Trenchless Construction Feasibility Analysis

Pennsylvania Pipeline Project

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TABLE OF CONTENTS

Section **Page**

List of Figures **Page**

List of Tables **Page**

1.0 GROUNDWATER PROTECTION PLANS

Sunoco Pipeline L.P. (SPLP) has developed four plans that accompany the Erosion and Sedimentation Plan (E&S Plan) that are designed to assess the potential impacts and provide for the protection of groundwater from contamination due to project activities. The overarching Prevention, Preparedness, and Contingency Plan (PPC Plan) is designed to address spill prevention in general, and potential impacts to surface waters and public and private water supplies in particular have been analyzed and addressed within two supplemental plans to the PPC Plan; the Water Supply Assessment, Prevention, Preparedness, and Contingency Plan (Water Supply Plan) and the Inadvertent Return Assessment, Prevention, Preparedness, and Contingency Plan (IR Plan). The Water Supply Plan provides for the assessment of the existing environment in terms of public and private water supplies in or along the project areas and impacted waters, as well as the prevention and preparedness measures to be implemented to protect those supplies. The IR Plan outlines the preconstruction activities implemented to ensure sound geological features are included in the HDD profile, the measures to prevent impact, and the preparedness plan if an impact were to occur. In addition, a Void Mitigation Plan for Karst Terrain and Underground Mining is provided as part of the E&S Plan and provides an assessment of potential impacts and avoidance and mitigation measures during open-cut and drilling procedures. The purpose of these plans is to protect groundwater resources project-wide.

2.0 TRENCHLESS FEASIBILITY ANALYSIS

Provided herein is a trenchless construction technology feasibility analysis for steel pipelines associated with the Pennsylvania Pipeline Project. Specifically, the construction methodologies analyzed are conventional boring and horizontal directional drilling. The intent is to compare these methodologies to each other, as well as to conventional trenched pipeline construction techniques.

2.1 CONVENTIONAL AUGER BORING

Conventional auger boring (CAB) or jack and bore is a dry trenchless method of installing a relatively shallow underground steel pipe, from an excavated entry pit to an excavated exit pit, beneath an avoidance obstacle. Specifically, a specialized track machine pushes the product pipe into and through the ground, while simultaneous auger boring to remove the spoil from within the pipe. This push and clean-out process is repeated for each pipe segment until the desired total installation length is achieved. The technique has been utilized extensively in the United States for numerous decades, primarily for pipelines constructed underneath road and railroad crossings. A representative animation of the CAB process is available at the following link: http://www.allenwatson.com/auger-boring.html

Notwithstanding the description of CAB, this construction method cannot be implemented in every location. There are various physical / technical, practical, and/or geotechnical constraints which can limit or completely eliminate the feasible use of CAB in particular locations.

2.2 HORIZONTAL DIRECTIONAL DRILLING

Horizontal directional drilling (HDD) is a steerable trenchless method of installing underground pipe, conduit, or cable in a shallow arc along a prescribed bore path by using a surface-launched drilling rig, with minimal to no surface impact along the bore path. The easiest forms of HDD emerged in the 1960s and have since been advanced and typically utilized when conventional trenching techniques are not desirable or practicable. It is suitable for a variety of soil conditions and primarily intended for obstacle avoidance including, but not limited to, river crossings, roads, and environmental features. A representative animation of the HDD process is available at the following link: https://www.youtube.com/watch?v=CkdOwJc_eR8

Notwithstanding the description of HDD, the application of HDD is not suitable in every location. There are various physical / technical, practical, and/or geotechnical constraints which can limit or completely eliminate the feasible use of HDD in particular situations.

3.0 PROCESS OVERVIEWS

3.1 CONVENTIONAL AUGER BORING PROCESS

3.1.1 SITE ARRANGEMENT

The CAB construction site is divided into three primary sections along a linear path as follows:

- Entry / working pit workspace
- Obstacle to be avoided
- Exit / receiver pit workspace

The entry pit workspace is generally 30 to 40 feet in length, 10 to 12 feet in width, and generally 10 to 15 feet in depth, but depth may vary depending upon site-specific topography. The entry pit workspace typically contains the following features (see Figures 1 and 2):

- Machine track
- Sheet pile pit backing plate
- Cutting head(s) & auger sections
- Boring machine
- Pipe casings & auger sections
- Spoil collection tray

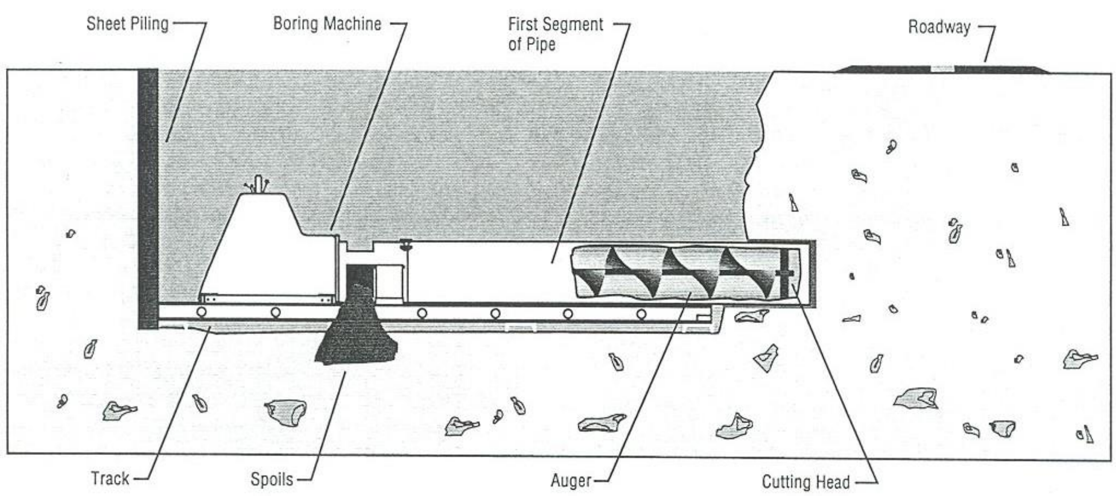

Figure 1: Typical CAB Entry Pit Workspace Area – Diagram

Figure 2: Typical CAB Entry Pit Workspace Area – Photo

The contents and size of the exit pit vary with the complexity of the site specific boring. Exit pit sizes range from as large as entry pits to no pit at all.

3.1.2 CAB Process Step #1 – Entry Pit Excavation and Preparation

The first step in the CAB process is the reaming of the pilot hole. This process is summarized below:

- Excavation pit boundaries and boring alignment are surveyed according to the detailed engineering design.
- Excavations are implemented pursuant to requisite Occupational Safety and Health Administration (OSHA) shoring and/or sloping regulations.
- The most critical part of the bore is the setting of the machine track on line and grade. Proper foundation support typically requires crushed stone and may include poured concrete.
- A backing plate, consisting of steel pilings, steel plate, concrete barrier, and/or wooden timbers, is normally installed along the back of the boring pit. This supports the thrust of the boring machine as the product pipe is advanced into the ground.
- The boring machine is placed upon the track.
- Pre-assembled casing pipe and imbedded auger is lowered into the pit, aligned on the track, and secured to the boring machine. In most cases, the leading casing has a slightly larger diameter band welded to the front, which compacts the soil and relieves pressure on the remaining casing by decreasing skin friction.

3.1.3 CAB Process Step #2 – Horizontal Boring

The second step in the CAB process is horizontal boring under the avoidance obstacle. This process is summarized below:

- The bore is begun by carefully thrusting the casing pipe into the ground along the correct line and grade. Simultaneously, the auger inside the casing is rotated by the boring machine to clear the progressing casing and pull the spoiling into the entry pit for removal.
- After the first section has been installed and checked for accuracy, the boring machine is disconnected from the casing pipe and auger and slid to the rear of the bore pit.
- The second casing / auger section is lowered into position. The auger ends are connected to the boring machine and tail end of the first auger section. The leading end of the casing pipe is welded to the tail end of the first casing pipe section.

- This process of casing / auger section installation, thrusting, boring, and clean-out is repeated until the desired total installation length is obtained.

3.1.4 CAB PROCESS STEP #3 – COMPLETION OF BORING

The final step in the CAB process is the completion of the boring. This process is summarized below:

- The boring machine is shut down and the cutting head is removed from the exit pit.
- The boring machine is re-activated and operated in the normal direction for final cleaning.
- The boring machine is pulled to the rear of the bore pit to expose a section of auger stem. The auger stem is removed and the bore machine pulled forward and connected to the remaining auger stem(s).
- This process of auger stem removal is repeated until the casing pipe is empty.
- The equipment in the entry and exit pits is removed in the reverse order to which it was installed.
- The workspace areas are restored pursuant to project specifications.

3.2 HORIZONTAL DIRECTIONAL DRILLING PROCESS

3.2.1 SITE ARRANGEMENT

The HDD construction site is divided into three primary sections along a linear path as follows:

- Drill entry workspace
- Obstacle to be avoided
- Drill exit workspace

The drill entry workspace typically contains the following features (see Figure 3):

- Drill rig & HDD entry point
- Mud pump
- Drill pipe
- Power unit & control trailer
- Fluid system & tank
- Other supporting equipment & supplies

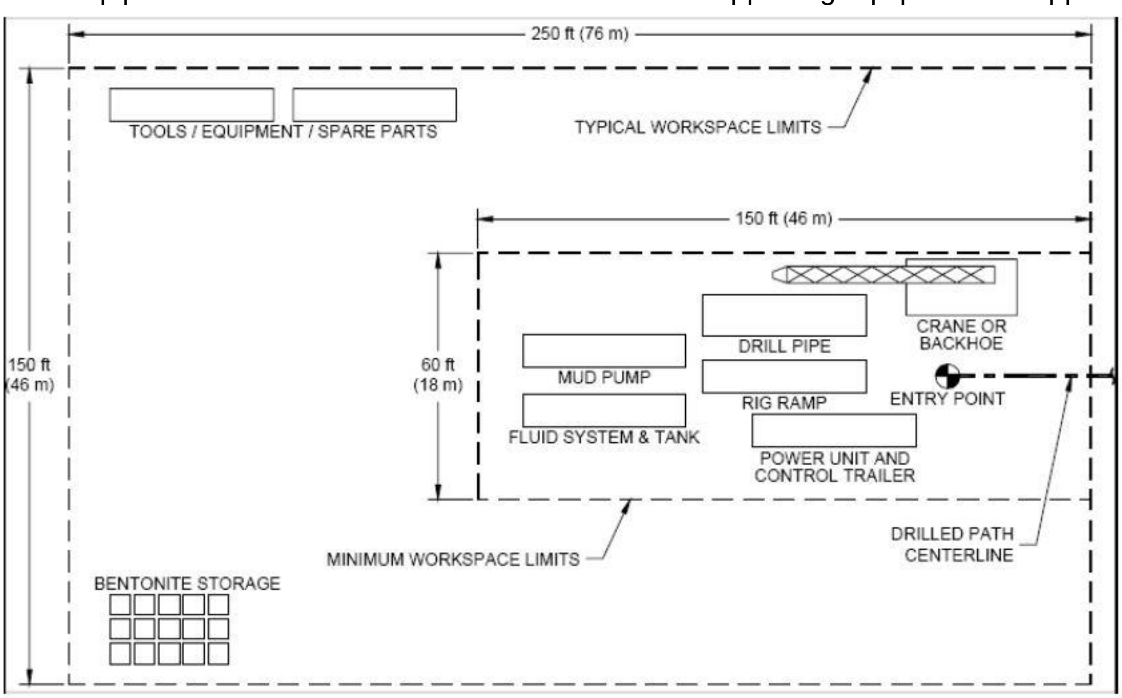

Figure 3: Typical HDD Entry Workspace Area

The drill exit workspace typically contains the following features (see Figure 4):

- Exit point
- Pipe handling equipment
- Prefabricated pullback pipeline section
- Other supporting equipment & supplies

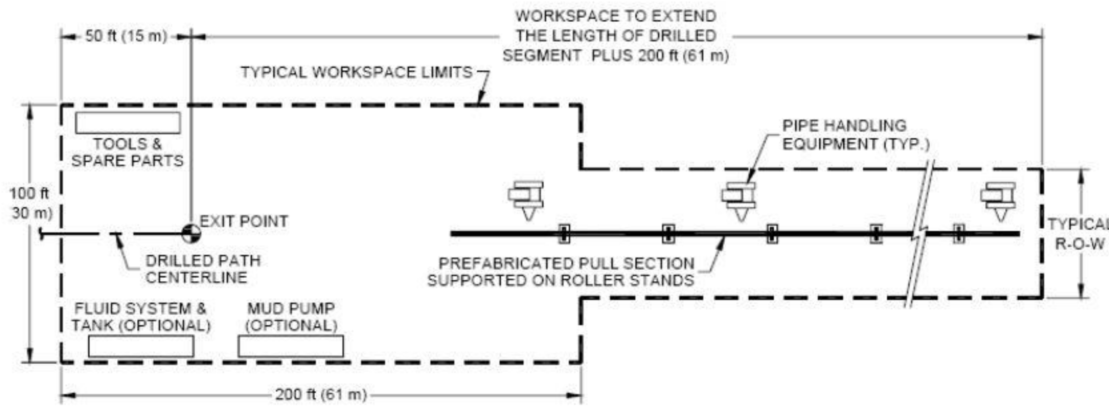

Figure 4: Typical HDD Exit Workspace Area

The size of the entry and exit workspace areas is directly related to the diameter of the pipe to be installed. A summary of typical workspace areas is provided in Table 1 below:

Table 1: Typical HDD Entry and Exit Workspace Areas

System Description	Entry Workspace	Exit Workspace
Maxi-HDD (24” to 48” diameter pipe)	150’ x 350’	150’ x 250’
Midi-HDD (12” to <24” diameter pipe)	150’ x 250’	100’ x 200’
Mini-HDD (2” to <12” diameter pipe)	Varies greatly per site	Varies greatly per site

3.2.2 HDD Process Step #1 – Drilling the Pilot Hole

The first step in the HDD process is drilling the pilot hole. A small diameter hole is drilled along an engineered design alignment from the entry point, under the obstacle to be avoided, and to the exit hole (see Figure 5).

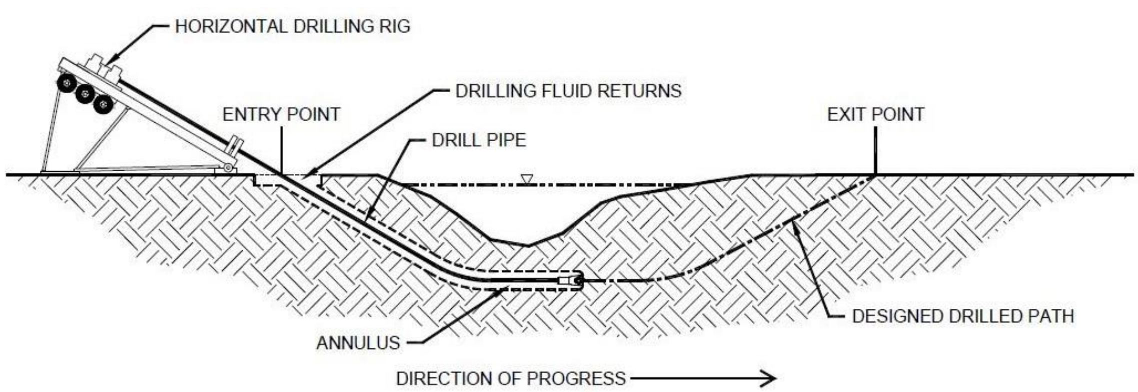

Figure 5: Drilling the Pilot Hole

3.2.3 HDD Process Step #2 – Reaming of the Pilot Hole

The second step in the HDD process is the reaming of the pilot hole. This process is summarized below (see Figure 6):

- o The pilot hole reamer (cutting head) is removed from the drill stem on the exit side.
- o A slightly larger reamer is installed on the drill stem, aimed towards the entry side, and pulled back to the drill rig.
- o Repetitive reaming passes between the entry and exit points are conducted with ever increasing reamer sizes until a bore hole is obtained which is approximately 1.5 times the diameter of the pipeline to be installed.

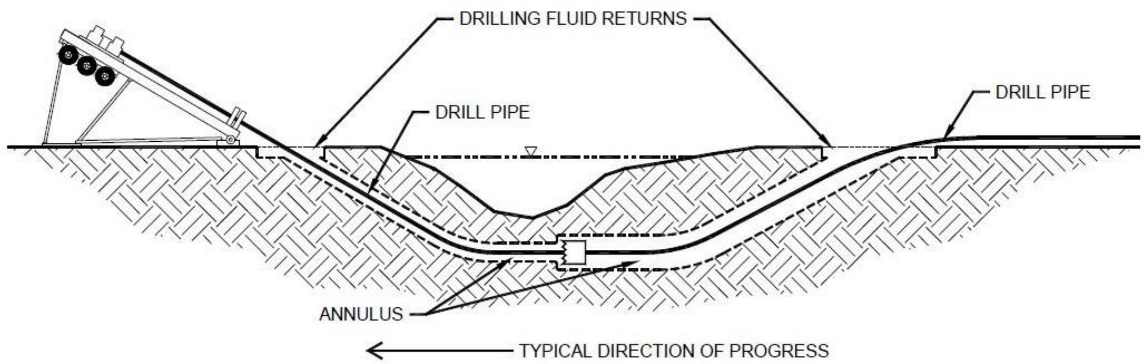

Figure 6: Reaming of the Pilot Hole

3.2.4 HDD Process #3 – Pipe Preparation and Pullback of the Pipeline String

The final step in the HDD process is the pipe preparation and pullback of the pipeline string. This process is summarized below (see Figure 7):

- o Pipe joints (segments) are placed on roller assemblies and welded into a continuous pipe string or drag section, that is slightly longer than the length of the drilled bore hole.
- o The pipe string is typically coated with a corrosion and abrasion resistant covering, and is commonly hydrostatically pretested to ensure pipeline integrity.
- o The pipe string is pulled over the rollers into the exit hole towards the entry point. The pullback continues until the entire pipe string has been pulled through the bore hole.
- o The external coating of the pipe string visible at the entry point is inspected for damage. An internal inspection of the pipe string is conducted to identify any damage done to the pipeline during pullback.
- o Upon successful inspections, the entry and exit workspaces are dismantled and demobilized.
- o The pipe string is ultimately tied-in (connected) to the conventionally laid pipeline.

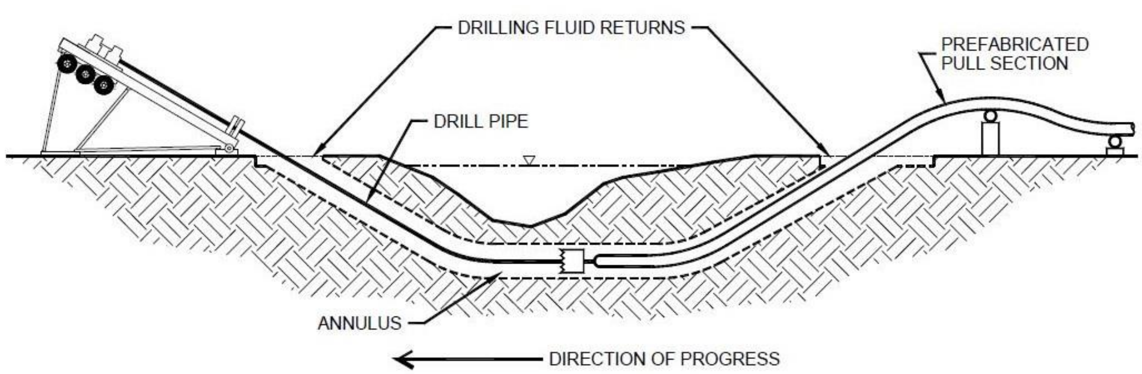

Figure 7: Pullback of the Pipeline String

3.2.5 HDD DRILLING FLUIDS

HDD drilling fluids are used to facilitate the boring. The principal functions of drilling fluid in HDD pipeline installation are listed below.

- Transportation of Spoil: Drilled spoil, consisting of excavated soil or rock cuttings, is suspended in the fluid and carried to the surface by the fluid stream flowing in the annulus between the bore hole and the pipe.
- Cooling and Cleaning of Cutters: Build-up of drilled spoils on bit or reamer cutters is removed by high velocity fluid streams directed at the cutters. Cutters are also cooled by the fluid.
- Reduction of Friction: Friction between the pipe and the hole wall is reduced by the lubricating properties of the drilling fluid.
- Hole Stabilization: Stabilization of the drilled hole is accomplished by the drilling fluid building up a "wall cake" which seals pores and holds soil particles in place. This is critical in HDD pipeline installation as holes are often in soft soil formations and are uncased.
- Transmission of Hydraulic Power: Power required to turn a bit and mechanically drill a hole is transmitted to a downhole motor by the drilling fluid.
- Hydraulic Excavation: Soil is excavated by erosion from high velocity fluid streams directed from jet nozzles on bits or reaming tools.
- Soil Modification: Mixing of the drilling fluid with the soil along the drilled path facilitates installation of a pipeline by reducing the shear strength of the soil to a near fluid condition. The resulting soil mixture can then be displaced as a pipeline is pulled into this formation.

The major component of drilling fluid used in HDD pipeline installation is fresh water, typically obtained at the crossing location or transported via water truck to the crossing location. To increase the hydraulic properties of the water, it is generally necessary to modify it by adding a viscosifier. The viscosifier used almost exclusively in HDD drilling fluids is naturally occurring bentonite clay, which is principally sodium montmorillonite. Bentonite clay is a Pennsylvania Department of Environmental Protection (PADEP)-recommended HDD drilling fluid additive, as reported in its *Recommended Practices Concerning Horizontal Directional Drilling Additives* (http://www.dep.pa.gov/Business/Energy/OilandGasPrograms/OilandGasMgmt/IndustryResources/InformationResources/Pages/default.aspx). It is not a listed hazardous material/substance as defined by the U.S. Environmental Protection Agency's (USEPA's) Emergency Planning and Community Right-to-know Act (EPCRA) or Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) regulatory criteria. If the product becomes a waste, it does not meet the criteria of a hazardous waste, as defined by the USEPA. Bentonite is non-toxic and commonly used in farming practices.

All stages of HDD involve circulating drilling fluid from equipment on the surface, through a drill pipe, and back to the surface through a drilled annulus. Drilling fluid returns collected at the entry and exit points are stored in a steel tank and processed through a solids control system which removes spoil from the drilling fluid, allowing the fluid to be recycled. The cleaned fluid is trucked back to the entrance point for reuse. The basic method used by the solids control system is mechanical separation using shakers, desanders, and desilters. The excess spoil and drilling fluid are transported to, and disposed of, at an approved and permitted solid waste landfill.

Drilling fluid expended downhole will flow in the path of least resistance. The path of least resistance is typically the bore hole itself; however, it may instead be an existing fracture, fissure, or formation opening in the soil or rock substrate. When this happens, circulation can be lost or reduced. This is a common occurrence in the HDD process, but does not prevent completion. However, the HDD process has an inherent risk of inadvertent return of drilling fluid to the surface at a location in an upland area, on a waterway's banks, or within a waterway or wetland. Although non-toxic, an inadvertent return has the potential to physically impact plants and fish if discharged to waterways in significant quantities.

4.0 FEASIBILITY ANALYSIS CRITERIA

The intent of this section is to provide a comparative assessment of the trenchless excavation methods CAB and HDD for steel pipelines. The following assessments will detail the physical / technical, practicability, and geological constraints.

4.1 CONVENTIONAL AUGER BORING

4.1.1 PHYSICAL / TECHNICAL CONSTRAINTS

Pipe Diameter
CAB can be utilized with welded steel pipe from 4" diameter to at least 60" diameter, with the most common diameters ranging from 8" to 36". Accordingly, CAB is a potentially feasible trenchless crossing method for the Project-proposed 16" and 20" pipelines based on existing technology.

Bore Pit Depth
CAB pit depths, and thus the product pipe installation depths, are a function of the avoidance obstacle constraints and the practicable depth at which operators can work safely. Comparatively, these depths are much less than those obtained by HDD.

Site Topography
Site-specific topographic conditions have a substantial bearing on the potential feasibility of conducting a successful CAB. A CAB fundamentally involves horizontal boring and straight alignment to install a pipe beneath the obstacle to be crossed. Accordingly, a CAB construction area requires not only proper bore pit depth, but also relatively level terrain from entry pit to exit pit, and site conditions that allow a straight bore alignment. In contrast, steeply sloping terrain, as well as topographic obstacles that prohibit a straight alignment, at either end of the crossing area is not conducive to supporting a CAB.

CAB Workspace
Additionally, the site topography and conditions (i.e., location of crossing area in relation to obstacles, structures, roads, other protected resources) must include adequate space to accommodate the CAB construction site configuration, including but not necessarily limited to the bore pits; spoil storage; and pipe and construction equipment storage, delivery, operation, and removal; to allow completion of a CAB in a safe and practicable manner.

4.1.2 PRACTICABILITY CONSTRAINTS

Comparison of Avoidance Obstacle Size vs. Length of HDD
Auger boring was initially developed to cross under two-lane roadways with an average length of 40 feet and a maximum length of 70 feet. However, with demand for longer installations increasing, the current maximum extent for a CAB installation of a 16" or 20" diameter pipeline is approximately 390 feet. Accordingly, this crossing methodology should only be considered for avoidance of obstacles of somewhat less than 390 feet in length.

4.1.3 GEOLOGICAL CONSTRAINTS

Impacted Geological Formations

An analysis of the geological characteristics along a proposed CAB alignment is a vital component of detailed engineering design. Geological characterizations and constraints which primarily affect CAB installations are summarized below:

- CAB can be used in a wide variety of soil conditions.
- However, soils with large boulders can cause problems with this methodology. Because the spoil is removed through the casing with an auger, any material encountered must be able to fit between the auger flights to be carried out. In general, the largest boulder or other obstacle that this method can handle is limited to one third of the nominal casing diameter of the pipe to be installed.
- CAB installations in sandy, cohesion-less soils can be difficult and may cause problematic settlement and voids ahead of the casing pipe as excess soil flows into the pipe. Mitigative measures must be implemented in the detailed engineering design phase to avoid this situation.
- CAB installations in rock formations are possible, but require different cutting head designs than for soil applications.

Ground Water Control

Because CAB operators and equipment function primarily below grade, ground water control is of vital importance. Ground water control characterizations and constraints which primarily affect CAB installations are summarized below:

- Dewatering is necessary whenever there is a high ground water table to facilitate bore pit operations and prevent workspace flooding. The water table elevation should be maintained at least 2 feet below the bottom of the casing pipe at all times.
- Minor water seepage or pockets of saturated soil is not a deterrent to CAB and is typically controlled through pumping.
- Larger volumes of ground water are typically controlled with one or more well points, staged deep wells, or other methods. A dewatering situation of this magnitude should be designed to prevent removing any adjacent soil that could weaken or undermine the bore pit(s), their supports, or other nearby structure.

Wetland and Waterbody Dewatering

If a CAB installation is planned to traverse beneath a wetland or waterbody, then consideration must be given to the impacts of the requisite adjacent dewatering that is necessary to successfully complete the process. Water produced from dewatering CAB pit(s) will also temporarily lower the ground water table to some degree in the adjacent avoidance obstacle, wetland, or waterbody. The impacts of this dewatering must be evaluated as a parameter in the feasibility analysis of utilizing this crossing methodology.

4.2 HORIZONTAL DIRECTIONAL DRILLING

4.2.1 PHYSICAL / TECHNICAL CONSTRAINTS

Pipe Diameter

Welded steel pipelines up to 56” in diameter have been installed utilizing HDD. Steel pipelines exceeding 56” in diameter are considered typically not feasible for HDD installation. Accordingly, HDD is a potentially feasible trenchless crossing method for the Project-proposed 16” and 20” pipelines based on existing technology.

Entry and Exit Angles

HDD operations are typically designed with entry angles between 8° and 16°, although steeper entry angles have been used where insufficient setback distance or steeply sloping ground exists for a given alignment. Exit angles are typically lower than a given entry angle, as consideration must be given to product pipe diameter, equipment necessary to transition the product pipe into the bore, and the induced stresses as the pipe is forced over the break-over location as it enters the HDD bore. Appropriate HDD bore hole entry and exit angles for steel pipelines are determined on a site specific basis during detailed engineering design. Conversely, the use of entry and exit angles beyond these minimum and maximum limits are considered not feasible for HDD installation.

Horizontal and Vertical Curvature

Vertical curvature is inherent to all HDD installations, thus site topography (e.g., entry and exit pit locations supportive of required entry and exit angles and pipe radius tolerances) and elevation (e.g., similarity between the entry and exit site elevations to minimize risk of dry bore hole conditions) are critical considerations to accommodate vertical curvature. The need for horizontal curvature, however, is dependent on the restrictions specific to a site specific crossing. Although horizontal curvature is feasible, the scope of design and construction greatly increases in complexity when horizontal curves are required. The addition of horizontal curvature also increases the stress, and therefore the risk to the product pipe. Steering in both planes is not a standard industry practice and typically leads to increased risk of HDD failure due to a variety of technical reasons. In short, there are site-specific maximum limits to the use of horizontal and vertical curves beyond which it is considered not feasible for HDD installation.

Installation Depth

The depth of cover for a given steel pipeline HDD installation is dependent on several factors. These include, but are not limited to, the following:

- Anticipated geologic conditions
- Design bending radius
- HDD installation length
- Presence of preferential bore pathways
- Presence of existing obstacles
- Ability to maintain bore stability

Of these, the most important site specific factor is the properties of the geologic conditions along the bore path and the resistance that it provides against the required installation induced bore fluid pressure necessary to remove bore hole cuttings. The appropriate HDD installation depth is determined on a site specific basis during detailed engineering design. Conversely, the use of an installation depth which notably deviates from that specified is typically considered not feasible for HDD installation.

4.2.2 PRACTICABILITY CONSTRAINTS

Drilling Fluid Make-Up Water and Source

HDD operations require a continuous source of water to support construction activities. Water sources and estimates of water required are typically generated during the detailed engineering design. To the extent a continuous water supply to a specific HDD site is unavailable or intermittent, then the feasibility of implementing an HDD at that location is diminished proportionately.

Comparison of Avoidance Obstacle Size vs. Length of HDD

The minimum and maximum length of an HDD are both directly related to the diameter of the product pipe.

- Minimum HDD Lengths: The smallest diameter steel product pipes can have HDD installations in the hundreds of feet, whereas the largest steel product pipes can have minimum HDD lengths in the thousands of feet. For this assessment, based on standard pipe radius and safety factors to accommodate drilling deviations during construction, the minimum HDD length considered feasible for the proposed 16” pipeline is 1,050 feet and 20” pipeline is 1,160 feet.

- Maximum HDD Lengths: Summarized in Table 2 are maximum HDD ranges for a range of common steel product pipes.

Table 2: HDD Maximum Installation Lengths

Product Pipe Diameter	Installation Length										
	1,000 m 3,281 ft	1,200 m 3,937 ft	1,400 m 4,593 ft	1,600 m 5,249 ft	1,800 m 5,905 ft	2,000 m 6,562 ft	2,200 m 7,218 ft	2,400 m 7,874 ft	2,600 m 8,530 ft	2,800 m 9,186 ft	3,000 m 9,842 ft
8”											
10”											
12”											
14”											
16”											
18”											
20”											
24”											
30”											
36”											
42”											
48”											

Color Coding:

Within typical capabilities of industry. Many contractors experienced in this installation length.

Zone of limited industry application. Considered feasible with an experienced contractor & favorable ground conditions.

Exceeds current capabilities of industry. Considered risky even with an experienced contractor and favorable ground conditions.

In comparing the avoidance obstacle size (length along pipeline centerline) to the minimum and maximum HDD lengths, it is necessary to balance the installation method implementation impacts, schedule, and economics with the comprehensive value of the resource to be avoided. Said differently, the avoidance obstacle should be of sufficient size and quality to warrant the increased effort, adjacent right-of-way impacts, and cost of an HDD installation. To consider an HDD installation for most or all wetland crossings is neither practicable nor prudent. Accordingly, the following feasibility guidance should be observed:

- An avoidance obstacle length of $\geq$ 400 feet is feasible for HDD installation of 16” and 20” steel product pipe.
- An avoidance obstacle length of < 400 feet should consider alternative crossing methodologies.

<u>Entry and Exit Workspace Areas</u>

Sufficient entry and exit workspace areas are necessary to successfully complete an HDD installation. Table 1 should be utilized as a feasibility guide for minimum required workspace areas. Additionally, sufficient additional temporary workspace (ATWS) is required to accommodate the pipe string to be installed in the drilled bore hole. Because the pullback typically is conducted as a single, continuous operation, the ATWS required to accommodate the pipe string is straight, contiguous (i.e., not interrupted by physical obstacles, such as roads or structures), long enough to accommodate the length of the pipe string, and situated behind and largely in line with the HDD alignment. In certain cases, two pipe strings, each approximately one-half the length of the full pipe string, may be used; however, this requires temporary suspension of the pullback operation (to weld the second pullback string to the first pullback string) before completing the pullback operation, and introduces a substantive risk of pullback operation failure.

4.2.3 GEOLOGICAL CONSTRAINTS

A comprehensive analysis of the geological characteristics along a proposed HDD alignment is a vital component of detailed engineering design. This investigative process is divided into three primary components:

- General geologic characteristics and formation origins
- Detailed soil borings
- Hydrogeology

General Geologic Characteristics and Formation Origins

It is important to have a general understanding of the geologic characteristics and formation origins along the proposed HDD alignment. Understanding the mechanism by which the site was developed, whether aeolian (airborne), colluvial (gravity), alluvial (river), lacustrine (lake), glacial, or marine (saltwater sea) depositional processes will forecast the types of materials to be expected, as well as the potential for anomalous impediments (boulders, cobble fields, buried logs, stumps, etc.) affecting HDD construction. This informational overview may not be representative in localized soil borings.

Detailed Soil Borings

Soil borings provide the most detailed data regarding geologic conditions. The sampling program for the Project was conducted as follows:

- Intervals: Borings were placed at the HDD entry and exit sites and at 1,000-foot intervals along the bore path to characterize geological conditions. The more borings conducted, the more information available for detailed engineering design.
- Locations: Borings were placed along the proposed HDD alignment, but not within 30 feet of the centerline. Borings taken near the centerline can create a path for inadvertent return of HDD drilling fluid.
- Depth: Borings were taken down to 20 feet below the proposed HDD drill path elevation or until the auger encountered refusal. In addition, bedrock cores were taken from 20% of samples where bedrock was encountered.

Hydrogeology

The main hydrogeological issue relates to the presence of artesian conditions. These are typically encountered where impermeable clay or shale bedrock layers overlie permeable water-bearing sands-gravels or sandstone bedrock at depth, forming a confining aquifer. When intersected by the pilot hole, such aquifers may be large-volume sources of groundwater under pressure. As such, HDD mud quality and fluid management problems may result. This situation is typically identified during the soil boring process and potentially mitigated during detailed engineering design. Mitigative measures include casing or cementing off the confined aquifer zone.

Geological Feasibility Analysis

Soil boring profiles are typically mapped spatially along the proposed HDD alignment. This overlay allows the design engineers to evaluate which specific geologic formations the bore hole will penetrate. Examination of these impacted formations determine the feasibility of segments along the bore hole pathway and collectively the overall HDD. The evaluation criteria summarized in Table 3 is typically utilized in the engineering evaluation process.

Table 3: HDD Geological Feasibility Analysis Criteria

Earth Material Type	Sieve Analysis Gravel %	HDD Feasibility Determination
Very soft to hard clay	N/A	Good to Excellent
Very loose to very dense sand with or without gravel traces	0% to 30%	Good to Excellent
Very loose to very dense gravelly sand	30% to 50%	Marginally Acceptable
Very loose to very dense sandy gravel	50% to 85%	Questionable
Very loose to very dense gravel	85% to 100%	Unacceptable
Rock	N/A	Excellent to Unacceptable

Notes: Rock characteristics that affect HDD vary greatly including, but not limited to:
- Hardness
- Degree of weathering
- Over burden layer
- Strength
- Degree of fracturing
- Continuousness

5.0 TECHNICAL FEASIBILITY ANALYSIS

5.1 WETLAND-SPECIFIC TRENCHLESS FEASIBILITY ANALYSIS

As presented in the Alternatives Analysis (Attachment 11, Enclosure E, Part 3), SPLP designed the proposed Project to be co-located (abut and overlap) with existing SPLP pipeline right-of-way and co-located (abut) with other existing utility rights-of-way, adopt major route alternatives to avoid and minimize obvious impacts on other (non-wetland) significant environmental resources and communities, and adopt further quantitative and qualitative impact avoidance and minimization measures in a concerted and successful effort to avoid, minimize, and mitigate site-specific and cumulative impacts to wetlands, as well as waterbodies and other (non-wetland) environmental resources, to the maximum extent practicable. This process resulted in the avoidance, minimization, and mitigation of adverse impacts to wetlands and waterbodies from the Project as a whole by investigating successively more site-specific information regarding potential environmental impacts, and developing alternative routing, locations, and designs to avoid and minimize those potential environmental impacts.

Following establishment of the Baseline Route Alternative and associated 200-foot-wide survey corridor (Attachment 11, Enclosure E, Part 3, Section 3.4), SPLP conducted the integrated evaluation of the route via the Management of Change (MOC) Process. This MOC Process considered opportunities to change the Baseline Route Alternative to further avoid and minimize potential environmental impacts, while simultaneously considering potential construction and operational constraints presented by affected landowners, existing land uses, infrastructure obstacles, and other factors affecting use of existing technology, cost, and logistics.

As presented in the Alternatives Analysis (Attachment 11, Enclosure E, Part 3, Section 5.0), the MOC Process was initiated on a site-specific basis as opportunities or constraints were raised by an Integrated Project Team, consisting of representatives from SPLP project management, engineering, land/right-of-way, and environmental specialists. The MOC Process engaged and solicited input from each member of the Integrated Project Team on a given alternative minor route variation or trenchless construction method (i.e., conventional bore or HDD) under consideration. With the approval from each member of the Integrated Project Team, including environmental, each adopted change was determined to avoid significant impacts on other (non-wetland) environmental resources, to avoid and minimize impacts on wetlands (as well as waterbodies) to the maximum extent practicable, and to be practicable (feasible, constructible, operable) with regard to current technology, cost, and logistics.

Implementation of this MOC Process resulted in the evaluation and adoption of minor route variations and trenchless crossings to avoid or minimize: 1) significant impacts on other (non-wetland) environmental resources, 2) permanent palustrine forested (PFO) wetland cover type conversion, and 3) remaining temporary and minor site-specific impacts on wetlands and waterbodies.

In response to PADEP comments, wetland (site)-specific trenchless feasibility analysis embodied in the MOC process is presented in the Alternatives Analysis (Attachment 11, Enclosure E, Part 3). This analysis addresses each crossing area (CA) that contains an individual or group of proximate individual wetland (and waterbody) resources that are proposed for open trench pipeline installation; crossing areas determined to be suitable, practicable, and proposed for trenchless construction methods (e.g., conventional bore and HDD) to entirely avoid surface impacts to wetland and other (non-wetland) sensitive environmental resources are presented in the Alternatives Analysis (Attachment 11, Enclosure E, Part 3, Section 5.2). Each crossing area represents a reasonable area of analysis for the consideration of alternative construction techniques (e.g., conventional bore, HDD, and trenching) potentially available based on current technology, cost, and logistics. As presented in the Alternatives Analysis (Attachment 11, Enclosure E, Part 3, Appendix D), the Project contains a total of 349 crossing areas, encompassing numerous wetland and waterbody resource crossings initially proposed for open trench pipeline installation. The Trenchless Construction Feasibility Analysis Matrix (Table 4) herein addresses each of the CAs, as well as additional CAs that address PADEP comments regarding trenchless crossing areas.

5.2 STREAM-SPECIFIC TRENCHLESS FEASIBILITY ANALYSIS

As requested by PADEP in it is technical deficiency comments, SPLP evaluated a total of 16 site-specific areas of proposed stream crossings not associated with any wetland crossing area (each designated with a unique Stream Area [SA] identification number). Specifically, SPLP evaluated each SA with regard to PADEP's site-specific comments regarding use of new or the potential extension of the length of currently proposed trenchless construction techniques, work space reconfiguration, or other actions to further avoid or minimize impacts on streams, which is provided in the Alternatives Analysis (Attachment 11, Enclosure E, Part 3, Appendix E).

For each designated SA wherein PADEP commented regarding use of new or the potential extension of the length of currently proposed trenchless construction techniques (12 of the 16 stream-specific areas), a stream-specific trenchless feasibility analysis is presented in the matrix (Table 4).

5.3 TRENCHLESS FEASIBILITY ANALYSIS MATRIX

For each CA and SA, a wetland or stream (site)-specific trenchless feasibility analysis was conducted and is presented in the form of a trenchless feasibility analysis matrix (Table 4). For each CA and SA, the trenchless feasibility analysis matrix assesses the technical feasibility of conducting a CAB or HDD construction technique to cross the subject wetland and/or stream resources in consideration of existing site-specific conditions. Specifically for each CA and SA, the matrix (Table 4) presents the CA or SA identification (ID) number, list of wetlands and streams encompassed within the CA or SA, and the minimum length of the CA or SA (encompassing the subject wetlands and/or streams).

For each CA and SA, the CAB technical feasibility analysis (Table 4):

- identifies the estimated length of a CAB needed to cross the CA or SA resources considering site-specific conditions;
- assesses whether the length of the bore is within the technical capabilities of CAB construction technology (i.e., not greater than 390 feet in length);
- assesses whether existing topography is conducive to supporting CAB construction technology;
- assesses whether sufficient additional temporary work space (ATWS) is available in proximity to the CAB to support bore pit excavation, soil storage, equipment, personnel, and associated CAB activities in a safe and prudent manner;
- assesses whether sufficient access is available in proximity to the CAB to support equipment and personnel transport throughout the duration of CAB construction in a safe and prudent manner; and
- based on the above evaluation criteria, assesses whether use of the CAB construction technology is technically feasible.

For each CA and SA, the HDD technical feasibility analysis (Table 4):

- identifies the estimated length of an HDD needed to cross the CA or SA resources considering site-specific conditions, using a minimum HDD length of 1,160 feet;
- assesses whether existing topography is conducive to supporting HDD construction technology;
- assesses whether the elevation change between an HDD entry site and exit site is conducive to supporting HDD construction technology (e.g., similarity between the entry and exit site elevations to minimize risk of dry bore hole conditions);
- assesses whether the required HDD path geometry (vertical curvature) is feasible (e.g., entry and exit pit locations supportive of required entry and exit angles and pipe radius tolerances);
- assesses whether sufficient pipe string pullback area and ATWS is available in proximity to the HDD to support entry and exit sites, pipe string pullback, equipment, personnel, and associated HDD activities in a safe and prudent manner;
- assesses whether sufficient access is available in proximity to the HDD to support equipment and personnel transport throughout the duration of HDD construction in a safe and prudent manner; and
- based on the above evaluation criteria, assesses whether use of the HDD construction technology is technically feasible.

For each CAB and HDD technical feasibility criterion evaluated, a determination of technical feasibility is noted based on the analysis of existing information. Determinations include:

- Yes ("Y"), meaning is technically feasible;
- No ("N"), meaning is not technically feasible; or
- Potentially ("P"), meaning is potentially technically feasible, but is considered marginally feasible considering site-specific conditions, current technology, and logistics, and/or requires additional site-specific information (e.g., bore profile) to confirm technical feasibility, based on existing information.

In the event any of the evaluation criteria fail ("N") the technical feasibility analysis, then the use of the subject trenchless construction technology is also determined to be not technically feasible. In the event none of the evaluation criteria fail ("N"), but any of the evaluation criteria are determined to be potentially technically feasible ("P"), then the use of the subject trenchless construction technology is also determined to be potentially technically feasible. Only in the event all of the evaluation criteria pass ("Y") is the use of the subject trenchless construction technology also determined to be technically feasible.

In addition to the CAB and HDD technical feasibility analysis, the matrix (Table 4) presents the estimated minimum cost for use of the CAB and HDD construction technology at each CA and SA. The estimated minimum construction cost is calculated for each case in which CAB or HDD was determined to be technically feasible ("Y") or potentially technically feasible ("P"). The estimated minimum construction cost is calculated for the 20-inch-diameter pipeline only, and includes: 1) the average cost per linear foot of pipeline (for the estimated length of the CAB or HDD crossing), and 2) the "move around" cost, which entails the movement (halting, loading, transport, and unloading) of all construction equipment and personnel around the CAB or HDD crossing (entry and exit sites) for the duration of pipeline construction. The cost for the 16-inch-diameter pipeline is not calculated, but would include a similar cost per linear foot of pipeline (about 6% less than 20-inch-diameter pipeline cost) and the "move around" cost. Where applicable, this estimated minimum cost information is further evaluated in the wetland and stream (site)-specific practicable alternatives analyses presented in the Alternatives Analysis (Attachment 11, Enclosure E, Part 3) to assess the practicability of use of the CAB and HDD construction technology at each CA and SA.

5.4 SUMMARY OF TRENCHLESS FEASIBILITY ANALYSIS RESULTS

As detailed in the CAB and HDD technical feasibility analysis matrix (Table 4), a total 393 areas (381 CAs and 12 SAs) were evaluated for the technical feasibility of conducting CAB and HDD construction technology. This includes the CAs discussed in the Alternatives Analysis (Attachment 11, Enclosure E, Part 3) and additional CAs assessed where

Based on this analysis, use of the CAB construction technology was determined to be not technically feasible ("N") for 357 of the 393 areas. Use of the CAB construction technology was determined to be:

- technically feasible ("Y") for eight (8) CAs (CA-335, CA-346, CA-352, CA-356, CA-379, CA-380, CA-394, CA-395, CA-398);
- technically feasible ("Y") for one (1) SA (SA-010, which is in an area already proposed for use of the CAB construction technology);
- potentially technically feasible ("P") for 26 CAs (CA-004, CA-036, CA-139, CA-208, CA-209, CA-212, CA-213, CA-218, CA-237, CA-241, CA-244, CA-282, CA-290, CA-294, CA-301, CA-302, CA-303, CA-304, CA-309, CA-366, CA-367, CA-372, CA-411, CA-413, CA-435, and CA-436); and

- potentially technically feasible (“P”) for one (1) SA (SA-011).

Based on this analysis, use of the HDD construction technology was determined to be not technically feasible (“N”) for 380 of the 393 areas. Use of the CAB construction technology was determined to be:

- technically feasible (“Y”) for six (6) CAs (CA-009, CA-016, CA-075, CA-075, CA-196, and CA-411, all of which are in areas proposed for use of the HDD construction technology);
- technically feasible (“Y”) for two (2) SAs (SA-008 and SA-015, both of which are in areas proposed for use of the HDD construction technology);
- potentially technically feasible (“P”) for three (3) CAs (CA-200; CA-352, which is proposed for HDD construction technology but requires travel lane and pullback string access across the wetlands and stream in the CA; and CA-353); and
- potentially technically feasible (“P”) for two (2) SAs (SA-010, which is proposed for CAB construction technology, and SA-011).

Table 4: Trenchless Construction Feasibility Analysis Matrix

TABLE 4
Trenchless Construction Feasibility Analysis Matrix
Pennsylvania Pipeline Project

				Conventional Auger Bore Construction Technology						Horizontal Directional Drill Construction Technology								
Crossing Area ID	Wetlands	Streams	Minimum Length of Crossing Area (feet)	Estimated Bore Length (feet)	Bore Crossing Length less than 390'	Topography Conducive to Bore	Sufficient ATWS Available	Sufficient Access (Travel Lane Required)	Bore Technically Feasible	Estimated HDD Length	Topography Conducive to HDD	Elevation Change Conducive to HDD	HDD is Geometrically Feasible	Sufficient HDD Pullback and ATWS Available	Sufficient Access (Travel Lane Required)2	HDD Technically Feasible	*Minimum Bore Cost*	*Minimum HDD Cost*
CA-002	T1		130	150	Y	Y	N	N	N	1300	N	N	N	N	N	N	*n/a*	*n/a*
CA-003	W42		40	60	Y	Y	N	N	N	1160	N	N	N	N	N	N	*n/a*	*n/a*
CA-004	A20A		70	90	Y	Y	P	Y	P	1160	N	N	N	N	N	N	*$ 496,627*	*n/a*
CA-005	T2		22	125	Y	N	N	N	N	1300	N	N	N	N	N	N	*n/a*	*n/a*
CA-006	W5	S8	30	50	Y	N	N	Y	N	1600	N	N	N	N	N	N	*n/a*	*n/a*
CA-008	W8, W9	S14, S15	50	70	Y	N	N	Y	N	1160	N	p	P	N	Y	N	*n/a*	*n/a*
CA-009	W43	S131, S132	735	750	N				N	725	Y	Y	Y	Y	Y	Y	*n/a*	*$ 1,864,181*
CA-010	W204		50	70	Y	N	N	N	N	1160	N	N	Y	N	N	N	*n/a*	*n/a*
CA-011	W44	S139	45	65	Y	Y	N	N	N	1200	N	N	N	N	N	N	*n/a*	*n/a*
CA-012	W12	S19, S20	40	60	Y	N	N	N	N	1160	N	N	N	N	N	N	*n/a*	*n/a*
CA-013	W37		100	120	Y	N	N	N	N	1160	Y	Y	N	N	N	N	*n/a*	*n/a*
CA-014	W13	S22	90	110	Y	Y	N	N	N	1160	N	N	N	N	N	N	*n/a*	*n/a*
CA-015	W14		25	45	Y	Y	N	N	N	1160	N	N	N	N	N	N	*n/a*	*n/a*
CA-016	W38		40	1100	N				N	1176	Y	Y	Y	Y	Y	Y	*n/a*	*$ 2,827,841*
CA-017	W62	S143, S219	130	150	Y	N	N	N	N	2600	Y	N	Y	N	N	N	*n/a*	*n/a*
CA-018	W63		285	305	Y	Y	N	N	N	1300	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-019	W46-1		80	100	Y	P	P	N	N	1500	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-020	CS1	S-CS1	80	100	Y	N	N	N	N	1160	N	N	N	N	N	N	*n/a*	*n/a*
CA-024	SZ6		90	110	Y	N	N	N	N	1600	N	N	N	N	N	N	*n/a*	*n/a*
CA-025	W48PEM-1	S173, S174	30	50	Y	N	N	N	N	1300	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-026	W49	S175	80	100	Y	Y	N	N	N	1200	p	p	N	N	N	N	*n/a*	*n/a*
CA-028	W71	S235	15	35	Y	Y	P	N	N	1500	Y	P	Y	P	N	N	*n/a*	*n/a*
CA-029	W52		40	60	Y	Y	N	N	N	1500	N	N	N	N	N	N	*n/a*	*n/a*
CA-031	W55, W56	S189, S190, S191	530	550	N				N	1200	N	N	N	N	N	N	*n/a*	*n/a*
CA-032	W54	S188	30	50	Y	N	N	N	N	1160	N	N	N	N	N	N	*n/a*	*n/a*
CA-033	W58		20	40	Y	N	N	N	N	1600	N	N	N	N	N	N	*n/a*	*n/a*
CA-034	W57		20	40	Y	N	N	N	N	1600	N	N	N	N	N	N	*n/a*	*n/a*
CA-035	W69, W70		310	330	Y	Y	N	N	N	1160	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-036	W60	S210	40	60	Y	Y	P	Y	P	1300	Y	Y	Y	N	P	N	*$ 436,104*	*n/a*
CA-037	Pond-XX16	S204, S205	150	170	Y	N	N	N	N	1300	N	N	N	N	p	N	*n/a*	*n/a*
CA-038	P25	S-P41, S-P42	120	115	Y	Y	N	N	N	1700	Y	N	Y	N	N	N	*n/a*	*n/a*
CA-039	P28	S-P43	270	270	Y	Y	N	N	N	1900	Y	N	Y	N	N	N	*n/a*	*n/a*
CA-040	P29	S-P44, S-P45	60	60	Y	Y	N	P	N	1900	Y	N	Y	N	N	N	*n/a*	*n/a*
CA-041	P30		105	105	Y	Y	N	P	N	1900	Y	N	Y	N	N	N	*n/a*	*n/a*
CA-042	P33, P35	S-P49, S-P50	300	90	Y	P	N	N	N	2400	N	N	N	N	p	N	*n/a*	*n/a*
CA-045	M78	S-M105, S-M106	55	55	Y	N	N	N	N	2100	Y	N	Y	N	N	N	*n/a*	*n/a*
CA-046	M77		25	25	Y	P	N	N	N	2100	Y	P	Y	N	N	N	*n/a*	*n/a*
CA-049	M75	S-M102	195	195	Y	N	N	N	N	1700	Y	N	Y	N	N	N	*n/a*	*n/a*
CA-050	M74, P26, P27	S-P36	210	280	Y	Y	N	N	N	1600	N	N	N	N	N	N	*n/a*	*n/a*

TABLE 4
Trenchless Construction Feasibility Analysis Matrix
Pennsylvania Pipeline Project

Crossing Area ID	Wetlands	Streams	Minimum Length of Crossing Area (feet)	Conventional Auger Bore Construction Technology: Estimated Bore Length (feet)	Bore Crossing Length less than 390'	Topography Conducive to Bore	Sufficient ATWS Available	Sufficient Access (Travel Lane Required)	Bore Technically Feasible	Horizontal Directional Drill Construction Technology: Estimated HDD Length	Topography Conducive to HDD	Elevation Change Conducive to HDD	HDD is Geometrically Feasible	Sufficient HDD Pullback and ATWS Available	Sufficient Access (Travel Lane Required)2	HDD Technically Feasible	*Minimum Bore Cost*	*Minimum HDD Cost*
CA-051	M73		110	220	Y	Y	P	N	N	1200	Y	P	Y	N	N	N	*n/a*	*n/a*
CA-052	M72		60	115	Y	Y	P	N	N	1200	Y	P	Y	N	N	N	*n/a*	*n/a*
CA-053	M71	S-M101	80	80	Y	Y	N	N	N	1300	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-054	M69	S-M99, S-M100	55	55	Y	N	N	N	N	1300	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-055	N81		90	110	Y	N	N	N	N	2600	N	N	N	N	N	N	*n/a*	*n/a*
CA-056	N82	S-N119	150	210	Y	N	N	N	N	2200	Y	N	Y	N	N	N	*n/a*	*n/a*
CA-057	M67	S-M97	50	50	Y	Y	P	N	N	1300	Y	N	P	N	N	N	*n/a*	*n/a*
CA-059	P22	S-P31, S-P32	70	80	Y	N	Y	Y	N	5500	N	N	N	N	Y	N	*n/a*	*n/a*
CA-060	P18, P20	S-P27	50	60	Y	N	N	N	N	1300	N	N	N	N	N	N	*n/a*	*n/a*
CA-061	N80		90	110	Y	P	N	N	N	2100	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-062	N79	S-N113, S-N114	230	240	Y	N	N	N	N	2100	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-063	N78	S-N112	95	95	Y	P	N	N	N	1400	Y	P	Y	N	N	N	*n/a*	*n/a*
CA-064	N76	S-N107, S-N108	120	180	Y	P	N	N	N	1500	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-065	N72, N73, N74	S-N104	65	150	Y	N	N	Y	N	1600	Y	N	Y	N	N	N	*n/a*	*n/a*
CA-066	P16		70	70	Y	P	N	N	N	1300	N	N	N	N	N	N	*n/a*	*n/a*
CA-067	P17		40	40	Y	Y	N	N	N	1600	N	N	Y	N	N	N	*n/a*	*n/a*
CA-068	P15		75	100	Y	N	N	N	N	1600	N	N	Y	N	N	N	*n/a*	*n/a*
CA-069	P14	S-P20	30	50	Y	N	N	Y	N	1400	N	N	N	N	Y	N	*n/a*	*n/a*
CA-070	P5	S-P10, S-P11, S-P12, S-13	260	400	N				N	3900	N	P	Y	N	N	N	*n/a*	*n/a*
CA-073	Q92		50	70	Y	Y	N	N	N	1160	Y	Y	N	N	N	N	*n/a*	*n/a*
CA-074	N28	S-N44	260	280	Y	N	N	N	N	1800	Y	Y	P	N	P	N	*n/a*	*n/a*
CA-075	J51	S-J53, S-J54	90	110	Y	N	N	N	N	1900	Y	Y	Y	Y	Y	Y	*n/a*	*$ 4,374,827*
CA-076	P1		120	140	Y	N	N	N	N	1900	Y	Y	Y	Y	Y	Y	*n/a*	*$ 4,374,827*
CA-078	CC30	S-P5	30	30	Y	P	N	N	N	1200	Y	Y	P	N	N	N	*n/a*	*n/a*
CA-079	N71	S-N103	70	80	Y	N	N	N	N	1200	N	N	N	N	p	N	*n/a*	*n/a*
CA-080	N70	S-N101	60	70	Y	N	N	N	N	1500	Y	P	Y	N	N	N	*n/a*	*n/a*
CA-081	N69		40	50	Y	P	N	N	N	1160	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-082	N65	S-N96, S-N99	45	75	Y	N	N	P	N	1700	P	P	Y	N	Y	N	*n/a*	*n/a*
CA-084	N60	S-N93	50	60	Y	N	N	N	N	1400	N	N	N	N	N	N	*n/a*	*n/a*
CA-085	O74	S-O111	40	60	Y	N	N	N	N	1160	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-086	O72	S-O102, S-O103	50	70	Y	N	N	Y	N	1160	P	P	P	N	Y	N	*n/a*	*n/a*
CA-088	N55	S-N84	340	360	Y	N	N	N	N	1900	N	N	N	N	p	N	*n/a*	*n/a*
CA-089	N54		120	150	Y	N	N	N	N	1900	N	N	Y	N	N	N	*n/a*	*n/a*
CA-090	N53	S-N83	50	50	Y	N	N	N	N	1900	N	N	N	N	N	N	*n/a*	*n/a*
CA-091	N52	S-N81	125	250	Y	N	N	N	N	1900	N	N	N	N	N	N	*n/a*	*n/a*
CA-092	N50	S-N78	50	50	Y	N	N	N	N	2600	N	N	N	N	N	N	*n/a*	*n/a*
CA-093	N49		55	55	Y	N	N	N	N	2600	N	N	N	N	N	N	*n/a*	*n/a*

TABLE 4
Trenchless Construction Feasibility Analysis Matrix
Pennsylvania Pipeline Project

				Conventional Auger Bore Construction Technology						Horizontal Directional Drill Construction Technology								
Crossing Area ID	Wetlands	Streams	Minimum Length of Crossing Area (feet)	Estimated Bore Length (feet)	Bore Crossing Length less than 390'	Topography Conducive to Bore	Sufficient ATWS Available	Sufficient Access (Travel Lane Required)	Bore Technically Feasible	Estimated HDD Length	Topography Conducive to HDD	Elevation Change Conducive to HDD	HDD is Geometrically Feasible	Sufficient HDD Pullback and ATWS Available	Sufficient Access (Travel Lane Required)2	HDD Technically Feasible	*Minimum Bore Cost*	*Minimum HDD Cost*
CA-094	N45, N47	S-N77	180	150	Y	N	N	N	N	2600	N	N	Y	N	N	N	*n/a*	*n/a*
CA-096	O71		150	170	Y	N	N	N	N	1800	N	N	N	N	N	N	*n/a*	*n/a*
CA-097	O70	S-O100, S-O101	80	80	Y	Y	N	N	N	1800	N	N	N	N	N	N	*n/a*	*n/a*
CA-098	O68		20	30	Y	Y	N	N	N	1800	Y	Y	N	N	N	N	*n/a*	*n/a*
CA-099	O57		130	150	Y	Y	N	Y	N	1500	Y	Y	N	N	N	N	*n/a*	*n/a*
CA-100	O58, O59	S-O84, S-O86	170	80	Y	P	N	N	N	3900	N	N	Y	N	N	N	*n/a*	*n/a*
CA-101	O60	S-O87, S-O88, S-O89, S-O90	385	420	N				N	3900	N	N	Y	N	N	N	*n/a*	*n/a*
CA-102	O61	S-O91	20	40	Y	P	N	N	N	3900	N	N	Y	N	N	N	*n/a*	*n/a*
CA-103	O62	S-O92	25	45	Y	P	N	N	N	3900	N	N	Y	N	N	N	*n/a*	*n/a*
CA-104	O63, O66	S-O94, S-O96	110	120	Y	Y	N	N	N	2500	Y	N	N	N	N	N	*n/a*	*n/a*
CA-105	N42, N43	S-N76	70	70	Y	N	N	N	N	2500	N	N	N	N	N	N	*n/a*	*n/a*
CA-106	N41	S-N75	50	50	Y	Y	P	N	N	1900	Y	Y	N	N	N	N	*n/a*	*n/a*
CA-107	N39	S-N73	50	50	Y	Y	N	N	N	1200	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-108	N38	S-N71	65	130	Y	N	N	P	N	1800	N	N	N	N	N	N	*n/a*	*n/a*
CA-109	N37	S-N69	60	90	Y	N	N	P	N	1800	N	N	N	N	N	N	*n/a*	*n/a*
CA-110	Pond-N6	S-N68	60	200	Y	N	N	P	N	1800	N	N	N	N	N	N	*n/a*	*n/a*
CA-111	O55	S-O78	100	100	Y	P	N	P	N	1200	N	N	N	N	P	N	*n/a*	*n/a*
CA-112	O51		30	130	Y	Y	N	P	N	1400	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-113	O48, Pond-O6	S-O66	100	130	Y	Y	N	P	N	1400	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-114	O46	S-O63, S-O64	700	700	N				N	1500	Y	P	Y	N	P	N	*n/a*	*n/a*
CA-115	W134, O52	S-O69, S-O70	170	180	Y	N	N	N	N	1500	Y	N	P	N	P	N	*n/a*	*n/a*
CA-116	W135		60	60	Y	P	N	P	N	1700	p	p	N	N	p	N	*n/a*	*n/a*
CA-117	W136	S-O73, S-O75	120	140	Y	P	N	P	N	1200	N	P	Y	N	P	N	*n/a*	*n/a*
CA-118	W137	S-O74	210	40	Y	N	N	N	N	1200	N	P	Y	N	P	N	*n/a*	*n/a*
CA-119	W139	S-N63	35	35	Y	Y	N	P	N	1600	N	N	Y	N	P	N	*n/a*	*n/a*
CA-120	W140	S-N62	90	90	Y	Y	N	P	N	1600	N	N	Y	N	P	N	*n/a*	*n/a*
CA-121	N33	S-N53, S-N54	250	250	Y	N	N	P	N	2000	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-122	N30, N31	S-N51, S-N52	290	350	Y	N	N	P	N	3000	N	N	Y	N	P	N	*n/a*	*n/a*
CA-123	N29	S-N45	50	90	Y	N	N	P	N	2000	N	N	N	N	P	N	*n/a*	*n/a*
CA-127	O27	S-O40	250	270	Y	Y	N	P	N	2800	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-128	O25		130	150	Y	Y	N	P	N	2800	Y	Y	Y	N	p	N	*n/a*	*n/a*
CA-129	O24		100	120	Y	P	N	P	N	2800	P	P	Y	N	P	N	*n/a*	*n/a*
CA-130	O23	S-O38	125	190	Y	N	N	P	N	1400	Y	Y	Y	n	p	N	*n/a*	*n/a*

TABLE 4
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Pennsylvania Pipeline Project

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Crossing Area ID	Wetlands	Streams	Minimum Length of Crossing Area (feet)	Estimated Bore Length (feet)	Bore Crossing Length less than 390'	Topography Conducive to Bore	Sufficient ATWS Available	Sufficient Access (Travel Lane Required)	Bore Technically Feasible	Estimated HDD Length	Topography Conducive to HDD	Elevation Change Conducive to HDD	HDD is Geometrically Feasible	Sufficient HDD Pullback and ATWS Available	Sufficient Access (Travel Lane Required)2	HDD Technically Feasible	*Minimum Bore Cost*	*Minimum HDD Cost*
CA-131	O21		160	200	Y	Y	N	P	N	1400	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-132	O20	S-O37	120	130	Y	N	N	p	N	2300	P	y	N	N	P	N	*n/a*	*n/a*
CA-133	O42	S-O56	240	260	Y	N	N	P	N	1500	P	Y	Y	N	P	N	*n/a*	*n/a*
CA-134	O37, O16	S-O30, S-O31, S-O45, S-O48	1100	1200	N				N	3900	N	N	N	N	P	N	*n/a*	*n/a*
CA-136	CC6, CC7	S-CC4, S-CC5, S-CC6	280	300	Y	N	N	P	N	1900	Y	N	Y	N	P	N	*n/a*	*n/a*
CA-137	CC20, CC21		225	245	Y	N	N	P	N	4200	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-138	CC13, CC15, CC16, C18, CC19		620	660	N				N	4200	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-139	CC12		220	240	Y	Y	N	P	N	4200	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-140	CC4	S-CC3	205	550	N				N	4200	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-141	CC2		50	70	Y	Y	N	N	N	4200	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-142	O15		100	120	Y	Y	N	P	N	1200	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-143	O12	S-O21, S-O23	365	395	N				N	3000	N	N	N	N	p	N	*n/a*	*n/a*
CA-144	O9, O10	S-O18, S-O19, S-O20	490	510	N				N	3100	N	N	Y	N	P	N	*n/a*	*n/a*
CA-145	O8		480	500	N				N	3100	N	N	Y	N	P	N	*n/a*	*n/a*
CA-147	N2	S-N4	50	70	Y	Y	N	P	N	1900	N	N	Y	N	P	N	*n/a*	*n/a*
CA-148	N4	S-N10	220	230	Y	Y	N	P	N	1800	N	Y	Y	N	P	N	*n/a*	*n/a*
CA-149	N5, N6	S-N13, S-N14	120	150	Y	N	N	P	N	1800	N	Y	Y	N	P	N	*n/a*	*n/a*
CA-152	N17	S-N33	210	230	Y	N	N	P	N	1700	Y	N	Y	N	P	N	*n/a*	*n/a*
CA-153	N15	S-N29, S-N30	140	160	Y	N	N	P	N	2700	N	N	N	N	N	N	*n/a*	*n/a*
CA-154	N14		250	270	Y	N	N	N	N	2700	N	N	N	N	N	N	*n/a*	*n/a*
CA-155	N12	S-N25, S-N26, S-N27, S-N28	405	250	Y	N	N	P	N	2700	N	N	N	N	N	N	*n/a*	*n/a*
CA-156	N11		30	50	Y	N	N	P	N	2600	N	N	N	N	N	N	*n/a*	*n/a*
CA-157	N10	S-N21, S-N22	90	110	Y	N	N	P	N	2600	N	N	N	N	N	N	*n/a*	*n/a*
CA-158	N9		150	170	Y	Y	N	P	N	2600	N	N	N	N	N	N	*n/a*	*n/a*
CA-159	N8	S-N18	150	170	Y	N	N	N	N	2600	N	N	N	N	N	N	*n/a*	*n/a*
CA-160	O6		120	135	Y	Y	N	P	N	2000	Y	N	Y	N	P	N	*n/a*	*n/a*
CA-161	O5	S-O11, S-O12	110	130	Y	P	N	P	N	2000	Y	N	Y	N	P	N	*n/a*	*n/a*
CA-162	O4	S-O7, S-O8, S-O9	120	140	Y	N	N	P	N	1500	P	Y	N	N	P	N	*n/a*	*n/a*

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Pennsylvania Pipeline Project

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CA-163	O3	S-O6	60	70	Y	N	N	P	N	1500	P	Y	N	N	P	N	*n/a*	*n/a*
CA-164	Pond-O1		160	180	Y	N	N	n	N	1500	P	Y	N	N	P	N	*n/a*	*n/a*
CA-165	O2	S-O4, S-O5	690	730	N				N	1200	p	p	p	N	p	N	*n/a*	*n/a*
CA-166	O1		50	70	Y	Y	N	P	N	1200	p	p	p	N	P	N	*n/a*	*n/a*
CA-167	K27		65	90	Y	Y	N	P	N	1160	p	p	N	N	p	N	*n/a*	*n/a*
CA-168	K28	S-K25	230	250	Y	Y	N	P	N	3500	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-169	K30	S-K27, S-K28, S-K29, S-K30, S-K31	220	240	Y	Y	N	P	N	3500	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-170	BB148	S-BB117	30	50	Y	Y	N	P	N	1160	N	N	N	N	P	N	*n/a*	*n/a*
CA-171	BB141, BB142, BB144, BB145	S-BB114	400	420	N				N	1160	N	N	N	N	P	N	*n/a*	*n/a*
CA-172	BB147	S-BB116	40	100	Y	Y	N	P	N	1160	N	N	N	N	P	N	*n/a*	*n/a*
CA-173	BB146		30	150	Y	Y	N	P	N	1160	N	N	N	N	P	N	*n/a*	*n/a*
CA-174	M61	S-M87, S-M90, S-Q57	250	275	Y	Y	N	P	N	1200	N	N	N	N	P	N	*n/a*	*n/a*
CA-175	L66		25	45	Y	Y	N	Y	N	1160	N	N	N	N	P	N	*n/a*	*n/a*
CA-177	M60		60	80	Y	Y	N	P	N	1800	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-178	BB67	S-M83, S-BB53	40	60	Y	Y	N	P	N	1800	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-179	L64	S-M84, S-BB54	360	170	Y	Y	N	P	N	1800	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-180	L63		220	240	Y	N	N	P	N	1800	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-183	Q65		30	350	Y	Y	N	P	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-185	BB111, L70		181	350	Y	Y	N	P	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-186	L61	S-L84	41	65	Y	Y	N	P	N	1500	N	P	P	N	P	N	*n/a*	*n/a*
CA-187	M57	S-M80	15	35	Y	Y	N	P	N	1700	y	y	N	N	p	N	*n/a*	*n/a*
CA-188	Q52		3	25	Y	Y	N	P	N	1700	y	y	N	N	p	N	*n/a*	*n/a*
CA-189	M56		33	250	Y	Y	Y	P	P	1700	Y	Y	Y	N	P	N	*$ 819,416*	*n/a*
CA-190	M55	S-M78	177	200	Y	N	Y	P	N	1700	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-192	Q54		60	70	Y	N	N	N	N	1350	N	N	N	N	N	N	*n/a*	*n/a*
CA-193	Q56		100	110	Y	N	N	N	N	1350	N	N	N	N	N	N	*n/a*	*n/a*
CA-194	Q57, BB60	S-BB49, S-KP1	350	380	Y	Y	N	P	N	1350	N	N	N	N	n	N	*n/a*	*n/a*
CA-195	BB59		150	170	Y	N	N	N	N	1350	N	N	N	N	N	N	*n/a*	*n/a*
CA-196	BB159		15	35	Y	N	N	N	N	2100	Y	Y	Y	Y	Y	Y	*n/a*	*$ 4,802,171*
CA-198	BB56		40	60	Y	N	N	N	N	1160	N	N	N	N	N	N	*n/a*	*n/a*
CA-199	BB52		80	110	Y	Y	N	P	N	1160	p	p	n	p	p	N	*n/a*	*n/a*
CA-200	BB50, BB51	S-BB44	287	310	Y	N	N	P	N	1160	P	Y	P	P	P	P	*n/a*	*$ 2,793,654*
CA-201	Q58		13	35	Y	Y	N	P	N	1400	Y	Y	N	N	P	N	*n/a*	*n/a*
CA-202	BB124	S-BB91	850	1000	N				N	4800	N	N	N	N	N	N	*n/a*	*n/a*
CA-204	L54	S-L72	305	1300	N				N	4800	N	N	N	N	N	N	*n/a*	*n/a*

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Pennsylvania Pipeline Project

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CA-205	L46, L48	S-BB96, S-L69	180	200	Y	Y	N	P	N	1160	Y	Y	N	N	P	N	*n/a*	*n/a*
CA-206	L44		38	80	Y	Y	N	P	N	1160	N	N	N	N	p	N	*n/a*	*n/a*
CA-207	L43		53	150	Y	Y	N	P	N	1160	N	N	N	N	N	N	*n/a*	*n/a*
CA-208	L42		115	160	Y	Y	Y	P	P	1160	N	N	N	N	N	N	*$ 637,847*	*n/a*
CA-209	L40		30	160	Y	Y	Y	P	P	1160	N	N	N	N	N	N	*$ 637,847*	*n/a*
CA-212	L35		18	160	Y	Y	Y	P	P	1160	Y	Y	Y	N	P	N	*$ 637,847*	*n/a*
CA-213	M23	S-L58	60	160	Y	Y	Y	P	P	1160	Y	Y	Y	N	P	N	*$ 637,847*	*n/a*
CA-214	L31, L32	S-L50, S-L51, S-L52	520	565	N				N	1200	P	P	Y	N	P	N	*n/a*	*n/a*
CA-215	Y13		20	40	Y	N	N	N	N	1200	N	N	N	N	N	N	*n/a*	*n/a*
CA-216	Y14	S-Y22	90	110	Y	Y	N	P	N	1160	Y	Y	N	N	P	N	*n/a*	*n/a*
CA-217	L36	S-L57	70	175	Y	Y	N	P	N	1250	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-218	CC28, Y7, Y8	S-Y6, S-Y7	50	75	Y	Y	Y	P	P	1700	N	N	N	N	N	N	*$ 466,366*	*n/a*
CA-219	Y12	S-Y18, S-Y19, S-Y20, S-JH2	775	800	N				N	1300	N	N	N	N	p	N	*n/a*	*n/a*
CA-220		S-BB108	4	50	Y	Y	N	P	N	1300	N	N	N	N	N	N	*n/a*	*n/a*
CA-221	L29	S-L47	12	70	Y	Y	N	P	N	1160	P	Y	Y	N	P	N	*n/a*	*n/a*
CA-222	L28		60	85	Y	Y	N	P	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-223	L24	S-L41	310	340	Y	N	N	P	N	1160	P	Y	N	N	p	N	*n/a*	*n/a*
CA-225	M17	S-M18, S-M19, S-M20	500	520	N				N	1250	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-226	M15	S-M16, S-M17	115	150	Y	p	N	P	N	1200	N	N	N	N	p	N	*n/a*	*n/a*
CA-227	M13, M14	S-M15	30	110	Y	Y	N	P	N	1200	N	N	N	N	N	N	*n/a*	*n/a*
CA-228	L21		380	400	N				N	2800	N	N	N	N	N	N	*n/a*	*n/a*
CA-229	L18, L20, L33	S-L33, S-L34	135	200	Y	Y	N	P	N	3000	Y	Y	N	N	P	N	*n/a*	*n/a*
CA-230	L16, L17	S-L31	260	320	Y	Y	N	P	N	2000	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-231	M7	S-M7	75	100	Y	p	N	P	N	1160	P	P	P	N	P	N	*n/a*	*n/a*
CA-232	M8		25	90	Y	Y	N	P	N	1160	Y	Y	P	N	P	N	*n/a*	*n/a*
CA-233	M9	S-M8	40	60	Y	p	N	P	N	1160	P	Y	Y	N	P	N	*n/a*	*n/a*
CA-234	M10	S-M9, S-M10, S-M11	65	90	Y	Y	N	P	N	1200	P	P	Y	N	P	N	*n/a*	*n/a*
CA-235	M12		145	165	Y	N	N	N	N	1160	p	Y	Y	N	N	N	*n/a*	*n/a*
CA-236	CC27		50	70	Y	Y	N	P	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-237	L15		30	60	Y	Y	Y	P	P	1160	Y	Y	Y	N	P	N	*$ 436,104*	*n/a*
CA-238	L11, L12, L13	S-JH4	250	270	Y	Y	N	P	N	1500	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-239	L14	S-L22	60	80	Y	Y	N	P	N	1500	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-240	M6		80	100	Y	Y	N	P	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-241	M3	S-M3	18	130	Y	Y	Y	P	P	1160	Y	Y	N	N	P	N	*$ 577,324*	*n/a*

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Pennsylvania Pipeline Project

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CA-242	M2	S-M2	245	265	Y	N	N	P	N	1160	P	Y	Y	N	P	N	*n/a*	*n/a*
CA-243	M1	S-M1	160	180	Y	N	Y	P	N	400	P	Y	P	N	P	N	*n/a*	*n/a*
CA-244	K71, K72	S-K96	5	115	Y	Y	Y	P	P	1160	Y	Y	Y	N	N	N	*$ 547,063*	*n/a*
CA-245	L10		65	95	Y	Y	N	N	N	1160	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-246	L9		90	125	Y	P	N	N	N	1550	P	Y	N	N	N	N	*n/a*	*n/a*
CA-247	L7, L8	S-L16, S-L18	310	330	Y	N	N	N	N	1550	P	Y	N	N	N	N	*n/a*	*n/a*
CA-248	L6		280	315	Y	P	N	N	N	1200	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-249	L5		245	270	Y	P	N	N	N	1200	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-250	Pond-L3, W332, W333	S-L13, S-L14, S-L15	250	275	Y	P	N	N	N	1200	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-252	K67	S-K90	125	150	Y	Y	Y	N	N	1050	P	Y	Y	N	N	N	*n/a*	*n/a*
CA-253	K66	S-K88	50	70	Y	Y	N	N	N	1200	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-254	K65	S-K87	25	70	Y	Y	N	P	N	1200	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-255	K63	S-K83, S-K84	35	55	Y	Y	N	P	N	1250	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-256	L3, L4	S-L8, S-L9, S-L10, S-L11, S-L12	420	440	N				N	1160	P	Y	Y	N	N	N	*n/a*	*n/a*
CA-257	Q64, K58	S-K73	200	280	Y	Y	Y	N	N	550	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-258	K56	S-K65	500	520	N				N	1160	P	Y	Y	N	P	N	*n/a*	*n/a*
CA-259	K55	S-K54	175	250	Y	Y	N	N	N	1500	P	Y	P	P	N	N	*n/a*	*n/a*
CA-260	K54	S-K52, S-K53	140	175	Y	Y	N	N	N	1500	P	Y	P	P	N	N	*n/a*	*n/a*
CA-261	K53	S-K51	20	90	Y	Y	N	N	N	1500	P	Y	Y	N	N	N	*n/a*	*n/a*
CA-262	K51, K52	S-K50	60	150	Y	N	Y	N	N	1160	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-263	Q63	S-Q63, S-Q64	195	235	Y	N	N	P	N	1300	P	Y	Y	N	P	N	*n/a*	*n/a*
CA-264	W25e, W26e, W338	S-Q65, S-Q66, S-Q77	645	665	N				N	1300	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-265	K49	S-K49	120	155	Y	Y	Y	N	N	1160	P	Y	Y	N	N	N	*n/a*	*n/a*
CA-266	K50		150	170	Y	Y	N	N	N	1160	P	Y	N	N	N	N	*n/a*	*n/a*
CA-267	W36d		40	190	Y	N	Y	N	N	1160	P	Y	Y	N	N	N	*n/a*	*n/a*
CA-268	J56	S-J60	92	112	Y	Y	Y	N	N	1200	P	Y	P	P	N	N	*n/a*	*n/a*
CA-269	J57, J58, J59	S-J62, S-J63	325	350	Y	P	P	N	N	1200	P	Y	P	P	N	N	*n/a*	*n/a*
CA-270	J69	S-J68, S-J69	340	420	N				N	1160	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-271	J37, Pond-J4	S-J43	25	60	Y	P	N	Y	N	1300	Y	Y	Y	N	Y	N	*n/a*	*n/a*

TABLE 4
Trenchless Construction Feasibility Analysis Matrix
Pennsylvania Pipeline Project

				Conventional Auger Bore Construction Technology						Horizontal Directional Drill Construction Technology								
Crossing Area ID	Wetlands	Streams	Minimum Length of Crossing Area (feet)	Estimated Bore Length (feet)	Bore Crossing Length less than 390'	Topography Conducive to Bore	Sufficient ATWS Available	Sufficient Access (Travel Lane Required)	Bore Technically Feasible	Estimated HDD Length	Topography Conducive to HDD	Elevation Change Conducive to HDD	HDD is Geometrically Feasible	Sufficient HDD Pullback and ATWS Available	Sufficient Access (Travel Lane Required)2	HDD Technically Feasible	*Minimum Bore Cost*	*Minimum HDD Cost*
CA-274	I62		180	215	Y	Y	N	Y	N	1160	Y	Y	Y	N	Y	N	*n/a*	*n/a*
CA-275	I64	S-I90	25	50	Y	N	N	N	N	1450	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-276	W33d	S-K16	30	60	Y	N	N	N	N	1450	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-277	K16	S-K14	115	135	Y	Y	N	N	N	1450	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-278	K15	S-K11	50	70	Y	N	N	N	N	1400	P	Y	Y	N	N	N	*n/a*	*n/a*
CA-279	K14		27	60	Y	Y	N	N	N	1400	P	Y	Y	N	N	N	*n/a*	*n/a*
CA-280	K12, K13	S-K8	60	80	Y	N	N	N	N	1160	P	Y	Y	N	N	N	*n/a*	*n/a*
CA-281	K11	S-K7	20	70	Y	P	N	N	N	1160	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-282	I54	S-I81	65	85	Y	Y	Y	P	P	1160	Y	Y	Y	N	P	N	*$ 486,540*	*n/a*
CA-283	I55, I56		90	150	Y	Y	N	P	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-284	W22d	S-I83	50	80	Y	Y	N	P	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-285	I58		50	100	Y	Y	N	Y	N	1160	Y	Y	N	N	Y	N	*n/a*	*n/a*
CA-286	I60	S-I84	45	65	Y	Y	Y	Y	Y	1160	Y	Y	N	N	Y	N	*$ 446,192*	*n/a*
CA-287	I61	S-I85	65	165	Y	Y	Y	Y	Y	1160	Y	Y	N	N	Y	N	*$ 647,935*	*n/a*
CA-288	K7	S-K4	80	255	Y	Y	N	P	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-289	K9		40	60	Y	Y	N	P	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-290	K6		55	75	Y	Y	Y	P	P	1700	Y	Y	Y	N	P	N	*$ 466,366*	*n/a*
CA-291	K5, W19d	S-K3	180	210	Y	Y	N	P	N	1700	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-292	K2, K3	S-K2	90	110	Y	Y	N	P	N	1700	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-293	K1	S-K1	165	190	Y	Y	N	P	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-294	BB155	S-BB119	153	210	Y	P	Y	P	P	1160	Y	Y	N	N	P	N	*$ 738,719*	*n/a*
CA-296	J36	S-J42	100	120	Y	Y	N	Y	N	1160	Y	Y	Y	N	Y	N	*n/a*	*n/a*
CA-298	J32		80	100	Y	Y	Y	N	N	550	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-301	J27		16	60	Y	Y	Y	P	P	1160	Y	Y	N	N	P	N	*$ 436,104*	*n/a*
CA-302	J26		76	100	Y	Y	Y	P	P	1160	Y	Y	P	N	P	N	*$ 516,802*	*n/a*
CA-303	J25		75	250	Y	Y	Y	P	P	1160	Y	Y	P	N	P	N	*$ 819,416*	*n/a*
CA-304	W14e		26	250	Y	Y	Y	P	P	1160	Y	Y	P	N	P	N	*$ 819,416*	*n/a*
CA-305	J24	S-J29	45	90	Y	Y	N	P	N	1500	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-306	J23		90	110	Y	Y	N	P	N	1500	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-307	J22		65	85	Y	Y	N	P	N	1500	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-308	J21	S-BB100	80	230	Y	Y	N	P	N	1160	Y	Y	N	N	P	N	*n/a*	*n/a*
CA-309	I41, I42	S-I69, S-I70	45	150	Y	P	Y	Y	P	1160	P	Y	Y	N	P	N	*$ 617,673*	*n/a*
CA-310	I53	S-I80	30	50	Y	Y	N	P	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-311	I52	S-I79	37	60	Y	Y	N	P	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-312	I45, I46, I48, I49, J19, J20	S-I75, S-I76, S-I77	456	480	N				N	2800	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-313	I44	S-I74	45	65	Y	Y	N	P	N	2800	Y	Y	Y	N	P	N	*n/a*	*n/a*

TABLE 4
Trenchless Construction Feasibility Analysis Matrix
Pennsylvania Pipeline Project

				Conventional Auger Bore Construction Technology						Horizontal Directional Drill Construction Technology								
Crossing Area ID	Wetlands	Streams	Minimum Length of Crossing Area (feet)	Estimated Bore Length (feet)	Bore Crossing Length less than 390'	Topography Conducive to Bore	Sufficient ATWS Available	Sufficient Access (Travel Lane Required)	Bore Technically Feasible	Estimated HDD Length	Topography Conducive to HDD	Elevation Change Conducive to HDD	HDD is Geometrically Feasible	Sufficient HDD Pullback and ATWS Available	Sufficient Access (Travel Lane Required)2	HDD Technically Feasible	*Minimum Bore Cost*	*Minimum HDD Cost*
CA-314	I43	S-I72	115	135	Y	N	N	Y	N	1160	Y	Y	Y	N	Y	N	*n/a*	*n/a*
CA-315	I39	S-I65	85	105	Y	Y	N	Y	N	1160	Y	Y	Y	N	Y	N	*n/a*	*n/a*
CA-316	I37, I38	S-I59	110	130	Y	N	N	N	N	1160	Y	Y	N	N	N	N	*n/a*	*n/a*
CA-317	BB15	S-J24	20	40	Y	Y	Y	N	N	1160	Y	Y	N	N	N	N	*n/a*	*n/a*
CA-318	J15		28	50	Y	Y	N	N	N	1160	Y	Y	N	N	N	N	*n/a*	*n/a*
CA-319	J14	S-J21	30	70	Y	Y	N	N	N	1160	Y	Y	N	N	N	N	*n/a*	*n/a*
CA-320	BB12, J13	S-J20	70	90	Y	Y	Y	N	N	1160	Y	Y	N	N	N	N	*n/a*	*n/a*
CA-322	J11		65	85	Y	Y	Y	N	N	80	Y	Y	Y	Y	N	N	*n/a*	*n/a*
CA-323	J10		1663	1695	N				N	1700	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-325	K41		52	75	Y	Y	N	Y	N	1160	Y	Y	N	N	Y	N	*n/a*	*n/a*
CA-326	Pond-J3		12	35	Y	Y	N	N	N	1160	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-328	BB129	S-BB101	150	190	Y	Y	Y	N	N	1160	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-329	BB43		55	75	Y	P	N	N	N	1160	P	Y	Y	N	P	N	*n/a*	*n/a*
CA-330	BB44		20	40	Y	P	N	N	N	1160	P	Y	Y	N	N	N	*n/a*	*n/a*
CA-331	I26, I27	S-I41, S-I42, S-I43	215	235	Y	Y	N	N	N	1360	Y	Y	Y	Y	N	N	*n/a*	*n/a*
CA-332	H54	S-H68, S-H69, S-H70	40	60	Y	N	N	Y	N	1160	Y	Y	N	N	Y	N	*n/a*	*n/a*
CA-333	I23, W3c	S-I33	20	165	Y	Y	N	P	N	750	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-334	I22	S-I31	144	165	Y	N	N	N	N	1160	N	Y	Y	N	N	N	*n/a*	*n/a*
CA-335	I20	S-I25, S-I26	9	80	Y	Y	Y	Y	Y	1160	Y	Y	N	N	Y	N	*$ 476,453*	*n/a*
CA-336	J63		5	50	Y	Y	N	P	N	1160	Y	Y	N	N	P	N	*n/a*	*n/a*
CA-337	BB152	S-BB118	50	110	Y	Y	N	P	N	1160	Y	Y	N	N	P	N	*n/a*	*n/a*
CA-338	BB21	S-BB18	80	140	Y	Y	N	P	N	1350	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-340	H50	S-H60	30	50	Y	Y	N	N	N	1350	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-341	B64	S-B75	34	60	Y	P	N	Y	N	1160	Y	Y	N	N	Y	N	*n/a*	*n/a*
CA-342	B76	S-B73	36	165	Y	N	Y	Y	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-343	B62	S-B72, S-B74	19	150	Y	Y	Y	N	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-345	A16		20	50	Y	Y	N	P	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-346	A17	S-A21	75	95	Y	Y	Y	Y	Y	1160	Y	Y	P	N	Y	N	*$ 506,714*	*n/a*
CA-347	C28		233	275	Y	Y	N	Y	N	1160	Y	Y	Y	N	Y	N	*n/a*	*n/a*
CA-349	BB38, BB39, B59, B60	S-B69	390	400	N				N	1160	Y	Y	Y	N	Y	N	*n/a*	*n/a*
CA-350	B55		40	55	Y	Y	N	Y	N	1160	P	Y	P	N	Y	N	*n/a*	*n/a*
CA-352	B56, B57	S-B60	33	55	Y	Y	Y	Y	Y	3850	Y	Y	Y	Y	P	P	*$ 426,017*	*$ 8,541,431*
CA-353	C27	S-B66, S-BB67	132	175	Y	Y	Y	N	N	700	Y	Y	Y	P	P	P	*n/a*	*$ 1,810,763*

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Pennsylvania Pipeline Project

Crossing Area ID	Wetlands	Streams	Minimum Length of Crossing Area (feet)	Conventional Auger Bore Construction Technology: Estimated Bore Length (feet)	Bore Crossing Length less than 390'	Topography Conducive to Bore	Sufficient ATWS Available	Sufficient Access (Travel Lane Required)	Bore Technically Feasible	Horizontal Directional Drill Construction Technology: Estimated HDD Length	Topography Conducive to HDD	Elevation Change Conducive to HDD	HDD is Geometrically Feasible	Sufficient HDD Pullback and ATWS Available	Sufficient Access (Travel Lane Required)2	HDD Technically Feasible	*Minimum Bore Cost*	*Minimum HDD Cost*
CA-354	B61	S-B71	205	240	Y	Y	Y	N	N	1160	Y	Y	P	N	N	N	*n/a*	*n/a*
CA-355	A22	S-A33	17	90	Y	Y	N	P	N	1160	P	Y	N	N	P	N	*n/a*	*n/a*
CA-356	A23		220	260	Y	Y	Y	Y	Y	1160	Y	Y	Y	N	Y	N	*$ 839,590*	*n/a*
CA-357	A25	S-A42	115	160	Y	P	N	Y	N	1160	Y	Y	Y	N	Y	N	*n/a*	*n/a*
CA-358	K23	S-A45	7	30	Y	Y	N	P	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-359	A27	S-A47	475	530	N				N	850	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-360	B66	S-B76, S-B77, S-B78, S-B78A	80	100	Y	Y	N	Y	N	1160	Y	Y	P	N	Y	N	*n/a*	*n/a*
CA-361	A1, A2	S-A1, S-A2, S-A3	526	550	N				N	1160	Y	Y	Y	N	Y	N	*n/a*	*n/a*
CA-362	A3		13	30	Y	Y	N	P	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-363	A4	S-A5, S-A5a	5	25	Y	Y	N	P	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-364	A6	S-A6, S-A7	50	70	Y	Y	N	P	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-365	A9	S-A10	103	150	Y	P	N	P	N	1250	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-366	A11	S-A16	165	200	Y	Y	P	Y	P	1200	Y	Y	Y	N	Y	N	*$ 718,545*	*n/a*
CA-367	A13		22	55	Y	Y	Y	P	P	120	Y	Y	Y	N	Y	N	*$ 426,017*	*n/a*
CA-369	BB154	S-A19	20	40	Y	Y	N	Y	N	1160	Y	Y	Y	N	Y	N	*n/a*	*n/a*
CA-370	A19	S-A23	30	100	Y	Y	N	Y	N	1160	Y	Y	Y	N	Y	N	*n/a*	*n/a*
CA-371	CJ2	S-A25	125	160	Y	Y	Y	Y	Y	1160	P	Y	N	N	Y	N	*$ 637,847*	*n/a*
CA-372	W5c		65	100	Y	Y	Y	P	P	1160	Y	Y	N	N	P	N	*$ 516,802*	*n/a*
CA-373	H4	S-H7	915	935	N				N	1200	Y	Y	Y	N	Y	N	*n/a*	*n/a*
CA-374	C17	S-C37, S-C38	108	130	Y	N	N	P	N	1160	P	Y	N	N	P	N	*n/a*	*n/a*
CA-375	C16	S-C35	247	340	Y	P	N	Y	N	1160	Y	Y	Y	N	Y	N	*n/a*	*n/a*
CA-376	H28	S-A85	44	65	Y	Y	N	Y	N	1160	Y	Y	P	N	Y	N	*n/a*	*n/a*
CA-377	W8c		8	30	Y	Y	N	P	N	1160	Y	Y	N	N	Y	N	*n/a*	*n/a*
CA-378	A52	S-A76	44	65	Y	Y	N	Y	N	1160	Y	Y	Y	N	Y	N	*n/a*	*n/a*
CA-379	A56	S-A87	300	315	Y	Y	Y	Y	Y	1160	Y	Y	N	N	Y	N	*$ 950,549*	*n/a*
CA-380	B72		324	335	Y	Y	Y	Y	Y	1160	Y	Y	Y	N	Y	N	*$ 990,898*	*n/a*
CA-381	B74, B75, Pond-B11A	S-B83	474	495	N				N	1160	Y	Y	P	N	Y	N	*n/a*	*n/a*
CA-382	B5	S-B8	168	190	Y	Y	N	Y	N	1160	Y	Y	N	N	Y	N	*n/a*	*n/a*
CA-383	B7	S-B11	67	90	Y	Y	N	p	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-384	B10	S-B13	128	150	Y	Y	N	p	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-385	B11		71	120	Y	Y	Y	p	P	1160	Y	Y	Y	N	P	N	*$ 557,150*	*n/a*

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CA-386	B16, B17, B18	S-B16	70	150	Y	Y	N	N	N	1160	P	Y	N	N	Y	N	*n/a*	*n/a*
CA-387	A49	S-A73	78	100	Y	Y	N	Y	N	1160	Y	Y	N	N	Y	N	*n/a*	*n/a*
CA-388	B21, B22	S-B22, S-B23, S-B24	446	470	N				N	1160	Y	Y	Y	N	Y	N	*n/a*	*n/a*
CA-389	B24	S-B25	78	100	Y	Y	N	p	N	1600	Y	Y	Y	N	Y	N	*n/a*	*n/a*
CA-390	K25		24	95	Y	Y	N	p	N	1600	Y	Y	Y	N	Y	N	*n/a*	*n/a*
CA-391	B42	S-B47	65	95	Y	Y	N	p	N	1600	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-392	B43	S-B48	84	105	Y	N	N	Y	N	1160	P	Y	Y	N	Y	N	*n/a*	*n/a*
CA-393	B44	S-B49	50	80	Y	Y	N	Y	N	1800	Y	Y	Y	N	Y	N	*n/a*	*n/a*
CA-394	B48		37	160	Y	Y	Y	Y	Y	1800	Y	Y	Y	N	Y	N	*$ 637,847*	*n/a*
CA-395	B49	S-B50	25	135	Y	Y	Y	Y	Y	1160	Y	Y	N	N	Y	N	*$ 587,412*	*n/a*
CA-396	B40		40	60	Y	Y	N	Y	N	1160	Y	Y	N	N	Y	N	*n/a*	*n/a*
CA-398	C12	S-C31	122	195	Y	Y	Y	Y	Y	1160	Y	Y	Y	N	Y	N	*$ 708,457*	*n/a*
CA-399	W48PEM-2	S-BB34. S-B33	8	30	Y	Y	N	p	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-400	AM2	S-C11	207	230	Y	Y	N	Y	N	1160	Y	Y	N	N	N	N	*n/a*	*n/a*
CA-401	C1	S-C1	116	190	Y	Y	N	Y	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-402	C2	S-C2	28	50	Y	Y	N	p	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-403	C5	S-C7	70	90	Y	p	N	Y	N	1160	Y	Y	Y	N	Y	N	*n/a*	*n/a*
CA-404	B32, B33	S-B30	247	395	N				N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-405	B27, B28, B29, B30, B31, W302	S-B29	830	850	N				N	1400	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-406	H24, H25, H26	S-H22, S-H23	220	320	Y	Y	N	p	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-407	H23		50	70	Y	Y	N	p	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-408	W301	S-H13, S-H15	85	105	Y	Y	N	p	N	1160	P	Y	N	N	P	N	*n/a*	*n/a*
CA-409	H21	S-H16	30	70	Y	Y	N	p	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
CA-410	W35	S-Q62	330	450	N				N	1160	Y	Y	Y	N	Y	N	*n/a*	*n/a*
CA-411	BA10		85	105	Y	Y	Y	p	P	120	Y	Y	Y	Y	Y	Y	*$ 526,889*	*$ 571,465*
CA-412	A45		93	250	Y	Y	N	Y	N	1160	Y	Y	Y	N	Y	N	*n/a*	*n/a*
CA-413	A46		16	40	Y	Y	Y	P	P	1160	Y	Y	Y	N	P	N	*$ 395,756*	*n/a*

TABLE 4
Trenchless Construction Feasibility Analysis Matrix
Pennsylvania Pipeline Project

				Conventional Auger Bore Construction Technology						Horizontal Directional Drill Construction Technology								
Crossing Area ID	Wetlands	Streams	Minimum Length of Crossing Area (feet)	Estimated Bore Length (feet)	Bore Crossing Length less than 390'	Topography Conducive to Bore	Sufficient ATWS Available	Sufficient Access (Travel Lane Required)	Bore Technically Feasible	Estimated HDD Length	Topography Conducive to HDD	Elevation Change Conducive to HDD	HDD is Geometrically Feasible	Sufficient HDD Pullback and ATWS Available	Sufficient Access (Travel Lane Required)2	HDD Technically Feasible	*Minimum Bore Cost*	*Minimum HDD Cost*
CA-414	B12, B13, B14	S-B14	128	150	Y	Y	N	Y	N	1160	Y	Y	Y	N	Y	N	*n/a*	*n/a*
CA-415	C33	S-C56	164	185	Y	Y	N	Y	N	1160	Y	Y	N	N	Y	N	*n/a*	*n/a*
CA-416	C34, C35	S-C58	202	225	Y	Y	N	Y	N	1160	Y	Y	N	N	Y	N	*n/a*	*n/a*
CA-417	B15	S-B15	132	195	Y	Y	Y	N	N	1160	Y	Y	N	N	Y	N	*n/a*	*n/a*
CA-418	C49		845	865	N				N	1160	Y	Y	Y	N	Y	N	*n/a*	*n/a*
CA-419	B19	S-B18, S-B19	464	485	N				N	1160	P	Y	N	N	Y	N	*n/a*	*n/a*
CA-420	H16	S-H9	32	180	Y	Y	N	N	N	1160	P	Y	N	N	Y	N	*n/a*	*n/a*
CA-421	H15		524	545	N				N	1160	P	Y	N	N	Y	N	*n/a*	*n/a*
CA-422	Q75	S-Q200, S-H52	20	40	Y	N	Y	N	N	1160	N	Y	N	N	N	N	*n/a*	*n/a*
CA-423	C40	S-C73, S-C74	182	195	Y	P	Y	N	N	1160	Y	Y	N	N	N	N	*n/a*	*n/a*
CA-424	C38	S-C72	62	85	Y	Y	N	N	N	1160	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-425	C48		97	120	Y	Y	Y	Y	Y	1200	Y	Y	Y	N	N	N	*$ 557,150*	*n/a*
CA-426	C47	S-C96	622	645	N				N	1200	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-427	C42		568	590	N				N	1160	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-429	C23	S-C44	244	265	Y	N	N	N	N	1160	Y	Y	P	N	N	N	*n/a*	*n/a*
CA-432	I5		112	135	Y	Y	N	Y	N	1160	Y	Y	N	N	Y	N	*n/a*	*n/a*
CA-433	H41		26	50	Y	P	N	N	N	1160	Y	Y	Y	N	N	N	*n/a*	*n/a*
CA-435	T27	S-T34	40	60	Y	P	P	P	P	1160	N	N	N	N	P	N	*$ 436,104*	*n/a*
CA-436	T28	S-T35	14	34	Y	Y	p	P	P	1500	Y	N	Y	N	P	N	*$ 383,651*	*n/a*
SA-001		S-P9, S-Q51	10	30	Y	N	N	P	N	1500	P	P	N	N	P	N	*n/a*	*n/a*
SA-002		S-M77	75	95	Y	N	N	P	N	1400	Y	P	y	N	P	N	*n/a*	*n/a*
SA-003		S-Q59	10	30	Y	P	N	P	N	1200	N	N	N	N	P	N	*n/a*	*n/a*
SA-004		S-M35	280	325	Y	N	N	P	N	1500	N	N	N	N	N	N	*n/a*	*n/a*
SA-005		S-M28	30	60	Y	N	N	P	N	1500	N	N	P	N	P	N	*n/a*	*n/a*
SA-006		S-K55, S-K58	1300	1400	N				N	4000	N	N	P	P	P	N	*n/a*	*n/a*
SA-007		S-H58	280	340	Y	Y	N	N	N	1160	P	Y	Y	N	N	N	*n/a*	*n/a*
SA-008		S-A82, S-A83	2784	2800	N				N	3435	Y	Y	Y	Y	Y	Y	*n/a*	*$ 7,654,692*
SA-009		S-B43	14	75	Y	Y	N	P	N	1160	Y	Y	Y	N	P	N	*n/a*	*n/a*
SA-010		S-H21	4	300	Y	Y	Y	Y	Y	1160	P	Y	Y	P	Y	P	*$ 920,288*	*$ 2,793,654*
SA-011		S-Q90	21	45	Y	P	Y	Y	P	1200	Y	Y	Y	P	Y	P	*$ 405,843*	*$ 2,879,123*
SA-015		S-Y3	80	100	Y	N	N	N	N	1600	Y	Y	Y	Y	Y	Y	*n/a*	*$ 3,733,811*