North American Society for Trenchless Technology (NASTT)
NASTT's 2017 No-Dig Show

Washington, D.C.
April 9-12, 2017

TM1-T5-05

IMPLEMENTATION OF A MULTIFACETED TRENCHLESS TECHNOLOGY PROJECT ALONG THE CALIFORNIA PACIFIC COAST

Keith Corcoran, Carollo Engineers, Sacramento, CA
Anne Prudhel, Carollo Engineers, Walnut Creek, CA
Shaun Deyhim, Santa Cruz County Sanitation District, Santa Cruz, CA

1. ABSTRACT

The Santa Cruz County Sanitation District's (SCCSD) Noble Gulch Trunkline Relocation project was implemented to relocate and upsize 8,540 linear feet of deteriorating 12-inch asbestos cement sewer trunkline. The District needed to relocate the trunkline for several reasons: (1) location in an environmentally sensitive gulch that required a riparian corridor permit for any maintenance activities; (2) access to most of the trunkline was available only by foot, making maintenance impossible; and (3) flow monitoring showed that the trunkline was likely leaking and contaminating downstream water bodies.

To relocate the sewer, the District obtained grant funding from California's Clean Beach Initiative. After evaluating numerous routing alternatives and considering the District's desire to eliminate an existing pump station, the only viable corridor was just outside the existing alignment through a nearby higher elevation mobile home community and underneath the scenic Pacific Coast Highway.

The selected route included many challenges which included narrow construction corridors, deep construction (up to 45 ft deep), challenging geological formations, steep terrain, and close proximity to residential neighborhoods. To address the project challenges and minimize the impact on local residents, micro-tunneling (a 42-inch tunneled casing with a 15-inch carrier pipe), horizontal directional drilling (HDD) (8-inch), and cured-in-place-pipe (CIPP)(12-inch) were selected for select portions of work.

This paper evaluates and describes the implementation of multiple trenchless technologies and how they were used to overcome accessibility, environmental, groundwater, and geological formation constraints along the Pacific Coast.

2. INTRODUCTION

The Santa Cruz County Sanitation District (SCCSD) is comprised of four sewersheds and five service areas which provide sewage collection services to 26,000 connections within the City of Capitola and unincorporated areas of Santa Cruz County. Pipelines range from 6 to 12 inches in diameter make up the Noble Gulch sewershed. The basin collects flow from primarily residential properties along with a limited number of commercial properties. Sewage collected is sent to the City of Santa Cruz (City) wastewater treatment plant through an agreement between agencies that allows a discharge of up to 8 million gallons per day (mgd) of wastewater to the City's treatment plant.

The Noble Gulch Sewer Relocation project was developed after a meeting with the Santa Cruz County Water Quality Program Manager had revealed that that human E.coli was present in Soquel Creek downstream of Noble Gulch. With the sewer trunkline location within the gulch, it was suspected that the 50+ year old asbestos cement pipeline could be leaking. Because Soquel Creek discharges into the Monterey Bay Sanctuary, it was a priority to remove this potential source of contamination from the creek. Additionally, the District was able to obtain grant funding from California's Clean Beach Initiative to help fund the relocation of the sewer.

Due to the environmental sensitivity and location of the project, the following permits and easements were required:

- Riparian Permit from Santa Cruz County
- Encroachment Permit from California Department of Transportation (Caltrans)
- Coastal Development Permit from the City of Capitola
- Lake and Streambed Alteration Permit from California Department of Fish and Game
- General Construction Activity Storm Water Permit from Central Coast Regional Water Quality Control Board
- Encroachment Permits from both City of Capitola and Santa Cruz County
- Eight (8) private property easements
- Encroachment permit from the State Architect for work within mobile home community

The challenge in replacing the trunkline included improving accessibility and designing it to continue to gravity flow to the downstream pump station while protecting the sensitive riparian environment of the gulch and downstream beaches. In addition to the known access constraints and environmental constraints identified during the preliminary design, additional geological constraints were identified which required the design team to put together and evaluate an alternative approach to the traditional dig and replace construction method.

3. GEOLOGICAL CHALLENGES

A geotechnical engineering report was completed, which included site reconnaissance, borings, and desktop research for the area. The geotechnical investigation encountered a wide variety of native and suburban development conditions along the proposed alternative pipeline routes. Based on the collected information, the subsurface soil and bedrock conditions were anticipated to vary significantly along the sewer alignment. None of the subsurface conditions were considered “fatal flaws”; however, the geotechnical conditions encountered presented challenges and limitations that needed to be taken into consideration during design to develop the most feasible and cost effective project including:

- Groundwater (including perched groundwater and seasonal drainage way flow)
- Porous and permeable soils (e.g., native sand and gravel, fill, weathered bedrock, cobbles, and granular utility bedding and trench backfill)
- Bedrock of the Purisima Formation consisting primarily of siltstone and sandstone
- Vertically and laterally variable native soil including cohesive clays and non-cohesive sands (with varying amounts of gravel)
- Vertically and laterally variable native soil density and consistency including loose to very dense sand (with varying amounts of gravel) and soft to very stiff clay
- Vertically and laterally variable native soil behavior in excavations including flowing and running non-cohesive sands that will have no stand-up time when exposed in vertical excavations, fast raveling cohesive fine-grained silts and clays that will have little to no stand-up time when exposed in vertical excavations, and soft squeezing fine-grained silts and clays
- Vertically and laterally variable bedrock character and composition including: degree of weathering, thin to thick bedding and very close to wide fracture spacing, with potentially adversely oriented shallow to steeply dipping bedding and fracture planes
- Historic fills that contain uncompacted materials and possibly deleterious debris
- Existing pipelines and utilities that contain variable trench backfill and bedding materials and variable trench-cut geometries
- Unconsolidated alluvial deposits located in the low lying gulch area
- Semi-consolidated terrace deposits located within the higher ground outside the gulch area
- Unconsolidated older flood plain deposits

Figure 1: Fossiliferous limestone (nature's concrete) encountered in deep excavations

4. DESIGN

The goal of the SCCSD Noble Gulch Trunkline Replacement Project was to relocate the trunkline out of Noble Gulch to improve access for maintenance and eliminate the need for a riparian corridor permit.

The first step was to identify an available corridor for the pipeline outside the gulch that would allow the District to maintain gravity flow. After evaluating a few alternatives, an alignment at a higher elevation was identified and selected. The alignment crossed through two separate private mobile home parks and public land, including the scenic Pacific Coast Highway (Highway 1) and the City of Capitola corporation yard. This alignment presented many challenges:

- Work within environmentally sensitive areas
- Narrow construction corridors
- Deep construction (up to 45 ft deep)
- Challenging geological formations
- Steep terrain
- Coordination with multiple jurisdictions and private property owners
- Close proximity to residences

Once the alignment was identified, the replacement/rehabilitation alternatives had to be determined. Outlined in Table 1 were the methods identified along with the feasibility and challenges associated with each method--this was based on the original limited geotechnical work completed as part of the preliminary design.

Table 1. Preliminary Replacement/Rehabilitation Alternatives.

Construction Method	Feasibility	Geotechnical Challenges/Risks
Open-Cut Trenching	- feasible for all alignments with the exception of the HWY 1 crossing, areas of environmental concern (e.g., along creek and heavily vegetated areas), and potentially within improved easements	- shoring - dewatering (low lying areas adjacent to the creek) - excavation through bedrock - will likely encounter existing, saturated utility trench backfill with little to no stand-up time and copious groundwater inflows in low lying areas adjacent to the creek and within the gulch
Tunneling: Auger bore and jack (AB), Guided Boring Method (GBM) and Microtunneling (MT)	- AB and GBM are feasible for HWY 1 crossing and Corp Yard slope, if groundwater is at or maintained below the tunnel and tunnel soils are stable - MT is feasible under high groundwater conditions and unstable tunnel soil, but may not be feasible for the alternative HWY 1 crossing if obstructions in fill and old trees roots are present	- presence of flowing and/or unstable ground and resulting loss of ground through the open tunnel face will produce voids above the tunnel for AB and GBM - obstructions in fill can stop AB and GBM requiring removal of the obstruction from the tunnel face and slowing production - obstructions in fill and tree roots can stop MT requiring 911 shafts - shafts for tunnel launching and receiving will require deep shoring and dewatering (see challenges/risks for open-cut trenching)
Horizontal Directional Drilling (HDD)	- Potentially feasible for HWY 1 crossing and Corp Yard slope for pipes designed with slopes greater than 2%	- installation accuracy of +2% of depth - risk of drilling fluids hydro-fracturing into adjacent Noble Gulch Creek - risk of encountering obstructions in fill areas will slow production rates
Sliplining and Cured-in-Place Pipe Lining	- feasible for existing alignment where decrease in diameter is not an issue	- generally insensitive to geotechnical conditions - will not correct sags - pits for ingress/egress for sliplining will require shoring and dewatering (see challenges/risks for open-cut trenching)
Pipe Bursting and Pipe Reaming	- most feasible for rehabilitation of pipelines composed of brittle materials (e.g. VCP, DI) when small upsize or same size is required - for asbestos cement (AC) pipe, environmental agencies (e.g., EPA will consider the existing pipe to be a hazardous material and the pipeline alignment (with remnant AC pipe) to be a hazardous site	- amount of feasible upsize is dependent on existing pipe zone backfill and native trench wall deposits - for 12-inch diameter pipe burst to a new 15-inch diameter pipe at depths greater than 12 feet, pipe bursting is considered challenging to moderately difficult - will not correct sags - ground heave can occur depending on pipe depth and/or amount of pipe upsize - pits for ingress/egress will require shoring and dewatering (see challenges/risks for open-cut trenching) - risk of drilling fluids hydrofracture for Pipe Reaming

Because it was determined that the final alignment would be constructed outside of the original alignment, pipe bursting and pipe reaming were ultimately eliminated from further consideration.

Figure 2 identifies the original and final alignment along with the installation methods used.

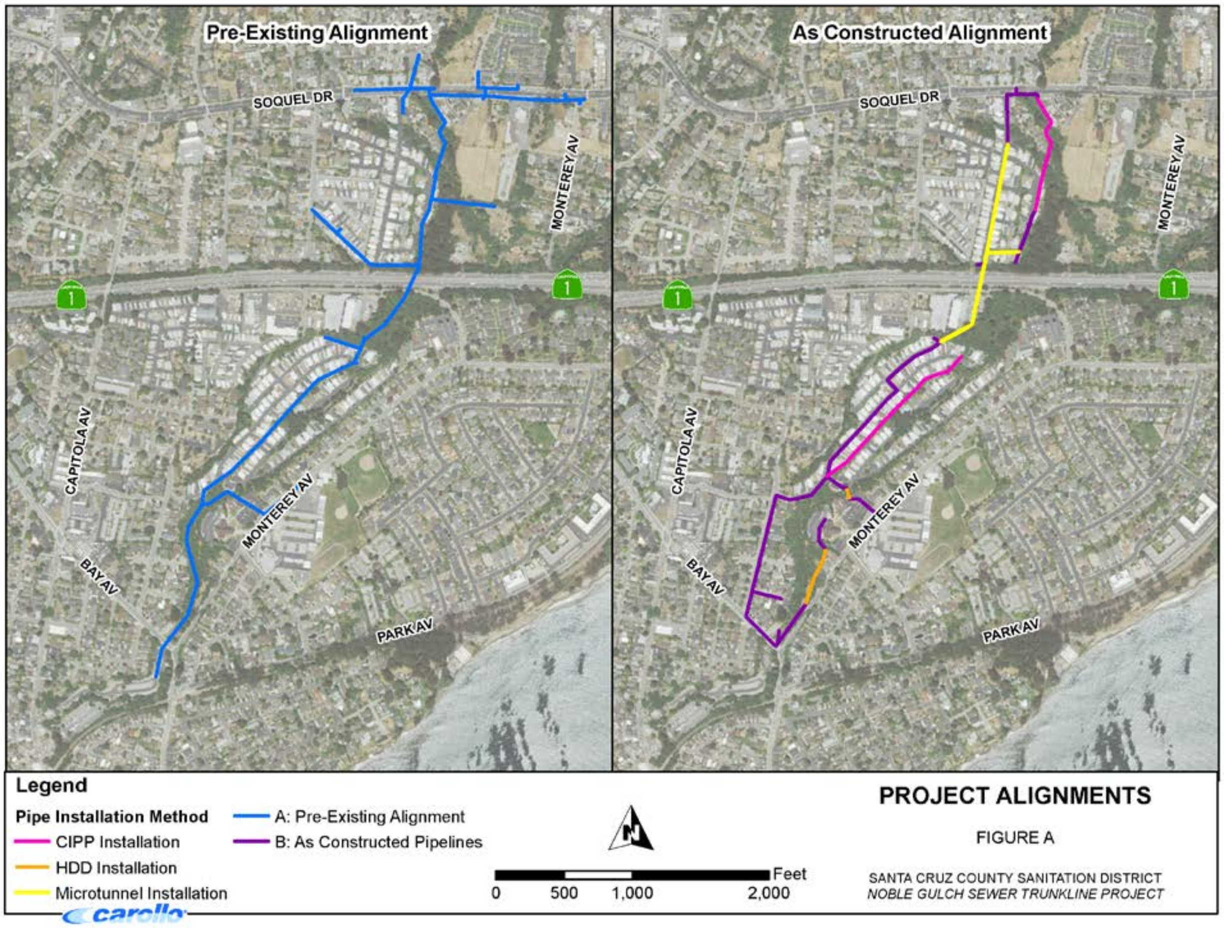

Figure 2. Project Alignments

Figure 3. Existing alignment behind residential homes in environmentally sensitive areas, underneath decks and misc. yard structures

To address the project challenges and minimize the impact on the local community, numerous trenchless technologies were incorporated into the design at key locations. The final design included the following trenchless technologies:

- *Micro-tunneling:* Installation of a 42-inch micro-tunneled casing to install a 15-inch carrier pipe was used to cross Highway 1, avoid deep (up to 45') open cut construction, and minimize impact to environmentally sensitive areas that were not conducive to other trenchless methods. The larger casing was required due to the long runs (up to 1/4-mile), high groundwater, and challenging geology along the alignment. Shoring up to 45-feet deep was required for the launching and receiving pits due to the varying California coastal topography.
- *Horizontal directional drilling (HDD):* HDD was utilized to install a new 8-inch diameter pipe through residents' backyards and through a park adjacent to the environmentally sensitive, Noble Gulch where access with traditional excavation equipment was not possible.
- *Sliplining:* HDPE or fusible PVC was allowed to be installed as the new carrier pipe for sections of the existing trunkline that had to remain in service to pick up a few local residential homes. The existing manholes were to be used as the insertion/receiving pits and were to be replaced with new rings.

5. CONSTRUCTION

The awarded general contractor, McGuire and Hester, started construction in January 2015 and was responsible for the open cut pipeline work as well as the excavation and shoring for their trenchless subcontractors. The open cut portions of the project were fairly straightforward and the original concerns of high groundwater turned out not to be an issue due to ongoing drought conditions in California at time of construction. This eliminated dewatering for the majority of the project except for the deep launching and receiving pits for the microtunneling portions of work.

The most challenging aspects of construction were the portions that were to be installed utilizing trenchless technology. Site access was extremely limited and both HDD and Microtunneling required a significant amount of space for the support equipment. A substantial portion of the civil work included the construction of five (5) microtunneling pits within the limits of the mobile home community and City of Capitola's Corp Yard. The two largest launching pits were 18' wide by 32' long by 45' deep. Excavation of the pits and the set-up for the microtunneling equipment was a slow process due to site constraints. Access was restricted to one way in and one way out in most locations but the contractor was able to meticulously install the necessary shoring and support equipment at each location required.

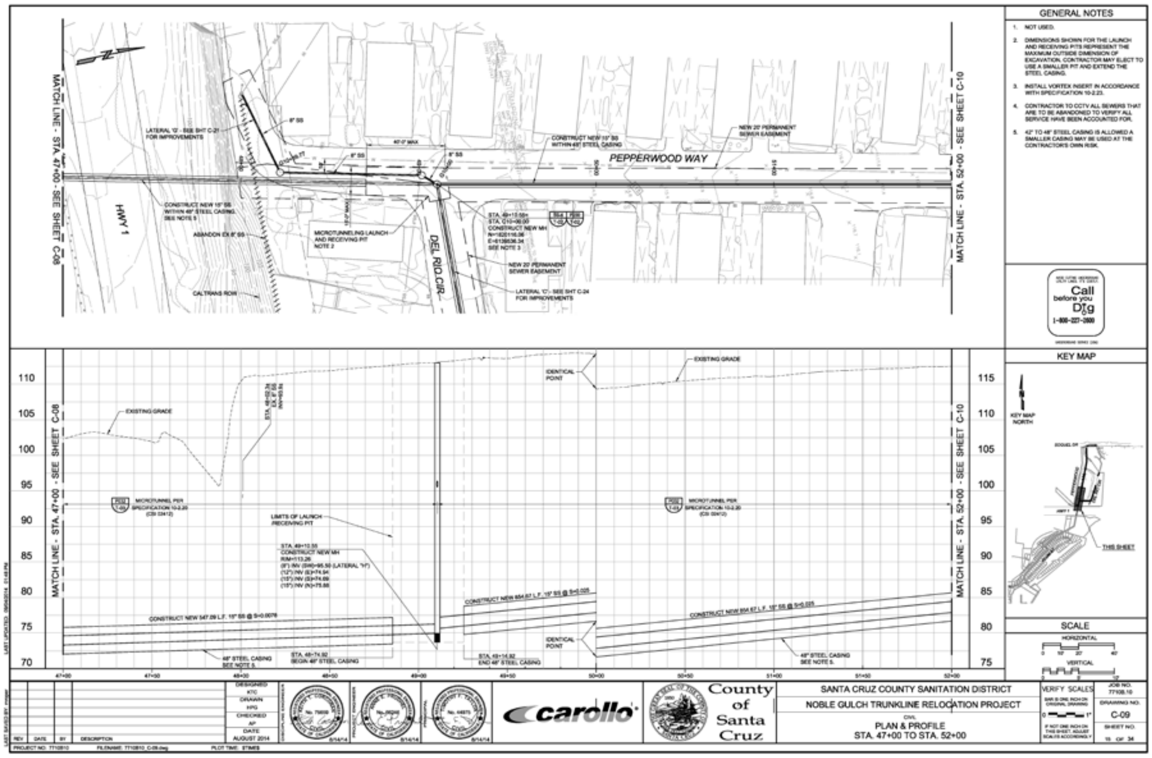

Figure 4. Plan and Profile of one of the deep launching pits

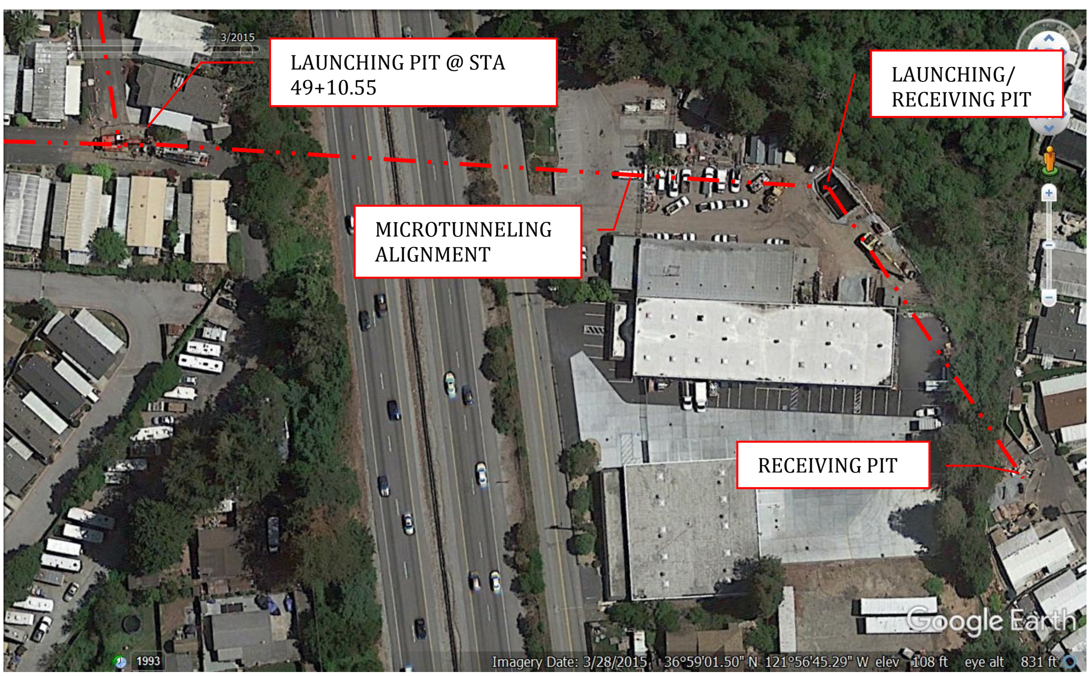

Figure 5. Highway 1 microtunneling crossing

Figure 6. Micro-tunneling support equipment in tight corridors around 45' deep jacking pit

During construction the contractor presented multiple value engineering (VE) options to the District and Carollo. Many of the items presented were to change planned open cut sections of work to trenchless construction methods.

The key VE opportunities included:

- Additional HDD underneath the gulch within an existing right of way in order to eliminate some of the deep open cut construction originally required. The additional HDD eliminated the need to impact the local middle school which would have required an extensive traffic control and work hour restrictions.
- *Cured-in-place pipe (CIPP):* a 12-inch CIPP was used to line the portion of the existing trunkline that needed to be left in service along Noble Gulch due to maintain a few of the residential connections that could not be rerouted. The original design called for sliplining to reduce the inside diameter due to the decrease in flow; however, during construction the Contractor suggested the use of CIPP to eliminate the need to excavate existing manholes behind the residential homes and within Noble Gulch. This was ultimately selected in lieu of sliplining.
- Elimination of a launching pit by modifying the microtunneling equipment and ordering shorter lengths of casing to fit within the narrower width of the launching pit which was originally designed as both a launching and receiving pit. This enabled the contractor to eliminate one of the launching pits and install a smaller receiving pit.

Figure 7. Installation of cured in place pipe behind residential homes within the gulch.

The original contract included 7,050 lineal feet of open cut but was reduced down to 5,900 lineal feet by installing 1,150 lineal feet using HDD--an approximately 15% reduction in open cut. In addition to reduction in overall open cut work, only 43 of the original planned 50 manholes were required.

6. CHALLENGES AND LESSONS LEARNED

Numerous adverse conditions made the project quite challenging from design through construction. It took 9 years to complete the overall project due to numerous chain of events that put the project on hold. In this time, a local water agency completed another project, occupying a portion of the corridor identified for the new Noble Gulch pipeline alignment due to conflicts identified on their project during construction. Additionally, numerous unmarked utilities, an abandoned buried bridge, and poor as-built documentation of utilities contributed to numerous changes. This ultimately resulted in coordination with the contractor and local utility providers to identify and redesign a significant portion of the trunkline during construction.

During the installation of the shoring for one of the microtunneling launching pits, a lens/pocket of the Purisima Formation was hit. The design geotechnical engineer took samples which identified the material to have a compressive strength in excess of 10,000 PSI--a Schmidt hammer was used due to the varying sample sizes. Specialty rock coring equipment had to be brought onsite in order to penetrate the rock and continue installation of the shoring. The location of the Purisima formation was at the elevation of part of new 42-inch casing that was to be installed and there was a concern that the microtunneling machine may not be able to maintain grade and would chase the softer material. Fortunately, once the shoring was installed, it was determined that it was an isolated piece of the Purisima formation and was able to be removed as part of the planned excavation of the pit.

Site access was difficult and lead to many challenges especially where construction activities cut off complete access to the mobile home community since there was only one way in and out. The mobile home community had many retired and elderly occupants, some of which required daily care, and many of the residents were home during active construction hours. Sound and vibration was a concern, especially when the microtunneling boring machine was being driven as the dewatering equipment had significant sound and vibration impacts to the community. To help mitigate, sound attenuation blankets were added as a change order as shown in Figure 8

Figure 8. Sound attenuation blanket around microtunneling drilling mud dewatering equipment

Site access in the upper mobile home park at the launching pit was extremely tight and limited amount of spoils and new material to be onsite at once without impacting the local residents. Figure 9 shows a 3-way intersection that was completely blocked at one of the launching pits.

Figure 9. Installation of carrier pipe in tight corridors

In addition to residential access in the mobile home community, access for USPS, Fed-Ex & UPS deliveries, garbage, and emergency services had to be maintained on a daily and weekly basis. While public outreach was not within the contractor's scope, they made significant effort to help residents from carrying groceries to rolling out garbage cans where the trucks could access them.

The "Lesson Learned" was that the success of this project was attributed to the multiple trenchless technologies available to overcome the unique access and geological challenges as well as the collaborative partnership between the contractor, designer, construction manager, and District were established early on. This partnership allowed the numerous challenges of the job to be openly discussed and efficiently overcome to ensure there were no impacts to the overall schedule and minimal cost impacts. In the end, the additional construction costs due to unforeseen conditions were ultimately covered by the value engineering opportunities implemented.

7. Conclusion

The Noble Gulch Trunkline Relocation project was completed on budget and 2 months ahead of schedule. The design and construction challenges included construction within a highly sensitive community, congested utility corridor, and within an environmentally sensitive area. The strategic use of trenchless technologies allowed the new alignment to be relocated away from the existing alignment and out of the environmentally sensitive areas and reduce the risks associated with deep open cut construction.