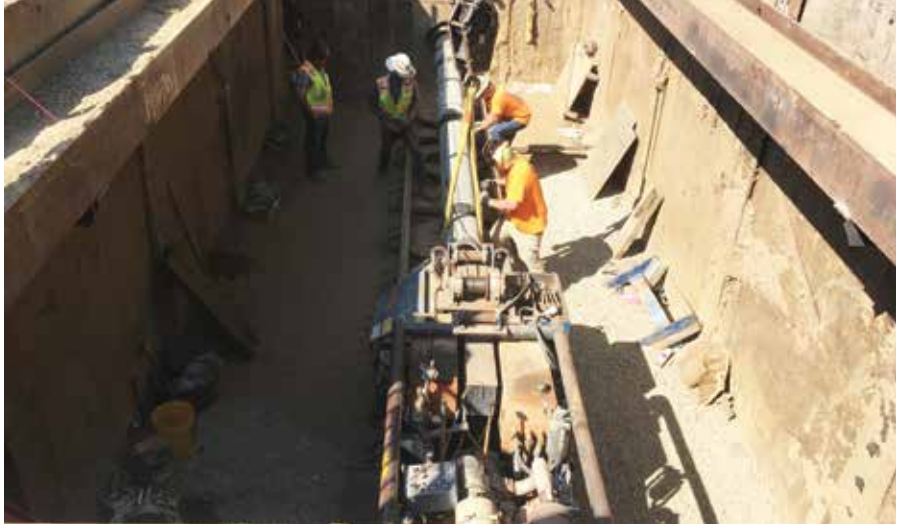

Figure 7. Installation of 12-inch cement-mortar lined and coated steel carrier pipe inside the 20-inch casing installed with guided boring took three days.

all shoring elements, backfilling and compacting the excavation, repaving the parking lot (including a section of pavement outside of the shaft footprint where construction equipment had caused damage), and reseeding the baseball field. Due to COVID-19 halting baseball operations, the completion deadline of September 1 was no longer a schedule constraint. Given the extra time available, the City is currently considering additional improvements to the ball field.

SETTLEMENT MONITORING AND RESULTS

As mentioned previously, one of the UPRR permit requirements for the trenchless crossing of their facilities was to limit track settlement to less than 0.25 inches. During design, a settlement evaluation was performed to identify the risk of exceeding this limit based on anticipated ground behavior for the selected trenchless construction method. An important component of the magnitude of settlement anticipated due to the collapse of the annular space between the pipe and the excavated bore (commonly known as systematic settlement) is the clearance between the bore and the feature of interest. For this project, the two sets of UPRR tracks were located on an embankment approximately 18 feet above the surrounding ground. The increased clearance provided by the embankment allowed the designer to avoid deep shafts while still maintaining low risk of settlement damage to the tracks.

During construction, settlement values were monitored using six sets of surface settlement monitoring points. Each set consisted of three points: one over the centerline of the bore and one offset 10 feet on each side of the centerline. Three sets of points were located inside the UPRR right of way, but none of them were at track level due to limited work area at the top of the embankment and safety concerns related to installation and reading of the survey points. All monitoring points were located at the elevation

of the surrounding grade (which was approximate the elevation of the toe of the UPRR embankment). Settlement points were monitored during shaft construction, daily during guided boring operations, and at intervals following completion of the crossing to check for possible ongoing ground movements.

Three of the 18 total settlement monitoring points exhibited ground motion values greater than 0.25 inches (just over 0.02 feet) during construction. It is notable, however, that no point was surveyed to have moved more than 0.03 feet (0.36 inches) at any time. On the surface, this might have been alarming but there were several factors that indicated to the design team that there was no cause for alarm. One of the three points showed 0.03 inches of ground movement the first time it was surveyed after the initial reading, well before guided boring operations began. Additionally, since the tracks had an additional 18 feet of cover, it was determined that even if settlements at the elevation of the surrounding ground surface were a hundredth of a foot greater than 0.25 inches, track settlements would be significantly less and therefore permit conditions were still met. Ultimately, the settlement monitoring points within the UPRR ROW did not indicate track settlement greater than 0.25 inches caused by guided boring operations and the points did not show any additional or continuing ground movement after trenchless operations were complete.

ACKNOWLEDGEMENTS

To date, approximately 94 percent of AWMP meters and 88 percent of water main replacements have been installed with final completion anticipated by mid-2021. The authors would like to thank Michelle Carrey (City of Sacramento DOU, Supervising Engineer), Marc Lee (City of Sacramento DOU, Senior Engineer), and Chris Powell (City of Sacramento DOU, Construction Coordinator) for their support and contributions to this article.

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