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**Trenchless Value Engineering: Switching from Open-Cut to Pilot  
Tube Auger Bore during Construction**

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**1. ABSTRACT**

The City of San Mateo, California (City) is constructing a new wet weather conveyance system to reduce sanitary sewer overflows. A number of trenchless technologies have been selected to build the system. The 25th Avenue Sanitary Sewer Relief Line is a segment in the system that required the use of pilot tube auger bore technology to install the pipeline under a State Highway and Railroad at the specified tolerances.

During design, the City looked at a number of pipeline installation techniques that would be acceptable to the involved stakeholders. The line needed to be constructed under two very busy traffic corridors: the El Camino Real (State Highway 82) and the Peninsula Corridor Joint Powers Board (PCJPB) rail line. While trenchless techniques were selected for these locations, the remainder of the alignment was specified for open-cut methods. During construction, the City's contractor submitted a value engineering proposal to install all segments via pilot tube auger bore. In the proposal, the contractor presented the concept of using an alternative pipe material to deliver material and installation cost savings.

The project was constructed using the value engineered alternative and is an example of how the bid market prices projects based on the least expensive installation technique, regardless of how the project is shown in the design documents. This aspect of trenchless bid and construction practices are examined in this case study to highlight how value engineering can be utilized in the bid documents in a manner that may lower risk and costs for the owner.

**2. PROJECT INTRODUCTION AND DESIGN**

The 25th Avenue Sanitary Sewer Relief Line (project) is part of the City's sanitary sewer wet weather improvements program. The project is intended to provide additional capacity within the sanitary sewer collection system during wet weather events and convey high flows by gravity to the City's wastewater treatment plant (WWTP). The Project alignment includes crossing of El Camino Real (State Highway 84) and the PCJPB right of way, which operates the CalTrain commuter rail system. In addition, the 25th Avenue corridor is a major business district with retail, restaurant, bar, and commercial operations. Finally, 25th Avenue also provides one of a handful of key crossing locations of the PCJPB system (see Figure 1).

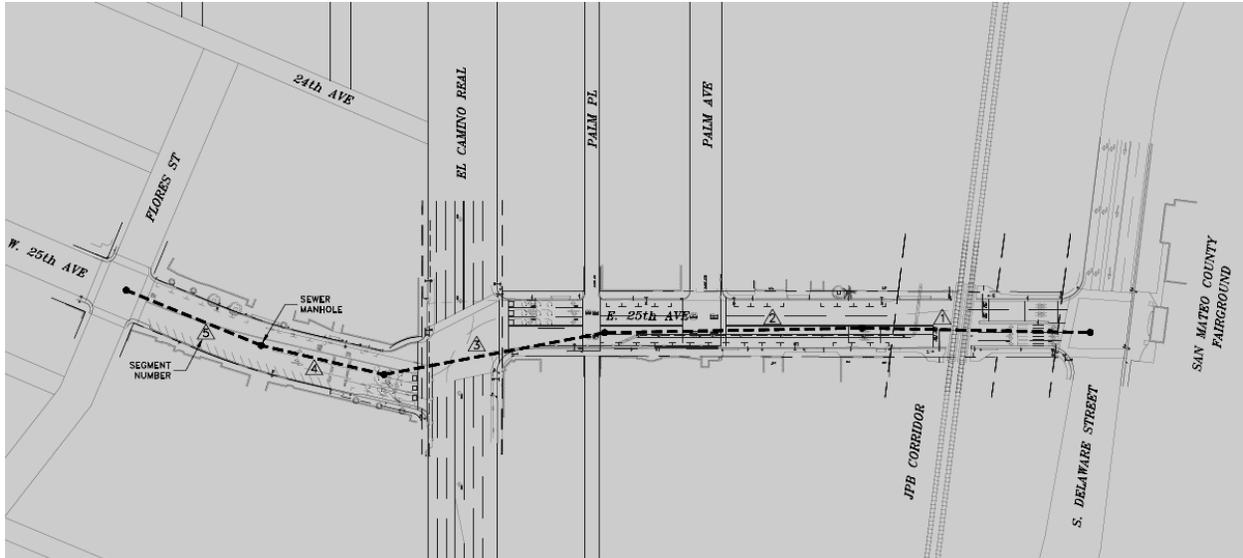


Figure 1. Alignment of the 25<sup>th</sup> Avenue Sanitary Sewer Relief Line.

Based on the planned alignment crossing two significant at-grade rights of way, the City determined that trenchless installation of both the El Camino Real and PCJPB corridor crossings would be required. Furthermore, the active commercial district within the project area further justified the use of trenchless methods which would reduce the total area of street closures and reduce impacts to parking. In order to determine the preferred horizontal and vertical alignment, a comprehensive Subsurface Utility Engineering (SUE) program was established. Over 20 potholes were made along the 1,250 linear foot alignment to establish locations of numerous critical utilities including telecommunication, signal, natural gas, electric, potable water, storm water, and sanitary sewer. The pothole data was supplemented with available as-built information provided by the utility owners identified during the SUE process.

Another challenge related to the project was the anticipated future grade separation between the installation and future high speed rail improvements along the PCJPB facilities. The improvements to the PCJPB alignment to accommodate the high speed rail was in the early planning stages during the time frame of the project. The City desired to attempt to accommodate the anticipated modifications to the finished grade of 25th Avenue to reduce the risk of potential future relocation of the relief line.

Following completion of the SUE efforts and in consideration of a future grade separation project, there was a limited horizontal window to accommodate the proposed relief line. The vertical constraints were less restrictive because the invert elevations required of the relief line to tie into the future upstream and downstream wet weather facilities were several feet below the lowest potential utility conflict. The vertical alignment was lowered an additional three feet to provide a buffer from the future grade separation improvements.

Once the vertical and horizontal constraints were identified, the project alignment was established. The portions of the alignment crossing both El Camino Real and the PCJPB tracks had limited horizontal space and the alignment was practically established by the existing utility arrangement. In addition, the horizontal alignment was limited to the southerly side of 25th Avenue to allow any future utility improvements to be accommodated within a second open zone on the northerly side of 25th Avenue (see Figure 2).

Once the alignment was established, the design team completed a high level of evaluation of potential trenchless methods to implement the project. Both horizontal directional drilling (HDD) and pilot tube auger bore methods were considered for the project. The design team determined that HDD was not feasible due to two primary reasons. First, the proposed pipeline is part of a gravity conveyance system and maintaining a consistent slope to avoid bellies in the pipeline was crucial. Second, the constrained surface area along the project alignment would not provide sufficient laydown and staging area for HDD. Therefore, the design team proceeded with final design based on pilot tube auger bore method.

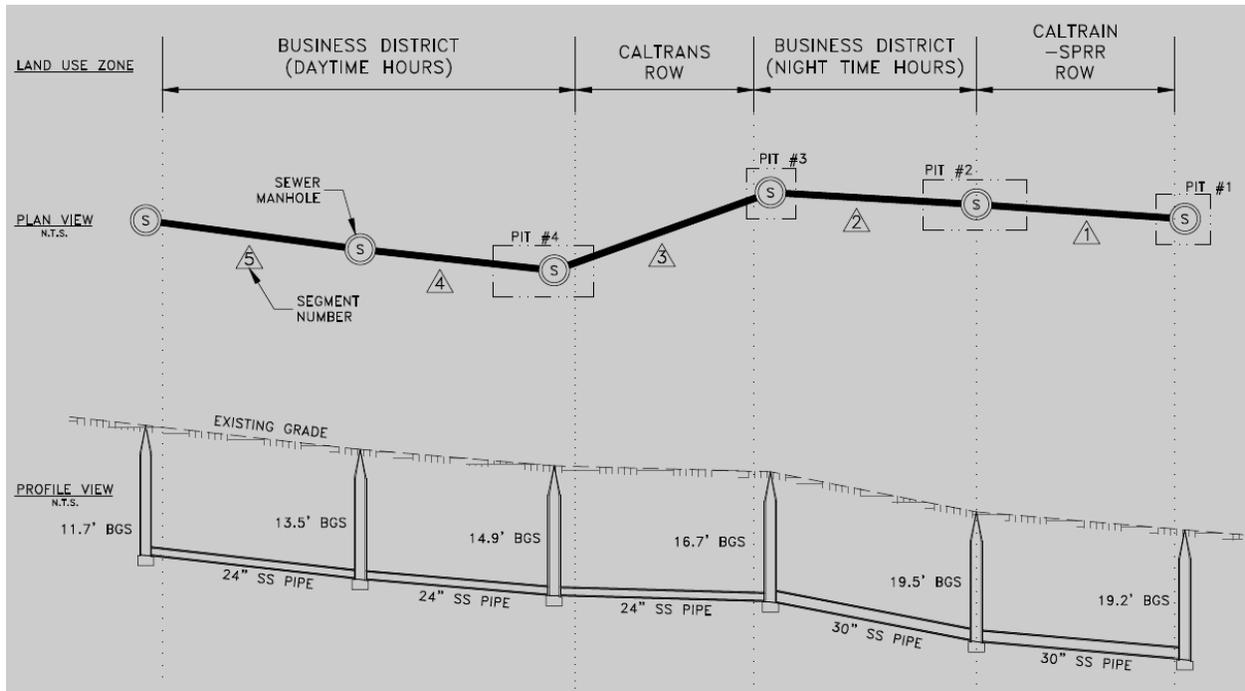


Figure 2. Plan and Profile Schematic with Land Use Constraints.

### 3. GEOTECHNICAL CONSIDERATIONS

In order to confirm that the soils within the planned alignment were suitable for the proposed pilot tube auger bore method, a comprehensive geotechnical program was implemented. A total of four borings were completed along the alignment. The geotechnical investigation confirmed that the soils anticipated to be encountered during construction were suitable for pilot tube auger bore methods, which was the preferred trenchless method to construct this type of pipeline alignment. The soils within the project area were largely stiff clays and there were minimal cobbles and other large rocks encountered during the soils investigation.

The geotechnical investigation also identified a potential for groundwater infiltration into open excavations although the infiltration rates were not anticipated to be significant enough to warrant the need for dewatering wells. An evaluation of potential additional hydrogeological investigation and study was considered in order to potential establish a range of infiltration rates to be provided to the contractor. In the end, the risk decision was made to not perform the hydrogeological study but rather require water tight shoring system to minimize the groundwater infiltration. The City determined potential expenses of water tight shoring system was more appropriate than performing additional studies that would not necessarily completely reduce the risk of a change order due to excessive groundwater infiltration into the excavations.

In addition, a strict groundwater dewatering program was established in the contract. The construction contractor would have significant limitations on the flow rate that could be discharge to the sanitary sewer. In addition, the potential presence of hydrocarbons and other contaminants in the groundwater due to the proximity of historic gas stations was a challenge that the construction contractor would have to accommodate. Ultimately the contract documents included provisions that required the construction contractor to setup and operate a groundwater holding and treatment system.

#### 4. BIDDING AND CONTRACTING

The alignment covers dense utility and transportation corridors with challenging road and railway geometries in a fully built urban environment (see Figure 1). The design team's challenge was to prepare clear project plan sheets that conveyed to the bidder's all of the project's major constraints. This required the design team to prepare plan sheets that coordinated limits of multiple agency right-of-ways, utility alignments and vaults in close proximity, irregular travel lanes and intersections, traffic controls for temporary lane realignments, and shoring footprints for pits that fit within the project constraints.

The alignment included five pipe segments that span challenging and varied land uses, including business districts, truck routes, and other agency right-of-ways (see Figure 2). The two segments located under other agency right-of-ways were selected to be installed using trenchless methods while the other three segments were considered for trenchless or open-cut methods. Two installation options were considered for the remaining three segments: trenchless or open-cut installation.

Two bidding options were screened to determine which one would provide the lower cost and risk to the owner. The two options considered included letting the contractor select the preferred installation method of trenchless or open-cut, or specifying the open-cut method and providing a value engineering clause in the bidding documents. Given the fact that there are many more open-cut than trenchless contractors, the second option was selected by the owner to create the most competitive bidding environment and in order to transfer risk to the party best able to manage it: the contractor.

The alignment spans several important transportation routes and is a vital utility corridor for key San Francisco Bay Area underground infrastructure. Trenchless methodologies are routinely selected based on these project constraints. In the case of this project, the design team's exhaustive utility investigation provided the owner with the assurance that trenchless or open-cut methods could be utilized for the installation. Since both methods were specified, considerable thought was given to writing the front end specifications so that underground risks were articulated and assigned to the contractor. The key constraints outlined in the bid documents included:

- Establishing a potholing unit price bid item
- Clear definition of potholing requirements, including protection and support during construction
- Defining groundwater level
- Establishing dewatering requirements
- Defining accuracy of geotechnical and hazardous material sampling presented

#### 5. CONSTRUCTION

The City received eight competitive bids for the project ranging in cost from \$2.1M to \$3.2M. The responsive lower bidder, Platinum Pipeline Inc. of Dublin CA, was awarded the construction contract.

##### Value Engineering Proposal

At the pre-construction conference, the contractor provided a value engineering proposal to convert the three open-cut segments to trenchless. As discussions ensued it became clear that the contractor's experience highlighted some risks that the owner did not appreciate during design, namely the high risk nature of segment no. 2 (shown in Figure No. 2). The owner's revised risk profile for segment no.2 included the following:

- Depth and width of open-cut to install the 30-inch diameter pipe
- Amount of potentially hazardous spoils generated from the open-cut
- High groundwater and need for dewatering wells in roadway to perform open-cut
- Number of idling trucks required for spoil removal and backfill for open-cut
- Large number of high value communication utilities crossing the open-cut trench
- Location of open-cut in front of businesses (bars) with hours concurrent with construction
- Depth of open-cut excavation next to structures and truck route
- Complexity of shoring system to meet the above requirements

The owner added the contractor-identified risks to the risk assessment developed during design. Out of this evaluation the owner determined that the value engineering proposal should be seriously considered. However, the owner had one major problem with the initial value engineering proposal: it did not result in a cost saving, instead it utilized all of the contingencies in the contract. The owner was not comfortable with this approach, so a negotiation ensued. The key criteria established during the negotiation included the following:

- Performing the high risk segment (segment no. 2) utilizing the open-cut method was untenable
- The contractor would waive all future change orders associated with impacts from underground conditions that arose from switching from open-cut to trenchless
- The value engineering proposal needed to provide a net cost and/or a significant schedule saving
- The pits specified in the contract could be utilized for the new trenchless alignment at no additional cost

During development of the revised value engineering cost proposal, the contractor found it hard to provide a tangible cost saving to the owner using the specified carrier pipe material. The contractor was approached by a material supplier with a proposal to reduce labor, equipment, and material cost utilizing an alternative carrier pipe material. This proposal provided the tipping point to make the value engineering proposal result in a cost and schedule saving to the owner.

The design in the bid documents called for 30 and 36-inch high density polyethylene (HDPE) carrier pipe to be used. This would require a 42 and 48-inch steel casing, respectively, to be installed to accommodate the carrier pipe sections, along with necessary casing spacers. A significant way to lower cost and risk for the pilot tube auger bore construction is to downsize the diameter of the casing pipes. Reducing the size of the casing pipes results in a material cost saving along with corresponding reduction in labor and equipment costs and risks, as follows:

- Decrease in time required to complete the boring
- Reduction in amount of potential hazardous spoils generated
- Lower risk in encountering obstructions

#### Considering Alternative Pipe Materials

The contractor's revised proposal utilized a different but similar carrier pipe material, fusible polyvinylchloride (FPVC) pipe as opposed to the specified HDPE. FPVC is similar to HDPE in that it is a thermoplastic pipe joined by thermal butt fusion, allowing it to be assembled in very long lengths with no mechanical couplers between manholes. FPVC is different than HDPE in its material strength properties, allowing FPVC to have a thinner wall than HDPE under some design conditions. In the case of this project, the design of the carrier pipe is based on a required flow area which translates into an average inner diameter requirement, and pipe stiffness, which is a measure of the pipe sections ability to resist deflection. The difference between the required wall thicknesses between the two materials means that a 24 and 30-inch FPVC pipe section could be used instead of the specified 30 and 36-inch HDPE sections. A decrease in the size of the carrier pipes translates to a decrease in the sized of the casing pipes. Instead of a 42 and 48-inch casing pipe, the project would now require a 36 and 42-inch casing pipe. See Figure 3 for this comparison.

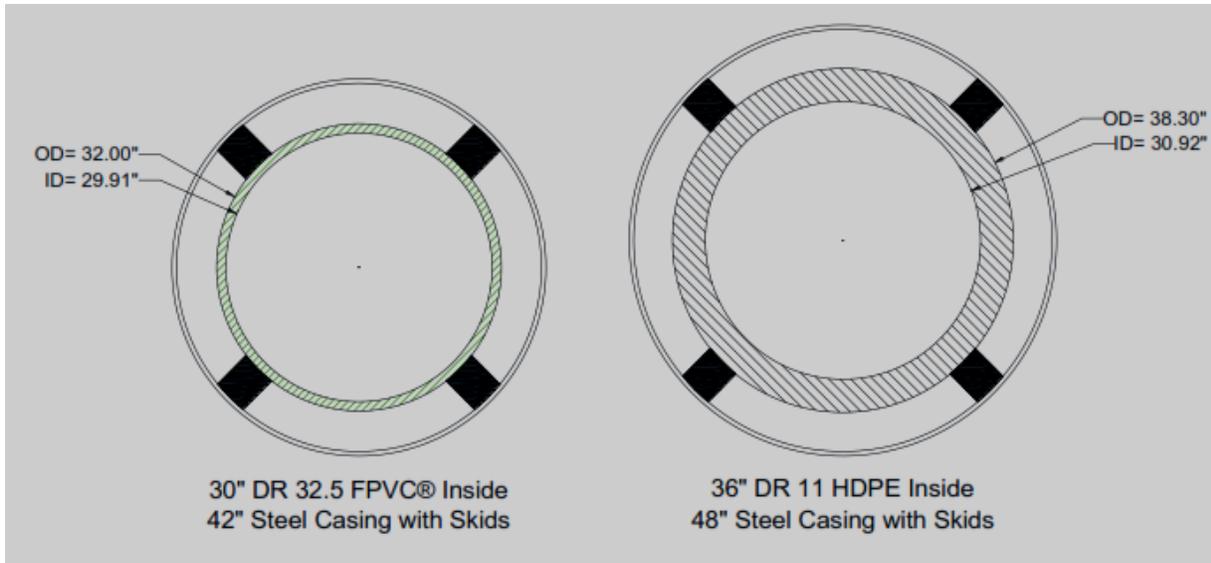


Figure 3. Comparable FPVC and HDPE Pipe Sections.

The contractor's revised value engineering proposal met all of the owner's criteria and was accepted by the owner. The key decision for the owner's acceptance included:

- Providing the owner with early completion of the schedule milestone
- Reducing the owner's risk and associated costs
- Delivering equivalent flow area for the gravity pipe

#### Mitigating Public Impacts

The Project alignment traverses a truck route, crosses a state route and commuter rail right-of-way, serves as a commuter route, and traversed two distinct commercial districts in the City. Based on factors such as traffic and noise impacts from daytime construction, the City chose to perform construction during nighttime hours. This mitigated potential impacts to the major business district with daytime business hours while impacting the other business district that had nighttime business hours.

The construction staging requirements for the project were significant, requiring temporary traffic controls that shifted travel lanes to existing street curb parking. In an area with no public off-street parking and limited on-street parking, every lost parking space resulted in an impact to businesses. The project design included parking mitigations through the construction of a temporary off-street parking lot.

The biggest percentage loss of on-street parking was in the businesses district with nighttime business hours. These businesses were located adjacent to segment no. 2 (see Figure 2), the portion of the project converted from open-cut to trenchless method. Use of trenchless methods in this area reduced the footprint of construction activities and reduced impacts to traffic and parking. Reduction of these construction impacts resulted in significant mitigations to the businesses with nighttime business hours.

#### Unanticipated Field Conditions

During excavation of the launch pit no. 2 (see Figure 2), the contractor encountered an unmarked telecommunication utility that caused them to shift the pit approximately five feet away from the alignment. The shift of the launch pit caused a significant geometric challenge because the trenchless alignment was no longer straight. Furthermore, the dense utility corridor did not allow adjustment of the easterly receiving pit no. 1, and there was limited ability to adjust the westerly receiving pit no. 3 (see Figure 4). In order to efficiently modify the design to accommodate the new field constraints, the City, design engineer, and contractor conducted a design workshop.

Resolving Unanticipated Field Condition Impacts

The project team came together for an intensive one-day design workshop in the design engineer's office. The purpose of the workshop was to collaboratively develop a location for westerly receiving pit no. 3 that would allow the two boring alignments to meet within the fixed launch pit location (see Figure 4). The initial alignment evaluation began with identifying the horizontal alignment constraints posed by the installed position of launch pit no. 2, the installed easterly receiving pit no. 1, and the limited window in the utility corridor for locating receiving pit no. 3. Figure 4 represents that starting point for the team's alignment study to establish the window for the two alignments such that the required manhole could be located within receiving pit no. 3 and be constructible.

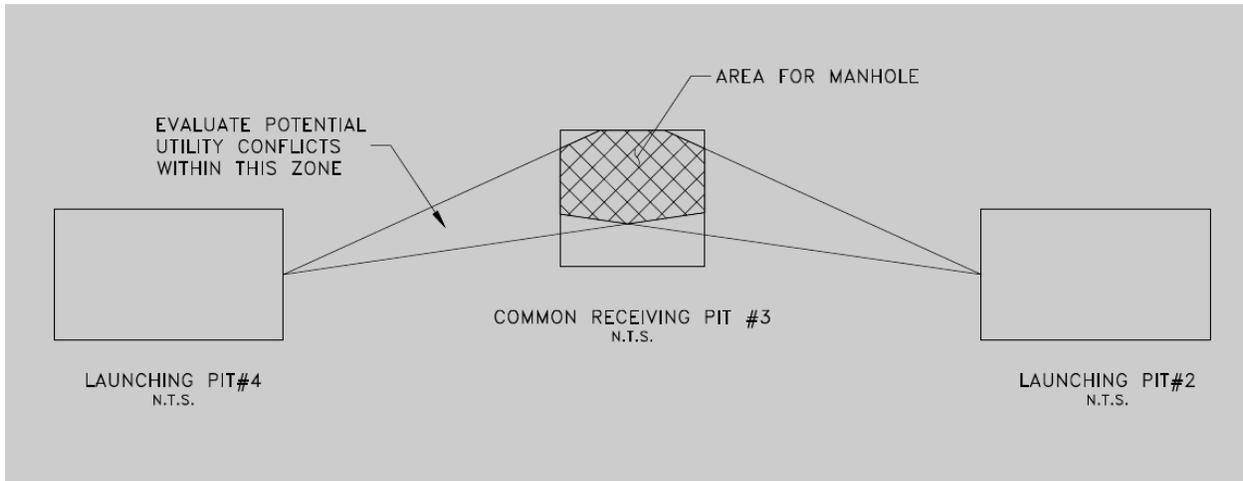


Figure 4. Alignment Constraint Analysis.

Several iterations of the location for receiving pit no. 3 were developed with varying angles to determine the most likely alignment that would allow a manhole to be built to accommodate the inflection point of the two trenchless alignments. A detailed as-built condition survey of installed launch pit no. 2 and launch pit no. 4 was completed to provide detailed constraints to the design team to establish a preferred location for receiving pit no. 3. During the design workshop process it was determined that receiving pit no. 3 needed to shift nearly forty feet to fit into the preferred location. A final confirmation survey and analysis was completed once receiving pit no. 3 was excavated. Figure 5 presents the construction detail developed by the contractor to guide the installation work.

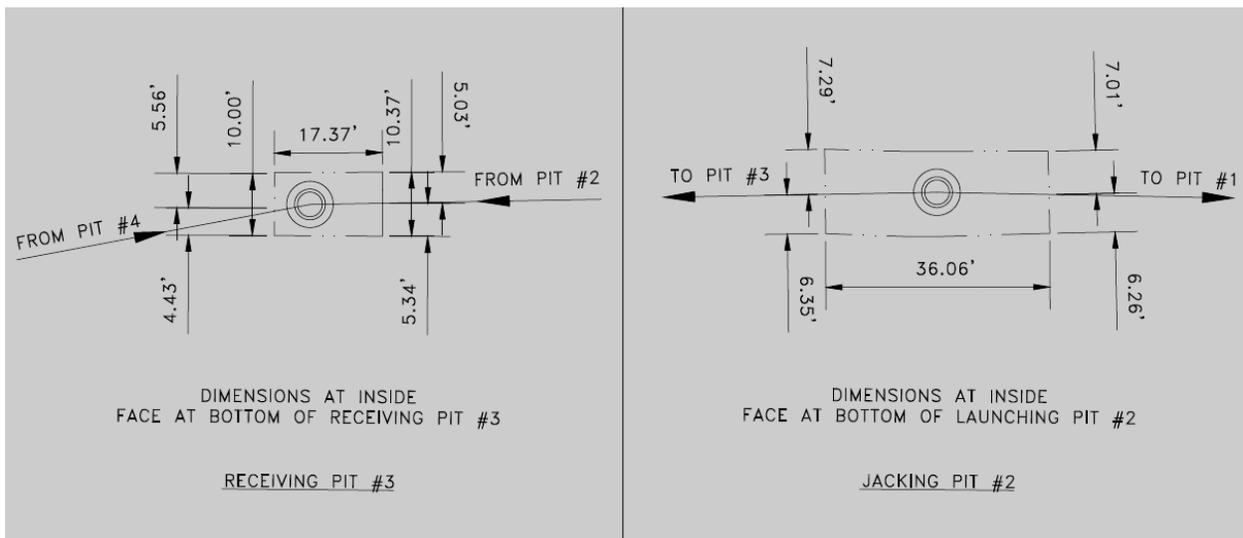


Figure 5. Surveyed Pit Dimensioning.

Once the office engineering was completed, supplemental potholing was completed to validate the modified design. The potholing showed a window between several utilities, including the previously unmarked telecommunication duct bank would accommodate the new project. Once the contractor validated there was a sufficient window to complete the pilot tube auger bore, work proceeded and was completed successfully with no impacts to the existing utilities.

## **6. CONCLUSIONS**

The project was successful and the critical wet weather flow pipeline was built despite several challenges during construction. The utility conflict and unforeseen conditions encountered during construction are not to be unexpected for any pipeline project but the utility constraints for the Project posed significant challenges. The design phase utility investigation proved to be invaluable for the design team and City to understand the specific subsurface alignment risks and develop an alignment that minimized those risks. The design phase utility investigation also allowed the bidding contractors to understand the constraints when developing proposed pricing.

The value engineering proposal submitted by the material supplier and contractor on this project is an example of how the specialized trenchless construction market can provide installation specific solutions based on project site constraints. The proposed value engineering change from the contractor was accepted because of the overall benefit to the project from cost, schedule, and risk reduction perspectives. The change from HDPE to FPVCP provided the opportunity to reduce the diameter of the overall pilot tube auger bores resulting in a cost reduction to build the project and provided the opportunity to utilize trenchless installation along the majority of the alignment, reducing impacts to the adjacent businesses.

The previously unmarked utility discovered during excavation of the pilot tube auger bore pit affected the alignment. This significant change could have derailed the construction project. This significant obstacle was overcome by a collaborative design workshop whereby each member of the project team participated in a solution that got the project back on schedule. The collaborative approach allowed the team to expeditiously perform the office and field work that identified a horizontal alignment which fit within the constrained utility corridor. Once the revised alignment was validated by additional utility potholing, the contractor was able to successfully complete the pilot tube auger bore, and complete the project on schedule and on budget with an owner happy that change orders were limited to four percent of the contract value on a very difficult construction project.