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Pushing Horizontal Auger Boring to the Limit

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1. ABSTRACT

Today, more electric utility companies are moving their overhead transmission lines underground. These installations often span long distances and require crossing under geographic features such as roads and freeways. In 2011, Arvid Veidmark III, trenchless technology expert and owner of Specialized Services Company, was contacted to consult on the constructability of an underground electrical transmission main for Tucson Electric Power. The plans called for a trenchless installation of 720 lf (219.5 m) of 24" (61 cm) casing underneath I-19 and ADOT Right of Way in Southern Arizona.

Several trenchless methodologies were presented for consideration including the use of HDD, SBU, BMTA or TBM but all were ruled out due to utility and land owner specifications. As options were evaluated and eliminated, the final conclusion was to construct the project with a 42" (106.7 cm) horizontal auger bore.

Once construction began in November 2012, several challenges were presented to SSC's crew including shortened schedule, limited work hours due to neighboring residential areas, unexpected soil conditions and equipment breakdowns due to the extended length of bore. After 117 working days, the crossing, installation of the conduit bundles and water-cooling system to perform the grouting operation were successfully completed.

"Pushing Horizontal Auger Boring to the Limit" examines the hands on experiences and learning opportunities that came from accomplishing this challenging project. Ideas and discussions will be presented that will benefit project engineers, designers, utility owners and contractors as they consider options for future trenchless installations to improve success on these projects for all stakeholders.

2. INTRODUCTION

The area south of Tucson, Arizona is a rapidly growing area and is home to the residential communities of Sahuarita and Green Valley and the Freeport McMoran Sahuarita Mine. In 1995, the Arizona Corporation Commission approved Tucson Electric Power to construct a new 138kV transmission alignment to provide redundancy and reliability to the TEP's system. The final phase of the project, which began in 1996, was the Green Valley Transmission Upgrade, Canoa Ranch to Cyprus Sierrita. This portion of the project spanned approximately 8 miles and included the requirement to bore under Interstate 19.

The bore would be 720' (219.5 m) long and would connect the newly constructed Canoa Ranch 138 kV substation and provide access to an existing underground conduit for relocation of distribution lines, as illustrated in Figure 1. TEP's original plans for the bore called out for the installation of 24" (61 cm) casing to carry 4 – 6" (15.2 cm) conduits.

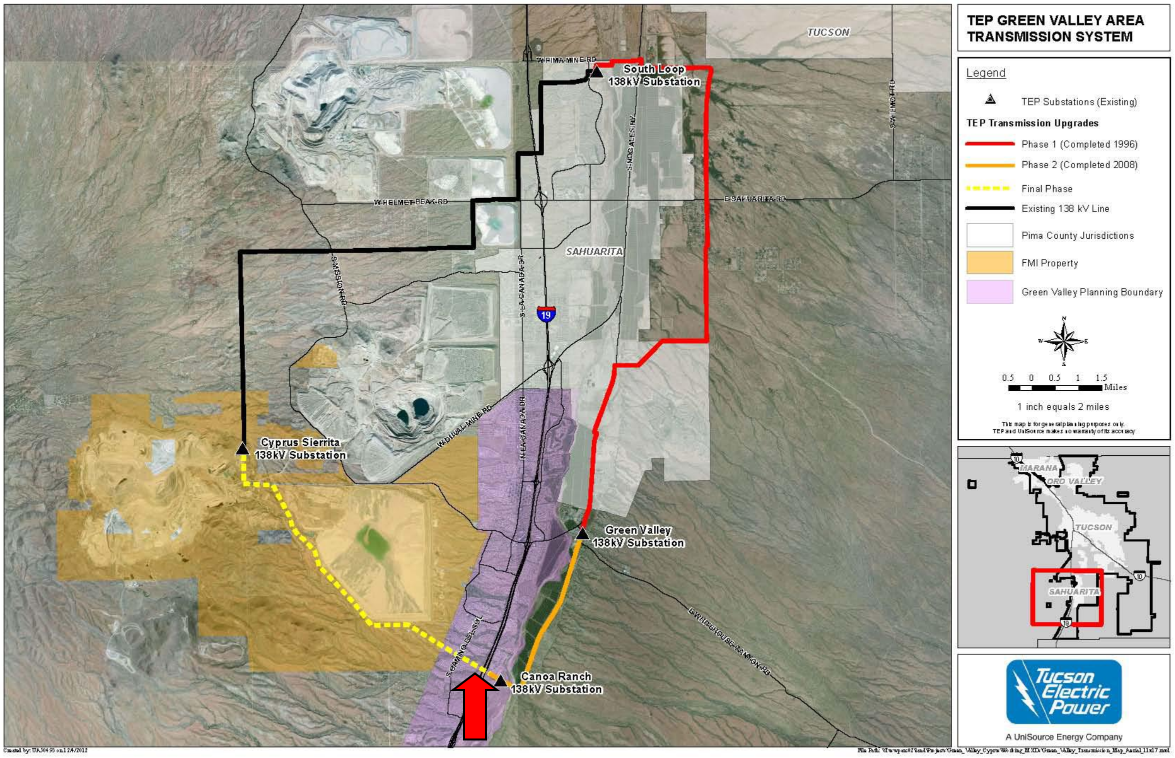

Figure 1: TEP project overview map (bore crossing indicated by red arrow).

2. DESIGN CONSIDERATIONS

In 2011 the Green Valley Transmission Upgrade project had reached the point of planning for the I19 crossing. TEP's initial plan for 24" (61 cm) installation faced logistical challenges for successful bore of this length (720'/219.5 m) and options, presented below in Table 1, were studied to determine the most feasible method.

Table 1: Method options considered for bore crossing.

Methods Considered	**Advantages**	**Disadvantages**
Directional Drilling	• Line and grade control • Able to use minimum casing size (24"/61 cm)	• Large setback required for setup and pull back
Tunnel Head • Motorized SBU (Small Boring Unit) • TBM (Tunnel Boring Machine) • BMTA (Boring Machine Tunnel Attachment)	• Mechanical ability to install this length of casing • Line and grade control	• Would require upsize of casing to 60" (152.4 cm) • Problems with head during crossing require digging up the head to remove
Hand Tunnel	• No concern of mechanical limitations • Line and grade control	• Require upsizing of casing to minimum 42" (106.7 cm) to allow room to work • Time
Auger Boring	• Speed	• Mechanical concerns • Require upsizing of casing to 42" (106.7 cm) in case of need to hand tunnel

With multiple options presented to the owner, the most critical factors of consideration had to be identified in order to decide on the best method. Ultimately it was the requirement to not infringe on Arizona Department of Transportation right of way that eliminated both directional drilling, which would have required setup in the ROW, and any use of a tunnel head (SBU, TBM or BMTA) which contain the risk of needing to dig up the head in case of failure, which could happen at any point under the freeway or in the right of way.

The second factor considered was time - the Canoa Ranch Substation was already completed, and this was the final component of a project that had been underway for 15 years. Because of the need to complete the crossing as quickly as possible, hand tunneling was eliminated as a choice.

This left auger boring as the most practical option, however this required upsizing to a 42" (106.7 cm) casing size in case of the need to transition to a hand tunnel operation at any point. Tucson Electric Power agreed to this design change and modified their plans to install 14 – 6" (15.2 cm) Schedule 80 PVC conduits for future use or sale/lease to another utility.

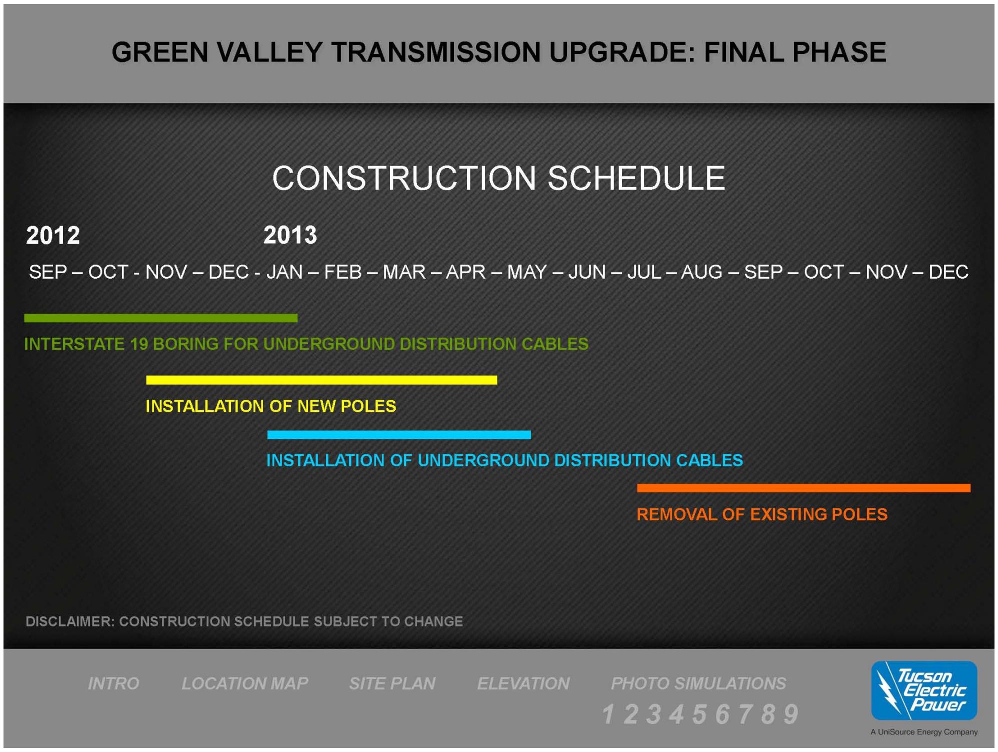

Figure 2: TEP original schedule showing bore starting in September 2012.

3. CONSTRUCTION

As shown in Figure 2, construction was scheduled to begin in September 2012 however a delay in the issuance of permits for the crossing by ADOT pushed back the start date to November. Mobilization began in late November followed by site preparations and digging and shoring of the 20' (6 m) deep bore pit. Auger began turning on December 14, 2012 marking the start of the 720' (219.5 m) bore. Boring continued successfully with little unexpected issues for the first 230' (70.1 m) of installation which was completed in 3 weeks of work.

Figure 3: Bore Pit for Auger Bore Installation of 42” (106.7 cm) Steel Casing, with blower hooked up to help with cooling the machine.

Equipment Challenges and Solutions

As had been anticipated when evaluating method options, equipment capacity was challenged with a crossing of this size and length. Issues were encountered with the bit, auger and bore machine during the course of the project. Figure 3 provides an overview of the bore pit set up and equipment utilized to perform the work.

The project was started using a 42” (106.7 cm) Drift-ring bit. Early on, due to soil conditions, this bit was changed out for a 42” (106.7 cm) Christmas-tree bit. This was used successfully for the first 230’ (70.1 m) of bore at which point the bit broke, creating a challenge to remove as the auger had come unhooked from the bit at the front of the bore. The auger had to be pulled out and then the bit cut apart to enable the crew to pull it out through the casing. It was replaced with a new 42” (106.7 cm) Christmas-tree bit.

The second challenge was the strain on the bore machine. At a weight of 6,792 lb (3,081 kg) per 20’ (6.1m) joint of casing and auger, by 300’ (91.4 m) the Barbco 60/66 auger bore machine was turning 35,000 lbs (15,876 kg) of auger and pushing 66,480 lbs (30,155 kg) of casing. At this 300’ point the need for lubricating the OD of the casing to reduce friction between the earth and the casing, as well as the ID to reduce friction between the auger and the casing became necessary. Slick lines had been installed from the beginning as this need was anticipated, and polymer began being pumped to ease the strain due to friction.

Now at the 517’ (157.6 m) mark for casing installed, the shear force exerted on the auger when that quantity is being turned resulted in the shaft snapping. This was the first occurrence of this problem which occurred again on February 19 at 530’ (161.5 m) and February 26 at 580’ (176.8 m). Each time the auger broke it created at least a two day delay for all of the auger to be removed, the broken piece to be removed – in some cases requiring it to be cut off inside the casing and in one case the flighting had to be cut inside the casing to allow the crew to reach the point of the break and free the broken auger. To expedite the process after the 580’ (176.8 m) break, a hydraulic tugger (shown in Figure 4) was brought in to use to pull out the auger instead of the bore machine.

Figure 4: Hydraulic tugger being used to pull broken auger out of casing.

Boring began again utilizing only 5” (12.7 cm) hex auger (previous breaks occurred on 4” (10.2 cm) hex sections) and after repairs to welds inside the casing that were damaged due to the force of the auger banging against the casing during the boring operations, and especially when it would break. By March 19, 640’ (195 m) of casing had been installed utilizing auger boring at which point the auger broke for the final time. It was apparent at this point that auger boring any further was not a feasible option due to both auger failure and bore machine already being forced to its maximum potential.

Transition to Open Cut

Meetings began with the project owner and with ADOT to discuss the plan for moving forward. TEP’s project had continued and promises to area residents of completion of the entire project by May had been made. These tight time requirements for the bore to be completed and carrier lines installed led to the recommendation that hand tunneling not be considered. The best option at this point was to open cut the final 80’ (24.5 m) of the crossing, as the bore had crossed the freeway fully and the only traffic restrictions now would be on the frontage road. After two weeks of meetings, ADOT granted permission for this open cut installation to take place in their Right of Way.

Figure 5: Reception side of crossing, showing 80’ (24.5 m) of open cut.

The 80’ (24.5 m) of open cut trench was dug on April 3 along with the reception pit. Figure 5 shows this completed section of open cut. While this was happening on the reception end of the bore, the auger was pulled from the casing on the bore side. On April 4 and 5 the remaining 80’ (24.5 m) of casing was welded to the bored casing and pushed from the bore side into the open trench until the full length had been installed and reached the reception pit. At this point the open cut trench was backfilled with slurry per ADOT specification, resulting in only 3 days of traffic restriction within the ADOT right of way.

Carrier Line Installation & Grouting

For the next two weeks, guide rails were welded inside the casing, and the PVC bundles of 14 – 6” (15.2 cm) Schedule 80 conduits were built and pushed – these are illustrated in Figures 6 and 7. Once all the conduit bundles were installed and bulkheads were built, the final step was to grout the annular space inside the casing.

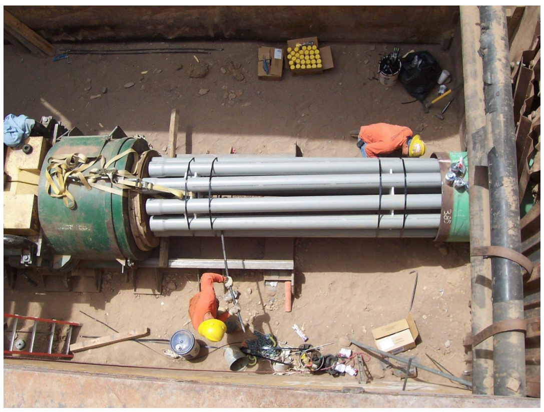

Figure 6: Conduit bundles being pushed into 42” (106.7 cm) casing

Figure 7: Conduit bundles of 14 – 6” (15.2 cm) Sch 80 PVC

Challenge: Grouting

A total of 145 yards of grout would need to be pumped to fill the annular space inside of the 720’ (219.5 m) of casing. As with any concrete product, as grout cures, heat is emitted. This heating effect is compounded in a grouting operation, where the curing is occurring in a confined space, giving the heat nowhere to escape. This combined with the large amount of grout being pumped inside of this casing led to great concern of how high the temperature could rise. Too much heating could lead to damage to the conduits, and once grouted, there is no way to replace or repair them.

Solution: Cooling System

The PVC conduits were utilized as part of the solution. As shown in Figures 8 and 9, a plumbing system consisting of couplers and connections to connect the individual PVC conduits and create a continuous pipeline through which cool water could be pumped to help dissipate the heat was constructed. Water was hauled in by water truck and pumped through the conduits and a 2000 gallon (7570.8 liter) water truck tank and then drained into a tub, shown in Figure 10, and subsequently pumped from the pit. This cooling operation continued for 24 hours after grouting was completed, and even the next day the water temperature was being raised over 30 degrees to 107 degrees Fahrenheit (41.7 degrees Celsius) by the heat generated from the grout.

Figure 8: Plumbing on bore side

Figure 9: Plumbing on reception side
3 grout lines open in center

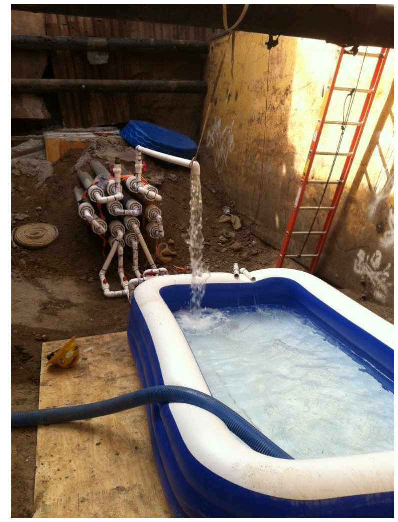

Figure 10: Heated water drained into
tub to be pumped out

4. CONCLUSION

As experienced auger boring contractors, Specialized Services Company was aware of the potential challenges that could be encountered in attempting a 720’ (219.5 m) long auger bore crossing. As the bore progressed most of these were encountered and subsequently overcome until the 640’ (195 m) mark. At that point the best option was to open cut the remaining 80’ (24.5 m), and although prior to the job it seemed that any work in the ADOT right of way would not be allowed, what was learned is that when all options are exhausted, the transportation administration will cooperate and allow for necessary work to be completed.

Ultimately, the ability to bore 90% of the crossing and traverse the freeway traffic lanes was a tremendous success. Open cutting the final 10% of the distance allowed the project to complete within the time constraints, as well as on line and grade. The ingenuity of crews to devise a cooling system for the grouting process allowed this final step to be completed successfully with no damage to the conduits. In 117 working days, the team at SSC turned over a finished underground freeway crossing to allow Tucson Electric Power to complete their project that had been 17 years in the making. Once again trenchless technology proved to be the critical link to completing a major utility project.